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Evaluation of Federal Energy Savings Performance Contracting—

Methodology for Comparing Processes and Costs of ESPC and Appropriations-Funded Energy Projects

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EVALUATION OF FEDERAL ENERGY SAVINGS PERFORMANCE CONTRACTING—METHODOLOGY FOR COMPARING PROCESSES AND COSTS OF ESPC AND APPROPRIATIONS-FUNDED ENERGY PROJECTS

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CONTENTS

Page

LIST OF FIGURES .... **vii**

LIST OF TABLES .... **ix**

ACKNOWLDGMENTS .... **xi**

ABBREVIATIONS AND ACRONYMS .... **xiii**

EXECUTIVE SUMMARY .... **xv**

PURPOSE OF THE STUDY xv

COMPARISON OF ALL-INCLUSIVE PRICES FOR ECMS xv

COMPARING PROCESSES xvi

USEFULNESS OF THE STUDY xvi

EXAMPLES OF USING THE PARAMETRIC TABLES xvii

CONCLUSIONS xix

1. INTRODUCTION **1**

1.1 AUTHORIZATION OF FINANCING FOR FEDERAL ENERGY PROJECTS 1

1.2 ROLE OF ESPCs IN STRATEGY TO MEET FEDERAL ENERGY GOALS 1

1.3 ACCEPTANCE OF ALTERNATIVE FINANCING IN THE FEDERAL SECTOR 2

1.4 OBJECTIVES OF THIS STUDY 2

1.5 COMPARISON OF ALL-INCLUSIVE PRICES FOR ECMs 3

1.6 COMPARING PROCESSES AND LIFE-CYCLE COSTS 3

1.7 USEFULNESS OF THE COST-COMPARISON METHODOLOGIES 4

2. ECM-LEVEL COST COMPARISON **5**

2.1 INTRODUCTION 5

2.2 SORTING COST ELEMENTS 5

2.3 SEPARATING ECM COSTS FROM TOTAL PROJECT COSTS 7

2.3.1 Cost Data Sources for ESPC ECMs 7

2.3.2 Cost Data Sources for Appropriations-Funded Projects 8

2.3.3 Example of Adjustments Used to Isolate Appropriations-Funded Costs for Bare ECMs 8

2.3.3.1 Source Data 8

2.3.3.2 Eliminating Unrelated ECM Costs 8

2.3.3.3 Recalculating Non-Construction Costs 9

2.3.3.4 Excluded Health, Safety, and Security Costs 10

2.3.3.5 Excluded Project Management and Oversight Costs 10

2.3.3.6 Total Adjusted Costs 10

2.3.3.7 Escalation to 2001 Dollars 10

2.3.3.8 Summary of Cost Adjustment Method 10

2.4 COMPARISON OF CHILLER REPLACEMENT COSTS 11

2.4.1 Chiller Samples for Appropriations-Funded Projects 11

2.4.2 Super ESPC Chiller Sample 13

2.4.3 Results of Chiller Cost Comparison 13

2.4.4 Regression Analysis of Chiller Cost Results 14

2.4.5 Additional Chiller Cost Data—Appropriations Set 2 17
2.4.6 Summary of Conclusions on Chiller Prices 19

2.5 COMPARISON OF LIGHTING UPGRADE COSTS 19
2.5.1 Lighting ECM Sample for Appropriations-Funded Projects 20
2.5.2 Lighting ECM Sample for Super ESPC Projects 22
2.5.3 Results of Lighting ECM Cost Comparison 22
2.5.4 Regression Analysis of Lighting ECM Results 22
2.5.5 Summary of Conclusions on Lighting ECM Prices 26

2.6 COMPARISON OF VARIABLE-FREQUENCY-DRIVE COSTS 26
2.6.1 VFD ECM Sample for Appropriations-Funded Projects 27
2.6.2 VFD ECM Sample for Super ESPC Projects 28
2.6.3 Results of VFD ECM Cost Comparison 28
2.6.4 Regression Analysis of VFD ECM Results 29

2.7 SUMMARY AND DISCUSSION OF RESULTS 31
2.7.1 Summary 31
2.7.2 Implications of ECM Pricing Analysis Results for Life-Cycle Cost Comparison 32
2.7.3 Comparison of Site Project Management and Construction Oversight Costs 32
2.7.4 Recommended Practices for Ensuring Fair Pricing 37

3. METHODOLOGY FOR COMPARING PROCESSES AND LIFE-CYCLE COSTS 39

3.1 INTRODUCTION 39

3.2 CHARACTERIZING THE AVERAGE ESPC 40
3.2.1 Super ESPC Implementation Process 40
3.2.2 Super ESPC Scheduling and Financial Parameters 40
3.2.2.1 Time to Award Delivery Order and Complete Construction 40
3.2.2.2 Implementation Price and Financed Amount 42
3.2.2.3 Interest Rate and Contract Term 42
3.2.2.4 Guaranteed Annual Cost Savings 42
3.2.2.5 Measurement and Verification Cost 43
3.2.2.6 Performance-Period Services 43
3.2.2.7 Percentage of Savings Paid to ESCO 43

3.3 CHARACTERIZING THE APPROPRIATIONS CASE 44
3.3.1 The Process of Requesting Appropriations 45
3.3.1.1 Requesting Funds for Survey and Feasibility Study 45
3.3.1.2 Survey, Feasibility Study, and 30% Design 45
3.3.1.3 Requesting Funds for Design Completion and Construction 45
3.3.1.4 Summary of Process Steps 46
3.3.2 Duration of Process Steps 46
3.3.3 Cost of Studies and Surveys 48
3.3.4 Design Completion and Construction 50
3.3.5 Cost Savings 50
3.3.6 Energy-Related Maintenance Costs 50

3.4 CALCULATING SUPER ESPC LIFE-CYCLE COST 50
3.4.1 Inflation and Discount Rates 51
3.4.2 Excess Energy and Related Costs Before Construction 51
3.4.3 Pre-Performance-Period Payment 51

3.4.4 Project Facilitation 51
3.4.5 Payments During Contract Term 52
3.4.6 Expenses through End of 20-Year Study Period 52
3.4.7 Equipment Salvage Value 52
3.4.8 Summary of Super ESPC Costs 52
3.4.9 Calculating Monthly Payments and Contract Term 53
3.5 CALCULATING LIFE-CYCLE COST OF APPROPRIATIONS CASES 54
3.5.1 Inflation and Discount Rates 54
3.5.2 Surveys/Studies and Funding Requests 54
3.5.3 Costs During and After Construction 54
3.5.4 Equipment Salvage Value 55
3.5.5 Summary of Appropriations Case Costs 55
4. RESULTS AND APPLICATION OF THE LCC COMPARISON METHODOLOGY 57
4.1 LIFE-CYCLE COST COMPARISON RESULTS 57
4.2 PERSISTENCE OF SAVINGS 58
4.3 KEY ASSUMPTIONS USED IN CALCULATING LIFE-CYCLE COSTS 62
4.3.1 ECM Pricing Parity 62
4.3.2 Survey and Study Costs 63
4.3.3 ESPC Process Time 63
4.3.4 O&M, M&V, and Other Performance-Period Services 63
4.3.5 Parameterizing the Appropriations Cases 63
4.3.6 Site Project Management and Construction Oversight Costs 63
4.4 USING THE PARAMETRIC LCC COMPARISON TABLES 64
4.5 EXAMPLE APPLICATIONS OF THE LCC COMPARISON METHODOLOGY 65
4.5.1 Comparing Past Appropriations-Funded Projects to an Average ESPC 65
4.5.2 Considering Whether to Finance or Wait for Appropriations 65
4.5.3 Appropriations Case Based on Small Sample of Project Data 65
4.5.4 Appropriations Case Where All Projects are Funded 66
4.5.5 Hypothetical Appropriations Best Case 66
4.5.6 Appropriations Case Based on Large Sample of Project Data 66
5. CONCLUSIONS 67
5.1 COMPARISON OF ALL-INCLUSIVE PRICES FOR ECMS 67
5.2 COMPARING PROCESSES ON A LIFE-CYCLE-COST BASIS 67
5.3 USEFULNESS OF THE STUDY 68
5.4 APPLICATIONS 68
6. REFERENCES 71
7. BIBLIOGRAPHY 73
Appendix: DEFINITION OF PARAMETERS USED IN LIFE-CYCLE COST ANALYSIS OF AVERAGE SUPER ESPC PROJECT 75

LIST OF FIGURES

Figure **Page**

ES-1 The shaded cells in this figure represent appropriations cases having a lower life-cycle cost than the average ESPC when savings in the appropriations cases annually degrade by 0%, 0.5%, 1%, and 2% xviii

2.1 The majority of expenses incurred in ESPCs and appropriations-funded energy projects are identical, but patterns of executing and funding the projects differ 6

2.2 Chiller ECMs: Design completion and construction costs in appropriations-funded projects, and implementation price in ESPC projects 14

2.3 Chiller ECMs: Design completion and construction costs in appropriations-funded projects, and implementation price in ESPC projects. Includes regression lines 16

2.4 Chiller ECMs: Design completion and construction costs in appropriations-funded projects including Appropriations Set 2, and implementation price in ESPC projects 17

2.5 95% confidence intervals for difference in chiller costs (appropriations-funded minus ESPC-funded) as a function of chiller capacity 19

2.6 Lighting ECMs: Design completion and construction costs in appropriations-funded projects, and implementation price in ESPC projects 24

2.7 Lighting ECMs: Design completion and construction costs in appropriations-funded projects, and implementation price in ESPC projects 24

2.8 95% confidence interval for the ratio of the cost of lighting retrofits performed with appropriations, to the cost of lighting retrofits performed under ESPC 26

2.9 Variable-frequency-drive ECMs: Design completion and construction costs in appropriations-funded projects, and implementation price in ESPC projects 29

2.10 95% confidence intervals for difference in cost of VFD projects (appropriations-funded minus ESPC-funded) as a function of motor horsepower 31

3.1 Energy savings performance contract flowchart 41

3.2 Flowchart showing process for implementing projects through the agency's appropriations-funded energy management program 47

3.3 Timelines of the average Super ESPC process and one agency site's appropriations process for implementing energy-efficiency projects 49

LIST OF TABLES

Table		Page
ES-1	Present value of life-cycle cost ratio (appropriations over ESPC) of typical project as a function of total survey and study costs and total process time	xvii
2.1	Original cost estimate for example appropriations-funded chiller project	9
2.2	Summary of adjusted costs for the example appropriations-funded chiller project (not adjusted for price inflation)	11
2.3	Itemized costs of (and amounts requested for) design completion and construction of appropriations-funded projects including chiller replacements (2001 dollars)	12
2.4	Itemized costs for design completion and construction of sample of appropriations-funded chiller projects (2001 dollars), adjusted to reduce project scope to chiller replacement	12
2.5	Summary descriptions of adjusted appropriations-funded chiller projects (2001 dollars)	13
2.6	Summary descriptions of adjusted Super ESPC chiller projects (2001 dollars)	13
2.7	Regression results for chiller cost data, without distinguishing between ESPC and appropriations-funded projects	15
2.8	Regression results for chiller cost data, using a model that distinguishes between ESPC and appropriations-funded projects	16
2.9	Analysis of variance for the two models of the chiller cost data. Model 1 does not distinguish between ESPC and appropriations-funded projects; Model 2 does distinguish	16
2.10	Appropriations Set 2: Adjusted costs for chiller replacement using a different source of appropriated funds (2001 dollars)	17
2.11	Regression results for chiller cost data (including Appropriations Set 2), without distinguishing between ESPC and appropriations-funded projects	18
2.12	Regression results for chiller cost data (including Appropriations Set 2), using a model that distinguishes between ESPC and appropriations-funded projects	18
2.13	Analysis of variance between Model 1 (which does not distinguish between ESPC and appropriations-funded chiller projects) and Model 2 (which does distinguish between the two sets)	18
2.14	Measures commonly included in lighting upgrade projects	20
2.15	Itemized costs of (and amounts requested for) completion of appropriations-funded lighting upgrade projects (2001 dollars)	21
2.16	Itemized costs of (and amounts requested for) completion of appropriations-funded lighting upgrades, adjusted to reduce project scope to only ECMs listed in Table 2.14 (2001 dollars)	21
2.17	Summary description of adjusted appropriations-funded lighting upgrades (2001 dollars)	22
2.18	Summary description of Super ESPC lighting upgrades (2001 dollars)	23
2.19	Regression output when ESPC and appropriations cost data for lighting ECMs are combined	25

2.20 Regression output for a model that distinguishes between ESPC and appropriations cost data for lighting ECMs 25

2.21 Analysis of variance between Model 1, which does not distinguish between ESPC and appropriations, and Model 2, which does distinguish 25

2.22 Itemized costs of (and amounts requested for) completion of appropriations-funded VFD projects (2001 dollars) 27

2.23 Itemized costs of (and amounts requested for) completion of appropriations-funded VFD projects, adjusted to reduce project scope to VFDs and associated equipment only (2001 dollars) 28

2.24 Summary descriptions of adjusted appropriations-funded VFD ECMs 28

2.25 Summary descriptions of adjusted Super ESPC VFD ECMs (2001 dollars) 29

2.26 Regression of VFD cost data, fitting costs of ESPC and appropriations-funded projects to a single linear equation 30

2.27 Regression of VFD cost data, fitting ESPC and appropriations-funded projects to separate linear equations 30

2.28 Analysis of variance between Model 1, which does not distinguish between ESPC and appropriations, and Model 2, which does distinguish between the two 30

2.29 Experience-based estimate of the all-agency average of project management and construction oversight costs for the typical ESPC project 33

2.30 Agency site's project management and construction oversight responsibilities and costs for an appropriations-funded energy project, through project acceptance 35

3.1 Financial and time-related parameters for the average Super ESPC project 44

3.2 Costs incurred in ESPC project 53

3.3 Costs incurred in appropriations-funded projects (agency site illustration) 55

4.1 Ratio of present value of life-cycle cost (thousands, 2001 dollars) of typical energy conservation project funded with appropriations to present value life-cycle cost of same project carried out using ESPC, as a function of total survey and study cost and total process time 57

4.2 Present value of life-cycle cost of typical project implemented with ESPC when savings degrade after completion of project term 59

4.3 Ratio of present value of life-cycle cost (thousands, 2001 dollars) of typical energy conservation project funded with appropriations to present value life-cycle cost of same project carried out using ESPC, as a function of total survey and study cost and total process time. Annual reduction of guaranteed annual cost savings is 0.5%, or about 7% over 15 years 60

4.4 Ratio of present value of life-cycle cost (thousands, 2001 dollars) of typical energy conservation project funded with appropriations to present value life-cycle cost of same project carried out using ESPC, as a function of total survey and study cost and total process time. Annual reduction of guaranteed annual cost savings is 1%, or about 14% over 15 years 61

4.5 Ratio of present value of life-cycle cost (thousands, 2001 dollars) of typical energy conservation project funded with appropriations to present value life-cycle cost of same project carried out using ESPC, as a function of total survey and study cost and total process time. Annual reduction of guaranteed annual cost savings is 2%, or about 25% over 15 years 62

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ABBREVIATIONS AND ACRONYMS

AE	Architectural/engineering
DOE	U.S. Department of Energy
DX	Direct expansion
ECM	Energy-conservation measure
EM	Energy management
ESCO	Energy services company
ESPC	Energy-savings performance contact(ing)
FEMP	Federal Energy Management Program
FY	Fiscal year
GDP-IPD	Gross Domestic Product Implicit Price Deflator
HVAC	Heating, ventilation, and air conditioning
LCC	Life-cycle cost
M&O	Management and operations (contractor)
M&V	Measurement and verification
O&M	Operations and maintenance
OMB	Office of Management and Budget
R&R	Repair and replacement
UESC	Utility energy services contract
VAV	Variable air volume
VFD	Variable-frequency drive

EXECUTIVE SUMMARY

Federal agencies have had performance contracting authority since 1985, when Congress first authorized agencies to enter into shared energy savings agreements with Public Law 99-272, the Consolidated Omnibus Budget Reconciliation Act. By the end of FY 2001, agencies had used energy savings performance contracts (ESPCs) to attract private-sector investment of over $1 billion to improve the energy efficiency of federal buildings. Executive Order 13123 directs agencies to maximize their use of alternative financing contracting mechanisms such as ESPCs when life-cycle cost effective to reduce energy use and cost in their facilities and operations. Continuing support for ESPCs at the Administration and Congressional levels is evident in the pending comprehensive national energy legislation, which repeals the sunset provision on ESPC authority and extends ESPC authority to water savings projects.

Despite the Congressional and Presidential directives to use ESPCs, some agencies have been reluctant to do so. Decision makers in these agencies see no reason to enter into long-term obligations to pay interest on borrowed money out of their own operating budgets if instead Congress will grant them appropriations to pay for the improvements up front. Questions frequently arise about whether pricing in ESPCs, which are negotiated for best value, is as favorable as prices obtained through competitive sourcing, and whether ESPC as a means of implementing energy conservation projects is as life-cycle cost effective as the standard practice of funding these projects through appropriations.

PURPOSE OF THE STUDY

The lack of any quantitative analysis to address these issues was the impetus for this study. ESPCs are by definition cost-effective because of their “pay-from-savings” requirement and guarantee, but do their interest costs and negotiated pricing extract an unreasonably high price? Appropriations seem to be the least-cost option, because the U.S. Treasury can borrow money at lower interest rates than the private sector, but appropriations for energy projects are scarce. What are the costs associated with requesting funding and waiting for appropriations? And how is the value of an energy project affected if savings that are not guaranteed do not last?

The objective of this study was to develop and demonstrate methods to help federal energy managers take some of the guesswork out of obtaining best value from spending on building retrofit energy improvements. We developed a method for comparing all-inclusive prices of energy conservation measures (ECMs) implemented using appropriated funds and through ESPCs that illustrates how agencies can use their own appropriations-funded project experience to ensure fair ESPC pricing. The second method documented in this report is for comparing life-cycle costs. This method illustrates how agencies can use their experience, and their judgment concerning their prospects for appropriations, to decide between financing and waiting.

COMPARISON OF ALL-INCLUSIVE PRICES FOR ECMS

The first methodology compares the all-in prices for same-sized ECMs having the same technical scopes that were implemented through Super ESPC and appropriations-funded projects. The methodology entails detailed analysis of financial and technical records to verify the technical scope of the ECMs and deducts all costs not related to the bare ECM. Researchers concentrated their study on three ECMs that represent about half of Super ESPC investment and are also common in appropriations-funded projects: chiller replacements, lighting retrofits, and variable-frequency drives. About $13 million worth of ECMs implemented each way were analyzed.

Using regression analysis techniques, the study team found no statistically significant differences between the all-in prices for similarly sized ECMs having the same technical scopes in the Super ESPCs and the studied sample of appropriations-funded projects. The analysis showed that in this case the pricing obtained in Super ESPCs, which use a design–build approach negotiated for best value, was as good as the pricing obtained for the appropriations-funded projects in the traditional bid-to-spec competitive procurements. The $13 million in appropriations-funded ECMs were all from two adjacent sites within one agency.

This method allows agencies to compare the pricing in their past appropriations-funded projects with the prices offered by ESCOs in their initial and final ESPC proposals. All-inclusive ECM prices are a much better indicator of value in pricing than intermediate accounting conventions such as mark-up, and this method can help agency teams who are negotiating ESPCs focus their pricing due diligence on obtaining reliable quantitative answers.

COMPARING PROCESSES

A second methodology was developed to compare the life-cycle costs of using ESPCs and appropriations to implement a "typical project," defined as the average project implemented under the DOE Super ESPC program. Researchers carefully studied the activities and costs of the two processes and used federally specified techniques for analyzing life-cycle costs to ensure that the method would yield valid and meaningful results.

The averages to characterize the ESPC process steps, timing, and costs were modeled on the DOE Super ESPC program, which accounts for nearly one quarter of all federal ESPC investment to date. Data were derived from program records and the financial schedules of the first 71 DOE Super ESPC delivery orders (worth $230 million), all awarded by the end of FY 2001.

The appropriations model is based on the two-step process used by several large agencies for distributing direct project funding to sites. First the site requests funds for an energy survey and feasibility study for a proposed project. If step-one funding is received, the site completes the survey and study, and submits a request for implementation funding supported by the study report and a detailed cost estimate (based on 30% completed design). The requested step-two funding, if received, is used to complete the design and construct the project. The steps, timing, and costs that characterize the appropriations model are based on about $28 million worth of projects proposed for agency funding by one federal site during federal fiscal years (FYs) 1994 and 1995.

USEFULNESS OF THE STUDY

The results of the analysis are expressed parametrically in 20-year life-cycle cost-comparison tables, represented here by Table ES-1 and Figure ES-1. There are several caveats associated with the use of the tables, but in general, agencies can refer to the table entries matching their historical or forward-looking estimates of the key parameters defining the appropriations case to obtain a customized comparison between the life-cycle costs of implementing the "typical project" (or a fleet of typical projects) with appropriations and the average ESPC. The key parameters defining the life-cycle cost when using appropriations are total process time (the time elapsed before the ECMs are operating and saving energy), costs for surveys and studies required in the process of requesting funding (as a percentage of design completion and construction costs), and degradation of savings over time (expressed as a percentage per year).

Those who use the parametric tables should be aware of the assumptions embedded in the comparisons. All the parameterized appropriations cases are modeled on the two-step appropriations funding process described above and common to several large agencies. It is certainly possible that agencies could conceive of and implement more efficient processes to allocate scarce appropriated funds. The ESPC model, to which the appropriations cases are compared, is based on all-agency averages, such as the 28-month timeline from kickoff meeting to government acceptance of an operating project. There is no inherent feature of the Super ESPC program that prevents any agency from achieving timelines equal to the average of all participating agencies, but even with their best efforts, some agencies may take

Table ES-1. Present value of life-cycle cost ratio (appropriations over ESPC) of typical project as a function of total survey and study costs and total process time. The shaded cells (ratio < 1) represent cases where life-cycle cost of appropriations is lower than life-cycle cost of an average ESPC.

Total process time (mos.)	Total survey and study costs (as percentage of design completion and construction cost)											
	4%	6%	8%	10%	12%	14%	16%	18%	20%	22%	24%	26%
28	0.8969	0.9099	0.9231	0.9361	0.9491	0.9623	0.9753	0.9883	1.0015	1.0145	1.0275	1.0407
30	0.9028	0.9160	0.9290	0.9422	0.9552	0.9682	0.9814	0.9944	1.0074	1.0206	1.0336	1.0466
32	0.9087	0.9217	0.9347	0.9479	0.9609	0.9739	0.9869	0.9999	1.0129	1.0259	1.0391	1.0521
34	0.9146	0.9276	0.9406	0.9536	0.9666	0.9796	0.9928	1.0058	1.0188	1.0318	1.0448	1.0578
36	0.9202	0.9332	0.9462	0.9592	0.9722	0.9855	0.9985	1.0115	1.0245	1.0375	1.0505	1.0635
38	0.9259	0.9389	0.9519	0.9649	0.9779	0.9909	1.0039	1.0171	1.0301	1.0431	1.0561	1.0691
40	0.9314	0.9444	0.9572	0.9702	0.9832	0.9962	1.0092	1.0222	1.0352	1.0482	1.0612	1.0742
42	0.9369	0.9497	0.9627	0.9757	0.9887	1.0017	1.0147	1.0277	1.0407	1.0537	1.0667	1.0797
44	0.9422	0.9552	0.9682	0.9812	0.9942	1.0072	1.0202	1.0332	1.0462	1.0592	1.0722	1.0852
46	0.9475	0.9605	0.9733	0.9863	0.9993	1.0123	1.0253	1.0381	1.0511	1.0641	1.0771	1.0901
48	0.9527	0.9655	0.9785	0.9915	1.0045	1.0176	1.0303	1.0433	1.0564	1.0694	1.0824	1.0952
50	0.9578	0.9708	0.9838	0.9966	1.0096	1.0226	1.0356	1.0486	1.0614	1.0744	1.0874	1.1004
52	0.9629	0.9759	0.9889	1.0017	1.0147	1.0277	1.0407	1.0537	1.0665	1.0795	1.0925	1.1055
54	0.9678	0.9808	0.9938	1.0066	1.0196	1.0324	1.0454	1.0584	1.0712	1.0842	1.0970	1.1100
56	0.9729	0.9857	0.9987	1.0115	1.0245	1.0375	1.0503	1.0633	1.0761	1.0891	1.1021	1.1149
58	0.9775	0.9905	1.0035	1.0163	1.0293	1.0421	1.0551	1.0681	1.0809	1.0939	1.1067	1.1197
60	0.9822	0.9952	1.0080	1.0210	1.0338	1.0468	1.0596	1.0724	1.0854	1.0982	1.1112	1.1240
62	0.9871	0.9999	1.0127	1.0257	1.0385	1.0515	1.0643	1.0773	1.0901	1.1029	1.1159	1.1287
64	0.9899	1.0027	1.0157	1.0285	1.0415	1.0543	1.0671	1.0801	1.0929	1.1059	1.1187	1.1317
66	0.9944	1.0074	1.0202	1.0330	1.0460	1.0588	1.0718	1.0846	1.0976	1.1104	1.1232	1.1362
68	0.9989	1.0117	1.0245	1.0375	1.0503	1.0631	1.0759	1.0889	1.1017	1.1145	1.1272	1.1402
70	1.0031	1.0161	1.0289	1.0417	1.0545	1.0675	1.0803	1.0931	1.1059	1.1189	1.1317	1.1445
72	1.0076	1.0204	1.0332	1.0460	1.0590	1.0718	1.0846	1.0974	1.1104	1.1232	1.1360	1.1488
74	1.0117	1.0245	1.0373	1.0501	1.0629	1.0759	1.0887	1.1014	1.1142	1.1270	1.1398	1.1526

The results of the life-cycle cost comparison are shown parametrically, enabling energy managers to compare their appropriations-funded projects—either past experience or with estimated prospects for project funding—to the average Super ESPC

longer than 28 months. To adjust the analysis, agencies can request the spreadsheet used by the authors and revise the ESPC case to match their agency-specific averages.

The comparison tables also assume parity between the ESPC and appropriations all-in pricing. Those who are uncomfortable with this assumption may want to perform an ECM-level price analysis on a sample of their own completed projects.

All the parameterized appropriations cases represented in Table ES-1 are modeled assuming that savings persist without degradation, as they do in the ESPC case. The effects on life-cycle cost of 0.5%, 1%, and 2% savings degradation per year for the appropriations cases are shown in a second set of tables in the report (4.3, 4.4, and 4.5), which are represented by Figure ES-1.

EXAMPLES OF USING THE PARAMETRIC TABLES

One use of the tables is to use estimated averages for the three key parameters based on historical experience with appropriations-funded projects, and refer to the tables for an indication of whether or not those past projects, as implemented with appropriations, had a lower life-cycle cost than could have been achieved through an average ESPC. For example, a federal energy manager who wants to compare life-cycle costs of a site's past energy projects to life-cycle costs of an average ESPC could use Table ES-1. If the site's estimated survey and study costs for past projects were 10% of design completion and construction costs, and it generally took 50 months to get the site's projects up and running, the energy manager would see from the table that the site's past projects had about the same life-cycle cost as the average ESPC.

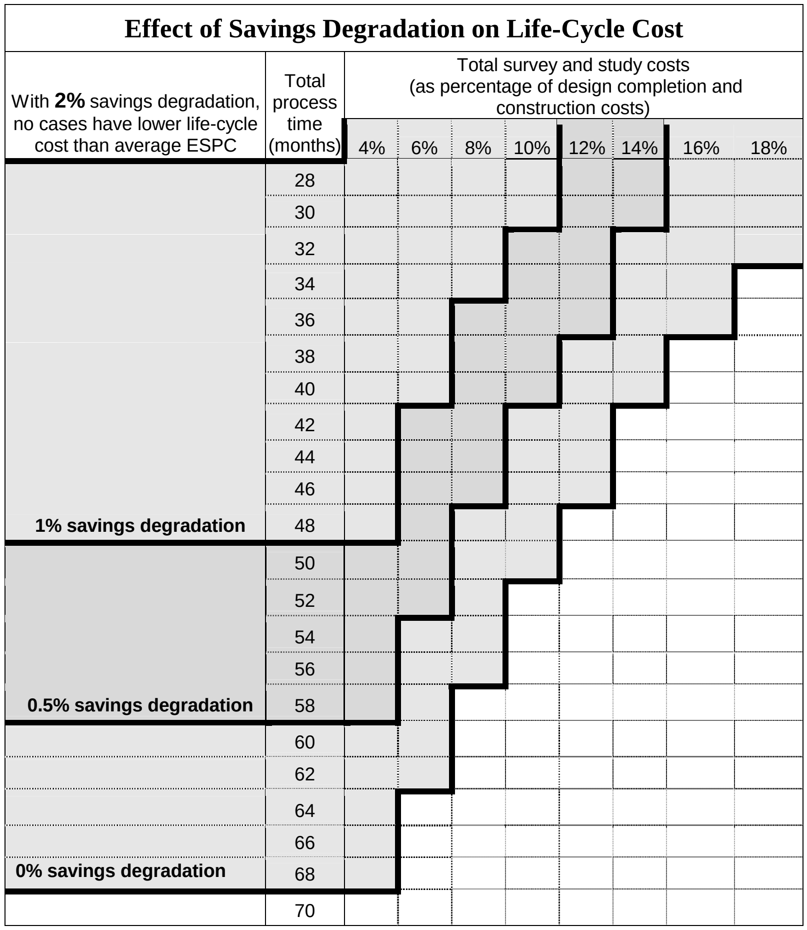

Figure ES-1. The shaded cells in this figure represent appropriations cases having a lower life-cycle cost than the average ESPC when savings in the appropriations cases annually degrade by 0%, 0.5%, 1%, and 2%. For this comparison, savings do not degrade in the ESPC case during the performance period (when savings are guaranteed), and thereafter degrade by the same percentage as the compared appropriations cases.

The tables could also be very useful to agencies who must decide how best to proceed when they face the need to implement a large inventory of projects to meet their goals and lack sufficient appropriations to directly fund them all. Suppose that every year an agency receives appropriations from Congress amounting to just 20% of the funds required to implement all of its required energy efficiency improvements. Is it better to implement the projects piecemeal—funding 20% of the total every year, and waiting five years to make all the improvements—or to fund them all up front with ESPC? If the projects are like the ones typically funded through ESPC, the parametric tables can be used to find the answer.

For example, assuming appropriations-funded projects can be carried out on the same 28-month schedule as ESPC, and that survey and study funds amount to 12%, Table 4.1 shows that the life-cycle cost of the typical energy efficiency project funded by appropriations is about 94.91% of the life-cycle cost of the same project carried out with an ESPC. Now assume an agency has five such projects to implement, but only enough appropriations to fund one of them per year. The ratio for the second year's project would be about 0.9832 (Table 4.1 with 28 + 12 = 40 month process time and 12% survey and study costs). Likewise, the ratio for the third year's project would be 1.0147 (Table 4.1 with 28 + 12 + 12 = 52 month process time and 12% survey and study costs). Altogether, the life-cycle cost ratio for funding all five projects with appropriations is 0.9491 + 0.9832 + 1.0147 + 1.0415 + 1.0675 = 5.065. Since we have added the individual ratios, if the cost of implementing the projects with appropriations were equal to the cost of implementing them with ESPC, the sum would be exactly 5. However in this case the sum is greater than 5, so the life-cycle cost of funding the projects over five years with appropriations is greater than the life-cycle cost of funding them all up front with ESPC.

