Assessing Green Building Performance

A Post Occupancy Evaluation of 12 GSA Buildings

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Pacific Northwest National Laboratory
Operated by Battelle for the
U.S. Department of Energy

GSA

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Assistance Was Crucial

With the need for a large quantity of data from each building, this study easily could have become a data collection nightmare. However, the site contacts for the GSA buildings were exceptionally generous with their time and data, allowing the PNNL research team to focus on the analysis rather than data collection. The positive attitudes of the site contacts and their willingness to participate in the study made visiting the buildings, on a very tight schedule, a pleasure. The site contacts offered their time to host site visits, provide data for the building performance metrics, and promptly responded to our requests for clarification. Only 14 of the buildings pursued in this study lent themselves to assembling comparable data sets for analysis that met our building selection criteria (described in the body of the report). The site contacts that helped make this study possible include the following (in alphabetical order)

- Paul Anderson, Davenport CH
- Jonathan Bringewatt, Lakewood FB
- Jim Brown, Ogden FB
- Diana Ciryak, Cleveland CH
- Pamela Coleman, Ogden FB
- Scott Crews, Ogden FB
- Dan Fenner, Sault Ste. Marie Port
- John Garner, Omaha NPS FB and Omaha DHS FB
- Christopher Grigsby, Denver CH

- Scott Hawkins, Greeneville CH and Knoxville FB
- Sue Heeren, Davenport CH
- Tina Hingorani, Santa Ana FB
- Jason Hunt, Fresno CH & FB
- Nicholas Infantino, Youngstown CH & FB
- Mary Ann Kosmicki, Omaha NPS FB and Omaha DHS FB
- Kristina Lee, Omaha NPS FB
- Jill McCormick, Omaha DHS FB
- J. Michael Ortega, Denver CH
- Peter Pocius, Sweetgrass Port
- Wendy Schuman, Lakewood DOT FB
- Sandy Sitton, Fresno CH & FB
- C. Johnathan Sitzlar, Greeneville CH and Knoxville FB
- Don Smyth, Omaha NPS FB
- Mark Stanford, Sweetgrass Port
- Christopher Wentzell, Sweetgrass Port
- Stephen West, Scowcroft FB

Thank you to these and all others that contributed to this research effort.

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Executive Summary: Why It Matters

The General Services Administration (GSA) sustainably designed buildings investigated under this study cost less to operate, have excellent energy performance, and have occupants that are more satisfied with the overall building than the occupants in typical commercial buildings. Among the many informative observations derived from the data analysis are the following findings

- water performance needs further investigation;
- maintenance, grounds, and janitorial costs vary by location;
- waste disposal costs are less than the baseline; and
- carbon dioxide equivalents for commute miles traveled are lower than the baseline for most buildings.

Figure S1 offers a summary representation of the energy, water, occupant satisfaction, and aggregate maintenance costs for each of the buildings investigated. All of the energy use intensity (EUI, energy use per gross square foot) values were better than the baseline typical building, two-thirds of the water use intensity (WUI, gallons/occupant) values were better than or at the baseline, all of the occupant satisfaction scores were higher than the 50th percentile (the length of the line represents the percentage satisfaction), and more than half of the buildings have aggregate maintenance costs that are below the baseline. The buildings performing the best in all categories would be located in the top right quadrant, with a brown box and long lines to the right.

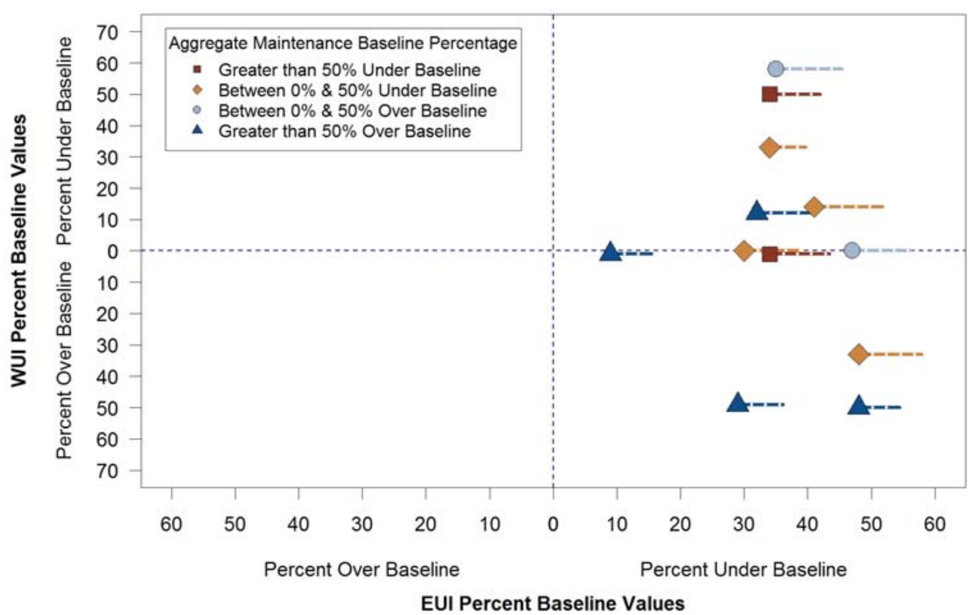

Figure S1. Energy performance and occupant satisfaction are better than the baseline for all buildings, aggregate maintenance costs are better for most buildings, and water performance is better than or at baseline for two-thirds of the buildings.

The intent of this whole building performance measurement analysis is to inform GSA on how its sustainably designed buildings are performing in comparison to traditionally designed buildings. Ideally, this information will be used to gain perspective, inform building design and construction, and advance the operation of GSA's buildings portfolio.

This study compares measured whole building performance for 14 GSA buildings located in half of its national regions (Figure S2) to industry standard performance of energy, water, maintenance and operations, waste, recycling, transportation, and occupant satisfaction metrics. Eight of the buildings are U.S. Green Building Council Leadership in Energy and Environmental Design (LEED®) certified, two are LEED registered, one used Green Building Challenge and has an equivalent LEED score, while another three buildings emphasized energy efficiency during design. Two of the 14 buildings are Port of Entry facilities, one LEED certified and one LEED registered. These are examined separately in an appendix, because no valid baseline for this building type exists. This study focused on the remaining 12 buildings for the analysis.

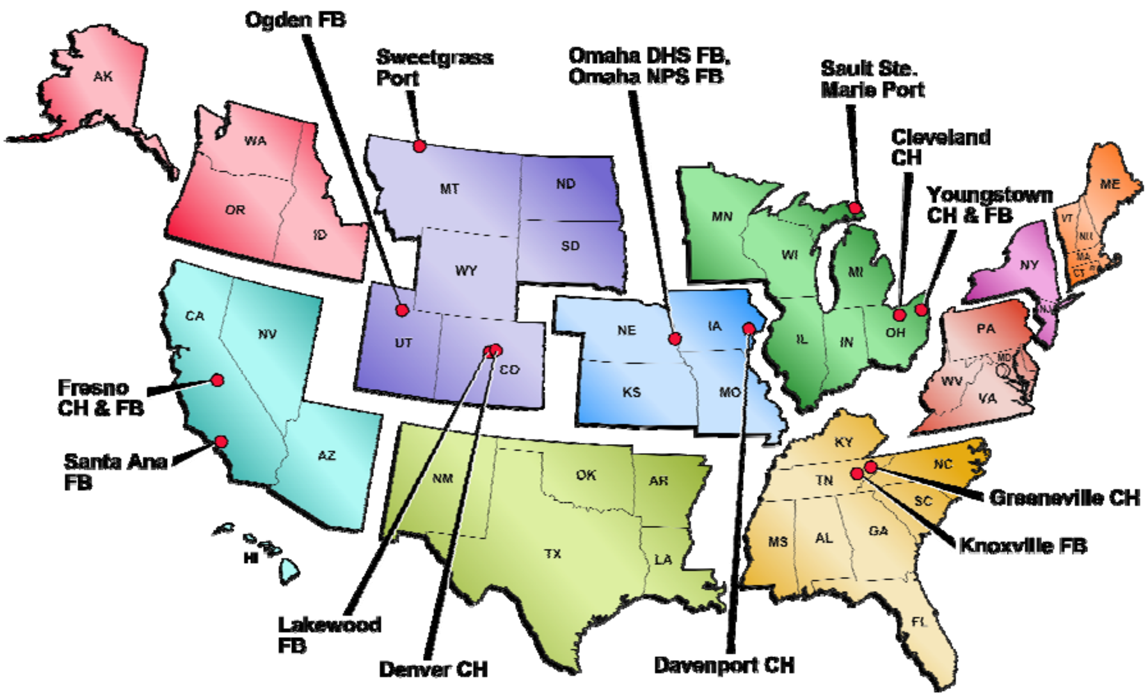

Figure S2. GSA buildings included in this study, shown by region.

As of the summer of 2007, GSA had 19 LEED-certified buildings. Although this study involved a small number of buildings, especially when considering the size of the GSA building stock, it includes more than one-third of GSA's LEED buildings, a respectable sampling of the buildings that have been officially identified as being sustainably designed.

LEED points and certification levels for each building are shown in Table S1. The Energy Star Portfolio Manager, an energy performance assessment tool, was used as a building comparison tool for this study. Energy Star scores in this table are unofficial, but are determined directly from the data provided by the sites for this study. All but one of the buildings scored above the 75th percentile, which means they could potentially qualify for an Energy Star rating. The remaining building still scored above the average building in the Energy Star database.

Table S1. "Green" scores of the GSA study buildings

Building Name	Certification Level	LEED® Total Points	LEED® EAc1 Points	LEED® WEc3 Points	Energy Star® Score
Ogden (L) FB	LEED-NC Silver	33	5	1	79
Lakewood (L) FB	LEED-NC Silver	35	4	0	80
Omaha DHS (L) FB	LEED-NC Gold	42	10	2	85
Omaha NPS (L) FB	LEED-NC Gold	40	3	2	86
Knoxville FB	LEED-EB Silver, Energy Star	29	8	2	91
Santa Ana FB	California Energy Standard Title 24	-	-	-	92
Denver CH	Green Building Challenge -- Score: 2.0	34	2	1	77
Davenport CH	LEED Registered	n/a	n/a	n/a	78
Cleveland CH	LEED-NC Certified	29	3	2	82
Greeneville CH	Energy Star 2007	-	-	-	87
Youngstown CH & FB	LEED-NC Certified	27	0	0	58
Fresno CH & FB	California Energy Standard Title 24	-	-	-	92

Table Notes
FB is the abbreviation used for Federal Buildings
CH is the abbreviation used for Courthouses
CH & FB is the abbreviation used for combined Courthouse and Federal Buildings
(L) identifies the leased facilities
LEED-NC is LEED for New Construction and Major Renovations
LEED-EB is LEED for Existing Buildings
EAc1 represents LEED Energy and Atmosphere credit 1 – Optimize Energy Performance
WEc3 represents LEED Water Efficiency credit 3 – Water Use Reduction

Performance metrics collected, normalized, and analyzed for the buildings include

- water
- energy
- maintenance and operations
- waste generation and recycling
- occupant satisfaction

- transportation.

Building contacts provided utility bills, maintenance budgets, and supported an occupant survey for the key data inputs. Twelve consecutive months of data were collected for each performance metric and then normalized using the building and site characteristics.

The performance data were compared to industry baselines developed from GSA, the U.S. Department of Energy (DOE), International Facility Management Association, Building Owners and Managers Association International, U.S. Environmental Protection Agency, University of California Berkeley's Center for the Built Environment, and the Energy Information Administration.

Aggregate Operational Cost Is Lower than Baseline

The "aggregate operating cost" metric used in this study is not the same as "total building operating cost." The aggregate operating cost represents the costs that were available for developing a comparative industry baseline for office buildings. The costs include water utilities, energy utilities, general maintenance, grounds maintenance, waste and recycling, and janitorial costs. All three of the buildings that cost more than the baseline in Figure S3 have higher maintenance costs than the baseline, and one has higher energy costs.

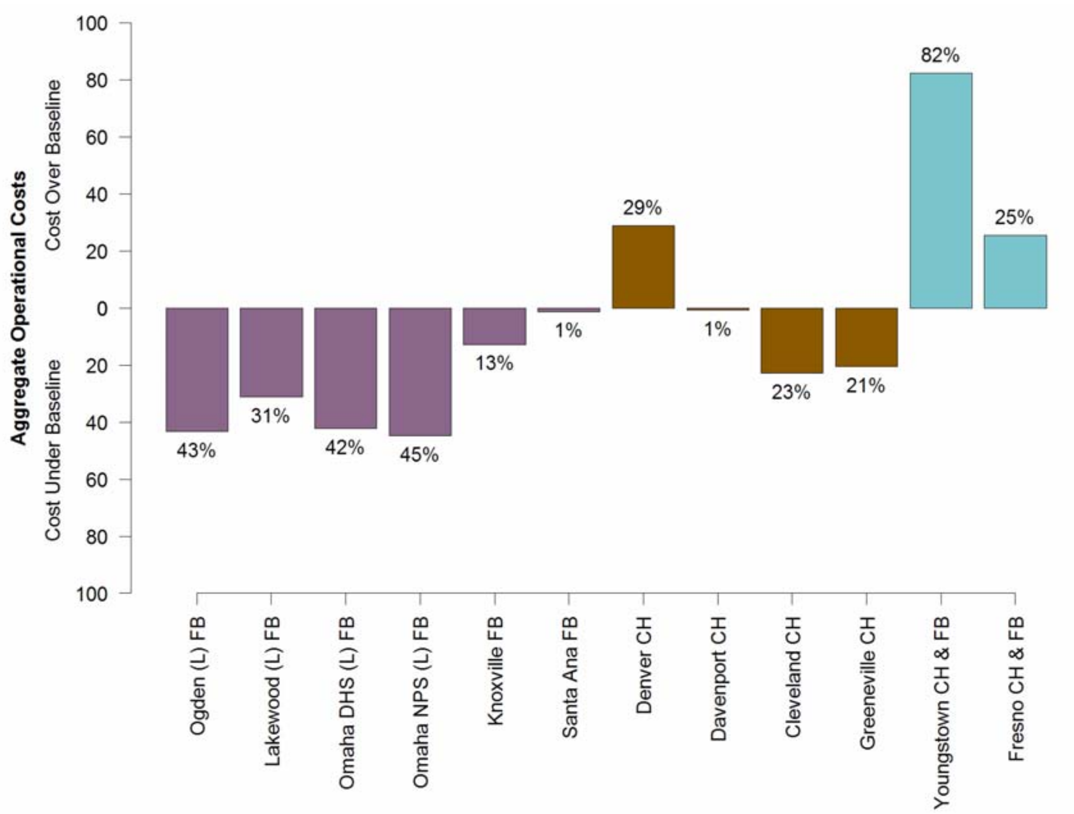

Figure S3. Aggregate operational costs are lower for most of the buildings.

Energy Performance Is Better when Energy Performance Is a Design Focus

Some of the observations confirmed "common beliefs," such as buildings that intentionally incorporate energy considerations into design have better energy performance (Figure S4). The data show that half of the change in the Energy Star score can be explained by the change in the LEED Energy and Atmosphere "Optimize Energy Performance" credits (EAc1). That is, the buildings that received more LEED EAc1 points tended to receive higher Energy Star scores.

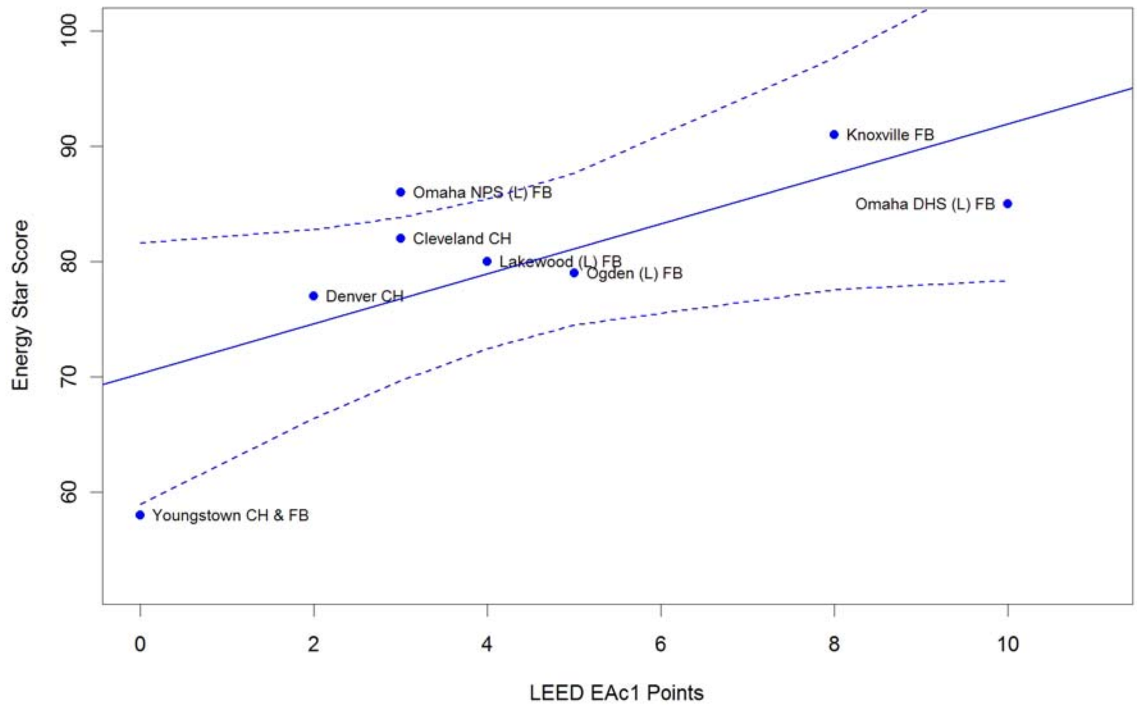

Figure S4. The more LEED Energy and Atmosphere Credit 1 (EAc1) Optimize Energy Performance points, the better the Energy Star rating

In addition to looking at the relationship between the design intent and energy performance, the measured energy performance of each building in the study was compared to the Commercial Buildings Energy Consumption Survey (CBECS) national, CBECS regional, and GSA national averages (Figure S5). The CBECS national average is for office buildings only built from 1990 – 2003, while the regional average is for all building types. The GSA national average is the Public Buildings Service goal for energy performance across the agency. All of the buildings performed better than the CBECS averages and most performed better than the GSA goal.

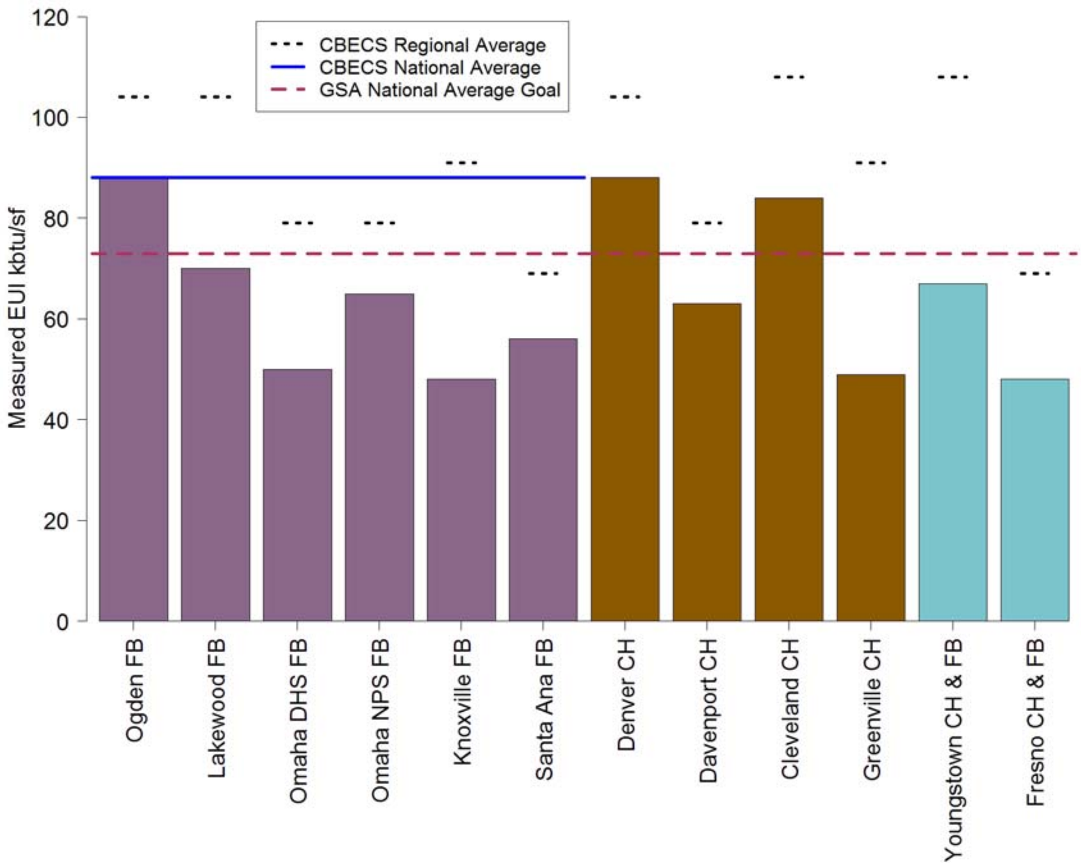

Figure S5. GSA buildings used less energy than the CBECS national and regional EUI averages.

On average the office buildings in the study performed 29% better than the CBECS national average for office buildings. All of the buildings performed 29% better than the CBECS regional averages. If the CBECS office buildings average is used as the baseline for all of the buildings, the buildings in the study performed 26% better than average office buildings. When compared to the GSA national goal for energy performance, these buildings perform 14% better.

Water Use Does Not Offer a Clear Story

Figure S6 shows how each building is performing in comparison to a water baseline for domestic water use. The water use data provided for eight of the buildings included process water and/or irrigation water. Because of this, domestic water use had to be estimated. Domestic water use was estimated as the base water load revealed from the monthly water use data. Sub-metering and more detailed information about each of the buildings' water use is needed before the water use at these buildings can be compared to relevant baselines. Given these estimates, the average water use of the GSA buildings in this study was 3% less than the calculated water use indices baseline.

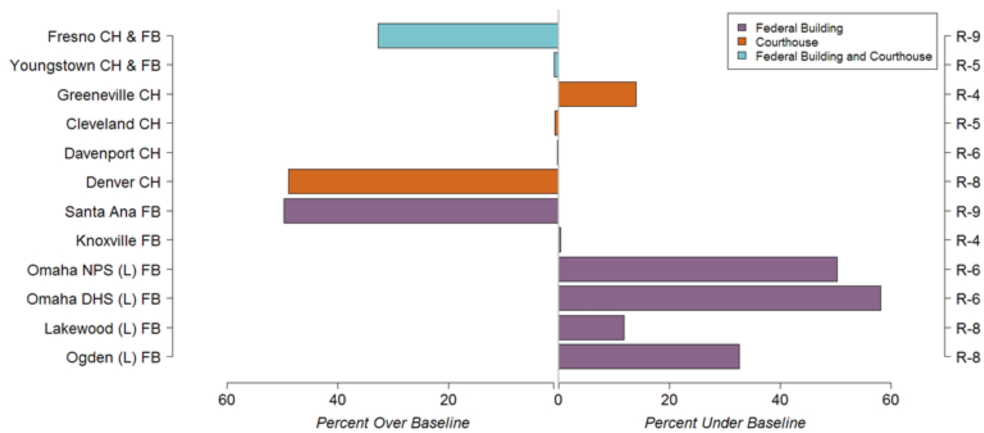

Figure S6. Water use per occupant compared to water baseline

Aggregate Maintenance Costs Do Not Exceed the Baseline Range for Most Buildings

There has been debate as to whether maintenance costs for sustainably designed buildings are higher than traditionally designed buildings. For comparison, the same maintenance costs were compared in the industry baseline and the buildings under this study. Figure S7 shows general maintenance, grounds maintenance, and janitorial costs per rentable square foot. Looking at the trends in these three figures, you can see that several buildings have consistently higher maintenance costs in each category. Similarly, several buildings have consistently lower maintenance costs or costs that fall within the baseline. When combined, average maintenance for these buildings cost 13% less than the average baseline cost.

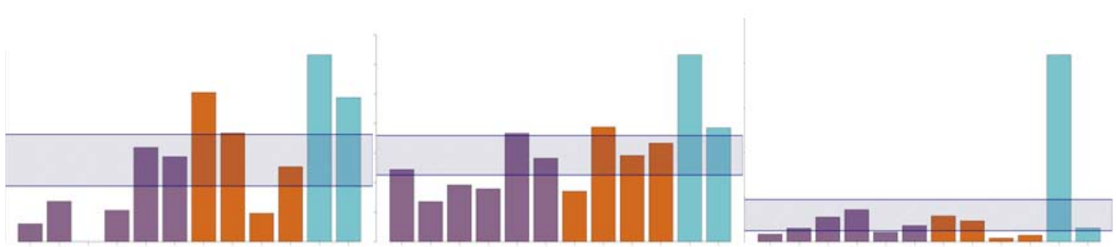

Figure S7. Maintenance costs fall within baseline range for most buildings.

Waste Disposal Cost per Occupant Is Less than Average

Although the collection of waste generation and recycling data was inconsistent, the data show that the waste disposal cost per occupant is less than the industry baseline (Figure S8). However, the ratio of the quantity of waste recycled to the quantity disposed did not offer a clear story.

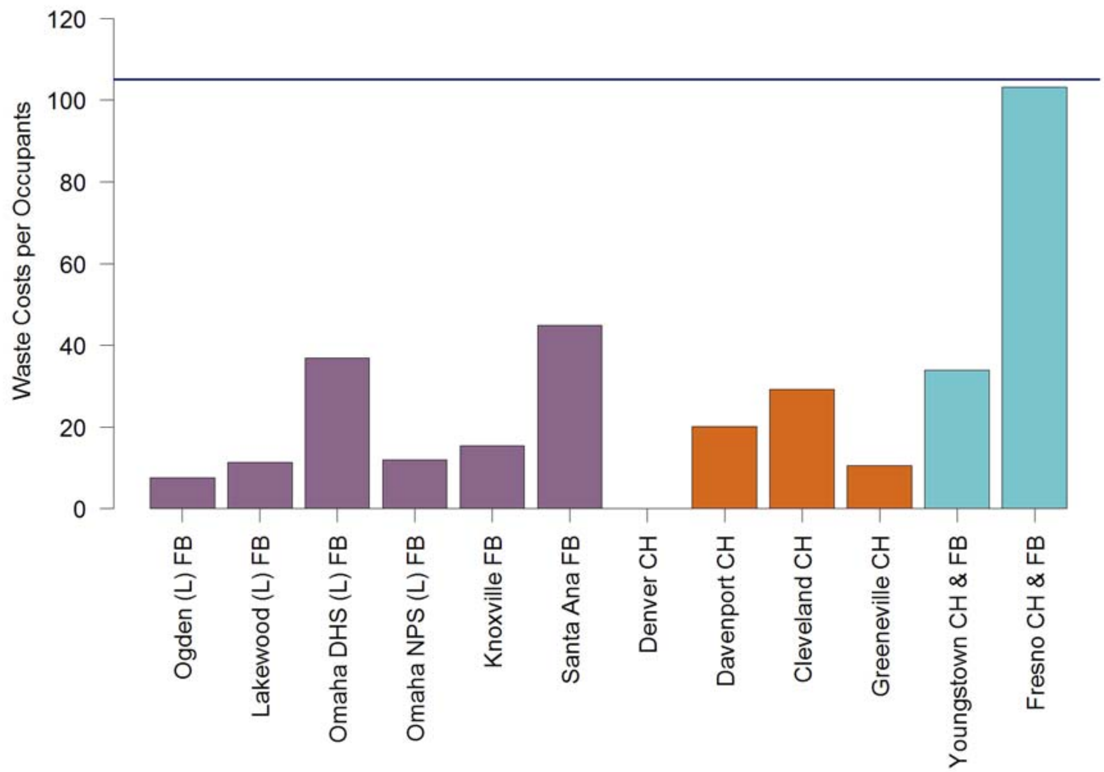

Figure S8. Waste disposal cost per occupant is lower than the industry baseline.

Occupants of GSA's Sustainably Designed Buildings Are Satisfied

All of the GSA buildings in this study scored above the 50th percentile for general building satisfaction based on the Center for the Built Environment (CBE) survey (reformatted by GSA for this study as the Sustainable Places and Organizational Trends [SPOT] survey [Figure S9]). On average these buildings scored 22% better than the CBE 50th percentile.

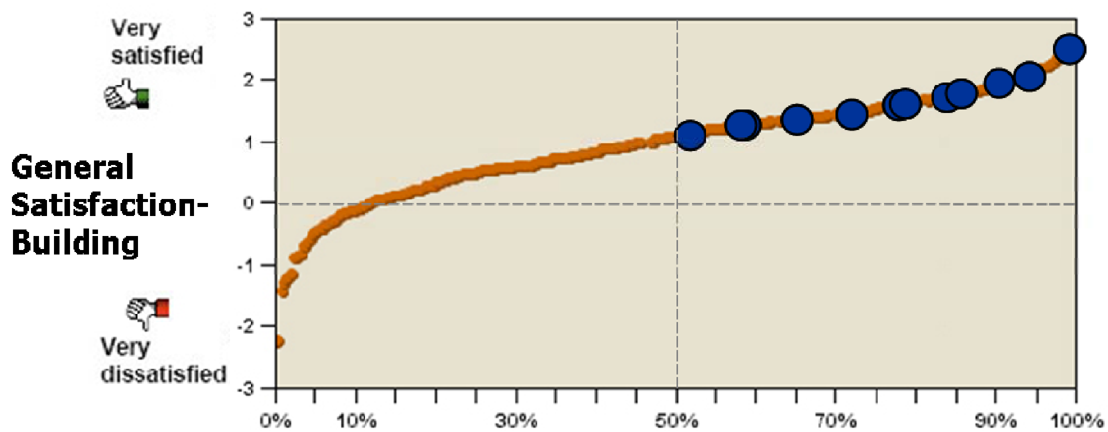

Figure S9. GSA building occupants are satisfied with their buildings overall.

In comparison to all non-LEED buildings in the CBE database, the GSA buildings in this study reported higher than average satisfaction scores in all categories. In comparison to the LEED buildings in the CBE database, the GSA buildings reported higher than average satisfaction scores in all categories except air quality (Figure S10).

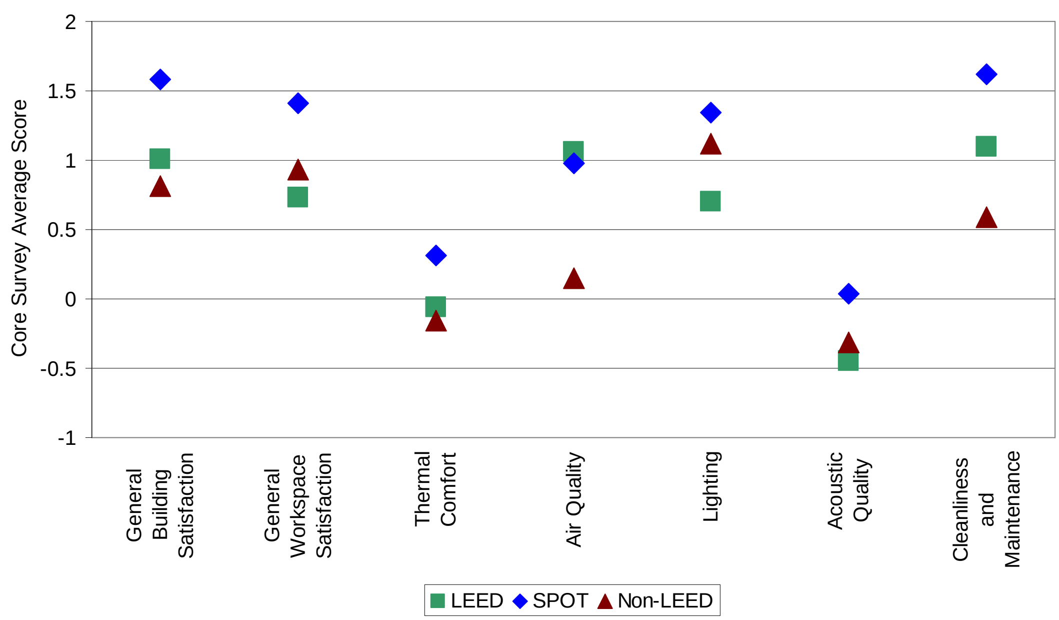

Figure S10. Study building occupants are more satisfied than the LEED and non-LEED building occupants in the CBE database.

Occupants of GSA Sustainably Designed Buildings Contribute Less to Global Climate Change

Based on the occupant commute response to in the CBE/GSA SPOT survey questions developed specifically for this study, the commute distance traveled and emissions from the identified transportation modes result in lower emissions than the average office worker commute (Figure S11). It is unclear whether this is the result of federal agency commute policies or sustainable design features such as preferred parking for carpools and alternative vehicles, showers and bike racks, or locating a building near mass-transit options.

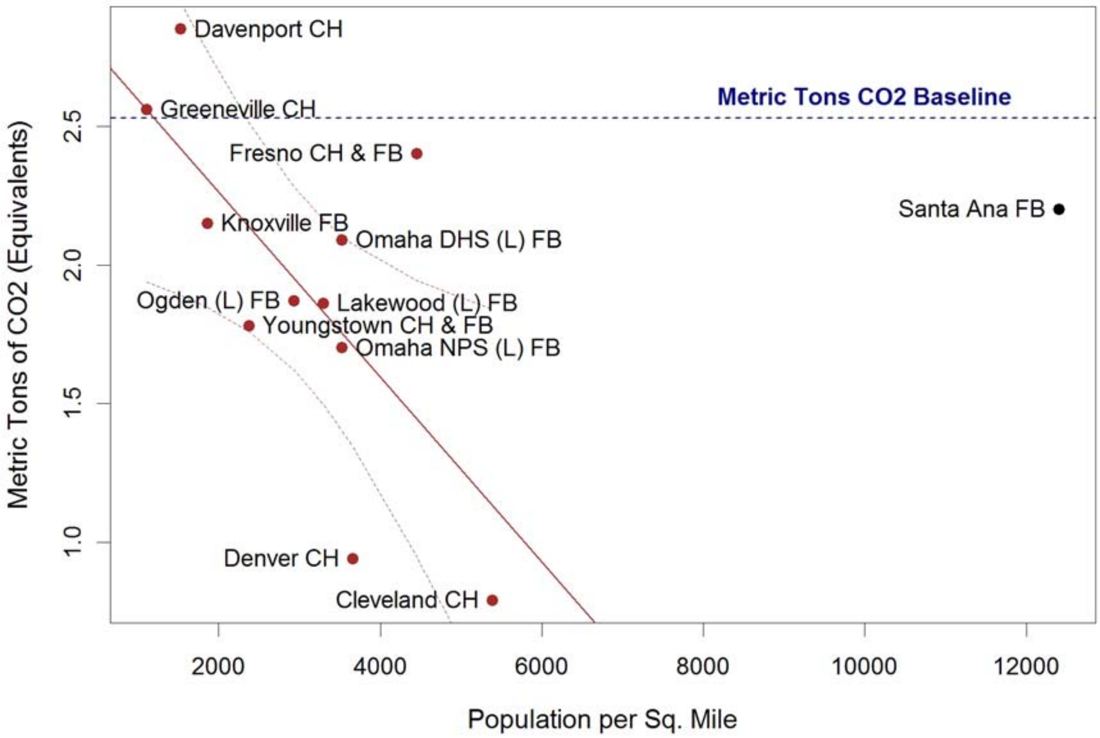

Figure S11. Lower emissions as a result of building occupant commute for most buildings.

Combining the emissions avoided from the occupant commute and the building energy performance shows that each building is significantly below the carbon-dioxide-equivalent emissions baseline (Figures S12).

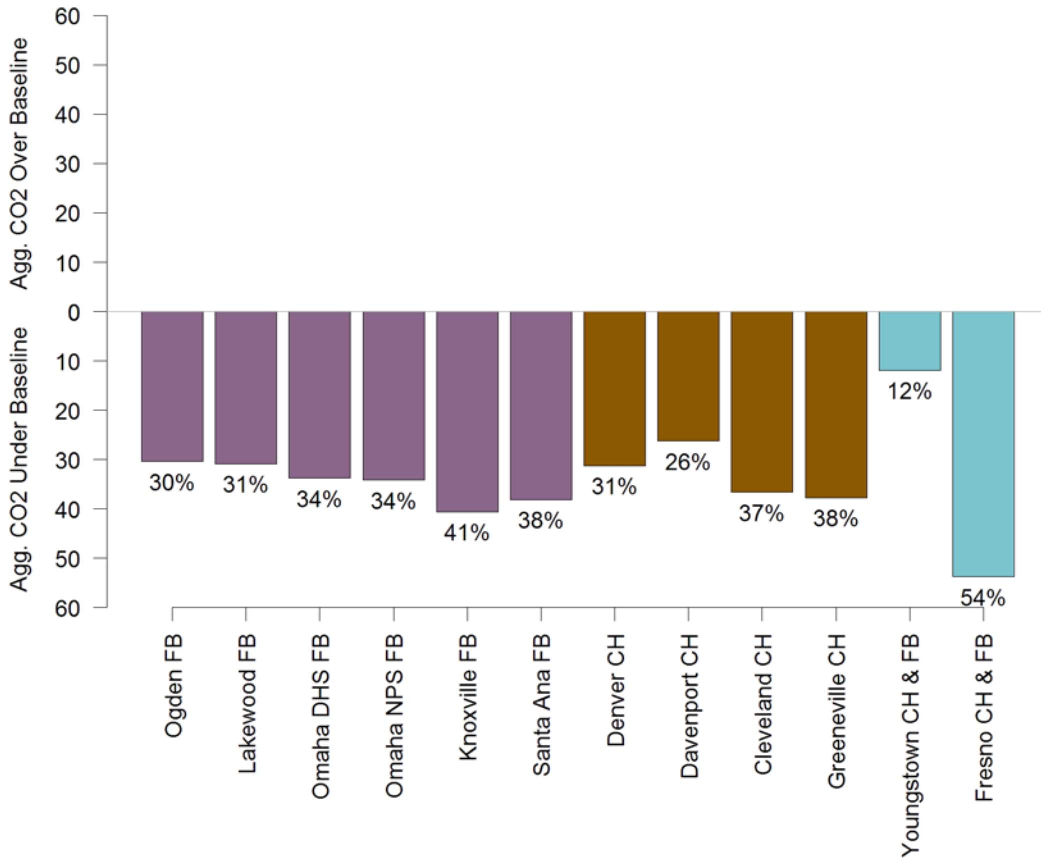

Figure S12. Lower emissions as a result of building energy performance and occupant commute.

LEED Gold Buildings Are Top Performers

All of the buildings in the study show above average performance for multiple metrics. The two LEED Gold buildings in this study performed better than the baselines for all of the key performance metrics. These buildings are the two best performers for water use, using 54% less than the baseline, they have an average Energy Star score of 85.5, have occupant satisfaction levels 34% higher than average and cost 43% less for utilities than the average building (Figure S13).

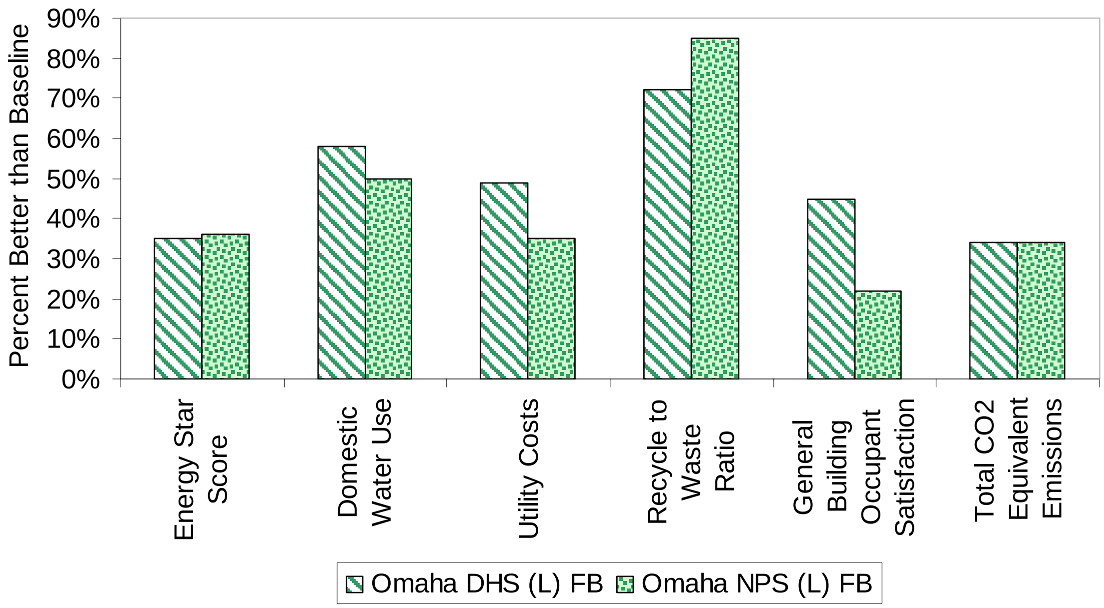

Figure S13. LEED Gold buildings show exceptional performance on all of the key performance metrics.

In summary, this study shows that for these 12 GSA buildings, the aggregate operational costs, the energy performance, and the waste costs are better than those of an average baseline building. Additionally, the building occupants are more satisfied with the buildings than occupants of baseline buildings, and the environmental impact with respect to carbon emissions of the study buildings are less than a baseline building.

Because this study involves a small number of buildings, data on many more buildings are needed before any of the findings can be generalized to a larger population of sustainably designed buildings. Detailed analysis on individual buildings would offer a better understanding as to why each of these buildings is performing as it is.

Acronyms

BOMA	Building Owners and Managers Association International
Btu	British thermal unit
CBE	Center for the Built Environment
CBECS	Commercial Buildings Energy Consumption Survey
CH	courthouse
DHS	Department of Homeland Security
DOE	U.S. Department of Energy
EAc1	Energy and Atmosphere Credit 1 (Optimize Energy Performance)
EUAS	Energy Usage and Analysis System
EUI	energy use intensity
FB	federal building
FEDS	Federal Energy Decision System
FEMP	Federal Energy Management Program
GSA	General Services Administration
gsf or GSF	gross square feet
HVAC	heating, ventilation, and air-conditioning
IEQ	indoor environmental quality
IFMA	International Facility Management Association
INS	Immigration and Naturalization Service
kw	kilowatt
kwh	kilowatt hour
L	leased facilities
LEED	Leadership in Energy and Environmental Design
LEED-EB	LEED for Existing Buildings
LEED-NC	LEED for New Construction and Major Renovations
O&M	operations and maintenance
PIP	Project Information Portal
PNNL	Pacific Northwest National Laboratory
PBS	Public Buildings Service
rsf or RSF	rentable square feet
SPOT	Sustainable Places and Organizational Trends (survey)
WBPM	whole building performance measurement
WEc3	Water Efficiency credit 3 (Water Use Reduction)
WUI	water use intensity

Contents

Figures

Tables

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Introduction

The U.S. General Services Administration (GSA) has been applying sustainable design principles to its building design projects since 1999. In 2003, GSA set its target for certification at the Silver level of the U.S. Green Building Council's (USGBC) Leadership in Energy and Environmental Design for New Construction (LEED®-NC) green building rating system for new building design starts. Now, GSA has chosen to analyze the performance of its sustainably designed buildings to determine the potential added benefits of such buildings.

GSA engaged several key stakeholders, including its own representatives, a research team from Pacific Northwest National Laboratory (PNNL), the University of California Berkeley's Center for the Built Environment (CBE), and site building managers and engineers to measure whole building performance in order to evaluate how well GSA's sustainably designed buildings are performing compared to industry norms. In contrast to LEED-NC, which is focused on design and specifications for new construction projects, "whole building performance measurement" (WBPM) assesses how well sustainably designed buildings are actually operating. Thus, the primary intent of this WBPM study is to demonstrate the impact of investing in sustainably designed buildings, thereby enabling GSA to better document how its sustainably designed buildings are performing compared to traditionally designed buildings. Ideally, the information derived from this study will be used to inform design, construction, and operation of GSA's building portfolio.

USGBC membership developed the LEED® green building rating system to provide a system for defining "green buildings." The rating system is organized by five aspects of building design

- Sustainable Sites
- Water Efficiency
- Energy & Atmosphere
- Materials & Resources, and
- Indoor Environmental Quality.

Points are earned for meeting the intent of specific design criterion in each of the above categories. A LEED rating is awarded based on the total number of points earned by a building design. The LEED ratings are

- Certified (26-32 points)
- Silver (33-38 points)
- Gold (39-51 points)
- Platinum (52-69 points).

LEED ratings can be achieved for new construction and major renovation (LEED-NC), existing buildings (LEED-EB), and several other building products.

Background

GSA buildings are typically built for a 100-year life and follow robust guidelines to enhance their asset value. The federal government owns or leases approximately 725 million square feet of office space and employs 2.7 million workers. GSA houses 1.1 million workers in 342 million square feet of office space (45% of federal government space).[1] Of the more than 1,000 LEED-NC certified projects, 46% are owned by federal, state, or local governments.[2]

It is commonly recognized that a whole building, integrated design approach is essential to creating a sustainable or green building design. This design is assumed to result in optimal building performance based upon the product and equipment specifications. Several studies have documented the projected benefits of sustainably designed buildings[3,4,5,6,7]. Often these studies projected savings based on design intent or measured performance of a single metric, such as occupant productivity. The measured whole building performance of sustainably designed buildings has rarely been documented. To fully measure the operational impact of sustainably designed buildings, multiple occupant and operational measures, more than energy use, need to be considered.

Although energy modeling of a building's performance is a very useful tool during the design process, it does not always accurately predict how a building will perform. Studies have shown that although modeled data can predict average performance, the data do not consistently predict the performance of an individual building[8,9]. This is one reason why more measured performance data are needed to better predict the performance of design strategies.

Some recent studies using measured building performance include the New Buildings Institute study, which focused on energy performance in LEED buildings.[10] This study noted that the energy performance for individual projects is highly variable and more building performance data need to be gathered and analyzed to compare design performance with design intent. It also documented that the energy performance of LEED-NC buildings in their study performed 24% better than the Commercial Buildings Energy Consumption Survey (CBECS) average for all commercial building stock and 33% better than the CBECS average for office buildings.[11]

Scope and Approach

The scope of this study is to evaluate the impact of GSA's sustainably designed buildings by collecting and analyzing actual performance data from operating buildings for comparison to industry baselines for building performance. As study collaborators, the PNNL research team was responsible for data collection, data management, data synthesis, analysis, and report development. The GSA representatives provided building and site contacts, building data derived from existing GSA systems—such as the Energy Usage and Analysis System (EUAS), the Asset Business Plan, and Project Information Portal (PIP)—and coordinated the completion of the study's version of the CBE survey to assess occupants' satisfaction with their buildings (also known as GSA's Sustainable Places and Organizational Trends [SPOT] survey). The CBE team was responsible for preparing, distributing, and summarizing the data from the SPOT building occupant satisfaction survey. The building managers and engineers hosted the site visit(s), provided data as requested, and deployed the SPOT survey. The quantity and quality of data were enhanced by the engagement of multiple stakeholders.

