Retro-Commissioning for Peak Electric Demand Reduction in New York City

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Synopsis

As an innovative strategy to reduce system coincident summer peak electric demand in New York City, the New York State Energy Research and Development Authority (NYSERDA) offered the Building Performance Program for Consolidated Edison Facilities. The Program contracted with three service providers to retro-commission 6 million square feet of gross floor area encompassing six building projects. Currently, the Program has identified peak electric demand reduction opportunities totaling 1.775 MW and over 8,979,900 kWh. Additional opportunities to reduce system coincident summer peak electric demand have been identified during retro-commissioning to further boot cost-effectiveness of the program.

This paper summarizes the basic program design and process to achieve the desired peak electric demand reduction goals. Systematic review of all energy using and control systems and early engagement of building operations staff and their support network are key elements which greatly impact the outcome and realization of electric demand reduction benefits during retro-commissioning. The benefits of the practical hands-on approach used to drive sustainable business practices within the organization and close collaboration with the facilities operations and maintenance staff is discussed. Expected program impacts, and demand savings categorized by building system and measure type are examined.

About the Author

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Program Design

On March 24, 2005, the New York State Public Service Commission (PSC), in Case 04-E-0572, issued an Order adopting a rate plan for Consolidated Edison. One aspect of the rate plan was the establishment of Demand Side Management (DSM) goals to be obtained through DSM programs administered by NYSERDA and Con Edison. The objective of the DSM programs is to enable demand resources to supplant a portion of the load growth anticipated to take place over the term of the rate plan. The PSC Order names NYSERDA as administrator of a System Wide Program (SWP) with a goal of achieving 150 MW of demand reductions in the Con Edison service territory through energy efficiency, load management, and distributed generation. Under the SWP, NYSERDA offered currently available **New York Energy $martK** programs and also developed new offerings. The Building Performance Program for Consolidated Edison Facilities was one of these new offerings, and served as an innovative means to achieve over 2 MW peak demand reduction within two years.

The Program sought proposals from experienced retro-commissioning (RCx) providers to reduce electric costs at large commercial facilities in the Con Edison service territory by conducting cost-effective RCx projects and implementing low and no-cost improvements to building operations that would result in electric demand reduction. Buildings in the Con Edison service territory (including New York, Bronx, Kings, Queens, Richmond and Westchester Counties) greater than 500,000 square feet, with peak electric demand of at least 1,500 kW, and a high normalized demand were targeted. The RCx provider was required to provide building information and obtain building owner commitment prior to proposal submission. To leverage the relationship between RCx provider and the building owner, proposal teams were encouraged to include multiple project sites for a single building owner under one proposal. Each building project was required to achieve a minimum of 125 kW demand reduction coincident with the system summer peak electric demand, and at least $10,000 cost-share from the building owner.

Financial incentives of $3,240,000 were made available on a competitive basis to fund the full cost of RCx services and a portion of the follow-on services to implement and monitor results of facility improvements. Incentives for implementation and other follow-on services were allocated to the retro-commissioning provider payable at the rate of $350/kW for achieving a minimum system coincident summer peak electric demand reduction of 125kW per facility, or $500/kW for achieving 200 kW or more. These incentives were expected to help offset the costs required for implementation of approved RCx and Peak Demand Reduction (PDR) capital improvement measures, documentation updates, staff training, and measurement and verification. Each of the six projects was required to meet minimum requirements as defined for each step of the RCx process including: 1) RCx Investigation, 2) Implementation and Monitoring, 3) Documentation and Training, and 4) Measurement and Verification (M&V).

