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Evolution of the U.S. Energy Service Company Industry: Market Size and Project Performance from 1990-2008

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Acronyms and Abbreviations

ARRA	American Reinvestment and Recovery Act
Btu	British thermal unit
DOE	U.S. Department of Energy
ECM	energy conservation measure
EERE	(DOE Office of) Energy Efficiency and Renewable Energy
EIA	Energy Information Administration
ESCO	energy service company
ESPC	energy savings performance contract
HVAC	heating, ventilation, air conditioning
LBNL	Lawrence Berkeley National Laboratory
MUSH	Municipal and state governments, universities and colleges, K-12 schools, and hospitals market sector
NAESCO	National Association of Energy Service Companies
O&M	operations and maintenance
OE	(DOE Office of) Electricity Delivery and Energy Reliability
REEP	Ratepayer-funded energy efficiency program

Abstract

The U.S. energy service company (ESCO) industry is an example of a private sector business model where energy savings are delivered to customers primarily through the use of performance-based contracts. This study was conceived as a snapshot of the ESCO industry prior to the economic slowdown and the introduction of federal stimulus funding mandated by enactment of the American Recovery and Reinvestment Act of 2009 (ARRA).

This study utilizes two parallel analytic approaches to characterize ESCO industry and market trends in the U.S.: (1) a "top-down" approach involving a survey of individual ESCOs to estimate aggregate industry activity and (2) a "bottom-up" analysis of a database of ~3,265 projects (representing over $8B in project investment) that reports market trends including installed EE retrofit strategies, project installation costs and savings, project payback times, and benefit-cost ratios over time. Despite the onset of an economic recession, the U.S. ESCO industry managed to grow at about 7% per year between 2006 and 2008. ESCO industry revenues are relatively small compared to total U.S. energy expenditures (about $4.1 billion in 2008), but ESCOs anticipated accelerated growth through 2011 (25% per year).

We found that 2,484 ESCO projects in our database generated ~$4.0 billion ($2009) in net, direct economic benefits to their customers. We estimate that the ESCO project database includes about 20% of all U.S. ESCO market activity from 1990-2008. Assuming the net benefits per project are comparable for ESCO projects that are not included in the LBNL database, this would suggest that the ESCO industry has generated ~$23 billion in net direct economic benefits for customers at projects installed between 1990 and 2008. We found that nearly 85% of all public and institutional projects *met or exceeded* the guaranteed level of savings. We estimated that a typical ESCO project generated $1.5 dollars of direct benefits for every dollar of customer investment. There is empirical evidence confirming that the industry is responding to customer demand by installing more comprehensive and complex measures—including onsite generation and measures to address deferred maintenance—but this evolution has significant implications for customer project economics, especially at K-12 schools. We found that the median simple payback time has increased from 1.9 to 3.2 years in private sector projects since the early-to-mid 1990s and from 5.2 to 10.5 years in public sector projects for the same time period.[1]

[1] Our analysis suggests that some ESCO projects in the public/institutional market, especially K-12 schools, are using performance contracting, at the behest of customers, to partially−but not fully− offset substantial accumulated deferred maintenance needs (e.g., asbestos removal, wiring, roof replacement). Many of these non-energy measures generate little or no energy-related savings, yet these projects are valued by customers. This trend is affecting the traditional economic measures policymakers use to evaluate success (e.g., benefit-cost ratios).

1. Introduction

The U.S. energy services company (ESCO) industry provides energy savings and other benefits to customers primarily through the use of performance-based contracting. This private industry, developed over the past 30 years, has largely been a successful model for the cost-effective delivery of energy-efficient technologies and services to public/institutional sector customers. Goldman et al. (2005) conducted an analysis of U.S. ESCO industry trends and performance-based contracts using empirical project-level and industry survey data. Other studies of the U.S. ESCO industry have described ESCO project activity in specific market sectors, such as state government markets (Bharvirkar et al. 2008), institutional markets (Hopper et al. 2005) or reported survey results on U.S. ESCO market activity levels in aggregate and growth prospects (see Hopper et al. 2007).

This study builds on Goldman et al. (2005) and was conceived primarily as a snapshot of the ESCO industry circa 2008, prior to the economic slowdown and the introduction of federal stimulus funding mandated by enactment of the American Recovery and Reinvestment Act of 2009 (ARRA).[2] The study utilizes two analytic approaches: (1) a "top-down" method involving a survey and interviews with ESCOs to estimate aggregate market activity and identify emerging trends (Satchwell et al. 2010) and (2) a "bottom-up" analysis of a large database of ~3250 projects provided by ESCOs and their customers (i.e., the LBNL/NAESCO database). The database includes projects implemented between 1990 and 2008 representing over $8 billion (2009$) in total project investments.[3] We use the database to characterize long-run trends in typical ESCO project characteristics, investment and savings levels as well as overall economic performance. Our examination of U.S. ESCO industry and market trends provides insights into the distinctive features and policy drivers of a relatively mature private sector energy efficiency services industry, which may be useful to policymakers in other countries interested in promoting similar business models.

For example, we find that U.S. ESCOs typically prefer guaranteed savings contracts. In contrast, Da-li (2009) report that the shared savings model is still preferred in the buildings sector in China, although the guaranteed savings model may be gaining momentum for projects currently being undertaken in the industrial sector.

Murakoshi and Nakagami (2009) report that installation costs (and payback times) are increasing at ESCO projects much faster than the rate of inflation in Japan, which is consistent with our analysis of installation cost and economic performance trends in the U.S. ESCO industry.

Lindgren (2009) surveys Swedish ESCO industry executives and reports some similarities to our findings for the U.S. ESCO market − a small number of ESCOs generating a majority of industry

[2] In a subsequent report, we will analyze the impact of the ARRA funding on ESCO industry and market trends.
[3] The terms "costs" and "investments" are used interchangeably throughout this article with project costs being borne by customers of ESCOs and project investments being made by ESCOs. Thus, we define total ESCO project investment as the turnkey costs associated with project development and installation (excluding the costs of project financing over the contract term after the project has been accepted by the customer).

revenue and most activity occurring in the public sector. In 2010, the European Commission confirmed strong ESCO industry growth for Sweden as well as several other countries, but reported a "common trend" of slower or decreasing growth across Europe since their last survey was conducted in 2007 (Marino et al. 2010). The global economic downturn was identified by Marino et al. (2010) and Satchwell et al. (2010) as a factor that contributed to slower than anticipated growth in the ESCO industry for a number of countries, including the United States. ESCO industries are at various stages of development in other countries.

Given its relative maturity, a comprehensive analysis of ESCO industry and market trends in the U.S. may provide insights to policymakers that are interested in facilitating the development of a robust, private sector energy efficiency services industry.

This article is organized as follows. Section 2 summarizes information about our sources and methods. We define the market and provide size and growth estimates from a recent survey of ESCO industry executives in Section 3. Section 4 describes ESCO market and overall project-level performance using information from both the survey and database. In Section 5, we analyze market trends over time for ESCO projects in public and private sector markets, drawing from the LBNL/NAESCO project database. In Section 6, we discuss the role of enabling policies to facilitate ESCO industry growth and transparency. Finally, we summarize conclusions and identify future research areas in Section 7.

2. Approach and Data Sources

In this section, we discuss data sources and methods used in the (1) "top-down" survey of the U.S. ESCO industry and (2) "bottom-up" analysis of project-level information. A more detailed discussion of the survey approach can be found in Satchwell et al. (2010) and methods used to collect, compile and analyze ESCO project data is described in Hopper et al. (2005) and the appendix to this report.

2.1 Survey of aggregate U.S. ESCO industry activity

We identified 53 companies that appeared to offer performance contracting as a service and conducted interviews with senior management.[4] ESCOs were asked to provide information on their annual revenues from energy services in 2008, growth in annual revenues from 2008 to 2011, activity in various market segments, types of contractual arrangements, revenues obtained from various types of technologies (e.g., energy efficiency, renewable energy, and onsite generation projects) and services (e.g., consulting, master planning), and their views on trends in project installation costs, payback times, and operation and maintenance (O&M) savings. Initially, 29 companies responded to our request; our estimated response rate was 55% among active ESCOs (29 out of 53). We then estimated annual revenues for 15 of the remaining ESCO non-respondents, which were all small companies, using a Delphi approach similar to the approach reported in Hopper et al. (2007)[5]. Accordingly, our estimates of aggregate revenues for the ESCO industry are based on a sample of 44 companies; the combined survey and Delphi revenue estimates provide information on nearly all ESCOs that are actively operating in the United States.

2.2 LBNL/NAESCO project database

LBNL has collected information about performance-based energy projects from various sources for more than fifteen years.[6] About 2,800 projects (87% of database) were provided by individual ESCOs as part of NAESCO's voluntary accreditation process. During the accreditation process, ESCOs are asked to submit information on a sample of their performance-based projects (up to 50) completed within the previous three to five years. Projects submitted by ESCOs are reviewed by members of an accreditation committee, which includes interviews with a sample of customers to verify project information submitted by ESCOs and allow customers to provide feedback on the performance of ESCOs in various areas (e.g., project design, construction, operation and maintenance of savings, ability to arrange financing).

[4] Our initial target list was 109 companies. Based on market research of company websites, 53 companies were eliminated either because they did not meet our definition of ESCOs or were not currently offering performance contracting as a service. We contacted senior executives that would be knowledgeable about their company's revenues and market activity, and would also have the authority to release the requested information.

[5] For the thirteen companies that did not respond, Satchwell et al. (2010) used their professional judgment to develop high and low revenue estimates for each company. The non-respondent companies were typically smaller ESCOs and represent only about 4% of the total ESCO market as a share of 2008 industry revenues

[6] See Goldman et al. 2000; Goldman et al. 2002; Osborn et al. 2002; Hopper et al. 2004; Hopper et al. 2005; Goldman et al. 2005; and Bharvikar et al. 2008.

Twelve state agencies that administer and oversee performance contracting programs also provided information on 271 projects completed by ESCOs (~8% of database projects) after being contacted by LBNL: Florida, Hawaii, Kentucky, Illinois, New York, Pennsylvania, Michigan, Washington, Kansas, California, Maryland, and Missouri.

We also obtained project information for projects completed as part of the Department of Energy's (DOE) Energy Savings Performance Contract (ESPC) program (i.e., DOE Super-ESPC), which account for ~5% of the projects in the database.

ESCOs are asked to submit a representative group of projects by NAESCO in the accreditation process, although LBNL has no way of determining the extent to which this guidance is followed by individual ESCOs. It is possible (or even likely) that ESCOs are selecting their most successful projects for submission to the NAESCO accreditation process. *Thus, in reporting results, we do not assume that ESCO project data represent a random sample from the entire population of U.S. ESCO projects.* Instead, we use similar analysis methods described by Hopper et al. (2005) and report "typical" project information (i.e., median values and inter-quartile ranges) that highlight both the central tendency and variation in project results.

Information requested for each project is shown in Table 1; note that ESCOs do not always collect or provide all relevant project information on customer projects. For example, information on project costs and installed retrofit measures is available for 98% and 93% of the projects, respectively (see Table 1). In contrast, only about 62% of the projects provided information on actual energy savings or the dollar value of savings in the year after the project was completed; thus we utilize predicted energy savings values when this data field is missing.[7] About 65% of the projects provided information on baseline energy usage prior to the retrofit, which reduces our sample size when we report percent savings for different types of projects. In addition, we calculate project net benefits and benefit cost ratios only for those projects that provide information on project installation cost, annual savings, and contract length (or average measure lifetimes). ESCOs also provide information on features that are optional (shown in italics in Table 1) and only offered by certain utilities (e.g. rebates for energy efficiency measures funded by utility customers which offsets a portion of the capital cost of projects) or are unique to specific projects (e.g., operational savings).

[7] ESCOs provide predicted energy savings for projects that are recently completed and for which there is not one year of measured data.

Table 1. Key project data fields and ESCO response rate

Category	Details	Percent of ESCO projects that provided information for data field (n=3265)
Project Location	City, state, zipcode, country	> 99%
Customer Contact	Name, phone, email	> 99%
Project Characteristics	Date of completion, floor area, number of buildings, market segment, facility type	72-99%
Project Economics	Project cost (including or excluding financing charges), project agreement type, contract term, Utility incentive program participation and amount (if applicable)	20-98%
Baseline Annual Energy	Baseline metric	65%
Consumption	Baseline consumption by fuel/energy source	59%
Annual Energy Savings	Predicted, guaranteed, actual savings	62-79%
Other Benefits	Operations and maintenance and other non-energy savings	37%
	over the project lifetime	
Measures Installed	Selected from a categorized list	93%

We utilize a methodological framework that is similar to previous LBNL reports (see Goldman et al. 2002, Goldman et al. 2005, Hopper et al. 2005) in order to adjust and analyze project information provided by ESCOs to ensure consistency in reporting project costs, savings and economic indicators. Comparative analysis of projects is facilitated by grouping projects by vintage, categorizing the energy conservation measures (ECMs) installed in projects into a primary retrofit strategy, and adjustments that normalize project costs and energy prices across time to account for inflation effects and express costs and dollar savings in real terms (2009 U.S. dollars).

A major focus of this article involves analyzing ESCO project trends over time; therefore, we grouped projects by vintage (i.e., the year the project was completed) into three distinct time periods: (1) 1990-1997, (2) 1998-2004, and (3) 2005-2008. During the 1990-1997 period, the ESCO industry was maturing; one key factor driving ESCO industry growth was that utilities in certain parts of the U.S. made significant investments in energy-efficiency as part of demand-side management (DSM) programs or integrated resource plans (IRPs). During the 1998-2004 period, the ESCO industry was heavily influenced by the promise of, and subsequent fallout from, electricity restructuring (e.g., retail competition increased interest in energy efficiency services initially; many utilities bought or started ESCOs; and then the ESCO industry consolidated as many utilities sold off their ESCO subsidiaries after the California electricity crisis and state interest in retail competition ebbed). ESCO activity in the federal market was also affected by a sunset to legislation enabling performance contracting in the federal market (i.e., ESPC program). During the 2005-2008 period, an increasing number of states adopted policies that promote energy efficiency (e.g., Energy Efficiency Resource standards, ramping up public benefit and ratepayer-funded energy efficiency and renewable energy programs) as a lower cost alternative to electricity generation and/or as part of a carbon reduction strategy. ESCO activity in the federal market has also been influenced positively by the re-authorization of ESPCs.

In order to facilitate comparative analysis across projects, it is useful to group the ~150 energy conservation measures reported by ESCOs into generalized primary retrofit strategies (see Table 2). We developed a method to categorize each project by its primary retrofit strategy, which included the following categories: major HVAC, minor HVAC, onsite generation, lighting-only, non-energy, and all other strategies.[8]

Table 2. Primary retrofit strategies utilized in ESCO projects

LBNL-defined Primary Retrofit Strategy	Example of Energy Conservation Measures (ECMs) Included
Lighting-only	Technologies installed only include various lighting efficiency measures, controls and strategies.
Major HVAC	Technologies installed include major HVAC equipment replacements (e.g., boilers, chillers, cooling towers, HVAC dist. improvements) and may include other HVAC control, high-efficiency lighting, and motors measures.
Minor HVAC	Technologies installed only include less-capital intensive HVAC measures and controls (and exclude major HVAC equipment replacements) and may include lighting and other measures.
Onsite generation	Technologies include installation of onsite generation equipment and may include other energy efficiency measures (e.g., lighting, HVAC equipment and controls, motor efficiency measures).
Non-energy[9]	Technologies installed include roof or ceiling replacement, asbestos abatement (i.e., measures that are not installed primarily for their energy savings, but may have other types of savings), and may include other efficiency measures (e.g., lighting or HVAC upgrades).
Other	Technologies installed include all other measures including domestic hot water (DHW), water conservation, and installation of energy-efficient equipment such as vending machines, laundry or office equipment, high-efficiency refrigeration, industrial process improvements and strategies such as staff training or utility tariff negotiation. These individual measures may also be included in other retrofit strategies (except lighting-only); projects categorized as "Other" retrofit strategy only installed these types of measures.

[8] See Goldman et al. (2002) and Hopper et al. (2005) for a more detailed discussion of methods and criteria used to categorize projects by retrofit strategy.

[9] Hopper et al. (2005) indicate that, in some cases, ESCO projects include some measures with significant costs that are not necessarily intended to produce energy savings (e.g., asbestos removal). Thus, we defined this retrofit strategy as "non-energy" to separate projects that may have relatively poor economic performance because they include some measures that provide non-energy benefits or are required for the project to move forward but whose value is difficult to monetize.

ESCOs typically estimate first-year dollar savings by valuing energy savings using existing utility tariffs at the project site; ESCOs estimate future savings using a variety of methods that involve escalating future energy prices. Because practices vary across ESCOs, we re-estimate the dollar value of project energy savings in an effort to facilitate comparisons among projects across different locations, sectors, and installation years.[10] ~1,200 projects reported O&M or other types of savings (annual or total savings). For ~30% of these projects, ESCOs reported either total operations and maintenance (O&M) savings or other savings. For these projects, we calculated an annual average of O&M savings and other non-energy savings by using the aggregate dollar information reported and dividing by the contract length for that project.

Finally, we adjust original turnkey project cost data to current 2009 dollars using annual GDP deflator information from the U.S. Bureau of Economic Analysis (BEA 2009a). We estimated the present value of future *direct* benefits for each project by summing the discounted future monthly dollar savings for the average estimated lifetime of the package of energy efficiency measures.

[10] We estimated the dollar value of first-year savings by multiplying reported energy savings by average electricity, gas (or water) prices for the appropriate year, state, and sector (i.e., residential, commercial, and industrial) based on Energy Information Administration (EIA) data. In order to capture the future value of energy savings beyond 2009, we used EIA forecasts of future electricity and natural gas prices to 2030 and consumer price escalation rates from the Federal Reserve Bank of Philadelphia for water price forecasts.

3. Overview of U.S. ESCO Industry

In this section, we define the ESCO market, present updated estimates of ESCO industry revenues and projected growth, and characterize the business ownership characteristics of ESCOs.[11]

3.1 Definition of the ESCO market

We define an Energy Service Company (ESCO) as:

> A company that provides energy-efficiency-related and other value-added services and for which performance contracting is a core part of its energy-efficiency services business. In a performance contract, the ESCO guarantees energy and/or dollar savings for the project and ESCO compensation is therefore linked in some fashion to the performance of the project.

This definition is in line with the European Commission Directive (2006/32/EC) on Energy End-use Efficiency and Energy Services (ESD) standard definition of an ESCO, in particular the delivery of energy services and that some degree of performance-based financial risk is held by the ESCO (Soroye and Nilsson 2010; Marino et al. 2010).

