U.S. DEPARTMENT OF ENERGY

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Prepared for the U.S. Department of Energy
under Contract DE-AC05-76RL01830

Evaluation of the Impact of EISA Federal Project Investments

KS Judd
EM Wendel
SL Morris
JL Williamson
MA Halverson
OV Livingston
SA Loper

December 2012

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Pacific Northwest National Laboratory
Richland, Washington 99352

Executive Summary

This study evaluates the energy, economic, and environmental impacts of investments in energy and water conservation projects that were made by federal agencies as a result of the Energy Independence and Security Act (EISA) of 2007. The Department of Energy's (DOE's) Federal Energy Management Program (FEMP) led this effort in response to a request from the Office of Management and Budget to evaluate the savings and carbon emissions reductions from federal energy management investments.

As the agency responsible for tracking federal agency progress toward the various energy and water management and monitoring requirements under EISA, FEMP designed the EISA Compliance Tracking System (CTS) to capture the data associated with agency compliance. The analyses in this study are based on the data reported in the CTS by federal agencies starting in fiscal year (FY) 2008 through FY 2012. These data include:

- annual energy and water use in facilities covered under EISA,
- potential energy and water savings and cost savings based on evaluations of these facilities,
- estimated savings from investments in energy and water conservation measures, and
- benchmark data for select buildings within the covered facilities.

As of the end of FY 2012, the CTS contained annual energy use and the corresponding gross building area data for over 7,000 covered facilities across the federal government, more than half of which were U.S. Postal Service (USPS) facilities. A covered facility in CTS may include a single building or multiple buildings at a site (e.g., a military installation). Forty-eight percent of all covered facilities have been completely evaluated as of the end of FY 2012, although these evaluated facilities represent 57% of the energy use in covered facilities. The government-wide energy-savings potential identified through these covered facility evaluations is estimated to be 33,274.6 billion British thermal units (Btus).

The focus of this study is on the project-level investments that have been entered into CTS. It should be noted that these investments do not provide a comprehensive view of efficiency efforts currently funded by the federal government because agency reporting in CTS has been somewhat selective to date. The $1.35 billion of project investments reported in CTS represent just 14% of the total spending on efficiency reported by agencies in their annual energy reports since FY 2008. Just one-third of the known Energy Savings Performance Contract (ESPC) funding and less than 10% of direct capital and Utility Energy Service Contract (UESC) investments have been entered in CTS to date. While not comprehensive, the data provides useful insights into the comparative impacts that agency investments in different types of energy conservation measures are having at the site level and across agencies.

The largest funding sources for projects in CTS have come from ESPCs and the American Recovery & Reinvestment Act of 2009 (ARRA). ESPCs represent 43% of all project investments, and projects that relied on this funding source have the largest average project size of $7.6 million. ARRA funds provided 33% of the total investment in projects and also supported larger projects on average as shown in Figure ES.1. In contrast, agency direct decentralized operations and maintenance budgets and centralized capital budgets fund significantly smaller projects on average. This suggests that without ARRA funds supporting efficiency investments in the future, it may be even more important to continue to find ways to make ESPCs and UESCs work as a mechanism for supporting large-scale improvements.

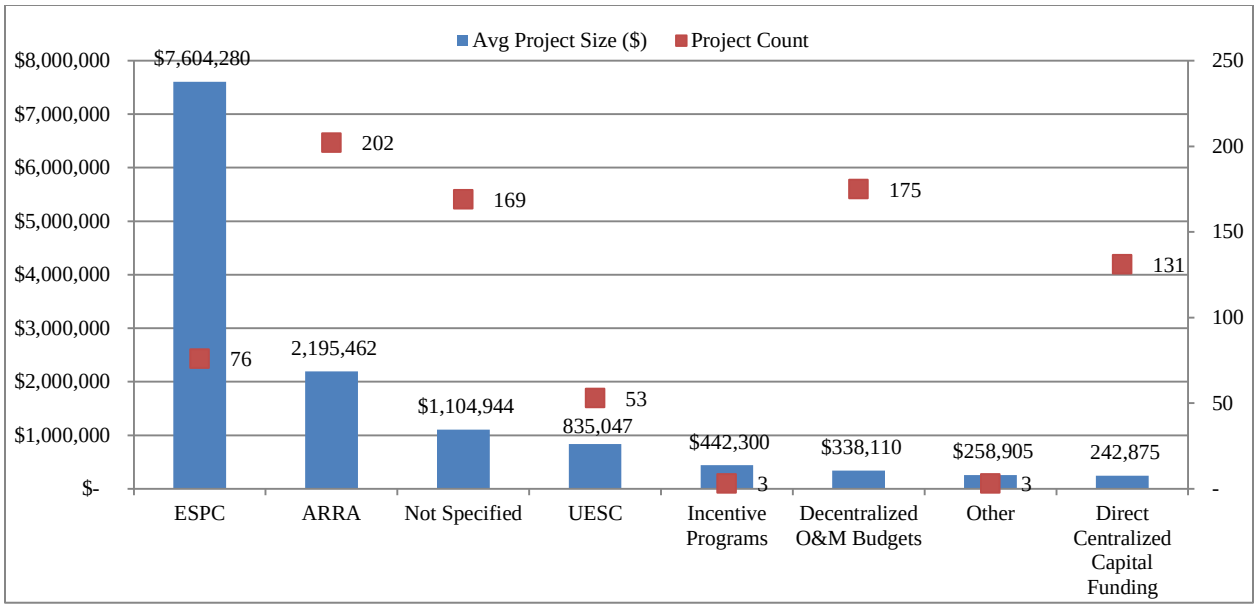

Figure ES.1. Average Project Size and Count of Projects by Funding Source

The 794 projects reported in CTS resulted in government-wide estimated energy savings of 4,078,279 million Btu (MMBtu) and water savings of 1.1 billion gallons coming from a broad set of energy and water conservation measures (ECMs). Agencies identified over 2,800 ECMs in these projects with Lighting; Heating, Ventilation and Air Conditioning (HVAC); and Energy Management and Control Systems (EMCS) being the most common ECM types implemented (see Figure ES.2).

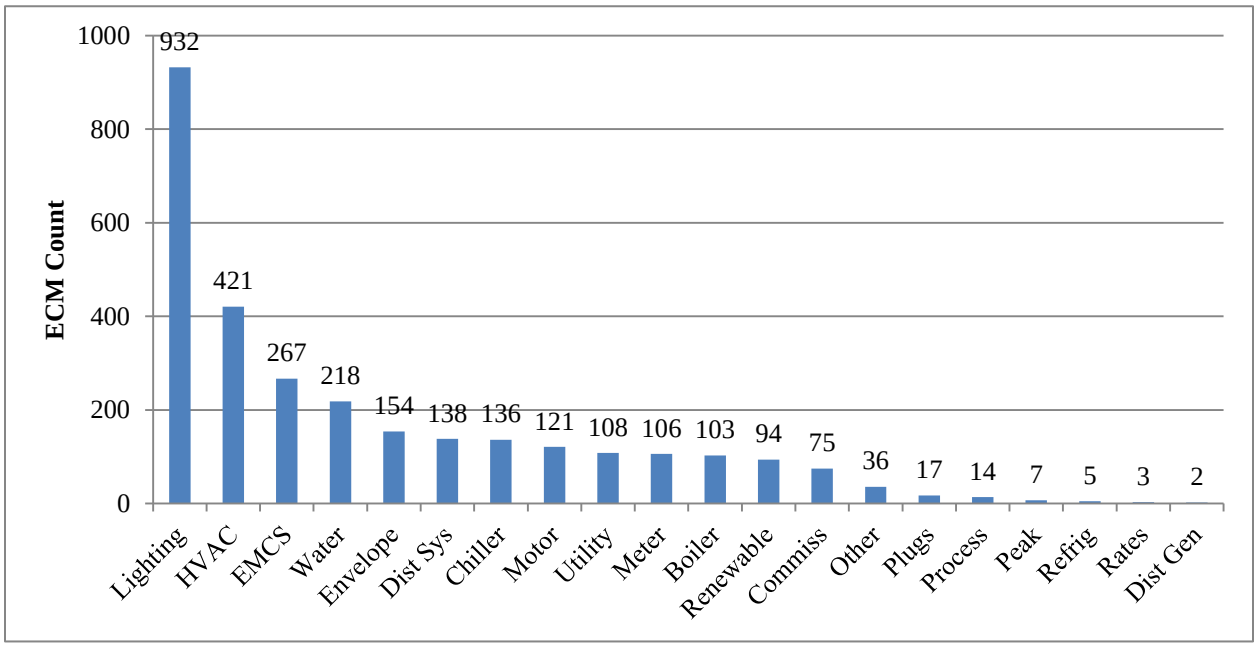

Figure ES.2. Sum of ECMs Implemented by Category

As illustrated by the dark green shading in Table ES.1, Lighting ECMs were among the most frequently implemented ECM types for several agencies, and represented the majority ECMs implemented for the Department of Defense (72% of its ECMs) and USPS (67% of its ECMs).

Table ES.1. Percent of Agency's Total Count of ECMs for the Top 10 ECM Categories[1]

Agency*	Lighting	HVAC	EMCS	Envelope	Water	Chiller	Boiler	Commiss	Meter	Motor
GSA	24%	16%	9%	3%	3%	8%	5%	7%	7%	10%
NASA	39%	11%	9%	1%	16%	2%	2%	0%	6%	0%
USPS	67%	4%	19%	1%	3%	1%	1%	0%	0%	2%
DOD	72%	7%	7%	4%	2%	1%	1%	1%	1%	0%
DOL	12%	35%	2%	39%	3%	1%	4%	0%	0%	0%
DOI	16%	23%	3%	11%	4%	2%	8%	0%	1%	4%
DOJ	13%	10%	16%	0%	13%	7%	4%	0%	0%	2%
DOT	16%	18%	3%	6%	29%	10%	3%	1%	1%	2%
DHS	12%	21%	12%	21%	3%	2%	9%	0%	0%	0%
DOE	16%	11%	9%	2%	9%	7%	9%	0%	7%	2%

* Abbreviations are defined in the Acronyms and Abbreviations list, which follows the Executive Summary.

While EISA encourages bundling of ECMs to optimize energy saving opportunities while promoting cost-effectiveness, just 28% of projects were found to have bundled ECMs, although these represent 68% of total project investment. Three agencies – Department of Justice, State Department, and General Services Administration – bundled ECMs for almost all of their implemented projects. Agencies that bundled ECMs appear to be taking advantage of the cost-effectiveness of Lighting to make more costly improvements, such as Boiler, Chiller, and other HVAC upgrades (Table ES.2). However Building Envelope improvements, which often are not cost-effective when implemented alone, were not among the most commonly bundled ECMs.

Table ES.2. Top 25 Most Commonly Bundled ECMs

	EMCS	HVAC	Commiss	Meter	Boiler	Chiller	Motor	Water
Lighting	118	93	51	49	39	50	48	46
HVAC	88		61	55	45	57	47	
EMCS			57	53	43	55	49	36
Chiller			39		39		37	
Commiss				54			36	

The energy savings from the energy efficiency investments reported in CTS since FY 2008 have resulted in an estimated 485,070 metric tons of Scope 1 and 2[2] carbon dioxide equivalent ($MTCO_2e$) emissions avoided by federal agencies. This represents approximately one percent of government-wide greenhouse gas (GHG) emissions. GHG emissions avoided by fuel source are presented in Figure ES.3

[1] Table ES.1 only includes 10 agencies with the highest number of ECMs reported. Information on ECMs reported by all agencies is included in the main body of the report.

[2] Scope 1 refers to direct emissions from onsite fuel combustion. Scope 2 refers to indirect emissions resulting from purchased electricity, heating, or steam.

for the 70% of projects in which agencies specified the fuel source that was saved. Most of these emissions avoided for these projects came from reductions in electricity use (67%) and natural gas (16%), followed by coal (7%), and other sources.

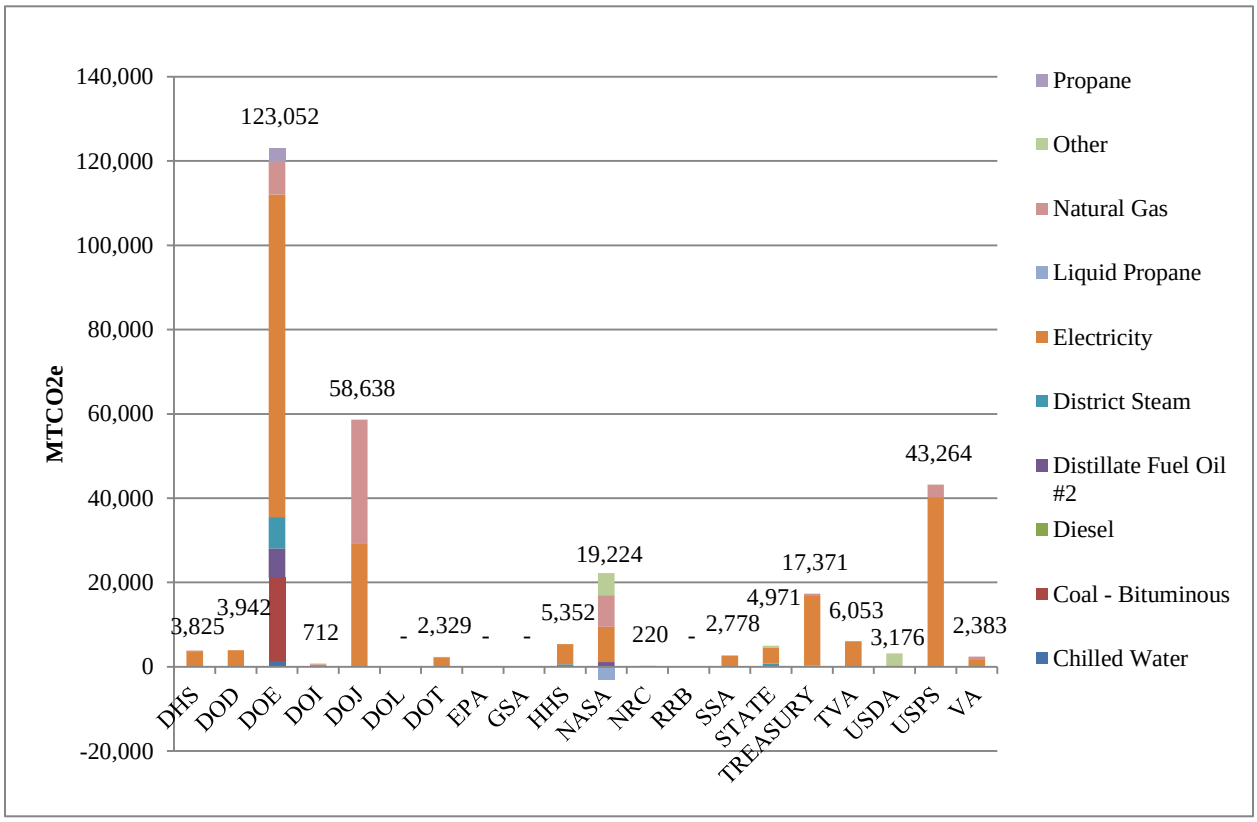

Figure ES.3. GHG Emissions Avoided by Agency for Projects with Known Savings by Fuel Source Only

The estimated annual energy and water savings per dollar invested provides one useful measure of return on investment for energy efficiency and water savings projects. The average savings per dollar invested for projects in which a single ECM was implemented was 5,340 Btu per dollar with over 90% of projects showing a return of less than 10,000 Btu per dollar.

As illustrated in Figure ES.4 below, single-ECM projects focused on Commissioning, EMCS, and Metering have the highest average energy savings per dollar invested, whereas Chiller, Building Envelope and Energy-Related Process improvement projects had the lowest average savings per dollar. ECM types with a high number of projects and lower relative variability, such as Chiller and Lighting improvements, are more likely to accurately characterize the energy savings per dollar and may be more useful to use as a basis for estimating savings levels for future projects when making general estimates prior to conducting a more rigorous energy saving audit. In contrast, ECMs such as Metering and Plug Loads, which have few observations and more variability in CTS, are less likely to accurately characterize energy savings per dollar invested.

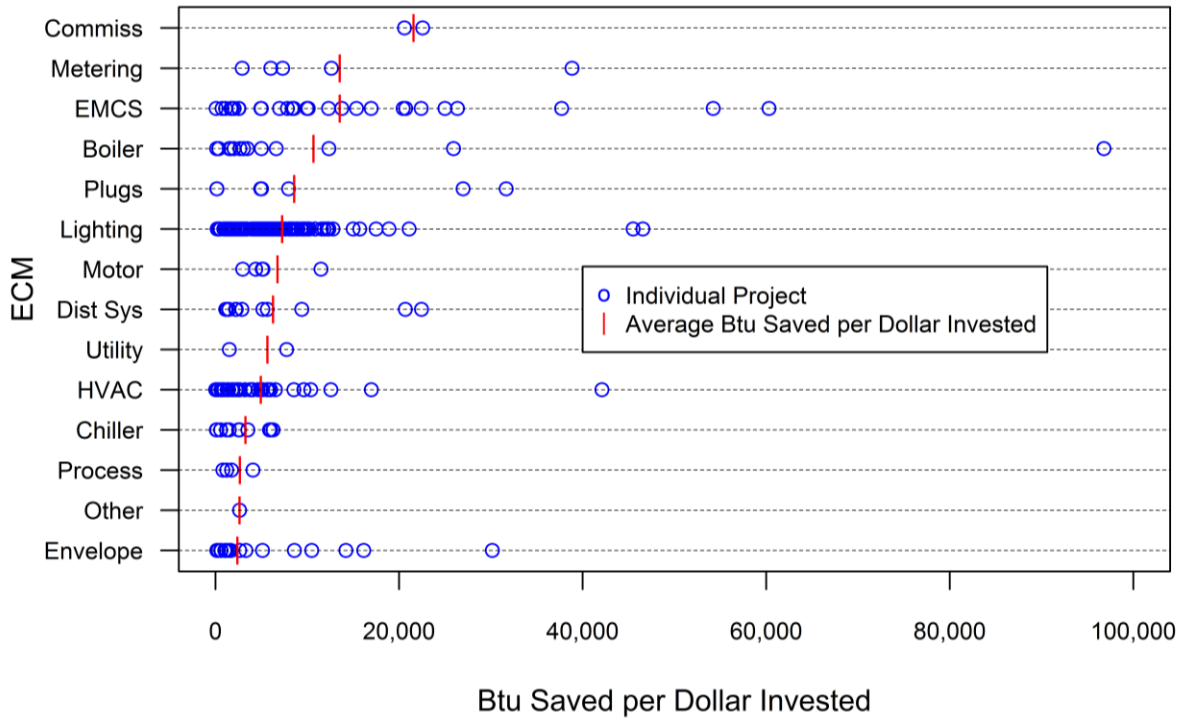

Figure ES.4. Savings per Dollar Invested by ECM Type (circles represent individual projects)

Estimates of water savings per dollar invested were more difficult to draw meaningful conclusions from based on the data currently reported in CTS. Just 31 projects included both water savings estimates and implementation costs and limited information was provided on the nature of the water projects implemented, which could have ranged from water-efficient irrigation to interior plumbing improvements. As water metering becomes more prevalent among federal agencies and details about the types of the water conservation measures implemented are added, there will be greater opportunity to gauge the impact of water projects entered in CTS.

Finally, life-cycle cost (LCC) analysis was used to calculate several economic performance measures for evaluation of projects in which a single ECM was implemented. Seven of 16 types of ECMs evaluated were cost-effective on average based on net savings, savings-to-investment ratio, and adjusted internal rate of return, as illustrated in Table ES.3 when financing costs were included as part of the total investment. Excluding the financing costs from the total cost calculation resulted in the three ECMs highlighted in red – Distribution Systems, Motor, and Chiller improvements – switching from cost-ineffective to cost-effective based on both the savings-to-investment ratio and adjusted internal rate of return. When not bundled with other ECMs, HVAC, Energy-Related Process, Boiler, Envelope, and Plug-Load ECMs were not cost-effective on average whether or not financing costs were included.

Table ES.3. Average Economic Performance Indicators by ECM Type, Financing Cost Included

ECM Type	Life-cycle Benefit ($)	Location-Adjusted Investment ($)	Net Savings ($)	Savings-to-Investment Ratio	Adjusted Internal Rate of Return
Commiss	8,441,711	2,053,604	6,388,107	4.11	19%
EMCS	4,423,204	1,322,088	3,101,117	3.35	11%
Renewable	134,663,627	25,272,100	109,391,572	5.33	11%
Dist Gen	1,140,968	197,665	943,304	5.77	10%
Lighting	632,577	332,605	299,972	1.90	7%
Meter	8,472,775	4,046,647	4,426,128	2.09	7%
Utility	267,073	149,999	117,074	1.78	6%
Other	4,987	5,358	($370)	0.93	3%
Dist Sys	16,171,604	21,397,510	($5,225,906)	0.76	2%
Motor	1,668,115	2,284,258	($616,143)	0.73	1%
Chiller	2,793,226	6,008,089	($3,214,863)	0.46	-1%
HVAC	267,765	826,706	($558,940)	0.32	-4%
Process	874,087	5,578,280	($4,704,193)	0.16	-4%
Plugs	15,707	49,117	($33,410)	0.32	-5%
Envelope	127,103	528,727	($401,625)	0.24	-6%
Boiler	536,381	5,476,869	($4,940,489)	0.10	-10%
Totals	**4,536,882,120**	**1,486,601,443**	**3,050,280,677**	**3.05**	**10.4%**

Acronyms and Abbreviations

AIRR	adjusted internal rate of return
ARRA	American Recovery and Reinvestment Act
ASCC	Alaska Systems Coordinating Council
BMP	Best Management Practices
Boiler	Boiler Plant Improvements
CBECS	Commercial Building Energy Consumption Survey
CDD	cooling degree days
Chiller	Chiller Plant Improvements
Commiss	Commissioning Measures
CTS	Compliance Tracking System
DHS	Department of Homeland Security
Dist Gen	Distributed Generation
Dist Sys	Chilled Water, Hot Water, and Steam Distribution Systems
DOC	Department of Commerce
DOD	Department of Defense
DOE	Department of Energy
DOI	Department of the Interior
DOJ	Department of Justice
DOL	Department of Labor
DOT	Department of Transportation
ECM	energy conservation measure
EISA	Energy Independence and Security Act
EMCS	Building Automation System/Energy Management and Control System
Envelope	Building Envelope Modifications
EPA	Environmental Protection Agency
ERCOT	Electric Reliability Council of Texas
ESPC	Energy Savings Performance Contract
EUI	energy use intensity
FEMP	Federal Energy Management Program
FRCC	Florida Reliability Coordinating Council
FY	fiscal year
GSA	General Services Administration
GHG	greenhouse gas
HDD	heating degree days
HHS	Department of Health and Human Services
HICC	Hawaiian Islands Coordinating Council
HUD	Department of Housing and Urban Development

HVAC	Heating, Ventilating, and Air Conditioning
LCC	life-cycle cost
LCB	life-cycle benefit
Lighting	Lighting Improvements
Meter	Advanced Metering Systems
MMBtu	Million British thermal units
Motor	Electric Motors and Drives
MRO	Midwest Reliability Organization
$MTCO_2e$	Metric Tons of Carbon Dioxide Equivalent
NARA	National Archives and Records Administration
NASA	National Aeronautics and Space Administration
NIST	National Institute of Standards and Technology
NPCC	Northeast Power Coordinating Council
NRC	Nuclear Regulatory Commission
OPM	Office of Personnel Management
O&M	operations and maintenance
Peak	Electrical Peak Shaving/Load Shifting
Plugs	Appliance/Plug-Load reductions
PNNL	Pacific Northwest National Laboratory
PPA	Power Purchase Agreements
Process	Energy Related Process Improvements
Rates	Energy Cost Reduction through Rate Adjustments
Refrig	Refrigeration
Renewable	Renewable Energy Systems
RFC	ReliabilityFirst Corporation
RRB	Railroad Retirement Board
SERC	SERC Reliability Corporation
SI	Smithsonian Institution
SIR	savings-to-investment ratio
SPP	Southwest Power Pool
SSA	Social Security Administration
STATE	Department of State
TMY	typical meteorological year
TREASURY	Department of the Treasury
TVA	Tennessee Valley Authority
UESC	Utility Energy Service Contract
USACE	Army Corps of Engineers
USDA	Department of Agriculture

USPS	United States Postal Service
Utility	Energy/Utility Distribution Systems
VA	Department of Veterans Affairs
Water	Water and Sewer Conservation Systems
WECC	Western Electricity Coordinating Council

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1.0 Purpose

Section 432 of the Energy Independence and Security Act (EISA) of 2007[3] establishes the expectation that federal agencies will implement energy and water efficiency projects in federal buildings and monitor the performance of those buildings over time. The Department of Energy's (DOE's) Federal Energy Management Program (FEMP) has been charged by the Office of Management and Budget to conduct "an evaluation on actual and verifiable energy savings and carbon emissions reductions from federal energy management investments" made across the federal government as a result of this statute. This study presents the findings from that evaluation, which was conducted by Pacific Northwest National Laboratory (PNNL) during fiscal year (FY) 2012.

The specific goals of this study were to:

1. Evaluate the accuracy of data reported in the EISA Compliance Tracking System (CTS) and assist agencies in addressing inaccuracies.
2. Characterize energy, water, and greenhouse gas (GHG) savings from the implemented energy and water efficiency projects.
3. Assess cost-effectiveness of various types of energy and water conservation measures (ECMs) that were implemented across the federal government.

[3] The Energy Independence and Security Act of 2007, 42 USC 17001 et seq., is summarized on the FEMP website at http://www1.eere.energy.gov/femp/regulations/eisa.html. The complete text of the Act may be found at http://www.gpo.gov/fdsys/pkg/BILLS-110hr6enr/pdf/BILLS-110hr6enr.pdf

2.0 Background

FEMP is responsible for tracking federal agency progress toward the various energy and water management and monitoring requirements under EISA. The EISA Section 432 CTS was designed to capture the data associated with agency compliance with the Facility Energy Management Guidelines and Criteria for Energy and Water Evaluations in Covered Facilities, Subsection (f), Use of Energy and Water Efficiency Measures in Federal Buildings (42 U.S.C. 8253(f)).

Specific EISA requirements of top-tier agencies include:

- Designate "covered facilities" that comprise at least 75% of the agency's facility energy use.
- Assign energy managers to 100% of those covered facilities.
- Conduct comprehensive energy and water evaluations for covered facilities (25% per year with all completed by June 2012), including energy and water audits and a commissioning assessment for the purpose of identifying ECM[4] opportunities.
- Prioritize potential ECMs for implementation and bundle them into projects that optimize energy-saving and/or environmental benefits and align with available funding.
- Report progress in implementing energy and water efficiency projects and follow up to confirm persistence of savings.

In December 2011, agencies began reporting data into CTS on initial implemented energy- and water-saving projects. The information in CTS is not only useful for assessing compliance with these EISA requirements, but can help agencies understand the real and comparative impacts that their investments in ECMs are having at the site level and across the agency as a whole. Analysis of CTS data can be used to direct and justify investment in ECMs to help achieve agency energy and water efficiency goals.

It is the intent of this study to assess the overall effectiveness of these investments and help agencies to learn from these past investments, rather than to evaluate agency compliance with specific requirements under the statute.

[4] For consistency with language in EISA Section 432(f)(3)-(8) and the CTS, the acronym ECM represents both water and energy efficiency measures.

3.0 Methodology

This analysis of the impact of investments in energy and water conservation projects in the CTS consisted of three major steps:

1. data quality checking of the CTS database entries
2. working with agencies to address any data quality issues identified
3. conducting a final analysis of the revised data in CTS.

Each of these steps is discussed below. A more detailed description of the methodology is contained in the Program Plan found in Appendix A.

3.1 Data Quality Checking

The CTS database contains data on energy and water use at over 7,000 facilities, as well as evaluation or audit results for those facilities and data on projects implemented at those facilities. FEMP has provided guidelines for data entry and supported agencies with biweekly meetings on the development and use of CTS to help provide consistency in how each data element is reported. Because the data has been entered by many individuals at many agencies over a period of two years, data-entry and calculation errors are inevitable.

The first step in the analysis was to make sure that the data was of sufficient quality to be analyzed. The entire database was examined for missing data, internal inconsistencies between multiple years of data for the same facility, and anomalies based on comparisons to the expected or "typical" performance ranges. Data quality checking focused on covered facility footprint and implemented project data, but also included a high-level review of covered facility evaluation data to identify obvious errors.

Specific checks undertaken include:[5]

1. number of ECMs per facility
2. missing data on implementation cost, facility area, and energy and water savings estimates
3. energy use intensity compared to expected ranges for commercial buildings
4. energy savings per square foot
5. renewable energy production relative to energy use
6. energy savings per dollar invested
7. energy and water savings reported relative to estimated baseline usage
8. evaluated area relative to gross covered facility area
9. other anomalies (e.g., unusually high increases or decreases in energy use at a facility in a single year).

[5] See Appendix A, PNNL Program Plan for Savings Evaluation of EISA Federal Project Investments, Task 6 for more details on these checks.

The most common problems identified and addressed in the database included:

1. missing required project data (i.e., implementation costs, energy or water savings estimates)
2. projects and evaluations with energy or water savings higher than (or an extremely high proportion of) total facility energy or water use
3. unusually high/low reported energy use in a single year, often due to poor quality source data
4. projects identified as a renewable energy ECM with no renewable energy generation estimates, or vice versa
5. projects identified as a Water and Sewer Conservation ECM with no water savings estimates, or vice versa
6. energy or water usage or savings estimates entered in the wrong units
7. evaluations with an evaluated facility area greater than the gross covered facility area
8. ECMs bundled as part of larger maintenance projects and "additional" costs for the ECM could not be easily separated out, resulting in unusually low energy savings-to-investment ratios.

Over 500 issues were identified as part of the data quality check. Some issues were resolved by reviewing the project notes and other details. Agencies were contacted for follow-up on issues that could not be resolved.

It should be emphasized that the CTS database is continually growing and changing as agencies add new facilities and projects to the database. The data quality issues identified and addressed in this analysis were from versions of the database reviewed in the summer of 2012 and there is a potential for additional data quality issues as new data is added. The research team recommended a set of automated quality checks that may be built into CTS to flag potential data-entry issues for agencies.

3.2 Working with Agencies to Address Data Quality Issues

For each issue identified during data quality checking, the research team reviewed the project details in CTS to help resolve or narrow down the problem. For those issues that could not be resolved, the research team contacted the agency-designated Facility Energy Manager to determine whether there was an actual data quality concern to be addressed or the data point was simply an outlier. Based on these interactions, corrections were made in the CTS database, either by the agency or by PNNL when requested by the agency. PNNL staff also assisted in the development of energy-savings estimates when requested.

It should be noted that all data quality issues were not resolved through this process. As of the end of September 2012, all agencies had been notified of outstanding issues; however over 100 potential issues had not been resolved. The data associated with these issues was evaluated on a case-by-case basis and pulled from the analyses where it could potentially skew the results. For this reason, the number of observations used in analyses throughout this report will vary.

3.3 Analysis of CTS Data

After all agencies were contacted about potential data quality issues and given an opportunity to correct these issues, final analysis of the database was undertaken. The results of that analysis are shown in this report. Specific analyses undertaken include:[6]

1. ECMs evaluated and implemented
2. energy savings by ECM type and by agency
3. project investment by ECM type, agency and funding source
4. energy and water savings relative to total agency energy and water use
5. energy and water savings per dollar invested
6. life-cycle cost economics
7. GHG emissions avoided
8. energy savings from implemented projects relative to evaluated energy savings potential
9. facility energy-use intensity changes.

As part of the final analysis, energy use data was normalized to account for the fact that the evaluation and measurement occurred in a particular year and reflects weather-specific patterns of that year. This normalized data was used in the analysis of energy savings relative to energy use described in Section 6.0.

[6] See Appendix A, PNNL Program Plan for Savings Evaluation of EISA Federal Project Investments, Task 10 for more details on these analyses.

4.0 Overview of Data in CTS

The CTS is a FEMP-administered, Web-based reporting system to track agency compliance with EISA Section 432 requirements to conduct energy and water evaluations, implement projects, monitor and verify savings from those projects, and benchmark building performance. This section provides an overview of the data entered into CTS by federal agencies as of the end of FY 2012 for the years 2008 to 2011.[7] The following sections provide analysis of facility evaluations (Section 5.0) and implemented projects (Section 6.0).

As depicted in Figure 4.1, CTS contains data reported at the *covered facility level* for project management tracking, and at the individual *building level* for performance monitoring. Most of the data reported in CTS and analyzed for this report is examined at the covered facility level, which may include a single building or multiple buildings at a site (e.g., a military installation). This represents more breadth and depth of energy and water savings potential and achievements than has previously been available across federal facilities. However, because covered facilities can include multiple buildings and there is not enough information in CTS to group covered facilities by building type or age, the findings on facility energy performance must be interpreted carefully and may not be relevant for building-level comparisons.

