The District of Columbia: A Case Study for Implementing a Data-Driven Approach for Sustaining Energy Consumption Reductions in Municipal-Owned Facilities

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Abstract

City sustainability plans establish goals to reduce energy consumption, greenhouse gas (GHG) emissions and other environmental impacts in anticipation of continued urban population growth. As one of the largest sources of urban energy use and greenhouse gas emissions, buildings feature prominently in these plans.

City administrations face a myriad of challenges and costs in reducing the environmental impacts of publicly-owned buildings across a diverse, aging portfolio of schools, offices, fire and police stations, libraries, shelters, recreational centers and hospitals. With building management handed down from one city administration to the next, cities must deploy effective, consistent and affordable practices in their buildings operations to achieve their energy and environmental targets.

This Masters Project evaluates the operational and capital energy conservation measures identified by the District of Columbia’s Project Game Change, which leverages interval electric meter data and consumption transparency to transform how the city operates its public buildings. By analyzing the potential economic and environmental impacts of their conservation measures and operational practices, this report provides guidelines to D.C. and other cities for their public built environment to meet their energy and GHG reduction targets.

Final analysis indicates that a priority of implementing no-to-low cost operational conservation measures can provide a substantial return on investment and, if the measures are sustained over time with improved facilities staff training, support, and transparency, they will enable D.C. and other cities to achieve their energy and environmental targets.
Table of Contents

Abstract 2

Introduction 4
  Project Objectives 6

Background 8
  Historical Context Using New York City’s Approach to Municipal Energy Efficiency 8
  Agency Management of New York City Energy Initiatives 9

The District of Columbia’s Sustainable DC Plan 12
  The District’s Department of General Services (DGS) 14
  A Culture of Reaction 15
  DGS Vision of Using Interval Data 17
  Creating Transparency: The Build Smart DC Portal 19

Case Study 20
  DGS Scope of Work for Project Game Change 20
  Targeted Outcomes 21
  The Multi-Organizational Design 22
  Setting Up Facilities Management For Success 23
  Evaluating and Finding Inefficiencies 24
  Prioritizing ECMs 26
  ECM Recommendations and Highlights 28

Summary of Potential Economic and Environmental Benefits 29
  Economic Potential 29
  Environmental Potential 30

Recommendations Ahead 31

Conclusion 33

References 35

Appendices 39
  Appendix A: BuildSmart DC portal 39
  Appendix B: Recommended design for improving FM Staff skills and tech support 40
**Introduction**

By 2050, in one more generation 37 years from now, the number of people living in urban cities is predicted to grow substantially, from 3.6 billion in 2011 to more than 6 billion (United Nations, 2012). The current population of the District of Columbia (D.C.) is approximately 635,000 people, who live on 61 square miles of land (U.S. Census Bureau, 2013). D.C. has grown by nearly 31,000 residents since April 2010, and over 60 construction cranes currently dot this urban landscape as new office and residential buildings, hotels and renovations rise to accommodate anticipated growth. Urban growth offers a critical remedy to economic volatility - the denser and more diverse the population, the higher and more stable the property and personal tax base can become. While D.C. welcomes the many opportunities and benefits growth will provide, the municipal government, led by the Mayor, recognizes that growth can also challenge the environment, economy, and quality of life for all residents if not properly managed.

A recent study indicates that of the 30 largest American cities, the majority of them were at their lowest revenue levels in 2010 or 2011 (Pew Charitable Trusts, 2013). There has already been a general tendency over the years among municipal governments to increase transparency, accountability and financial efficiency amidst volatility in traditional revenue resources. The Great Recession has only accelerated the importance to reduce asset costs and improve operational efficiencies where possible. Public buildings are one of the city’s largest fixed asset costs.

Municipalities own a substantial number of public buildings. Municipal facilities house city employees to run and operate the numerous services for an urban population: police, fire, hospitals, libraries, shelters, public education, offices, recreation centers, and jails. City portfolios are very diverse in age, purpose, system technologies, materials, and use. These assets require continuous financial resources each year to renovate, restore, operate and maintain. Their varying occupants and facilities management (FM) staff may change from one administration to the next, but the buildings continuously operate to serve city residents.

The D.C. government owns and operates about 400 public facilities, occupying nearly 30 million square feet (DGS, 2013). No more than a half dozen new municipal facilities may be built within the next five years (DGS, 2013). Whereas private facility owners look for profitable development opportunities and strategies to increase the value of their assets, municipal portfolios abide by a different and simpler motivation: to accommodate city-employee tenants for comfort, safety and productivity in order to serve the residents of the city. Like their private owner
counterparts, however, city governments must abide by a fiduciary responsibility to minimize asset costs for their taxpayer owners.

As the United States has steadily adopted “sustainability” and “green” practices to reduce greenhouse gas (GHG) emissions, cities have increasingly promoted such environmental stewardship. To reduce GHG emissions, cities have targeted building portfolios as a critical priority. In the United States, buildings account for about 36% of energy use, 65% of electric consumption and 30% of GHG emissions (EPA, 2013).

Efficiency improvements to the built environment feature prominently in many city sustainability plans, including the District of Columbia’s. The District’s current mayor, the Honorable Vincent Gray, launched the Sustainable DC Plan in July 2011 after 18 months of gathering and evaluating numerous community-wide ideas (District of Columbia, 2011). The Plan lays out specific solutions and targets to reach by 2032 and addresses four primary challenges during this period of growth: Jobs and the Economy, Health and Wellness, Equity and Diversity, and Climate and Environment (District of Columbia, 2011). This focus includes not only planning for future urban development, but also properly modernizing, managing, and operating existing private and public buildings to more directly contribute to the Plan’s goals and targets. Leadership in Energy & Environmental Design (LEED) certification requirements, energy benchmarking, revised construction codes and other building policies aim to ensure healthier and safer work environments, reduce GHG emissions, reduce resource and operating costs, create employment in “green” services and publicly demonstrate long-term, environmental stewardship.

Comprehensive energy management plans for municipal portfolios typically commit extensive capital funds for a variety of upgrades and retrofits to facility systems. These large investments are made so that new lights, boilers and other building systems run more efficiently and consume less energy. While many of these investments indeed offer and produce attractive returns and payback periods, many cities have been realizing that any substantive reliance on technology alone to sustain these energy consumption reductions has its limits. Funding, for instance, is not infinite. And if the replaced lights are always left on, dampers are always open, the systems and technologies are not operating as designed, facility engineers aren’t trained to properly operate current and new building systems and capital investments, and tenants don’t improve their energy consumption behaviors, then capturing and sustaining measurable energy efficiency benefits can be rapidly diluted, if not erased altogether.
Operational and behavioral measures are therefore as important as capital investments. A city’s implementation and coordination of energy efficiency measures requires measurement and effective management that can readily transition from one administration to the next. What is not given attention, measured and verified with accurate data can be very wasteful and expensive. This paper explores these operational factors and its importance to cities in capturing the economic and environmental benefits from energy efficiency measures in their municipal portfolio.

This Master Project analyzes the District’s new data-driven focus and approach to improving operational best practices and human effort across a sample portfolio of seven diverse municipal buildings in Project Game Change. The paper compares “business as usual” facility practices in these buildings to analyze how and if the use of interval meter data can change and improve operations. It assesses how creating a more transparent, performance-based culture among FM personnel can potentially make their jobs more productive, while evaluating how they are currently prepared to leverage better data and transparency in the buildings.

This MP also reviews how New York City, with a municipal portfolio ten times larger than D.C., has been implementing their comprehensive energy efficiency approach and making decisions for a more effective, successful implantation of operational energy conservation measures (ECMs) to sustainably reduce their GHG emissions. For this D.C. case study of seven buildings, this MP evaluates the potential economic outcomes by estimating annual electric energy savings for the first 12 months after no-to-low cost operational ECMs are implemented in these seven buildings; assesses the potential environmental outcomes in avoided GHG emission emissions as these electric savings are captured; and assesses the potential combined economic and environmental impacts across a much larger portion of the municipal portfolio if ECMs are applicable on a larger scale.