3.2 ESCO projects that target public/institutional sector customers tend to prefer performance-based contracts

Overall, about 68% of the 3,265 projects in our database utilized performance-based contracts. However, there are significant differences in contractual arrangements for ESCO projects in the public and private sector. About 73% of the public and institutional sector projects utilized a performance contract; in contrast, only about 40-45% of the private sector ESCO projects utilized a performance contract (see Figure 1). Among performance-based contracts, U.S. ESCOs and customers strongly favor guaranteed savings contracts; these contracts account for ~92% and ~75% of performance-based contracts in public and private sector markets, respectively.[12] Public sector customers prefer guaranteed savings contracts because of greater certainty of savings, while ESCOs cite lower financing costs (most public and institutional

[11] Some material in this section draws upon previous LBNL studies that analyzed ESCO industry and market trends (Hopper et al. 2007, Goldman et al. 2002) and defined the ESCO market (Goldman et al. 2005).

[12] In a guaranteed savings contract, the ESCO guarantees a certain level of energy or dollar savings sufficient to cover the annual debt service obligation, which limits the customer's performance risk. Projects are typically financed by a third party financial entity and the customer repays the loan to this entity; thus the lender manages credit risk (see Okay and Akman 2010), rather than the ESCO. If there is a shortfall in savings, the ESCO reimburses the customer for the shortfall. If savings exceed the ESCO guarantee, the customer typically keeps the excess.

customers can obtain tax-exempt financing) and lower transaction costs (ESCOs can focus on project performance).[13]

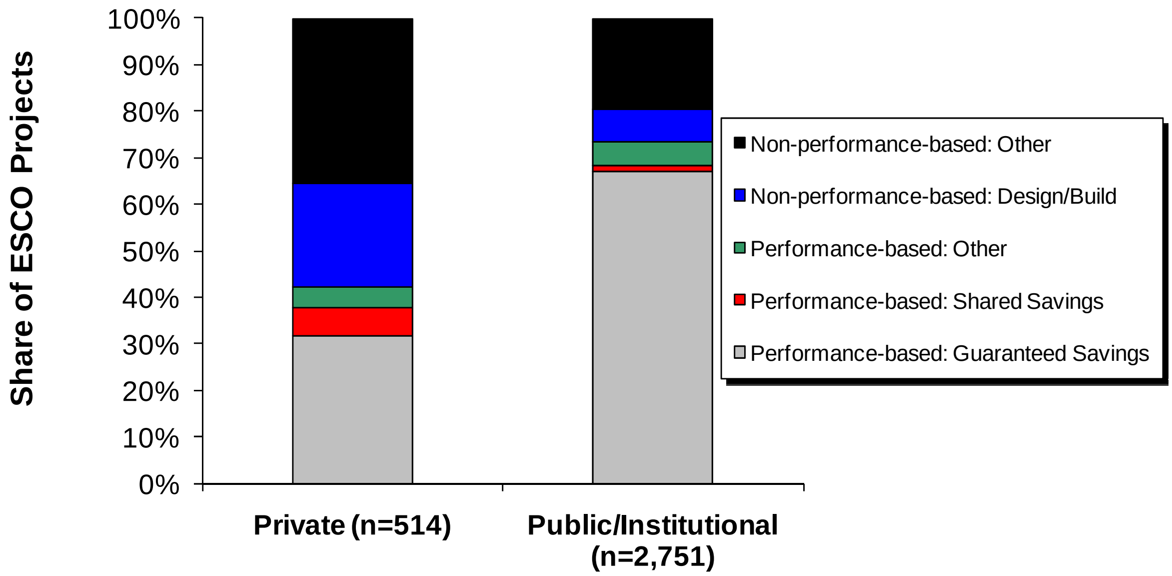

Figure 1. Contractual arrangements in ESCO projects: Public vs. private sector markets

3.3 U.S. ESCO industry: Current market size and prospects for growth

Survey respondents were asked to report their revenues from energy services in 2008[14], average annual growth rates since 2007, and projected growth in revenues for the 2009-2011 period. Aggregate revenues for the ESCO industry are estimated at about $4.1 billion in 2008 and are expected to increase significantly (see Figure 2).[15]

[13] In developing countries, shared savings contracts tend to be the preferred contract type for building retrofits (see Okay and Akman 2010). However, recent research on the rapidly growing Chinese ESCO industry indicated that there is a trend towards implementing guaranteed savings contracts, especially for the industrial sector (Da-li 2009).

[14] Survey respondents were asked to exclude retail commodity sales and projects built to supply power to wholesale markets from revenues.

[15] In estimating the size of the ESCO industry, we do not include companies such as engineering and architectural firms, HVAC, lighting, windows or insulation contractors, and consultants that offer energy efficiency services on a fee-for service basis or design/build contracts but typically do not enter into long term contracts that link compensation to the project's energy savings and/or performance. We also exclude companies that only provide onsite generation or renewable energy systems and do not implement energy efficiency measures in their projects under a performance-based contract.

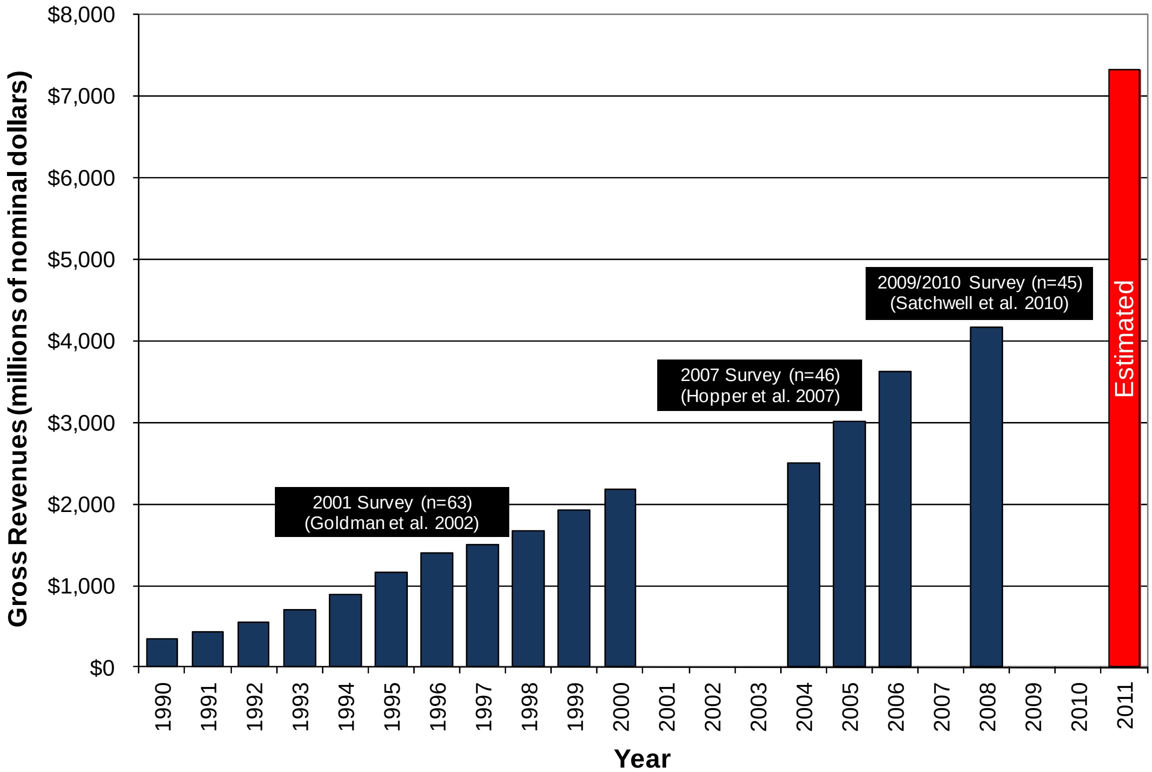

Figure 2. U.S. ESCO industry revenues with 2011 estimate

Hopper et al. (2007) estimated that ESCO industry revenues were $3.6 billion in 2006. Thus, our analysis suggests that ESCO revenues have increased about 7% per year since 2006. Based on the survey responses of individual ESCOs, we estimated that the ESCO industry in aggregate had annual revenues of about $7.1 billion in 2011 (see Figure 2); this represents an average annual growth rate of 26% per year for the 2009-2011 period. It is important to note that ESCOs are quite optimistic about their business prospects, even though the U.S. economy is just beginning to recover from a recession.[16] ESCOs clearly hoped to capitalize on energy efficiency programs initially funded by the American Reinvestment and Recovery Act (ARRA) of 2009. For example, about 51% of the $3 billion for the State Energy Program block grants was targeted at building retrofits primarily in public sector markets that have historically been receptive to ESCOs and performance contracts (Goldman et al. 2011). Some ESCOs also expected that the significant ramp-up in ratepayer-funded energy efficiency programs would improve the economics of projects for targeted customers (Barbose et al. 2009).

[16] There are several factors that may account for the gap between actual ESCO industry revenues in 2008 and the projections of 2008 revenues from the Hopper et al. (2007) study. These factors include: (1) an unexpected downturn in the U.S. economy, (2) ESCOs' projected activity level in private sector markets did not materialize, (3) tightening of customer credit markets, (4) slower than expected acceleration of the federal ESPC market, (5) industry consolidation, and (6) overly optimistic projections provided by our survey respondents.

3.4 ESCO business and ownership characteristics

We grouped ESCO survey respondents into four categories of business ownership: (1) companies that are owned by building equipment or controls manufacturers, (2) companies that are subsidiaries of electric or gas utilities, (3) companies that are owned by other types of energy companies such as gas producers and pipelines, and (4) companies that provide engineering services and are "independent" in the sense that they are not owned by utilities, energy companies, or equipment/controls manufacturers. ESCOs that are owned by building equipment manufacturers account for nearly half of all 2008 ESCO market share, which represents a significant increase in market share compared to the early 2000s (Goldman et al. 2005). Utility-owned ESCOs have the smallest market share at 8% of 2008 revenues (see Table 3). While many utilities acquired existing ESCOs or started their own ESCO business in the late 1990s as electric industry restructuring was beginning to unfold, their relatively low market share shows that this phenomenon was short-lived as many utilities divested their ESCO businesses as the enthusiasm for retail competition waned in the U.S. after the California electricity crisis. Engineering services companies are numerous (n=25), yet tend to be smaller in size and account for a smaller proportional market share (22%).

Table 3. ESCO business type and market share in U.S. (2008)

Company Type	Number of Companies	Percent share of 2008 U.S. ESCO industry revenues
Building equipment manufacturers	4	49%
Utility affiliates	5	8%
Engineering services companies	25	22%
Other energy companies	10	21%

4. Overall performance of projects and market activity

We estimate that the LBNL/NAESCO project database contains about 20% of all ESCO industry activity since 1990, representing over $8 billion ($2009) in total project investments.[17]

4.1 ESCO project activity in states: LBNL/NAESCO project database results

In establishing regional or local offices for business development and project implementation, ESCOs may consider the following factors: market potential of targeted sectors, favorable state policies (e.g., enabling legislation that allows or encourages performance contracting in various institutional markets, ratepayer-funded energy-efficiency programs), level of economic activity, population density, and actual and projected energy costs. ESCOs reported the geographic location of each project that was completed (see Figure 3). Five states (California, New York, Texas, Pennsylvania and Maryland) account for more than one-third of the total market activity based on projects in the database, with aggregate ESCO project investments exceeding $500M in each of these five states between 1990 and 2008.

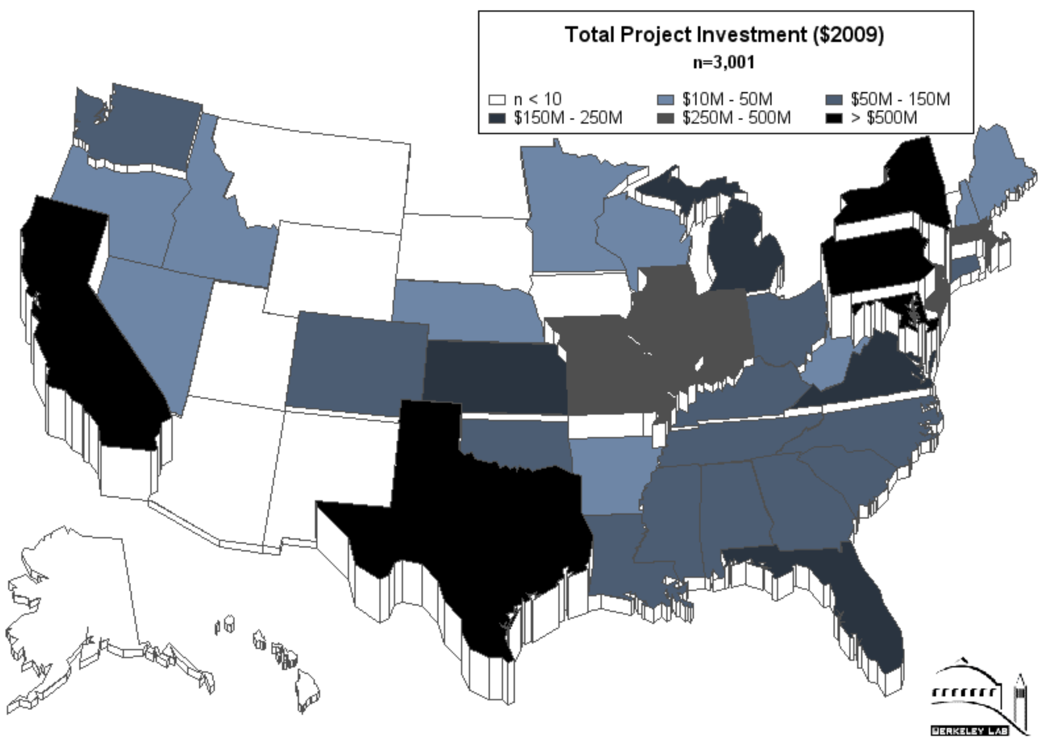

Figure 3. Aggregate ESCO database project investment levels by U.S. state

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[17] We estimated the share of ESCO industry projects in the LBNL/NAESCO database (~20%) by converting aggregate real project investment levels ($8.0 billion in 2009$) to nominal dollars ($6.7 billion) and then dividing by aggregate industry revenues for the period 1990 to 2008 ($33.8B) as reported by Satchwell et al. (2010) [see Figure 2]).

Goldman et al. (2002) ranked the top ten states in ESCO project activity in the LBNL/NAESCO database at that time and compared those rankings to economic, population, and policy factors. We have replicated this analysis with updated numbers for the top fifteen states in terms of project activity−in nominal dollars−and compare the results to the rankings in the Goldman et al. (2002) study (see Table 4).

Table 4. State-level ESCO project investments, economic activity, population, and utility incentive payments

State	ESCO Project Investment (database)		ESCO Project Investment (2002 database report)		Economic Activity (2008 GSP)[18]		Population (2009)[19]		Ratepayer Funded EE Program (REEP) Budgets (2009)[20]	
	Rank	($M)	Rank	($M)	Rank	($B)	Rank	(Million People)	Rank	($M 2009)
New York	1	773	1	328	3	1144	3	19.5	2	378.3
Pennsylvania	2	615	10	75	6	553	6	12.6	10	96.9
California	3	536	3	230	1	1847	1	37.0	1	998.3
Maryland	4	451	N/A[21]	175	15	269	19	5.7	21	38
Texas	5	447	4	199	2	1224	2	24.8	9	98.7
Missouri	6	348	N/A	97	22	229	18	6.0	27	22.7
Illinois	7	348	7	109	5	634	5	12.9	11	89.9
New Jersey	8	271	2	267	7	475	11	8.7	6	132.3
Massachusetts	9	227	5	136	13	352	15	6.6	3	183.8
Indiana	10	210	6	120	18	246	16	6.4	35	13.6
Florida	11	189	8	106	4	744	4	18.5	5	132.6
Kansas	12	184	N/A	15	32	123	33	2.8	43	3.7

[18] BEA (2009b)

[19] U.S. Census Bureau (2009)

[20] Molina et al. (2010)

[21] Goldman et al. (2002) reported only rankings for the top-ten states in terms of total project investment. We calculated the project investment for Maryland, Missouri, Michigan, Kansas, Virginia, and Washington, DC for all projects prior to 2002 but could not replicate rankings by state.

State	ESCO Project Investment (database)		ESCO Project Investment (2002 database report)		Economic Activity (2008 GSP)[18]		Population (2009)[19]		Ratepayer Funded EE Program (REEP) Budgets (2009)[20]	
	Rank	($M)	Rank	($M)	Rank	($B)	Rank	(Million People)	Rank	($M 2009)
Virginia	13	180	N/A	27	11	397	12	7.9	47	0.4
Michigan	14	172	N/A	131	12	383	8	10.0	16	50.1
Washington, DC	15	141	N/A	92	35	97	50	0.6	37	12.5

The data suggests that ESCOs tend to focus on larger markets, as defined by economic activity, but not exclusively (i.e., 11 states are ranked in the top 15 in terms of Gross State Product). Several states have a large number of federal customer facilities (e.g., Washington DC, MD, VA), which help explain the relative prominence of the ESCO industry in those states given the level of ESCO activity in the federal market. ESCOs also tend to focus on states with large populations (e.g., CA, TX, and NY) as 10 of the states with the largest dollar amount of project investment are ranked in the top 15 in terms of population (see Table 4).

We also compare ESCO project investment to ratepayer-funded energy efficiency program (REEP) budgets, as a proxy for an enabling state policy that may support the development of an ESCO industry (i.e. treating energy efficiency as a resource in the power sector that can defer and/or avoid supply-side investments). Eight states that rank in the top 15 in terms of spending on utility energy efficiency programs (CA, NY, MA, FL, NJ, TX, PA, IL) also rank in the top 15 in ESCO market activity. Several of these states (CA, NY, MA, NJ) have offered energy efficiency programs funded by utility customers for two decades; other states (PA, IL) have recently started to ramp up spending on utility energy efficiency programs, which suggests that this has not been a major factor driving ESCO market activity in those states. It should be noted that larger states tend to have larger REEP budgets. If we normalize for state population, five states that are ranked high in ESCO market activity are also highly ranked in terms of per-capita spending on ratepayer-funded energy efficiency programs (e.g., CA, NY, and MA spend ~$20-27 per person on utility energy efficiency programs).

State policies that permit performance contracting in the public sector may well be the single most important factor driving ESCO market activity in some states. For example, states such as Missouri, Kansas, and Indiana rank high in ESCO market activity; energy offices in these states have championed performance contracting in institutional/public sector markets, although they are not highly ranked in terms of population, economic activity or large-scale energy efficiency programs funded by utility customers. Bharvirkar et al. (2008) studied the magnitude of energy efficiency activity in the state government market, with a focus on performance contracting activity and found that Pennsylvania, Maryland, Massachusetts Missouri, Kansas, and Texas had the highest levels of performance contracting investment in the state government sector since 2000.

