APPENDIX B. MARGINAL ENERGY PRICES AND NATIONAL ENERGY SAVINGS

B.1 COMMERCIAL SECTOR MARGINAL ENERGY PRICES

B.1.1 Background

Previous analyses of the life-cycle costs of and consumer bill savings possible from appliance energy efficiency standards were based on *average* energy prices.[a] Using *marginal* energy prices in these analyses is more theoretically sound.[b] Accordingly, in April 1998 the Advisory Committee on Appliance Energy Efficiency Standards delivered a letter to the Secretary of Energy recommending, among other things, that DOE should replace the use of national average energy prices with the full range of consumer marginal energy rates in its life-cycle cost analyses. Because neither published nor readily available data existed for consumer marginal energy prices, a major research effort was required to derive consumer marginal energy price. The full report on this research effort, "Marginal Energy Prices Report," can be obtained from DOE[1].

In the near term, several sources of information were available for research and analysis on marginal prices. Commercial customers' utility bills could be approximated knowing monthly usage and likely utility tariff. Monthly usage for a large sample of commercial buildings was available from a commercial product, the MAISY® commercial database.[2] Utility tariff sheets, generally those applicable during 1997, were available from utility web sites, commercial services, or the utilities themselves. Data on utility sales and number of customers on various tariffs were available for investor-owned utilities from the Federal Energy Regulatory Commission (FERC) Form 1 filings made by those utilities. For municipal utilities and co-ops, equivalent tariff-level data were obtained from either the utility itself or was available from the Rural Utility Service. In the future, given that restructuring of parts of the energy supply sector will complicate billing, energy pricing information would best come directly from the customers. Because of the complexity inherent in utility tariffs, methods to approximate marginal prices that simply subtract fixed costs from average costs did not constitute a credible method for calculating marginal prices.

B.1.2 Overview

Commercial marginal electricity prices were derived by calculating monthly bills for a distribution of buildings (with energy usage information) using a set of modeled commercial tariffs. The sections below describe the utility tariffs that were chosen and modeled for this analysis. The MAISY® database (acquired from Jackson Associates) provided the source of information for the building energy and demand levels among buildings of different types.

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[a]*Average* energy prices for a consumer were derived by dividing annual energy costs by annual energy consumption. At the utility level, average energy prices were derived by dividing annual revenues by annual energy sales.

[b]*Marginal* prices as discussed here are those prices consumers pay (or save) for their last units of energy used (or saved). Marginal prices reflect a change in a consumer's bill (that might be associated with new energy efficiency standards) divided by the corresponding change in the amount of energy the consumer used.

This section describes the process for calculating the electricity bills and the marginal electricity prices for the sampled commercial buildings. The Commercial Tariffs Spreadsheet, or CTAS, contains a collection of modeled commercial electric utility tariffs, a collection of modeled commercial buildings, and Visual Basic program modules. Each building was assigned to a group of applicable tariffs based on building demand and monthly bills were calculated for each tariff for a calendar year. Then, building energy usage and demands were decremented to account for savings expected from a new energy efficiency standard, monthly bills were recalculated, and the differences in bills and energy use used to calculate marginal prices. A brief description of the demand decrement methodology is included. We also describe the method by which the sampled buildings were weighted in the analysis. Lastly, we present the results of the commercial analysis.

B.1.3 Sample Tariffs

B.1.3.1 Tariff Collection

For a variety of utilities around the country, we collected commercial tariffs and then modeled them for use in the bill calculation process. We chose utilities in an attempt to obtain a sample that is generally representative of commercial customers throughout the nation. In choosing utilities, the key factors we considered were geographic location, type of ownership (e.g. investor owned, publicly owned, or cooperatively owned), and size. We chose those factors to capture regional differences in such issues as climate, the availability of inexpensive sources of energy, the structure of regulatory oversight, and the scale of operation. Table B.1 below is a list of the commercial utility sample used in this analysis. We obtained utility tariffs from the following sources: utility web sites, a consulting company, and utilities themselves. In order to be able to properly weight results, we also obtained FERC Form 1 (or equivalent) data for the chosen utilities showing the number of customers and the sales for each of a utility's tariffs.

Table B.1. Characterization and Summary of Commercial Electric Utility Sample

			By Utility		*By Modeled Tariffs*		*Percent of US in Modeled Tariffs*		*Sample as Percent of Utility*	
Utility	State	Type	Total Commercial Customers	Total Megawatt-hour Sales	Sampled Commercial Customers	Sampled Megawatt-hour Sales	Cust.	MWh Sales	Cust.	MWh Sales
PG&E	CA	IOU	552,901	49,530,911	401,747	16,025,437	3.0%	1.7%	73%	32%
SoCal Edison	CA	IOU	481,417	51,410,408	419,163	23,057,727	3.1%	2.5%	87%	45%
Commonwealth Edison	IL	IOU	292,709	49,933,859	291,143	25,859,649	2.2%	2.8%	99%	52%
Virginia Power	VA	IOU	189,301	20,061,476	137,813	2,696,019	1.0%	0.3%	73%	13%
Detroit Edison	MI	IOU	177,088	17,997,214	166,003	7,613,394	1.2%	0.8%	94%	42%
Alabama Power	AL	IOU	174,602	11,330,312	154,077	7,917,907	1.1%	0.9%	88%	70%
Penn Power & Light	PA	IOU	149,221	20,475,206	143,849	8,781,171	1.1%	0.9%	96%	43%
Niagara Mohawk Power	NY	IOU	148,124	23,279,622	143,590	4,550,295	1.1%	0.5%	97%	20%
NSP (MN)	MN	IOU	135,183	5,009,755	110,807	4,461,852	0.8%	0.5%	82%	89%
Union Electric Co	MO	IOU	134,699	12,189,235	120,596	8,735,132	0.9%	0.9%	90%	72%
Appalachian Power	VA	IOU	110,740	16,390,313	78,554	674,926	0.6%	0.1%	71%	4%
Jersey Central P&L	NJ	IOU	106,157	10,510,309	104,922	5,358,036	0.8%	0.6%	99%	51%
Wisconsin Elec Power	WI	IOU	93,973	18,454,563	85,735	2,705,293	0.6%	0.3%	91%	15%
Boston Edison	MA	IOU	87,644	7,991,349	80,255	2,820,415	0.6%	0.3%	92%	35%
Ohio Power Company	OH	IOU	87,314	24,917,126	6,442	6,348,160	0.0%	0.7%	7%	25%
Central Power & Light	TX	IOU	85,311	12,844,712	74,107	2,099,439	0.5%	0.2%	87%	16%
Arizona Public Service	AZ	IOU	79,755	8,524,882	78,530	6,989,968	0.6%	0.8%	98%	82%
PEPCO	MD	IOU	70,909	15,307,001	53,620	1,317,800	0.4%	0.1%	76%	9%
Cleveland Electric Illum	OH	IOU	64,907	5,883,328	63,161	2,765,339	0.5%	0.3%	97%	47%
Seattle City Light	WA	Muni	43,497	3,081,941	43,497	3,081,941	0.3%	0.3%	100%	100%
NSP (WI)	WI	IOU	31,236	866,425	27,449	831,739	0.2%	0.1%	88%	96%
Madison Gas & Electric	WI	IOU	16,220	1,727,832	14,815	685,233	0.1%	0.1%	91%	40%
Savannah Elec & Power	GA	IOU	14,100	1,156,078	708	517,052	0.0%	0.1%	5%	45%
Poudre Valley REA	CO	Co-op	2,774	377,974	2,101	96,424	0.0%	0.0%	76%	26%
Sample Total			3,329,782	389,251,831	2,802,684	145,990,348	20.7%	15.7%	84%	38%
US TOTAL			13,540,374	928,440,265						

Because tariff-level information on sales is not as readily available for publicly and cooperatively owned utilities as it is for investor-owned utilities that must report such information annually to FERC, our sample contained only one municipal utility and one co-op. While the co-op we included in our analysis had an average commercial price nearly the same as the average commercial price of all of the co-ops in the country, the same was not true for the municipal utility in our sample. As a sensitivity analysis, we later added several more municipal utilities, which brought the weighted average electricity price of the municipal utilities in our sample closer to the average commercial price of all of the municipal utilities in the country. We then re-ran the bill calculator (which is described below) using the expanded set of tariffs. See the Results Section below for the conclusions of this sensitivity analysis.

Electric utilities calculate customer bills using tariffs that define the type and amount of each charge. These charges are generally levied on a monthly basis, and generally have three main components: fixed charges, usage charges, and demand charges. We collected these tariffs for a number of US electric utilities and modeled them for inclusion in CTAS calculations. CTAS contains the specific commercial tariffs for the utilities shown in Table B.2.

Table B.2 Tariffs Used in the Commercial Analysis

Utility	State	Tariff	Utility	State	Tariff
Alabama Power	AL	LPEM	NSP	WI	Cg-5
Alabama Power	AL	LPM	Niagara Mohawk Power Corp	NY	SC-2 Demand
Alabama Power	AL	LPS	Niagara Mohawk Power Corp	NY	SC-2 Non-Demand
Appalachian Power Co	VA	SGS	Ohio Power Co	OH	GS3-11
Arizona Public Service	AZ	E30	PEPCO	DC	GS
Arizona Public Service	AZ	E32	Pacific Gas & Electric	CA	A1
Boston Edison	MA	G-1	Pacific Gas & Electric	CA	A10
Boston Edison	MA	G-2	Pennsylvania Power and Light	PA	GS-1
Central Power and Light	TX	21	Pennsylvania Power and Light	PA	GS-3
Cleveland Electric Illum. Co	OH	Gen Comm	Poudre Valley	CO	B-97
Cleveland Electric Illum. Co	OH	Lg Comm	Savannah Electric and Water	GA	GS-7
Commonwealth Edison Co	IL	Rate 6 non-TOU	Seattle City Light	WA	Rate 31
Detroit Edison	MI	D3	Seattle City Light	WA	Rate 34
Jersey Central Power & Light	NJ	GS	SoCal Edison	CA	GS-1
Madison G&E	WI	Cg-1	SoCal Edison	CA	GS-2
Madison G&E	WI	Cg-5	Union Electric Co	MO	No. 2
NSP	MN	A10, D12, E13	Union Electric Co	MO	No. 3
NSP	MN	A14, D16, E15	Virginia Power Co	VA	GS-1
NSP	WI	Cg-2	Wisconsin Electric Power	WI	Cg-1
NSP	WI	Cg-2 unmetered			

B.1.3.2 Commercial Tariff Structure

Commercial tariffs can be complex. A commercial tariff usually includes the following types of information:

- Applicability / Availability — the type of customer served under this tariff.
- Character of Service — the type of current, voltage, and phase (single or three-phase).
- Monthly Rate — customer charge, energy charge, demand charge (if applicable), and extra charges.
- Definition of demand charges.
- Rate periods (if time-of-use) and definition of seasons.

- Minimum monthly charge.
- Power factor adjustments and reactive power demand charges.

B.1.3.3 Commercial Tariff Spreadsheet Modeling

Electric utilities typically have many commercial tariffs. Southern California Edison, for instance, has over 100 commercial tariffs. Most of these tariffs target a very small number of customers, or even individual customers, and thus have been ignored in CTAS. CTAS was designed as an analysis tool to investigate marginal prices experienced by a range of customers over a range of commercial tariffs throughout the country. It attempts to maximize coverage by running a prototypical set of customers/buildings against as broad a set of tariffs as possible. Only the most-used two or three commercial tariffs for each utility have been included in CTAS. Taken together, these tariffs covered 84 percent of the customers in our utility sample and 38 percent of the commercial electricity sales by those sampled utilities.

Generally, the commercial tariff modeling effort focused on two common categories of commercial tariffs: small general service and general service. We modeled the collected commercial tariffs in spreadsheet form, excluding some tariffs and/or components that could not be applied to buildings in MAISY®. For instance, if a tariff provided both single and three-phase service, only the charges for single phase were modeled. Also, some tariffs charged different prices for primary, secondary, and transmission voltage levels, but the buildings used in MAISY® only received service at secondary levels. We ignored power factor and reactive demand charges, which are an adjustment based on voltage and demand usage. We ignored other factors if the information could not be used in MAISY® or was rarely applicable.

In addition to the parameters necessary to calculate customer bills, the spreadsheet also contained the number of customers in a tariff, total number of customers in a commercial utility, the megawatt-hours sold, kilowatt-hours sold per customer, and average price per kilowatt-hour. These data were extracted from FERC Form 1 for IOU's and from comparable sources for municipal utilities and co-ops. We used these tariff-level data on customers and delivered energy to weight the resulting bill and marginal price calculations to represent a national distribution of marginal prices. Our calculations did not use a tariff unless it was also possible to collect usage and delivered energy data for that individual tariff (as opposed to being able to collect such information only for the entire utility or a group of that utility's tariffs). Industrial tariffs, as contrasted to commercial tariffs, have not been included in CTAS. This is primarily because the MAISY® database does not include industrial buildings.

B.1.4 Sample Buildings/Customers

The collection of buildings contained in CTAS came from MAISY®, a proprietary database containing weighted, representative building collections for each state. We selected a subset of buildings from MAISY®, the subsequent weighting of which was intended to create a "prototypical" set of buildings that would exist in relatively the same proportions throughout the country, and would thus be representative of customers existing within any of the modeled utility tariffs. Each sampled building in MAISY® had a large number of associated characteristics, such as size, annual peak demand, etc. Also included are hourly load profiles for an entire year. For each of seven states (California, Washington, Colorado, Illinois, Texas, New York and Georgia) a subset of buildings was selected for inclusion in CTAS. The hourly load profiles for these buildings were then extracted from MAISY® and summed up over a month. Then these monthly loads and demand peaks were inserted into CTAS. For each state, 189 buildings, with their MAISY® building weights, were included, for a total of 1323 buildings. The 1323 buildings were apportioned to the main types of commercial buildings used in CBECS 1995 as shown in Table B.3.[3]

Table B.3: Building Types in the CTAS Sample

CBECS Building Type	Percent of Total Commercial Buildings in US	Number of Buildings in Sample	Percent of Buildings in Sample
Education	7.6%	98	7.4%
Food Sales	3.5%	63	4.8%
Food Service	6.7%	91	6.9%
Health Care	2.5%	35	2.6%
Lodging	3.4%	42	3.2%
Mercantile and Service	30.9%	406	30.7%
Office	17.9%	231	17.5%
Public Assembly	7.6%	98	7.4%
Public Order & Safety	2.1%	28	2.1%
Religious	5.0%	63	4.8%
Warehouse & Storage	9.7%	126	9.5%
Other/Vacant	3.0%	42	3.2%
TOTAL	100.0%	1323	100.0%

Generally speaking, commercial customers were assigned to a particular tariff based on their peak monthly and/or annual demand as measured in kilowatts over a short period of time, e.g. 15 or 30 minutes. We used this demand "window" to determine which of all the tariffs to apply to a particular building in the CTAS collection. For instance the GS-2 tariff carried by Southern California Edison was applied to a customer/building whose monthly peak demand is between 20 and 500 kW. This assignment by demand window means that a particular building had bills calculated using some subset of all the modeled tariffs, typically one tariff per utility.

