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Commercial Buildings Energy Survey

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In Conjunction with the Bay Area Climate Collaborative and the Silicon Valley Leadership Group

Urban Studies 164: Sustainable Cities
Final Report

Table of Contents

Executive Summary

The Bay Area Climate Collaborative (BACC) and the Silicon Valley Leadership Group (SVLG) approached our team with the goal of constructing an energy profile of Bay Area commercial buildings. This profile sought to identify *interest in and opportunities for* energy efficient upgrade projects in large commercial buildings.

To realize this goal, the BACC requested collaboration in project refinement and execution. In order to better inform our project aim, our first task was to perform an extensive literature review of the following materials:

1. LEED Existing Buildings Criteria
2. DOE Reports on Energy Efficiency Trends in Residential/Commercial buildings
3. BACC Bridge to Clean Economy paper
4. DOE Commercial Buildings Energy Consumption Survey

In planning project methodology and implementation, we subsequently elicited the advice of the following experts within the BACC and Stanford University network:

1. Gil Masters (Member of Precourt Energy Efficiency Center, Stanford Civil and Environmental Engineering Professor)
2. Leslie Kramer (Senior Energy Engineer, Stanford Facilities Energy Management)
3. Michael Lechner (Program Manager at Quantum Energy Services and Technologies, Inc.)
4. Rosemary Bryan (Principal-Consulting Engineer, Eichler Associates)
5. Rafael Reyes (Executive Director, Bay Area Climate Collaborative)

Based on this literature review and discussions with experts in the community, we recommended a refined target audience: facilities managers of large office buildings. Office buildings consume 24% of our nation's total commercial building electricity allotment[1] and while more extensive documentation can be found in the Project Refinement section of this report, this is a representative finding that highlights the impact that office buildings have on our energy footprint. Office buildings therefore are an integral part of the commercial building energy profile and consequently present a great opportunity to implement energy efficient retrofits. Additionally, we chose facilities managers as the target audience primarily due both to their level of access to energy-related building information and to their professional stake in our project's findings.

[1] The California Energy Commission. "California Commercial End-Use Survey." Consultant Report. March 2006. 8.

We then proposed refining the project goals and narrowing the scope of work to include:

1. Quantifying current energy efficiency retrofitting trends
2. Assessing owner interest/buy-in for various energy efficiency retrofits.

We chose to collect data via both an online, Qualtrics-based survey and in-depth phone interviews. We selected phone interviews as the second medium due to their ability to gather qualitative, nuanced information. This would prove to nicely compliment the more quantitative data collected by the survey. To increase the likelihood of a high survey response rate, we limited the survey to 20-25 questions falling in 7 categories:

1. Basic Building Characteristics and Use
2. Heating, Ventilation, and Air Conditioning (HVAC)
3. Lighting
4. Current and Planned Energy Related Updates to Building
5. Building Energy Management Systems
6. Incentive Program Participation
7. Budgeting

Commercial building lighting schemas and heating and cooling (HVAC) systems require the most resource input[2] within a building. Therefore, we lent more consideration to the data that we collected in these categories when proposing recommendations. The remaining categories gathered information regarding the feasibility and practicality of potential retrofit implementation. Because of the more nuanced nature of feasibility questions, phone interviews were primarily used to gain a more complete understanding of such issues.

A preliminary analysis of both the survey responses (35 sent with 5 responses) and expert interviews (12 solicited with 5 responses) yielded the following results:

1. Payback period and budgeting for energy efficient retrofits are very important
2. Lighting is the most promising area, both in terms of adoption and buy-in. Most instances of tenants approaching management about energy efficiency dealt with lighting improvements, especially Compact Fluorescent Lights (CFLs), Light-Emitting Diodes (LEDs), and better controls
3. Knowledge of and interest in energy efficiency incentives and programs is high, including power management and peak shaving programs. Facilities managers and companies alike have contacted Pacific Gas and Electric (PG&E) about potential program participation, but those that have participated report varying levels of satisfaction with them
4. HVAC systems lag somewhat in energy efficiency retrofits compared to lighting and Building Energy Management upgrades

[2] Masters, Gil. "Energy Efficient Buildings: Introduction." Lecture. January 7, 2009. Slide 10.