The selection criteria for the buildings in the study included the following

- Buildings built or remodeled since 2000 that included sustainable design or energy efficiency as a key design consideration.
- Ability to collect a minimum of 12 months of data, at least 6 months after the building occupancy date.
- Data availability for the key performance metrics and occupants' willingness to participate in the SPOT survey.
- Comparability considerations, which included
  - selecting common GSA building types – office, courthouse, and port of entry
  - co-location of buildings by region
  - building ownership – leased or owned.

Using the above criteria helped to narrow the GSA portfolio of buildings to a list of 18 buildings. The list was reduced to 14 buildings based on occupants' willingness to participate in the SPOT survey and the availability of data. (Site summaries for each building can be found in Appendix A.) Of the 14 buildings that were investigated under this study, data from 12 buildings were used for the analysis. Of the 14 buildings in this study

- two are port-of-entry facilities
- four are courthouses
- six are federal buildings
- two are courthouses and federal buildings

For the remainder of the report, the buildings are organized by building type (Table 1). Federal buildings (FB) are typical office buildings for the most part and are designated by the color purple. Courthouses (CH), designated by the color orange, include bankruptcy and criminal courtrooms and related offices. The combined courthouse and federal building (CH & FB) type includes significant courtroom space and equally significant typical office space. The CH & FBs are designated by the color blue. Four of the buildings are leased facilities, and the rest are GSA-owned. Port-of-Entry facilities are a unique building type. Initial analysis of the Port of Entry data demonstrated that none of the commonly used baselines for office buildings would apply to Ports-of-Entry. Therefore, the two Port-of-Entry buildings were removed from the analysis in the main body of this report and the information collected can be found in Appendix B.

Table 1. GSA buildings studied

Region	Building Full Name	Abbreviation
Federal Buildings		
8	Scowcroft Internal Revenue Service Building	**Ogden (L) FB**
8	Department of Transportation Office Building	**Lakewood (L) FB**
6	Department of Homeland Security/INS	**Omaha DHS (L) FB**
6	Carl T. Curtis Midwest Regional Headquarters of the National Park Service	**Omaha NPS (L) FB**
4	John J. Duncan Federal Building	**Duncan FB**
9	Santa Ana Federal Building	**Santa Ana FB**
Courthouse		
8	Alfred A. Arraj United States Courthouse	**Denver CH**
6	Davenport United States Courthouse	**Davenport CH**
5	Howard M. Metzenbaum United States Courthouse	**Cleveland CH**
4	James H. Quillen United States Courthouse	**Greeneville CH**
Courthouse and Federal Building		
5	Frank J. Battisti and Nathaniel R. Jones Federal Building and United States Courthouse	**Youngstown CH & FB**
9	Robert E. Coyle United States Courthouse and Federal Building	**Fresno CH & FB**
Port of Entry		
5	Port of Entry, Sault Sainte Marie, MI	Sault Ste. Marie Port
8	Shared Port-of-Entry, Sweetgrass, MT; Coutts, AB	Sweetgrass Port

The buildings were located in five different GSA regions (Figure 1)

- two in the Southeast Region 4
- three in the Great Lakes Region 5
- three in the Heartland Region 6
- four in the Rocky Mountain Region 8
- two in the Pacific Region 9.

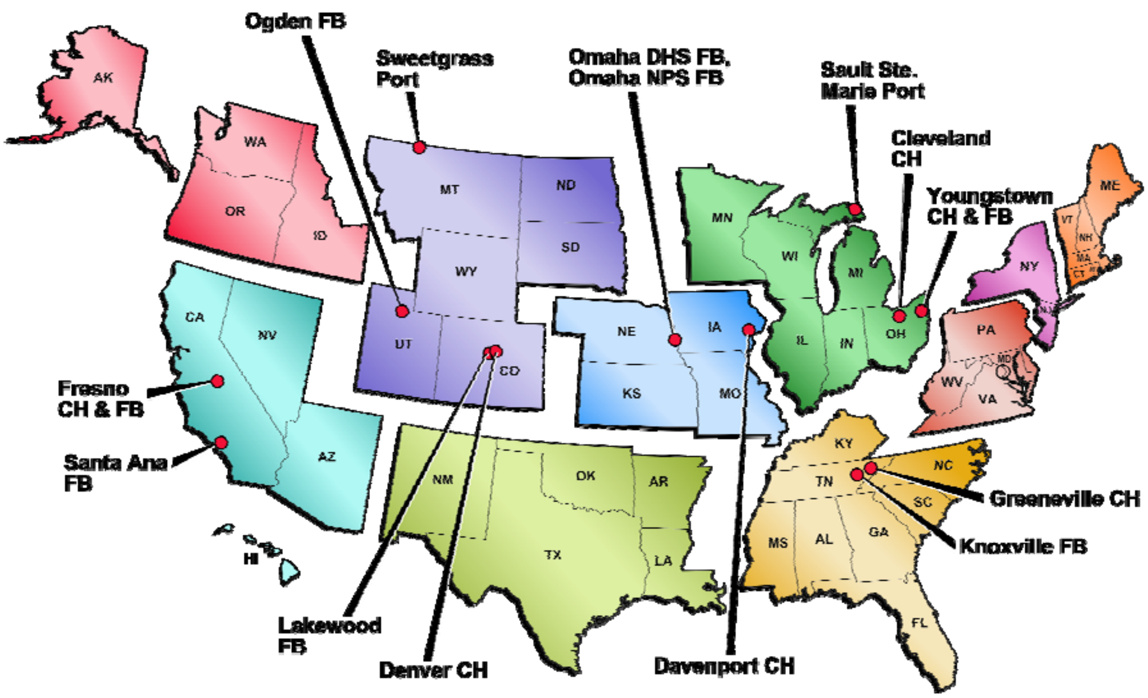
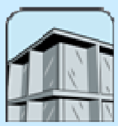


Figure 1. Study buildings by region

Seven of the buildings are U.S. Green Building Council LEED-certified buildings, one is LEED registered, one used Green Building Challenge but has a LEED-equivalent score for this report, and three buildings emphasized energy efficiency during design. It is assumed GSA design expectations have resulted in a number of undocumented sustainably designed buildings. As of the summer of 2007, the GSA had 19 LEED-certified buildings.[12] For the current GSA building stock, LEED offers the most consistent way to track sustainably designed buildings within the agency.

The PNNL research team collected building and site characteristics data (Table 2) to be able to normalize the building performance metrics in order to report on key building performance indicators. For example, gross interior floor area (gsf) is the total building square footage value used to estimate costs per square foot, energy use per square foot, and more. The Department of Energy (DOE) Federal Energy Management Program (FEMP) *Building Cost and Performance Metrics: Data Collection Protocol*[13] was the tool used to identify, normalize, and analyze the performance data collected for each building.

Table 2. Building and site characteristics metrics

Building Specifications 	Building Location *address, city, state, zip code*
	Building Function *Federal building, courthouse, port of entry*
	Key Building Features *LEED checklist and design highlights*
	Building Occupancy Date *Year*
	Gross Interior Floor Area (gsf) ft^2
	Rentable Floor Area (rsf) ft^2
Occupancy 	Hours of Operation $\frac{hours}{week}$
	Total Number of Regular Occupants and Visitors $\frac{occupants}{work\ day}$ $\frac{visitors}{work\ day}$
	Occupant Gender Ratio *Number of female & male occupants*
First Costs 	Total Building Cost *Design and Construction Cost* $\frac{\$}{ft^2}$

For each of the buildings, data were collected and analyzed for the key performance metrics provided in Table 3. The PNNL research team collected a minimum of 12 consecutive months of data and documented an industry baseline for each metric. Site and building contacts provided utility bills, maintenance budgets and schedules, and supported the distribution of the occupant satisfaction survey.

Table 3. Whole building performance metrics

Water 	Total Building Potable Water Use $\frac{gal}{year}$ $\frac{\$}{year}$
	Indoor Potable, Outdoor, and Process Water Use $\frac{gal}{year}$ $\frac{\$}{year}$
Energy 	Total Building Energy Use $\frac{Btu}{year}$ $\frac{\$}{year}$
Maintenance & Operations 	Building & Grounds Maintenance $\frac{Service\ Calls}{year}$ $\frac{Preventative\ Maintenance}{year}$ $\frac{\$}{year}$
Waste Generation & Recycling 	Solid Sanitary Waste $\frac{ton}{year}$ $\frac{\$}{year}$
	Recycled Materials $\frac{ton}{year}$ $\frac{\$}{year}$
Occupant Satisfaction 	Building Occupant Self-Reported Satisfaction and Productivity $\frac{Occupant\ Rating}{Survey\ Metric}$
Transportation 	Regular Commute (from survey data) $\frac{miles}{gallon}$ $\frac{miles}{week}$

Report Contents and Organization

The analysis results for each of the key performance metrics addressed under this study are provided in the Summary Analysis section of this report. The values used for comparison include the following

- water use per occupant
- water cost per rentable square foot
- Energy Star rating
- energy cost per gross square foot
- ratio of preventative maintenance to service calls
- general, grounds, and janitorial maintenance cost per rentable square foot
- ratio of quantity recycled to solid waste generation
- waste and recycling cost per occupant
- occupant satisfaction scores
- miles traveled and vehicle emissions per occupant.

General observations from the study are provided in the Conclusion section. Site-specific observations are provided in the site summaries in Appendix A. The two Port-of-Entry buildings that were removed from the analysis in the main body of text are described in Appendix B. A description of how the water baseline was developed is provided in Appendix C. The units used for the reporting metrics and how they connect to the performance metrics can be found in Appendix D. Sample occupant satisfaction survey questions can be found in Appendix E. Appendix F, G, and H contain the conversion factors, site contacts, and references respectively.

Summary Analysis: What We See

This section is organized by metric type. First, the key building and site characteristics are provided as a reference for the analysis. Next, the building performance data are analyzed for each performance metric, with the information provided in the following order

- water
- energy
- maintenance and operations
- waste generation and recycling
- occupant satisfaction
- transportation.

The discussion for each metric includes performance data, costs, and operational, occupant, or environmental impact, as available. At the end of each metric discussion, the two LEED Gold buildings', Omaha DHS FB and Omaha NPS FB, results are highlighted.

The data represented in this section were provided by GSA representatives, site contacts, and CBE. It is important to note that data for each metric were not available for the exact same timeframe for each building. The general date range is April 2005 through March 2007, but in some cases data are as recent as November 2007. In most cases data are only available for 12 consecutive months, which offers only a snapshot in time of building performance. In some cases we had multiple years of data. Multiple years of data were used when trends were being investigated, but otherwise 1 year of data was used to be consistent across the building analysis. Future analysis would benefit from multiple years of data for each metric in order to be able to average the data and investigate potential trends.

The building and site characteristics data collected for each building are used to normalize the performance metrics (Table 4). The gross square footage (gsf) and rentable square footage (rsf) are the primary building geometry characteristics used for normalizing the performance metrics. The building geometry metrics are needed as part of the water, energy, and maintenance and operations metrics. The number of regular building occupants (Occ) and visitor (Vis) estimates are needed as part of the water, energy, waste and recycling, and transportation metrics.

Table 4. Key building and site characteristics

Building Name	Region	Year Occupied	GSF	RSF	# Occ	Occ-Vis Equiv	Hours/ week	# Comps
Ogden (L) FB	8	2004	105,000	102,579	514	521	120	745
Lakewood (L) FB	8	2004	128,342	122,225	318	336	70	383
Omaha DHS (L) FB	6	2005	86,000	73,459	65	360	112	80
Omaha NPS (L) FB	6	2004	68,000	62,772	125	134	70	140
Knoxville FB	4	2005	172,684	120,171	285	310	65	285
Santa Ana FB	9	2005	280,365	205,378	409	459	70	424
Denver CH	8	2002	327,103	256,718	170	370	65	185
Davenport CH	6	2005	79,872	68,391	45	63	70	60
Cleveland CH	5	2005	251,314	185,105	105	143	60	120
Greeneville CH	4	2001	160,975	136,104	85	103	70	100
Youngstown CH & FB	5	2002	52,240	44,476	45	243	60	60
Fresno CH & FB	9	2005	495914	393243	235	510	68	250

In addition to the building and site characteristics, the research team also captured the following information about the buildings that was of general interest (Table 5)

- Four of the buildings are leased, eight are GSA-owned.
- Five of the buildings had major renovations, seven are new construction.
- Half of the buildings are 4 stories tall or fewer.
- Three of the buildings have GSA personnel co-located with the occupants.
- Four buildings have underfloor air distribution systems.
- Four buildings purchase central steam.
- Three buildings purchase central chilled water.

Table 5. Additional building and site characteristics

Building Name	Owned or Leased	Renovation	# of Stories	GSA Personnel On Site	Underfloor Air HVAC Distribution	Purchased Steam	Purchased Chilled Water
Ogden (L) FB	Leased	**Yes**	5	No	**Yes**	No	No
Lakewood (L) FB	Leased	No	3	No	No	No	No
Omaha DHS (L) FB	Leased	No	1	No	No	No	No
Omaha NPS (L) FB	Leased	No	3	No	**Yes**	No	No
Knoxville FB	Owned	**Yes**	8	No	No	No	No
Santa Ana FB	Owned	**Yes**	10	No	No	**Yes**	**Yes**
Denver CH	Owned	No	13	No	**Yes -Partial**	**Yes**	**Yes**
Davenport CH	Owned	**Yes**	4	**Yes**	No	No	No
Cleveland CH	Owned	**Yes**	6	**Yes**	No	**Yes**	**Yes**
Greeneville CH	Owned	No	4	No	No	No	No
Youngstown CH & FB	Owned	No	4	No	No	**Yes**	No
Fresno CH & FB	Owned	No	11	**Yes**	**Yes -Partial**	No	No

The assumption that these items of general interest would offer observable trends did not materialize. Future studies will continue to collect data on these general interest items to see if more data points offer additional information.

Water

Many communities periodically experience droughts and some are in the situation of an ever decreasing availability of potable water. Commercial buildings use 12% of potable water in the U.S.[14] Tracking water use offers opportunities for identifying possible strategies for water use reduction. In addition to the resource management benefits, there is a monetary incentive to track and decrease water consumption.

The water metric used for comparing domestic water use (i.e., toilets, urinals, and faucets) to the industry baseline is indoor potable water in gallons per year. The potable water use data for some buildings included a combination of domestic water use, landscape water use, and/or process water use. The metric determined the most representative of domestic potable water use was the DOE FEMP water use indices, which provides guidance for the calculation of water use values per building occupant. Eight of the buildings in the study have water data that included process and/or landscape water use that needed to be excluded from the water use values in order for the buildings to be fairly compared to the baseline. The buildings that required estimation of outdoor potable water use and/or process potable water include

- Ogden (L) FB
- Lakewood (L) FB
- Omaha DHS (L) FB
- Knoxville FB
- Denver CH
- Davenport CH
- Greenville CH
- Fresno CH & FB

> Domestic water consumption depends on human operation and fixed equipment efficiency. Therefore, typical indoor water consumption is best expressed as per occupant. For water use comparisons to the baseline, water use intensity (WUI) is defined as gallons per occupant per year.

Details on how water use was estimated can be found in Appendix C. In general the PNNL research team estimated the annual domestic water use for those buildings based on a review of monthly water use to identify a base water load.

The water baseline for each building is unique to the building based on occupancy. Water use is normalized to number of building occupants. The ratio of female-to-male occupants and the number and type of visitors provides additional detail for understanding water use. For the water analysis, a visitor-occupant equivalent was developed (calculation details are in Appendix C).

Given the estimated domestic water use, half of the buildings are using less domestic water than the calculated baseline. Of the three buildings using significantly more than the water baseline, two focused on energy performance during design, rather than sustainable design, and the third has evaporative cooling and an irrigated park area that may be impacting the water base load. When landscape and process water uses are included, the buildings use significantly more water.

The top diagram in Figure 2 offers a detailed representation of only the calculated baseline for domestic water. Domestic water use per occupant type and water cost per occupant type are also shown (in the second and third diagrams) to provide water use perspective outside of the baseline assumptions. Although on average the top third of the buildings in the study are performing 39% better than their baselines, all the buildings in the study averaged only 3% better than baseline performance expectations.

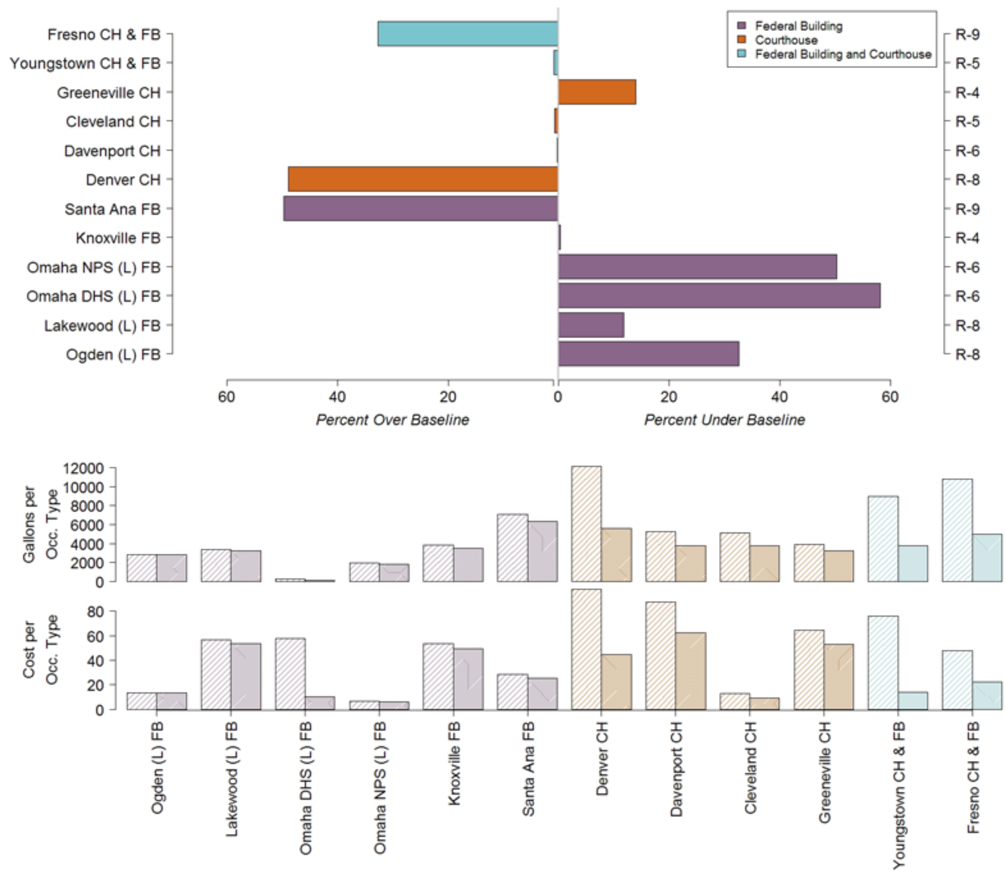


Figure 2. Water use per occupant compared to the water use baseline

The research team investigated why the domestic water use was not "better than the baseline." Although some speculation about the water use could be made, a detailed investigation into the water use for each building would be needed to establish, with any confidence, an accurate understanding of water use. Based on the information the PNNL research team has, the speculation regarding higher than baseline water use includes the following

- Estimates for domestic water use base load are not accurate, and/or not compatible with the baselines.
- Occupant and/or visitor use is higher than average or the estimate of visitors is not reflective of domestic water use, thus impacting the baseline.
- Maintenance and operations challenges, such as leaks or clogging, are impacting the water use.
- Lower cost of water is a disincentive to minimize use.

In some cases, this may be an outcome of operational changes in the building. For example, the Ogden FB was designed to be operated during normal business hours, but is being operated 22 hours, six days a week to accommodate shift work. Some building maintenance records indicated regular lavatory issues. Those records were not provided in a uniform format for each building, so the research team cannot definitively indicate maintenance as a reason for high water use. Without separately metered domestic water use, the inferences are speculative. Additional investigation into the design strategies and building operations offers additional information on why the domestic water use appears to be higher than the water baseline for some buildings.

LEED® Water Efficiency credit 3, Water Use Reduction, is achieved by reducing potable water use by 20% or more than a baseline design. Two WEc3 points can be achieved if potable water is reduced by 30%. An Innovation in Design point can be achieved for exemplary performance of potable water use reduction greater than 40%.

Table 6 shows the number of LEED points received for water efficiency credits. Half of the buildings pursued indoor water use reduction strategies (WEc3). Eight of the twelve buildings, all that had LEED documentation, attempted some water use reduction with either efficient landscape or innovation wastewater technologies. One of the buildings received an Innovation in Design credit for exemplary performance in water efficiency and thus has 3 credits listed.

Table 6. LEED Water Efficiency credits pursued

	LEED® Water Points		
Building Name	Efficient Landscaping WEc1	Innovative Wastewater Technologies WEc2	Water Use Reduction WEc3
Ogden (L) FB	1	0	1
Lakewood (L) FB	1	0	0
Omaha DHS (L) FB	0	1	3
Omaha NPS (L) FB	2	0	2
Knoxville FB	0	0	2
Santa Ana FB	-	-	-
Denver CH	0	0	1
Davenport CH	n/a	n/a	n/a
Cleveland CH	2	0	2
Greeneville CH	-	-	-
Youngstown CH & FB	2	0	0
Fresno CH & FB	-	-	-

For the buildings in this study, there is a 48% correlation between water use and the overall LEED score (Figure 3). When looking at the Water Efficiency credit 3 (WEc3; Figure 4) there is no significant correlation (16%) when the LEED buildings are considered. If all of the buildings in the study are included, the correlation jumps to 28%.

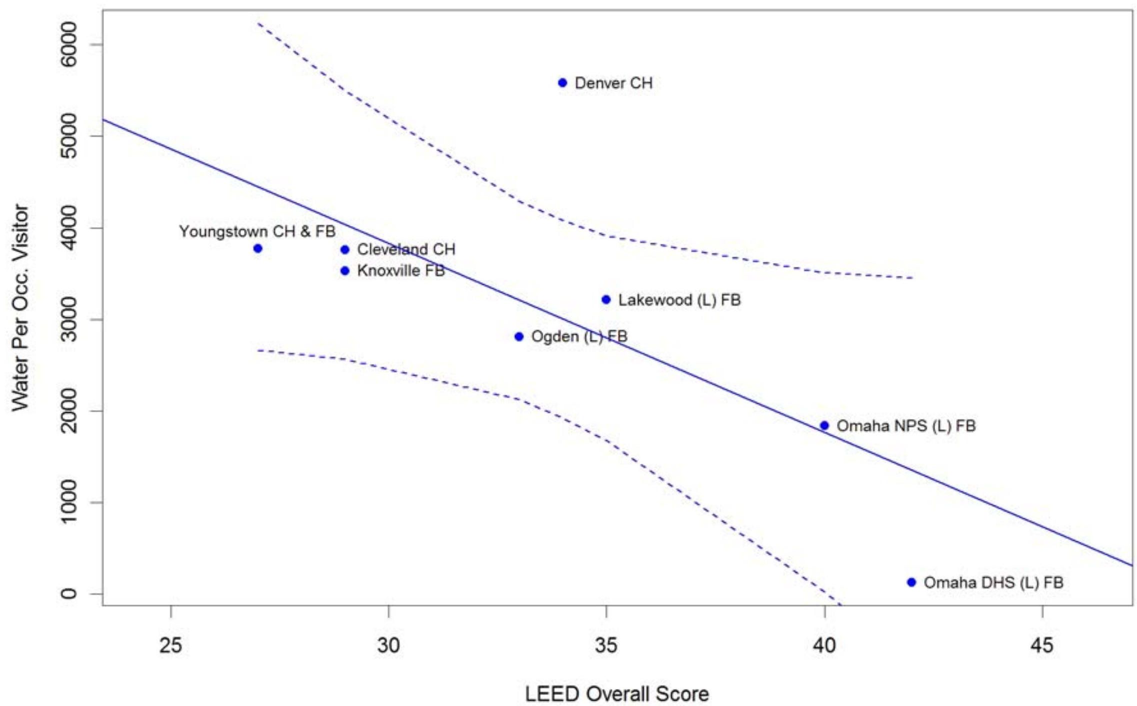


Figure 3. LEED overall score and water usage

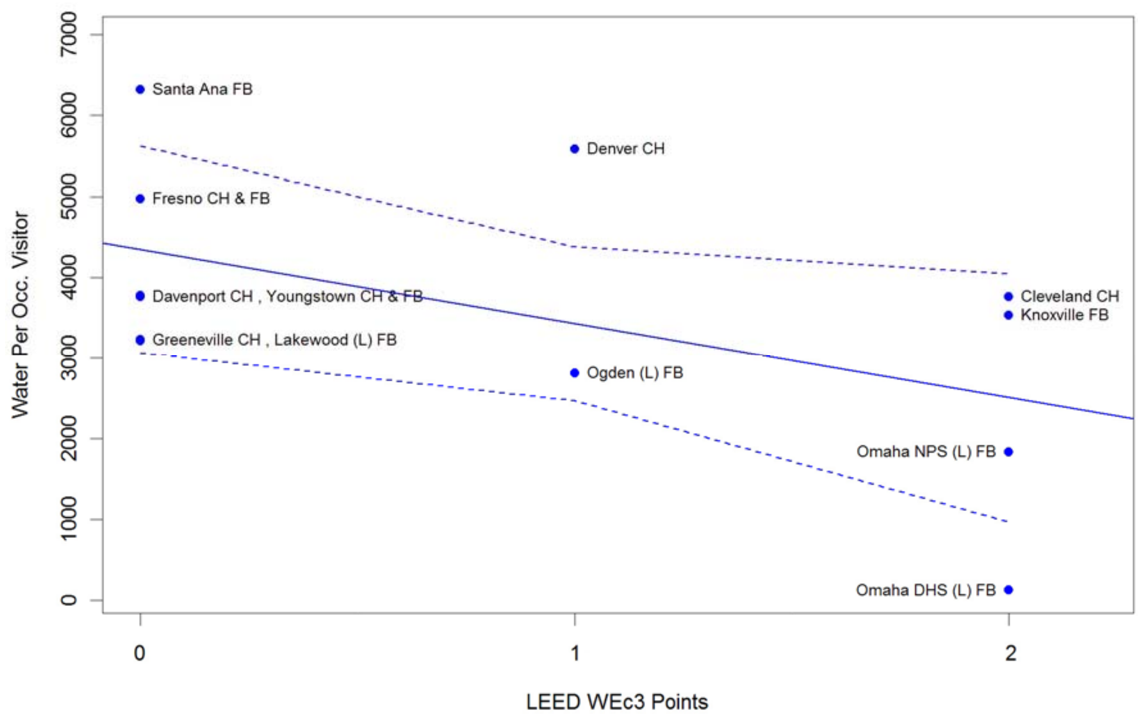


Figure 4. LEED WEc3 points and water usage

For Figure 5, the units are water cost per rentable square foot (rsf) rather than by occupant. The baseline value for the water cost per gross square foot is based on office building values from the International Facility Management Association (IFMA) and Building Owners and Managers Association (BOMA) International[15,16,17]. None of the buildings in this study has annual water cost per gross square foot higher than the baseline range. Four buildings were within the range and the remainder cost less than the baseline range. The four buildings within the range and the two closest to the bottom of the range have process and/or irrigation water costs included.

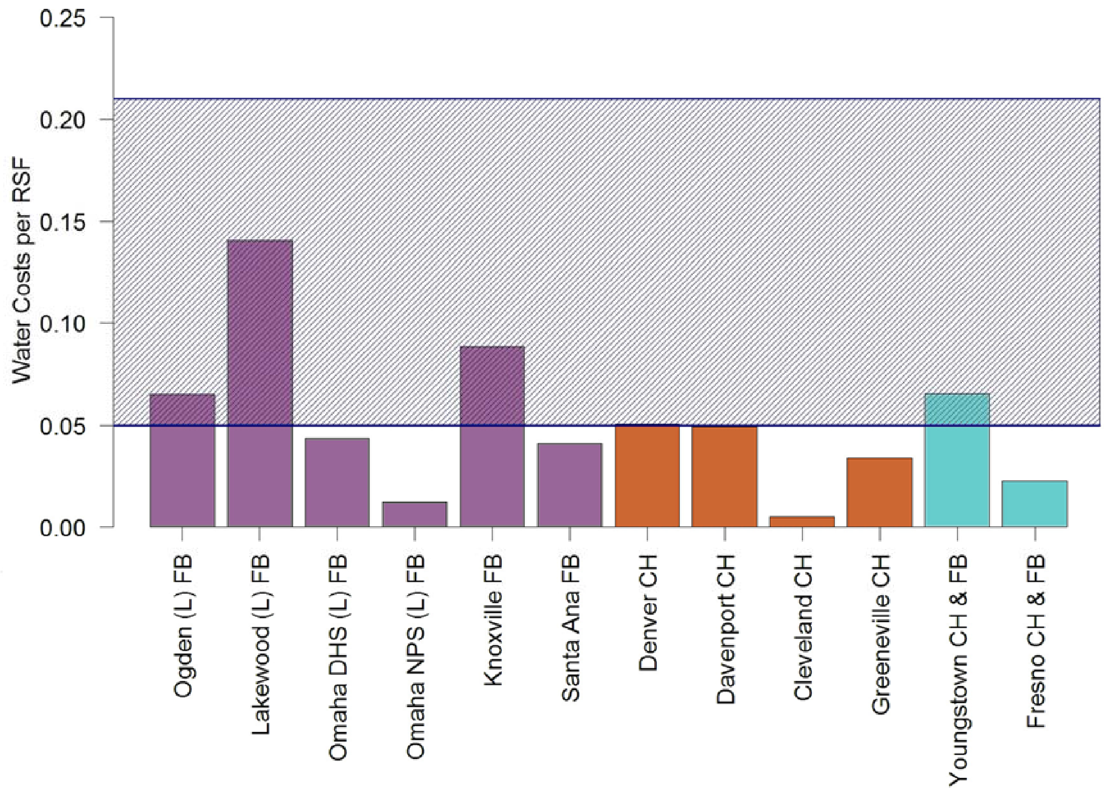


Figure 5. Water cost per rentable square foot compared to industry baseline

Another frequently used metric is total water use per gross square foot. For the buildings that have evaporative cooling, cooling towers, and/or irrigation potable water use, this metric provides an opportunity to compare total building water use to an industry baseline and agency expectations. This metric does not address the water use of a densely occupied building, as it ignores the number of building occupants in a building. At the same time it is easier to collect consistently because daily occupancy variation does not need to be considered. IFMA[18] offers an average water use per gross square foot as 19.1 gallons for office and headquarters building types. GSA has developed a water baseline and water reduction goals to meet the requirements in Executive Order 13423.

Figure 6 shows that most of the GSA buildings in this study use less water than the industry baseline. The two buildings above the industry baseline have the two highest occupancy densities of the buildings in the study, which, as mentioned previously, impacts water use.

The building with the lowest water use per gross square foot has the lowest occupancy density. Approximately one-third of the buildings are already below the GSA 2007 baseline and the GSA 2015 water reduction goal.

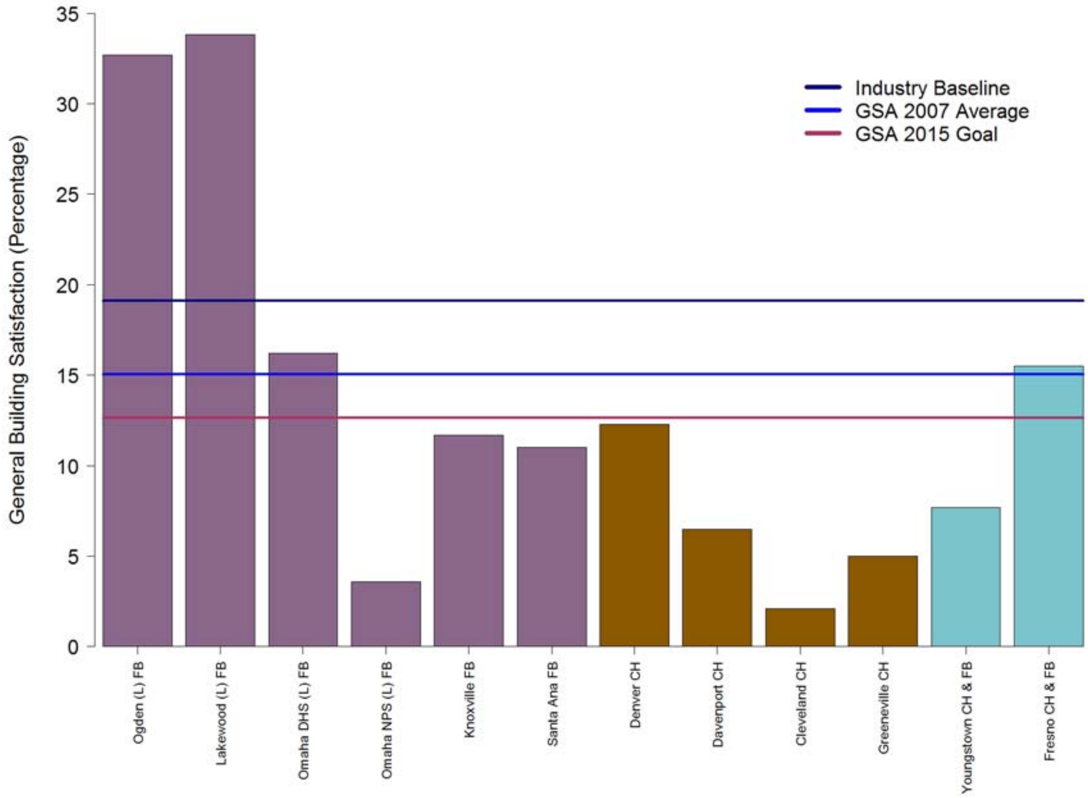


Figure 6. Water use per gross square foot

When considering domestic water use, the LEED Gold buildings in this study performed the best. Both of the LEED Gold buildings emphasized water use reduction in their design and on average they used 54% less than the water use per occupant baseline. Additionally, both buildings had a lower water cost per rentable square foot and were below the industry baseline for water use per gross square foot. One of the LEED Gold buildings is using more water than the GSA 2007 baseline and the GSA 2015 goal, but the non-domestic water use for that building is likely to decrease because the rainwater capture system is functioning and will reduce irrigation water needs.

Overall the water use will not offer a valid comparison to the industry baseline without the irrigation and process water use separately metered. For the cost of water use per rentable square foot it appears, even with the additional water costs, the buildings are fitting within the typical water cost for office buildings. Further analysis of how the total building water use relates to energy use is discussed in the energy and the observations sections.

Energy

Commercial buildings in the U.S. consume about 18% of the total energy.[19] Energy costs tend to be the largest utility cost for a building and with the current emphasis on global climate change there is an even greater interest to reduce energy use and modify energy sources in order to reduce the building's environmental impact.

The buildings in this study were selected because they were sustainably-designed or they were designed with energy efficiency as a goal. Table 7 shows that nine buildings documented the sustainable design aspects of their building while the remaining three had a heavy emphasis on energy efficiency. All but one of the buildings achieved an Energy Star rating of 75 or greater, which qualifies a building for an Energy Star certification. The remaining building still scored above the 50th percentile, and although it was LEED-certified, it did not earn any "Optimize Energy Performance" points.

> Energy Star® Portfolio Manager is a benchmarking tool that ranks the annual energy use of a building compared to average commercial buildings data. Each building receives a score between zero and 100. Buildings with scores above 50 can be considered better than average. Buildings with scores above 75 can receive an Energy Star Buildings Label that recognizes the building as performing in the top 25% of nationwide energy performance.

Table 7. "Green" design certification by building

Building Name	Certification Level	LEED® Total Points	LEED® EAc1 Points	Energy Star® Score
Ogden (L) FB	LEED-NC Silver	33	5	79
Lakewood (L) FB	LEED-NC Silver	35	4	80
Omaha DHS (L) FB	LEED-NC Gold	42	10	85
Omaha NPS (L) FB	LEED-NC Gold	40	3	86
Knoxville FB	LEED-EB Silver, Energy Star	29	8	91
Santa Ana FB	California Energy Standard Title 24	-	-	92
Denver CH	Green Building Challenge -- Score: 2.0	34	2	77
Davenport CH	LEED Registered	n/a	n/a	78
Cleveland CH	LEED-NC Certified	29	3	82
Greeneville CH	Energy Star 2007	-	-	87
Youngstown CH & FB	LEED-NC Certified	27	0	58
Fresno CH & FB	California Energy Standard Title 24	-	-	92

The research team chose Energy Star as the primary mechanism for comparison because it offers an easy to understand performance compared to similar building types and geographic locations. Other mechanisms for comparison include a national and regional CBECS and national GSA averages, as well as average costs from BOMA and IFMA.

The unofficial Energy Star scores for each building were calculated using the following data from each site

- building type
- building location
- 12 to 24 months of energy use data
- number of occupants
- occupancy hours
- number of computers.

In California, compliance is mandatory with Title 24, Part 6, of the California Code of Regulations: California's Energy Efficiency Standards for Residential and Nonresidential Buildings.

DOE's Building Energy Codes Program deems Title 24 more stringent than the ASHRAE 90.1-2004.

LEED® Energy and Atmosphere credit 1, Optimize Energy Performance, allows for up to 10 points for reducing energy consumption by 42% or more.

In addition to the LEED Optimize Energy Performance credits, key energy management credits are documented in Table 8. Note that the Youngstown FB & CH has zero energy credits.

Table 8. LEED Energy and Atmosphere Credits pursued

	LEED® Energy Points			
Building Name	**Optimize Energy Performance EAc1**	**Additional Commissioning EAc3**	**Measurement & Verification EAc5**	**Green Power EAc6**
Ogden (L) FB	5	0	1	1
Lakewood (L) FB	4	1	1	1
Omaha DHS (L) FB	10	0	1	1
Omaha NPS (L) FB	3	1	1	1
Knoxville FB	8	n/a	n/a	n/a
Santa Ana FB	-	-	-	-
Denver CH	2	0	1	1
Davenport CH	n/a	n/a	n/a	n/a
Cleveland CH	3	0	0	0
Greeneville CH	-	-	-	-
Youngstown CH & FB	0	0	0	0
Fresno CH & FB	-	-	-	-

The next two figures display the correlation between the Energy Star rating to the total number of LEED points and to the LEED Optimize Energy Performance points. LEED-certified buildings are now required to achieve a minimum of two Optimize Energy Performance points[20], thus Youngstown would not have received certification under the current system.

Figure 7 shows that 20% of the change in the Energy Star rating can be correlated to the change in the overall LEED score.

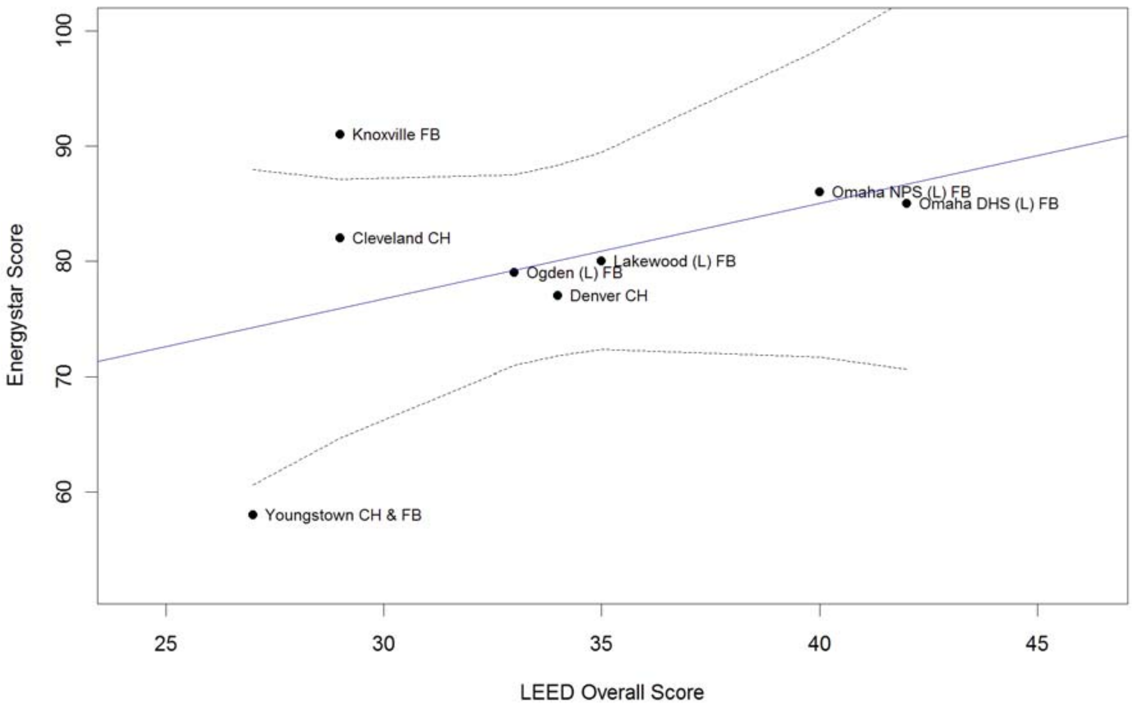


Figure 7. Correlation between Energy Star rating and total LEED credits

The trend line in Figure 8 shows that 50% of the change in then Energy Star rating can be correlated to the change in the LEED Optimize Energy Performance points. The correlation between the total LEED Energy and Atmosphere points and the Energy Star rating is very similar to Figure 8 and thus is not shown separately.

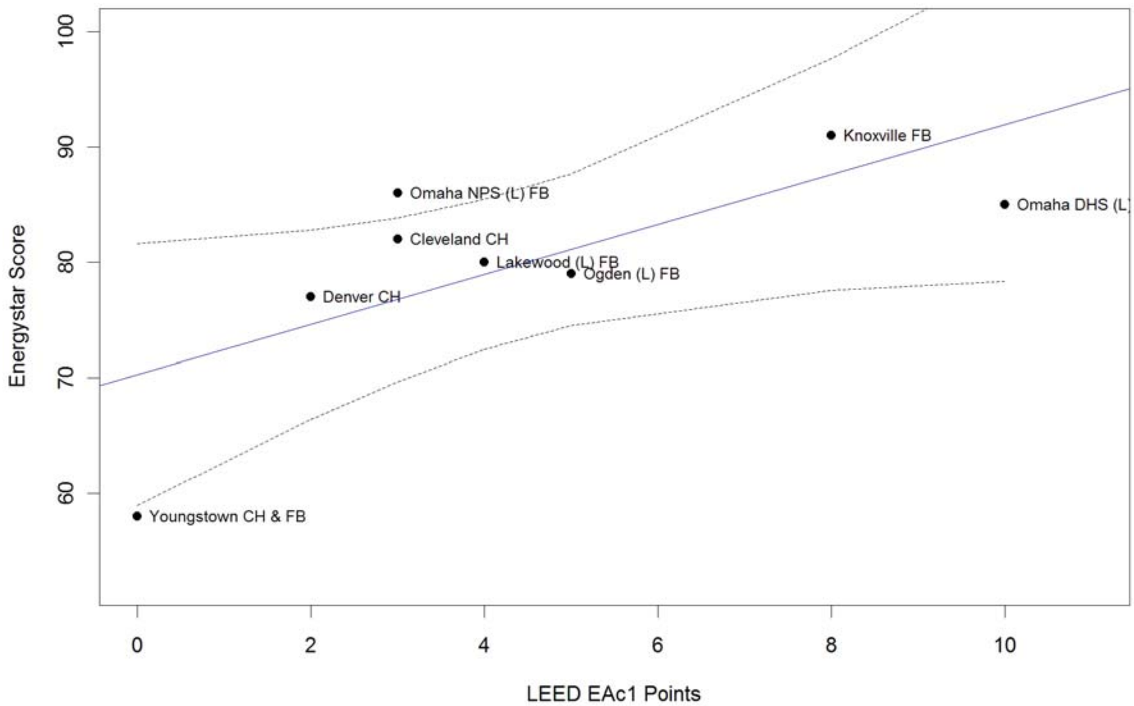


Figure 8. Correlation between Energy Star rating and LEED energy credits

Although the Energy Star rating is a useful baseline for comparison, there are other commonly used references for comparison that provide useful benchmarks. Table 9 offers a summary of the energy performance measurement data collected for each building in this study. These data were used to derive the Energy Star rating as well as for the energy intensity analysis and the energy cost comparison.

Table 9. Energy use and cost by building

Building Name	Electricity (MWH)	Nat Gas (1000 ft^3)	Steam (MLB)	Chilled Water (Ton Hr)	Electric Demand (MW)	Electric Demand Cost	Total Energy Cost
Ogden (L) FB	2,252	1,699	0	0	4.5	$54,181	$146,877
Lakewood (L) FB	1,983	2,225	0	0	5.8	$69,879	$256,060
Omaha DHS (L) FB	1,270	0	0	0	3.7	included	$79,464
Omaha NPS (L) FB	840	16,011	0	0	3.9	included	$83,177
Knoxville FB	1,867	1,878	0	0	0.0	$0	$165,181
Santa Ana FB	2,351	0	1,383	518,210	0.0	$0	$528,772
Denver CH	3,140	0	12,170	480,144	0.0	$0	$802,692
Davenport CH	923	1,829	0	0	0.0	$0	$76,949
Cleveland CH	1,633	0	9,822	477,249	5.2	included	$449,509
Greeneville CH	1,682	2,173	0	0	0.0	$0	$151,679
Youngstown CH & FB	735	0	1,153	0	0.0	$0	$98,343
Fresno CH & FB	5,379	5,136	0	0	0.0	$0	$810,745

The Omaha DHS achieved the highest number of total LEED EA credits but had similar energy performance as Omaha NPS, which achieved half of the total points Omaha DHS achieved. Acknowledging the importance of commissioning, it is worth noting that Omaha NPS achieved a credit for Additional Commissioning (EAc3) while Omaha DHS did not.

Figure 9 compares the Energy Star scores to energy use per occupant, energy use per hours of occupancy, and energy use per gross square foot. Energy use per gross square foot trend shows that with an increase in Energy Star scores there is a decrease in energy use intensity (EUI). The buildings with higher energy use per work hour also tended to have higher energy use per occupant. There doesn't appear to be a correlation between the energy use per work hour or number of occupants and the Energy Star score.

EUI is a commonly used metric calculated when the annual energy use divided by the building square footage. EUI does not consider the impact of the occupants with respect to how occupant density and plug load use may impact the energy use.