B.1.5 Commercial Tariffs Spreadsheet (CTAS)

B.1.5.1 CTAS Calculations

CTAS does its work in batch mode; that is, a run is executed and output is produced, automatically weighted by building type, without any further user intervention. A run consists of the following steps, nested and repeated as explained:

- Each customer/building is considered in turn.
- For each building a selection is made of applicable tariffs, based on that building's peak annual demand.
- For each tariff a calculation of a monthly bill in $/month is performed.
- A second calculation with the same month, tariff and building is performed with decremented monthly energy use and peak demand to obtain a change in the building's bill representing ballast energy and demand savings under a ballast standard. The assumed energy use decrement is 5 percent; the demand decrement is 80 percent of 5 percent, that is, 4 percent (see below for derivation of these percentages).
- A monthly marginal price in $/kWh for this month-tariff-building is computed by dividing the difference between the two bills by the difference between the two energy consumption levels, e.g., change in $/change in kWh
- An average price in $/kWh is computed by dividing the original, undecremented bill by the original energy use, e.g. bill $/total kWh.
- The percentage difference between the average and marginal price is calculated by subtracting the average price from the marginal price and dividing by the marginal price.
- These calculations are repeated for the 12 months of a calendar year.
- Annual values are obtained for average price, marginal price, and percent difference by summing each month's values over the year and dividing by 12.
- The process is repeated for each applicable tariff for the particular customer/building.
- The next building is considered and the complete process repeated, until all customer/buildings have been processed.

B.1.5.2 CTAS Output

The output from a CTAS run is written to a comma-separated-values, or "csv" file, with a record for each building-tariff match. This file, containing the fields shown below, is loaded into a FoxPro table where additional processing occurs to produce various charts and distributions.

Field Name	Field Description
ACCTNO	MAISY® customer / building ID number
STATE	State from which sample customer was drawn
ANPKKW	Building annual peak demand in kW measured over 1 hour

TARFTYP	Tariff group index defined by demand “window”
ARFINDX	Index used in program
TARPTR	Index used in program
UTILCO	Electric utility’s name, e.g. Consolidated Edison
TARFNAME	Name of particular tariff, e.g. GS-1
NCUS	Number of customers billed under that tariff
DELVDMWH	Annual megawatt-hours delivered by utility to customers under this tariff
BLDGWT	Calculated weight of building, derived in part from MAISY® weight
BLDGOPHR	Weekly hours of operation of building
ANAVGRAT	Annual average electricity price
ANMR1	Annual average electricity marginal price
ANE1	Annual percent difference between marginal and average electricity price
AVGBILL	Annual average bill, defined as average of 12 monthly bills
AVGBILL1	Annual average decremented bill, defined as average of 12 monthly average bills
AVGKWH	Annual average energy use, defined as average of 12 monthly energy usage levels
AVGKWH1	Annual average decremented energy use, defined as average of 12 monthly decremented energy usage levels

B.1.5.3 Demand Decrement Due to Standards - The Role of Lighting Coincidence and Diversity

In the process of marginal price estimation, it was necessary to account for demand charges in the calculation of some commercial sector bills. Demand charges depend upon the peak building demand (kW) each month. For each customer or building analyzed, the monthly energy use (kWh) and the monthly demand (kW) were based on actual annual kWh and actual summer and winter peak kW and summer and winter average peak kW. Since a change from energy-efficient magnetic (EEM) ballasts meeting the current standard to electronic ballasts for four-foot T12 systems would save about 15 percent of lighting energy used by fluorescent systems and since about 30-35 percent of building energy use is for lighting, about 5 percent of building energy use will be saved if EEM ballasts are converted to electronic ballasts. We assumed that the 5 percent reduction occurs every month.

It was also necessary to estimate the reduction in peak demand if building energy use is reduced by 5 percent on average. Some analysts prefer to discuss this issue in terms of diversity and coincidence. Coincidence is the lighting kW during the building peak divided by the lighting peak kW. In this situation, we expected the coincidence factor to be close to 1.0 since whatever the maximum number of systems that operate during the lighting peak, a very similar number of systems can be expected to operate during the building peak. Edison Electric Institute (EEI) suggested using 0.9 for the default coincidence factor.[4]

Coincidence factor (C) = lighting kW during building peak/lighting peak kW

The diversity factor is a measure of the percent of the installed kW for lighting used during the lighting peak. Diversity was already accounted for because the actual building energy usage (which we have from the MAISY® database) already excluded those systems not in use during some parts of the day. We were instead concerned with lighting average kW because that was, in essence, reduced by 5 percent in the bill calculator when monthly energy use was reduced by 5 percent. We assumed that the lighting hours would not change when more efficient ballasts were installed.

Diversity (D) = lighting peak kW/lighting kW installed

Although some analysts might multiply coincidence (C) times diversity (D), that would not yield the desired ratio of lighting kW during the building peak to lighting average kW.

In relative terms, we assumed demand reduction to be 80 percent of energy savings. We chose 80 percent because we believe that coincidence is the main factor we need to consider and the only two data points we had available averaged to 0.80. These two data points were EEI's suggestion of 0.90 as a default value and data from Massachusetts Electric (also submitted by EEI) indicating an annual average coincidence factor of approximately 0.70.[5] For our case of 5% energy savings, we assumed that the demand reduction would be 4% of peak kW. This means that if 500 identical fixtures are operating on average, that only 400 (or 80%) are operating during the building peak demand period. We use the 80% value relative to the average value because the monthly lighting energy use can be considered to be equal to the average kW times the monthly lighting hours and we are reducing monthly lighting energy use by a fixed percentage.

B.1.5.4 Weighting Method

The sample of commercial buildings consisted of 1323 buildings from seven states with each building supplying multiple observations to the final data set, one for each applicable tariff. Each observation in the final data set represented a unique combination of a building and an applicable tariff, for a total of 29,133 observations.

The composition of our sample posed a dual weighting problem: distributing weights across buildings and across tariffs. Our weighting approach solved these problems sequentially. For each building a weight was derived from its original MAISY® building weight and scaled up to the national level. This adjusted building weight was then apportioned across all the tariffs that were applied to the building. A composite weighting factor for each building/tariff pair combined both of these weighting factors. These weights were based on energy, average monthly kWh usage at the building level and annual MWh sales for each tariff.

B.1.6 RESULTS

Figure 1 below displays the results of the commercial analysis by showing the distribution of the differences we derived between marginal electricity prices and average electricity prices. (These are the outputs from the marginal electricity price analysis; see chapter 4, Figure B.3, for the distribution of inputs to the LCC analysis). Electricity marginal prices range from 85 percent below to 51 percent above the average price for the same customer. At the consumption-weighted mean of the differences, electricity marginal prices are 5.2 percent lower than average prices.[c] In our LCC analysis of commercial sector ballasts, we used this distribution of differences along with a distribution of average commercial sector electricity prices (which we obtained from EIA data on over 3000 utilities serving commercial customers for the year 1997) to generate a distribution of marginal electricity prices.

In the LCC analysis of industrial sector ballasts, we used this same distribution of differences along with a distribution of average industrial sector electricity prices (from EIA data on over 2000 utilities serving industrial customers for the year 1997) to generate a distribution of marginal electricity prices.

As a result of the sensitivity analysis mentioned earlier (where we included additional municipal utility tariffs), we found a similar distribution of weighted amounts by which average prices exceeded marginal prices, the mean of which was –5.6 percent. We also performed a sensitivity analysis to determine the impact of altering the percentage energy savings and demand reduction. For a 10 percent energy savings and 5 percent demand reduction, we calculated an average percent difference from the average price of -5.6 percent, compared to the base case of -5.2 percent.

Table B.4 shows the time series of marginal electricity prices used for the NES analysis, adjusted from the AEO Reference Case forecast. A factor was used to calculate the marginal price from the average and marginal prices as follows. The average price for the commercial sector was 7.62¢/kWh (1997$), which came from the weighted binned distribution of average prices from *EIA 1997 Electric Utilities.* Note that it differed slightly from the 1997 price reported by *AEO 99.* For the industrial sector, the average price was 4.55¢/kWh (1997$) from a similar distribution from utilities serving the industrial sector. The adjustment factor was the ratio of the weighted average of the modeled *marginal* price of $0.05815 to the weighted average of the *average* prices of $0.06119 from the marginal rates analysis (see section B.1 above). This factor reduced the average prices noted above for each sector by approximately 5 percent.

[c] The individual amounts by which average prices exceeded marginal prices had to be binned to prepare inputs for the Crystal Ball LCC analysis. The weighted mean of the binned distribution was –5.7 percent.

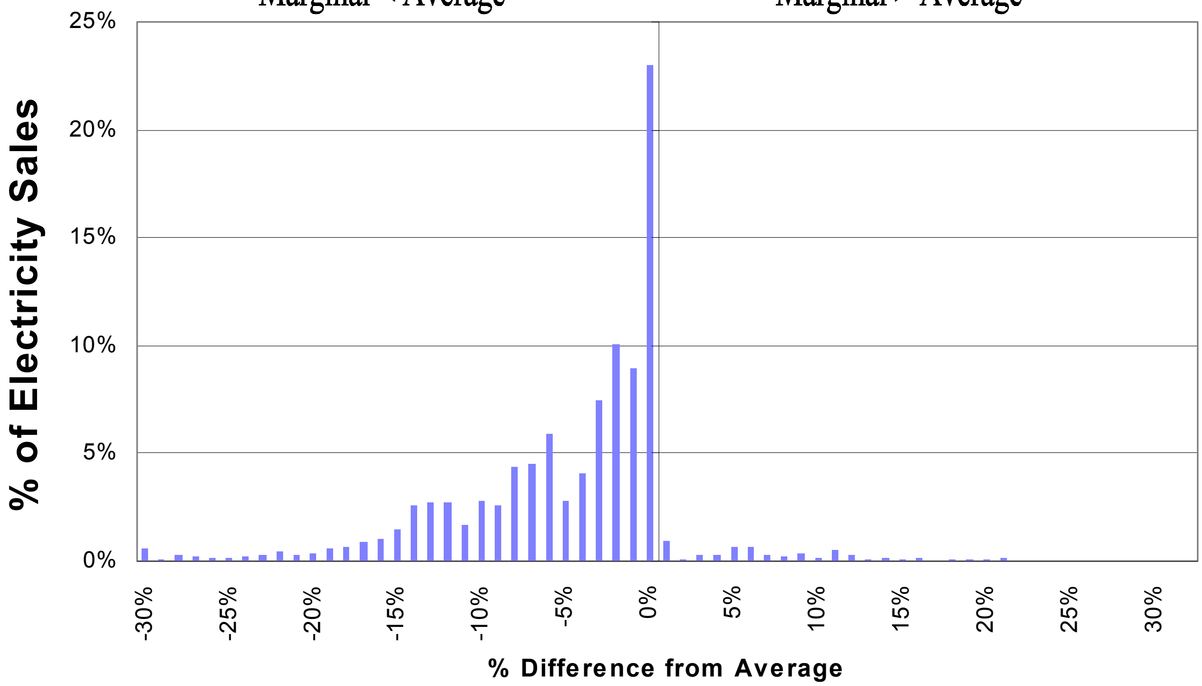
Table B.4 Marginal Prices, Commercial and Industrial Sectors

	Commercial *(cent/kWh)*	Industrial *(cent/kWh)*
1997	7.24	4.32
1998	7.08	4.21
1999	6.97	4.20
2000	6.84	4.16
2005	6.53	4.00
2010	6.26	3.79
2015	5.92	3.54
2020	5.71	3.41
2025	5.71	3.41
2030	5.71	3.41

Figure B.1

Commercial Electricity Marginal Prices Differences from Annual Average

Marginal < Average   Marginal > Average



Mean = -5.2 percent   Median = -3.3 percent
Minimum = -85 percent   Maximum = +51 percent

B.2 NES SPREADSHEET DOCUMENTATION

The following is the documentation for the NES spreadsheet model used for the national energy savings analysis. See Chapter 5 for details on assumptions and scenarios for the ballast analysis. The NES model (NES_v4.xls) is found on DOE's website http://www.eren.doe.gov/buildings/codes_standards/applbrf/ballast.html.

B.2.1 Overview

The NES spreadsheet performs calculations of national energy savings based on user inputs similar to those for the LCC spreadsheet (see Appendix A). These are used along with forecasts of magnetic ballast shipments and a social discount rate to perform projections for converting from magnetic ballasts to more efficient ballast options: electronic ballasts and cathode cutout ballasts. The national energy savings, energy cost savings, equipment costs, and net present value for four major ballast classes (1F40T12, 2F40T12, 2F96T12, and 2F96T12HO) are forecasted from the start year through 2030.

The NES spreadsheet operates in Excel 97 or Excel 7 (Windows 95). When the spreadsheet is opened, always select "Enable Macros" in the Excel pop-up window.

The defaults listed in each section below have been set to model Scenario 1 for the two ballast trial standards levels (electronic and cathode cutout). The user makes selections to model the other Scenarios, as described in the instructions in section B.2.3.9 below.