Ten (10) projects were submitted by 3 RCx providers with projected estimates to achieve over 2.3 MW system coincident summer peak electric demand reduction and 11.2 GWh of energy savings for a cost of approximately $2,500,000. Each RCx provider proposed multiple projects with opportunities well over 125 kW for each building project. Less building projects were submitted than expected due to the limited time available for proposal submission. A Technical

Evaluation Panel (TEP), made up of external professionals and internal NYSERDA reviewers, reviewed and ranked each of the 10 building projects and recommended 6 of the 10 projects for funding, including at least one facility form each of the four proposals. Rankings were based on project cost-effectiveness, demand reduction opportunity, building owner commitment and cost-share, teamwork, and overall responsiveness to the solicitation. NYSERDA approved $1,804,305 to achieve an estimated 1.775 MW summer coincident peak electric demand reduction. Based on project performance to date, NYSERDA expects to award increased performance incentives to achieve greater demand reduction benefits as determined during the retro-commissioning process. Program costs may increase to $2,067,000 to achieve a more cost-effective 2536 kW peak electric demand reduction at $815/kW. Additional funds established at 10% of the program budget will be used for third-party quality assurance and technical assistance during project measurement and verification.

RCx Investigation

RCx Investigation Report

RCx Investigation included conducting a detailed, structured interview with management and building personnel about operating conditions, known performance problems and plans for future corrective action on major energy using equipment such as: chillers, cooling towers, boilers, pumps, air handlers, packaged heating and cooling equipment, other fans (exhaust, make-up, etc.), lighting controls, electrical system and the Energy Management Control Systems (EMCS). Tasks included reviewing current Operations and Maintenance (O&M) practices and service contracts, developing diagnostic monitoring and test plans, spot testing equipment and controls, trending or electronic data logging of pressures, temperatures, power, air and water flows, and lighting levels and use. Building documentation and equipment specs were evaluated, including electrical and mechanical drawings, sequences, points lists, Test and Balance (TAB) reports, O&M manuals, and maintenance records. Detailed information about the building's main energy using systems was gathered, including the EMCS, HVAC, lighting control system schedules, set-points, and sequences. This task included an on-site inspection of major building system's condition and functionality, control configurations, documentation of system performance and space temperatures. During investigation, items were identified that may not reduce demand but would save the operator money (e.g. steam leaking into a return air duct). This comprehensive view helped build credibility with the building operator and was a key driver in gaining participation. To support project measurement and verification, the provider was encouraged to install permanent monitoring equipment including whole building gas and electric meters, boiler BTU meters, and pressure and temperature sensors on air and water systems.

NYSERDA provided Microsoft Excel templates to summarize project findings. Measures that were not assessed to provide continuous demand reduction during the peak period were included in the findings and will later be evaluated for eligibility under NYSERDA's Commercial Industrial Performance Program. Minor repairs and simple improvements were allowed to be implemented during the investigation. However, major improvements were expected to occur at the end of the investigation phase, after NYSERDA approval. Investigation services included the

calculation of projected energy and demand savings, and delivery of the RCx Report and M&V Plan.

Project Benchmarking

Each provider was required to evaluate a minimum of 24 months whole building electricity usage, peak demand, gas and steam data, and analyze interval data on major building systems including, but not limited to, selected air-handling units (AHUs), electric chiller, and pump systems. The space use was evaluated to determine square footage by space usage type (office space, storage, cafeteria, etc.). These data, along with the number of desktop computers and hours of operation by usage was entered into the U.S. Environmental Protection Agency's ENERGY STAR® Portfolio Manager to report an ENERGY STAR® rating for each facility. The Portfolio Manager software compares and ranks buildings against other similar buildings, adjusting for climate, space use and heating and cooling degree days.

Project Implementation Plan

The providers worked with their respective building owners to prioritize improvements based on cost-effectiveness and demand reduction benefits, and submitted a final Project Implementation Plan. The Project Implementation Plan summarized the final kW reduction goals, RCx measures, and capital-intensive PDR measures to be implemented during the project term. Performance incentives were estimated based on the engineering estimates and calculated savings projected upon delivery of the Project Implementation Plan, and will be paid to the provider based on calculated and measured savings determined during project measurement and verification.

