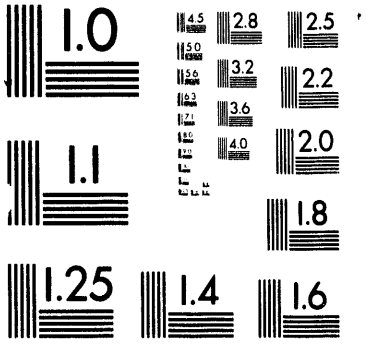
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Estimate of Federal Relighting Potential and Demand for Efficient Lighting Products

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MASTER

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Preface

One of the goals of the U.S. Department of Energy (DOE) Federal Energy Management Program (FEMP) is to facilitate energy-efficiency improvements at federal facilities. This accomplished by a balanced program of technology development, facility assessment, and use of cost-sharing procurement mechanisms. Technology development focuses upon the tools, software, and procedures used to identify and evaluate energy-efficiency technologies and improvements. For facility assessment, FEMP provides metering equipment and trained analysts to federal agencies exhibiting a commitment to improve energy use efficiency. To assist in procurement of energy-efficiency measures, FEMP helps federal agencies devise and implement contr acting and utility demand-side management strategies.

Pacific Northwest Laboratory (PNL)[a] supports the FEMP mission of energy systems modernization. Under this charter, the Laboratory and its contractors work with federal facility energy managers to assess and implement energy-efficiency improvements at federal facilities nationwide.

(a) Pacific Northwest Laboratory is operated for the U.S. Department of Energy by Battelle Memorial Institute under Contract DE-AC06-76RLO 1830.

Executive Summary

The increasing level of electric utility rebates for energy-efficient lighting retrofits has recently prompted concern over the adequacy of the market supply of energy-efficient lighting products (*Energy User News* 1991). In support of the U.S. Department of Energy's Federal Energy Management Program, Pacific Northwest Laboratory (PNL) has developed an estimate of the total potential for energy-efficient lighting retrofits in federally owned buildings. This estimate can be used to address the issue of the impact of federal relighting projects on the supply of energy-efficient lighting products. The estimate was developed in 1992, using 1991 data. Any investments in energy-efficient lighting products that occurred in 1992 will reduce the potential estimated here.

The potential for energy savings from relighting federally owned buildings with energy-efficient lighting products is tremendous. We estimate that the total potential cost-effective energy savings could amount to over 52% of the current annual lighting electricity consumption. Fluorescent lighting fixtures could be cost-effectively retrofitted to reduce their annual electricity use by 47%, electricity used by incandescent fixtures could be reduced by 55%, and the electricity used by exit signs could be reduced by over 90% through the installation of a light-emitting diode (LED) and self-luminescent (tritium gas) signs. All of these retrofits would be cost-effective because their life-cycle cost would be less than that of the existing fixtures.

This analysis proceeds by estimating the existing stock of lighting fixtures in federally owned buildings. The lighting technology screening matrix is then used to determine the minimum life-cycle cost retrofit for each type of existing lighting fixture. Estimates of the existing stock are developed for 1) four types of fluorescent lighting fixtures (2-, 3-, and 4-lamp, F40 4-foot fixtures, and 2-lamp, F96 8-foot fixtures, all with standard magnetic ballasts); 2) one type of incandescent fixture (a 75-watt single bulb fixture); and 3) one type of exit sign (containing two 20-watt incandescent bulbs). Table S.1 presents the estimates of the existing stock of lighting fixtures in federally owned buildings, and Table S.2 presents the estimates of the total potential demand for energy-efficient lighting products if all cost-effective retrofits were undertaken immediately. Table S.3 shows the total potential annual energy savings (in MWh and dollars), the total investment required to obtain the energy savings and the present value of the efficiency investment.

Some categories of potential energy-saving lighting products were not considered in this analysis. These include high-intensity discharge lighting fixtures, high- and low-pressure sodium fixtures, daylighting, dimming controls, and motion detectors. Retrofits for exterior lighting were also not considered in this analysis.

Table S.1. Existing Stock of Lighting Fixtures

Type of Fixture	Number of Fixtures (thousands)
Fluorescent Fixtures	**17,681**
8-foot, 2-lamp F96	5,304
4-foot, 2-lamp F40	4,491
4-foot, 3-lamp F40	3,550
4-foot, 4-lamp F40	4,336
Incandescent Fixtures	**42,338**
Exit Signs	**1,035**

Table S.2. Total Potential Product Demand

Product	Units (thousands)
8-Foot Fluorescent Products	
2-lamp reflectors	5,125
2-lamp electronic ballasts	5,304
8-foot, 60-watt lamps	10,250
4-Foot Fluorescent Products	
2-lamp reflectors	3,550
3-lamp reflectors	4,325
1-lamp T-8 electronic ballasts	4,294
2-lamp T-8 electronic ballasts	12,358
1-lamp T-8 efficient magnetic ballasts	31
2-lamp T-8 efficient magnetic ballasts	31
4-foot F32 T-8 lamps	29,102
Compact Fluorescent Products	
Compact fluorescent lamps	21,264
Exit Sign Products	
LED exit signs	649
Self-luminous exit signs	386

Table S.3. Total Potential Annual Energy Savings, Investment, and Net Present Value

Potential annual energy savings (MWh)	9,490,272
Value of annual energy savings (1991 $)	$641,486,000
Total required investment (1991 $)	$1,819,264,000
Net present value (1991 $)	$8,099,608,000

The analysis assumes that there would nct be sufficient federal funding to undertake all cost-effective relighting projects immediately. Instead, a portion of the cost-effective relighting activities is assumed to occur each year, beginning in 1992, in accordance with an estimated level of federal funding for relighting. The funding estimates were derived from conversations with all defense agencies (DoD) and General Services Administration (GSA) personnel, as well as with individuals familiar with the federal efficiency fund. These estimated levels should be treated as hypothetical, as they represent one possible scenario. Table S.4 gives the estimated annual funding levels and sources.

It is further assumed that the level of utility cost-sharing (a critical variable in the determination of the optimal retrofit technology) will increase over the next several years. Two scenarios were developed to represent the increasing level of utility cost-sharing: 1) the base case scenario, and 2) the Federal Relighting Initiative (FRI) scenario. The base case scenario assumes that the level of utility cost-sharing that federal facilities are able to obtain remains at roughly the current level through 1994 and increases to a maximum level in 1995. The FRI scenario assumes that the shift to the maximum level of cost-sharing occurs in 1993, and it further assumes that the maximum level is higher than the maximum level assumed in the base case scenario. Utility cost-sharing assumptions are discussed further in Section 3.1. Table S.5 shows the annual energy-efficient product demand by year for each of the scenarios. Finally, Table S.6 shows the total energy savings (in MWh and dollars), the total investment required, and the net present value of the investment (by year) for each scenario. The total net present value of the relighting project through 1996 is more than $300 million greater under the FRI scenario than under the base case scenario.