5. Energy efficiency programming processes utilized by universities offer a possible model for office campus-wide energy efficiency retrofit programs

While the results highlight several meaningful trends, we recommend using this pilot project primarily as a foundation for future work due to the limited sample size. In subsequent work, we recommend a deployment pool that anticipates a 10:1 sent surveys to received responses ratio.

Based on our work for this project, our team recommends the following for future surveying efforts:

1. Extending the survey response period, with continued phone check-ins or email follow ups
2. Providing greater incentives for survey respondents
3. Revolving primary data collection around phone interviews or focus groups which, while more time intensive, yielded better results
4. Making the survey more concise by cutting out questions on building characteristics and focusing on past, avoided, and future EE retrofits. We found that the latter highlighted the immediately actionable items based on practicality, feasibility, and stake holder interest. The former not only produced similar data across all responses due to our narrow target audience, but also did not reveal the more important trends.
5. Partnering with Silicon Valley Organizations (Building Owners and Managers Association, International Facility Management Association) already interested in building energy efficiency. Increasing communication and working with companies to further improve results.

We thank the BACC and the SVLG for the opportunity to collaborate on such a meaningful project. We hope that our recommendations provide useful insight and inform future work. For any further questions, please contact the Stanford liaison to the BACC, Arianna Vogel at <ariannav@stanford.edu>.

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Project Refinement:

How an in-depth literature review precipitated refined goals, scope, and methodology

Commercial buildings account for a significant portion of our nation's energy profile. Not only are they responsible for consuming 18% of the United States' given energy supply, but they emit a comparable percentage of our nation's greenhouse gas emissions.[3] Furthermore, commercial buildings demand 35% of the United States' total electricity bank.[4]

What specifically is it about commercial buildings that make their operation so energy intensive? Primarily, commercial building lighting schemas and heating and cooling (HVAC) systems require the most resource input[5] and therefore should be considered heavily when proposing retrofit recommendations. Therefore, the survey question categories we generated focused on these areas with the goal of further understanding how lighting and HVAC contribute to the energy makeup of the building.

Having identified the above trouble *areas* in commercial building operation, we needed to further define the most troubling *type* of commercial building. The commercial building spectrum comprises office buildings, warehouses, churches, and retail locations, to name a few. Faced with such a wide spectrum, we sought to identify the type that, upon enacting energy retrofits, would have the most potential to significantly decrease the energy demand of the commercial building sector as a whole. We considered total floor space, total buildings, and primary energy consumption data and we noticed that office buildings led in all three categories[6]. In addition, we found that office buildings account for 24% of the electricity use allocated in the commercial buildings category.[7] Therefore, we chose to specifically diagnose office buildings' energy use and subsequently identify potential improvements within that subcategory.

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[3] Masters, Gil. "Energy Efficient Buildings: Introduction." Lecture. January 7, 2009. Slide 6.
[4] Masters, Gil. "Energy Efficient Buildings: Introduction." Lecture. January 7, 2009. Slide 8.
[5] Masters, Gil. "Energy Efficient Buildings: Introduction." Lecture. January 7, 2009. Slide 10.
[6] U.S. Department of Energy. "Energy Efficiency Trends in Residential and Commercial Buildings." Report. Slide 20. October 2008.
[7] The California Energy Commission. "California Commercial End-Use Survey." Consultant Report. March 2006. 8.

Having conducted an in-depth literature review (referenced above) to contextualize and frame the project, we analyzed the methodology and implementation of example commercial building energy use surveys. Analyzing the methodology behind the California Commercial End-Use Survey corroborated our initial idea of involving the facilities managers of office buildings[8]. We reasoned that facilities managers would have both quick access to their building's energy profile and readily available contact information for ease of survey deployment. We also reasoned that, of potential parties to involve, they would be among the most interested and therefore subsequently receptive to involvement in an energy survey. Next, we consulted the U.S. Department of Energy's Commercial Buildings Energy Consumption Survey for 2003. This survey helped to inform our survey wording and overall structure.

