LA Better Buildings Challenge: Unlocking the Efficiency Opportunities in Small Buildings

Final Report

May 2018

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This research was supported by the LA-BBC. We thank our colleagues David Hodgins and Wayne D. Alldredge who provided insight and expertise that greatly assisted the research, although they may or may not agree with all of the interpretations/conclusions of this paper.

I. Introduction

Los Angeles is a city of almost 4 million people, home to a thriving entertainment, business and technological base. Along with this, Los Angeles also manages to be a leader in the environmental community. However, this is not without a complicated history. Historically, we have received majority of our water from imported sources in Northern California, and our air quality has been riddled with smog issues that have now become synonymous with the city's past. Los Angeles has been able to learn from its past and carve out a future that looks significantly different.

There has been a strong initiative from community, government and environmental organizations to build a resilient Los Angeles, with greater local sources of water and stronger energy efficiency measures. The Los Angeles Better Buildings Challenge (LABBC) is one of the organizations leading the charge on this front. LABBC works with the city's buildings, providing a collaborative forum with the tools to achieve greater energy and water efficiency[1]. They have been tasked with assisting the Mayor's office in the implementation of The Existing Buildings Energy and Water Efficiency Ordinance, passed in December 2016, which requires annual benchmarking of water and energy use in buildings 20,000 sq. ft. and above. Starting in 2019, buildings must either achieve certain efficiency targets or perform audits and retro-commissioning on a 5 year cycle[2]. Buildings are broken into size categories for implementation dates. Privately owned buildings that are over 50,000 square feet have a benchmarking deadline of June 1, 2018[2].

The Mayor's office projects that the ordinance will reduce L.A.'s greenhouse gas emissions by nearly 10 percent by 2025, and energy consumption by 7 percent, as compared to business as usual. This translates to cost savings of over $368 million for LA through reduced utility bills[3].

This report provides a set of common recommendations for buildings, 50,000-100,000 sq. ft, to be able to achieve energy and water efficiency targets. It focuses on the 5 most common building types in the given size range in Los Angeles and identifies the measures with the highest energy- and water-savings potential for these buildings, along with the associated cost savings. Many assumptions have been used in the execution of this methodology, which are outlined clearly throughout, so the reader can put the information into context.

II. Methodology

1. Property Type Category

The Energy Star[4] Guide was used as the starting point for building categorization. This program, provided by EPA, is a tool for helping businesses and individuals achieve energy efficiency. In order to make benchmarking buildings easier, the Guide has categorized buildings to 18 broad building types, so that property owners can easily compare their building's performance with others in the same category. Using existing literature and conversations with experts in the field, we narrowed down these categories to the five building types that are most prevalent to Los Angeles and thus hold the most potential for energy and water savings. These are: Office Building, Retail, Lodging/Hotel, Warehouse, and Educational Institution.

Our analysis is meant to support the LA City ordinance[2] for building efficiency. In particular, small- and mid-sized buildings, 50,000 square feet to 100,000 square feet, often face challenges to achieve high efficiency in energy and water use. Their small floor plans often limit economy of scale of energy and water consumption and tend to make return on investment (ROI) longer than larger structures, which ROI for energy equipment retrocommissioning is around 0.2 years to 2.1 years[5]. Furthermore, owners of small properties are not likely to own multiple buildings, thus they often lack the latest technical expertise in implementing energy and water efficiency. Considering these issues, this project aims to provide a resource that may help owners of 50,000 square feet to 100,000 square feet properties to save energy and water use.

2. Energy Use and Cost Savings Estimation

Our ultimate objective was to obtain the energy use in BTU per square foot for each building type. This was achieved using four steps.

1. First we identified the five methods with the greatest energy-saving potential for each of our building types through conversation with experts from LABBC team in the field. As an example, for office buildings, this includes an HVAC system customized based on occupancy, and LED lights with dimming capabilities. Then we calculated an estimate of the amount of energy being currently used by our study building (e.g. an office building in the size range of 50-100,000 sq. ft.) for a particular end-use (e.g. lighting), assuming no energy-efficiency.
2. This was then scaled up to reflect the total number of buildings nationally of that use type and size. We used the Commercial Buildings Energy Consumption Survey 2012, offered through the U.S. Energy Information Administration[6] to help us. This resource provides data on the number of buildings of a specific type with a particular end-use, as well as energy consumption for an end-use. It provided us national values for the building sizes and types used by our study, as well as associated energy use in BTU[6]. We could use these to calculate the amount of energy used for each end-use, specific to our building category and size range. Energy intensity (BTU/sq. ft.) was calculated by simply dividing by the building size.
3. Next we calculated the energy savings associated with the five energy-saving methods we identified for each building category. Expert interviews and historical implementation gave us estimated percent energy savings if each method was implemented in the specific building

category. We applied this to the output of step two above to obtain estimates for energy savings by end-use. This gave us a [BTU/sq ft] figure.