In the end, the research will provide D.C. and city governments implementation guidance and recommendations for leveraging data intelligence, transparency, facilities personnel engagement and other practices to more effectively and consistently achieve preferred environmental and economic outcomes from their city-owned built environment.

Project Objectives

Project Game Change is designed is to leverage FM personnel, existing and new technologies, mayoral support and budget, interval utility meter data, and the guidance and expertise of a handful of contractors to identify, address, and correct energy consumption
inefficiencies in municipal-owned buildings. Under *Project Game Change*, human behavior and its impacts inside the District’s buildings are being studied and analyzed by the Department of General Services (DGS) for the first time.

DGS, which is responsible for the management and operations of D.C.’s entire municipal buildings portfolio, aims to create a performance-driven culture whereby data and public transparency inform, motivate and change behavior that largely determines eventual energy and GHG reductions in these buildings. D.C. has spent millions in modernizing buildings with expensive capital energy efficiency improvements only to see some returns on investment undermined by underprepared or overtaxed FM personnel who have never been properly trained on these modern systems and technologies, as well as a void in reliable data measuring and verifying their operational performance.

With *Project Game Change* underway just this year, and as a Director for my company contracted by DGS as one of the partners for this project, I provide a mostly qualitative analysis of this D.C. case study to explore and document the organization, management methods, drivers, barriers, and practices of the project. I employ findings from personal observations, informal interviews, content analysis, case studies and policy research to explain the genesis, framework, and effort by the District to transform how it manages its fixed building assets, accelerate economic and environmental benefits, and further publicize government accountability for creating a “greener, healthier” quality of life for its 600,000 citizens.

Much of the data is conducted from my own and company’s direct engagement with DGS on this project. Numerous informal interviews were conducted with DGS management staff, FM staff, and contractor staff. Kick-off meetings, bi-weekly project meetings and analyses of contractor findings from the walk-throughs, night audits, ECM recommendations, payback analyses, plus literature review provided both qualitative and quantitative determinations on the potential effectiveness and estimated outcomes of this case study.

Transforming human behavior has its many challenges. Transformation doesn’t occur quickly, especially within municipal governments. Poor operational practices will produce poor outcomes. When you multiply ineffectiveness across thousands of behavioral decisions in 400 buildings, 30 million square feet, 24 hours a day, and 365 days a week, the city and its taxpayers are underutilizing their potential to sustainably and consistently reduce energy costs and GHG emissions.
Background

**Historical Context Using New York City’s Approach to Municipal Energy Efficiency**

Energy efficiency remains one of the cheapest and lowest-risk investments of any energy resource (Efficiency Cities Network, 2013). Such resource conservation has been publicized across many city sustainability plans; such plans date back as early as 1993 when Portland and other cities participated in the CO2 Urban Reduction Project (City of Portland, 1993). Cities have created their respective plans for sustainable growth, preparing for an increased population while trying to mitigate its environmental impact and improve their residents’ quality of life.

This first edition of the *City Energy Efficiency Scorecard*, produced this year by the American Council for an Energy-Efficient Economy, ranks 34 U.S. cities on their respective policies and actions to advance energy efficiency (ACEEE, September 2013). The top ten cities all have comprehensive plans for achieving improved energy and environmental outcomes, with a focus on buildings, transportation, local government operations, and energy and water utilities. The cities were ranked using a points system based on ACEEE’s assessment of the policies in place. ACEEE’s first high-level strategic recommendation is for cities to “lead by example by improving efficiency in local government operations and facilities.” (ACEEE, September 2013).

New York City offers an example of a comprehensive approach to committing energy efficiency resources to its built environment, including its municipal portfolio. Its experience also illustrates the challenges and complexities of sustaining effective change, especially if reliable and detailed performance measurement and verification data is not readily available, scalable, and used.

New York City’s built environment is a mammoth portfolio. With nearly one million buildings in just 300 square miles, about 75 percent of their GHG emissions come from emissions linked to the energy consumed in buildings; this percentage is about twice the national average (City of New York, 2013). New York City’s Sustainability Plan, *PlaNYC*, was launched in 2007 by Mayor Michael Bloomberg with a priority of reducing citywide GHG emissions. A ‘30x17’ initiative within *PlaNYC* aims to reduce GHG emissions 30% by 2017 across the city’s government operations, equal to reducing total GHG by 1.06 million metric tons from a 2006 baseline total of 3.5 million metric tons (City of New York, 2012). The City developed a roadmap, the *Long-Term Plan to Reduce Energy Consumption and Greenhouse Gas Emissions from City Operations and Buildings* to achieve the ‘30x17’ goal (NYC Citywide Administrative Services, 2012). This Plan identified their 4,000 city-owned buildings and 325 million square feet as their largest opportunity.
for emission reductions, accounting for over half of the total reductions needed to achieve ‘30x17’ (NYC Citywide Administrative Services, 2012).

In fiscal year 2008, the city's annual energy consumption from its municipal portfolio cost taxpayers about $800 million (City of New York, 2007). The Mayor signed an Executive Order in December of 2007 whereby 10% of this energy expenditure ($80 million) would be dedicated each year to energy efficiency projects in its portfolio (City of New York, 2007).

The city also passed a series of Local Laws for GHG reductions in its built environment. Local Law 84, for instance, requires city-wide facilities of more than 10,000 square feet, including municipal buildings, to be benchmarked in the EPA’s Energy Star Portfolio Manager by May 2010 (City of New York, 2013). If the building does not have enough information for an Energy Star score, it must use an Energy Use Intensity (EUI) rating, calculated by dividing its annual energy consumption by the building's total floor space. Approximately 2,700 of the municipality’s 4,000 buildings (68%) are 10,000 square feet or more and have been benchmarked. Local Law 87 requires ASHRAE Level 2 energy audits and retro-commissioning in buildings 50,000 square feet or larger in order to identify specific energy conservation measurements inside the building to reduce energy consumption and lower GHG emissions (City of New York, 2013). Of the 2,700 municipal buildings benchmarked under Law 84, about 1,500 of them meet the 50,000 or larger size threshold. Local Law 88 requires the installation of more energy-efficient lighting upgrades and electricity sub-meters by 2025 (City of New York, 2013). Sub-metering is a critical strategy, as it allows much more granular analysis and identification of what building systems are consuming the most energy. All of the benchmarking, auditing and sub-metering data supplied by these Local Laws are intended to help the city prioritize actionable investments in energy efficiency.

**Agency Management of New York City Energy Initiatives**

DCAS Energy Management (DEM) manages theses energy efficiency projects for the New York City municipal portfolio. *Figure 1* outlines the estimated investment costs and their anticipated economic and environmental outcomes from some of DEM’s planned energy efficiency projects and practices. Capital measures are estimated to produce about 45 percent of the projected municipal GHG emission reductions, while the O&M measures would contribute another 12 percent:
### Table 1: DEM Breakdown of Investment Cost and Savings by Project Subcategory (FY’08 dollars); Non-Facilities Project groups, including new construction, not include. *(PlaNYC, 2008)*

<table>
<thead>
<tr>
<th></th>
<th>Investment Costs</th>
<th>Estimated Annual Bill Savings</th>
<th>Estimated GHG Reductions</th>
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<tbody>
<tr>
<td></td>
<td>$ Mil.</td>
<td>% of Total</td>
<td>$ Mil.</td>
</tr>
<tr>
<td><strong>Existing Buildings: Equipment Replacements &amp; Retrofits</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Replacements</td>
<td>182</td>
<td>7.8%</td>
<td>37</td>
</tr>
<tr>
<td>Retrofits</td>
<td>1,002</td>
<td>42.8%</td>
<td>142</td>
</tr>
<tr>
<td>Other Capital Measures</td>
<td>219</td>
<td>9.4%</td>
<td>20</td>
</tr>
<tr>
<td><strong>Existing Buildings: Operations &amp; Maintenance</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Improved Practices</td>
<td>423</td>
<td>18.1%</td>
<td>51</td>
</tr>
<tr>
<td>Retro-commissioning</td>
<td>12</td>
<td>0.5%</td>
<td>3</td>
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Projects Include:

- **Equipment Capital Measures:** Projects include upgrading lighting systems, refrigeration units, and heating, ventilation, and air-conditioning (HVAC) systems; data center upgrades, replacing old oil boilers, and installing/upgrading building automation systems (BAS).