In summary, our literature review informed our decisions to select:

1. **Office Buildings** as our desired sub-category
2. **Lighting and HVAC** as our primary focus points
3. **Facilities Managers** as our target audience

[8] The California Energy Commission. "California Commercial End-Use Survey." Consultant Report. March 2006. 2.

Survey Iteration:

How consulting experts within the community helped create a highly informed, relevant, and professional deliverable

After developing an initial survey, we solicited the expert opinion of professionals with the goal of refining both the individual questions and the overall organizational theory behind the survey. We conducted both in person and phone interviews with the following individuals (see Executive Summary for credentials, and Appendix 1 for contact information): Gil Masters, Michael Lechner, Rosemary Bryan, and Leslie Kramer.

While each mentor analyzed and edited each individual question of the survey, they also offered several larger, umbrella suggestions that were extremely helpful in refining our deliverable. In order to ensure a focused and directed survey, Gil Masters suggested we craft the survey around several specific energy efficient retrofits we would like to promote. Whether that be the Serious Materials iWindow schema, rooftop ice systems to shave peak demand, or the Nest Learning Thermostat, having these ideas in the forefront of our mind, he contended, would help to craft more necessary and relevant questions. This mental exercise proved extremely helpful in generating more targeted and specific questions in subsequent survey iterations. Michael Lechner also specifically stressed the importance of understanding the financial feasibility of the potential retrofits. This prompted the creation of a more robust section on finance within the survey.

The synthesis of our survey critique can be summarized by Michael Lechner's assertion that "surveys are tricky business." This is in reference to the multitude of considerations that must go into creating and distributing a quality survey. These considerations span a large spectrum from target audience attention span, response follow-up, question quality, and larger organizational structure. All mentors highlighted the need for simplicity and brevity both in creating a short survey and succinct questions. This is dual functioning to ensure that we both stayed focused on our goals and created a survey that did not discourage responses due to length. Finally, mentors across the board mentioned the need for additional finance questions to illuminate incentives to funding

avenues and budgeting schemas.

To complete the survey iteration process, we needed to draft an introductory email (see appendix 2) that would invite recipients to participate in our survey. After discussions with the BACC, we decided that the invite email should come directly from the BACC instead of our project team. This would positively affect the survey's credentials by directly communicating the BACC's underwriting and support of the survey. This introductory email would not only invite recipients to participate in our survey but also assure them that their privacy and anonymity would be maintained. This privacy statement emphasized that results would be aggregated so that individual companies and buildings would not be explicitly named or profiled.

Results:

A Presentation of Survey Response Trends

The subsequent lists present the most salient trends found within their respective survey question categories. They should be considered preliminary due to the limited sample size (35 sent survey invitations with 5 received responses).

Building Characteristics

1. Almost all reported office space Class A
2. Half of buildings built from 1978-2000
3. Occupancy range: 400 to 1000
4. All respondents were part of building campuses, with 67% having Central Heating and Cooling plant
5. All served by Pacific Gas and Electric (PG&E)

HVAC

1. Boilers still most common for heating (almost 80%) - most respondents' boilers were 10-15 years old
2. Central chillers most common for cooling
3. HVAC audits uncommon
4. Most companies reported using air economizers

Lighting

1. All respondents: if reported, only 1-25% of lights left on at night
2. Fluorescents: all respondents had 3rd generation T8s with electronic ballasts
3. Wide range of daylighting percentages
4. Use of photocells uncommon
5. Occupancy sensors common
6. 4 out of 5 companies reported lighting retrofits in the last 5 years with Light-Emitting Diodes (LEDs), Compact Fluorescent Lights (CFLs), and better controls as the focus of these retrofits

Current and Planned Energy Updates to Building

1. All buildings had tenants approach management requesting renewables deployment on site
2. Fuel Cell Usage: ⅖ "yes", ⅗ "no" due to long return on investment
3. Tenants approaching management on energy efficiency have also focused on lighting issues

Building Energy Management Systems (BEMS)

1. BEMSs vary, but those with them have updated them frequently and have Direct Digital Control
2. All have investigated power management and peak demand shaving programs

Incentive Program Participation

1. Some, but not overwhelming
2. Varied levels of success with PG&E programs, with some managers reporting underwhelming experiences
3. Very wide array of informational sources for energy efficiency – PG&E, SVLG, DSIRE, International Facility Management Association (IFMA), American Society of Heating Refrigerating and Air Conditioning Engineers (ASHRAE), Building Owners and Managers Association (BOMA)