Table S.4. Federal Relighting Funding (millions of 1991 dollars)

Year	DoD Operations and Maintenance	Federal Efficiency Fund	GSA	Total
1992	15	45	15	75
1993	30	80	30	140
1994	45	100	30	175
1995	60	100	30	190
1996 on	60	100	30	190

Table S.5. Estimated Annual Product Demand (thousands of units)

	1992	1993	1994	1995	1996
Base Case Scenario					
8-Foot Fluorescent Products					
2-lamp reflectors	336	579	537	775	494
Electronic ballasts	336	579	537	777	506
8-foot, 60-watt lamps	673	1,158	1,075	1,551	989
4-Foot Fluorescent Products					
2-lamp reflectors	225	387	360	520	339
3-lamp reflectors	275	473	439	635	413
1-lamp T-8 electronic ballasts	275	473	439	635	413
2-lamp T-8 electronic ballasts	785	1,351	1,254	1,742	1,181
4-foot T-8 lamps	1,845	3,175	2,947	4,118	2,775
Compact Fluorescent Products					
Compact fluorescent lamps	1,242	2,159	2,215	2,660	2,084
Exit Sign Products					
LED exit signs	0	0	27	48	60
Self-luminous exit signs	63	109	77	95	39
FRI Scenario					
8-Foot Fluorescent Products					
2-lamp reflectors	336	659	682	659	491
Electronic ballasts	336	659	682	659	502
8-foot, 60-watt lamps	673	1,318	1,364	1,313	982
4-Foot Fluorescent Products					
2-lamp reflectors	225	441	456	441	336
3-lamp reflectors	275	539	557	539	410
1-lamp T-8 electronic ballasts	275	539	557	539	410
2-lamp T-8 electronic ballasts	785	1,538	1,521	1,539	1,171

Table S.5. (contd)

	1992	1993	1994	1995	1996
Base Case Scenario					
4-foot T-8 lamps	1,845	3,615	3,599	3,616	2,751
Compact Fluorescent Products					
Compact fluorescent lamps	1,242	2,404	2,867	2,298	2,085
Exit Sign Products					
LED exit signs	0	0	11	52	60
Self-luminous exit signs	63	123	121	70	39

Table S.6. Total Potential Annual Energy Savings, Investment, and Net Present Value (by year and scenario)

	1992	1993	1994	1995	1996
Base Case Scenario					
Annual energy savings (MWh)	583,980	1,011,153	978,848	1,280,914	914,008
Annual energy savings (thousand 1991 $)	58,271	86,318	81,867	86,474	61,446
Required investment (thousand 1991 $)	75,000	140,000	175,000	190,000	190,000
Net present value (thousand 1991 $)	826,042	1,196,526	1,087,587	1,158,100	759,817
FRI Scenario					
Annual energy savings (MWh)	583,980	1,138,382	1,240,893	1,102,260	916,545
Annual energy savings (thousand 1991 $)	58,271	94,021	94,531	84,087	62,307
Required investment (thousand 1991$)	75,000	140,000	175,000	190,000	190,000
Net present value (thousand 1991 $)	826,042	1,317,869	1,282,074	1,118,091	771,945

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1.0 Introduction

The increasing level of electric utility rebates for energy-efficient lighting retrofits has recently prompted concern over the adequacy of the market supply of energy-efficient lighting products (*Energy User News* 1991). In support of the U.S. Department of Energy's Federal Energy Management Program (FEMP), Pacific Northwest Laboratory (PNL) developed an estimate of the total potential for energy-efficient lighting retrofits in federally owned buildings. This estimate can be used to address the issue of the impact of federal relighting projects on the supply of energy-efficient lighting products. The estimate was developed in 1992 using 1991 data. Any investments in energy-efficient lighting products that occurred in 1992 will reduce the potential for energy-efficient lighting retrofits that are estimated here.

PNL estimates that the total potential cost-effective energy savings from relighting federally owned buildings with energy-efficient lighting products could amount to over 52% of the current annual lighting electricity consumption. Fluorescent and incandescent fixtures could be retrofitted to reduce their annual electricity use by 47% and 55%, respectively, and the electricity used by exit signs could be reduced by over 90% with the installation of light-emitting diode (LED) and self-luminescent (tritium gas) signs.

The analysis proceeds by estimating the existing stock of lighting fixtures in federally owned buildings. The Lighting Technology Screening Matrix (LTSM 1993) is then used to determine the minimum life-cycle cost retrofit for each type of existing lighting fixture. Estimates of the existing stock were developed for the following: 1) four types of fluorescent lighting fixtures (2-, 3-, and 4-lamp F40, 8-foot fixtures, as well as 2-lamp F96, 8-foot fixtures, all with standard magnetic ballasts), 2) one type of incandescent fixture (a 75-watt, single-bulb fixture), and 3) one type of exit sign (containing two 20-watt incandescent light bulbs).

Two scenarios were developed to represent the impact of the Federal Relighting Initiative (FRI) on increasing level of utility cost-sharing that federal installations receive: 1) the base case scenario and 2) the FRI scenario. The base case scenario assumes that the level of utility cost-sharing that federal facilities are able to obtain remains at roughly the current level through 1994 and increases to a maximum level in 1995. The FRI scenario assumes that the shift to the maximum level of cost-sharing occurs in 1993, and it assumes that the maximum level is higher than the maximum level assumed in the base case scenario. The total net present value of the relighting project through 1996 is more than $300 million greater under the FRI scenario than under the base case scenario.

Some categories of potential energy-saving lighting products were not considered in this analysis. These include high-intensity discharge lighting fixtures, high- and

low-pressure sodium fixtures, daylighting, dimming controls, and motion detectors. Also, retrofits for exterior lighting were not considered.

Following the Introduction, the existing stock of fixtures is discussed in Section 2.0. Section 3.0 contains a discussion on optimal retrofit selection, Section 4.0 discusses cost-effective relighting potential, and Section 5.0 contains product demand forecasts. Conclusions are given in Section 6.0, followed by references in Section 7.0. Supporting documentation is found in the appendixes: Appendix A - Building Stock, Appendix B - Existing Stock of Fixtures, Appendix C - Optimal Retrofits, and Appendix D - Product Demand.

2.0 Existing Stock of Fixtures

Estimation of the existing stock of fixtures is proceeded by estimating the existing square footage of federally owned buildings and applying an estimate of the fixture density (the number of fixtures per square foot of building space). Section 2.1 describes the process of estimating the existing building stock, and Section 2.2 describes the development of fixture density estimates. Estimates of the existing stock of fixtures were developed for 4-foot and 8-foot fluorescent fixtures, incandescent fixtures, and exit signs. The estimates were separated by state to allow state-level variations in electricity prices and in the level of utility cost-sharing. The estimates were further separated by building type to allow variation in the annual hours of operation of lighting fixtures. Finally, the estimates were separated by government agency group to allow for variations in the level of annual funding for relighting projects. Three government agency groups were used: all defense agencies (DoD), General Services Administration (GSA), and other federal agencies (OFA).

2.1 Estimation of Building Stock

The GSA report, *Summary Report of Real Property Owned by the United States (GSA 1989)*, was used to estimate the square footage of federally owned building space in the United States by state, agency group, and building type. Estimation of the building stock by state, agency group, and building type required the calculation of the percentage of the total building area of each building type that is DoD, GSA, and OFA, respectively. These ratios are given in Table A.1 in Appendix A. The ratios were then applied to the square footage of building space of each building type in each state to estimate the square footage of building space by state, agency, and building type. These final estimates of the building stock are contained in Table A.2 in Appendix A.

2.2 Fixture Density Estimates

End-use load and conservation assessment program (ELCAP) data were used to derive fluorescent and incandescent fixture density estimates. The ELCAP data provide estimates of the watts per square foot of building space, by building type, that are consumed by fluorescent lighting and by incandescent lighting. The incandescent lighting was assumed to consist entirely of 75-watt fixtures, making a straightforward translation to fixtures per square foot. The fluorescent watts per square foot were assumed to consist of 2-, 3-, and 4-lamp, 4-foot F40 fixtures and 2-lamp, 8-foot F96 fixtures. It was first assumed that each fixture was 4-foot and that the proportions for the lamp fixtures were 36.28% of 2-lamp fixtures, 28.68% of 3-lamp fixtures, and 35.04% of 4-lamp fixtures. This allowed the calculation of fixture density estimates, assuming that only 4-foot fixtures existed.

The fixture density estimates were then adjusted to reflect the fact that 30% of all fluorescent fixtures are assumed to be 8-foot fixtures, as noted above. Note that these fixture density estimates are derived from the measured watts per square foot. While there may be uncertainty in the distribution of the existing fixtures among fixture types, the estimates are constructed so the total watts per square foot remain in line with the ELCAP measurements. After the ELCAP measurements were translated into fixtures per square foot, the ELCAP building types were translated into GSA building types, which is shown in Table B.1 of Appendix B.