- **Operations & Maintenance (O&M) Measures:** Best practices implemented by building operators to prevent energy waste and to identify energy management improvements, such as pipes that leak, poor air distribution, clogged steam traps, as well as retro-commissioning measures to optimize the building systems as originally designed.

New York’s approach is common among cities with more comprehensive energy efficiency initiatives: use benchmarked data to prioritize which buildings consume the most energy and target for energy reduction and GHG mitigation measures; dedicate staff and dollars to audit buildings and invest in prioritized capital projects to replace inefficient building systems; create Operations and Maintenance (O&M) best practices, including preventive and predictive maintenance, to optimize facility operations and performance; and communicate lessons learned and best practices to encourage the general public to adopt more conservation-based habits.
While benchmark data and audits can be used with more rudimentary practices of design, engineering, and industry experience to prioritize capital improvements, correlating energy savings specifically with each capital investment is difficult unless some form of metering is monitoring performance data specific to that installation. Equipment replacements and retrofits are often one-time investments and installations, each with assumed lifecycles before they have to be repeated. Energy savings are estimates while actual savings will be directly impacted by ongoing building management practices and more even unpredictable tenant behavior.

For New York City, getting energy system renovations identified, staffed, competitively bid and selected, procured and installed takes 2 to 3 years on average (M. Dipple, personal conversation, October 1, 2013). Predicted savings don’t become real savings until ECMs are implemented; thus predicted payback periods from capital measures of 5 to 7 years can actually become 7 to 10 years out from original planning. Add a contingency for any combination of budget limitations, mayoral changes, political battles, staff turnover, and technological advancements further delaying implementation, capturing the originally-designed energy savings from these measures may take well over 10 years. This timeline assumes the personnel managing the buildings are properly trained to operate these investments and have appropriate access to performance indicators that monitors how the systems are continuously operating.

Implementing O&M conservation measures and best practices among ever changing building attributes and inconsistent facilities staff and tenant behavior can be just as challenging as capital measures. Operations, maintenance and retro-commissioning are ongoing costs, and their timing is typically prioritized by assessing the manufacturer’s recommendations, audit findings, and the suggestions of facilities management operating the buildings. Many maintenance decisions are made on an ad hoc basis, since real time performance data is rare among municipal facilities portfolios.

A benefit of ongoing data analysis of facility performance indicators is that operators can use that intelligence in predictive maintenance decisions. The greater the insight facilities personnel have on how a building is performing, and how well systems are operating 24/7 under varying attributes, the better they can predict when maintenance may be needed. Similar to managing the performance of our own personal health, the more factual and current health data inputs our doctor has – from our personal history, physical check-ups, electrocardiogram measurements, dietary habits, family histories, frequency of exercise – the better he can predict health risks and prescribe a specific regime. Decisions that are based on factual, integrated
performance data instead of prescribed maintenance time-schedules can reduce the risk of premature maintenance efforts that waste money, time and effort. New York City recognizes that such data-driven decisions in O&M are necessary for predictive analysis: “Predictive maintenance activities are conducted as required based on the results of regular monitoring of equipment operation.” (New York City, July 2008).

Another strategic recommendation for cites in ACEE’s City Energy Efficiency Scorecard to improve their energy efficiency is to “actively manage energy performance, track and communicate about progress toward goals, and enable broader access to energy use information” (ACEEE, September 2013). Performance data measures and verifies that the energy savings goals are being truly achieved while providing building stakeholders actionable and factual intelligence on how to conserve energy and the impacts of their actions. DCAS is currently developing a standard methodology that can be used to validate energy savings for their owned and managed municipal facilities. Methodologies include the use of interval building data and improved management and operations of building automation systems (DCAS, 2013). Interval building data measures energy usage in short intervals, such as 15 minutes.

For continuous, long-term environmental and economic benefits to occur in a municipal portfolio, a cultural shift may be needed among portfolio leadership to create a more performance-based, transparent environment, whereby continuous streams of detailed energy consumption data can be captured, analyzed, and used as actionable intelligence and decision support for multiple stakeholders.

The District of Columbia is now on that transformative path.

The District of Columbia’s Sustainable DC Plan

Mayor Vincent Gray published a vision in 2011 to make Washington the “healthiest, greenest, and most livable city in the nation” by addressing four primary challenges in the District: Jobs and the Economy, Health and Well-being, Equity and Diversity, and Climate and the Environment (Sustainable DC, 2011). The Sustainable DC plan provides 32 goals and targets and over 143 actions across 7 solution areas aimed at impacting these challenges. The “Built Environment” and “Energy” are two of these solution areas.

Like New York and other cities, D.C. also seeks to align its energy reduction goals to reducing GHG emissions from its existing buildings. Table 2 aligns some of the Sustainable DC 2032 environmental and economic goals and targets with D.C’s built environment. These
objectives and actions aim to create a citywide portfolio of high performance buildings: “Enhancing buildings and infrastructure performance ensures efficient resource use, saves money, reduces pollution, and improves the quality of indoor environments for overall health benefits” (Sustainable DC, 2011).

<table>
<thead>
<tr>
<th>Goals</th>
<th>Targets</th>
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<tr>
<td>Increase urban density to accommodate future urban population growth</td>
<td>By 2032, increase the District population by a net of 250,000 residents</td>
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<tr>
<td>Improve the efficiency of energy use to reduce overall consumption</td>
<td>Cut citywide energy use by 50%</td>
</tr>
<tr>
<td>Improve the sustainability performance of existing buildings</td>
<td>Retrofit 100% of commercial buildings to achieve net-zero standards</td>
</tr>
<tr>
<td>Ensure the highest standards of green building design for new construction</td>
<td>Update the Green Building Act to require higher levels of LEED certification</td>
</tr>
<tr>
<td>Require all new facility and major infrastructure projects to undergo climate change impact assessment as part of the regulatory planning process</td>
<td>Require building energy audits and disclosure of energy performance</td>
</tr>
<tr>
<td>Minimize the generation of greenhouse gas emissions from all sources.</td>
<td>By 2032, reduce greenhouse gas emissions by 50% from a 2011 baseline of 8.9 million metric tons</td>
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Table 2: Sustainable DC Plan. (Sustainability DC, 2011)

The District’s municipal portfolio is approximately 30 million square feet across nearly 400 public schools, fire and police stations, recreation centers, office buildings, hospitals, homeless shelters, and more. While D.C.’s municipal portfolio is about one-tenth the size of New York City’s, objectives of their respective Sustainability programs are very similar: seek to achieve GHG emission reductions through a comprehensive approach, including efforts to lower energy consumption. Electricity use generates about 75 percent of all greenhouse gases in the District and about 59 percent of emissions from the District government’s operations (Sustainable DC, 2011).

D.C. also passed a series of laws to improve the environmental features of existing, new, and renovated buildings. Beginning with the Green Facility Act in 2006 and followed by the Clean Affordable Energy Act of 2008, D.C. was one of the first cities in the nation to pass laws holding both public and private facilities to green building standards (Whiteford Taylor Preston, LLP, 2013). These actions committed D.C. to a more environmentally-focused buildings landscape. From both laws:

- All public facilities must meet environmental performance LEED certification standards.
• All public and private buildings must use E.P.A.’s ENERGY STAR Portfolio Manager for energy performance benchmarking, with annual results disclosed publically.
• The District will become a Department of Energy’s Better Buildings Challenge Community Partner, with 90 million square feet committed, including municipal buildings.
• All new building and major projects must undergo a climate change impact analysis.

In 2011, the District’s GHG emissions from electricity consumption and other direct sources totaled 8.9 million metric tons of carbon dioxide equivalents (DDOE, 2012). Of this 8.9 million metric ton total, the District government generated about 528,000 metric tons with government buildings and facilities accounting for 56% of this, at about 295,000 metric tons of CO₂ (DDOE,2012). The municipal portfolio’s annual electricity cost is about $75 million, with $30 million from the public school buildings alone (DGS, 2013). Effectively pushing these numbers lower and lower is in the hands of their Department of General Services.