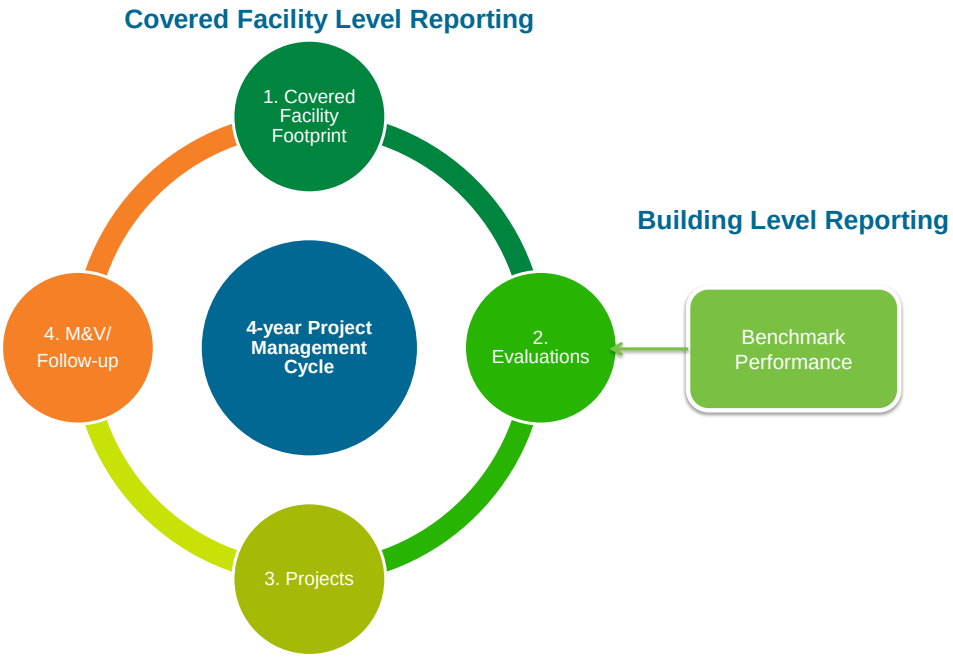


Figure 4.1. Reporting Structure for Covered Facilities and Individual Buildings in CTS

4.1.1 Covered Facility Footprint

Covered facility data in CTS includes floor area, energy use and water use for FY 2008 through FY 2011. As of the end of FY 2012, the CTS contains annual energy use and the corresponding gross

[7] While 2008 is the first year of reporting in CTS, EISA allows agencies to include in CTS projects implemented up to two years prior.

building area data for 7,001 covered facilities across the federal government.[8] The U.S. Postal Service (USPS) accounts for the greatest number of active covered facilities in CTS, with 59% of all covered facilities by number. While the Department of Defense (DOD) manages just 9% of the active covered facilities, those facilities comprise 68% of total energy use and covered facility gross square footage in CTS. This is because DOD covered facilities typically represent multiple buildings managed as part of an integrated operation at large site (e.g., installation).

Water-use reporting for covered facilities in CTS is currently optional for agencies as water metering is not required under EISA and has not yet been widely adopted. As a result, the total water use reported is likely to be significantly lower than actual use for many agencies. Just 11 of the 20 agencies reported water use for all covered facilities in FY 2011. Table 4.1 below indicates which agencies have incomplete reporting of water use.

Table 4.1. Covered Facility Annual Footprint for FY 2011

Agency*	Total # of Active Covered Facilities	Covered Facility Gross Square Feet (Thousands)	# of Metered Buildings	Total FY 2011 Covered Facility Energy Use (Million Btu)	Total FY 2011 Water Use (Thou. Gallon)
All Agencies	**7,001**	***2,796,600***	***22,263***	***334,541,205***	***122,621,089***
DHS	180	*37,051*	*4,855*	*3,571,053*	*198,643*
DOC	7	11,694	*64*	2,112,833	376,962
DOD	606	*1,906,670*	*4,935*	*194,868,101*	*95,973,019*
DOE	49	87,559	*1,695*	24,653,294	*6,987,428*
DOI	505	46,518	*2,821*	3,842,382	*1,948,956*
DOJ	74	53,087	*76*	7,364,236	8,369,165
DOL	59	17,495	*119*	1,771,832	*744,013*
DOT	623	16,457	*894*	*2,812,184*	285,317
EPA	16	2,840	*16*	989,170	102,355
GSA	197	139,207	*230*	13,888,553	2,275,446
HHS	80	22,133	*129*	9,165,243	1,442,536
HUD	1	1,441	*1*	106,300	21,039
NARA	7	3,492	*7*	413,600	65,490
NASA	12	32,327	*844*	5,964,147	2,053,370
NRC	2	*763*	*2*	*90,246*	*26,336*
OPM	3	1,014	*3*	77,038	29,500
RRB	1	347	*1*	33,600	4,480
SI	10	*6,105*	-	*1,012,700*	-
SSA	8	6,320	*8*	820,695	127,613
STATE	10	4,656	*16*	556,162	*83,299*
TREASURY	13	*8,721*	*10*	*1,485,521*	185,540
TVA	53	*19,456*	*9*	1,267,880	*98,423*
USACE	46	*7,052*	*48*	*1,389,877*	*116,679*
USDA	165	*17,968*	*265*	3,302,941	*1,097,793*
USPS	4,105	191,568	*4,105*	24,117,258	-
VA	169	154,661	*1,110*	28,864,360	7,688

* Abbreviations are defined in the Acronyms and Abbreviations list, which follows the Executive Summary.

For energy use, data was not reported for some facilities in 2011 and was estimated based on most recent year. For water use, data is missing for a small proportion (<10%) of the total number of facilities.

Water use data was not reported for a substantial proportion (>10%) of total number of facilities in 2011.

[8] Because agencies do not report the number of buildings that constitute a covered facility, it is not possible to specify what proportion of total federal buildings these 7,001 covered facilities represent. Based on annual energy use reporting, however, these facilities represented 87% of the total annual federal facility energy use in 2011.

5.0 Covered Facility Evaluations

This section provides an overview of the potential savings identified by agencies through their required evaluations, or audits, of covered facilities. It also examines the types of ECMs identified through those evaluations to support comparisons to implemented ECMs in the next section.

5.1 Evaluation Summary Data

Comprehensive evaluations of covered facilities are required to identify potential life-cycle cost-effective ECMs that can be implemented separately or as bundled projects. Evaluations also identify estimated implementation costs and estimated energy and water savings or energy production. Just under half of the 7,001 covered facilities that have been entered into the CTS by federal agencies have been completely evaluated as of the end of FY 2012. This represents 57% of covered facility energy use and 49% of government-wide energy use. Findings from these evaluations are summarized in Table 5.1 below.

The number of ECMs identified through evaluations varies substantially across agencies and does not have a strong correlation with estimated potential energy savings. There appears to be a lack of consistency in how agencies count ECMs. Over 50% of all potential ECMs identified were in DOD facilities, yet these represent just 28% of the total energy-savings potential identified in CTS. Similarly, DOI accounts for 16% of the potential ECMs identified, but those represent just 2% of total energy savings across all agencies. Both Treasury and DOE have identified very few ECMs (0.2% and 2%, respectively) yet these represent a substantial portion of total federal agency energy savings potential (16% and 13%, respectively). This may be due to DOI reporting on a number of comparatively small covered facilities and DOE reporting ECMs for larger covered facilities with multiple buildings.

The estimated investment required to implement all life-cycle-cost-effective ECMs identified in the most recent evaluation of each covered facility exceeds $9.3 billion, with an annual estimated cost savings potential of $689.4 million. The corresponding potential energy savings of 33,274,578 million British thermal units (MMBtu) represents 18% of the total annual energy used by those covered facilities. Because the most recent evaluation may have been in 2008, it should be noted that some of these conservation measures may have already been implemented as projects so no longer represent the full potential.

Table 5.1. Covered Facility Evaluation Summary Table

Agency	# of Covered Facilities Evalu-ated	Gross Square Feet Evaluated (Thousands)	Annual Energy Use of Evaluated Facilities (MMBtu)	Potential Annual Energy Savings (MMBtu)	Annual Water Use of Evaluated Facilities (Thou. Gallons)	Potential Annual Water Savings (Thou. Gallons)[9]	Total ECMs Identified	Total Potential Implementation Cost ($M)	Total Potential Annual Cost Savings ($M)
All	**3,203**	**1,478,018**	**189,130,701**	**33,274,578**	**38,213,884**	**14,510,524**	**68,454**	**$9,323**	**$689.4**
DHS	92	26,564	2,709,049	579,616	140,118	1,934,819	1,125	$144.32	$18.39
DOC	5	9,643	1,961,270	88,903	384,781	6,515	57	$19.92	$3.10
DOD	355	791,179	85,167,819	11,064,530	23,318,119	3,807,033	35,350	$1,338.84	$196.16
DOE	40	53,332	17,192,886	5,088,224	4,359,494	1,005,471	1,504	$3,375.86	$90.09
DOI	372	42,990	3,590,150	639,329	1,862,241	131,499	11,138	$210.56	$13.17
DOJ	4	2,527	314,006	148,672	479,620	174,419	25	$31.48	$3.31
DOL	59	17,911	1,950,151	86,880	576,930	96,530	225	$11.28	$3.06
DOT	79	3,029	464,032	58,669	34,706	58,785	636	$27.00	$4.18
EPA	16	2,827	987,322	317,010	83,263	27,022	378	$109.62	$4.33
GSA	196	136,816	13,868,938	1,874,378	2,118,633	5,241,735	2,085	$1,881.48	$94.15
HHS	68	20,629	6,968,972	567,758	1,178,077	82,184	872	$52.16	$14.09
NARA	7	3,492	432,600	27,440	67,400	2,868	69	$42.28	$0.83
NASA	9	25,433	3,922,085	723,731	1,463,500	61,355	1,053	$156.85	$13.27
NRC[10]	2	763	90,246	314,540	26,336	-	2	$0.23	$0.12
OPM	1	86	8,508	1,145	4,800	2,973	3	$0.20	$0.05
RRB	1	347	30,596	100	4,608	1,152	5	$0.12	$0.07
SI	6	4,171	616,600	99,904	-	13,956	60	$24.13	$4.30
SSA	6	5,705	574,825	105,841	62,538	6,254	89	$45.41	$3.04
STATE	9	4,543	460,141	38,402	-	13,529	43	$24.71	$4.32
TREASURY	9	6,100	1,023,308	377,560	152,130	22,051	148	$103.99	$11.34
TVA	46	18,751	1,263,388	227,752	10,173	19,279	280	$34.98	$7.62
USACE	1	64	7,833	839	3,415	-	173	$0.17	$0.02
USDA	164	17,633	2,978,021	321,281	1,881,294	77,450	1,400	$56.20	$5.68
USPS	1487	139,825	14,501,367	3,901,772	-	490,679	7,191	$1,050.00	$104.20
VA	169	143,658	28,046,590	6,620,302	1,707	1,232,967	4,543	$580.87	$90.51

[9] The three agencies with evaluated annual water savings greater than annual water use (DHS, TVA, and VA) are all agencies with substantially incomplete reporting of water use data as noted in Table 1.

[10] Data reported from audits of two NRC facilities each showed energy-savings potential higher than energy use, but could not be resolved by the agency.

5.2 ECM Types Identified in Evaluations

Over 78,000 ECMs were identified in the 3,203 fully completed facility evaluations reported in CTS. Another 241 facility evaluations were "in progress" at the time of this report and are included in the charts and tables in this section. These evaluations were examined for trends by the types of ECMs evaluated and the savings potential identified. Evaluations entered into CTS had 20 different parent ECM types available to characterize the activities. Table 5.2 below lists these categories with a corresponding short name used in this analysis and subsequent graphs and tables.

Table 5.2. ECM Types and Abbreviations for Evaluations

ECM Type	ECM Short Name
Advanced Metering Systems	Meter
Appliance/Plug-Load Reductions	Plugs
Boiler Plant Improvements	Boiler
Building Automation Systems/Energy Management Control Systems	EMCS
Building Envelope Modifications	Envelope
Chilled Water, Hot Water, and Steam Distribution Systems	Dist Sys
Chiller Plant Improvements	Chiller
Commissioning Measures	Commiss
Distributed Generation	Dist Gen
Electric Motors and Drives	Motor
Electrical Peak Shaving/Load Shifting	Peak
Energy Cost Reduction Through Rate Adjustments	Rates
Energy Related Process Improvements	Process
Energy/Utility Distribution Systems	Utility
Lighting Improvements	Lighting
Other	Other
Other Heating, Ventilating, and Air Conditioning	Other HVAC
Refrigeration	Refrig
Renewable Energy Systems	Renewable
Water and Sewer Conservation Systems	Water

Lighting was the most common ECM included in the facility evaluations next to Water and Sewer projects, Other HVAC and Energy Management and Control Systems (EMCS) upgrades. These four project types accounted for two-thirds of the total ECM count for federal facilities. Figure 5.1 shows the total number of ECMs identified in the evaluation by type.

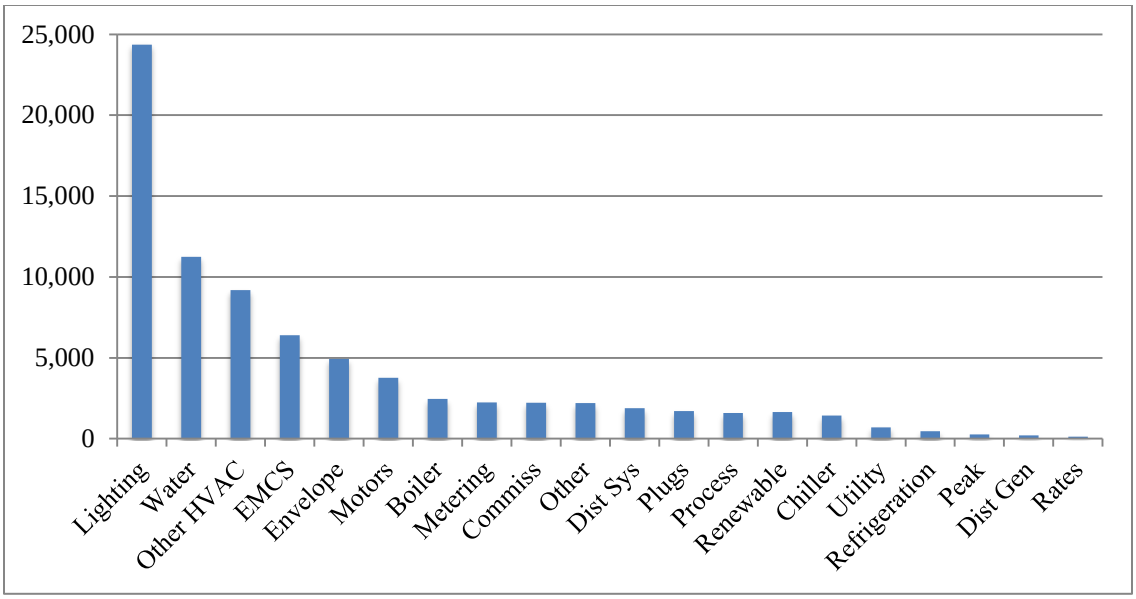


Figure 5.1. Sum of ECMs Evaluated by Category

The majority of evaluations identified more than one ECM type and 18% of facilities identified savings potential from all 20 ECM types in their evaluations. Because covered facility evaluations are intended to be comprehensive, it is expected the evaluations would have multiple ECMs.

5.3 Potential Savings from ECMs Evaluated

The ECMs identified through covered facility evaluations in CTS have an average simple payback of 12.5 years when all ECMs are considered, and 8.4 years when evaluations with Water ECMs are removed from the analysis and only energy ECMs are considered. Sixty-five percent (65%) of facility evaluations had a less than 10-year payback and 14% had a payback of over 20 years (see Table 5.3). The trend is similar with evaluations with Water ECMs are removed from the analysis. This suggests that facility evaluations may include ECMs that are not all cost-effective. The longer-payback projects tended to include more renewable energy and distributed-generation ECMs. The simple payback ranges were calculated using all three cost types associated with the evaluations (water cost savings, energy cost savings, and ancillary cost savings).

Table 5.3. Number of Facilities with Evaluations within Simple Payback Ranges

Payback Range (Years)	Number of Facility Evaluations within Range (All ECMs)	Percent of Evaluations (All ECMs)	Number of Facility Evaluations within Range (Without Water ECMs)	Percent of Evaluations (Without Water ECMs)
0 to 5	1035	30%	547	31%
5 to 10	1220	35%	605	35%
10 to 15	397	12%	188	11%
15 to 20	179	5%	91	5%
20 to 25	106	3%	47	3%
>25	378	11%	115	7%
None Identified	129	4%	156	9%
Grand Total	**3444**	**100%**	**1749**	**100%**

The estimated potential annual energy savings per dollar of investment required was also analyzed to illustrate the relative energy saving impact that the different ECMs are projected to have. Because implementation costs and savings are attributed to a project and not individual ECMs, only facility evaluations that identify a single ECM type can be analyzed for their relative savings impact. Of the 287 evaluations with a single ECMs identified, Other HVAC, Refrigeration and Electric Motors and Drives had the highest potential energy savings per dollar invested.[11] Figure 5.2 and Table 5.4 below show the average potential energy savings for each ECM type with the minimum and maximum values included. In many cases the evaluated ECMs show a wide variance (standard deviation) in potential savings.

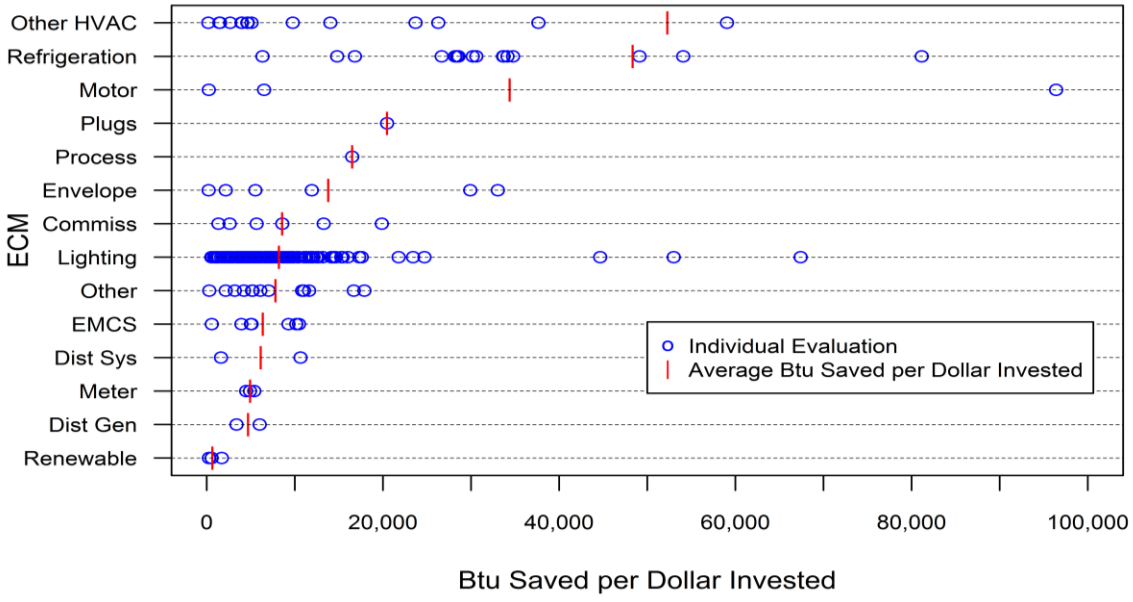


Figure 5.2. Distribution of Savings per Dollar Invested by ECM for Evaluations[12]

[11] 82 of the evaluations were removed from this analysis because they had incomplete values or obviously incorrect values (e.g., implementation costs or savings of $1).

[12] Values above 100,000 Btus per Dollar Invested are not shown on this graph but are included in the average calculation.

Table 5.4. Potential Energy Savings Ranges of Evaluated Projects per Dollar Invested for Evaluations with Single ECMs

		Potential Btus Saved per Dollar Invested			
ECM Type	Number of Evaluations	Minimum	Maximum	Average	Standard Deviation
Other HVAC	18	179	419,667	52,267	104,749
Refrigeration	18	6,316	194,450	48,337	47,732
Motor	3	219	96,400	34,373	53,809
Plugs	1	20,465	20,465	20,465	N.A.
Process	1	16,505	16,505	16,505	N.A.
Envelope	6	215	33,031	13,785	14,297
Commiss	6	1,326	19,864	8,547	7,015
Lighting	203	0.8	182,696	8,191	14,304
Other	13	281	17,895	7,789	5,440
EMCS	7	573	10,451	6,351	3,708
Dist Sys	2	1,604	10,631	6,118	6,383
Meter	3	4,466	5,385	4,915	460
Dist Gen	2	3,376	6,001	4,689	1,856
Renewable	4	48	1,705	638	740

Just five evaluations identified Water ECMs only and could be analyzed to show their impact in terms of the potential water saved per dollar invested (Table 5.5). The expected average savings was over 2,200 gallons per dollar invested however the variance in these evaluations was significant as indicated by the large standard deviation.

Table 5.5. Water Savings per Dollar Invested for Evaluations with Only Water ECMs

		Gallons Avoided per Dollar Invested			
ECM Type	Number	Minimum	Maximum	Average	Standard Deviation
Water	5	230	5,059	2,288	1,738

A total of 489 facilities identified water savings potential in their evaluations. This broader set of evaluations was analyzed to determine the projected water savings over baseline water use. Over half of the evaluations (54%) projected water savings representing more than 10% of their total water use (Figure 5.3).

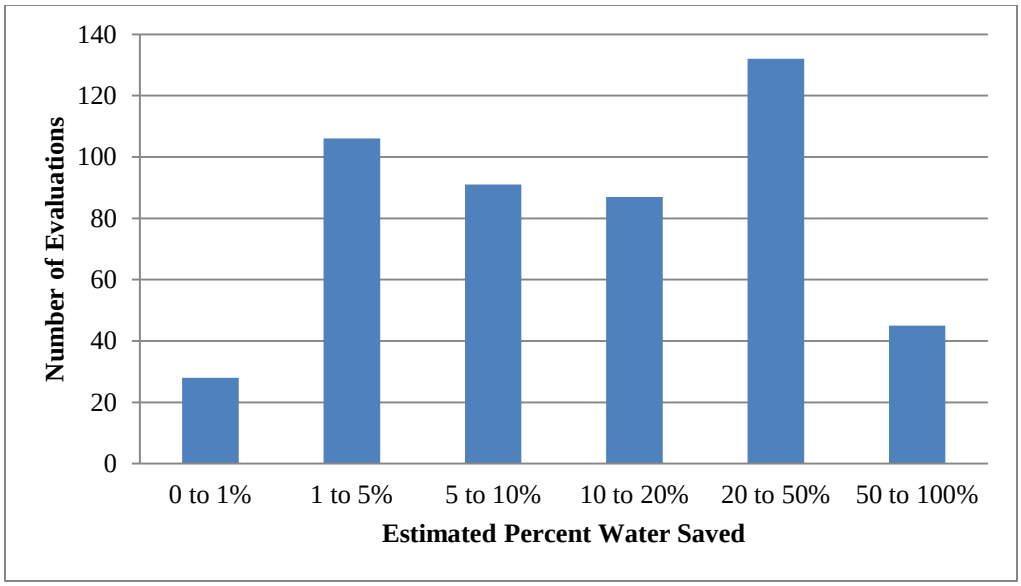


Figure 5.3. Projected Evaluated Water Savings Relative to Baseline Use

6.0 Analysis of Implemented Projects

Agencies may implement any energy or water-saving ECMs identified in the evaluations that are life-cycle cost-effective. Projects can include single ECMs or multiple ECMs with varying paybacks bundled to help make their implementation cost-effective. This section presents findings from the analysis of project investments reported in CTS.

6.1 Location of Projects

From FYs 2008 through 2011, agencies reported 794 projects in CTS. As shown in Figure 6.1, states with the highest density of implemented projects were California, Pennsylvania, and Georgia.

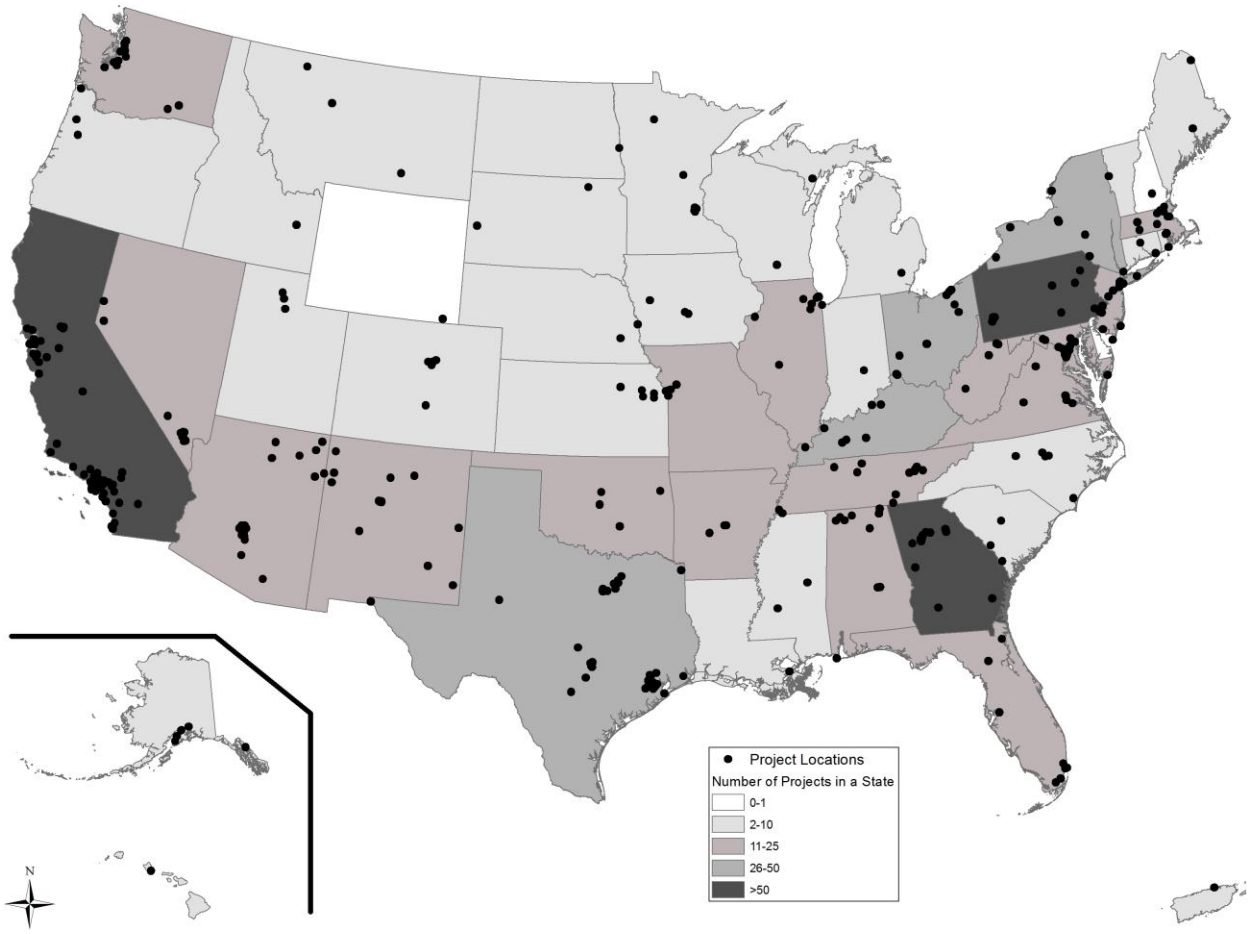


Figure 6.1. Locations of Projects Reported in CTS and Project Density by State

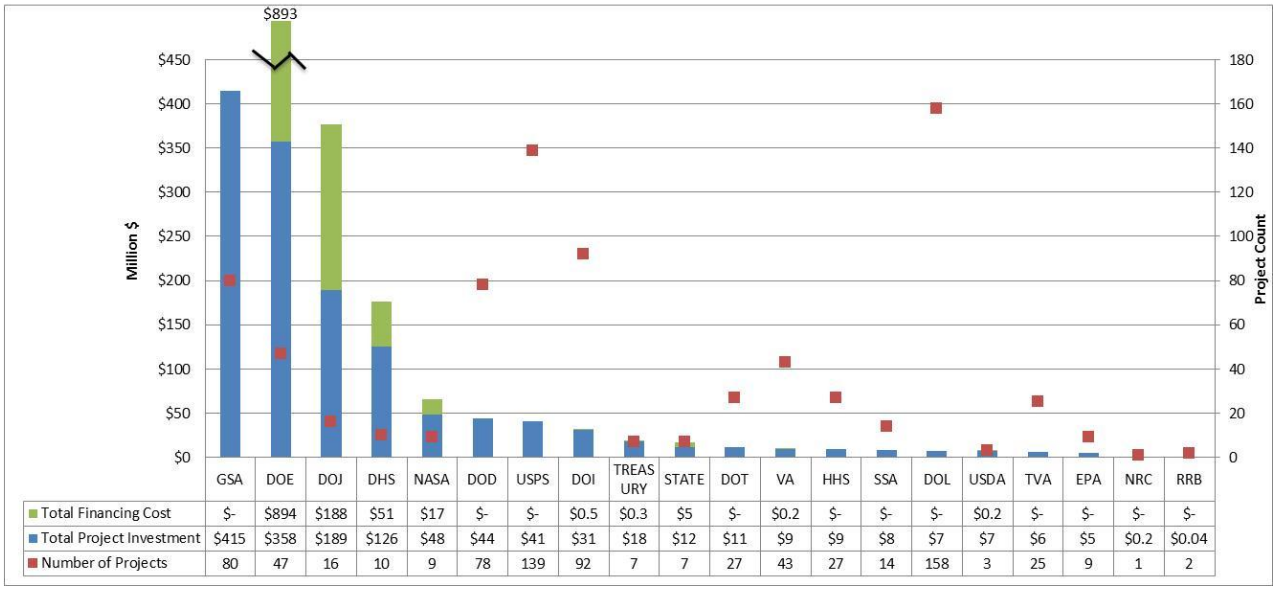
6.2 Agency Project Investment

The projects reported in CTS represent a subset of total agency spending on efficiency each year. Total agency investment through both direct and third-party funding sources between FY 2008 and

FY 2011 was $9.89 billion, based on annual agency energy reporting to the DOE. While CTS represents an important source of information on what agencies are investing in at the project level, it does not yet provide a comprehensive picture of agency investments in efficiency and renewables.

6.2.1 Average and Total Project Investment

The 794 implemented projects reported in CTS by federal agencies as of the end of FY 2012 represent $1.35 billion of total investment and $2.5 billion in total awarded contract values, which include financing costs. The total investment comprises just 14% of the $9.89 billion of total spending on efficiency reported by agencies since the period FY 2008 through FY 2011.[13] As illustrated in Figure 6.2, GSA, DOE, and DOJ represent nearly three-quarters of all federal project funding reported in CTS.



	GSA	DOE	DOJ	DHS	NASA	DOD	USPS	DOI	TREASURY	STATE	DOT	VA	HHS	SSA	DOL	USDA	TVA	EPA	NRC	RRB
Total Financing Cost	$-	$894	$188	$51	$17	$-	$-	$0.5	$0.3	$5	$-	$0.2	$-	$-	$-	$0.2	$-	$-	$-	$-
Total Project Investment	$415	$358	$189	$126	$48	$44	$41	$31	$18	$12	$11	$9	$9	$8	$7	$7	$6	$5	$0.2	$0.04
Number of Projects	80	47	16	10	9	78	139	92	7	7	27	43	27	14	158	3	25	9	1	2

Figure 6.2. Number of Implemented Projects by Agency and Level of Investment ($M)

Analysis of the project data in CTS shows a wide range of investment levels, with individual energy and water projects ranging in size from $0 to $137 million and the average project costing $1.69 million to implement.[14] (See Figure 6.3) The difference in total investments and average project sizes by agency are in part a function of agency budget levels. Another factor is the type of funding sources the agency has used for project investments. It is also possible that there is some data-entry bias in CTS toward larger projects. Agencies may be less likely to enter small project investments in CTS, because energy and water savings values may be more difficult to estimate without the robust analysis of a third party leading a performance contract. Furthermore, the requirement to do measurement and verification on all project investments entered in CTS may not be cost-effective for all small projects.

[13] FY 2012 spending data was not available at the time of this report.

[14] Agencies may have indicated $0 project cost if ECMs are being incorporated into larger maintenance projects that would be carried out anyway and they are unable to attribute a specific dollar amount to the efficiency upgrade. In other cases, agencies reported the total cost of maintenance projects, which would result in artificially high project costs because all dollars are not directly supporting ECMs.