CONCLUSIONS

The initial applications of the cost-analysis methods demonstrated in this report and the parameterized results only reinforce the traditional knowledge in federal energy management: If appropriations are in hand, using them to directly fund energy projects results in the lowest life-cycle cost, assuming that operating projects are achieved on a short schedule and that their savings persist. However, in recent years appropriations have been insufficient to directly fund all life-cycle cost-effective retrofit projects, and it appears unlikely that Congress will place a higher priority on funding such projects in the near future than it has in the recent past. Lacking sufficient appropriations, the next best thing in terms of life-cycle cost is to finance projects rather than wait for appropriations.

When they do use ESPCs, federal energy managers need assurance that the pricing negotiated in those contracts is comparable to the pricing they can obtain through the competitive bid-to-spec procurement process with appropriations funding. Our method for comparing all-inclusive prices can be used to ensure fair ESPC pricing. For most ECMs agencies can derive all-inclusive price benchmarks from their own appropriations-funded projects. These benchmarks can be used to compare the prices offered by ESCOs in their initial and final ESPC proposals to what the agency paid for the same thing with appropriations funding. Using this method, agency teams who are negotiating ESPCs can learn to focus their pricing due-diligence on all-inclusive ECM prices rather than intermediate accounting conventions such as mark-ups, which are included in the all-inclusive prices.

The life-cycle cost-comparison methods described in this report can be used by federal energy managers to consider the relative merits of waiting for appropriations or using an ESPC. Using estimates of a facility's historical averages for the key parameters, energy managers can refer to the parametric tables and see how the life-cycle costs of the alternatives compare. Using their own experience and judgment concerning their prospects for appropriations, they can decide whether financing, waiting, or some combination of both is the best business decision.

To make the most progress toward all their goals, it is important for agencies to use their limited in-hand appropriations and other tools—such as alternative financing vehicles—wisely. Rather than using scarce appropriations to fund projects that can easily pay for themselves, they should be used to make progress toward renewables goals or to directly fund marginally economic infrastructure projects. The cost-comparison methods described in this report offer federal decision makers the tools to learn from their past projects and move forward with confidence that they are making optimum progress and obtaining best value for the government.

1. INTRODUCTION

1.1 AUTHORIZATION OF FINANCING FOR FEDERAL ENERGY PROJECTS

A fact that is virtually unknown among the general public is that the U.S. government and its agencies—civilian and military—have steadily improved the energy efficiency of federal facilities in the last ten years. The Energy Policy Act of 1992, building on the National Energy Conservation Policy Act of 1978 as amended by the Federal Energy Management Act of 1988, first established statutory energy savings mandates for U.S. federal agencies. Subsequent Presidential executive orders in 1994 and 1999 set increasingly ambitious goals. Federal agencies are now (collectively) on track to meet the mandate set by Executive Order 13123 to use 35% less site energy per square foot in standard buildings by 2010 than consumed in 1985. The order also sets federal site energy reduction goals for energy-intensive facilities (as opposed to standard buildings) and sets goals for water conservation, reduction of carbon emissions, use of renewable energy, and other improvements.

To accelerate investment in cost-effective energy conservation measures (ECMs), these laws and executive orders authorized and encouraged the use of private-sector financing for implementing federal energy-efficiency projects. Executive Order 13123 directs agencies to maximize their use of alternative financing contracting mechanisms, when life-cycle cost effective, to reduce energy use and cost in their facilities and operations. Energy savings performance contracts (ESPCs) and utility energy service contracts (UESCs) account for almost all of the financed federal energy projects accomplished to date.

The U.S. Department of Energy (DOE) was charged with developing rules for federal use of ESPCs and in 1995 issued its rule-making as 10 CFR Part 436. DOE delegated the responsibility for implementing a federal ESPC program to its Federal Energy Management Program (FEMP). FEMP's overall mission is to "reduce the cost and environmental impact of the government by advancing energy efficiency and water conservation, promoting the use of renewable energy, and improving utility management decisions at Federal sites."

FEMP integrated an Alternative Financing Program into its other activities, published model ESPC solicitations, and began helping agencies implement financed energy projects. ESPCs allow agencies to accomplish major energy-efficiency improvements without relying on capital appropriations from Congress. Under an ESPC, a private energy services company (ESCO) provides the project development and design–build construction expertise to finance and implement ECMs and guarantees that the improvements will result in a specified level of energy and cost savings. The cost savings generated by the project must cover the payments for the ESPC over the term of the contract.

However, the process of awarding stand-alone ESPCs for individual agency sites—a new and unfamiliar procurement practice in the federal sector—proved cumbersome and time-consuming. To streamline the process and make ESPCs a more practical option, FEMP competitively awarded indefinite-delivery, indefinite-quantity contracts, "Super ESPCs," to a number of ESCOs in 1997–1998. (The Air Force and Army also have umbrella-type ESPCs in place.) The Super ESPCs establish the general scope of work, terms, and conditions for fixed-price performance-based energy-savings projects, so a major part of the procurement process is already done. In a fraction of the time it takes to develop a site-specific ESPC, federal customers can place and implement delivery orders under the umbrella Super ESPC contracts.

1.2 ROLE OF ESPCs IN STRATEGY TO MEET FEDERAL ENERGY GOALS

FEMP's programs are designed to help and encourage agencies to improve their facilities' energy efficiency and meet federal energy goals. FEMP provides energy management training and technical and design assistance through a number of programs, as well as guidelines to help agencies select the most efficient equipment available when making purchases. FEMP also conducts outreach, awareness campaigns, and awards programs. FEMP's project financing efforts include the Super ESPC Program, a

Utility Program to support agencies' use of UESCs, and initiatives to help agencies use enhanced-use and other leasing authorities. FEMP supports agencies in using these financing mechanisms in keeping with the spirit of the legislation and executive orders that direct agencies to use them. FEMP uses every practical means at its disposal to support agencies' efforts to reduce energy use and costs to the government.

In recent years a significant share of agencies' progress toward meeting federal energy-use reduction goals has been the result of retrofitting buildings through the Air Force, Army, and DOE ESPCs; UESCs; and direct appropriations funding. Recent analysis indicates that significant cost-effective energy retrofit potential still exists at federal sites (Brown, Dirk, and Hunt, 2000).

1.3 ACCEPTANCE OF ALTERNATIVE FINANCING IN THE FEDERAL SECTOR

Many federal facility managers and energy managers have found UESCs and ESPCs to be a good way—if not the only possible way—to accomplish significant energy improvements. Direct funding in the form of capital appropriations for energy-efficiency projects is simply not adequate to accomplish the goals. By the end of fiscal year (FY) 2001, agencies had used ESPC (and its predecessor authority, shared energy savings) to attract over $1 billion in private investment to improve federal buildings (FEMP, 2002). It is conservatively estimated that private investment through UESCs up to the same point in time was $675 million (FEMP, 2002a). At current investment rates this means total private-sector investment through UESCs and ESPCs exceeded $2 billion by the end of FY 2002.

Given the Congressional and Presidential directives for agencies to use these financing vehicles to improve their facilities, the degree of resistance to their use is surprising. Continuing support for ESPCs at the Administration and Congressional levels is evident in the pending comprehensive national energy legislation, which repeals the sunset provision on ESPC authority and extends ESPC authority to include water conservation projects, among other things.

Then again, perhaps the persistent reluctance to finance energy projects is the natural response to a procurement practice that is diametrically opposed to the more familiar government approach of requesting appropriations to directly fund projects, waiting for the funds, and then competitively sourcing the building improvements to the low-bid contractor. Decision makers in these agencies see no reason to pay interest out of their own budgets on borrowed money if instead Congress grants them appropriations to pay for the improvements and thereby directs the U.S. Treasury to do the borrowing. Questions frequently arise about whether pricing in ESPCs, which are negotiated for best value, is as favorable as pricing through competitive sourcing.

On the other hand, by some accounts the most expensive choice is to do nothing, allowing inefficient, obsolete equipment to remain in service, and continually wasting appropriated funds on unnecessary energy use and emergency maintenance, repairs, and replacements. Some agencies have accepted the extra cost that financing entails as the necessary price for making mission-critical improvements to their facilities and making progress toward their energy goals. Many regard Super ESPCs to be a financially smart choice because of (among other benefits) the guarantee that all costs, including debt repayment and the ESCO's follow-up responsibilities, will be covered by the cost savings produced by new ECMs. Others are understandably more concerned about the perceived loss of flexibility inherent in a long-term commitment (Super ESPCs can have terms up to 25 years), are fiscally or philosophically opposed to the government paying interest (except on borrowing through the Treasury), or are unconvinced that negotiation can yield pricing as favorable as that obtained through competition.

1.4 OBJECTIVES OF THIS STUDY

The lack of any quantitative answers to the questions about fair pricing and comparison of life-cycle costs raised in the foregoing discussion was the impetus for this study. ESPCs are by definition cost-effective because of their "pay-from-savings" requirement and guarantee, but do their interest costs and negotiated ECM pricing extract an unreasonably high price? Appropriations are assumed to be the least-cost option, because the U.S. Treasury can borrow money at lower interest rates than the private sector, but appropriations for energy projects are scarce, and it costs agencies money to get appropriated money. What are the costs associated with requesting funding and waiting for appropriations? And how is the value of an energy project affected if savings that are not guaranteed do not last?

The objective of this study was to develop and demonstrate methods to help federal energy managers take some of the guesswork out of obtaining best value from spending on building retrofit energy improvements. We developed a method for comparing all-inclusive prices of ECMs implemented using appropriated funds and through ESPCs that illustrates how agencies can use their own appropriations-funded project experience to ensure fair ESPC pricing. The second method documented in this report is for comparing life-cycle costs. This method illustrates how agencies can use their experience, and their judgment concerning their prospects for appropriations, to decide between financing and waiting.

1.5 COMPARISON OF ALL-INCLUSIVE PRICES FOR ECMs

Chapter 2 describes the method for comparing the all-inclusive prices for same-sized ECMs having the same technical scopes that were implemented through Super ESPC and appropriations-funded projects. The methodology entails detailed analysis of financial and technical records to verify the technical scope of the ECMs and deducts all costs not related to the bare ECM. Researchers concentrated their study on three ECMs that represent about half of Super ESPC investment and are also common in appropriations-funded projects: chiller replacements, lighting retrofits, and variable-frequency drives. About $13 million worth of ECMs implemented each way were analyzed.

Using regression analysis techniques, the study team found no statistically significant differences between the all-in prices for similarly sized ECMs having the same technical scopes in the Super ESPCs and the studied sample of appropriations-funded projects. The analysis showed that in this case the pricing obtained in Super ESPCs, which use a design–build approach negotiated for best value, was as good as the pricing obtained for the appropriations-funded projects in the traditional bid-to-spec competitive procurements. The $13 million in appropriations-funded ECMs were all from two adjacent sites within one agency.

1.6 COMPARING PROCESSES AND LIFE-CYCLE COSTS

We also developed a methodology to compare the life-cycle costs of using ESPCs and appropriations to implement a “typical project,” defined as the average project implemented under the DOE Super ESPC program. Researchers carefully studied the activities and costs of the two processes and used federally specified techniques for analyzing life-cycle costs to ensure that the method would yield valid and meaningful results. This method and some examples of its use are described in Chapters 3 and 4.

The averages to characterize the ESPC process steps, timing, and costs were modeled on the DOE Super ESPC program, which accounts for nearly one quarter of all federal ESPC investment to date. Data were derived from program records and the financial schedules of the first 71 DOE Super ESPC delivery orders (worth $230 million), all awarded by the end of FY 2001.

The appropriations model is based on the two-step process used by several large agencies for distributing direct project funding to sites. Step-one funding sponsors the surveys and studies required to request the step-two funding for project implementation (i.e., design completion and construction). The key parameters defining the life-cycle cost when using appropriations are total process time (the time elapsed before the ECMs are operating and saving energy), costs for surveys and studies required in the process of requesting implementation funding (as a percentage of design completion and construction costs), and degradation of project cost savings over time (expressed as a percentage per year). These three key parameters are inputs to the model and allow agencies to customize the appropriations case to match their circumstances. The appropriations process model must also allocate total process time between intermediate milestones where the costs occur. The time proportioning assumptions are based on a detailed examination of about $28 million worth of projects proposed for agency direct funding by one federal site during federal FY 1994 and 1995.

The results of the analysis are expressed parametrically in life-cycle cost comparison tables (Tables 4.1, 4.3, 4.4, and 4.5). There are several caveats associated with the use of the tables, but in general, agencies can refer to the table entries matching their historical or forward-looking estimates of the key parameters defining the appropriations case to obtain a customized comparison between the life-cycle costs of using appropriations to implement the "typical project" (or a fleet of typical projects) and the average ESPC.

1.7 USEFULNESS OF THE COST-COMPARISON METHODOLOGIES

The initial applications of the cost-analysis methods demonstrated in this report and the parameterized results only reinforce the traditional knowledge in federal energy management: If appropriations are in hand, using them to directly fund energy projects results in the lowest life-cycle cost, assuming that operating projects are achieved on an acceptably short schedule and that their savings persist. However, in recent years appropriations have been insufficient to directly fund all life-cycle cost-effective retrofit projects, and it appears unlikely that Congress will place a higher priority on funding such projects in the near future than it has in the recent past. Lacking sufficient appropriations, the next best thing in terms of life-cycle cost is to finance projects rather than wait for appropriations.

When they do use ESPCs, federal energy managers need assurance that the pricing negotiated in those contracts is comparable to the pricing they can obtain through the competitive bid-to-spec procurement process with appropriations funding. Our method for comparing all-inclusive prices can be used to ensure fair ESPC pricing. For most ECMs agencies can derive all-inclusive price benchmarks from their own appropriations-funded projects. These benchmarks can be used to compare the prices offered by ESCOs in their initial and final ESPC proposals to what the agency paid for the same thing with appropriations funding. Using this method, agency teams who are negotiating ESPCs can learn to focus their pricing due-diligence on all-inclusive ECM prices rather than intermediate accounting conventions such as mark-ups, which are included in the all-inclusive prices.

The life-cycle cost-comparison methods described in this report can be used by federal energy managers to consider the relative merits of waiting for appropriations or using an ESPC. Using estimates of a facility's historical averages for the key parameters, energy managers can refer to the parametric tables and see how the life-cycle costs of the alternatives compare. Using their own experience and judgment concerning their prospects for appropriations, they can decide whether financing or waiting or some combination of both is the best business decision.

To make the most progress toward all their goals, it is important for agencies to use their limited in-hand appropriations and other tools—such as alternative financing vehicles—wisely. Rather than using scarce appropriations to fund projects that can easily pay for themselves, they should be used to make progress toward renewables goals or to directly fund marginally economic infrastructure projects. The cost-comparison methods described in this report offer federal decision makers the tools to learn from their past projects and move forward with confidence that they are making optimum progress and obtaining best value for the government.

2. ECM-LEVEL COST COMPARISON

2.1 INTRODUCTION

Questions frequently arise about whether pricing in ESPCs, which are negotiated for best value, is as favorable as pricing obtained through competitive sourcing. These questions are central to the issue of value in energy retrofit projects and are pivotal in developing methodologies for comparing life-cycle costs of energy projects.

The methodology documented in this report for comparing all-inclusive prices of ECMs implemented using appropriated funds and through ESPCs illustrates how agencies can use their own appropriations-funded project experience to ensure fair ESPC pricing. This method compares the all-in prices for same-sized ECMs having the same technical scopes and entails detailed analysis of financial and technical records to verify the technical scope of the ECMs. All costs not related to the bare ECM are deducted in all cases.

This method allows agencies to compare the pricing in their past appropriations-funded projects with the prices offered by ESCOs in their initial and final ESPC proposals. All-inclusive ECM prices are a much better indicator of value in pricing than intermediate accounting conventions such as mark-up, which are included in the ESPC implementation price, and this method can help agency teams who are negotiating ESPCs focus their pricing due diligence on what is important—the bottom-line price.

In our initial application of this methodology, we analyzed data on $13 million worth of ECMs implemented under Super ESPCs and $13 million worth of appropriations-funded ECMs from two adjacent sites within one agency. Using regression analysis techniques, we found no statistically significant differences between the all-in prices for similarly sized ECMs having the same technical scopes in the Super ESPCs and the studied sample of appropriations-funded projects. The analysis showed that in this case the pricing obtained in Super ESPCs, which use a design–build approach negotiated for best value, was as good as the pricing obtained for the appropriations-funded projects in the traditional bid-to-spec competitive procurements.

2.2 SORTING COST ELEMENTS

ESPCs and most appropriations-funded projects entail similar activities and expenses, but different patterns of execution and funding, as charted in summary form in Figure 2.1. To compare ECM prices, we first had to compare the processes and ensure that cost elements were appropriately segregated and accounted for. The total ESPC implementation price (adjusted as described below) is compared to only the analogous costs in the appropriations-funded projects (also adjusted).

The agency-administered appropriations-funded program used by several large agencies required the agency site to compete for funding with other sites in a two-step process. Sites requested funding for surveys and feasibility studies in Step 1, and in Step 2 requested funds to implement the projects that were defined using Step 1 funding.

The site would first prepare a request for survey and study funds from the agency. If received, the funds would be used for a detailed energy survey and feasibility study, including estimates of energy and maintenance cost savings, and a unit-cost-level estimate of all funding required to implement the project at the site. In general, the amount requested for survey and study funding included resources sufficient to carry design to 30% completion, because this level of detail is required to support credible estimates of costs for design completion, construction, and energy and maintenance cost savings. These detailed estimates were needed at this early stage because the agency required that a formal life-cycle cost analysis be submitted as part of the Step 2 request, as funding decisions were based on criteria such as savings-to-investment ratio (SIR).

The unit-cost estimate for design completion and construction that supported the Step 2 request for project implementation funding included most of the expenses covered by the ESPC implementation

Appropriations Funding	Cost Elements	ESPC
Requested from agency program in competitive process for survey and study funding **(Step 1)**	• Site surveys and feasibility studies • Engineering to 30% design completion	**Implementation price** (Also includes up-front costs of M&V—development of baseline and M&V plan and installing all provisions for M&V)
Design completion and construction cost Requested from agency program in competitive process for implementation funding **(Step 2)**	• Engineering from 30 to 100% design completion • Construction—materials, labor, equipment, subcontractors, taxes, permits, insurance, contingencies • Commissioning • Project management and construction oversight by contractor • Mark-up (contractor's overheads, sales effort, and profit)	
✶Deducted from implementation funding to determine design completion and construction cost, which was compared to ESPC implementation price.	✶ **Agency site project management** Appropriations: – Design reviews – Bid-to-spec package – Pre-bid walk-through – Coordination/access – Proposal evaluation – Negotiation to award ESPC: – Coordination/access – Initial proposal review – DO RFP – Final proposal review – Negotiation to award – Design reviews	✶Not included in ESPC price and not included in life-cycle cost analysis or ECM-level price comparison
	✶ **Agency site construction oversight** – Coordination/access – Outage scheduling – Monitoring of progress – Inspections – Acceptance	

Figure 2.1. The majority of expenses incurred in ESPCs and appropriations-funded energy projects are identical, but patterns of executing and funding the projects differ.

price, but naturally did not include costs for surveys, studies, and engineering to 30% design completion, which had already been disbursed to the site in Step 1. The site's estimates and funding requests did include the costs of agency site project management and construction oversight. If the request was approved, the agency would disburse the entire amount to the site to be used to complete project design, develop a bid-to-spec package and send it out for bids, evaluate bids, award a construction contract to the lowest bidder, and pay the contractor to construct the project.

According to our analysis of the cost elements of the two processes, the design completion and construction cost for an appropriations-funded project is comparable to the ESPC project implementation price. In other words, ECM pricing parity is shown if, to implement exactly the same ECMs, an ESCO would require the same amount for all of the direct and indirect costs necessary to take the project to final completion and government acceptance as would be required for the site to complete the design and to competitively hire a general contractor to provide the site work, materials, labor, and project management necessary to construct the project and gain government acceptance. The analysis described in this chapter isolates these cost elements and tests whether they are indeed equivalent for the average Super ESPC and our sample of appropriations-funded projects. In this section we present the data and analysis used for this comparison of ECM pricing.

Although agency site personnel perform some project management and construction oversight activities in both ESPC projects and appropriations-funded projects, their costs are not included in the average Super ESPC implementation price, which is our basis for comparison. Therefore, to conserve the validity of the comparison, these costs were deducted from the appropriations cases.

One straightforward approach to analyzing pricing parity would be to compare several pairs of projects of identical scope, one of each pair implemented under ESPC and the other with appropriated funds. Because no such paired projects exist, we turned to ECM-level data. This was possible because the financial schedules of Super ESPC projects break costs down by ECM category, and the unit-cost-level estimates for appropriations-funded projects are detailed enough to allow the cost of individual ECMs to be separated. Our objective was to determine whether for ECMs of similar size and scope, any significant statistical differences exist between the implementation price required to install the ECMs under ESPC, and the amount a site would request for design completion and construction (minus site project management and construction oversight costs) to implement the same ECMs under the agency's appropriations-funded energy management program.

Based on the project data available, we chose to study three ECM categories: chiller replacements, lighting retrofits, and installation of variable-frequency drives (VFDs). Together, these three comprise nearly 50% of the $230 million in building improvements carried out through FY 2001 using Super ESPC. They also represent a significant fraction of the energy conservation projects proposed to the agency for appropriated funding by the two adjacent sites whose records we examined.

We began with the financial schedules of the 71 Super ESPC projects and a file containing records (feasibility studies, unit-cost estimates, etc.) for 35 energy conservation projects proposed for appropriations funding by the two adjacent sites. After identifying the projects that contained chiller replacements, lighting retrofits, or VFD installations, we performed a careful analysis of the cost data to separate the cost of the bare ECMs we were interested in from the total cost of each project. To account for inflation and regional price variation, we then adjusted prices according to the GDP-IPD, or Gross Domestic Product Implicit Price Deflator (U.S. Department of Commerce, 2002) appropriate for the project date.

2.3 SEPARATING ECM COSTS FROM TOTAL PROJECT COSTS

Comparing the costs of individual ECMs from different projects at different sites presents a number of difficulties. The cost to install even an identical piece of equipment at two different sites could vary widely depending on the site work and tie-ins required, the cost of labor and materials, and the overhead and profit charged by two different contractors in two different locations. Nevertheless, we feel it is reasonable for federal site managers to expect answers to questions such as, "On average, what does it cost to replace 300 tons of chiller capacity at my site?" Such questions can only be answered with historical data. Undoubtedly, the best source of information is real projects having both detailed ECM scope descriptions and detailed cost estimates.

2.3.1 Cost Data Sources for ESPC ECMs

Financial schedules for Super ESPC projects provided us with ECM-level cost information for a large number of actual projects. Schedule DO-2 (formerly H-2 in some regions prior to contract amendments) requires ESCOs to separate implementation prices into ECM categories, and in most cases the ECM price includes all of the direct and indirect costs (plus mark-up) listed in Figure 2.1. Projects awarded after the consistency amendments have the survey and study costs broken out as a separate line item. When ECMs from these projects were included in the samples, the ECM prices included their proportional share of the survey and study costs. In these cases, the cost of the project-wide survey and study was allocated to each ECM in proportion to the percent of the total price it represented.

A significant problem with the financial schedule data, however, is that the financial schedules include only a short description of the ECM. For example, an ECM described as a “lighting upgrade” could be focused on tube and ballast replacements, occupancy or daylighting controls, fluorescent fixture upgrades, conversion from incandescent to fluorescent fixtures, fixture replacements, or any combination of these improvements. “Chiller replacement” tells nothing about the number of chillers replaced, their size, or the supplemental equipment often embedded in the ECM (i.e., cooling towers, VFDs, pumps, piping modifications, and others). For this reason it was necessary to also examine the ECM scope descriptions of the sampled ECMs, which were contained in the delivery order final proposals. This required access to the final proposals, and because proposals for the Southeast region were readily available to us, our analysis is based primarily on Super ESPC projects in the Southeast region of the United States. Since the appropriations-funded ECM records we examined were from adjacent sites in the Southeast within one agency, this was probably just as well. The scope descriptions enabled us to build samples of ECMs from Super ESPC projects in each ECM category that were sufficiently homogeneous and comparable to similar samples of ECMs from appropriations-funded projects. In some cases cost adjustments were necessary, as described in greater detail in the sections pertaining to each ECM category.

2.3.2 Cost Data Sources for Appropriations-Funded Projects

For appropriations-funded projects the detailed cost estimates that supported the Step 2 requests for design completion and construction funds were our source of ECM cost data. In all cases when requests were funded, the funds provided to the site for ECM completion equaled the amount requested, which equaled the amount from the detailed cost estimate. By examining the ECM scope descriptions in the study reports and using the detailed cost estimates to make adjustments, samples of ECMs from appropriations-funded projects were developed that were comparable to those from Super ESPC projects.

2.3.3 Example of Adjustments Used to Isolate Appropriations-Funded Costs for Bare ECMs

The following is an example of how we used the detailed cost estimates to adjust costs where necessary. The example pertains to an energy conservation project for a 45,000-square-foot office building. The existing HVAC equipment consisted of a multi-zone hot deck/cold deck air handling system using steam coils to provide heated air to the hot deck, and direct expansion (DX) coils fed by four R-12 air-cooled vapor-compression machines to provide chilled air to the cold deck. To meet the zone set-point temperatures, heated and cooled air were mixed and supplied at a constant flow rate to each zone. In 1994, the site requested funds to replace the R-12 air-cooled vapor compression machines with a CFC-free 120-ton air-cooled screw chiller to produce chilled water. The DX coils would be replaced with water-to-air coils, and the constant-volume air handling system would be converted to variable air volume (VAV).

2.3.3.1 Source Data

As required by the agency, engineers at the site carried the design through 30% completion and prepared a detailed cost-benefit study for the project, including estimates of energy savings, maintenance savings, and costs for design completion and construction, project management, and construction oversight. The unit-cost-level design/construction cost estimate prepared by the site’s cost estimators was detailed enough to allow us to estimate the project cost with the scope reduced to chiller replacement only.

2.3.3.2 Eliminating Unrelated ECM Costs

The original cost estimate for the project is summarized in Table 2.1. Our first step was to examine all of the line items listed under the category of construction to determine which were related specifically to

Table 2.1. Original cost estimate for example appropriations-funded chiller project

Category		Cost	Cost as fraction of construction
Engineering (Title I, II, & III)		$116,614	0.278
Field support		$71,817	0.171
Construction and AE support		$27,601	0.066
Project management		$14,271	0.034
Construction			
Electrical	$47,712		
HVAC	$205,809		
Piping	$136,413		
Structural	$29,584		
Subtotal, construction		$419,518	
Contractor direct & indirect costs		$84,630	0.202
Health and safety		$15,000	0.036
Subtotal		$749,451	
Overheads (15.7%)		$117,764	
Contingency (20%)		$173,443	
Total		**$1,040,658**	

the chiller replacement and which should be assigned to the associated equipment. Some of the line item costs we deducted were the following:

- VAV boxes
- VAV coils
- DDC control system
- Air handler piping
- Air handler supports
- Steam piping
- Controls and instrumentation
- HVAC supports
- VFDs

Altogether, these deletions reduced the construction costs by $256,978—from an original figure of $419,518 down to $162,540.

2.3.3.3 Recalculating Non-Construction Costs

Next we determined how each of the other cost categories in the original estimate was related to the total construction cost. For example, engineering, at a cost of $116,614, is 0.278 times the total construction cost of $419,518. Likewise, the cost of field support is $71,817, or 0.171 times the total construction cost. The fractions of construction cost represented by all the cost categories are listed in Table 2.1.

Note that the cost of "field support" remains in the adjusted costs for appropriations-funded ECM projects. It is true that as a matter of site policy, tasks such as refrigerant recovery and final electrical and mechanical tie-ins must be performed by site management and operation (M&O) contractor personnel rather than construction subcontractors. However, these site requirements are described in the bid-to-spec package, so the selected general contractor has not priced these costs into the subcontract. The costs are the same whether performed by the M&O contractor personnel or subcontractors. These costs are included in the ESPC ECM implementation prices and are retained in the appropriations-funded ECM costs to preserve an apples-to-apples comparison.

With all of the additional costs expressed as a percentage of construction costs, we then applied the same percentages to the reduced construction cost of $162,540. For example, we estimate that with the reduced construction costs, the cost of engineering would be $162,540 × 0.278 = $45,181, and the cost of field support would be $162,540 × 0.171 = $27,825.

2.3.3.4 Excluded Health, Safety, and Security Costs

In this case, the cost adjustment strategy is complicated by the fact that the category "contractor direct & indirect costs" included some health and safety costs. One would expect that all the health and safety costs would be in the health and safety line item, but a close examination revealed that this was not the case. This level of health and safety costs would not be present at the majority of federal sites and were not present in the ESPC ECM prices. Therefore all health and safety costs, including the separate line item and those embedded in "contractor direct & indirect costs," were deleted from the appropriations-funded ECM cost. The embedded cost amounted to 0.005 times the total construction cost, so in the adjusted estimate, we reduce the "contractor direct & indirect costs" fraction from 0.202 to 0.197.

2.3.3.5 Excluded Project Management and Oversight Costs

In the adjusted estimate, we eliminated the cost associated with "construction and AE [architectural/engineering] support." Site policy also requires the site (M&O) contractor to provide a certain level of support and oversight of any construction at the site. The cost of this oversight is not included in the implementation price of ESPC ECMs and for consistency was deleted from the cost of the appropriations-funded ECMs.

We also exclude the costs associated with "project management," which refers to the management and operating (M&O) contractor's project management over the general contractor. In this particular project it represents about 1.4% of the total cost of the project, and we recognize that it is a real cost. Even when all aspects of an ECM project are being implemented by a general contractor and its subcontractors, there is a need for a representative from the site to coordinate access to buildings and equipment, schedule service outages, monitor and report progress, inspect the work, observe start-ups, etc. We eliminate this cost from appropriations-funded projects because, as stated above, it is not included in the implementation price of ECM projects under ESPC. To make an "apples-to-apples" comparison we do not consider these costs in the life-cycle cost analysis of either option, because these costs are the same in either case. (This assumption is discussed in more detail in Section 4.3.)

2.3.3.6 Total Adjusted Costs

A summary of the adjusted cost estimate is presented in Table 2.2. Given all of the reductions we estimate that if the scope of work were reduced strictly to activities associated with removal of the existing DX machines and installation of the 120-ton air-cooled chiller, the site would have requested $371,604.

2.3.3.7 Escalation to 2001 Dollars

Finally, note that the cost estimate for the project was produced in November of 1994. By interpolation from the quarterly values, the GDP-IPD index in November 1994 was 96.98. In December 2001, the base year for this study, the index was at 110.02. To escalate the adjusted construction cost estimate to December 2001 we multiply it by the ratio of the two indices. Thus the final adjusted cost estimate for this project is 371,604 × (110.02/96.98) = $421,568.