Implementation and Monitoring

Measure Implementation

To encourage implementation within three months of completion of the RCx investigation, the provider was given responsibility for implementation oversight. In most cases the provider implemented approved measures in accordance with the M&V and Project Implementation Plan. In cases where it was more cost-effective or more desirable for the building staff or other party to implement the approved measures, the provider continued to oversee implementation and post-implementation testing to ensure that improvements were working as expected and had a positive affect on other systems, equipment, and building occupants.

Project Implementation Report

The provider was responsible for summarizing project metrics and delivering a Project Implementation Report showing all calculations and savings measurements as stipulated in the M&V Plan. A Performance Incentive payable at $350/kW for achieving between 125 kW and 200 kW, or $500/kW for achieving greater than 200 kW was determined from the estimated system coincident summer peak demand reduction expected for the project. *System coincident*

summer peak demand reduction was defined as the average electric demand reduction that occurs continuously during the Con Edison On-Peak period, May 1 – October 31, Monday – Friday excluding holidays, from 12:00PM – 6:00PM. Incentive demand reductions not occurring continuously during these hours is prorated accordingly [(kWh savings between 12:00PM and 6:00PM)/6 hours].

The third party NYSERDA Consultant reviewed the Project Implementation Report, conducted field verification, and provided general quality assurance for the project. Upon NYSERDA approval of the Project Implementation Report, the provider was eligible to submit an invoice for 50% of the Performance Incentive. If review of the Project Implementation Report and subsequent Field Verification reveals the estimated implementation conditions are not met, NYSERDA plans to recalculate the savings and adjust incentive payments accordingly. If the minimum requirement of 125 kW is not met, NYSERDA will adjust the milestone payment accordingly, and reserve the right to cancel the project making no further milestone payments.

Documentation and Training

The provider recommended revisions to documentation as appropriate for the project, including EMCS documentation, control schema, and O&M manual updates. Documentation was updated either by building staff or the provider and later incorporated into the staff training programs. The provider was encouraged to develop training videos, presentations, and other materials, as appropriate for all major improvements accomplished at the facility. The training elements were incorporated as part of the persistence plan as presented in the M&V Plan. Training was incorporated into the projects in a manner that facilitated knowledge transfer to the building operations staff to achieve greater persistence of energy savings and demand reduction benefits.

Measurement and Verification

The provider was responsible for project M&V, with quality assurance oversight by a third-party NYSERDA Consultant assigned to the project at no cost to the provider. The International Performance Measurement and Verification Protocol (IPMVP) served as the basis for the M&V approach, using retrofit isolation with key parameters measured (Option A), retrofit isolation with all parameters measured periodically or continuously (Option B), and whole building performance and utility analysis (Option C). To coordinate various approaches to project M&V, Nexant, Inc. was contracted to develop guidelines for the measurement and verification protocols to be used for these projects. These guidelines will be utilized to ensure that NYSERDA obtains reliable savings and performance metrics (kW, kWh, MMBtu, IEQ, and persistence).

The IPMVP Option C, whole-building analysis, was applicable to those projects where the savings were large enough to be differentiated from the natural variance observed in utility bills. Measurements of whole building energy and demand at the utility meters and captured in energy bills exhibit a certain amount of random behavior that is not easily predicted and contributes to 10% to 20% uncertainty. Most retro-commissioning measures typically result in less than 10% bill savings, thereby making it difficult to separate the natural background noise of fluctuating energy use from the effect of the retro-commissioning work. The approach taken in the M&V

Guidelines for these projects was to use Option C and normalized billing consumption to validate the results calculated from the end-use M&V activities for building systems affected by the retro-commissioning effort. End-use M&V approaches were established for groupings of RCx measures defined by the boundary across which energy flows along with the variable(s) that determine energy use. Appropriate M&V techniques using IPMVP Options A and B were then used to determine savings for these system-level groupings of measures. For example, one project proposed to alter the sequence of cooling tower operation, alter the sequence of pump operation to take advantage of existing variable speed drives, remove an orifice plate from the water line, and eliminate an unneeded bypass leg. All of these measures reduce condenser water pumping energy, but savings calculated from individual measures are not additive due to their interactive nature. By combining all of these measures and reporting savings under condenser water pumps, the project M&V is simplified. The pumping energy in the baseline case is readily estimated with simple measurements, the post-RCx pumping energy can also be estimated through continuous monitoring.