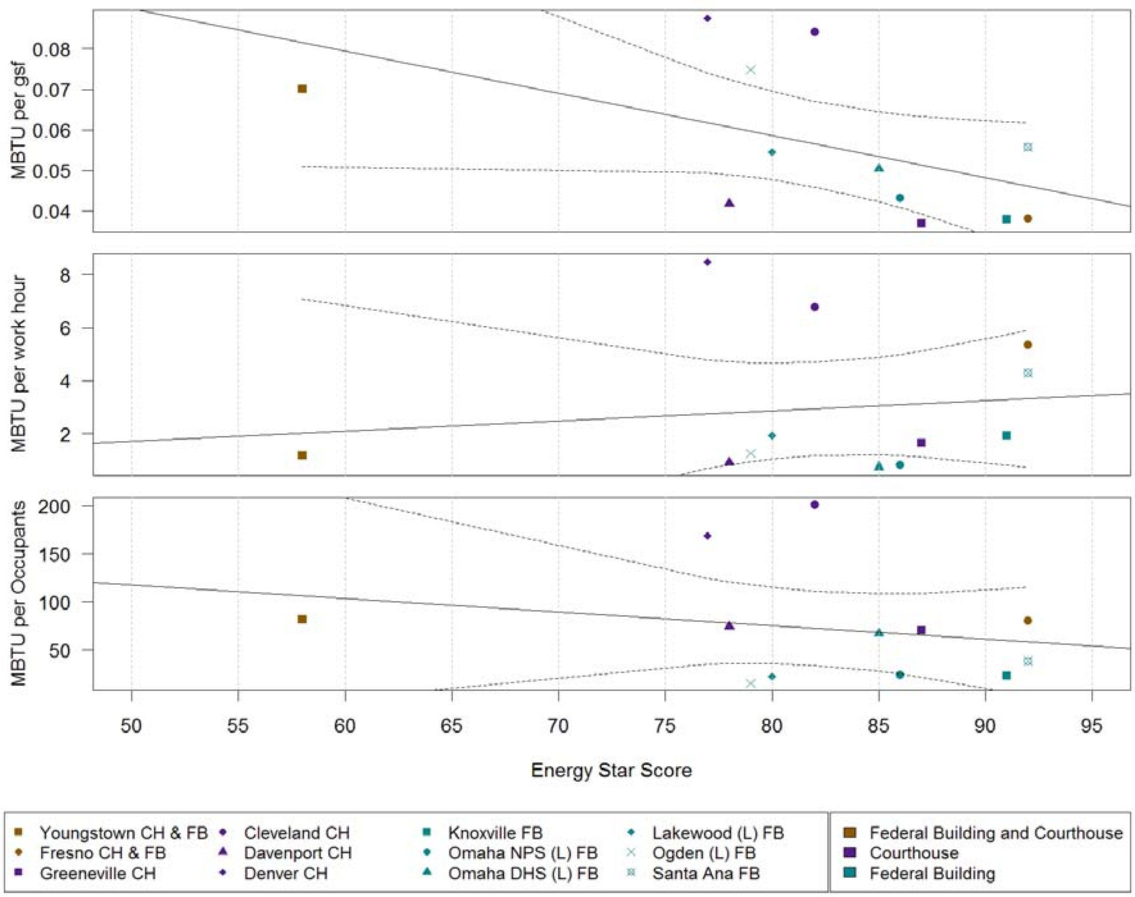


Figure 9. Energy Star rating compared to energy intensity

Table 10 summarizes the EUI data available for each building.

- "Current EUI" is the EUI calculated in Energy Star from data provided by the sites and GSA's EUAS database.

- "FY06 and FY07 GSA EUI" values were provided by GSA energy professionals, which is why there is no leased building information in those columns. The most likely reason for these values being different is that different date ranges were used for the data sets. In most cases, the study used data from April 2005 to March 2007, rather than by fiscal year.

- "Energy Star Baseline" is the 50th percentile value calculated within Energy Star based on the buildings' specific information.

- "CBECS by Region" includes the average EUI for all building types within specific geographic regions, correlated to GSA regions.

- "CBECS Office" is the national average EUI for office buildings using 2003 data for office buildings built between 1990 – 2003.[21]

CBECS is a publicly available database comprised of national survey data on US commercial building energy consumption. CBECS data can be sorted by building type, age, region, size, fuel type, and various other parameters.

- "GSA FY07 Target" is the EUI goal documented in the Public Buildings Service (PBS). It represents the average EUI expected for all GSA buildings in order to meet GSA's energy efficiency goals under the Energy Policy Act of 2005.

- "Estimated CO_2 Equiv/Bldg" is the Energy Star calculated carbon dioxide equivalents per building based on quantity and type of energy use.

Table 10. Various EUI values of interest

Building Name	EUI (kBTU/gsf) Current EUI	FY06 GSA	FY07 GSA	Energy Star Baseline (50 Percentile)	CBECS by Region	CBECS Office	GSA FY07 Target	Estimated CO_2 Equiv/Bldg (metric
Ogden (L) FB	88	-	-	132	104	88	73	1,161
Lakewood (L) FB	70	-	-	104	104	88	73	2,150
Omaha DHS (L) FB	50	-	-	77	79	88	73	1,168
Omaha NPS (L) FB	65	-	-	99	79	88	73	872
Knoxville FB	48	48	49	90	91	88	73	1,516
Santa Ana FB	56	38	41	107	69	88	73	1,344
Denver CH	88	76	77	124	104	-	73	4,668
Davenport CH	63	66	70	89	79	-	73	945
Cleveland CH	84	62	66	128	108	-	73	2,440
Greeneville CH	49	59	52	84	91	-	73	1,397
Youngstown CH & FB	67	68	70	74	108	-	73	655
Fresno CH & FB	48	45	49	92	69	-	73	2,666

Figure 10 represents the EUI compared to the CBECS national average, regional average and GSA's national average target. All of GSA's buildings in this study perform better than or equivalent to the CBECS averages. Of the three of the buildings that are not performing better than the GSA national average target, two are courthouses, one is operated 22 hours a day, and all three are in cold climate zones. More detailed energy use analysis would be needed to determine how energy performance in any of these buildings could be improved or optimized.

GSA has established national baseline averages and targets in order for the GSA building stock to meet the energy and water reduction goals in Executive Order 13423, the Energy Policy Act of 2005, and the Energy and Infrastructure Security Act or 2007.

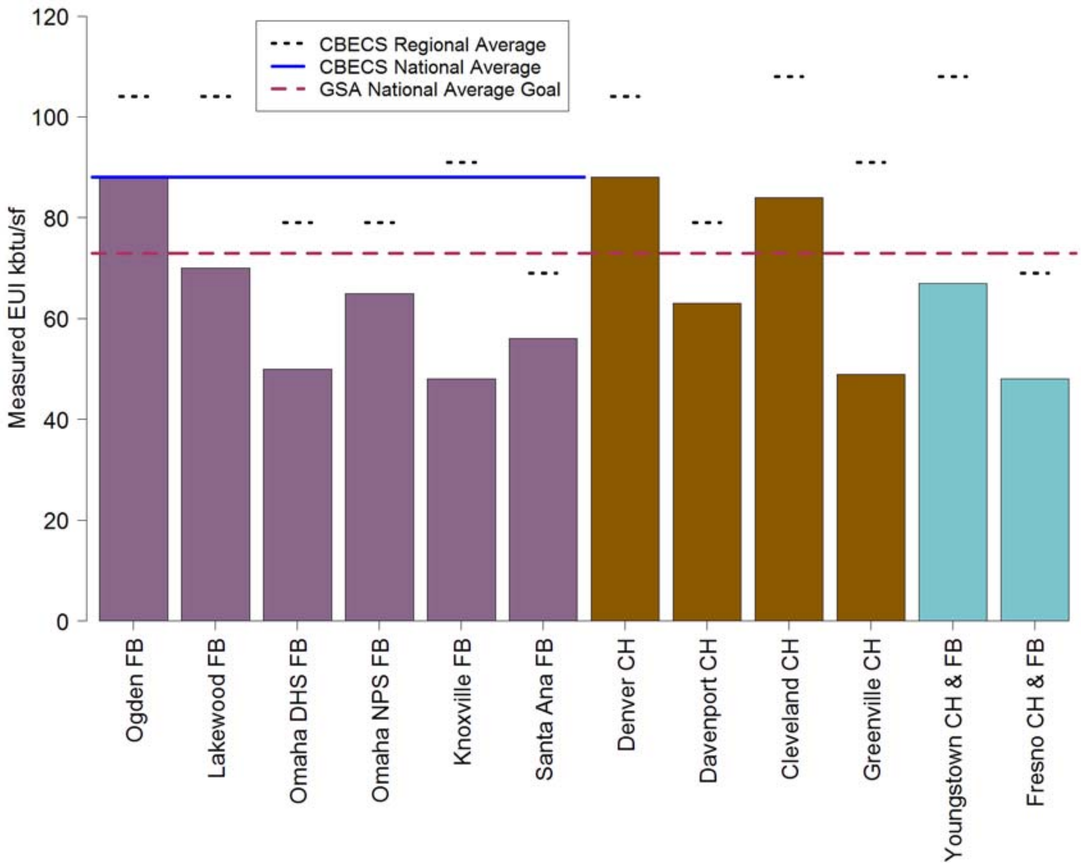


Figure 10. Study building EUIs compared to the GSA national average and CBECS national and regional EUIs

The energy performance for all of the buildings in this study is noticeably better than average and the water use per gross square foot is better than average for most of the buildings. In many of the buildings the water performance contributes to the energy efficiency of the buildings. Figure 11 shows the EUI in relationship to the water use per gross square foot. The black dots are the buildings with domestic and process water use, the black triangles are buildings with domestic, process water and landscape water use, the clear box is a building with domestic and landscape water use, and the black squares are the buildings with domestic water use only.

All of the buildings that used water for only domestic water purposes are performing above the industry baseline. As mentioned previously, a better understanding of the water use in these buildings is needs to be derived from metering and detailed data collection regarding typical water use.

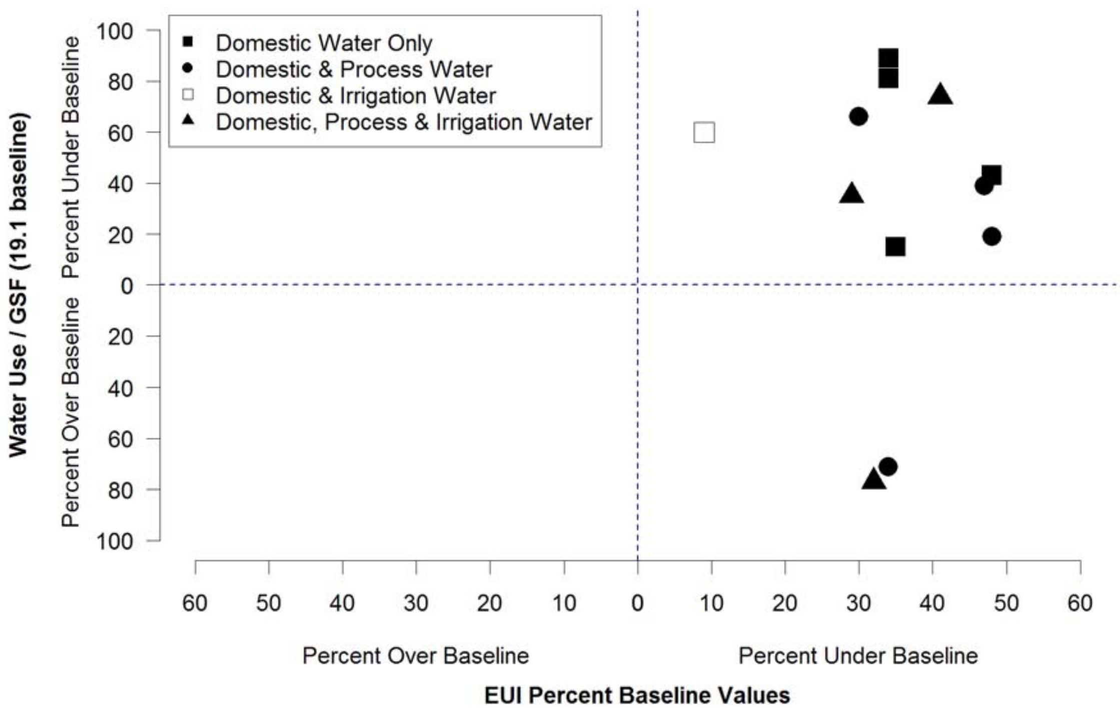


Figure 11. EUI and water use per GSF performance

One key environmental impact of energy use is emissions. The carbon dioxide (CO_2) equivalents for the buildings are calculated using the Energy Star Portfolio Manager. Figure 12 shows the relative baselines for each building given the energy use and utility. All of the buildings studied are below the industry average and all but one is below the Energy Star buildings expected CO_2 equivalent emissions. Five of the buildings also have contracts to purchase green power, not represented in this figure, which would result in lower emissions.

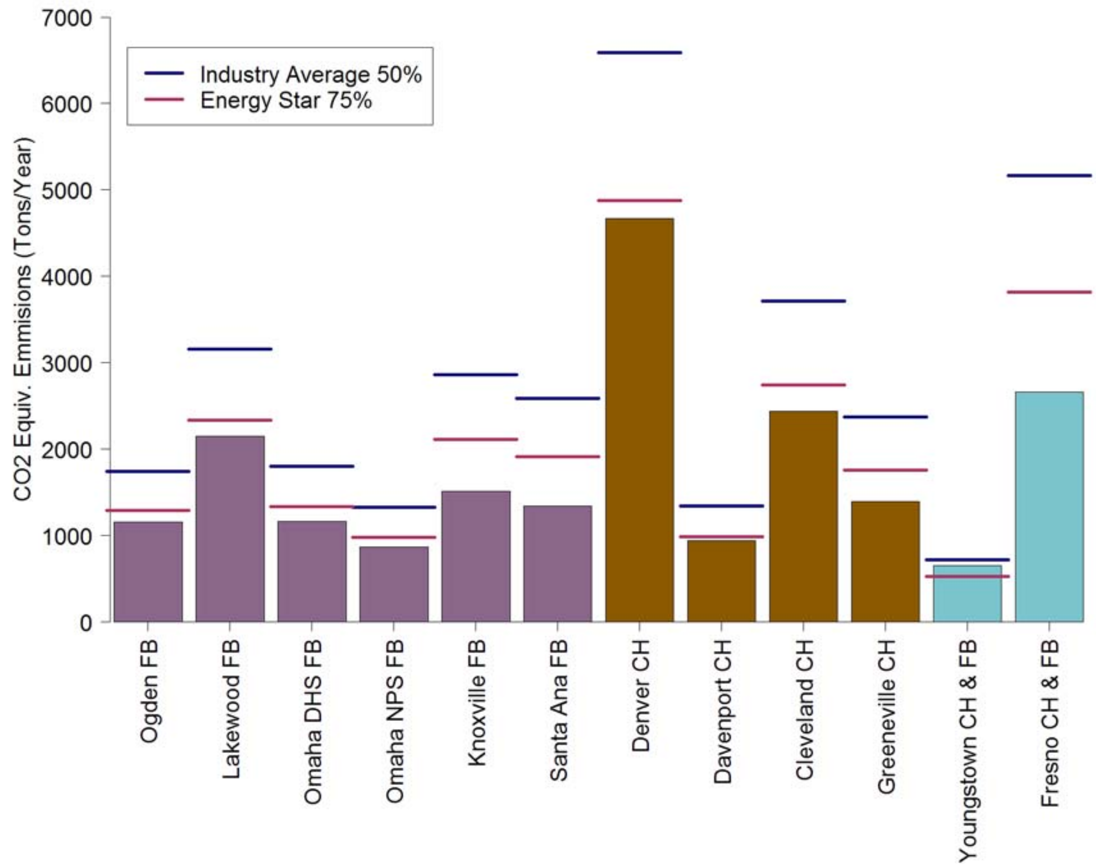


Figure 12. CO_2 equivalents compared to Energy Star baseline

Given the information provided in the preceding figure, Figure 13 shows the percent of building CO_2 equivalent emissions under the industry baseline, identified as the Energy Star 50th percentile. The buildings with the best Energy Star scores have the best CO_2 equivalent emissions performance.

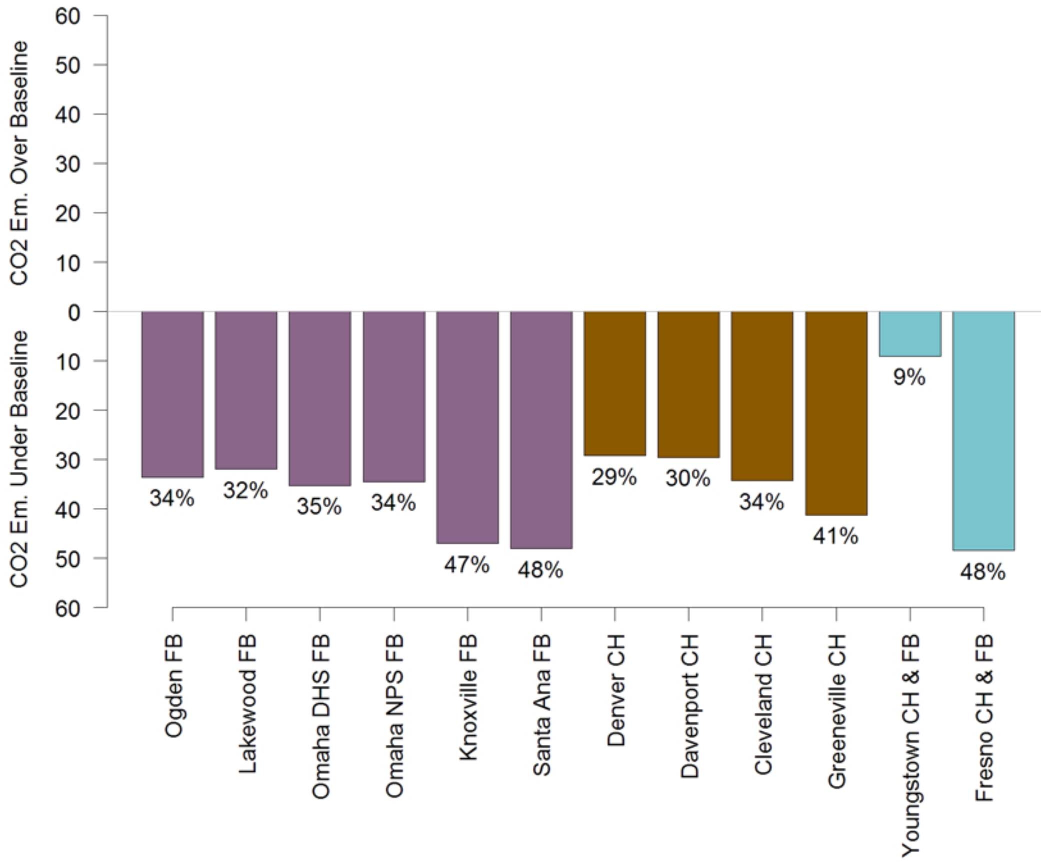


Figure 13. Building CO_2 equivalent emissions compared to baseline

The baseline value for energy costs per gross square foot is based on office building values from IFMA and BOMA.[22,23,24,25] All of the buildings in the study had energy costs that were either below or within the energy cost baseline (Figure 14).

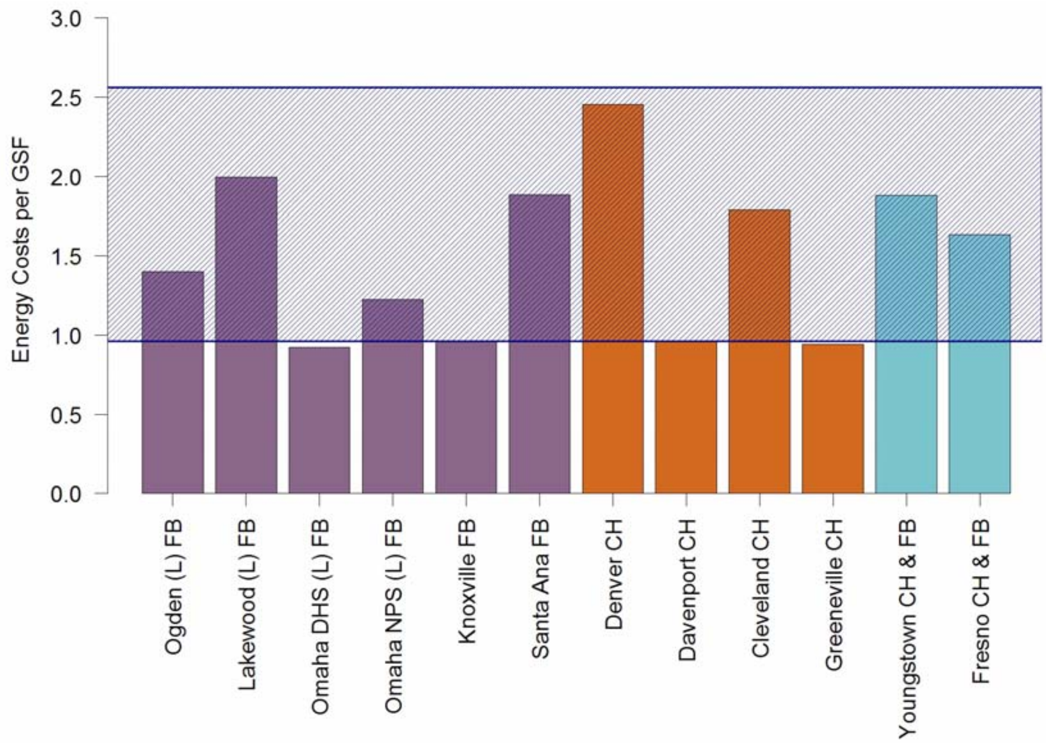


Figure 14. Energy cost per gross square foot

The LEED Gold buildings in the study had an average Energy Star score of 85.5 and an average EUI 35% better than the industry baseline. Based on the Energy Star rating baseline and CBECS baselines, the energy use of the study buildings can be classified as better than the average building and, in many cases, noticeably better than the baselines. On average the office buildings in the study performed 29% better than the CBECS national average for office buildings. If the CBECS office buildings average is used as the baseline for all of the buildings, the buildings in the study performed 26% better than average office buildings. When compared to the GSA national goal for energy performance, these buildings perform 14% better. Given the better energy performance, the CO_2 equivalents are also below the baseline for these buildings. Additionally, the cost of energy use per gross square foot appears to fit within the typical energy cost range for office buildings.

Maintenance and Operations

Interdependence in building systems means that a cost effective and high-performing operations and maintenance (O&M) program may cost more in training, monitoring, and preventative maintenance, but reduces the costs of occupant satisfaction and productivity, energy, water, materials, and repair costs. For this study, an attempt was made to compare the same maintenance costs for each building as those addressed in the industry baseline. The details provided for each building's maintenance records varied and thus, when details were not available, it was assumed that the maintenance costs represented equivalent activities. The O&M data available for each building are summarized in Table 11. The italicized values highlight the sites where maintenance records were not tracked consistently with the other sites.

Table 11. O&M data and cost by building

Building Name	Green House-keeping	Maint Calls / Total Maint	Prev Maint / Total Maint	General Maint Cost	Janitorial Maint Cost	Grounds Maint Cost
Ogden (L) FB	Some	n/a	n/a	$39,068	$125,892	$3,584
Lakewood (L) FB	No	*0.05*	*0.95*	$103,644	$83,220	$7,394
Omaha DHS (L) FB	Some	0.38	0.62	n/a	$70,800	$8,200
Omaha NPS (L) FB	Yes	0.62	0.38	$41,600	$56,400	$9,050
Knoxville FB	Some	0.16	0.84	$237,836	$220,948	$5,300
Santa Ana FB	No	0.43	0.57	$366,483	$290,888	$15,018
Denver CH	No	0.44	0.56	$804,051	$220,046	$29,791
Davenport CH	Some	0.31	0.69	$155,892	$133,026	$6,421
Cleveland CH	Yes	0.46	0.54	$111,329	$270,476	$3,100
Greeneville CH	Some	0.14	0.86	$214,100	$227,620	$4,000
Youngstown CH & FB	Yes	0.29	0.71	$174,182	$140,767	$37,300
Fresno CH & FB	No	0.20	0.80	$1,188,000	$759,402	$24,236

Notice that eight of the buildings have some form of green housekeeping. For the buildings in this study, there does not appear to be a janitorial cost impact for employing green housekeeping strategies.

Figure 15 shows general maintenance costs per rentable square foot. The baseline values for the general, grounds, and janitorial maintenance costs were collected from IFMA and BOMA resources.[26,27,28,29] More than half of the buildings fell within or below the baseline range. Several buildings have noticeably higher general maintenance costs per square foot. Again, although an attempt was made to compare similar costs for each building, it is possible that the data contain unique items or omit common items. Additionally, because these data only represent 1 year of building O&M costs, they should not be assumed to represent an average or expected cost for the building.

The International Facilities Management Association (IFMA) and the Building Owners and Managers Association (BOMA) provide the main source of statistics on the state of commercial buildings.

Each organization publishes benchmarking reports on a variety of development, operations and maintenance topics. Their data are obtained primarily through surveys of their members which exceeds 15,000 in each organization.

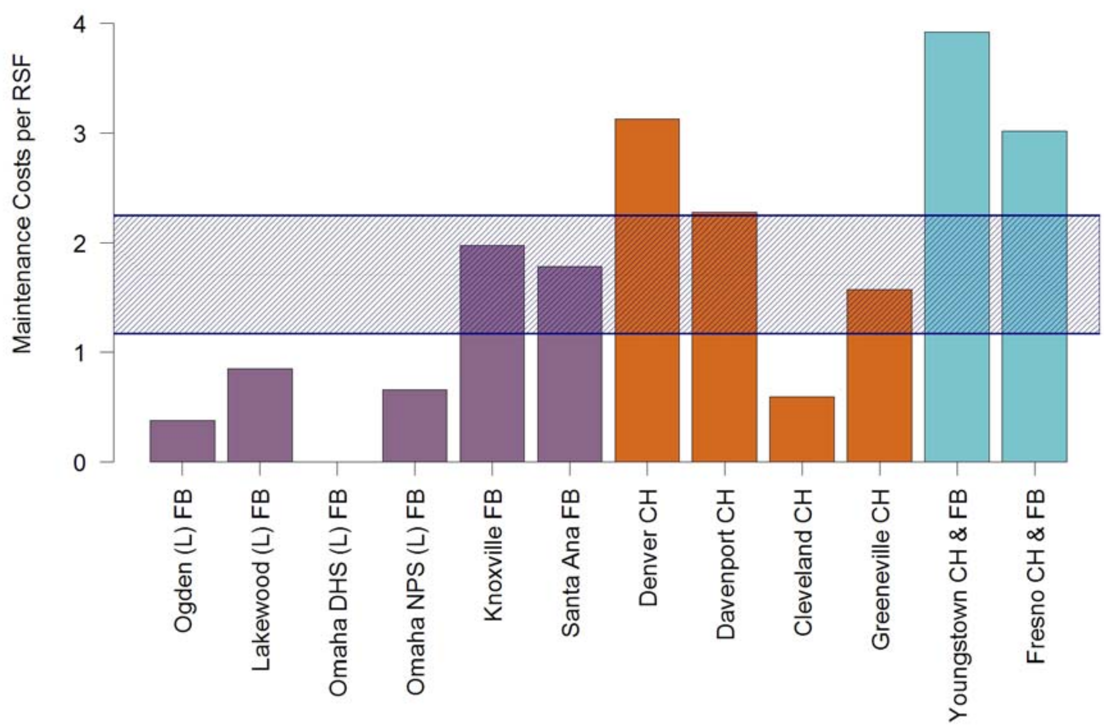


Figure 15. General maintenance cost per rentable square foot

Figure 16 shows grounds maintenance costs per rentable square foot. All but one of the buildings fell within or below the baseline range. The building significantly above the baseline has manually weeded native prairie grass for landscaping, which may contribute to the higher grounds maintenance costs. Because this study only includes 1 year of data, more information is needed to know if this is a typical grounds maintenance cost or a one-time cost.

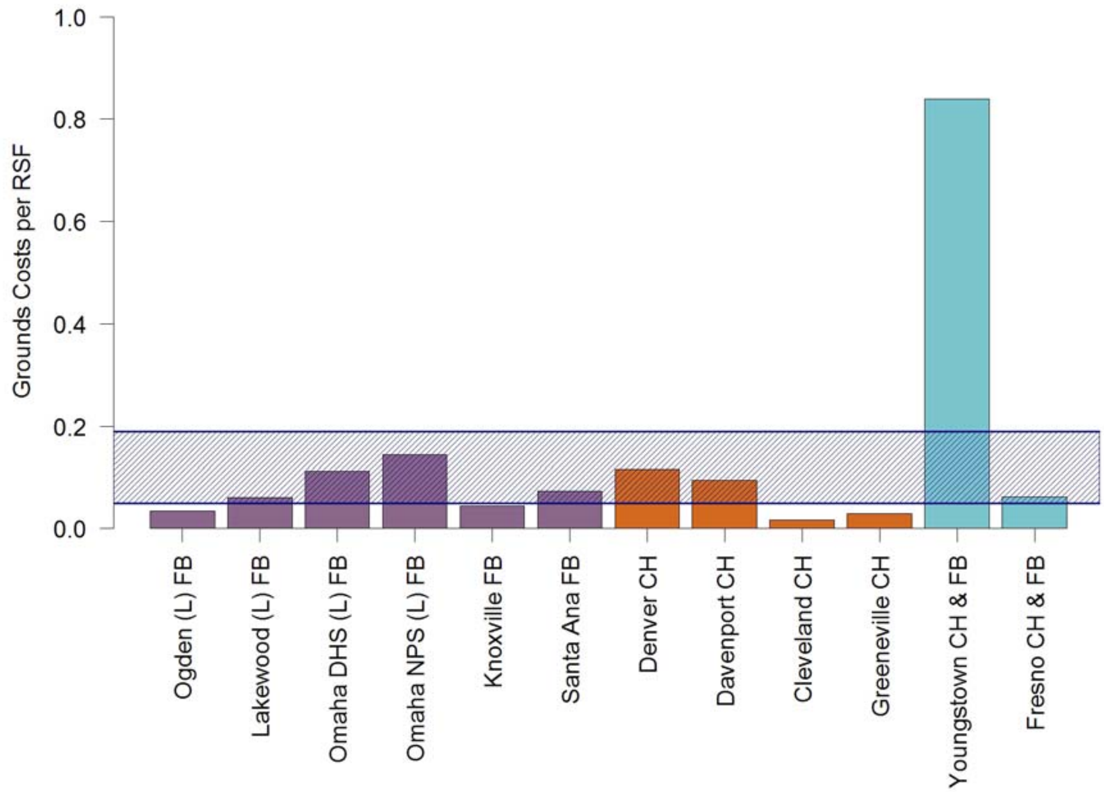


Figure 16. Grounds maintenance cost per rentable square foot

The janitorial costs for a third of the buildings were above the baseline costs (Figure 17). The remaining two-thirds of the buildings were at or below the baseline. The 1 year of costs does not address the quality of work, potential regional cost differences, or the uniqueness of the year's janitorial needs. For example, one of the buildings with higher-than-baseline janitorial cost dealt with multiple floods during the building's lifetime, which may have increased janitorial costs. Note that IFMA and BOMA include different tasks within janitorial costs. The janitorial activities undertaken for each GSA building were not investigated and may also offer an explanation as to why there is a wide range of costs per rentable square foot.

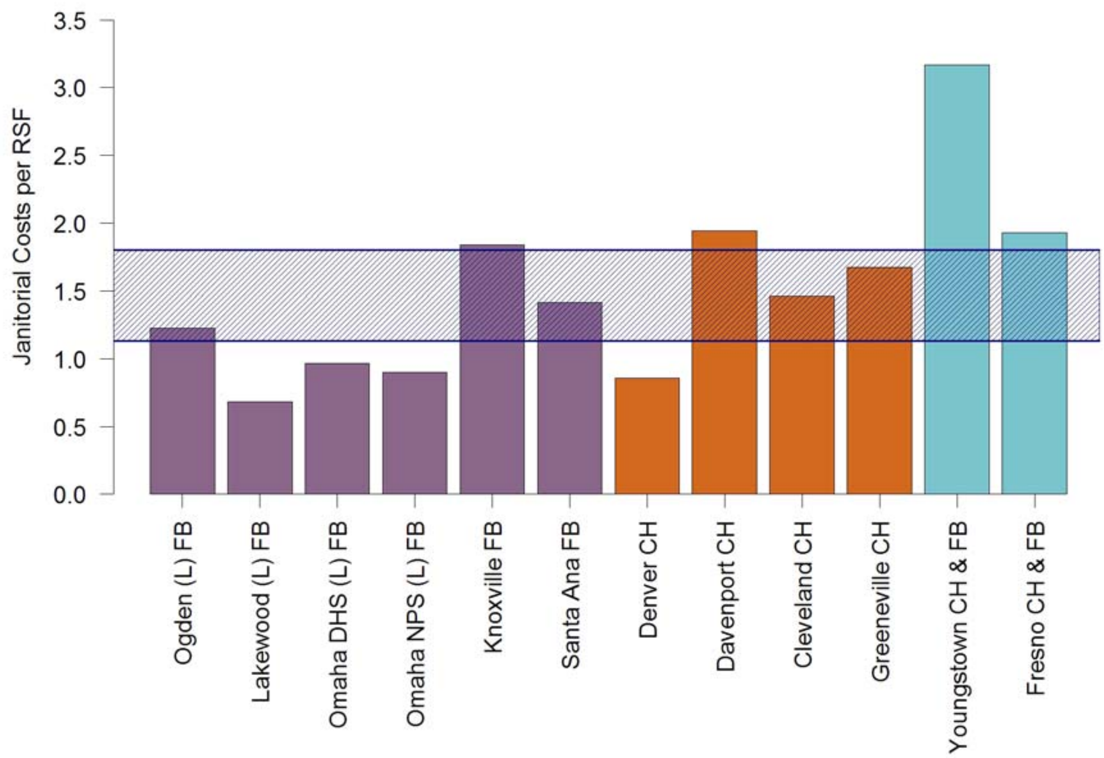


Figure 17. Janitorial cost per rentable square foot

According to the IFMA research, a building less than 5 years old would spend 73% of maintenance funds on preventative maintenance and 27% on regular maintenance.[30] For buildings 5 to 10 years old the ratio changes to 63% to 37%. The averaged ratio for the buildings in this study is 69% for preventative maintenance and 31% for regular maintenance. Five of the buildings in the study were built in the last 5 years. Five of the buildings have had major renovations in the last 5 years. The remaining two buildings are 5 and 6 years old. Given the age of the study buildings, the ratio appears to be comparable to the IFMA baseline.

The LEED Gold buildings had lower than or within baseline maintenance costs, where data were available. Omaha DHS was not able to provide a general maintenance cost.

Waste Generation and Recycling

Waste disposal is a utility cost incurred by buildings that is an indicator of resource use by the building occupants. Although occupant waste generation is not typically seen as having a connection to a building, LEED requires recycle bins as part of the building design. This performance measure is being used to investigate whether the occupants of green buildings recycle at a greater rate than the industry baseline.

Although the building designer, manager and/or owner can offer space, services, and encouragement to recycle, recycling programs are more commonly successful when they are promoted by the building occupant's employer. In other words, recycling goals and/or incentives offered by the federal agencies that occupy these buildings, and coordinated with the building management would offer the greatest opportunity to reduce solid sanitary waste. Although some buildings had exemplary recycling programs, the research team did not observe a consistent emphasis to reduce solid sanitary waste or to increase recycling at all of the buildings in the study. Table 12 provides a summary of the waste and recycling quantity and cost data available for each building.

Table 12. Waste generation and recycling data and cost by building

Building Name	Waste per Year (Tons)	Waste Cost	Recycled Material	Recycle per year (Tons)	Recycle Cost	% Recycle to Waste
Ogden (L) FB	220.0	$3,940	Paper & Cardboard	67.0	$16,081	30%
Lakewood (L) FB	374.1	$3,600	Paper	204.2	$0	55%
Omaha DHS (L) FB	112.5	$2,400	Paper	23.5	$0	21%
Omaha NPS (L) FB	561.6	$1,500	Paper & Cardboard	11.0	$1,020	2%
Knoxville FB	40.5	$4,380	Paper & Metal	20.3	n/a	50%
Santa Ana FB	561.6	$18,360	Paper	10.7	$1,600	2%
Denver CH	38.5	n/a	Paper	n/a	n/a	-
Davenport CH	59.4	$907	Paper	2.4	$0	4%
Cleveland CH	24.0	$3,067	Paper & Metal	2.8	-$101	12%
Greeneville CH	39.0	$900	Paper	2.4	-$71	6%
Youngstown CH & FB	16.8	$1,530	Paper	28.8	$0	171%
Fresno CH & FB	16.2	$24,236	Paper	18.0	$0	111%

Figure 18 represents the recycling to waste ratio for each building. The waste and recycling data were not consistently available for each building. Some buildings shared services with other buildings and some estimated the quantity of waste or recycled material based on the frequency of service rather than measured quantities. However, based on the site visits it was clear that recycling was not a strong expectation of the building occupants for at least some of the buildings. Although paper was recycled in all of the buildings, other commonly recycled items — glass, aluminum, and cardboard — were not consistently collected. In at least one building the PNNL research team was told how the building management gave up on recycling anything but paper because the occupants used the recycle bins as trash cans.

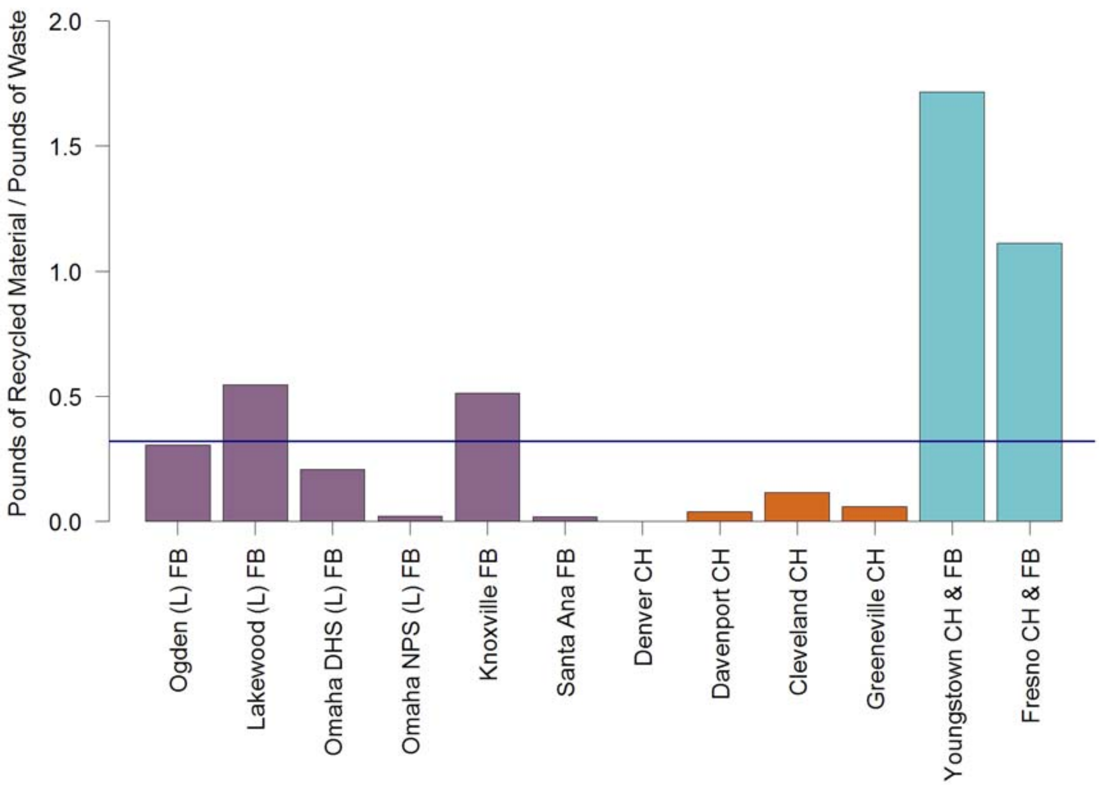


Figure 18. Recycling to waste generation ratio

Figure 19 shows the waste cost per occupant per year. All of the buildings are below the baseline with only one building approaching the baseline.

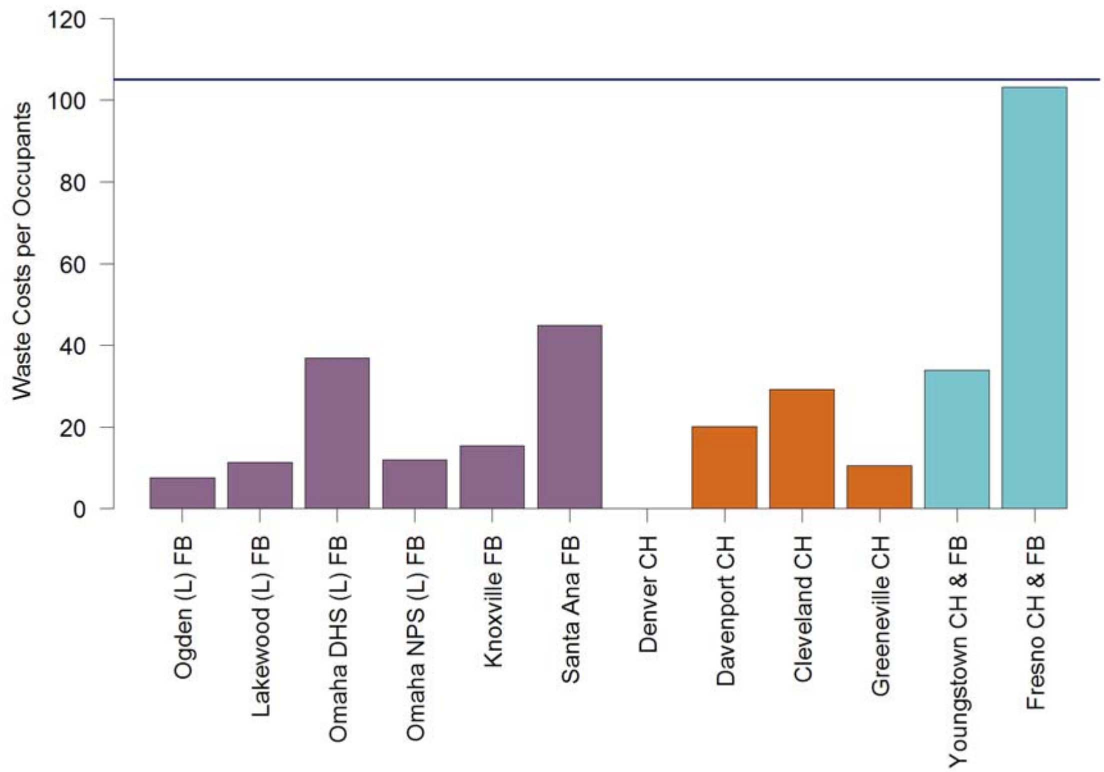


Figure 19. Waste generation cost per occupant

To better understand the impact the building design and operation have on the quantity of materials recycled, the building occupant employer programs would need to be equivalent. Additionally, the cost and availability of recycling programs in the community and the willingness of the building manager to manage a recycling program might impact the ability of building occupants to recycle.

Occupant Satisfaction

A primary aim of sustainable design is maximizing the occupant comfort and satisfaction, while minimizing the environmental impact and costs. Indoor environmental quality (IEQ) is the commonly used term to describe the building features that directly impact the occupants. The IEQ of a workplace reflects the interaction of air, lighting, and surroundings with occupants in a holistic sense. IEQ effects include occupant health, productivity, and satisfaction. Occupant satisfaction is crucial to staff retention. Studies have shown that employees planning to leave an organization were 25% less satisfied with their physical workplace than those that planned to stay.[31]

Occupant surveys are the typical mechanism used to gather occupant satisfaction data. This study used the Center for the Built Environment's (CBE) occupant satisfaction survey. The CBE core survey questions fit within the following categories

- Office Layout
- Office Furnishings
- Thermal Comfort
- Air Quality
- Lighting
- Acoustic Quality
- Cleanliness and Maintenance
- General Comments.

The University of California Berkeley's Center for the Built Environment (CBE) has developed an occupant satisfaction survey that has had over 48,000 survey responses. Occupants in 335 buildings have taken the CBE survey, with approximately 215 of them being GSA buildings and 44 being LEED buildings. The survey is distributed via the internet, takes approximately 10 minutes to complete, and protects the confidentiality of the respondents.

CBE allows for customization of the core survey. Previously, GSA has used a modified version of the CBE survey. This project started with the GSA modified survey and then added questions related to occupant commute. The additional questions increased the estimated time to complete the survey to 20 minutes. A copy of the key questions provided in the survey can be found in Appendix E.

The industry baseline for the occupant satisfaction metrics is the CBE core survey responses. The survey questions offer a numerical response of between -3 and 3. CBE prepares building specific survey summary reports. These reports provide the average scores for each of the key elements addressed in the survey. The average response score and the average responses within the CBE database are compared. For example, if a building scored at the 50th percentile, 50% of the buildings in the database would have a lower score and 50% would have a higher score.

The tool used to measure building occupant satisfaction survey for this study is called SPOT (Sustainable Places and Organizational Trends). This survey is a GSA modified version of the CBE core survey that removes the office furnishings and office layout questions and adds occupant commute questions. The SPOT survey was distributed to building occupants electronically. For a few buildings the electronic distribution, via an internet site, was unsuccessful because of limited access to the internet. In those cases, a paper version of the survey was distributed, collected, and the resulting data were entered by GSA representatives into the electronic survey. The CBE preferred response rate for the survey is greater than 50%. Half of the buildings in the study had response rates lower than desired.

Table 13 provides a summary of the SPOT survey response rates and the percentile ranking for each building.

		Percentile Rank within CBE database					
Building Name	Response Rate	Acoustics	Air Quality	Cleanliness	Lighting	Thermal Comfort	General Building
Ogden (L) FB	29%	16%	57%	55%	35%	41%	52%
Lakewood (L) FB	41%	45%	78%	80%	48%	59%	78%
Omaha DHS (L) FB	89%	92%	90%	85%	68%	90%	95%
Omaha NPS (L) FB	68%	9%	79%	80%	30%	50%	72%
Knoxville FB	36%	50%	64%	79%	82%	57%	84%
Santa Ana FB	35%	36%	61%	49%	47%	88%	59%
Denver CH	58%	63%	67%	94%	74%	50%	65%
Davenport CH	61%	76%	86%	90%	47%	92%	80%
Cleveland CH	57%	74%	89%	95%	76%	79%	86%
Greeneville CH	54%	97%	94%	98%	93%	84%	98%
Youngstown CH & FB	37%	68%	62%	97%	42%	1%	59%
Fresno CH & FB	30%	92%	91%	81%	72%	61%	90%

Table 13. SPOT Survey scores ranked against CBE database

The building results for key summary survey questions have been compared to the full CBE survey database. Figure 20 shows that the occupants of more than half of the buildings in the study were more satisfied with their acoustical quality than the 50th percentile of those surveyed by CBE.