Although closely related to population, states with significant accumulated deferred maintenance in K-12 schools appear to be another factor considered by ESCOs in selecting target markets. Crampton and Thompson (2008) discuss state-by-state accumulated deferred maintenance issues for K-12 schools.

4.2 Market activity

The "MUSH" markets—municipal and state governments, universities and colleges, K-12 schools, and hospitals—have historically been targeted by U.S. ESCOs and account for 68% of the projects in the LBNL/NAESCO database. When combined with ESCO projects that target federal customers, we observe that ~85% of ESCO projects in the database target public and institutional sector markets (see Table 5).

Table 5. ESCO activity by market sector and segment

Market Sector	Market Segment	Percentage Share of Projects (n=3,265)
Public and Institutional Sector (85%)	K-12 Schools	33%
	State/Local Government	15%
	Federal Government	14%
	Universities/Colleges	12%
	Health/Hospitals	8%
	Public Housing	3%
Private Sector (15%)	Commercial Office	6%
	Industrial	4%
	Retail	2%
	Other	2%
	Hotel/Hospitality	1%
	Residential	1%

The most recent survey of ESCOs found very similar results: the MUSH markets account for $2.8 billion in ESCO revenues in 2008 or about 69% of total industry activity (see Figure 4). ESCOs report that the MUSH market share of total ESCO revenues has increased over 10% since 2006 and we found similar market trends within the project database.

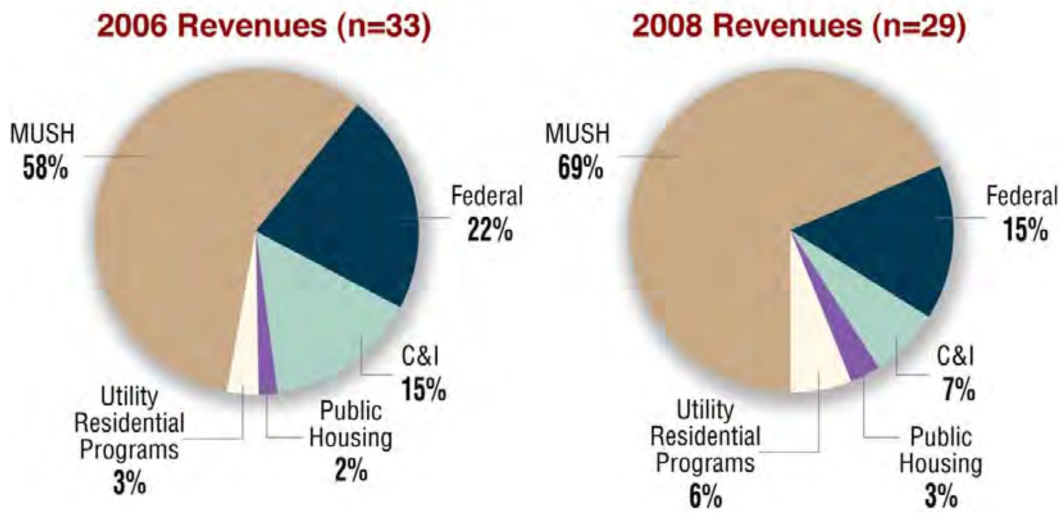

Figure 4. 2006 and 2008 ESCO industry revenues by market segment[22]

The U.S. MUSH market is relatively mature as ESCOs have actively been developing projects for more than two decades in this market. However, the remaining market potential for energy efficiency is still quite large. An analysis conducted by LBNL indicated that remaining energy efficiency opportunities in larger facilities in the MUSH market could produce annual energy savings of 160 million MMBtu, lifetime savings of 2.4 billion MMBtu and require about $35 billion in additional ESCO investment (Goldman and Bharvirkar 2007).[23]

4.3 Overall economic performance of ESCO projects from the customer's perspective

We calculated simple payback times and net benefits for ESCO projects. Figure 5 shows the median and inter-quartile range of simple payback time for ESCO projects in K-12 schools, all other public sector markets, and private sector projects, grouped by retrofit strategy.[24] ESCO projects in K-12 schools had the longest median payback times for all retrofit strategies (i.e., 7-15 years). With the exception of non-energy projects, ESCO projects in other public and institutional markets had longer median payback times compared to ESCO projects that targeted private sector customers for each retrofit strategy. The median payback times for ESCO projects in the public/institutional sector (except for K-12 schools) was 7-10 years for onsite generation, non-energy, and major HVAC retrofits. In contrast, median payback time for lighting only

[22] Breakdown of industry revenues by market segment came from surveys conducted by Hopper et al. (2007) and Satchwell et al. (2010).

[23] LBNL assumed that ESCOs would target facilities greater than 50,000 square feet (which accounts for about 65% of the floor area), that ESCOs had achieved ~40-45% market penetration in the MUSH market based on survey responses from ESCO senior executives, and that ESCOs could achieve savings and cost per square foot levels that were comparable to completed projects in the ESCO database.

[24] Project simple payback times are project installation costs—with no financing charges included—divided by the dollar value of annual energy and operations and maintenance (O&M) savings.

retrofits was 2 to 3 years in ESCO projects that target private and public sector customers, respectively.

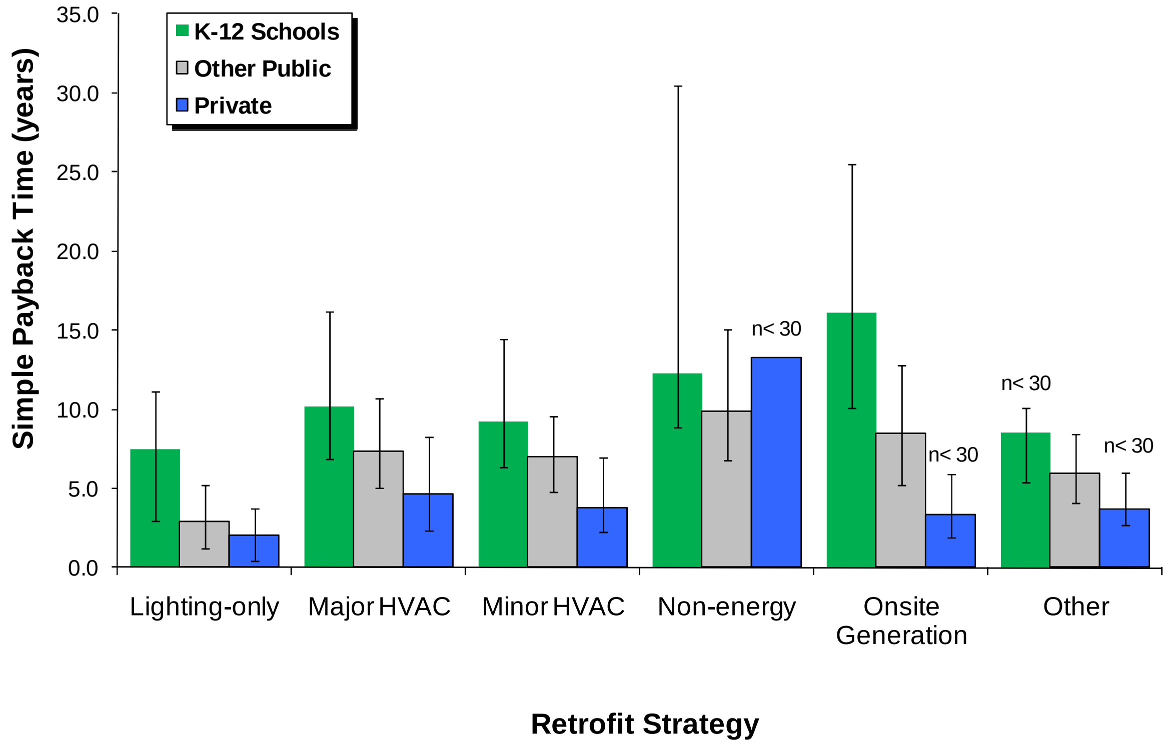

Figure 5. Simple payback times for K-12 schools, all other public, and private sector projects[25]

We also calculated net benefits[26] for a sample of 2,484 projects that provided sufficient information and aggregated project-level results in order to report aggregate net benefits for projects in various market segments: federal government, state/local government, hospitals, public housing, K-12 schools, universities/colleges, and private sector (see Table 6). We estimate that public sector projects in our database generated over $3.4 billion (n=2,131) while private sector projects produced over $500 million (n=353) in direct net economic benefits to customers.

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25 The top and bottom whiskers represent the inter-quartile range – the 75th and 25th percentile of the data, respectively. The height of the bar represents the 50th percentile (i.e., median) of the range of data.

26 Direct benefits – energy cost and non-energy operational savings (when reported) – are included in our analysis, but not indirect benefits, such as improved building comfort, employee productivity, avoided capital costs, environmental benefits. We also do not attempt to quantify societal benefits (e.g., reduced pollution, avoided greenhouse gases, avoided generation or transmission infrastructure costs or economic development benefits). *Complete details of our economic analysis assumptions are discussed in Appendix A of this report.* Net benefits for each project were estimated by subtracting the project cost without financing from the discounted gross benefits. Gross project benefits were estimated by discounting future monthly dollar savings for each year through the average ECM lifetime for every project and then summing these discounted values to produce the present value of future benefits. We used a monthly discounting method, because project savings transactions are typically settled each month and not at the end of each year.

If we assume that the net benefits per project are comparable for ESCO projects that are not included in our database sample, this would suggest that projects installed by ESCOs between 1990 and 2008 have generated nearly $23 billion ($2009) in net direct economic benefits for customers.[27] We estimate that a typical private and public sector project had benefit-cost ratios of 2.6 and 1.4, respectively. A typical ESCO project targeting private sector customers produced $2.52 in net benefits for every square foot of floor area, while a typical ESCO public sector project generated $0.89 in direct net benefits per square foot of floor area.

Table 6. Direct net benefits[28] of ESCO projects by market segment

Market Segment	Count	Total Net Benefits* (million US$)	Median Project Benefit-cost Ratio*
Federal Government	319	$2,111.9	1.7
State/local Government	367	$442.3	1.5
Health/Hospitals	186	$330.5	2.6
Public Housing	68	$68.8	1.4
K-12 Schools **	910	$28.4	1.1
Universities/colleges	281	$442.9	1.4
Private	353	$512.9	2.6
Total	***2,484***	***$3,937.8***	

* Estimate includes projects implementing all retrofit strategies including major HVAC, minor HVAC, onsite generation, lighting-only, non-energy, and other.
** Discussion of performance of K-12 schools immediately follows in Section 4.4.

4.4 Deferred maintenance and the performance of projects at K-12 schools

Net direct benefits were typically lowest–and in some cases negative–for ESCO projects implemented in K-12 schools (see Table 6)[29]. There are examples of K-12 schools paying for the entire cost of facility renovations using energy savings from performance-based contracts (Zorn 2006). Our results indicate that a typical K-12 school's direct benefits−over the average lifetime of the installed measures−are slightly more than the turnkey installation costs (i.e., the median value of 920 K-12 schools projects).

Our analysis suggests that several additional factors help explain the marginal economics of many ESCO projects in K-12 schools. First, ESCO projects are being implemented to partially offset substantial accumulated deferred maintenance needs in K-12 schools and include some

[27] We estimated aggregate net direct benefits to customers for all projects installed by ESCOS during the 1990-2008 period by multiplying the inverse of the nominal dollar market share of projects with net benefits (i.e., 1/0.172) against the total net benefits for projects in our database ($3.94 billion; see Table 6). We determined the nominal dollar industry share for projects with net benefit information (17.2%) by dividing the nominal industry revenue estimate for 1990-2008 from our periodic surveys ($33.8 billion) by the aggregate project installation costs (nominal) for projects with net benefits ($5.8 billion).

[28] We report results assuming a 3% and 8% real discount rate for public and private projects, respectively.

[29] We estimate that ~50% of all school projects in our database (n=415) had negative net benefits, while less than 20% of projects in other markets had negative net benefits (n=306).

measures (e.g., new roofs) that do not provide energy savings but are integral to maintaining or repairing the physical infrastructure. K-12 schools projects installed the greatest share of "non-energy improvements" (e.g., asbestos, wiring) and miscellaneous equipment systems" (e.g., exit signs, alarm systems).[30] Non-energy retrofits at K-12 schools typically cost more to install per square foot relative to other retrofit strategies and at other types of public and private projects (see Figure 7). We found that ~40% of all K-12 schools projects installed non-energy related retrofits between 2005 and 2008. Over the same period, less than 15% of projects from other public and private market segments reported undertaking non-energy retrofits. Hopper et al. (2005) noted that non-energy measures often "piggyback" on energy savings measures, which are vital to the project. Thus, it should not be concluded that these types of projects do not save energy, but they may have relatively poor economic performance because the savings are used to partially offset non-energy-related infrastructure upkeep.

Second, K-12 schools tend to have lower hours of operation than other public/institutional sector markets and often have minimal operations during summer months when energy costs are typically highest.[31] Third, energy efficiency savings potential may be lower in K-12 schools than other public sector markets because K-12 schools tend to be less energy-intensive and have lower baseline energy use prior to retrofits than other public/institutional sectors. We discuss these three factors in more depth in the following section.

Crampton and Thompson (2008), Bello and Loftness (2010), and ASCE (2009) report that U.S. public schools are the oldest buildings that typically have the largest backlogs of deferred maintenance compared to all other public facilities and infrastructure. Crampton and Thompson (2008) estimate that K-12 schools in the U.S. have a total backlog of infrastructure upkeep that exceeds $250 billion.[32] Underfunding K-12 school facility upkeep and maintenance is not a new issue or unique to the United States (OECD 1992). For example, Mahoney and Thompson (1998) suggest using performance contracting to address capital improvement needs in lieu of budget shortfalls; their report focuses on how the ESCO business model can be used to upgrade facilities without relying on public debt (i.e., bonds). ESCO projects in K-12 schools are using performance-based contracting to partially−but not fully− offset substantial accumulated deferred maintenance needs, which impacts project performance. First, the types of measures being installed by K-12 schools (Figure 6) to address the backlog of infrastructure upkeep typically cost more to install per square foot (see non-energy projects in Figure 7).

[30] There is a statistically significant difference in the share of projects reporting certain measures among K-12 schools compared to other public and private sector projects (see Figure 6). The Kruskal-Wallis test was used to test for differences among groups of data with the assumption that the underlying data is not normally distributed.
[31] Lower operating hours during times when energy prices are high means that payback times are longer for schedule-driven measures (e.g., lighting, air-conditioning).

[32] Crampton and Thompson (2008) focused on identifying the top ten states in terms of K-12 school infrastructure funding needs. Their list of top ten states is closely aligned with our database results showing ESCO project activity by state (see Table 4).

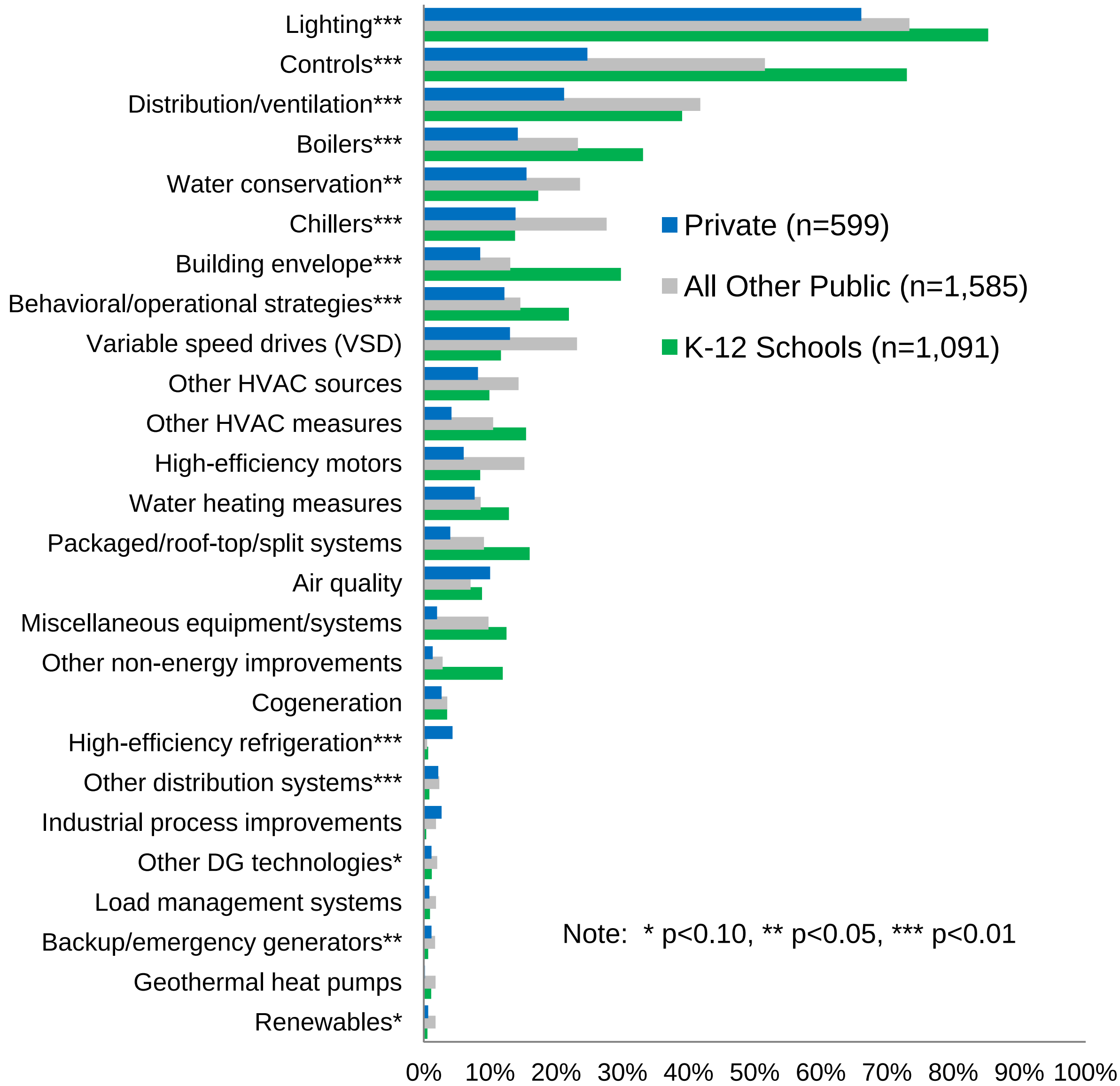

Figure 6. Percentage of projects installing different types of measures

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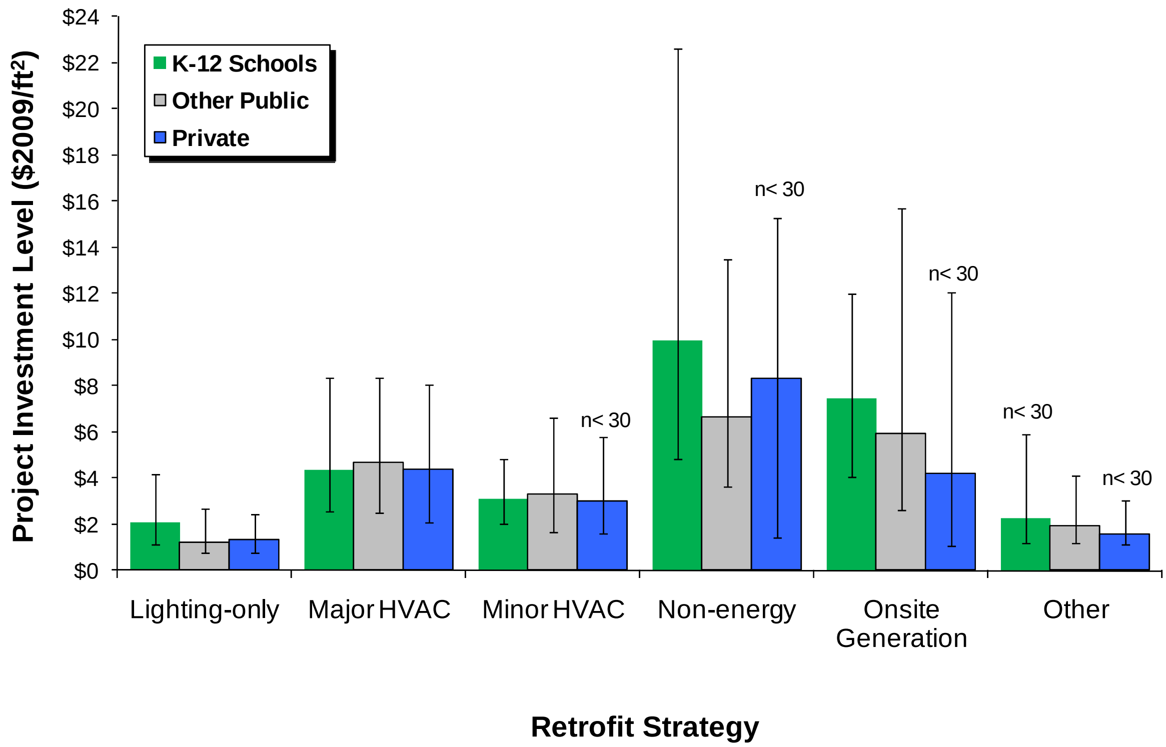

Figure 7. Normalized project investment levels for K-12 schools, other public and private projects

Median annual electricity and fuel (i.e., blended) usage before and after retrofit is lower in the typical K-12 schools project compared to other public sector and private sector projects (see Figure 8).[33] One contributing factor is that schools are typically open fewer hours in the year compared to other types of facilities and, in some cases, K-12 schools do not operate at full capacity during the summer months when electricity prices are typically higher.