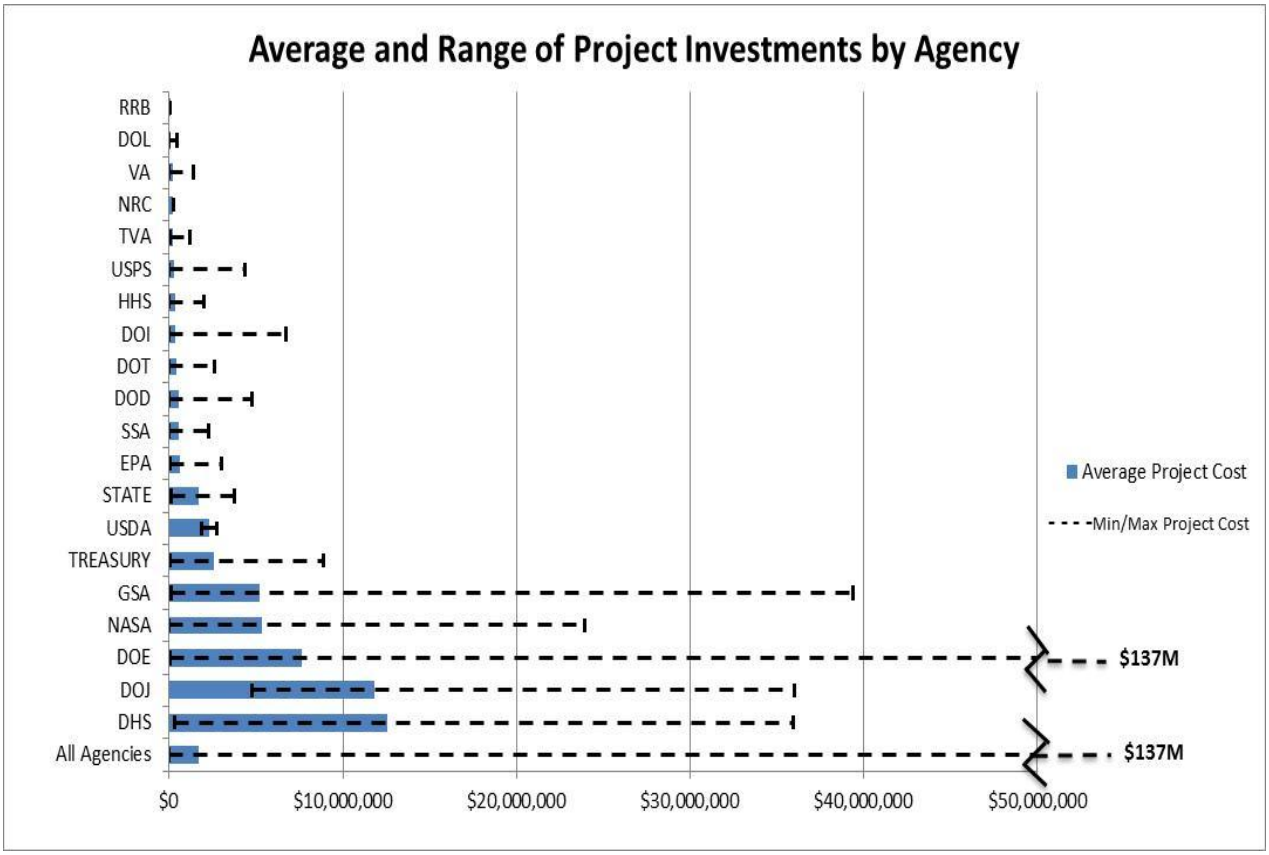


Figure 6.3. Average (blue bar) and Range of Individual Project Investments by Agency

The $137 million DOE investment is for the development of a biomass plant. Without this project in the analysis, the maximum implementation cost becomes $59 million, which is for another DOE biomass project.

Figure 6.4 illustrates the wide range in the count and average size of projects across agencies for projects entered in CTS through 2012. About half of these 794 projects have been implemented by three agencies: DOL, USPS, and DOI. These agencies may have a higher number of projects because they tend to have smaller, single-building facilities.

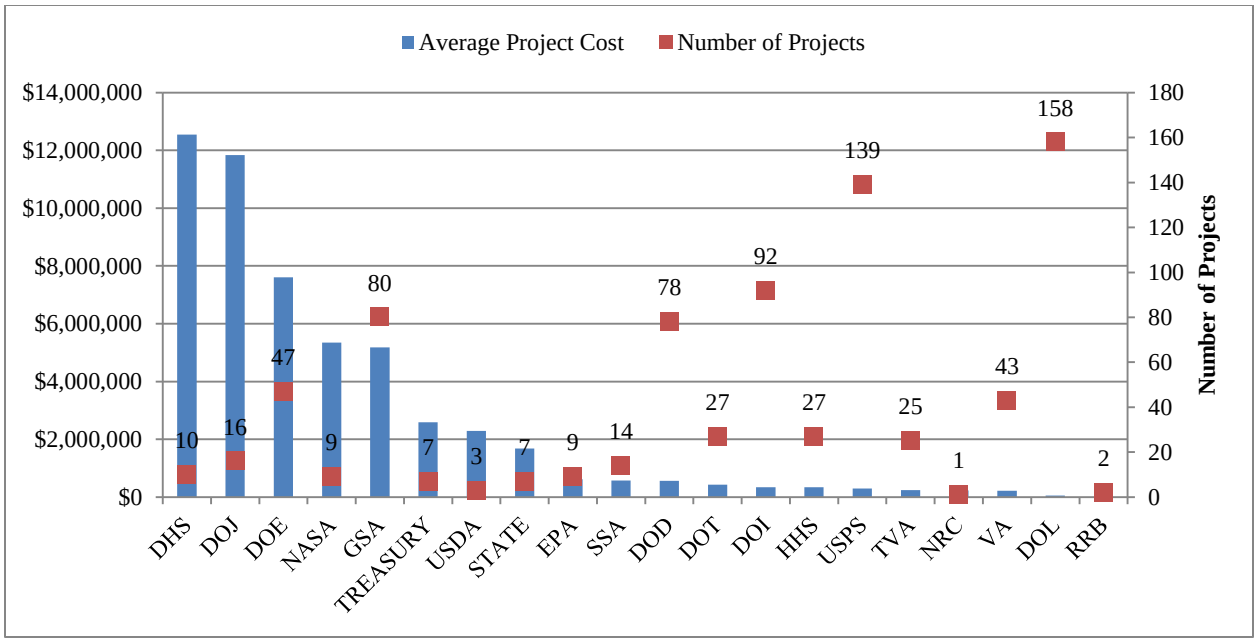


Figure 6.4. Average Project Cost Relative to Number of Projects

To help normalize project investments across agencies, Figure 6.5 presents ECM investments reported in CTS as a proportion of each agency's annual facility energy costs. This figure also shows efficiency investments reported in annual energy reports from 2008 through 2011 as a proportion of the agency's annual energy costs. ECM investments reported in CTS represent between 0% and 25% of agency annual facility energy costs, whereas total energy efficiency investments from annual energy reports represent between 0% and 366% of energy costs. Based on project reporting in the CTS, DHS, DOJ, and GSA are spending the largest proportion of their energy costs on ECMs, at 25%, 25%, and 24% respectively. Based on top-down reporting of agency efficiency investments, HUD and GSA are spending the greatest proportion of their energy costs on efficiency projects, at 366% and 189% respectively. This may be due to one-time ARRA investments.

Comparing energy investments reported in CTS to those reported in the annual energy reports helps to illustrate how comprehensive project reporting in CTS has been. Agencies on left side of this figure have a greater proportion of the agency's total efficiency investment entered in CTS.[15]

[15] CTS project investments to date have been predominantly in energy conservation measures but also include some water conservation measures. Because a single investment value is reported for projects, these investments include some water ECMs as well.

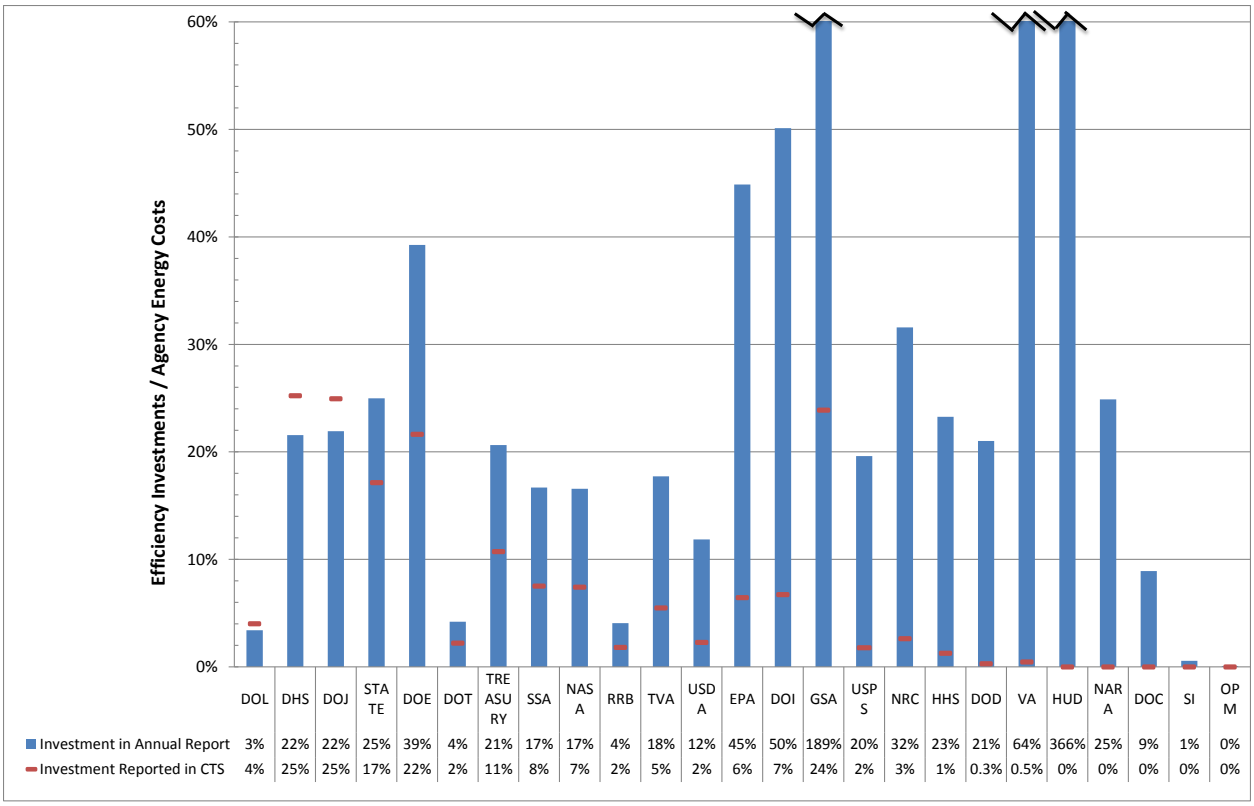


Figure 6.5. Percent of Dollars Invested in Efficiency per Dollar Spent on Energy Utility Bills as Reported in CTS (red) and Agency Annual Energy Reports (blue)

As noted above, this provides a snapshot of the CTS database as of the end of FY 2012 and it under-represents the total actual investment in efficiency measures identified by agencies in their agency annual energy reports to DOE. For example, while DOD's investments in CTS appear relatively small as a proportion of total energy costs (0.3%), no Army project investments have been entered into CTS at this time. The Army's Energy Conservation Investment Program (ECIP) is funded at approximately $30 million per year and would increase DOD's percentage to 0.5% if included in CTS. Other sources of Army project funding (e.g., ESPCs, UESCs, and direct sustainment, restoration and modernization funds) would increase this further. This is probably the case with other agencies as well.

6.2.2 Project Investment by Funding Source

An analysis of funding sources provides an indication of the extent to which agencies are leveraging third-party funding to support their energy- and water-saving measures versus using internal resources to support those measures. This provides an opportunity to evaluate the comparative impact of investments made through different funding sources. Analysis of the investment by funding source can also help to assess the potential volatility of investment, and whether such levels are likely to be sustained.

For each project investment, agencies must identify funding sources from the categories below and may include multiple funding sources for a single project:

- **Direct Centralized Capital Funding** – In general, direct funding includes appropriations or other funding from centralized agency funding accounts for larger capital-intensive projects.

- **Decentralized Operations and Maintenance (O&M) Budgets** – Funding is provided from decentralized operations and maintenance budgets.
- **ARRA** – Funding is provided from the American Recovery and Reinvestment Act.
- **Energy Savings Performance Contract (ESPC)** – An ESPC is a contract between a federal agency and a third party (e.g., a task order awarded to an energy service company) that provides for the performance of services for the design, acquisition, financing, installation, testing, operation, maintenance and repair of an identified energy, water conservation, or renewable energy measure or series of measures, at one or more locations.
- **Utility Energy Service Contract (UESC)** – A UESC is a contract between a federal agency and a local utility providing energy or water services, as well as provision of technical services and/or up-front project financing for energy efficiency, water conservation, and renewable energy investments, allowing federal agencies to pay for the services with the savings generated from improvement projects over time, either on their utility bill or through a separate agreement.
- **Power Purchase Agreements (PPA)** – A PPA is funded through an agreement between an agency and developer of a renewable or other energy system project. Under a PPA, a developer installs the energy system on agency property and the agency purchases the power generated by the system. The agency pays for the system through these power payments over the life of the contract. After installation, the developer owns, operates, and maintains the system for the life of the contract.
- **Incentive Programs** – Funding is provided from state and utility incentive programs that help offset energy costs while promoting energy and water efficiency and renewable energy technologies.
- **Enhanced Use Lease (EUL)** – An Enhanced Use Lease is an authority by which some federal agencies can lease underutilized real property to the public or private sector as a means of obtaining services, facilities, revenue, space, etc., that enhance their mission.
- **Other** – Funding is provided by a source other than those listed above.
- **Not Specified** – Indicates the agency did not document the funding source in CTS.

As indicated in Figure 6.6 below, funding from ESPCs (43%) and ARRA (33%) have provided the greatest proportion of total investment in energy and water projects reported in CTS over the past four years. End-use leases and PPAs have not been used at all by agencies based on entries in CTS. Direct funding through annual operating budgets—either from decentralized O&M budgets or centralized capital funding sources—represent just 7% of all investments entered into CTS over the past four years.

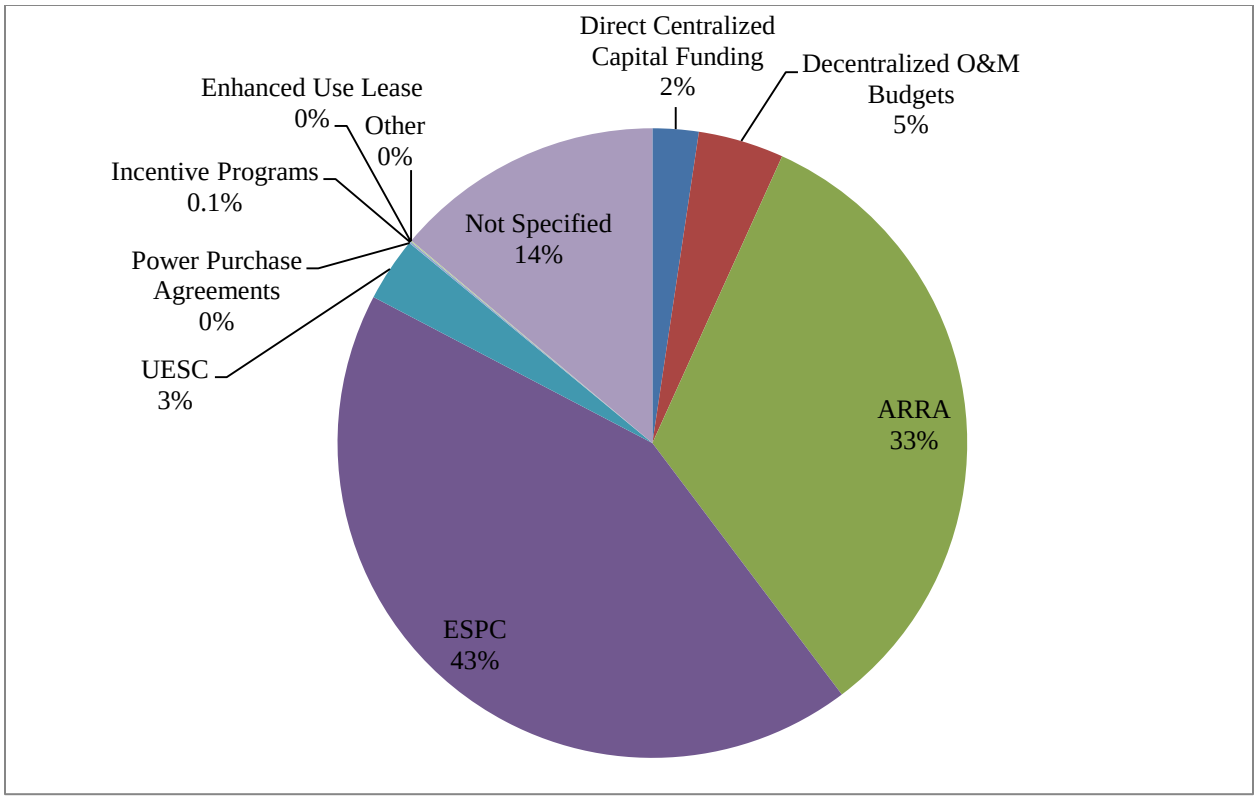


Figure 6.6. Percent of Total Project Investment Reported in CTS by Source

A comparison to agency top-down reporting of efficiency investments by funding source suggests that while all funding areas are being under-reported in CTS, projects funded through direct obligations appear to be under-reported at a much higher rate. The $577 million of ESPC funding reported in CTS represents 33% of total ESPC funding reported by agencies in their annual energy reports, whereas the $534 million of direct funding from centralized capital, decentralized O&M, and ARRA funding together represent just 7% of the total direct obligations reported in Figure 6.7.

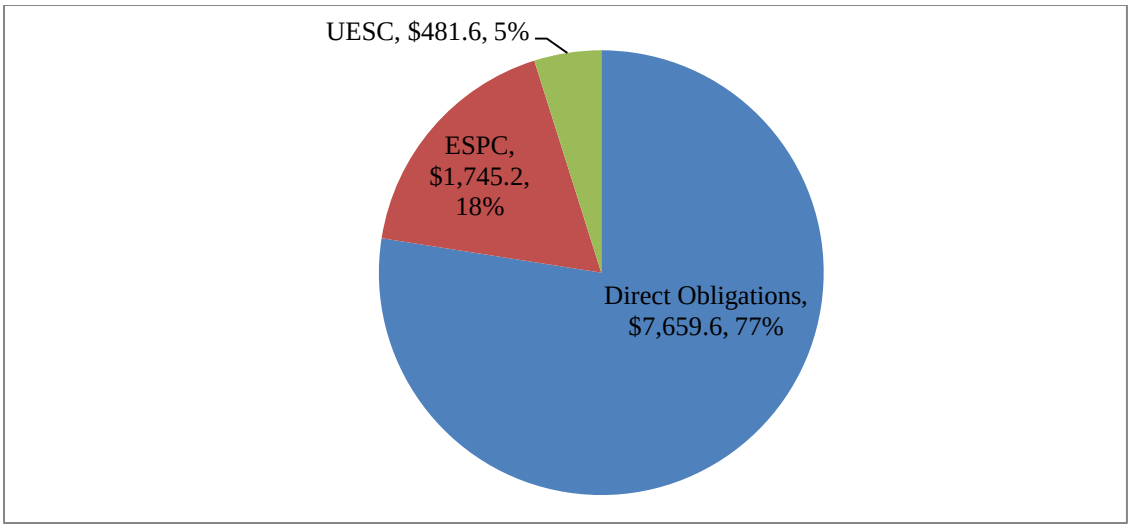


Figure 6.7. Value ($M) and Percent of Total Efficiency Investments Reported in Annual Energy Reports by Source

While ESPCs are the predominant source of funding for projects reported in CTS government-wide, only one-third of agencies reported ESPC projects (see Table 6.1). Projects implemented by DOE and DOJ represent 94% of government-wide ESPC project investment.

Table 6.1. Federal Project Total Investment in CTS by Funding Source and Agency ($M)

Agency	Direct Central-ized Capital Funding	Decentral-ized O&M Budgets	ARRA	ESPC	UESC	Incent-ive Prog-rams	Other	Not Specified	Total
All Agencies	**$31.8**	**$59.2**	**$443.5**	**$577.9**	**$44.3**	**$1.3**	**$0.8**	**$186.7**	**$1,345.5**
DHS	-	-	-	-	-	-	-	$125.5	$125.5
DOD	$3.7	$10.1	-	-	-	-	-	$30.2	$44.0
DOE	-	-	-	$357.6	-	-	-	-	$357.6
DOI	$1.3	$0.4	$15.9	-	$3.5	-	$0.03	$10.0	$31.2
DOJ	-	$4.4	-	$185.0	-	-	-	-	$189.4
DOL	$3.5	-	$3.8	-	-	-	-	-	$7.4
DOT	-	$2.2	-	-	-	-	-	$9.3	$11.5
EPA	-	-	-	-	-	-	-	$5.5	$5.5
GSA	$1.9	-	$412.8	-	-	-	-	-	$414.7
HHS	$4.4	-	-	-	$4.6	-	-	-	$9.1
NASA	$2.7	$0.5	-	$19.7	$23.2	$1.3	$0.7	-	$48.2
NRC	-	$0.2	-	-	-	-	-	-	$0.2
RRB	-	$0.04	-	-	-	-	-	-	$0.04
SSA	$4.9	$0.1	-	$2.0	$0.7	-	-	$0.2	$7.9
STATE	-	-	-	$11.7	-	-	-	-	$11.7
TREASURY	$9.3	-	$6.0	-	$2.8	-	-	-	$18.1
TVA	-	-	-	-	-	-	-	$5.9	$5.9
USDA	-	-	$5.0	$1.9	-	-	-	-	$6.9
USPS	-	$41.3	-	-	-	-	-	-	$41.3
VA	-	-	-	-	$9.4	-	-	-	$9.4

Figure 6.8 helps to illustrate the predominant funding sources used by each agency. For example, GSA's primary source of project investment in CTS has been ARRA funding, and only a portion of this has been entered into CTS. This suggests that the unusually high level of investment (which was noted above to represent 189% of GSA's energy costs over four years) is short-term and not likely to be sustained. DOE's and DOJ's investments in CTS are dominated by ESPC projects. NASA used predominantly UESC funding; of the six agencies using UESC as a funding source, NASA represents 52% of this investment. USPS has relied exclusively on decentralized operating budgets to fund its ECMs reported in CTS. Overall, third-party project financing is used by about half of agencies and represents $1.16 billion of funding to the private sector, or 46% of the total investment in projects.

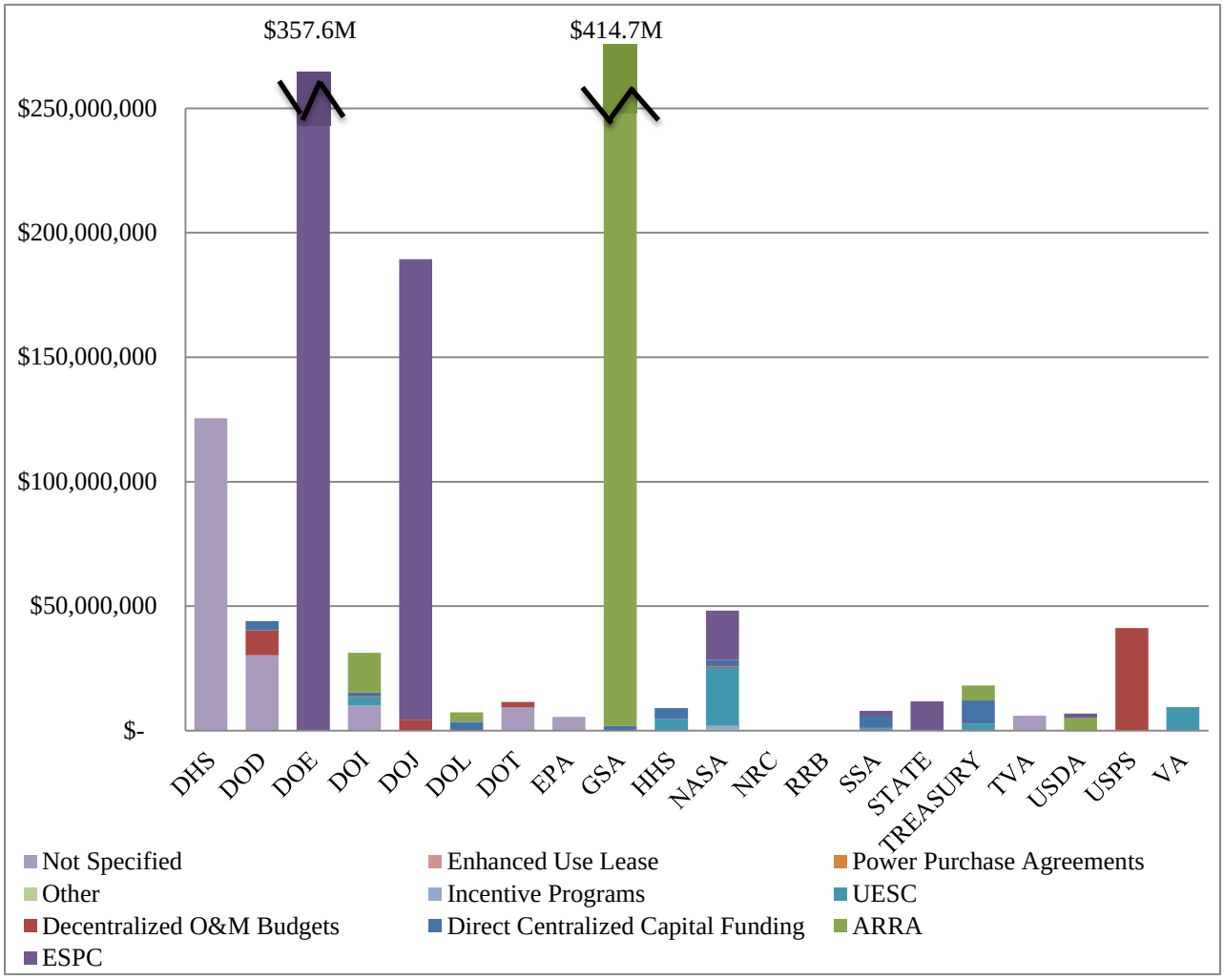


Figure 6.8. Total Project Investment by Agency and Funding Source

In addition to representing the predominant total funding sources, ESPC projects have the largest average project size, at $7.6 million. ARRA projects are the next largest on average, at $2.2 million (see Figure 6.9). All other projects with funding sources specified are under $1 million on average. Projects funded through direct centralized capital funding have the smallest average project size, at $252,513. In terms of frequency of use, the greatest number of projects in the database used ARRA as a full or partial funding source. While projects funded with decentralized O&M budgets and centralized capital together

represent just 7% of total agency investment reported in CTS, these are among the most frequently used funding sources in terms of number of individual projects funded.

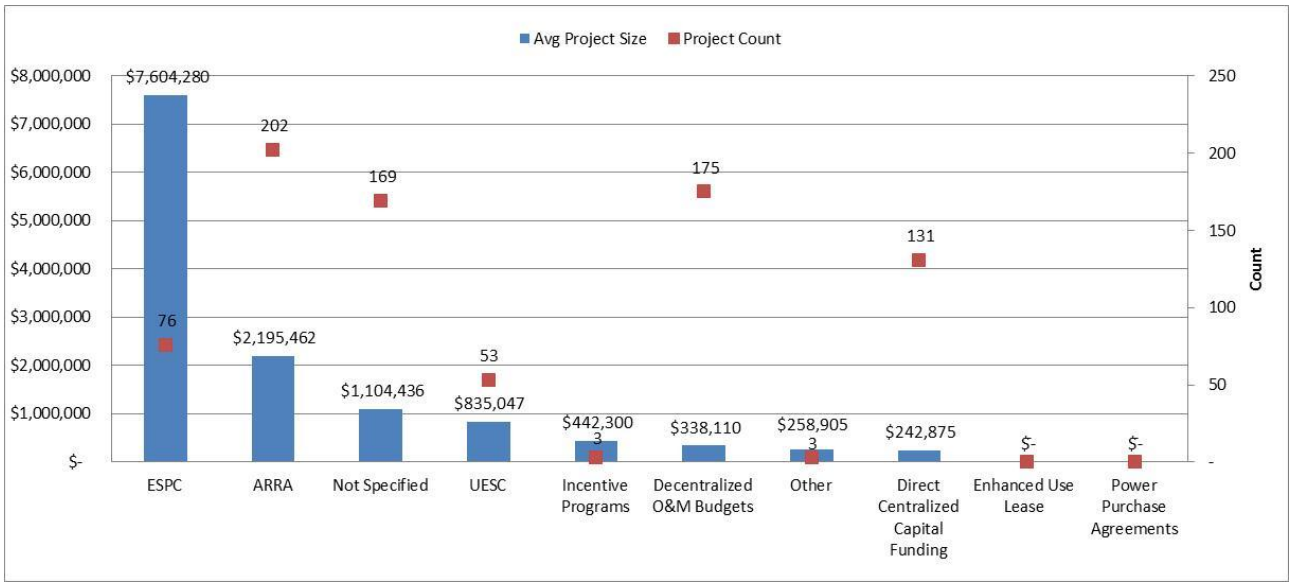


Figure 6.9. Average Size and Count of Implemented Projects by Funding Source

Figure 6.10 illustrates variation in the average project size by funding source and agency. For most agencies using UESCs, the average project size was under $3.5 million; NASA was the exception with a single UESC project valued at over $23 million. Most agencies reporting ARRA projects in CTS had average project sizes under $3 million; GSA's average project size for ARRA projects was slightly higher than other agencies at $5.3 million.

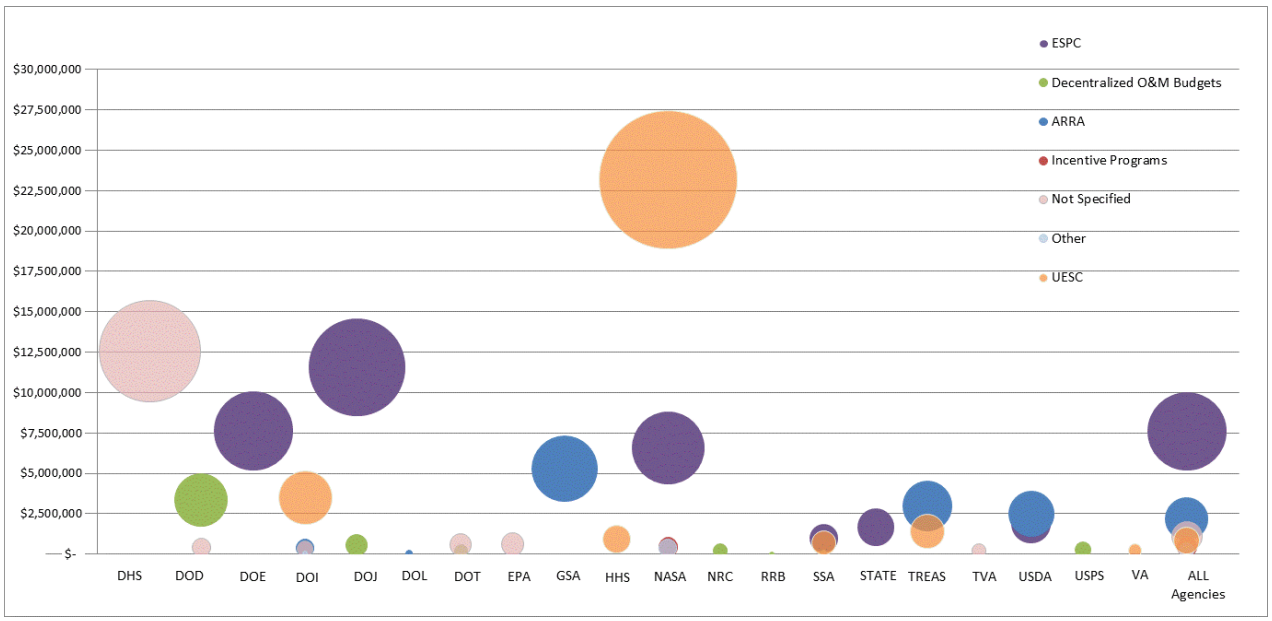


Figure 6.10. Average Project Size by Agency and Funding Source

6.3 Energy and Water Savings from Projects

The implemented projects reported in CTS resulted in a total energy savings of 4,078,279 MMBtu government-wide. DOE projects represent 26% of all reported savings, followed by DOJ (18%), GSA (11%), and DOD (11%). DOJ projects are making the greatest contribution to water savings, comprising 66% of all reported water savings investments. Fewer agencies have reported renewable electricity production or renewable thermal projects. DOE projects also represent the greatest portion of renewable output based on projects reported by federal agencies in CTS over the past four years. (See Table 6.2)

Table 6.2. Total Annual Energy Savings and Renewable Output from Projects in CTS

Agency	Total Annual Energy Savings (MMBtu)	% of Total Energy Savings	Total Annual Renewable Electricity Output (MMBtu)	% of Total Renewable Electricity Output	Total Annual Renewable Thermal Output (MMBtu)	% of Total Renewable Thermal Output	Total Annual Water Savings (thou. gal)	% of Total Water Savings
All Agencies	**4,078,279**	**100%**	**359,643**	**100%**	**1,350,859**		**1,140,147**	**100%**
DHS	213,920	5%	21,685	6%			17,799	2%
DOD	443,958	11%			16	0.001%	3,493	0.3%
DOE	1,076,883	26%	265,272	74%	1,336,985	99%	173,983	15%
DOI	21,823	1%	1,205	0.3%	186	0.01%	16,548	1%
DOJ	752,930	18%					747,614	66%
DOL	24,642	1%					3,458	0%
DOT	19,293	0.5%	8,486	2%			6,678	1%
EPA	41,327	1%	61	0.02%				
GSA	465,466	11%	57,043	16%				
HHS	73,091	2%					878	0.1%
NASA	280,793	7%	0.5	0.0001%			125,879	11%
NRC	1,741	0.04%						
RRB							130	0.01%
SSA	53,384	1%	5,202	1%	13,671	1%	4,876	0.4%
STATE	44,502	1%					1,194	0.1%
TREASURY	121,071	3%	672	0.2%			6,292	1%
TVA	33,361	1%					10,085	1%
USDA	54,220	1%						
USPS	325,034	8%					5,171	0.5%
VA	30,840	1%					16,069	1%

6.4 Energy Conservation Measures Implemented

This section examines the ECMs most frequently implemented as individual projects and bundles. For projects with a single ECM type, it evaluates the energy and cost savings associated with different ECMs. This provides insights into where the most opportunities for energy efficiency have been identified thus far and what their relative impacts have been.