Public-Private Partnership

Provider Leadership

Participating retro-commissioning providers played an important role in forging the unique partnership between owner, property management firm, and the public sector. A key attribute of the provider's success is their creditability with owner and property manager in the sense that they understand the host's business practices and needs and are able define measures that meet these needs as well as the shared commitment to environmental sustainability, energy efficiency, and electric demand reduction that can be leveraged to achieve common building performance goals. One provider's innovation in proposing a unique "Performance Incentive Sharing Program" to reward teamwork helped to support O&M staff functions that reinforced persistence of savings and achievement of the established demand reduction goals. These projects planned to allocate fifty percent (50%) of the NYSERDA Performance Incentives that exceeded the total implementation costs to the O&M staff to purchase energy related testing equipment, certifications such as Certified Building Operator (CBO), Certified Energy Manager (CEM), LEED Certification, and related staff training to sustain their success. Success of these early pilots can easily motivate the owner to commit further funding and resources for similar projects within their portfolio.

Owner/Property Management Commitment

Building owner commitment results in the highest level of success for each retro-commissioning project. Engaged facilities staff enables active participation and assistance in the investigation, implementation and training efforts which will ensure project success while simultaneously creating project ownership. The highest level of commitment was exemplified on these pilot projects, where each building owner came into the Program with a solid corporate and cultural commitment to sustainable design, construction and operations and maintenance. Each building owner had achieved various levels of recognition from US EPA (Energy Star Partner, Partner of

the Year) and served as members of the US Green Buildings Council (USGBC). Prior to participating in this Program, two of the building owners had previously committed to the retro-commissioning process in pursuit of LEED Existing Building (EB) certification by the USGBC.

Public Benefit

Retro-commissioning provides a cost-effective methodology to achieve demand reduction in load pocket areas. Through a structured retro-commissioning process, providers can often achieve more than what is initially proposed during the scoping phase. For example, one of the six projects increased their estimated system coincident summer peak electric demand reduction from 377kW to 902kW (140% increase) and leveraged over $500,000 owner investment. Whereas it was expected that these RCx projects would deliver 5 to 7 percent kW reduction at a cost ranging from $0.20 - $0.65 per square foot, it was found that by selecting appropriate building projects, the program expects to achieve 10% demand reduction at $0.17/sq ft for RCx services and an average project cost including both RCx and incentives of $0.34 per square foot.

Program Impact

Program Participants

The Program contracted with three providers to service approximately 6 million gross square feet of building floor area through 6 projects. Approximately 75% of the gross floor area was for commercial office, with the balance in the hospitality/hotel sector. The participants are summarized in **Table 1**, along with the estimated savings opportunity defined at time of the proposal, before comprehensive retro-commissioning investigation was completed.

Table 1: Program Participants and Estimated Savings

Provider/ Project Site	Building Type	Total Area (ft^2)	kWh Savings Identified	kW Reduction Identified
Strategic Building Solutions, LLC				
Site 1	Office	880,248	2,135,424	377
Site 2	Office	1,346,135	2,959,678	422
Site 3	Office	682,857	1,752,300	215
KEMA Services, Inc./ Amicus Energy Solutions				
Site 4	Hotel	1,200,000	649,000	317
Site 5	Hotel	350,000	299,500	144
Phoenix Facilities Management, LLC				
Site 6	Office	1,600,000	1,184,000	300
TOTAL		6,059,240	8,979,902	1,775

Project Data

Only one of the six projects has completed the RCx investigation at time of this paper. The results obtained from the completed investigation are therefore presented along with the estimated savings projected for the five remaining projects. The completed project far exceeded the projection of the originally 27 proposed Energy Conservation Measures (ECMs). Through the process of retro-commissioning, the provider identified an additional 29 ECMs to achieve over 900 kW summer coincident peak electric demand reduction. Approximately 300 kW of the projected demand reduction was attributed to approval of a demand limiting measure to provide real time electrical demand measurement on the BMS and implement an automated control sequence to measure and control peak electrical demand through the use of global BMS setpoints. This was implemented alongside additional BMS programming to continuously track, monitor, and compare benchmarks of the total building energy use, chiller efficiency, boiler plant operation, and air handling unit operations. This allowed the operators to continuously monitor and measure building system performance. Expected program impacts, and demand savings categorized by building system and measure type are presented in **Table 2**.