4. The final part of our analysis was to calculate cost savings. Energy costs are variable[7] by provider, time of day, and quantity, therefore, for our calculations, we used a flat rate of 15 cents/kWh[8] as an example rate, not a guaranteed cost, to calculate the associated reduction in costs due to energy saved. In order to calculate total cost savings for one property, we assumed an average building size of 75,000 sq. ft. which falls in the middle of our study size range of 50,000-100,000 sq. ft. Additionally, we calculated a range of total cost savings where the upper limit corresponds to the measure that provided highest savings and the lower limit to the measure with the lowest savings.

3. Water Use and Cost Savings Estimation

Our estimation of water use and cost savings followed a similar set of steps as the energy calculations.

1. First, the LABBC experts identified the principal water consuming equipment in each of the five building types. Then, we computed the average number of each equipment type installed in each property of 50,000 square feet (bottom-line) to 100,000 square feet (top-line) based on the California Plumbing Code. This regulation mandates the minimum requirements of facilities according to its purpose and building occupancy rate [9].

   To make an estimate of the occupancy rate, we needed an estimate of people per square footage, which would be different for every use type. For offices and warehouses, the occupancy rate of office space is calculated per 1000 square feet, and we used the estimate of 5 people for offices and 0.59 for warehouses. For hotels, the industry standard is rooms per 1000 square feet, with an average of 1.95 [10]. For educational institutions, California Department of Education published that the median square feet of a high school classroom per student is 95 square feet [11].

   With these figures in mind we were able to compute the total number of each equipment type in each building.
2. Next we calculated the water use of each building, according to the equipment identified in step 1. This calculation was based on water consumption data provided by the United States Environmental Protection Agency (EPA) by equipment type [12]. Subsequently, we evaluated potential water savings achieved when a building owner would replace the existing equipment with the most efficient models recommended or certified by the EPA. We estimated the total water savings for a whole building at 50,000 square feet to 100,000 square feet by multiplying the water savings volume per unit of water consuming equipment by the total units of water consuming equipment in an entire property.

   To complete these estimates of the average water consumption for an individual property, we used the following assumptions:
   a. The sex ratio of workers, students, or guests who use the five building types is equal (fifty percent of students enrolled at a given college are female). he California Plumbing Code specifies the minimum facility requirements by genders, so, we estimated the number of water-consuming facilities for men and women, respectively.

b. We assumed that the average man goes to the toilet 4 times a day (1 time for the water closet and 3 times for the urinal) and an average woman goes to the toilet 3 times a day [13].
c. The number of food service facilities, such as service sinks and dishwashers, and frequency of use do not change regardless of the difference in the floor area size. The reason for this is that the floor size is not directly related to the number of users.
d. A hotel of 100,000 square feet uses twice as many laundry machines as a hotel of 50,000 square feet. Because the number of guest rooms is proportional to the floor area size of a building, we assumed that medium-sized hotels (100,000 square feet) tend to have a larger load of laundry than small-sized hotels (50,000 square feet).
e. All hotel guests take only a shower and do not use a bathtub during their stay, thus analysis focused on the water consumption by shower facilities.

3. The final section of our analysis was a calculation of the associated reductions in operating costs due to the facility replacements. Unlike the energy savings estimation per square feet, we calculated the cost reductions for an individual building. For the cost assessment, we needed two assumptions:
    a. The unit water rate in the city of Los Angeles is $10 per 1,000 gallons according to an LABBC expert.
    b. Office buildings, educational institutions, and warehouses only operate during weekdays (22 days per month), and retail and lodging spaces are run during both weekdays and weekends (30 days per month).

4. Constraints

Our methodology is limited by data availability. Los Angeles-specific data was not available for building type or end-use consumption, so we relied on national-level data. Based on our conversations with experts, we were reassured that Los Angeles would reflect national averages. Once the June 1 benchmarking date passed, more specific information could be used to update our calculations, as well as help scale it up to city-wide savings.