Budgeting

1. Only ⅗ have budgeted funds for energy efficiency retrofits in 2013 - 10k, 200k, 250k
2. Only ⅕ has budgeted funds for renewables in 2013 - 5k

Recommendations:

Suggestions for Future Work and Information Procurement

While extremely productive and informative, our project met some challenges along the way. The process of coping with these challenges and brainstorming potential solutions has taught us several lessons that future work may draw on. It is our hope that subsequent work will not only be informed by the results we have obtained, but also by the specific challenges we faced throughout our project.

Several obstacles presented themselves around survey deployment. First and foremost, response pool and rate were difficult to augment. We suggest that if a survey platform is to be the primary mode of data collection that the response pool should be robust enough to mitigate a 10:1 ratio of sent surveys to received responses. We also recommend embedding an incentive into the survey in order to encourage responses.

We also began to notice a variety of Silicon Valley organizations (BOMA, IFMA, SVLG, PG&E) currently in the space of commercial building energy auditing. Furthermore, we noticed their interest in gathering similar data that we had set out to obtain. Partnering with these organizations would increase the potential pool of respondents and better inform data collection to avoid repetition.

We also recommend increasing the amount of phone interviews and focus groups in future work. These media present the opportunity to spontaneously ask the respondent to clarify or expand on a specific response and build a personal relationship with the respondent for future partnership. The personal nature of interviews and focus groups allow for a nuanced conversation that enhances the quantitative data collected via survey.

Appendix 1

Contact List

Name	Position	Email	Phone Number	Date Contacted	Nature of Engagement
Leslie Kramer	Senior Energy Engineer, Stanford Facilities Energy Management, Sustainability and Energy Management	lfkramer@stanford.edu	(650) 725-5388	4/25/12	Consultation for Survey Revision, Expert Interview
Gil Masters	Professor Emeritus, Stanford University Department of Civil and Environmental Engineering, Precourt Energy Efficiency Center	gmasters@stanford.edu	(650) 725-1049	4/25/12	Consultation for Survey Revision
Michael Lechner	Program Manager, Quantum Energy Services and Technologies, Inc.	mlechner@quest-world.com	(408) 309-6015	5/3/12	Consultation for Survey Revision
Rosemary Bryan	Principle Consulting Engineer, Eichler Associates, Inc.	eichlerassociates@mac.com	(408) 482-7027	5/3/12	Consultation for Survey Revision
Miguel Liencres	SF Office Services Manager, McKinsey and Company	miguel_liencres@mckinsey.com	(415) 318-5198	5/8/12	Expert Interview
Jericho Gilmore	SF Office Facilities Manager, The Parthenon Group,	JGilmore@VNO.com		5/9/12	Expert Interview
Judy Chess	Assistant Director of Green Building Programs, Capital Projects and Facilities Services, University of California Berkeley	jchess@cp.berkeley.edu	(510) 643-8689	6/4/12	Expert Interview
Patrick Macardle	Energy Efficiency Program Manager, University of California Berkeley	pmacardle@cp.berkeley.edu		6/4/12	Expert Interview

Appendix 2

BACC Generated Invite Letter

Dear {insert name},

Could you take a brief moment to fill out this survey on commercial building energy efficiency? SVLG is working with the Bay Area Climate Collaborative and a team of Stanford students to assess the feasibility of reducing greenhouse gas emissions through near-term energy saving opportunities for medium and large companies in the region.

We want our programs and offerings to best suit you and your facilities. In order to do that, we ask that you take a moment to fill out this survey, which should take less than 15 minutes of your time. As a token of our appreciation for your feedback, we will be sharing high-level insights gleaned from survey responses.

If you do not have the time to fill out the survey, please reply indicating your preferred mode of participation:

- 15 or 30 minute interview with a student
- Sharing a link to your corporate sustainability or energy report and plan

We are looking for responses by May 23rd. If you need more time to respond, please let us know by responding to this e-mail or calling (408) 501-7871.