ELCAP provided no measurements of the fixture density of exit signs. To estimate the density of these fixture types, a small audit was done of PNL-occupied buildings in Richland, Washington. Four buildings were audited, noting their total square footage and counting the exit signs. The buildings varied in size and configuration, but all were office-type buildings. The estimates of signs per square foot were similar for all buildings and are found in Table B.2 of Appendix B. These estimates were applied directly to office buildings and similar types of buildings, and the estimates were adjusted for use in other building types.

ELCAP also provided no measurements of fixture density in housing. This project found that more than 95% of residential lighting wattage was incandescent and the hours of the incandescent fixture operation were measured. These findings supported the simplifying assumption that housing is entirely incandescent, and the findings were used to develop density estimates according to daily hours of operation (see Section 3.1 for further discussion of the annual hours of operation). Data on the total number of fixtures per house and on the distribution of fixtures among the use categories were used to calculate the incandescent fixture density estimates. Final fixture density estimates are given in Table B.3 of Appendix B.

3.0 Optimal Retrofit Selection

The optimal retrofit for an existing lighting fixture was defined to be the minimum life-cycle cost fixture. The minimum life-cycle cost retrofit was found using the Lighting Technology Screening Matrix (LTSM 1993), which varies according to existing fixture type, electricity price, annual hours of operation, and utility rebate level.

Determining the optimal retrofit is dependent on the input data used in the LTSM. There are three types of input data affecting this analysis. The first type includes the analysis variables, such as electricity price, hours of operation, and utility rebate level, which are discussed in Section 3.1. The second type of input data are the input parameters such as the discount rate, the rate of energy price escalation, and the analysis period, which are discussed in Section 3.2. The third type of input data affecting the analysis are the technology cost and performance data, which are discussed in Section 3.3. Note that the minimum life-cycle cost fixture can be the existing fixture; thus, for some combinations of low operating hours, low electricity prices, and low utility rebates, the optimal action is no retrofit. Section 3.4 discusses optimal retrofit selection for self-luminous exit signs.

3.1 Analysis Variables

Electricity prices are developed at a state level and are state averages taken from the *Energy User News* (1991, 1992). Prices for each state are listed by utility, for both industrial and commercial customer classes. Simple unweighted averages were calculated for each state for the industrial and commercial classes, and the industrial and commercial classes were then averaged together to get the state average electricity price. The calculated state averages are given in Table C.1 of Appendix C.

Annual hours of operation (found in Table C.2 of Appendix C) are developed at a building-type level and are derived from ELCAP data for fluorescent and incandescent fixtures in nonhousing buildings. Housing incandescent-use intensity was broken down into six categories based on annual hours of operation. The distribution of fixtures among the categories was used to develop the fixture density estimates, as described in Section 2.2. Hours of operation for housing are given in Table C.3 of Appendix C. Exit signs are assumed to operate 24 hours per day for 365 days annually, or 8,760 hours per year.

Utility rebates were developed at a state level. Rebate levels were estimated for 1992 and were forecast for use in estimating future product demand. Utility rebates are offered by individual utilities on individual technologies. They differ by customer class and can be customized to differ by individual customers. This analysis attempted to describe the average level of rebates available to federal customers at a statewide level, and this required some generalizations. The basic framework used in this analysis was taken from a publication titled *Rebate Report* (D&R International 1991). The report classified utilities with comprehensive rebate programs as "leaders," utilities with seven or more rebate programs as "advanced," utilities with five or more as "market penetrating," and utilities with two or fewer rebate programs as being "underdeveloped." For the purposes of this analysis, utilities were assigned to the states containing their primary service territories, and states were then classified as having high-, medium-, or low-levels of rebates, in accordance with the number of utilities that fell into each of the above categories. The state classifications are given in Table C.4 of Appendix C. High-level states are those states with one or more utilities having leading or advanced programs. Medium-level states are states with one or more utilities having market penetration of rebate programs. Low-level states are all of the remaining states, with the exception of Georgia. Georgia was included in the medium-level states because of the recent participation of Georgia Power in FEMP-initiated, customized rebate programs.

The three rebate categories were then assigned average levels of rebates. These levels are defined as the average percentage of installed cost of retrofit technologies that a utility will pay in a federal relighting activity. The 1992 rebate levels for each category are 50% (high), 25% (medium), and 5% (low). These rebate levels increase to 60%, 40%, and 5%, respectively, in 1995 under the base case scenario, and the levels increase to 60%, 40%, and 25%, respectively, in 1993 in the FRI scenario. Table C.5 in Appendix C gives the rebate assigned to state classification. These average rebates are higher than the standard programs published by the utilities because of the presence of FEMP activities such as FRI. The FRI has increased and will continue to increase the ability of federal energy managers to obtain higher than standard utility rebates. The FRI's workshops and its tools have resulted in federal energy managers being more aware of existing rebate programs, and the workshops have allowed energy managers to participate in complex, customized demonstration programs, resulting in higher than standard rebates. This increase in acquired rebates is projected to continue, as reflected by both the base case and FRI scenarios.

3.2 Input Parameters

The discount rate used was 4.6%, as required for use by federal facilities in evaluating energy-efficient technologies. Note that this is a real rate, so it excludes general price inflation. The entire analysis is done in real 1991 dollars, and fuel prices are allowed to

escalate above the rate of general inflation, as is also required. The average U.S. commercial sector fuel price escalation rates were applied. A 25-year analysis period was used, which is consistent with assuming an average building life of 50 years and assuming the building stock vintage is uniformly distributed.

3.3 Technology Cost and Performance Data

Technology cost and performance data have been collected from a number of sources in the development of the LTSM (1993). Performance data has been derived from a number of published sources and supplemented by discussions with manufacturers and distributors and also in manufacturer's literature. Most cost data have been derived from discussions with distributors.

3.4 Self-Luminous Exit Signs

The analysis assumes that the federal government would retrofit existing fixtures with the most cost-effective replacements. In the case of exit signs, this may not be entirely accurate. It is possible that federal agencies will not purchase self-luminous exit signs, even if they are cost-effective, because of concern over safety and disposal issues (disposal costs are not included in the analysis). If self-luminous exit signs are eliminated from the analysis, LED exit signs would be installed in their place, resulting in an overall lower level of energy and dollar savings, lower required investment, and lower net present value.

4.0 Cost-Effective Relighting Potential

The cost-effective relighting potential is calculated for each technology type, for each state (to determine the electricity price and utility rebate), and for each building type (to determine the annual operating hours). The cost-effective relighting potential is characterized by five dimensions, as shown in Table 4.1.

Table 4.1. Dimensions of Cost-Effective Relighting Potential

Dimension	Units
Product demand	Number of ballasts, lamps, etc.
Annual energy savings	Millions of watt-hours (MWh)
Value of annual energy savings	1991 $
Required investment	1991 $
Net present value	1991 $

4.1 Product Demand

Each of the existing fixture types has a number of potential retrofits. Table 4.2 shows an example of two retrofit strategies for a 4-foot, 4-lamp, F40 fluorescent fixture. One

Table 4.2. Example of Differing Product Demand Implications from Differing Retrofit Strategies

Existing Fixture	Retrofit Strategy	Product Demands
4-foot, 4-lamp F40	Delamp, install reflector, install T-8s with electronic ballasts	Three 4-foot F32 T-8 lamps One 4-foot, 3-lamp reflector One 1-lamp T-8 electronic ballast One 2-lamp T-8 electronic ballast
4-foot, 4-lamp F40	Delamp, install reflector, install electronic ballasts	One 4-foot, 3-lamp reflector One 1-lamp F40 electronic ballast One 2-lamp F40 electronic ballast

strategy consists of removing the four F40 lamps and replacing them with three F32 T-8 lamps, installing a reflector, and installing a 1-lamp and a 2-lamp T-8 electronic ballast. A less expensive strategy consists of removing one lamp, installing a reflector, and replacing the existing magnetic ballasts with one 1-lamp and one 2-lamp F40 electronic ballast. The optimal retrofit choice will depend on the hours of operation, the price of electricity, and the level of utility cost-sharing for a given state and building type.