6.4.1 ECMs Implemented by Type

Projects entered into CTS had 20 different parent ECM types available to characterize the activities. Table 5.2 in the previous section lists these categories with a corresponding short name used in this analysis and subsequent graphs and tables. Several of the parent ECM types have subcategories with more specific ECM descriptions, which are listed in Appendix B. Agencies had the option of entering these

more detailed descriptions in CTS; however they were not used consistently across agencies, with less than 10% of the projects identifying sub-ECM categories. Therefore the overall ECM analysis uses the parent ECM categories, and the subcategories are used where appropriate.

Agencies identified over 2,800 ECMs in the 794 valid projects[16] entered in CTS. Lighting, HVAC, EMCS, and Water and Sewer Conservation Systems are the four most common ECM types. Figure 6.11 below shows the count of ECMs identified by type in CTS.

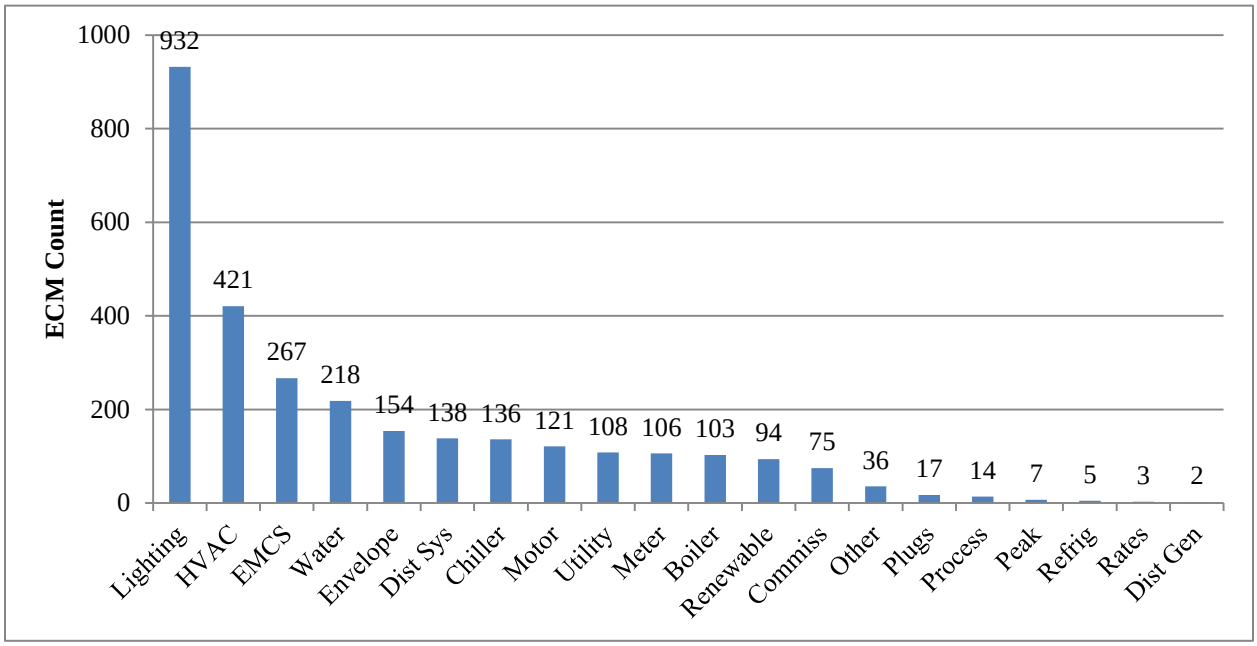


Figure 6.11. Sums of ECMs Implemented by Category

The types of ECMs that the agencies are implementing vary. Figure 6.12 illustrates the diversity of ECM types within the agencies' project portfolios. The percentage of ECM types is displayed in the stacked bar graphs. For example, all of NRC's projects are energy and utility distribution system projects while DOJ and DOE had a more even split of ECM types within their implemented projects.

[16] Projects are valid when the following information has been entered in CTS at a minimum: project has been initiated (contract awarded date), implementation cost, annual energy savings, and the ECM type.

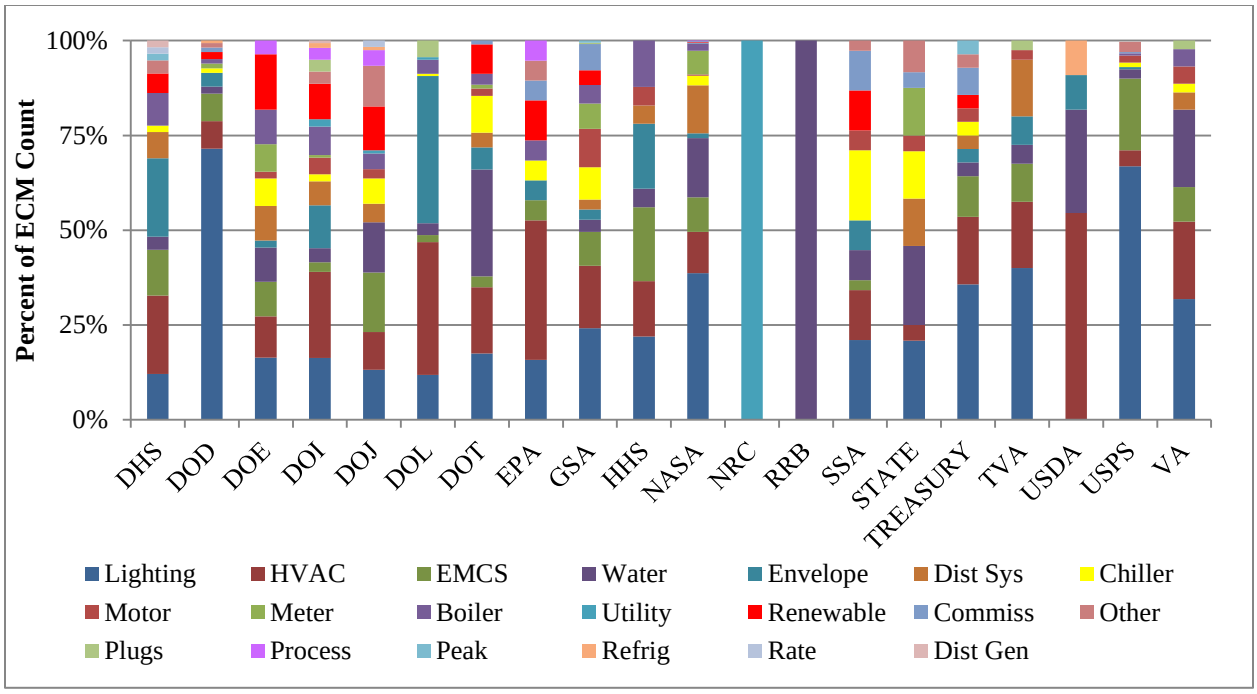


Figure 6.12. Type of ECMs Implemented by Agency

The table below shows the 10 most common ECMs at the 10 agencies with the highest number of ECMs in CTS (Table 6.3). A calculation was performed for each agency to show the percentage of total ECMs by category with respect to the agency's total ECM count. For several agencies with high ECM counts, such as GSA and USPS, Lighting is the most common ECM identified; for others, such as DOL and DOI, HVAC, EMCS, Envelope and Water projects are the most common.

Table 6.3. Percent of Agency's Total Count of ECMs for the Top 10 ECM Categories[17]

Agency	Lighting	HVAC	EMCS	Envelope	Water	Chiller	Boiler	Commiss	Meter	Motor
GSA	24%	16%	9%	3%	3%	8%	5%	7%	7%	10%
NASA	39%	11%	9%	1%	16%	2%	2%	0%	6%	0%
USPS	67%	4%	19%	1%	3%	1%	1%	0%	0%	2%
DOD	72%	7%	7%	4%	2%	1%	1%	1%	1%	0%
DOL	12%	35%	2%	39%	3%	1%	4%	0%	0%	0%
DOI	16%	23%	3%	11%	4%	2%	8%	0%	1%	4%
DOJ	13%	10%	16%	0%	13%	7%	4%	0%	0%	2%
DOT	16%	18%	3%	6%	29%	10%	3%	1%	1%	2%
DHS	12%	21%	12%	21%	3%	2%	9%	0%	0%	0%
DOE	16%	11%	9%	2%	9%	7%	9%	0%	7%	2%

[17] Note that conditional formatting has been applied to each agency to identify the largest ECM categories. The darkest cells have the largest value for the agency, where the lightest colored cells have the smallest value.

6.4.2 Bundling of Projects

EISA encourages agencies to bundle ECMs as a way to optimize the energy- and water-saving or environmental benefits of a project, while making sure that the overall investment is life-cycle cost-effective. Looking at all projects in CTS, the majority (72%) have only one ECM type identified (Figure 6.13).[18]

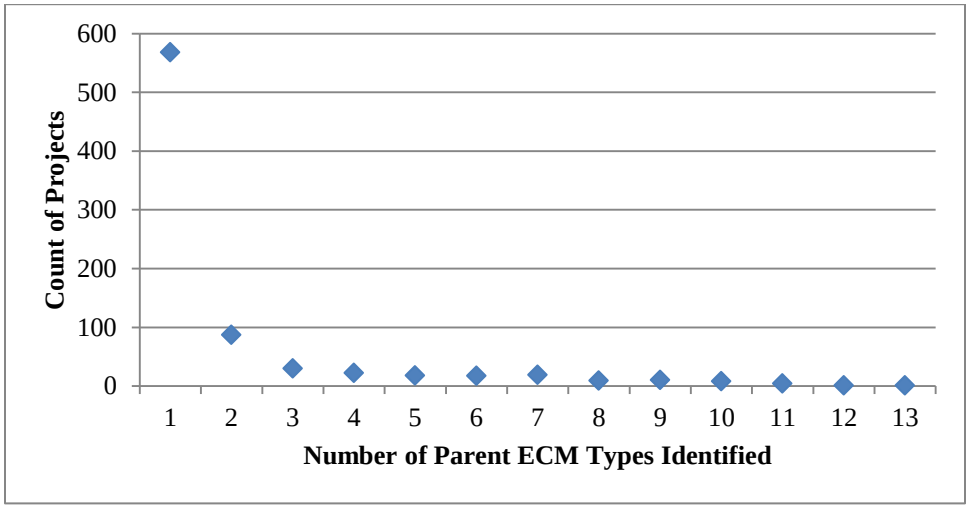


Figure 6.13. Number of Projects with One or More ECM Types

A comparison of the number of projects by agency to the number of projects with single parent ECMs shows that some agencies included several ECMs in each project while others did not. The red dots in Figure 6.14 indicate the total number of ECMs identified by the agencies. Projects in CTS had ECM counts ranging from 1 to 97. As illustrated in Figure 6.14, GSA, NASA and USPS implemented the most ECMs and tended to bundle different ECM types into a single project.

[18] Because most agencies reported ECMs at the parent ECM level, this summary does not indicate whether multiple ECMs were bundled within a parent ECM category. For example, a project could include both daylighting and occupancy sensor ECMs and still be characterized as a single ECM type in this analysis.

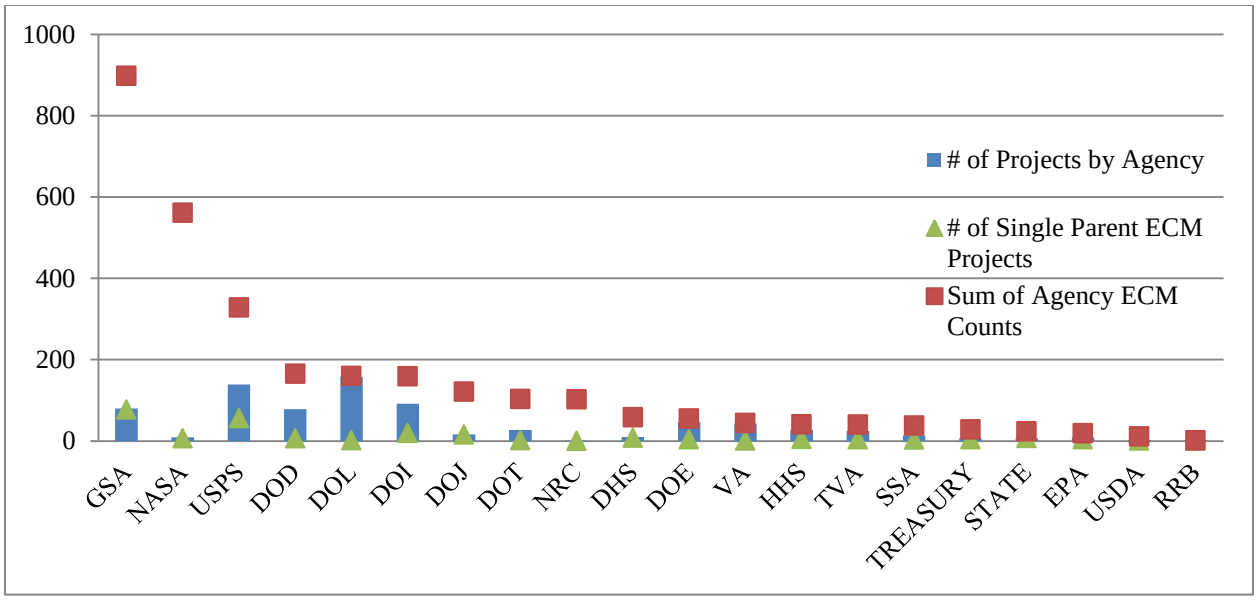


Figure 6.14. Number of Projects, Number of Single Parent ECM Projects, and Sum of ECMs by Agency

An alternative way of looking at the agency data is to evaluate how frequently they bundle their projects as a ratio of bundled projects to nonbundled projects. As shown in Table 6.4, DOJ and STATE bundled ECM types in every project entered in CTS. Six out of 20 agencies bundled ECMs in projects more than half of the time. Agencies with a larger number of projects (e.g., DOL, USPS and DOI) tended not to bundle the majority of their projects.[19]

[19] Note: This does not account for the cases where multiple ECM subcategories are bundled within the broad categories (e.g. daylighting and occupancy sensors within lighting).

Table 6.4. Bundling of ECMs in Projects by Agency

Agency	% of Agency's Projects with Bundled ECMs
DOJ	100%
STATE	100%
GSA	96%
DHS	80%
NASA	67%
TREASURY	57%
EPA	44%
USPS	40%
USDA	33%
DOI	22%
SSA	21%
HHS	19%
TVA	16%
DOE	9%
DOD	8%
DOT	7%
VA	2%
DOL	1%
RRB	0%
NRC	0%

The most common ECM bundle groups are Lighting improvements with EMCS, Lighting with HVAC, and HVAC with EMCS. Commissioning measures were frequently bundled with Lighting, HVAC, EMCS and Chiller plant retrofits. It is likely that agencies are adding Commissioning projects to Building Automation System upgrades, and Advanced Metering to larger capital projects during the project development phase. Agencies also appear to be taking advantage of more economical Lighting and EMCS projects to implement Water and Sewer Conservation system projects. Table 6.5 below highlights the top 25 most commonly bundled ECMs.

Table 6.5. Top 25 Most Commonly Bundled ECMs[20]

	EMCS	HVAC	Commiss	Meter	Boiler	Chiller	Motor	Water
Lighting	118	93	51	49	39	50	48	46
HVAC	88		61	55	45	57	47	
EMCS			57	53	43	55	49	36
Chiller			39		39		37	
Commiss				54			36	

6.4.3 Energy Savings by Implemented ECM

Projects with a single ECM type identified can be analyzed for their relative contribution to total energy savings. Because a single savings value is entered in CTS for projects and is not attributed to individual ECMs, there is significant uncertainty around analysis of energy savings by ECM type for

[20] Note: The most frequent bundles are shaded in dark green and the less frequent bundles are lighter in color. The number in the cell refers to the number of projects that have both ECMs in the matrix.

projects with bundled ECMs. Analysis of single-ECM projects provides the most accurate estimated savings ranges.

Table 6.6 and Table 6.7 show the reported amounts of energy avoided through energy efficiency ECMs. Projects implemented with a single ECM type account for 45% of the energy savings reported in CTS but account for the majority of projects. This suggests that single-ECM projects have a lower savings amount per project than projects with more than one ECM. Bundled projects tend to be larger in size. On average each project with a single ECM saved 3,600 MMBtu, while bundled projects saved over 14,000 MMBtu each.

Table 6.6. Energy Savings Grouped by Number of ECM Types per Project

	Energy Savings (MMBtu)	Percent of Total Savings Reported	Number of Projects with Energy Savings	Energy Savings Per Project (MMBtu)
Projects with One ECM Type	1,928,494	45%	541	3,565
Projects with Two ECM Types	419,754	10%	81	5,182
Projects with Three or More ECM Types	1,948,958	45%	135	14,437
Total CTS Project Energy Savings	4,297,206[21]		757	5,677

An alternative way to look at these savings values is to compare the number of ECMs identified within each project to the energy-savings estimates. In Table 6.7 below, the projects with more than three ECM types have a lower savings per ECM value than the projects with only one or two ECMs identified. This means that the bundled projects are including several ECMs with smaller individual energy savings, which is expected.

Table 6.7. Energy Savings per ECM Group by Number of ECMs

	Energy Savings (MMBtu)	Number of ECMs with Energy Savings	Energy Savings Per ECM (MMBtu)
Projects with One ECM Type	1,928,464	840	2,296
Projects with Two ECM Types	419,754	233	1,802
Projects with Three or More ECM Types	1,948,958	1,807	1,079
Total CTS Project Energy Savings	4,297,206	2,880	1,492

Figure 6.15 below depicts the energy savings for all ECM types in projects with only one ECM type. The ECMs that account for the largest amount of estimated annual savings are Lighting, EMCS, Renewable Energy projects with an energy-savings component, and Chilled Water, Hot Water, and Steam Distribution systems. Together, these four single-ECM project types account for two-thirds of the energy savings of single projects in CTS. This means that these types of ECMs are implemented more independently because they are either cost-effective by themselves or there is a higher ease of implementation to fund and execute these types of projects on their own.

[21] Note that the totals have been adjusted based on quality checks of the data. A few renewable ECMs reported their data as energy savings rather than renewable energy production. The values have been corrected in this analysis.

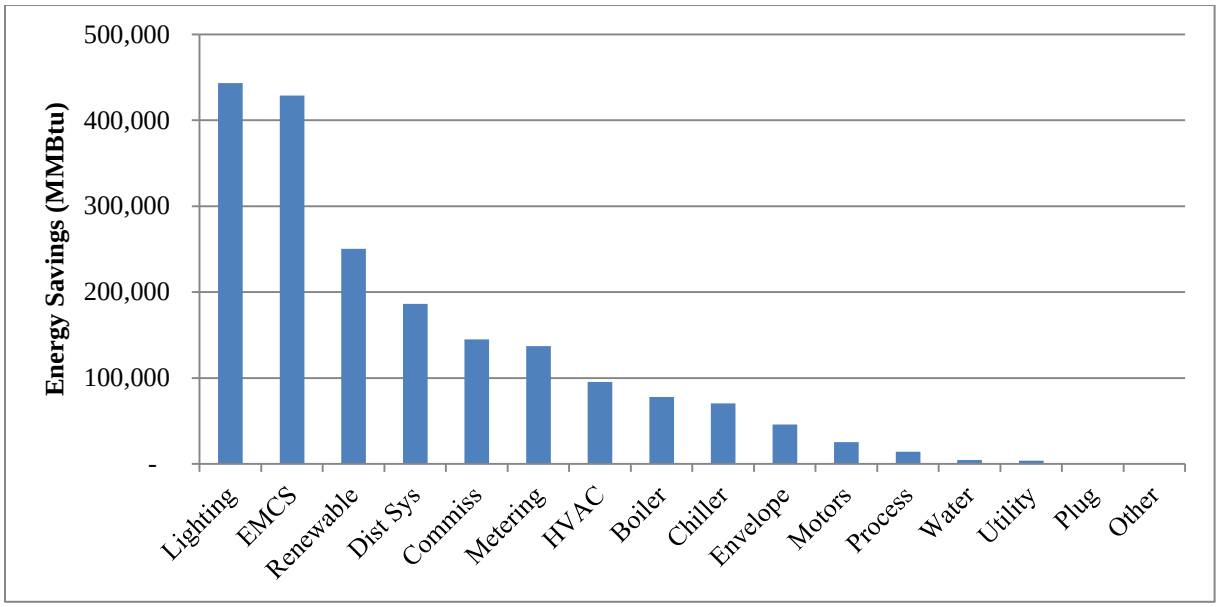


Figure 6.15. ECM Savings by Category for Projects with a Single ECM Type

6.4.4 Renewable Energy Output by Implemented ECM

Renewable energy ECMs account for a third of the total energy avoided by projects. There were far fewer renewable energy projects than energy efficiency projects, and on average the renewable projects generated nearly 35,000 MMBtu per project. Most of the projects produced renewable electricity, with one large biomass project producing 70% of the total energy savings realized by all federal projects. Without this large project, the overall average annual generation per project is 21,000 MMBtu.

Table 6.8. Annual Renewable Energy Output Summary

	Renewable Electricity	Renewable Thermal	Total Renewable[22]
Renewable Output	105,400,520 KWh (359,627 MMBtu)	1,350,859 MMBtu	1,710,485 MMBtu
Number of Projects	42	13	53[23]
MMBtu of Production per Project[24]	8,563	103,912	32,273

The renewable energy projects were reviewed in more detail to determine the specific types of projects that were implemented. Information from the project titles and notes was assembled to create Table 6.9, with a portion of the project types unable to be determined (noted as nonspecified RE). DOE's large biomass project makes up the bulk of the renewable output, with nonspecified renewable energy and photovoltaic projects generating the next largest amounts.

[22] Adjustments were made to these totals. Based on the project details provided in CTS it was determined that one project had renewable energy output inadvertently entered in the energy savings fields. 16MMBtu of renewable energy project savings were moved to renewable thermal energy output fields.
[23] Two projects have both renewable electricity output and renewable thermal output.
[24] This is calculated by dividing the renewable output by the number of projects.

Table 6.9. Renewable Energy Output by Project Type

Project Type	Sum of Renewable Energy Output (MMBtu)	Percent of Renewable Energy Contribution
Biomass	1,450,021	85%
Nonspecified RE	192,734	11%
Photovoltaic	51,907	3%
Biogas	15,056	<1%
Solar Transpired Wall	503	<1%
Solar Hot Water	179	<1%
Wind	62	<1%
Ground-Coupled Heat Pump	24	<1%
Grand Total	**1,710,486**	

6.4.5 Cost of Implementing ECMs by Type

Projects that had multiple ECMs bundled represented over half of the implementation cost reported in CTS. The values in Table 6.10 show all of the projects with the exception of the $137M biomass project and ECMs as part of larger maintenance projects with zero implementation costs, so as not to skew the averages. On average each project with a single ECM cost $660k, while bundled projects were over $5M each.

Table 6.10. Implementation Costs Grouped by Number of ECM Types per Project

	Total Implementation Cost ($M)	Percent of Total Cost Reported	Number of Projects with Implementation Cost	Average Cost per Project ($k)
Projects with One ECM Type	372.1	30%	561	663
Projects with Two ECM Types	153.0	12%	86	1,780
Projects with Three or More ECM Types	712.0	58%	136	5,235
Total CTS Project Costs	1,237.2		783	1,580

The ECMs in which the largest investments were made were Chilled Water, Hot Water, and Steam Distribution Systems; Lighting Improvements; Building Envelope; Renewable Energy; and HVAC, as shown in Figure 6.6. Together, these five project types account for 70% of the implementation cost. As noted previously, these results are only for projects with one ECM type because only an overall implementation cost is entered into CTS by project. Projects that are bundled do not break out the costs by ECM type. Note that the large DOE biomass project ($137M) was also taken out of this figure and accounts for the majority of the investment in renewable energy projects.

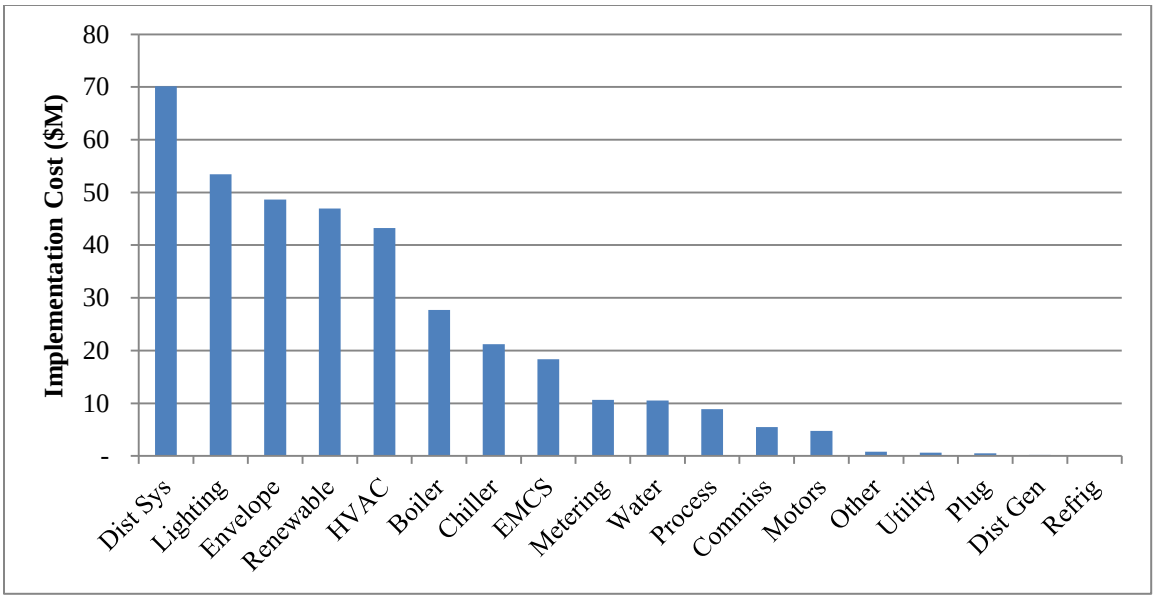


Figure 6.16. Total Implementation Cost by Category for Projects with a Single ECM Type

As shown in Figure 6.17, the ECMs that have the largest average implementation cost per project are Distribution Systems, Renewable Energy, Advanced Metering, Commissioning, Boiler and Chiller Plants, and Process Improvements. On average, these projects cost over $1M each, while the others generally cost between $100,000 and $500,000 each.

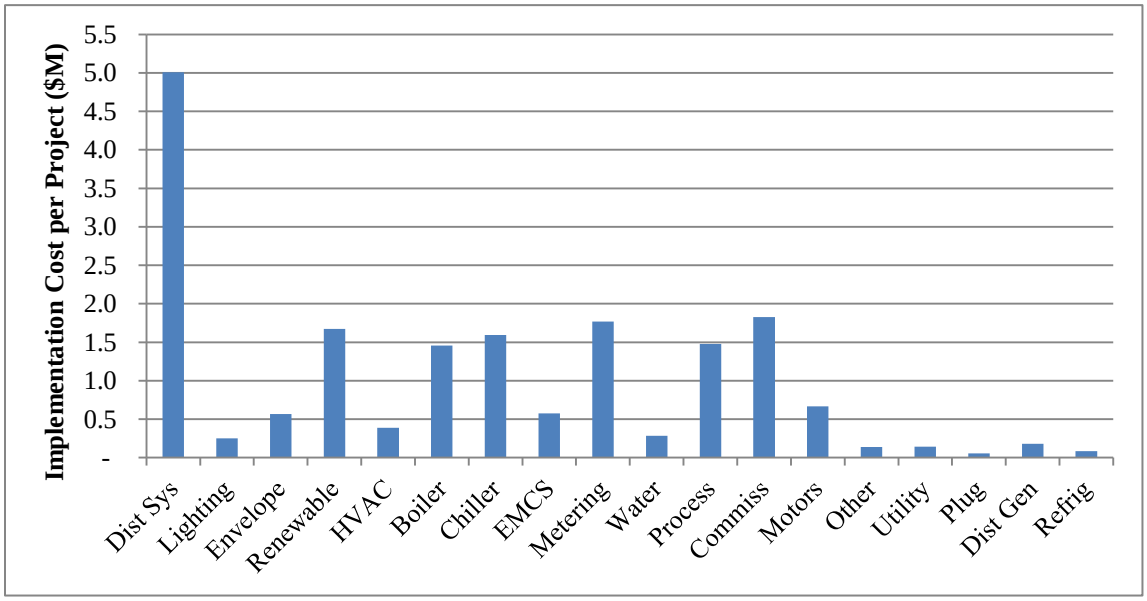


Figure 6.17. Average Implementation Cost per ECM for Projects with a Single ECM Type

6.4.6 Water Conservation Measures Implemented

This section examines projects in CTS that reported implementing a water savings ECM. The projects were analyzed to determine water savings by ECM type. Analysis of the available data presented some challenges. There is a broad range of potential water conservation measures that could be implemented

under the umbrella of Water and Sewer Conservation. The potential water savings for these measures also varies significantly. The lack of specific information on the nature of the water conservation measure implemented limits the research team's ability to establish meaningful average savings.

A total of 77 projects reported in CTS included water savings. Nine projects were removed from the analysis due to obvious data quality issues that could not be resolved through follow-up with the agencies (e.g., reported annual water savings were greater than annual water use). The remaining 69 projects shown in Table 6.11 were broken down by the project information provided in CTS. The category "Plumbing ECM" is a combination of two water sub-ECMs included in CTS: low-flow faucets and showerheads, and low-flow plumbing equipment. Only 13 of the ECMs could be identified as a specific project type from the data provided in CTS, either because the agency specified what the sub-ECM was or by reviewing the project details. A majority of the water savings were simply identified by the parent ECM "Water and Sewer Conservation Systems" with no additional description. Water savings were also recorded under projects with predominantly energy-savings ECMs, including HVAC, Refrigeration, Boiler, Chiller, and Distribution Systems.

Table 6.11. Water Savings by ECM Type

	Number of Projects	Total Water Savings (k gal)	Median Water Savings (k gal)	Average Water Savings (k gal)	Percent of Total Water Savings
Plumbing ECM	12	31,858	52	2,655	3%
Irrigation ECM	1	39	N.A.	N.A.	0%
General Water and Sewer ECMs	36	895,697	4,647	24,880	80%
Energy ECMs with Water Savings	19	187,861	1,187	9,887	17%
Totals	68	1,115,455	5,058	16,404	

Determining cost savings for water projects was also difficult due to the fact that many projects with reported water savings were bundled with energy ECMs. Of the 69 projects listed above, only 12 reported water savings with no energy savings. The total implementation cost for these 12 projects was $8,701,470 and the average was $725,123. The lowest implementation cost of $0 came from an ECM that was bundled into a maintenance project. Excluding this maintenance project, the cost of projects ranged from $2,500 to $5,735,445.