Our calculations were also based on the assumption that the small- and medium-sized properties have not installed the latest high efficiency facilities, so our estimates represent the high end of consumption.

Finally, we had initially hoped to calculate return on investment after construction and retrofit costs were taken into account but were unable during the study period. Instead we only included end-use changes that traditionally have a two-year ROI in our analysis. Existing literature tells us that potential payback period for energy savings solutions are between 0.2 and 2.1 years[14]. Our methodology is intended as a template and that can be built upon so we hope a future analysis will be able to include more specific information, and validate the two year ROI assumptions.

III. Energy & Water Use and Cost Savings

In this project, we examined the possibility of energy and water use and cost savings for the following five property types.

1. Estimated impact of measures

a. Office

Office buildings includes properties used for general office space, professional office, or administrative office.

Top measures for energy savings are modifying the HVAC system and LED lighting to make it specific to time of day and occupancy, and more intensive upgrades to the HVAC system including switching to variable primary flow which adjusts for cooling load. Top measures for water savings are replacement of existing plumbing fixtures to the latest high efficiency models.

Energy

Measures	Average System Savings		Potential Cost Savings ($/property/year)*[1]
	Reduction in Use (%)	Cost ($/sq. ft./year)	
Occupancy based HVAC	30%	$0.37	$23,250 ~ 66,750
LED lighting with dimming occupancy and daylighting	40%	$0.89	
Static pressure reduction	40%*[2]	$0.31	
Variable Primary Flow Central plant with AHU mounted circulation pumps	30%*[3]	$0.37	
Variable refrigerant flow either by RTU Retrofit or installation of VRF units	40%	$0.5	

Water

Measures (Replacement)	Average System Savings*[4] (/property/year)		Total Savings for All Measures Together*[4](/property/year)	
	Reduction in Use (%)	Cost ($)	Reduction in Use (%)	Cost Reduction ($)
WC	20%	$422 ~ 845	28%	$1,495 ~ 2,990
Urinal	50%	$495 ~ 990		
Lavatory/Faucets	25%	$578 ~ 1,155		

*[1] Using an average building size of 75,000 sq. ft. and range of savings corresponds to implementation of the highest vs lowest savings measure.

*[2] Of fan horsepower

*[3] Of pump horsepower

*[4] Presenting the bottom line (50,000 square feet) and the topline (100,000 square feet) in the table.

b. Retail

Retail buildings include properties used for sales and display of goods and foods, such as grocery stores, malls/shopping centers, restaurants, and convenience stores.
Top measures for energy savings are upgraded LED lighting and HVAC systems, variable refrigerant flow and upgrades to water fixtures. Top measures for water savings are replacement of existing plumbing fixtures to the latest high efficiency models.

Energy

Measures	Average System Savings		Potential Cost Savings ($/property/year)*[1]
	Reduction in Use (%)	Cost ($/sq. ft./year)	
LED lighting with dimming controls	60%	$2.03	$3,300 ~ 59,625
Occupancy based HVAC	30%	$0.24	

Water

Measures (Replacement)	Average System Savings*[2] (/property/year)		Total Savings for all Measures together*[2](/property/year)	
	Reduction in Use (%)	Cost ($)	Reduction in Use (%)	Cost ($)
WC	20%	$1,129 ~ 2,253	31 ~ 34%	$4,474 ~ 8,452
Urinal	50%	$1,323 ~ 2,640		
Lavatory/Faucets	25%	$1,543 ~ 3,080		
Dipper wells	40%	$396		
Pre-rinse spray valves	19%	$44		
Dishwasher*[3]	50%	$40		

*[1] Using an average building size of 75,000 sq. ft. and assuming implementation of the highest vs. lowest savings measure.
*[2] Presenting the bottom line (50,000 square feet) and the topline (100,000 square feet) in the table.
*[3] Assuming that a restaurant installs one dishwasher machine on site and use it 5 times a day (2 times for lunch time and 3 times for dinner time).

c. Lodging/Hotel

Lodgings and Hotels include properties used to offer multiple accommodations for short-term or long-term residents. This includes hotels, multifamily apartment buildings, dormitories, etc. These buildings often have laundry facilities.