Each of these two retrofit strategies has different product demand implications. The first retrofit strategy results in demand for a 3-lamp reflector, three T8 lamps, and two T-8 electronic ballasts. The second retrofit strategy results in demand for one 3-lamp reflector and two F40 electronic ballasts. Table 4.3 lists the retrofit strategies considered for all of

Table 4.3. Retrofit Strategies

	Existing Fixture Description		Potential Retrofit Strategies
A	8-foot fluorescent, two F96 lamps, standard magnetic ballast	A.1	Install two 8-foot, 60-watt lamps, electronic ballast, reflector
		A.2	Install electronic ballast
B	4-foot fluorescent, two F40 lamps, standard magnetic ballast	B.1	Install two T8 lamps, electronic ballast
C	4-foot fluorescent, three F40 lamps, standard magnetic ballast	C.1	Install two T8 lamps, electronic ballast, reflector
		C.2	Remove one lamp, install electronic ballast, reflector
		C.3	Remove one lamp, install reflector
D	4-foot fluorescent, four F40 lamps, standard magnetic ballast	D.1	Install four T8 lamps, electronic ballast
		D.2	Install electronic ballast
		D.3	Install three T8 lamps, electronic ballast, reflector
		D.4	Install three T8 lamps, energy-efficient magnetic ballast, reflector
		D.5	Remove one lamp, install reflector
E	75-watt incandescent	E.1	18-watt compact fluorescent globe unit
F	Exit sign with two 20-watt incandescent lamps	F.1	Self-luminescent exit sign
		F.2	LED exit sign

the existing fixture types. Tables D.1 through D.6 in Appendix D contain a comprehensive list of the product demand resulting from the possible retrofit strategies for all existing fixture types.

Total product demands are estimated by determining the optimal retrofit for each existing fixture by state and building type. The number of existing fixtures is then multiplied by the product demands associated with the optimal retrofit. The product demands are then totaled to find the total potential cost-effective product demand, given 1992 rebate levels. Table 4.4 gives the total potential cost-effective product demand. The potential product demand would be realized if sufficient funding were available to relight all federal buildings in 1992. Given that several years will be needed to relight all federal buildings, the potential product demand has to be recalculated annually using the forecasted utility rebate levels. This process is described in Section 5.0.

Table 4.4. Total Potential Product Demand

Product	Units (thousands)
8-Foot Fluorescent Products	
2 lamp reflectors	5,125
2 lamp electronic ballasts	5,304
8-foot, 60-watt lamps	10,250
4-Foot Fluorescent Products	
2-lamp reflectors	3,550
3-lamp reflectors	4,325
1-lamp T-8 electronic ballasts	4,294
2-lamp T-8 electronic ballasts	12,358
1-lamp T-8 efficient magnetic ballasts	31
2-lamp T-8 efficient magnetic ballasts	31
4-foot F32 T-8 lamps	29,102
Compact Fluorescent Products	
Compact fluorescent lamps	21,264
Exit Sign Products	
LED Exit Signs	649
Self-Luminous Exit Signs	386

4.2 Annual Energy Savings

Annual energy savings is determined for each retrofit using the difference in watt draw and the annual hours of operation. The potential annual energy savings from relighting all federal buildings is given in Table 4.5.

4.3 Value of Annual Energy Savings

The value of the annual energy savings is calculated for each retrofit using the energy savings and the price of electricity. The value of the annual energy savings from relighting all federal buildings is given in Table 4.5.

4.4 Required Investment

The investment required to obtain the retrofits is the sum of the capital cost of the retrofit and the labor cost of installing the retrofit, less the utility rebate. The total investment required to relight all federal buildings is given in Table 4.5.

4.5 Net Present Value

The net present value of the investment is a measure of the cost-effectiveness of the retrofit strategy. Selecting the minimum life-cycle cost retrofit is equivalent to selecting the maximum net present value strategy. In the event that no retrofit is cost-effective, the existing fixture would be chosen, which has a net present value of zero. The total net present value of relighting all federal buildings is given in Table 4.5.

Table 4.5. Total Potential Annual Energy Savings, Investment, and Net Present Value

Potential Annual Energy Savings (MWh)	9,490,272
Value of Annual Energy Savings (1991 $)	$641,486,000
Total Required Investment (1991 $)	$1,819,264,000
Net Present Value (1991 $)	$8,099,608,000

5.0 Product Demand Forecasts

Total product demand was forecast for 1992 through 1996. Two scenarios were forecast concerning the likely levels of utility cost-sharing that federal facilities will receive. Under the base case scenario, current cost-sharing levels remain in effect through 1994 and increase in 1995. Under the FRI scenario, federal facilities are able to obtain higher rebates as early as 1993. The FRI scenario also assumes that the lowest utility cost-sharing states increase their average levels of cost-sharing slightly.

The annual forecasted product demands are given in Table 5.1. The annual energy and cost savings, the annual investment, and the net present value of the investment are given in Table 5.2.

Table 5.1. Estimated Annual Product Demand (thousands of units)

	1992	1993	1994	1995	1996
Base Case Scenario					
8-Foot Fluorescent Products					
2-lamp reflectors	336	579	537	775	494
Electronic ballasts	336	579	537	777	506
8-foot, 60-watt lamps	673	1,158	1,075	1,551	989
4-Foot Fluorescent Products					
2-lamp reflectors	225	387	360	520	339
3-lamp reflectors	275	473	439	635	413
1-lamp T-8 electronic ballasts	275	473	439	635	413
2-lamp T-8 electronic ballasts	785	1,351	1,254	1,742	1,181
4-foot T-8 lamps	1,845	3,175	2,947	4,118	2,775
Compact Fluorescent Products					
Compact fluorescent lamps	1,242	2,159	2,215	2,660	2,084
Exit Sign Products					
Led exit signs	0	0	27	48	60
Self-luminous exit signs	63	109	77	95	39
FRI Scenario					
8-Foot Fluorescent Products					
2-lamp reflectors	336	659	682	659	491
Electronic ballasts	336	659	682	659	502
8-foot, 60-watt lamps	673	1,318	1,364	1,313	982

Table 5.1. (contd)

	1992	1993	1994	1995	1996
Base Case Scenario					
4-Foot Fluorescent Products					
2-lamp reflectors	225	441	456	441	336
3-lamp reflectors	275	539	557	539	410
1-lamp T-8 electronic ballasts	275	539	557	539	410
2-lamp T-8 electronic ballasts	785	1,538	1,521	1,539	1,171
4-foot T-8 lamps	1,845	3,615	3,599	3,616	2,751
Compact Fluorescent Products					
Compact fluorescent lamps	1,242	2,404	2,867	2,298	2,085
Exit Sign Products					
LED exit signs	0	0	11	52	60
Self-luminous exit signs	63	123	121	70	39

Table 5.2. Total Potential Annual Energy Savings, Investment, and Net Present Value (by year and scenario)

	1992	1993	1994	1995	1996
Base Case Scenario					
Annual energy savings (MWh)	583,980	1,011,153	978,848	1,280,914	914,008
Annual energy savings (thousand 1991 $)	58,271	86,318	81,867	86,474	61,446
Required investment (thousand 1991 $)	75,000	140,000	175,000	190,000	190,000
Net present value (thousand 1991 $)	826,042	1,196,526	1,087,587	1,158,100	759,817
FRI Scenario					
Annual energy savings (MWh)	583,980	1,138,382	1,240,893	1,102,260	916,545
Annual energy savings (thousand 1991 $)	58,271	94,021	94,531	84,087	62,307
Required investment (thousand 1991$)	75,000	140,000	175,000	190,000	190,000
Net present value (thousand 1991 $)	826,042	1,317,869	1,282,074	1,118,091	771,945

6.0 Conclusions

PNL estimates that the total potential cost-effective energy savings from relighting federally owned buildings with energy-efficient lighting products could amount to over 52% of the current annual lighting electricity consumption. Fluorescent and incandescent fixtures could be retrofitted to reduce their annual electricity use by 47% and 55%, respectively, and the electricity used by exit signs could be reduced by over 90% with the installation of LED and self-luminescent (tritium gas) signs. Each of these retrofits would be cost-effective because the life-cycle costs would be less than that of the current fixtures.