6.4.7 Energy and Water Evaluation Estimate Relative to Implemented Projects

The total evaluated energy savings was compared to the estimated project savings, and 18 % of the evaluated (potential) energy savings from both efficiency projects and renewable projects has been implemented to date, if it is assumed that the implemented projects were identified in the agency's evaluations. About 8% of the total evaluated (potential) water savings has been implemented in projects, if it is assumed that those water savings opportunities were identified in the evaluations.

6.5 Annual Savings per Dollar Invested

The estimated annual energy and water savings per dollar invested provides one measure of return on investment for energy efficiency and water savings projects. This metric reveals the relative value of

savings. This section evaluates energy savings per dollar invested overall, by ECM type, by agency, and by funding source. It also examines savings per dollar invested in water ECM projects.

6.5.1 Annually Recurring Energy Savings per Dollar Invested

Figure 6.18 shows the distribution of values of energy saved (Btu) per dollar invested for the projects entered into CTS that have energy savings and implementation costs identified.[25] Energy projects that included water savings, which may have been bundled in the total costs, were excluded from this analysis. Over 90% of these projects save less than 10,000 Btu per dollar invested. Across all the available data, the mean and median values of Btu per dollar invested are 5,340 and 4,887, respectively. Note that any projects that were calculated to save over 50,000 Btu per dollar invested were omitted from this analysis because the integrity of the data was questionable.

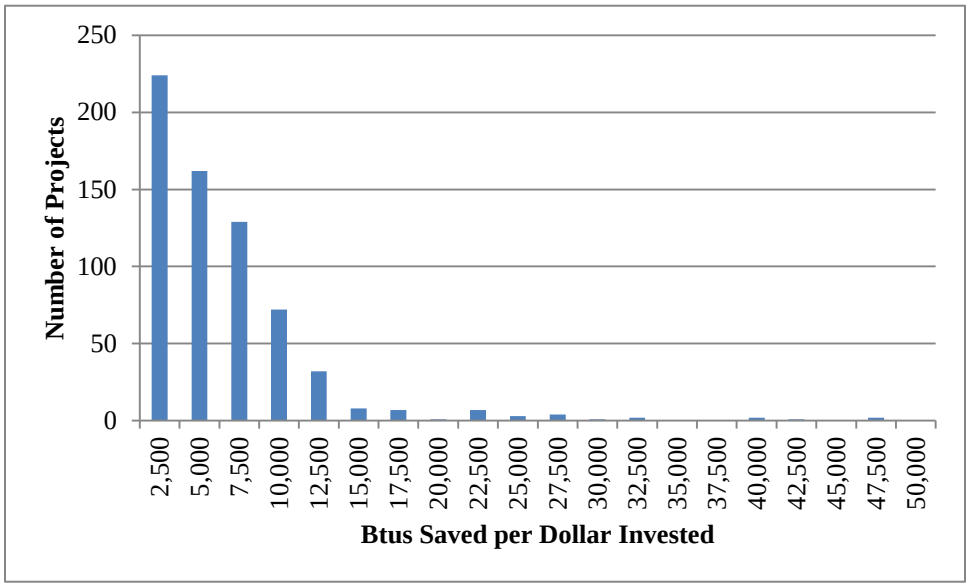


Figure 6.18. Annual Energy Savings (Btu) per Dollar Invested for All Energy Projects

6.5.2 Energy Savings per Dollar Invested by ECM

In order to establish the average energy savings per dollar invested associated with a particular ECM, all single-ECM projects were examined. As shown in Figure 6.19, the economics of lighting projects (in terms of savings per dollar invested) are consistently better than other ECM types reported. Of all single-ECM projects, 88 percent save less than 10,000 Btu per dollar invested. Furthermore, the mean and median savings across all single-ECM projects of Btu per dollar invested are 6,389 and 5,000, respectively. The mean savings are much higher than the median savings because a few single-ECM projects with very high savings per dollar invested pull the mean upward.

Because there is significant variability within ECM types, it is useful to see how widely the savings vary. Figure 6.19 gives the minimum and maximum savings per dollar invested by ECM as well as the average savings per dollar by ECM. A wide range in minimum and maximum savings reveals that the

[25] There were six observations that had annual savings per dollar over 40,000 Btu. The research team did not receive clarification from agencies on the reason for these unusually high ratios.

average Btu per dollar invested is not representative for that particular ECM. Those with less variability may be more useful to use as a basis for estimating future potential savings levels prior to conducting a more rigorous energy saving audit. For example, because ECMs such as Lighting and HVAC have relatively low variability for the number of projects implemented, they are more likely to accurately characterize the Btu savings per dollar as opposed to ECMs such as Metering and Plug Loads, which have few observations and more variability. Furthermore, the Boiler ECM has just 17 observations, most of which are less than 10,000 Btu saved per dollar invested, but the few very high-savings observations significantly influence the mean. Table 6.12 gives the number of observations and average (mean) Btus saved per dollar invested by ECM for single-ECM projects.

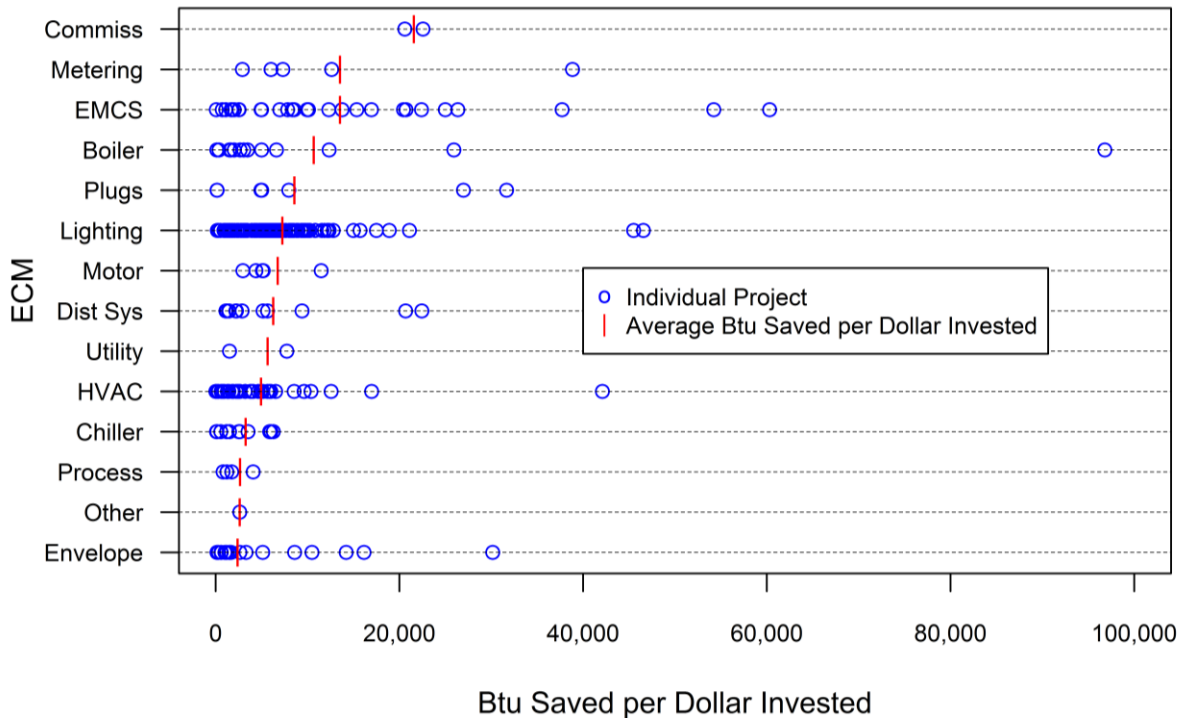


Figure 6.19. Distribution of Savings per Dollar Invested by ECM Type

Table 6.12. Btus Saved per Dollar Invested for Single-ECM Projects

ECM Type	Number of Projects	Average Btus Saved per Dollar Invested
Commiss	2	21,574
Metering	5	13,583
EMCS	31	13,535
Boiler	17	10,674
Plugs	9	8,564
Lighting	191	7,257
Motor	6	6,758
Dist Sys	13	6,269
Utility	3	5,659
HVAC	99	4,929
Chiller	13	3,269
Process	6	2,661
Other	1	2,615
Envelope	83	2,382

Because energy savings are estimated for projects and not for individual ECMs, it is not possible to establish the Btus saved per dollar invested for projects with multiple ECMs. However, some general observations about bundled ECMs within projects can be made. Table 6.13 shows the average and range of Btus saved per dollar invested for all projects reported in CTS with two or more ECMs bundled, where the first column indicates the presence of the listed ECM within the project bundle. That is, Boiler ECMs are bundled within 41 projects with other ECMs, and those projects save an average of 2,402 Btu per dollar invested.

Table 6.13. Btus Saved per Dollar Invested for Bundled Projects by ECM Presence within Project

		Btus Saved per Dollar Invested			
ECM Type	Number of Projects	Minimum	Maximum	Average	Standard Deviation
Process	5	2,262	77,269	19,921	32,169
Refrig	2	4,652	27,442	16,047	16,115
Utility	3	4,169	7,738	6,548	2,060
Lighting	174	137	77,269	6,533	9,023
Rates	3	97	7,800	5,015	4,271
Other	18	1,526	9,641	4,841	2,332
Dist Sys	34	559	17,059	4,494	3,934
Plugs	3	2,068	7,867	4,426	3,048
EMCS	136	157	23,858	4,403	3,774
HVAC	115	157	77,269	4,000	7,729
Motor	56	208	17,059	3,376	3,385
Chiller	57	234	9,641	2,835	2,166
Envelope	33	60	11,866	2,492	2,749
Commiss	65	137	23,858	2,482	3,237
Boiler	41	234	7,800	2,402	1,645
Peak	5	1,324	3,343	2,326	877
Meter	60	60	6,830	2,190	1,632

This analysis suggests that bundled ECM projects with Energy-Related Process improvements and Refrigeration had the highest average savings per dollar invested. Projects containing lighting and Energy/Utility Distribution System ECMs also had higher Btus per dollar invested than projects with most other ECM types. Metering, Peak Shaving, Boiler Improvements, Commissioning and Envelope bundled projects had comparatively lower savings per dollar invested.

6.5.3 Energy Savings per Dollar Invested by Agency

There are a number of factors that may contribute to differences in the average energy savings per dollar invested by agency, including the function of the buildings in an agency's covered facility portfolio, local and regional factors such as climate, the number of projects, and the particular ECMs selected by agencies. As shown in Figure 6.20 and Table 6.14, energy savings per dollar invested varies by agency from approximately 2,000 Btu per dollar invested to 14,000 Btu per dollar invested. The USDA had the highest savings per dollar invested as shown in Figure 6.20. This value is based on two single-ECM projects for Refrigeration and Building Envelope improvements. The lowest savings per dollar shown, for GSA, is based on GSA's portfolio of over 70 projects with varying ECMs, many of which are EMCS and Metering ECMs. This analysis does not include the monetary costs associated with water projects or renewable generation systems.

Like the breakdown of savings by ECM, there is variability within agencies' energy conservation projects. Figure 6.20 gives the distribution of savings per dollar by agency, with the average savings per dollar overlaid. In general, agencies with higher average savings also vary more in terms of savings per dollar. This is because there are high outliers, which pull the mean upward. Note that while the USDA has the highest average savings per dollar invested, there are only two observations on which this statistic is based. Considering the number of observations, variation, and values of data shown, agencies such as USPS and DOD consistently save more Btus per dollar invested.

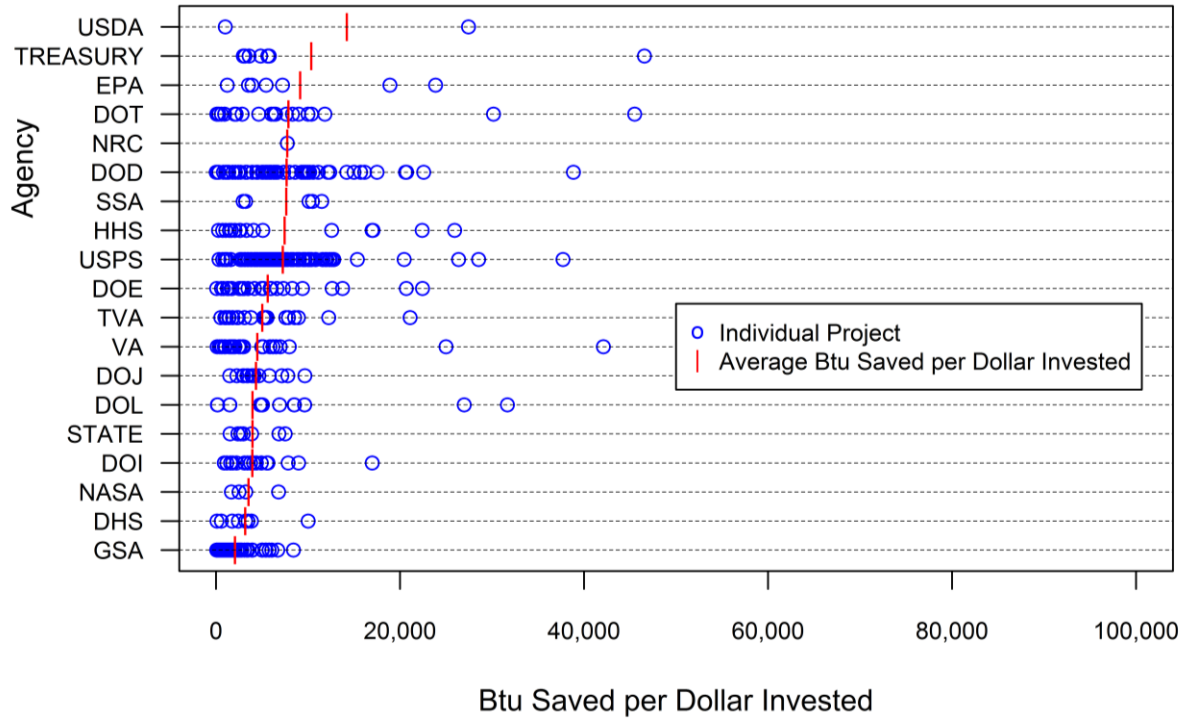


Figure 6.20. Distribution of Savings per Dollar Invested by Agency

Table 6.14. Btus Saved per Dollar Invested by Agency

Agency	Number of Projects	Average Btus Saved per Dollar Invested
USDA	2	14,223
TREASURY	7	10,353
EPA	7	9,145
DOT	21	7,877
NRC	1	7,738
DOD	67	7,677
SSA	5	7,644
HHS	18	7,462
USPS	138	7,253
DOE	31	5,615
TVA	25	5,029
VA	34	4,490
DOJ	16	4,344
DOL	155	3,960
STATE	7	3,960
DOI	28	3,949
NASA	4	3,540
DHS	8	3,168
GSA	75	2,065

6.5.4 Energy Savings per Dollar Invested by Funding Source

Project funding sources can influence the types of projects implemented, and therefore the economics of those projects. Figure 6.21 and Table 6.15 illustrate the overall energy savings (Btu) per dollar invested

by funding source. Note that the results shown in this figure include only those projects that had a single source of funding, and do not include financing costs for performance contracts. Direct ARRA funding is the only funding source that does not have several high outliers.

Figure 6.21. Distribution of Savings per Dollar Invested by Funding Source for Projects with One Funding Source[26]

Table 6.15. Btus Saved per Dollar Invested by Funding Source

Funding Source	Number of Projects	Average Btus Saved per Dollar Invested
Decentralized O&M	156	7,793
Not Specified	123	6,121
UESC	42	6,078
ESPC	47	5,771
Direct Centralized Capital	102	4,634
ARRA	165	2,908

6.5.5 Water Savings per Dollar Invested

A total of 31 projects in the CTS database reported both an implementation cost and savings estimate for water only. These projects were analyzed to determine the water savings as a function of investment cost, as shown in Figure 6.22. The majority of the projects reported saved 10 gallons or less per dollar invested to implement the project. Projects reporting savings of 10 to 100 gallons per dollar invested were

[26] Because "Incentive Program" and "Other" funding sources only occurred in conjunction with other funding sources, they are not represented in this figure.

identified simply as Water and Sewer Conservation Systems, with no further details on the nature of the investments made; the exception was one project titled "Domestic Water Conservation," probably referring to an interior plumbing project, which saved just over 20 gallons per invested dollar. The one project that reported over 100 gallons saved per dollar invested was a project to eliminate a once-through cooling system with its associated water use. The high gallons saved per dollar invested in this case are considered reasonable since water use in this particular project was completely eliminated.

Figure 6.22 shows the count of projects with different levels of water savings per dollar invested. Given the relatively small number of water projects available for analysis and the water reporting information, meaningful conclusions regarding which types of water projects tend to save the most water per invested dollar cannot be made.

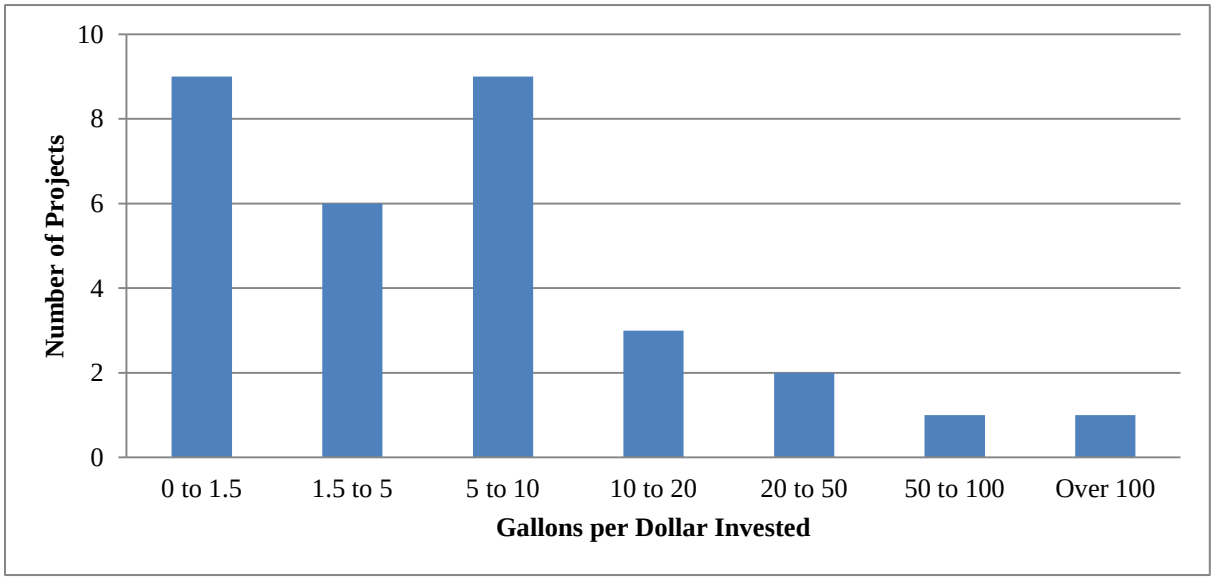


Figure 6.22. Number of Projects versus Range of Gallons Saved per Dollar Invested

6.6 Savings Relative to Annual Energy and Water Use

6.6.1 Energy Savings as a Percent of Annual Energy Use

While the goal of any energy conservation project is to maximize energy savings, examining savings relative to use provides a basis for normalizing those savings across ECMs and agencies. Several projects in CTS saved significant amounts of energy, but relative to the energy initially used by the facility the savings may not be as dramatic. One reason for this may be that many facilities have multiple buildings at their location and the projects may not have covered the entire facility.

Because energy use measurements are influenced by year-to-year differences in weather, energy use data reported in CTS was normalized to account for these differences each year in order to put energy-use and energy-savings estimates on a comparable basis. Table 6.16 gives the average annual energy savings relative to non-normalized and weather-normalized energy use by agency. This table illustrates the relatively small differences between the raw data and weather-normalized values.

Table 6.16. Comparison of Average Annual Savings Relative to Non-Normalized and Weather-Normalized Energy Use

Average Annual Energy Savings Relative to Use for Non-Normalized and Weather-Normalized Use Data (%)		
Agency	Non-Normalized	Weather-Normalized
DOJ	42.4	42.3
NASA	30.6	31.2
USPS	25.9	25.9
DHS	24.6	24.7
TREASURY	16.6	16.8
USDA	13.3	13.0
GSA	13.0	13.2
STATE	11.4	11.2
DOT	6.9	6.9
TVA	6.4	6.4
EPA	5.4	5.6
NRC	4.3	4.2
HHS	3.2	3.2
SSA	2.6	2.6
DOE	2.0	2.0
DOI	1.9	1.9
DOD	1.6	1.6
VA	0.9	1.0
DOL	0.5	0.5

Figure 6.23 shows the percentage of energy savings relative to initial energy use for the projects entered into CTS. Over 60% of all projects analyzed saved less than 5% of the facility's annual energy use. The mean and median percentages of decreased energy consumption for all projects are 9.8% and 1.4%, respectively. The mean is heavily influenced by the relatively few projects that have higher energy savings relative to use.

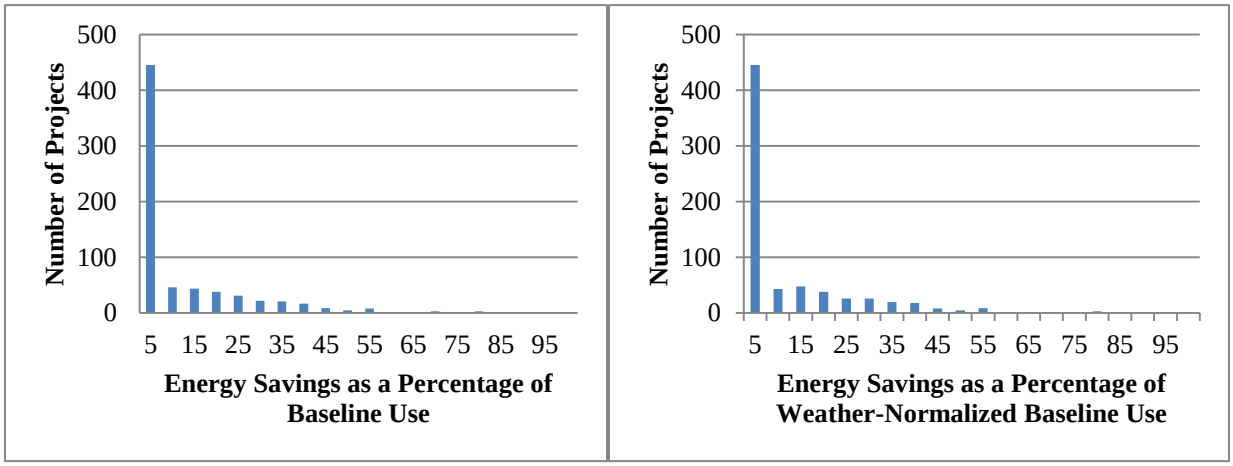


Figure 6.23. Energy Savings Relative to Annual Baseline (left) and Weather-Normalized (right) Energy Use for All Energy Projects

As illustrated in Figure 6.23 there are no appreciable differences between the weather-normalized and non-normalized savings as a percentage of use. Henceforth, weather-normalized data are used in the analysis of energy savings as a percentage of use.

6.6.2 Energy Savings Relative to Annual Energy Use by ECM

Figure 6.24 shows the average percentage of energy savings relative to annual energy use overlaid on the distribution of all energy saving single-ECM projects. Note that there are numerous factors that influence savings relative to use values for single-ECM versus multiple-ECM projects.

Lighting ECMs have the highest ratio of energy savings relative to baseline energy use at 10%, followed by EMCS. Plug Load ECMs had the lowest savings-to-use ratios at 0.2%.

In general, ECMs with higher average savings also vary more widely across all single-ECM projects that implemented that ECM. For example, Lighting has the highest mean, but there are several projects with very high savings, which pull the overall mean upward. Savings over 50% may reflect data quality issues that could not be resolved by agencies during quality checks by the research team. Table 6.17 gives the number of observations and mean percentage savings by ECM.

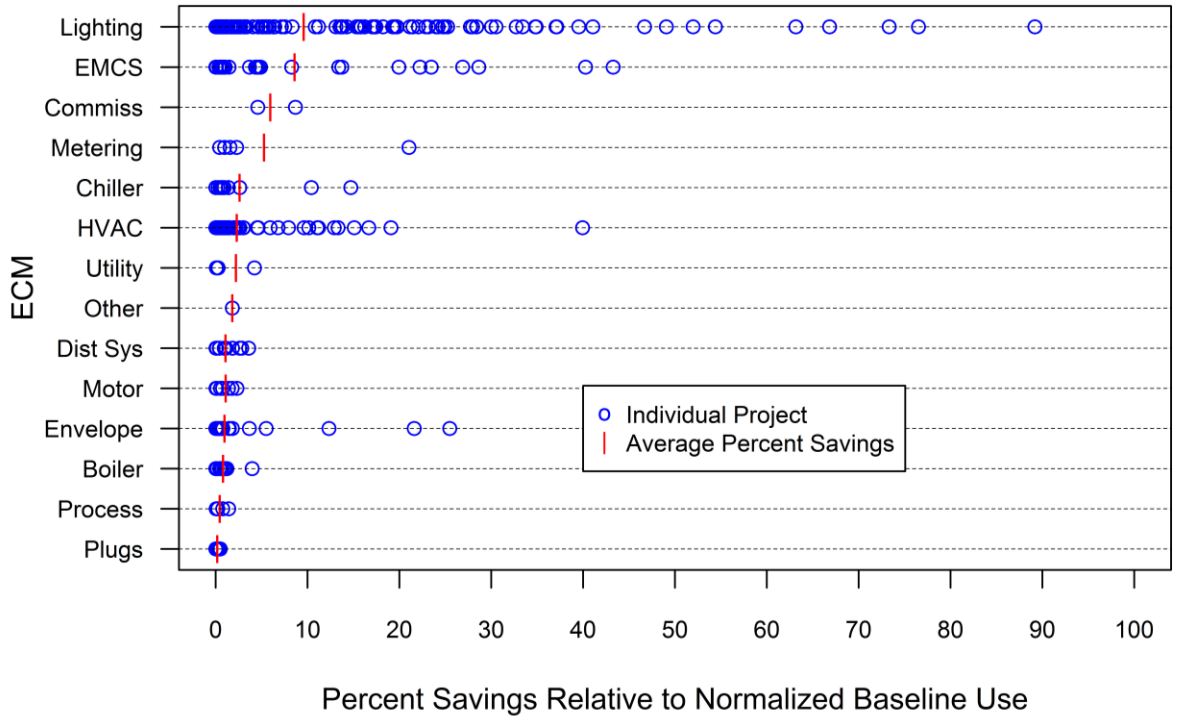


Figure 6.24. Distribution of the Ratio of Energy Savings to Energy Use by ECM Type

Table 6.17. Energy Savings as a Percentage of Normalized Baseline Use for Single-ECM Projects

ECM Type	Number of Projects	Average Savings as a Percent of Facility Energy Use
Lighting	197	9.6
EMCS	32	8.6
Commiss	3	5.9
Metering	5	5.3
Chiller	13	2.6
HVAC	105	2.3
Utility	4	2.2
Other	1	1.8
Dist Sys	13	1.1
Motor	8	1.1
Envelope	87	1.0
Boiler	18	0.8
Process	6	0.4
Plugs	9	0.2

6.6.3 Energy Savings Relative to Annual Energy Use by Agency

Because there are varying uses for different agencies' buildings, it is expected that agencies' savings as a percentage of baseline energy use may differ significantly among agencies. Figure 6.25 gives the distribution of energy savings as a percentage of use by agency, with averages overlaid, in the facilities where projects were implemented. Note that several agencies, including DOJ, NASA, USPS, and DHS, implemented projects that save, on average, over 20 percent of their facility baseline energy use. At the other end of the spectrum, many projects save only 5% (or less) of their facility's baseline use energy use.

The agency with the highest savings as a percentage of baseline use was DOJ, which had only 13 implemented projects. The ECMs implemented were primarily Building Envelope, HVAC, and Lighting. In contrast, the agency with the lowest percentage of energy savings relative to baseline use—DOL—recorded 156 projects in CTS, but many of these projects were known to have used conservative estimates of energy savings when no project-level estimates were available. In general, agencies with higher average savings also vary more in terms of percent savings; however, this trend is not as distinct as it is for savings relative to use by ECM type. Note that while DOJ and DHS appear to have the highest percent savings, there are very few observations that support the average being so high. Conversely, although the percent savings shown for USPS are relatively variable, there is a significant amount of data that supports a relatively high average. Table 6.18 gives the number of observations and average values for the agencies in this analysis.

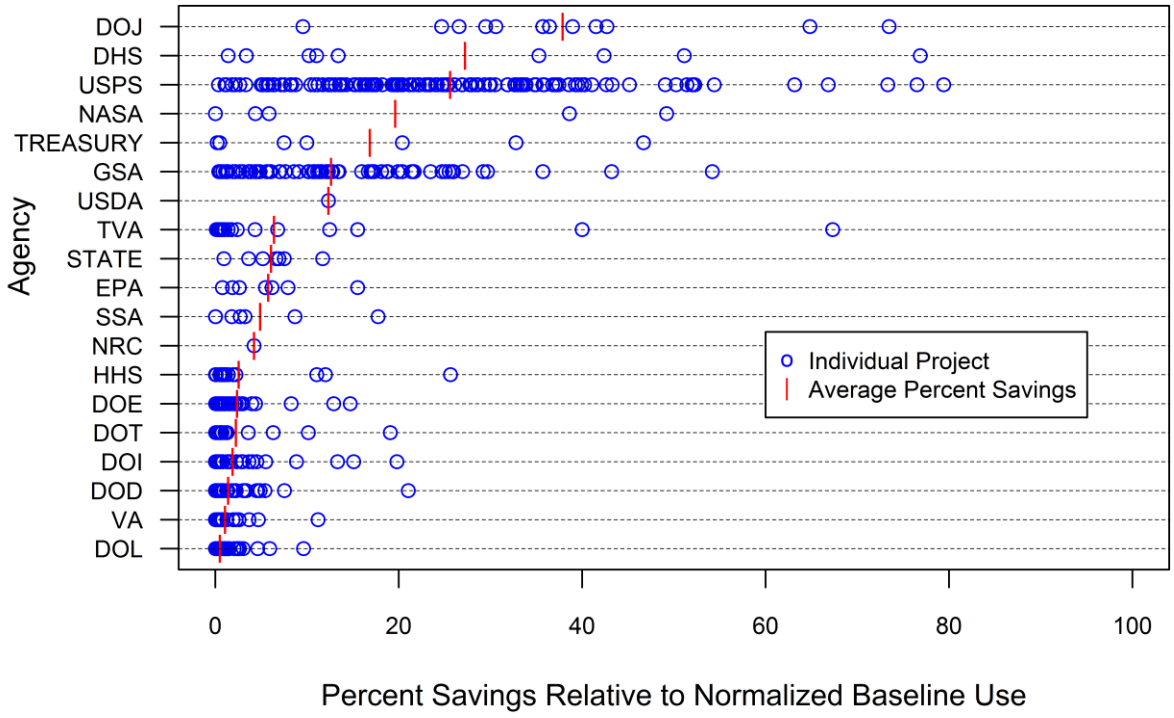


Figure 6.25. Distribution of Energy Savings Relative to Annual Normalized Baseline Energy Use, by Agency

Table 6.18. Percentage of Energy Savings Relative to Normalized Baseline Energy Use, by Agency

Agency	Number of Projects	Average Savings as a Percent of Energy Use
DOJ	12	37.9
DHS	9	27.2
USPS	138	25.6
NASA	5	19.6
TREASURY	7	16.9
GSA	78	12.6
USDA	1	12.3
TVA	25	6.4
STATE	7	6.1
EPA	7	5.8
SSA	7	4.9
NRC	1	4.2
HHS	25	2.5
DOE	32	2.4
DOT	21	2.2
DOI	52	1.9
DOD	71	1.4
VA	34	1.1
DOL	155	0.5

6.6.4 Water Savings Relative to Annual Water Use

A subset of the implemented projects that reported water savings also reported annual water use. For the 42 projects for which both values were reported, the ratio of water savings to the baseline water use was evaluated. Figure 6.26 below shows the water savings as a percentage of the baseline water use for implemented projects. The average water savings across all 42 projects is 19.5% of total water use in those facilities.