2.3.3.8 Summary of Cost Adjustment Method

The same basic methodology was used to adjust the costs for all the appropriations-funded ECM projects so that costs would correspond to bare ECM scopes, and would be comparable to the bare ECM samples from ESPC. We examined each appropriations-funded ECM detailed cost estimate line by line. In the above example the line-by-line examination was done in order to (1) remove costs not associated

Table 2.2. Summary of adjusted costs for the example appropriations-funded chiller project (not adjusted for price inflation)

Category		Cost	Cost as fraction of construction
Engineering (Title I, II, & III)		$45,182	0.278
Field maintenance		$27,825	0.171
Construction & AE support		-	0
Project management		-	0
Construction			
Electrical	$24,368		
HVAC	$84,750		
Piping	$38,118		
Structural	$15,304		
Subtotal, construction		$162,540	
Contractor directs & indirect costs		$32,071	0.197
Health and safety		-	0
Subtotal		$267,618	
Overheads (15.7%)		$42,052	
Contingency (20%)		$61,934	
Total		**$371,604**	

with the chiller and its mechanical and electrical tie-ins, (2) remove health, safety, and security costs that are unlikely to be present at other federal sites and are not present in the ESPC ECM samples, and (3) eliminate M&O contractor costs for construction and AE support and project management, which are real costs but are not in the ESPC ECM samples. Costs for engineering, field support, and contractor direct and indirect costs were apportioned according to the adjusted construction costs. Costs were then escalated to December 2001 dollars using the GDP-IPD.

Fewer of the ESPC ECMs needed cost adjustments because the actual ECM projects had the desired scopes. When adjustments were needed they were not as involved, because the cost backup information readily available was not as detailed. Where it was possible to determine average costs for ECMs "contaminated" by auxiliary equipment (for example, cooling tower replacement contained in a chiller ECM) these costs were subtracted from the implementation price. The ECM prices were then corrected for geographical location and general price inflation.

2.4 COMPARISON OF CHILLER REPLACEMENT COSTS

One of the most common uses of Super ESPC has been to replace inefficient chillers. Of the $230 million invested through Super ESPC by end of FY 2001, about $49 million, or 21% of the total, was invested in chiller plant upgrades. Chiller replacements and upgrades were also common among the energy conservation projects submitted for appropriations funding by the adjacent sites.

2.4.1 Chiller Samples for Appropriations-Funded Projects

We located seven detailed cost estimates for chiller replacement projects that were submitted for appropriations funding between 1993 and 1996. As described above, we examined the estimates line by line in order to (1) remove costs not associated with the chiller and its mechanical and electrical tie-ins (e.g., air handler coil piping, steam piping, mechanical room ventilation, controls, etc.), (2) remove health, safety, and security costs that are unlikely to be present at other federal sites and are not present in the ESPC ECM samples, and (3) eliminate M&O contractor costs for construction and AE support and project management, which are real costs but are not in the ESPC ECM samples. Costs were then adjusted to December 2001 dollars using the GDP-IPD. Table 2.3 presents the costs of the full scopes of the original projects, and Table 2.4 presents the same projects with the scope and costs reduced to chiller replacement only. The project scopes are summarized in Table 2.5.

Table 2.3. Itemized costs of (and amounts requested for) design completion and construction of appropriations-funded projects including chiller replacements (2001 dollars)

Cost category	Project								
	1	2	3	4	5	6	7	Total	Percent of total
Engineering (Title I, II, & III)	132,293	235,644	56,415	83,205	235,644	235,644	235,644	1,214,491	10.2
Field support	81,473	4,731	5,964	7,979	9,462	9,462	22,710	141,782	1.2
Construction & AE support	31,312	95,275	0	21,256	95,275	95,275	95,275	433,668	3.7
Project management	16,190	45,886	0	14,880	45,886	45,886	45,886	214,611	1.8
Electrical	54,127	11,949	13,693	81,814	14,852	23,986	48,017	248,438	2.1
HVAC	233,481	224,376	204,248	226,430	415,692	388,526	2,488,446	4,181,198	35.2
Piping	154,755	104,982	0	142,324	196,753	196,753	454,566	1,250,134	10.5
Structural	33,562	0	0	28,278	0	0	0	61,840	0.5
Support	0	9,382	0	310,950	9,638	11,834	29,721	371,525	3.1
Contractor directs & indirects	96,009	84,281	103,098	248,298	149,164	145,315	662,057	1,488,223	12.5
Health and safety	17,017	0	889	0	0	0	0	17,906	0.2
Subtotal	850,219	816,506	384,307	1,165,415	1,172,366	1,152,680	4,082,322	9,623,816	81.1
Additional overheads	133,598	45,561	37,448	48,382	47,739	47,739	53,834	414,301	3.5
Total w/o contingency	983,817	862,067	421,755	1,213,798	1,220,105	1,200,419	4,136,156	10,038,117	84.6
Contingency	196,763	129,224	84,351	242,760	244,021	192,547	742,440	1,832,106	
Grand Total	1,180,581	991,291	506,106	1,456,557	1,464,126	1,392,967	4,878,596	11,870,224	100.0

Table 2.4. Itemized costs for design completion and construction of sample of appropriations-funded chiller projects (2001 dollars), adjusted to reduce project scope to chiller replacement

Cost category	Project number							
	1	2	3	4	5	6	7	Total
Engineering (Title I, II, & III)	51,256	173,865	56,131	50,400	185,472	183,343	179,701	880,168
Field support	31,566	3,491	5,934	4,833	7,448	7,362	17,137	77,771
Construction & AE support	0	0	0	0	0	0	0	0
Project management	0	0	0	0	0	0	0	0
Electrical	27,644	2,822	13,693	80,469	5,624	9,758	22,381	162,391
HVAC	96,145	201,641	200,322	204,591	386,899	364,431	2,022,323	3,476,353
Piping	43,244	9,809		110,768	19,601	19,636	78,386	281,443
Structural	17,362			26,490				43,852
Support		5,332		55,600	5,684	6,867	18,684	92,168
Contractor directs & indirects	36,383	62,185	72,956	150,401	117,405	113,063	502,727	1,055,120
Health and safety	0	0	0	0	0	0	0	0
Subtotal	303,601	459,144	349,035	683,553	728,133	704,460	2,841,338	6,069,265
Additional overheads	47,706	7,194	35,569	28,378	9,388	9,280	13,661	151,175
Total w/o contingency	351,307	466,338	384,605	711,931	737,521	713,741	2,854,999	6,220,440
Contingency	70,261	69,904	76,921	142,386	147,504	114,484	512,472	1,133,933
Grand Total	421,568	536,242	461,525	854,317	885,025	828,225	3,367,471	7,354,373

Table 2.5. Summary descriptions of adjusted appropriations-funded chiller projects (2001 dollars)

Project	Nominal capacity	Installed cost	Description
1	120	$421,568	1 air-cooled screw chiller
2	200	$536,242	1 water-cooled screw chiller
3	270	$461,525	1 air-cooled screw chiller
4	300	$854,317	1 air-cooled screw chiller
5	400	$885,025	2 200-ton water-cooled screw chillers
6	400	$828,225	1 100-ton, 1 300-ton, water-cooled screw chillers
7	4000	$3,367,471	4 1000-ton water-cooled centrifugal chillers
Total	**5960**	**$7,354,373**	

2.4.2 Super ESPC Chiller Sample

We identified a total of six ESPC projects in the Southeast region containing chiller replacement ECMs. No detailed cost estimates were available, but based on the scopes of work, implementation prices were adjusted to remove the cost of cooling towers and VFDs in four of the six projects. For ECMs that included cooling tower replacement, we subtracted a figure of $486 per ton based on cooling tower replacement costs seen in other ESPC projects in the region. For ECMs that included VFDs, we subtracted $15,361 plus $528 per horsepower. This equation is based on the correlation of the cost of VFD-only ECMs in eight ESPC projects in the Southeast region presented in Section 2.6 below. Finally, the implementation prices were multiplied by the ratio of the GDP-IPD for the particular site during the month the ESPC was awarded to the GDP-IPD at the agency site with the appropriations-funded ECM projects during December 2001. The adjusted costs for the six ECMs carried out with Super ESPC are presented in Table 2.6.

Table 2.6. Summary descriptions of adjusted Super ESPC chiller projects (2001 dollars)

Project	Nominal capacity	Implementation price	Project description
1	180	$318,968	1 180-ton water-cooled chiller
2	225	$77,239	1 150-ton water-cooled, 1 75-ton air-cooled
3	500	$806,192	1 140-ton, 1 360-ton. water-cooled chillers
4	1125	$524,746	3 375-ton water-cooled chillers
5	1950	$1,443,885	2 1250-ton water-cooled centrifugal chillers
6	3000	$2,625,253	3 1000-ton water-cooled centrifugal chillers
Total	**6980**	**$5,796,283**	

2.4.3 Results of Chiller Cost Comparison

Figure 2.2 is a plot of the adjusted cost versus installed capacity for both the appropriations-funded and the ESPC projects. We recognize several limitations in the data. First, although the information provided does distinguish between air-cooled and water-cooled chillers, the particular chiller design (centrifugal, screw, reciprocating, etc.) was not available in all cases. Also, the data set of appropriations-funded projects contains more air-cooled chillers (690 tons out of the total of 5,960, or about 12% of the nominal capacity represented) than the set for Super ESPC projects, which contains only a single air-cooled chiller of 75 tons. Although we have removed the cost of cooling towers from all of the water-cooled chiller projects, we do not expect the cost of air-cooled and water-cooled chillers to be exactly the same for a given size. Nevertheless, examination of public sources of construction cost data (R. S. Means,

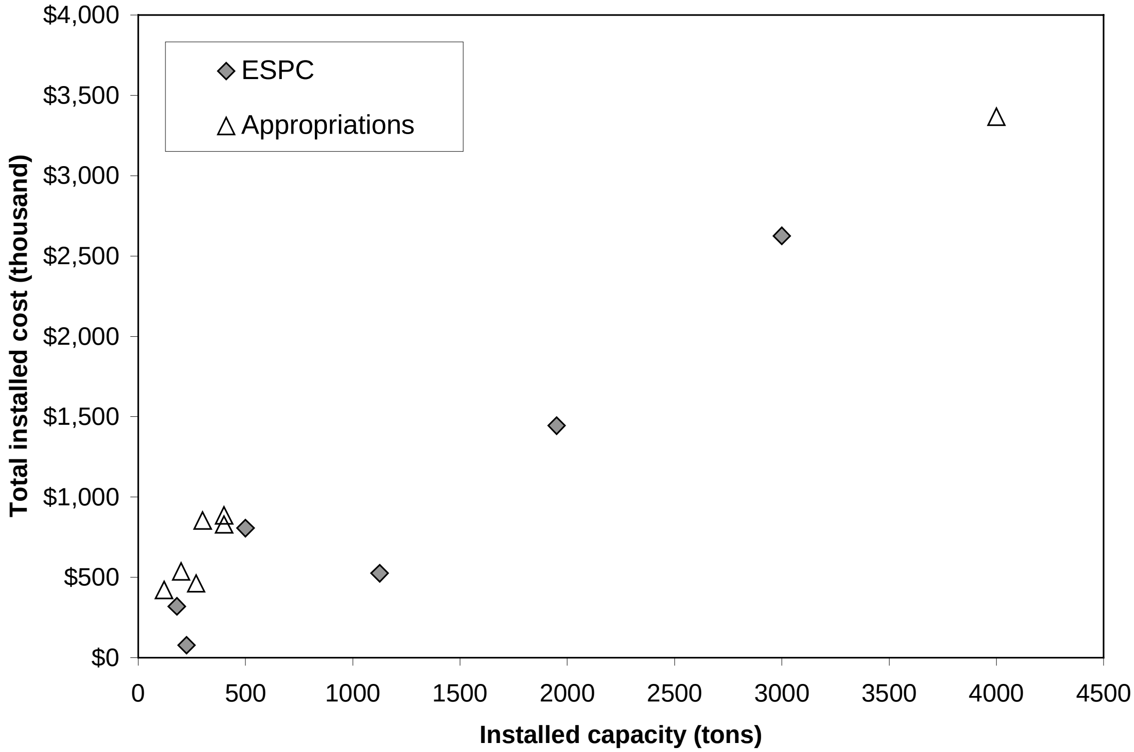

Figure 2.2. Chiller ECMs: Design completion and construction costs in appropriations-funded projects, and implementation price in ESPC projects.

2001) shows that for sizes below 300 nominal tons, the costs of similarly sized air-cooled and water-cooled chillers are comparable. Obviously, if sufficient data were available it would be better to perform separate cost comparisons for each chiller type, as opposed to grouping them all together as we have done here.

Another problem with the data is that the appropriations set contains six relatively small projects and a single large one. This means that any conclusions we draw about the relationship between cost and capacity will be highly influenced by the single large project. Again, it would be preferable to have more data. Nevertheless, although both data sets are sparse, Figure 2.2 suggests a linear relationship between cost and capacity. This result seems intuitively correct, and also agrees with the findings of McLain et al. (1991), who noted a similar relationship.

2.4.4 Regression Analysis of Chiller Cost Results

Visual inspection of Figure 2.2 suggests that the cost of design completion and construction (not including survey and study costs) of this sample of chiller replacements using appropriated funds may be somewhat higher than the full implementation price (survey, study, design, construction, and commissioning, plus mark-up) of similarly sized chiller replacements using Super ESPC. To test this hypothesis we use a standard statistical test. First we combine the ESPC and appropriations-funded project cost data and fit the combined data to a single straight line (Model 1) using ordinary least-squares regression. We then fit the data to two separate straight lines (Model 2), one for appropriations-funded projects and one for ESPC projects. Analysis of the variance associated with each model allows us to determine whether there is a statistically significant difference between the two models, or whether the difference could be due strictly to the variability of the data.

To carry out these calculations we use the R statistical software package (Venables and Ripley, 1999; Venables and Smith, 2002). For the benefit of readers who are statistically inclined, we have included in the tables below the standard parameters and results associated with the statistical analysis performed. Other readers should not be concerned if some of this information appears meaningless because the conclusions of the analysis are also expressed in non-technical terms.

We begin by fitting *all* of the data (ESPC and appropriations-funded) to a single linear model of the following form, using ordinary least squares:

$$\text{cost} = a + b \times \text{capacity}\ . \tag{2.1}$$

The results of the regression are presented in Table 2.7.

Table 2.7. Regression results for chiller cost data, without distinguishing between ESPC and appropriations-funded projects

Parameter	Estimate	Standard error	t value	Pr(>|t|)
a	296664.5	103521.4	2.866	0.0154
b	733.5	67.1	10.931	3.02E-07
Residual standard error: 289300 on 11 degrees of freedom				
Multiple R-squared: 0.9157, adjusted R-squared: 0.908				
F-statistic: 119.5 on 1 and 11 DF, p-value: 3.016e-07				

Next we fit a model that distinguishes between the appropriations and ESPC data, namely an equation of the form

$$\text{cost} = (a + b \times \text{capacity}) + p \times (\Delta\, a + \Delta b \times \text{capacity})\ \ , \tag{2.2}$$

where p is a dummy variable equal to 0 for ESPC projects and 1 for appropriations-funded projects. The interpretation of Eq. (3.2) is that for ESPC projects, the data are fit to cost = $a + b \times$ capacity , whereas for appropriations-funded projects, the equation is

$$\text{cost} = (a + \Delta a) + (b + \Delta b) \times \text{capacity}\ . \tag{2.3}$$

The results of the regression, presented in Table 2.8, are inconclusive. The value of Δa is weakly significant at the 95% confidence level, but the value of Δb is not. This suggests that the costs associated with appropriations-funded chiller projects may be higher than the costs of similar projects funded under ESPC; however, there is no evidence to support a difference in the cost per ton of chiller capacity between the two funding mechanisms. Table 2.9 presents the results of the analysis of variance between Model 1 and Model 2. The analysis of variance tests the hypothesis that both Δa and Δb are equal to zero—i.e., that there is no difference between the chiller prices for the ESPC and appropriations-funded projects. The probability value of 0.0744 means there is a 7.44% probability that the differences between the two data sets are due to random variation. The conclusion is that the data provide little reason to reject the hypothesis that Δa and Δb are equal to zero. In other words, based on the available data, there appears to be no statistically significant difference between the pricing of ESPC-funded chillers and the pricing of chillers funded with appropriations.

Table 2.8. Regression results for chiller cost data, using a model that distinguishes between ESPC and appropriations-funded projects

Parameter	Estimate	Standard error	t value	Pr(>|t|)
a	36920.34	148158.51	0.249	0.8088
b	798.68	95.63	8.352	1.57E-05
Δa	418953.29	182601.84	2.294	0.0474
Δb	–67	118.19	–0.567	0.5847
Residual standard error: 239700 on 9 degrees of freedom				
Multiple R-squared: 0.9527, adjusted R-squared: 0.9369				
F-statistic: 60.39 on 3 and 9 DF, p-value: 2.768e-06				

Table 2.9. Analysis of variance for the two models of the chiller cost data. (Model 1 does not distinguish between ESPC and appropriations-funded projects; Model 2 does distinguish)

Model	Residual degrees of freedom	Residual sum of squares	Degrees of freedom	Sum of squares	F	Pr(>F)
1	11	9.21E+11				
2	9	5.17E+11	2	4.04E+11	3.5151	0.07445

In Figure 2.3 we have included the (single) regression line that fits both data sets. Note that all but one of the data points from the appropriations-funded projects falls above the line. Nevertheless, the statistical analysis shows that this could arise from the variability of the data.

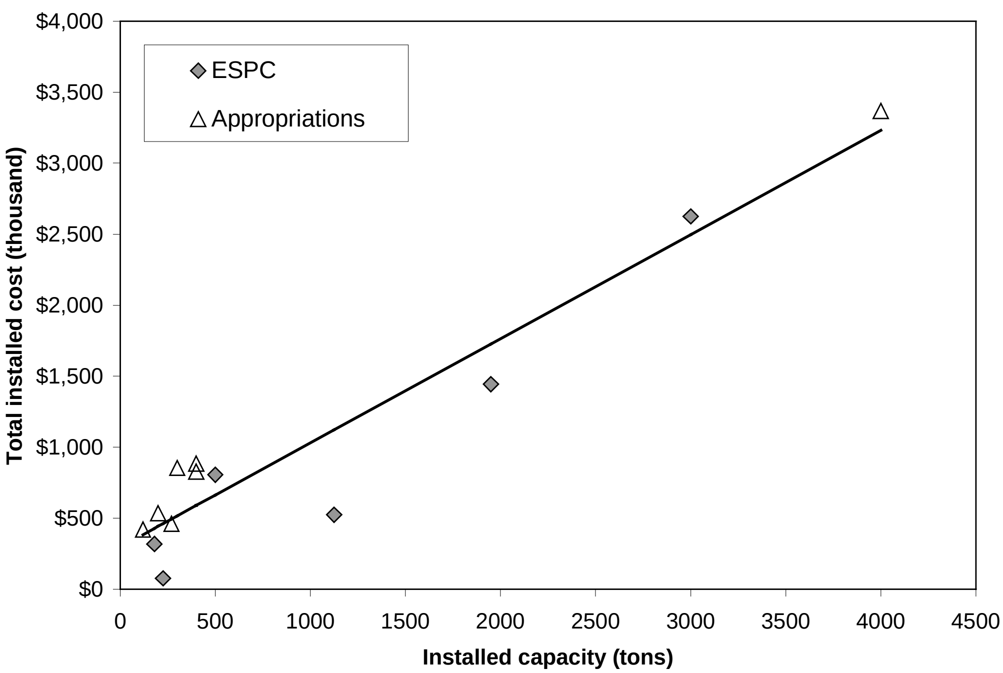

Figure 2.3. Chiller ECMs: Design completion and construction costs in appropriations-funded projects, and implementation price in ESPC projects. Includes regression lines.

2.4.5 Additional Chiller Cost Data—Appropriations Set 2

We obtained cost figures for an additional four appropriations-funded chiller replacement projects implemented at the site between 1997 and 1999. Although funding for these chillers did not come from the same agency-administered program as the other seven, they were installed using appropriated funds. There are several limitations to this additional data. First, since we did not receive detailed cost estimates for these projects, we cannot be certain that the projects involved chiller replacement only. We recognize also that the costs may be contaminated by some of the health and safety costs and M&O contractor management costs that we eliminated from the cost estimates of the other seven appropriations-funded chiller projects. On the other hand, the reason no detailed cost estimates exist is that a more streamlined design–build implementation approach was used for these chillers, and any advantages should appear as lower costs. Despite all these differences, when adjusted for inflation to December 2001, costs for these four appear comparable to the costs of the other chillers. Table 2.10 presents the costs and nominal capacities of these projects, and in Figure 2.4 we include these projects (labeled “Appropriations Set 2”) along with the costs of the other appropriations-funded and Super ESPC chiller ECMs.

Table 2.10. Appropriations Set 2: Adjusted costs for chiller replacement using a different source of appropriated funds (2001 dollars)

Project	Nominal capacity	Installed cost	Project description
1	300	$314,849	1 water-cooled centrifugal chiller
2	400	$685,142	1 water-cooled centrifugal chiller
3	1,000	$826,751	1 water-cooled centrifugal chiller
4	1,200	$919,937	1 water-cooled centrifugal chiller
Total	**2,900**	**$2,746,679**	

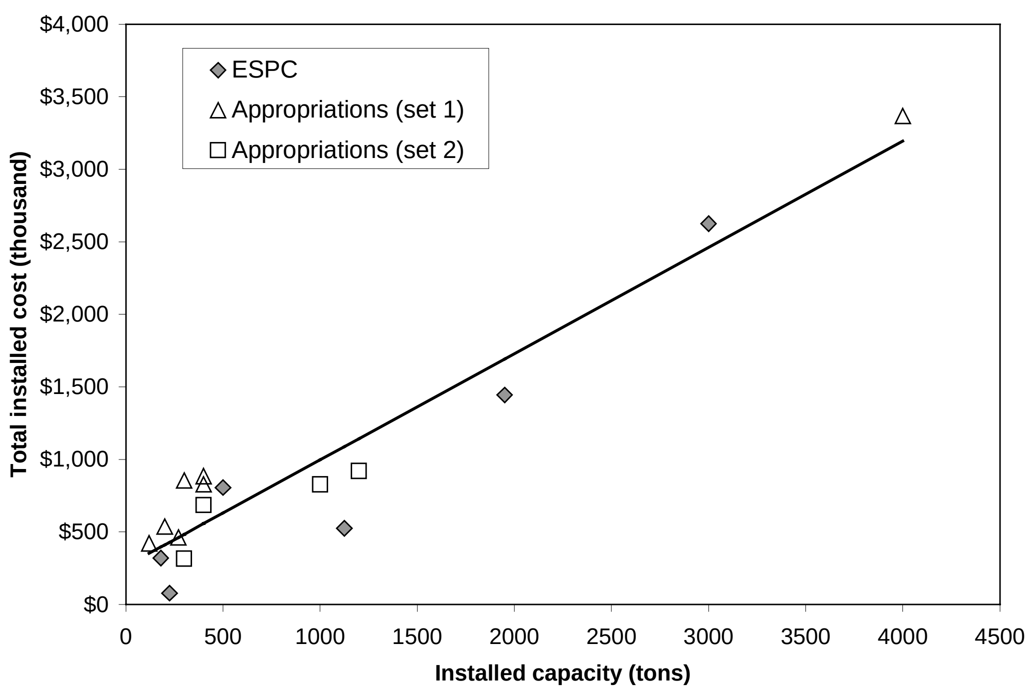

Figure 2.4. Chiller ECMs: Design completion and construction costs in appropriations-funded projects including Appropriations Set 2, and implementation price in ESPC projects.

We included these four in the set of appropriations-funded chillers and repeated the analysis to determine whether there is any statistically significant difference between the appropriations and ESPC data, assuming a linear cost model. The results are presented in Tables 2.11 through 2.13.

Table 2.11. Regression results for chiller cost data (including Appropriations Set 2), without distinguishing between ESPC and appropriations-funded projects

Parameter	Estimate	Standard error	t value	Pr(>|t|)
a	263997.71	84920.14	3.109	0.00719
b	732.78	60.38	12.136	3.70E-09
Residual standard error: 265700 on 15 degrees of freedom				
Multiple R-squared: 0.9076, adjusted R-squared: 0.9014				
F-statistic: 147.3 on 1 and 15 DF, p-value: 3.703e-09				

Table 2.12. Regression results for chiller cost data (including Appropriations Set 2), using a model that distinguishes between ESPC and appropriations-funded projects

Parameter	Estimate	Standard error	t	p-value
a	36920.34	155410.78	0.238	0.816
b	798.68	100.31	7.962	2.36E-06
Δa	313412.45	181596.11	1.726	0.108
Δb	–71.39	122.93	–0.581	0.571
Residual standard error: 251400 on 13 degrees of freedom				
Multiple R-squared: 0.9283, adjusted R-squared: 0.9117				
F-statistic: 56.1 on 3 and 13 DF, p-value: 1.071e-07				

Table 2.13. Analysis of variance between Model 1 (which does not distinguish between ESPC and appropriations-funded chiller projects) and Model 2 (which does distinguish between the two sets)

Model	Residual degrees of freedom	Residual sum of squares	Degrees of freedom	Sum of squares	F	Pr(>F)
1	15	1.06E+12				
2	13	8.22E+11	2	2.37E+11	1.8784	0.192

Once again, the analysis of variance results show that there is a reasonable probability (0.192, or an 19.2% chance) that there is no difference between the two data sets. In other words, we conclude that the data provide no evidence to reject the hypothesis that Δa and Δb are both equal to zero, and there is no statistically significant difference between the two data sets, given the linear cost model.

Figure 2.5 shows the 95% confidence interval for the cost difference of chiller projects (appropriations-funded minus ESPC) as a function of installed capacity, given the available data and the regression of Table 2.12. The mean difference is positive over the range of the data, which suggests that appropriations-funded chiller projects may be slightly more expensive than projects funded with ESPC, although the difference is not statistically significant. Due to the variance in the data and the small amount of data available, the confidence interval is wide across the entire range of chiller capacities. Obviously, more data would be required to draw any firm conclusions about differences in costs.

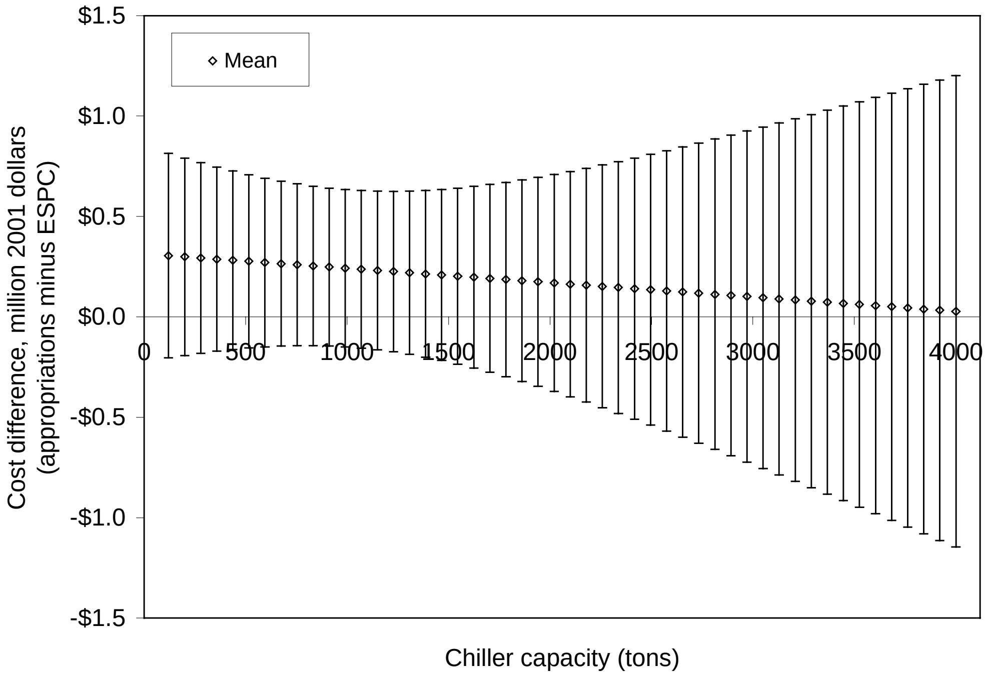

Figure 2.5. 95% confidence intervals for difference in chiller costs (appropriations-funded minus ESPC-funded) as a function of chiller capacity.

2.4.6 Summary of Conclusions on Chiller Prices

In summary, the available data provide no reason to believe that the cost for design completion and construction of a chiller ECM using appropriated funds from the agency's energy management program is higher than the all-in price (for survey, study, design, construction, and commissioning, plus mark-up) an ESCO would charge to implement a similar chiller replacement using Super ESPC. This was confirmed with two different data sets—one from a traditional appropriations-funded energy management program, and another from a more streamlined design–build methodology also funded with appropriations. Nevertheless, costs were available from only a small number of chiller projects, and more data would be required to draw any final conclusions about pricing differences.

2.5 COMPARISON OF LIGHTING UPGRADE COSTS

Lighting retrofits are another major category of ECM installed using Super ESPC. By the end of 2001, lighting projects represented about $52 million, or 21% of the $230 million invested in Super ESPC. In this section we compare the costs of lighting ECMs implemented under Super ESPC and through use of appropriated funds.

One problem when comparing different lighting projects is selecting the variable to use for the measure of project size. For chiller projects, nominal refrigeration capacity (tons) is the obvious choice, but lighting projects could be compared in a number of ways. One possibility would be to compare projects on the basis of the total building area affected, but this information was not readily available for all projects. Projects could also be compared on the basis of total connected wattage reduction, but some measures (occupancy sensors, for example) have significant installation costs but do not reduce fixture wattage at all.

Traditional physical indicators of size were available for the other two ECMs (tons of capacity for chillers, horsepower for VFDs). For lighting upgrades we chose to compare projects on the basis of annual kWh savings, which are estimated for appropriations-funded projects and guaranteed for ESPC projects. Although kWh savings is not generally the same as a physical indicator of size, in the context of our study it is. Both samples of ECMs were dominated by T-12 to T-8 conversions, including new fixtures, in federal office space keeping normal business hours. Since the pre-existing lighting equipment, new lighting equipment, and operating hours were all similar in both samples; kWh savings in this case can be thought of as a proxy for a physical indicator of size that affects project cost.

Another concern with lighting projects is variability of scope. ECMs classified as "lighting upgrades" cover a number of different measures with widely varying costs. All of the projects chosen for this comparison involve comprehensive lighting upgrades including conversions to new T-8 fixtures, which appeared to be the dominant cost item. Beyond that, however, the elements of the projects vary. Table 2.14 is a list of the measures most commonly encountered.