Table 2: Program Impact by Measure Type

ECM/System	Total Identified Savings (kW)	Total Identified Savings (kWh)	Average Annual Savings ($)	Average Install Cost ($)	Average Simple Payback
BMS Global Resets/ Demand Limiting	300	100,000	20,000	48,000	2.4
BMS Control/ Loop Tuning	49	133,196	18,907	53,100	2.8
AHU	438	3,466,981	842,303	318,900	0.4
Chiller	439	1,229,095	249,752	523,833	2.1
Cooling Tower Optimization	195	792,533	138,828	100,080	0.7
Critical HVAC (Data Center)	294	1,455,323	204,569	2,651,409	13.0
HVAC/Steam	54	36,000	30,326	43,000	1.4
HVAC/VAV	243	1,440,681	256,140	1,605,076	6.3
OA Management/DCV	143	761,275	145,036	152,100	1.1
Load/Schedule Optimization	10	48,000	4,008	12,700	3.2
Pumps	30	96,000	11,617	38,100	3.3
DX Units	22	30,400	5,252	6,750	1.3
DHW Optimization	14	23,860	7,088	37,700	5.3
Exhausts/Garages	20	158,234	25,317	40,803	1.6
Lighting/Controls	267	1,236,638	185,451	1,779,153	9.6
Kitchen/Controls	27	225,222	74,600	167,000	2.2
IT/Plug Load	18	425,075	85,015	84,141	1.0
TOTAL	2,536	11,658,513	2,304,209	7,661,845	3.3

Conclusions

Retro-commissioning alongside the implementation of selected cost-effective capital investment provides a cost-effective demand reduction resource for utility and program administrators. Likewise, providers need the backing of program administrators to support the enhanced services generally provided along with comprehensive retro-commissioning projects. Providers with stellar engineering staff, training expertise, and innovative teaming strategies are able to position themselves within the owner organization to achieve demand reduction goals needed by program administrators. To offset the high cost of project M&V, it is desirable to design the program such that larger projects with greater potential for demand reduction and energy savings (over 20%) are targeted. The likelihood of project success depends upon 1) a committed building owner with influential decision-making structure, 2) experienced facility staff, 3) availability of advanced building control systems, and 4) large potential savings opportunity. Third-party oversight is necessary to provide quality assurance and help meet the reporting needs of the program administrator, thereby taking some burden off the RCx provider.

A comprehensive scoping report is necessary to provide early insight into project metrics, and projects benefit by providing sufficient time for the provider to properly scope the building opportunities. To uncover retro-commissioning measures in a cursory survey is incredibly difficult and project performance to date would suggest that the actual implemented RCx measures vary somewhat from the measures identified in the initial PON 970 proposals. Generally speaking, it is much easier to identify capital measures in a quick walkthrough (lighting retrofits, chiller replacement, etc.) than operational measures in a more modern well run "efficient" building. Therefore, programs may benefit from requiring completion of a RCx investigation prior to awarding performance incentives for project implementation.

Further program design consideration should be given to ascertaining relative costs for project measurement and verification. The conundrum of implementing retro-commissioning measures with relatively low-cost and short simple paybacks versus the necessary expenditures for program quality assurance and project measurement and verification when part of a utility funded program is something that should be further evaluated. The costs needed to calculate the estimated energy savings during investigation and to measure and verify results to satisfy program administrator requirements need to be justified by the program metrics. These costs, although required for a utility funded program, are often counter to the RCx opportunity as described to the building owner during the sales pitch and therefore need to be managed well.