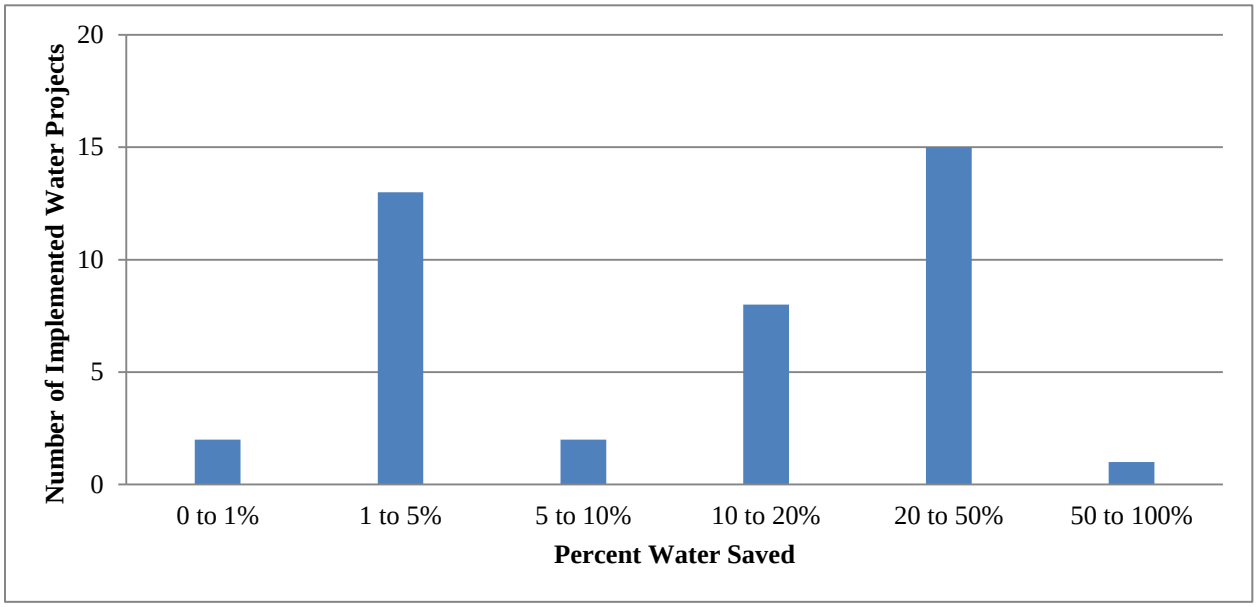


Figure 6.26. Water Savings Relative to Baseline Use

As noted above, it is difficult to draw conclusions about water savings based on the data currently available in CTS. The primary limitation is the lack of information regarding what type of water conservation project has been implemented. Recommendations are made at the end of this report suggesting possible enhancements to the reporting process for water ECMs. Reporting of data at the building level and occupancy information would also be useful for normalizing water savings across projects and agencies.

6.7 Life-Cycle Cost Economics

Life-cycle cost analysis is used to calculate several economic performance measures for evaluation of potential and implemented projects. This analysis examines the life-cycle cost (LCC), life-cycle benefit (LCB), net savings, savings-to-investment ratio (SIR), and adjusted internal rate of return (AIRR) for implemented projects with single-ECM types only.

In the context of this study, LCB represents the present value of future energy savings induced by the ECM. It is calculated as a product of annual cost of saved energy as of the base year (including produced thermal output and renewable electricity) and FEMP fuel-adjusted uniform present value factors, also referred to as fuel-adjusted escalation rates. Net savings is the difference between LCB and LCC, where LCC is calculated as a total cost of project implementation and financing. SIR uses the same inputs as net savings, but LCB is divided by LCC. In order for the project to be considered cost-effective, SIR should

be greater than 1. Net savings and SIR are relative economic performance indicators and should be used only in a comparative context.

AIRR is another relative measure of cost-effectiveness. It shows annual percentage yield over the ECM lifetime. In order for the project to be cost-effective, the annual percentage yield should be higher than the discount rate. For this analysis, the DOE discount rate of 3% is assumed. If AIRR equals the discount rate, the project breaks even.

Additional assumptions about equipment lifetime and discount rate are necessary to calculate LCC. Agencies have the option of reporting LCC savings for projects in CTS; however these estimates were only provided for 44% of the projects in CTS. The missing values were filled in using the FEMP Handbook on LCC[27] for discounting fuel-related savings, as well as recommendations by the National Institute of Standards and Technology (NIST). Several projects in CTS assumed a life of 40–49 years, which is an unusually long life for an ECM. Those entries were adjusted to assume a 30-year lifetime in order to comply with the NIST requirements regarding the discounting period (lack of specific details about each of those ECMs prevents equipment replacement tracking). For the entries where lifetime was not specified, average lifetime across the corresponding ECM was assumed.

LCC and LCB are estimated based on the weighted average that accounts for typical fuel shares across buildings as suggested by the 2003 Commercial Building Energy Consumption Survey (CBECS).[28] Since electricity constitutes 52% of the sector energy consumption, followed by natural gas (33%), the fuel prices and escalation rates were scaled accordingly. An average weighted price of $21.27 per MMBtu was assumed for this analysis when an ECM could reduce either electricity or natural gas. An electricity-specific price of $0.1012 per kWh was used for ECM's that would only save electricity, including Lighting, Chiller, Motor, and Plug Load ECMs. A natural gas price of $7.87 per MMBtu was used for Boiler improvement projects. Discounting is implemented using the federal fuel-adjusted escalation rates, which are based on the DOE discount rate of 3%. Additional results for high and low cases are included in Appendix C.

6.7.1 Economic Performance Indicators by ECM

Key results of the LCC analysis by ECM are presented in this section. The results were obtained first by averaging the LCC and LCB across similar ECMs. Averaged LCC and LCB were then used to derive the other standard economic indicators for each ECM type.

Several projects in CTS had significant financing costs; therefore results with and without the cost of financing (Table 6.19 and Table 6.20) and the comparative AIRR ranking (Table 6.21) are included below. Values in green are considered cost effective based on the criteria described below, whereas values in red are cost ineffective. The ECMs highlighted in red in the first table and green in the second reflect measures that are cost ineffective when financing costs are considered but cost effective when financing costs are excluded from the analysis.

[27] NIST Handbook 135, *Life-Cycle Costing Manual for the Federal Energy Management Program*, 1995 edition. Available at http://www.nist.gov/customcf/get_pdf.cfm?pub_id=907459.
[28] EIA – US Energy Information Administration Commercial Building Energy Consumption Survey (2003 Edition). Accessed at http://www.eia.gov/consumption/commercial/.

Table 6.19. Average Economic Performance Indicators by ECM Type,[29] Including Financing Cost

ECM Type	Life-cycle Benefit ($)	Location-Adjusted Investment ($)	Net Savings ($)	Savings-to-Investment Ratio	Adjusted Internal Rate of Return
Commiss	8,441,711	2,053,604	6,388,107	4.11	19%
EMCS	4,423,204	1,322,088	3,101,117	3.35	11%
Renewable	134,663,627	25,272,100	109,391,572	5.33	11%
Dist Gen	1,140,968	197,665	943,304	5.77	10%
Lighting	632,577	332,605	299,972	1.90	7%
Meter	8,472,775	4,046,647	4,426,128	2.09	7%
Utility	267,073	149,999	117,074	1.78	6%
Other	4,987	5,358	($370)	0.93	3%
Dist Sys	16,171,604	21,397,510	($5,225,906)	0.76	2%
Motor	1,668,115	2,284,258	($616,143)	0.73	1%
Chiller	2,793,226	6,008,089	($3,214,863)	0.46	-1%
HVAC	267,765	826,706	($558,940)	0.32	-4%
Process	874,087	5,578,280	($4,704,193)	0.16	-4%
Plugs	15,707	49,117	($33,410)	0.32	-5%
Envelope	127,103	528,727	($401,625)	0.24	-6%
Boiler	536,381	5,476,869	($4,940,489)	0.10	-10%
Totals	4,536,882,120	1,486,601,443	3,050,280,677	3.05	10.4%

Table 6.20. Average Economic Performance Indicators by ECM Type, Excluding Financing Cost

ECM Type	Life-cycle Benefit ($)	Location-Adjusted Investment ($)	Net Savings ($)	Savings-to-Investment Ratio	Adjusted Internal Rate of Return
Commiss	8,441,711	2,053,604	6,388,107	4.11	19%
EMCS	4,423,204	575,150	3,848,054	7.69	17%
Renewable	134,663,672	7,602,674	127,060,998	17.71	17%
Dist Gen	1,140,968	197,665	943,304	5.77	10%
Meter	8,472,775	2,219,330	6,253,445	3.82	10%
Lighting	632,577	255,254	377,323	2.48	9%
Dist Sys	16,171,604	6,161,158	10,010,446	2.62	7%
Motor	1,668,115	754,762	913,353	2.21	7%
Utility	267,073	149,999	117,074	1.78	6%
Chiller	2,793,226	1,838,027	955,199	1.52	5%
Other	4,987	5,358	(370)	0.93	3%
Process	874,087	1,606,136	(732,049)	0.54	1%
HVAC	267,765	400,903	(133,138)	0.67	0%
Boiler	536,381	1,639,457	(1,103,076)	0.33	-4%
Plugs	15,707	49,112	(33,405)	0.32	-5%
Envelope	127,103	528,727	(401,625)	0.24	-6%
Totals	4,536,882,120	534,961,041	4,001,921,080	8.48	17.6%

[29] Because there were only four water-only projects, the water ECM was not studied.

Table 6.21. Comparative AIRR Ranking by ECM Type with and without Financing

ECM Type	AIRR Ranking with Financing	AIRR Ranking without Financing
Commiss	1	1
EMCS	2	2
Renewable	3	3
Dist Gen	4	4
Lighting	5	6
Meter	6	5
Utility	7	9
Other	8	11
Dist Sys	9	7
Motor	10	8
Chiller	11	10
HVAC	12	13
Process	13	12
Plugs	14	15
Envelope	15	16
Boiler	16	14

While traditional LCC is used to compare several alternative projects at one facility, this analysis is focused on comparing similar ECMs across multiple facilities, taking into account the geographic regions of the ECMs. As a result, the investment cost was scaled according to the regional pricing factors for a consistent comparison basis. Similarly, adjusted national fuel prices were used to derive the LCC and net savings estimates.

Net savings are estimated by subtracting total LCC (regionally adjusted) from the LCB. Out of the 16 ECM types analyzed in single-ECM projects, only seven had positive net savings on average (across all facilities and projects) when financing cost is taken into account. The Renewables ECM shows the highest net savings, because benefit calculation included annual thermal output, as well as annual renewable electricity output. When financing costs are excluded from the analysis, 10 out of 16 ECM types have positive net savings. Distribution Systems, Motor, and Chiller ECMs have positive net savings once financing cost is removed from the analysis.

An SIR above 1 generally indicates that the project is cost-effective. For example, the SIR for Lighting is 1.90 (including financing), which implies that all projects of this ECM type return $1.90 for every dollar invested. When financing cost is included, the most cost-effective ECMs based on the SIR are Distributed Generation and Renewables, followed by Commissioning and EMCS. The average SIR across all single-ECM projects combined is 2.4 when financing is taken into account and 6.9 when financing cost is removed from calculation.

The AIRR should be greater than the assumed discount rate (3%) in order for the ECM to be considered cost-effective. When financing cost is included, AIRR is greater than the 3% discount rate for Commissioning, EMCS, Renewables, Distributed Generation, Lighting Metering, and Utility and ECMs. These are the same set of ECMs that have an SIR ratio above 1 and a positive net savings. Average AIRR rates for cases with and without financing across all analyzed ECMs are 8% and 14%, respectively.

Excluding the financing cost from the total cost calculation had the most impact on Distribution Systems, Motor and Chiller ECMs, which switched from being cost-ineffective to cost-effective with an

SIR of 2.62, 2.21 and 1.52 respectively, and an AIRR well above 3%, as indicated in Table 6.20. HVAC, Process, Plug Load, Envelope, and Boiler ECMs appeared to be below desired levels of SIR and AIRR in both cases.

6.7.2 Economic Performance Indicators by Agency

A similar analysis was performed across ECMs, but grouped by agency. Economic performance results are presented below by agency, both with and without financing included in the total cost (Table 6.22 and Table 6.23). Note that no LCC analysis is presented for STATE or DOJ because they did not have single-ECM projects reported in CTS.

Table 6.22. Average Economic Performance Indicators by Agency, Including Financing Cost

Agency	Life-cycle Benefit ($)	Location-Adjusted Investment ($)	Net Savings ($)	Savings-to-Investment Ratio	Adjusted Internal Rate of Return
SSA	9,198,311	411,504	8,786,807	22.35	22%
TREASURY	4,446,307	467,954	3,978,353	9.50	21%
DHS	42,722,588	4,601,060	38,121,529	9.29	15%
DOD	1,615,882	560,694	1,055,188	2.88	10%
USPS	663,507	256,033	407,475	2.59	10%
DOE	111,621,052	35,903,262	75,717,789	3.11	8%
DOT	663,984	344,013	319,971	1.93	7%
NRC	730,830	235,443	495,386	3.10	7%
TVA	336,150	183,066	153,084	1.84	7%
VA	306,770	241,510	65,260	1.27	4%
HHS	480,769	396,181	84,588	1.21	4%
EPA	766,254	728,374	37,880	1.05	3%
DOI	291,812	302,753	(10,941)	0.96	3%
DOL	36,990	49,427	(12,437)	0.75	1%
USDA	1,154,361	2,866,569	(1,712,208)	0.40	0%
GSA	2,218,444	9,946,937	(7,728,493)	0.22	-5%
NASA	16,693	59,664	(42,972)	0.28	-9%
Totals	4,536,882,120	1,486,601,443	3,050,280,677	3.05	10.39%

Table 6.23. Average Economic Performance Indicators by Agency, Excluding Financing Cost

Agency	Life-cycle Benefit ($)	Location-Adjusted Investment ($)	Net Savings ($)	Savings-to-Investment Ratio	Adjusted Internal Rate of Return
SSA	9,198,311	411,504	8,786,807	22.35	22%
TREASURY	4,446,307	373,374	4,072,933	11.91	22%
DHS	42,722,588	3,452,581	39,270,007	12.37	17%
DOE	111,621,052	10,258,075	101,362,977	10.88	15%
DOD	1,615,882	560,694	1,055,188	2.88	10%
USPS	663,507	256,033	407,475	2.59	10%
DOT	663,984	344,013	319,971	1.93	7%
NRC	730,830	235,443	495,386	3.10	7%
TVA	336,150	183,066	153,084	1.84	7%
VA	306,770	235,820	70,950	1.30	4%
HHS	480,769	396,181	84,588	1.21	4%
EPA	766,254	728,374	37,880	1.05	3%
DOI	291,812	302,753	(10,941)	0.96	3%
DOL	36,990	49,427	(12,437)	0.75	1%
USDA	1,154,361	2,866,569	(1,712,208)	0.40	0%
GSA	2,218,444	9,946,937	(7,728,493)	0.22	-5%
NASA	16,693	59,664	(42,972)	0.28	-9%
Total	4,536,882,120	534,961,041	4,001,921,080	8.48	17.63%

Using the same assumptions as were applied to the ECM analysis, the project data was organized by agency to derive average economic performance indicators. When financing cost is taken into account, the agencies with the highest net savings are DOE, DHS, SSA and Treasury. Their average SIRs range between 3 and 22 dollars of return per dollar invested, with a SIR of 1 being generally a breaking point for cost-effectiveness.

For the case without financing, the SIR increases significantly for DOE (from 3.11 to 10.88), DHS (from 9.29 to 12.37), and Treasury (from 9.85 to 11.91). The highest increase in SIR is observed for DOE because of the biomass project with significant financing. Whether financing for the biomass project is taken into account or not, DOE is well above the SIR-based threshold for cost-effectiveness. In the case that includes the cost of financing, DOE is closely followed by NRC with a SIR of 3.10. The group with the next highest SIR consists of DOD with a SIR of 2.88 and USPS with a SIR of 2.59. It is followed by DOT, TVA, VA, HHS and EPA with SIRs ranging between 1.93 and 1.05. SIR ordering remains the same when financing is excluded from the computation. The SIR for the rest of the agencies is below 1 irrespective of financing.

As was noted in the ECM comparison, in order for the project to be considered cost-effective, AIRR should be equal or greater than the DOE FEMP discount rate of 3%. When financing is taken into account, the agencies with the highest AIRRs are SSA (22%), Treasury (21%), DHS (15%), DOD and USPS (both at 10%), and DOE (8%). They are followed by DOT, NRC and TVA (about 7% each), VA and HHS (both at 4%), and EPA (3%). For the remaining agencies, AIRR is below the desired 3% threshold with or without financing cost in the calculation.

Another potential issue that may be impacting the apparent cost-effectiveness of agency investment is individual projects that are very large and not cost-effective, which are skewing the agency average results. For example, the DOI has two projects with large losses that skew the results for the rest of the projects across the agency. It should also be noted that traditional LCC metrics are not suitable for all of

the agencies. For example, for DOJ, the significant increase in prison population density is not taken into account by any of the standard comparative metrics. The population density data is not reported in the CTS to allow for normalization. EPA and GSA also have a small number of projects that drive down the average LCC results for the whole agency. Additional issues might arise from the fact that there was a group of entries removed from the analysis because either cost or savings data were missing.

6.8 GHG Emissions Avoided

Executive Order (E.O.) 13514 expanded the energy reduction and reporting requirements under EISA and other federal mandates by making GHG management a priority for federal agencies. This part of the analysis examines the impact that federal investments in energy efficiency projects have had on agency GHG emissions.

To calculate GHG emissions using estimated project energy savings, those savings estimates must be disaggregated by fuel source because GHG emission factors vary by fuel type. Because agencies have the option of entering estimated annual energy savings by fuel type or by the total MMBtu, savings estimates by fuel type are not available for all projects. Projects with estimated energy savings by fuel type represent 67% (2,865,950 MMBtu) of total estimated energy savings (see Table 6.24). Eight of the 19 agencies with energy savings reported all energy savings by fuel type, and as a result will have more accurate GHG savings estimates. For the 33% of energy savings that are not associated with a fuel source, the average energy consumption ratios for U.S. residential and commercial buildings in 2010 were applied to provide estimates of fuel use by major fuel source (e.g., electricity, natural gas, coal).[30]

[30] Estimates came from Table 1.1.1 of the U.S. Department of Energy's *Building Energy Data Book 2011* (March 2012). Available at: http://buildingsdatabook.eren.doe.gov/TableView.aspx?table=1.1.1.

Table 6.24.Estimated Annual Energy Savings (MMBtu) by Agency with Known and Unspecified Fuel Sources

Agency	Total Annual Energy Savings	Fuel Source Known	Fuel Source Not Specified	% of Total Energy Use with Fuel Source Known
All Agencies	**4,280,381**	**2,865,950**	**1,414,431**	**67%**
DHS	213,920	30,736	183,184	14%
DOD	443,974	31,128	412,846	7%
DOE	1,076,883	1,076,883	-	100%
DOI	21,823	6,587	15,236	30%
DOJ	752,930	752,930	-	100%
DOL	24,642	-	24,642	0%
DOT	221,379	12,094	209,285	5%
EPA	41,327	-	41,327	0%
GSA	465,466	-	465,466	0%
HHS	73,091	43,786	29,305	60%
NASA	280,793	280,793	-	100%
NRC	1,741	1,741	-	100%
SSA	53,384	22,995	30,389	43%
STATE	44,502	44,502	-	100%
TREASURY	121,071	121,071	-	100%
TVA	33,361	33,361	-	100%
USDA	54,220	51,470	2,750	95%
USPS	325,034	325,034	-	100%
VA	30,840	30,840	-	100%

Emission factors were then applied to those fuel savings estimates by fuel type based on established methodologies for federal GHG accounting.[31] While most fuel types have a single emission factor regardless of where the fuel is combusted, electricity emissions vary depending on the region of the electric grid where the electricity was saved. Electricity savings were mapped to grid regions based on facility zip code when the fuel sources was specified, then the appropriate regional grid emission factors from EPA's eGRID database were applied.[32]

Based on this calculation, an estimated 485,070 metric tons of Scope 1 and 2 CO_2 equivalent ($MTCO_2e$) were avoided by federal agencies as a result of energy efficiency investments reported in CTS since 2008. This represents approximately one percent of government-wide GHG emissions, which were estimated at 47.2 million $MTCO_2e$ based on FY 2011 reporting.[33] As illustrated in Figure 6.27 and Figure 6.28 below, the majority of those emissions are the result of electricity savings (75%), followed by natural gas savings (14%).

[31] FEMP – Federal Energy Management Program. 2012. *Federal Greenhouse Gas Accounting and Reporting Guidance*. Revision 1: June 4, 2012. Available at: http://www.whitehouse.gov/sites/default/files/microsites/ceq/revised_federal_greenhouse_gas_accounting_and_reporting_guidance_060412.pdf

[32] Emission factors from eGRID2012 were used. For more information on eGRID, go to: http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html.

[33] Annual Energy/GHG Data Reports submitted to FEMP by federal agencies.

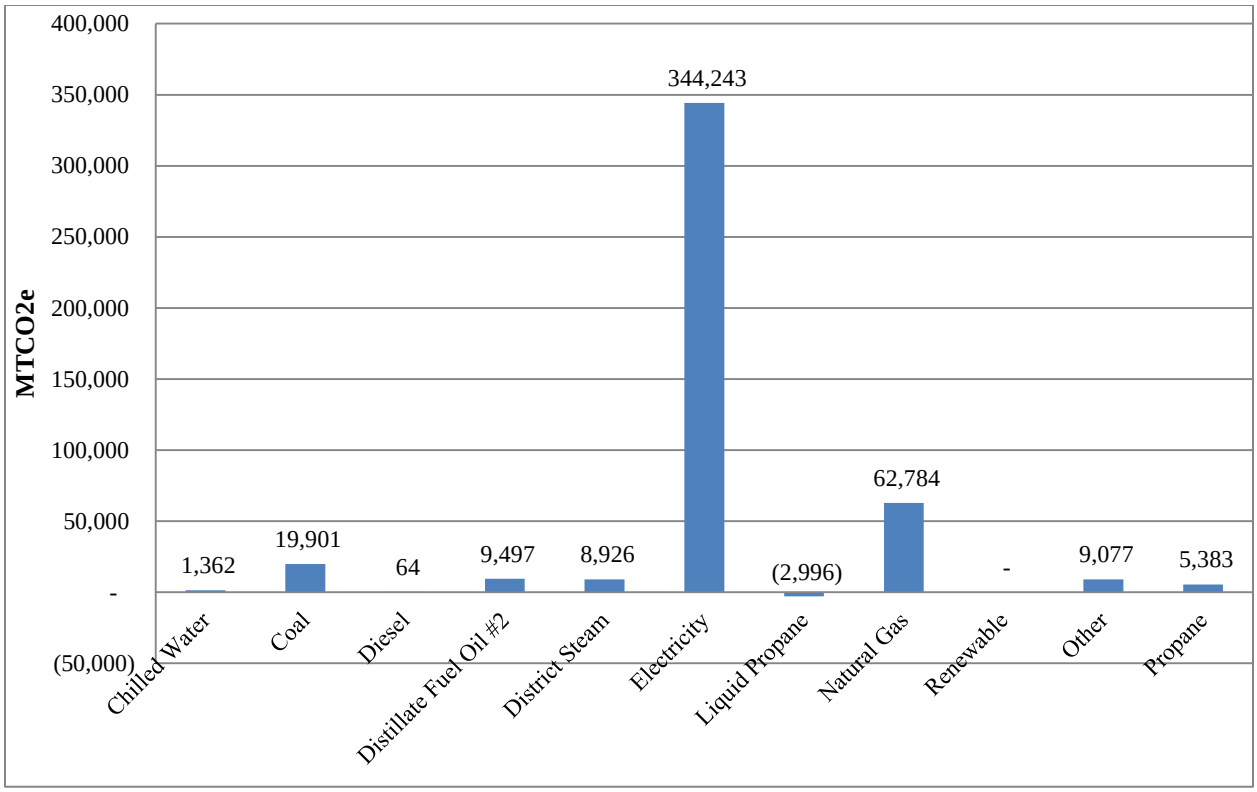


Figure 6.27. Estimated Annual Government-wide GHG Emissions Avoided by Fuel Source

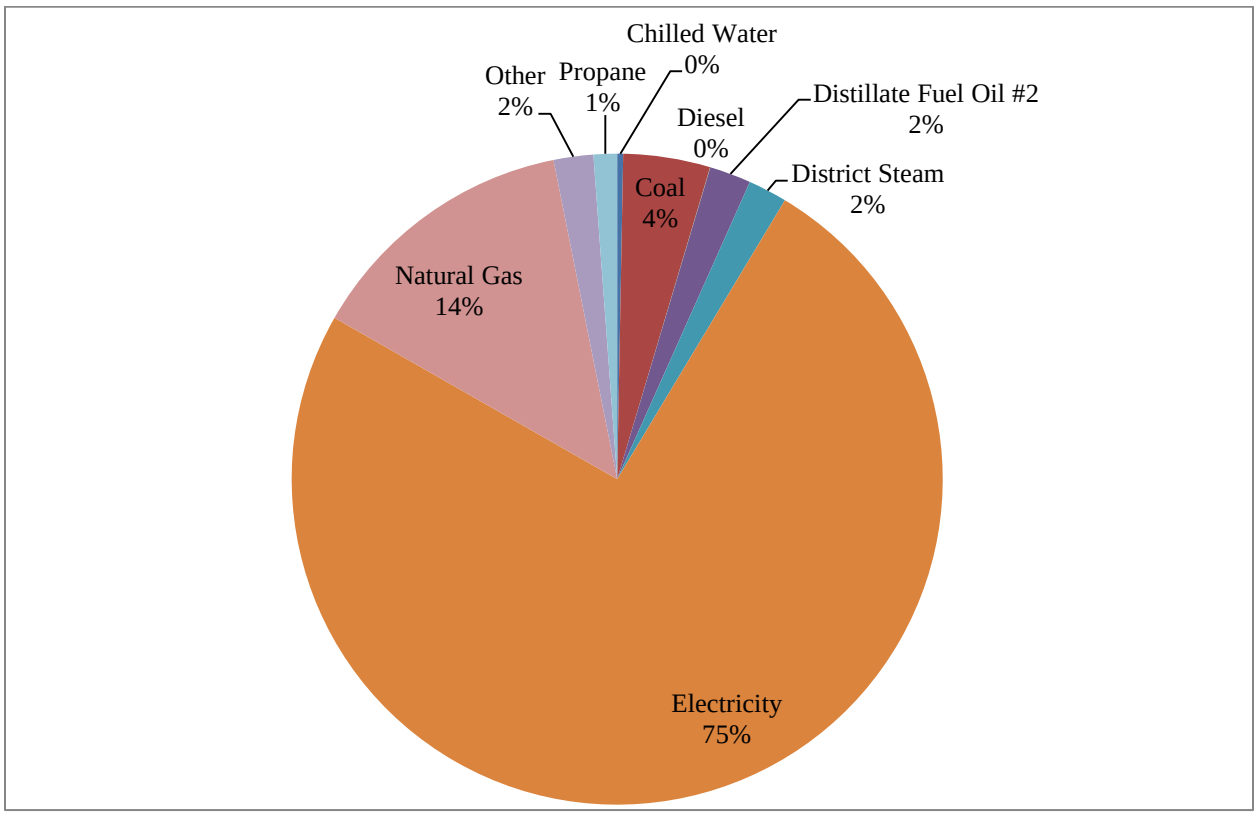


Figure 6.28. Estimated Proportion of Annual Government-wide GHG Emissions Avoided by Fuel Type

Figure 6.29 below shows GHG emissions avoided by agency based on the reported fuel types. For the nine agencies that reported all project energy savings by fuel type (underlined in red), this represents total GHG emissions avoided by CTS projects. For the other agencies, this presents a partial picture of GHG emissions avoided. Estimates were made for the remainder in aggregate, so are not included in this figure by agency. While most agencies' avoided GHG emissions come predominantly from electricity savings, this figure shows that coal represents a substantial source of savings for DOE and natural gas represents a substantial portion of avoided emissions for DOJ. The major source of coal savings was from two large biomass and steam plant projects in the Southeast.

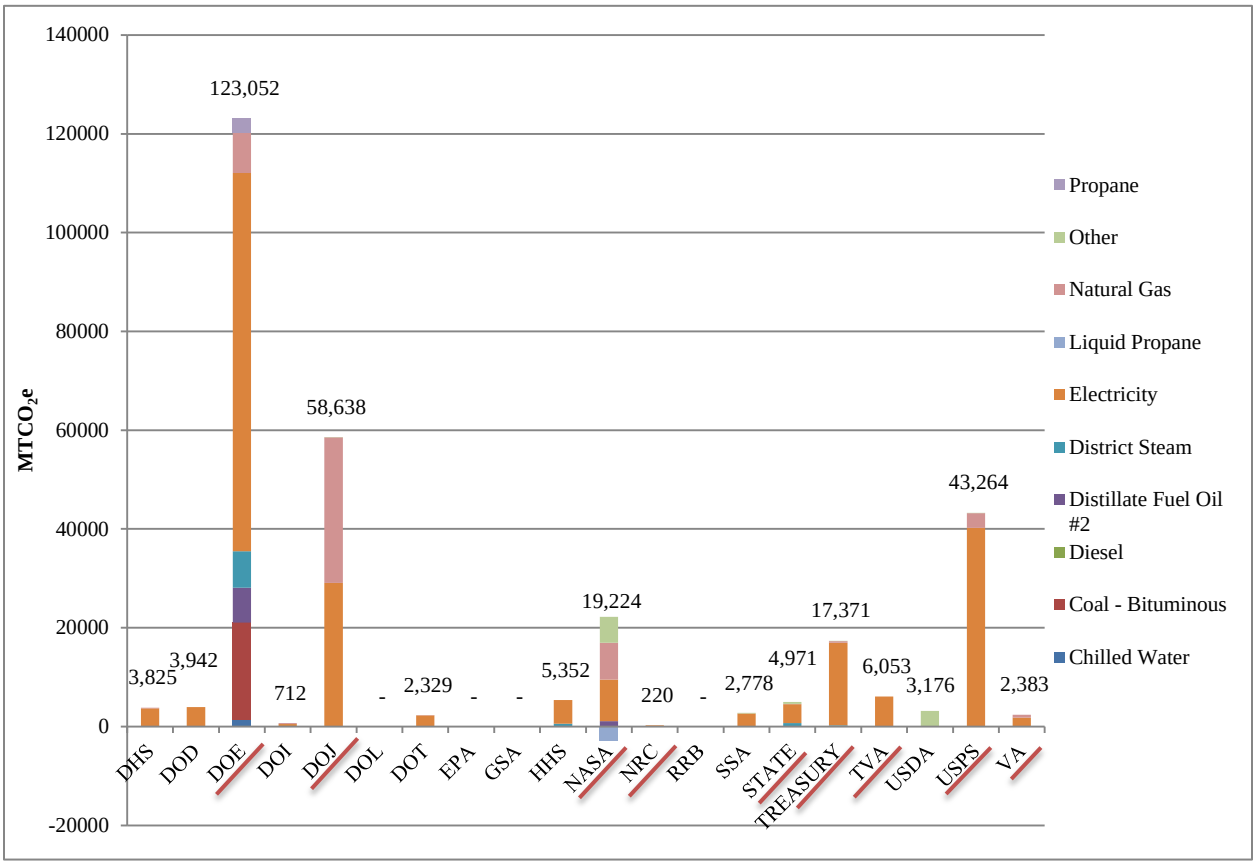


Figure 6.29. GHG Emissions Avoided by Agency for Projects with Known Fuel Sources. Red arrows indicate agencies with complete estimates of all avoided GHG emissions due to reporting by fuel type.

Because fuel types and regions of the grid differ in terms of their contributions to GHG emissions, energy savings from more carbon-intensive fuels will have a greater GHG reduction impact. Figure 6.28 below illustrates that while electricity represents 56% of energy savings, those savings represent a much greater proportion of total GHG emissions avoided (76%). This is primarily because energy savings reflect site-delivered Btu for electricity rather than the Btu used to generate the electricity. Approximately 70% of Btus used to generate the delivered heat content of a kWh of electricity is lost during the conversion process and through transmission and distribution losses. A portion of electricity savings is also probably coming from coal-intensive grid regions, which may contribute to this difference.