Although there is not sufficient federal funding to undertake all cost-effective relighting projects immediately, some portion of these activities is assumed to occur each year (beginning in 1992), in accordance with an estimated level of federal funding for relighting. The estimated funding levels (obtained from DoD and GSA personnel, as well as individuals familiar with the federal efficiency fund) should be treated as hypothetical, as they represent only one possible scenario.

The base case and FRI scenarios were developed to represent the increasing level of utility cost-sharing. The base case scenario assumes that the level of utility cost-sharing that federal facilities are able to obtain remains at roughly the current level through 1994 and increases to a maximum level in 1995. The FRI scenario assumes that the shift to the maximum level of cost-sharing occurs in 1993, and it assumes that the maximum level is higher than the maximum level assumed in the base case scenario. The total net present value of the relighting project through 1996 is more than $300 million greater under the FRI scenario than under the base case scenario.

7.0 References

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Appendix A

Building Stock

Table A.1. Percentage Distribution of Floorspace by Agency for Individual Building Types

Agency	Office	Hospital	Prison	School	Other Inst.	Housing	Storage	Industrial	Service	R&D	Other
GSA	35.4%	0.4%	0.0%	0.1%	0.2%	0.0%	10.0%	0.8%	0.2%	0.6%	6.8%
DoD	29.4%	30.6%	0.0%	82.5%	79.0%	91.9%	79.4%	56.5%	88.7%	44.4%	36.2%
OFA	35.2%	69.0%	100%	17.4%	20.8%	8.1%	10.6%	42.7%	11.1%	55.0%	57.1%

Table A.2. Building Stock by Building Type, Agency, and State

Agency	State	Office	Hospital	Prison	School	Other Inst.	Housing
GSA	Alabama	2,985	10	0	2	6	3
	Alaska	1,702	4	0	1	2	6
	Arizona	1,895	9	0	3	5	7
	Arkansas	1,243	11	0	0	2	2
	California	17,436	50	0	8	15	28
	Colorado	3,642	10	0	2	4	4
	Connecticut	1,258	4	0	1	0	2
	Delaware	302	2	0	0	0	1
	D.C.	16,360	13	0	0	2	1
	Florida	5,281	21	0	3	2	8
	Georgia	5,345	18	0	4	12	9
	Hawaii	2,476	3	0	1	4	10
	Idaho	814	4	0	0	0	1
	Illinois	7,130	19	0	4	4	5
	Indiana	2,350	5	0	1	3	1
	Iowa	1,014	3	0	0	1	0
	Kansas	1,492	7	0	1	6	4
	Kentucky	2,003	11	0	2	6	5
	Louisiana	2,277	9	0	1	3	4
	Maine	587	2	0	0	0	2
	Maryland	7,447	22	0	4	6	7
	Massachusetts	3,283	13	0	1	3	3
	Michigan	3,239	10	0	1	1	2
	Minnesota	1,895	11	0	0	0	0
	Mississippi	1,453	7	0	2	1	3
	Missouri	4,591	10	0	1	3	3
	Montana	895	2	0	0	1	1
	Nebraska	1,656	5	0	0	0	2
	Nevada	903	2	0	0	1	1
	New Hampshire	661	1	0	0	0	1
	New Jersey	3.745	8	0	1	5	4
	New Mexico	2,832	6	0	2	4	4
	New York	10,700	37	0	3	11	6
	North Carolina	3,023	12	0	2	5	9
	North Dakota	728	3	0	1	0	3
	Ohio	4,986	16	0	1	4	1
	Oklahoma	1,982	8	0	2	3	3
	Oregon	1,769	5	0	0	1	1

Table A.2. (contd)

Agency	State	Office	Hospital	Prison	School	Other Inst.	Housing
	Pennsylvania	7,718	23	0	2	5	1
	Rhode Island	547	2	0	0	0	1
	South Carolina	2,018	9	0	2	4	6
	South Dakota	632	4	0	1	1	1
	Tennessee	3,105	13	0	1	4	2
	Texas	9,820	38	0	7	13	14
	Utah	1,477	3	0	1	2	1
	Vermont	268	1	0	0	0	0
	Virginia	12,659	18	0	5	12	12
	Washington	3,705	9	0	2	6	7
	West Virginia	914	4	0	0	1	0
	Wisconsin	1,063	12	0	1	2	1
	Wyoming	566	2	0	0	11	1
Total		177,872	531	0	77	187	204

Table A.2. (contd)

Agency	State	Office	Hospital	Prison	School	Other Inst.	Housing
DoD	Alabama	2,480	773	0	3,261	2,750	10,439
	Alaska	1,414	327	0	1,250	1,155	20,627
	Arizona	1,574	716	0	3,472	2,113	21,078
	Arkansas	1,033	885	0	679	1,018	5,498
	California	14,485	3,858	0	10,653	7,021	88,523
	Colorado	3,026	766	0	3,246	1,999	12,811
	Connecticut	1,045	302	0	711	64	5,109
	Delaware	251	134	0	351	56	2,435
	D.C.	3,592	999	0	497	1,045	3,769
	Florida	4,387	1,655	0	4,401	997	25,116
	Georgia	4,440	1,364	0	5,906	5,390	27,584
	Hawaii	2,057	266	0	921	1,980	32,679
	Idaho	676	286	0	415	175	3,368
	Illinois	5,924	1,470	0	4,807	1,944	15,326
	Indiana	1,952	413	0	1,061	1,266	4,362
	Iowa	842	201	0	583	277	303
	Kansas	1,240	531	0	1,345	2,703	13,286
	Kentucky	1,664	820	0	2,216	2,685	16,900
	Louisiana	1,892	700	0	1,505	1,573	11,994
	Maine	488	153	0	552	182	5,149
	Maryland	6,187	1,663	0	5,633	2,882	21,162
	Massachusetts	2,727	985	0	1,488	1,611	9,282
	Michigan	2,691	735	0	1,006	446	6,836
	Minnesota	1,574	834	0	563	180	757
	Mississippi	1,208	561	0	2,344	482	8,515
	Missouri	3,814	790	0	1,576	1,366	8,721
	Montana	744	117	0	355	243	3,797
	Nebraska	1,376	352	0	177	231	4,776
	Nevada	750	160	0	287	340	4,653
	New Hampshire	549	112	0	278	90	2,581
	New Jersey	3,111	620	0	1,949	2,172	12,289
	New Mexico	2,353	499	0	2,483	1,769	13,647
	New York	8,890	2,837	0	4,529	5,049	19,036
	North Carolina	2,511	927	0	2,863	2,259	30,224
	North Dakota	605	248	0	792	112	9,542
	Ohio	4,142	1,217	0	1,244	1,719	4,153
	Oklahoma	1,647	599	0	2,390	1,508	9,961
	Oregon	1,470	357	0	632	406	2,771

Table A.2. (contd)

Agency	State	Office	Hospital	Prison	School	Other Inst.	Housing
	Pennsylvania	6,412	1,763	0	2,071	2,256	4,695
	Rhode Island	454	149	0	672	80	3,677
	South Carolina	1,676	689	0	2,131	1,860	19,260
	South Dakota	525	293	0	1,175	541	4,599
	Tennessee	2,579	1,041	0	843	1,771	6,055
	Texas	8,158	2,963	0	9,422	5,856	45,576
	Utah	1,227	260	0	709	719	4,641
	Vermont	223	86	0	138	19	85
	Virginia	10,517	1,377	0	6,287	5,693	36,923
	Washington	3,078	718	0	2,609	2,832	23,342
	West Virginia	760	314	0	384	426	241
	Wisconsin	883	893	0	706	1,117	3,581
	Wyoming	470	135	0	168	4,942	3,238
Total		147,773	40,913	0	105,736	87,370	654,972