Section 1: Basic Building Characteristics and Use

Your responses to these questions will be kept strictly confidential. Data disclosure will classify buildings in descriptive categories, omitting specific names or identifying details. Anecdotes will be edited to communicate the thrust of the respondent's point without disclosing the identity of the building in question. Please click "Yes" if you have read and understood this data confidentiality statement.

Yes

Contact information

Your name

Company name

E-mail address

Phone number (optional)

Are you interested in a high-level summary of results?

What is the gross or total square footage of all the space in the building(s), both finished and unfinished, including basements, hallways, lobbies, stairways, elevator shafts, and indoor parking levels? Please make your best estimate.

	Building		
	1	2	3
1,000 to 5,000 square feet			
5,001 to 25,000 square feet			
25,001 to 100,000 square feet			
100,001 to 500,000 square feet			
More than 500,001			

If known, what is the building's class?

	Building 1	Building 2	Building 3
Class A			
Class B			
Class C			

What time period was this building (or buildings if you oversee several) constructed? If there have been major additions, give the year that the largest portion of the building was completed.

	Building 1	2	3
Pre World War II			
1945-1978			
1978-2000			
2000-present			
Don't Know			

What are the primary hours of operation, both weekday and weekend, and how many people occupy this building during those hours?

Hours of Operation Weekday

Hours of Operation Weekend

Est. # of Occupants

Is this building part of a multi-building campus or complex?
If so, how many buildings are there in this campus or complex?

	# of Buildings
Yes	
No	

Is there a central plant for heating or cooling?

Yes

No

Is your building either ENERGY-STAR labeled or LEED certified?

	Certified?	Rating	for LEED: EB (existing) or NC (new)?
LEED			
ENERGY-STAR			

Could you enter your utility provider or territory?

Would you be able to provide an approximate annual figure for your building(s'):

	Building	Building	Building

	Building 1	Building 2	Building 3
Electricity consumption (kWh)?			
Peak demand (kW)?			
Natural gas consumption (therms)?			
Overall electricity bill ($)?			
Overall natural gas bill ($)?			

Looking at this list of heating equipment types, please tell me which types are used in this building. Additionally, if you know the age of the building's heating equipment, please state that as well.

	Building 1	Building 2	Building 3
Furnaces that heat air directly, without using steam or hot water			
Boilers inside the building that produce steam or hot water			
Packaged heating units, other than heat pumps			
Individual space heaters, other than heat pumps			
Other			

Of the heating equipment types you selected above, please indicate their age

	Age		
	Building 1	Building 2	Building 3
Furnaces that heat air directly, without using steam or hot water			
Boilers inside the building that produce steam or hot water			
Packaged heating units, other than heat pumps			
Individual space heaters, other than heat pumps			
Other			

Looking at this list of cooling equipment types, please tell me which types are used in this building.

	Building 1	Building 2	Building 3
Packaged air conditioning units, other than heat pumps			
Individual room air conditioners, other than heat pumps			
Central chillers inside the building that chill water for air conditioning			
Heat pumps for cooling			

Heat pumps for cooling	
Rooftop ice generation during off-peak hours, for cooling during peak hours, or other thermal storage	
Other	

Looking at this list of cooling equipment types, please tell me the age of the types used in this building.

	Age		
	Building 1	Building 2	Building 3
Packaged air conditioning units, other than heat pumps			
Individual room air conditioners, other than heat pumps			
Central chillers inside the building that chill water for air conditioning			
Heat pumps for cooling			
Rooftop ice generation during off-peak hours, for cooling during peak hours, or other thermal storage			
Other			

Have you recently (within the last five years) initiated an audit or otherwise assessed the state of your ventilation system to check for leaks and overall energy efficiency?
If so, did that audit lead to retrofits of the ventilation system?
If not, what has been the primary inhibitor against such changes?

	Explanation
Yes	
	Explanation
No	

Does your HVAC system employ air economizers?

	Building 1	Building 2	Building 3
Yes			
No			

What percent of lights are left on at night in the building?