In the next set of figures, the orange line represents the average survey responses by question category in the CBE database and the blue dots are the average scores for the 12 buildings in this study.

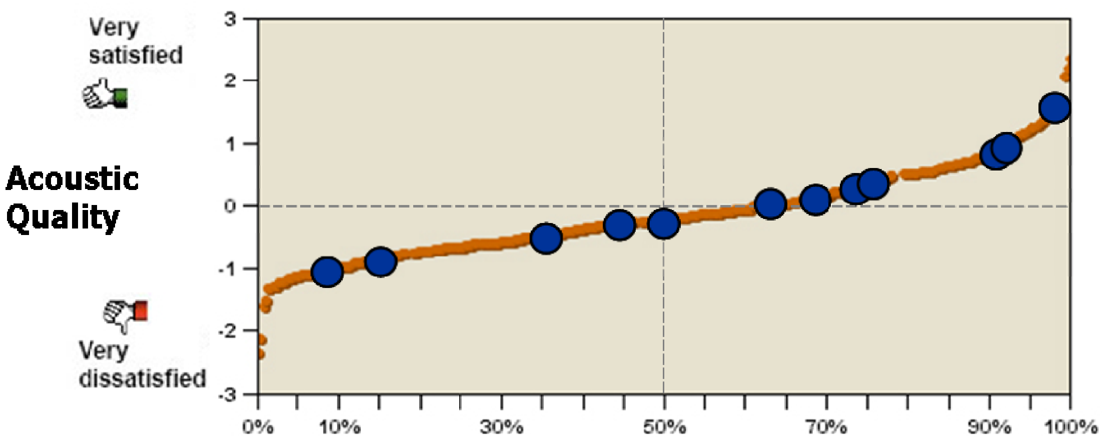


Figure 20. Acoustic quality rating from the occupant survey

Figure 21 illustrates that occupants of all the buildings in the study were satisfied with building air quality. Occupants from all but one of the buildings were more satisfied with the air quality than the 50th percentile of those surveyed by CBE.

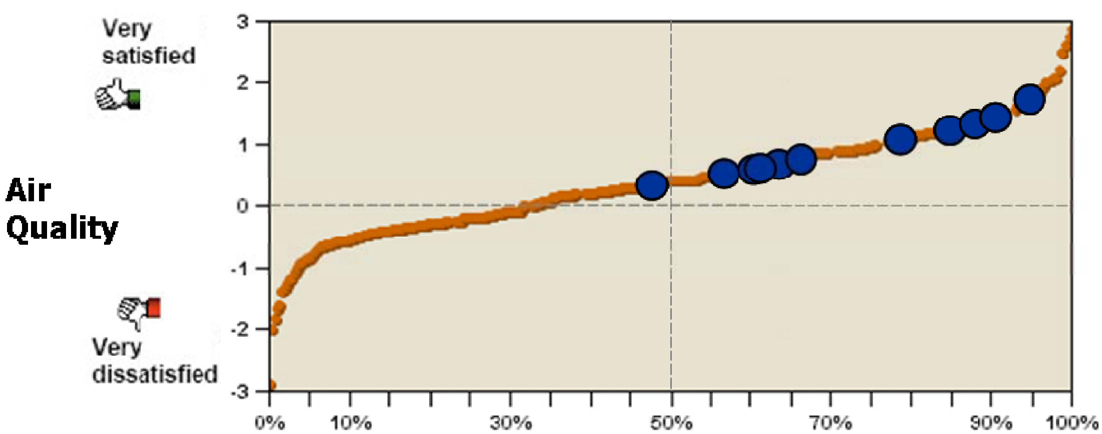


Figure 21. Air quality rating from the occupant survey

Figure 22 illustrates that occupants in all of the buildings in the study identified cleanliness and maintenance as being better than the 50th percentile of the CBE database. A cluster of buildings scored at the 75th percentile and above. When considering the cost data, the maintenance costs of some of the buildings in the study are high, yet the building occupants are pleased with the service they are receiving.

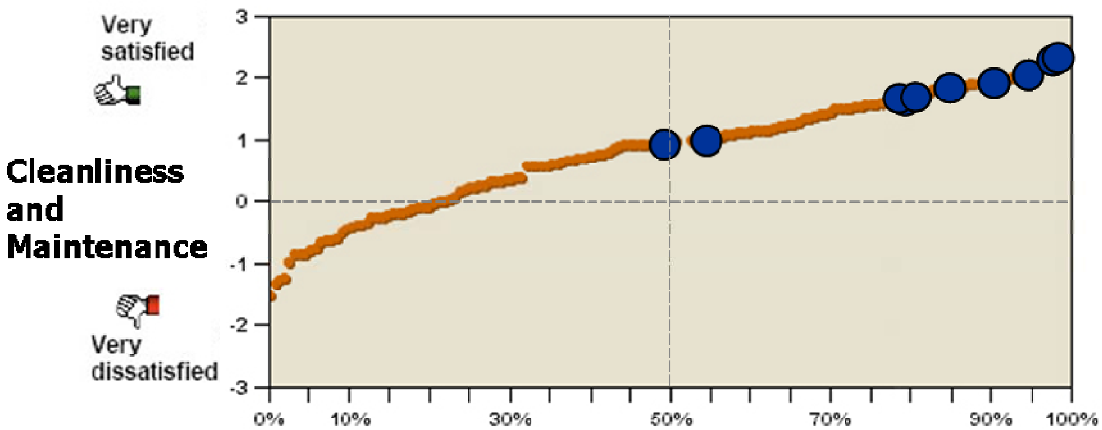


Figure 22. Cleanliness and maintenance rating from the occupant survey

Figure 23 illustrates that occupants of about half of the buildings in the study identified lighting as being better than the 50th percentile and the other half were below the 50th percentile of the CBE database, yet all of the buildings averaged a positive lighting score. The lighting occupant satisfaction rating needs to be considered in context with energy use.

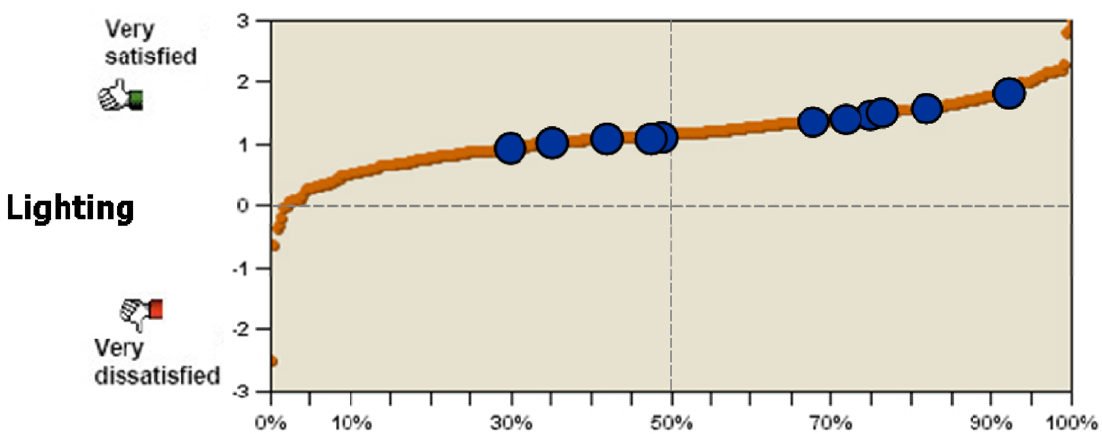


Figure 23. Lighting quality rating from the occupant survey

For thermal comfort, most of the buildings scored above the 50th percentile (Figure 24). One of the buildings whose occupants stated they were very dissatisfied with the thermal comfort has a high female occupancy rate and has additional work spaces have been created from spaces that were not originally designed to be occupied. The building manager of this building commented that the additional occupant spaces negatively impacted ventilation.

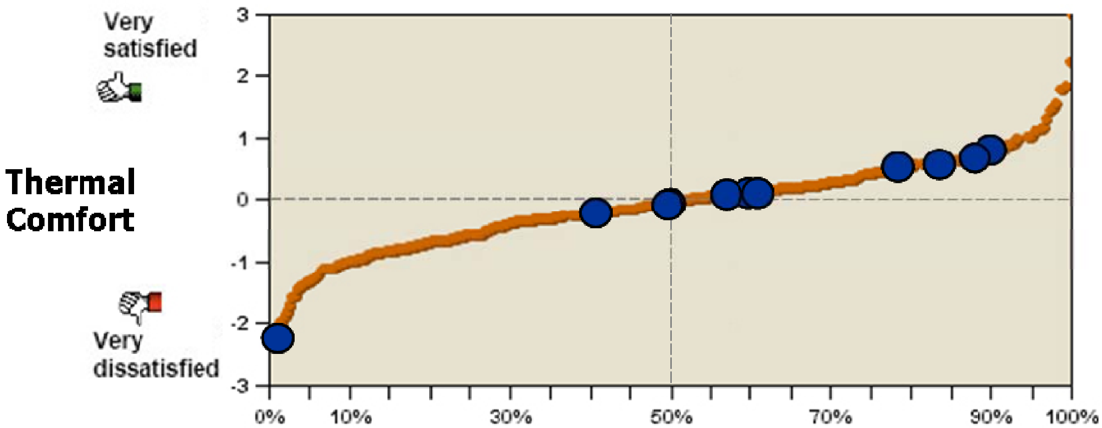


Figure 24. Thermal comfort rating from the occupant survey

Overall building occupant satisfaction varied by building, yet as Figure 25 shows, all of the GSA buildings in the study scored above the 50th percentile in comparison to the industry baseline, and they are satisfied.

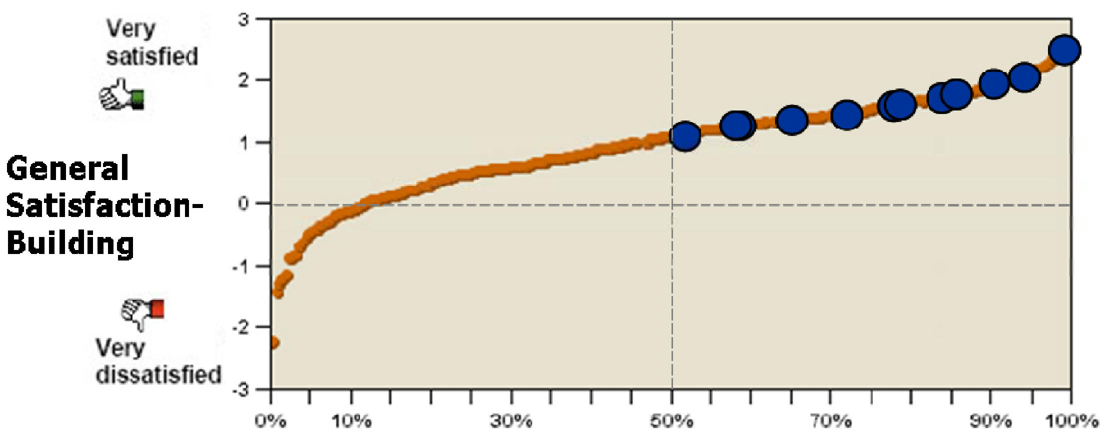


Figure 25. General building satisfaction rating from the occupant survey

In comparison to all non-LEED buildings in the CBE database, the GSA buildings report higher average satisfaction scores in all categories. In comparison to the LEED buildings in the CBE database, the GSA buildings report higher average satisfaction scores in all categories except air quality (Figure 26). There were 44,174 individual responses in the non-LEED buildings data set, 4344 in the LEED buildings data set, and 664 in the SPOT survey data set.

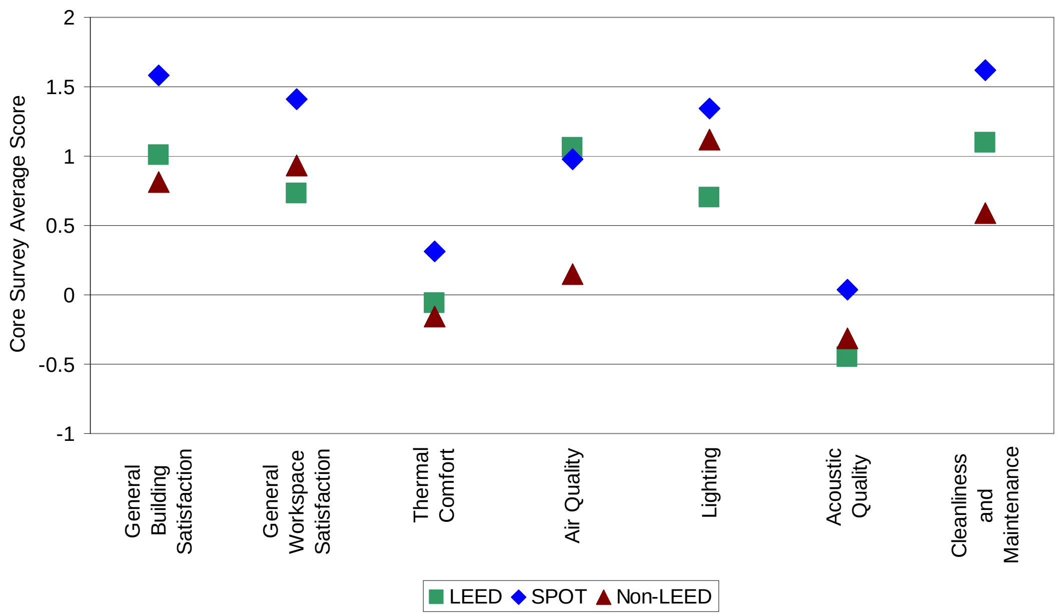


Figure 26. Study building occupants are more satisfied than the LEED and non-LEED building occupants in the CBE database.

Both of the LEED Gold buildings scored above the baseline for general building satisfaction. The occupant satisfaction information compared to the CBE baseline offers a snapshot of the relative satisfaction of these buildings' occupants at this point in time. More detailed building studies of why building occupants are responding as they are would offer additional insight. These data connect with the other building metrics, such as maintenance and janitorial costs compared to cleanliness and maintenance satisfaction scores and thermal comfort compared to EUI. Additional analysis can be found in the conclusion section.

Transportation

The occupant commute to a building reflects the impact of siting, agency incentives, and the environmental ethic of the building occupants. The information for the transportation metric was collected using the SPOT survey. The impact of the occupant transportation choices is represented by the average distance traveled and the CO_2 equivalents. Table 14 shows the summary transportation data and CO_2 equivalents based on responses to the questions about occupant commute distance and vehicle type questions.

Table 14. Transportation data by building

Building Name	Survey N-Value	# Occ	Avg Daily Roundtrip Miles Traveled	Avg Annual Gallons Used/Occ	Estimated CO_2 Equiv/Occ (metric tons)	Estimated CO_2 Equiv/Bldg (metric tons)
Ogden (L) FB	151	514	19.6	202	1.9	961
Lakewood (L) FB	103	318	23.1	201	1.9	592
Omaha DHS (L) FB	16	65	29.7	225	2.1	136
Omaha NPS (L) FB	82	125	21.4	184	1.7	213
Knoxville FB	98	285	28.9	232	2.2	613
Santa Ana FB	118	409	29.7	237	2.2	898
Denver CH	58	170	24.4	102	0.9	160
Davenport CH	22	45	26.5	308	2.9	128
Cleveland CH	55	105	25.8	86	0.8	83
Greenville CH	55	85	22.4	276	2.6	217
Youngstown CH & FB	28	45	28.8	192	1.8	80
Fresno CH & FB	64	235	n/a	n/a	n/a	0

Although occupant commute is not typically seen as having a connection to a building, LEED encourages the consideration of the occupant commute during the building design. LEED points can be earned for siting the building near public transportation, providing preferred parking for carpools and alternative vehicles, and offering space and services for bicycle riders. This performance measure is being used to investigate whether the roundtrip commute of green building occupants has a lower environmental impact than the industry baseline.

In addition to the strategies used during building design, the building manager and/or owner can offer space, services and encouragement to alter commute practices. For example, the cost and availability of parking and/or public transportation may have a greater impact on occupant commute choices than preferential parking spaces for carpoolers. Other incentives provided by the occupant's employer, such as public transportation vouchers or the ability to telecommute, will also have an impact on occupant transportation decisions. Of course there is also the personal decision of vehicle type, and housing location that is not being addressed in this study. The economics of single occupant vehicle transportation has changed, which may impact the baseline in the future.

One reference point for the impact of occupant commute is the average roundtrip commute. The average commute distance is compared to the size of the community in Figure 27. In this study, there is no correlation between the size of the community and the average length of commute. Sustainable design siting considerations would ideally show a decrease in commute distance traveled, but there would also be a CO_2 emission shift because of preferential parking incentives to carpool and access to public transportation.

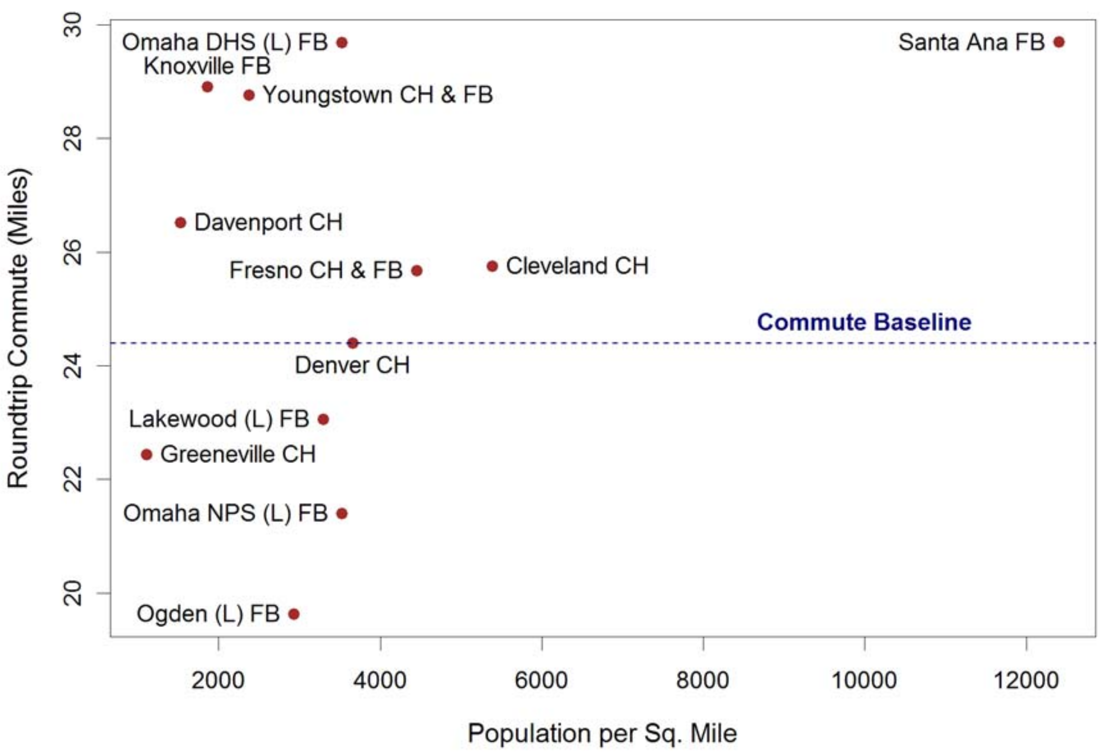


Figure 27. Average commute distance and community size

Figure 28 indicates that only two of the buildings are above the commute emissions baseline and that there is a 40% correlation that as population size increases, the CO_2 equivalent emissions will decrease. Note that Santa Ana was removed from the fit equation because of the community size being more than double all of the other buildings. As stated previously, there are three buildings included in this study that focused on building energy efficiency rather than sustainable design. If those three buildings are removed from the study, the correlation between population size and CO_2 equivalent emissions is 75%.

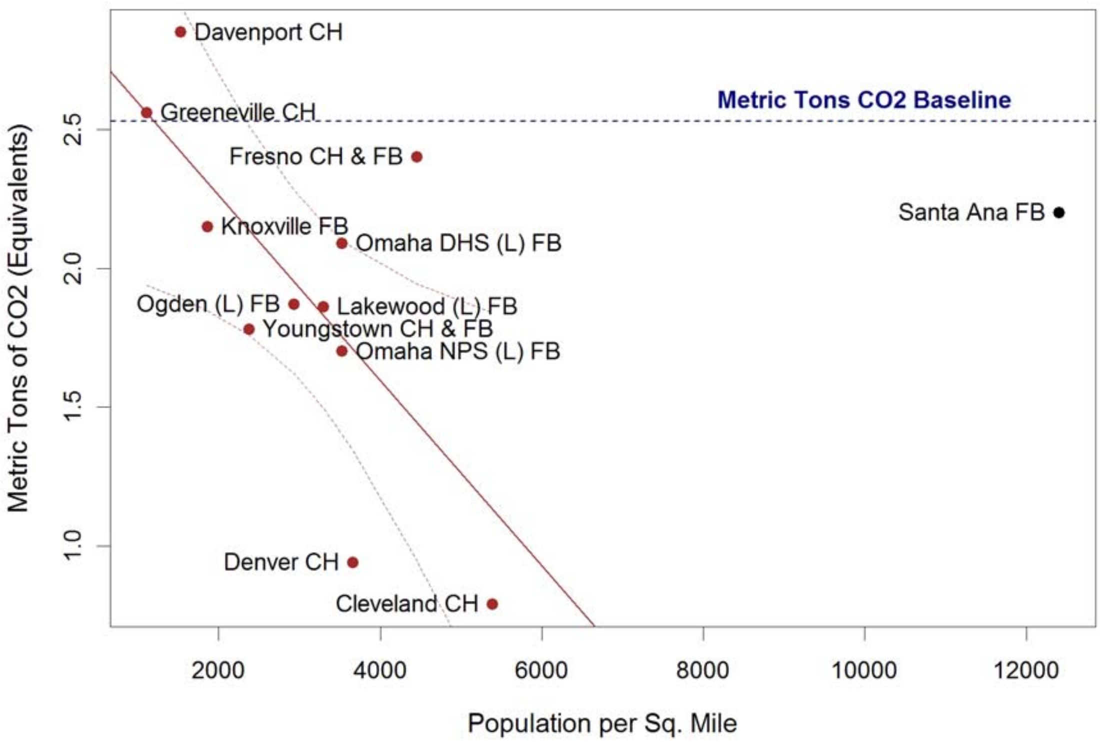


Figure 28. CO_2 equivalent emissions by community size

Less than half of the buildings have an average commute distance less than the industry average and only two buildings have CO_2 equivalent emissions greater than the baseline. From this, it can be observed that more people in these buildings use mass transit, non-motorized transportation, or more fuel efficient vehicles.

Figure 29 combines the CO_2 equivalent emissions of the building energy use and the occupant commute. All of the buildings are better than the industry baseline, primarily because of the building energy efficiency.

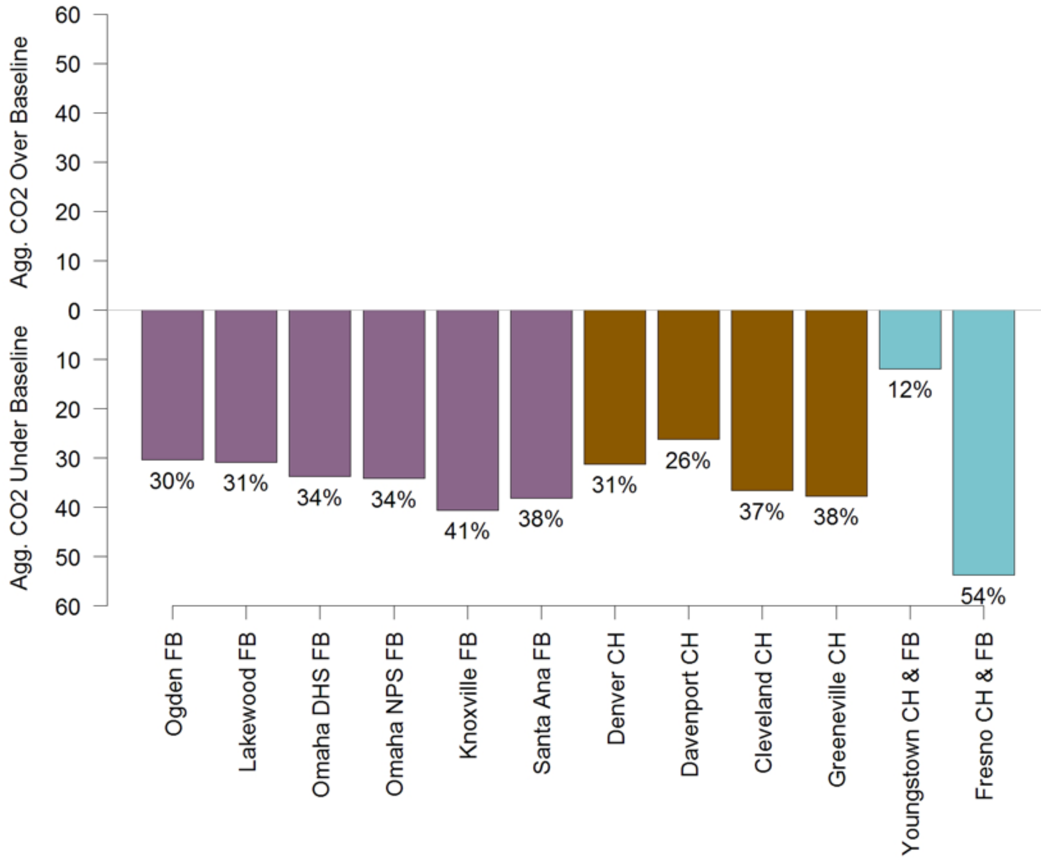


Figure 29. Aggregate CO_2 equivalent emissions compared to the baseline

Both of the LEED Gold buildings resulted in CO_2 equivalent emissions lower than the industry baseline. When considering the impact of CO_2 equivalent emissions from these buildings, the commute played a small part. Given that less than half of the buildings had a roundtrip commute lower than the industry average, and that all but two had emissions lower than the industry baseline, the results imply that occupants are choosing to telecommute, carpool, walk, bicycle, or use public transportation more than the general population. It is unclear whether this can be attributed to sustainable design practices, or is just a coincidence. More detailed roundtrip commute data from sustainably designed buildings may offer an opportunity to understand the relationship between the building and occupant commute practices.

Conclusions: What We Learned

The purpose of this study was to provide an overview of measured whole building performance as it compares to an industry baseline. The PNNL research team found the data analysis illuminated strengths and weaknesses of individual buildings and as a group of buildings. This section includes summary data, observations that cross multiple performance metrics, discussion of lessons learned from this research, and opportunities for future research.

The following two summary tables provide the costs and performance for each whole building performance metric. A summary of the total first cost and total operating costs is provided in Table 15. The total operating cost provided in this table is a summation of the costs collected for the selected set of metrics.

Table 15. Annual costs and total project cost by building

			Annual Costs (US$)				
Building Name	Project Cost New ($M)	Project Cost Renov ($M)	Aggregate Maintenance	Waste & Recycle	Total Water	Total Energy	Aggregate Ops Cost
Ogden (L) FB		$11.4	$168,544	$20,020	$6,849	$146,877	$342,290
Lakewood (L) FB	$25.1		$194,258	$3,600	$18,056	$256,060	$471,974
Omaha DHS (L) FB	n/a		n/a	$2,400	$3,765	$79,464	n/a
Omaha NPS (L) FB	$27.9		$107,050	$2,520	$839	$83,177	$193,586
Knoxville FB		$0.3	$464,084	-	$15,302	$165,181	$644,567
Santa Ana FB		$27.9	$672,389	$19,960	$11,569	$528,772	$1,232,691
Denver CH	$99.1		$1,053,889	-	$16,604	$802,692	$1,873,185
Davenport CH		$20.0	$295,338	$907	$3,942	$76,949	$377,135
Cleveland CH		$44.6	$384,905	$2,966	$1,330	$449,509	$838,709
Greeneville CH	$31.1		$445,720	$829	$5,468	$151,679	$603,696
Youngstown CH & FB	$16.5		$352,248	$1,530	$3,426	$98,343	$455,547
Fresno CH & FB	$132.7		$1,971,638	$24,236	$11,227	$810,745	$2,817,847

The summary of annual data for each of the performance metrics is provided in Table 16. The data represent 1 year of data and are not associated with any specific design features or strategies. When multiple years of data for these buildings become available, it would be of interest to track the changes in performance for the individual buildings and the buildings as a group. Investigating what the connection is between the building performance and the design intent would offer potential design guidance and possible insight into building operation strategies.

Table 16. Summary values for each performance metric

Building Name	GSF	Energy Star® Score	Total Water (1000 gal)	Aggregate Maintenance Cost	Waste Cost	General Bldg % Satisfaction	Metric Tons of CO_2 equivs/Occ
Ogden (L) FB	105,000	79	3,435	$168,544	$3,940	72%	1.87
Lakewood (L) FB	128,342	80	4,340	$194,258	$3,600	82%	1.86
Omaha DHS (L) FB	86,000	85	1,392	n/a	$2,400	100%	2.09
Omaha NPS (L) FB	68,000	86	246	$107,050	$1,500	81%	1.70
Knoxville FB	172,684	91	2,027	$464,084	$4,380	89%	2.15
Santa Ana FB	280,365	92	3,071	$672,389	$18,360	72%	2.20
Denver CH	327,103	77	4,039	$1,053,889	n/a	74%	0.94
Davenport CH	79,872	78	516	$295,338	$907	89%	2.85
Cleveland CH	251,314	82	538	$384,905	$3,067	89%	0.79
Greeneville CH	160,975	87	800	$445,720	$900	98%	2.56
Youngstown CH & FB	52,240	58	402	$352,248	$1,530	70%	1.78
Fresno CH & FB	495,914	92	7,706	$1,971,638	$24,236	92%	2.40

The "aggregate operating cost" metric used in this study is not the same as "total building operating cost." It represents the costs that were available for developing a comparative industry baseline for office buildings. The aggregate operating cost represents the costs that were available for developing a comparative industry baseline for office buildings. The costs include water utilities, energy utilities, general maintenance, grounds maintenance, waste and recycling, and janitorial costs. All three of the buildings that cost more than the baseline in Figure 30 have higher maintenance costs than the baseline, and one has higher energy costs.

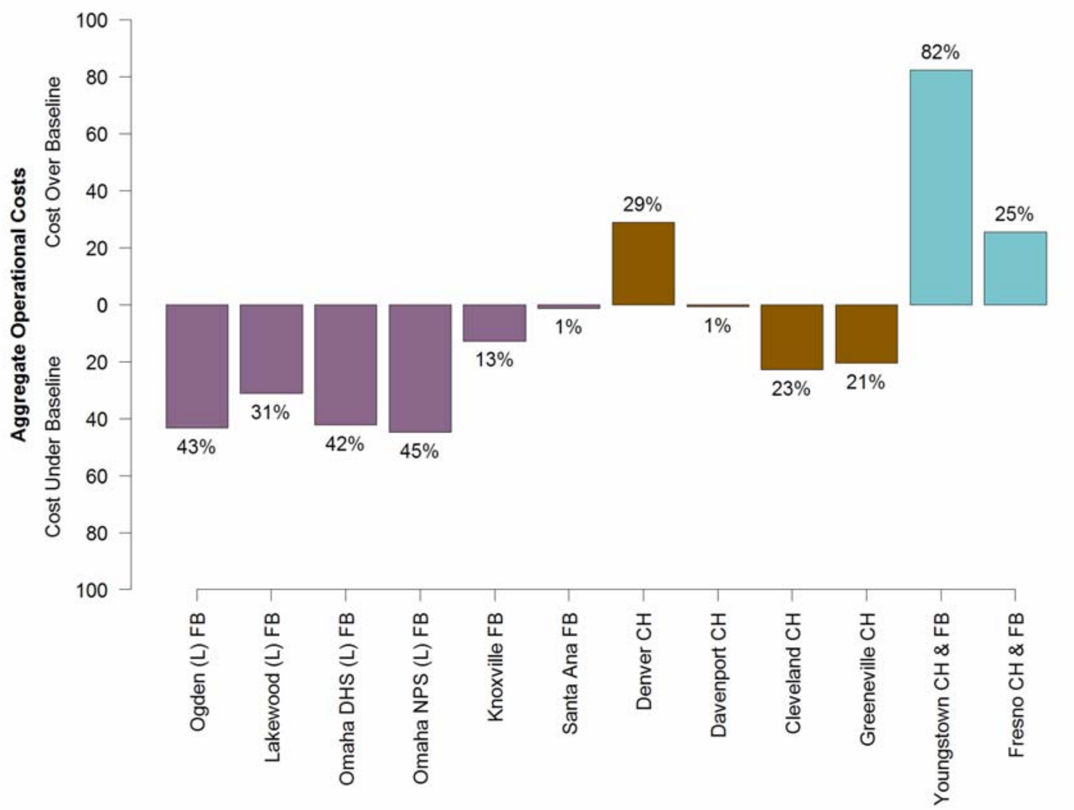


Figure 30. Aggregate operational costs compared to the baseline

Observations

Whole building performance measurement (WBPM) brought forward the interaction between the different metrics. Many comparisons can be made between energy, water, maintenance, and occupant satisfaction. Additional comparisons could include waste generation and commute data, but for this data set no significant findings were evident.

Based on the LEED credits and Energy Star ratings, it was observed that when projects had incorporated sustainable design principles from the start and had included energy savings goals, the overall performance of the building was better than the industry standard. Additionally, the LEED Gold buildings performed consistently well in each metric.

Looking at the detailed SPOT survey results we have already discussed how almost all of the buildings have better than average thermal satisfaction and all of the buildings' energy performance was above the baseline. Figure 31 shows that the building with the lowest thermal comfort satisfaction is the one with the lowest EUI and with maintenance costs more than 50% greater than the baseline.

In the next set of figures, the color of the dot represents the aggregate maintenance cost. The length of the dashed line to the right of the dot represents the general building satisfaction score for the building. Performance better than the baseline by the metrics on the x and y axis are placed to the right and above the baseline lines.

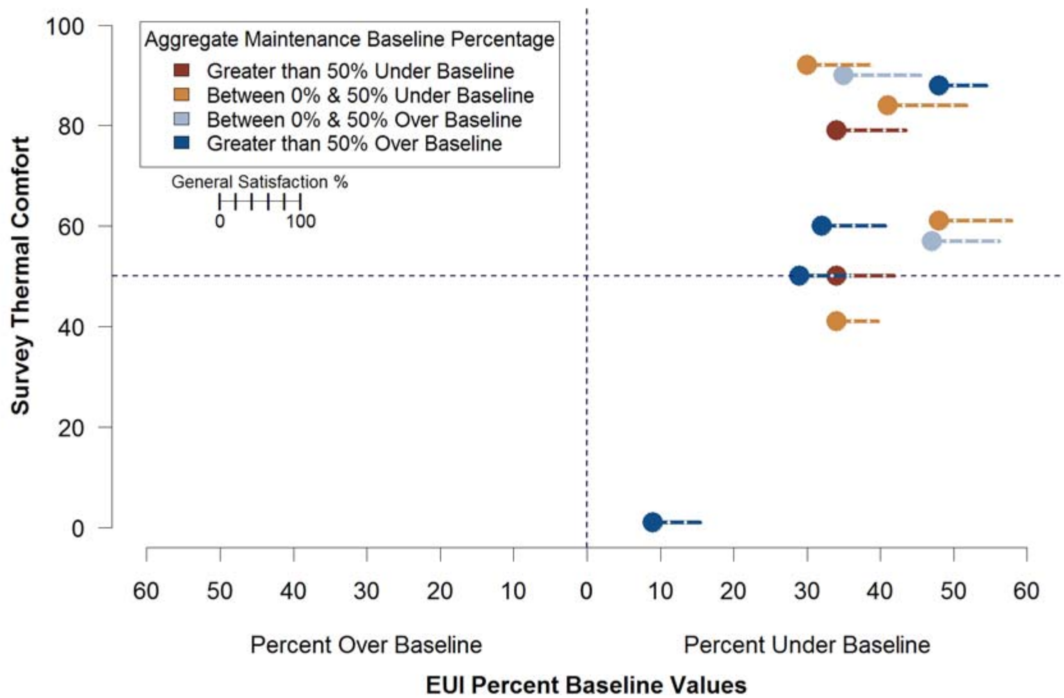


Figure 31. Thermal comfort compared to EUI and maintenance costs

Occupant satisfaction for cleanliness and maintenance was higher than the baseline for all but one building (Figure 32). The building with the lowest satisfaction level had the highest janitorial costs, and maintenance costs that were greater than 50% over the baseline. The operational challenges of the buildings that have lower satisfaction levels and higher costs need to be investigated further before they are judged as good or bad performers.

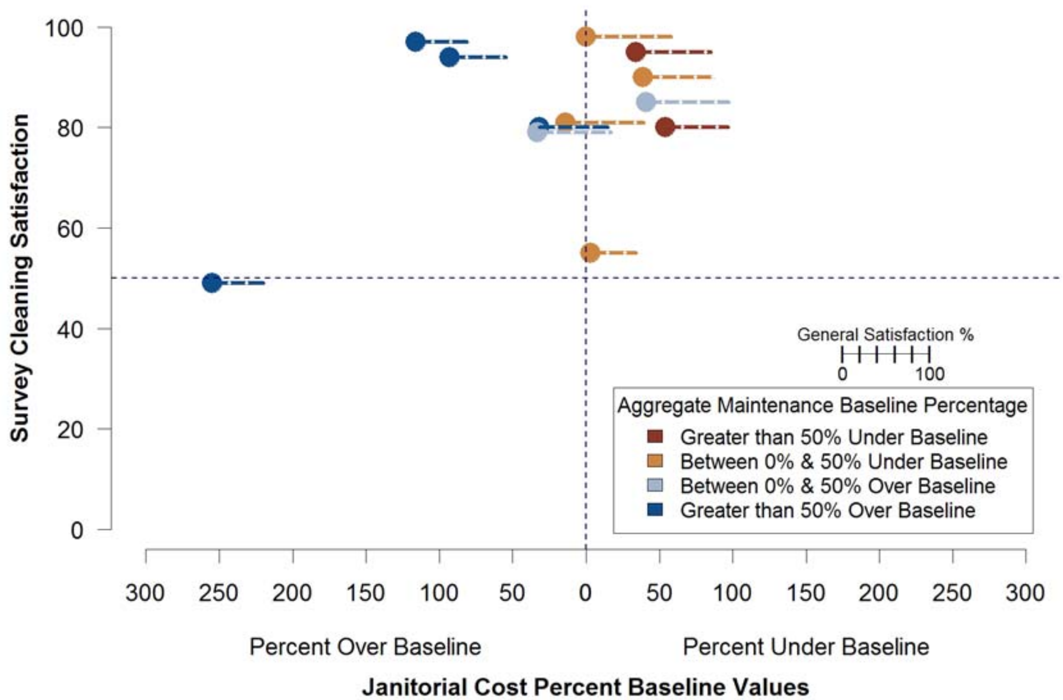


Figure 32. Janitorial cost compared to cleanliness satisfaction score and maintenance costs

Half of the buildings had lighting satisfaction survey responses that were higher than the baseline. The building with the lowest lighting satisfaction level has an aggregate maintenance cost under the baseline by 50% or more. The other building with the low maintenance cost had a lighting satisfaction level above the 50^{th} percentile. Based on the data for the buildings in this study, there does not appear to be a correlation between the energy performance, maintenance cost, and lighting satisfaction scores (Figure 33).

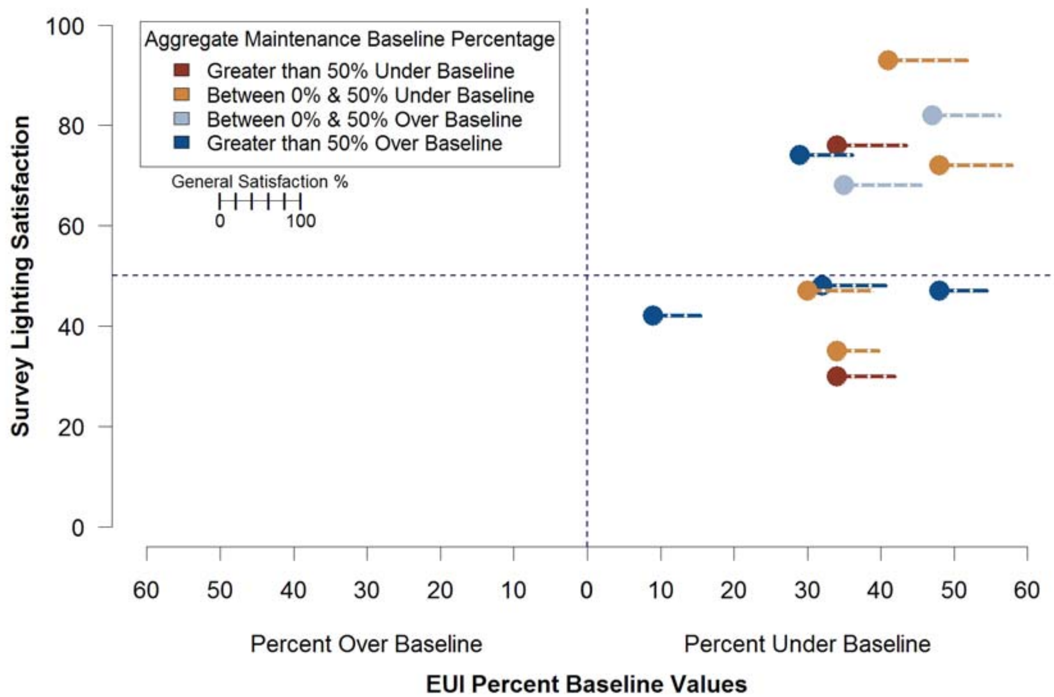


Figure 33. Lighting satisfaction compared to EUI and maintenance costs

Figure 34 offers a summary representation of the energy, water, occupant satisfaction, and aggregate maintenance costs for each of the buildings investigated. All of the energy use intensity (EUI, energy use per gross square foot) values were better than the baseline typical building, two-thirds of the water use intensity (WUI, gallons/occupant) values were better than or at the baseline, all of the occupant satisfaction scores were higher than the 50th percentile (the length of the line represents the percentage satisfaction), and more than half of the buildings have aggregate maintenance costs that are below the baseline.

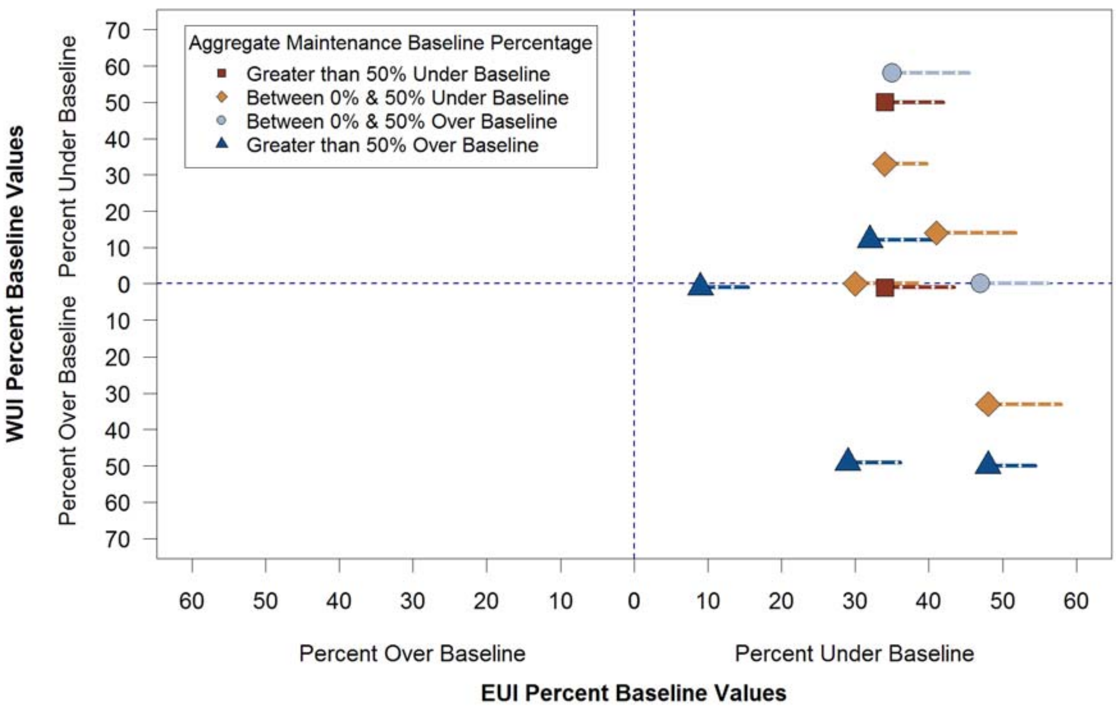


Figure 34. WUI compared to EUI and aggregate maintenance costs

Overall, the GSA sustainably designed buildings investigated under this study cost less to operate, have excellent energy performance, and have occupants who are more satisfied with the overall building than the occupants in typical commercial buildings. On average the office buildings in the study performed 29% better than the CBECS national average for office buildings. All of the buildings performed 29% better than the CBECS regional averages. If the CBECS office buildings average is used as the baseline for all of the buildings, the buildings in the study performed 26% better than average office buildings. When compared to the GSA national goal for energy performance, these buildings perform 14% better. Among the many informative observations derived from the data analysis are the following findings

- Water performance needs further investigation, but estimates have the average domestic water use 3% below the baseline.

- Maintenance, grounds, and janitorial costs vary by location. When combined, average maintenance for these buildings cost 13% less than the average baseline cost.
- Waste disposal costs are less than the baseline.
- Carbon dioxide equivalents for commute miles traveled are lower than the baseline for most buildings.

Lessons Learned and Future Research Opportunities

This study includes almost half of GSA's LEED buildings. This is a respectable representation of the buildings that have been officially identified as being sustainably designed. However, because the sample size of this study is small, it doesn't lend itself to broader inferences for the entire GSA building stock. Nevertheless, the lessons learned may be helpful for future design, construction, and operation of GSA buildings. Measuring the performance of more buildings will allow for a greater understanding of how sustainably designed buildings perform as a group.

Based on the data collection and analysis experiences the following includes future research opportunities and observations of the current data set

- A detailed investigation into the water use for each building would be needed to determine, with any confidence, an accurate understanding of water use.
- Inferences from the regular maintenance and preventative maintenance ratio should be considered speculative unless the more consistent data and details are provided for each metric.
- A more detailed study of individual buildings could be used to determine which design features offer the best value. This type of investigation may be able to show the difference between early design expectations, as-built expectations, and operations. For example, with energy, compare design modeled data, number of LEED credits received, measured energy data, and Energy Star score.
- The ability to collect consistent data from each site is critical for building-to-building comparisons to industry baselines and for building to building comparisons.
- The potential building performance impact needs to be accounted for when there are occupancy changes and/or unplanned uses of the buildings.
- Occupant employer programs for recycling and commute may impact the metric's performance. Therefore, ideally, those programs would be accounted for in the analysis.