Table 2.14. Measures commonly included in lighting upgrade projects

Conversion to T-8 fixtures and tubes
Installation of occupancy sensors
Installation of electronic ballasts
Fixture delamping
Installation of tandem wiring
Conversion to compact fluorescent lighting

We considered this to be the list of allowable lighting measures for our comparison. For the appropriations-funded projects, for which we had detailed cost estimates, if a project included an ECM not on that list (for example, the use of photocells to control outdoor lighting), we removed the construction cost of that measure and reduced the kWh savings by the amount that corresponded to the measure. For ESPC projects we did not have access to detailed cost estimates, so if an ECM included a measure not in Table 2.14, we did not use it in our analysis. Altogether, we identified 20 ESPC lighting projects and 10 appropriations-funded lighting projects that included T-8 conversions and at least one other measure from the list of Table 2.14. Neither of the samples—ESPC or appropriations-funded—have completely identical scopes, however, and we recognize that this variability reduces the accuracy of our comparison.

2.5.1 Lighting ECM Sample for Appropriations-Funded Projects

Of the lighting projects submitted by the site to the agency's appropriations-funded energy conservation program, we selected ten, each of which is focused on one specific building. Although multiple buildings tended to be included in a single funding request, detailed cost estimates were prepared for each building, presumably to provide flexibility in selecting an optimal mix of buildings given the funding available.

As with the chiller projects, we examined the unit-cost-level estimates for each of the ten projects in order to remove (1) costs not associated with the lighting retrofit, (2) health, safety, and security costs that are unlikely to be present at other federal sites or in the ESPC ECM samples, and (3) M&O contractor costs for construction and AE support and project management, which are real costs but are not in the ESPC ECM samples.

In order to make the appropriations-funded projects comparable to the ESPC projects, we also deleted the cost of lighting measures not included in Table 2.14 from the unit cost estimates of the appropriations-funded projects. These items were identified in the cost estimates as switches, handle-locks, timers, photocells, and contactors. Because we are using annual kWh savings as the basis for comparison, where one of these measures was deleted from a cost estimate, we also deleted the kWh savings associated with the measure from the project's total savings estimate. We were able to do this because the feasibility studies contained savings estimates for each individual measure.

The original cost estimates (escalated to December 2001 dollars) for the ten projects are summarized in Table 2.15, and Table 2.16 presents a summary of the adjusted estimates. Finally, the adjusted costs and annual kWh savings are presented in Table 2.17.

Table 2.15. Itemized costs of (and amounts requested for) completion of appropriations-funded lighting upgrade projects (2001 dollars)

Cost category	Project											
	1	2	3	4	5	6	7	8	9	10	Total	Percent of total
Engineering (Title I, II, & III)	11,481	12,332	9,712	45,902	45,902	45,902	45,902	992	2,639	16,897	237,661	10.2
Field support	1,330	1,520	1,235	16,589	16,589	16,589	16,589	0	0	0	70,438	3.0
Construction & AE support	6,168	6,664	5,252	28,582	28,582	28,582	28,582	76	151	1,217	133,857	5.7
Project management	4,540	4,895	3,839	20,613	20,613	20,613	20,613	314	829	6,301	103,172	4.4
Electrical	66,978	74,120	57,129	44,503	41,001	18,249	15,776	4,823	14,038	95,531	432,147	18.5
Support	0	0	0	0	0	0	0	0	0	0	0	0.0
Contractor directs & indirects	38,082	47,662	40,113	87,759	87,759	87,759	87,759	3,085	8,981	40,335	529,292	22.6
Health and safety	2,707	2,966	2,321	24,024	24,024	24,024	24,024	0	0	17,818	121,906	5.2
Subtotal	131,286	150,158	119,600	267,971	264,469	241,717	239,245	9,290	26,637	178,099	1,628,473	
Overhead	10,443	11,283	8,897	71,014	70,757	69,078	68,896	524	1,503	10,972	323,367	13.8
Total w/o contingency	141,729	161,442	128,497	338,985	335,226	310,796	308,141	9,814	28,140	189,071	1,951,840	
Contingency	28,346	32,288	25,699	67,797	67,045	62,159	61,628	1,914	5,487	36,869	389,233	16.6
Grand Total	170,075	193,730	154,196	406,782	402,271	372,955	369,769	11,728	33,628	225,940	2,341,073	100.0

Table 2.16. Itemized costs of (and amounts requested for) completion of appropriations-funded lighting upgrades, adjusted to reduce project scope to only ECMs listed in Table 2.14 (2001 dollars)

Cost category	1	2	3	4	5	6	7	8	9	10	Total
Engineering (Title I, II, & III)	10,006	10,775	8,486	12,575	7,797	4,790	2,705	902	658	3,337	62,031
Field support	1,159	1,328	1,079	4,545	2,818	1,731	978	0	0	0	13,636
Construction & AE support	0	0	0	0	0	0	0	0	0	0	0
Project management	0	0	0	0	0	0	0	0	0	0	0
Electrical	58,371	64,757	49,919	44,503	27,591	16,952	9,573	4,383	3,500	18,868	298,417
Support	0	0	0	0	0	0	0	0	0	0	0
Contractor directs & indirects	28,751	37,192	30,542	21,825	13,531	8,313	4,695	2,013	1,617	7,967	156,446
Health and safety	1,180	1,295	1,014	4,056	2,515	1,545	872	0	0	982	13,459
Subtotal	99,466	115,346	91,041	87,504	54,251	33,332	18,822	7,298	5,775	31,154	543,989
Overhead	7,912	8,667	6,772	14,516	9,001	5,529	3,122	412	326	2,590	58,847
Total w/o contingency	107,378	124,014	97,813	102,020	63,251	38,861	21,945	7,710	6,101	33,744	602,837
Contingency	21,476	24,803	19,563	20,404	12,650	7,772	4,389	1,503	1,190	6,580	120,330
Grand Total	128,854	148,817	117,375	122,424	75,901	46,633	26,334	9,213	7,291	40,324	723,166

Table 2.17. Summary description of adjusted appropriations-funded lighting upgrades (2001 dollars)

Project	Annual kWh savings	Cost	Project scope
1	438,746	$128,854	T-8 conversion, occupancy sensors
2	348,476	$148,817	T-8 conversion, occupancy sensors
3	299,531	$117,375	T-8 conversion, occupancy sensors
4	313,434	$122,424	T-8 conversion, occupancy sensors
5	145,350	$75,901	T-8 conversion, occupancy sensors
6	118,944	$46,633	T-8 conversion, occupancy sensors, CFLs
7	28,622	$26,334	T-8 conversion, occupancy sensors, CFLs
8	29,976	$9,213	T-8 conversion, occupancy sensors
9	20,717	$7,291	T-8 conversion, occupancy sensors
10	58,282	$40,324	T-8 conversion, occupancy sensors
Total	**1,802,078**	**$723,166**	

2.5.2 Lighting ECM Sample for Super ESPC Projects

By the end of FY 2001, Super ESPC projects in the Southeast region included 27 separate lighting upgrade ECMs. Seven of these included measures not on the list of Table 2.14. Since detailed cost estimates were not available for these projects, we were unable to remove these extra measures from the cost. We therefore eliminated the entire ECM from the comparison. For the remaining 20 ECMs, the only adjustment we made was to escalate the costs to December 2001. No city escalation was necessary in this case since all projects were carried out in the Southeast region.

Table 2.18 presents the annual kWh savings estimates and the implementation prices for the 20 lighting upgrade ECMs. The scope was essentially the same for all 20 projects and included the measures listed in Table 2.14: upgrade to T-8s, electronic ballasts, delamping, tandem wiring, and CFLs.

2.5.3 Results of Lighting ECM Cost Comparison

Figure 2.6 plots cost versus kWh savings for the 20 ESPC projects and the 10 appropriations-funded projects outlined above. We note several things about this figure. First, both data sets show a definite relationship between cost and annual kWh savings: As one would expect, projects that achieve higher savings cost more to implement. Note, however, that the variance of cost with savings (i.e., the “scatter” of the data) seems to increase with increasing electrical savings. This fact, coupled with the wide range in kWh savings (from approximately 20,000 to 3.5 million), suggests that the costs may be better modeled by a log–log relationship. Figure 2.7 is a plot of the data of Figure 2.6 on a log–log scale. In this form, the linear relationship is much more evident than in Figure 2.6, and the variance of the data appears constant over the range of kWh savings.

A log–log model assumes a relationship of the form: $\ln(\text{cost}) = a + b \times \ln(\text{kWh})$, or $\text{cost} = a \times (\text{kWh})^b$. Here the parameter *a* has the units of dollars per kWh saved. If the cost per kWh saved is fairly constant over the range of kWh savings, we would expect the parameter *b* to be fairly close to 1.

2.5.4 Regression Analysis of Lighting ECM Results

As with the chiller data, we used ordinary least squares regression and analysis of variance to determine whether there is any statistically significant difference between the costs in the appropriations and ESPC sets. In this case we begin by combining the two data sets and fitting the data to an equation of the form $\ln(\text{cost}) = a + b \times \ln(\text{kWh})$, using ordinary least squares. The results, presented in Table 2.19, confirm the initial impression that the costs of these ECMs are highly correlated with annual electricity savings. Next we fit the data to a model that distinguishes between the two data sets. For the ESPC ECMs

Table 2.18. Summary description of Super ESPC lighting upgrades (2001 dollars)

Project	Annual kWh savings	Implementation price	Project scope
1	1,227,500	$428,024	T-8 conversion, occupancy sensors, delamping, electronic ballasts, tandem wiring, CFLs
2	2,616,065	$907,807	T-8 conversion, occupancy sensors, delamping, electronic ballasts, tandem wiring, CFLs
3	2,333,566	$546,068	T-8 conversion, occupancy sensors, delamping, electronic ballasts, tandem wiring, CFLs
4	357,449	$218,380	T-8 conversion, occupancy sensors, delamping, electronic ballasts, tandem wiring, CFL
5	454,357	$285,870	T-8 conversion, occupancy sensors, delamping, electronic ballasts, tandem wiring, CFL
6	876,112	$500,698	T-8 conversion, occupancy sensors, delamping, electronic ballasts, tandem wiring, CFL
7	210,407	$119,098	T-8 conversion, occupancy sensors, delamping, electronic ballasts, tandem wiring, CFL
8	211,862	$96,818	T-8 conversion, occupancy sensors, delamping, electronic ballasts, tandem wiring, CFL
9	164,910	$69,719	T-8 conversion, occupancy sensors, delamping, electronic ballasts, tandem wiring, CFL
10	1,067,048	$508,962	T-8 conversion, occupancy sensors, delamping, electronic ballasts, tandem wiring, CFL
11	108,164	$54,518	T-8 conversion, occupancy sensors, delamping, electronic ballasts, tandem wiring, CFL
12	89,967	$53,541	T-8 conversion, occupancy sensors, delamping, electronic ballasts, tandem wiring, CFL
13	3,477,748	$1,725,998	T-8 conversion, occupancy sensors, delamping, electronic ballasts, tandem wiring, CFL
14	33,591	$11,884	T-8 conversion, occupancy sensors, delamping, electronic ballasts, tandem wiring, CFL
15	15,315	$7,654	T-8 conversion, occupancy sensors, delamping, electronic ballasts, tandem wiring, CFL
16	93,840	$50,500	T-8 conversion, occupancy sensors, delamping, electronic ballasts, tandem wiring, CFL
17	25,506	$11,768	T-8 conversion, occupancy sensors, delamping, electronic ballasts, tandem wiring, CFL
18	352,107	$84,297	T-8 conversion, occupancy sensors, delamping, electronic ballasts, tandem wiring, CFL
19	590,969	$282,802	T-8 conversion, occupancy sensors, delamping, electronic ballasts, tandem wiring, CFL
20	29,364	$12,962	T-8 conversion, occupancy sensors, delamping, electronic ballasts, tandem wiring, CFL
Total	**14,335,847**	**$5,977,368**	

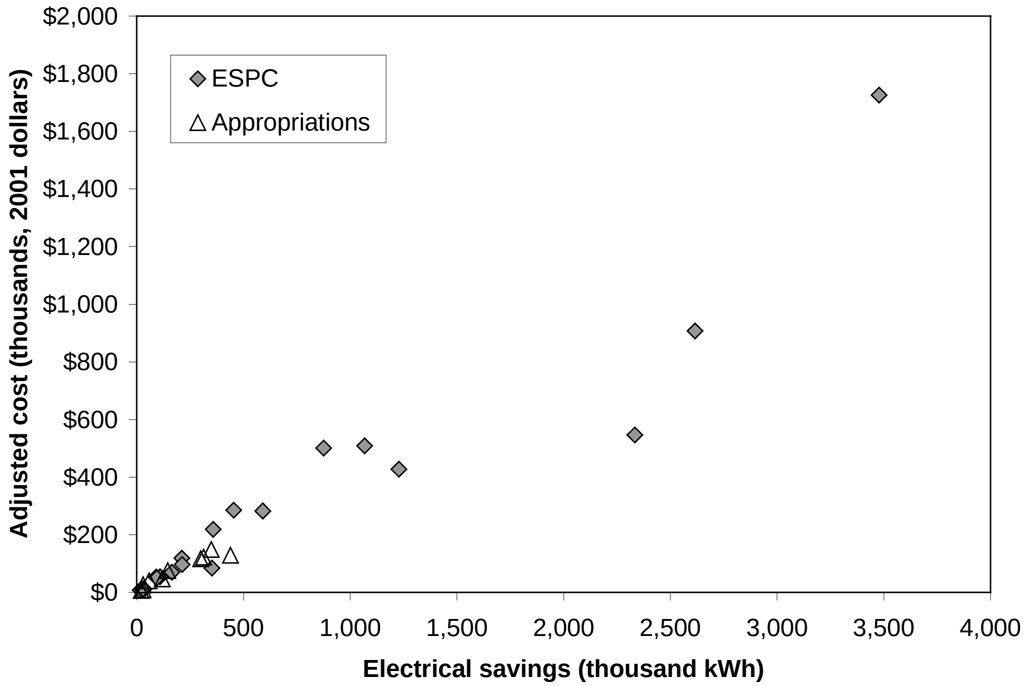

Figure 2.6. Lighting ECMs: Design completion and construction costs in appropriations-funded projects, and implementation price in ESPC projects.

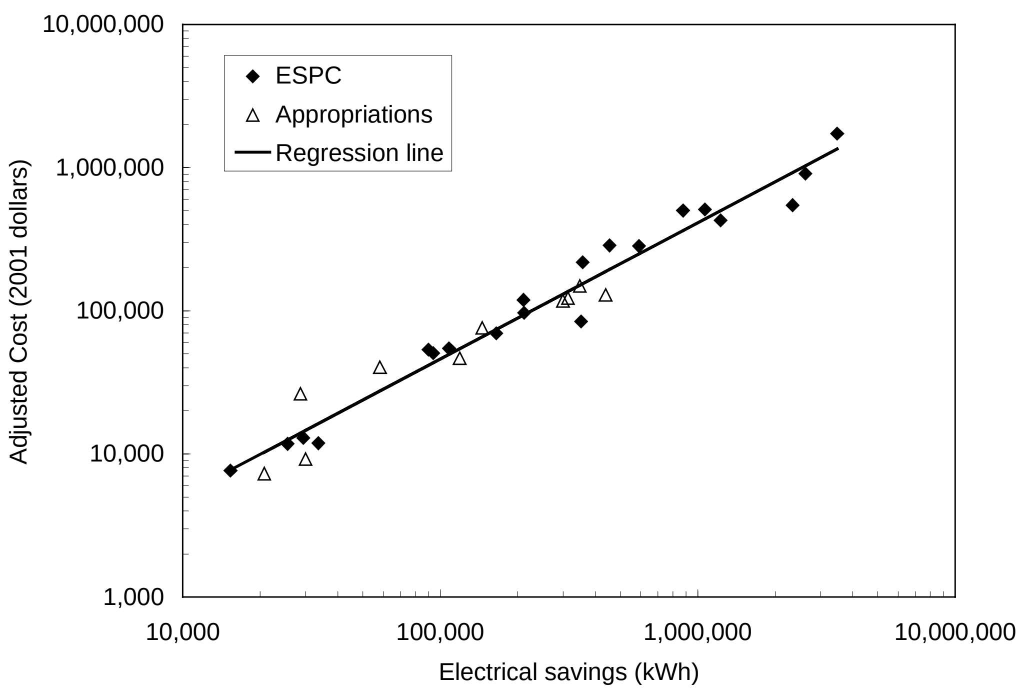

Figure 2.7. Lighting ECMs: Design completion and construction costs in appropriations-funded projects, and implementation price in ESPC projects.

Table 2.19. Regression output when ESPC and appropriations cost data for lighting ECMs are combined

Parameter	Estimate	Standard error	t value	Pr(>|t|)
a	–0.22157	0.44914	–0.493	0.626
b	0.9518	0.03659	26.012	<2e-16
Residual standard error: 0.2986 on 28 degrees of freedom				
Multiple R-squared: 0.9603, adjusted R-squared: 0.9588				
F-statistic: 676.6 on 1 and 28 DF, p-value: <2.2e-16				

we use $1n(\text{cost}) = a + b \times 1n(\text{kWh})$, and for the appropriations-funded projects we use $1n(\text{cost}) = (a + \Delta a) + (b + \Delta b) \times 1n(\text{kWh})$.

The results of this regression are presented in Table 2.20. The positive value for Δa suggests that the cost per kWh of savings may be higher in appropriations-funded lighting projects than in ESPC-funded projects. On the other hand, the negative value for Δb suggests that costs per kWh savings may not rise as rapidly with kWh savings in appropriations-funded projects. Nevertheless, the probabilities associated with these parameters indicate that there is a high probability that the non-zero values obtained are due to chance. The analysis of variance between the two models, presented in Table 2.21, confirms this. The value of 0.7226 for Pr(>F) means there is a 72.3% probability that the difference between the two data sets is due to random variation. In other words, there is no statistically significant difference between the two sets.

Table 2.20. Regression output for a model that distinguishes between ESPC and appropriations cost data for lighting ECMs

Parameter	Estimate	Standard error	t value	Pr(>|t|)
a	–0.27765	0.5468	–0.508	0.616
b	0.95792	0.0435	22.022	<2e-16
Δa	0.64096	1.16176	0.552	0.586
Δb	–0.06	0.09809	–0.612	0.546
Residual standard error: 0.3061 on 26 degrees of freedom				
Multiple R-squared: 0.9612, adjusted R-squared: 0.9568				
F-statistic: 214.9 on 3 and 26 DF, p-value: < 2.2e-16				

Table 2.21. Analysis of variance between Model 1, which does not distinguish between ESPC and appropriations, and Model 2, which does distinguish

Model	Residual degrees of freedom	Residual sum of squares	Degrees of freedom	Sum of squares	F	Pr(>F)
1	28	2.49733				
2	26	2.43571	2	0.06163	0.3289	0.7226

Figure 2.8 presents the 95% confidence interval for the ratio of the cost of appropriations-funded lighting projects to the cost of ESPC-funded lighting projects for the regression equation of Table 2.20. As with the chiller data, the confidence intervals are very wide, due both to the variance of the data and to

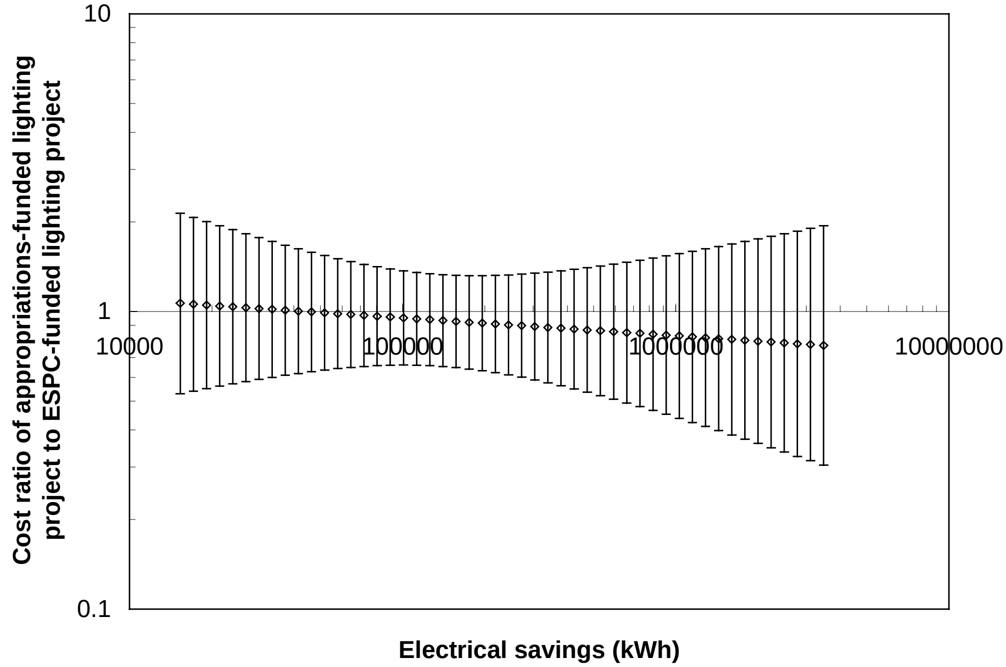

Figure 2.8. 95% confidence interval for the ratio of the cost of lighting retrofits performed with appropriations, to the cost of lighting retrofits performed under ESPC.

the small amount of data available. Appropriations-funded lighting projects seem to have a higher price than ESPC projects for annual savings under 60,000 kWh, while the opposite appears true for projects with savings over 60,000 kWh. Nevertheless, neither difference is statistically significant. Again, it seems that additional data would be required to draw any firm conclusions.

2.5.5 Summary of Conclusions on Lighting ECM Prices

In summary, we compiled two sets of cost data for lighting ECMs: one from a relatively small sample of appropriations-funded projects from two adjacent agency sites, and another from Super ESPC projects. The costs in the appropriations case represents the cost to complete design (from 30% to 100%), develop a bid-to-spec package and send it out for bids, evaluate bids, award a construction contract to the lowest bidder, and pay the contractor to implement the lighting project. In the ESPC case, the cost is the all-in implementation price (for survey, study, design, construction, and commissioning, plus mark-up). The data suggested a linear relationship between the natural logarithm of cost and the natural logarithm of the estimated annual electrical savings in kWh. We found no statistically significant difference between the cost of lighting ECMs implemented with ESPC and our sample of those carried out with appropriated funds. Nevertheless, the 95% confidence region for the difference between appropriations-funded and ESPC-funded projects is very wide, suggesting that additional data would be required to draw any firm conclusions about differences in pricing.

2.6 COMPARISON OF VARIABLE-FREQUENCY-DRIVE COSTS

The final conservation measure we examined was the installation of VFDs, also called variable-speed drives), which reduce energy use in HVAC systems by allowing fans and pumps to be operated at reduced speeds during part-load conditions. VFD installation has been another popular ECM under Super ESPC, responsible for about $11.6 million of the $230 million invested by the end of FY 2001.

As with the other ECMs, we obtained data on the implementation price of VFDs in Super ESPC projects from a database of Super ESPC projects. For appropriations-funded projects, we examined feasibility studies and unit-cost-level estimates for VFD projects submitted by a site as part of the request for design completion and construction funding from the agency's appropriations-funded energy management (EM) program. We then compared the design completion and construction costs of appropriations-funded VFD ECMs to the implementation prices of VFDs in Super ESPC.

2.6.1 VFD ECM Sample for Appropriations-Funded Projects

VFDs are most often included as a component of larger energy conservation projects. This was the case with the projects proposed to the agency by the federal site whose records we examined. Fortunately the feasibility studies and unit-level cost estimates included in the funding requests contained sufficient detail to allow us to remove the cost of items not associated with the installation of VFDs. Construction costs remaining in the estimate include the VFD itself, electrical connections to the VFD, overload protection, controllers, software, and general electrical work.

As with the chiller replacement and lighting upgrade projects, we examined the unit-cost-level estimates for each of the VFD projects in order to remove (1) costs not associated with the VFD retrofit, (2) health, safety, and security costs that are unlikely to be present at other federal sites or in the ESPC ECM samples, and (3) M&O contractor costs for construction and AE support and project management, which are real costs, but are not in the ESPC ECM samples.

Altogether, we located cost estimates for five appropriations-funded projects involving installation of VFDs. The unadjusted costs for these projects (escalated to 2001 dollars) are presented in Table 2.22. The adjusted costs are presented in Table 2.23. Table 2.24 shows the cost of each project, the total horsepower of the electric motors controlled by the VFDs, and the reduced scope of each project.

Note that in the cost breakdowns in Tables 2.23 and 2.24, the line item for overheads is zero for each project. For some reason, in this set of projects overheads were incorporated into each subcategory, rather than as a separate line item.

Table 2.22. Itemized costs of (and amounts requested for) completion of appropriations-funded VFD projects (2001 dollars)

Cost category	Project						
	1	2	3	4	5	Total	Percent of total
Engineering (Title I, II, & III)	46,698	39,510	39,795	51,078	93,006	270,087	16.9
Field support	16,082	13,283	1,310	1,310	35,553	67,539	4.2
Construction & AE support	25,144	0	0	0	42,975	68,119	4.3
Project management	13,277	13,277	21,575	24,014	25,016	97,158	6.1
Electrical	21,978	7,617	11,083	8,636	29,649	78,963	5.0
HVAC	40,380	12,676	37,196	29,939	95,159	215,350	13.5
Support	14,458	10,203	4,455	7,955	29,089	66,160	4.1
Contractor directs & indirects	40,973	29,379	0	10,955	129,135	210,442	
Health and safety	38,432	31,240	26,287	36,817	68,579	201,355	12.6
Subtotal	15,419	11,565	0	3,602	23,563	54,149	
Overhead	0	0	0	0	0	0	0.0
Total w/o contingency	272,842	168,748	141,701	174,307	571,724	1,329,322	83
Contingency	0	0	0	0	0	0	
Grand Total	**272,842**	**168,748**	**141,701**	**174,307**	**571,724**	**1,329,322**	**100**

Table 2.23. Itemized costs of (and amounts requested for) completion of appropriations-funded VFD projects, adjusted to reduce project scope to VFDs and associated equipment only (2001 dollars)

Cost category	Project number					
	1	2	3	4	5	Total
Engineering (Title I, II, & III)	19,223	9,071	23,462	23,207	29,331	104,294
Field support	512	571	772	595	1,055	3,505
Construction & AE support	0	0	0	0	0	0
Project management	0	0	0	0	0	0
Electrical	16,882	5,687	2,080	1,719	21,529	47,896
HVAC	35,313	7,252	27,510	21,296	63,230	154,602
Support	2,114	2,458	1,499	3,103	4,499	13,673
Contractor directs & indirects	24,252	12,618	15,498	19,790	39,775	111,932
Health and safety	0	0	0	0	0	0
Subtotal	98,296	37,657	70,821	69,710	159,418	435,902
Overhead	0	0	0	0	0	0
Total w/o contingency	98,296	37,657	70,821	69,710	159,418	435,902
Contingency	19,659	7,531	14,164	13,942	31,884	87,180
Grand Total	**117,955**	**45,188**	**84,985**	**83,653**	**191,301**	**523,083**

Table 2.24. Summary descriptions of adjusted appropriations-funded VFD ECMs

Project	Cost	Motor horsepower	Scope
1	$117,955	98	3 VFDs (60, 7.5, & 30 hp)
2	$ 45,188	20	1 20-hp VFD
3	$ 84,985	75	1 75-hp VFD
4	$ 83,653	50	1 50-hp VFD
5	$191,301	245	3 VFDs (125-, 100-, and 20-hp)
Total	**$523,082**	**488**	

2.6.2 VFD ECM Sample for Super ESPC Projects

For VFDs implemented under Super ESPC, we located eight ECMs in the Southeast region. The only adjustment made to the implementation price of these ECMs was to escalate them to 2001 dollars. Table 2.25 presents the adjusted implementation prices and total affected motor horsepower for the eight Super ESPC ECMs.

2.6.3 Results of VFD ECM Cost Comparison

Figure 2.9 is a plot of the data of Tables 2.24 and 2.25. We observe that there is more variability in this data than in the cost data from the other two ECMs. While the cost of the VFD projects does appear to increase with increasing horsepower, other causes of variation besides horsepower also have an important impact on the cost of VFD installations.

Table 2.25. Summary descriptions of adjusted Super ESPC VFD ECMs (2001 dollars)

Project	Cost	Motor horsepower	Scope
1	$ 280,924	300	20 VFDs of various sizes
2	$ 322,708	495	12 VFDs of various sizes
3	$ 273,381	540	7 VFDs of various sizes
4	$ 53,652	100	2 VFDs
5	$ 91,247	205	2 VFDs
6	$ 247,792	360	3 VFDs
7	$ 95,846	300	2 VFDs
8	$ 261,561	550	10 VFDs of various sizes
Total	**$1,627,111**	**2850**	

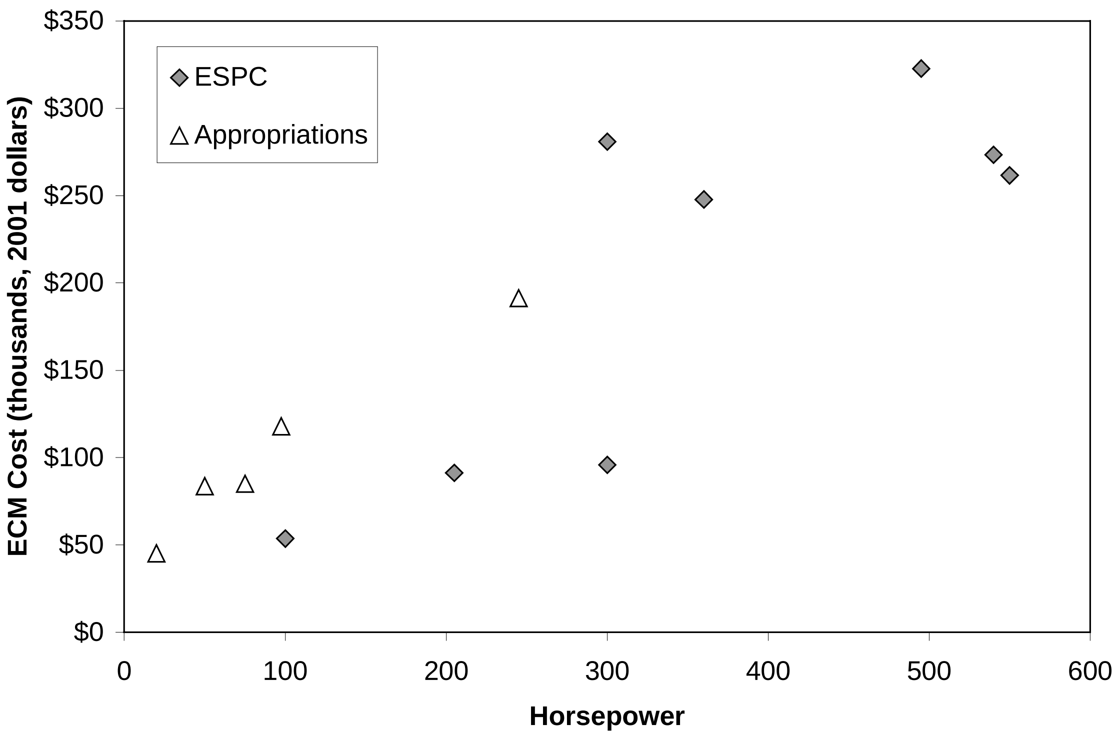

Figure 2.9. Variable-frequency-drive ECMs: Design completion and construction costs in appropriations-funded projects, and implementation price in ESPC projects.