B.2.2 Model Worksheets

The workbook **NES_v4.xls** includes the following worksheets:

RESULTS contains the summary table of energy savings, benefits (energy cost savings), equipment costs, and NPV for the four ballast classes and the national totals. The screen also shows the current inputs for fuel price projection, weights, delay period, and shipments.

Annual contains annual energy savings (for the Utility, Environmental and Indirect Employment Analyses and annual benefits and costs (for the Indirect Employment Analysis).

Engineering contains inputs for the calculations of energy savings and change in equipment costs for each ballast class.

Com Elec Price contains various projections of commercial sector average and marginal electricity prices.

Ind Elec Price contains various projections of industrial sector average and marginal electricity prices.

1F40T12 through 2F96T12HO
contain the forecast calculations for the four separate ballast classes.

Elec Conv contains conversion factors from kWh to Btus derived from EIA's Annual Energy Outlook 1999. The results are used to convert the energy savings results from site TWh to source Quads.

Shipments contains the summary of the shipments forecasts for magnetic ballasts and the electronic and cathode cutout ballasts that replace them under the standards.

Ballast Retire Schedule contains ballast retirement schedules for the four ballast classes.

Lamp Repl Schedule contains lamp equipment and replacement costs, to account for lamp replacements over the lifetime of each set of annual ballast shipments. The equipment costs are different for T12 and T8 lamps. The equipment and labor costs are different for lamps used with cathode cutout ballasts vs. magnetic and electronic ballasts (since their lifetime is shortened by CC ballasts and they are replaced more frequently over the lifetime of the ballast).

Default Engr contains the default engineering and price data.

Setup is used as an interface between user inputs and the rest of the worksheets. This sheet also contains the marginal electricity price calculations, calculations of weights based on user inputs for percentage conversion to electronic and cathode cutout ballasts and percentage T12 and T8 electronic, temporary shipments calculations for the Shipments worksheet, and electricity prices for the graphs in the Fuel Price Projection menu.

B.2.3 Spreadsheet Operation

The user interacts with the spreadsheet by clicking choices or entering data using the graphical interface. The entry point to the user interface is the **LIST INPUTS** menu. The **LIST INPUTS** menu can be invoked by clicking the **[LIST INPUTS]** button on the **RESULTS** worksheet or by hitting **<CRTL>L** from any worksheet.

From the **LIST INPUTS** menu, the user can make selections as well as enter the input screens for selecting (1) ***Electricity Price Projection***, (2) ***Effective Date of Ballast Standards*** and

Delay Period, (3) ***Discount Rate*** *and* ***Discount Year***, (4) ***Shipments Forecast,*** (5) ***Ballast Assumptions***, and (6) ***Ballast Weights*** by clicking the corresponding button.

When inside any one of the six input screens, the user can switch over to any other screen or back to the **LIST INPUTS** menu by clicking the corresponding button at the bottom.

After making the selections, the user can start the calculation by clicking the **[CALCULATE]** button or by hitting **<ALT>C**. In case the user wants to disregard the selections that have been made, the setup session can be canceled by clicking the **[CANCEL]** button in the **LIST INPUTS** menu, or the **X** at the top right of any screen. Note that the **RESULTS** screen will still reflect any changes made prior to the last calculation.

In the **Ballast Assumptions** screen, to return to the default input values, click on the [**Load Defaults]** button. If new results were previously calculated, another calculation must be done (using **[CALCULATE]** or **<ALT>C**) in order to produce the default results. This button resets only the **Ballast Assumption** and **Weights** inputs; it does not affect changed inputs from other menus in **LIST INPUTS**.

The user may view a summary of the inputs for fuel price projection, weights, and shipments in the upper right of the **RESULTS** screen; the summary is updated after each calculation. In Weights Assumptions, % Converted to Electronic, the first period is listed as "skipped" if there is no delay period.

IMPORTANT NOTE: Input changes should always be made in the **LIST INPUTS** menu. The user may view the impacts on the other worksheets, but editing those sheets could cause calculation errors, especially if formulae are overwritten.

The exception is the **Default Engr** worksheet; here the user may change the default engineering values. These values will then be loaded when **Load Defaults** is selected. (Results will then be different than those from the original NES_v.4 model.)

Fuel Price Projection Menu

The user selects one of the five available electricity forecasts for 1999. The selected forecast trend is used for projecting future marginal electricity prices, which are shown in graphic and table form for the commercial and industrial sectors. Selecting **<Show Comparison>** produces a graph of the average prices for the five forecasts (the trend line is similar to that of the marginal prices). The default is the AEO 1999 Reference Case projection.

Marginal prices for both the commercial and industrial sectors are used in the NPV calculations. The NES model and analysis uses a single point value for each year (rather than a distribution of marginal prices as used for the LCC analysis). The marginal prices used in this analysis, calculated from the AEO Reference Case forecast, are shown in Table B.4 above.

Marginal prices for any NES electricity price scenario are calculated in the model as follows. As shown in cells G5 and H5 of the **Setup** worksheet, a ratio is used to calculate the 1997 marginal price from the 1997 EIA weighted average electricity price (see section B.1.6 above). For any projection selected, the model uses the resulting 1997 estimated marginal price and adjusts electricity prices for future years based on the price trend for 1997 through 2030 in that projection.

The average prices as well as marginal prices appear in the **Com Elec Price** and **Ind Elec Price** sheets for all the price projections. The marginal prices appear also in the **Setup** sheet under "Marginal Elec Price Projection."

Year to Start Standard Menu

The assumed effective date for the ballast standards is chosen from the menu. The user may also select a **Delay Period for Replacement Ballast Market** in years, assuming that the standards would apply to ballasts sold in luminaires in the start year and apply to ballasts sold separately (for the replacement market) a specified number of years later. The default values are the year 2003 with no delay period (0 years). To select the relative sizes of these markets, use the **Weights** menu as described below.

Discounting Menu

The user selects the *social* discount rate. Note that this is the discount rate used for national Net Present Value calculations, and is not the same as the discount rate used in the LCC analysis. The default value is 7 percent.

The user selects the year to which the equipment costs are to be discounted for the NPV calculation. The default value is 1997.

Shipments Menu

The **Shipments** menu allows the user to select **Decreasing Shipments** or **Constant Shipments**. In the decreasing shipments scenario, magnetic ballasts shipments decrease to a selected base value by a certain year, and remain constant at that value through 2030. The user selects these shipment values in the **Reduce Shipments to (millions)** and **By Year** boxes. The default **Decreasing Shipments** scenario uses a magnetic ballast shipments forecast for the start year based on a linear regression through actual 1993 - 1997 shipments for the 2F40 ballast class until 2015 and assumes that a small number of magnetic ballasts (10 percent of the 1997 shipments) will continue to be sold each year after 2015. This is called the "Decreasing Shipments to 2015" scenario in the ballast analysis. To run the "Decreasing Shipments to 2027" scenario, select 2027 from the pull-down menu right under the **By Year** label. To select another year (other than 2015 and 2027), or to enter different years for different lamp/ballast combinations, enter the years in the four separate boxes below.

The **Constant Shipments** scenario assumes that magnetic ballast shipments remain constant at near-1997 levels through 2030.

By selecting **<Show Shipments>** on this menu, the user may view the graphs of shipments for the four lamp-ballast combinations. Note that the 1F40 graph has two lines; the lower line is for 1-lamp F40T12 ballasts in one-lamp fixtures, and the upper line is for all 1F40 shipments, including those in 3-lamp fixtures. The linear regression through historical data for 1993 - 1997 is also shown. For the default scenario, the 2F40 and 2F96 lines follow this linear regression, while the 1F40 and 2F96/HO lines do not; however, the same year (2015) is chosen for all four lamp-ballast combinations for simplicity.

Ballast Assumptions Menu

This menu has categories for 1-lamp four-foot, 2 to 4-lamp four-foot, 2F96T12, and 2F96T12HO ballasts. The four-foot categories have data for ballasts in 1-lamp, 2-lamp, 3-lamp tandem-wired, 3-lamp non-tandem-wired, and 4-lamp fixtures.

In **view/edit**, the user can observe or adjust:

& **Ballast Price**, which automatically changes these values, shown for reference:

> **Total Equip + Install. Cost** = Ballast Price + Install. + Lamp Cost, where
>
> **Install. + Lamp Cost** = Ballast Labor Cost + Initial Lamp Equipment + Lamp Labor Cost

Note that EEM 3-lamp and 4-lamp ballast prices adjust automatically as 2-lamp and 1-lamp ballast prices are changed by the user. CC ballast prices for 3- and 4-lamp fixtures are not shown, but they function in the same manner as the EEM ballast prices.

& **Mean Lumens** (four-foot fixtures) for 1-lamp and 2-lamp fixtures
& **CU** (coefficient of utilization) for four-foot fixtures using 2, 3, and 4 lamps
Load Defaults restores the default ballast assumptions.

The default values for mean lumens are found in Chapter 3, Table 3.8. The default CU values are 1.0; see the discussion in Chapter 3, section 3.6. Other default values in this screen (annual lighting hours, ballast lifetime, and equipment and labor costs) are the same as those in the LCC spreadsheet, as described in Chapter 3 and Appendix A.

Weights Menu

This menu allows the user to make three different types of choices, reflecting different *weights* or percentages of the total for each category.

In the upper left section of the sheet, **% Converted to Electronic** allows the ballast market under an electronic ballast standard to be separated into the *New/Renovation* segment, for ballasts sold in luminaires and the *Replacement* segment, for ballasts sold separately. These weights (percentages) apply to 4-foot, 8-foot, and 8-foot HO ballasts. These percentages may be selected separately for the **1st Period** and the **2nd Period**. The delay period chosen in the **Year to Start Standard** menu is automatically displayed to the right as **(x) Years Later**. If there is a delay period, the value for the first period for the **(Replacement Market)** should be set as 0 percent; this is the default value. This means that the standard will not apply to this percentage of the market during the delay period, while the percentage comprised by ballasts for new/renovation period (default 70 percent) will be affected. The default value for the **(New/Renovation Market) 1st Period** is 70 percent. The default values for the second period are 70 percent for the new/renovation market and 30 percent for the replacement market, selected as described in Chapter 5, section 5.3. For the second period, the two percentages should always add to100 percent.

In the upper right section, **New/Renovation % Converted to...** and **Replacement % Converted to...** allow the user to select percentages of 4-foot magnetic ballasts converted to either T8 ERS ballast/lamp systems or T12 ERS systems. These may be selected separately for the new/renovation and the replacement markets (headings on the left). The user may select a single value for all 5 system types in the box outlined in red, or individually in the boxes below. The user selects the T8 percentages and the T12 percentages automatically adjust to equal 100 percent. The default values are 100 percent T12 ERS.

In the middle section, **Ballast Weights in Fixtures** shows the percentage of four-foot 2-lamp magnetic ballasts in fixture types by number of lamps and configuration (2-lamp, 3-lamp tandem-wired, 3-lamp non-tandem-wired, and 4-lamp fixtures). The model uses the weights for the years 1997 and 2009, assigning weights linearly to each year in between, and uses the 2009 weights for all years thereafter. The user may specify the weights for 2009. The default weights for both years are estimated by LBNL (see section B.3 below). By 2009, the weights are assumed to have saturated the building stock and are used for all years thereafter.

Load Defaults restores the default weights.

Weights for the Cathode Cutout Standard

In the List Inputs menu lower left corner, **For CC Standard, % of EEM Conversion to** allows the user to select the percentage of magnetic ballasts converted to cathode cutout and percentage to electronic ballasts under a cathode cutout standard. The default value is 100 percent cathode cutout. The weights selected in **Weights** for the New/Renovation market segment determine the percentage of the electronic ballasts that are T12 ERS and T8 ERS.

Shipments Worksheet

The **Shipments** worksheet contains the shipments that result from user inputs as described below. These are used as input to the GRIM (Government Regulatory Impact Model). <u>The NES</u>

user should not change shipments in this sheet. The magnetic ballast shipments from 1998 on are calculated by the model based on the scenario and inputs chosen by the user in **List Inputs**, **Shipments** menu. The electronic and cathode cutout shipments are calculated by the model based on user selections in **Weights** and the percent of EEM Conversion to CC and Electronic in **List Inputs**. As described above, the weights for the 2-lamp ballasts in four-foot fixtures vary from 1997 to 2009.

This worksheet contains two alternative sets of shipments from 1997 to 2030. The upper half shows shipments for the electronic ballast standard (which can include conversion to T12 as well as T8, depending on user input), and the lower half for the cathode cutout standard (which can include some electronic ballast T12 and T8 conversion, depending on user input).

Note that these shipments represent only those ballasts that would replace magnetic ballasts sold in the base case. Three-lamp fixtures with magnetic ballasts that are not tandem wired being replaced by electronic ballasts are assumed to use single 3-lamp electronic ballasts, while tandem-wired magnetic ballasts are replaced by tandem-wired electronic ballasts. Four-lamp fixtures with magnetic ballasts being replaced by electronic T8 ballasts are assumed to use single 4-lamp ballasts, while those with T12 electronic ballast replacements have 2 ballasts. Therefore, the electronic shipment totals are lower than the magnetic shipment totals.

In the cathode cutout standard, since there are no F96T12 cathode cutout ballasts, the magnetic shipments are assumed to remain magnetic ballasts.

B.2.4 Instructions for Modeling the Standards Scenarios

This section contains instructions on how to change the Default settings to reflect each scenario's assumptions.

Scenario 1A&5A:	Use Default inputs
Scenario 1B&5B:	In Shipments, change "By Year" value from 2015 to 2027.
Scenario 2A&5A:	In List Inputs, change "For CC Standard, % of EEM Conversion" to 30% from 100%. In Weights, change "% Converted to T8 ERS" to 95% for both New and Replacement markets.
Scenario 2B&5B:	Ditto, and in Shipments, change "By Year" value from 2015 to 2027.
Scenario 3A:	In Year to Start Standard, change the "Delay Period" to 5 years. In Weights, change "% Converted to T8 ERS" to 100% for New/Renovation market and 95% for Replacement market.
Scenario 3B:	Ditto, and in Shipments, change "By Year" value from 2015 to 2027.
Scenario 4A:	In Year to Start Standard, change the "Delay Period" to 2 years. In Weights, change "% Converted to T8 ERS" to 100% for New market and 95% for Replacement market.
Scenario 4B:	Ditto, and in Shipments, change "By Year" value from 2015 to 2027.