[33] Blended means use and savings associated with electricity, gas, oil, and other fuel types. Results are typically reported in Btu/ft^2.

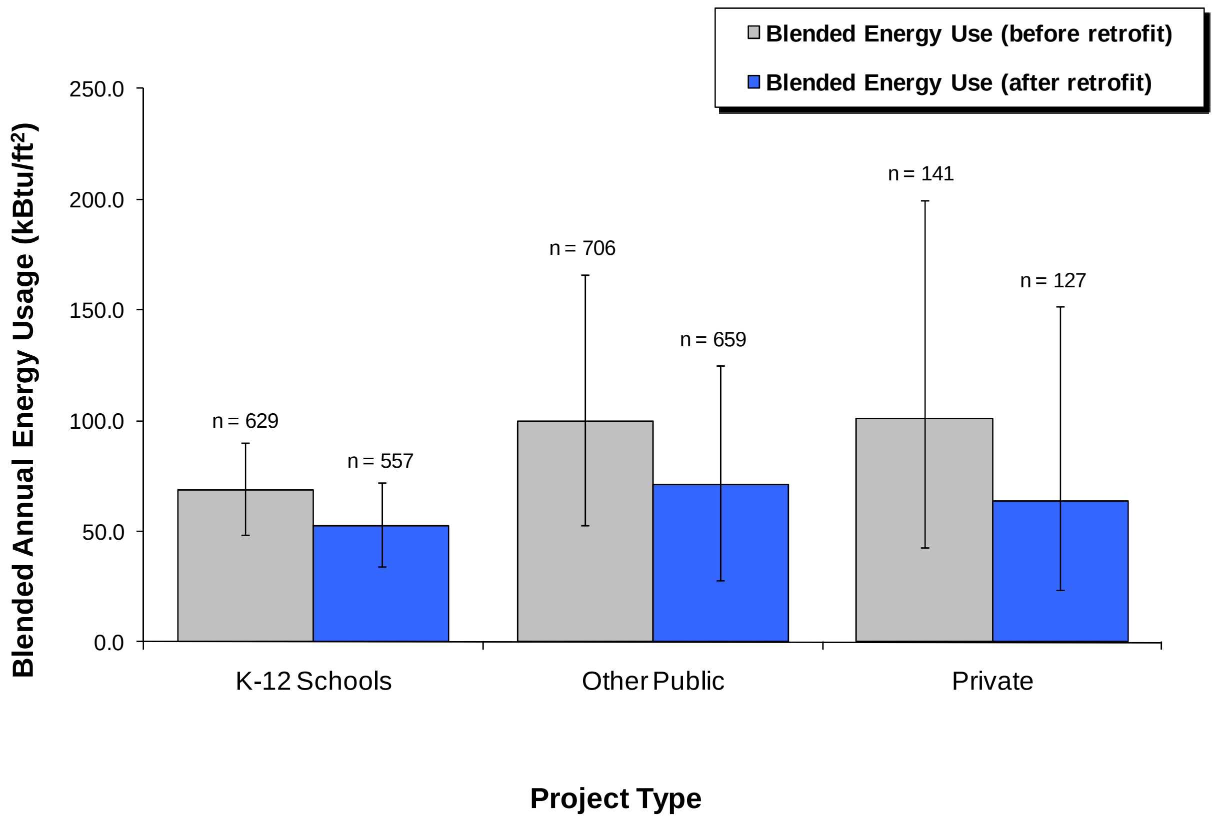

Figure 8. Blended annual energy usage before and after facility retrofit by project type

Thus, the median value for reported annual dollar savings at K-12 schools lag behind other market sectors (see Figure 9) and K-12 schools report the largest share of non-energy savings to overall savings.[34]

[34] It is important to note that ESCOs typically estimate energy savings from projects using an accepted method from the International Performance, Measurement, and Verification Protocol (IPMVP) , but there are currently no international standards in place for collecting, estimating, and/or monetizing non-energy savings (e.g., avoided O&M and capital costs) despite a clear need (Birr and Singer 2008). Standardizing methods to monetize and report the value of avoided capital costs and other non-energy benefits will allow us to more accurately capture the value of these projects to K-12 schools customers.

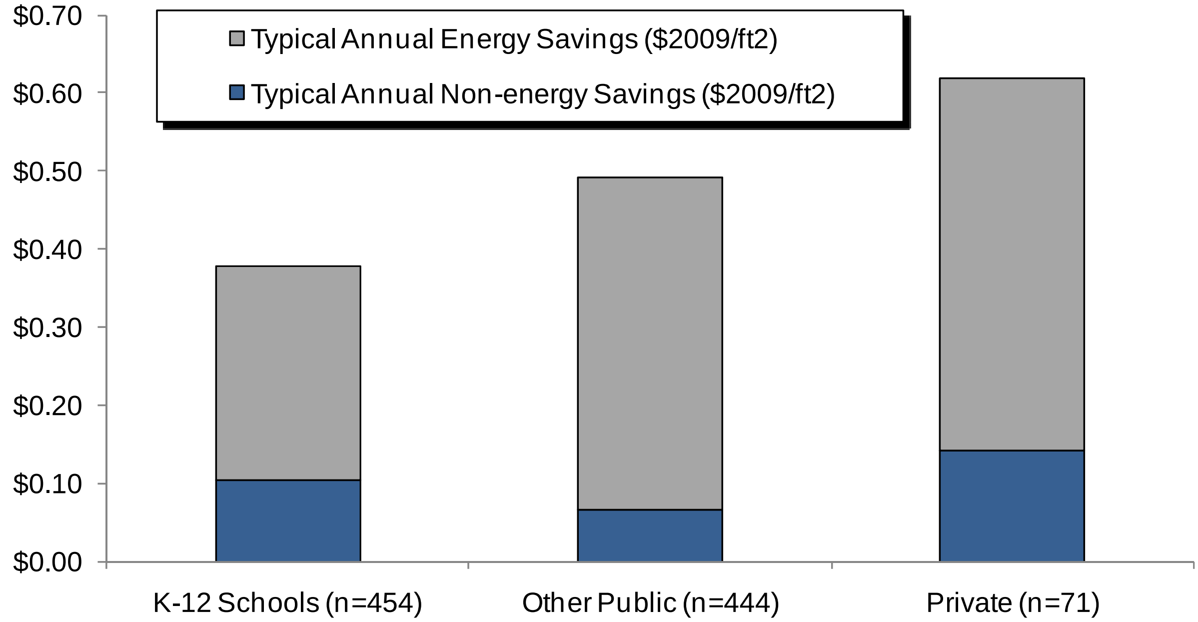

Figure 9. Median annual energy and non-energy-related annual dollar savings per square foot by project type

In summary, the combined effect of: (1) installing measures with relatively higher costs per square foot that address accumulated deferred maintenance, (2) lower overall energy savings potential, and (3) a lower dollar savings potential due to reduced operating hours during times of high energy prices leads to many K-12 schools projects having modest net direct economic benefits. That said, it appears that these projects are highly valued by facility managers at K-12 schools because they are often funded by supplemental sources (e.g., capital improvement bonds) and help address O&M issues associated with aging equipment and deteriorating physical infrastructure.

5. ESCO project-level trends in public and private sector markets

Our analysis of ESCO project data strongly suggests that the ESCO industry is moving away from installing lighting-only retrofits and is increasingly focused on developing more complex, comprehensive and capital-intensive projects in all markets segments. In this section, we define a comprehensive retrofit and analyze market, cost and savings trends for various types of retrofit strategies. We show that project installation costs per square foot are increasing faster than savings which leads to longer project payback times and lower benefit-cost ratios.

5.1 Definition of a comprehensive retrofit

We build on research by Amann and Mendelsohn (2005) and define a comprehensive retrofit as the:

> Installation of multiple measures that address the full range of energy efficiency and, in some cases, supply opportunities in an individual building as well as any interactive effects among system components or building systems. For purposes of this analysis, comprehensive retrofits incorporate multiple measures and include strategies related to address major HVAC, onsite/distributed generation, and non-energy savings.

5.2 Public and private projects are installing more comprehensive retrofits over time

We explored trends over time in the comprehensiveness of ESCO projects by analyzing the relative market shares of different retrofit strategies in various market segments and by tracking counts for the number of measures installed at a typical project (i.e., the number of unique measures installed at a project).

For projects installed by ESCOs in the facilities of private sector customers, lighting-only retrofits accounted for 53% of all projects during the 1990-97 period and then decreased to 33% of all private sector projects during the 2005-2008 period (see Figure 10). However, the popularity of onsite generation projects has increased over time as they account for 24% of all private sector projects between 2005 and 2008.

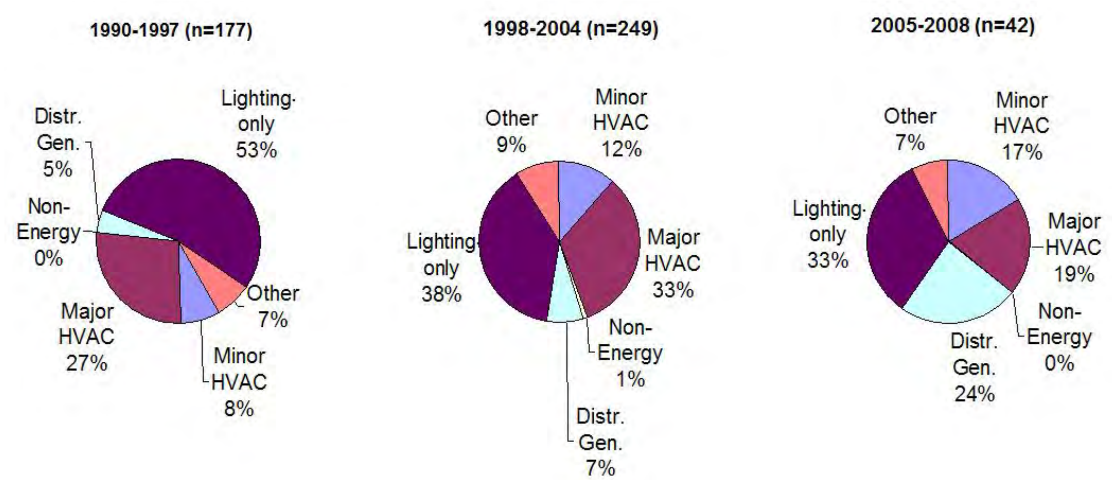

Figure 10. Types of retrofit strategies utilized by ESCOs in private sector projects: 1990-2008

A different picture emerges in the public /institutional sector where major HVAC has remained the dominant retrofit strategy since the early 1990s (46% to 54% of public sector projects were major HVAC retrofits; see Figure 11). Lighting-only projects in the public/institutional sector have decreased from 25% of all projects between 1990 and1997 to only 3% between 2005 and 2008. Onsite generation projects account for an increasing share of ESCO projects in the public sector (5% in 1990-97 vs. 11% in 2005-2008).

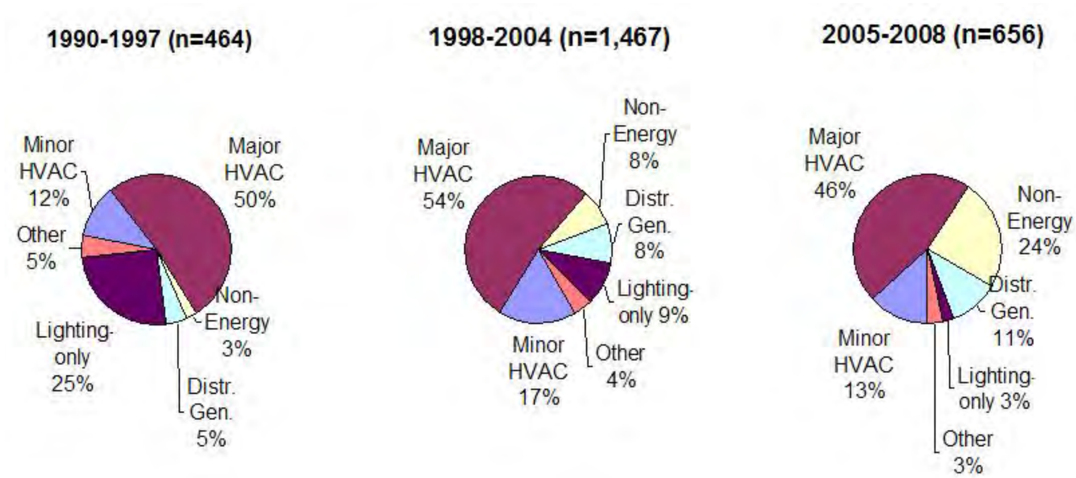

Figure 11. Types of retrofit strategies utilized by ESCOs in public sector projects: 1990-2008

We also found that the number of unique, efficiency measures typically installed by ESCOs in K-12 schools projects tended to increase over time (i.e., four measures per project in 1990-1997 to ~7 measure per project in the 2005-2008 period), which is an indicator of more comprehensive retrofits (see Figure 12). We also observed this trend of more measures installed among other public sector and private sector projects in earlier time periods (through 2005), although the typical number of ECMs installed appears to be leveling off over time since 2005.

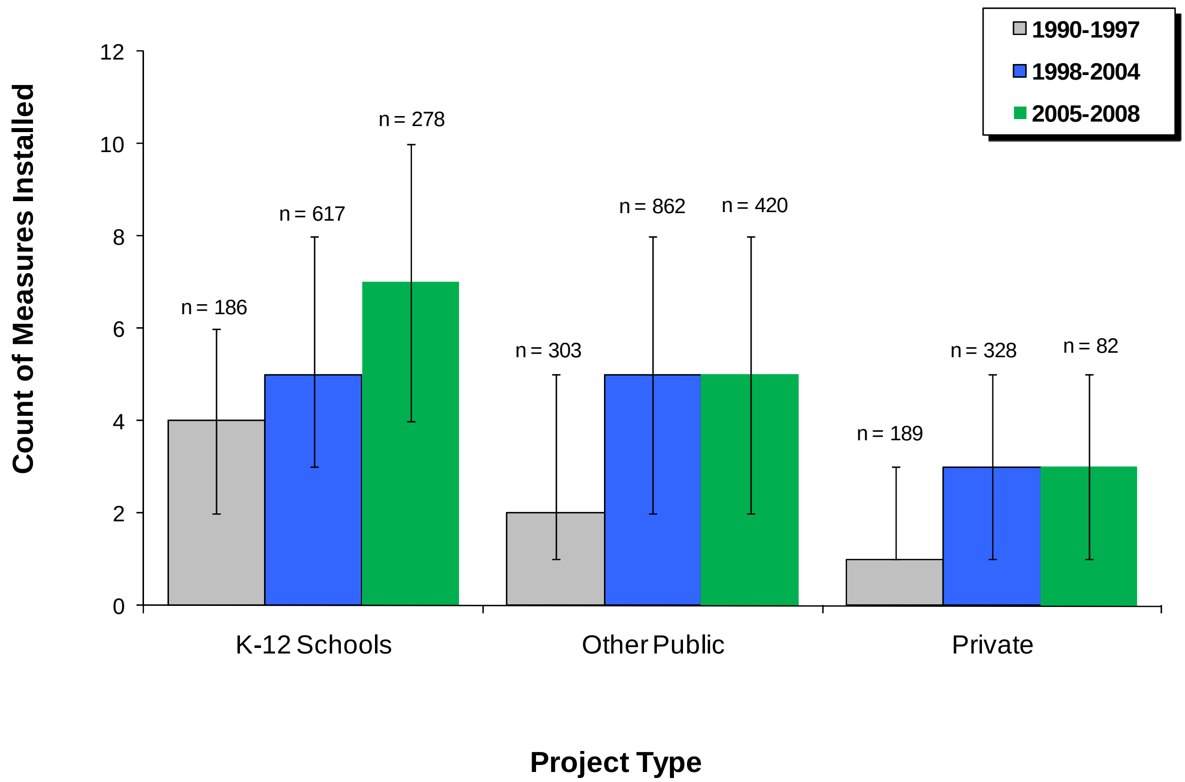

Figure 12. Median number of energy conservation measures installed per project in K-12 schools, and projects in other public/institutional and private sector markets

5.3 Comprehensive retrofits typically cost more to install per square foot of floor area

In section 4.4, we reported project installation costs per square foot disaggregated by market segment (K-12 schools, all other public sector facilities, and private sector projects) and retrofit strategy (see Figure 7). We find significant variation in project costs normalized by floor area for each retrofit strategy: for projects that implement a similar retrofit strategy, costs/ft^2 vary by a factor of ~2-4 for the middle 50% of projects (i.e. inter-quartile range). Among the six retrofit strategies, we assume that projects that implemented major HVAC, onsite generation and non-energy measures (along with other measures) can be characterized as "comprehensive" retrofits. Median project installation costs per square foot were ~2-4 times higher for major HVAC projects ($4.6/ft^2; n=1,085), onsite generation projects ($6.8/ft^2; n=165), and non-energy projects ($9.1/ft^2; n=253) compared to lighting only and minor HVAC projects (see Figure 7). In Figure 13, we classify projects as "comprehensive" or "non-comprehensive" based on their retrofit strategy and present results by market segment. We find that median project costs tend to be higher for comprehensive projects compared to non-comprehensive projects and that project costs tend to be higher at K-12 school projects compared to projects implemented in other public/institutional and private sector facilities.