2.6.4 Regression Analysis of VFD ECM Results

In what follows, we make the assumption that the cost of VFD ECMs is a linear function of horsepower, and use the same techniques to assess whether there is a statistically significant difference between the cost to complete VFD installations using appropriated funds and the cost to implement them using Super ESPC. We recognize that the data provides only weak support for the linear model, but in the absence of additional information this is the best that can be done.

As before, we combined the two data sets and fit the combined data to a model of the form, cost = $a + b \times$ horsepower. The results of the regression are presented in Table 2.26. Note that the adjusted R-squared value—a measure of how well the variation in the data is explained by the regression equation—is only 0.7372, compared to the values of 0.8 and 0.9 we have seen for the other ECMs.

Table 2.26. Regression of VFD cost data, fitting costs of ESPC and appropriations-funded projects to a single linear equation

Parameter	Estimate	Standard error	t value	Pr(>|t|)
a	46551.59	24664.19	1.887	0.085756
b	462.93	78.64	5.887	0.000105
Residual standard error: 51080 on 11 degrees of freedom				
Multiple R-squared: 0.7591, adjusted R-squared: 0.7372				
F-statistic: 34.65 on 1 and 11 DF, p-value: 0.0001051				

We performed a second regression, fitting the ESPC data to an equation of the form, cost = $a + b \times$ horsepower, and the appropriations data to an equation of the form, cost = $(a + \Delta a) + (b + \Delta b) \times$ horsepower. The results of this regression are presented in Table 2.27. Both Δa and Δb are positive, indicating that the cost of appropriations-funded projects is higher than the cost of ESPC projects, but neither parameter is statistically significant.

Table 2.27. Regression of VFD cost data, fitting ESPC and appropriations-funded projects to separate linear equations

Parameter	Estimate	Standard error	t value	Pr(>|t|)
a	15361.07	48208.91	0.319	0.75727
b	527.8	124.44	4.242	0.00217
Δa	29113.01	61584.02	0.473	0.64766
Δb	89.05	330.98	0.269	0.79396
Residual standard error: 53590 on 9 degrees of freedom				
Multiple R-squared: 0.7831, adjusted R-squared: 0.7108				
F-statistic: 10.83 on 3 and 9 DF, p-value: 0.002419				

Finally, we performed an analysis of the variance between the two models. The results, presented in Table 2.28, indicate that there is no statistically significant difference between the two data sets.

Table 2.28. Analysis of variance between Model 1, which does not distinguish between ESPC and appropriations, and Model 2, which does distinguish between the two

Model	Residual degrees of freedom	Residual sum of squares	Degrees of freedom	Sum of squares	F	Pr(>F)
1	11	2.87E+10				
2	9	2.58E+10	2	2.86E+09	0.4983	0.6234

Figure 2.10 shows the 95% confidence region for the difference between the means of the cost of appropriations-funded VFD projects and the cost of ESPC-funded VFD projects. As with the other ECMs, the confidence region is wide due to the variance of the data and the small quantity of data

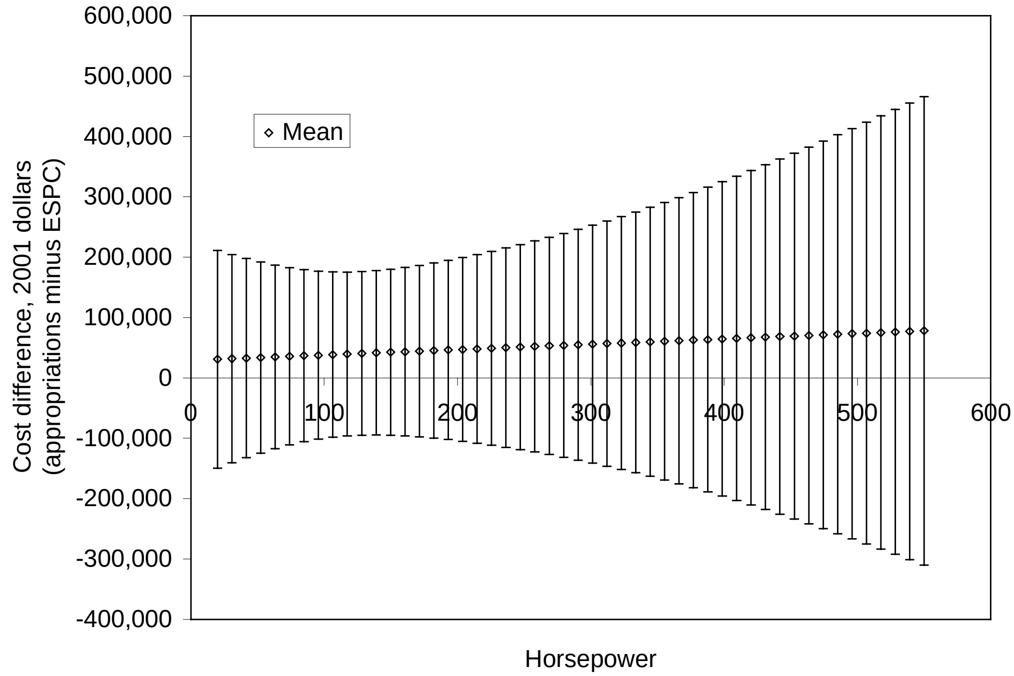

Figure 2.10. 95% confidence intervals for difference in cost of VFD projects (appropriations-funded minus ESPC-funded) as a function of motor horsepower.

available. There is weak evidence that appropriations-funded projects are more costly than ESPC-funded projects, but the difference is not statistically significant. Once again, any firm conclusions about pricing differences would require additional data.

2.7 SUMMARY AND DISCUSSION OF RESULTS

2.7.1 Summary

In this section, we analyzed the costs of three different ECMs: chiller replacements, lighting upgrades, and installation of VFDs. Altogether, these three ECMs have been responsible for $112.6 million, or about 50% of the $230 million in Super ESPC investments by the end of FY 2001. These ECMs were also common in the appropriations-funded projects at the two adjacent agency sites whose records we examined.

For appropriations-funded ECMs, we examined the detailed feasibility study reports and unit-level design completion and construction cost estimates and adjusted costs so each ECM included in the sample would have a technical scope and cost as consistent as possible with the isolated ECM. For Super ESPC ECMs we examined the final proposals and financial schedules and again were able to adjust implementation prices so each ECM included in the sample would have a technical scope and price as consistent as possible with the isolated ECM. The resulting appropriations-funded and ESPC ECM samples were then sufficiently homogeneous and consistent with the technical scope of the isolated ECMs to be comparable to each other.

Then for each ECM, we plotted the appropriations-funded design completion and construction cost and the Super ESPC implementation price versus a measure of the ECM project size, and used classical statistical tests to determine whether any statistically significant difference exists between these two sets of costs.

In the case of chillers, we found a reasonable probability that the appropriations-funded design completion and construction cost no different from the implementation price of similarly sized chillers installed under Super ESPC. This result held both for projects from a traditional two-step appropriations-funded EM program, and for projects funded with a more streamlined appropriations process.

Using the same methodology for lighting projects and for the installation of VFDs, we found no statistically significant difference between the appropriations-funded design completion and construction cost and the implementation price of Super ESPC ECMs of similar size.

2.7.2 Implications of ECM Pricing Analysis Results for Life-Cycle Cost Comparison

In projects funded with appropriations, contracting officers require independent government cost estimates to ensure that the prices contractors propose for labor and materials are in accordance with the cost of similar projects. A similar determination is made in ESPC projects where the contracting officer determines whether the pricing proposal is fair and reasonable. Because contracting officers are likely to draw on the same body of expertise and experience to assess cost proposals regardless of the funding source, we would not expect to see large differences in the pricing of ECMs installed with appropriations, compared to the pricing of ECMs installed under ESPC. Both funding mechanisms entail similar activities and expenses (though with different patterns of execution) and should cost approximately the same for similarly sized projects. The data we analyzed support this. We believe it is reasonable to assume that for ECMs in general, the appropriations-funded design completion and construction cost and the implementation price of Super ESPCs are more or less equal for similarly sized ECMs having the same technical scope. Therefore, in the life-cycle cost analysis presented in Chapters 3 and 4, we assume that the implementation price in Super ESPC equals the design completion and construction cost for the appropriations-funded project.

The significance of this is that in appropriations-funded projects, survey and study costs are in addition to design completion and construction costs, as opposed to being included in the all-in implementation price, as in Super ESPCs. In ESPC the implementation price includes all direct project implementation expenses (surveys, feasibility studies, design, construction, commissioning) plus mark-up to recover indirect costs (ESCO overheads, sales effort, surveys and studies for projects never awarded, etc.) and profit. In appropriations-funded projects the design completion and construction cost includes all direct project implementation expenses after the survey and feasibility study phase—the remaining direct implementation expenses (design from 30% completion to final, development of a bid-to-spec package, bid evaluation and general contractor selection, construction, commissioning) plus mark-up to recover indirect costs (general contractor overheads, sales effort, etc.) and profit.

Furthermore, the Super ESPC implementation price also includes, in addition to the direct survey and study costs, the project’s proportional share (via the mark-up) of the ESCO’s costs for surveys and studies on other projects, which the ESCO tried to develop but never proceeded to award. In appropriations-funded projects both the direct survey and study costs and the project’s proportional share of the site’s survey and study costs that never resulted in funded projects are extra costs in addition to the design completion and construction costs.

In our life-cycle cost analysis we express the total (direct and indirect) survey and study costs as a percentage of the design completion and construction cost. However, since the average percentage of design completion and construction costs that comprise the survey and study costs can vary widely from site-to-site and agency-to-agency (as can total process time), we allow agencies to estimate their own values for these key parameters by expressing our results in the form of LCC comparison tables.

2.7.3 Comparison of Site Project Management and Construction Oversight Costs

At the beginning of this chapter it was explained that the site’s project management and construction oversight costs were deducted from the Step 2 appropriations funding received for project implementation. Although these activities are required in both ESPC projects and appropriations-funded projects, their cost is not included in the average Super ESPC implementation price, which is our basis for comparison. Therefore, to conserve the validity of the comparison, these costs were deducted from the appropriations cases.

An assumption of our life-cycle cost analysis in Chapter 3 is that the site's project management and construction oversight costs can be left out of both the ESPC and appropriations-funded cases because they are the same either way. We support this assumption as follows. After adjustments for the pricing parity analysis described above, the original cost for the appropriations-funded ECMs was reduced from over $19 million to about $13 million for 11 chiller replacement ECMs, 10 lighting upgrade ECMs, and 5 VFD ECMs at the two adjacent agency sites. Costs deducted for the site's project management and construction oversight were 9.4% of the $13 million. Based on this average, if a site using appropriations in this agency is going to have $3,263,000 available to fund design completion and construction of the typical energy conservation project, its Step 2 funding request will have to include an additional 9.4%, or $306,722, for a total of $3,569,722, to also have sufficient resources for the site's project management and construction oversight. This $306,722 appears to be ample resource to perform the analogous duties for an ESPC project with an implementation price of $3,263,000.

Tables 2.29 and 2.30 present detailed task listings and prices for project management and construction oversight for implementing the typical $3,263,000 project using ESPC and appropriations, respectively. The prices are based on an FY 2001 M&O contractor all-in labor rate of $115 per hour,

Table 2.29. Experience-based estimate of the all-agency average of project management and construction oversight costs for the typical ESPC project

Task		Labor Hours[a]	Cost ($)
	Phase 1: Project Planning		
1.1	Compile basic data on buildings; verify that a delivery order (DO) is feasible	8	920
1.2	Obtain decision makers' support for pursuing a DO project	24	2,760
1.3	Assemble acquisition team, build consensus in support of project, and develop the initial plan, objectives, and general scope for the DO project	12	1,380
1.4	Educate acquisition team about Super ESPC (DO Guidelines, Workshop, etc.)	48	5,520
1.5	"Select" an ESCO partner based on informal communications	30	3,450
	Phase 2: Initial Project Development		
2.1	Kickoff meeting—roles, possible scope, schedule expectations	15	1,725
2.2	Items researched, compiled, calculated, and/or provided to ESCO at or following the kickoff meeting:		
	a. Original as-built mechanical, electrical, and architectural drawings for the project buildings	2	230
	b. As-built drawings for any renovations of the project buildings	0	0
	c. Site electrical, coal, natural gas, etc., energy rates to use for the project	2	230
	d. Historical energy consumption (and demand if relevant) by fuel type for the project buildings if possible, otherwise for the site	8	920
	e. Existing energy audits	1	115
	f. Existing inventories of energy consuming equipment	2	230
	g. Existing studies and/or designs of potential ECMs for the project buildings	2	230
	h. Existing equipment operating log data for the project buildings	4	460

Table 2.29 (continued)

Task		Labor Hours[a]	Cost ($)
	i. Existing site recorded weather data, if any	0.5	58
	j. Existing metered data of any sort that may be useful	4	460
	k. Electronic copies of the site's Master Construction Technical Specifications in CSI format (Divisions 2–18)	2	230
	l. Hardcopies of figures, attachments, etc., from the site's Master Construction Technical Specifications that are not available electronically	2	230
	m. Copy of site's construction labor agreement, if any	0	0
2.3	Escort for ESCO preliminary survey of project buildings used as basis for Initial Proposal	2	230
2.4	Review and comment on Initial Proposal	40	4,600
2.5	Discuss w/ ESCO & agree on required Initial Proposal changes	2	230
2.6	Review updated Initial Proposal, clear the go/no-go decision	8	920
2.7	Prepare and issue DO RFP and develop the site's ESPC Master Construction Technical Specifications (Division 1) for attachment. (Note: Follow-on DO RFPs require 85–90% less time because the first DO RFP will be available as a model. However, other support activities are still generally required.)	40	4,600
2.8	Issue Notice of Intent to Award Letter	1	115
	Phase 3: Negotiate and Award Final Delivery Order		
3.1	Escort for ESCO detailed energy survey (DES) of project buildings used as basis for Revised Proposal	2	230
3.2	Review and comment on first post-DES Revised Proposal	40	4,600
3.3	Discuss w/ ESCO & agree on required Revised Proposal changes	4	460
3.4	Prepare Congressional Notification and work it through approval chain	0	0
3.5	Review and comment on second post-DES Revised Proposal	16	1,840
3.6	Compile, forward to ESCO current service contract and Davis–Bacon wage rates	0	0
3.7	Prepare and submit Davis–Bacon paperwork	4	460
3.8	Price evaluation of ESCO's Final Proposal based on review of detailed "open-book" backup information (some contract officers [CO's] may require preparation of an independent government estimate)	40	4,600
3.9	Provide tech support to final price and other negotiations by CO	8	920
3.10	Revise DO RFP to incorporate negotiations	4	460
3.11	Verify that all agreements are incorporated into the ESCO's Final Proposal	2	230
3.12	Prepare Delivery Order Selection Document	1	115
3.13	Prepare Delivery Order award documentation	4	460
	Phase 4: Implementing the Delivery Order		
4.1	Form site construction phase team, identify rates & overheads	8	920
4.2	Prepare and submit NEPA paperwork	24	2,760
4.3	Pre-design meeting/telecon	16	1,840
4.4	Prepare construction oversight plan & budget, secure resources	8	920
4.5	Review and comment on ESCO's first Installation Plan	80	9,200
4.6	Advance pre-construction meeting with ESCO and sub-tier subcontractors	0	0
4.7	Escort sub-tier subcontractors on site familiarization walkthrough; debriefing	0	0
4.8	Send lockout/tagout forms to ESCO	1	115
4.9	Review and approve ESCO's final installation plan and other various plans (depends on agency site requirements as per DO RFP; examples include ESCO & subcontractors' safety and health program, activity hazard analysis, lift plans, spill contingency plan, environmental protection plan, etc.)	120	13,800

Table 2.29 (continued)

Task		Labor Hours[a]	Cost ($)
4.10	Miscellaneous: Badge/pass, coordination, documentation, reporting, issue resolution, admin, management	80	9,200
4.11	Pre-construction meeting	0	0
4.12	Construction kickoff meeting	28	3,220
4.13	Coordinate site-specific training for subcontractors	4	460
4.14	Attend/conduct/document biweekly progress/coordination meetings (6 person-hr/mtg, assume 26 mtgs over a 52-week construction period—varies by project)	114	13,110
4.15	Review outage requests & coordinate w/Facility Manager (1 hr/week)	38	4,370
4.16	Review construction work permit requests and coordinate (1 hr/week)	38	4,370
4.17	Provide electrical support for final tie-ins (1 hr/week)—engineer	20	2,300
	Provide electrical support for final tie-ins—tech or craft	60	3,000
4.18	Health Physics (name depends on site—Health & Safety, Hazardous Materials, etc.) inspectors to monitor and survey components being removed prior to transport to waste facility (8 hr/week)	0	0
4.19	Safety personnel support/inspections (2 hr/week)	76	8,740
4.20	Inspect construction, review and approve routine construction documents and any other construction engineer work (6 hr/week)	228	26,220
4.21	Review, approve, and accept as-built drawings and other post-construction submittals and services (depends on requirements per DO RFP; e.g., operating manuals, preventive maintenance plans, and training of site staff)	24	2,760
4.22	Review and approve ESCO's acceptance report and prepare acceptance letter	8	920
	Summary: Labor Hours and Cost	**Hours**	**Cost ($)**
	Total project manager or engineer labor hours ($115 per hour) and cost	1299.5	149,443
	Total technical or craft labor hours ($50 per hour) and cost	60	3,000
	Total site labor cost		152,443

[a]All labor hours are for project managers or engineers except for 60 technical or craft personnel hours for task 4.17.

Table 2.30. Agency site's project management and construction oversight responsibilities and costs for an appropriations-funded energy project, through project acceptance

Task		Labor Hours[a]	Cost ($)
	Engineering Design		
1.1	Form site design-phase team, identify rates and overheads	8	920
1.2	Prepare systems requirement document (SRD), design criteria (DC)	120	13,800
1.3	Transmit SRD and DC to AE and request bid for design services	10	1,150
1.4	Prepare cost estimate for design activities	24	2,760
1.5	Review AE's proposal; compare work scope to SRD & DC; compare proposed price to government estimate	24	2,760
1.6	Negotiate terms, date of completion, price with AE	4	460
1.7	Award contract to AE.	2	230
1.9	Design kickoff meeting	28	3,220
1.10	Escort AE on site familiarization walk-through	24	2,760
1.11	Prepare and submit NEPA paperwork	24	2,760
1.12	Review and comment on AE's first design package submittal	120	13,800

Table 2.30 (continued)

Task		Labor Hours[a]	Cost ($)
1.13	Send Lockout/Tagout forms to AE	1	115
1.14	Review and approve AE's final design package submittal	160	18,400
	Procurement of Construction Contractor		
2.1	Preparation of independent government estimate	140	16,100
2.2	Reproduction of design package	4	460
2.3	Meeting with Procurement group to develop acquisition plan	4	460
2.4	Preparation of general terms and conditions	24	2,760
2.5	Davis–Bacon wage rate determinations	4	460
2.6	Procurement develops RFP (competitive bid, firm fixed price, low bid award)	20	2,300
2.7	Agency field office review of RFP	4	–
2.8	Procurement issues RFP	2	230
2.9	Conduct pre-bid conference and site tour	40	4,600
2.10	Review bids for compliance and comparison with government estimate; Cost Estimating reviews all bids (assuming 4 bidders)	80	9,200
2.11	Procurement reviews lowest bidder's package, to include QA plan, safety & health plan, small business plan, FOCI	24	2,760
2.12	Award contract to low bidder	2	230
	Construction		
3.1	Miscellaneous: badge/pass, coordination, documentation, reporting, issue resolution, admin, management	80	9,200
3.2	Pre-construction meeting	28	3,220
3.3	Construction kickoff meeting	28	3,220
3.4	Coordinate site-specific training for prime and subcontractors	4	460
3.5	Attend/conduct/document biweekly progress/coordination meetings (6 person-hours per meeting, assume 26 meetings in a 52-week construction period)	156	17,940
3.6	Review outage requests & coordinate w/Facility Manager (1 hr/week)	52	5,980
3.7	Review construction work permit requests and coordinate (1 hr/week)	52	5,980
3.8	Provide electrical support for final tie-ins—engineer	52	5,980
	Provide electrical support for final tie-ins—tech or craft	160	8,000
3.9	Health Physics (or health & safety, hazardous materials, etc.) inspectors monitor and survey components being removed prior to transport to waste facility (8 hr/week)	416	47,840
3.10	Safety personnel support/inspections (2 hr/week)	104	11,960
3.11	Inspect construction; review and approve routine construction documents and other construction engineer work (6 hr/week)	312	35,880
3.12	Review, approve, and accept as-built drawings and other post-construction submittals and services (per contract, examples include operating manuals, maintenance plans, and training of site staff)	24	2,760
3.13	Review and approve commissioning report and prepare acceptance letter	8	920
	Summary: Total Labor Hours and Cost		
	Total project manager or engineer hours ($115 per hour) and cost	2213	254,495
	Total technical or craft labor hours ($50 per hour) and cost	160	8,000
	Total site labor cost		262,495

[a]All labor hours are for project managers or engineers except for 160 technical or craft personnel hours for task 3.8.

typical for the engineering skill level required to perform the tasks. These task listings and price estimates were developed by facilities engineers who are among the most experienced DOE FEMP Super ESPC project facilitators, responsible for about 35% of awarded project investment through FY 2001. These same engineers were also responsible for the majority of the appropriations-funded projects at the two adjacent agency sites examined here. Table 2.29 is the experience-based estimate of the all-agency average for ESPC, assuming that the agency reimburses DOE for the standard package of services provided by an experienced FEMP project facilitator, that agency management is committed to effective utilization of the Super ESPC program, and that the agency and ESCO teams function as partners working toward a common goal. Table 2.30 is the experience-based estimate for project management and construction oversight of the typical project when implemented at either of the two adjacent agency sites using appropriations.

Although it appears that project management and construction oversight costs should be significantly less for ESPC projects than appropriations-funded projects, based on the experience of these engineers, the ESPC estimate ($152,443 or 4.7%) in Table 2.29 is an all-agency average, and the appropriations estimate ($262,495 or 8.0%) in Table 2.33 is for the two adjacent agency sites. Due to this agency's required processes and procedures, the costs for ESPC project management and construction oversight at these sites may actually be more like those for the appropriations experience. It is interesting to note that the Table 2.30 value of 8.0% from the engineers' experience with appropriations at these sites is similar to the 9.4% average from the ECM sample. We assume the project management and construction oversight costs are the same for ESPC and appropriations and exclude them from both cases for the life-cycle cost analysis presented in Chapters 3 and 4.

2.7.4 Recommended Practices for Ensuring Fair Pricing

Agencies have a number of tools at their disposal for ensuring fair pricing in their ESPC projects. Several tools based on pricing experienced in previously awarded Super ESPC projects that are useful at the initial proposal stage are available through FEMP Project Facilitators. Agencies concerned about the possibility that past prices under Super ESPCs were higher than prices they can obtain when using appropriated funds can use the method documented here to derive benchmarks from their own past appropriations-funded projects. At the final proposal stage agencies can use their own benchmarks or employ an experienced professional cost estimator to verify that the ESCO's pricing is fair and reasonable. The recommended practices for ensuring fair pricing in ESPC projects are summarized below.

Agencies that engage the support of FEMP Project Facilitators have access to pricing data on all preceding Super ESPC delivery orders. Project Facilitators use this data at the initial proposal stage. The data is compiled in two formats: *Super ESPC Pricing Benchmarks,* and the *ECM Locator.*

FEMP has compiled *Super ESPC Pricing Benchmarks* for the ECMs most common in Super ESPCs—comprehensive lighting upgrades, geothermal heat pump systems, chiller replacements, variable-frequency drives, and building automation systems. These benchmarks show the range of all-inclusive prices (including mark-up) and associated statistics for these ECMs and can quickly alert Project Facilitators if the prices in the initial proposal are unusually high or low. Currently the ECM benchmarks are averages across all years and locations; adjustments for these factors may be implemented in the future if users feel it would be worthwhile.

Project Facilitators use the *ECM Locator* to find data on any individual ECM, particularly those not benchmarked with a group of similar ECMs. This comprehensive inventory gives Project Facilitators access to all-inclusive prices, guaranteed savings, and descriptive information on any ECM implemented under a past Super ESPC delivery order.

The method documented here for comparing all-inclusive prices of ECMs implemented with appropriated funds and through ESPCs can also help agencies to ensure fair pricing in their ESPC projects. For most ECMs agencies can derive all-inclusive-price benchmarks from their own past appropriations-funded projects. Using historical, documented design completion and construction costs for ECM projects, less agency site project management and construction oversight costs, adjusted to the appropriate timeframe with the GDP-IPD, agencies will be able to compare the prices for past appropriations-funded projects with the prices offered by ESCOs in their initial and final proposals.

Other approaches for the final proposal stage involve the use of professional cost estimators. One approach is to obtain open-book backup information on proposed prices from the ESCO and have the cost estimator review the ESCO's estimate. A more expensive approach is to have the cost estimator develop an independent government estimate "from scratch," based on the technical scope descriptions of the ECMs that appear in the ESCO's final proposal.

Agencies can ensure that they are obtaining fair prices by following these recommended pricing review procedures prior to awarding their ESPCs, and they are encouraged to do so.

3. METHODOLOGY FOR COMPARING PROCESSES AND LIFE-CYCLE COSTS

3.1 INTRODUCTION

ESPCs allow federal agencies to improve the energy efficiency of their facilities without depending on Congressional appropriations to pay for the improvements. Since 1988, federal agencies have used ESPCs (and their “shared energy savings” predecessors) to leverage more than $1 billion in private-sector investments to improve their facilities and to help meet federal energy, water, and emissions-reduction goals. Nevertheless, some disagreement remains over the financial value of ESPCs as a method for funding energy conservation projects. Because they use private capital, ESPCs incur interest costs that are not incurred in appropriations-funded projects. On the other hand, it usually requires much less time for a federal site to obtain private-sector financing for an ESPC than it does to obtain appropriated funds from the site’s managing federal agency. Once an agency receives appropriations from Congress for energy conservation, the agency must decide how to divide these funds up among the many sites it manages. This headquarters decision process takes time and entails significant site costs for surveys and studies and funding applications, and any delay in implementing an energy conservation project causes inefficient equipment to remain in service longer, wasting appropriated funds on unnecessary energy use and emergency maintenance, repairs, and replacements.

Obviously, a comparison of the two funding alternatives requires careful consideration of the costs associated with each, as well as the time frames in which these costs are incurred. In this chapter we present a methodology for such a comparison and examples of its application. Our objective was to compare the life-cycle costs of using ESPCs and appropriations to implement a “typical project,” which was defined as the average project implemented under the DOE Super ESPC program. The capital investment, annual cost savings from energy and related operations and maintenance (O&M), and other characteristics of this typical project correspond to the average characteristics of all Super ESPC projects awarded through FY 2001.

The two project implementation mechanisms have different scheduling delays and process costs. Sections 3.2 and 3.3 describe how each process was characterized. The timeline and costs for the ESPC case correspond to the average values for all Super ESPC projects awarded through FY 2001. The appropriations process model is based on the two-step process used by several large agencies for distributing direct project funding to sites. First, the site requests funds for an energy survey and feasibility study for a proposed project. If step-one funding is received, the site completes the survey and study, and submits a request for implementation funding supported by the study report and a detailed cost estimate (based on 30% completed design). The requested step-two funding, if received, is used to complete the design and construct the project. The appropriations process model must also allocate total process time between intermediate milestones where the costs occur. The time proportioning assumptions are based on a detailed examination of historical documentation of all projects at one federal site that received funding over a two-year period from its governing agency’s energy management program.

Having defined the parameters of the typical project and characterized the process costs and time delays of the two different mechanisms for project development, financing, and implementation, we could then estimate the life-cycle costs of each option over a 20-year study period. Sections 3.4 and 3.5 detail the calculation of life-cycle costs.

In the course of our work we found that the life-cycle cost when using appropriations depended strongly on several key parameters such as (1) total process time (the time elapsed before the ECMs are operating and saving energy) and (2) costs for surveys and studies that are required in the process of requesting funding (as a percentage of design completion and construction costs). For this reason we performed a parametric analysis, varying the survey and study costs and process delays over a wide range.

The results of the life-cycle cost analysis (given in Chapter 4) are expressed in tables that compare the average ESPC and the entire range of appropriations cases.

3.2 CHARACTERIZING THE AVERAGE ESPC

3.2.1 Super ESPC Implementation Process

Figure 3.1 provides an overview of the process typically used to set up an ESPC at a federal facility using one of the ESCOs holding a pre-competed DOE Super ESPC contract. The process begins with a one-day kickoff meeting during which site personnel present their objectives for the ESPC and provide an overview of the buildings and energy systems they wish the ESCO to consider. Following the meeting, the ESCO begins its own preliminary survey of buildings and systems to determine whether a feasible pay-from-savings project exists. Typically within two months, the ESCO presents an initial proposal to the site. If the site is satisfied with the general direction of project development, the initial proposal is accepted and the site issues the ESCO a notice of intent to award. DOE project facilitator services are provided without the need for reimbursement up to this stage, but after the notice of intent the site usually enters into an interagency agreement to reimburse DOE for the continuation of project facilitator services through award and one year beyond, when the first annual measurement and verification (M&V) report is submitted. With the notice of intent in hand, the ESCO begins a more in-depth audit of the site's facilities (the detailed energy survey) with the objective of developing designs to 30% completion to support firm estimates of the costs and savings of the proposed ECMs. This detailed survey and associated design development, feasibility study, and final proposal development including M&V and commissioning plans take about six months. When completed, the ESCO presents a final proposal to the site.

The final proposal gives a complete description of the project, including the firm, fixed prices of all ECMs to be installed, the energy and related O&M cost savings that will be guaranteed, and a schedule of the payments the site will make to the ESCO over the term of the contract. The proposal also provides detailed financial schedules that specify the amount of private financing the ESCO will obtain, the financing procurement price, the total annual interest rate, and the ESCO's operating budget over the contract term for debt repayment and performance-period services such as M&V, O&M, and repair and replacement (R&R). The site reviews the final proposal, and after a final round of negotiations awards a delivery order to the ESCO to implement the project. The ESCO completes the designs and then constructs and commissions the project. When the project is accepted, the site begins making monthly payments according to the negotiated schedule for the duration of the contract term.

3.2.2 Super ESPC Scheduling and Financial Parameters

The Federal Energy Management Program (FEMP) maintains a database of information from the financial schedules of all awarded Super ESPC delivery orders. By the end of FY 2001, 71 delivery orders had been awarded. We used this database and other information about the Super ESPC program to select 16 characteristics that define an average or typical Super ESPC project. In what follows, we provide a definition of these parameters, which are shown in bold face. For reference, a formal definition of each parameter is provided in the appendix.