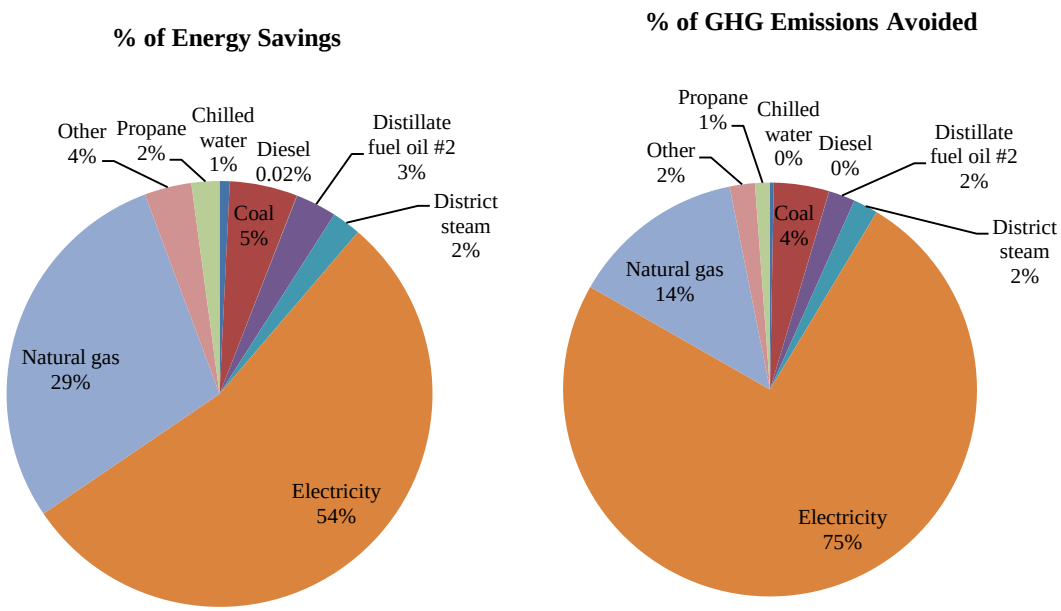


Figure 6.30. Comparison of Annual Estimated Energy Savings (left) and GHG Emissions Avoided (right) by Fuel Type as a Percentage of Total Annual Savings and Emissions Avoided (estimates are for savings reported by fuel source only)

Figure **6.31** summarizes electricity savings from projects reporting savings by fuel type against the eGRID subregion. Nearly a third of the 200,615 $MTCO_2e$ avoided by electricity savings (for projects that specified fuel sources only) were in the SERC Reliability Corporation (SERC) Tennessee Valley region, and 19% of the GHGs avoided came from a single $3.5 million DOE project to deploy a building automation system in this region. This is a comparatively carbon-intensive subregion, which probably contributed to the high emissions avoided from electricity savings. Six of the 26 eGRID subregions did not have any project savings reported in CTS (HICC Miscellaneous, HICC Oahu, RFC Michigan, SERC Midwest, and NPCC Long Island).

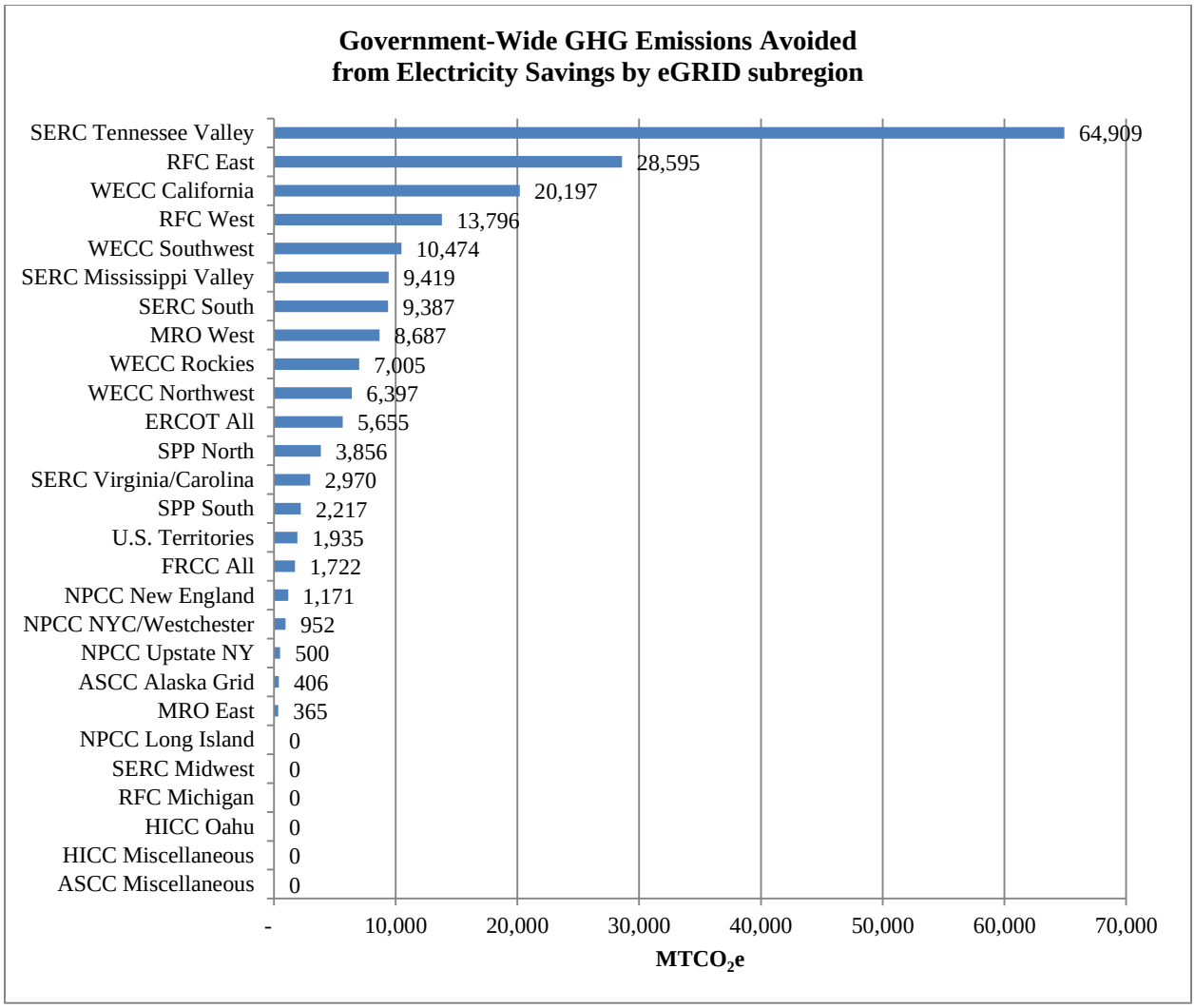


Figure 6.31. Government-wide GHG Emissions Avoided from Electricity Savings by eGRID Subregion[34]

[34] Abbreviations are defined in the Acronyms and Abbreviations list, which follows the Executive Summary

7.0 Building Energy Performance

Five specific energy use intensity (EUI) analyses were undertaken on the CTS. First, the reported average EUI for agency covered facilities in CTS was compared to typical EUI data for various building types and to the average EUI for agencies as included in FEMP's 2011 Report to Congress.[35] Second, changes over time in EUI for covered facilities were examined, both for all facilities and by agency. Third, agency estimates of the EUI savings reduction expected from evaluations was examined. Fourth, EUI savings achieved in projects was examined. And fifth, the EUI reductions estimated in the evaluations and achieved in projects was compared to the FY 2011 agency average EUI.

7.1 EUI Ranges by Agency

In the first EUI analysis, EUI ranges by agency for covered facilities were determined. While facilities are not directly comparable to individual buildings, it would be expected that federal facilities would fall into the range of EUIs associated with the federal buildings that make up those facilities. While no source of federal building EUI data is known, commercial-sector building EUI data is available from DOE's Buildings Energy Data Book[36], which lists commercial building EUIs by building type estimated from the 2003 CBECS. This table is simplified in Table 7.1 below by combining the vintage categories in Table 3.1.9 into a single upper and lower bound.

Table 7.1. Simplified Version of Table 3.1.9 of DOE's Building Energy Data Book—Commercial Building EUIs (kBtu/ft^2)

Building Type	Lower End of EUI Range (kBtu/ft^2)	Upper End of EUI Range (kBtu/ft^2)
Health Care	84	255
Food Sales	197	206
Lodging	88	112
Office	88	94
Mercantile	80	104
Education	78	89
Service	62	86
Food Service	145	361
Religious Worship	40	47
Public Order and Safety	101	111
Warehouse and Storage	33	39
Public Assembly	62	120
Vacant	21	23
Other	125	205

Table 7.2 shows the minimum, average, and maximum EUIs (in kBtu/ft^2) reported by each agency in CTS for FY 2011. Agencies are listed in terms of average EUI. The covered facility agency average EUI column was calculated based on the total agency energy usage and total agency square footage in CTS as

[35] Federal Energy Management Program. 2012. FY 2011 Federal Energy Management Report to Congress. Provided in E-mail message from Chris Tremper, Federal Energy Management Program, to Kathleen Judd and Emily Wendel, Pacific Northwest National Laboratory, October 24, 2012.

[36] DOE – U.S. Department of Energy. March 2012. *Buildings Energy Data Book 2011*. Table 3.1.9. Accessed at http://buildingsdatabook.eere.energy.gov/docs/xls_pdf/3.1.9.xlsx.

reported in Table 4.1. The unadjusted and adjusted[37] agency average EUI columns are taken from the 2011 FEMP Report to Congress.[38]

Table 7.2. Minimum, Average, and Maximum EUI (kBtu/ft^2) Reported in FY 2011 by Agency

Agency	CTS Covered Facility FY 2011 Average EUI (kBtu/ft^2)	Unadjusted Agency FY 2011 Average EUI (kBtu/ft^2)	Adjusted Agency FY 2011 Average EUI (kBtu/ft^2)
All Agencies	120	109	105
DHS	96	104	102
DOC	181	209	204
DOD	102	104	100
DOE	282	181	175
DOI	83	66	64
DOJ	139	140	139
DOL	101	99	97
DOT	171	76	75
EPA	348	320	311
GSA	100	68	62
HHS	414	324	277
HUD	74	74	72
NARA	118	131	128
NASA	184	184	177
NRC	118	N.A.	N.A.
OPM	76	84	83
RRB	97	N.A.	N.A.
SI	166	N.A.	N.A.
SSA	130	125	122
STATE	119	98	96
TREASURY	170	159	155
TVA	65	54	54
USACE	197	81	81
USDA	184	69	67
USPS	126	81	81

Comparing Table 7.1 and Table 7.2 points out a number of interesting features of the federal facility data in CTS:

1. A number of agencies have average covered facility EUIs that are higher than most of the commercial building EUIs listed in Table 7.1. This fact points out that not all federal facilities (or buildings) are adequately covered in the CBECS data. Federal facilities may contain buildings with very high EUIs

[37] Adjustments are with regard to renewable energy purchases and source savings.
[38] FY 2011 Federal Energy Management Report to Congress. Provided in E-mail message from Chris Tremper, Federal Energy Management Program, to Kathleen Judd and Emily Wendel, Pacific Northwest National Laboratory, October 24, 2012.

due to the presence of large computer loads, large industrial loads or research-related loads, and these types of buildings are not always included in surveys of "typical commercial buildings." The average EUI for HHS (home to National Institutes of Health laboratories) and EPA and DOE (laboratory-intensive agencies) are all near the top of the list. USACE also has very high EUIs because of a series of locks and pumping stations with higher energy usage and low square footage. NASA (another laboratory/industrial-assembly-intensive agency) and VA (hospital intensive) are also towards the top of the list.

2. There is generally good agreement between the covered facility EUIs in Table 7.2 and the average EUIs rolled up at the agency level and reported in the 2011 FEMP Report to Congress. Some agencies, including DOE, DOT, EPA, HHS and USACE, do have much higher covered facility EUIs than the agency average EUIs. This may be due to these agencies focusing on their higher-EUI facilities as part of their covered facilities.

7.2 Covered Facility EUI Changes Over Time

In the second EUI analysis, the facility footprint data was also examined for trends in reported energy consumption over the four years of entries. EUI changes from 2010 to 2011 and from 2008 to 2011 were examined. Only a subset (n=827) of the 7,000 facilities had the same footprint across all four years and more than half of these are in the USPS's portfolio. This subset of facilities was then used to compare the reported energy use of the facility from year to year. Overall, only a quarter of these facilities showed an improvement in their energy use values. USPS has identified quality issues with their energy use data reported during this period, which may be contributing to these increases, and is in the process of correcting these values.

Specific agency EUI changes from 2008 to 2011 are shown in Figure 7.1 and changes from 2010 to 2011are shown in Figure 7.2. The facility count represents the number of facilities that had consistent footprint data from the comparison year to 2011. The green bars show the percentage of the agency's facilities with a reduced EUI and the red bars show the percentage of agency facilities with an increased EUI. Just 3,515 facilities had consistent footprint data from 2010 to 2011 and could be compared; only 827 facilities had consistent footprint data from 2008 to 2011.

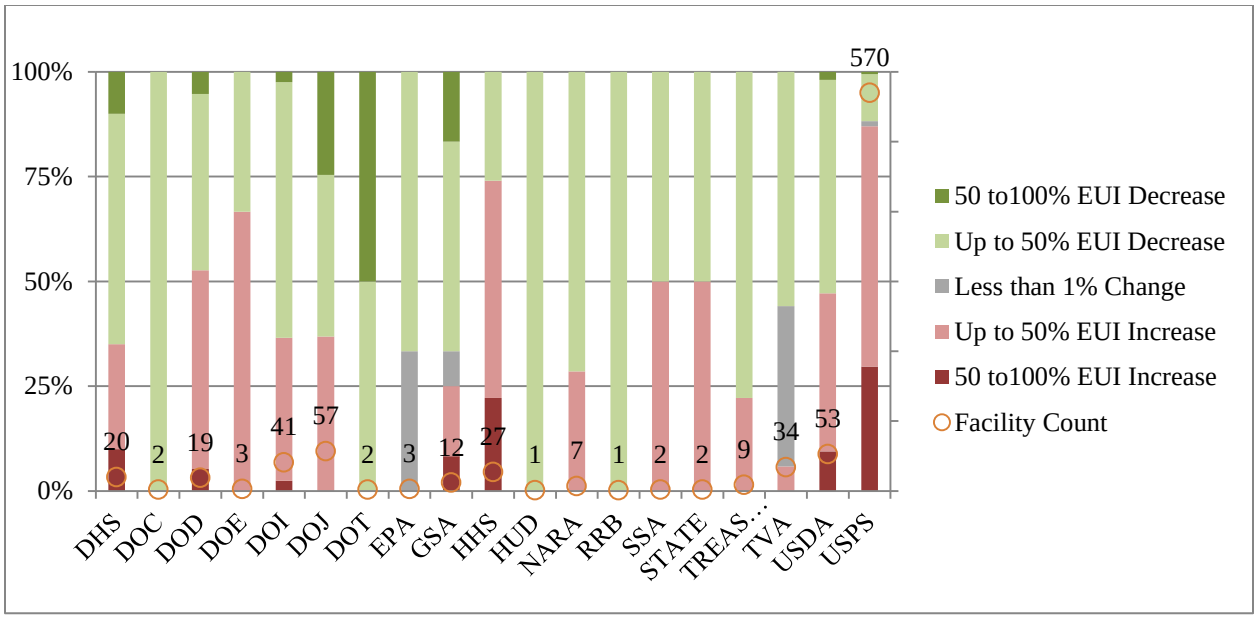


Figure 7.1. Comparison of EUI Changes from 2008 to 2011 by Agency

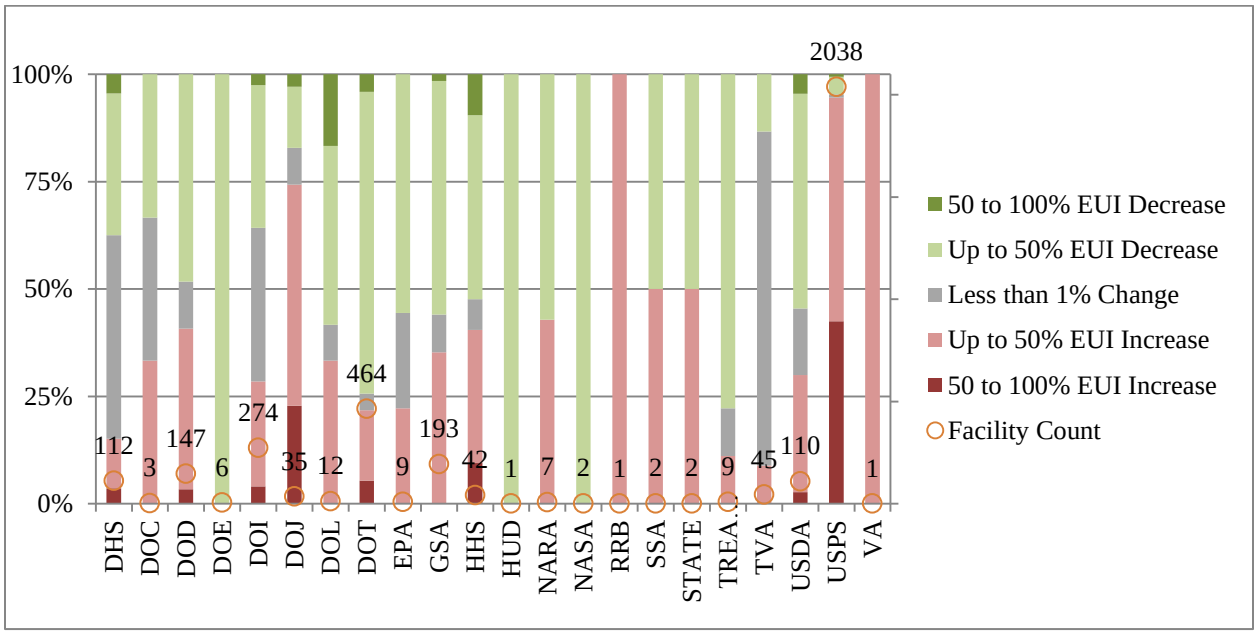


Figure 7.2. Comparison of EUI Changes from 2010 to 2011 by Agency

Overall, the EUI changes from year to year are fairly consistent except that the 2010 to 2011 comparison has a larger percentage of facilities with less than 1% change, which is expected for the tighter timeframe. Within each agency there is some variation of percentage of facilities with an EUI increase or decrease year to year.

7.3 Energy Savings per Square Foot for Evaluated ECMs

In the third EUI analysis, estimates of EUI reductions were made based on the sum of energy savings potential reported for each agency's evaluated facilities (see Figure 7.3). Facilities that were not evaluated are not included in this estimate. EPA shows an EUI reduction of over 125, followed by DOE with an EUI reductions of over 75, while the Treasury Department and DOJ are the next highest with estimates over 50 kBtu/ft^2.

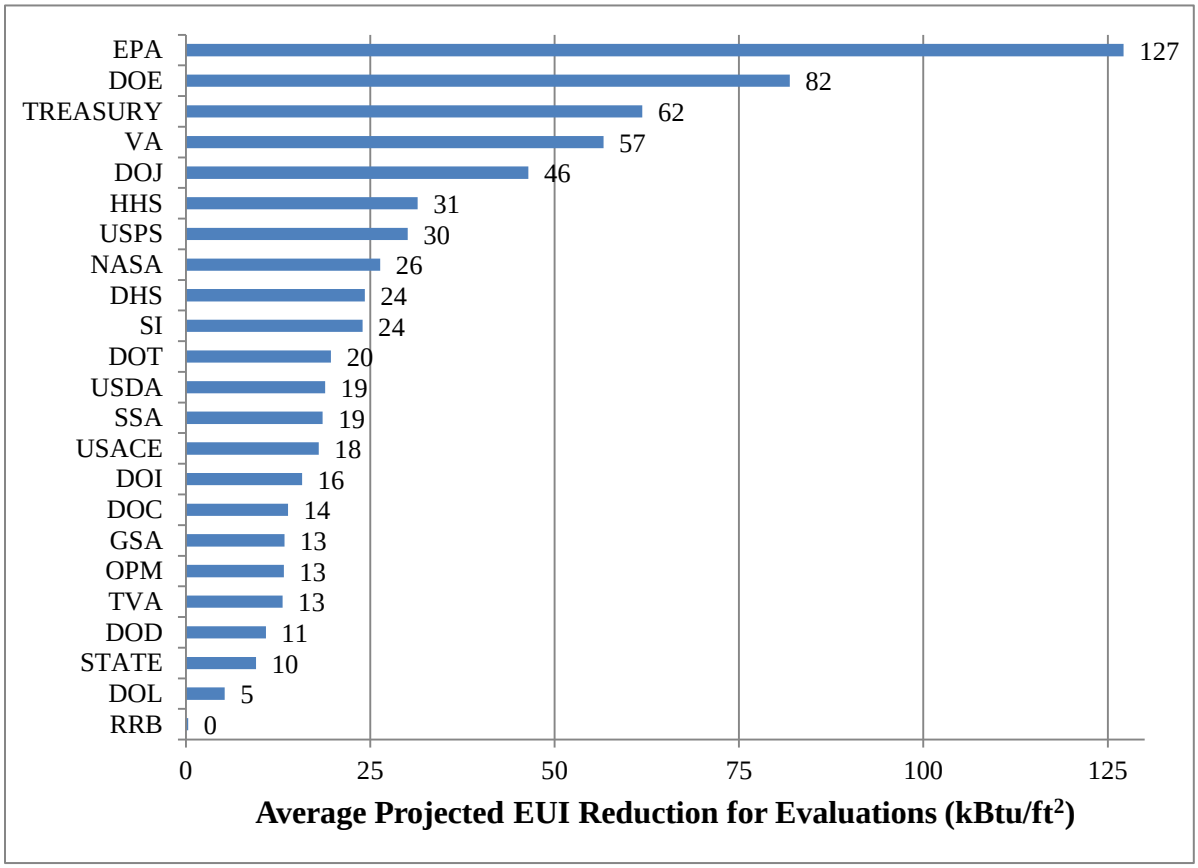


Figure 7.3. Average Projected EUI Reduction Estimates by Agency for Evaluated ECMs

7.4 Energy Reduction per Square Foot for Implemented Projects

In the fourth EUI analysis, estimates of reductions in EUI were made based on agency-estimated annual energy savings and renewable energy output from projects. The chart below shows the average potential reduction in EUI by agency in the covered facility in which the projects were done. DOJ's estimated annual energy savings per square foot of facility area was the highest at 49 kBtu/ft^2. Many of DOJ's projects had high estimated savings amounts relative to the existing EUI of the covered facility; some projects were estimated to save more energy than the covered facility footprint energy usage. This also occurred in the DHS and NASA projects. Note that for DOL, when project-specific estimates were not available, conservative estimates of energy savings for ECM types were used by the agency, which may have contributed to their savings per square foot being unusually low. The average EUI savings are expected to be between 1 and 30% depending on the type of retrofit and the existing facility energy

consumption.[39] This would equate to EUI savings between 1 and 36 kBtu/ft^2 based on the agency average EUI of 120 kbtu/ft^2 reported in Table 7.2 for "All Agencies." Of the agencies listed in

Figure 7.4, only DOJ is outside this range.

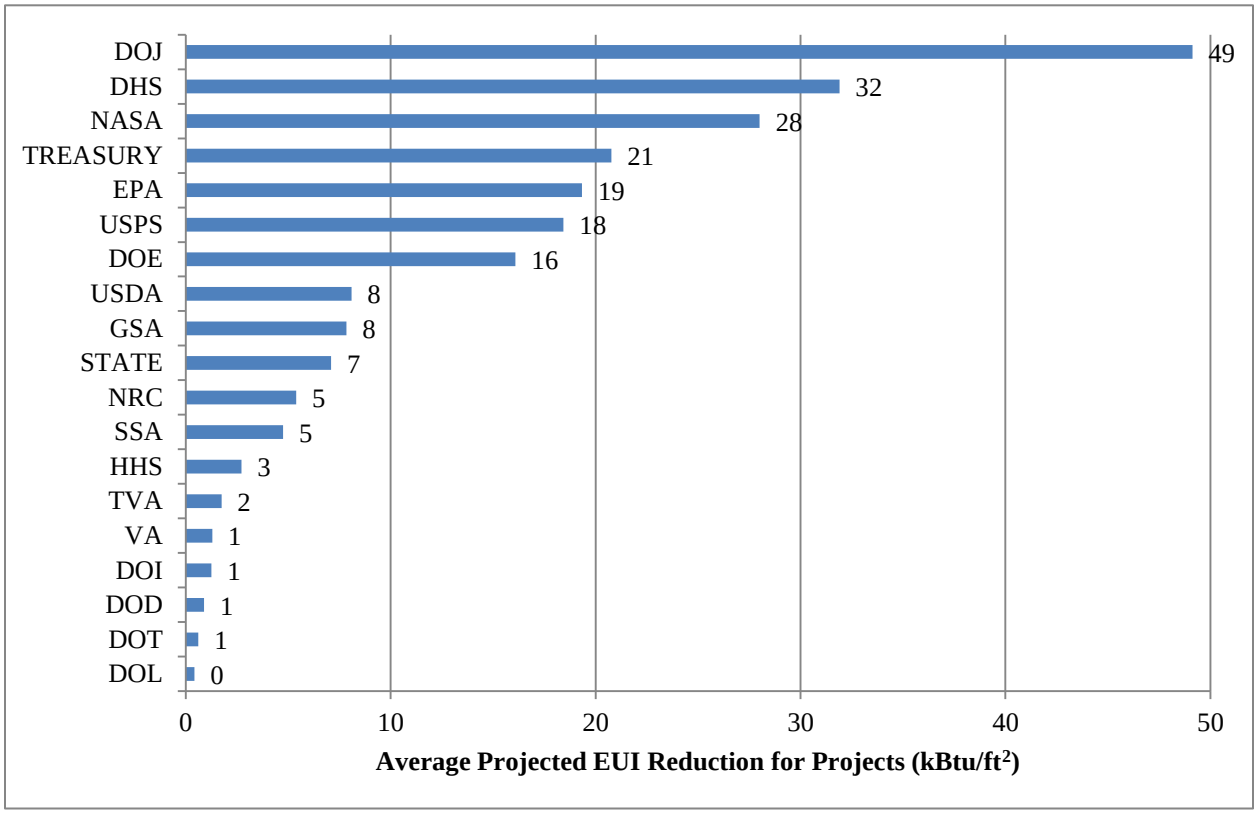


Figure 7.4. Average Projected EUI Reduction Estimates for Agencies for Active Projects

7.5 Comparison of EUI Reductions to Facility EUIs

In the fifth and final EUI analysis, the average estimated EUI reduction from evaluations and the projected EUI reduction from projects were compared to the FY 2011 agency average EUI values. The results are shown in Table 7.3.

[39] PNNL– Pacific Northwest National Laboratory. 2011. *Advanced Energy Retrofit Guides: Office Buildings*. PNNL-20761. Pacific Northwest National Laboratory, Richland, Washington. Accessed at http://www.pnnl.gov/main/publications/external/technical_reports/pnnl-20761.pdf

Table 7.3. Average EUI (kBtu/ft^2) and Average EUI Reduction for Evaluations and Projects Reported in FY 2011 by Agency

Agency	Covered Facility FY2011 Average EUI (kBtu/ft^2)	Average EUI Reduction for Evaluations	Average EUI Reduction for Projects (kBtu/ft^2)	Average Percent Reduction for Evaluations	Average Percent Reduction for Projects
All Agencies	120	18	6	15%	5%
DHS	96	24	32	25%	33%
DOC	181	14	N.A.	8%	N.A.
DOD	102	11	1	11%	1%
DOE	282	82	16	29%	6%
DOI	83	16	1	19%	1%
DOJ	139	46	49	33%	35%
DOL	101	5	0	5%	0%
DOT	171	20	1	12%	1%
EPA	348	127	19	36%	5%
GSA	100	13	8	13%	8%
HHS	414	31	3	7%	1%
HUD	74	N.A.	N.A.	N.A.	N.A.
NARA	118	N.A.	N.A.	N.A.	N.A.
NASA	184	26	28	14%	15%
NRC	118	N.A.	5	N.A.	4%
OPM	76	13	N.A.	17%	N.A.
RRB	97	0	N.A.	0%	N.A.
SI	166	24	N.A.	14%	N.A.
SSA	130	19	5	15%	4%
STATE	119	10	7	8%	6%
TREASURY	170	62	21	36%	12%
TVA	65	13	2	20%	3%
USACE	197	18	N.A.	9%	N.A.
USDA	184	19	8	10%	4%
USPS	126	30	18	24%	14%
VA	187	57	1	30%	1%

As shown in Table 7.3, evaluated savings can range up to 36% of the FY 2011 agency EUI (for EPA), while projected savings from projects range up to 35% of the FY 2011 agency EUI (for DOJ). These numbers are consistent with typical estimates for retrofit projects, ranging up to 30% of existing building energy use.

For many agencies, there is a significant difference between EUI reduction estimates based on facility evaluations (audits) and EUI reduction estimates from implemented projects, with most agencies showing higher evaluation EUI reduction than project EUI reduction. However, three agencies (DHS, DOJ, and NASA) are achieving project EUI reductions higher than evaluation EUI reductions. The fact that most agencies have higher evaluation EUI reduction than project EUI reduction while some agencies have shown the reverse trend may be a matter of how agencies have chosen to implement projects in their covered facilities. Agencies could conceivably be choosing either to implement projects in facilities with higher-than-average evaluated savings or to implement easier and simpler projects that may have lower-than-average savings.

8.0 Benchmarked Facilities

Benchmarking data for the individual buildings that constitute covered facilities is reported in CTS to help agencies monitor annual performance, as well as to identify buildings with the greatest potential to benefit from energy- and water-saving projects. These buildings are benchmarked using either Energy Star Portfolio Manager or another benchmarking tool (e.g., Labs21) using monthly metering utility bills, occupancy, and other building characteristics. As shown in Table 8.1, a total of 1,419 individual buildings representing an estimated 11% of covered facility floor space and 20% of energy use in covered facilities have been benchmarked.[40] The EPA is currently the only agency to have benchmarked all of its covered facility area. GSA, SSA, and STATE have over 90% of covered facility floor area benchmarked. While a relatively small percentage of DOE's floor area is benchmarked (19%) this represents a substantial portion of its covered facility energy use (70%).

Table 8.1. Benchmarked Buildings in CTS (FY 2011 data)

Agency	Number of Bench-marked Buildings	Covered Facility Gross Square Feet (Thou.)	Bench-marked Floor Space (Thou. ft^2)	% Floor Space Bench-marked	Covered Facility Energy Use (MMBtu)	Bench-marked Building Site-Delivered Energy Use (MMBtu)	% Total Covered Facility Energy Use
All Agencies	1,419	2,784,721	315,847	11%	334,558,600	66,961,094	20%
DHS	68	37,066	2,691	7%	3,583,200	221,478	6%
DOC	14	11,694	5,993	51%	2,112,800	1,043,617	49%
DOD	1	1,902,489	9,311	0.5%	194,868,100	2,713,446	1%
DOE	399	86,656	16,496	19%	24,653,300	17,133,437	70%
DOI	23	46,518	1,877	4%	3,842,400	198,913	5%
DOJ		53,087		0%	7,364,200		0%
DOL	16	17,495	2,465	14%	1,771,800	203,159	12%
DOT	3	16,411	210	1%	2,817,400	21,002	0.7%
EPA	16	2,840	2,840	100%	989,200	989,208	100%
GSA	196	139,207	125,578	90%	13,888,600	12,942,878	93%
HHS	129	22,133	16,742	76%	9,165,200	8,304,528	91%
HUD		1,441		0%	106,300		0%
NARA		3,492		0%	413,600		0%
NASA	344	32,327	9,544	30%	5,964,100	1,065,242	18%
NRC		763		0%	90,200		0%
OPM		1,014		0%	77,000		0%
RRB		347		0%	33,600		0%
SI		6,105		0%	1,012,700		0%
SSA	7	6,320	5,754	91%	820,700	576,184	70%
STATE	15	4,656	4,506	97%	556,200	568,758	102%
TREASURY	10	8,861	7,229	82%	1,485,600	1,141,961	77%
TVA	8	19,456	2,566	13%	1,267,900	170,089	13%
USACE		147		0%	1,389,900		0%
USDA	56	17,968	2,221	12%	3,302,900	182,098	6%
USPS		191,568		0%	24,117,300		0%
VA	114	154,661	99,825	64%	28,864,400	19,485,095	68%

[40] While water use and water use intensity can be reported in Portfolio Manager, it is not reported for all sites, and at this time there are no established benchmark targets for water use intensity.

9.0 Limitations of Analysis

There are a number of limitations to this analysis that should be kept in mind when drawing conclusions from the results shown in this document.