The District's Department of General Services (DGS)

The District of Columbia’s Department of General Services (DGS) was created by Mayor Grey in 2011 to centrally and effectively manage the city’s municipal buildings portfolio. DGS consolidated the portfolio functions and responsibilities of several other District agencies to focus on (DGS, 2013):
• Achieving Efficiency in Operations
• Quality in Design and Execution
• Excellence in Service and Maintenance
• Secure and Safe Places of Work for District Employees; and
• Aggressive and Attentive Management of the District’s Resources.

DGS operates from 8 organizational divisions using of the following proportionate share of its fiscal budget (District of Columbia, 2013):
Over half the budget can impact the energy, operations, and management of the municipal buildings portfolio.

D.C.’s Energy & Sustainability Division (ESD) within DGS was created specifically to manage the government facilities portfolio and seeks: efficiency in both energy consumption and cost, improvements from school modernization projects, improvements in indoor air quality, improvements in storm water and waste management, increases in the city’s tree canopy, expansion of renewable energy sources, and development of sustainability education, policies and practices throughout the city. While DGS focuses on providing resources, technologies and policies to allow for these improvements, achieving actual improvements and efficiencies across their municipal buildings, like in New York and other cities, will largely occur from the responsibilities and actions by city employees. The most important group is the facilities management staff assigned and accountable for operating these buildings.

**A Culture of Reaction**

Analysis indicates that “managing” the D.C. municipal building has largely become reactionary – the staff goes to buildings that have issues to be addressed on any given day, whether reacting to tenant complaints about their office temperature, addressing system problems that arise unexpectedly, or to handle scheduled maintenance issues. The use of the system data inside the buildings, where available, that can help improve operational performance, has historically been neither a priority nor a concern of FM staff. Since, until recently, it has not been a priority of management, it has not been available and a priority of FM staff.

The primary role of FM staff for D.C. municipal buildings is to ensure the safety and comfort of the municipal employees occupying these buildings. The current staff is approximately between 150 and 200 engineering staff and about the same in maintenance staff disbursed across
the 400-building portfolio within five geographical areas (Z. Wilson, personal communication, November 15, 2013). Each area has a different number and types of buildings; on average there are three buildings assigned to each FM staff manager. This is a comparatively high ratio of staff to buildings. In an adjoining County, the municipal FM staff average 15 buildings per manager thanks largely to two factors – they have continuous access to building system data from their building control systems, and they understand how to interpret the data in relation to systems’ performance (M. Abaza, personal communication, November 11, 2013). Performance data access and fundamental system knowledge suggest a more efficient staff utilization practice. Better trained FM staff can reduce personnel head count requirements.

D.C. staff is also rotated on occasion to the different geographical areas. Territorial shifts increase the risk of continuity lapses in building operations. Without any central depository of building information - systems, tenants, hours of operations, energy use, ECMs, maintenance schedules - staff is required to spend time familiarizing themselves with the numerous attributes. Information and understanding what directly impacts the building operations could get lost in translation. Custodians clean, HVAC and boiler tradesmen maintain HVAC and boilers, and building managers respond to the relationships with the municipal tenants. Each entity operates under its own silo of objectives with tasks to perform and complete. Any given buildings, on the other hand, have varying systems and technologies whereby the performance of one impacts the performance and wear and tear of the other.

New York City has its own inefficiencies to contend with. Most building engineers are in place because of code or union agreements (M. Dipple, personal conversation, November 20, 2013). For example, there is a requirement in the City for ‘stationary engineers’ (a licensed, union trade) to staff facilities 24x7 with boilers of a certain size. These rules exist largely because in the “old days” boilers would blow up more frequently than today; but once that requirement is in place it’s difficult to change rules especially after they are embedded. (M. Dipple, personal conversation, November 20, 2013). Some of these embedded positions have little to do with proactively managing the day to day performance of the building itself.

Analysis from the seven buildings indicates that the experience, training and knowledge of building systems and operations among the assigned FM staff are very inconsistent. As part of its in-building audits, AtSite engineering staff frequently engaged with FM staff and reported their evaluations back to DGS. These evaluations provided important information to indicate which operational ECMs the building engineer would most likely be comfortable with and knowledgeable
to perform directly versus the need to outsource to a contractor. Some were “very familiar” with BAS programming whereby others had “basic knowledge” of building systems and “no understanding” of the BAS (M. Abaza, personal communication, October 15, 2013). Many engineers will directly call the BAS contractor, under a maintenance contract by the city, to come troubleshoot expected issues. While the BAS programming may be then corrected, the building manager would not be in a knowledgeable position to understand the changes or how they impacted the energy performance of the building.

Beginning in 2009, the City of New York partnered with universities and engineering associations to provide municipal facilities staff training for a variety of skills necessary for successful energy efficiency building operations and maintenance; this included levels of Building Operator Certification, Commissioning, Energy Auditors, and Certified Energy Managers (City of New York, 2012). This training develops better consistency in skills and competencies to manage toward building performance and more proactive practices. With over 1,200 municipal building engineers undergoing training, this emphasis on up-to-date system knowledge illustrates how New York City understands the correlation between staff knowledge and building performance outcomes.

The staff evaluations in D.C. identified engineers who were not only quite competent with systems and the BAS, but also quite enthusiastic and passionate about their building and discussed their “very large appetite for energy conservation measures” and data to help them improve building operations (M. Abaza, personal communication, November 11, 2013). This insight provides DGS very constructive feedback to build upon with a more data-rich program.

**DGS Vision of Using Interval Data**

DGS leadership has shaped the city’s recent focus on and approach to on using interval meter data and greater transparency to transform how their buildings perform. With such a diverse portfolio of building uses and types, any municipality is faced with the task to sort through a vast array of data sets to begin aggregating and understanding how similar facilities and attributes compare. From 2000 to 2009, the municipal utility bills provided by the city’s main power utility were manually entered and converted into spreadsheets; fifteen file cabinets of monthly bills yielded a 1,400-row spreadsheet, accommodating over 1,400 meter accounts established by the utility for nearly 400 facilities (S. Brooks, personal communications, July 15, 2013). Any manual error in data-entry could result in inaccurate information being used for
establishing the baseline. DGS leadership, both at the Director level and in their Energy and Sustainability Division, recognized the inefficiencies in the city’s energy management practices and leveraged its industry knowledge and relationships to change the culture and practices to align portfolio energy management to the Mayor’s vision represented by Sustainable DC.

Benchmarking allows owners to track performance metrics against an annual baseline, and offers comparative data on national trends and similar building types. For example, FY2009 data for 194 District of Columbia government buildings showed that they were overall less efficient than similar U.S. municipal buildings on average and that D.C.’s schools were in the 29th percentile compared to schools nationwide (ACEEE, 2012). Benchmarking, however, does not offer building management and staff a reliable, specific understanding of what is causing energy waste in a building on any specific day or hour.

Interval data, which is measured in short time intervals, such as every 15 minutes, provides more actionable and relevant intelligence on how a building is consuming energy on a 24 hour cycle over changing conditions. Interval data allows FM staff to construct a more optimal “whole building electric load” curve where they know what energy is being used and why at any given interval time (Lawrence Berkeley National Lab, 2010). Changes in that curve can indicate problems in building systems or changes in building attributes, such as a tenant using space late at night for a number of days. Unless an air handling unit that may be continuously running in unoccupied space is connected to a sub-meter that can itemize that unit during continuous measurement and verification, that anomaly may be less obvious on a whole building meter and continue undetected.