The snapshot view of these sustainably designed buildings provides a valuable picture of the overall performance for 1 year's use. This study is an important first step to making inferences about whole building performance. Future work to identify year-to-year variation in whole building performance could improve the accuracy and depth of this assessment. Future analysis would benefit from multiple years of data for each metric in order to be able to average the data and investigate potential trends.

Appendix A: Site Summaries

Members of the research team visited the 14 buildings reviewed under this study and collected a considerable amount of data for each building. The site summaries in this appendix provide an overview for each building and offer site-specific observations. Each site summary includes the following

- building photo
- general building description
- table listing building and site characteristics data
- operation costs compared to baseline costs (graphed)
- occupant satisfaction survey summary results (graphed)
- table summarizing building performance data.

The site summaries are presented in the following order

Region	Building Full Name	Abbreviation
Federal Buildings		
8	Scowcroft Internal Revenue Service Building	**Ogden (L) FB**
8	Department of Transportation Office Building	**Lakewood (L) FB**
6	Department of Homeland Security/INS	**Omaha DHS (L) FB**
6	Carl T. Curtis Midwest Regional Headquarters of the National Park Service	**Omaha NPS (L) FB**
4	John J. Duncan Federal Building	**Duncan FB**
9	Santa Ana Federal Building	**Santa Ana FB**
Courthouse		
8	Alfred A. Arraj United States Courthouse	**Denver CH**
6	Davenport United States Courthouse	**Davenport CH**
5	Howard M. Metzenbaum United States Courthouse	**Cleveland CH**
4	James H. Quillen United States Courthouse	**Greeneville CH**
Courthouse and Federal Building		
5	Frank J. Battisti and Nathaniel R. Jones Federal Building and United States Courthouse	**Youngstown CH & FB**
9	Robert E. Coyle United States Courthouse and Federal Building	**Fresno CH & FB**
Port of Entry		
5	Port of Entry, Sault Sainte Marie, MI	Sault Ste. Marie Port
8	Shared Port-of-Entry, Sweetgrass, MT; Coutts, AB	Sweetgrass Port

The table above shows both the official building name and the name used within the body of this report, which includes building location and type. In this appendix, each site summary is titled using the same name as the body of the report and then the official building name is used throughout the text so that the site is recognizable to those who occupy each building.

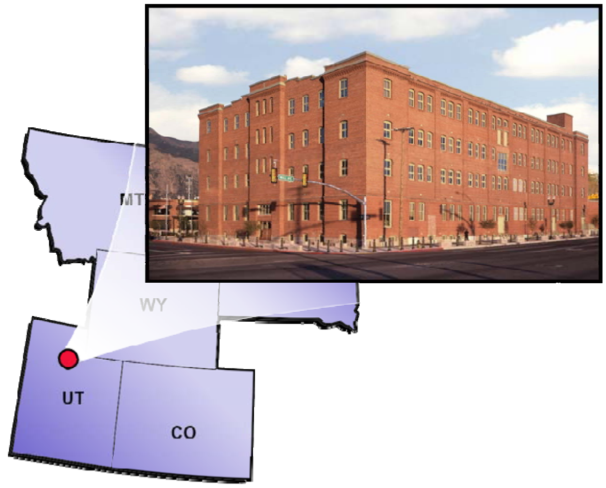
The research team derived the majority of the information summarized in this appendix from site or other General Services Administration (GSA) contacts and databases. For each site, the general building characteristics are summarized in the first table, and the operational data are summarized in the final table.

The costs associated with whole building performance are represented as a percentage above or below the baseline for each metric. The baseline is the industry standard for each metric's cost per gross square foot or occupant. The aggregate operational cost compares the summation of the building's costs to the aggregate baseline costs. "Below the baseline" suggests it costs less to operate the building than the industry standard. The different colors for different buildings are the same colors used in the body of the report.

GSA representatives modified the University of California Berkeley's Center for the Built Environment's (CBE's) occupant satisfaction survey to address the occupant commute questions and GSA specific interests. The survey for this study was called the GSA Sustainable Places and Organizational Trends (SPOT) survey. GSA representatives distributed the survey to building occupants electronically, providing an internet link, and provided a hard copy of the SPOT survey at a few of the buildings where electronic distribution was not available to all occupants. GSA representatives manually entered the hard copy SPOT survey responses into the CBE database so that a summary report could be generated.

The SPOT survey questions offer a numerical response of between -3 and 3. CBE prepares building-specific survey summary reports. These reports provide the average scores for each of the key elements addressed in the survey. In this appendix, the average scores for each key element are provided.

Ogden Federal Building



Description

Prior to its transformation to a four-story office building, the Scowcroft Internal Revenue Service (IRS) Federal Building was a warehouse. The original main staircase and middle stairs have been preserved, and an office suite has been restored.

Building Location:	**105 23rd Street**	
	Ogden Utah 84401-1306	
Building Function:	**Federal Building**	
Project Type:	**Renovation**	**5** *floors*
Design Recognition:	**LEED-NC, v.2/v.2.1--Level: Silver (33 points)**	
Year Built	**1900**	*renovated:* **2004**
Gross Square Foot:	**105,000**	
Rentable Square Foot:	**102,579**	
Hours of Operation:	**120**	
Regular Occupants:	**514**	
Occupant Visitor Equiv.	**521**	
Electronic Equipment:	**745**	
Total Project Cost:	**$11,442,705**	
Construction Cost:	**n/a**	

The original stone foundation is visible in the basement. The renovation cost included costly earthquake prevention upgrades and tenant specific requests. The building had been abandoned for years, had two previous fires, and had become a “sanctuary” for the homeless and birds. The fire damage was removed using cornmeal as a “sand blaster” to eliminate dust issues. Upon reconstruction of the facility, the tenant needed to transform unconditioned storage space into usable office space.

The Scowcroft Federal Building remodel incorporated improved roof insulation, radiant baseboard heating, variable speed condensers, and improved lighting power density. The underfloor air distribution system was coupled with indirect/direct evaporative cooling. These systems allowed for increased ventilation effectiveness and temperature controllability for nonperimeter spaces. Presently, the building and operates 22 hours a day, 350 days a year. Office space includes a high number of cubicles with varying heights (6 to 10 feet).

Each building in the study had operational highlights and potential opportunities for improvement. Although it was not the focus of this study to investigate and/or document operational highlights and opportunities, the research team observed the following:

- Based on the CBE survey results, it appears that issues exist with thermal comfort, daylighting, lighting, cleanliness and maintenance, and acoustics. Interviews of occupants regarding these issues may result in a more detailed understanding of how operations might be adjusted to improve occupant satisfaction.

- Separately metering the process water would allow for the comparison of Scowcroft Federal Building domestic water use to a comparable baseline. Once measured domestic water use data are available, potential water conservation opportunities could be identified.

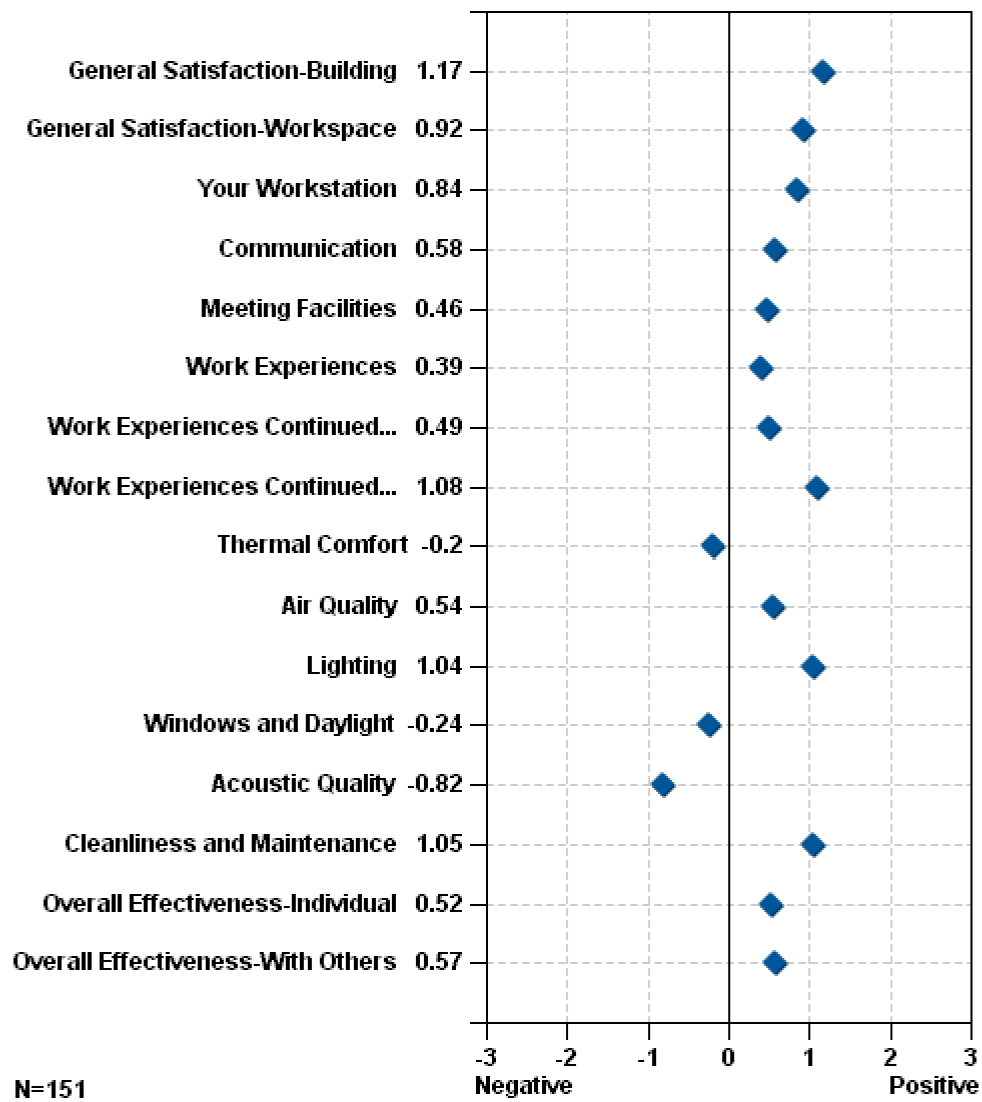
- The building landscaping is minimal, but attractive. The size of the landscaped space and the choices of plants offer a balance between attractive and environmentally sensitive landscaping.

Whole Building Performance

The costs of operating the Scowcroft Federal Building are lower than the industry baseline for energy, water, waste, general maintenance, and janitorial costs. The recycling costs are slightly higher than the industry baseline. Overall, the building costs less to operate than a baseline building.

Occupant Satisfaction Survey

All 514 of the Scowcroft Federal Building occupants were surveyed and 151 responded. In addition to the electronic survey, GSA representatives issued the survey in hardcopy form because many staff did not have electronic access to the survey. The results indicated that occupants are generally more satisfied with their building than occupants in the CBE baseline (52nd percentile). The acoustic quality, thermal comfort, and lighting all scored below the 50th percentile of the CBE buildings surveyed. Cleanliness and maintenance scored above the 50th percentile, but it was the lowest score for all of the GSA buildings in the study. Frequently clogged toilets were identified as a persistent maintenance issue, and a large number of snack tables located throughout the building may be impacting the occupant satisfaction ratings.



Performance Data Summary

The research team collected, normalized, and compared the whole building performance data for the Scowcroft Federal Building to industry baselines. The following table summarizes the annual performance data that were collected and normalized. The facility uses evaporative cooling for its air conditioning system; therefore, the amount of water used for evaporative cooling was estimated using the "rule-of-thumb" that 27% of total water use is process water.

Metrics	Annual Performance Measurements	Annual Reporting Metrics
		
		
		
		
		
		(metric tons CO_2 equiv) ***1.87***

Lakewood Federal Building

Description

The Lakewood Department of Transportation (DOT) Federal Building is a leased facility designed by Opus Architects and Engineers, Incorporated. This LEED Silver-certified building incorporated low-emitting materials, adhesives, and sealants; daylight and views in 91% of regularly occupied spaces; and recycled content materials. Seventy-two percent of the building materials were manufactured locally, and 41% of the materials were harvested locally. Additional features include light and motion sensors, air-side economizers, and carbon dioxide (CO_2) monitors. Although the building is located on a large plot of land in a suburban community outside of Denver, a portion of the landscape is xeriscape.

Building Location:	**12300 W. Dakota Ave.**	
	Lakewood Colorado 80228-2583	
Building Function:	**Federal Building**	
Project Type:	**New**	**3** *floors*
Design Recognition:	**LEED-NC Silver 2004**	
Year Occupied	**2004**	
Gross Square Foot:	**128,342**	
Rentable Square Foot:	**122,225**	
Hours of Operation:	**70**	
Regular Occupants:	**318**	
Occupant Visitor Equiv.	**336**	
Electronic Equipment:	**383**	
Total Project Cost:	**$25,108,301**	
Construction Cost:	**n/a**	

All building occupants received a booklet about the design and operations of the building. The building was designed to house 400 occupants and currently has 318 occupants.

Each building in the study had operational highlights and potential opportunities for improvement. Although it was not the focus of this study to investigate and/or document operational highlights and opportunities, the research team observed the following:

- The educational booklet for the building occupants was a noteworthy approach to engaging the occupants in assessing the performance of the building.

- The formal system for tracking service calls is not being regularly utilized. Using the service call tracking system is recommended to identify maintenance trends, and to anticipate future maintenance needs.

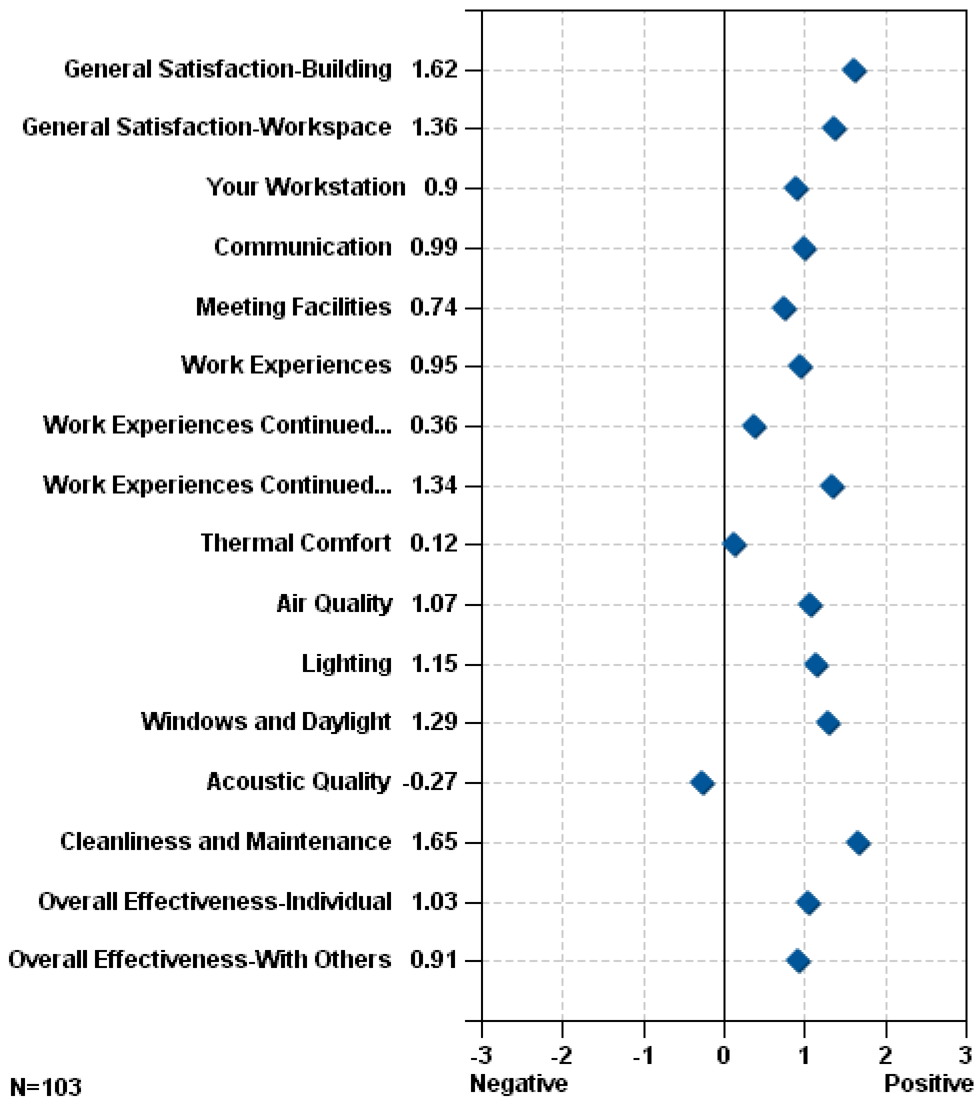
- Based on the CBE survey results, issues appear to exist with acoustics, air quality, and lighting. Interviews of occupants regarding these issues may result in a more detailed understanding of how operations might be adjusted to improve occupant satisfaction.

Whole Building Performance

The Lakewood Federal Building energy and water costs are slightly higher than the industry baseline; however, the aggregate maintenance and waste costs are lower than the industry baseline. There is no direct cost associated with the recycling program. Overall, the building costs less to operate than a baseline building.

Occupant Satisfaction Survey

Of the 318 occupants in the building, 250 were surveyed and 103 responded. The result indicated that occupants of the Lakewood Federal Building are more satisfied with their building than occupants in the CBE baseline (79th percentile). Acoustic quality, air quality, and lighting all scored below the 50th percentile of the CBE buildings surveyed. Note that daylighting and access to views was a design highlight, yet the occupant satisfaction survey results do not indicate the daylighting and views is perceived as above average. Cleanliness and maintenance and thermal comfort scored above the 50th percentile.

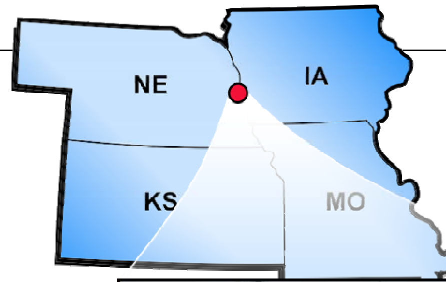


Performance Data Summary

The research team collected, normalized, and compared the whole building performance data for the Lakewood DOT Federal Building to industry baselines. The following table summarizes the annual performance data collected and normalized. The facility uses water-cooled chillers for its air-conditioning system; therefore, the cooling tower water use was estimated using the "rule-of-thumb" that 27% of total water use is process water. Outdoor water use was estimated using the "rule-of-thumb" that 20% of total water use is for landscaping.

Metrics	Annual Performance Measurements		Annual Reporting Metrics	
	Water Use (gal)	*4,340,000*	Gallons per occupant	*5,185*
	Process Water Use (gal)	*1,171,800*	Water Cost per occupant	*$27.61*
	Outdoor Water Use (gal)	*868,000*	Gallons per GSF	*26.42*
	Water Cost	*$18,056*	Water Cost per GSF	*$0.15*
	Energy Star Score	*80*	Energy Use (kBTU) per GSF	*70*
	Energy Cost	*$6,992*	Energy Cost per GSF	*$2.00*
			Energy Emissions per building (metric tons CO_2 equiv)	*2,150*
	General Maintenance Cost	*$103,644*	General Maint Cost per RSF	*$0.85*
	Janitorial Services Cost	*$83,220*	Janitorial Services Cost per RSF	*$0.68*
	Grounds Maintenance Cost	*$7,394*	Grounds Maint Cost per RSF	*$0.06*
	Quantity of Maint Requests	*25*	Ratio of Maint Requests to Total Maintenance Jobs	*0.05*
	Quantity of Prev Maint Jobs	*528*		
	Solid Waste Generated (tons)	*374*	Solid Waste (lb) per occupant	*9.41*
	Solid Waste Cost	*$3,600*	Solid Waste Cost per RSF	*$0.03*
	Quantity Recycled (tons)	*204*	Solid Waste Cost per occupant	*$10.71*
	Recycling Cost	*$0*	Ratio of Recycled to Solid Waste	*0.55*
	Survey # of Invitees	*250*		
	Survey # of Respondents (n)	*103*	Survey Return Rate	*41%*
	Commute Miles per occ (avg)	*23*	Commute Emissions per occ (metric tons CO_2 equiv)	*1.86*
	Commute fuel per occ (avg gal)	*201*		

Omaha DHS Federal Building



Description

The Omaha Department of Homeland Security (DHS) Federal Building was designed to accommodate the varying needs of multiple DHS agencies and is the central facility for all immigration services. The LEED Gold certified building uses a ground source heat pump system, and in combination with the building envelope and daylight-harvesting system, the building energy model predicted a 66% energy reduction over ASHRAE 90.1-1999. The use of rainwater-harvesting system, and low-flow and auto-flow lavatory fixtures resulted in a projected an aggregate water use reduction of 77% as compared to the Energy Policy Act of 1992 requirements. Green Seal janitorial products are used consistently throughout the building. The building recently won the 2007 American Council of Engineering Award for its design.

Building Location:	**1717 Avenue H**	
	Omaha Nebraska 68110-2752	
Building Function:	**Federal Building**	
Project Type:	**New**	**1** *floors*
Design Recognition:	**LEED-NC Gold**	
Year Occupied	**2005**	
Gross Square Foot:	**86,000**	
Rentable Square Foot:	**73,459**	
Hours of Operation:	**112**	
Regular Occupants:	**65**	
Occupant Visitor Equiv.	**360**	
Electronic Equipment:	**80**	
Total Project Cost:	**n/a**	
Construction Cost:	**n/a**	

The majority of the building square footage is devoted to detention, courthouse, public, or unoccupied space. The occupied office portion of the building consumes approximately 40% of the gross square footage.

Each building in the study had operational highlights and potential opportunities for improvement. Although it was not the focus of this study to investigate and/or document operational highlights and opportunities, the research team observed the following:

- The rainwater-harvesting system is an innovative concept that has the potential of eliminating potable water use for landscaping and water closets. Erosion from the construction fill and clogged filters from the roof runoff have resulted in maintenance challenges with the system. Investigating strategies to address the current maintenance and operations issues and communicating the lessons learned from this design and operations challenge will improve future implementation of rainwater-harvesting systems.

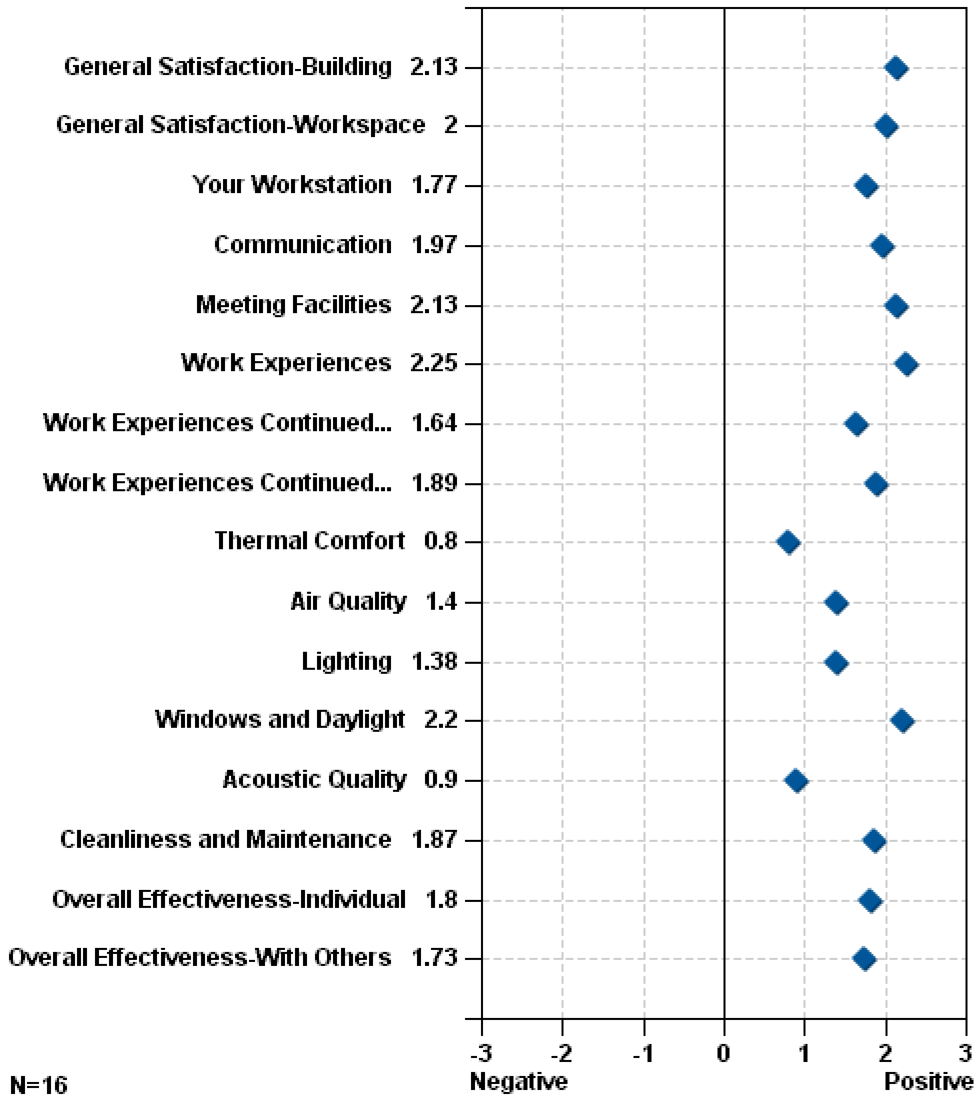
- The ground source heat pump system (GSHP) is innovative as well, resulting in a low energy use intensity for the building. Connecting the high level of satisfaction with the building's thermal comfort (90th percentile on the CBE Survey) enhances that success. Communicating this operational success improves the chances of the GSHP technology being implemented effectively on future building projects.

Whole Building Performance

The Omaha DHS Federal Building operating costs are lower than the industry baseline for energy, water, waste, janitorial, and grounds maintenance costs. The general maintenance and recycling costs were not provided for the study. Overall, the building costs less to operate than a baseline building.

Occupant Satisfaction Survey

Of the 65 regular occupants in the Omaha DHS Federal Building, 18 were surveyed and 16 responded. It is unknown why such a small percentage of the occupants were invited to take the survey. The survey results indicated that building occupants are significantly more satisfied with their building than occupants in the CBE baseline (95th percentile). Acoustic quality, air quality, cleanliness and maintenance, and thermal comfort scored in the 85th percentile or above. Occupant satisfaction with lighting scored in the 68th percentile, which is in the top half of the buildings in this study.

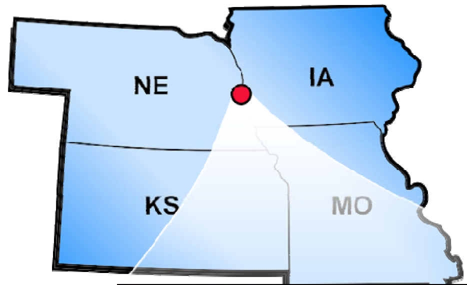


Performance Data Summary

The research team collected, normalized, and compared the whole building performance data for the Omaha DHS Federal Building to industry baselines. The following table summarizes the annual performance data that were collected and normalized. The rainwater-harvesting system that was intended for landscaping and nonpotable water use, was not functioning properly at the time of the site visit. No outdoor potable water use was estimated because researchers assumed that the system was functioning during the period of time that water use data were collected and that the system would be repaired.

Metrics	Annual Performance Measurements		Annual Reporting Metrics	
	Water Use (gal)	*1,392,123*	Gallons per occupant	*3,276*
	Cooling Tower Water Use (gal)	-	Water Cost per occupant	*$8.86*
	Outdoor Water Use (gal)	-	Gallons per GSF	*16.19*
	Water Cost	*$3,765*	Water Cost per GSF	*$0.05*
	Energy Star Score	*85*	Energy Use (kBTU) per GSF	*50*
	Energy Cost	*$4,333*	Energy Cost per GSF	*$0.92*
			Energy Emissions per building (metric tons CO_2 equiv)	*1,168*
	General Maintenance Cost	*n/a*	General Maint Cost per RSF	*n/a*
	Janitorial Services Cost	*$70,800*	Janitorial Services Cost per RSF	*$0.96*
	Grounds Maintenance Cost	*$8,200*	Grounds Maint Cost per RSF	*$0.11*
	Quantity of Maint Requests	*150*		
	Quantity of Prev Maint Jobs	*240*	Ratio of Maint Requests to Total Maintenance Jobs	*0.38*
	Solid Waste Generated (tons)	*113*	Solid Waste (lb) per occupant	*13.85*
	Solid Waste Cost	*$2,400*	Solid Waste Cost per RSF	*$0.03*
	Quantity Recycled (tons)	*24*	Solid Waste Cost per occupant	*$6.67*
	Recycling Cost	*n/a*	Ratio of Recycled to Solid Waste	*0.21*
	Survey # of Invitees	*18*		
	Survey # of Respondents (n)	*16*	Survey Return Rate	*89%*
	Commute Miles per occ (avg)	*30*		
	Commute fuel per occ (avg gal)	*225*	Commute Emissions per occ (metric tons CO_2 equiv)	*2.09*

Omaha NPS Federal Building



Description

The Carl T. Curtis Midwest Regional National Park Service (NPS) Headquarters Federal Building in Omaha was built on a brownfield as part of an urban redevelopment effort. This LEED Gold-certified building uses passive solar design; daylighting for 75% of building occupants; daylight harvesting; lightshelves; high-efficiency windows; heating, ventilation, and air-conditioning (HVAC) occupancy sensors; and underfloor air distribution. Use of native and adaptive vegetation eliminated the need for irrigation water, and use of a composting toilet, waterless urinals, low-flow fixtures, and water-efficient appliances resulted in a projected reduction of 39% of potable water use.

Building Location:	**601 Riverfront Drive**	
	Omaha Nebraska 68102-4226	
Building Function:	**Federal Building**	
Project Type:	**New**	**3** *floors*
Design Recognition:	**LEED --NC, v.2/v.21 --Level: Gold (40 points)**	
Year Occupied	**2004**	
Gross Square Foot:	**68,000**	
Rentable Square Foot:	**62,772**	
Hours of Operation:	**70**	
Regular Occupants:	**125**	
Occupant Visitor Equiv.	**134**	
Electronic Equipment:	**140**	
Total Project Cost:	**n/a**	
Construction Cost:	**$8,500,000**	

The building occupants are aware of the "green" building features and were involved in selecting the office furniture. To minimize materials during construction, the building has exposed concrete interior walls and beams. Operation of the facility incorporates green janitorial practices.

Each building in the study had operational highlights and potential opportunities for improvement. Although it was not the focus of this study to investigate and/or document operational highlights and opportunities, the research team observed the following:

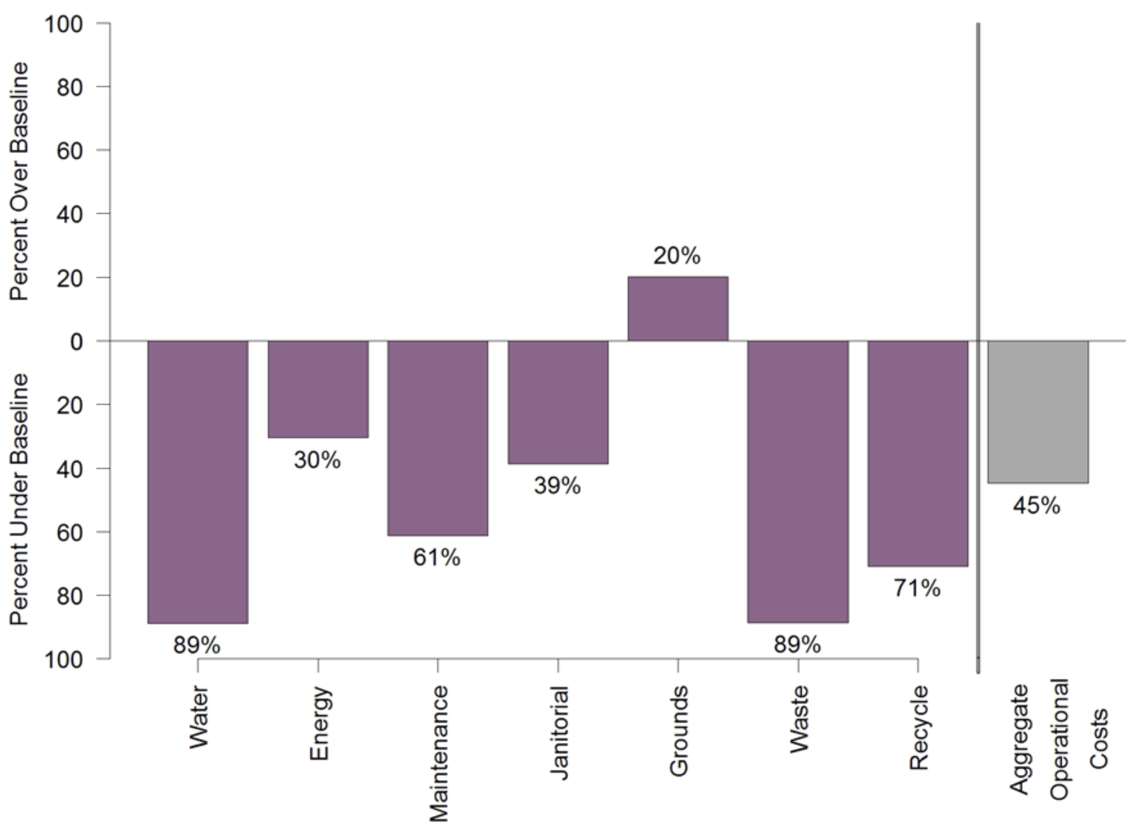
- In an open office layout, it is important to offer small meeting spaces for staff to schedule and conduct impromptu meetings. The acoustic quality CBE score for the Omaha NPS was the lowest of all the buildings in the study and well below the average building at the 9th percentile. Identifying opportunities to increase alternative locations for staff to convene and investigating sound-masking technologies may improve the occupants' perception of the building's acoustic quality.

- Reclaiming a brownfield site and contributing to Omaha's riverfront redevelopment efforts were impressive land-use strategies. Staff may have initially commented that the location was not as convenient as the downtown location from a transportation perspective, but the use of mass transit and carpooling is less than the industry average and on par with the expectations for a community of Omaha's size.

- Although considerable thought went into the daylighting design features, the CBE survey lighting score was below the 50th percentile. Interviews of the occupants regarding these issues may result in a more detailed understanding of how operations might be adjusted to improve occupant satisfaction.

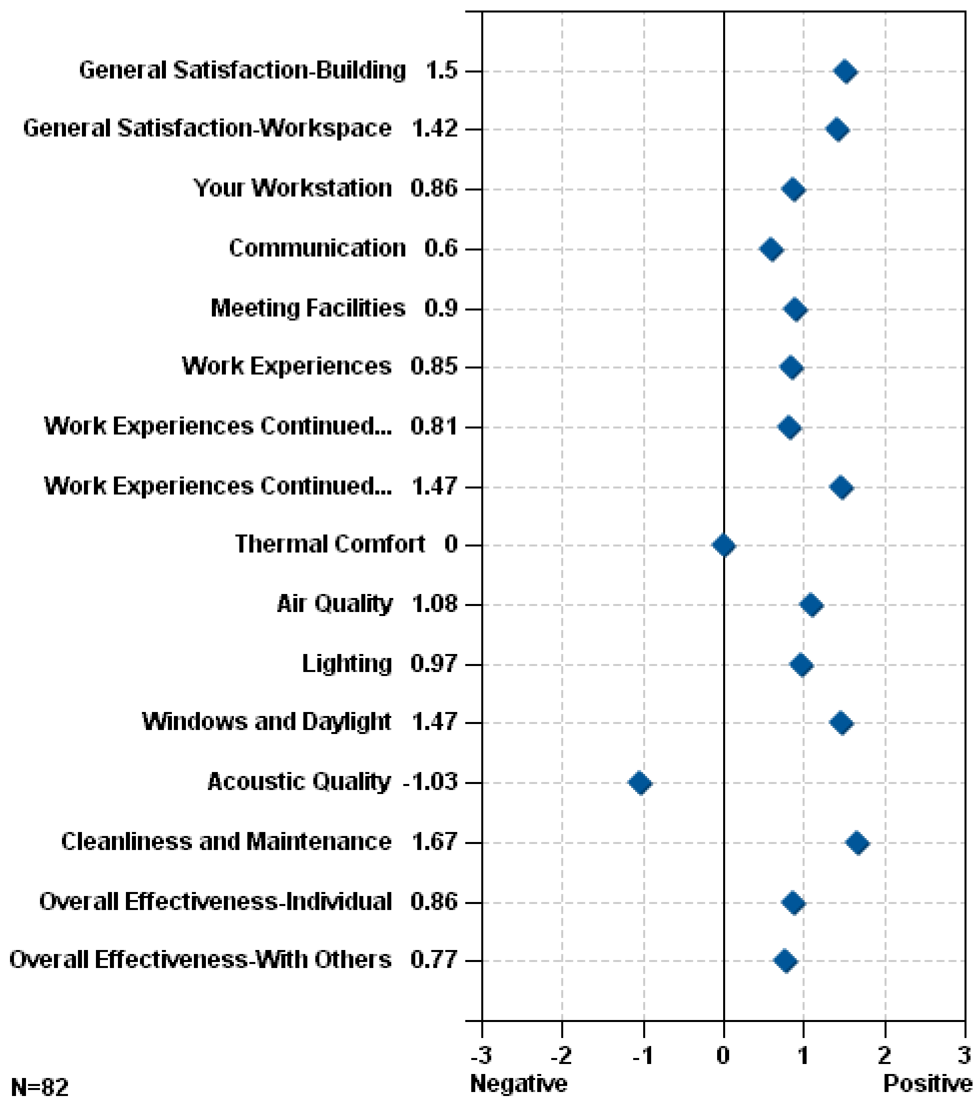
Whole Building Performance

The Omaha NPS operating costs are lower than the industry baseline for all of the key metrics except grounds maintenance. Overall, the building costs less to operate than a baseline building.



Occupant Satisfaction Survey

Of the 125 regular occupants in the Omaha NPS Federal Building, 120 were surveyed and 82 responded. The results indicated that building occupants are more satisfied with their building than occupants in the CBE baseline (72nd percentile). Acoustic quality scored at the 9th percentile of the CBE buildings database, which was the lowest score of all the buildings in the study. Lighting scored at the 30th percentile, which was one of the lowest of the buildings in the study. Thermal comfort, air quality, and cleanliness and maintenance scored at or above the 50th percentile.



Performance Data Summary

The research team collected, normalized, and compared the whole building performance data for the Omaha NPS Federal Building to industry baselines. The following table summarizes the annual performance data collected and normalized.

Metrics	Annual Performance Measurements		Annual Reporting Metrics	
	Water Use (gal)	*246,092*	Gallons per occupant	*950*
	Process Water Use (gal)	-	Water Cost per occupant	*$3.24*
	Outdoor Water Use (gal)	-	Gallons per GSF	*3.62*
	Water Cost	*$839*	Water Cost per GSF	*$0.01*
	Energy Star Score	*86*	Energy Use (kBTU) per GSF	*65*
	Energy Cost	*$3,023*	Energy Cost per GSF	*$1.08*
			Energy Emissions per building (metric tons CO_2 equiv)	*872*
	General Maintenance Cost	*$41,600*	General Maint Cost per RSF	*$0.66*
	Janitorial Services Cost	*$56,400*	Janitorial Services Cost per RSF	*$0.90*
	Grounds Maintenance Cost	*$9,050*	Grounds Maint Cost per RSF	*$0.14*
	Quantity of Maint Requests	*180*	Ratio of Maint Requests to Total Maintenance Jobs	*0.62*
	Quantity of Prev Maint Jobs	*109*		
	Solid Waste Generated (tons)	*562*	Solid Waste (lb) per occupant	*35.94*
	Solid Waste Cost	*$1,500*	Solid Waste Cost per RSF	*$0.02*
	Quantity Recycled (tons)	*11*	Solid Waste Cost per occupant	*$11.19*
	Recycling Cost	*$1,020*	Ratio of Recycled to Solid Waste	*0.02*
	Survey # of Invitees	*120*		
	Survey # of Respondents (n)	*82*	Survey Return Rate	*68%*
	Commute Miles per occ (avg)	*21*	Commute Emissions per occ (metric tons CO_2 equiv)	*1.70*
	Commute fuel per occ (avg gal)	*184*		

Knoxville Federal Building

Description

The John J. Duncan Federal Building was remodeled in 2005, incorporating a new energy management system, high-efficiency lighting, motion sensors, variable frequency drives, enhanced metering, low-flow fixtures, and a 1400-gallon rainwater catchment system to increase both energy and water efficiency in the facility. The roof meets emissivity requirements to reduce heat the island effect, and houses solar lighting panels to power the roof lights. The steel-framed building has a curved front that includes a generous amount of glass in and above the entrance. The interior has an acoustic-tile ceiling and recessed fluorescent lighting, marble floors in the public areas and carpet in the private offices.

Building Location:	**710 Locust Street**
	Knoxsville Tennessee 37902-2540
Building Function:	**Federal Building**
Project Type:	**Renovation** **8** *floors*
Design Recognition:	**LEED EB Silver 2007, Energy Star 2005, 2007, BOMA - Southern Region Earth Award**
Year Built	**1986** *renovated:* **2005**
Gross Square Foot:	**172,684**
Rentable Square Foot:	**120,171**
Hours of Operation:	**65**
Regular Occupants:	**285**
Occupant Visitor Equiv.	**310**
Electronic Equipment:	**285**
Renov Project Cost:	**$269,000**
Renov Construction Cost:	**n/a**

The facility is located in downtown Knoxville and currently houses eight federal agencies. A small café is on the first floor and is used by many of the tenants. Operation of the facility incorporates a low-impact cleaning and pest-management policy and management encourages tenants to use public transit and alternative forms of transportation.

Each building in the study had operational highlights and potential opportunities for improvement. Although it was not the focus of this study to investigate and/or document operational highlights and opportunities, the research team observed the following:

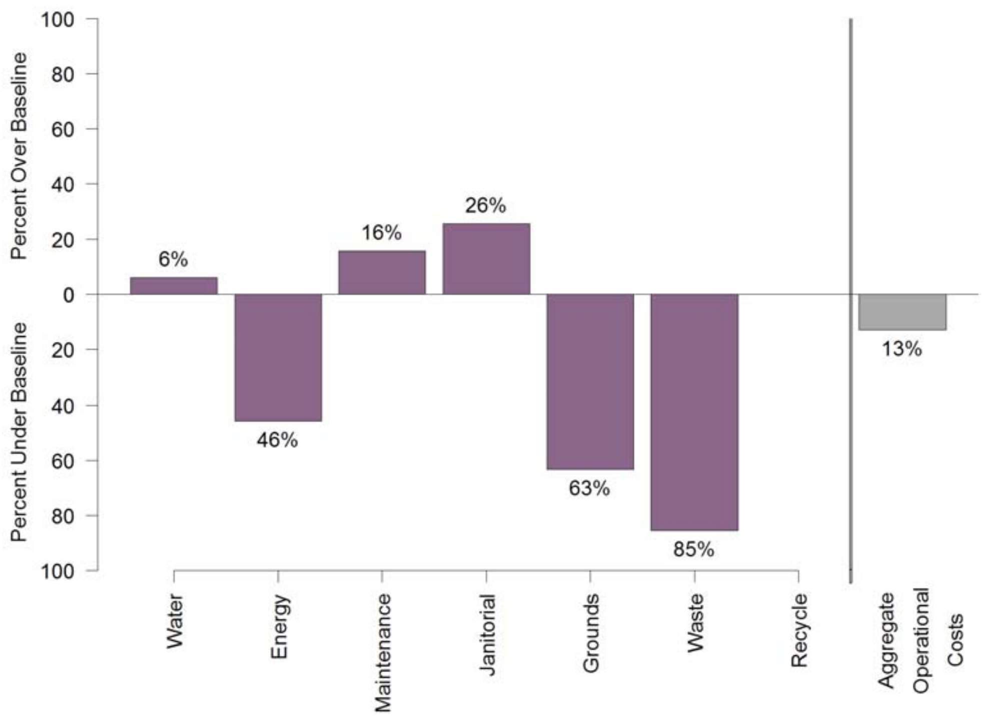
- Although the Duncan Federal Building structure blends in with the other federal and state buildings it is near, the landscaping was very attractive with trees, shrubs, groundcover, and minimal grass. In addition to the landscaping being attractive, it is environmentally sensitive because it uses no potable water.

- The proximity of the bus stop to the building offers staff an opportunity not seen at many of the other buildings in this study: an easy commute via public transportation. Only 4% of those responding to the survey claimed they use the public transportation system. The availability of underground parking may have an impact on the incentive to use public transportation.

- The fact that many of the building occupants are not in the building every day may offer energy-management opportunities for the unoccupied spaces. Investigating whether occupant computers can be turned off when occupants are not present could reduce plug load and heat gain within the building.