Scenario 7A:	In Year to Start Standard, change the "Effective Date" to 2005 and "Delay Period" to 5 years. In Weights, change "% Converted to T8 ERS" to 100% for New/Renovation market and 95% for Replacement market for all 5 types.
Scenario 7B:	Ditto, and in Shipments, change "By Year" value from 2015 to 2027.
Scenario 7C:	Use inputs for 7A, and in Shipments, select "Constant Shipments."

B.2.5 Modeling the Regulatory Impact Analysis Alternative Cases

We used the NES model for the Regulatory Impact Analysis in the RIA section of this document. Refer to that section for discussion of the basis of the assumptions. As defined in that section, "conversion rate" means the percentage of ballasts that would be magnetic for any year in the base case that are electronic T8 in the alternative case (the base case already assumes that some ballasts would be electronic.) The standards cases shown in Chapter 5 have a 100 percent conversion rate to electronic ballasts (either T12 or T8).

We implemented the conversion rate in **Weights**, "% Converted to Electronic" for the New/Renovation Market for both periods, using 0 percent in the Replacement Market. Whenever 0 percent is used in the two New/Renovation fields, the NES model requires a non-zero value because of calculation equations, so we used 0.0001[d]. We assumed that the policy would affect this market (in the model this input simply means that x percent of the total market is affected, and the results are the same as if the input were applied to the other market segment). In **Weights**, "% Converted to T8ERS," we used 100 percent for both the New/Renovation and the Replacement Markets.

Following are instructions for modeling the RIA cases. To adjust the conversion rates, follow the method in the paragraph above. Each case was run under the 2027 Shipments scenario; adjust the "By Year" values in the Shipments menu accordingly. The Start Year was 2003 for all the alternative policies except Voluntary Efficiency Targets, which was modeled with a start year of 2005.

Tax Credits to Consumers

Approach: Reduce the incremental ballast price by 50 percent for 1-lamp and 2-lamp four-foot and all 8-foot and 8-foot HO ballasts. Use a 7 percent conversion rate.

Method: Reduce the ballast price by half in **1F40T12**, **2F40T12** (2-lamp and 3-lamp tandem wired), **2F96T12**, and **2F96HOT12** worksheets, in the cells for *Unit Incr. Price from EEM* (for four-foot systems adjust the T8 ERS price and for eight-foot systems adjust the EIS or ERS price). In **Weights**, use a 7 percent conversion rate as described above. (Note: It would be difficult to adjust the conversion rate so that it didn't apply to 3-lamp non-tandem-wired and 4-lamp ballasts; we

[d]Note also that the percentage values after the decimal point no longer appear after the calculation, but they do affect the results.

assumed that the existence of rebates for 1- and 2-lamp ballasts would influence these systems, whose price differential was minimal or negative, to convert to electronic at the same rate.)

Tax Credits to Manufacturers

Approach: Reduce incremental ballast price by $0.04.

Method: Reduce the *Unit Incr. Price from EEM* in the 4 worksheets for all systems.

Rebates to Consumers

Approach: Reduce the incremental price by 50 percent. Use a 12 percent conversion rate.

Method: Implement in a similar manner to Tax Credits to Consumers, but with a 12 percent conversion rate in **Weights.**

Voluntary Targets, 10 Years

Approach: Assume that the entire market experiences a 10-year delay after 2005.

Method: In **Year to Start Standard,** select 2005 as the Effective Date and select a 10 year delay period. In **Weights**, "1st Period", use 0 percent for both market segments.

Voluntary Targets, 5 Years

Approach: Assume that the entire market experiences a 5-year delay after 2005.

Method: In **Year to Start Standard,** select 2005 as the Effective Date and select a 5 year delay period. In **Weights**, "1st Period", use 0 percent for both market segments.

Labels and Consumer Education, Current Technologies

Approach: Assume a 3 percent conversion rate.

Method: Use a 3 percent conversion rate in **Weights.**

Enhanced Labeling and Consumer Education, Alternative Technologies

Approach: Increase ballast kWh savings by 40 percent for F40 and F96. Assume no daylighting potential for industrial sector F96HO. Increase electronic ballast incremental cost by $7. Assume 0.6 percent conversion rate to dimming ballasts. Assume that consumers not converting to dimming ballasts would still convert to regular electronic ballasts due to consumer education.

Method: In the **1F40T12**, **2F40T12**, and **2F96T12** worksheets, increase *Unit kWh Savings from EEM* by 40 percent. In the same worksheets, increase *Unit Incr. Price from EEM* by $7. In **Weights,** use a 0.6 percent conversion rate.

Run another case with default kWh savings and default ballast prices and a 2.4 percent conversion rate (3 percent - 0.6 percent) in **Weights**. Add the results to those from the first run.

Government Purchases

Approach: Use a 10 percent conversion rate.

Method: Use a 10 percent conversion rate in **Weights**.

Policy 9. Lighting Research

Approach: Increase the incremental kWh savings by 40 percent, incremental cost by $7. Use a conversion rate of 1.6 percent and a time delay of 5 years. Assume these impacts are also achievable in the industrial sector.

Method: In the **1F40T12**, **2F40T12**, **2F96T12**, and **2F96T12HO** worksheets, increase *Unit kWh Savings from EEM* by 40 percent. In the same worksheets, increase *Unit Incr. Price from EEM* by $7. In **Weights,** use a 1.6 percent conversion rate (may be entered as 1.1 percent New/Renovation and 0.5 percent Replacement to represent their relative sizes). In **Year to Start Standard,** use a 5 year delay period. In **Weights**, "1st Period", use 0 percent for both market segments.

Building Codes

Approach: Use a 1 percent conversion rate for the 2015 scenario and a 3 percent conversion rate for the 2027 scenario. Assume that the code takes effect in 2005.

Method: In the 2015 base case, use a 1 percent conversion rate in **Weights.** In **Year to Start Standard,** use a 2 year delay period. In **Weights**, "1st Period", use 0 percent for both market segments.

In the 2027 base case, assume 3 percent conversion rate in **Weights.** In **Year to Start Standard,** use a 2 year delay period. In **Weights**, "1st Period", use 0 percent for both market segments.

B.3 SHIPMENTS AND BALLAST WEIGHTS

The shipments scenarios used for the NES analysis are described in Chapter 5 (sections 5.2.1 and 5.3.1).

This section describes the calculations of the "ballast weights" assumed for two-lamp magnetic ballasts in four-lamp fixtures for use in the NES model. Two-lamp ballasts may be used in two-lamp fixtures, three-lamp tandem-wired fixtures, three-lamp non-tandem wired fixtures (with a one-lamp ballast), and four-lamp fixtures.

The goal was to estimate the weights, or percentages, of two-lamp magnetic ballasts that were used in each of these fixture types. The first step was to estimate the "fixture weights" for one-, two-, three-, and four-lamp fixtures, and the second step was to estimate the "ballast weights." Both types of weights were estimated for the year 1997 and the year 2009, which is the midpoint between the year the standard starts, 2003, and the year the magnetic ballast shipments reach their base level in the "Decreasing Shipments to 2015" scenario. The NES model uses the ballast weights for these two years and estimates those for the intervening and succeeding years. See section B.2.3, Weights Menu, for discussion of user inputs.

The fixture weights (and therefore the ballast weights) were assumed to be changing over time. Fixture weights in existing buildings were taken from the Xenergy database and were assumed to represent the year 1995. Fixture weights for new buildings were estimated from the Bureau of Census report on Electric Lighting Fixtures (MA-36L) for 1997, which reports the fluorescent fixture sales by number of lamps for common fixture types. We assumed that the fixtures with the 1995 weights would be replaced by those with the new building fixture rates, and estimated that fixtures in new buildings or in renovated systems had an average turnover rate of 16 years. The resulting fixture weights for existing buildings in 1997 and in 2009 are shown in Table B.5. By 2009, the new weights are assumed to have saturated the building stock and are used in the NES model for all years thereafter. Note that three-lamp fixtures are becoming increasingly popular.

From these fixture weights, we calculated the ballast weights, making the following assumptions: Two-lamp fixtures each had 1 two-lamp ballast; three-lamp fixtures were 20 percent tandem wired with 1.5 two-lamp ballasts per fixture and 80 percent non-tandem-wired with 1 two-lamp ballast (and a one-lamp ballast); and four-lamp fixtures had 2 two-lamp ballasts. The resulting ballast weights for 1997 and for 2009 are shown in Table B.6. These are the weights used in the NES analysis. As noted in section B.2.3, the weights for 1997 are fixed in the NES model, but the user can adjust the 2009 ballast weights.

Table B.5. Fluorescent Fixture Weights by Number of Lamps (percent of market)

Fixture Type	Existing 1995	New	Existing 1997	Existing 2009
One-lamp	9 %	7 %	9 %	7 %
Two-lamp	51 %	38 %	49 %	40 %
Three-lamp	7 %	24 %	10 %	22 %
Four-lamp	33 %	31 %	33 %	31 %

Table B.6. Fluorescent Ballast Weights (percent of two-lamp market)

Fixture Type	Existing 1995	Existing 1997	Existing 2009
Two-lamp	41 %	39 %	32 %
Three-lamp tandem wired	2 %	2 %	5 %
Three-lamp non-tandem-wired	4 %	6 %	14 %
Four-lamp	53 %	52 %	49 %

B.4 LIGHTING/HVAC INTERACTIONS

B.4.1 Methodology

We used the DOE-2 building simulation model to calculate energy load changes due to installation of more efficient lighting for each of eleven major building prototypes with several subtypes in five different climate zones (a total of 36 combinations). Also, we used CBECS data to determine the square footage of each building type found in each climate zone. Using a spreadsheet, we combined the load information with the following additional information to calculate the change in HVAC energy use resulting from a unit reduction in lighting energy. The multipliers that calculate the change in cooling or heating energy per unit of lighting energy are called the cooling or heating *coincidence factors*. We combined market shares for the different equipment types (e.g. oil-fired boiler, gas furnace, heat pump) by building type with heating and cooling coincidence factors by building type, equipment efficiencies and distribution system losses.

In hot climates the use of more efficient lighting results in smaller heat losses that generate large savings from reductions in cooling energy use. However, in cold climates the additional energy needed for heating generally outweighs the cooling savings. Our study attempted to estimate the *net average* national energy impacts for all climates and building types in the nation.

B.4.2 Savings in Existing Buildings

The first approach used CBECS 1992[6] data that represented the building stock in 1989. The results showed averages for this building stock for each building type across several climate zones, weighted by floor space of that building type found in each climate zone. The results are shown in Table B.7. We found that substantial net HVAC savings can be attained in large offices, large hotels, and hospitals. These building types constitute 23 percent of the floor area of the building types for which calculations were performed (see next paragraph for building type coverage). Schools, on the other hand, constitute close to 20 percent of the same commercial floor area, and lighting efficiency improvements generate large heating increases in this building type. We obtained this result because in schools the cooling-lighting coincidence is low and the heating-lighting coincidence is high. The other building types (small office, large and small retail, grocery, restaurant, small hotel, and warehouse) showed small net increases in energy consumption from installation of more efficient lighting.

When averaged, the net effect of lighting/HVAC interactions for the U.S. building stock was very small (approximately zero). It should be noted that this calculation covered about 76 percent of the commercial building area. The other 24 percent included assembly buildings, parking garages, public order and safety buildings, building types not covered by the conventional categories, and vacant buildings. We assumed that the average lighting/HVAC interactions for these building types would be approximately equal to that found in the 76 percent of buildings for which we performed calculations.[e]

In response to comments that these savings were lower than those of other researchers, we compared our findings to theirs and found them consistent. E-source indicated that the bonus savings presented in their document are representative of typical large office buildings[7]. They presented two sets of calculations. The first set was based on a previous LBNL publication[8] which formed the basis of the more recent LBNL study.[9] The second set was based on Rundquist, et al. (1993).[10] For large offices, E-source indicated that cooling site energy savings are in the range of 28 - 36 percent. The Eley Memo was based on DOE-2 runs that showed that the cooling bonus is about 10 percent to 20 percent of the lighting savings.[11] As shown in Table B.7, we calculated a 28 percent reduction in cooling energy in large office buildings due to the installation of efficient lighting.

The numbers for heating penalties were not directly comparable because we presented results in terms of primary energy, while E-Source presented results as site energy. Nevertheless, E-source indicated that the heating site energy penalty is 0 to 21 percent. We showed an average heating penalty of 16 percent for large office buildings in the United States in terms of primary energy. It should be noted that the Rundquist study used two generic commercial building types (small and large). In the LBNL studies, 36 prototypical building models were simulated.

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[e] The calculations were not performed for the other 24 percent of buildings because there were not enough buildings of those types in enough different climate zones in the CBECS data set. Although these building types represent 24 percent of floor area, they are likely to represent a smaller percentage of building energy consumption.

Table B.7 Lighting/HVAC Interactions for the U.S. Building Stock in 1989: Averaged Using Floor Area
(Percent change in HVAC source energy per one unit change in lighting primary energy)

	Small Office	Large Office	Small Retail	Large Retail	Small Hotel	Large Hotel	Hospital	Grocery	School	Restaurant	Warehouse	All Buildings
Floor Area Share	7%	17%	14%	12%	2%	3%	3%	2%	17%	2%	19%	100%
Change in Heating (kWh/kWh Lighting)(1)	23%	16%	21%	30%	22%	17%	13%	36%	31%	28%	6%	20%
Change in Cooling (kWh/kWh Lighting)(1)	-23%	-30%	-14%	-27%	-21%	-27%	-33%	-34%	-18%	-24%	-5%	-20%
Change in HVAC (kWh/kWh Lighting)(1)	0%	-14%	6%	3%	1%	-11%	-20%	2%	13%	4%	1%	0%

(1) Values in source energy: 1 kWh lighting electricity corresponds to 3.2 kWh source energy

In response to further comments that the results be weight-averaged from the lighting energy consumption of each building type rather than by the floor area, we used lighting consumption numbers from EIA[12] and calculated an overall HVAC bonus of 4 percent (in contrast to 0 percent calculated using floor area).