3.2.2.1 Time to Award Delivery Order and Complete Construction

Since the beginning of the program in FY 1998, FEMP has kept track of the "cycle time" for setting up a Super ESPC, i.e., the time from kickoff meeting to delivery order award. The cycle time is calculated for each fiscal year by averaging across all projects kicked off in that year. It is not possible to include projects in the average until they are awarded. For this reason, average cycle times for the most recent years can appear artificially low. At the time our analysis was performed, the FY 2001 average was

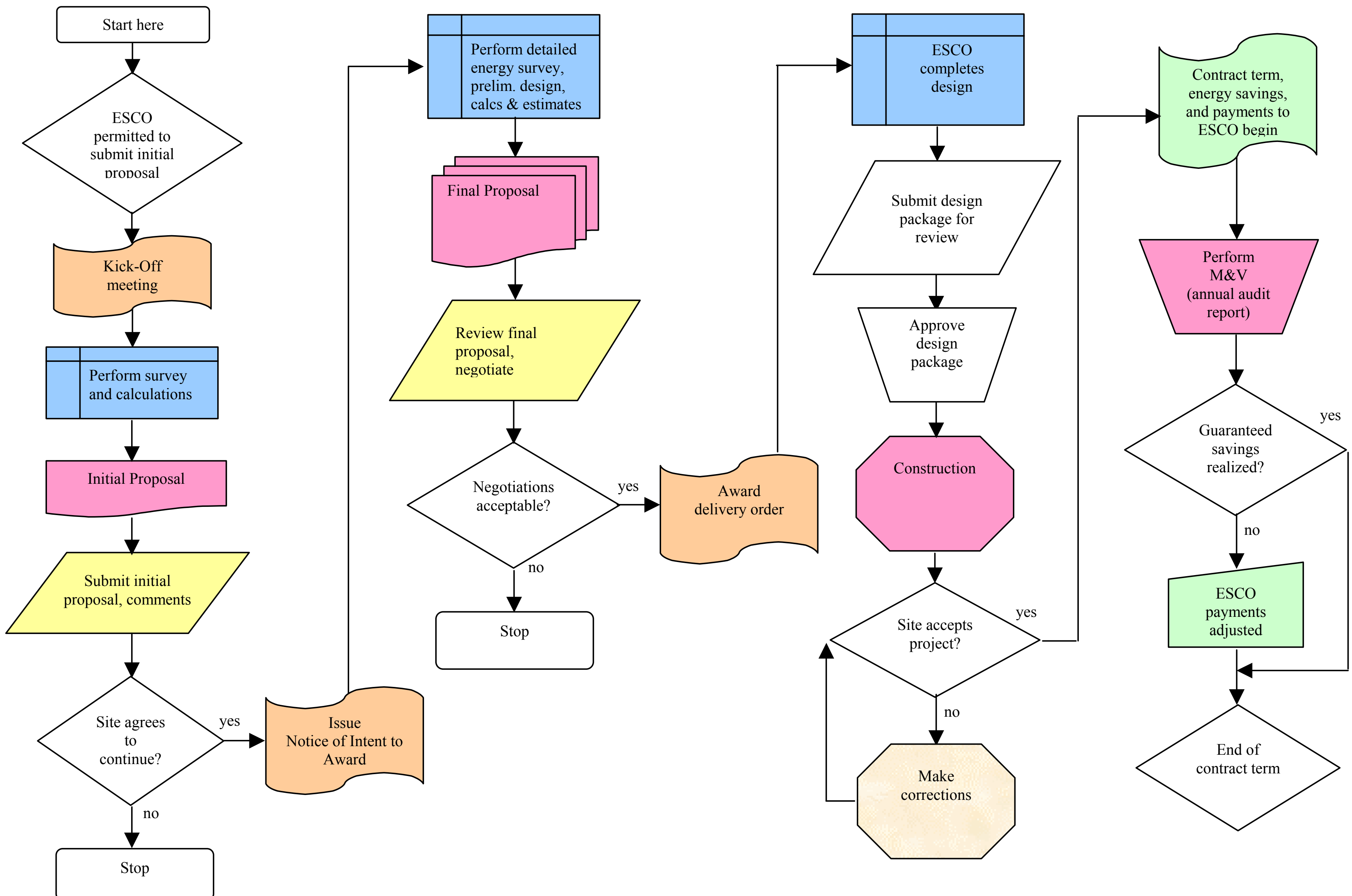

Figure 3.1. Energy savings performance contract flowchart.

clearly artificially low and could not be used because many projects kicked off in FY 2001 were not yet awarded. We therefore used the FY 2000 average at the time, which was 14.9 months, for the first parameter that defines the average ESPC project, **average time to delivery order award**. Since we performed a monthly analysis, we rounded the FY 2000 value up to 15 months. For the **average design/construction period** we considered all 71 projects; the average is 10.7 months. We round this to the nearest whole month and add an extra month for commissioning and acceptance, bringing the value to 12 months.

3.2.2.2 Implementation Price and Financed Amount

The database shows that the **average implementation price** for the 71 awarded projects, i.e., the average price for developing the ECM projects and purchasing and installing the ECMs, is approximately $3,263,000. An ESPC implementation price includes all direct project implementation expenses (surveys, feasibility studies, design, construction, commissioning) plus mark-up to recover indirect costs (overheads, sales effort, surveys and studies for projects never awarded, etc.) and profit. The **average financed amount** is $2,990,000. Both of these numbers are straight averages, i.e., the totals from all projects of implementation prices and financed amounts, respectively, divided by 71.

The price the ESCO charges to arrange project financing, to obtain required payment and performance bonds, to lock in interest rates in advance of financial closings (in cases where this strategy is used), and to cover construction-period interest is called the financing procurement price. The **average financing procurement price** across all 71 projects is $236,000.

Note that the implementation price plus the financing procurement price does not add up to the financed amount. Sites implementing holistic energy-efficiency solutions with ESPCs often find that the project eliminates the need for one or more repair and renewal projects that were previously planned, and for which funds are available. Sites can apply these funds from avoided project savings to an ESPC in the form of a one-time pre-performance-period payment to the ESCO. Another type of pre-performance-period payment is when energy and related O&M cost savings that accrue during the construction period are paid to the ESCO at acceptance (large projects with long construction periods can generate significant savings before all ECMs are accepted). By reducing the amount of financing required to install the ECMs, pre-performance-period payments reduce interest costs, and the resulting savings can be used to shorten the contract term. The **average pre-performance-period payment** across the 71 projects is $509,000. This is a simple average as well.

3.2.2.3 Interest Rate and Contract Term

A weighted average was used to determine the total annual interest rate for the representative project. We multiplied the total annual interest rate of each project by the financed amount, took the sum over all projects, then divided by the total financed amount. The **average project total annual interest rate** as calculated by this definition is 8.07%. We used the same weighting technique to determine the term of the representative project. The **average delivery order term** was found to be about 17 years (206 months).

3.2.2.4 Guaranteed Annual Cost Savings

Under Super ESPC, the ESCO guarantees that the installed ECMs will generate a certain level of annual cost savings. These savings generally increase from year to year because of price inflation. However, even when adjusted for inflation, first-year savings are often higher than the savings in the following years. This is because of minor inconsistencies in how ESCOs have been completing the Super ESPC financial schedules, or inconsistencies in the schedules themselves (before amendments to all the Super ESPC prime contracts eliminated the inconsistencies). In some projects, energy and energy-related O&M savings that occur during the construction period are paid to the ESCO during the first year of the performance period, as opposed to being included in pre-performance-period payments. To work around the uncertainty in what is included in first-year savings, we used values from the fifth year of each project to determine the average year-5 guaranteed cost savings. This is a simple average over all 71 projects. Then to determine the rate at which the annual guaranteed savings escalates over time, we made a second calculation: for those projects with delivery order terms of at least ten years, we determined (a) the sum of the annual guaranteed cost savings in year 5; and (b) the sum of the annual guaranteed cost savings in year 10. This allowed us to determine the **average escalation rate for guaranteed annual cost savings**, assuming constant price escalation. We calculated this rate to be 1.87%, and used it to bring the simple average of the year-5 cost savings of all 71 projects back to year 1. The result of these calculations is the **average first-year guaranteed cost savings**, which is $354,000. We assume that the representative project results in this amount of savings in the first year, and that these savings escalate at a constant rate of 1.87% per year.

3.2.2.5 Measurement and Verification Cost

The site uses the annual guaranteed cost savings to make payments to the ESCO; the ESCO in turn uses these funds for two purposes: to pay debt service (principal and interest) on the financed amount, and to pay for the performance-period services that are assigned to the ESCO (maintenance, repair, replacement, etc.). In Super ESPC contracts, one of the ESCO’s performance-period responsibilities is measurement and verification of savings. We chose to break M&V costs out separately because they are not incurred in appropriations-funded projects.

The price the ESCO charges for M&V generally varies from year to year according to price inflation, but the project-specific plan may also require more M&V costs in the first year of the contract than in later years. For this reason, we decided that year-5 M&V costs would be more representative of annual M&V costs. As with annual guaranteed cost savings, we used year-5 and year-10 M&V costs to calculate an **average escalation rate for annual M&V price,** then used this rate to bring the average year-5 M&V price back to year one, defining the **average year-1 M&V price**. Using this definition, we found the average year-1 M&V price to be $13,300 and the escalation rate to be 3.78%.

3.2.2.6 Performance-Period Services

We used the same strategy to calculate the price the ESCO charges for performance-period responsibilities other than M&V. Again, since the price is generally higher in year 1, we used year-5 and year-10 performance-period-services prices to determine the **average escalation rate for annual performance-period-services price (excluding M&V),** and then used this rate to bring the average year-5 price back to year 1 to determine the **average first-year performance-period-services price (excluding M&V)**. The average first-year performance-period-services price (excluding M&V) was found to be $36,400 with an average annual escalation rate of 3.95%.

3.2.2.7 Percentage of Savings Paid to ESCO

The final two parameters involve payments made by the site to the ESCO. Across all 71 projects, the **average percentage of guaranteed cost savings paid to the ESCO** is 98%. Given the average first-year guaranteed cost savings of $354,000, this means that the average first-year contractor payment is about $347,000. Using the same year-5 to year-10 comparison described above, we found the **average escalation rate for annual contractor payment** to be 1.87%, which is identical to the **average escalation rate for guaranteed annual cost savings**.

Table 3.1 summarizes the 16 parameters that define the average Super ESPC project.

Table 3.1. Financial and time-related parameters for the average Super ESPC project

1. Average time to DO award	15 months
2. Average design/construction period	12 months
3. Average implementation price	$3,263,000
4. Average financed amount	$2,990,000
5. Average pre-performance-period payment	$509,000
6. Average financing procurement price	$236,000
7. Average project total annual interest rate	8.07%
8. Average delivery order term	206 months
9. Average first-year guaranteed cost savings	$354,000
10. Average escalation rate for guaranteed annual cost savings	1.87%
11. Average first-year M&V price	$13,300
12. Average escalation rate for annual M&V price	3.78%
13. Average first-year performance-period-services price, excluding M&V	$36,400
14. Average escalation rate for annual performance-period-services price, excluding M&V	3.95%
15. Average percentage of guaranteed cost savings paid to ESCO	98%
16. Average escalation rate for annual contractor payment	1.87%

3.3 CHARACTERIZING THE APPROPRIATIONS CASE

The appropriations cases in this study are modeled on the two-step process for disbursing energy management funds that is used by several agencies, including the Department of Defense, Department of Energy, Housing and Urban Development, and General Services Administration. We have reviewed web sites and interviewed personnel involved with other agencies' appropriations-funded energy programs, and are confident the process we modeled is representative of most agencies. For example, Department of Defense sites request survey and study funds from the Energy Engineering Analysis Program and use the results to request design completion and construction funding from the Energy Conservation Investment Program. In all of these programs, competition for funds is fierce, and principal scoring criteria include savings-to-investment ratio (SIR) and payback period. These criteria require the sites to perform feasibility studies, cost estimates, and life-cycle cost analyses, and the end result is the type of process modeled here.

To obtain an understanding of actual appropriations-funded project schedules and process costs, we examined in detail one agency site's records of all projects that received funding from the agency's energy management (EM) program—either for surveys and studies or for design completion and construction—during FY 1994 and FY 1995. While the program is no longer active, many of the individuals who were involved in requesting funds and managing these appropriations-funded efforts are still involved in energy conservation at the site. The following description of the process is based on interviews with those individuals, as well as an examination of historical records from the program.

The two-step process outlined below is typical of the process faced by other federal agency sites when implementing conservation projects using their own agency programs. We recognize, however, that the costs and delays associated with each milestone in the process may vary considerably from agency to agency, and from program to program. For this reason we kept our process model general enough to allow for variations in these factors. The only appropriations process model assumption that relies on the small sample of projects we examined from one agency site relates to the allocation of total process time between intermediate milestones where the costs occur.

What follows is a general description of the steps involved in implementing projects with appropriations using one agency site as an example to fill in the details.

3.3.1 The Process of Requesting Appropriations

3.3.1.1 Requesting Funds for Survey and Feasibility Study

The first step in the process of obtaining funds from the headquarters EM program was for the site's engineers to perform a minimal in-house assessment to determine if the ECM was likely to receive funding from headquarters for a more detailed site survey and feasibility study. If the ECM had a reasonable chance of receiving survey/feasibility study funds, the second step was to write up a request and submit it to the agency. Headquarters expected these requests in August, and survey and study funds for approved projects were supposed to be released the following November. Of course, the ECMs submitted were in competition with submissions from other agency sites, so not all requests for detailed survey and feasibility study funds were granted. Requests were sometimes resubmitted in a number of years before the survey and study funds were finally received.

3.3.1.2 Survey, Feasibility Study, and 30% Design

For projects that did receive survey and study funding, the third step in the process was to perform the detailed survey and feasibility study. Ideally, funds to perform the study would be transferred from the agency in November, and the study would begin shortly afterward. In reality, funds were sometimes transferred later in the fiscal year. Ongoing work at the site sometimes delayed the start of the study as well.

The study required for the EM program involved surveying the facilities and developing a detailed engineering and financial analysis to estimate project costs and benefits, with the ultimate goal of determining parameters such as simple payback and savings-to-investment ratio (SIR), which would be used to score the project in the selection process. To estimate project costs, engineers would develop ECM designs to the 30% completion stage to serve as the basis for detailed cost estimates. Estimating benefits (i.e., energy and energy-related cost savings) typically required some modeling with a building energy analysis program such as DOE-2 or Market Manager. Officially, the EM program would consider funding projects with simple paybacks of 10 years or less, but engineers knew from experience that projects with short paybacks—especially those in the range of 3–5 years—had the best chance of being funded.

3.3.1.3 Requesting Funds for Design Completion and Construction

Sometimes the study would find that the simple payback was longer than acceptable, and the project idea would be shelved. But if the study did identify ECMs with paybacks in the acceptable range, the fourth step was to submit the study to headquarters along with a request for design completion and construction funds. As with requests for survey and study funds, these requests had to be submitted in August. If headquarters funded the project, it would release funding the following November. Once these funds were received, the project proceeded like any other design and construction project, with completion of the design and bid-to-spec package, a request for proposals for construction, receipt of bids, contractor selection and, finally, project construction. Again due to limited appropriations, not all design and construction requests were funded, and some funding requests were resubmitted in multiple years.

3.3.1.4 Summary of Process Steps

To summarize, the tasks involved in implementing ECMs under the EM program (illustrated in Figure 3.2) were the following:

- Perform minimal assessment of ECM.
- Develop request for funds to perform formal survey and feasibility study and submit the request to the agency EM program.
- Perform survey and feasibility study (if funding received).
- Develop request for design completion and construction funds and submit to the agency EM program along with the study report and detailed cost estimate (if study shows payback in the range of 3–5 years).
- Complete design and construction (if design/construction funding received).
- Accept construction project (and begin energy savings).

3.3.2 Duration of Process Steps

One of the key parameters in the life-cycle cost of appropriations-funded projects is total process time, which is determined by the duration of the process steps. This section demonstrates the use of the methodology for estimating this parameter and documents our findings on the duration of the process steps as experienced by the site whose records we examined. However, our life-cycle cost comparisons (in Chapter 4) show appropriations cases with a range of 28 months to 74 months for this parameter.

To estimate the average duration of each step, we examined the records of all the site projects that received funding from the EM program—either for a survey and study or for design completion and construction. The projects were classified by the year in which funding was received. Records from FY 1994 and FY 1995 contained the most complete information, so we used these records as the basis of our study. For each project that received some type of funding during FY 1994 and FY 1995, the records contain the following information:

- Cost of survey and study
- Date survey and study began
- Date survey and study ended
- Cost of design completion and construction
- Date construction began
- Date construction ended

The records encompass 23 EM-funded surveys and studies carried out between May of 1991 and September of 1997. The project where the survey and study was performed in FY 1991 was included in the sample because the design/construction funds were requested annually but not received until FY 1994. The project where the survey and study was completed in September 1997 was included because the survey and study funds were received in FY 1995. Funds were requested for design completion and construction for a total of 39 ECMs, indicating that some studies covered multiple ECMs. Because funding was normally received in November, we expected to see most of the surveys and studies beginning in December or January, but the records indicate that the work could start in any month of the year. The mean starting month for the 23 surveys and studies was May, which is a delay of six months after receipt of funding.

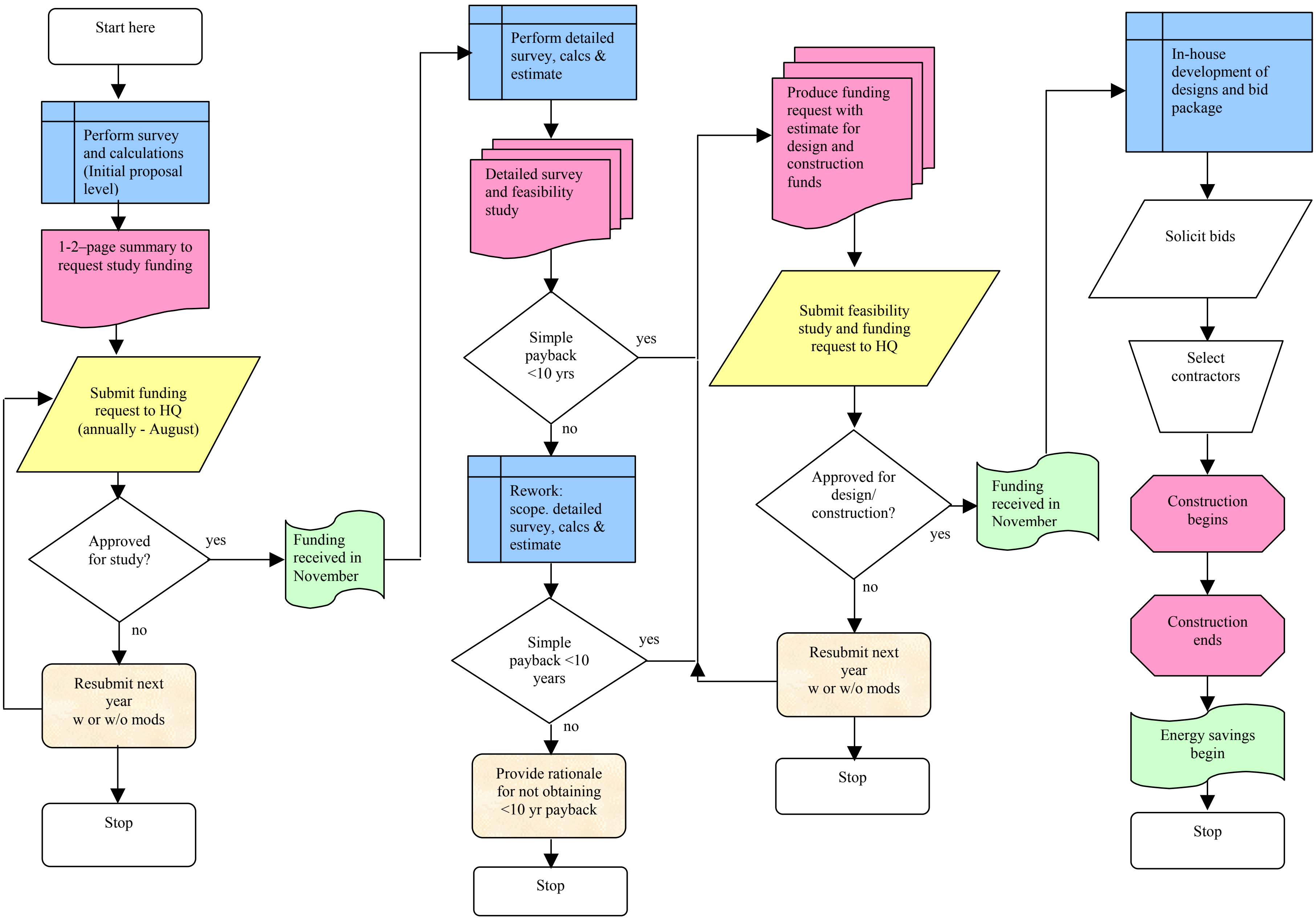

Figure 3.2. Flowchart showing process for implementing projects through the agency's appropriations-funded energy management program.

The average duration of the 23 surveys and studies was 6.65 months. For the purposes of this analysis, we rounded that number up to 7 months. If the average feasibility study is assumed to begin in May, it would be completed in December. Applications for design and construction funds would be submitted in August of the following year, and funds were provided for successful applicants in the following November. Of the 39 ECMs studied, 30% (12) eventually received additional EM funding for design completion and construction. The average delay between the end of the survey and study and the beginning of the design completion effort was 17.6 months. The design completion period averaged 10.1 months. There was an average 1.9-month delay before construction began. The construction period averaged 10.0 months. Rounding all of these to the nearest month, we have the following schedule, assuming a project whose feasibility study began in May of 1994:

Submit funding request:	Aug 1993
Receive funding:	Nov 1993
Begin survey and study:	May 1994
End survey and study:	Dec 1994
Begin design completion:	Jun 1996
End design:	Apr 1997
Begin construction:	Jun 1997
End construction:	Apr 1998
Project accepted:	May1998

One piece of information missing from the files was the date when the preliminary in-house study was performed. According to engineers familiar with the process, these studies could be performed at any time throughout the year prior to August, when applications for survey and study funds were due. It could be argued that the most likely time to perform these assessments was in December: The agency released survey and study and design/construction funds for successful projects in November, and after finding out which projects had been funded, the site could begin looking for other potential projects. However, engineers insisted that these studies were performed throughout the year. For the purposes of this analysis, it was assumed that the initial study was performed in February, six months prior to the deadline for submitting new study requests. With this date, and the average durations of the major activities, the average schedule for the site's appropriations-funded projects is fixed. According to our analysis, the period of time from when an ECM was first identified until it began saving energy was, on average, 63 months.

Figure 3.3 is a graphic comparison of the timelines of this particular appropriations case and the average Super ESPC case.

3.3.3 Cost of Studies and Surveys

As noted above, because projects were in competition for limited appropriations, only 12 out of 39 ECMs studied were ultimately funded. In fact, projects dropped out of the process at each step along the way. The initial assessment identified some unfeasible projects, and these were not submitted for funding. Not all of the survey and study funding requests submitted were approved. Not all of the surveys and studies identified feasible ECMs that could be submitted to the agency for design completion and construction funding. Then, not all the design completion and construction requests were funded. Obviously, costs may be incurred for surveys and studies whether or not an ECM is ultimately installed.

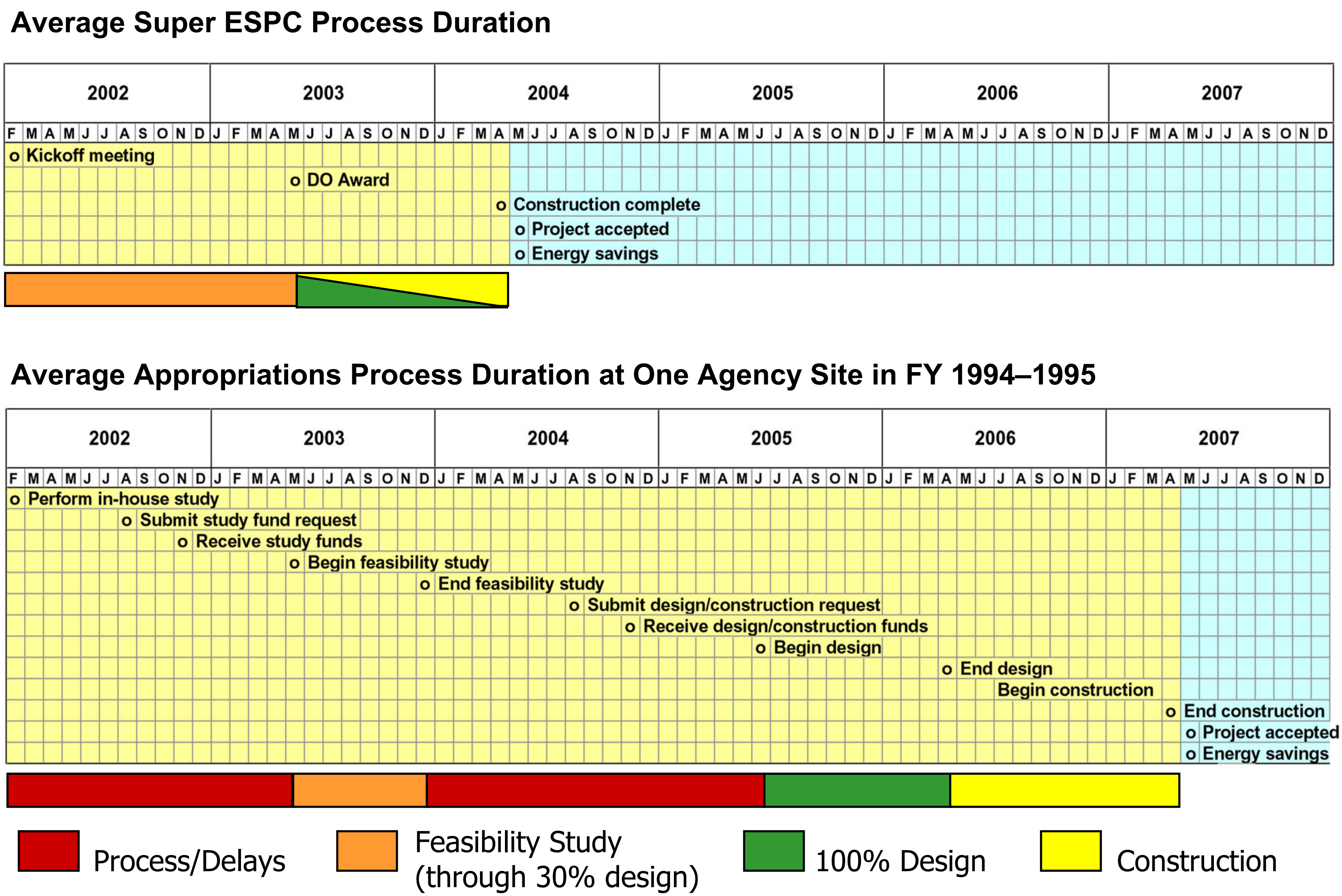

Figure 3.3. Timelines of the average Super ESPC process and one agency site's appropriations process for implementing energy-efficiency projects. The Super ESPC timeline is based on averages from the 71 projects awarded through the end of FY 2001. The appropriations timeline was constructed from averages based on records of 23 energy project studies at one agency site during a two-year period that led to requests for $27.5 million in design/construction funding and ultimately $5 million in built projects.

Unfortunately the records provided to us cover only those projects that were awarded survey and study funds from the agency. We can estimate the cost of the preliminary studies performed for the ECMs that received study funds, but we have no way of determining how many of the ECMs assessed in step 1 were not submitted for survey and study funds (because the payback was determined to be too long); or of those submitted, how many did not receive the survey and study funds (because of the limited availability of appropriations). Nevertheless, the cost of the preliminary assessments was much smaller than the cost of the surveys and studies, so ignoring the cost of assessing unsuccessful ECMs at this early stage does not introduce much error. It should be recognized however that the cost calculated here provides a lower bound for the true study costs incurred in this sample.

The records show that in FY 1994–1995, $1,251,000 was received from the EM program to perform surveys and feasibility studies for the 39 ECMs. The total estimated cost to implement these ECMs was $27,472,000. Ultimately, however, only 12 of the 39 were approved, and a total of $4,996,400 in design completion and construction funds was received. Based on these data, the cost of surveys and feasibility studies was about 25% (= 1,251,000/4,996,400) of the cost of implementing the ECMs.

On the other hand, the costs of surveys and feasibility studies for only the ECMs that ultimately received design completion and construction funding was $195,000, or closer to 4% (= 195,000/ 4,996,400) of the cost of implementing the ECMs. While project records did not indicate the cost of performing the initial assessments, an engineer familiar with the process estimated that an assessment required 20 person-hours on average. The same individual estimated that the applications for funds required 6 person-hours to perform. An hourly rate of $100 was assumed to determine the cost of these activities.

Costs for surveys and studies that are required in the process of requesting funding (as a percentage of design completion and construction costs) can vary widely. The parametric tables (in Chapter 4) show appropriations cases with survey and study costs ranging from 4% to 26% of design completion and construction costs.

3.3.4 Design Completion and Construction Cost

Design completion and construction cost is equal to Super ESPC average implementation price of $3,263,000.

3.3.5 Cost Savings

Cost savings in the appropriations case are the same as the guaranteed cost savings for the average Super ESPC. In both cases, cost savings are accounted for in the analysis as a reduction in energy and energy-related costs.

3.3.6 Energy-Related Maintenance Costs

For the appropriations case, we assume that the site spends the same amount on O&M and R&R of the new equipment as in the average Super ESPC case, based on the $36,400 first-year price for performance-period services, which excludes all M&V costs.

3.4 CALCULATING SUPER ESPC LIFE-CYCLE COST

All of the scenarios analyzed involve the implementation of ECMs with a total investment value of $3,263,000—an amount that corresponds to the **average implementation price** of the 71 ESPC projects as defined above and in Appendix A—inflated to the appropriate date by the rate of general price inflation.

Once accepted by the government, the ECMs are assumed to generate energy and energy-related O&M savings in the amount of the **average first-year guaranteed cost savings**, inflated by the **average**

escalation rate for guaranteed annual cost savings. The "cost savings" is accounted for in the analysis as a reduction in energy and energy-related costs.

We calculated the life-cycle cost of the typical project implemented using a Super ESPC as $4,922,607. This is the present value of all payments made by the facility during the 20-year study period. In the material below we describe how this calculation was made.

3.4.1 Inflation and Discount Rates

In our life-cycle cost analysis we use the DOE nominal discount rate from the annual supplement to NIST Handbook 135 (NIST, 2001). Federal agencies and contractors to federal agencies are required by 10 CFR 436, Part A, §14a to use the DOE discount rate when conducting life-cycle cost analysis related to energy conservation, renewable energy resources, and water conservation projects for federal facilities. The nominal rate effective at the time of our analysis was 6.1% and equals the real discount rate plus general price inflation, which was 2.7%. The DOE real discount rate is based on long-term U.S. Treasury bond rates averaged over the 12 months prior to the preparation of the annual supplement. In essence, the DOE nominal discount rate includes the Treasury's cost of borrowing money plus general price inflation. In our analysis general price inflation was applied to all costs occurring in future years to be consistent with use of the nominal discount rate for calculating the present value of life-cycle costs.