The monthly bill data did enable the city to fulfill municipal benchmarking and start providing Energy Star ratings for some of its municipal facilities. Energy Star ratings provided a good starting point by offering DGS visibility into which buildings were most energy intensive. Now DGS needs to use interval data for FM staff to gain a more granular understanding of what specific actions to take to consistently combat the sources of energy waste inside each facility. Getting access to interval data was not as easy as the city would have hoped. Although Pepco, the utility that serves the area, had deployed smart meters, it still took six to eight months to get the data from the utility (Tweed, 2013). New York City has experienced the same challenges in getting its local utility to cooperate and provide whole building data to the city. “Getting utilities to be partners and ultimately get the Public Service Commissions around the country to require support of uploading whole building data ... It is more difficult to get data than it should be, making
owners do things that they shouldn't have to do because it is so inefficient, causing extra effort and frustration." (Case Study: GGBC, 2012).

Accessing interval data will be one of the more challenging practices for municipalities. Not all buildings have building automations systems, smart meters and other resources to collect and extract the data. The local utility can, however, provide a direct feed of such interval data directly to the city as DGS has done.

Creating Transparency: The Build Smart DC Portal

In addition to gaining access to interval meter data, DGS had a second priority for transforming how the municipal portfolio operates: making all of this daily energy use available for the public to see anytime. DGS created the Build Smart DC web portal (www.buildsmartdc.com) to provide all stakeholders - the general public, the city Administration, facility operators, tenants, school children, teachers, etc. - with an open window into how well their municipal facilities are performing (S. Brooks, personal communications, July 15, 2013). See Appendix A for an illustration. Such transparency for the first time in the city’s history publicly and permanently places the D.C. government’s fiduciary accountability and environmental stewardship in constant public view. All stakeholders who impact that consumption and cost in any of the nearly 400 facilities can see their previous day’s energy consumption curve. The portal increases accountability for wasteful spending and poor operations and offers the potential to sustain economic and environmental benefits year over year through dynamic public and academic education and information.

The DGS vision for the portal can become a powerful teaching tool for tenants and facility operators alike. Energy efficiency projects can be narrated, offering direct lessons on how specific projects provide benefits. D.C. public schools can conduct inter-school and school-to-school energy conservation competitions where the results of their conservation efforts can literally be publicized daily on the portal. The portal can become a teaching laboratory for energy conservation and efficiency best practices where school-organized “green teams” can monitor and evaluate their achievements. Build Smart DC can stimulate action, which produces conservation practices that can lead to more consistent, if not permanent occupant and staff behavior habits.

The portal will also directly serve the FM staff operating the buildings. DGS has seen firsthand how modernized schools, with millions spent in new capital investments, can often lead to a jump in energy costs not only because of an increase in plug loads accommodating an increased inventory of computers and other technologies, but also because undertrained facilities
personnel can quickly become overwhelmed operating these modern systems (S. Brooks, personal communications, July 15, 2013). With many facilities personnel not properly trained and prepared for installed modernized energy management technologies, such “operational drift” can continue unabated. The *Build Smart DC* portal exists to help reduce this risk.

DGS’ envisions the portal evolving as a dynamic repository of the unique building attributes for each and every municipal building: an inventory of all building systems with their manufacturers, models, and the years installed; maintenance contracts and preventative maintenance schedules for the inventory; best practice standard operating procedures; the number and type of tenants using the facility; operating hours; current and trending energy load curves; an up-to-date log of all installed and implemented energy conservation measures; and reminders, notifications and policies for tenants. With this current and comprehensive information at hand, any FM staff member rotated to a new geographical territory and set of buildings will no longer have to go through a laborious learning curve. The portal can become a dynamic, ongoing self-audit of key performance metrics and best practices logged into the portal directly by staff for that building. This repository for best practices can reduce the risk that improper changes will be made to these operational best practices. This cuts down on human errors and improves the opportunity to continue operating that building as efficiently as possible. Better, more robust data will bring efficiency. Embracing transparency enables cities to create an immediate cultural change.

**Case Study**

*DGS Scope of Work for Project Game Change*

*Project Game Change* is a six-month project running from July to the end of 2013 for 8.5 million square feet across 39 municipal-owned buildings. It seeks to accomplish the following objectives (DGS, 2012):

1. Analyze interval electricity data and in-building surveys and audits to identify inefficiencies in electric energy consumption and establish a more optimal base load for electricity consumption in each individual building,

2. Determine a number of Operational & Maintenance no-to-low costs ECMs., such as improved scheduling and set points on chiller and boiler operations,

3. Identify which conservation measures and practices are most applicable and scalable across the larger portfolio,
4. Create improved operational best practices for each building’s facilities personnel that leverages limited human and financial resources,
5. Quantify the cost-payback of these operational ECMs,
6. Complete the implementation of the recommended ECMs by the end of 2013 for capturing financial savings and GHG emission reductions beginning in 2014

This case study analysis examines 7 of the 39 buildings equaling 1.8 million square feet in total. These 7 facilities represent a cross-section of building types. This sample represents about 21% of the total square feet and 18% of the total kWh of electricity consumed during the 12 month baseline for the 39 buildings (D. Last, personal communication, October 7, 2013):

<table>
<thead>
<tr>
<th>Building Type</th>
<th>Gross Ft2</th>
<th>Annual Electric Baseline kWh*</th>
<th>Annual Electric Spend</th>
<th>GHG Equivalent (Annual kWh baseline converted to metric tons)**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Municipal Gov’t (DBL-LEED Platinum)</td>
<td>350,000</td>
<td>8,255,833</td>
<td>$965,932</td>
<td>4.951</td>
</tr>
<tr>
<td>High School</td>
<td>288,800</td>
<td>4,128,053</td>
<td>$457,906</td>
<td>2.476</td>
</tr>
<tr>
<td>High School</td>
<td>376,507</td>
<td>4,880,360</td>
<td>$571,002</td>
<td>2.927</td>
</tr>
<tr>
<td>Middle School</td>
<td>181,000</td>
<td>3,207,989</td>
<td>$375,335</td>
<td>1.924</td>
</tr>
<tr>
<td>Middle School</td>
<td>182,500</td>
<td>1,736,504</td>
<td>$203,171</td>
<td>1.041</td>
</tr>
<tr>
<td>Elementary School</td>
<td>104,200</td>
<td>2,946,920</td>
<td>$344,790</td>
<td>1.767</td>
</tr>
<tr>
<td>Shelter</td>
<td>350,000</td>
<td>2,876,799</td>
<td>$336,585</td>
<td>1.726</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1,833,007</td>
<td>28,032,458</td>
<td>$3,279,798</td>
<td>16,812</td>
</tr>
</tbody>
</table>

Table 3: Case Study building, (*kWh baseline is 6/1/12 thru 5/1/13). **Conversion by EPA at: http://www.epa.gov/cleanenergy/energy-resources/calculator.html (National average converted for DC)

**Targeted Outcomes**

At the conclusion of the 6-month engagement, DGS will possess a high-quality, well-documented assessment of energy conservation measures at the selected facilities; this data-driven platform should empower facilities managers to understand how to use daily interval data to monitor and manage their facilities more efficiently (DGS, 2013).
Once operational ECMs are identified, DGS has asked the project team to estimate what the subsequent 12-month reduction in electricity consumption will be for calendar year 2014 with the assumption that the DGS-approved ECMs will all be implemented by the end of 2013. DGS’s economic objective for Project Game Change calls for a 12-month reduction in electricity consumption of at least 20% following ECM implementations. A 20% reduction for all 39 project buildings would be approximately 31 million kWh from a mid-2012 to mid-2013 baseline. The economic savings from this 20% reduction, based on the current utility rate, would equal approximately $3.6 million.

A 20% reduction following ECM implementations for the 7 case study buildings would be equal to approximately 5.6 million kWh and approximately $656,000 in electric savings.

**The Multi-Organizational Design**

Federal, state and city government agencies often use Energy Savings Performance Contracts (ESPC) as a financing mechanism for a selected Energy Savings Company (ESCO) to install energy efficiency systems and technologies. These contracts are often over multiple years since the large cost of the capital projects is being financed by electricity savings “guaranteed” by the ESCO. A risk to DGS of using an ESPC is the contractual reliance on a single vendor over a long period of time. A reliance on a single vendor could limit the portfolio owner’s benefits. The “independence” of an ESCO’s measurement and verification of the owner’s savings may be compromised since the ESCO is financially motivated to minimize their own risk in paying for any contractual savings “guarantees” that become unrealized.