There were also comments that hot climates with high cooling loads were under-represented and that one climate zone used weather data from a non-representative city. We selected another city for that climate zone, and the results for the 1989 existing building stock increased from 4 to 5 percent. The final results for the existing buildings are found in Table B.8.

Table B.8 Lighting/HVAC Interactions for the U.S. Building Stock in 1989: Averaged Using Lighting Energy

(Percent change in HVAC source energy per one unit change in lighting primary energy where the unit change is distributed over the building types proportional to the lighting energy use)

	Small Office	Large Office	Small Retail	Large Retail	Small Hotel	Large Hotel	Hospital	Grocery	School	Restaurant	Warehouse	All Buildings
Lighting Energy Share	8%	18%	9%	8%	6%	9%	17%	2%	18%	1%	4%	100%
Change in Heating (kWh/kWh Lighting)(1)	23%	16%	21%	30%	22%	17%	13%	36%	31%	28%	6%	21%
Change in Cooling (kWh/kWh Lighting)(1)	-23%	-30%	-14%	-27%	-21%	-27%	-33%	-34%	-18%	-24%	-5%	-24%
Change in HVAC (kWh/kWh Lighting)(1)	0%	-14%	6%	3%	1%	-11%	-20%	2%	13%	4%	1%	-4%

(1) Values in source energy: 1 kWh lighting electricity corresponds to 3.2 kWh source energy

B.4.3 Savings in Newer Buildings

The comments noted that the analysis was for the existing building stock as a whole in 1989, and suggested that recent higher construction rates in the south be considered to better represent future interactions over the analysis period. We addressed these issues by performing an analysis for buildings built from 1990-1995. We took the floor area developed by building type and climate region from CBECS 1995.[13] The commercial floor area developed during 1990-1995 was about 4 billion square feet, while the total floor area for the commercial sector as a whole is about 60 billion square feet.

One of the main reasons for the higher savings was that during the period 1990 to 1995, the proportion of health care buildings to the total buildings was double that for the building stock in 1989. The hospital lighting energy use and cooling coincidence factor were both very high. A few other building types (grocery and restaurant) also showed small HVAC savings because of higher construction rates in the South. These factors shifted the average net savings from lighting/HVAC interactions to 10 percent.

Tables B.9 and B.10 show the results for buildings built from 1990-1995, using floor area and lighting energy, respectively, as the weighting factor.

Table B.9 Lighting/HVAC Interactions for U.S. Buildings Built During 1990-1995: Averaged Using Floor Area
(Percent change in HVAC source energy per one unit change in lighting primary energy)

	Small Office	Large Office	Small Retail	Large Retail	Small Hotel	Large Hotel	Hospital	Grocery	School	Restaurant	Warehouse	All Buildings
Floor Area Share	5%	16%	15%	10%	2%	4%	7%	3%	15%	3%	20%	100%
Change in Heating (kWh/kWh Lighting)(1)	24%	17%	15%	27%	21%	9%	5%	25%	31%	23%	7%	17%
Change in Cooling (kWh/kWh Lighting)(1)	-18%	-27%	-14%	-31%	-20%	-30%	-29%	-32%	-22%	-24%	-4%	-20%
Change in HVAC (kWh/kWh Lighting)(1)	5%	-10%	2%	-5%	1%	-21%	-24%	-7%	9%	-1%	3%	-2%

(1) Values in source energy: 1 kWh lighting electricity corresponds to 3.2 kWh source energy

Table B.10 Lighting/HVAC Interactions for U.S. Buildings Built During 1990-1995: Averaged Using Lighting Energy
(Percent change in HVAC source energy per one unit change in lighting primary energy where the unit change is distributed over the building types proportional to the lighting energy use)

	Small Office	Large Office	Small Retail	Large Retail	Small Hotel	Large Hotel	Hospital	Grocery	School	Restaurant	Warehouse	All Buildings
Lighting Energy Share	5%	15%	9%	6%	4%	9%	31%	3%	14%	1%	4%	100%
Change in Heating (kWh/kWh Lighting)(1)	24%	17%	15%	27%	21%	9%	5%	25%	31%	23%	7%	15%
Change in Cooling (kWh/kWh Lighting)(1)	-18%	-27%	-14%	-31%	-20%	-30%	-29%	-32%	-22%	-24%	-4%	-25%
Change in HVAC (kWh/kWh Lighting)(1)	5%	-10%	2%	-5%	1%	-21%	-24%	-7%	9%	-1%	3%	-10%

(1) Values in source energy: 1 kWh lighting electricity corresponds to 3.2 kWh source energy

B.4.4 Average Savings During the Analysis Period

Table B.11 compares the savings for the stock in 1989 to those of buildings built during 1990-1995, using lighting energy as the weighting factor.

Table B.11. Energy Savings due to Lighting/HVAC Interactions in Buildings of Different Vintages

	Building Stock in 1989	Buildings Developed During 1990-1995
Extra Savings due to Lighting/ HVAC Interactionsas a Percentage of the Savings in Lighting Source Energy	5%	10%

Clearly, the lighting/HVAC interactions in the newer buildings cause more net savings than they do in the older buildings. It is not unreasonable to assume that over the next 30 years, the net savings for the building stock will move from 5 percent towards 10 percent. Assuming that commercial buildings have a 60 year lifetime, we reasoned that the building stock would be at about the midpoint by 2030, for a net savings of 7.5 percent. To represent the analysis period between 2003 and 2030, we assumed a midpoint between 5 percent and 7.5 percent, resulting in a 6.25 percent additional national energy savings. The analysis indicated that extra savings due to interactions are very sensitive to the proportion of health care buildings in the total commercial floor stock, and future values depend on the growth of floor stock for the different building types relative to each other.

As discussed in Chapter 5, the analysis presented in this document considered HVAC interactions for energy savings, but did not include them in the NPV calculations. Estimation of the relatively small impacts on the energy cost savings would be complicated by the need to analyze shifting fuel prices as well as changing building heating and cooling types over time.

B.5 NON-REGULATORY PROGRAMS

This section summarizes our research on quantifying the impacts of key non-regulatory programs on the market for efficient fluorescent ballasts. These analyses was intended to serve as a background for the base case assumptions used in projecting national energy savings. We analyzed the following non-regulatory programs that are implicit in the base case forecasts. Where possible, we have attempted to quantify the impacts in terms of number of electronic ballasts that would be purchased as a result of each program. The programs that influence the ballast market that were studied in this analysis were:

- Electric Utility Demand-Side Management (DSM) Programs
- ASHRAE/IES 90.1-1999 Building Code
- Environmental Protection Agency (EPA) Energy Star Buildings/Green Lights
- Federal Energy Management Program (FEMP)
- Energy Cost Savings Council (NEMA)

Other programs will have an influence on the future of energy-efficient lighting, but were too new or too broad in scope to analyze in quantitative detail. For example, the Department of Energy's Lighting Technology Roadmap is a comprehensive approach with many interactive options that promote the use of more efficient lighting equipment.

Quantifying the impacts of non-regulatory programs was a challenge due to several factors, including the following:

- Lack of data on most programs, particularly projections for future years

- Interactions between various non-regulatory programs as well as with building codes (which are regulatory but not component-based, as discussed below).

B.5.1. Utility DSM Rebates

B.5.1.1 Introduction

LBNL analyzed utility and national energy-efficiency spending data from several major U.S. electric utilities to produce national estimates of Demand-Side Management (DSM) rebates for electronic ballasts.[14] The study estimated the number of rebates paid for electronic ballasts annually and the monetary value of these rebates since their widespread emergence in the early 1990s, and the fraction of national ballast sales that rebates comprised. The objective was to discern trends over time in DSM rebates and their impact on the market share garnered by electronic ballasts.

B.5.1.2 Utility Data

Nine utilities provided time series data on their DSM electronic ballast rebates from 1992 - 1997. Two sample data sets, referred to as the core and expanded samples, were created. The *core* sample data set included information from six utilities, whose total energy efficiency (EE) spending represented about 17 percent of national utility spending on energy efficiency programs during that period. The *expanded* sample data set added three utilities, which provided partial data, to the core sample. Total energy efficiency expenditures for utilities in the expanded sample accounted for about 30 percent of national expenditures. The estimation technique used to incorporate these three utilities in the analysis is described below.

The six utilities that comprised the core sample data set were: Central Maine Power Company (ME), the Long Island Lighting Company (NY), Pacific Gas & Electric (CA), Rochester

Gas & Electric (NY), San Diego Gas and Electric (CA) and one utility that requested that its identity remain confidential.

Three large utilities— Baltimore Gas & Electric (MD), Southern California Edison (CA), and Consolidated Edison (NY) — also provided data that were useful and extensive, but not as complete. Baltimore Gas & Electric provided annual figures on the number of rebated ballasts installed, but not the dollar value of these rebates. Southern California Edison provided data on yearly spending on ballasts, but not the corresponding number of rebated ballasts. Consolidated Edison provided data that involved estimation of the number of electronic ballasts rebated under some measures for each year, while later years lacked specific information on the value of each rebate.

Using the average rebate value from the core sample data set, it was possible to incorporate the information provided by the three utilities listed above to create an expanded sample data set. In the case of Southern California Edison, the figures provided on annual expenditures for electronic ballast rebates were divided by the average rebate value from the core sample to estimate the number of ballasts rebated annually (expenditures on electronic ballast rebates ÷ $s per rebate = total number of electronic ballasts rebated). In the case of Baltimore Gas & Electric, the figures for the annual number of rebates were multiplied by the average rebate value to estimate the utility's annual spending on electronic ballast rebates (number of rebates x $s per rebate = total spending on electronic ballast rebates). For the years for which Consolidated Edison provided information on the number of rebates only, the same approach was used as in the case of Baltimore Gas & Electric.

While the expanded sample data enlarged the sample size and provided a greater breadth of data, the core data set contained the more reliable data and might represent the better national estimate.

B.5.1.3 DSM and Energy Efficiency Spending

Electric utility DSM programs grew rapidly in the late 1980s and early 1990s due to incentives created by state regulatory commissions to encourage integrated resource planning.[15] Electronic ballast rebates fell into the Energy Efficiency (EE) component of DSM programs.[f] National EE spending reached a peak in 1993, leveled off, and declined sharply in 1996 and1997. In 1995, EE spending fell by 12 percent from the year before and in 1996 it fell by 26 percent. Table B.12 lists national spending on the EE programs from 1992-1997, as well as the percentage of that national total accounted for by the two sample data sets analyzed in this study.

[f] In addition to energy efficiency, the other components of DSM programs are: direct load control, interruptible load, and other load management.

Table B.12: Energy Efficiency Spending as Percent of National Total

Year	National EE $s (millions)*	Core Sample % of National	Expanded Sample % of National
1992	1,205	18%	33%
1993	1,608	14%	29%
1994	1,592	18%	31%
1995	1,409	19%	27%
1996	1,052	18%	30%
1997	892	17%	NA**
Avg		17%	30%

* as reported in the DOE/EIA Annual Reports on DSM, "U.S. Electric Utility Demand-Side Management," for 1993, 1994, 1995, 1996, 1997 (EIA-0589(93-97). No report was published for 1992; data for the year were provided directly by EIA.

** not available

In Table B.12, the column "National EE $s" indicates total national DSM expenditures on energy efficiency for each year. The column "Core Sample %" lists the percentage of national EE expenditures represented by the energy efficiency spending of the six utilities that comprised the core sample data set. The column "Expanded Sample %" lists the percentage of national EE expenditures represented by the nine utilities that comprised the expanded sample data set.

B.5.1.4 Methodology

We used two values derived from each sample to estimate the number of electronic ballasts for the nation and their dollar value annually for the years 1992 to 1997. First, we calculated the fraction of energy efficiency spending devoted to electronic ballast rebates and the average value of the rebate per ballast for the sample data. Next, we assumed that the average rebate value and fraction of EE spending going to ballast rebates was the same for the nation as in the sample. For each year, nationally-aggregated energy efficiency spending was multiplied by the fraction of EE spending that went to ballast rebates in the sample to estimate national spending on ballast rebates. Then, we divided this estimate of spending on ballast rebates by the average rebate per ballast to estimate the number of ballasts rebated for the year.

$$\text{National Ballast Rebates (ballasts)} = \frac{\textit{National Rebate \$s}}{\textit{Average Rebate in Sample (\$ per ballast)}}, \text{ where:}$$

$$\textit{National Rebate \$s} = \textit{Percent EE \$s to Rebates in Sample} * \textit{National EE \$s}$$

B.5.1.5 Results

Analysis of the core and expanded samples using this approach led to the two national estimates of the sample percentage of EE expenditures for rebates, national rebate spending, average sample rebate amount, the national number of electronic ballast DSM rebates, shown in Tables B.13 and B.14. The tables also show the estimated percentage of national electronic ballast shipments that received rebates; the average percentage for the core sample was 41 percent (1993-1997) and for the expanded sample it was 37 percent (1993-1996).

Table B.13. Core Sample Data Set Estimates

Year	1992	1993	1994	1995	1996	1997*
% of EE $s to electronic ballast rebates in the sample	5%	8%	11%	13%	7%	2%
National estimate of rebate spending (millions of $s)	$64	$126	$171	$183	$78	$21
Average $/rebate in the sample	$14.16	$13.18	$9.34	$11.91	$7.64	$3.35
Estimated number of rebates nationwide (millions)	4.5	9.6	18.3	15.4	10.2	6.4
National electronic ballasts shipments (millions)		22.9	26.0	33.1	29.7	35.4
Percent of electronic ballasts with rebates		42%	70%	46%	34%	18%

Following the equation above, the estimate of the number of rebates nationwide, listed in row four, results from dividing the estimate of national spending on rebates in row two by the weighted average rebate value found in row three (row four = row two / row three). The national estimate of spending on electronic ballast rebates in row two results from multiplying national spending on rebates (listed in Table B.14) by the fraction of energy efficiency dollars going to rebates listed in row one.