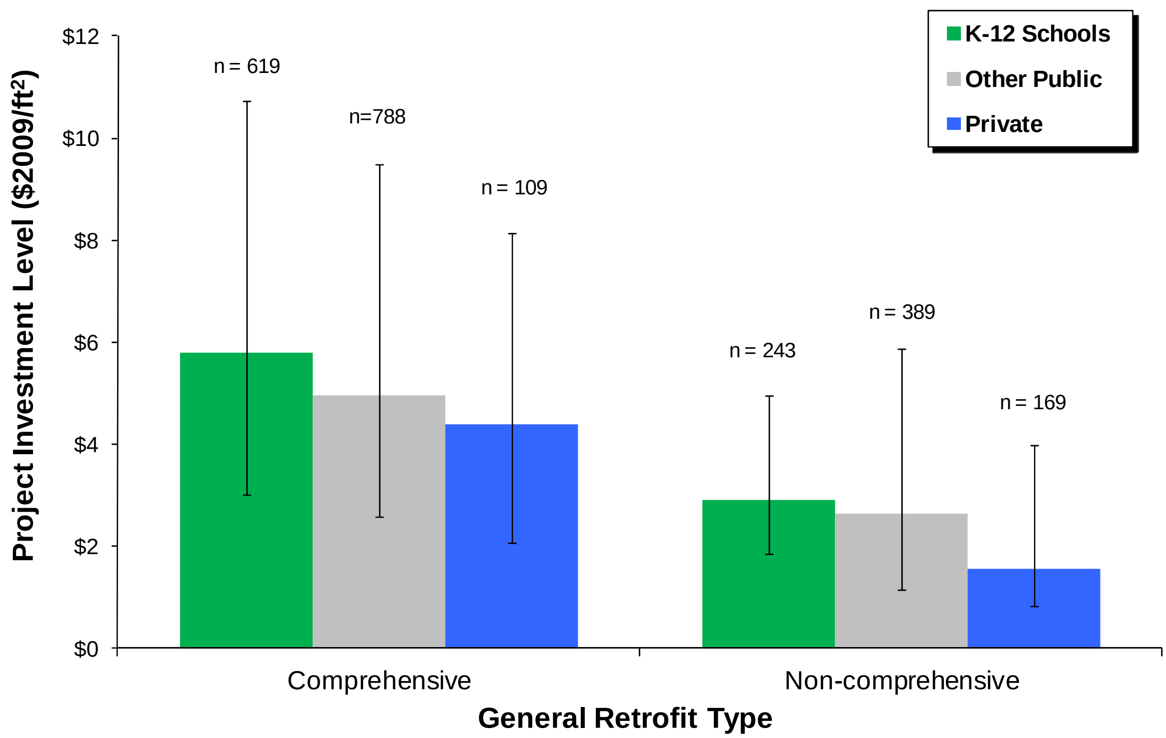

Figure 13. Project investment levels for comprehensive and non-comprehensive projects in K-12 schools, other public and institutional, and private sector markets

5.4 Project installation costs are increasing faster than savings

Our results suggest that changes in the mix of retrofit strategies over time (e.g., more distributed generation projects, fewer lighting only projects, more projects that include non-energy measures in K-12 schools) may be influencing the observed trend of increased per-project investment levels in various market segments. We found that median project investment levels more than doubled in the last decade, even after accounting for the effects of inflation and floor area (see Figure 14).[35]

[35] In Japan, Murakoshi and Nakagami (2009) found that per-contract investment levels were also increasing due in part to trends related to project diversification, onsite generation, and a general move towards larger scale EE projects.

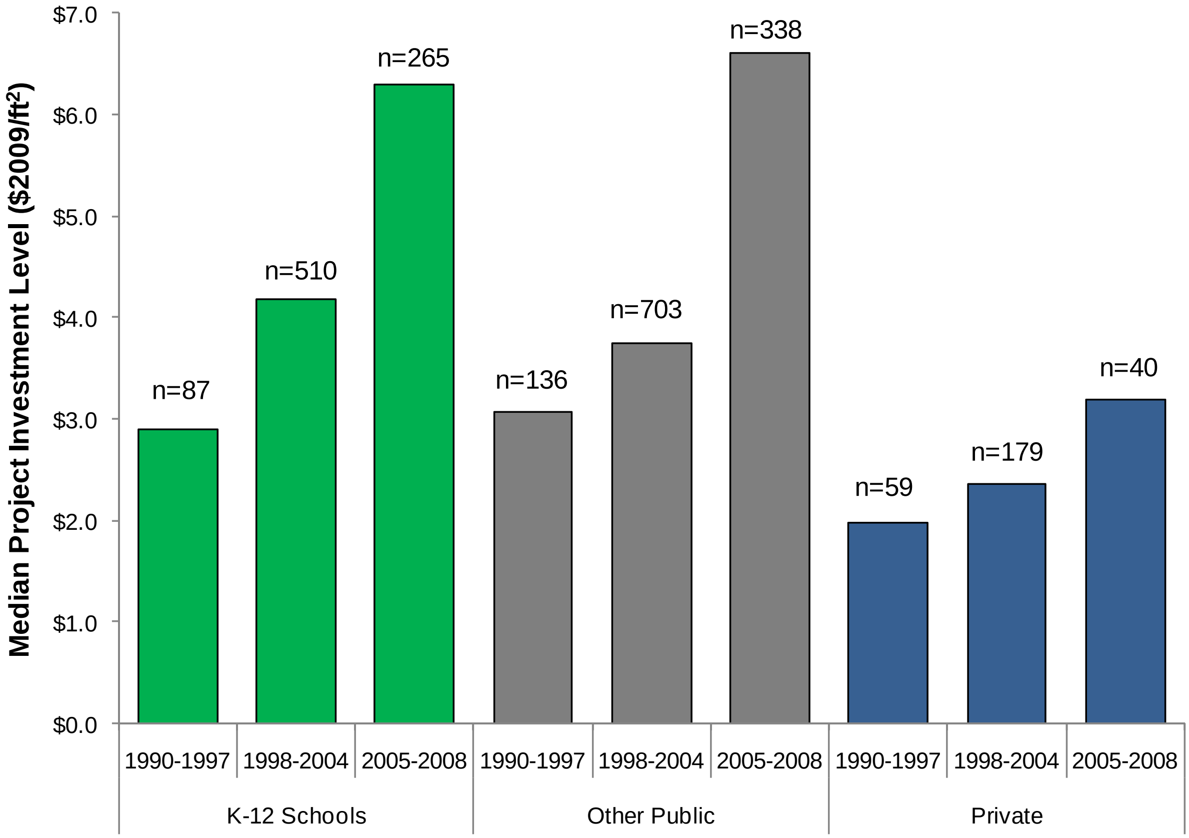

Figure 14. Median values for investment intensity over time in K-12 schools, and projects in other public/institutional and private sector markets

We also surveyed ESCO industry executives to learn more about their views on trends in project investment levels in an effort to better understand results from our analysis of the LBNL/NAESCO project database. Specifically, we asked ESCOs whether they believed installed project costs (i.e., per-project ESCO investment levels) have been increasing, decreasing, or staying about the same over the past decade. About 60% of the 26 ESCOs that responded to this question stated that they believed project installation costs have been increasing over the past decade, while 40% indicated that project installation costs have remained “about the same” (see Figure 15).

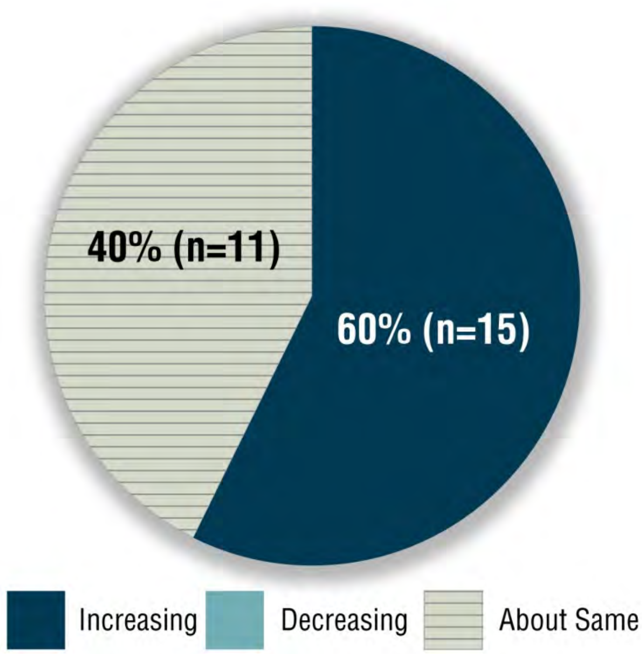

Figure 15. Have project installation costs been increasing, decreasing, or staying about the same over the past decade?

We also asked ESCOs to rank factors that they believe are most influential in changing long-run project installation costs. Table 7 ranks factors listed by ESCOs in order of most influential to least influential. Not surprisingly, the most influential factor in project cost increases has been increasing costs of ESCO production inputs, including labor and material costs. This response suggests that labor and materials costs may be increasing faster than the rate of inflation, which we corrected for in our analysis of project installation costs. ESCOs ranked factors such as market barriers (e.g., transaction costs and contract rules), demand for more comprehensive (larger) retrofits, and "other factors" (e.g. outside consultant costs) as having moderate influence (scores of 5 to 6 on average) in contributing to increased project costs; these factors ranked much lower than ESCO production inputs.

Table 7. What factors most influenced increasing project investment levels (i.e., customer installation costs)?

Factor[36]	Rank	Average Score[37]
ESCO production inputs (e.g., labor and material costs)	1	2.6
Market barriers (e.g., transaction costs, contract rules)	2	5.1
Demand for comprehensive/capital-intense retrofits	3	5.1
Other factors	4	6.3

5.5 Trends in project savings metrics

ESCOs typically use several M&V options included in the International Performance Measurement Verification Protocol (IPMVP) to estimate savings for energy efficiency measures installed at a project site relative to baseline usage. For some projects, including lighting-only installations, ESCOs reported baseline consumption only for the lighting equipment to be replaced (IPMVP Option A or B). In more comprehensive projects, ESCOs typically estimate baseline consumption using total facility energy consumption from an analysis of customer utility bills (IPMVP Option C). The majority of projects reported baseline values using either total (utility bill) or equipment-targeted metrics (see Figure 16).[38]

[36] The survey included nine factors for the ESCO respondent to rank and we combined the nine factors into four mutually exclusive factors for purposes of analysis and reporting.

[37] 1=most influential; 9=least influential.

[38] ESCOs report annual project savings in a number of different units of measurement including: kilowatt-hours (kWh), therms of natural gas, therms of other fuel types (e.g., coal, oil), and gallons of water.

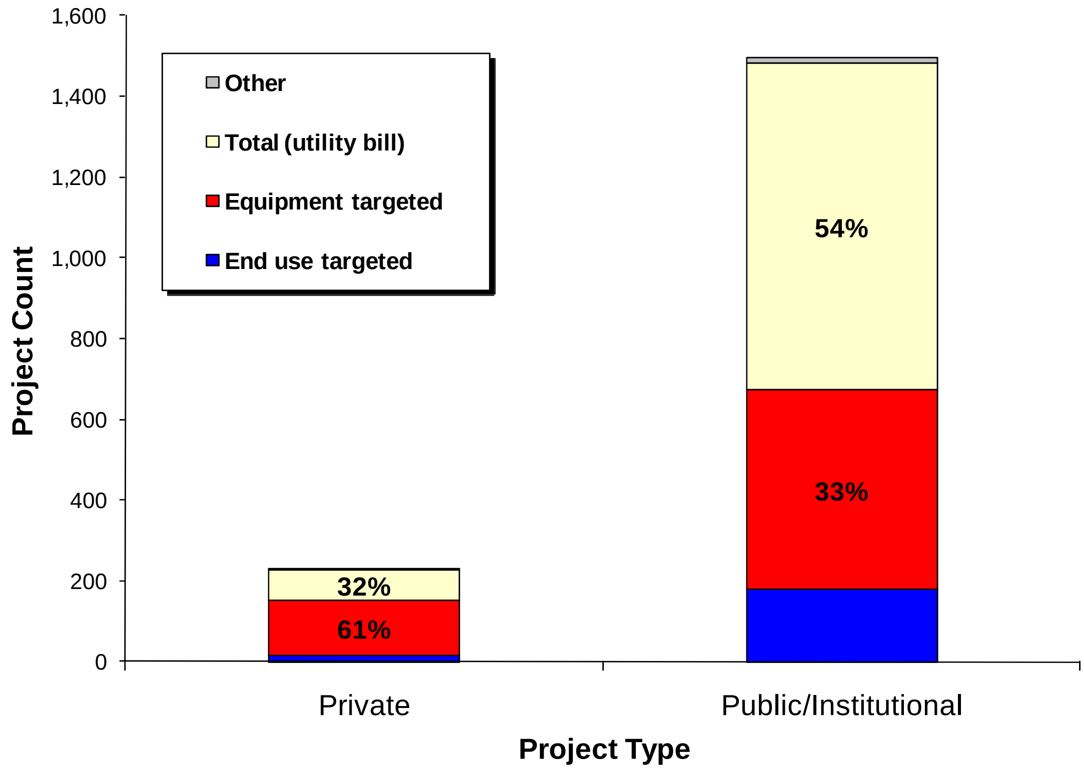

Figure 16. Share of reported baseline consumption metrics

Because ESCOs install measures that produce savings in both electricity and/or fuel consumption, we calculated the dollar value of savings for each project. We found that median values for annual dollar savings (normalized for floor area) increased since the 1990-97 period for K-12 schools, other public sector and private sector projects, but at a much slower pace than the observed rate of increase in project installation costs (see Figure 17).

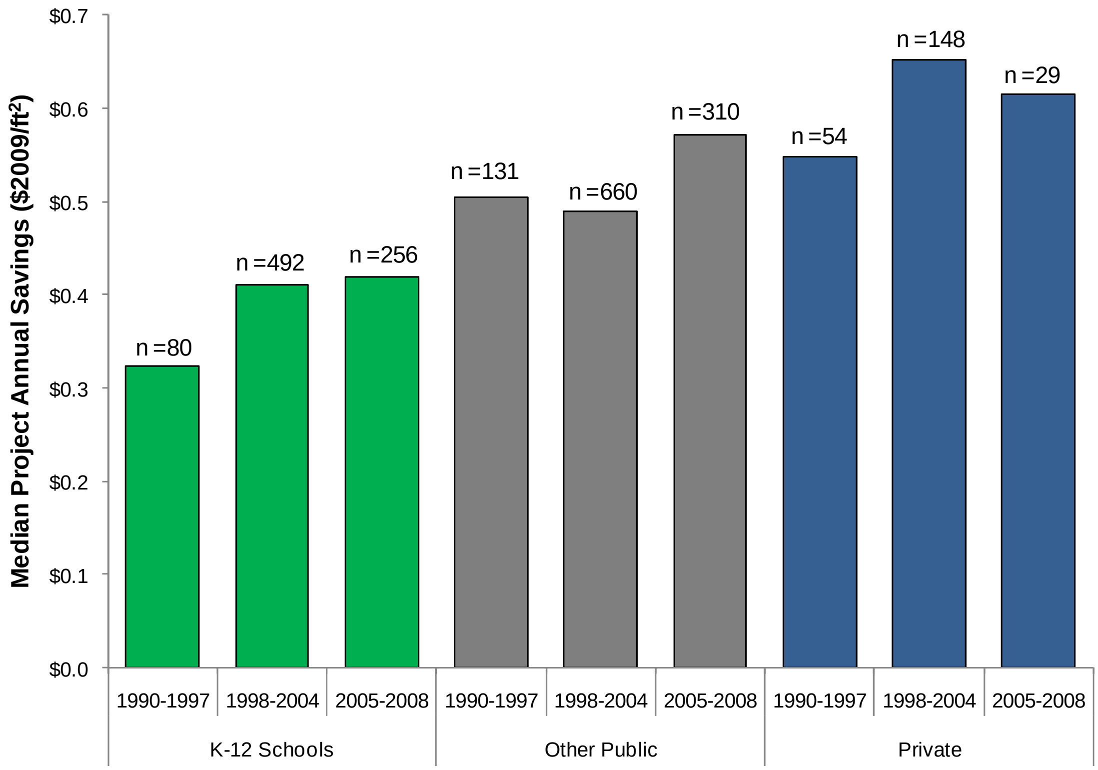

Figure 17. Median values for annual savings intensity over time for ESCO projects in K-12 schools, and projects in other public/institutional and private sector markets

5.6 Trends in project economics and net benefits

Table 8 shows median simple payback times and benefit-cost ratios for K-12 schools, all other public sector, and private sector projects disaggregated by time period: 1990-1997, 1998-2004, and 2005-2008.