For Project Game Change DGS chose a multi-contractor approach with companies of complementary skills and expertise in building performance managed services. None of the savings are “guaranteed” by the companies and the project is not a “shared savings” contract. Instead, each company is paid a fee from the DGS budget with specific tasks designed to achieve the project’s objectives. Some contractors are direct competitors. Despite this competitive framework, DGS leadership created a collaborative framework for the contractors to work together. By working together, and learning from each other within a very short window of six months, the collective group has plenty of incentives to succeed as a whole. The contractor partners understand that the only way further scale across the portfolio is politically and financially feasible is to create, capture and demonstrate successful outcomes.
Without a passionate, consistent and vocal leadership, DGS would probably have a much more difficult time coordinating and actually implementing effective, measurable improvements with building staff. A number of facilities personnel mentioned in interviews at the beginning of these project discussions that they treated this as any other large scale city initiative – with great skepticism. Other “change management” programs have historically been deferred or cancelled altogether with a new mayor. Typical for municipal governments, large projects have been the subject of many budgetary and political challenges, and then never put into place. Project Game Change has not succumbed to this fate for a handful of reasons: the Mayor vocally supports the project, DGS leadership has been proactive and persistent, and they included FM personnel very early in this discussion and collaboration. For example, FM management was provided a list of these ECMS early on so that they could schedule the time needed for building management personnel to be available. As gaps were identified in DGS personnel’s availability or skills, DGS could make sure the ECMS could be implemented through the contracted support personnel qualified for such oversight and project management.

Coordination and communication is critical, especially with a short deadline. The contractors conducted a standing bi-weekly call/meeting with DGS leadership. Respective status reports, scheduling, road blocks, and next steps were discussed in detail. Table 4 illustrates the type of reports submitted to DGS each week for collaboration:

**Accomplishments & Milestones**

<table>
<thead>
<tr>
<th>Area</th>
<th>Key Activities &amp; Dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>HVAC scheduling &amp; standard operating procedure recs.</td>
<td>Sent DGS recommended zone schedules for 6/7 sites. Waiting on CCNV until a DGS engineer is assigned to the site.</td>
</tr>
<tr>
<td>Standard Operating Procedures</td>
<td>Sent DGS recommended SOPs for 6/7 sites.</td>
</tr>
<tr>
<td>ECM Implementation</td>
<td>Con-call with DGS to discuss procedure for implementing recommended ECMS. Will begin quantifying savings/ROI for each ECM to allow team to prioritize which ECMS to pursue immediately.</td>
</tr>
<tr>
<td>Facility Engineer BAS Training</td>
<td>Will provide DGS with recommendations for BAS training within two weeks.</td>
</tr>
<tr>
<td>Night Audits</td>
<td>Completed Night Audit at Municipal building on 9/12. Summary of findings is forthcoming. All night audits to be completed by 9/30.</td>
</tr>
</tbody>
</table>

Table 4. (D. Last, personal communications, September 19, 2013)

**Setting Up Facilities Management For Success**

As discussed earlier, building engineers have many daily responsibilities including
managing a variety of building systems, keeping the building comfortable and productive for city employees, and responding to requests (NRDC, 2013). They must perform multiple responsibilities daily amidst ever-changing circumstances and leverage limited time and resources. Prioritizing time and decisions is becoming more and more challenging. The early stages of the project offer some encouraging signs that it can help transform this “reactive” facilities management culture into a more “proactive” culture. Staff interviews have shown that many didn’t understand how they would be helped at the beginning (J. Varre, personal communication, October 4, 2013).

DGS leadership has been very passionate and consistent preaching the project’s potential benefits to FM staff: saving money that can be used for other FM resources; supplying data analysis and trending to improve predictive maintenance forecasting; providing additional time to implement tenant-oriented energy savings education and services; and offering more professional development through the collaboration and knowledge transfer from both contractor support personnel and system/technology training. The buildings currently lack an established energy base load curve that reflects typical tenant arrival and departure times, the hours of operation, and how many occupants work in the building. If personnel know how and why the building should perform and operate using comparative baselines and measurements, then they can work with specific objectives in mind rather than always reacting to problems as they arise.

With these messages being communicated over and over again, coupled with committed funding to accomplish these objectives, facilities personnel are realizing that Project Game Change is becoming more fact than fiction. The project offers credible, tangible benefits facilities personnel can use. Facilities personnel are translating these potential benefits into personal benefits – they see opportunities that help them as individuals instead of just a program that is mandated without their input. The effectiveness of scaling this collaborative assistance across a larger share of the portfolio can hinge not only on the number of FM staff participating but also on the effect of the collaboration on each FM participant. Improved building performance can occur with improved human performance by those responsible for the operations.

**Evaluating and Finding Inefficiencies**

The project uses a combination of virtual energy audits, such as provided by companies like First Fuel, and in-building audits and managed services by contractors such as AtSite. Virtual audits use energy modeling techniques to analyze a host of building data sets across the portfolio to recommend energy savings in the buildings (St. John, 2013). In-building audits and assessments have skilled personnel in mechanical systems, energy management and building technologies, who
walk through the building with the FM staff responsible for that building. Walk-through audits were conducted exclusively for these 7 buildings.

Two walk-throughs were conducted, once during the day then another late at night. The purpose of the daytime walk-through was to inventory systems, tenant behavior and facility operations while further understanding the building’s many nuances from the FM staff’s perspective. This discussion between the contractor and manager provided an opportunity to better understand the engineer’s level of aptitude and comfort with the operations. A high-risk practice would be to provide an engineer a list of ECMs to implement that he is neither trained in nor comfortable with. The contractors are qualified not only to find the ECM opportunities, but also to assist FM manager implement ECMs. This collaborative trust and effort not only assures that ECMs are implemented correctly from the start, but also helps train and empower the staff member on location.

The in-building audits often focus on the four core areas that can reduce energy consumption with a short payback periods:

- **Lights** (e.g. Are more efficient lighting replacements needed and are building floors and work areas lit up during the day and night when no one is occupying the space?)
- **Mechanical** (e.g. Does an air handling unit bring in outside air without a heat recovery wheel or outside air economization?)
- **Plug load** (e.g. How many fans, coffee makers, computers, vending machines, copiers, portable electric heaters and other devices are left on during the day or night?)
- **Building automation control systems (BAS)** (e.g. At what time does the HVAC system turn on and off compared to building occupancy levels and hours of operation?)

The observational list from one of the night audits, conducted between 8 pm and midnight on the 300,000 square foot, LEED-certified municipal building, highlight how an efficiency label such as LEED does not mean it operates efficiently (M. Abaza, personal communications, October 16, 2013):

<table>
<thead>
<tr>
<th>Both chillers were running all day and evening</th>
</tr>
</thead>
<tbody>
<tr>
<td>Three chilled water pumps and three pumps and cooling tower was running all out</td>
</tr>
<tr>
<td>60 fan powered Variable Air Volume systems (12 per floor) were running in all spaces supplying conditioned air to all spaces, even totally unoccupied spaces</td>
</tr>
</tbody>
</table>
1st floor: 90% of space lighting was on all time (5-10 people in occupied space)

2nd and 3rd floor: 100% of space lighting was on (15-20 people in occupied space on the 2nd floor, 2 people were on the 3rd floor)

4th floor: 50% of space lighting was on (one person in space)

Each floor: all vending machines (total 15) were running continuously

Each floor: all copiers, fax machines, printers were on, and not on standby (total 60 (~12 per floor))

Each floor: most PCs were left on, in screen saver mode, and a notable number of task lights were left on

**Prioritizing ECMs**

DGS requested recommendations for no-to-low cost operational ECMs whose payback would be in aggregate under 12 months following implementation. Capital ECM recommendations required a payback of 4 years or less. For these 7 buildings, AtSite developed Scopes of Work for DGS for each operational ECM. Examples include (D. Last, personal communications, October 25, 2013):

**Adjust Building HVAC Schedule to Match Building Hours of Operation**

**Description:** *Incrementally push back HVAC equipment start times in order to match the time of building start-up with the time that a significant amount of occupants arrive in the morning.*

**Explanation:** Start by establishing a safe starting point (at least 2 hours or more) to minimize the potential for discomfort.