Table A.2. (contd)

Agency	State	Office	Hospital	Prison	School	Other Inst.	Housing
OFA	Alabama	2,972	1,744	483	689	724	921
	Alaska	1,695	739	27	264	304	1,819
	Arizona	1,887	1,617	89	734	556	1,859
	Arkansas	1,237	1,998	17	144	268	485
	California	17,359	8,713	1,410	2,252	1,849	7,806
	Colorado	3,626	1,729	194	686	526	1,130
	Connecticut	1,252	682	203	150	17	450
	Delaware	300	302	0	74	15	215
	D.C.	16,288	2,256	0	105	275	332
	Florida	5,258	3,738	561	930	262	2,215
	Georgia	5,321	3,081	606	1,248	1,419	2,432
	Hawaii	2,465	600	13	195	521	2,882
	Idaho	811	647	0	88	46	297
	Illinois	7,099	3,321	585	1,016	512	1,351
	Indiana	2,340	933	673	224	333	385
	Iowa	1,010	454	0	123	73	27
	Kansas	1,485	1,199	855	284	712	1,172
	Kentucky	1,994	1,852	990	468	707	1,490
	Louisiana	2,267	1,582	7	318	414	1,058
	Maine	584	344	0	117	48	454
	Maryland	7,414	3,755	23	1,191	759	1,866
	Massachusetts	3,269	2,225	0	315	424	818
	Michigan	3,224	1,660	386	213	117	603
	Minnesota	1,886	1,883	142	119	47	67
	Mississippi	1,447	1,267	0	495	127	751
	Missouri	4,570	1,783	423	333	360	769
	Montana	891	264	0	75	64	335
	Nebraska	1,649	795	0	37	61	421
	Nevada	899	361	62	61	89	410
	New Hampshire	658	253	0	59	24	228
	New Jersey	3,729	1,400	110	412	572	1,084
	New Mexico	2,820	1,126	0	525	466	1,203
	New York	10,653	6,407	501	957	1,329	1,678
	North Carolina	3,010	2,092	271	605	595	2,665
	North Dakota	725	560	0	167	30	841
	Ohio	4,964	2,748	0	263	453	366
	Oklahoma	1,973	1,352	597	505	397	878
	Oregon	1,762	807	0	134	107	244

Table A.2. (contd)

Agency	State	Office	Hospital	Prison	School	Other Inst.	Housing
	Pennsylvania	7,684	3,980	1,011	438	594	414
	Rhode Island	544	338	0	142	21	324
	South Carolina	2,009	1,556	2	450	490	1,698
	South Dakota	629	662	0	248	143	406
	Tennessee	3,091	2,351	272	178	466	534
	Texas	9,777	6,692	1,837	1,991	1,542	4,019
	Utah	1,470	586	0	150	189	409
	Vermont	267	194	0	29	5	8
	Virginia	12,603	3,109	353	1,329	1,499	3,256
	Washington	3,689	1,622	47	551	746	2,058
	West Virginia	910	709	716	81	112	21
	Wisconsin	1,058	2,016	475	149	294	316
	Wyoming	564	304	0	36	1,301	285
Subtotal		177,088	92,388	13,941	22,347	23,004	57,755
Total		502,733	133,832	13,941	128,160	110,561	712,931

Table A.2. (contd)

Agency	State	Storage	Industrial	Service	R&D	Other	Total
GSA	Alabama	1,319	16	14	34	16	4,774
	Alaska	582	2	23	2	94	4,135
	Arizona	677	7	16	8	46	4,545
	Arkansas	387	3	7	4	36	1,920
	California	6,328	63	140	123	508	28,617
	Colorado	973	18	17	10	148	4,752
	Connecticut	59	7	3	3	11	1,218
	Delaware	64	0	5	0	3	613
	D.C.	323	12	8	26	87	5,730
	Florida	659	11	44	46	123	7,668
	Georgia	1,885	42	33	9	113	8,855
	Hawaii	1,186	1	26	1	98	6,030
	Idaho	229	5	6	10	48	1,287
	Illinois	1,562	41	18	24	107	7,033
	Indiana	515	25	9	6	44	2,504
	Iowa	253	11	3	4	27	924
	Kansas	769	24	10	1	37	3,495
	Kentucky	727	58	12	2	43	4,527
	Louisiana	480	33	14	4	26	3,482
	Maine	119	0	8	0	37	1,183
	Maryland	1,223	16	25	112	137	8,772
	Massachusetts	258	6	8	24	37	3,138
	Michigan	286	10	10	4	81	2,633
	Minnesota	198	36	4	4	40	1,607
	Mississippi	330	6	8	18	23	2,486
	Missouri	721	44	7	3	54	3,827
	Montana	178	1	5	1	38	1,072
	Nebraska	181	21	6	2	40	1,632
	Nevada	982	4	10	3	24	2,058
	New Hampshire	107	0	7	1	27	853
	New Jersey	1,621	0	15	28	67	4,957
	New Mexico	586	5	15	50	62	4,328
	New York	1,782	31	20	30	135	9,142
	North Carolina	766	5	15	4	107	5,662
	North Dakota	188	0	9	5	19	1,800
	Ohio	1,827	134	19	54	77	6,572
	Oklahoma	1,376	25	24	3	43	4,389
	Oregon	499	1	5	5	55	1,604

Table A.2. (contd)

Agency	State	Storage	Industrial	Service	R&D	Other	Total
	Pennsylvania	2,479	15	25	16	87	6,728
	Rhode Island	244	0	3	1	14	899
	South Carolina	634	25	25	13	53	4,797
	South Dakota	103	0	6	1	27	1,196
	Tennessee	1,284	110	18	29	113	5,257
	Texas	3,074	86	67	26	167	15,511
	Utah	1,705	4	21	4	31	3,351
	Vermont	18	0	1	0	3	155
	Virginia	2,728	23	54	26	415	13,392
	Washington	1,279	12	36	15	208	6,777
	West Virginia	65	1	1	2	19	629
	Wisconsin	253	23	4	5	15	1,729
	Wyoming	112	0	7	4	28	1,441
Total		46,183	1,023	896	810	3,898	231,686

Table A.2. (contd)

Agency	State	Storage	Industrial	Service	R&D	Other	Total
DoD	Alabama	10,511	1,114	5,975	2,397	85	39,852
	Alaska	4,637	123	9,750	138	503	34,520
	Arizona	5,398	456	6,927	598	245	37,943
	Arkansas	3,083	216	2,931	282	191	16,026
	California	50,442	4,300	59,407	8,656	2,720	238,885
	Colorado	7,756	1,271	7,388	720	791	39,669
	Connecticut	467	514	1,250	195	57	10,169
	Delaware	514	0	2,006	12	18	5,116
	D.C.	2,578	809	3,372	1,818	466	47,832
	Florida	5,250	747	18,587	3,251	658	64,009
	Georgia	15,025	2,897	14,070	658	605	73,916
	Hawaii	9,455	64	10,884	99	523	50,337
	Idaho	1,828	354	2,389	718	259	10,740
	Illinois	12,453	2,827	7,589	1,705	572	58,709
	Indiana	4,103	1,690	3,801	414	234	20,901
	Iowa	2,015	790	1,109	313	143	7,717
	Kansas	6,131	1,651	4,170	53	199	29,177
	Kentucky	5,794	3,962	5,076	154	229	37,787
	Louisiana	3,826	2,254	5,944	302	137	29,065
	Maine	949	5	3,442	12	200	9,873
	Maryland	9,752	1,111	10,823	7,875	733	73,227
	Massachusetts	2,054	397	3,444	1,700	199	26,191
	Michigan	2,279	701	4,185	307	436	21,981
	Minnesota	1,578	2,445	1,748	277	214	13,412
	Mississippi	2,634	438	3,613	1,301	126	20,752
	Missouri	5,748	3,021	2,970	225	288	31,944
	Montana	1,416	59	2,273	83	206	8,951
	Nebraska	1,439	1,476	2,623	113	214	13,622
	Nevada	7,830	268	4,221	222	127	17,180
	New Hampshire	851	2	2,804	90	145	7,124
	New Jersey	12,925	14	6,260	1,986	361	41,383
	New Mexico	4,671	347	6,560	3,492	331	36,127
	New York	14,208	2,113	8,625	2,105	724	76,314
	North Carolina	6,107	354	6,201	267	576	47,265
	North Dakota	1,502	14	3,990	331	102	15,025
	Ohio	14,567	9,224	7,956	3,789	414	54,860
	Oklahoma	10,965	1,706	10,161	193	230	36,640
	Oregon	3,977	42	2,066	324	296	13,390