Table 8. Median payback times and benefit-cost ratios for ESCO projects by market segment

Market segment	Installation Year	Simple Payback Time (years)	Benefit-cost Ratio
K-12 Schools	1990-1997	8.2 (n=125)	1.5 (n=121)
K-12 Schools	1998-2004	9.6 (n=540)	1.1 (n=536)
K-12 Schools	2005-2008	13.1 (n=263)	0.9 (n=263)
Other Public	1990-1997	3.9 (n=225)	3.0 (n=220)
Other Public	1998-2004	7.0 (n=724)	1.6 (n=708)
Other Public	2005-2008	9.0 (n=353)	1.2 (n=339)
Private	1990-1997	1.9 (n=138)	4.3 (n=138)
Private	1998-2004	3.7 (n=197)	2.2 (n=185)
Private*	2005-2008	3.2 (n=33)	2.7 (n=31)

Median payback times for ESCO projects are increasing over time in all market segments. For example, the median payback time in private sector projects increased from 1.9 years to 3.7 years after the initial installation period (1990-1997), but the most recent time period—with a smaller sample size—shows a slight reduction in payback time (to 3.2 years). Payback times are much longer in other public sector and K-12 schools projects, ranging from 9 to 13 years in the 2005-2008 period. Not surprisingly, the median benefit cost ratio value has generally decreased over time in these market segments (with the exception of private sector projects in the 2005-2008 period[39]). The median benefit cost ratio is very attractive for ESCO projects installed in private sector facilities (2.7 in the 2005-2008 period) and is 1.2 for other public sector projects in recent years. Direct benefits from K-12 school retrofits—completed after 2005— do not typically cover turnkey installation costs over the lifetime of the project. As discussed earlier, K-12 schools are using performance-based contracts to partially pay for asbestos removal, building envelope, wiring, and other non-energy-related improvements and this trend is being reflected in the economic performance of these projects.

[39] Figure 14 shows that private costs per square foot increased from 1998-2004 to 2005-2008. Figure 17 shows that annual savings per square foot decreased from 1998-2004 to 2005-2008. Intuitively, these findings suggest that payback times at private projects should have increased from 1998-2004 to 2005-2008. However, Appendix A describes how simple payback time (SPT) and benefit-cost ratios are calculated without normalizing by project floor area and for projects that had *both* cost and savings information. Therefore, we used different samples to calculate annual savings per square foot, installation costs per square foot, payback times, and benefit-cost ratios over time. Differences in sample sizes and trends in project size (expressed in square footage of floor area) led to the counter-intuitive results reported for private projects in the most recent time period.

6. Enabling Policies

The following section discusses several enabling policies that could be explored in order to provide more transparency for the ESCO industry, evaluate the effect of accumulated facility depreciation issues at public facilities, and ultimately facilitate additional growth for this important industry.

6.1 Promote international EM&V standards to quantify and report relevant avoided O&M and capital costs

In addition to the direct financial benefits (e.g., energy-related dollar savings), indirect financial benefits (O&M savings, avoided capital costs) from ESCO projects may be monetized and included as part of a performance-based contract.

There are other indirect societal benefits that are not typically considered within the contractual framework between the ESCO and their customer (e.g., dollar value of reduced pollution, worker "happiness"). For example, Gillingham et al. (2006) report on the literature detailing environmental externalities and found that reducing electricity use provided societal benefits that were approximately 10% of the dollar value of the electricity savings. Sorrell (2005) notes that an ESCO customer has a range of motivations for entering into an energy service contract, but the majority of these reasons cannot be incorporated into a cost-benefit (i.e., contractual) framework. Unfortunately, one of the challenges with cost-benefit analysis is the difficulty inherent in monetizing the impacts of a project, especially the benefits (Boardman et al. 2006).

We reported in Section 4 that significant non-energy-related economic benefits are being accrued in ESCO projects in the public and institutional sector–including avoided O&M and capital costs. However, unlike existing international protocols that standardize how energy and water-related savings are computed (EVO 2010), there are no international standards in place to collect and then monetize information about avoided O&M and capital costs specifically related to ESCO projects (Birr and Singer, 2008)[40].

Existing methods to quantify the value of ESCO projects to their customers were built on the assumption that nearly all of the installation costs are covered by the energy-related savings. It is clear that new methods–including a deeper analysis of the lifecycle costs of infrastructure replacement–are needed to more accurately quantify the value of ESCO projects, especially in the K-12 schools market.

Given the accumulated depreciation value of infrastructure in the U.S. public sector, especially at K-12 schools, we recommend that the International Performance Measurement and Verification Protocol (IPMVP) team, government agencies at all levels, and private energy service companies

[40] In evaluating measurement and verification (EM&V) guidance provided to the U.S. Department of Energy's Federal Energy Management Program (FEMP) it was noted that non-energy savings are typically comprised of O&M savings and/or reduced water consumption (Nexant 2008). However, there is no mention in the FEMP EM&V protocol of other types of non-energy project benefits that are occasionally included in other public facilities' performance-based contracts, including benefits related to avoided capital costs.

and contractors, promote EM&V documentation and practices that include standards for the collection, verification, and monetization of avoided O&M and capital costs.

6.2 Collect additional project-level data detailing measure-specific and transactional costs

In section 5, we reported that median project installation costs more than doubled in the last decade, even after accounting for the effects of inflation and normalized by floor area. ESCO executives who were surveyed cited increasing labor, material, and transactional costs related to comprehensive retrofits as possible reasons that might explain this significant trend in project investment levels.

We have shown that many ESCO project installations are becoming more complex at the same time that reporting requirements for some public/institutional projects are also increasing (SEP 2010). Sorrell (2005) noted that ESCO project transaction costs are partially a function of the complexity of the energy services included within the contract, the competitiveness of the market, and the difficulties in monitoring the contractual terms and conditions.

At present, the LBNL/NAESCO database does not contain and local/state/federal energy offices do not typically organize and release a breakdown of individual measure, labor, or raw material costs for performance-based energy efficiency projects. Furthermore, it would be useful to know more about the share of costs associated with infrastructure upkeep that may or may not generate energy savings. In order to more accurately characterize factors driving trends in ESCO project costs, local, state, and federal administrators of ESPC programs may want to collect, organize, and publicly release more disaggregated cost information on ESPC projects.

6.3 Provide access to project-level performance benchmarking information

There is a general lack of access to project benchmarking information including data detailing typical building consumption, retrofit costs, estimated savings, types of measures installed, interest rates, and energy price escalation rates. Public and institutional facility managers are looking for ways to benchmark project feasibility and success against ESCO and other commercial building industry benchmarks[41], but publicly available information for this purpose is often dated or not available. This information gap can lead to poor decisions that ultimately affect project energy savings performance and cost-effectiveness. It is important that public funding sources be put to good use in order to meet rigorous state energy savings targets and new federal SEP reporting requirements. Bertoldi et al. (2006) discuss several strategies for fostering the development of the ESCO industry in Europe including a strategy to increase information about the performance of ESCO projects. Goldman et al. (2005) indicated the importance of developing tools to "standardize methods to report project characteristics, costs, and savings…to understand industry and market trends" (p. 404). Lindgren (2009) reported that there was little incentive for ESCOs to push savings levels beyond the guaranteed amount in guaranteed savings contracts in Sweden; results from the LBNL project database provide some evidence of this phenomenon in the United States. For example, the share of public and institutional projects

[41] The most recent Commercial Building Energy Consumption Survey (CBECS) in the U.S. was released nearly ten years ago and another survey is needed to understand facility characteristics about the existing stock of commercial buildings.

that exceed the guaranteed level is decreasing over time (see Figure 18). However, it is important to note that nearly 85% of all public and institutional projects *met or exceeded* the guaranteed level of savings.

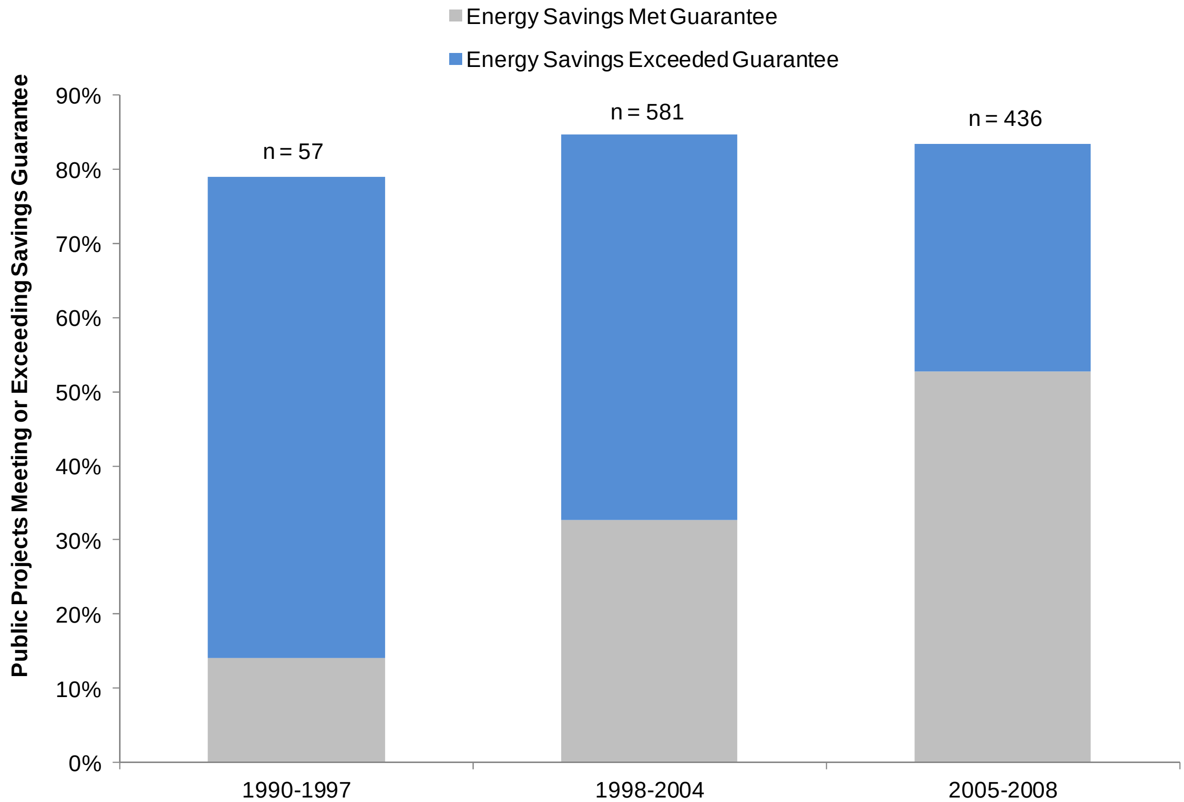

Figure 18. Public and institutional projects meeting or exceeding savings guarantee

In a typical performance-based contract, ESCO customers receive any savings that exceed the guarantee, so facility managers may be making retrofit decisions based on ESCO predictions of future performance. Therefore, improved access to historical information about how often ESCOs meet and exceed savings guarantees could improve the decision making process at the facility being retrofitted. It is clear that public/institutional sector project benchmarking, along with additional ESPC education and outreach, can help all parties avoid situations where there are large differences between projected, guaranteed, and actual savings. To address this need, LBNL has developed a project input and benchmarking tool that shows typical project performance of ESCO projects by market segment (e.g., installation costs, annual savings, payback time) and retrofit strategy, which should be of value to facility managers in public/institutional sector (LBNL 2011; LBNL 2012).

7. Summary and future research

This study discusses results from a recent survey of U.S. ESCO executives and a parallel analysis of project-level data going back to 1990. Despite the onset of an economic recession, the U.S. ESCO industry managed to grow at about 7% per year between 2006 and 2008. We estimate that ESCO industry revenues are about $4.1 billion in 2008. While ESCO industry growth was slower than anticipated, the industry continued to deliver energy efficiency services to many market sectors even when facing higher financing costs. In aggregate, we estimate that 2,484 projects in the database generated approximately $4 billion in direct net economic benefits to customers. If we assume that the net benefits per project are comparable for all ESCO industry projects that are not included in our calculation of net benefits, this would suggest that the ESCO industry has generated nearly $23 billion ($2009) in net direct economic benefits for customers at projects installed between 1990 and 2008. We estimated that a typical ESCO project generated $1.5 dollars of direct benefits for every dollar of customer investment.

The project-level data suggests that ESCOs tend to focus on larger states, as defined by economic activity, but several other factors including budgets for ratepayer-funded energy efficiency programs, condition of existing commercial facilities, aggressive state energy programs, and the number of federal customers also influence where ESCOs conduct business. ESCOs derive about 85% of their revenues from projects in the public/institutional sector.

The LBNL project database and a majority of ESCO survey respondents – 60% – indicated that typical project installation costs have increased over the past decade. We discussed the trend of installing more comprehensive, “deep” retrofits in both the public and private sector and how this relates to the increased installation costs over time. K-12 schools, which represent the largest share of projects in our database, are using the ESCO business model to address substantial deferred maintenance needs. EM&V protocols—including the measurement of indirect and non-energy-related benefits—need to be further developed to truly capture the intrinsic value of these projects to customers. In aggregate, ESCOs are still able to deliver cost-effective energy solutions to their customers as evident by significant net economic benefits generated by projects in our database.

We believe that an important new area of research involves supporting benchmarking and standardization efforts to quantify non-energy (and other indirect benefits) for energy efficiency projects. Finally, it is important for industry analysts and researchers to explore the factors that contribute to the dramatic increase in inflation-adjusted project installation costs over time. Specifically, additional research should be undertaken to disaggregate the capital, O&M, and transactional costs associated with complex building retrofits.

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Appendix A: LBNL ESCO Project Database – Data Analysis Methods and Quality Assurance

A.1 Overview of ESCO Project Database

LBNL, in collaboration with NAESCO, has collected information about performance-based energy efficiency projects from many different sources since the late 1990s. As of spring 2012, the LBNL ESCO database has more than 4,000 energy efficiency-related projects representing 49 states and a number of foreign countries. The database is housed on a secure server located within the Energy Analysis and Environmental Impacts Department at LBNL. The LBNL database is comprised of a number of linked tables, including the *master project*, *annual savings*, and *project measures* tables.

The *master project* table contains critical project information including the ESCO name, project size, installation costs (with and without financing), geographic location, market segment, year completed, contract length, and average annual energy and/or dollar savings. The *annual savings* table contains information about reported annual energy and dollar savings for projects that reported this information. Finally, the *project measures* table contains a list of the unique energy conservation measures installed at projects since 1990.

Most projects in the database are self-reported by ESCOs and are subject to potential self-selection bias. We implemented a number of filters, adjustments, and calculations to the project data in order to address some reporting inconsistencies. This appendix describes key data quality control and analysis activities including: (1) description of the sample of projects from the database that are included in this study.; (2) grouping of projects by market segments; (3) identification and removal of projects with inadequate information or poor data quality; (4) treatment of onsite generation and fuel conversion/substitution projects; (5) estimation of missing project costs; (6) flagging true outlier projects; (7) grouping of project measures into retrofit strategies; (8) import, conversion, and inflation of fuel prices; (9) estimation of missing annual dollar savings; (10) estimation of project economic measure lifetimes; and (11) final data conversions.

A.2 Project Database used in this Study

We reviewed and screened a number of projects from the *master project* table from the raw LBNL database to create the project analysis database used in this study. Projects were screened out for various reasons, including poor data quality, projects located outside of the U.S., project that we felt were too old (pre-1990) or did not have post-implementation data (after 2008). Specifically, all non-U.S. projects (n=75), projects with missing market segments (n=10), and projects with no state (n=30) identified were removed from this analysis. Any projects that were coded with a low confidence level (i.e., confidence level="9") were removed (n=17), because at the time of their entry into the database, LBNL analysts felt that these projects had problematic data that should not be used in any formal analysis. Furthermore, all projects before 1990, after 2008, in progress or with unknown installation year (n=264) were also removed from this specific analysis. Figure A-1 is a graphical depiction of the initial removal of ESCO projects from this analysis.

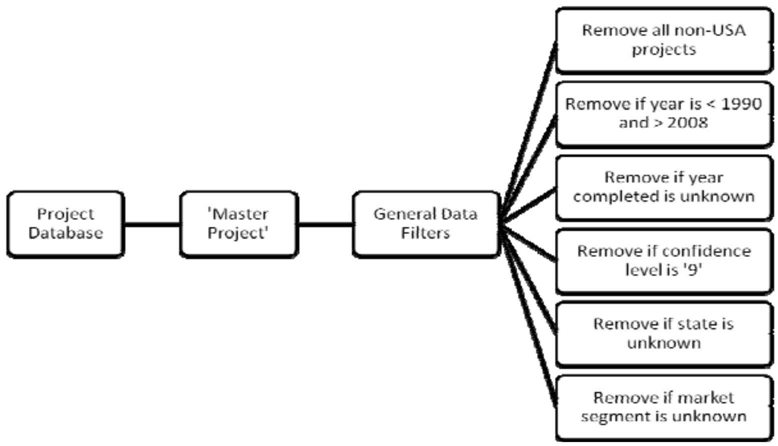

Figure A- 1. Initial Screening of Projects from the LBNL Project Database

After the initial screening, we also excluded a number of projects for inclusion in specific calculations involving energy and/or economic performance measures, although other data fields (e.g. project costs, floor area) were included in the results for the database sample. These values were excluded from specific calculations, because during data entry procedures, LBNL analysts had reasons to believe that either the energy and/or economic variables were not accurate. Since 1990, analysts have been assigning a confidence level of "2" to projects with inadequate information for savings values (n=116) (e.g., measurement units were incorrectly entered) b) and a confidence level of "3" to projects with inadequate information for economic variable values (n=189) (e.g., installed measures were not reported so hard to assess accuracy of project cost information).

Finally, we conducted a formal analysis of outliers to determine which specific projects were reasonable outliers and those projects that should not be included in the analysis because reported values for numerous variables within these projects did not make sense. For each of the primary energy and economic variables (floor area, project costs, and energy savings), a sequence of extreme outlier[42] screens was applied. We identified and removed a very small number of projects (n=2) prior to *any* analysis which failed the outlier screen in <u>all</u> three primary energy and economic variables.

A.3 Classifying Projects by Market Segment

ESCOs are asked to classify projects into one of 13 market segments in the LBNL database. Following the organization of earlier LBNL reports, we grouped the 13 specific market segments into three more general market sectors: *MUSH*, *Federal*, and *Other Private*. The *MUSH* segment is composed of the public housing, state/local government, K-12 schools, universities/colleges, and health/hospital projects. The *Other* grouping contains all industrial, office, residential, retail, and all other types of private sector projects. The *Federal* grouping only contains federal ESCO projects. Figure A-2 is a graphical depiction of the general classification of the market segments.

[42] We considered a project an extreme outlier if the reported values were higher or lower than 99 percent of all other projects in the database.