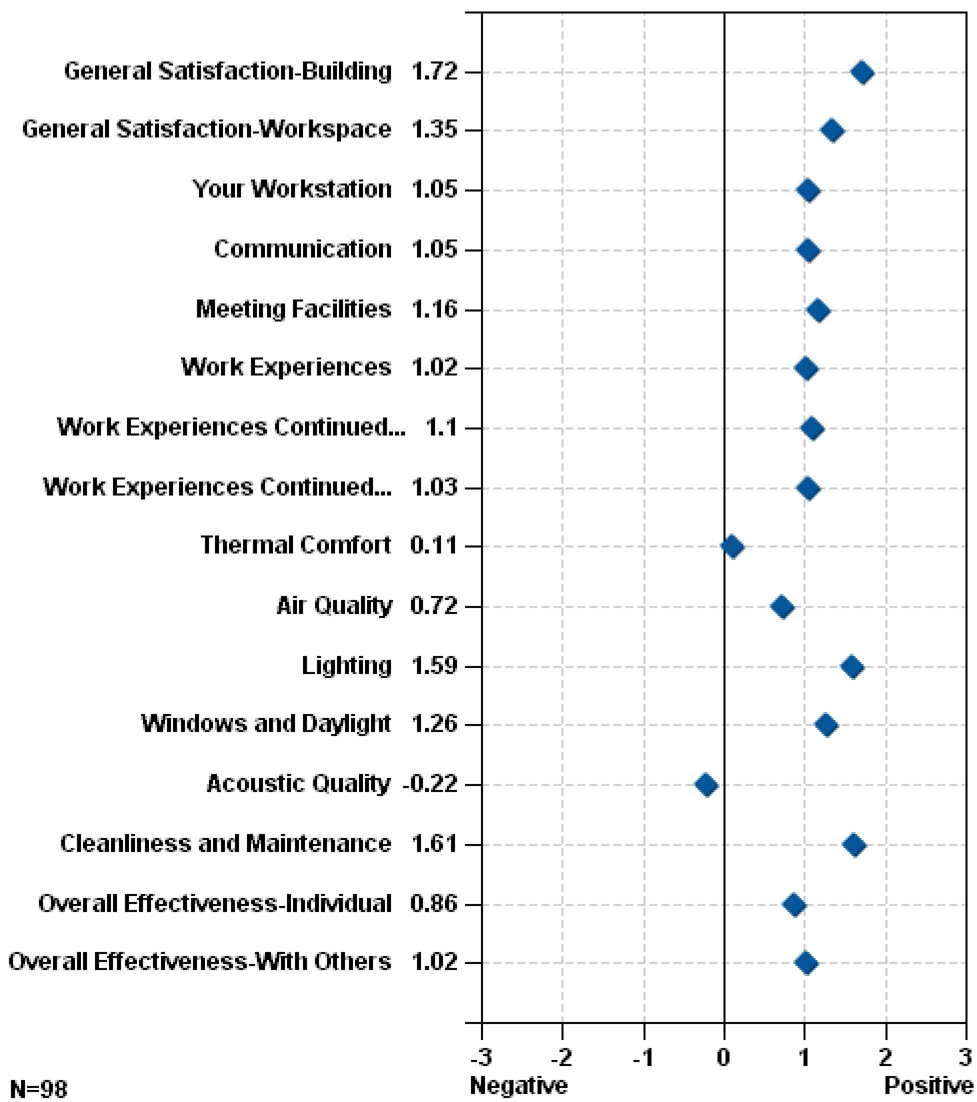
Whole Building Performance

The Duncan Federal Building operating costs are lower than the industry baseline for energy, water, and waste costs, and slightly higher for general maintenance and janitorial costs. When personnel from the Office of Surface Mines are working in the field and returning to the building, there are increased janitorial responsibilities because of dirty floors. There is no cost for operating the recycling program. Overall, the building costs less to operate than a baseline building.



Occupant Satisfaction Survey

Of the 285 occupants in the Duncan Federal Building, 275 were surveyed and 98 responded. In addition to the electronic survey, GSA representatives issued the survey in hard-copy form to increase the response rate. Survey results indicated that the occupants of the Duncan Federal Building are more satisfied with their building than occupants in the CBE baseline (84th percentile). The acoustic quality score is at the 50th percentile of all buildings surveyed by CBE. In the remainder of the categories, the Duncan Federal Building rated above the buildings in the CBE database.

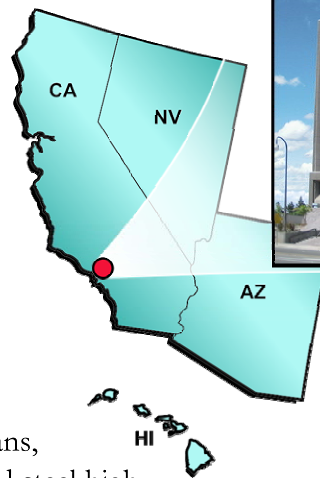


Performance Data Summary

The research team collected, normalized, and compared whole building performance data for the Duncan Federal Building to industry baselines. The following table summarizes the annual performance data collected and normalized. The facility uses water-cooled chillers for its air-conditioning system; therefore, the cooling tower water use was estimated using the "rule-of-thumb" that 27% of total water use is process water.[32]

Metrics	Annual Performance Measurements		Annual Reporting Metrics	
	Water Use (gal)	*2,027,222*	Gallons per occupant	*1,769*
	Process Water Use (gal)	*547,350*	Water Cost per occupant	*$25.72*
	Outdoor Water Use (gal)	*-*	Gallons per GSF	*6.09*
	Water Cost	*$15,302*	Water Cost per GSF	*$0.13*
	Energy Star Score	*91*	Energy Use (kBTU) per GSF	*48*
	Energy Cost	*$6,559*	Energy Cost per GSF	*$0.96*
			Energy Emissions per building (metric tons CO_2 equiv)	*1,516*
	General Maintenance Cost	*$237,836*	General Maint Cost per RSF	*$1.98*
	Janitorial Services Cost	*$220,948*	Janitorial Services Cost per RSF	*$1.84*
	Grounds Maintenance Cost	*$5,300*	Grounds Maint Cost per RSF	*$0.04*
	Quantity of Maint Requests	*660*	Ratio of Maint Requests to Total Maintenance Jobs	*0.16*
	Quantity of Prev Maint Jobs	*3,541*		
	Solid Waste Generated (tons)	*41*	Solid Waste (lb) per occupant	*1.14*
	Solid Waste Cost	*$4,380*	Solid Waste Cost per RSF	*$0.04*
	Quantity Recycled (tons)	*20*	Solid Waste Cost per occupant	*$14.13*
	Recycling Cost	*-*	Ratio of Recycled to Solid Waste	*0.51*
	Survey # of Invitees	*275*		
	Survey # of Respondents (n)	*96*	Survey Return Rate	*35%*
	Commute Miles per occ (avg)	*29*	Commute Emissions per occ (metric tons CO_2 equiv)	*2.15*
	Commute fuel per occ (avg gal)	*232*		

Santa Ana Federal Building



Description

The Santa Ana Federal Building was remodeled in 2005, incorporating new lighting and HVAC systems, a new roof, variable frequency drives, energy-efficient elevators, occupancy temperature control, and light-level sensors. All major commodities used in the building are recycled, including plastic, glass, cans, batteries, paper, and cardboard. A concrete and steel high-rise building originally built in 1975, the Santa Ana Federal Building is located in the heart of the civic center district. The landscaping requires minimal maintenance and attractive.

Building Location:	**34 Civic Center Plaza**			
	Santa Ana	**Californi**	**92701-4025**	
Building Function:	**Federal Building**			
Project Type:	**Renovation**		**10** *floors*	
Design Recognition:	**None**			
Year Built	**1975**	*renovated:*	**2005**	
Gross Square Foot:	**280,365**			
Rentable Square Foot:	**205,378**			
Hours of Operation:	**70**			
Regular Occupants:	**409**			
Occupant Visitor Equiv.	**459**			
Electronic Equipment:	**424**			
Renov Project Cost:	**$27,864,000**			
Renov Construction Cost:	**$26,875,000**			

The building currently houses five federal agencies. One of those offices serves approximately 300 customers daily and another office processes 75 to 100 detainees daily. The family-owned, full-service restaurant has an estimated 250 to 300 customers per day.

Each building in the study had operational highlights and potential opportunities for improvement. Although it was not the focus of this study to investigate and/or document operational highlights and opportunities, the research team observed the following:

- The Santa Ana Federal Building has a low energy use intensity and thus is performing well from an energy performance perspective. Applying for an Energy Star rating and/or LEED Existing Building certification would formally document the impact of this building.

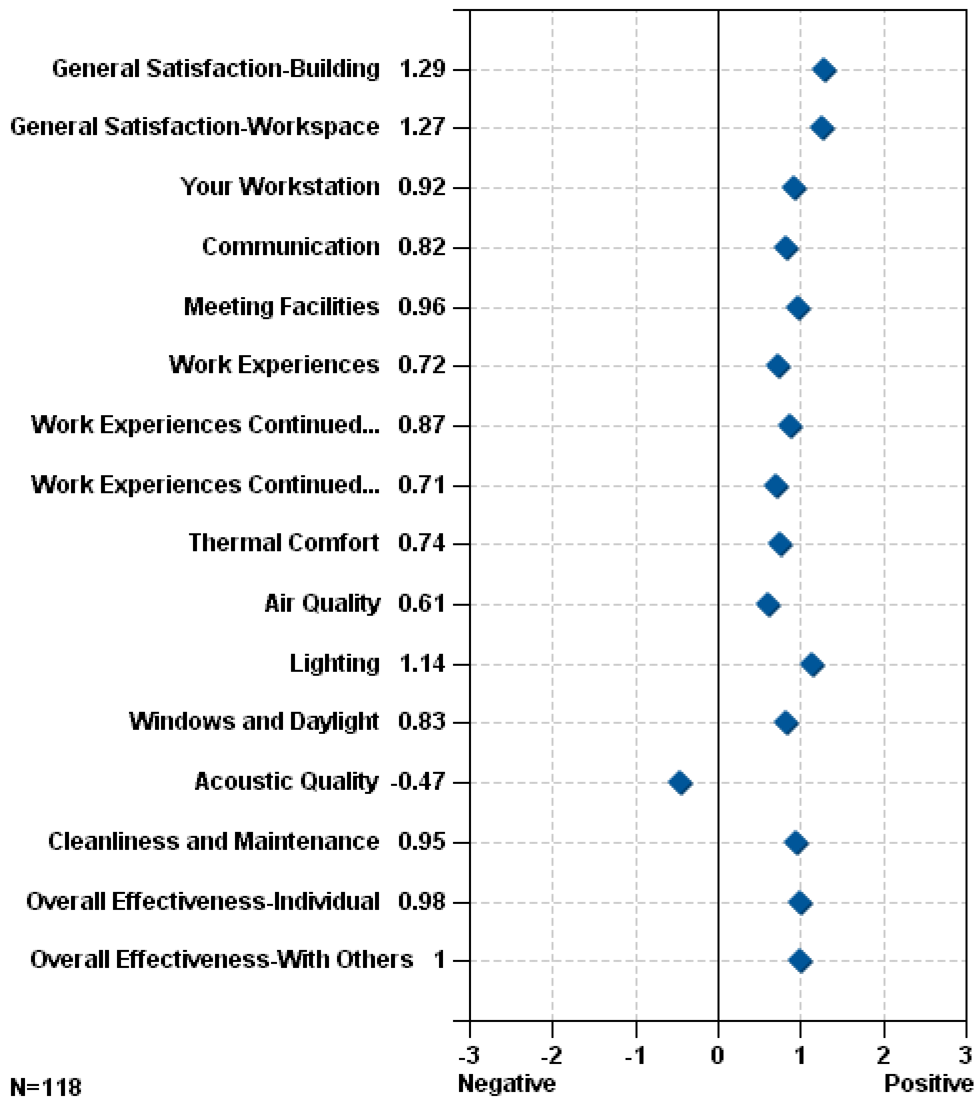
- Thermal comfort scored high (88th percentile) and acoustic quality, cleanliness and maintenance, and lighting scored below the 50th percentile on the CBE buildings survey. Interviews of occupants regarding these issues may result in a more detailed understanding of how operations might be adjusted to improve occupant satisfaction and what to communicate regarding the thermal comfort success.

Whole Building Performance

The Santa Ana Federal Building operating costs are lower than the industry baseline for water, grounds maintenance, janitorial, waste, and recycling costs. Overall, the building costs slightly less to operate than a baseline building.

Occupant Satisfaction Survey

Of the 409 occupants in the building, 336 were surveyed and 118 responded. The results indicated that occupants of the Santa Ana Federal Building are generally more satisfied with their building than occupants in the CBE baseline (59th percentile). The Acoustic quality, cleanliness and maintenance, and lighting scored below the 50th percentile of the CBE buildings surveyed. Thermal comfort and air quality scored above the 50th percentile, with thermal comfort at the 88th percentile (one of the highest scoring buildings in the study).

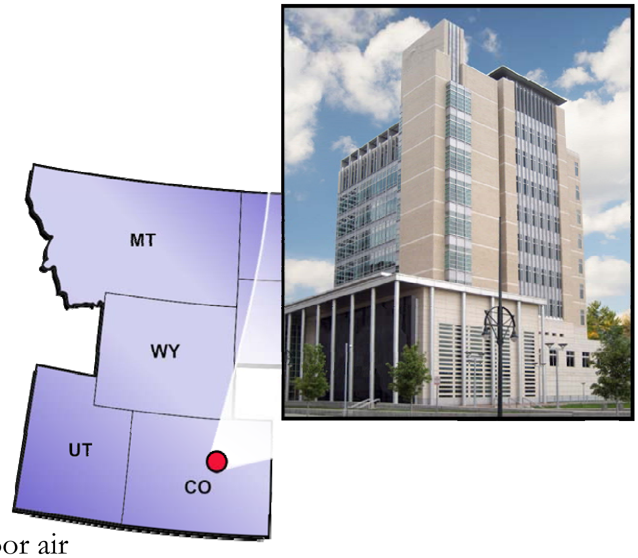


Performance Data Summary

The research team collected, normalized, and compared the whole building performance data for the Santa Ana Federal Building to industry baselines. The following table summarizes of the annual performance data collected and normalized.

Metrics	Annual Performance Measurements		Annual Reporting Metrics	
	Water Use (gal)	*3,070,741*	Gallons per occupant	*3,538*
	Cooling Tower Water Use (gal)	*-*	Water Cost per occupant	*$13.33*
	Outdoor Water Use (gal)	*-*	Gallons per GSF	*10.95*
	Water Cost	*$11,569*	Water Cost per GSF	*$0.06*
	Energy Star Score	*92*	Energy Use (kBTU) per GSF	*56*
	Energy Cost	*$15,625*	Energy Cost per GSF	*$1.89*
			Energy Emissions per building (metric tons CO_2 equiv)	*1,344*
	General Maintenance Cost	*$366,483*	General Maint Cost per RSF	*$1.78*
	Janitorial Services Cost	*$290,888*	Janitorial Services Cost per RSF	*$1.42*
	Grounds Maintenance Cost	*$15,018*	Grounds Maint Cost per RSF	*$0.07*
	Quantity of Maint Requests	*327*		
	Quantity of Prev Maint Jobs	*438*	Ratio of Maint Requests to Total Maintenance Jobs	*0.43*
	Solid Waste Generated (tons)	*562*	Solid Waste (lb) per occupant	*10.98*
	Solid Waste Cost	*$18,360*	Solid Waste Cost per RSF	*$0.09*
	Quantity Recycled (tons)	*11*	Solid Waste Cost per occupant	*$40.00*
	Recycling Cost	*$1,600*	Ratio of Recycled to Solid Waste	*0.02*
	Survey # of Invitees	*336*		
	Survey # of Respondents (n)	*118*	Survey Return Rate	*35%*
	Commute Miles per occ (avg)	*30*		
	Commute fuel per occ (avg gal)	*237*	Commute Emissions per occ (metric tons CO_2 equiv)	*2.20*

Denver Courthouse



Description

The Alfred A. Arraj Courthouse is the U.S. District Courthouse of Colorado, and it houses 15 courtrooms. The Arraj Courthouse uses the Green Building Challenge system to evaluate the sustainable design features of the building, which GSA has equated to a LEED Silver-certified building. The building has an underfloor air distribution system on the first floor and in the courtrooms on the second floor, occupancy sensors for HVAC and lighting in the courtrooms, indirect T-5 fluorescent lamps, photocell controls, and electronic dimming ballasts. Photovoltaic solar power panels are on the building roof, but they generate a low amount of energy.

Building Location:	**901 19th Street**	
	Denver Colorado 80294-2500	
Building Function:	**Courthouse**	
Project Type:	**New**	**13** *floors*
Design Recognition:	**Green Building Challenge --Level: Total Weighted Building Score: 2.0**	
Year Occupied	**2002**	
Gross Square Foot:	**327,103**	
Rentable Square Foot:	**256,718**	
Hours of Operation:	**65**	
Regular Occupants:	**170**	
Occupant Visitor Equiv.	**370**	
Electronic Equipment:	**185**	
Total Project Cost:	**$99,088,000**	
Construction Cost:	**$83,086,000**	

The Court gives its occupants passes for mass transit and despite the availability of inexpensive parking within two blocks, the occupants have a smaller CO_2-equivalent than the baseline and a smaller than would be expected based on the size of the community. The sanitary waste and recycling programs are combined with other federal buildings in the neighborhood. Currently, 900 tons of central chilled water per month must be purchased regardless of the quantity used. The values provided and used for this study were for only the quantity used, not the total purchased.

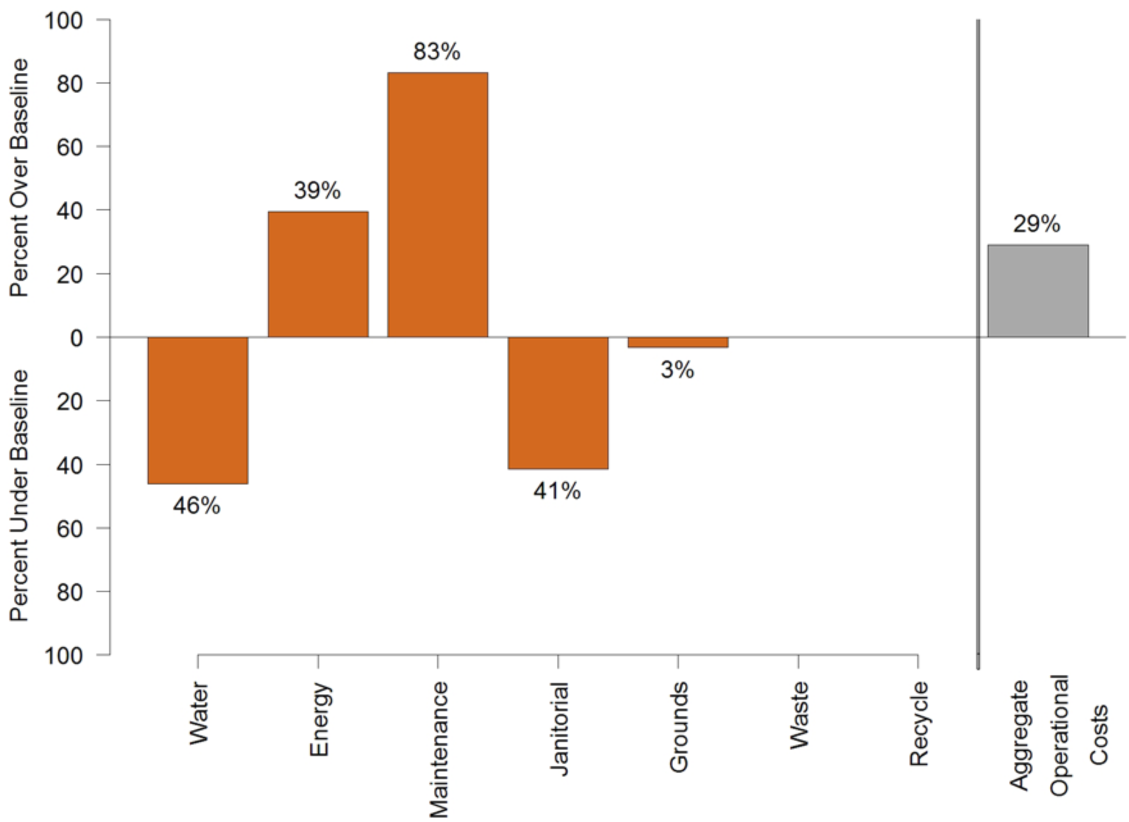
Each building in the study had operational highlights and potential opportunities for improvement. Although it was not the focus of this study to investigate and/or document operational highlights and opportunities, the research team observed the following:

- In addition to using central chilled water, the Arraj Courthouse has onsite evaporative cooling and an irrigated grassy park area. Although the research team attempted to estimate domestic water use, separately metering these water uses would allow for a greater understanding of why courthouse water use is almost 60% greater than the industry baseline.

- Energy use intensity (EUI) for the Arraj Courthouse is better than the Energy Star baseline; however, the courthouse has the highest EUI of the courthouses in the study, and its EUI is higher than expected when considered against GSA's National Baseline. Sub-metering end uses and/or performing a re-commissioning study could be used to investigate and optimize building operations.

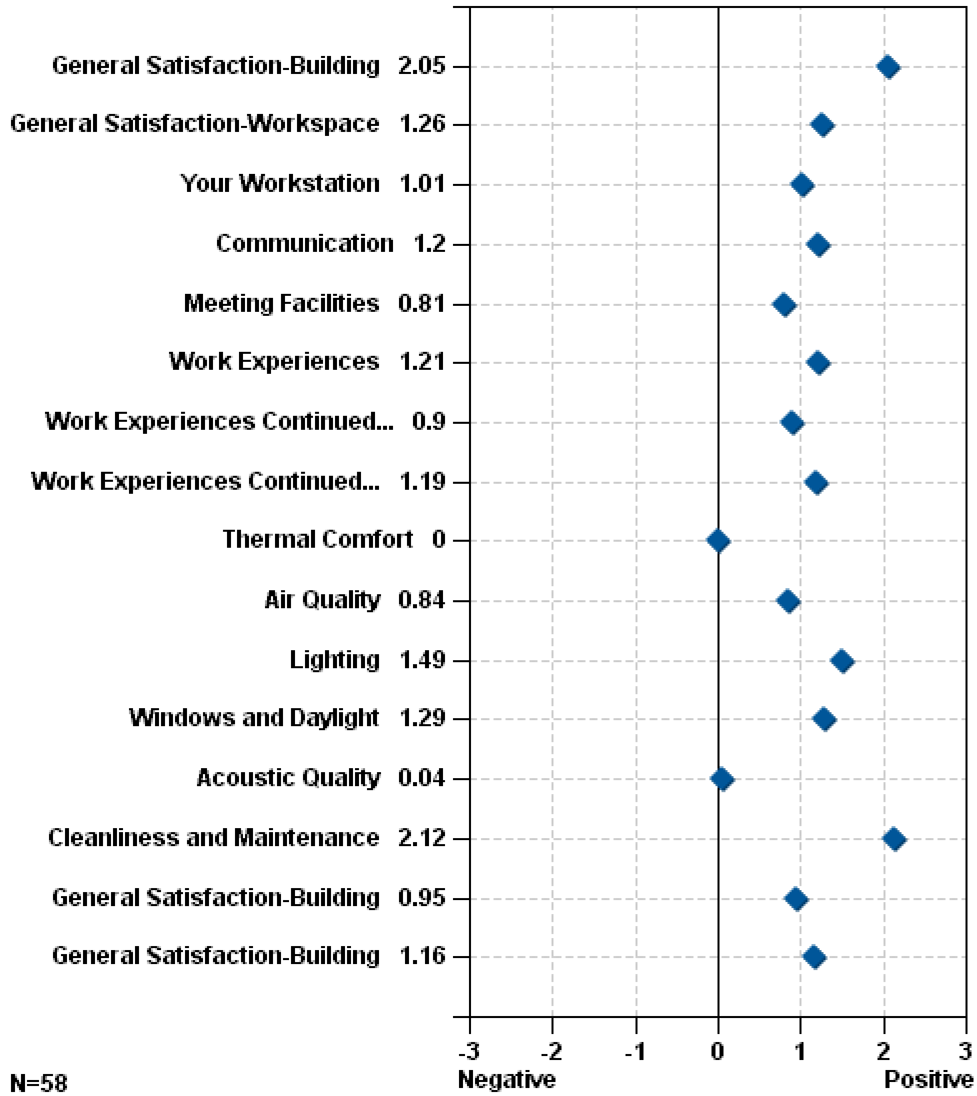
Whole Building Performance

The Arraj Courthouse operating costs are higher than the industry baseline for energy and general maintenance costs. No building-specific recycling and waste costs were available for this courthouse, because waste and recycling services are combined with other nearby buildings. Overall, the building costs more to operate than a baseline building.



Occupant Satisfaction Survey

Of the 170 building occupants, 100 were surveyed and 50 responded. The results indicated that occupants of the Arraj Courthouse are more satisfied with their building than occupants in the CBE baseline (65th percentile). For all of the survey categories that were the primary focus of this study—acoustic quality, air quality, lighting, cleanliness and maintenance, and thermal comfort—the Arraj Courthouse scored at the 50th percentile or better.



Performance Data Summary

The research team collected, normalized, and compared whole building performance data for the Arraj Courthouse to industry baselines. The following table summarizes the annual performance data collected and normalized. The facility uses evaporative cooling for its primary air-conditioning system; therefore, the evaporative cooling water use was estimated using the "rule-of-thumb" that 27% of total water use is process water. Outdoor water use was estimated using the "rule-of-thumb" that 20% of total water use if for landscaping.

Metrics	Annual Performance Measurements		Annual Reporting Metrics	
	Water Use (gal)	*4,039,000*	Gallons per occupant	*7,480*
	Process Water Use (gal)	*1,090,530*	Water Cost per occupant	*$30.75*
	Outdoor Water Use (gal)	*807,800*	Gallons per GSF	*12.35*
	Water Cost	*$16,604*	Water Cost per GSF	*$0.06*
	Energy Star Score	*77*	Energy Use (kBTU) per GSF	*88*
	Energy Cost	*$28,648*	Energy Cost per GSF	*$2.45*
			Energy Emissions per building (metric tons CO_2 equiv)	*4,668*
	General Maintenance Cost	*$804,051*	General Maint Cost per RSF	*$3.13*
	Janitorial Services Cost	*$220,046*	Janitorial Services Cost per RSF	*$0.86*
	Grounds Maintenance Cost	*$29,791*	Grounds Maint Cost per RSF	*$0.12*
	Quantity of Maint Requests	*684*		
	Quantity of Prev Maint Jobs	*881*	Ratio of Maint Requests to Total Maintenance Jobs	*0.44*
	Solid Waste Generated (tons)	*38*	Solid Waste (lb) per occupant	*1.81*
	Solid Waste Cost	*-*	Solid Waste Cost per RSF	*-*
	Quantity Recycled (tons)	*-*	Solid Waste Cost per occupant	*-*
	Recycling Cost	*-*	Ratio of Recycled to Solid Waste	*-*
	Survey # of Invitees	*100*		
	Survey # of Respondents (n)	*58*	Survey Return Rate	*58%*
	Commute Miles per occ (avg)	*24*		
	Commute fuel per occ (avg gal)	*102*	Commute Emissions per occ (metric tons CO_2 equiv)	*0.94*

Davenport Courthouse

Description

The Davenport Courthouse is on the National Register of Historic Places. The renovation was completed in 2005 and increased the number of courtrooms, improved security by building new holding cells and a vehicle sally port, and updated the mechanical systems and controls in the building.

Building Location:	**131 E. 4th Street**		
	Davenport	**Iowa**	**52801-1516**
Building Function:	**Courthouse**		
Project Type:	**Renovation**	**4** *floors*	
Design Recognition:	**LEED registered**		
Year Built	**1933**	*renovated:*	**2005**
Gross Square Foot:	**79,872**		
Rentable Square Foot:	**68,391**		
Hours of Operation:	**70**		
Regular Occupants:	**45**		
Occupant Visitor Equiv.	**63**		
Electronic Equipment:	**60**		
Renov Project Cost:	**$20,000,000**		
Renov Construction Cost:	**n/a**		

The remodel retained the historic integrity of the original the courtroom, the main lobby, staircases, windows, and hallways throughout the building.

The new courtrooms incorporate daylighting and the mechanical systems use variable frequency drives. The HVAC system consists of water-cooled chillers, boilers, and air handling units. The mailroom was specifically remodeled with high-efficiency particulate air filters for HAZMAT purposes.

Each building in the study had operational highlights and potential opportunities for improvement. Although it was not the focus of this study to investigate and/or document operational highlights and opportunities, the research team observed the following:

- Two third-party commissioning studies have been performed at the Davenport Courthouse to investigate operational challenges related to the mechanical equipment. Reevaluating the energy performance, maintenance costs, and occupant satisfaction following the implementation of the studies' recommendations would offer tangible evidence of the impact.

- Mechanical equipment is difficult to access. Future Federal design projects should carefully evaluate mechanical room space to enable easy access for maintenance.

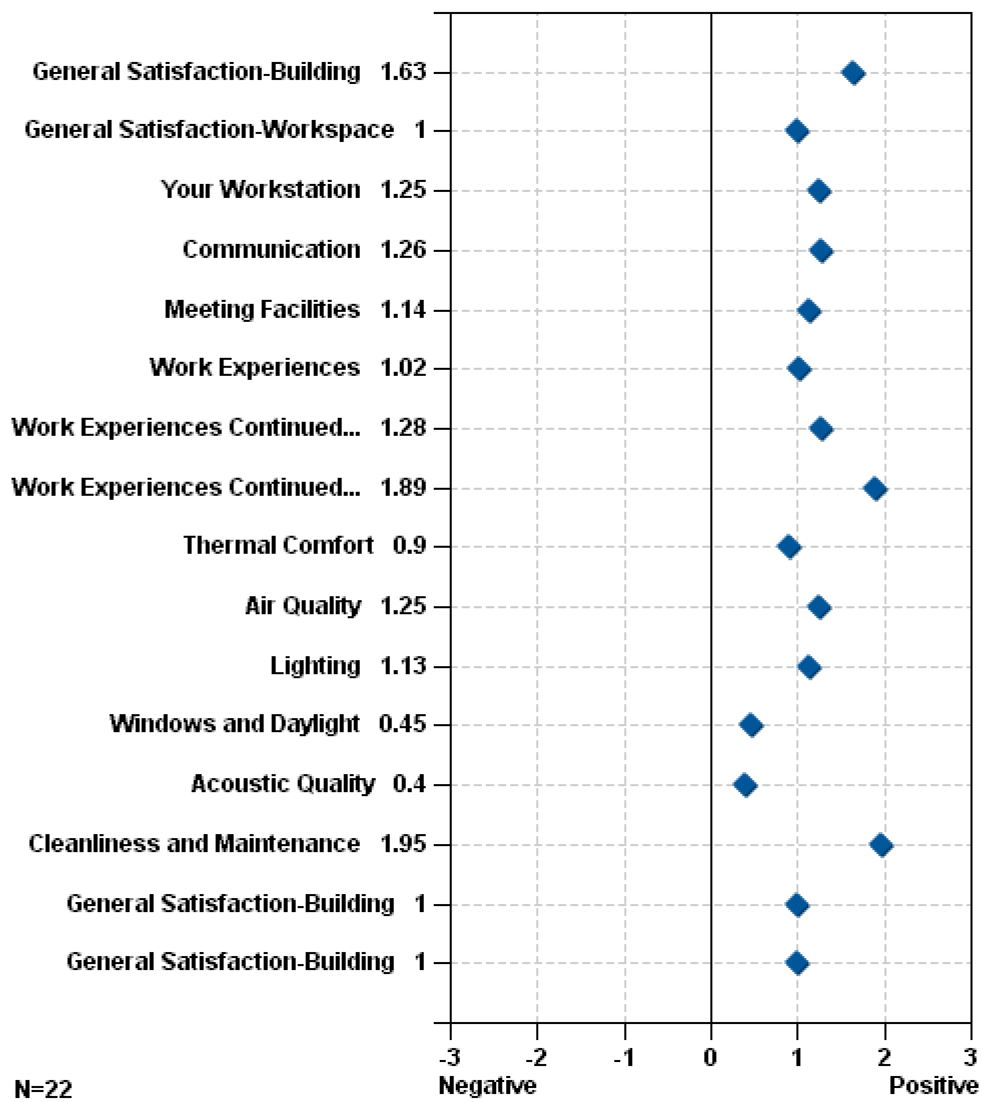
- Based on the CBE survey results and site visit, it appears that issues exist with lighting, acoustics, and some security features. Interviews of the occupants and design team regarding these issues may result in a more detailed understanding of how future designs might be adjusted to improve occupant satisfaction.

Whole Building Performance

The Davenport Courthouse operating costs are lower than the industry baseline for water, energy, grounds, and waste costs. The general maintenance, and janitorial costs are higher the industry baseline. Overall, the building costs less to operate than a baseline building. Because parts of the facility are still original (dating back to 1933) and the building flooded in April 2006, maintenance and janitorial cost could be more than industry baseline.

Occupant Satisfaction Survey

All 45 of the Davenport Federal Building occupants were surveyed and 22 responded. The results indicated that the occupants of the Davenport Courthouse are generally more satisfied with their building than occupants in the CBE baseline (80th percentile). Lighting quality scored below the 50th percentile of the CBE buildings surveyed. Acoustic quality, thermal comfort, cleanliness and maintenance, and air quality all scored above the 50th percentile.

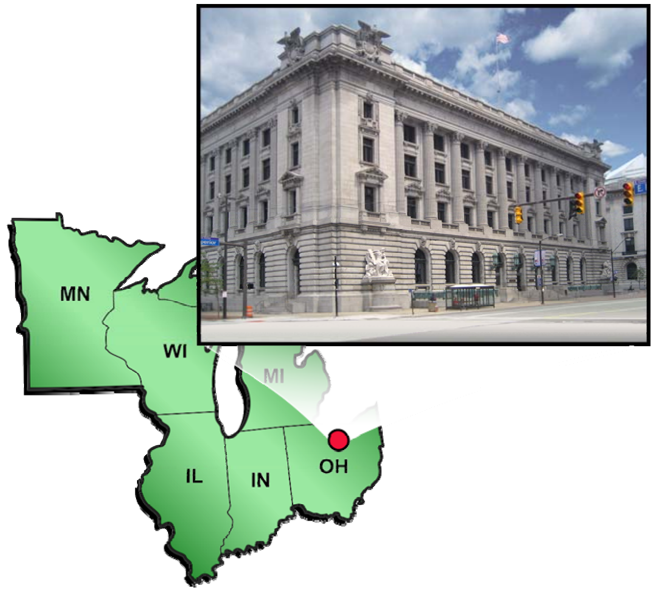


Performance Data Summary

The research team collected, normalized, and compared whole building performance data for the Davenport Courthouse to industry baselines. The following table summarizes the annual performance data collected and normalized. The facility uses water-cooled chillers for its air-conditioning system; therefore, the cooling tower water use was estimated using the "rule-of-thumb" that 27% of total water use is process water.

Metrics	Annual Performance Measurements		Annual Reporting Metrics	
	Water Use (gal)	*516,000*	Gallons per occupant	*1,923*
	Process Water Use (gal)	*139,320*	Water Cost per occupant	*$36.50*
	Outdoor Water Use (gal)	-	Gallons per GSF	*2.60*
	Water Cost	*$3,942*	Water Cost per GSF	*$0.06*
	Energy Star Score	*78*	Energy Use (kBTU) per GSF	*63*
	Energy Cost	*$3,333*	Energy Cost per GSF	*$0.96*
			Energy Emissions per building (metric tons CO_2 equiv)	*945*
	General Maintenance Cost	*$155,892*	General Maint Cost per RSF	*$2.28*
	Janitorial Services Cost	*$133,026*	Janitorial Services Cost per RSF	*$1.95*
	Grounds Maintenance Cost	*$6,421*	Grounds Maint Cost per RSF	*$0.09*
	Quantity of Maint Requests	*520*	Ratio of Maint Requests to Total Maintenance Jobs	*0.31*
	Quantity of Prev Maint Jobs	*1,179*		
	Solid Waste Generated (tons)	*59*	Solid Waste (lb) per occupant	*10.56*
	Solid Waste Cost	*$907*	Solid Waste Cost per RSF	*$0.01*
	Quantity Recycled (tons)	*2*	Solid Waste Cost per occupant	*$14.39*
	Recycling Cost	*n/a*	Ratio of Recycled to Solid Waste	*0.04*
	Survey # of Invitees	*36*		
	Survey # of Respondents (n)	*22*	Survey Return Rate	*61%*
	Commute Miles per occ (avg)	*27*	Commute Emissions per occ (metric tons CO_2 equiv)	*2.85*
	Commute fuel per occ (avg gal)	*308*		

Cleveland Courthouse



Description

The Howard M. Metzenbaum U.S. Courthouse is located in the hub of Cleveland's central business district. This LEED Certified facility maintained 96% of the existing shell and 59% of interior elements during its renovation.

To increase the energy efficiency a 15 % energy reduction from the ASHRAE 90.1-1999 standard was built into the design. The facility uses city's central steam and chilled water system.

Building Location:	**201 Superior Ave**		
	Cleveland	**Ohio**	**44114-1203**
Building Function:	**Courthouse**		
Project Type:	**Renovation**	**6** *floors*	
Design Recognition:	**LEED-NC v2.1 certified - 29points**		
Year Built	**1910**	*renovated:*	**June 2005**
Gross Square Foot:	**251,314**		
Rentable Square Foot:	**185,105**		
Hours of Operation:	**60**		
Regular Occupants:	**105**		
Occupant Visitor Equiv.	**143**		
Electronic Equipment:	**120**		
Renov Total Project Cost:	**$44,613,000**		
Renov Construction Cost:	**$37,925,000**		

Due to its urban location, alternative transportation is used widely and encouraged by management.

No new landscaping was added during the building renovation. The existing trees do not require irrigation, and the building's low-flow fixtures increase its water efficiency.

The Metzenbaum Courthouse won GSA's Environmental Award for Recycling because of its seven-material collection system. The building has low-emitting carpets, CO_2 sensors, and practices green housekeeping to maintain high indoor environmental quality standards for its occupants.

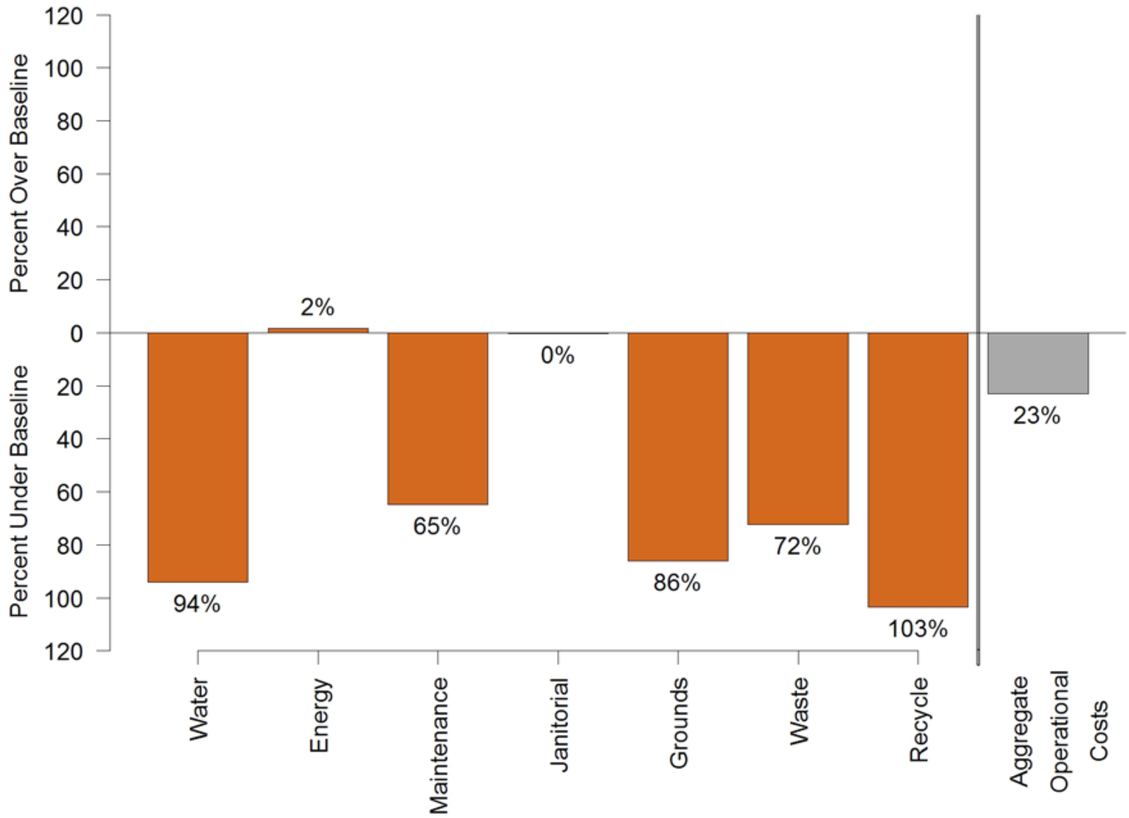
Each building in the study had operational highlights and potential opportunities for improvement. Although it was not the focus of this study to investigate and/or document operational highlights and opportunities, the research team observed the following:

- During one of the site visits, researchers observed rust on new mechanical equipment caused by water leaking into the basement from the sidewalk. Addressing the leak will minimize maintenance costs in the future.

- The high level of occupant satisfaction on all categories implies that Metzenbaum's building systems are working well. Identifying and communicating the causes of these operational successes offers successful building operations strategies for other Federal buildings and courthouses.

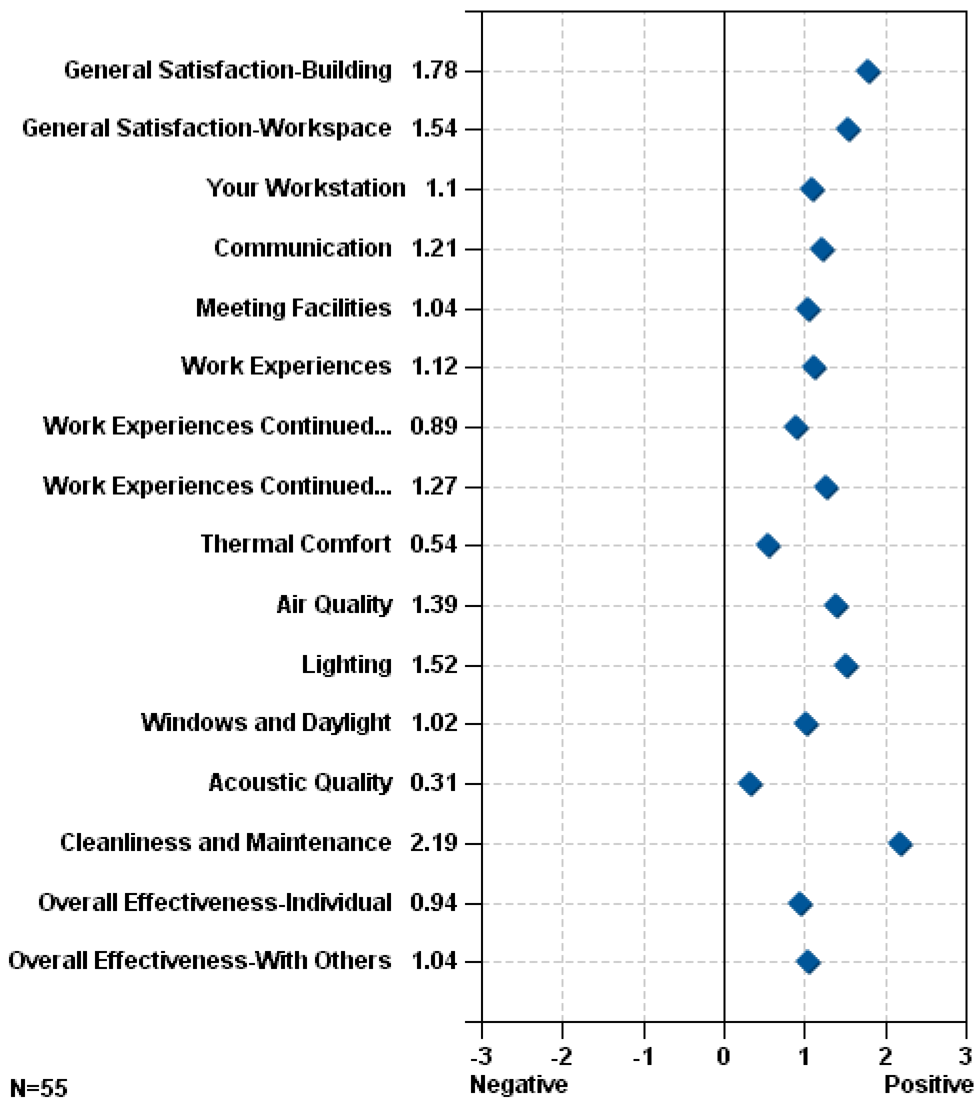
Whole Building Performance

The Metzenbaum Courthouse operating costs are lower than the industry baseline for all metrics other than energy, which was only slightly above baseline. Overall, the building costs less to operate than a baseline building.



Occupant Satisfaction Survey

Of the 105 occupants in the building, 95 were surveyed and 54 responded. The results indicated that occupants of the Metzenbaum Courthouse are more satisfied with their building than occupants in the CBE baseline (86th percentile). In all of the key measurements—acoustic quality, air quality, cleanliness and maintenance, thermal comfort and lighting—Metzenbaum occupants scored above the 50th percentile of the CBE buildings surveyed.

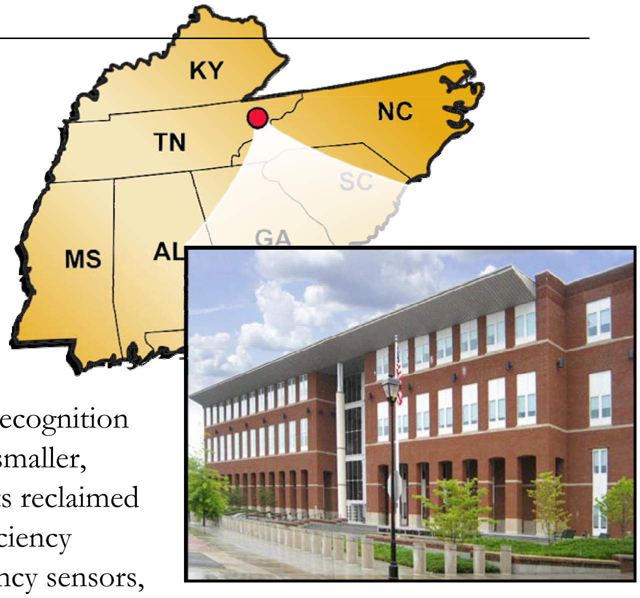


Performance Data Summary

The research team collected, normalized, and compared whole building performance data for the Metzenbaum Courthouse to industry baselines. The following table summarizes the annual performance data collected and normalized.

Metrics	Annual Performance Measurements		Annual Reporting Metrics	
	Water Use (gal)	***537,849***	Gallons per occupant	***2,169***
	Process Water Use (gal)	***-***	Water Cost per occupant	***$5.36***
	Outdoor Water Use (gal)	***-***	Gallons per GSF	***2.14***
	Water Cost	***$1,330***	Water Cost per GSF	***$0.01***
	Energy Star Score	***82***	Energy Use (kBTU) per GSF	***84***
	Energy Cost	***$21,123***	Energy Cost per GSF	***$1.79***
			Energy Emissions per building (metric tons CO_2 equiv)	***2,440***
	General Maintenance Cost	***$111,329***	General Maint Cost per RSF	***$0.60***
	Janitorial Services Cost	***$270,476***	Janitorial Services Cost per RSF	***$1.46***
	Grounds Maintenance Cost	***$3,100***	Grounds Maint Cost per RSF	***$0.02***
	Quantity of Maint Requests	***684***	Ratio of Maint Requests to Total Maintenance Jobs	***0.46***
	Quantity of Prev Maint Jobs	***805***		
	Solid Waste Generated (tons)	***24***	Solid Waste (lb) per occupant	***1.83***
	Solid Waste Cost	***$3,067***	Solid Waste Cost per RSF	***$0.02***
	Quantity Recycled (tons)	***3***	Solid Waste Cost per occupant	***$21.45***
	Recycling Cost	***-$101***	Ratio of Recycled to Solid Waste	***0.12***
	Survey # of Invitees	***95***		
	Survey # of Respondents (n)	***54***	Survey Return Rate	***57%***
	Commute Miles per occ (avg)	***26***	Commute Emissions per occ (metric tons CO_2 equiv)	***0.79***
	Commute fuel per occ (avg gal)	***86***		

Greeneville Courthouse



Description

The James H. Quillen U.S. Courthouse was completed in 2001 and received Energy Star recognition in 2007. The Quillen Courthouse replaced a smaller, historic courthouse, from which the occupants reclaimed the quality furniture. Some of the energy-efficiency features in the building include use of occupancy sensors, a well-insulated white roof, and Energy Management Control System (EMSC) control of lighting and occupancy sensors. During the site visit, researchers noticed that occupants had their office lights turned off if they had sufficient daylight from a window.