Table B.14. Expanded Sample Data Set Estimates

Year	1992	1993	1994	1995	1996
% of EE $s to electronic ballast rebates in the sample	11%	6%	7%	12%	5%
National estimate of rebate spending (millions of $s)	$131	$98	$112	$165	$54
Average $s/rebate in the sample	$20.65	$12.01	$9.42	$11.91	$7.64
Estimated number of rebates nationwide	6.3	8.1	11.8	13.9	7.0
National electronic ballasts shipments (millions)		22.9	26.0	33.1	29.7
Percent of electronic ballasts with rebates		36%	46%	42%	24%

*None of the three utilities added to the core data set provided information for 1997.

Analysis of the core sample data set showed that electronic ballast rebates peaked in 1994 in terms of the number of ballasts rebated and utility spending on rebates. Estimates of the number of rebates declined slightly in 1995 and substantially in the last two years. Analysis of the expanded sample data set showed the same general trend in DSM rebates. The expanded data set indicated that rebates peaked in 1995 rather than 1994. However, as with the core sample, the analysis pointed to a sharp drop from 1995 to 1996.

Tables B.12 through B.14 also show that the decrease in spending on electronic ballast rebates fell much more sharply than did utility spending on energy-efficiency in DSM programs in the later analysis years. In the core sample, rebate spending in 1996 fell to less than half of the 1995 spending, and in the expanded sample it fell to one-third of its 1995 level. In contrast, national energy-efficiency spending in 1996 decreased to only about 3/4 of its 1995 level.

B.5.1.6 Market Impacts of DSM Rebates

Table B.15 shows the number of magnetic ballast shipments falling from 1993 to 1996. In 1997, the number of magnetic ballast shipments rose slightly and in 1998 essentially leveled off. As rebates for electronic ballasts were on the increase in 1994 and 1995 (see Tables B.13 and B.14), the number of magnetic ballast shipments was declining. The numbers suggested some correlation between DSM rebates and magnetic ballast shipments.

Data on market share shown in Table B.15 revealed a similar pattern to data on the number of shipments. The table shows the shares of the total market held by magnetic ballasts. The market share for magnetic ballasts decreased from 1993 to 1995 when rebates for electronic ballasts were still on the rise. A levelling-off of magnetic market share similar to that of the magnetic ballast shipments can be seen from 1995 to 1997, during the time when ballast rebates were on the wane. This demonstrated the potential impact of the decline of the rebate programs.

Table B.15. Shipments and Market Shares of Rebated Ballasts

Year	Magnetic Ballast Shipments (millions) [1]	Total Ballast Shipments (T12 and T8, millions)	Magnetic Ballast Market Share (% of Ballast Market)
1993	39.0	61.9	63%
1994	36.0	62.0	58%
1995	32.7	65.8	50%
1996	30.1	59.8	50%
1997	31.1	66.5	47%
1998	30.9	68.7	45%

[1] Shipments data from NEMA (see Chapter 5, Table 5.2). Almost all magnetic ballasts sold were for T12 lamps. Data are for those operating both 4-foot and 8-foot lamps.

B.5.2 ASHRAE/IES 90.1-1999 Building Code

This section reports (draft) results of analysis of the impact of the lighting provisions in the upcoming ASHRAE/IES 90.1 revised building code on electronic ballast shipments. This code is not actually "non-regulatory," since state compliance with the code was mandated by EPAct. However, it is included in this section as a base case market driver that is not a component standard. The building code sets limits on the lighting power density (or unit power density) in Watts per square foot or square meter, but these limits do not prescribe any specific equipment type that must be used to meet them. Nonetheless, this analysis assumed that the code would strongly encourage the specification of electronic ballasts (with T8 lamps) for new and renovated lighting systems.

B.5.2.1 Introduction

A study by Pacific Northwest National Laboratories (PNNL) and LBNL attempted to quantify the number of magnetic ballasts that would become electronic as a result of the adoption of the lighting provisions in ASHRAE/IES 90.1-1999 building code by the states.[16] This study assumed that the code revision (version 90.1-1999) would be published and that DOE would designate it as the appropriate code for state adoption under EPAct. The code was estimated to begin affecting new and renovated buildings in the year 2005. It was assumed that electronic ballasts would be used to achieve compliance with the lighting power density requirements in the code. These ballasts would be purchased in place of the magnetic ballasts that would be used in the absence of the revised code. However, the rate of adoption by the states, as well as the rate of compliance by building owners, were both assumed to be less than 100 percent and to increase over time. Both rates would increase as a result of DOE support through PNNL's Building Standards and Guidelines (BSG) program, which provides technical assistance to the states in adopting and using the code. Impacts were analyzed through the year 2020.

B.5.2.2 Methodology

A base case forecast of ballast sales was established using the National Energy Modeling System (NEMS) output forecasted for the Annual Energy Outlook 1999.[17] The projections of lighting service demand were developed in NEMS using a market-based approach which takes into account the annualized life cycle costs of competing lighting technologies. Additionally, current EPAct lamp standards, current NAECA ballast standards, and impacts of EPA's lighting programs were incorporated into NEMS. The NEMS output provided a forecast of lighting service demand from 1996 through 2020 for representative fluorescent system types.

The lighting service demand was translated into ballast sales using the following equations:

$$BS \quad \frac{\frac{E}{CapFac}}{8{,}760 \times FW} \times BF$$

and

$$E \quad \frac{8{,}760 \times SD}{e}$$

where BS = Ballast Sales
E = Annual energy use (watt hours)
CapFac = Weighted Lighting Capacity Factor
FW = Weighted Fixture wattage
BF =Weighted Ballasts per fixture
SD = Service Demand (billion lumen years)
e = Fixture efficacy (lumens/watt)
8,760 = hours per year

The NEMS output provided lighting service demand. NEMS inputs provided and lighting capacity factors by building type; these were weighted using 1995 CBECS floorspace information to determine a weighted lighting capacity factor. Fixture wattages and efficacies were the same as those LBNL provided to EIA for AEO 98 (used again for AEO 99); these data were from the LBNL 1997 Draft Report.

To estimate a weighted fixture wattage, fixture sales by 2-, 3-, and 4-lamp fixtures from the Bureau of Census report "Current Industrial Reports - Electric Lighting Fixtures - 1998," Table 2 were used. Fixture sales by number of lamps were only available for 4-foot fixtures, so sales by lamp for 8-foot fixtures were estimated to be 55 percent 2-lamp, 40 percent 4-lamp, and 5 percent 1-lamp. A weighted average of ballasts per fixture was derived using ballast sales information from the Bureau of Census report "Current Industrial Reports - Fluorescent Lamp Ballasts - Summary for 1998," and "Summary for 1999", Table 3.

The current model inputs used in this TSD that have been updated since the 1997 Draft Report were not updated for this building code study, since EIA was unable to rerun the NEMS analysis to reflect the changes.[g] Inputs that might affect lighting service demand that should be updated in future analyses were ballast service life and ballast prices, both of which received relatively small adjustments.

The NEMS output is separated into four decision categories for equipment purchases: New, Replacement, Retrofit/ Surviving, and Total. In NEMS, the Replacement category signifies substantially renovated lighting systems, while Retrofit/Surviving signifies replacement at failure in existing buildings. In this analysis, the LBNL/PNNL base case contained only those ballasts associated with New and Replacement decisions, as it was assumed that the revised codes would only be applicable to new construction and substantial renovation. Within the NEMS base case, use of magnetic ballasts shifted down after 2005 because of a switch from the F32T8 - Magnetic Ballast

[g]The current model inputs for ballast and lamp lifetimes, wattage, and mean lumen output were used for AEO 2000; ballast prices will be provided to EIA for future AEO analyses.

fixtures to primarily F32T8 - Electronic Ballast fixtures due to the NEMS assumptions regarding their relative annualized life cycle costs.

B.5.2.3 Base Case Forecast without Upgraded Code

The base case ballast sales forecast is presented in Table B.16. The results were based on the NEMS output, which in turn was based on that model's assumptions of consumer behavior in response to life-cycle cost. The magnetic ballast shipments were greater than in the LBNL NES model forecast, in part because these shipments represented the new and renovation component of all fluorescent ballast sales, rather than those of the smaller subset of "covered products" considered in this analysis and shown in Chapter 5, Table 5.1 and 5.2.

The magnetic market share of 51 percent was congruent with the data submitted by Osram Sylvania, Inc. in its comments to DOE on December 14, 1998, which showed the magnetic market share for total new and renovation (OEM) ballasts as 56 percent.[h] We compared only the ballasts for the new and renovation markets, since the NEMS forecast did not have many "early replacement" retrofits; the NEMS model assumed that these occurred only when the capital cost plus operation and maintenance of the new system was lower than the operation and maintenance cost of the old system, without accounting for financial incentives such as rebates. Note that the electronic share grew rapidly in the base case shown in Table B.16, surpassing 85 percent by the year 2006.

B.5.2.4 Impact of Upgraded Code

To estimate the impact on ballast sales due to the proposed changes in ASHRAE 90.1-1999, the proposed lighting standards were compared to the current standard, ASHRAE 90.1-1989. When comparing the allowable lighting power densities for whole buildings (watts per square foot), on average, the 90.1-1999 would allow about 10 percent fewer watts per square foot than the current standard for those building types where standards existed previously. To translate this into an impact on ballast sales, it was assumed that fluorescent fixtures would need to use, on average, 10 percent fewer watts than those that met the current standard. In effect, an electronic ballast would need to be used to meet the proposed standard.

[h] Those data distinguished ballasts from the early retrofit market from those in the new/renovation market; more recent NEMA data provided in their comments of April 15th, 1999 included (early) retrofits with new and renovation.

Table B.16. Base Case Ballast Sales, New and Renovated Systems (Thousands)

Year	Magnetic Ballast		Electronic Ballast	
	Sales	% of Total	Sales	% of Total
2000	32796	51%	31786	49%
2001	31362	48%	33449	52%
2002	26664	41%	38656	59%
2003	18900	28%	47909	72%
2004	15782	23%	52034	77%
2005	15912	23%	52331	77%
2006	8819	13%	60629	87%
2007	8904	13%	61273	87%
2008	9004	13%	61857	87%
2009	9089	13%	62361	87%
2010	9138	13%	62748	87%
2011	9163	13%	63018	87%
2012	9191	13%	63192	87%
2013	9196	13%	63255	87%
2014	9177	13%	63108	87%
2015	9161	14%	57767	86%
2016	9137	14%	57310	86%
2017	9088	14%	56785	86%
2018	9030	14%	56066	86%
2019	8966	14%	54948	86%
2020	8906	14%	53993	86%

Using the base case sales information, the number of ballasts sold for fixtures not expected to meet the 2005 standard was calculated. As discussed above, this was all of the magnetic ballasts forecasted to be sold in the base case beginning in 2005. Changes in sales patterns based on increased state adoption and code compliance for the BSG program were applied to those sales to determine the estimated impact of the program on ballast sales. The assumed rates for state adoption and code compliance (from the FY99 DOE-EE GPRA[i] Metrics effort) are shown in Table B.17. The decrease in state adoption rates after 2010 was based on the assumption that adoption rates would slip slightly over time.

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[i] Government and Performance Results Act

Table B.17 Expected Impact of Existing Programs on State Adoption and Code Compliance

Year	State Adoption (% of Buildings)	Code Compliance (% of Net Potential)	Total Impact
2006	66%	58%	39%
2007	70%	61%	43%
2008	73%	64%	47%
2009	77%	67%	51%
2010	80%	70%	56%
2011	79%	70%	56%
2012	79%	70%	55%
2013	78%	70%	55%
2014	77%	70%	54%
2015	77%	70%	54%
2016	76%	70%	53%
2017	75%	70%	53%
2018	74%	70%	52%
2019	74%	70%	52%
2020	73%	70%	51%

The estimated impact on ballast sales is presented in Table B.18.

Table B.18. Ballast Sales with Upgraded Code with BSG Program Support (Thousands)

Year	Magnetic Ballast		Electronic Ballast		Change
	Sales	% of Total	Sales	% of Total	(Ballasts)
2000	32796	51%	31786	49%	0
2001	31362	48%	33449	52%	0
2002	26664	41%	38656	59%	0
2003	18900	28%	47909	72%	0
2004	15782	23%	52034	77%	0
2005	10399	15%	58045	85%	5514
2006	5423	8%	64025	92%	3996
2007	5113	7%	65064	93%	3791
2008	4786	7%	66076	93%	4218
2009	4424	6%	67026	94%	4664
2010	4021	6%	67865	94%	5117
2011	4090	6%	68120	94%	5103
2012	4134	6%	68249	94%	5057
2013	4182	6%	68270	94%	5015
2014	4218	6%	68067	94%	4959
2015	4255	6%	62673	94%	4906
2016	4289	6%	62158	94%	4848
2017	4310	7%	61562	93%	4777
2018	4327	7%	60769	93%	4703
2019	4341	7%	59574	93%	4626
2020	4355	7%	58544	93%	4551

The resulting magnetic ballast shipments were slightly greater than those in the NES model after the year 2014 for the 2015 Base Case and after the year 2024 for the 2027 Base Case. This indicated that the while the assumptions for both scenarios about the decline of magnetic ballast future shipments included some impacts from the upgraded building code, they also included additional impacts from other programs. The building code was estimated to cause an overall reduction of magnetic ballast shipments from 2003 to 2030 (the analysis period for the NES model) of 27 percent from the base case without the code.

We analyzed the implied "conversion rate" from magnetic to electronic ballasts by calculating the conversion rate for each year, summing the annual rates, and dividing by the number of years from 2005 to 2020. The magnetic ballast shipments (for all uses) implied by the EIA NEMS output had a 3 percent average annual conversion rate without an upgraded building code for the period 2005 - 2020. With the fairly aggressive partial adoption and compliance rates assumed in this analysis, the upgraded ASHRAE/IES 90.1-1999 code caused a conversion rate of 5 percent. The LBNL NES model 2027 base case shipments had a 6 percent average annual conversion rate from 2005 to 2020 due to all programs (including EPA programs as well as an upgraded building code). The LBNL NES 2015 base case had an 11 percent conversion rate from 2005 to 2020. Again, this implied that both NES model base cases incorporate the impacts of the building code, but included the impacts of other non-regulatory programs as well.