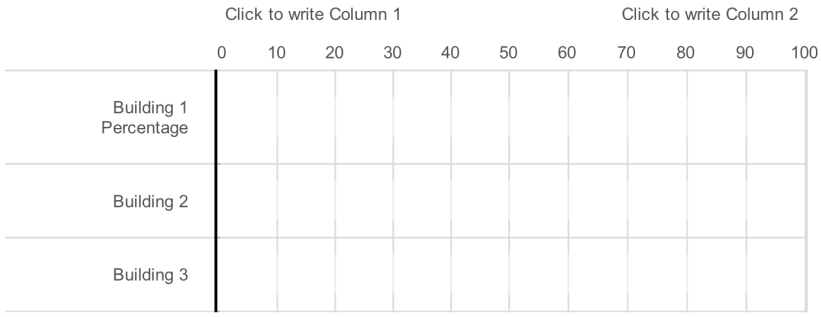
	Building 1	Building 2	Building 3
1% to 25%			
26% to 50%			
51% to 75%			
76% to 100%			

Of the fluorescent lighting in your building, is the majority:

Of the fluorescent lighting in your building, is the majority:

	Building 1	Building 2	Building 3
3rd Generation T8 Fluorescents with Electronic Ballasts?			
Older T8 Fluorescents with Electronic Ballasts?			
Older T8 Fluorescents with Other Ballasts?			
T12 Fluorescents with Other Ballasts?			
Other?			

What percent of the building receives enough outside light so that the interior lights do not need to be turned on during daylight hours?



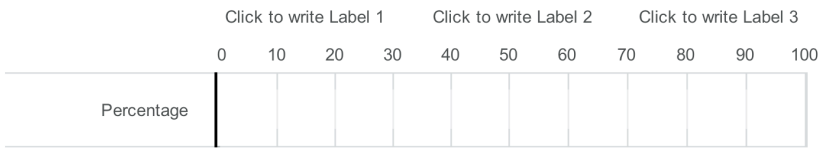
Does your building have photocells installed for automatically adjusting indoor lights?

	Building 1	Building 2	Building 3
Yes			
No			

Does your building have occupancy sensors for automatically adjusting indoor lights?

	Building 1	Building 2	Building 3
Yes			
No			

If yes to the previous question, approximately what percentage of the floor area utilizes this technology?



Have you recently (within the last five years) undertaken efforts to replace old, inefficient lighting sources such as incandescent bulbs with newer, more efficient ones, such as compact fluorescents or LEDs?

Yes

No

If so, did these efforts lead to the installation of such technologies?
If not, what factors contributed to the decision not to deploy such technologies?

Have tenants/occupants in your building or the building owner approached you requesting the investigation of deploying solar or other renewable energy technologies on the building grounds?

Yes

No

If so, did these efforts lead to the installation of such technologies?
If not, what factors contributed to the decision not to deploy such technologies?

Have tenants/occupants in your building or the building owner approached you regarding the implementation of any other specific energy-related retrofits or building improvements?

Yes

No

If so, what sort of retrofits have they suggested?
If not, what factors contributed to the decision not to take such measures?

Does your building have a computerized building energy management system?

If so, how old is this system, approximately?

If so, does this system incorporate direct digital control (DDC)?

If so, have you investigated a

controls update for this system as an energy efficiency upgrade?

If so, who controls this system?

If no, why not?

Which of the following most accurately describes the temperature control in your building?

	Building 1	Building 2	Building 3
automatic, centrally regulated			
accessible by employees of			
the building			

Have you investigated the possibility of beginning participation in power management programs such as automated demand response, as offered through utilities?

Yes

No

If so, have you specifically investigated peak shaving program options to reduce your peak demand charge on your electricity bill?

Yes

No

Has your building taken part in energy efficiency incentive programs offered by local governments, the California state government, or utilities?

If so, which programs have you utilized, and what has your experience been with these programs?

What are your main sources or information channels for learning about energy efficiency related programs?

Have you or any of your tenants explicitly budgeted money for energy efficiency retrofits in 2013?

Yes

No

If so, how much have you allocated?

If so, what funding method are you using to pay for such retrofits?

Have you or any of your tenants explicitly budgeted money for on-site renewable energy technology deployment in 2013?

Yes

No

If so, how much have you allocated?

If so, what funding method are you using to pay for such renewable energy deployment (for example, power purchase agreements, on-bill financing, etc.)?