3.4.2 Excess Energy and Related Costs Before Construction

We assume that during the first year of operation, the ESPC results in cost savings corresponding to the **average first-year guaranteed cost savings** ($354,000); these savings increase from year to year by the **average escalation rate for guaranteed annual cost savings** (1.87%). In the months between the kickoff meeting and project acceptance, the facility is assumed to incur excess energy and energy-related costs in the amount of the guaranteed cost savings. Since we are performing a monthly analysis, we divide the annual savings by 12. Specifically, the excess energy and energy-related costs incurred in month 1 (when the kickoff meeting is held) are calculated as

$$(\$354{,}000/12) \times (1 + 0.0187)^{1/12} = \$29{,}546 \ .$$

Likewise, the excess energy and energy-related costs incurred in month 2 are

$$(\$354{,}000/12) \times (1 + 0.0187)^{2/12} = \$29{,}591 \ ,$$

and so forth, until month 28 (27 months after the kickoff meeting) when the project is accepted. At project acceptance, the new, more efficient equipment begins operation, and the facility no longer pays the excess energy and energy-related costs because they are negated by the onset of guaranteed savings.

3.4.3 Pre-Performance-Period Payment

There are two types of pre-performance-period payments to the ESCO: (1) a payment corresponding to a "one-time savings" accrued by the site resulting from avoidance of planned projects that are rendered unnecessary by the ESPC, which occurs after the ESCO implements the part of the ESPC that eliminates the need for the stand-alone project, and (2) payments equivalent to the energy and related O&M cost savings accrued during the construction period, which are generally paid to the ESCO near acceptance. For the purposes of this analysis it is assumed that all pre-performance-period payments occur in month 28 when the delivery order is accepted. The payment is $541,646, which corresponds to the **average pre-performance-period payment** ($509,000) escalated at the rate of general price inflation to month 28.

3.4.4 Project Facilitation

Agency sites generally enter into an interagency agreement with DOE and reimburse DOE for the services of a project facilitator when the initial proposal is accepted and notice of intent to award is issued. On average, this occurs about three months after kickoff, so for the purposes of this analysis we assume the site pays $30,268 to DOE for project facilitation in month 4. This represents $30,000 inflated to month 4 at 2.7%, the rate of general price inflation.

3.4.5 Payments During Contract Term

The ESPC performance period formally begins in month 28, and the facility then begins making monthly payments to the ESCO from guaranteed savings. The monthly amount depends on the **average first-year guaranteed cost savings** ($354,000), the **average percentage of guaranteed cost savings paid to the ESCO** (98%) and the **average escalation rate for annual contractor payment** (1.87%). Specifically, in month 28 the facility pays:

$$(0.98 \times \$354{,}000/12) \times (1 + 0.0187)^{28/12} = \$30{,}187 \quad .$$

Likewise, the payment to the ESCO in month 29 is:

$$(0.98 \times \$354{,}000/12) \times (1 + 0.0187)^{29/12} = \$30{,}234 \quad ,$$

and so forth, until the ESPC performance period is completed.

3.4.6 Expenses through End of 20-Year Study Period

After completion of the ESPC performance period, the ESCO no longer maintains the installed equipment, and the facility begins incurring additional operations and maintenance costs. Note that the facility's O&M costs are identical to the costs the ESCO was paying, except that the facility does not perform M&V. Thus the facility's costs after completion of the ESPC depend on the **average first-year performance-period-services price, excluding M&V** ($36,400), and the **average escalation rate for annual performance-period-services price, excluding M&V** (3.95%). For example in month 228, the facility incurs O&M costs in the amount of $(\$36{,}400/12) \times (1 + 0.0395)^{228/12} = \$6333$, and so forth, until the end of the 20-year study period.

3.4.7 Equipment Salvage Value

At the end of the study period, the facility gets a credit for the salvage value of the equipment accepted in month 28. The equipment is assumed to have its full value of $3,472,280 in month 28 (the amount corresponds to the **average implementation price** inflated to month 28 at the rate of general price inflation) and zero value in month 268, which is 20 years after acceptance. We use straight-line depreciation to calculate the salvage value in month 240. The result is a credit of $405,099 in month 240, the end of the 20-year study period.

3.4.8 Summary of Super ESPC Costs

In summary, there are six types of costs incurred by the facility in a Super ESPC: (1) monthly costs due to excess energy and energy-related O&M in the months prior to installation of the ECMs, (2) a fee for project facilitation incurred 3 months after kickoff when the initial proposal is accepted, (3) a pre-performance-period payment made at acceptance, (4) monthly contractor payments to cover debt repayment (principal and interest) and performance-period services (M&V, O&M, R&R) beginning when the ECMs are accepted and continuing throughout the performance period, (5) monthly O&M and R&R costs, incurred from the end of the ESPC performance period until the end of the 20-year study period, and (6) a salvage value (listed as a negative cost) for the equipment installed under the ESPC in month 240. These costs are summarized in Table 3.2.

Table 3.2. Costs incurred in ESPC project

Description	Base year cost	Annual escalation rate	Cost type	Month(s) in which cost occurs
Excess energy and energy-related O&M costs	$29,500	1.87%	Monthly	1–27
Project facilitation fee	$30,000	2.70%	One-time	3
Pre-performance-period payment	$509,000	2.70%	One-time	28
Contractor payment (debt service, M&V, etc.)	$28,910	1.87%	Monthly	28–226
Operations/maintenance/repair/replacement	$3,033	3.95%	Monthly	227–240
Salvage*	($405,099)	n/a	One-time	240

*Salvage value is in year-20 dollars (i.e., at month 240).

Given all the costs and the months in which they occur, we calculate the present value (in month 0) of each cost using the discount rate of 6.1%. For example, the present value of the pre-performance-period payment of $541,646 made in month 28 is calculated as:

$$\frac{\$541{,}646}{(1+0.061/12)^{28}} = \$469{,}956 \ .$$

3.4.9 Calculating Monthly Payments and Contract Term

When the delivery order is signed, the ESCO must procure financing in the amount of $3,098,122, which corresponds to the **average financed amount** inflated by the rate of general price inflation to month 16. Modeled here is the escrow style of financing where the ESCO closes on the permanent financing at the beginning of the construction period, and in essence the capitalized construction period interest is calculated from the negative arbitrage between interest earned on the escrow account and interest paid on the entire permanent financing principal balance. The ESCO uses the escrowed funds to pay for project implementation in increments as construction progresses and to pay for financing procurement costs, which include the capitalized construction-period interest from month 16 until month 28, when the first payment is received from the facility.

Beginning in month 28, the ESCO receives monthly contractor payments; these payments are used to pay four types of costs: interest on the outstanding loan balance; a principal payment; M&V costs; and non-M&V performance-period service costs. We calculate the principal payment as the monthly contractor payment, minus the interest payment, minus the M&V, minus the non-M&V performance-period services. This means that in general, the ESCO's loan payments are variable. For example, we showed above that the contractor payment in month 28, the first month of the ESPC, is $30,187. To calculate the M&V cost for month 28, we use the **average first-year M&V price** ($13,300) and the **average escalation rate for annual M&V price** (3.78%):

$$(13{,}300/12) \times (1 + 0.0378)^{28/12} = \$1209 \ .$$

To calculate the ESCO's other monthly expenses, we use the **average first-year performance-period-services price, excluding M&V** ($36,400) and the **average escalation rate for annual performance-period-services price, excluding M&V** (3.95%):

$$(36{,}400/12) \times (1 + 0.0395)^{28/12} = \$3320 \ .$$

At the beginning of month 28, the entire principal of $3,098,122 remains on the loan (remember, the pre-performance-period payment essentially lowers the financed amount). We use this amount and the **average project total annual interest rate** (8.07%) to calculate the monthly interest payment:

$$3{,}098{,}122 \times 0.0807/12 = \$20{,}835 \ .$$

The amount the ESCO pays toward the principal is then the contractor payment, minus the interest payment, minus M&V costs, minus non-M&V performance-period costs, or

$$30{,}187 - 20{,}835 - 1{,}209 - 3{,}320 = \$4{,}823 \ .$$

Then the remaining principal at the end of month 29 (and at the beginning of month 30) is 3,098,122–4,823, or $3,093,299.

The same calculations are made for each month during the ESPC performance period to determine the principal payment. Finally, a point is reached when the amount available for the principal payment is greater than the remaining principal balance. This is the final month of the ESPC performance period. In this month, we reduce the payment from the site to the ESCO such that the ESCO receives just enough to pay the remaining principal, the final month's interest, and for the performance-period services.

Using the financial and scheduling parameters for the average Super ESPC project and the escrow financing style, the variable loan payment schedule described above results in a project term of 200 months. This compares well with the **average delivery order term** of 206 months. The difference is due to several factors. For example, some of the 71 Super ESPC projects were financed with separate construction period and permanent financing rather than the escrow approach, and some were financed with fixed monthly debt service payments rather than the variable payments modeled in this analysis.

3.5 CALCULATING LIFE-CYCLE COST OF APPROPRIATIONS CASES

The sections below illustrate how we calculated life-cycle cost for the appropriations cases. In this illustration, we use the values derived from our analysis of the agency site data.

3.5.1 Inflation and Discount Rates

The discount and inflation rates used in calculating life-cycle costs for the appropriations cases are the same as those used for the ESPC case, described in Section 2.5.1.

3.5.2 Surveys/Studies and Funding Requests

We assume the site requests funds equal to the **average implementation price** ($3,263,000) for design completion and construction of ECMs. The process begins with the minimal in-house study required to gather information for the formal survey and study fund request. The in-house study requires 20 hours at a labor cost of $100 per hour, or $2,000, which is inflated to month 1 according to the rate of general price inflation. Preparation and submission of the study fund request takes place in month 7 and requires 6 hours at the labor rate of $100 per hour, or $600 inflated to month 7. The survey and study funds are disbursed by headquarters in month 10. In the small sample of projects, survey and study funds are 25% of the implementation price.

The facility begins the survey/feasibility study in month 16 and completes it in month 23. In month 31, the facility submits a request to the agency EM program for design completion and construction funds. Preparation and submission of this request takes 6 hours at the base hourly rate of $100, or $600 inflated to month 31 at the rate of general price inflation.

3.5.3 Costs during and after Construction

Headquarters disburses the design completion and construction funds in month 34, in an amount equal to $3,263,000 inflated to month 34 at the rate of general price inflation. The facility then completes the design and constructs the ECMs, using a combination of in-house and contracted services. Construction ends in month 63 and the project is accepted and begins saving energy in month 64.

Until the ECMs are installed and accepted, in every month the facility pays excess energy and energy-related costs equal to one-twelfth of the **average first-year guaranteed savings**, inflated monthly according to the **average escalation rate for guaranteed annual cost savings**. Once the project is accepted, the facility assumes responsibility for maintaining the equipment, and pays a monthly charge that depends on the **average first-year performance-period-services price, excluding M&V** ($36,400), and the **average escalation rate for annual performance-period-services price, excluding M&V** (3.95%).

As in the ESPC case, the ECMs are assumed to generate energy and energy-related O&M savings in the amount of the ESPC **average first-year guaranteed cost savings**, inflated by the **average escalation rate for guaranteed annual cost savings**. The "cost savings" is accounted for in the analysis as a reduction in energy and energy-related costs.

3.5.4 Equipment Salvage Value

As with the ESPC, at the end of the study period the facility gets a credit for the salvage value of the equipment accepted in month 64. Straight-line depreciation is used to calculate the salvage value in month 240. Since government acceptance of equipment is later in the appropriations case than in the ESPC case, the equipment salvage value at the end of the study period is also greater.

3.5.5 Summary of Appropriations Case Costs

The costs to the facility of implementing the typical project using appropriations are summarized in Table 3.3. Given all the costs and the months in which they occur, we calculate the present value (in month 0) of each cost using the discount rate of 6.1%. The life-cycle cost of this appropriations case is then $5,531,718.

Table 3.3. Costs incurred in appropriations-funded projects (agency site illustration)

Description	Base year cost	Annual escalation rate	Cost type	Month(s) in which cost occurs
Excess energy and energy-related O&M costs	$29,500	1.87%	Monthly	1–63
Perform in-house pre-feasibility study	$2,000	2.70%	One-time	1
Submit survey and study funds request	$600	2.70%	One-time	7
Provide survey and study funding	$815,750	2.70%	One-time	10
Submit design/construction funds request	$600	2.70%	One-time	31
Provide design/construction funding	$3,263,000	2.70%	One-time	34
Operations/maintenance/repair/replacement	$3,033	3.95%	Monthly	64–240
Salvage[a]	($1,002,986)	n/a	One-time	240

[a]Salvage value is in year-20 dollars (i.e., at month 240).

4. RESULTS AND APPLICATION OF THE LCC COMPARISON METHODOLOGY

In this chapter we present the results of the life-cycle cost (LCC) comparison in the form of parametric tables that enable the average ESPC to be compared to appropriations cases having a wide range of survey and study costs and total process times. The effects of degradation of savings on life-cycle cost are also analyzed and displayed in parametric tables for the entire range of appropriations cases.

There are several caveats associated with the use of the LCC comparison tables, but in general the tables can be used to obtain a customized LCC comparison between implementing the typical project (or fleet of typical projects) with appropriations and the average ESPC. The limitations of the tables and the assumptions embedded in the comparisons are discussed in Section 4.3. Applications of the methodology are discussed and use of the tables is demonstrated with several examples in Section 4.4.

4.1 LIFE-CYCLE COST COMPARISON RESULTS

Table 4.1 presents the results of the life-cycle cost comparison. The average Super ESPC (see Section 3.2) is compared to parameterized appropriations cases with a range of process times and survey

Table 4.1. Ratio of present value of life-cycle cost (thousands, 2001 dollars) of typical energy conservation project funded with appropriations to present value life-cycle cost of same project carried out using ESPC, as a function of total survey and study cost and total process time. The shaded cells represent cases with life-cycle cost lower than the ESPC case.

Total process time (months)	Total survey and study cost (as percentage of design completion/construction cost)											
	4%	6%	8%	10%	12%	14%	16%	18%	20%	22%	24%	26%
28	0.8969	0.9099	0.9231	0.9361	0.9491	0.9623	0.9753	0.9883	1.0015	1.0145	1.0275	1.0407
30	0.9028	0.9160	0.9290	0.9422	0.9552	0.9682	0.9814	0.9944	1.0074	1.0206	1.0336	1.0466
32	0.9087	0.9217	0.9347	0.9479	0.9609	0.9739	0.9869	0.9999	1.0129	1.0259	1.0391	1.0521
34	0.9146	0.9276	0.9406	0.9536	0.9666	0.9796	0.9928	1.0058	1.0188	1.0318	1.0448	1.0578
36	0.9202	0.9332	0.9462	0.9592	0.9722	0.9855	0.9985	1.0115	1.0245	1.0375	1.0505	1.0635
38	0.9259	0.9389	0.9519	0.9649	0.9779	0.9909	1.0039	1.0171	1.0301	1.0431	1.0561	1.0691
40	0.9314	0.9444	0.9572	0.9702	0.9832	0.9962	1.0092	1.0222	1.0352	1.0482	1.0612	1.0742
42	0.9369	0.9497	0.9627	0.9757	0.9887	1.0017	1.0147	1.0277	1.0407	1.0537	1.0667	1.0797
44	0.9422	0.9552	0.9682	0.9812	0.9942	1.0072	1.0202	1.0332	1.0462	1.0592	1.0722	1.0852
46	0.9475	0.9605	0.9733	0.9863	0.9993	1.0123	1.0253	1.0381	1.0511	1.0641	1.0771	1.0901
48	0.9527	0.9655	0.9785	0.9915	1.0045	1.0176	1.0303	1.0433	1.0564	1.0694	1.0824	1.0952
50	0.9578	0.9708	0.9838	0.9966	1.0096	1.0226	1.0356	1.0486	1.0614	1.0744	1.0874	1.1004
52	0.9629	0.9759	0.9889	1.0017	1.0147	1.0277	1.0407	1.0537	1.0665	1.0795	1.0925	1.1055
54	0.9678	0.9808	0.9938	1.0066	1.0196	1.0324	1.0454	1.0584	1.0712	1.0842	1.0970	1.1100
56	0.9729	0.9857	0.9987	1.0115	1.0245	1.0375	1.0503	1.0633	1.0761	1.0891	1.1021	1.1149
58	0.9775	0.9905	1.0035	1.0163	1.0293	1.0421	1.0551	1.0681	1.0809	1.0939	1.1067	1.1197
60	0.9822	0.9952	1.0080	1.0210	1.0338	1.0468	1.0596	1.0724	1.0854	1.0982	1.1112	1.1240
62	0.9871	0.9999	1.0127	1.0257	1.0385	1.0515	1.0643	1.0773	1.0901	1.1029	1.1159	1.1287
64	0.9899	1.0027	1.0157	1.0285	1.0415	1.0543	1.0671	1.0801	1.0929	1.1059	1.1187	1.1317
66	0.9944	1.0074	1.0202	1.0330	1.0460	1.0588	1.0718	1.0846	1.0976	1.1104	1.1232	1.1362
68	0.9989	1.0117	1.0245	1.0375	1.0503	1.0631	1.0759	1.0889	1.1017	1.1145	1.1272	1.1402
70	1.0031	1.0161	1.0289	1.0417	1.0545	1.0675	1.0803	1.0931	1.1059	1.1189	1.1317	1.1445
72	1.0076	1.0204	1.0332	1.0460	1.0590	1.0718	1.0846	1.0974	1.1104	1.1232	1.1360	1.1488
74	1.0117	1.0245	1.0373	1.0501	1.0629	1.0759	1.0887	1.1014	1.1142	1.1270	1.1398	1.1526

and study costs. The table allows comparison of the average Super ESPC to appropriations cases having total process times between 28 and 74 months, and total survey and study costs between 4% and 26% of design completion and construction costs. In all of the appropriations cases in Table 4.1, we assume the same initial level of savings as in the Super ESPC case and no degradation of savings.

The results of the comparisons are expressed in the cells of Table 4.1 as ratios of the average Super ESPC life-cycle cost to the life-cycle cost of the parameterized appropriations cases. The shaded cells in Table 4.1, showing values less than one, represent combinations of process times and total survey and study costs that make the life-cycle cost of the appropriations-funded project lower than that of the average ESPC case. For example, the value showing in the table for the appropriations case having a total process time of 40 months and survey and study costs of 10% of design completion and construction costs is 0.972, indicating a lower cost than for the average Super ESPC.

The 28-month lower bound on total process time equals the average time to acceptance for Super ESPC. Since Super ESPC is a streamlined design–build process that taps private sector financing when needed rather than waiting for appropriations, we felt that implementing an appropriations-funded project faster than the average Super ESPC would be unlikely. The upper bound of 74 months is the next highest even number beyond the 73-month average reported for a large sample of appropriations-funded projects (75% of all projects funded FY 1985 to 1993) in a 1993 report on an agency EM program that used the two-step process modeled for this study (not referenced to preserve anonymity).

The 4% lower bound on total survey and study costs represents the average direct survey and study costs observed when we examined the 1994–1995 sample of projects from one agency site. Since no proportional share of indirect dead-ended survey and study costs is included, it seems unlikely that any agency could claim a lower value than 4% for the total of direct and indirect survey and study costs. The upper value of 26% is the next even number beyond the 25% observed during 1994–1995 at the agency site whose records we examined.

4.2 PERSISTENCE OF SAVINGS

The achievement of expected savings and persistence of savings over time has been a concern in federal and other energy conservation programs (see for example Bronfman et al., 1991, Chapter 6). Definitive studies on the subject are scarce, but conventional wisdom in the energy field is that savings do not persist (and sometimes are never realized at all) without planned and funded follow-up to verify that equipment is performing properly and savings are delivered.

One of the perceived advantages of Super ESPCs is the requirement for ESCOs to guarantee cost savings and to perform annual measurement and verification audits to ensure that savings are achieved. There is some evidence that contracts with guarantees and specified follow-up plans do succeed in delivering the expected savings (Osborn et al., 2002).

In this section we quantify the effect of savings degradation on life-cycle cost. There are a number of ways to model reductions in savings, and in general the same model would not apply for all technologies. Given that we analyze a typical project and no ECMs in particular, here we adopt a simple model and assume that in the absence of M&V, savings decrease at a constant annual rate. For example, if a given project results in a first-year savings of $10,000 and savings decrease at an annual rate of 1%, then the savings in year 2 would be $9,900, in year 3 savings would be $9,801, and so on, until the end of the study period.

Only actual costs are treated in this analysis, so energy savings appear throughout as decreased energy costs. This means that degradation of energy savings is shown as an increase in energy costs. In the calculation of life-cycle costs for appropriations cases where savings degrade, costs equal to decreased savings occur monthly, whereas these costs did not occur in the cases where no savings degradation is assumed (Table 4.1).

We calculated the life-cycle cost of both the ESPC and the appropriations-funded cases using three rates of decrease for annual energy and related O&M savings. For the appropriations-funded cases, we assume that the decrease in savings begins shortly after project acceptance. For the ESPC project, our assumption is that the required M&V maintains the guaranteed savings throughout the performance period, but once the term expires and the agency resumes responsibility for follow-up activities, savings decrease at the same rate as in an appropriations-funded project. As shown in Table 4.2, the reduction in savings has only a small effect on the present value of life-cycle cost of the typical project implemented with ESPC. This is because of our assumption that the M&V performed during the 227-month performance period maintains savings at a constant level (except for energy price escalation). Savings degradation is assumed to occur only after the performance period ends, i.e., during the 13 remaining months until the end of the 20-year study period.

Table 4.2. Present value of life-cycle cost of typical project implemented with ESPC when savings degrade after completion of project term

	Life-cycle cost
No annual decrease in savings	$4,922,607
0.5% annual decrease in savings	$4,923,022
1% annual decrease in savings	$4,923,434
2% annual decrease in savings	$4,924,249

Tables 4.3 through 4.5 show the present value of the life-cycle cost of the typical project funded by appropriations, for annual savings reduction rates of 0.5%, 1% and 2%, and for a variety of total survey and study costs and total process times. The shaded cells indicate combinations of parameters that result in lower life-cycle cost than the average ESPC case. These tables can be compared with Table 4.1, which represents the same range of parameters with no reduction in savings.

The conclusion here is obvious: Degradation of savings can greatly increase the life-cycle cost of a project. At very low rates of savings reduction—0.5% to 1%—appropriations-funded projects can still have lower life-cycle costs than the average ESPC case. However, even at a modest savings reduction rate of 2%, which results in a total savings reduction of 25% over 15 years, appropriations-funded projects are no longer competitive with ESPC, no matter how low the total survey and study costs, or how quickly the funds are delivered. Remember, however, that the analysis assumes that annual savings degradation for appropriations-funded projects begins shortly after acceptance, whereas savings degradation for ESPC begins after the 17-year performance period because of the guaranteed savings contract structure and follow-up annual M&V audits.

Table 4.3. Ratio of present value of life-cycle cost (thousands, 2001 dollars) of typical energy conservation project funded with appropriations to present value life-cycle cost of same project carried out using ESPC, as a function of total survey and study cost and total process time. Annual reduction of guaranteed annual cost savings is 0.5%, or about 7% over 15 years. The shaded cells represent cases with life-cycle cost lower than the ESPC case.

Total process time	**Total survey and study cost (as percentage of design completion/construction cost)**											
(months)	**4%**	**6%**	**8%**	**10%**	**12%**	**14%**	**16%**	**18%**	**20%**	**22%**	**24%**	**26%**
28	0.9271	0.9401	0.9533	0.9663	0.9793	0.9925	1.0055	1.0185	1.0317	1.0447	1.0577	1.0709
30	0.9324	0.9456	0.9586	0.9716	0.9848	0.9978	1.0108	1.0240	1.0370	1.0500	1.0632	1.0762
32	0.9376	0.9506	0.9636	0.9766	0.9896	1.0028	1.0158	1.0288	1.0418	1.0548	1.0678	1.0808
34	0.9427	0.9557	0.9689	0.9819	0.9949	1.0079	1.0209	1.0339	1.0469	1.0601	1.0731	1.0861
36	0.9478	0.9610	0.9740	0.9870	1.0000	1.0130	1.0260	1.0390	1.0522	1.0652	1.0782	1.0912
38	0.9529	0.9659	0.9789	0.9921	1.0051	1.0181	1.0311	1.0441	1.0571	1.0703	1.0833	1.0963
40	0.9577	0.9707	0.9837	0.9967	1.0097	1.0227	1.0357	1.0487	1.0617	1.0747	1.0877	1.1007
42	0.9626	0.9756	0.9886	1.0016	1.0146	1.0276	1.0406	1.0536	1.0666	1.0796	1.0926	1.1056
44	0.9675	0.9805	0.9935	1.0065	1.0195	1.0325	1.0455	1.0585	1.0715	1.0845	1.0975	1.1105
46	0.9722	0.9852	0.9980	1.0110	1.0240	1.0370	1.0500	1.0628	1.0758	1.0888	1.1018	1.1148
48	0.9768	0.9898	1.0026	1.0156	1.0286	1.0416	1.0546	1.0674	1.0804	1.0934	1.1064	1.1194
50	0.9813	0.9943	1.0073	1.0203	1.0333	1.0461	1.0591	1.0721	1.0851	1.0981	1.1109	1.1239
52	0.9860	0.9990	1.0118	1.0248	1.0378	1.0508	1.0638	1.0766	1.0896	1.1026	1.1156	1.1284
54	0.9902	1.0032	1.0162	1.0290	1.0420	1.0548	1.0678	1.0808	1.0936	1.1066	1.1194	1.1324
56	0.9947	1.0077	1.0205	1.0335	1.0463	1.0593	1.0723	1.0851	1.0981	1.1109	1.1239	1.1369
58	0.9990	1.0120	1.0248	1.0378	1.0508	1.0636	1.0766	1.0894	1.1024	1.1154	1.1282	1.1412
60	1.0032	1.0160	1.0290	1.0418	1.0546	1.0676	1.0804	1.0934	1.1062	1.1192	1.1320	1.1448
62	1.0073	1.0203	1.0331	1.0461	1.0589	1.0717	1.0847	1.0975	1.1105	1.1233	1.1363	1.1491
64	1.0097	1.0227	1.0355	1.0483	1.0613	1.0741	1.0871	1.0999	1.1127	1.1257	1.1385	1.1515
66	1.0138	1.0266	1.0396	1.0524	1.0654	1.0782	1.0912	1.1040	1.1168	1.1298	1.1426	1.1556
68	1.0177	1.0305	1.0435	1.0563	1.0691	1.0819	1.0949	1.1077	1.1205	1.1332	1.1462	1.1590
70	1.0215	1.0345	1.0473	1.0601	1.0729	1.0859	1.0987	1.1115	1.1243	1.1373	1.1501	1.1629
72	1.0254	1.0384	1.0512	1.0640	1.0768	1.0898	1.1026	1.1154	1.1282	1.1412	1.1540	1.1668
74	1.0292	1.0420	1.0548	1.0676	1.0804	1.0932	1.1060	1.1188	1.1316	1.1444	1.1572	1.1700

Table 4.4. Ratio of present value of life-cycle cost (thousands, 2001 dollars) of typical energy conservation project funded with appropriations to present value life-cycle cost of same project carried out using ESPC, as a function of total survey and study cost and total process time. Annual reduction of guaranteed annual cost savings is 1%, or about 14% over 15 years. The shaded cells represent cases with life-cycle cost lower than the ESPC case.

Total process time (months)	Total survey and study cost (as percentage of design completion/construction cost)											
	4%	**6%**	**8%**	**10%**	**12%**	**14%**	**16%**	**18%**	**20%**	**22%**	**24%**	**26%**
28	0.9556	0.9686	0.9816	0.9948	1.0078	1.0208	1.0340	1.0470	1.0600	1.0732	1.0862	1.0992
30	0.9603	0.9733	0.9865	0.9995	1.0125	1.0257	1.0387	1.0517	1.0649	1.0779	1.0909	1.1041
32	0.9648	0.9780	0.9910	1.0040	1.0170	1.0300	1.0430	1.0562	1.0692	1.0822	1.0952	1.1082
34	0.9694	0.9824	0.9954	1.0086	1.0216	1.0346	1.0476	1.0606	1.0736	1.0868	1.0998	1.1128
36	0.9739	0.9871	1.0001	1.0131	1.0261	1.0391	1.0521	1.0653	1.0783	1.0913	1.1043	1.1173
38	0.9784	0.9916	1.0046	1.0176	1.0306	1.0436	1.0566	1.0698	1.0828	1.0958	1.1088	1.1218
40	0.9829	0.9958	1.0088	1.0218	1.0348	1.0478	1.0608	1.0738	1.0868	1.0996	1.1126	1.1256
42	0.9871	1.0001	1.0131	1.0261	1.0391	1.0521	1.0651	1.0781	1.0911	1.1041	1.1171	1.1301
44	0.9914	1.0044	1.0174	1.0304	1.0434	1.0564	1.0694	1.0824	1.0954	1.1084	1.1214	1.1344
46	0.9954	1.0084	1.0214	1.0344	1.0474	1.0602	1.0732	1.0862	1.0992	1.1122	1.1250	1.1380
48	0.9997	1.0127	1.0255	1.0385	1.0515	1.0645	1.0775	1.0903	1.1033	1.1163	1.1293	1.1423
50	1.0038	1.0168	1.0298	1.0426	1.0556	1.0686	1.0816	1.0944	1.1074	1.1204	1.1334	1.1464
52	1.0078	1.0206	1.0336	1.0466	1.0596	1.0726	1.0854	1.0984	1.1114	1.1244	1.1374	1.1502
54	1.0117	1.0245	1.0375	1.0505	1.0633	1.0763	1.0891	1.1021	1.1151	1.1279	1.1409	1.1537
56	1.0156	1.0286	1.0413	1.0543	1.0671	1.0801	1.0931	1.1059	1.1189	1.1317	1.1447	1.1577
58	1.0194	1.0322	1.0452	1.0582	1.0710	1.0840	1.0968	1.1098	1.1228	1.1356	1.1486	1.1614
60	1.0231	1.0359	1.0489	1.0617	1.0747	1.0875	1.1002	1.1132	1.1260	1.1390	1.1518	1.1648
62	1.0267	1.0397	1.0525	1.0653	1.0783	1.0911	1.1041	1.1169	1.1297	1.1427	1.1555	1.1685
64	1.0288	1.0415	1.0543	1.0673	1.0801	1.0931	1.1059	1.1189	1.1317	1.1445	1.1575	1.1703
66	1.0322	1.0452	1.0580	1.0708	1.0838	1.0966	1.1096	1.1224	1.1354	1.1482	1.1610	1.1740
68	1.0357	1.0485	1.0615	1.0743	1.0870	1.0998	1.1128	1.1256	1.1384	1.1512	1.1642	1.1770
70	1.0391	1.0519	1.0649	1.0777	1.0905	1.1033	1.1163	1.1291	1.1419	1.1547	1.1677	1.1805
72	1.0426	1.0554	1.0682	1.0812	1.0940	1.1067	1.1195	1.1325	1.1453	1.1581	1.1709	1.1839
74	1.0458	1.0586	1.0714	1.0842	1.0970	1.1098	1.1226	1.1354	1.1482	1.1610	1.1740	1.1868

Table 4.5. Ratio of present value of life-cycle cost (thousands, 2001 dollars) of typical energy conservation project funded with appropriations to present value life-cycle cost of same project carried out using ESPC, as a function of total survey and study cost and total process time. Annual reduction of guaranteed annual cost savings is 2%, or about 25% over 15 years. At this rate of annual reduction, there are no cases where life-cycle cost is lower than the ESPC case.