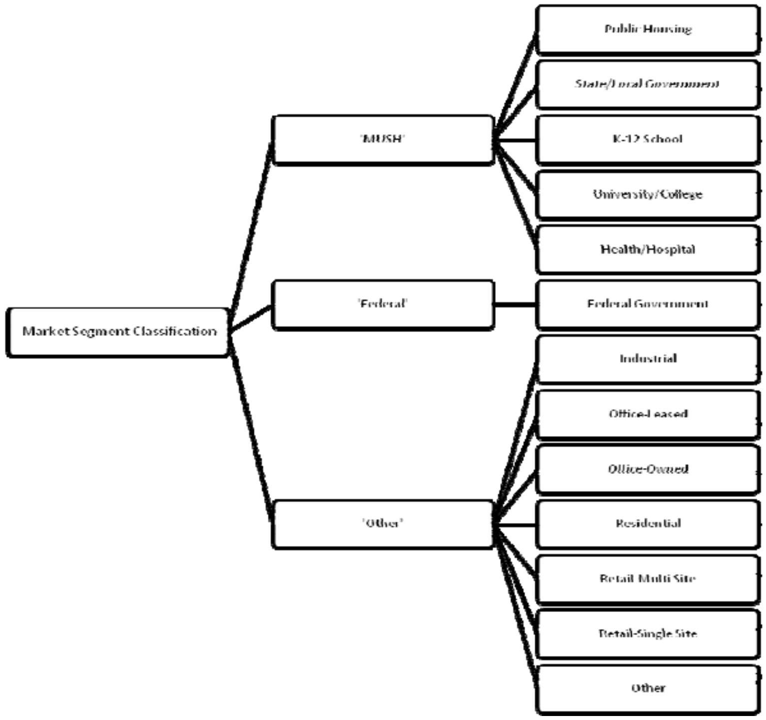

Figure A- 2. General classification of market segments

A.4 Projects Reporting Negative Energy or Water Savings

ESCOs reported a number of projects with negative annual energy savings values (n=194) which would suggest that energy usage at facilities increased after installation of energy conservation measures. We analyzed these projects in more depth, including an analysis of installed measures and retrofit strategies, finding that ESCOs: 1) incorrectly entered positive savings data as negative; 2) installed on-site generation; or 3) installed fuel substitution measures which had the effect of increasing usage of one fuel after the retrofit while usage may have decreased in an alternative fuel (e.g., electricity). In these cases, negative electricity, fuel, or water savings estimates were excluded from the calculation of total annual savings (we replaced the negative energy or water savings with missing values). However, many of these projects reported other fields with positive annual savings (e.g., dollars), so we were able to include these projects in our calculation of cost-benefit ratios, simple payback time and other performance metrics.

A.5 Estimating Missing Project Costs

A significant number of projects had missing project costs *without* financing, but had reported project costs *with* financing (n=467). LBNL has traditionally used project costs without financing (e.g., see Goldman et al. 2002, Hopper et al. 2005) when calculating project economic indicators (e.g., simple payback time, benefit-cost ratios), so it was important to estimate missing project costs without financing for as many of those projects as possible. LBNL undertook a number of steps to estimate missing project costs without financing.
The first step involved estimating average interest rates by market segment for two periods: 1990-2001 and 2002-2008 for projects where we had project costs with *and* without financing as

well as the contract length. If the contract length was less than four years and the total project cost was less than the project cost without financing, records were removed for purposes of calculating the average interest rates. Following the average interest rate calculation by market segment, we estimated project costs without financing for those projects where costs were missing by using the reported project costs with financing, the reported contract length in months, and the estimated market segment interest rate for the applicable time-period (i.e., 1990-2001 or 2002-2008). A compounding annuity function was used in SAS to calculate the average interest rates in the first step as well as the missing project costs without financing: (SAS, 2009a):

$$a = \frac{\frac{p}{n}((1+r)^n - 1)}{r(1+r)^n} \tag{1}$$

where:
a=project costs *without* financing;
p=project costs *with* financing;
r=monthly interest rate; and
n=contract length in months.

A.7 Grouping Project Energy Conservation Measures into Retrofit Strategies

Project ECMs were grouped into general retrofit strategies (see Goldman et al. 2002) and the numbers of measures undertaken were counted for all projects. It is important to note that the LBNL database has nearly 200 different types of ECMs listed. Therefore, for reporting purposes it was necessary to group the measures into more generalized strategies, including major and minor HVAC, onsite generation, lighting, non-energy, and other retrofit strategies. Sources for ECM and retrofit strategy lifetimes include the: (1) 1995 and 2011 DEER databases; (2) Efficiency Maine Technical Reference Manual; (3) Massachusetts Technical Reference Manual; (4) NEEP Mid-Atlantic Technical Reference Manual; (5) Northwest Power and Conservation Council's 6th Conservation and Electric Power Plan; and (6) estimates by LBNL researchers (Goldman et al. 2002, Hopper et al. 2005). For the "other" retrofit strategy, a maximum lifetime of 25 years was assumed. Figure A-3, which was adapted from Hopper et al. (2005), shows the basic retrofit strategies used in this analysis.

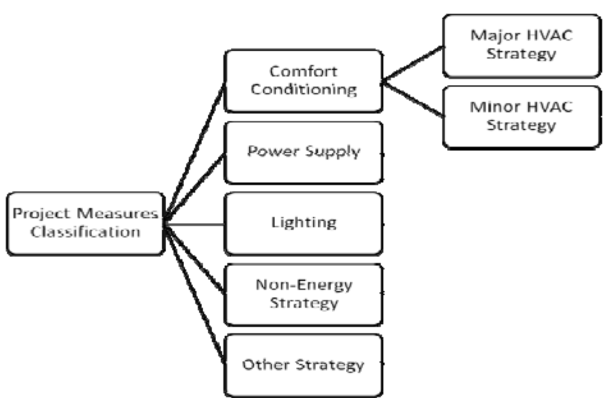

Figure A- 3. Grouping energy conservation measures into retrofit strategies

A.8 Energy and Water Price Data: Historic price data and forecasting future prices

As part of our economic analysis, we also collected information on historical annual heating oil (EIA, 2009e), electricity (EIA, 2009a), and natural gas prices (EIA, 2009b; EIA 2009c; EIA 2009d) by end-use sector from the Department of Energy's Energy Information Administration (see Table A-1). In addition, U.S. average water prices were used from previous LBNL reports (Hopper et al. 2005; Hopper et al 2007) and simple extrapolations were made to estimate average water prices from 2001 to 2008.[43]

Table A- 1. Energy and Water Prices Source Information

Savings Metric	Time-scale	Spatial-scale	End-use Sectors?	Original Units	Time Periods	Source(s)
Water	Annual	U.S. Average	Yes	dollars per gallon	1990-2008; 2009-2030[2]	Hopper et al 2005; Hopper et al 2007
Electricity	Annual	State-level	Yes	cents per kWh	1990-2008; 2009-2030[1]	EIA 2009a
Fuel oil	Annual	State-level	No	cents per gallon	1990-2008; 2009-2030[1]	EIA 2009e
Natural gas	Annual	State-level	Yes	dollars per Mcf	1990-2008; 2009-2030[1]	EIA 2009b; EIA 2009c; EIA 2009d

Notes: [1]Annual electricity, fuel oil, and natural gas prices were escalated to 2030 using annual EIA price forecast escalation rates (EIA, 2009f).
[2]Annual water prices were escalated to 2030 using long-term consumer price index forecasts provided by the Federal Reserve Bank of Philadelphia (FRBP, 2009).

Natural gas prices were converted from dollars per Mcf into $/MMBtu and $/therm. Electricity prices were converted from cents per kWh to dollars per kWh. Fuel oil prices were converted from cents per gallon into dollars per therm. Finally, we inflated the converted energy and water prices to 2009 dollars using annual GDP deflator information from the U.S. Bureau of Economic Analysis (BEA 2009).

In order to estimate the value of future energy savings (e.g., for projects with installed measures that would be in place after 2008), we used EIA forecasted energy price information to 2030 and consumer price escalation rates from the Federal Reserve Bank for the water prices forecasts. The forecasted energy and water prices were kept in 2009 dollars in order to be consistent with the rest of the analysis.

A.9 Estimation of Annual Dollar Savings

[43] There are very few projects with reported water savings. Thus, our simplifying approach of relying on estimates of average U.S. water prices (rather than location-specific prices) has a minimal effect on the annual dollar savings estimates reported in this analysis.

Project dollar savings include dollar savings directly related to energy conservation measures, but also indirect savings including lower costs to customer operations and maintenance (O&M) activities, etc.

Estimation of Energy-related Dollar Savings

Every ESCO project has a unique source of energy price information and every ESCO has a slightly different energy-related dollar savings verification method. Therefore, we felt that using a consistent source for project energy (or water) prices would improve the comparison of projects among ESCOs and across different locations, sectors, and installation years. Accordingly, the first step when estimating dollar savings was to clear the energy-related annual dollar savings values reported by ESCOs and re-calculate annual energy dollar savings values for all projects by multiplying reported energy savings against energy (or water) prices for the appropriate year, state, and sector (i.e., residential, industrial, etc.).

Next, if actual energy savings data was not reported and the project agreement type was listed as "guaranteed savings" (n=703), then the guaranteed energy savings values, if they were reported, were used in the annual dollar savings calculation. For all other projects where actual savings data was missing and the project agreement types were not guaranteed savings (n=810), projected energy savings values were used, if reported. It was assumed that ESCOs with guaranteed savings contracts were financially responsible for annual project dollar savings, so guaranteed energy savings were also used in calculations for projects where annual energy savings were less than guaranteed energy savings, because the ESCO is responsible for making up the shortfall. All measured or estimated annual dollar savings were converted to 2009 dollars using the GDP deflator (see above).

For projects with multiple years of reported energy savings, but no average annual energy savings reported (n < 50), the average annual savings was calculated by taking a simple average of the reported years of savings.

There are a number of projects that continue to generate annual energy savings beyond 2008. For these projects, we estimated future annual dollar savings by multiplying forecasted energy and water prices against the historical average annual energy savings. Annual electricity, fuel oil, and natural gas prices were escalated to 2030 using annual EIA price forecast escalation rates (EIA, 2009f). Annual water prices were escalated to 2030 using long-term consumer price index forecasts provided by the Federal Reserve Bank of Philadelphia (FRBP, 2009). Figure A-4 depicts a decision tree for calculating energy/water-related dollar savings.

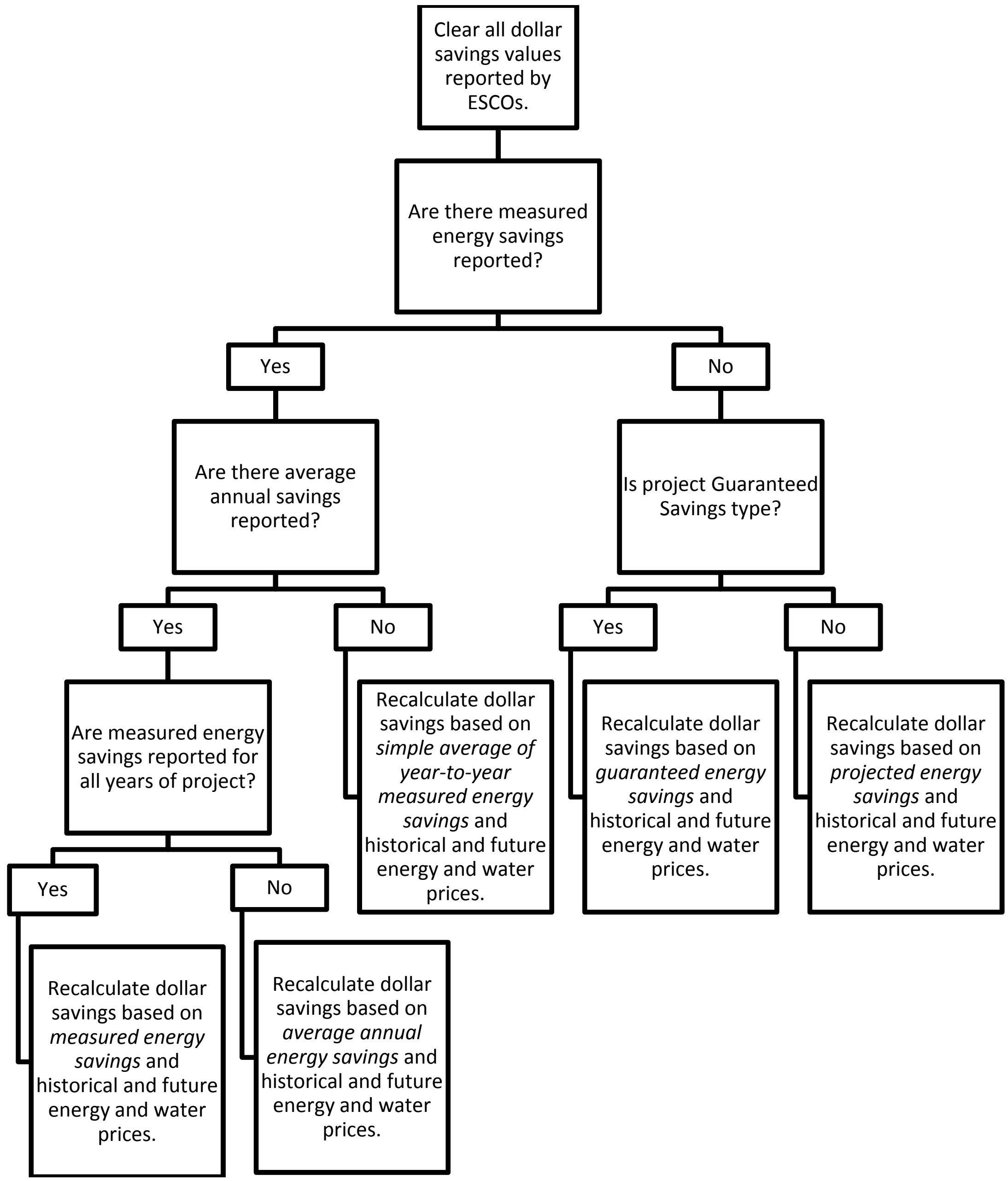

Figure A- 4. Decision tree for calculating energy/water-related dollar savings

Figure A-5 is a depiction of how we mapped the end-use sector energy prices to the different projects using market segments as a proxy for end-use.

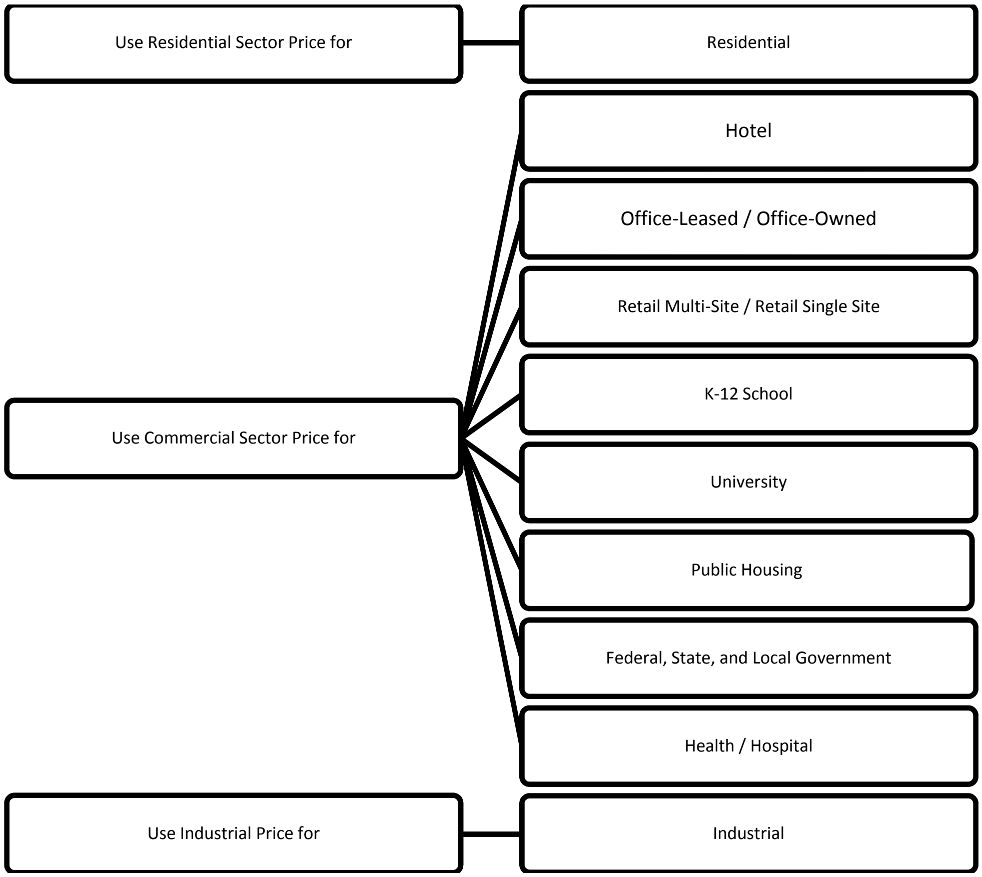

Figure A- 5. Mapping and end-use sector energy prices to projects using market segments

Estimation of O&M and Other Dollar Savings

For some projects, ESCOs reported *total* operations and maintenance (O&M) but not *annual* O&M savings (n=271) or reported *total* other savings but not *annual* other savings (n=70). For these projects, we calculated an annual average of O&M savings and other non-energy savings by using the aggregate dollar information reported and dividing by the contract length for that project.

Annual dollar savings were aggregated by summing annual dollar savings from energy, annual O&M savings, and annual other non-energy savings (see equation 2). The annual dollar savings values are used in several of the project economic metrics discussed in the following section.

$$S_k = E_k + OM_k + Other_k \quad (2)$$

where:
S_k=annual dollar savings at project k;
k=ESCO project;
E_k=annual energy-related dollar savings at project k;
OM_k=annual operations and maintenance savings at project k; and
$Other_k$=annual other savings at project k.

A.10 Estimating Project Economic Indicators

We calculated simple payback time, gross project benefits, net project benefits, and benefit-cost ratios using several discount rates and also normalized costs and savings per floor area. Simple payback time (SPT) is calculated by dividing the annual dollar savings from the total project cost without financing to roughly estimate the number of years it would take to pay the project back. We used the following equation for this analysis:

$$SPT_k = \frac{a_k}{s_k} \tag{3}$$

where:
a_k=project cost *without* financing;
k=ESCO project; and
s_k=annual dollar savings at project k.

Gross project benefits were estimated by discounting future monthly dollar savings for each year through the maximum measure effective useful lifetime (EUL) reported for every project and then summing these discounted values to produce the present value of future benefits for each project.[44] We used a monthly discounting method, because project savings transactions are typically settled each month and not at the end of each year. Equation (4) depicts the discrete discounting method used in this analysis (SAS, 2009b).

$$GB_k = \sum_{n=1}^{N} \frac{s_{nk}}{(1+r)_k^{\,n}} \tag{4}$$

where:
s_{nk}= real monthly dollar savings at year n and project k;
r=real monthly discount rate;
N=weighted average of energy conservation measure EULs at project k;
n=age (in months) of average energy conservation measure; and
k=ESCO project.