Building Location:	**220 W. Depot Street**		
	Greeneville	**Tennessee 37743-1100**	
Building Function:	**Courthouse**		
Project Type:	**New**	**4** *floors*	
Design Recognition:	**Energy Star 2007**		
Year Occupied	**2001**		
Gross Square Foot:	**160,975**		
Rentable Square Foot:	**136,104**		
Hours of Operation:	**70**		
Regular Occupants:	**85**		
Occupant Visitor Equiv.	**103**		
Electronic Equipment:	**100**		
Total Project Cost:	**$31,068,600**		
Construction Cost:	**$25,672,000**		

The landscape includes a large grassy area. Some green cleaning products are being used, but not all products would have been considered "green." The building has auto-flush toilets, but the building engineer wants them removed because of the maintenance challenges of this technology.

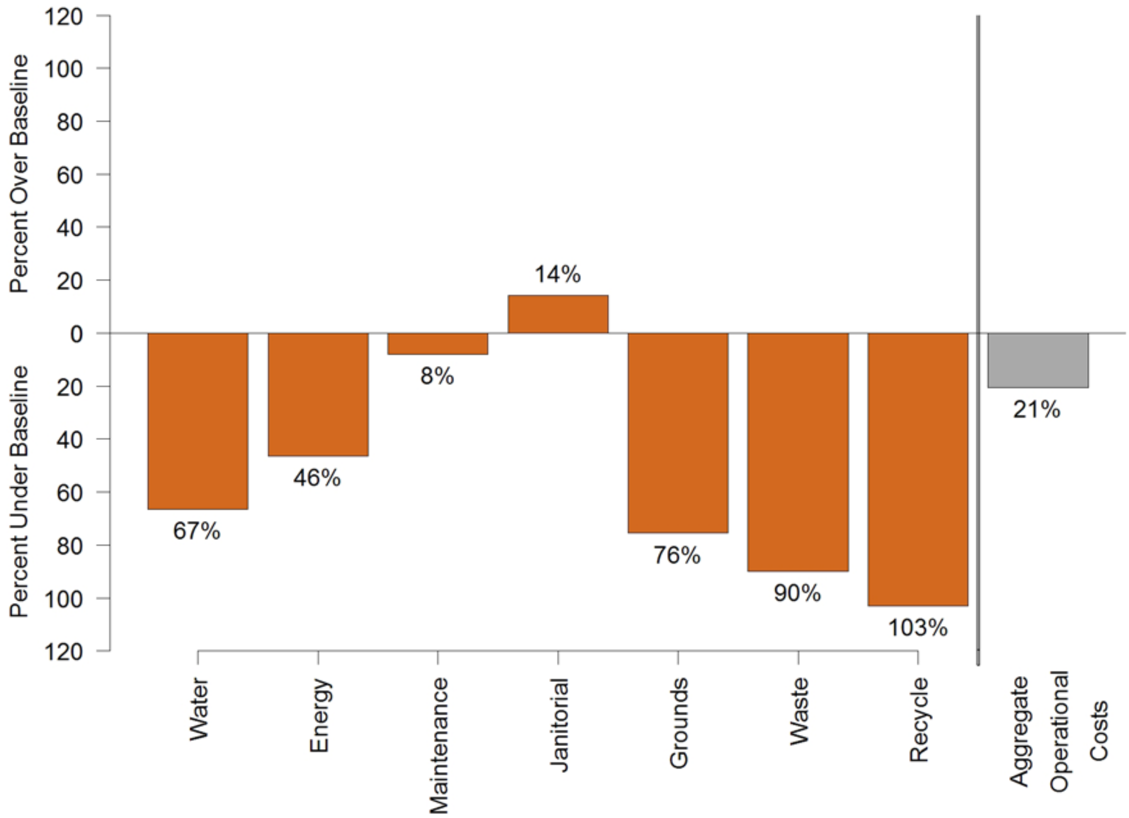
The building houses four courtrooms and sees a significant fluctuation in visitors depending on the need for those courtrooms.

Each building in the study had operational highlights and potential opportunities for improvement. Although it was not the focus of this study to investigate and/or document operational highlights and opportunities, the research team observed the following:

- Consider pursuing LEED for Existing Buildings Certification.

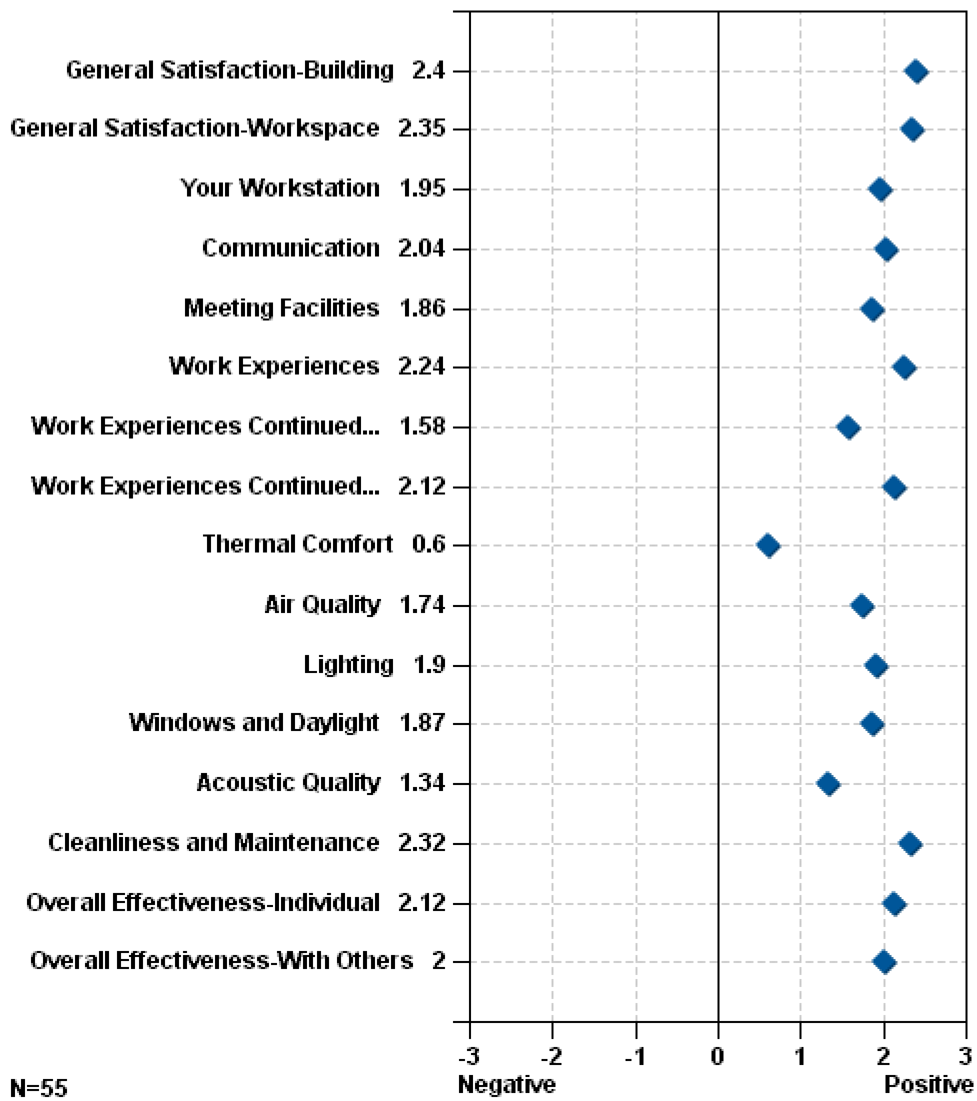
Whole Building Performance

The Quillen Courthouse operating costs are lower than the industry baseline for water, energy, general maintenance, grounds maintenance, waste, and recycling costs. The janitorial costs are higher than the industry baseline. Overall, the building costs less to operate than a baseline building.



Occupant Satisfaction Survey

All 85 of the Quillen Courthouse occupants were surveyed and 54 responded. In addition to the electronic survey, GSA representatives issued the survey in hardcopy form as many staff did not have electronic access to the survey. The results indicated that occupants of the Quillen Courthouse are significantly more satisfied with their building than occupants in the CBE baseline (98^{th} percentile), with the highest occupant satisfaction score for all of the buildings in the study. The Quillen Courthouse also had the highest occupant satisfaction scores in the study for acoustic quality, air quality, cleanliness and maintenance, and lighting. Thermal comfort was the lowest scored occupancy metric, yet it scored in the 84^{th} percentile when compared to the CBE building database.



Performance Data Summary

The research team collected, normalized, and compared whole building performance data for the Quillen Courthouse to industry baselines. The following table summarizes the annual performance data collected and normalized. The facility uses water-cooled chillers for its air-conditioning system; therefore, the cooling tower water use was estimated using the "rule-of-thumb" that 27% of total water use is process water. Outdoor water use was estimated using the "rule-of-thumb" that 20% of total water use if for landscaping.

Metrics	Annual Performance Measurements		Annual Reporting Metrics	
	Water Use (gal)	*800,414*	Gallons per occupant	*1,230*
	Process Water Use (gal)	*216,112*	Water Cost per occupant	*$29.09*
	Outdoor Water Use (gal)	*160,083*	Gallons per GSF	*1.44*
	Water Cost	**$5,468**	Water Cost per GSF	*$0.04*
	EnergyStar Score	*87*	Energy Use (kBTU) per GSF	*49*
	Energy Cost	*$5,958*	Energy Cost per GSF	*$0.94*
			Energy Emissions per building (metric tons CO_2 equiv)	*1,397*
	General Maintenance Cost	*$214,100*	General Maint Cost per RSF	*$1.57*
	Janitorial Services Cost	*$227,620*	Janitorial Services Cost per RSF	*$1.67*
	Grounds Maintenance Cost	*$4,000*	Grounds Maint Cost per RSF	*$0.03*
	Quantity of Maint Requests	*180*		
	Quantity of Prev Maint Jobs	*1,078*	Ratio of Maint Requests to Total Maintenance Jobs	*0.14*
	Solid Waste Generated (tons)	*39*	Solid Waste (lb) per occupant	*3.67*
	Solid Waste Cost	*$900*	Solid Waste Cost per RSF	*$0.01*
	Quantity Recycled (tons)	*2*	Solid Waste Cost per occupant	*$8.74*
	Recycling Cost	*-$71*	Ratio of Recycled to Solid Waste	*0.06*
	Survey # of Invitees	*100*		
	Survey # of Respondents (n)	*54*	Survey Return Rate	*54%*
	Commute Miles per occ (avg)	*22*		
	Commute fuel per occ (avg gal)	*276*	Commute Emissions per occ (metric tons CO_2 equiv)	*2.56*

Youngstown Courthouse and Federal Building

Description

The Frank J. Battisti and Nathaniel R. Jones Federal Building and United States Courthouse (Youngstown CH & FB) is a part of the urban revitalization of the city's downtown district. The building houses one bankruptcy courtroom and various types of office space to accommodate a variety of tenants.

Building Location:	**10 East Commerce Street**
	Youngstown Ohio 44503-1677
Building Function:	**Federal Building and Courthouse**
Project Type:	**New** 4 *floors*
Design Recognition:	**LEED -- NC, v.2/v.21 --Level: Certified (27 points)**
Year Occupied	**2002**
Gross Square Foot:	**52,240**
Rentable Square Foot:	**44,476**
Hours of Operation:	**60**
Regular Occupants:	**45**
Occupant Visitor Equiv.	**243**
Electronic Equipment:	**60**
Total Project Cost:	**$16,465,331**
Construction Cost:	**$10,594,831**

The facility is GSA's first courthouse to achieve LEED certification. The facility was built on a brownfield and incorporates building controls, combined with air-cooled chillers and municipal utility steam, and daylighting to over 75% of occupied spaces into building operations.

There are five primary federal agency tenants in the building. Unique features of the Youngstown CH & FB include a native landscape and stormwater management demonstration adjacent to the building, and use of a white membrane roof and light-colored pavement to reduce the heat island effect.

Each building in the study had operational highlights and potential opportunities for improvement. Although it was not the focus of this study to investigate and/or document operational highlights and opportunities, the research team observed the following:

- The Youngstown CH & FB was the lowest scoring in the thermal comfort category of the CBE survey (1st percentile). Building management is aware of problems with its cooling system and plans exist to upgrade the system.

- Although the building was designed with no irrigation system, the plants and grass require staff to apply potable water to the landscaping. The other water conservation features in the building are attributable to the building using less water than the industry baseline.

- Youngstown CH & FB was one of the highest scoring buildings in the cleanliness and maintenance category of the CBE survey (97th percentile). The facility also had the highest maintenance, janitorial, and grounds costs on a per square-foot basis.

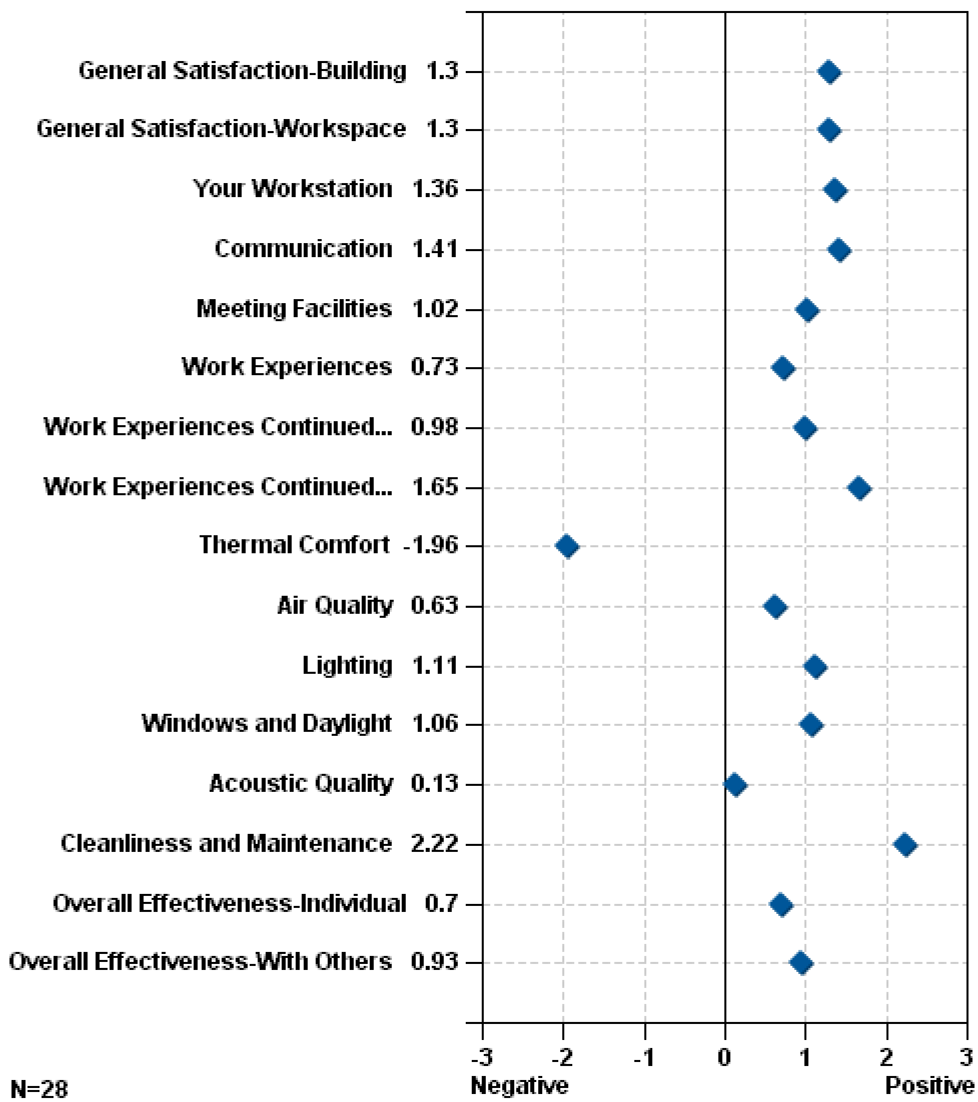
- Native prairie grass landscaping is manually weeded, which may contribute to the higher grounds maintenance costs.

Whole Building Performance

The costs of operating the Youngstown CH & FB are lower than the industry baseline for water and waste costs. The energy, general maintenance, janitorial, and grounds maintenance costs were higher than the industry baseline. Overall, the building costs more to operate than a baseline building. The building's mechanical systems have been malfunctioning, and the basement has flooded five times since its commissioning, potentially affecting the maintenance and janitorial costs.

Occupant Satisfaction Survey

All 45 of the Youngstown CH & FB occupants were surveyed and 28 responded. The results indicated that occupants of the Youngstown CH & FB are generally more satisfied with their building than occupants in the CBE baseline (59th percentile). Thermal comfort and lighting quality scored below the 50th percentile of the CBE buildings surveyed. Acoustics, air quality, and cleanliness and maintenance all scored above the 50th percentile.



Performance Data Summary

The research team collected, normalized, and compared whole building performance data for the Youngstown CH & FB to industry baselines. The following table summarizes the annual performance data collected and normalized. The facility uses potable water for its landscaping upkeep; therefore, the outdoor water use was estimated using the "rule-of-thumb" that 20% of total water use is outdoor water.

Metrics	Annual Performance Measurements		Annual Reporting Metrics	
	Water Use (gal)	*402,484*	Gallons per occupant	*1,398*
	Process Water Use (gal)	*-*	Water Cost per occupant	*$11.89*
	Outdoor Water Use (gal)	*80,497*	Gallons per GSF	*7.70*
	Water Cost	*$3,426*	Water Cost per GSF	*$0.08*
	Energy Star Score	*58*	Energy Use (kBTU) per GSF	*67*
	Energy Cost	*$3,662*	Energy Cost per GSF	*$1.88*
			Energy Emissions per building (metric tons CO_2 equiv)	*655*
	General Maintenance Cost	*$174,182*	General Maint Cost per RSF	*$3.92*
	Janitorial Services Cost	*$140,767*	Janitorial Services Cost per RSF	*$3.17*
	Grounds Maintenance Cost	*$37,300*	Grounds Maint Cost per RSF	*$0.84*
	Quantity of Maint Requests	*232*	Ratio of Maint Requests to Total Maintenance Jobs	*0.29*
	Quantity of Prev Maint Jobs	*579*		
	Solid Waste Generated (tons)	*17*	Solid Waste (lb) per occupant	*2.99*
	Solid Waste Cost	*$1,530*	Solid Waste Cost per RSF	*$0.03*
	Quantity Recycled (tons)	*29*	Solid Waste Cost per occupant	*$6.30*
	Recycling Cost	*n/a*	Ratio of Recycled to Solid Waste	*1.71*
	Survey # of Invitees	*75*		
	Survey # of Respondents (n)	*28*	Survey Return Rate	*37%*
	Commute Miles per occ (avg)	*29*	Commute Emissions per occ (metric tons CO_2 equiv)	*1.78*
	Commute fuel per occ (avg gal)	*192*		

Fresno Courthouse and Federal Building

Description

The Fresno Courthouse and Federal Building is a part of the urban revitalization of the city's downtown district. There are 14 courtrooms that house district, magistrate and bankruptcy courts, and eight elevators in the tallest building in Fresno.

Building Location:	**2500 Tulare Street**	
	Fresno	**California 93721-0000**
Building Function:	**Federal Building and Courthouse**	
Project Type:	**New**	**11** *floors*
Design Recognition:	**none**	
Year Occupied	**2005**	
Gross Square Foot:	**495,914**	
Rentable Square Foot:	**393,243**	
Hours of Operation:	**68**	
Regular Occupants:	**235**	
Occupant Visitor Equiv.	**510**	
Electronic Equipment:	**250**	
Total Project Cost:	**$132,718,000**	
Construction Cost:	**$119,589,000**	

The facility was designed under California's Title 24 energy standards and incorporates high-efficiency lighting (T5s, T8s and CFLs), underfloor air distribution systems for floors 1 through 4, water-cooled chillers, natural gas boilers, and variable speed drives. The lighting controls operate both on occupancy and time-of-day routines.

There are five primary federal agency tenants in the building. Unique features include a nurse's station that is supported by the tenants, a fitness room, underground parking, a public garden, and a library with original Ansel Adams photographs of the Yosemite Valley.

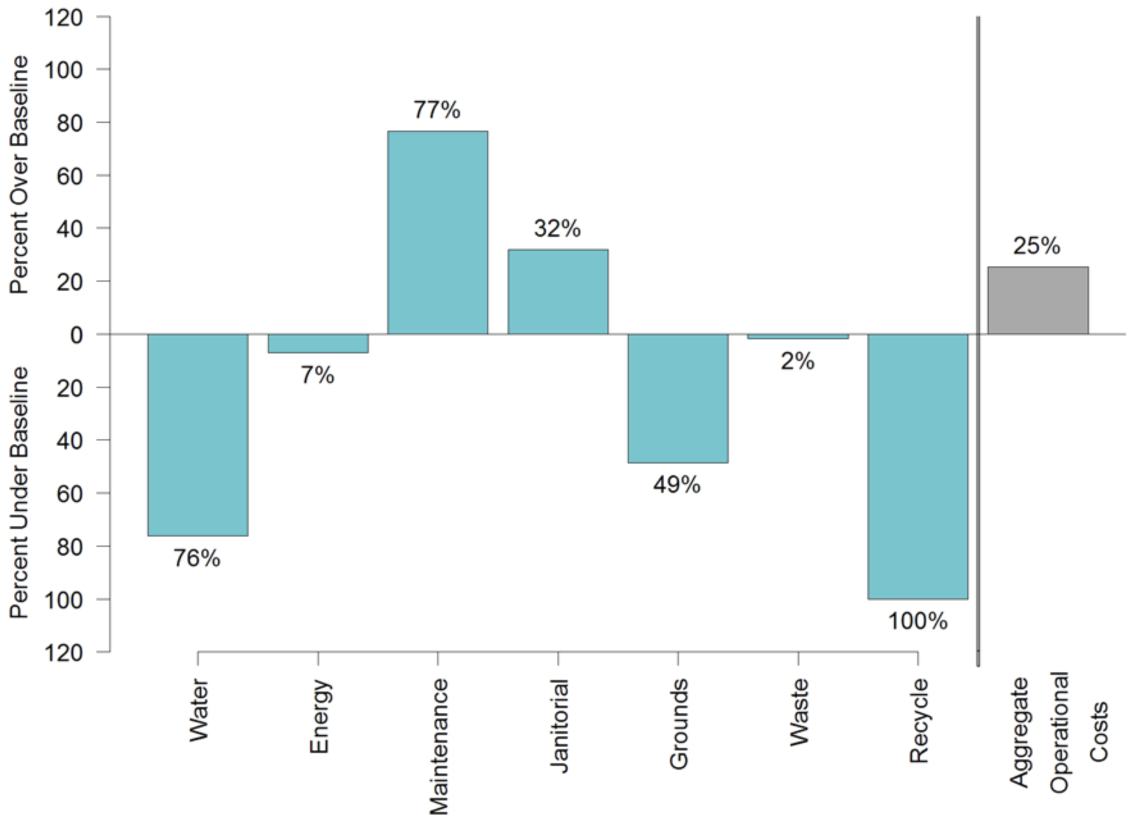
Each building in the study had operational highlights and potential opportunities for improvement. Although it was not the focus of this study to investigate and/or document operational highlights and opportunities, the research team observed the following:

- The building landscaping is attractive, but water intensive. There is a large public garden (1.5 acres of the total 3.9-acre property size). The outdoor pond and waterfall, native plants, and conifers along with the indoor water feature offer a gathering space and a key attribute to the urban revitalization.

- A project is underway to purchase new window blinds with reflective backing to block heat and glare.

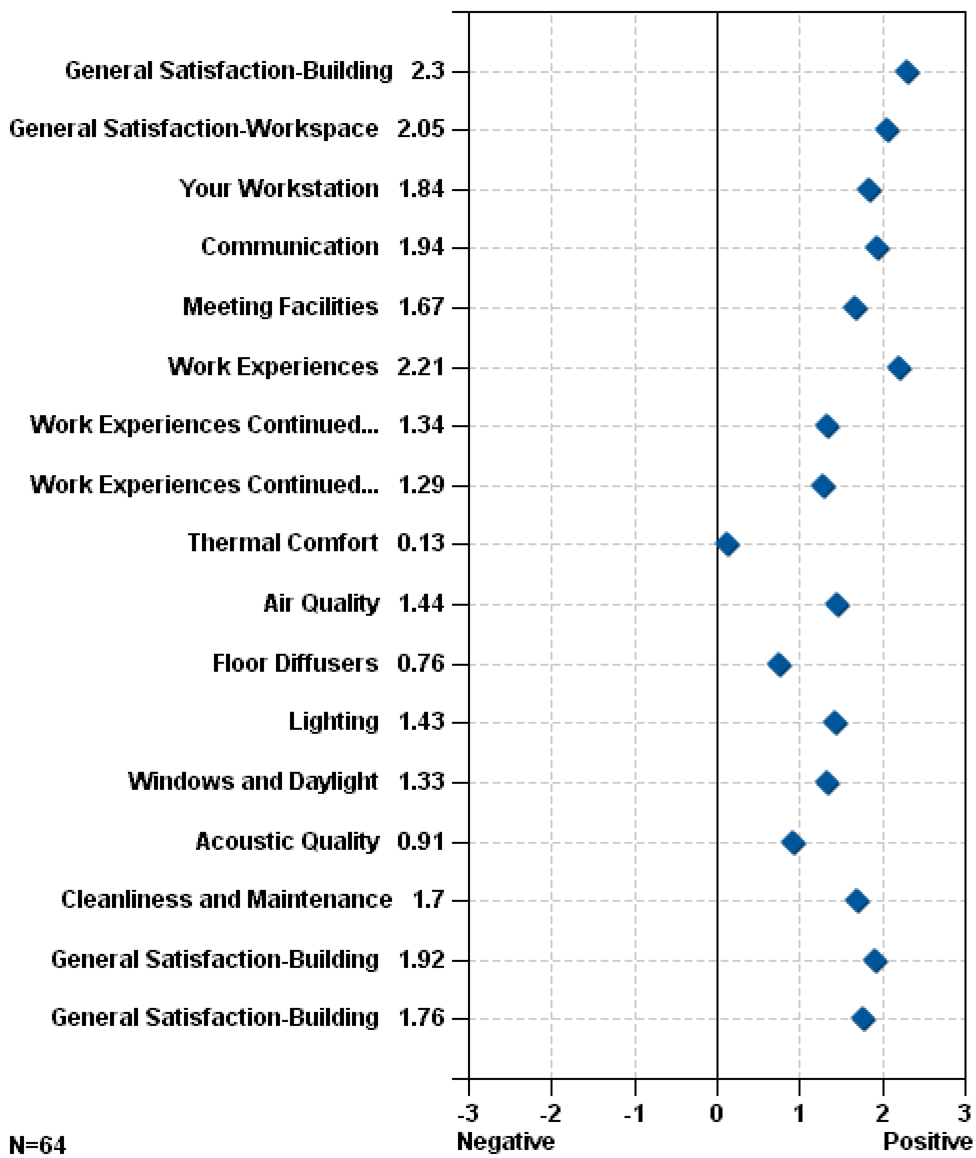
Whole Building Performance

The costs of operating the Fresno CH & FB are lower than the industry baseline for water, energy, grounds, and waste costs. The general maintenance and janitorial costs were higher than the industry baseline. Overall, the building costs more to operate than a baseline building.



Occupant Satisfaction Survey

All 235 of the Fresno CH & FB occupants were surveyed and 73 responded. The result indicated that occupants of the Fresno CH & FB are more satisfied with their building than occupants in the CBE baseline (90^{th} percentile). Acoustic quality, air quality, and cleanliness and maintenance scored in the 80^{th} percentile or above. Occupant satisfaction with lighting and thermal comfort scored above the 50^{th} percentile.



Performance Data Summary

The research team collected, normalized, and compared whole building performance data for the Fresno CH & FB to industry baselines. The following table summarizes the annual performance data collected and normalized. The facility uses water-cooled chillers for its air-conditioning system; therefore, the cooling tower water use was estimated using the "rule-of-thumb" that 27% of total water use is process water. Outdoor water use is separately metered.

Metrics	Annual Performance Measurements		Annual Reporting Metrics	
	Water Use (gal)	*7,705,663*	Gallons per occupant	*1,459*
	Process Water Use (gal)	*1,392,607*	Water Cost per occupant	*$12.65*
	Outdoor Water Use (gal)	*2,547,858*	Gallons per GSF	*2.19*
	Water Cost	*$9,421*	Water Cost per GSF	*$0.02*
	Energy Star Score	*92*	Energy Use (kBTU) per GSF	*48*
	Energy Cost	*$18,870*	Energy Cost per GSF	*$1.63*
			Energy Emissions per building (metric tons CO_2 equiv)	*2,666*
	General Maintenance Cost	*$1,188,000*	General Maint Cost per RSF	*$3.02*
	Janitorial Services Cost	*$759,402*	Janitorial Services Cost per RSF	*$1.93*
	Grounds Maintenance Cost	*$24,236*	Grounds Maint Cost per RSF	*$0.06*
	Quantity of Maint Requests	*1,200*		
	Quantity of Prev Maint Jobs	*4,932*	Ratio of Maint Requests to Total Maintenance Jobs	*0.20*
	Solid Waste Generated (tons)	*16*	Solid Waste (lb) per occupant	*0.55*
	Solid Waste Cost	*$24,236*	Solid Waste Cost per RSF	*$0.06*
	Quantity Recycled (tons)	*18*	Solid Waste Cost per occupant	*$47.52*
	Recycling Cost	*incl*	Ratio of Recycled to Solid Waste	*1.11*
	Survey # of Invitees	*232*		
	Survey # of Respondents (n)	*64*	Survey Return Rate	*28%*
	Commute Miles per occ (avg)	*26*		
	Commute fuel per occ (avg gal)	*259*	Commute Emissions per occ (metric tons CO_2 equiv)	*2.40*

Sault Ste. Marie Port

Description

The Sault Ste. Marie Port-of-Entry is located on the U.S. side of the northern international border and operates 24 hours a day, 365 days a year. The building has primary and secondary vehicle inspection bays and two commercial truck lanes and three car lanes for in-bound inspections.

Building Location:	**989 W. Portage Ave**
	Sault Sainte Michigan 49783-0000
Building Function:	**Port of Entry**
Project Type:	**New** **2** *floors*
Design Recognition:	**LEED registered, but not verified**
Year Occupied	**2005**
Gross Square Foot:	**63,874**
Rentable Square Foot:	**39,709**
Hours of Operation:	**168**
Regular Occupants:	**74**
Occupant Visitor Equiv.	**84**
Electronic Equipment:	**80**
Total Project Cost:	**$13,711,500**
Construction Cost:	**$10,653,500**

The facility's steel-frame construction with glass curtainwall offers daylighting to the interior space, and the facility sits on top of an at-grade parking garage.

The facility houses an indoor firing range, a fitness room and locker facilities, holding cells and customs related laboratories. The multi-pitched roof features vegetative cover. The facility operates three boilers, a chiller, and three air-handling units. Lighting is controlled by both occupancy and daylight sensors.

Because of the facility's security function, the space houses various types of monitors, screening machines, and cameras. The screening booths and inspection bays are mostly open to the outside and pose a challenge for temperature control during the winter months.

Each building in the study had operational highlights and potential opportunities for improvement. Although it was not the focus of this study to investigate and/or document operational highlights and opportunities, the research team observed the following:

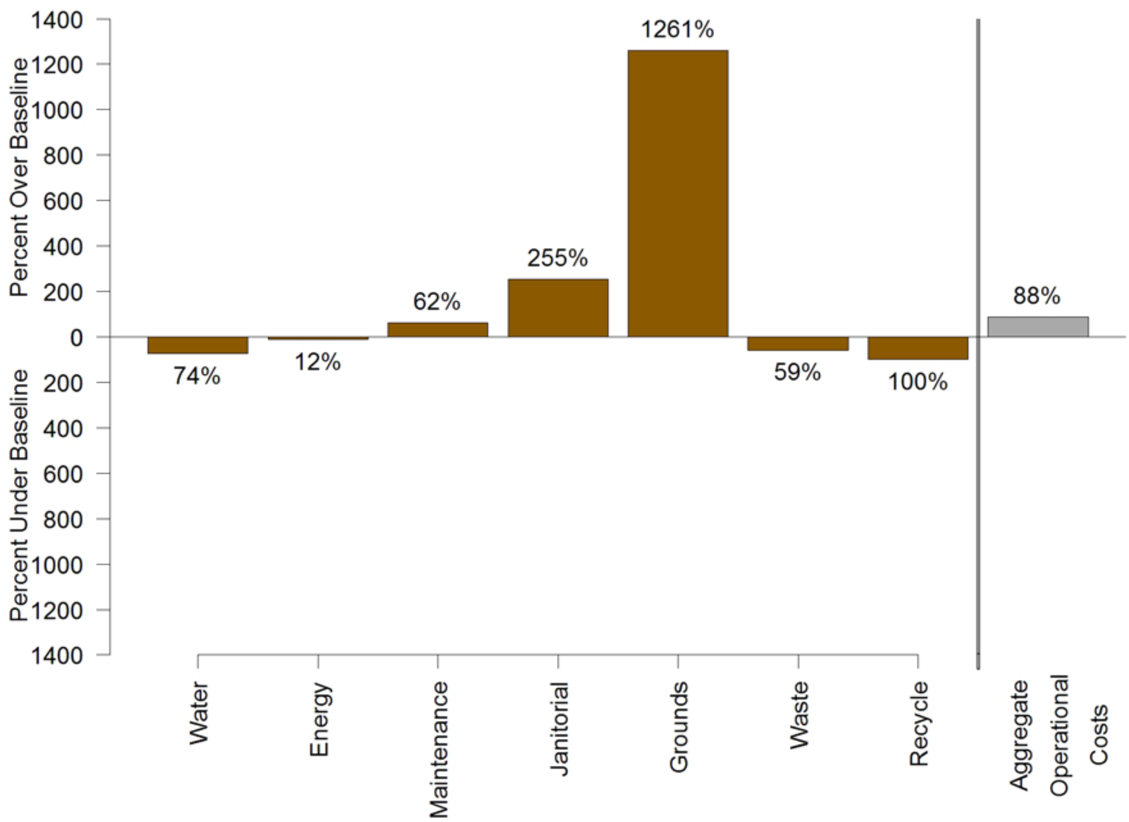
- For both the Sault Ste. Marie and Sweetgrass Port facilities, this study used an office building baseline, because there is nothing equivalent to a Port in the publically available industry baseline data. To fairly assess the performance of these buildings, an alternative baseline is needed.

- The vegetative roof has been a challenge to keep up due to potential installation flaws and the less-than-average annual rainfall over the past two years. Maintenance personnel training on upkeep of this feature may improve the health of the roof.

- Based on the CBE survey results, issues appear to exist with thermal comfort, daylighting, lighting, and acoustics. Interviews of occupants regarding these issues may result in a more detailed understanding of how operations might be adjusted to improve occupant satisfaction.

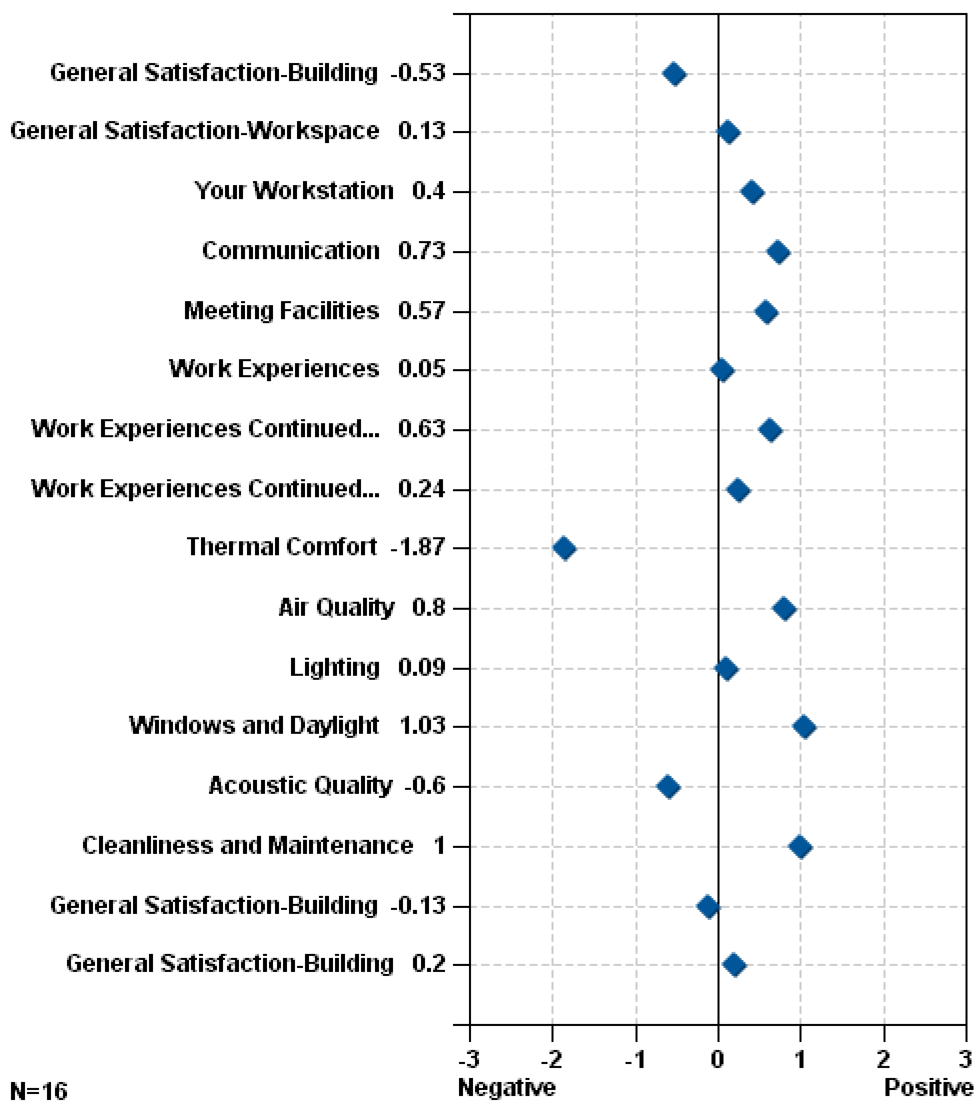
Whole Building Performance

The Sault Ste. Marie Port's operating costs are higher than the industry baseline for general maintenance, janitorial, and grounds costs. The water, energy and waste costs are lower than the industry baseline. Overall, the building costs more to operate than a baseline building. The baseline used for this analysis was an office building, because there is no equivalent to Ports available for comparison. Significant consideration must be given to the building's operational function when reviewing these costs.



Occupant Satisfaction Survey

All 74 of the Sault Ste. Marie Port occupants were surveyed and 16 responded. The results indicated that occupants of the Sault Ste. Marie Port are generally less satisfied with their building than occupants in the CBE baseline (9th percentile), and the building scored the lowest of all of the GSA buildings surveyed in this study. The acoustic quality, thermal comfort, and lighting all scored below the 50th percentile of the CBE buildings surveyed. Cleanliness and maintenance and air quality scored above the 50th percentile. Problems with glare and temperature due to the daylighting were identified as a persistent lighting and thermal comfort issue.

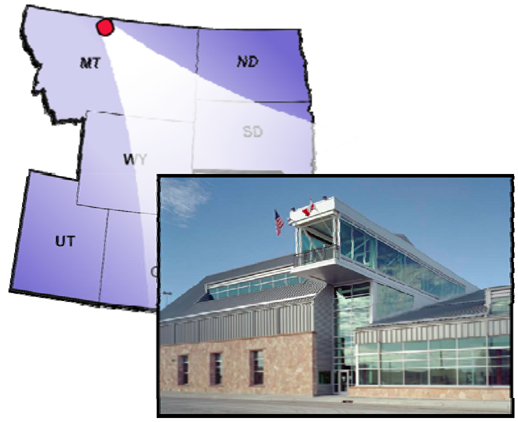


Performance Data Summary

The research team collected, normalized, and compared whole building performance data for the Sault Sainte Marie Port to industry baselines. The following table summarizes the annual performance data collected and normalized.

Metrics	Annual Performance Measurements		Annual Reporting Metrics	
	Water Use (gal)	*13,000*	Gallons per occupant	*155*
	Process Water Use (gal)	*-*	Water Cost per occupant	*$22.12*
	Outdoor Water Use (gal)	*-*	Gallons per GSF	*0.20*
	Water Cost	*$1,858*	Water Cost per GSF	*$0.03*
	Energy Star Score	*17*	Energy Use (kBTU) per GSF	*166*
	Energy Cost	*$6,943*	Energy Cost per GSF	*$1.54*
			Energy Emissions per building (metric tons CO_2 equiv)	*1,727*
	General Maintenance Cost	*$109,962*	General Maint Cost per RSF	*$2.77*
	Janitorial Services Cost	*$206,281*	Janitorial Services Cost per RSF	*$5.19*
	Grounds Maintenance Cost	*$64,860*	Grounds Maint Cost per RSF	*$1.63*
	Quantity of Maint Requests	*278*	Ratio of Maint Requests to Total Maintenance Jobs	*0.43*
	Quantity of Prev Maint Jobs	*375*		
	Solid Waste Generated (tons)	*70*	Solid Waste (lb) per occupant	*5.20*
	Solid Waste Cost	*$3,182*	Solid Waste Cost per RSF	*$0.002*
	Quantity Recycled (tons)	*0*	Solid Waste Cost per occupant	*$37.89*
	Recycling Cost	*$0*	Ratio of Recycled to Solid Waste	*0.00*
	Survey # of Invitees	*74*		
	Survey # of Respondents (n)	*16*	Survey Return Rate	*22%*
	Commute Miles per occ (avg)	*17*	Commute Emissions per occ (metric tons CO_2 equiv)	*1.95*
	Commute fuel per occ (avg gal)	*211*		

Sweetgrass Port



Description

The Shared Port-of-Entry, bordering the towns of Sweetgrass, Montana and Coutts, Alberta, Canada was constructed as a facility jointly shared between GSA, the Canada Border Services Agency, and the regional U.S. and Canadian highway departments. This is the nation's first LEED Certified Port, and it has won GSA's Environmental Award because of its water-efficiency features, indoor air quality, sustainable siting, and green housekeeping features.

The site is located directly on the US/Canadian border. This study included the main port building as well as two commercial inspection bays, two vehicle inspection bays, and two hazardous materials inspection bays. Half of these facilities are located in the United States and half are in Canada, resulting in contracting challenges for the maintenance and operations of the facilities.

Building Location:	**Main Port Building**
	Sweetgrass Montana 59485-9707
Building Function:	**Port of Entry**
Project Type:	**New** **3** *floors*
Design Recognition:	**LEED -- NC, v.2/v.21 --Level: Certified (27 points)**
Year Occupied	**2003**
Gross Square Foot:	**98,196**
Rentable Square Foot:	**84,928**
Hours of Operation:	**168**
Regular Occupants:	**190**
Occupant Visitor Equiv.	**253**
Electronic Equipment:	**320**
Total Project Cost:	**$31,200,000**
Construction Cost:	**n/a**

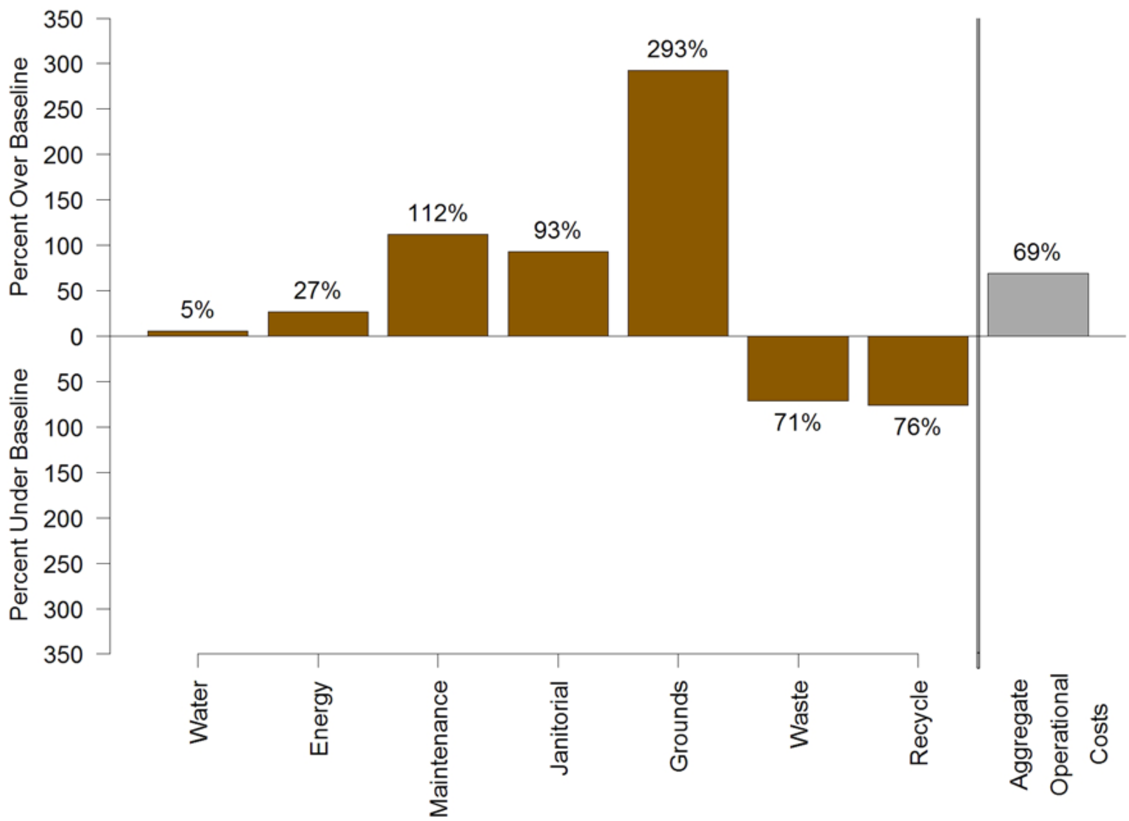
The design incorporated the security function of the building with the goal of 96% of all occupants having a direct line of sight to the outdoors. The building also uses low-emitting paints, carpets, and composite wood to further increase the indoor environmental quality for its occupants. The landscaping incorporates native and adaptive vegetation, and the building has low-flow fixtures and equipment to increase its water efficiency. Because of Sweetgrass' northern location and function, snow removal is critical to building operations. Glycol loops are used to heat the traffic areas and inspection facilities during the winter season.