Table A.2. (contd)

Agency	State	Storage	Industrial	Service	R&D	Other	Total
	Pennsylvania	19,762	1,054	10,497	1,131	465	56,163
	Rhode Island	1,942	1	1,065	38	75	7,505
	South Carolina	5,052	1,693	10,623	938	285	40,040
	South Dakota	821	8	2,675	73	145	9,986
	Tennessee	10,237	7,550	7,783	2,068	607	43,883
	Texas	24,503	5,933	28,599	1,808	893	129,483
	Utah	13,591	289	8,839	306	166	27,972
	Vermont	140	11	249	11	18	1,292
	Virginia	21,748	1,609	23,149	1,805	2,226	111,795
	Washington	10,194	816	15,422	1,023	1,115	56,572
	West Virginia	521	44	553	173	100	5,251
	Wisconsin	2,019	1,591	1,766	355	80	14,431
	Wyoming	897	5	2,882	279	151	12,030
Total		368,14	70,380	380,692	57,183	20,883	1,934,03

Table A.2. (contd)

Agency	State	Storage	Industrial	Service	R&D	Other	Total
OFA	Alabama	1,406	841	747	2,970	134	13,194
	Alaska	620	93	1,219	170	793	11,429
	Arizona	722	344	866	741	386	12,562
	Arkansas	412	163	366	350	301	5,306
	California	6,749	3,246	7,428	10,728	4,289	79,089
	Colorado	1,038	959	924	892	1,248	13,133
	Connecticut	62	388	156	242	90	3,367
	Delaware	69	0	251	15	28	1,694
	D.C.	345	611	422	2,253	734	15,836
	Florida	702	564	2,324	4,030	1,038	21,192
	Georgia	2,010	2,187	1,759	815	955	24,472
	Hawaii	1,265	48	1,361	123	825	16,665
	Idaho	245	267	299	889	408	3,556
	Illinois	1,666	2,134	949	2,113	902	19,437
	Indiana	549	1,276	475	514	369	6,920
	Iowa	270	596	139	388	226	2,555
	Kansas	820	1,246	521	65	313	9,660
	Kentucky	775	2,991	635	191	362	12,510
	Louisiana	512	1,701	743	374	216	9,623
	Maine	127	3	430	14	315	3,269
	Maryland	1,305	838	1,353	9,760	1,157	24,243
	Massachusetts	275	299	431	2,108	313	8,671
	Michigan	305	529	523	380	687	7,277
	Minnesota	211	1,846	219	343	338	4,440
	Mississippi	352	331	452	1,613	199	6,871
	Missouri	769	2,280	371	278	455	10,576
	Montana	189	44	284	102	325	2,964
	Nebraska	193	1,114	328	140	338	4,510
	Nevada	1,048	203	528	276	200	5,688
	New Hampshire	114	2	351	112	229	2,359
	New Jersey	1,729	10	783	2,462	569	13,701
	New Mexico	625	262	820	4,328	522	11,961
	New York	1,901	1,595	1,078	2,609	1,142	25,266
	North Carolina	817	267	775	331	908	15,648
	North Dakota	201	11	499	411	161	4,975
	Ohio	1,949	6,964	995	4,697	652	18,163
	Oklahoma	1,467	1,288	1,270	240	363	12,131
	Oregon	532	32	258	402	467	4,433

Table A.2. (contd)

Agency	State	Storage	Industrial	Service	R&D	Other	Total
	Pennsylvania	2,644	796	1,312	1,402	733	18,594
	Rhode Island	260	0	133	47	118	2,485
	South Carolina	676	1,278	1,328	1,162	449	13,256
	South Dakota	110	6	334	91	228	3,306
	Tennessee	1,370	5,700	973	2,563	957	14,529
	Texas	3,279	4,479	3,576	2,241	1,408	42,869
	Utah	1,819	218	1,105	379	262	9,261
	Vermont	19	9	31	14	29	428
	Virginia	2,910	1,215	2,894	2,237	3,511	37,012
	Washington	1,364	616	1,928	1,268	1,758	18,729
	West Virginia	70	33	69	215	158	1,739
	Wisconsin	270	1,201	221	439	126	4,778
	Wyoming	120	4	360	345	238	3,983
Subtotal		49,257	53,128	47,596	70,872	32,932	640,315
Total		463,585	124,531	429,184	128,865	57,713	2,806,035

Appendix B

Existing Stock of Fixtures

Appendix B

Existing Stock of Fixtures

Table B.1. Mapping of ELCAP Building Types to GSA Building Types

GSA Building Type	ELCAP Building Type
Office	Average of small and large office
Hospital	Health
Prison	Hotel/motel
School	Education
Other institutions	Average of small and large office
Housing	Not in ELCAP data
Storage	Warehouse
Industrial	Warehouse
Service	Average of fast-food and full-service restaurants
Research and development	Average of small and large office
All other	Average of small and large office

Table B.2. Exit Sign Audit[a]

Building	Description	Sq. ft	Signs	1,000 Sq. ft
Sigma 4	1-story office	20,440	9	0.44031
Sigma 5	2-story office	46,620	25	0.53625
ISB1	1-story office	50,200	40	0.79681
2400 Stevens	2-story office	75,400	45	0.59682
Total		192,660	119	0.61767

(a) Data are based on survey of PNL buildings in Hanford 3000 Area.

Table B.3. Fixture Density Estimates by Technology and Building Type[a]

	Office	Hospital	Prison	School	Other Institution
Fl. 1x8 2-96	0.0038	0.0024	0.0005	0.0031	0.0038
Fl. 2x4 2-40	0.0032	0.0020	0.0004	0.0026	0.0032
Fl. 2x4 3-40	0.0026	0.0016	0.0003	0.0020	0.0026
Fl. 2x4 4-40	0.0031	0.0020	0.0004	0.0025	0.0031
Inc. 75-ceil (.5)	0.0015	0.0033	0.0044	0.0007	0.0015
Inc. 75-ceil (1.5)	0.0015	0.0033	0.0044	0.0007	0.0015
Inc. 75-ceil (2.5)	0.0015	0.0033	0.0044	0.0007	0.0015
Inc. 75-ceil (3.5)	0.0015	0.0033	0.0044	0.0007	0.0015
Inc. 75-ceil (4.5)	0.0015	0.0033	0.0044	0.0007	0.0015
Inc. 75-ceil (5.5)	0.0015	0.0033	0.0044	0.0007	0.0015
Exits	0.0006	0.0006	0.0003	0.0006	0.0006

	Housing	Storage	Industrial	Service	R&D	All Other
Fl. 1x8 2-96	0.0000	0.0014	0.0014	0.0016	0.0038	0.0038
Fl. 2x4 2-40	0.0000	0.0012	0.0012	0.0013	0.0032	0.0032
Fl. 2x4 3-40	0.0000	0.0010	0.0010	0.0011	0.0026	0.0026
Fl. 2x4 4-40	0.0000	0.0012	0.0012	0.0013	0.0031	0.0031
Inc. 75-ceil (.5)	0.0111	0.0004	0.0004	0.0040	0.0015	0.0015
Inc. 75-ceil (1.5)	0.0061	0.0004	0.0004	0.0040	0.0015	0.0015
Inc. 75-ceil (2.5)	0.0025	0.0004	0.0004	0.0040	0.0015	0.0015
Inc. 75-ceil (3.5)	0.0030	0.0004	0.0004	0.0040	0.0015	0.0015
Inc. 75-ceil (4.5)	0.0022	0.0004	0.0004	0.0040	0.0015	0.0015
Inc. 75-ceil (5.5)	0.0028	0.0004	0.0004	0.0040	0.0015	0.0015
Exits	0.0000	0.0002	0.0003	0.0006	0.0006	0.0006

(a) Fixture density estimates are by fixtures per square foot, technology type, and building type.