Top measures for energy savings are upgraded LED lighting and smart room thermostats that allow better temperature control. Top measures for water savings are replacement of existing plumbing fixtures and upgrades to laundry facilities to the latest high efficiency models.

Energy

Measures	Average System Savings		Potential Cost Savings ($/property/year)*[1]
	Reduction in Use (%)	Cost ($/sq. ft./year)	
Smart room thermostats	20%	$0.45	$33,750 ~ 50,250
LED lighting with dimming controls	60%	$0.67	

Water

Measures (Replacement)	Average System Savings*[2] (/property/year)		Total Savings for all Measures together*[2](/property/year)	
	Reduction in Use (%)	Cost ($)	Reduction in Use (%)	Cost ($)
WC	20%	$4,710 ~ 9,420	22%	$12,788 ~ 39,360
Lavatory/Faucets	24%	$6,802 ~ 27,388		
Shower	20%	$945 ~ 1,889		
Laundry*[3]	46%	$331 ~ 662		

*[1] Using an average building size of 75,000 sq. ft. and assuming implementation of the highest vs. lowest savings measure.

*[2] Presenting the bottom line (50,000 square feet) and the topline (100,000 square feet) in the table.

*[3] Assuming that a small- and mid-sized lodging/hotel installs one laundry machine on site and doing the laundry 4 times a day (2 times for dry laundry and 2 times for wet laundry).

d. Warehouse

Warehouse buildings include properties used to store goods, manufactured products, merchandise, raw materials, or personal belongings, such as self-storage.
Top measures for energy savings are upgraded LED lighting to account for time of day and occupancy and upgraded ventilation systems, allowing more efficient use of energy for heating/cooling. Top measures for water savings are replacement of existing plumbing fixtures to the latest high efficiency models.

Energy

Measures	Average System Savings		Potential Cost Savings ($/property/year)*[1]
	Reduction in Use (%)	Cost ($/sq. ft./year)	
LED lighting with dimming occupancy and daylighting	80%	$2.21	$1,500 ~ 165,750
Ventilation upgrade	50%	$0.02	

Water

Measures*[3] (Replacement)	Average System Savings*[2] (/property/year)		Total Savings for all Measures together*[2](/property/year)	
	Reduction in Use (%)	Cost ($)	Reduction in Use (%)	Cost ($)
WCs	20%	$51 ~ 100	22%	$90 ~ 178
Lavatory/Faucets	25%	$40 ~ 78		

*[1] Using an average building size of 75,000 sq. ft. and assuming implementation of the highest vs. lowest savings measure.
*[2] Presenting the bottom line (50,000 square feet) and the topline (100,000 square feet) in the table.
*[3] Because California Plumbing Code does not require a property owner to install urinals, we did not include water savings estimation for urinal facilities.

e. Educational Institution

Educational buildings include properties used for academic or technical classroom instruction, such as elementary, middle, or high schools, and classroom buildings on college or university campuses. Buildings on education campuses for which the main use is not a classroom are not included in this category (for example, administration buildings are part of "Office", and dormitories are "Lodging").

Top measures for energy savings are upgraded LED lighting and HVAC systems, variable refrigerant flow and upgrades to water fixtures. Top measures for water savings are replacement of existing plumbing fixtures to the latest high efficiency models.

Energy

Measures	Average System Savings		Potential Cost Savings ($/property/year)*[1]
	Reduction in Use (%)	Cost ($/sq. ft./year)	
LED lighting with dimming occupancy and daylighting	40%	$0.78	$58,500 ~ 356,250
Occupancy based HVAC	30%	$4.75	
LED area lighting	50%	$0.97	

Water

Measures (Replacement)	Average System Savings*[2] (/property/year)		Total Savings for all Measures together*[2](/property/year)	
	Reduction in Use (%)	Cost ($)	Reduction in Use (%)	Cost ($)
WCs	20%	$918 ~ 1,837	27%	$3,429 ~ 6,858
Urinals	50%	$1,076 ~ 2,152		
Lavatory/Faucets	25%	$1,435 ~ 2,870		

*[1] Using an average building size of 75,000 sq. ft. and assuming implementation of the highest vs. lowest savings measure.