- Record how long it takes for the building to reach set point upon start-up. Buildings with trending capabilities on the associated BAS can utilize trends to acquire this information. Facilities without BAS systems will need to rely on manual readings of the temperature in various zones to make the assessment of the length of time to reach the set point. It is also important to note the outside air temperature when the assessment has been done. Extreme hot or cold temperatures overnight will affect the required time for start-up.
- Use the data collected from this exercise to determine the optimal starting time for the building in various weather conditions.
- Programmer to create new equipment schedules to match building hours of operation
- Graphic modifications for identification of new schedules
- Testing and Checkout
C-7: Boiler hot water temperature reset based on Outdoor Air (OA)

**Description:** Write in programming to Building Management System to reset heating loop building hot water at each steam to hot water converter is reset based on OA. Use a linear strategy with a lower limit of 110 F and upper limit of 180 F based on OA temperatures of 100 F for lower limit and 0 F for upper limit.

Includes:

- Outside Air temperature and humidity sensor to be tested and re-calibrated as required
- Programmer to create new programming for the Boilers to reset hot water supply temperature based on OA.
- Graphic modifications for identification of hot water temperature reset
- Testing and Checkout

These Scopes of Work for each building included a summary Table of ECMS prioritized and agreed to by DGS to pursue. Each Table was organized as follows:

- ECM Description
- ECM type: Operational or Capital
- Party Responsible for Implementation
- Savings profile – when during the year does this ECM benefit apply – Winter, Shoulder, Summer or constantly?
- Cost/Savings estimates.

Table 5 provides a sample subgrouping list:

<table>
<thead>
<tr>
<th>ECM Description</th>
<th>Type</th>
<th>Party Responsible</th>
<th>Savings Profile</th>
<th>Project Cost</th>
<th>Annual Energy Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seasonal static pressure reset on all AHUs tied to VAVs</td>
<td>Operational</td>
<td>Controls</td>
<td>Constant</td>
<td>$4,850</td>
<td>$10,328</td>
</tr>
<tr>
<td>Schedule HVAC equipment (AHUs, SCUs, ERUs and FP VAVs) to turn off at night with building operation</td>
<td>Operational</td>
<td>Controls</td>
<td>Constant</td>
<td>$1,293</td>
<td>$39,670</td>
</tr>
<tr>
<td>Schedule Chilled water and boiler plant to shut down at night with building operation</td>
<td>Operational</td>
<td>Controls</td>
<td>Constant</td>
<td>$323</td>
<td>$33,757</td>
</tr>
<tr>
<td>Unoccupied ventilation, night purge</td>
<td>Operational</td>
<td>HVAC</td>
<td>Summer</td>
<td>$2,910</td>
<td>$3,500</td>
</tr>
<tr>
<td>DWH Supply temperature reset from 140 F to 120 F</td>
<td>Operational</td>
<td>Controls</td>
<td>Summer</td>
<td>$647</td>
<td>$1,381</td>
</tr>
<tr>
<td>Provide and Install plastic strip curtains on Walk in freezer and Walk in Refrigerator doors</td>
<td>Capital</td>
<td>HVAC</td>
<td>Constant</td>
<td>$808</td>
<td>$412</td>
</tr>
<tr>
<td>Daylight dimming lighting controls using photocells in all perimeter spaces</td>
<td>Capital</td>
<td>Lighting</td>
<td>Constant</td>
<td>$8,423</td>
<td>$4,005</td>
</tr>
<tr>
<td>Implement chiller plant optimization to increase dT</td>
<td>Capital</td>
<td>Controls</td>
<td>Summer</td>
<td>$43,785</td>
<td>$14,030</td>
</tr>
</tbody>
</table>

Table 5. Sample ECM Recommendations & Payback (D. Last, personal communications, November 7, 2013):

**ECM Recommendations and Highlights**

1. A total of 125 Operational no-to-low cost ECMs were recommended for immediate implementation in these 7 buildings, an average of 18 per building, each which can provide a rapid payback in less than 12 months.

   - Of these, 30 ECMs only required the physical labor on-site: educating cleaning crews at night to turn off lights and devices, changing occupied set point temperatures, etc.
   - The remaining 95 ECMs range in cost from $50 to $11,000 each all with an aggregate payback of less than 12 months following their implementation.
   - The 125 Operational ECMs are estimated to save 47,000 kWh on average apiece over 12 months after implementation, a total energy reduction of 5,875,000 kWh from the baseline of 28,032,458 kWh – a 12 month reduction potential of 21%.
   - The 125 Operational ECMs are estimated to save $6,828 on average apiece over 12 months after implementation, a total electricity cost savings of approximately $853,000 from the annual baseline spend of $3,279,798 – a 12 month reduction potential of 26%.
   - A total of 60 Capital ECMs were recommended for immediate implementation with an average cost of $33,000 apiece. This approximate $2 million investment would provide a payback of 4 years or less and take approximately 6 months to implement.
   - The 60 Capital ECMs are estimated to save 111,000 kWh on average apiece over 12 months after implementation, a total energy reduction of 6,660,000 kWh from the baseline of 28,032,458 kWh – a 12 month reduction potential of 24%.
   - The 60 Capital ECMs are estimated to save $8,800 on average apiece over 12 months after implementation, a total electricity cost savings of approximately $528,000 from the annual baseline spend of $3,279,798 – a 12 month reduction potential of 16%
Summary of Potential Economic and Environmental Benefits

Economic Potential

The operational ECMs alone can very likely achieve the 20% minimum reduction in electricity consumption and savings DGS is seeking in Project Game Change within 12 months after implementation:

<table>
<thead>
<tr>
<th>ECMs</th>
<th>Potential Electric $ Savings: 7 Buildings</th>
<th>Potential Annual % Savings from Baseline</th>
<th>2 Year ROI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational</td>
<td>$853,000</td>
<td>26%</td>
<td>219%</td>
</tr>
<tr>
<td>Capital</td>
<td>$528,000</td>
<td>16%</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>$1,381,000</td>
<td>42%</td>
<td></td>
</tr>
</tbody>
</table>

Of the 125 Operational ECMs, about 25% of them are solely labor-based. Assume each of these 30 ECMs takes 4 hours to implement at an average contracted rate of $100 per ECM, these 30 ECMs would cost $12,000. The remaining 95 ECMs were estimated to cost on average $5,400 apiece to implement, thus a subtotal cost of $522,500. Therefore, the total cost of 125 ECMs is approximately $535,000. The potential two year gain in electric savings after these ECMs are implemented is ($835,000 x 2 years) about $1.7 million. The 2 year ROI is equal to the (investment gain – investment cost)/(investment cost), or 219%.

These 7 buildings had a baseline electricity consumption total of 28,032,458 kWh. If DGS were to achieve the 21% savings in the first 12 months after only the Operational ECMs, this would lower the next annual consumption to just over 22 million kWh. If improved operational and behavioral practices were to continuously optimize building electricity performance and produce a 2% savings per annum to 2032, DGS would have total electricity consumption that year of about 14,800,000 kWh, or nearly a 50% reduction from the 2013 baseline.

This does not take into consideration any utility rate increases and assumes FM staff is capable of understanding how to continuously optimize electricity consumption and reduction tactics from actionable data intelligence. Nonetheless, this precipitous drop in the first year, maintained for subsequent years, shows how the city could very well fulfill its 50% energy reduction target by 2032 in its municipal portfolio. If DGS added the Capital measures and the total Operational and Capital measures achieved the nearly 42% reduction, then the cities 50% reduction target by 2032 is even more readily achievable.
The following Figure compares the current total kWh baseline for the 7 buildings operating as “business as usual”, assuming a 1 percent consumption increase per year, to the same baseline reductions from the first year of Operational ECMs and a 2 percent reduction per year thereafter.