Appendix C

Optimal Retrofits

Appendix C

Optimal Retrofits

Table C.1. State Average Electricity Prices[a]

State	Average Industrial Price ($/kWh)	Average Commercial Price ($/kWh)	Average Price ($/kWh)
AK	$0.094	$0.088	$0.091
AL	$0.045	$0.069	$0.057
AR	$0.063	$0.074	$0.068
AZ	$0.061	$0.088	$0.075
CA	$0.090	$0.112	$0.101
CO	$0.046	$0.044	$0.045
CT	$0.080	$0.093	$0.087
DC	$0.066	$0.081	$0.073
DE	$0.047	$0.071	$0.059
FL	$0.049	$0.064	$0.057
GA	$0.048	$0.069	$0.058
HI	$0.071	$0.108	$0.089
IA	$0.039	$0.073	$0.056
ID	$0.027	$0.041	$0.034
IL	$0.061	$0.088	$0.075
IN	$0.042	$0.059	$0.050
KS	$0.047	$0.065	$0.056
KY	$0.038	$0.054	$0.046

(a) Data are taken from *Energy User News* (1991, 1992).

Table C.1. (contd)

State	Average Industrial Price ($/kWh)	Average Commercial Price ($/kWh)	Average Price ($/kWh)
LA	$0.039	$0.069	$0.054
MA	$0.088	$0.100	$0.094
MD	$0.078	$0.087	$0.083
ME	$0.064	$0.082	$0.073
MI	$0.060	$0.083	$0.071
MN	$0.045	$0.066	$0.056
MO	$0.052	$0.067	$0.059
MS	$0.042	$0.070	$0.056
MT	$0.024	$0.043	$0.033
NC	$0.052	$0.063	$0.058
ND	$0.047	$0.059	$0.053
NE	$0.039	$0.060	$0.049
NH	$0.087	$0.104	$0.095
NJ	$0.077	$0.095	$0.086
NM	$0.052	$0.085	$0.069
NV	$0.067	$0.062	$0.064
NY	$0.066	$0.118	$0.092
OH	$0.044	$0.078	$0.061
OK	$0.033	$0.068	$0.050
OR	$0.037	$0.047	$0.042
PA	$0.065	$0.077	$0.071
RI	$0.094	$0.113	$0.103
SC	$0.043	$0.060	$0.052
SD	$0.048	$0.080	$0.064
TN	$0.042	$0.057	$0.050
TX	$0.042	$0.066	$0.054

Table C.1. (contd)

State	Average Industrial Price ($/kWh)	Average Commercial Price ($/kWh)	Average Price ($/kWh)
UT	$0.037	$0.059	$0.048
VA	$0.042	$0.057	$0.050
VT	$0.049	$0.086	$0.068
WA	$0.023	$0.048	$0.035
WI	$0.040	$0.060	$0.050
WV	$0.035	$0.053	$0.044
WY	$0.034	$0.052	$0.043

Table C.2. Annual Hours of Operation for Nonhousing Buildings

Building	Annual Hours of Operation
Office	3,700
Hospital	4,800
Prison	5,800
School	2,000
Other Inst.	3,700
Storage	3,000
Industrial	3,000
Service	4,800
R&D	3,700
All Other	3,700

Table C.3. Annual Hours of Operation for Housing Buildings

Lighting Technology	Annual Hours of Operation[a]
Inc. 75-ceil (.5)	182.5
Inc. 75-ceil (1.5)	547.5
Inc. 75-ceil (2.5)	912.5
Inc. 75-ceil (3.5)	1,277.5
Inc. 75-ceil (4.5)	1,642.5
Inc. 75-ceil (5.5)	2,007.5

(a) Based on average fixture housing buildings.

Table C.4. State Rebate Classifications

State	Classification	State	Classification
AK	Low	MT	High
AL	Medium	NC	Low
AR	Low	ND	Low
AZ	Low	NE	Low
CA	High	NH	Low
CO	Low	NJ	High
CT	High	NM	Low
DC	Low	NV	Low
DE	Low	NY	High
FL	Medium	OH	Low
GA	Medium	OK	Medium
IA	Low	OR	High
ID	High	PA	High
IL	Medium	RI	Low
IN	Medium	SC	Low
KS	Low	SD	Low
KY	Medium	TN	Low
LA	Low	TX	Low
MA	High	UT	Low
MD	Low	VA	Low
ME	High	VT	High
MI	Low	WA	High
MN	High	WI	High
MO	Low	WV	Low
MS	Low	WY	Low

Table C.5. Average Rebate Levels by Classification

	Base Case Scenario			FRI Scenario		
Year	Low	Medium	High	Low	Medium	High
1992	5%	25%	50%	5%	25%	50%
1993	5%	25%	50%	15%	40%	60%
1994	5%	25%	50%	15%	40%	60%
1995	5%	40%	60%	15%	40%	60%
1996	5%	40%	60%	15%	40%	60%

Appendix D

Product Demand

Appendix D

Product Demand

Table D.1. Fluorescent 2x8 F96 and Retrofits

Existing Fixture	Retrofit	60-Watt Action	8-Foot, 2 Lamp	2-Lamp Lamp Ref.
Fl. 1x8 2-96 std.	LW + REF + ELC	2	1	1
	ELC	0	0	1

Table D.2. Fluorescent 2x4 F40 2-Lamp and Retrofits

Existing Fixture	Retrofit	T-8 Action	2-Lamp T-8 Lamps
F1. 2x4 2-40 std.	T-8 + ELC	2	1

Table D.3. Fluorescent 2x4 F40 3-Lamp and Retrofits

Existing Fixture	Retrofit	T-8 Action	2-Lamp T-8 Lamps	2-Lamp F40 Elect. Ballast	2-Lamp Elect. Ballast
Fl. 2x4 3-40 std.	DL1 + T-8 + REF + ELC	2	1	0	1
	DL1 + REF + ELC	0	0	1	1
	DL1 + REF	0	0	0	1

Table D.4. Fluorescent 2x4 F40 4-Lamp and Retrofits

Existing Fixture	Retrofit	T-8 Action	2-Lamp T-8 Lamps	2-Lamp F40 Elec. Ballast	3-Lamp Elec. Ballast
Fl. 2x4 4-40 std.	T-8 + ELC	4	2	0	0
	ELC	0	0	2	0
	DL1 + T-8 + REF + ELC	3	1	0	1
	DL1 + T-8 + REF + EEF	3	0	0	1
	DL1 + REF	0	0	0	1
Fl. 2x4 4-40	T-8 + ELC	0	0	0	
	ELC	0	0	0	
	DL1 + T-8 + REF + ELC	1	0	0	
	DL1 + T-8 + REF + EEF	0	1	1	
	DL1 + REF	0	0	0	

Table D.5. Incandescents and Retrofits

Existing Fixture	Retrofit	Compact Fluorescent Action
Inc. 75-ceil	CFL 18-globe unit	1

Table D.6. Exit Signs and Retrofits

Existing Fixture	Retrofit	Self-Luminous Action Sign	LED Sign
Exit-Inc. 2x20	Self-lum.	1	0
	LED	0	1

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