1. **Underestimation of Investment and Savings** – The current CTS data set is continually being updated and is not yet a comprehensive list of projects. Comparisons to efficiency investments reported in agency annual energy reports to FEMP suggest that the CTS data set underestimates the total investment and savings that will eventually occur. Some agencies are currently only reporting a subset of their projects, focusing on larger, third-party-funded projects first, and then entering other projects later.
2. **ECM Definition** – ECMs often refer to a technology implemented in a single building, but in CTS, ECMs may also refer to measures implemented in multiple buildings because covered facilities can comprise multiple buildings. This has implications for how this analysis can interpret the energy savings associated with specific ECMs.
3. **Data Quality** – While the CTS data was subjected to numerous data quality checks, no attempt was made to look at each of the approximately 7,000 facilities individually to make sure all the data was entered correctly. Data quality checks can find the "gross" errors, but may not find less obvious errors such as offsetting errors where two independent data parameters were both entered incorrectly yet the resulting calculation shows the facility data is within some predetermined range. For example, if both the square footage and energy usage are entered incorrectly, the resulting EUI may still be within range, even though the underlying data is incorrect.
4. **Limited Building-Level Data** – There is potentially much more analysis that could have been done on the CTS data if data had been entered at the building level rather than the facility level. However, requiring CTS data to be entered at the building level would have greatly increased the data-entry burden on agencies. The end result is that a number of analyses that can be done for benchmarked facilities (which are typically buildings) cannot be done for other facilities in CTS.
5. **Limited Amount of Water Use Data** – Interpretation of the results of the water analysis in this report should be made carefully. Water use is provided for a very limited number of facilities and limited data is reported on the nature of the water projects implemented.
6. **Lack of Project Implementation Dates** – CTS currently allows agencies to enter separate dates for project initiation and implementation. Project initiation refers to the project award or approval date and is a required field in CTS. Project implementation refers to the date the project was actually completed and is optional reporting. Throughout this analysis, project initiation was used as a surrogate for implementation since only 62% of projects reported actual implementation dates. It was therefore assumed that the year of initiation was the year projects were implemented and savings began to occur.

10.0 Conclusions and Recommendations

CTS is a very large and complex data set of federal building energy usage. The creation of CTS represents an enormous effort on the part of federal agencies and FEMP. It also presents agencies and energy and water resource management professionals with an opportunity to gauge impact of their ECM investments at a scale and level of detail that were not previously available. Observations about the relative cost-effectiveness and energy-savings impact of past projects can help inform and justify future planning to achieve federal energy and water management goals most cost-effectively.

This report contains a snapshot of the contents of CTS as of the end of FY 2012. The contents may be quite different in future years as agencies continue to add and revise the data in CTS.

The data quality effort associated with this analysis also points out the need for ongoing data quality screening of CTS. Data-entry errors have been made in the past and will be made in the future. Tracking down and resolving these issues with agencies can be an extremely time-consuming task.

In the interest of supporting the continued improvement of the reporting process and increasing the potential value that federal agencies and their service providers gain from the information in CTS, the research team offers the following recommendations:

1. Automate some of the data quality checks discussed in this report so that agencies or others entering data into CTS receive immediate feedback that their entry (or entries) seems problematic.
2. Update the analyses found in this report on an annual basis to track changes in CTS.
3. Encourage agencies to enter baseline water usage for their covered facilities.
4. Revamp the water conservation ECMs available in the main ECM list beyond Water and Sewer Conservation Measures to expand the options available and make them more precise. The current category of water ECMs and its subcategories are not sufficient to accurately depict the water conservation projects being implemented by agencies. Consideration should be given to deleting the existing "Water and Sewer Conservation Measures" category and all water-related subcategories and adding the following ECM categories that are based on the FEMP Best Management Practices (BMP):[41]
    a. Plumbing – includes toilets, urinals, faucets and showerheads (BMP #s 6 and 7).
    b. Landscaping and Irrigation – includes water-efficient landscaping and water-efficient irrigation (BMP #s 4 and 5).
    c. Industrial/Process Water – includes boiler/steam systems, single-pass cooling equipment, and cooling tower management (BMP #s 8, 9, and 10).
    d. Non-Plumbing Water Equipment – includes commercial kitchen equipment and laboratory/medical equipment (BMP #s 11 and 12).
    e. Other Water – includes water management planning; information and education programs; distribution system audits, leak detection, and repair; and alternate water sources (BMP #s 1, 2, 3, and 13).

[41] Additional information on FEMPs Water Efficiency Best Management Practices is available at http://www1.eere.energy.gov/femp/program/waterefficiency_bmp.html.

Appendix A

PNNL Program Plan for Savings Evaluation of EISA Federal Project Investments

Appendix A - PNNL Program Plan for Savings Evaluation of EISA Federal Project Investments

Note: The program plan below was drafted prior to the analysis and was updated throughout the analysis as methodological changes were made.

This Program Plan details the tasks, methodology, timeline, and specific types of analyses to be completed by Pacific Northwest National Laboratory (PNNL) as part of a study to evaluate the energy, economic, and environmental savings resulting from Energy Independence and Security Act (EISA) 432 federal project investments. This document is also intended to meet the milestone for a detailed program plan for the investment impact study. Detail on project objectives, budget, and milestones can be found in the Statement of Work.

Methodology

The primary tasks in the development of the EISA 432 savings impact study are described below.

1. **Data source review –** While the Compliance Tracking System (CTS) is the primary source of data on implemented projects, ancillary data will be required to help establish assumptions about critical pieces of information that are missing from the CTS data set. These ancillary data sources will include:
    a. Energy Savings Performance Contract (ESPC) Awarded Projects list
    b. DOE's Commercial Initiative Reference Building Models – typical buildings based on analysis of the Commercial Building Energy Consumption Survey (CBECS)
    c. DOE's Building Energy Codes Program Standard 90.1 Building Models – typical buildings based on DOE's reference buildings with refinements made by practicing engineers and architects associated with ASHRAE Standing Standard Product Committee 90.1
    d. DOE Buildings Performance Database – for energy savings summaries and distributions
    e. Federal Energy Management Program (FEMP) Annual Report to Congress – for overall agency energy use and energy expenditures
    f. Agency and subagency budgets from the Office of Management and Budget – to estimate spending ratio for energy conservation measures (ECM)
    g. Commercial and Institutional End-Uses of Water prepared by the Water Research Foundation – water end-use benchmark data on specific building types
    h. Federal Water Use Indices – typical water use per person by building type
2. **Establish assumptions for missing data –** Assumptions will primarily be used to establish energy use intensity (EUI) of buildings so that baseline energy use can be estimated when not reported. Assumptions may also be necessary establish corresponding greenhouse gas reductions and water savings. A preliminary review of available data in the CTS suggests that assumptions will need to be established for the following:
    a. **Building types** – For projects in which it is not clear from the description what building types are involved, a default building type or building types will be developed for each agency. This may

be based on the agency's most common "predominant use," and if that is not clear, a conservative assumption about the building's predominant use (e.g. Office building) may be used. Evaluation of available data on building type by agency will be used to inform these assumptions.

b. **Building quantity** – For projects in which the data or project titles do not convey how many buildings are covered by the project, it will be assumed that one building is impacted. If a project appears to be a campus or multi-building project, clarification may be sought from the Facility Energy Manager (FEM); this will depend on the number of projects that require follow-up.

c. **Building floor area and physical geometry** – For projects implemented in facilities where the building area affected is not known (i.e. no benchmarking to correspond with the project) or how the buildings are shaped, recently completed evaluations of CBECS and Residential Energy Consumption Surveys (RECS) for typical private sector construction will be used.

d. **Fuel type ratio** – Where it is not clear what fuel type (e.g. natural gas, propane, electricity) is being saved by the project, assumptions may be made based on geography and the nature of the ECM.

e. **Type of water ECM** – Where it is not clear from the project description what type of water project has been implemented, clarification will be sought from the project FEM.

f. **Ratio of irrigation, industrial and domestic water use** – Where it is not clear from the project description what type of water has been saved by a project, the project will be assumed to be a domestic water savings project.

3. **Database development** – An Excel®-based database will be developed to support analysis at the project, ECM, agency and government-wide levels. The database will integrate data from the CTS and supplementary data sources described in Task 1, as well as calculated values provided by the research team.[42]

   The following practices will be established to provide data integrity and quality control:

   a. The database administrator will maintain a master control copy of the data set. The administrator will check CTS for updates once weekly—or at a frequency that better corresponds with FEMP's planned updates—to make sure the most current data set is being analyzed.

   b. All other team members will have "read" access only and will copy data from the master file to support analyses.

   c. The master file will be backed up daily by the administrator.

   d. Analysts will send data to be integrated into the master database to the administrator in xls or csv format. Data provided will include the unique identification, the calculated value, and a description of the calculation (e.g., EUI = total energy/gross square feet).

   e. As noted in Task 6, if agency personnel request that PNNL make corrections to the reported data, such changes will be made in CTS and incorporated into the PNNL data set in the next CTS download.

   f. The administrator will notify team members of specific structural or content changes that occur during database maintenance and regular CTS uploads.

4. **Data preparation** – Consolidate data from the CTS including evaluated projects, implemented projects, and benchmarking reports, and other sources as appropriate. Review entries with similar

[42] Excel is a registered trademark of Microsoft Corporation.

titles and headings consolidate fields when they are clearly referring to the same source (e.g. DOE and Department of Energy).

5. **Clarify definition of ECM**[43] – Agencies do not appear to be using a common definition of an "energy conservation measure" when it comes to counting the number of ECMs implemented as part of a project (e.g. some are counting individual fixtures, some counting a set of fixtures incorporated into a building). To help provide consistency, PNNL proposes to work with FEMP and with agencies to establish a common definition of an ECM along the lines of "a specific set of equipment and controls replacements, additions, or modifications made to an individual building," as well as supporting examples. Thus, installation of 200 occupancy sensors in one building would be one ECM; installation of 200 occupancy sensors in two separate buildings would be two ECMs. This will clarify analyses that look for the most commonly used ECMs and saving by ECM types.

6. **Data quality check** – Each agency's data reported in CTS will be checked for potential data-entry, calculation, or estimation errors prior to data analysis. Quality checks will be performed on the covered facility footprint, project, and evaluation data. Facility benchmark data has been entered by agencies at a slower rate due in part to data-entry and data-import challenges, and will not be included in the quality check. Specific data quality checks include:

    a. **Number of ECMs** – The range of ECMs implemented per facility will be examined for project data. Those facilities with very large numbers of ECMs in a single project may suggest that the agency is not using a common definition of ECM. If so, PNNL will work with the agency to define an appropriate number of ECMs based on the common definition developed in Task 5. Agencies may have limited ability to change ECM-count audits, particularly if conducted by a third party. Therefore, evaluations will not be reviewed for high ECM counts.

    b. **Missing required data** – If required data fields in CTS or other data that is key to the analysis of investments is missing, PNNL will contact the agency to help enter those values or remove the project from CTS, as appropriate. Examples include missing gross building area, project implementation cost, energy savings estimates for energy ECMs, water savings estimates for water ECMs, and renewable production estimates for renewable ECMs; PNNL will provide guidance to agencies on estimating savings for different ECM types using savings-per-dollar-invested ranges from past analyses and engineering judgment.

    c. **Energy use intensity –** Facilities with EUIs greater than 500 kBtu/ft^2 in any reporting year will be investigated further and followed up unless there is an obvious reason for the high EUI based on the agency mission or facility function (e.g. Federal Aviation Administration radar stations).

    d. **Energy savings per square foot** – Projects with savings greater than 50 kBtu/ft^2 will be flagged and investigated to check whether the types of ECMs implemented warrant such high savings levels. If there is no clear reason for the high savings levels, PNNL will contact the agency to determine whether savings estimates are appropriate.

    e. **Water savings per square foot –** While there are no generally accepted ranges for water savings per square foot for buildings, projects will be checked for extreme outliers (e.g. > 100 gallons saved/ft^2) to determine whether such savings estimates are appropriate for the type of facility described.

    f. **Renewable energy production relative to energy use –** There are no clear upper and lower limits to renewable energy production; however, projects with extremely large ratios of

[43] For consistency with language in EISA Section 432(f)(3)–(8) and the CTS, the abbreviation ECM represents both water and energy efficiency measures.

renewable energy production to energy use will be checked to see whether the type of project described corresponds with such savings (e.g., from a large biomass project).

g. **Energy savings per dollar invested** –A FEMP analysis of federal ESPC projects found that the average annual energy savings per dollar invested in projects over a ten-year period was between 5,000 and 15,000 Btus per dollar invested. Because this range represents annual averages over multiple projects, this range will not be used to identify outliers, but will be used to validate rolled-up project averages by agency. However, projects with extremely low or high energy savings per dollar invested (<100 Btu/$ or >100,000 Btu/$) will be examined further. Unusually low savings may be the result of projects bundling ECMs with broader maintenance projects and not separating the ECM cost from the total implementation cost, which can be difficult to do. If confirmed by the agency to be general maintenance projects, these will be flagged in the database and pulled from analyses that specifically look at savings per dollar invested.

h. **Savings reported relative to estimated baseline use** – If the savings reported for implemented projects at covered facilities represent a significant portion of energy or water use (e.g. >20%), or are greater than total energy use or water use at the facility, these projects will be flagged and investigated further. If there is no obvious reason for the high savings levels, (for example, due to the magnitude of changes or projects involving renewable energy or distributed generation systems), the agency will be contacted. Follow-up will typically occur only on projects with savings-to-use ratios greater than 50%.

i. **Evaluated area relative to gross area** – The FEMP guidance in CTS requires that the evaluated area of a facility be less than the gross area reported as the covered facility footprint. Facilities with evaluated area greater than the gross area may be including energy and water savings potential from evaluations and projects that are not included in the agency's covered footprint. If a facility's evaluated area differs from the footprint by more than 10% in the year of the evaluation (or a subsequent year) then the agency will be contacted to correct the evaluated area or footprint as appropriate. Differences of less than 10% may be the result of auditors and facility managers using slightly different building areas for the same buildings.

j. **Other anomalies** – As other anomalies in each agency's data sets are discovered, PNNL will follow up with those agencies to make corrections as necessary. Examples include:

   - Multiple projects with the same name and savings estimates appear at the same facility, indicating likely duplicate entries.
   - Energy and water use spikes in one year that appear to be an order of magnitude off.

7. **Agency follow-up** – PNNL will e-mail the agency-level energy coordinator, copying the FEM contact if identified, with any issues that are identified during the quality check and offer to provide technical assistance as appropriate to establish the correct data in CTS.

8. **Data corrections** – When data is determined to have been entered incorrectly, the agency may correct the data in CTS or PNNL will make the correction if asked to do so by the agency. (Note that changes will be made in CTS directly, not to the PNNL data set.) These may include entering a rationale for the anomalous data in the "comments" field of CTS. For example, it may be noted that lower than expected energy savings were the result of an increase in mission tempo or occupancy at a given site. To support data quality, all requests and approvals must be by written (e-mail) correspondence. PNNL will request that the CTS Administrator create a field in the CTS for documenting any changes made by third parties, by whom they were made, and on what date.

9. **Normalization**

a. **Normalization of energy use data for weather** – Energy use data was normalized by PNNL to account for the fact that the evaluation and measurement occurred in a particular year and reflects specific weather patterns of that year. Savings reported by agencies are estimated, which implies that the typical meteorological year (TMY) was used. To bring energy use data and savings estimates to a comparable basis, weather normalization was implemented.

Ideally, normalization for weather can be done when energy consumption for cooling and heating days is shown separately; then it can be scaled based on the ratio of cooling degree days (CDD) and heating degree days (HDD) of the data year to the CDD and HDD of the TMY, correspondingly.

Since only aggregate annual energy use is available in CTS, cooling and heating portions were approximated first. This was done based on the breakdown of energy consumption by end use for typical buildings estimated in CBECS 2003 as shown in Table A.1.

Table A.1. Energy Consumption by Census Division and End Use

Census Division Number	Census Division	Heating	Cooling	Other
1	New England	54%	3%	43%
2	Middle Atlantic	46%	4%	50%
3	East North Central	50%	3%	47%
4	West North Central	43%	5%	52%
5	South Atlantic	22%	13%	65%
6	East South Central	33%	8%	59%
7	West South Central	19%	17%	64%
8	Mountain	37%	7%	56%
9	Pacific	21%	9%	70%

Once energy consumption was split out, it was scaled to account for difference in the HDD and CDD of the actual year versus the TMY. 2000–2011 National Oceanic and Atmospheric Administration (NOAA) state data[44] for HDD and CDD was used to derive the adjustment factors between a specific year's energy use and the HDD and CDD for the TMY. The resulting weather-normalized expected energy use estimates were used as a basis for calculating energy-savings fraction. (See Task 10.l below).

One limitation of this approach is that the weather-adjusted energy use estimates are developed based on a uniform split between heating and cooling, while the facilities within CTS probably have very heterogeneous heating and cooling loads even within each facility/building type.

While Portfolio Manager provides a weather-adjusted energy use estimate, only 4% of benchmarked buildings in CTS appear to "match" the building area of the corresponding covered facility. So it is not possible to use the weather-normalized data from the benchmark set.

[44] NOAA – National Oceanic and Atmospheric Administration, National Climatic Data Center, Historical Climatology Series 5-1, *State Regional and National Monthly and Seasonal Heating Degree Days Weighted by Population*. Accessed at http://www.ncdc.noaa.gov/oa/documentlibrary/hcs/hcs.html

b. **Normalization of water use and savings –** Water savings for projects related to irrigation have the potential to be normalized based on historic weather data. However, only one project is readily identifiable as an irrigation project at this time. For building interior water use, ranges of water-use intensity based on occupant density are available for certain building types, but there are no established estimates of typical water use per occupant or per square foot when building types are not known. Benchmark data imported from Portfolio Manager identifies the building type, but lacks occupancy rates and is available for very few facilities with water projects. Due the limited data available for water projects in CTS, water use and savings estimates will not be normalized. Water savings will be totaled by agency and it will be noted that savings estimates would be slightly higher or lower if data were normalized.

10. **Savings Impact Analysis** – Specific analyses to be completed will include:

a. **ECMs implemented** – This analysis will be a simple count of ECMs implemented by facility, including analysis of those used most/least often, ECMs that are typically implemented alone or bundled with other ECMs, and aggregated by agency and building type. This analysis will provide FEMP an opportunity to see which ECMs agencies are focusing on and which ECMs some agencies may be missing.

b. **Energy savings by ECM** – This analysis will be a simple summation of the energy savings reported for each ECM and by agency. For single-ECM projects, reporting of energy savings by ECM will be simple. Bundled ECMs will first be analyzed as a separate group. Then, using the estimates from the single-measure projects, a suggested attribution of the bundled project savings to its component ECMs will be calculated. This analysis will allow FEMP to see which ECMs are generating the greatest total energy savings in the federal sector.

c. **Water savings by ECM** – Water-related projects will be assessed by plotting water saved against dollars invested in the project. This plot will show trends in relative water savings compared to the up-front capital expense of the project. This analysis will provide information on outliers in the data set that may indicate projects outside the normal range of savings. Also, this comparison may reveal "clusters" of relative savings that show trends in specific technology types. This analysis will allow FEMP to see which water-related ECMs are generating the most water savings in the federal sector.

d. **Project funding by source** – This analysis will be a simple summation of the reported project funding by source (e.g. ARRA, UESC, ESPC, appropriated funds) and by agency. This analysis will allow FEMP to see whether agencies are making full use of the project funding options available to them.

e. **Project investment by agency and subagency** – This analysis will be a summation of project investment by agency and subagency, coupled with a normalization of that total to the agency or subagency's reported budget. Note that it is not expected that all agencies or subagencies will spend the same normalized fraction of their budget on buildings. Some agencies may be more (or less) "building intensive" and be expected to spend a larger (or smaller) proportion of their allocated budgets on building energy efficiency. This analysis will provide FEMP with information on what fraction of agency budgets are being spent on this activity and which agencies tend to spend a larger (or smaller) fraction on this activity.

f. **Project implementation cost by ECM** – This analysis will establish the total and average cost of implementing individual ECMs or bundles of ECMs. This will help FEMP to understand the total investment levels by ECM and the relative cost of implementing those ECMs to support future planning efforts.

g. **Average savings by building type –** When the covered facility building type is known (i.e., when the benchmarked building area and energy use are equal to covered facility area and energy

use, we can assume the covered facility is a single building), normalized energy savings per square foot and per dollar invested will be characterized by building type.

h. **Average energy savings and savings ranges per dollar invested** – This analysis will establish average savings per dollar invested overall and by individual ECM, as the data set allows. Ranges of savings by ECM (or for bundles of similar ECMs) will be established based on the data reported in the CTS, and percentiles and standard deviations will be used to provide an indication of uncertainty around those estimates.

i. **Life-Cycle Cost Economics** – This analysis will focus on providing return on investment, net savings, and average payback periods for individual ECMs, ECM bundles, subagencies, and agencies. Life-cycle cost and savings analysis will be implemented using the equipment lifetime data where it was reported in CTS, or alternatively, using lifetime assumptions for various energy measures from cost-effectiveness assumptions prescribed by the National Institute of Standards and Technology. In addition, the total implementation cost will be subject to regional cost inflator adjustment in order to perform LCC analysis on the comparable national scale. This analysis will allow FEMP to promote various ECMs or packages of ECMs to agencies as life-cycle cost-effective.

j. **Greenhouse Gas (GHG) emissions avoided** – Zip codes will be associated with eGRID subregions and reported electricity savings will be multiplied by a CO_2-equivalent emission factor for the region to estimate GHGs avoided. When facilities report total fuel savings from projects, rather than savings by fuel type, PNNL will apply fuel share ratios for standard commercial buildings from the National Energy Modeling System/Annual Energy Outlook by location. GHG emissions avoided will be estimated for each project and totaled by:

   - Federal government
   - Agency
   - Subagency
   - State or Region
   - ECM type for single-ECM projects

k. **Implemented project energy savings relative to evaluated project savings potential** – An initial comparison of the most recent evaluated energy savings potential and implemented project savings will be made. This analysis may provide FEMP with a general indication of remaining potential projects that could be implemented cost-effectively, but it will be presented with several caveats. It will be noted that not all projects have been entered into CTS yet and that the results should not be construed as a complete representation of activities. It will also be noted that, due to the fluid nature of covered facility portfolios, not all initial savings identified will remain relevant to the agency.

l. **Total implemented project energy and water savings relative to total agency energy and water use –** This analysis will provide FEMP with information on the relative impact the agency projects have. As with many building-related activities, cumulative savings over time will be important as well.

11. **CTS updates and process improvements –**To facilitate and improve the quality of the EISA savings impact analyses, PNNL will recommend modifications to the CTS and the reporting process, and work with FEMP contractors to integrate aspects of PNNL's data set back into the CTS.

Timeline

Task		Completion Date
1.	Data Source Review	3/3/12
2.	Establish Assumptions for Missing Data	3/3/12
3.	Database Development	3/31/12
4.	Data Preparation/Cleanup	4/30/12
5.	Data Quality Check	8/17/12
6.	Agency Follow-Up	8/31/12
7.	Data Corrections	ongoing
Milestone: Compilation of Data Sets for Basis of Analysis Complete		8/30/12
8.	Normalization of Energy and Water Use and Savings	8/31/12
Milestone: Analysis of Non-Project Savings Variables Complete		8/24/12
9.	Savings Impact Analysis	9/21/12
10.	Extrapolation of Future Potential Energy Savings	9/30/12
11.	Extrapolation of Future Potential GHG Reductions	9/30/12
12.	Extrapolation of Future Potential Water Savings	9/30/12
Milestone: Draft Savings Impact Study Complete		9/30/12
Milestone: Presentation Summarizing Key Findings / Deliver at Conference or Webinar		10/30/12
Milestone: Final Savings Impact Report complete		12/15/12

Appendix B

List of ECM Types and Subtypes in CTS

Appendix B – List of ECM Types and Subtypes in CTS

ECM Types and Subtypes
Advanced Metering Systems
Appliance/Plug-Load reductions
De-lamp vending machines
Energy Star® products
Plug timers
Replace air-cooled ice/refrigeration equipment
Replace refrigerators
Other
Boiler Plant Improvements
Boiler control, including new controls and retrofits to existing controls
Boiler decentralization
Other
Replacement of existing boilers with high-efficiency boilers
Building Automation Systems/Energy Management Control Systems (EMCS)
Heating, Ventilating, and Air Conditioning (HVAC) upgrade from pneumatics to Direct Digital Control
Other
Upgrade or replacement of existing EMCSs
Building Envelope Modifications
Insulation installation
Other
Reflective solar window tinting
Weatherization
Window replacement
Chilled Water, Hot Water, and Steam Distribution Systems
Hot water heater repair and replacement
Other
Piping insulation installation
Repair or replacement of existing condensate return systems and installation of new condensate return systems
Steam trap repair and replacement
Chiller Plant Improvements
Chiller plant pumping, piping, and controls retrofits and replacements
Chiller retrofits or replacements
Other
Commissioning Measures
Distributed Generation
Cogeneration systems installation
Fuel cells installation
Microturbines installation
Other
Heating, Ventilating, and Air Conditioning
Cooling tower retrofits or replacements
Economizer installation
Fans and pump replacement or impeller trimming
HVAC damper and controller repair or replacement
Other
Packaged air conditioning unit replacements
Thermal energy storage
Variable air volume retrofit
Window air conditioning replacement with high-efficiency units

ECM Types and Subtypes
Electrical Peak Shaving/Load Shifting
Gas cooling
Other
Thermal energy storage
Electric Motors and Drives
Motor replacement with high-efficiency motors
Other
Variable speed motors or drives
Energy Cost Reduction Through Rate Adjustments
Change to more favorable rate schedule
Energy service billing and meter auditing recommendations
Lower energy cost supplier(s) (where applicable)
Other
Energy Related Process Improvements
Industrial process improvement
Other
Production and/or manufacturing improvements
Recycling and other waste stream reductions
Energy/Utility Distribution Systems
Gas distribution systems installation
Other
Power factor correction
Power quality upgrades
Transformer installation
Lighting Improvements
Daylighting
Fiber optic lighting technologies
Intelligent lighting controls
Interior and exterior lighting retrofits and replacements
Light emitting diode technologies
Occupancy sensors
Other
Spectrally enhanced lighting
Other
Refrigeration
Other
Replacement of ice/refrigeration equipment with high-efficiency units
Renewable Energy Systems
Landfill gas, wastewater treatment plant digester gas, and coalbed methane power plant installation
Other
Passive solar heating installation
Photovoltaic system installation
Replacement of air conditioning and heating units with ground-coupled heat pump systems
Solar hot water system installation
Solar ventilation preheating system installation
Wind energy system installation
Wood waste and other organic waste stream heating or power plant installation
Water and Sewer Conservation Systems
Low-flow faucets and showerheads
Low-flow plumbing equipment
On-site sewer treatment systems
Other
Water-efficient irrigation

Appendix C

High and Low LCC Results by ECM and Agency

Appendix C – High and Low LCC Results by ECM and Agency

High and low LCC results are obtained based on using either electricity or natural gas rates to account for the uncertainty around the fuels saved in the different ECMs. The escalation rates for the LCC discounting by fuels are included below. Low case was calculated based on using the natural gas price, assuming that all savings on the ECMs where fuel type is not identified are attributed to natural gas. High case was calculated by attributing all generated savings to electricity, and applying electricity price and escalation factors.

Table C.1. Federal Energy Management Program Uniform Present Value Discount Factors Adjusted for Fuel Price Escalation by Fuel Type, Commercial Sector

N	Electric	Natural Gas
1	0.96	0.95
2	1.87	1.85
3	2.75	2.70
4	3.61	3.53
5	4.43	4.33
6	5.23	5.12
7	6.01	5.89
8	6.76	6.66
9	7.49	7.41
10	8.20	8.16
11	8.89	8.90
12	9.56	9.63
13	10.22	10.35
14	10.85	11.06
15	11.47	11.77
16	12.07	12.46
17	12.65	13.14
18	13.21	13.80
19	13.76	14.45
20	14.29	15.09
21	14.81	15.71
22	15.31	16.32
23	15.80	16.93
24	16.28	17.52
25	16.74	18.11
26	17.20	18.69
27	17.63	19.26
28	18.06	19.81
29	18.48	20.36
30	18.88	20.90

Table C.2. High and Low Average Life-Cycle Cost Results by Energy Conservation Measure, without Financing Cost

	Life-cycle Benefit ($)		Location-Adjusted	Net Savings ($)		Savings-to-Investment Ratio		Adjusted Internal Rate of Return	
ECM*	Low	High	Investment ($)	Low	High	Low	High	Low	High
Boiler	536,381	536,381	5,476,869	($4,940,489)	($1,103,076)	0.10	0.33	-10.20%	-3.57%
Chiller	2,793,226	2,793,226	6,008,089	($3,214,863)	$955,199	0.46	1.52	-0.79%	5.13%
Commiss	3,101,608	11,748,270	2,053,604	$1,048,004	$9,694,666	1.51	5.72	7.34%	22.63%
Dist Gen	1,140,968	1,140,968	197,665	$943,304	$943,304	5.77	5.77	10.48%	10.48%
Dist Sys	6,248,601	21,771,488	21,397,510	($15,148,909)	$15,610,329	0.29	3.53	-2.10%	8.51%
EMCS	1,696,409	5,985,227	1,322,088	$374,321	$5,410,077	1.28	10.41	4.62%	19.31%
Envelope	48,191	173,318	528,727	($480,536)	($355,409)	0.09	0.33	-11.47%	-4.01%
HVAC	101,747	364,592	826,706	($724,958)	($36,311)	0.12	0.91	-9.86%	2.38%
Lighting	632,577	632,577	332,605	$299,972	$377,323	1.90	2.48	7.36%	9.20%
Meter	3,228,762	11,514,548	4,046,647	($817,885)	$9,295,217	0.80	5.19	1.84%	11.84%
Motor	1,668,115	1,668,115	2,284,258	($616,143)	$913,353	0.73	2.21	1.45%	7.02%
Other	1,899	6,780	5,358	($3,458)	$1,423	0.35	1.27	-2.20%	4.22%
Plugs	15,707	15,707	49,117	($33,410)	($33,405)	0.32	0.32	-4.54%	-4.54%
Process	337,744	1,176,760	5,578,280	($5,240,536)	($429,376)	0.06	0.73	-7.93%	1.73%
Renewable	125,273,289	139,963,729	25,272,100	$100,001,189	$132,361,054	4.96	18.41	10.33%	16.73%
Utility	104,199	357,154	149,999	($45,800)	$207,155	0.69	2.38	1.14%	7.57%
Total	3,978,214,976	4,854,678,728	534,961,041	3,443,253,936	4,319,717,687	7.44	9.07	16.67%	18.13%

* Abbreviations are defined in the Acronyms and Abbreviations list, which follows the Executive Summary.

Table C.3. High and Low Average LCC Results by Agency, without Financing Cost

	Life-cycle Benefit ($)		Location-Adjusted	Net Savings ($)		Savings-to-Investment Ratio		Adjusted Internal Rate of Return	
Agency*	Low	High	Investment ($)	Low	High	Low	High	Low	High
DHS	42,490,856	42,861,517	3,452,581	$39,038,275	$38,260,458	12.31	9.32	16.77%	15.16%
DOD	1,030,964	1,965,997	560,694	$470,270	$1,405,303	1.84	3.51	7.18%	11.80%
DOE	98,584,154	118,979,005	10,258,075	$88,326,079	$83,075,743	9.61	3.31	14.14%	8.76%
DOI	261,921	308,727	302,753	($40,832)	$5,974	0.87	1.02	2.20%	3.11%
DOL	20,730	46,737	49,427	($28,698)	($2,690)	0.42	0.95	-2.77%	2.62%
DOT	591,600	706,643	344,013	$247,587	$362,630	1.72	2.05	6.31%	7.42%
EPA	401,770	984,557	728,374	($326,603)	$256,183	0.55	1.35	-0.35%	4.74%
GSA	1,179,582	2,841,266	9,946,937	($8,767,354)	($7,105,670)	0.12	0.29	-8.31%	-3.80%
HHS	297,357	590,472	396,181	($98,824)	$194,291	0.75	1.49	1.28%	5.44%
NASA	6,133	23,231	59,664	($53,531)	($36,433)	0.10	0.39	-17.96%	-6.27%
NRC	286,245	974,669	235,443	$50,802	$739,226	1.22	4.14	3.67%	7.99%
SSA	8,775,203	9,460,232	411,504	$8,363,699	$9,048,729	21.32	22.99	21.26%	21.75%
TREASURY	4,431,813	4,454,997	373,374	$4,058,439	$3,987,043	11.87	9.52	22.40%	20.54%
TVA	316,350	347,672	183,066	$133,284	$164,606	1.73	1.90	6.39%	6.98%
USDA	452,131	1,539,511	2,866,569	($2,414,438)	($1,327,058)	0.16	0.54	-3.15%	0.89%
USPS	491,793	766,454	256,033	$235,760	$510,421	1.92	2.99	7.54%	10.75%
VA	175,531	382,975	235,820	($60,289)	$141,465	0.74	1.59	1.49%	5.40%
Total	3,978,214,976	4,854,678,728	534,961,041	3,443,253,936	4,319,717,687	7.44	9.07	16.67%	18.13%

* Abbreviations are defined in the Acronyms and Abbreviations list, which follows the Executive Summary.

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