Each building in the study had operational highlights and potential opportunities for improvement. Although it was not the focus of this study to investigate and/or document operational highlights and opportunities, the research team observed the following:

- The primary challenge facing the Sweetgrass Port is available labor for operations and maintenance tasks such as snow removal and window washing. Joint ownership by Canada and the United States requires that employees and contractors working on the respective sides of the border must be citizens of the country in which they are working. The challenge of needing two contracts for each task is further complicated by the remoteness of the location. An agreement between the two governments to resolve the citizenship related contracting requirements would decrease operating costs and improve operations.

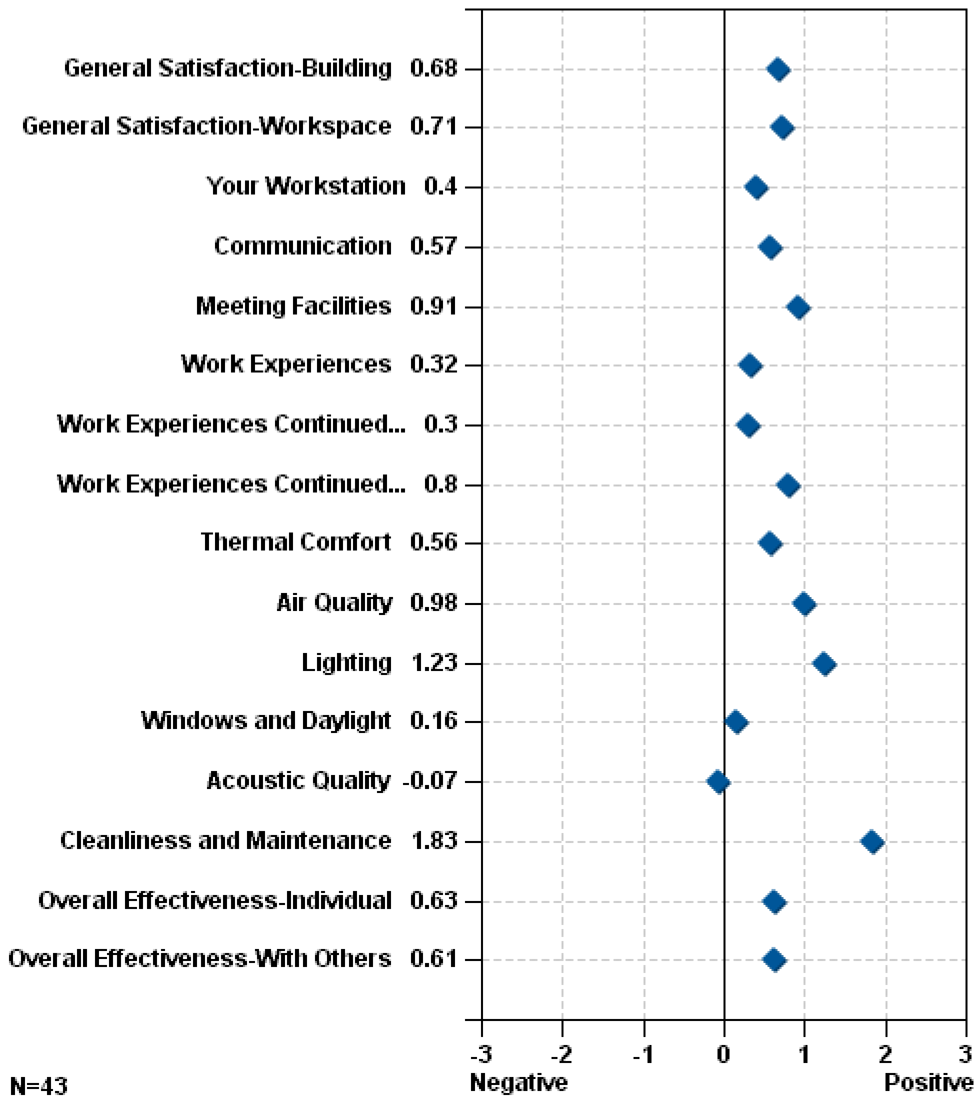
Whole Building Performance

The Sweetgrass Port operating costs are generally higher than the industry baseline for energy, general maintenance, janitorial, and grounds maintenance. The water, waste, and recycling costs were lower than the industry baseline. Overall, the building costs more to operate than a baseline building. The baseline used for this analysis was an office building, because no equivalent to Ports is available for comparison. Significant consideration must be given to the building's operational function and remote location when reviewing these costs.



Occupant Satisfaction Survey

Of the 190 building occupants, 70 were surveyed and 40 responded. The results indicated that occupants of the Sweetgrass Port are less satisfied with their building than occupants in the CBE baseline (34th percentile), yet all of the major satisfaction metrics scored above the CBE baseline buildings. Acoustic quality and lighting scored in the 58th and 56th percentile respectively, while air quality, cleanliness and maintenance, and thermal comfort all scored in or above the 75th percentile..



Performance Data Summary

The research team collected, normalized, and compared whole building performance data for the Sweetgrass Port to industry baselines. The following table summarizes the annual performance data collected and normalized.

Metrics	Annual Performance Measurements		Annual Reporting Metrics	
	Water Use (gal)	*123,144*	Gallons per occupant	*487*
	Process Water Use (gal)	-	Water Cost per occupant	*$31.91*
	Outdoor Water Use (gal)	-	Gallons per GSF	*1.25*
	Water Cost	*$8,073*	Water Cost per GSF	*$0.08*
	Energy Use (MBTU)	*16*	Energy Use (kBTU) per GSF	*19*
	Energy Cost	*$1,193*	Energy Cost per GSF	*$1.02*
			Energy Emissions per building (metric tons CO_2 equiv)	*1,783*
	General Maintenance Cost	*$308,055*	General Maint Cost per RSF	*$3.63*
	Janitorial Services Cost	*$240,630*	Janitorial Services Cost per RSF	*$2.83*
	Grounds Maintenance Cost	*$40,035*	Grounds Maint Cost per RSF	*$0.47*
	Quantity of Maint Requests	*9*		
	Quantity of Prev Maint Jobs	*228*	Ratio of Maint Requests to Total Maintenance Jobs	*0.04*
	Solid Waste Generated (tons)	*n/a*	Solid Waste (lb) per occupant	*n/a*
	Solid Waste Cost	*$5,770*	Solid Waste Cost per RSF	*n/a*
	Quantity Recycled (tons)	*n/a*	Solid Waste Cost per occupant	*$22.80*
	Recycling Cost	*$1,260*	Ratio of Recycled to Solid Waste	*n/a*
	Survey # of Invitees	*70*		
	Survey # of Respondents (n)	*42*	Survey Return Rate	*60%*
	Commute Miles per occ (avg)	*39*		
	Commute fuel per occ (avg gal)	*386*	Commute Emissions per occ (metric tons CO_2 equiv)	*3.57*

Appendix B: Port of Entry Data

Initial analysis of the Port of Entry data demonstrated that none of the commonly used baselines for office buildings would apply to Ports of Entry. Some of the reasons for removing the Port of Entry buildings from the body of the report include the following:

- Port of Entry buildings operate 24 hours a day for 365 days a year.
- Ports of Entry contain a considerable amount of electronic equipment (e.g., monitoring equipment, computers, etc.).
- A considerable number of public visitors impact the water use, energy use, and janitorial costs.
- The remote location of Ports of Entry tends to increase their associated labor costs.
- A portion of the space includes large heated garages for vehicle inspections.

For these reasons, the Port of Entry building data for Sweetgrass and Sault Sainte Marie are provided in this appendix.

General Building Information

The Sault Sainte (Ste.) Marie Port of Entry is on the US-side of the US-Canadian border surrounded by a small community. The Sweetgrass, Montana/Coutts, Alberta (Sweetgrass) Port of Entry straddles the US-Canadian border in a remote location. Appendix A offers a detailed site summary for both of these facilities.

For each of the key metrics in this study, the following table offers the summary results. The remainder of the tables in this appendix provide detail for each individual metric.

Building Name	GSF	Energy Star® Score	Total Water (1000 gal)	Aggregate Maintenance Cost	Waste Cost	General Bldg % Satisfaction	Metric Tons of CO_2 equivs/Occ
Sault Ste. Marie Port	63,874	17	13	$381,104	$3,182	47%	1.95
Sweetgrass Port	98,196	16	123	$588,720	$5,770	61%	3.57

The Sweetgrass Port of Entry is larger than the Sault Sainte Marie Port of Entry and has more daily visitors that stopped to use the facilities.

Building Name	Region	Vintage	GSF	RSF	Occ	Occ-Vis Equiv	Hours/ week	# Comps
Sault Ste. Marie Port	5	2005	63,874	39,709	74	84	168	80
Sweetgrass Port	8	2003	98,196	84,928	190	253	168	320

Sweetgrass is LEED-NC certified (i.e., certified by the U.S. Green Building Council as representing Leadership in Energy and Environmental Design for New Construction) with no Energy & Atmosphere (EA) Optimize Energy Performance (EAc1) points and only one Water Efficiency (WE) Water Use Reduction (WEc3) point. Both buildings had Energy Star scores below 20. Although not shown in this table, Sweetgrass also has one EA point for Green Power (EAc6) and two points for Water-Efficient Landscaping (WEc1).

Building Name	Certification Level	LEED® Total Points	LEED® EAc1 Points	LEED® WEc3 Points	Energy Star® Score
Sault Ste. Marie Port	LEED Registered	n/a	n/a	n/a	17
Sweetgrass Port	LEED-NC Certified	27	0	1	16

Water

Neither site uses process water for cooling or potable water for landscaping. Sault Ste. Marie has a vegetated roof, but no significant landscaping. Sweetgrass has minimal trees and native plants that require no additional water once they are established.

	Water Use (thousand gallons)					
Building Name	**Water Consuming Equipment**	**Total Water**	**Estimated Landscape**	**Estimated Process**	**Domestic Portion**	**Total Water Cost**
Sault Ste. Marie Port	-	13	0	0	13	$1,858
Sweetgrass Port	-	123	0	0	123	$8,073

Energy

Neither Port of Entry building has access to central steam or chilled water. Both buildings use natural gas and electricity.

Building Name	Electricity (MWH)	Nat Gas (1000 ft^3)	Steam (MLB)	Chilled Water (Ton Hr)	Electric Demand (MW)	Electric Demand Cost	Total Energy Cost
Sault Ste. Marie Port	1,918	3,982	0	0	0.0	$0	$98,472
Sweetgrass Port	2,420	11,934	0	0	8.7	$42,904	$146,877

The most comparable information for the energy use intensity (EUI) is information specific to the GSA information. When all GSA Port of Entry energy use is averaged the EUI is 109 kBTU/gsf. When only the northern Port of Entry energy use is averaged, the EUI is 132 kBTU/gsf, which is closer to the measured use than the Commercial Buildings Energy Consumption Survey (CBECS) values by region.

	EUI (kBTU/gsf)							
Building Name	Current EUI	FY06 GSA	FY07 GSA	Energy Star Baseline (50 Percentile)	CBECS by Region	GSA Port Average	GSA Northern Port Avg	Estimated CO_2 Equiv/Bldg (metric tons)
Sault Ste. Marie Port	166	155	174	114	108	109	132	888
Sweetgrass Port	190	n/a	n/a	134	104	109	132	917

Maintenance and Operations

The site personnel at the Sweetgrass Port of Entry indicated that they had considerable difficulty getting reasonably priced contractors on site because of their remote location of the site. The site does not routinely track maintenance calls, thus the estimated ratio of maintenance calls to preventative maintenance provided by site personnel is shown in *italics*.

Building Name	Green House-keeping	Maint Calls / Total Maint	Prev Maint / Total Maint	General Maint Cost	Janitorial Maint Cost	Grounds Maint Cost
Sault Ste. Marie Port	Some	0.43	0.57	$109,962	$206,281	$64,860
Sweetgrass Port	Yes	*0.04*	*0.96*	$308,055	$240,630	$40,035

Waste Disposal and Recycling

Sault Ste. Marie did not have a recycling program, and although a recycling program exists at Sweetgrass, the PNNL research team was not able to obtain the numbers related to quantities of waste and recycled materials to enable a performance comparison.

Building Name	Waste per Year (Tons)	Waste Cost	Recycled Material	Recycle per year (Tons)	Recycle Cost	% Recycle to Waste
Sault Ste. Marie Port	70.2	$3,182	None	0.0	$0	0%
Sweetgrass Port	n/a	$5,770	Paper	n/a	$1,260	n/a

Transportation

The occupants of the Sault Ste. Marie Port of Entry building have the shortest average commute distances of all the buildings in the study, while Sweetgrass building occupants have the longest average commute distance. For both buildings, the majority of the building occupants drive trucks or sport utility vehicles.

Building Name	Survey N-Value	# Occ	Avg Daily Roundtrip Miles Traveled	Avg Annual Gallons Used/Occ	Estimated CO_2 Equiv/Occ (metric tons)	Calculated CO_2 Equiv/Bldg (metric tons)
Sault Ste. Marie Port	16	74	16.7	211	2.0	187
Sweetgrass Port	43	190	38.6	386	3.6	480

As more Port of Entry buildings are designed and built, the need to understand how to optimize the design and operation of this building type will become greater. A detailed analysis of a Port of Entry building's performance would offer additional insight into factors impacting the water and energy use, maintenance and waste costs, occupant commute, and occupant satisfaction considerations. This level of analysis would require sub-metered energy and water use and more detailed investigation into costs and occupant-related factors.

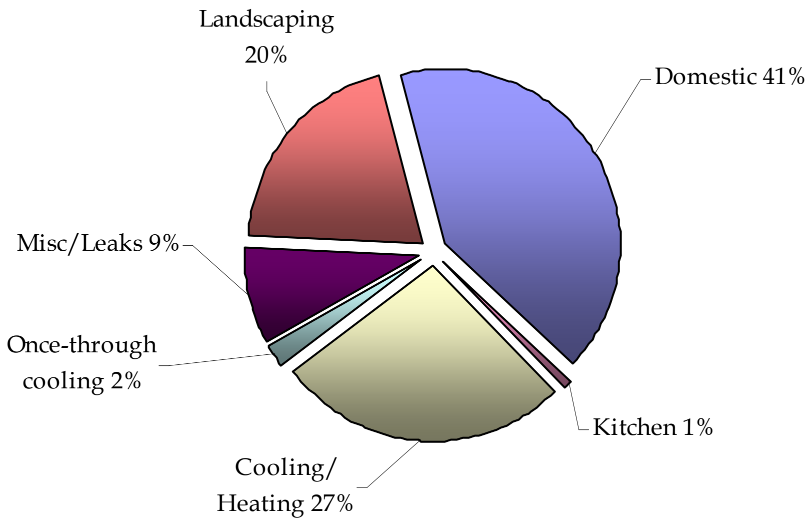
Appendix C: Baseline Development Documentation

For each of the major whole building performance metrics, an industry baseline was determined for comparison purposes. These baselines were developed for the selected General Services Administration (GSA) buildings in this study and should therefore be evaluated for applicability if they are considered for use with other building sectors. How each baseline was developed is provided below.

Water

Water consumption in a commercial office building typically consists primarily of domestic use (i.e., faucet, toilet, and urinal use), landscape irrigation, and process water (i.e., cooling and/or heating processes).[33]

Water Distribution in a Typical Office Building



These three primary uses of water were separated for each building. Domestic water consumption depends on human operation and fixed equipment efficiency. Therefore, typical indoor water consumption is best expressed as per occupant. For water use comparisons to the baseline, gallons per occupant per year is used. Occupancy gender data allow for a more accurate comparison of indoor water use, because the quantity and type of water-using fixtures vary by gender. Many of these buildings also have a large number of visitors, who are likely to contribute to the total domestic water consumption. To address this, an estimate of visitor water use was added to the total based on expected quantities of visitors and an appropriate gallon also compared to a visitor-adjusted baseline in gallons used per occupant and visitor per year value.

For water use analysis, the indoor potable water use data had to be estimated from the water utility bills. The baselines for comparison include indoor potable water use per occupant per day, total water use per gross square footage, and water cost per rentable square foot. Process and landscape water analysis were not performed as detailed water use information was not available.

Indoor Water Use Per Occupant

The reference data used for calculating the water use baseline was the federal Water Use Indices (Indices).[34] The Indices provide basic guidance on typical water usage for different building types. Indoor water use for office buildings is estimated at an average of 15 gallons per occupant per day (gpd/occupant), with a range of 8 to 20 gpd.

When landscape irrigation water and process water have been removed from the total water consumption, the majority of the building water consumption is from "domestic uses." Due to the difference in fixture type (i.e., urinals and toilets), occupant gender plays a role in the quantity of water used in a typical federal building, courthouse, or port of entry building. However, the federal Indices do not provide detail on use for male and female building occupants. The following assumptions were made to support the adjustment of the Indices and develop a gender-specific water use baseline:

- The federal Indices were developed with a 50-50 ratio of male-to-female building occupants.
- In an office building, 61% of the domestic water use is for toilets, 17% for urinals, and 22% for faucets.
- On average, females use toilets three times per day with males only once per day plus urinals two times per day.[35]
- Faucet use is equal for males and females.
- 15 gpd/occupant is the average between male and female water use.

Based on these assumptions, the following calculations were made:

Domestic Water Use = Female Toilet Use + Male Toilet Use + Female Faucet Use + Male Faucet Use + Male Urinal Use

Toilet Use = Female Use (75%) + Male Use (25%)

Faucet Use = Female Use (50%) + Male Use (50%)

*Female Use = [(75% Toilet) * (61% Water Use for Toilets)] + [(50% Faucets) * (22% Water use for Faucets)]*

Female Use = 57% Total Water Use or 17.1 gpd/occupant

*Male Use = [(25% Toilet) * (61% Water Use for Toilets)] + [17% Urinal] + [(50% Faucets) * (22% Water use for Faucets)]*

Male Use = 43% Total Water Use or 12.9 gpd/occupant

Thus, the quantity of male and female occupants was used to adjust the Indices for the Indoor Water Use baseline as follows:

*Water Use Baseline (gpd/occupant) = (Total Occupants * % Female * 17.1 gpd/occupant) + (Total Occupants * % Male * 12.9 gpd/occupant)*

The baseline also includes water use associated with visitors to the buildings. This added value is based on data on visitors to the buildings. For each building, the number and type of visitors was requested in order to estimate visitor impact on water use. The building contacts typically provided the number of visitors per day, the typical length of stay for each visitor, and reason for visit. Some buildings offered estimates of restroom visits per visitor. Depending on the type and length of visit, the visitors were assumed to use the restroom the equivalent of zero to 100% of a regular building occupant use.

The Port of Entry buildings, the Department of Homeland Security federal building, and the Santa Ana courthouse and federal building also included inmates. Inmate water use was assumed to be 120 gpd/occupant. Although several buildings had showers and one building had a small restaurant, those water usages were not included in the baseline calculations. And finally, in all but the Port of Entry buildings, it was assumed the water use would occur 250 days per year (i.e., five workdays a week and fifty workweeks per year). The following table provides the baseline values for each of the buildings.

Building Number	Building Name	# Regular Occupants	Water Baseline gal/occupant/ year	Occupant & Visitor Use	Water Baseline gal/person/year
UT1434ZZ	Ogden (L) FB	514	2,143,380	521	2,172,570
CO1923ZZ	Lakewood (L) FB	318	1,159,110	336	1,222,898
NE1430ZZ	Omaha DHS (L) FB	65	243,750	139	864,455
NE1425ZZ	Omaha NPS (L) FB	125	462,188	134	494,726
TN0076ZZ	Knoxville FB	285	1,158,900	310	1,248,285
CA0200ZZ	Santa Ana FB	409	2,152,500	459	2,371,286
CO0061ZZ	Denver CH	170	637,500	370	1,387,500
IA0027ZZ	Davenport CH	45	168,750	63	236,250
OH0033ZZ	Cleveland CH	105	393,750	143	534,375
TN0012ZZ	Greenville CH	85	318,750	103	386,250
OH0302ZZ	Youngstown CH & FB	45	168,750	107	400,313
CA0309ZZ	Fresno CH & FB	235	881,250	510	1,912,500
MI0724SB	Sault Ste. Marie Port	74	258,075	84	292,950
MT0767AI	Sweetgrass Port	190	662,625	253	880,594

Visitor Calculations

For each building, the number and type of visitors were requested in order to estimate visitor impact on water use. The building contacts typically provided the number of visitors per day, the typical length of stay for each visitor, and the reason for the visit. Some buildings offered estimates of restroom visits per visitor. Depending on the type and length of visit, the visitors use of the restroom was assumed to be the equivalent of zero to 100% of a regular building occupant use.

Building Number	Regular Occupants /day	% Female	% Male	Detainees /year	Detainees /week	Detainees /day	Visitors /year	Visitors /day	Hrs/visitor Estimate	Visitor Occupant Equivalent	Occupant & Visitor Use
UT1434ZZ	514	90%	10%	-	-	-	1,800	7	equiv to occ	7	521
CO1923ZZ	318	40%	60%	-	-	-	9,900	40	1 use for 7500 + meetings for 2400	18	336
NE1430ZZ	65	50%	50%	2860	55	7.9	65,250	250	-	74	139
NE1425ZZ	125	45%	55%	-	-	-	8,800	35	1 use	9	134
TN0076ZZ	285	30%	70%	-	-	-	25,250	101	1 use	25	310
CA0200ZZ	409	50%	50%	260	5	0.7	50,000	200	1 use	50	459
CO0061ZZ	170	50%	50%	-	-	-	100,000	400	half	200	370
IA0027ZZ	45	50%	50%	-	-	-	9,000	36	half	18	63
OH0033ZZ	105	50%	50%	-	-	-	18,750	75	half	38	143
TN0012ZZ	85	50%	50%	-	-	-	9,000	36	half	18	103
OH0302ZZ	45	50%	50%	-	-	-	61,750	247	1 use	62	107
CA0309ZZ	235	50%	50%	-	-	-	275,000	1,100	1 use	275	510
MI0724SB	74	25%	75%	-	-	-	36,500	100	1 use	10	84
MT0767AI	190	25%	75%	-	-	-	91,250	250	1 use	63	253

Indoor Water Use Baseline Observations

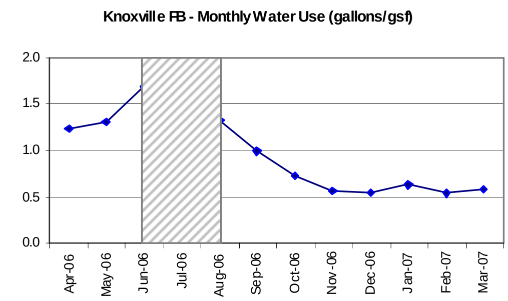
The Indices have not been updated since 1996. The last federal ruling on flow rates of water-consuming technologies was in the Energy Policy Act (EPAct) of 1992. As buildings update their faucets, toilets, urinals, and showerheads, it is conceivable that a savings of 50% could be achieved. When the Indices are updated, it is likely that the average use per occupant will decrease. Rather than updating the water baseline to an assumed use under the EPAct standard, the documented FEMP Water Use Indices baseline were used, which may represent a greater savings than current practice would offer.

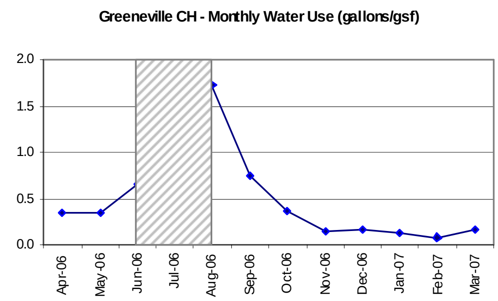
Outdoor Water Use

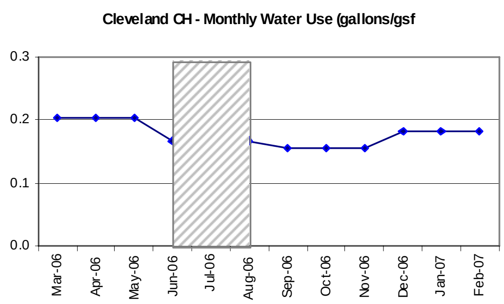
Irrigation water use depends on the size of the irrigated area, as well as the climate and type of plants or turf being watered. A water-thirsty landscape (appropriate for climates with 40+ inches of annual precipitation) in a dry climate typically uses about 25 gallons of water per square foot per season. However, use of native and drought-tolerant plants can reduce irrigation needs to about 5 to 10 gallons per square foot per season.[36]

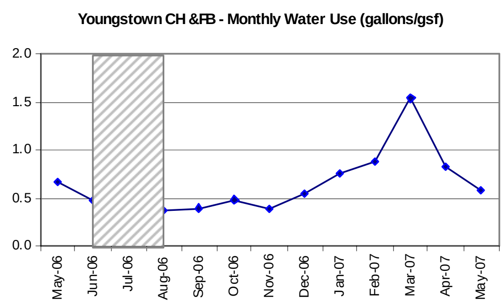
Only one of the buildings in the study had separately metered landscape irrigation (Fresno Courthouse and Federal Building). Many of the buildings had minimal landscaping. For those it was easy to dismiss landscape water use as minimal (see Ogden FB, Cleveland CH, Davenport CH, and Santa Ana FB). Other buildings have rainwater capture systems that are used to store irrigation water (Knoxville FB and Omaha Department of Homeland Security FB), and Omaha National Park Service's property only has native trees, plants, and grasses that do not require any irrigation. However, several buildings had enough water-intensive landscaping that it was necessary to examine seasonal water use in order to estimate landscape irrigation use. A FEMP estimate of 20 percent of a building's water use being attributed to landscaping was applied to buildings with water-intensive landscaping.

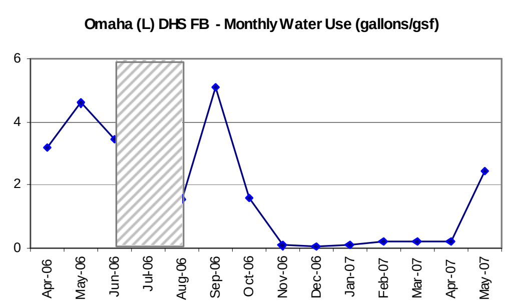
Seasonal water use can be observed for the Greenville CH, Knoxville FB, Davenport CH, Lakewood FB, Denver CH, Odgen FB, Omaha DHS FB, and Fresno CH & FB. These buildings have evaporative cooling and/or cooling towers and/or landscaping that cause spikes in water use. The following figures show the water use by month for each building, with the summer months shaded gray. Only 11 of the buildings are shown, because not all buildings have the necessary detail to represent the trend.

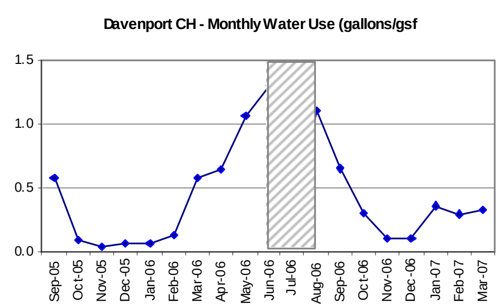


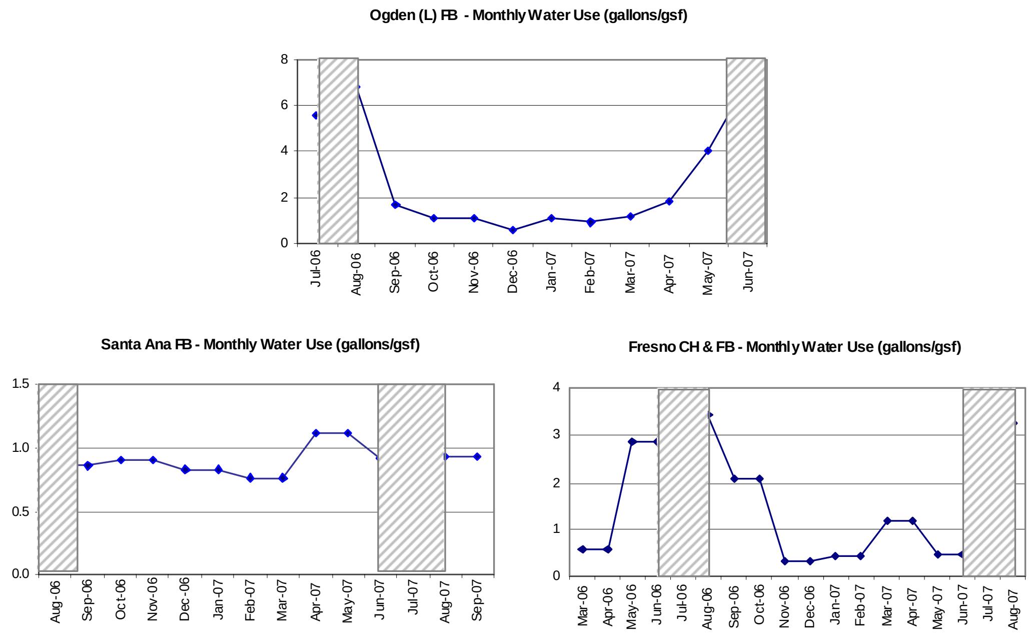












Water Use Trends by Building

(Grouped by region; Gray shading indicates summer months)

Process Water Use

Seven of the fourteen GSA buildings included in this study use water for building cooling systems. Two methods were attempted to estimate this use, and neither were used. Initially, a Federal Energy Decision System (FEDS) which provided a modeled estimate of the water use for the cooling systems to allow for a normalized comparison. FEDS is a PNNL-developed tool used by multiple federal agencies to identify energy and water saving opportunities. FEDS uses actual weather data from the building location to estimate heating, cooling, ventilation, lighting, and plug loads. The tool uses building characteristics such as envelope, geometry, occupancy hours, age and capacity of mechanical equipment, and lighting types to estimate all of the typical building end uses. Unfortunately the initial FEDS estimates did not yield realistic values based on the total water use values obtained from the sites. A second method was the application of a 27% cooling equipment use. For the purposes of this study process water estimates were obtained by applying a 27 percent factor FEMP. The process water estimates are shown below. The FEDS estimates are model based and therefore susceptible to varying inputs. It is clear that in at least one case the process estimate is over the total water use.

The final approach that was chosen to estimate the domestic water use was to examine the monthly water data provided by the utilities and observe where changes in building processes (i.e., an increase in air conditioning) occurred. The high water use tended to occur from April to October. Those months were removed from the annual domestic water use calculation and an estimated domestic value was used for analysis.

Building Name	Water Consuming Equipment	Water Use (thousand gallons) Total	27 % Estimated Process	FEDS Estimated Process
Ogden (L) FB	Evap Cooling	3,435	927	1,066
Lakewood (L) FB	Cooling Towers	4,340	1,172	562
Knoxville FB	Cooling Towers	2,027	547	272
Denver CH	Evap Cooling	4,039	1,091	508
Davenport CH	Cooling Towers	516	139	440
Greenville CH	Cooling Towers	800	216	813
Fresno CH & FB	Cooling Towers	7,706	1,393	869

Water Cost

The water cost baseline was calculated from the International Facility Management Association (IFMA) Benchmarks IV Research Report and Operations and Management Benchmarks, as well as the Building Owners and Managers Association (BOMA) International Experience Exchange Report. The water cost baseline was provided in gross square footage from IFMA and rentable square footage for BOMA. The BOMA values tended to be lower than the IFMA values and had fewer buildings in the data set. The BOMA values were modified from a rentable square foot basis to gross square footage. Given these references, the water cost range is $0.05 to $0.19 per gross square foot.

Appendix D: Reporting Metrics Table

Metric Categories	Performance Measurement	Reporting Metrics
Water 	**Total Building Potable Water Use** $\frac{gal}{year}$ $\frac{\$}{year}$ **Indoor Potable, Outdoor, and Process Water Use** $\frac{gal}{year}$ $\frac{\$}{year}$	**Annual Domestic Water Use** $\frac{gal}{occupant}$ $\frac{\$}{occupant}$ $\frac{gal}{gsf}$ $\frac{\$}{gsf}$
Energy 	**Total Building Energy Use** $\frac{Btu}{year}$ $\frac{\$}{year}$	**Annual Energy Use** $\frac{Btu}{gsf}$ $\frac{\$}{gsf}$ $\frac{Gkg\ CO_2}{year}$
Maintenance & Operations 	**Building & Grounds Maintenance** $\frac{Service\ Calls}{year}$ $\frac{\$}{year}$ $\frac{Preventative\ Maintenance\ Calls}{year}$	**Annual M&O** $\frac{Service\ Calls}{Total\ Maint}$ $\frac{Prev\ Maint\ Calls}{Total\ Maint}$ $\frac{Maint\ \$}{rsf}$ $\frac{Grounds\ \$}{rsf}$ $\frac{Janitor\ \$}{rsf}$
Waste Generation & Recycling 	**Solid Sanitary Waste** $\frac{ton}{year}$ $\frac{\$}{year}$ Recycled Materials $\frac{ton}{year}$ $\frac{\$}{year}$	**Annual Waste & Recycled** $\frac{lb}{occupant}$ $\frac{\$}{rsf}$ $\frac{\$}{occupant}$ $\frac{lb\ recycled}{lb\ sanitary\ waste}$
Occupant Satisfaction 	**Building Occupant Self-Reported Satisfaction and Productivity** $\frac{Occupant\ Rating}{Survey\ Metric}$	**2007 Building Occupant Satisfaction and Productivity** *(CBE Baseline Percentile – Total Building Occupant Satisfaction)*
Transportation 	**Regular Commute (from survey data)** $\frac{miles}{gallon}$ $\frac{miles}{week}$	**Annual Transportation Impacts** $\frac{Gkg\ CO_2}{year}$

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Appendix E: Occupant Satisfaction Key Survey Questions

This appendix includes the key questions included in the GSA adaptation of the CBE survey, which was named the Sustainable Places and Organizational Trends "SPOT" survey.

Part 1 - Background Information

1. How would you describe the work you do?
2. Which organization do you work for?
3. How many years have you worked in this building?
4. How long have you been working at your present workspace?

Part 2 – Commute

1. On average, how many days per week do you travel to the office (i.e., commute)?
2. How far is your typical daily commute to and from this building?______ Miles Roundtrip

3. Please indicate the *number of days* per week you commute to and from this building for each mode of transportation that applies.

	Walk		Bicycle
	Car, truck or van - single occupant		Car, truck or van - multiple occupants (e.g. carpool, vanpool or rideshare)
	Bus		Train (including light rail)
	Combination of multiple modes (e.g., driving to ride share locations then taking mass transit)		
	Other		

4. Please describe any other issues related to your commute to and from this building that are important to you; and/or provide additional detail on your modes of transportation as you see fit.

Part 3 – Personal Workspace Location

1. On which floor is your workspace located?
2. In which area of the building is your workspace located?
3. Are you near a window (within 15 feet)?
4. Describe your personal workspace.

Part 4 – Your Workstation

In this section, please note your level of satisfaction with features and attributes of your workstation.

If any of these aspects are not important to you, please indicate so instead of answering with a level of satisfaction.

1. How satisfied are you with the comfort of your office furnishings (chair, desk, computer, equipment, etc.)? This is not important to me ____

VERY SATISFIED VERY DISSATISFIED

7	6	5	4	3	2	1

2. How satisfied are you with your ability to adjust your furniture to meet your needs?

This is not important to me ____

VERY SATISFIED VERY DISSATISFIED

7	6	5	4	3	2	1

3. How satisfied are you with the colors and textures of flooring, furniture, and surface finishes?

This is not important to me ____

VERY SATISFIED VERY DISSATISFIED

7	6	5	4	3	2	1

4. How satisfied are you with the amount of space available for individual work?

This is not important to me ____

VERY SATISFIED VERY DISSATISFIED

7	6	5	4	3	2	1

5. How satisfied are you with the level of visual privacy in your workspace?

This is not important to me ____

VERY SATISFIED						VERY DISSATISFIED
7	6	5	4	3	2	1

6. Please describe any other issues related to your personal workspace that are of importance to you.

Part 5 – Communication

1. How satisfied are you with your ability to communicate with co-workers in person (face to face)?

This is not important to me ____

VERY SATISFIED						VERY DISSATISFIED
7	6	5	4	3	2	1

2. How satisfied are you with the ease of interaction with co-workers?

This is not important to me ____

VERY SATISFIED						VERY DISSATISFIED
7	6	5	4	3	2	1

3. How satisfied are you with your ability to communicate in privacy?

This is not important to me ____

VERY SATISFIED						VERY DISSATISFIED
7	6	5	4	3	2	1

4. How satisfied are you with the availability of space where you and your colleagues can talk into a speaker phone together?

This is not important to me ____

VERY SATISFIED | VERY DISSATISFIED

7	6	5	4	3	2	1

5. Please describe any other issues related to communication with others that are important to you.

Part 6 – Meeting Facilities

1. How satisfied are you with the availability of meeting rooms on short notice?

This is not important to me ____

VERY SATISFIED | VERY DISSATISFIED

7	6	5	4	3	2	1

2. How satisfied are you with the availability of equipment in meeting rooms? (white boards, speaker phone, computer access, LCD projectors, etc.)

This is not important to me ____

VERY SATISFIED | VERY DISSATISFIED

7	6	5	4	3	2	1

3. How satisfied are you with the temperature of meeting rooms?

This is not important to me ____

VERY SATISFIED | VERY DISSATISFIED

7	6	5	4	3	2	1

4. How satisfied are you with the acoustic quality of meeting rooms?

This is not important to me ____

VERY SATISFIED						VERY DISSATISFIED
7	6	5	4	3	2	1

5. How satisfied are you with the variety of meeting rooms available to you?

This is not important to me ____

VERY SATISFIED						VERY DISSATISFIED
7	6	5	4	3	2	1

6. Please describe any other issues related to meeting facilities that are important to you.

Part 7 – Work Experiences

In this section, please rate your level of agreement with the following statements about experiences at work.

1. I look forward to working in the building.

STRONGLY AGREE						STRONGLY DISAGREE
7	6	5	4	3	2	1

2. I am proud to show the office to visitors.

STRONGLY AGREE						STRONGLY DISAGREE
7	6	5	4	3	2	1

3. The overall appearance of the workplace is consistent with the mission of the agency.

STRONGLY AGREE STRONGLY DISAGREE

7 6 5 4 3 2 1

4. There is a good sense of connection to the outdoors from inside the building.

STRONGLY AGREE STRONGLY DISAGREE

7 6 5 4 3 2 1

5. There is a definite space that is the 'heart' of the workplace.

STRONGLY AGREE STRONGLY DISAGREE

7 6 5 4 3 2 1

6. It is easy to locate other people and spaces (offices, meeting rooms, etc.) even when I have not been there before.

STRONGLY AGREE STRONGLY DISAGREE

7 6 5 4 3 2 1

7. Communication within my group is good.

STRONGLY AGREE STRONGLY DISAGREE

8. I learn a lot about what is going on by seeing and hearing others.

STRONGLY AGREE STRONGLY DISAGREE

7 6 5 4 3 2 1

9. I often stop and talk to others in corridors or break areas.

STRONGLY AGREE — STRONGLY DISAGREE

7	6	5	4	3	2	1

10. The security features of our building are adequate.

STRONGLY AGREE — STRONGLY DISAGREE

7	6	5	4	3	2	1

11. I feel safe walking to and from the building.

STRONGLY AGREE — STRONGLY DISAGREE

7	6	5	4	3	2	1

12. We have comfortable spaces to have lunch or takes breaks inside the building.

STRONGLY AGREE — STRONGLY DISAGREE

7	6	5	4	3	2	1

13. We have adequate restroom facilities in our offices.

STRONGLY AGREE — STRONGLY DISAGREE

7	6	5	4	3	2	1

14. I use the building stairs rather than the elevator at least once a day.

STRONGLY AGREE — STRONGLY DISAGREE

7	6	5	4	3	2	1

Part 8 – Indoor Environmental Quality

The following section of the survey focuses on your satisfaction with indoor environmental quality in your workplace. How important is each of the following items to doing your job well?

Thermal Comfort

1. Which of the following do you personally adjust or control in your workspace? (check all that apply)

☐	Window blinds or shades	☐	Operable window
☐	Thermostat	☐	Portable heater
☐	Permanent heater	☐	Room air-conditioning unit
☐	Portable fan	☐	Ceiling fan
☐	Adjustable air vent in wall or ceiling	☐	Adjustable air vent in floor (diffuser)
☐	Door to interior space	☐	Door to exterior space
☐	None of the above	☐	Other

2. How satisfied are you with the temperature in your workspace?

VERY SATISFIED — VERY DISSATISFIED

7	6	5	4	3	2	1
☐	☐	☐	☐	☐	☐	☐

Air Quality

1. How satisfied are you with the air quality in your workspace (i.e. stuffy/stale air, cleanliness, odors)?

VERY SATISFIED — VERY DISSATISFIED

7	6	5	4	3	2	1
☐	☐	☐	☐	☐	☐	☐

Lighting

1. Which of the following controls do you have over the lighting in your workspace? (check all that apply)

- [ ] Light switch for ceiling lights
- [ ] Dimmer switch for ceiling lights
- [ ] Window blinds or shades
- [ ] Desk (task) light
- [ ] None of the above
- [ ] Other

2. How satisfied are you with the amount of light in your workspace?

VERY SATISFIED — VERY DISSATISFIED

7	6	5	4	3	2	1

3. How satisfied are you with the visual comfort of the lighting (e.g., glare, reflections, contrast)?

VERY SATISFIED — VERY DISSATISFIED

7	6	5	4	3	2	1

4. How satisfied are you with the degree of control you have over the lighting in your workspace?

VERY SATISFIED — VERY DISSATISFIED

7	6	5	4	3	2	1

Windows and Daylight

1. How satisfied are you with the amount of daylight in your general office area?

VERY SATISFIED — VERY DISSATISFIED

7	6	5	4	3	2	1

2. How satisfied are you with your access to a window view?

VERY SATISFIED						VERY DISSATISFIED
7	6	5	4	3	2	1

Acoustic Quality

1. How satisfied are you with the noise level in your workspace?

VERY SATISFIED						VERY DISSATISFIED
7	6	5	4	3	2	1

2. How satisfied are you with the speech privacy in your workspace (ability to have conversations without your neighbors overhearing and vice versa)?

VERY SATISFIED						VERY DISSATISFIED
7	6	5	4	3	2	1

Cleanliness and Maintenance

1. How satisfied are you with the cleanliness and maintenance of the building?

VERY SATISFIED						VERY DISSATISFIED
7	6	5	4	3	2	1

Please describe any other issues related to Indoor Environmental Quality that are important to you.

Part 9 – General Comments

1. All things considered, how satisfied are you with your personal workspace?

VERY SATISFIED						VERY DISSATISFIED
7	6	5	4	3	2	1

2. How satisfied are you with the building overall?

VERY SATISFIED						VERY DISSATISFIED
7	6	5	4	3	2	1

3. To what extent does your workplace enhance or interfere with your <u>individual work effectiveness</u>?

ENHANCES						INTERFERES
7	6	5	4	3	2	1

4. To what extent does your workplace enhance or interfere with your ability to <u>work effectively with others</u>?

ENHANCES						INTERFERES
7	6	5	4	3	2	1

5. If you wanted to show a visitor around the building, but could only show one space, which space would you show?

6. Any additional comments or recommendations about your personal workspace or building overall?

Appendix F: Conversion Factors

Volume Conversions[37]

Water:	1 cubic feet = 7.48052 gallons
	1 cubic meter = 264.172 gallons
Dry:	1 cubic yard = 27 cubic feet

Energy Utility Conversions

Electricity:	1 kwh = 3,413 Btu
Natural Gas:	1 cubic feet average = 1000 Btu
	1 ccf = 100 cubic feet
	1mcf = 1000 cubic feet
	1 gigajoule = 948 cubic feet
	1 therm = 100,000 Btu
	1 decatherm = 10 therms
Steam:	1 lb. steam = 1,000 Btu
Chilled Water:	1 ton hour of chilled water = 12,000 Btu

Material Conversions[38]

Municipal Solid Waste:	1 cubic yard = 450 pounds
Recycled Computer Paper:	1 cubic yard = 655 pounds

Monetary Conversions

For purposes of this study, Canadian and American dollars were estimated to be at par.

Currency Exchange:	1 U.S. $ = 1 CDN $

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Appendix G: Building Contacts

Many GSA site personnel assisted the PNNL research team with this study. The following is a list, in alphabetical order, of those that contributed time and data.

Paul Anderson	Senior Property Manager, Iowa Office Davenport CH
Jonathan Bringewatt	Public Buildings Service Lakewood DOT FB
Jim Brown	Building Engineer - Cottonwood Management Services Ogden FB
Diana Ciryak	Property Manager Cleveland CH
Pamela Coleman	IRS Real Estate and Facilities Management Ogden FB
Scott Crews	Cottonwood Management Services Ogden FB
Dan Fenner	Michigan Service Center -Public Buildings Service Sault Ste. Marie Port
John Garner	Lease Management Representative Omaha NPS FB and Omaha DHS FB
Christopher Grigsby	Asset Management Services Denver CH
Scott Hawkins	Building Engineer - Urban/Meridian Joint Venture Greeneville CH and Knoxville FB
Sue Heeren	Public Buildings Service Davenport CH
Tina Hingorani	Property Manager Santa Ana FB
Jason Hunt	Property Manager Fresno CH & FB
Nicholas Infantino	Property Manager Youngstown CH & FB
Mary Ann Kosmicki	Deputy Director - Nebraska Office Omaha NPS FB and Omaha DHS FB

Kristina Lee	Senior Property Manager - Grubb & Ellis Omaha NPS FB
Jill McCormick	Asset Services - CBRE Omaha DHS FB
J. Michael Ortega	Public Buildings Service Denver CH
Peter Pocius	Property Manager, Montana Field Office Sweetgrass Port
Wendy Schuman	Property Manager -Opus Northwest Management Lakewood DOT FB
Sandy Sitton	Program Analyst Fresno CH & FB
C. Johnathan Sitzlar	Property Manager Greeneville CH and Knoxville FB
Don Smyth	NPS Property Management & Office Services Omaha NPS FB
Mark Stanford	Site Engineer – Public Works and Government Services Canada Sweetgrass Port
Christopher Wentzell	Property Manager - Public Works and Government Services Canada Sweetgrass Port
Stephen West	Property Manager – Cottonwood Management Services Ogden FB

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