Total process time (months)	Total survey and study cost (as percentage of design completion/construction cost)											
	4%	6%	8%	10%	12%	14%	16%	18%	20%	22%	24%	26%
28	1.0077	1.0209	1.0339	1.0469	1.0601	1.0731	1.0863	1.0993	1.1123	1.1255	1.1384	1.1514
30	1.0115	1.0245	1.0375	1.0507	1.0637	1.0767	1.0899	1.1029	1.1159	1.1291	1.1421	1.1551
32	1.0150	1.0280	1.0410	1.0542	1.0672	1.0802	1.0932	1.1062	1.1192	1.1322	1.1454	1.1583
34	1.0186	1.0316	1.0446	1.0576	1.0706	1.0836	1.0968	1.1098	1.1228	1.1358	1.1488	1.1618
36	1.0221	1.0351	1.0481	1.0611	1.0743	1.0873	1.1003	1.1133	1.1263	1.1393	1.1525	1.1655
38	1.0255	1.0385	1.0515	1.0647	1.0777	1.0907	1.1037	1.1167	1.1297	1.1427	1.1559	1.1689
40	1.0288	1.0418	1.0548	1.0678	1.0808	1.0938	1.1068	1.1198	1.1328	1.1458	1.1588	1.1718
42	1.0322	1.0452	1.0582	1.0712	1.0842	1.0972	1.1102	1.1232	1.1362	1.1492	1.1622	1.1752
44	1.0355	1.0485	1.0615	1.0745	1.0875	1.1005	1.1135	1.1265	1.1395	1.1525	1.1655	1.1785
46	1.0387	1.0517	1.0647	1.0775	1.0905	1.1035	1.1165	1.1293	1.1423	1.1553	1.1683	1.1813
48	1.0420	1.0548	1.0678	1.0808	1.0938	1.1068	1.1196	1.1326	1.1456	1.1586	1.1715	1.1843
50	1.0450	1.0580	1.0710	1.0840	1.0968	1.1098	1.1228	1.1358	1.1486	1.1616	1.1746	1.1876
52	1.0481	1.0611	1.0741	1.0871	1.1001	1.1129	1.1259	1.1389	1.1519	1.1646	1.1776	1.1906
54	1.0511	1.0641	1.0769	1.0899	1.1027	1.1157	1.1287	1.1415	1.1545	1.1673	1.1803	1.1933
56	1.0542	1.0670	1.0800	1.0930	1.1058	1.1187	1.1315	1.1445	1.1575	1.1703	1.1833	1.1961
58	1.0570	1.0700	1.0828	1.0958	1.1088	1.1216	1.1346	1.1474	1.1604	1.1734	1.1862	1.1992
60	1.0599	1.0727	1.0856	1.0984	1.1114	1.1242	1.1372	1.1500	1.1628	1.1758	1.1886	1.2016
62	1.0627	1.0755	1.0885	1.1013	1.1143	1.1271	1.1401	1.1529	1.1657	1.1787	1.1915	1.2044
64	1.0637	1.0767	1.0895	1.1025	1.1153	1.1281	1.1411	1.1539	1.1669	1.1797	1.1927	1.2055
66	1.0666	1.0794	1.0923	1.1051	1.1179	1.1309	1.1437	1.1567	1.1695	1.1825	1.1953	1.2081
68	1.0692	1.0820	1.0948	1.1076	1.1206	1.1334	1.1462	1.1590	1.1720	1.1847	1.1975	1.2103
70	1.0718	1.0846	1.0974	1.1102	1.1232	1.1360	1.1488	1.1616	1.1746	1.1874	1.2002	1.2130
72	1.0743	1.0873	1.1001	1.1129	1.1257	1.1387	1.1514	1.1642	1.1770	1.1900	1.2028	1.2156
74	1.0767	1.0897	1.1025	1.1153	1.1281	1.1409	1.1537	1.1665	1.1793	1.1921	1.2049	1.2176

4.3 KEY ASSUMPTIONS USED IN CALCULATING LIFE-CYCLE COSTS

Those who use the parametric tables should be aware of the assumptions embedded in the comparisons. The tables enable agencies to compare only the LCCs of two alternatives methods of implementing the same typical project. The methods and tables do not accommodate comparison of, for example, two different projects having three- and ten-year paybacks, respectively.

Other key assumptions are discussed in the following sections.

4.3.1 ECM Pricing Parity

Given the data we gathered and our comparative analysis of ECM-level pricing (see Chapter 2), we believe it is reasonable to assume that for ECMs in general, the appropriations-funded design completion and construction cost and the implementation price of Super ESPCs are essentially equal for similarly sized ECMs having the same technical scope. Therefore, in the life-cycle cost analysis method we assume parity between the all-inclusive ECM prices in the ESPC and appropriations cases. (See Figure 2.1 and

Section 2.3.) Those who are uncomfortable with this assumption may want to perform an ECM-level price analysis on a sample of their own completed projects.

4.3.2 Survey and Study Costs

Survey and study costs are included in the Super ESPC implementation price, but are not included in the design completion and construction cost in appropriations-funded projects. These costs are also highly variable. The appropriations cases are parameterized with costs for surveys and studies varying from 4% to 26% of design completion and construction costs. In calculating life-cycle costs, survey and study costs accrue in the months when they occurred, on average, in the projects used to model the appropriations case. (See sections 3.3.3 and 3.5.2 and Table 3.3.)

4.3.3 ESPC Process Time

The ESPC model, to which the appropriations cases are compared, is based on all-agency averages, such as the 28-month timeline from kickoff meeting to government acceptance of an operating project. There is no inherent feature of the Super ESPC program that prevents any agency from achieving timelines equal to the average of all participating agencies, but even with their best efforts, some agencies may take longer than 28 months. To adjust the analysis, agencies can request the spreadsheet used by the authors and revise the ESPC case to match their agency-specific averages.

4.3.4 O&M, M&V, and Other Performance-Period Services

Included in the life-cycle costs of the Super ESPC case are the price of services provided by the ESCO during the term of the delivery order (the performance period)—M&V, O&M, and R&R. The price of these services are included in the site's payments to the ESCO, and as with the debt service portion of the payment, are covered by guaranteed cost savings.

While the ESPC case bears the average cost of M&V, O&M and R&R across the 71 Super ESPC projects, the appropriations-funded cases only bear the average cost of O&M and R&R. In essence we assume that the price the ESCO charges for O&M/R&R is the same as the cost the site would incur to maintain the same equipment under the appropriations scenarios. In Table 4.1, with zero savings degradation, the average ESPC case is still bearing the cost of M&V and the appropriations case is not.

4.3.5 Parameterizing the Appropriations Cases

To parameterize the appropriations case for the life-cycle cost study, we had to make some assumptions about when the intermediate steps in the appropriations process would take place if the whole schedule (the total process time) were compressed or lengthened from what was observed in the small sample of FY 1994 and 1995 projects from one agency site. For example, consider the receipt of design completion and construction funds. As shown in Table 3.3, based on the small sample that had a 63-month total process time, design completion and construction funds are received in month 34 on average, or 33 months from the beginning of the process. When we varied the total process time, we maintained a constant ratio between the delay to receipt of these funds and the total process time. In other words, for a total process time of 73 months, we assumed a delay to receipt of design completion and construction funds of 38 months (= $33 \times 73/63$, rounded to the nearest whole number), so the funds would be received in month 39. The only assumptions embedded in the parameterized appropriations case model that rely on averages from the small sample of projects are these time proportioning assumptions that allow us to allocate total process time between intermediate milestones where the costs occur.

4.3.6 Site Project Management and Construction Oversight Costs

In the ECM-level pricing analysis in Chapter 2, the site's project management and construction oversight costs were deducted from the Step 2 appropriations funding received for project implementation. Although these activities are required in both ESPC projects and appropriations-funded projects, their costs are not included in the average Super ESPC implementation price, which is our basis for comparison. Therefore, to conserve the validity of the comparison, these costs were deducted from the appropriations cases. (See Section 2.7 for more detailed discussion.)

4.4 USING THE PARAMETRIC LCC COMPARISON TABLES

This report describes a methodology for performing rigorous, "apples to apples" comparisons between the life-cycle costs of average ESPCs and appropriations-funded projects. The life-cycle cost of appropriations-funded projects—and therefore any comparisons of appropriations and average ESPC—are highly sensitive to total survey and study costs as a percentage of design completion and construction costs, total process time, and savings degradation. Agency and site personnel can gain insight on which approach has historically been best for them by using their own historical data on appropriations-funded projects to estimate the three parameters and referring to Tables 4.1, 4.3, 4.4, and 4.5. Then, assuming the past is a guide to the future, agencies and their sites can use these methods to inform their decisions going forward.

Before embarking on this exercise, agency personnel should consider whether the appropriations-funded EM program described in this report resembles their own. In general the authors believe the tables in this report do a good job of characterizing processes where sites first compete for survey and study funds, and then compete for design completion and construction funds. Guidance on estimating the three key parameters from historical records is provided below.

For agency-level EM programs, sources of data for estimating the agency-wide total survey and study cost as a percentage of design completion and construction cost are finance or budget records indicating amounts disbursed to sites for surveys and studies and design completion and construction. Agency sites should have the same kinds of finance or budget records to show amounts received from the agency for surveys and studies and design completion and construction. In both cases, using averages over several years is preferred. Given these two figures, the total survey and study cost as a percentage of design completion and construction cost is calculated by dividing the latter into the former and multiplying by 100.

The total process time averaged across all projects agency-wide or site-wide, i.e., the number of months elapsed from initial conception of a project until the project is finally operating and accepted, may prove more difficult for agencies to determine accurately, but the number can also be estimated. Some agency personnel may have already studied their EM programs and will have reports available. If such reports are not available, our study shows that reasonably accurate estimates of process time can be obtained from examining a small multi-year sample of project records. Another good source of information is site energy managers and engineers. These individuals have experience with the program and usually have a very good idea of the total process time required. For example, the individuals we interviewed at the agency site estimated process time to be about five years. Examination of a small multiyear sample of records led to an estimated average of 63 months, or 5 years and 3 months.

Of the three parameters required, the annual rate of savings reduction will of course be the most difficult to estimate. In general, determination of this rate would require a fairly extensive data collection effort. Here our recommendation is to speak with site energy managers and engineers. Many individuals would be willing to estimate the savings that remain from the typical conservation project after 15 years, given the level of maintenance performed at the site. Tables 4.3 through 4.5 provide the 15-year loss consequences, as well as annual rates of reduction.

4.5 EXAMPLE APPLICATIONS OF THE LCC COMPARISON METHODOLOGY

The following examples demonstrate the application of the LCC comparison methodology and illustrate the relationship of the key parameters to life-cycle cost. In all of these cases, we assume that savings from appropriations-funded projects persist without degradation, as they do in the ESPC case.

4.5.1 Comparing Past Appropriations-Funded Projects to an Average ESPC

One application of LCC methodology and Table 4.1 is to compare past appropriations-funded projects to an average ESPC. For example, if a site's estimated survey and study costs for past projects were 10% of design completion and construction costs, and it generally took 50 months to get the site's projects up and running, we would see from the table that the site's past projects had about the same life-cycle cost as the average ESPC.

4.5.2 Considering Whether to Finance or Wait for Appropriations

Federal energy managers must often consider the relative merits of waiting for appropriations or using an ESPC. Using estimates of a facility's survey and study costs, total process time, and persistence of savings, energy managers can refer to the parametric tables and see how the life-cycle costs of the alternatives compare. Using their own experience and judgment concerning their prospects for appropriations, they can decide whether financing or waiting or some combination of both is the best business decision.

The tables could also be very useful to agencies who must decide how best to proceed when they face the need to implement a large inventory of projects to meet their goals and lack sufficient appropriations to directly fund them all. Suppose that every year an agency receives appropriations from Congress amounting to just 20% of the funds required to implement all of its required energy efficiency improvements. Is it better to implement the projects piecemeal—funding 20% of the total every year, and waiting five years to make all the improvements—or to fund them all up front with ESPC? If the projects are like the ones typically funded through ESPC, the parametric tables can be used to find the answer.

For example, assuming appropriations-funded projects can be carried out on the same 28-month schedule as ESPC, and that survey and study funds amount to 12%, Table 4.1 shows that the life-cycle cost of the typical energy efficiency project funded by appropriations is about 94.91% of the life-cycle cost of the same project carried out with an ESPC. Now assume an agency has five such projects to implement, but only enough appropriations to fund one of them per year. The ratio for the second year's project would be about 0.9832 (Table 4.1 with 28 + 12 = 40 month process time and 12% survey and study costs). Likewise, the ratio for the third year's project would be 1.0147 (Table 4.1 with 28 + 12 + 12 = 52 month process time and 12% survey and study costs). Altogether, the life-cycle cost ratio for funding all five projects with appropriations is 0.9491 + 0.9832 + 1.0147 + 1.0415 + 1.0675 = 5.065. Since we have added the individual ratios, if the cost of implementing the projects with appropriations were equal to the cost of implementing them with ESPC, the sum would be exactly 5. However, in this case the sum is greater than 5, so the life-cycle cost of funding the projects over five years with appropriations is greater than the life-cycle cost of funding them all up front with ESPC.

4.5.3 Appropriations Case Based on Small Sample of Project Data

Now we consider the same small sample of projects funded in FY 1994–95 from one agency site that is described in Chapter 3. It took the site 63 months on average to get projects in the ground. Records from the studied site showed that $1,251,000 was received from the agency to perform surveys and feasibility studies for 39 ECMs having a total estimated implementation cost of $27,472,000. Ultimately only 12 of the 39 were funded, and a total of $4,996,400 in implementation funding was received. Based on these data, the cost of all surveys and studies for this program was about 25% of the cost of the funded ECMs. Given the 63-month total process time and the 25% total survey and study costs, the LCC comparison tables indicate that implementing this small sample of projects with an average ESPC would have resulted in lower life-cycle costs for these projects.

However, FY 1994–95 was the heyday for this agency's direct-funding program, which had seen stable to rising appropriations throughout the previous decade, but in FY 1996 appropriations dropped to zero and stayed there for a number of years. The fact that total survey and study costs (as a percentage of design completion and construction costs) spiked to 25% is an artifact of the funding history, and is mostly interesting only as an example of what can happen when agency appropriations become unreliable and already defined projects are never funded for implementation.

4.5.4 Appropriations Case Where All Projects are Funded

This case uses the same 63-month total process time as the previous example, but considers only the direct survey and study costs for the 12 funded ECMs in the study site sample (4% of total ECM funding). This case represents what might have been achievable at the site if every project defined with survey and study money had been funded with appropriations and total process time remained the same. Since all projects get funded in this scenario, total survey and study costs equal direct survey and study costs. Even in this more optimistic case, the tables indicate that the life-cycle cost of appropriated projects is comparable to the life-cycle cost under an average ESPC. Given current Congressional funding priorities, agencies may fare better by investing in an ESPC now rather than betting on the likelihood of future appropriations, particularly for those projects that are economically viable through alternative financing.

4.5.5 Hypothetical Appropriations Best Case

The appropriations best-case scenario is defined as having total process time equal to that of the average Super ESPC case (28 months) and total survey and study costs of 4% of total ECM funding. In this scenario, the tables indicate that direct funding would have a lower life-cycle cost than using the average ESPC by a significant margin. Clearly, if appropriations are in hand, using them to directly fund projects will result in the lowest life-cycle cost if operating projects are achieved on a short schedule and savings persist.

4.5.6 Appropriations Case Based on Large Sample of Project Data

Although the work predates our analysis, we found a 1993 report (not referenced to preserve anonymity) that is an example of an agency examining its own historical records in an independent and unbiased fashion and estimating total survey and study costs and total process time. The authors of the report examined $122 million in projects at six different sites of one agency and found average values of 73 months for total process time and 14% for total survey and study costs. The sample included three-fourths of the agency's appropriations-funded projects for the FY 1985–1993 period. For these projects, LCC comparison Table 4.1 indicates that implementing this large representative sample of projects through an average ESPC would have resulted in a lower life-cycle cost.

As this example illustrates, agencies can use the LCC comparison tables to compare the cost of using an average ESPC to the cost of using appropriations, given their agency's own historical ability to streamline their appropriations process and reduce analysis costs.

5. CONCLUSIONS

The objective of this study was to develop and demonstrate methods to help federal energy managers take some of the guesswork out of obtaining best value from spending on building retrofit energy improvements. We developed a method for comparing all-inclusive prices of ECMs implemented using appropriated funds and through ESPCs that illustrates how agencies can use their own appropriations-funded project experience to ensure fair ESPC pricing. The second method documented in this report is for comparing life-cycle costs. This method illustrates how agencies can use their experience, and their judgment concerning their prospects for appropriations, to decide between financing and waiting.

The motivation for this study was the lack of quantitative answers to certain questions about the comparative costs of ESPCs and appropriations-funded energy projects: Is it better to wait for appropriations or implement a financed ESPC project? Where is the break-even point? Are the prices negotiated in ESPCs as favorable as those obtained through competitive sourcing? How is life-cycle cost affected if energy and cost savings degrade over time?

5.1 COMPARISON OF ALL-INCLUSIVE PRICES FOR ECMS

The first methodology compares all-inclusive prices for ECMs that have the same technical scopes and were funded through Super ESPCs or appropriations. The methodology employs detailed analysis of financial and technical records to verify the technical scope of ECMs and deducts all costs not related to the bare ECMs.

The scope of the study was limited, with research concentrated on three ECMs that represent about half of Super ESPC investment and are common in appropriations-funded projects: chiller replacements, lighting retrofits, and variable-frequency drives. The analysis considered approximately $13 million worth of ECMs implemented through Super ESPCs and another $13 million worth of ECMs funded through appropriations. All of the appropriations-funded ECMs examined by the study were implemented at two adjacent sites by one agency.

Using regression analysis techniques, the study team found no statistically significant differences between the all-in prices for ECMs implemented through Super ESPCs and comparable ECMs funded through appropriations. The analysis showed that the pricing obtained through Super ESPCs, which use a design/build approach negotiated for best value, was as good as the pricing obtained for the appropriations-funded projects in the traditional bid-to-spec competitive procurements.

The study team hopes to repeat this analysis using project data from other agencies to test the generality of this result. But, regardless of the current study's limited scope, for agency teams evaluating pricing on their ESPCs, the key message is to focus due diligence on all-in prices rather than intermediate accounting conventions such as the mark-up. If the all-in price is about the same as when using appropriations, then the mark-up doesn't matter.

5.2 COMPARING PROCESSES ON A LIFE-CYCLE-COST BASIS

The second methodology compares the life-cycle costs of using ESPCs and appropriations to implement a "typical project," defined as the average project implemented under the DOE Super ESPC program. We carefully studied the activities and costs of the two processes and used federally specified techniques for analyzing life-cycle costs to ensure that the method would yield valid and meaningful results.

The "average" ESPC model was derived from program records and the financial schedules of the first 71 DOE Super ESPC delivery orders (worth $230 million), all awarded by the end of FY 2001. The "average" appropriations model is based on the two-step process used by several large agencies for distributing direct project funding to sites. First the site requests funds for an energy survey and feasibility study for a proposed project. If step-one funding is received, the site completes the survey and study, and submits a request for implementation funding supported by the study report and a detailed cost estimate (based on 30% completed design). The requested step-two funding, if received, is used to complete the design and construct the project.

The results of this analysis are expressed parametrically in a life-cycle cost (LCC) comparison table (Table 4.1). The key parameters defining the life-cycle cost when using appropriations are (1) total process time (the time elapsed before the ECMs are operating and saving energy), and (2) costs for surveys and studies that are required in the process of requesting funding (as a percentage of design completion and construction costs). The table allows an agency to compare the life-cycle cost of an average ESPC project with the life-cycle cost of a project funded by appropriations, given the agency's assumptions or determination of the two key parameters.

Separate tables (Tables 4.3, 4.4, and 4.5) allow agencies to apply their own assumptions regarding potential degradation of savings over time with appropriations-funded projects, since cost savings are not typically guaranteed in these cases. If an agency assumes that some savings will be lost over time with appropriations-funded projects, Super ESPC projects will offer lower life-cycle costs in an even greater number of cases than Table 4.1 below suggests, holding other assumptions about process time and survey costs constant.

5.3 USEFULNESS OF THE STUDY

The results of the life-cycle cost analysis are expressed parametrically in life-cycle cost comparison tables in Chapter 4. There are several caveats associated with the use of the tables, but in general, agencies can refer to the table entries matching their historical or forward-looking estimates of the key parameters defining the appropriations case to obtain a customized LCC comparison between implementing the typical project (or a fleet of typical projects) with appropriations and the average ESPC. The key parameters defining the life-cycle cost when using appropriations are total process time (the time elapsed before the ECMs are operating and saving energy), costs for surveys and studies required in the process of requesting funding (as a percentage of design completion and construction costs), and degradation of savings over time (expressed as a percentage per year).

Those who use the parametric tables should be aware of the assumptions embedded in the comparisons. All the parameterized appropriations cases are modeled on the two-step appropriations funding process described above and common to several large agencies. It is certainly possible that agencies could conceive of and implement more efficient processes to allocate scarce appropriated funds. The ESPC model, to which the appropriations cases are compared, is based on all-agency averages, such as the 28-month timeline from kickoff meeting to government acceptance of an operating project. There is no inherent feature of the Super ESPC program that prevents any agency from achieving timelines equal to the average of all participating agencies, but even with their best efforts, some agencies may take longer than 28 months. To adjust the analysis, agencies can request the spreadsheet used by the authors and revise the ESPC case to match their agency-specific averages.

The comparison tables also assume parity between the ESPC and appropriations all-inclusive pricing. Those who are uncomfortable with this assumption may want to perform an ECM-level price analysis on a sample of their own completed projects.

5.4 APPLICATIONS

The initial applications of the cost-analysis methods demonstrated in this report and the parameterized results only reinforce the traditional knowledge in federal energy management: If appropriations are in hand, using them to directly fund energy projects results in the lowest life-cycle cost, assuming that operating projects are achieved on a short schedule and that their savings persist. However, in recent years appropriations have been insufficient to directly fund all life-cycle cost-effective retrofit projects, and it appears unlikely that Congress will place a higher priority on funding such projects in the near future than it has in the recent past. Lacking sufficient appropriations, the next best thing in terms of life-cycle cost is to finance projects rather than wait for appropriations.

When they do use ESPCs, federal energy managers need assurance that the pricing negotiated in those contracts is comparable to the pricing they can obtain through the competitive bid-to-spec procurement process with appropriated funding. Our method for comparing all-inclusive prices of ECMs implemented using appropriated funds and through ESPCs shows how agencies can use their own appropriations-funded project experience to ensure fair ESPC pricing. For most ECMs agencies can derive all-inclusive price benchmarks from their own past appropriations-funded projects and compare those benchmarks to the prices offered by ESCOs in their initial and final proposals. Using this method, agency teams who are negotiating ESPCs can learn to focus their pricing due-diligence on all-inclusive ECM prices rather than intermediate accounting conventions such as mark-ups, which are included in the all-inclusive prices.

The life-cycle cost-comparison methods described in this report can be used by federal energy managers to consider the relative merits of waiting for appropriations or using an ESPC. Using estimates of a facility's historical averages for the key parameters, energy managers can refer to the parametric tables and see how the life-cycle costs of the alternatives compare. Using their own experience and judgment concerning their prospects for appropriations, they can decide whether financing or waiting or some combination of both is the best business decision.

To make the most progress toward all their goals, it is important for agencies to use their limited in-hand appropriations and other tools—such as alternative financing vehicles—wisely. Rather than using scarce appropriations to fund projects that can easily pay for themselves, they should be used to make progress toward renewables goals or to directly fund marginally economic infrastructure projects. The cost-comparison methods described in this report offer federal decision makers the tools to learn from their past projects and move forward with confidence that they are making optimum progress and obtaining best value for the government.

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Appendix: DEFINITION OF PARAMETERS USED IN LIFE-CYCLE COST ANALYSIS OF AVERAGE SUPER ESPC PROJECT

1. **Average time to delivery order award.** Simple average of the delay in months between the kickoff meeting and delivery order award. Average time to delivery order award is defined as the sum of the kickoff–delivery order award delays for all projects, divided by the total number of projects (71).

2. **Average design/construction period.** Simple average of the time in months required for design completion and construction, once a delivery order is signed. Average design/construction period is defined as the sum of the design/construction periods for all projects, divided by the total number of projects.

3. **Average implementation price.** Simple average of the implementation prices of all projects. Average total implementation price is defined as the sum of the implementation prices for each project, divided by 71. Note that implementation price includes all direct project implementation expenses (surveys, feasibility studies, design, construction, commissioning) plus mark-up to recover indirect costs (overheads, sales effort, surveys/studies for projects never awarded, etc.) and profit.

4. **Average financed amount.** Simple average of the total financed amount of all projects. Average total financed amount is defined as the sum of the total financed amounts for each project, divided by the total number of projects.

5. **Average pre-performance-period payment.** Simple average of the pre-performance-period payments from all projects. Average pre-performance-period payment is defined as the sum of such payments for all projects (some of which may be zero), divided by the total number of projects.

6. **Average financing procurement price.** Simple average of the financing procurement prices of all projects. Average financing procurement price is defined as the sum of the financing procurement prices for each project divided by the total number of projects.

7. **Average project total annual interest rate.** Average (weighted by financed amount) of the total annual interest rates of all projects. Let F_i and r_i be the total financed amount and project total annual interest rate, respectively, for the i^{th} project. The average project total annual interest rate is:

$$\bar{r}_p = \frac{\sum_{i=1}^{71} F_i r_i}{\sum_{i=1}^{71} F_i}$$

8. **Average delivery order term.** Average (weighted by financed amount) of the delivery order terms of all projects. Let F_i and t_i be the total financed amount and delivery order term (preferably in months, but years are acceptable) for the i^{th} project. The average delivery order term is:

$$\bar{t} = \frac{\sum_{i=1}^{71} F_i t_i}{\sum_{i=1}^{71} F_i}$$

9. **Average first-year guaranteed cost savings.** Let *n* be the number of projects with delivery order terms greater than 5 years, and let $s_{i,5}$ be the guaranteed annual cost savings in year 5 for project i. Then the average annual cost savings for these *n* projects in year 5 is:

$$\bar{s}_5 = \frac{1}{n}\sum_{i=1}^{n} s_{i,5}$$

We calculate the average first-year guaranteed cost savings $\bar{s}_1$ by discounting $\bar{s}_5$ to year 1 as follows:

$$\bar{s}_1 = \frac{\bar{s}_5}{(1+\bar{r}_s)^5}$$

where $\bar{r}_s$ is the average escalation rate for guaranteed annual cost savings, defined in Paragraph 10.

10. **Average escalation rate for guaranteed annual cost savings.** Let *n* be the number of projects with delivery order terms greater than or equal to 10 years. Then considering only these *n* projects, let $s_{i,5}$ be the guaranteed annual cost savings in year 5 for project i and $s_{i,10}$ be the guaranteed annual cost savings in year 10 for project i. The average escalation rate for guaranteed annual cost savings is:

$$\bar{r}_s = \left(\frac{\sum_{i=1}^{n} s_{i,10}}{\sum_{i=1}^{n} s_{i,5}} \right)^{\frac{1}{5}} - 1$$

11. **Average first-year M&V price.** Let *n* be the number of projects with delivery order terms greater than 5 years, and let $m_{i,5}$ be the M&V price in year 5 for project i. Then the average M&V price for these *n* projects in year 5 is:

$$\bar{m}_5 = \frac{1}{n}\sum_{i=1}^{n} m_{i,5}$$

We calculate the average first-year guaranteed cost savings $\bar{m}_1$ by discounting $\bar{m}_5$ to year 1 as follows:

$$\bar{m}_1 = \frac{\bar{m}_5}{(1+\bar{r}_m)^5}$$

where $\bar{r}_m$ is the average escalation rate for annual M&V price, as defined in Paragraph 12.

12. **Average escalation rate for annual M&V price.** Let *n* be the number of projects with delivery order terms greater than or equal to 10. Then considering only these *n* projects, let $m_{i,5}$ be the annual M&V price in year 5 for project i and $m_{i,10}$ be the annual M&V price in year 10 for project i. The average escalation rate for annual M&V price is:

$$\bar{r}_m = \left(\frac{\sum_{i=1}^{n} m_{i,10}}{\sum_{i=1}^{n} m_{i,5}} \right)^{\frac{1}{5}} - 1$$

13. **Average first-year performance-period-services price, excluding M&V.** Let *n* be the number of projects with delivery order terms greater than 5 years, and let $p_{i,5}$ be the performance-period-services price excluding M&V in year 5 for project *i*. Then the average performance-period-services price excluding M&V for these *n* projects in year 5 is:

$$\bar{p}_5 = \frac{1}{n} \sum_{i=1}^{n} p_{i,5}$$

We calculate the average first-year guaranteed cost savings $\bar{p}_1$ by discounting $\bar{p}_5$ to year 1 as follows:

$$\bar{p}_1 = \frac{\bar{p}_5}{\left(1 + \bar{r}_p\right)^5}$$

where $\bar{r}_p$ is the average escalation rate for performance-period-services price excluding M&V, as defined in Paragraph 14.

14. **Average escalation rate for annual performance-period-services price, excluding M&V.** Let *n* be the number of projects with delivery order terms greater than or equal to 10 years. Then considering only these *n* projects, let $p_{i,5}$ be the annual M&V price in year 5 for project i and $p_{i,10}$ be the annual M&V price in year 10 for project i. The average escalation rate for annual performance-period expenses, excluding M&V is:

$$\bar{r}_p = \left(\frac{\sum_{i=1}^{n} p_{i,10}}{\sum_{i=1}^{n} p_{i,5}} \right)^{\frac{1}{5}} - 1$$

15. **Average percentage of guaranteed savings paid to contractor.** This is the sum of all contractor payments, divided by the sum of all guaranteed savings, for all 71 projects.

16. **Average escalation rate for annual contractor payment.** Let *n* be the number of projects with delivery order terms greater than or equal to 10 years. Then considering only these *n* projects, let $c_{i,5}$ be the annual contractor payment in year 5 for project i and $c_{i,10}$ be the annual contractor payment in year 10 for project i. The average escalation rate for guaranteed annual cost savings is:

$$\bar{r}_c = \left(\frac{\sum_{i=1}^{n} c_{i,10}}{\sum_{i=1}^{n} c_{i,5}} \right)^{\frac{1}{5}} - 1$$