While the NEMS base case did include impacts from EPA programs, EIA did not assume those impacts to be as great in the early years of the forecast as the LBNL base cases imply. See further discussion contrasting the EIA and EPA assumptions in section B.5.3 below.

only when the capital cost plus operation and maintenance of the new system are lower than the operation and maintenance of the old system, without accounting for financial incentives such as rebates

B.5.3. EPA Energy Star Buildings and Green Lights Programs

In 1997, the EPA provided data to LBNL from its Green Lights database as well as its Climate Change Action Plan. The Green Lights Program, Marketing and Implementation Data Base (Program Snapshot) showed the annual total sales of electronic ballasts from 1992 - 1996. EPA's forecast for the revised Climate Change Action Plan[j] contained the historical and projected building floor space (in square feet) retrofit from 1992 - 2015. From these EPA estimated the electronic ballasts that would be used to retrofit this floor space from 1997 - 2015. We have been unable to determine whether the EPA has prepared updated forecasts since 1997.

Integration of these data with the analyses from the other programs proved to be complex. EPA assumed that their projections represented the impacts of their programs on the market for electronic ballasts, as well as past, present, and future market drivers including the Green Lights and Energy Star Buildings programs, the success of past research and development in advancing the technologies, and utility DSM programs in jump-starting the market. Therefore, while the historical impacts of the Green Lights program were fairly straightforward, the interactions between all the market drivers in the future forecast years were not quantifiable.

EPA projected that about 7 percent of all commercial and industrial floor space would be retrofit by the year 2000. By the year 2015, this increased to about 48 percent of floor space.

The EPA data analysis is shown in Table B.19.

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[j]EPA projections were revised due to funding cuts for program budgets.

Table B.19 Green Lights/Energy Star Buildings Program Impacts on Electronic Ballast Sales

Year	Ballasts Annual (million)	Sq. Ft. Upgraded (billion)	Percent Total Sq. Ft. Upgraded	Sq. Ft. Recruited (billion)	Sq. Ft. Projected Upgraded (billion)	Percent Total Sq. Ft. Projected Upgraded
1992	0.1					
1993	0.7					
1994	1.8	0.48				
1995	3.6	0.98				
1996	3.4	1.27	1%	6	4.8	6%
1997	8.3	2.36		7.5	6	
1998	10.8	3.77		9	7.2	
1999	12.2	5.37		10.25	8.2	
2000	12.8	7.05	8%	11	8.8	10%
2001	18.2	9.44				
2002	15.7	11.49				
2003	16.3	13.63				
2004	18.1	16.00				
2005	21.0	18.75	19%			
2006	24.1	21.91				
2007	23.7	25.02				
2008	26.6	28.51				
2009	26.1	31.93				
2010	22.4	34.87	34%			
2011	29.6	38.75				
2012	26.2	42.18				
2013	25.9	45.58				
2014	25.6	48.93				
2015	25.3	52.25	48%			

Ballast counts from 1991 - 1996 were from Green Lights Program Snapshots.
Annual ballast counts included an estimate for January 1992 (data gathering began in 2/92).
Ballast counts from 1997 - 2015 were calculated from square feet retrofit,
assuming a constant ratio of electronic ballasts/square foot retrofit from 1992 - 1996.
Sq. ft. estimates from EPA: 1996 from Snapshot, 1997 - 2000 from Climate Change Action Plan (revised).
Sq. ft. recruited * 0.9 = sq. ft. committed.
Sq. ft. projected upgraded = sq. ft. committed * 0.8 (this represented EPA's 10 percent dropout rate).
(A more conservative estimate of dropout rate could be used for another scenario).

Note from Table B.12 that the actual sales of electronic ballasts for 1995 were higher than the estimates in Table B.19 that supposedly represent all market drivers, especially in the early years. The EPA ballast sales estimates in the early years included only the EPA program impacts. Also, the EPA estimates are built up from the Energy Information Administration's Annual Energy Outlook 1997 Reference Case forecast, and that forecast implied a much more modest penetration of electronic ballasts. The AEO 1997 Reference Case showed a very modest penetration of electronic ballasts in early years. This was partly because that forecast was based on the penetrations of efficient technologies from the 1992 CBECS survey.[k] Also, as mentioned in section B.5.2, in the EIA NEMS model the economic criteria for the early replacement retrofits were strict enough that they didn't often meet most consumers'discount rate criteria for investment. EIA did attempt to include the impacts of EPA programs and utility DSM programs. However, the two estimates showed considerable variation because of the different original assumptions.

To answer the question of whether the lack of utility rebates would cause fewer ballast retrofits in the future, EPA stated that the internal rate of return for electronic ballast retrofits was typically well over the Green Lights IRR criterion of 20 percent. Therefore, EPA assumed that the retrofit rate would be unaffected as utility rebates diminish. From the Green Lights Program Database, based on reports submitted by Green Lights program participants on completed upgrades, we calculate that about 35 percent of building retrofit projects took advantage of utility rebates. However, the database did not link these rebates specifically to electronic ballasts.

We were unable to locate an independent assessment of the EPA's program projections, dropout rates, overlap with ballast rebates, etc. EPA asked its partners to retrofit 90 percent of their recruited floor space, and estimated that they would convert all but 10 percent of this. Since partners pledged to retrofit their floor space within 5 years, the first partners to join the program in 1991 and 1992 were just finishing their upgrades when these data were taken. EPA attributed their higher dropout rates to early emphasis on recruitment rather than assistance and follow-up.

B.5.4 Federal Energy Management Program

This section presents results from LBNL's analysis of the Federal Energy Management's Procurement Challenge recommendations for fluorescent ballasts and fluorescent luminaires. It also shows our estimates of the impacts of the Federal Relighting Initiative.

B.5.4.1 Procurement Challenge (PEERs)

Product Energy Efficiency Recommendations (PEERs) are issued by the Federal Energy Management Program (FEMP) to assist Federal agencies in complying with the requirements of the Energy Policy Act of 1992 (EPACT) and Executive Order 12902. The Executive Order directs all Federal agencies to buy products in the upper quartile with respect to energy and water efficiency, or to choose products that are at least 10 percent more efficient than existing Department of Energy (DOE) standards. A further goal of EPACT and the Executive Order is to use the buying power of the Federal government to "pull" the overall commercial market for particular products towards greater efficiency. The PEERs offer a mechanism with which to implement these goals by providing

[k] The AEO 1999 forecasts used data from CBECS 1995 survey. Subsequent AEO forecasts also use data and modeling assumptions from LBNL more consistent with the analysis in this document

Federal purchasers with technical and market guidance on efficiency levels for a given product in order to meet the requirements of the Executive Order.

The PEER for ballasts recommends electronic ballasts. The PEER for fluorescent luminaires is based on the LER or luminaire efficacy rating, a metric with units of lumens/Watt that incorporates the effects of lamp/ballast input wattage, lamp light output, ballast factor, and luminaire efficiency. The higher LERs required to meet the recommendation are achievable with electronic ballasts. Thus, for both products, selection of an electronic ballast either individually or in a luminaire was assumed to meet the recommendation.

LBNL estimated the impacts of the PEERs for fluorescent ballasts and fluorescent luminaires as part of a larger study on all the product recommendations.[18] We provided a characterization of the federal sector building and equipment stock, including the data and assumptions used to estimate impacts for the PEERs We first needed to quantify both the ballasts purchased individually and those purchased in luminaires for the federal sector in the absence of PEERs. Data on compliance with the PEERs would be difficult and expensive to gather, and require detailed knowledge about federal purchases. At this stage of the program, such data were not available, and consequently we relied on assumptions concerning the Federal building stock, Federal market data, and product/end-use definitions.

Background and Methodology

The Federal market for energy-related products was estimated at $12 billion annually, of which about $4 billion or 25 percent were building-related purchases.[19] Of this $4 billion, approximately 10 percent were lighting equipment purchases. The installed ballast stock and usage were calculated using the lighting equipment densities and usage from the XENERGY commercial buildings database. Lighting technology sales are relatively constant because we have assumed no changes in product density. The usage assumption for fluorescent lighting was 3600 hours per year.

We developed a modeling framework based on the building and equipment stock in order to estimate stock turnover and purchases for each product over the period from 1996-2010. We then adopted a number of energy-economic assumptions for trends in efficiency.

The analysis covered the period from 1996 to 2010. The recommendations were assumed to apply to ballasts and luminaires starting in 1998. The analysis went out to 2010, which corresponded to a target year for federal energy savings—a 35 percent reduction on a square foot basis from the 1985 levels.[20] Extension of the analysis beyond 2010 would be straightforward, but the assumptions regarding changes in efficiency and technologies would be less stable over a longer time frame.

Three characteristic assumptions were required in defining the scenarios—eligibility, program penetration, and factors to avoid double-counting of ballast and luminaire stock. Eligibility referred to the share of products that were technically eligible (or compatible) for replacement. Program penetration, ranging from 0 percent to 100 percent, referred to the proportion of federal purchases that adhere to the Recommendations. For program penetration, we recognized that it was perhaps unrealistic to assume that all purchasers would use the guidelines, in spite of the Executive Order and the Procurement Challenge, and the simplicity-of-use of the PEERs themselves. However, as the program continued and reached more and more purchasers, it made sense to assume that the penetration would increase. Consequently we assumed that 20 percent of purchases were at the Recommended levels for each product in the first year, but this percentage increased proportionally over the ensuing years until it reached 80 percent in 2010, such that the average annual rate over the 12-year period is 50 percent. For eligibility, the fraction of federal purchases that were magnetic ballasts was assumed to be 94 percent for ballasts in 1998, based on the replacement market shares from the NEMA data (NEMA comments, April 15, 1999). In succeeding years the eligibility was reduced by 2 percent, assuming that a smaller percentage of these ballasts would be magnetic. The eligibility for luminaires was assumed to be 56 percent in 1998, based on the Osram Sylvania comments as noted in section B.5.3, since this analysis did not cover early retrofits. The eligibility was reduced by 5 percent in future years, again assuming that the market share of magnetic ballasts in luminaires would decrease.

An implicit assumption in the analysis was that there was no early replacement of equipment; products were assumed to be replaced at the end of their useful lives. In practice, there would indeed be early replacement for various reasons, and consequently the above analysis may not have estimated these savings. Early replacement might be undertaken mainly on the basis of cost-effective energy efficiency investments, or it might be based on other sources of changing product demand. Certain types of construction, such as renovation projects, would generally result in early product replacement, and the PEERs could serve as a mechanism to coordinate energy-efficient purchasing with product replacement that occurred for other reasons. Early replacement retrofits were analyzed as discussed in the Federal Relighting Initiative, as discussed in section B.5.4.2 below.

Results

Table B.20 shows the estimated numbers of ballasts and luminaires affected by the PEERs for the analysis period. The results implied a average annual percentage decrease of magnetic ballasts in federal buildings of 49 percent from 1998 - 2010 resulting from this program.

Table B.20 Fluorescent Electronic Ballasts Purchased from FEMP Programs (thousands)

Program	1992	1993	1994	1995	1996	1997	1998	1999	2000	
PEERS Ballasts							562	690	812	
PEERS Luminaires							441	553	664	
PEERS Total							1104	1370	1629	
Federal Relighting Initiative	1256	2462	2484	2463	1875	1860	1860	1860	1860	
Program	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
PEERS Ballasts	928	1042	1159	1269	1372	1468	1559	1649	1737	1814
PEERS Luminaires	773	885	1004	1121	1236	1349	1462	1577	1695	1806
PEERS Total	1879	2131	2394	2648	2892	3128	3358	3589	3822	4036
Federal Relighting Initiative	1860									

B.5.4.2 Federal Relighting Initiative (FRI)

The Federal Relighting Initiative encouraged early replacement retrofits of federal building lighting systems, including fluorescent ballasts. The lighting PEERs were not considered to impact these types of retrofits, since the products were replaced at the end of their useful lives. FEMP has done no evaluation of the impacts of the FRI program on building retrofits. The program concentrated on training and specifications. A survey of a subset of those in the training courses was performed, but this was not specific to the impact on specific technologies.

For background, we estimated the federal ballast existing building stock as about 28 million ballasts. In 1997, there were about 700 million ballasts in the commercial and industrial sectors (see section B.2 above). The PEERs analysis estimated 2.5 million square feet in U.S. non-residential floor space for federal buildings in 1997. This was about 4.3 percent of the national total from CBECS 1995; assuming that national floorspace grew from 1995 to 1997, we rounded the percentage to 4 percent. Thus, the federal ballast existing stock would be about 4 percent of the 700 million, or 28 million ballasts.

In 1993, Pacific Northwest National Laboratory prepared "Estimate of Federal Relighting Potential and Demand for Energy-Efficient Lighting Products," a study of potential impacts of FRI.[21] This study included both federally owned and leased space, from the GSA Summary Report of Real Property Owned by the United States (1989). Since we could not assume that the federal government would be able to retrofit its federally-leased space, we calculated the federally-owned floor space using separate figures from GSA for 1995 for federally-owned and federally-leased space, as described above. About 90 percent percent of federally-owned and leased space was estimated as federally-owned in 1995.

The PNNL report estimated potential sales of 22 million electronic ballasts if all retrofit projects were implemented at once. Assuming that 90 percent of these were for federally-owned space, the total potential was 19.8 million ballasts.

The report projected ballast retrofits under two scenarios, one with utility rebates at 1992 levels projected through 1995, and the other with higher rebate levels due to FRI. However, FRI did not track the actual retrofits made through the program during these years. Also, as discussed in section B.5.1, utility rebates have been diminishing from 1996 on.

In the absence of verifying data, we simply used the "FRI Scenario" estimates for ballasts installed from 1992 - 1996. Taking 90 percent of these values gave a total of 10.5 million. The remaining 9.3 million ballasts were apportioned equally through 2001. The results are shown in Table B.20 above.