*[2] Presenting the bottom line (50,000 square feet) and the topline (100,000 square feet) in the table

2. Discussion

For energy efficiency, top measures across all the building types include simple things like optimizing, or setting-back, your HVAC system so as to only condition a room based on actual occupancy by installing smart room thermostats, rather than the default maximum occupancy; a similar thing can be done by implementing dimming capabilities for LED lighting. These measures optimize systems already in place, saving energy that is being wasted currently. These simple measures result in some of the highest cost savings, indicating a lot of potential for energy savings with minimal construction and cost. Businesses that are interested in diving deeper in the world of efficiency have the option of investing in measures like implementing variable primary flow in HVAC chiller systems, which allows a system to vary flow rate according to cooling load rather than the traditional constant-flow pump system for office buildings, or upgrades to kitchen equipment in hotels.

As with the energy measures discussed above, simple operational improvements and facility repair are also effective to reduce water consumption. For example, according to the EPA, "household water leaks can waste more than 1 trillion gallons of water annually nationwide [15]. Therefore, fixing leaking facilities, such as worn toilet flappers and dripping faucets, can save substantial water use. As these types of leaks are often easy to repair, requiring a few tools and hardware that does not accrue a significant financial burden to property owners. Likewise, as some studies already showed, a communication-based approach to reducing water consumption like posting water use volume and its cost regularly may work to change each user's' water consuming behaviors [16]. These operational improvements are easier and quicker to implement than facility replacements, thus enabling property owners to start from small steps to conserve water use.

A recommended first step is to perform an internal energy audit or retro-commissioning investigation. Frequently, the building owner, manager, or internal maintenance personnel are knowledgeable enough to find simple, no-cost corrective measures to implement before engaging an outside consultant or contractor. The following are no-cost, quick actions that should be considered:

- Check the operating schedule of your HVAC system. Do thermostats run the equipment according to the schedule they are actually needed?
- Set your HVAC temperatures to reasonable settings. Thermostats set to 68 degrees for heating and 76 degrees for cooling can produce big savings compared to 70 degrees heating and 72 degrees cooling.
- Check that time clocks for lighting, water features, irrigation, etc., are set appropriately.
- Remind your building occupants to turn out the lights when they leave a room.
- Check to make sure your water heaters are not set higher than you need for your use. There is a thermostat setting on nearly all water heaters.
- Check your irrigation system regularly throughout the year. Look for overspray and broken heads. Reset the timing of zones to something appropriate for the season.

IIII. Conclusion

In the past, energy and water saving solutions and initiatives were often focused on large-sized buildings; however, in this study, we found out that small- and mid-sized buildings also have huge potential to save energy and water. In particular, replacement of lighting fixtures with LED bulbs will be the most effective measure for energy reduction, saving 40% to 80% energy on average. The principle water consuming facilities are water closets, urinals, and faucets, thus renovating old equipment with the latest high efficiency models will decrease water use at a property by 20% to 50%.

When you scale this information up from a single building to the entire city, even more dramatic savings can be seen. As one example, according to data provided by the LA Better Buildings Challenge, there are currently 99 office buildings of 50,000 to 100,000 square feet size within the city. If we apply our methodology and recommended measures to only those 99 office buildings, the city would save 52 billion BTU toto 148 billion BTU of energy and 22 million gallons water of every year*.

We believe that the proposed recommendations presented in this report will help small building owners achieve the target reductions in energy and water consumption set in The Existing Buildings Energy and Water Efficiency Ordinance. We also understand that it is challenging for property owners to employ all of the measures due to the financial burdens accrued by equipment acquisition and installation cost. Many government subsidies can help owners bridge this gap and groups like the LA Better Building Challenge can help connect property owners with these resources. Furthermore, Lawrence Berkeley National Laboratory estimated that the average payback period of energy equipment retrocommissioning is around 0.2 years to 2.1 years[5]. With these financial factors in mind and the strong resulting energy and water savings, the measures explored in this study can be implemented to the benefit of the property owner and our environment.

*Assuming that the floor area of all 99 buildings is 75,000 square feet, an average of 50,000 and 100,000 square feet. Calculation formulas are as follow.
Energy savings:

- Using the highest energy saving methods: 99 buildings * 75,000sq ft * 20,000 BTU/sq ft savings = 148 billion BTU for LA City
- Using the lower energy saving methods = 99 buildings * 75,000sq ft * 7,000 BTU/sq ft savings = 52 billion BTU for LA City

Water savings:

- Using the recommended water saving methods: 99 buildings * 224,235 gallons savings per building annually = 22.2 million gallons for LA City

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