![Case Study: Total kWh Consummed Year Over Year After Operational ECMS Only](image)

**Environmental Potential**

<table>
<thead>
<tr>
<th>ECMs</th>
<th>Potential Electric kWh Savings: 7 Buildings</th>
<th>Potential Annual % kWh Savings from Baseline</th>
<th>Avoided GHG Equivalent (Annual kWh converted to metric tons)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational</td>
<td>5,875,000</td>
<td>21%</td>
<td>3.523</td>
</tr>
<tr>
<td>Capital</td>
<td>6,660,000</td>
<td>24%</td>
<td>3.994</td>
</tr>
<tr>
<td>Total</td>
<td>12,535,000</td>
<td>45%</td>
<td>7.517</td>
</tr>
</tbody>
</table>

* Conversion by EPA at: [http://www.epa.gov/cleanenergy/energy-resources/calculator.html](http://www.epa.gov/cleanenergy/energy-resources/calculator.html) (National average then converted for DC region)

Whereas New York City had estimated Capital measures and Operational measures to contribute 45% and 12% respectively to their GHG emission reductions, this case study shows a potentially more equitable distribution; no-to-low cost Operational measures can have an even more significant impact on avoided GHG emissions.

The potential rate of avoided GHG reductions is rather dramatic. The District’s GHG reduction goal is 50% in about 20 years (2032). If the same avoidance rates of 21% to 45% were applicable to every building in the portfolio in their first 12 to 24 months after ECM implementation, the portfolio could readily meet these GHG reduction goals if not substantially pass it well before 2032.
Recommendations Ahead

The following recommendations apply to D.C. for this project, but can also apply to any city moving ahead with a more data-driven approach to consistently and effectively capturing energy efficiency savings in its municipal portfolio. The New York City and Washington case studies demonstrate that regardless of how early or advanced each may be in developing a data-centric approach, the following recommendations should be strongly considered by any city as vital for achieving consistent and more predictable benefits:

Training

Only about 20 of the 125 Operational ECMs were recommended for implementation directly by the FM staff due to their limited knowledge of BAS programming. Over 80% of these Operational ECMs will need to be implemented by BAS controls contractors; thus, the first recommendation is to develop an aggressive FM staff training program. As New York has demonstrated, and decided, skills development through training is essential for improved building operations (City of New York, 2012). With so much of the economic and environmental savings tied to the labor functions of building system programs and operations, FM staff must elevate their skills and knowledge so that the implemented ECMs can sustain their effectiveness; otherwise, good practices coupled with poor skills will increase the risk that any energy efficiency gains will erode with time.

Instead of starting off with a training regime for all FM staff, DGS should consider two simultaneous approaches: provide universal training in system and BAS fundamentals; also train a select group of staff, primarily those who, like in this case study, demonstrated an eagerness and enthusiasm to leverage better data and conservation practices. Instead of substantially training staff nearing retirement, DGS should create a subgroup of FM staff, well trained in building performance, BAS programming, energy management practices and smart building technologies, as a “Level 2” support between the rest of the FM staff (“Level 1”) and the BAS and HVAC contractors (“level 3”). Appendix B illustrates this design. This design can help facilitate greater internal accountability and transparency of a performance based operations. FM staff can rely more on themselves to proactively operate the buildings armed with data-rich feedback and better knowledge. Compensation for this support group should match their improved skills sets and be competitive with the private sector. Year over year savings in the buildings should be reinvested in facilities staff in the form of financial bonuses, further training, recognition awards and other incentives. Facilities staffing needs could over time be reduced as better training and knowledge of
systems and data management allow staff to be responsible for more buildings than the current ratio of one staff to 2-3 buildings. The city should also consider relaxing hiring priorities for District resident candidates for FM positions; more FM staff positions with existing building system and control skills could be filled from suburban-based candidates from the private sector.

Scale

DGS can leverage cloud-based computing and other web enabled platforms to scale the effective use, measurement and verification of energy interval data across more and more buildings. It has already demonstrated its capabilities by having most of its portfolio interval data already publicly posted on its Build Smart DC portal. Scaling the implementation of ECMs will most likely require tactics demonstrated in this case study. Effective implementation of Operational ECMs will initially require the prioritization and coordination of responsible parties, including FM staff, in each building where building controls are installed and other labor-based changes would occur. DGS should consider securing contractual relationships with trusted companies and internal agencies who can fulfill the immediate implementation of the Operational and Capital ECMs.

With over 150 ECMs recommended for just 7 buildings to achieve aggressive savings and GHG reductions, the number of ECMs necessary for 100, 200 or 400 buildings across 61 square miles will be substantial. FM staff is not currently prepared to provide these managed services. DGS should contractually develop a hierarchy for managed services that will continue to oversee the successful implementation of ECMs on a coordinated scale, even as DGS leadership may change with a newly elected administration. Implementation continuity parallel to improved FM staff training will together accelerate the city’s optimally capturing the potential economic and environmental opportunities demonstrated in this case study. Buildings don’t stop operating as even as administration, staff and leadership change.

Further Metering

Lastly, as New York City has done with Local law 88, D.C. should strongly consider a policy or similar law for further sub-metering in its municipal buildings. Capturing and using interval metered data is an extremely important step in analyzing and measuring whole building electricity and energy consumption. As FM staff grow more comfortable in understanding how to use this data for their optimizing operational performance, further sub-metering will allow them to pinpoint consumption anomalies to specific lighting,
chillers, boilers and other building systems tied to that specific sub-meter. This more granular data resource will allow more time savings in more specifically pinpointing systems issues among many that are impacting consumption.

**Conclusion**

The District of Columbia, like many cities, has taken an assertive approach to improving government transparency, operating efficiencies, and prudent fiscal management. The city has proactively set attainable environmental goals in conjunction with anticipated urban growth and further density. This case study has demonstrated that substantial, short and long term economic and environmental benefits exist from applying such transparency and efficiencies toward how it operates and manages its municipal buildings portfolio. Low to no cost operational energy conservation measures, equivalent to turning power off when not necessary, was shown to potentially reduce consumption by at least 20% just in the first 12 months.

The government’s Department of General Services is now moving toward a more public and data-rich framework to transform the culture and performance of its municipal buildings today and for future administrations. If such a sudden drop in kWh consumption and costs could be achieved through a larger majority of buildings, and those savings sustained through improved operations and data intelligence, then the municipal buildings portfolio will directly contribute to reducing the city’s emission and energy levels to the Sustainable DC targets.

The success and failure of the city to actually capture these economic and environmental benefits for its citizens rest on the daily decisions of city employees responsible for the operations and management of this portfolio. Human accountability trumps all building function design, models, and intent. Our trusted doctor may recommend health measures to improve our body’s performance, but our direct choice and decision of if, when and how we use these measures will ultimately determine whether or not we sustain the improvement benefits.

“Affecting deep and lasting changes in our energy systems requires an integral, layered approach to changing behavior—using multiple methods and means of reaching people both as individuals and as members of groups” (ACEEE, 2013). With access to more granular real-time energy consumption data in any given facility 24 hours per day, 7 days per week, well-trained and motivated operational personnel will have more robust resources for improving how they operate and optimize city buildings. Public transparency will facilitate greater civic participation,
accountability and contributions. To be become a truly sustainable D.C., future Environmental, Facilities and Fiscal leadership in charge will be able to use and improve this data-rich, performance-based culture to enable continuity in environmental and economic sustainability from one generation to the next.
References


Appendices

Appendix A: Build Smart DC portal

The District of Columbia is saving money, saving energy and creating one of the greenest cities in the world.

Langley School
101 T ST NE, Washington DC 20002

Building Information
The new Langley Education Campus for Science, Technology, Engineering and Mathematics (STEM) is a fully modernized campus that provides high quality instruction infused with exposure to real world concepts, inquiry and innovation. Located in Northeast Washington DC, Langley Education Campus is a neighborhood school for students from the Ward 5, Bloomingdale, and Edgewood communities. Additionally, Langley provides services to students from around the city through the out-of-boundary process and in our diverse Instructional Disability Program. Our goal at Langley is to ensure that students are inspired to imagine, inquire, and innovate.

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Appendix B: Recommended design for improving FM Staff skills and tech support