B.5.5. Energy Cost Savings Council (ECSC)

The Energy Cost Savings Council program created by NEMA is a broad and ambitious program that aims to convince key business decision makers, such as chief financial officers, to upgrade their buildings with more efficient electrical equipment. The ECSC complements EPA's program, advising building owners they can achieve up to 50 percent savings ($1/sq ft) and paybacks of 3 to 5 years (30 to 50 percent return on investment or ROI).[22] Note that these estimates are for all end-uses, not only for lighting. An ECSC analysis of 248 lighting upgrade projects documented by *Energy User News* showed an average project payback period of 2.2 years and an ROI of 45 percent.[23]

ECSC has estimated that despite the successes of the non-regulatory programs already discussed in this section, the potential for lighting retrofits is very large. The Council estimates that the floor space committed to be retrofit under the EPA Green Lights/Energy Star Buildings programs still represents only 10 percent of the potential national commercial, industrial, and institutional square footage. ECSC estimates that all the electronic ballasts sold since 1989 have replaced only 10 percent of the installed base of ballasts in existing buildings (which they estimate at 1.6 billion ballasts, considerably higher than the LBNL estimate described in Chapter 5, section 5.3.6). Since conversion of magnetic to electronic ballasts is one of the primary lighting retrofits, the expansion of efficiency upgrades through the ECSC's influence could cause an increase in electronic ballast sales.

However, we determined from interviewing ECSC staff that data on ballast retrofits directly attributable to ECSC efforts would be difficult to obtain. Unlike the EPA programs, which recruit "partners" and "allies" and ask them to report on their efficiency retrofits, ECSC does not gather data on the activities of those reached through their educational programs. A participant could be motivated to seek the services of an energy service company (ESCO), for instance, but only if that ESCO were an ECSC member could the Council track the resulting retrofits. Therefore, this program will most likely have to be evaluated through qualitative rather than quantitative means.

B.5.6 Voluntary Luminaire Program

The voluntary luminaire program presents energy-efficiency information in the form of a "Luminaire Efficacy Rating" (LER) for the luminaire system (defined in the FEMP PEERs discussion in 5.4.1 above). Using an electronic ballast greatly improves the LER of a luminaire. A 1999 report to DOE on the program showed widespread manufacturer participation, with 75 percent of manufacturers publishing LER information in their product literature in 1997, and 100 percent doing so by 1999.

It was difficult to evaluate the direct impact this voluntary program has had and will have on the fluorescent ballast market. The Bureau of Census began to collect data on ballast usage in luminaires in 1998, and has collected data on the number of lamps per luminaire since 1995. However, the voluntary luminaire program interacts with and reinforces other educational programs to encourage the use of electronic ballasts, and its specific influence was hard to quantify.

B.5.7 Summary

Table B.21 shows the number of electronic ballast shipments affected by each of the programs analyzed above. We have not attempted to calculate the overlap between programs. Remember that the EPA projections, as discussed above, were intended to represent the impacts of all market forces. Therefore a sum of the individual program impacts shown in the table is not meaningful.

Table B.21 Shipments of Electronic Ballasts Affected by Programs (millions)

	1992	1993	1994	1995	1996	1997	1998	1999	2000
Total Electronic Shipments (NEMA)		22.9	26.0	33.1	29.7	35.4	37.8		
DSM (Core Sample Estimates)	4.5	9.6	18.3	15.4	10.2	6.4			
Green Lights/Energy Star Buildings	0.1	0.7	1.8	3.6	3.4	8.3	10.8	12.2	12.8
ASHRAE/IES 90.1-1999 Code									
FEMP Programs	1.3	2.5	2.5	2.5	1.9	1.9	3.0	3.2	3.5

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Total Electronic Shipments (NEMA)										
DSM (Core Sample Estimates)										
Green Lights/Energy Star Buildings	18.2	15.7	16.3	18.1	21.0	24.1	23.7	26.6	26.1	22.4
ASHRAE/IES 90.1-1999 Code					5.5	3.4	3.8	4.2	4.7	5.1
FEMP Programs	3.7	2.1	2.4	2.6	2.9	3.1	3.4	3.6	3.8	4.0

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Total Electronic Shipments (NEMA)										
DSM (Core Sample Estimates)										
Green Lights/Energy Star Buildings	29.6	26.2	25.9	25.6	25.3					
ASHRAE/IES 90.1-1999 Code	5.1	5.1	5.0	5.0	4.9	4.8	4.8	4.7	4.6	4.6
FEMP Programs										

B.6 NATIONAL ENERGY SAVINGS DETAILED RESULTS

B.6.1 Electronic Ballast Standards

This section contains the NES results for the electronic ballast standards for the four lamp-ballast combinations using the AEO Reference Case electricity price projection. The results reported are for the same Scenarios found in Chapter 5, Table 5.5. The energy savings include HVAC impacts, while the total benefit (energy cost savings) and equipment costs do not.

Table B.22 Scenario 1A

For Units Sold from 2003 to 2030 *Discounted at 7% to 1997 (in billion 1997 $)*					
	2F40	***1F40***	***2F96/ES***	***2F96HO/ES***	***Total***
Total Quads Saved	0.71	0.02	0.26	0.02	1.01
Total Quads Saved w/ HVAC	0.75	0.02	0.28	0.02	1.08
Total Benefit	1.38	0.04	0.51	0.03	1.97
Total Equipment Cost	0.66	0.03	0.31	0.01	1.01
Net Present Value	0.72	0.02	0.21	0.02	0.96

Table B.23 Scenario 1B

For Units Sold from 2003 to 2030					
Discounted at 7% to 1997 (in billion 1997 $)					
	2F40	***1F40***	***2F96/ES***	***2F96HO/ES***	***Total***
Total Quads Saved	1.25	0.04	0.46	0.04	1.79
Total Quads Saved w/ HVAC	1.33	0.04	0.49	0.04	1.90
Total Benefit	2.20	0.07	0.81	0.04	3.13
Total Equipment Cost	1.06	0.05	0.49	0.02	1.62
Net Present Value	1.13	0.03	0.32	0.03	1.51

Table B.24 Scenario 2A

For Units Sold from 2003 to 2030 *Discounted at 7% to 1997 (in billion 1997 $)*					
	2F40	***1F40***	***2F96/ES***	***2F96HO/ES***	***Total***
Total Quads Saved	1.34	0.03	0.26	0.02	1.66
Total Quads Saved with HVAC*	1.42	0.04	0.28	0.02	1.76
Total Benefit	2.62	0.07	0.51	0.03	3.22
Total Equipment Cost	0.46	0.02	0.31	0.01	0.80
Net Present Value	2.16	0.05	0.21	0.02	2.43

Table B.25 Scenario 2B

For Units Sold from 2003 to 2030 *Discounted at 7% to 1997 (in billion 1997 $)*					
	2F40	***1F40***	***2F96/ES***	***2F96HO/ES***	***Total***
Total Quads Saved	2.37	0.06	0.46	0.04	2.93
Total Quads Saved with HVAC*	2.52	0.07	0.49	0.04	3.12
Total Benefit	4.17	0.11	0.8	0.04	5.13
Total Equipment Cost	0.73	0.03	0.49	0.02	1.27
Net Present Value	3.43	0.08	0.32	0.03	3.86

Table B.26 Scenario 3A

For Units Sold from 2003 to 2030 *Discounted at 7% to 1997 (in billion 1997 $)*					
	2F40	***1F40***	***2F96/ES***	***2F96HO/ES***	***Total***
Total Quads Saved	1.16	0.03	0.22	0.02	1.43
Total Quads Saved with HVAC*	1.23	0.03	0.24	0.02	1.52
Total Benefit	2.18	0.05	0.42	0.02	2.68
Total Equipment Cost	0.37	0.02	0.25	0.01	0.64
Net Present Value	1.81	0.04	0.17	0.01	2.03

Table B.27 Scenario 3B

For Units Sold from 2003 to 2030 *Discounted at 7% to 1997 (in billion 1997 $)*					
	2F40	***1F40***	***2F96/ES***	***2F96HO/ES***	***Total***
Total Quads Saved	2.15	0.06	0.41	0.03	2.66
Total Quads Saved with HVAC*	2.29	0.06	0.44	0.04	2.82
Total Benefit	3.63	0.09	0.69	0.04	4.46
Total Equipment Cost	0.62	0.03	0.42	0.01	1.08
Net Present Value	3.02	0.07	0.27	0.02	3.38

Table B.28 Scenario 4A

For Units Sold from 2003 to 2030 *Discounted at 7% to 1997 (in billion 1997 $)*					
	2F40	***1F40***	***2F96/ES***	***2F96HO/ES***	***Total***
Total Quads Saved	1.27	0.03	0.24	0.02	1.57
Total Quads Saved with HVAC*	1.35	0.03	0.26	0.02	1.67
Total Benefit	2.43	0.06	0.46	0.03	2.98
Total Equipment Cost	0.41	0.02	0.28	0.01	0.72
Net Present Value	2.02	0.04	0.19	0.02	2.26

Table B.29 Scenario 4B

For Units Sold from 2003 to 2030					
Discounted at 7% to 1997 (in billion 1997 $)					
	2F40	*1F40*	*2F96/ES*	*2F96HO/ES*	*Total*
Total Quads Saved	2.30	0.06	0.44	0.04	2.84
Total Quads Saved with HVAC*	2.45	0.06	0.47	0.04	3.02
Total Benefit	3.95	0.10	0.76	0.04	4.85
Total Equipment Cost	0.67	0.03	0.46	0.02	1.18
Net Present Value	3.28	0.07	0.30	0.03	3.68

B.6.2 Cathode Cutout Standards

This section contains the NES results for the cathode cutout ballast standards for the four lamp-ballast combinations using the AEO Reference Case electricity price projection. The cases reported are the same Scenarios found in Chapter 5, Table 5.6.

Table B.30 Scenario 5A

For Units Sold from 2003 to 2030					
Discounted at 7% to 1997 (in billion 1997 $)					
	2F40	***1F40***	***2F96/ES***	***2F96HO/ES***	***Total***
Total Quads Saved	0.46	0.01	0.00	0.01	0.48
Total Quads Saved w/ HVAC	0.49	0.01	0.00	0.01	0.51
Total Benefit	0.90	0.02	0.00	0.02	0.94
Total Equipment Cost	0.76	0.02	0.00	0.01	0.78
Net Present Value	0.15	0.00	0.00	0.01	0.16

Table B31. Scenario 5B

For Units Sold from 2003 to 2030					
Discounted at 7% to 1997 (in billion 1997 $)					
	2F40	***1F40***	***2F96/ES***	***2F96HO/ES***	***Total***
Total Quads Saved	0.82	0.01	0.00	0.02	0.85
Total Quads Saved w/ HVAC	0.87	0.02	0.00	0.03	0.91
Total Benefit	1.44	0.03	0.00	0.03	1.49
Total Equipment Cost	1.21	0.03	0.00	0.01	1.26
Net Present Value	0.22	-0.01	0.00	0.02	0.23

Table B.32 Scenario 6A

For Units Sold from 2003 to 2030 *Discounted at 7% to 1997 (in billion 1997 $)*					
	2F40	*1F40*	*2F96/ES*	*2F96HO/ES*	*Total*
Total Quads Saved	1.08	0.03	0.00	0.02	1.12
Total Quads with HVAC	1.14	0.03	0.00	0.02	1.19
Total Benefit	2.10	0.05	0.00	0.02	2.18
Total Equipment Cost	0.55	0.02	0.00	0.01	0.58
Net Present Value	1.55	0.03	0.00	0.02	1.60

Table B.33 Scenario 6B

For Units Sold from 2003 to 2030 *Discounted at 7% to 1997 (in billion 1997 $)*					
	2F40	*1F40*	*2F96/ES*	*2F96HO/ES*	*Total*
Total Quads Saved	1.90	0.05	0.00	0.03	1.98
Total Quads with HVAC	2.02	0.05	0.00	0.04	2.11
Total Benefit	3.35	0.08	0.00	0.04	3.47
Total Equipment Cost	0.88	0.03	0.00	0.01	0.93
Net Present Value	2.47	0.05	0.00	0.02	2.54

B.7 FLOOR SPACE PROJECTIONS

Table B.34. shows the commercial and industrial historical and projected floor space (including federal buildings) from 1980 to 2030. The forecasts by building types were based on data developed by Regional Economic Research (RER).

The commercial floor space was estimated by RER based on the 1992 *Commercial Buildings Energy Consumption Survey* (CBECS).[24] The industrial floor stock forecast was estimated by RER based on the 1991 *Manufacturing Energy Consumption Survey* (MECS)[25], and on the 1995 *Annual Energy Outlook*[26] manufacturing employment forecast to 2010 and then extended to 2030, using the same growth rate.

Table B.34 US Commercial and Industrial Floor Stock Projections (Billions of square feet)

Year	Small Office	Large Office	Retail	Restaurant	Grocery	Warehouse	School	College	Health	Lodging	Assembly	Misc	Indus-trial	Total
1980	4.64	5.65	9.20	1.10	0.57	9.41	4.73	2.82	1.23	1.75	5.91	5.66	9.87	62.54
1985	4.93	6.01	10.70	1.28	0.66	10.13	4.83	2.86	1.43	2.17	6.76	6.47	11.28	69.53
1990	5.39	6.56	11.98	1.44	0.74	11.11	5.24	3.01	1.68	2.68	7.88	7.54	13.15	78.39
1995	5.89	7.17	13.26	1.59	0.82	12.06	5.59	3.16	1.93	3.13	8.68	8.44	13.96	85.66
2000	6.36	7.75	14.58	1.75	0.90	13.09	5.57	3.16	2.05	3.46	9.27	9.30	14.11	91.36
2005	6.78	8.26	16.01	1.92	0.98	13.99	5.48	3.14	2.12	3.59	9.78	10.26	14.28	96.5.9
2010	7.19	8.76	17.64	2.11	1.08	14.67	5.39	3.13	2.18	3.63	10.10	11.40	14.40	101.68
2015	7.66	9.34	19.49	2.33	1.20	15.55	5.30	3.12	2.26	3.72	10.54	12.69	14.54	107.73
2020	8.13	9.91	21.34	2.56	1.31	16.44	5.22	3.10	2.33	3.80	10.99	13.98	14.68	113.78
2025	8.60	10.48	23.19	2.78	1.43	17.32	5.13	3.09	2.40	3.89	11.44	15.26	14.83	119.82
2030	9.07	11.05	25.04	3.00	1.54	18.20	5.04	3.07	2.47	3.98	11.89	16.55	14.97	125.87

Note: To convert values above to metric units, divide by 10.764 to get square meters (m^2).

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