We calculated net benefits for each project by subtracting the project cost without financing from the discounted gross benefits. We also calculated project benefit-cost ratios (BCRs) by dividing discounted project gross benefits (See equation 6) by project cost without financing. For the main body of the analysis, we assumed a 3% public and 8% private discount rate. In Technical Appendix B, we report alternative economic results using discount rates of 5% and 11% respectively for public and private sector projects.

$$BCR_k = \frac{GB_k}{a_k} \tag{5}$$

where:
GB_k=discounted gross project benefits at project k
a_k=total project cost *without* financing at project k

Any rebates paid to the customer, including demand side management (DSM) payments, were netted out from the project costs (without financing). If the DSM program was listed in the database as a "rebate" then 100% of the rebate was subtracted from the project cost. If the DSM program type was listed as a "standard performance contract" or "bidding", then 50% of the rebate value was subtracted from the project cost. This method of subtracting customer rebates from project installation costs is consistent with previous LBNL reports (Hopper et al., 2005,

[44] If the contract length was missing or less than six years, we estimated gross benefits using the weighted average energy conservation measure lifetime at the project.

Hopper et al., 2007) and more closely reflects the true project installation cost from the energy efficiency measures from the customer's perspective.

Project costs and savings were normalized by floor area as a means of comparison among years, market segments, and regions (see equation 6).

$$a_{fk} = \frac{a_k}{f_k} \text{ and } s_{fk} = \frac{s_k}{f_k} \qquad (6)$$

where:

a_k=total project cost *without* financing at project k;

s_k=annual dollar savings at project k;

k=ESCO project; and

f_k=floor area in square feet at project k.

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Appendix B: Economic Analysis Indicators for ESCO projects

B.1 Discount Rates

Appendix B includes a summary of sensitivity analysis of the impact of alternative discount rates on our estimates of aggregate net benefits and benefit cost ratio. Discount rates were used to determine the present value of the annual stream of economic benefits to reflect the time value of money; choice of a discount rate has a significant impact on the cost-benefit analysis, because it influences the present value of future dollar savings from ESCO projects. All discount rates are reported in real terms in order to eliminate the effect of expected inflation.

In this study, we report economic indicators assuming a 3% and 8% real discount rate respectively for public and private sector projects. In Appendix B, we also report the results of our sensitivity analysis using a 5% and 11% real discount rate for public and private projects, respectively. The real discount rates we used are based on feedback from industry experts and previous LBNL reports (e.g., Osborn et al, 2002; Hopper et al., 2005).[45]

To calculate our real discount rates, we used methodology consistent with the Office of Management and Budget (OMB)'s guidance that a real discount rate can be approximated by subtracting expected inflation from a nominal interest rate (OMB 2009). We chose nominal interest rates of 5% and 7% for the public and institutional sector and nominal interest rates of 10% and 13% for the private sector based on the nominal treasury rate over the years of completion (1990-2008) for projects in the analysis. We applied a higher real discount rate to private projects as compared to public and institutional projects to reflect a higher cost of alternative private sector investment opportunities. We calculated real discount rates by subtracting an expected inflation rate of 2%. This inflation rate is based on a survey of professional forecasters conducted by the Federal Reserve Bank of Philadelphia (FRBP 2009). The quarterly FRBP survey includes a median ten-year forecast of inflation. Historically, this inflation value has averaged about 2%.

B.2 Sensitivity Analysis

The following two tables contain a sensitivity analysis of economic indicators with alternative discount rate assumptions.

[45] Friedrich et al. (2009) used a 5% real discount rate in their analysis of utility sector EE economics that includes the cost of capital, but does not include the impact of inflation. Our discounting method differs, because we discounted future benefits to the present assuming both the future impact of inflation as well as different financing rates for public and private projects.

Table B- 1. Aggregate Project Benefits (millions of $2009)

	Aggregate Gross Benefits (millions of $2009)			Aggregate Net Benefits (millions of $2009)		
Market Sector	*n*	*Analysis Discount Rate (3% Public/8% Private)*	*High Discount Rate (5% Public/11% Private)*	*n*	*Analysis Discount Rate (3% Public/8% Private)*	*High Discount Rate (5% Public/11% Private)*
Public/ Institutional	2,181	$9,730.3	$8,528.8	2,131	$3,424.9	$2,255.4
Private	357	$888.6	$749.3	353	$512.9	$374.3

Table B- 2. Typical Benefit-Cost Ratios

		Benefit-Cost Ratios					
		Analysis Discount Rate (3% Public/8% Private)			*High Discount Rate (5% Public/11% Private)*		
Market Sector	*n*	*25th percentile*	*Median*	*75th percentile*	*25th percentile*	*Median*	*75th percentile*
Public/ Institutional	2,131	0.9	1.3	2.1	0.8	1.2	1.9
Private	353	1.6	2.6	8.3	1.3	2.2	7.1

The following two figures contain results from our sensitivity analysis with alternative discount rate assumptions.

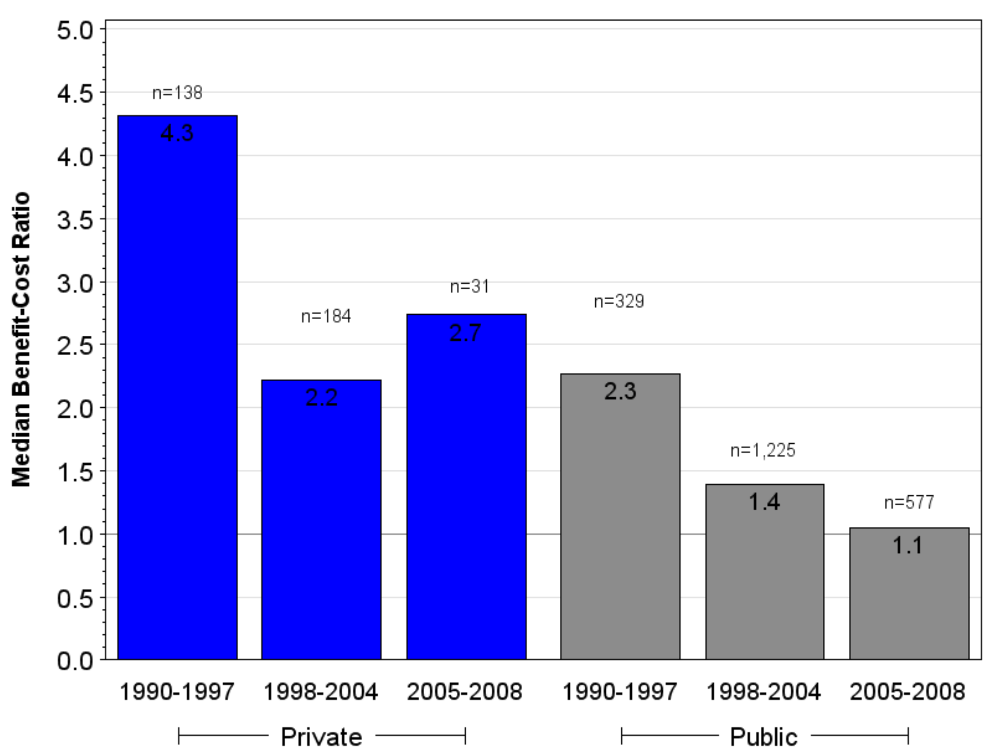

Figure B- 1. Benefit-cost ratios with analysis discount rate over time

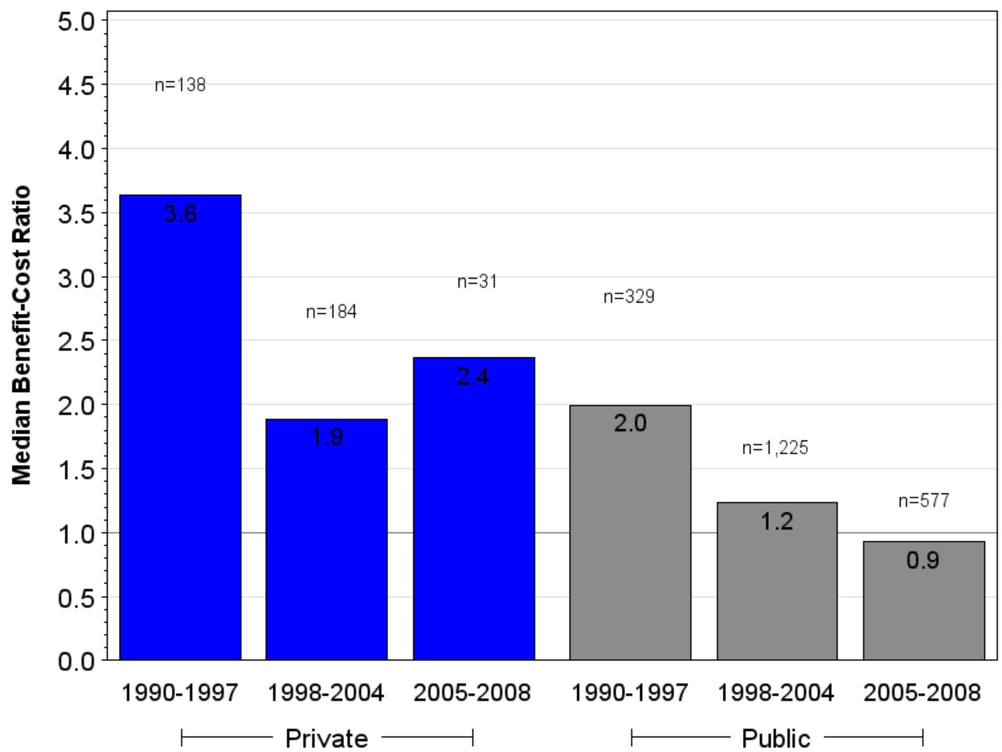

Figure B- 2. Benefit-cost ratios with high discount rate over time

Appendix B: References

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Appendix C: Estimating Effective Useful Lifetime for Energy Efficiency Measures

C.1 Measure Life Data

We rely heavily on the use of energy conservation measure lifetimes in our calculation of project-level economic indicators including: gross benefits, net benefits and benefit-cost ratios. For this reason, we include a technical appendix detailing our sources and assumptions regarding effective useful lifetime of energy efficiency measures implemented by ESCOs. Measure life, also called effective useful life (EUL), is based on the lifetime of equipment[46] and measure persistence[47] (as opposed to savings persistence). In many energy efficiency programs, the estimated measure lifespan takes into account both the expected remaining life of the measure being replaced and the expected changes in operational baselines over time (GDS 2011; Mass Save 2011).

We reviewed eight current technical reference manuals (TRMs) from several U.S. states and regions to compile EUL data for this analysis. TRMs are publicly-available documents that provide estimates of energy and peak demand savings, costs and measure life for energy efficiency measures. Typical users of TRM data include EE program planners; local/state/federal regulatory staff; utility forecasters; and the consultants who support these groups.

Specific measures in the LBNL database (1) do not always appear in TRMs; (2) appear in only one TRM; or (3) have competing definitions in multiple TRMs. In cases where the EUL varied across two or more TRMs, we used a weighted average based partially on the judgment of energy efficiency experts at LBNL. In some TRMs, EULs were listed for both existing building retrofits and new building applications[48]. In this analysis, we used the existing building retrofit EUL, because virtually all of the projects in our database are for retrofit projects in existing buildings. If current information was unavailable, we relied on assumptions used by LBNL in earlier reports (Goldman et al. 2002; Hopper et al. 2005). Table C-1 contains a summary of EUL assumptions and information sources.

Table C- 1. Effective Useful Life Assumptions

Measure Name	Measure Count	EUL (years)	Source
Air-cooled condensers	191	18	DEER 2011
Asbestos abatement	28	25	LBNL
Boilers	640	18	NEEP 2010

[46] Equipment life is the number of years that a measure will operate until failure.

[47] Measure persistence takes into account business turnover, early retirement of installed equipment, and other reasons measures might be removed or discontinued before failure.

[48] Typically the measure lifetime for an existing building retrofit is shorter than the lifetime for a new building project.

Measure Name	Measure Count	EUL (years)	Source
Chillers	529	23	Massachusetts
Cogeneration	119	20	LBNL ESTIMATE
Cooling towers	164	15	DEER 2011
Economisers - air/water	46	10	DEER 2011
Ovens/stoves	31	12	DEER 2011
Energy management systems	1793	15	DEER 2011
Engines	9	15	DEER 2011
Fuel conversion	242	20	LBNL Estimate
Furnaces/heaters	109	18	Massachusetts
Gas-fired turbines	15	20	LBNL Estimate
Backup generators	29	20	LBNL Estimate
Heat exchangers	96	14	DEER 2011
Heat recovery/storage	129	14	DEER 2011
High efficiency refrigerators/freezers	24	10	Average of DEER 2011, NEEP and Massachusetts
Air handling units	513	14	DEER 2011
Comfort conditioning controls	237	15	DEER 2011
Exhaust/fans	175	18	Average of DEER 2011 and Massachusetts
HVAC general	389	15	DEER 2011
Industrial processes	35	20	LBNL Estimate
Insulation/weather proofing	325	20	DEER 2011
Ballasts	453	15	Northwest Council
Controls/motion sensors	482	10	Average of several sources
Lamps	458	15	Average of Northwest Council, NEEP, Efficiency Maine
Reflectors	228	13	Efficiency Maine
Lighting retrofit	2673	13	Average of GDS, Massachusetts, NEEP
Load management systems	41	10	LBNL Estimate
Low-flow showers/faucets	174	10	DEER 2011
Metering/billing systems	183	10	LBNL Estimate
Electric motors	131	15	DEER 2011
Piping/steam distribution	310	18	DEER 1995
Pool systems	76	5	DEER 2011
Power quality	42	20	LBNL Estimate
Propane-air systems	5	20	LBNL Estimate
Pumps & priming systems	259	18	DEER 1995
Refrigeration plants	13	18	DEER 1995
Roof replacement/repair	145	20	Ctr for Environmental Innovation in Roofing
Staff training	413	1	LBNL Estimate
Steam/heat traps	316	6	DEER 2011
Variable speed drives	621	15	DEER 2011
Water conservation	575	7	DEER 1995
Water heaters	97	15	DEER 2011
Windows	293	25	Average of DEER and Northwest Council
Exit signs	250	10	Average of DEER, Northwest Council, NEEP, VEIC
Parking lot/outdoor lighting	39	13	Average of DEER, Northwest Council, Maine
Daylighting	22	20	DEER 2011
Spot/computer room AC	29	15	DEER 2011
Variable air volume	237	15	DEER 2011
Ducts/fittings	72	18	DEER 2011
Economisers (air side)	16	18	DEER 1995

Measure Name	Measure Count	EUL (years)	Source
Economisers (water side)	46	15	DEER 2011
Dampers/blowers	52	10	DEER 2011
Fume hoods	27	18	Northwest Council
Desiccants	9	18	DEER 1995
Heat pipes	1	18	DEER 1995
Thermostats	248	11	DEER 2011
Drain water heat recovery	6	13	DEER 1995
Water heater heat pumps	7	15	DEER 2011
Solar water heaters	29	15	DEER 2011
Motor retrofit	64	15	DEER 2011
New/replacement motors	188	15	DEER 2011
Motor resizing	3	15	DEER 1995
UPS	1	20	LBNL Estimate
Distribution transformers	25	20	LBNL Estimate
Food preparation equipment	37	12	DEER 2011
Vending/ice machines	113	10	DEER 2011
Office/computer equipment	10	6	Average of DEER and PA PUC
Injection molders	0	20	LBNL Estimate
Rate analysis/tariff change	155	1	LBNL Estimate
Doors	97	25	DEER 1995
Ceilings	85	25	LBNL Estimate
Low-flow toilets/urinals	164	7	DEER 1995
Spout diverters	3	7	DEER 1995
Fuel cells	7	20	LBNL Estimate
Microturbines	18	20	LBNL Estimate
Photovoltaics	31	20	LBNL Estimate
Fuel/water tanks	3	25	LBNL Estimate
Gas-fired water heaters	70	15	DEER 2011
Oil-fired water heaters	6	20	DEER 2011
Electric water heaters	7	15	DEER 2011
Water heater heat exchangers	8	14	DEER 2011
Demand/instantaneous water heaters	6	20	DEER 2011
Water heater replacement/upgrade	113	15	DEER 2011
Water heater electronic ignition	0	13	DEER 1995
Water heater heat traps	0	13	DEER 1995
Water heater timers	6	15	DEER 2011
Water heater insulation	5	7	DEER 2011
Packaged/roof-top systems	83	18	Northwest Council
Traffic signals	30	10	Average of Pennsylvania, VEIC
Equipment scheduling controls	214	5	LBNL Estimate
Laundry equipment	40	11	DEER 2011
Compressed air	28	15	VEIC
Alarm systems	36	20	LBNL Estimate
Humidifiers	6	18	DEER 1995
Waste disposal equipment	26	15	LBNL Estimate
Wiring	78	20	LBNL Estimate
Fuel-air mixing	11	20	LBNL Estimate
Airflow control	73	15	Northwest Council
Infra-red heaters	15	15	LBNL Estimate
Burner retrofit	9	20	LBNL Estimate
Refrigeration	8	12	DEER 2011

Measure Name	Measure Count	EUL (years)	Source
Steam turbines	6	20	LBNL Estimate
Motors/drives	19	15	DEER 2011
Process water reduction	0	20	LBNL Estimate
Water-cooled condensers	27	18	DEER 1995
Hydro-electric generators	2	20	LBNL Estimate
Peak shaving	9	5	LBNL Estimate
Plug loads	14	6	DEER 2011
Diesel engines	16	20	LBNL Estimate
Wind turbine	5	20	LBNL Estimate
Water treatment	23	20	LBNL Estimate
Distillation process modifications	1	20	Ernst Worrell
Filters	10	18	DEER 1995
Biomass digesters	5	20	LBNL Estimate
Reflective roofs/low-e coatings	12	15	DEER 2011
Natural gas engines	6	20	LBNL Estimate
Hot water piping/distribution	50	13	DEER 1995
Generators - type unknown	7	20	LBNL Estimate
Heat pumps	6	15	DEER 2011
Evaporative coolers	2	15	DEER 2011
Automated transport systems	2	20	LBNL Estimate
Land-fill gas generators	2	20	LBNL Estimate
Other non-energy improvements	52	10	LBNL Estimate
Boiler modifications	140	20	LBNL Estimate
Commissioning	159	10	DEER 2011
Air-source heat pumps	55	15	DEER 2011
Ground-source heat pumps	47	15	DEER 2011
Chiller modifications	78	15	DEER 2011
Cooling tower modifications	28	20	LBNL Estimate
Indoor air quality	4	15	LBNL Estimate
Pipelines	1	25	LBNL Estimate
Xeriscaping	1	5	LBNL Estimate
Water-source heat pumps	1	15	DEER 2011
Condensers - air/water unknown	12	20	LBNL Estimate
Leak detection equipment	22	15	LBNL Estimate
Combustion analyzers	21	15	LBNL Estimate
Plant pressurization control	2	10	LBNL Estimate
New/replacement boilers	191	20	DEER 2011
New/replacement cooling towers	48	15	DEER 2011
New/replacement chillers	142	20	DEER 2011
Street lighting	1	14	Northwest Council
Unknown	5	10	LBNL Estimate

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