CHAPTER 8. LIFE-CYCLE COST AND PAYBACK PERIOD ANALYSIS

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CHAPTER 8. LIFE-CYCLE COST AND PAYBACK PERIOD ANALYSIS

8.1 INTRODUCTION

This chapter describes the Department of Energy (DOE)'s methodology for analyzing the economic impacts of possible energy efficiency standards on individual consumers. The effect of standards on individual consumers includes a change in operating expense (usually decreased) and a change in purchase price (usually increased). This chapter describes three metrics DOE used in the consumer analysis to determine the effect of standards on individual consumers:

- **Life-cycle cost** (LCC) is the total consumer expense over the life of an appliance, including purchase expense and operating costs (including energy expenditures). DOE discounts future operating costs to the time of purchase, and sums them over the lifetime of the equipment.

- **Payback period** (PBP) measures the amount of time it takes customers to recover the assumed higher purchase price of more energy-efficient equipment through lower operating costs.

- **Rebuttable payback period** is a special case of the PBP. Where LCC and PBP are estimated over a range of inputs reflecting actual conditions, rebuttable payback period is based on laboratory conditions, specifically DOE test procedure inputs.

Inputs to the LCC and PBP are discussed in sections 8.2 and 8.3, respectively, of this chapter. Results for the LCC and PBP are presented in section 8.4. The rebuttable PBP is discussed in section 8.5. Key variables and calculations are presented for each metric. DOE performed the calculations discussed here using a series of Microsoft Excel® spreadsheets which are accessible on the Internet (http://www.eere.energy.gov/buildings/appliance_standards/). Details and instructions for using the spreadsheets are discussed in Appendix 8A.

This chapter presents information and results pertaining solely to CCWs. As described in section 1.3 of chapter 1 of this technical support document (TSD), DOE is continuing the rulemaking for energy conservation standards for microwave oven standby power, and analyses related to these products will be published in a separate TSD. In addition, DOE issued a final rule[1] adopting energy conservation standards for conventional cooking products (*i.e.*, cooktops and ovens) and microwave oven energy factor (EF), and details of the analyses for these products are contained in the corresponding final rule TSD.[2]

8.1.1 General Approach for LCC and PBP Analysis

Recognizing that several inputs to the determination of consumer LCC and PBP are either variable or uncertain, DOE conducted the LCC and PBP analysis by modeling both the uncertainty and variability in the inputs using Monte Carlo simulation and probability

distributions. A detailed explanation of Monte Carlo simulation and the use of probability distributions is contained in Appendix 8B. DOE developed LCC and PBP spreadsheet models incorporating both Monte Carlo simulation and probability distributions by using Microsoft Excel® spreadsheets combined with Crystal Ball® (a commercially available add-in program).

As described in Chapter 6, DOE established the variability and uncertainty in energy and water use by defining the uncertainty and variability in the usage (in cycles per day) of the equipment. As will be described later in this chapter, the variability and uncertainty in energy and water pricing are characterized by regional differences in energy and water prices.

DOE displays the LCC and PBP results as distributions of impacts compared to the baseline conditions. Results are presented at the end of this chapter and are based on 10,000 samples per Monte Carlo simulation run. To illustrate the implications of the analysis, DOE generated a frequency chart depicting the variation in LCC and PBP for each standard level considered.

8.1.2 Overview of LCC and PBP Inputs

The LCC is the total consumer expense over the life of the equipment, including purchase expense and operating expense (including energy expenditures). DOE discounts future operating expenses to the time of purchase and sums them over the lifetime of the equipment. The PBP is the change in purchase expense due to an increased efficiency standard divided by the change in annual operating expense that results from the standard. It represents the number of years it will take the customer to recover the increased purchase expense through decreased operating expenses.

DOE categorizes inputs to the LCC and PBP analysis as follows: (1) inputs for establishing the purchase expense, otherwise known as the total installed cost, and (2) inputs for calculating the operating cost.

The primary inputs for establishing the total installed cost are:

- *Baseline manufacturer cost*: The costs incurred by the manufacturer to produce equipment meeting existing minimum efficiency standards.

- *Standard-level manufacturer cost increases*: The change in manufacturer cost associated with producing equipment to meet a particular standard level.

- *Markups and sales tax*: The markups and sales tax associated with converting the manufacturer cost to a consumer equipment price. The markups and sale tax are described in detail in Chapter 7, Markups for Equipment Price Determination.

- *Installation cost*: The cost to the consumer of installing the equipment. The installation cost represents all costs required to install the equipment other than the marked-up consumer equipment price. The installation cost includes labor, overhead, and any

miscellaneous materials and parts. Thus, the total installed cost equals the consumer equipment price plus the installation cost.

The primary inputs for calculating the operating cost are:

- *Equipment energy and water consumption*: The equipment energy consumption is the site energy use associated with operating the equipment. The water consumption is the site water use associated with operating the equipment. Chapter 6, Energy and Water Use Determination, details how DOE determined the equipment energy and water consumption based on various data sources.

- *Equipment efficiency*: The equipment efficiency dictates the equipment energy and water consumption associated with standard-level equipment (i.e., equipment with efficiencies greater than baseline equipment). Chapter 6, Energy and Water Use Determination, details how energy and water consumption change with increasing equipment efficiency.

- *Energy and water prices*: Energy and water prices are the prices paid by consumers for energy (i.e., electricity, gas, or oil) and water. DOE determined current energy prices based on data from the DOE- EIA. DOE determined water prices based on data from the American Water Works Association (AWWA).

- *Energy and water price trends*: DOE used the EIA *Annual Energy Outlook 2009* (*AEO2009*) to forecast energy prices into the future. For the results presented in this chapter, DOE used the *AEO2009* reference case to forecast future energy prices. DOE used consumer price index data specific to water and sewerage maintenance from the Bureau of Labor Statistics as the basis for its water price trend.

- *Repair and maintenance costs*: Repair costs are associated with repairing or replacing components that have failed. Maintenance costs are associated with maintaining the operation of the equipment.

- *Lifetime*: The age at which the equipment is retired from service.

- *Discount rate*: The rate at which DOE discounted future expenditures to establish their present value.

Figure 8.1.1 graphically depicts the relationships between the installed cost and operating cost inputs for the calculation of the LCC and PBP. In the figure below, the yellow boxes indicate the inputs, the green boxes indicate intermediate outputs, and the blue boxes indicate the final outputs (the LCC and PBP).

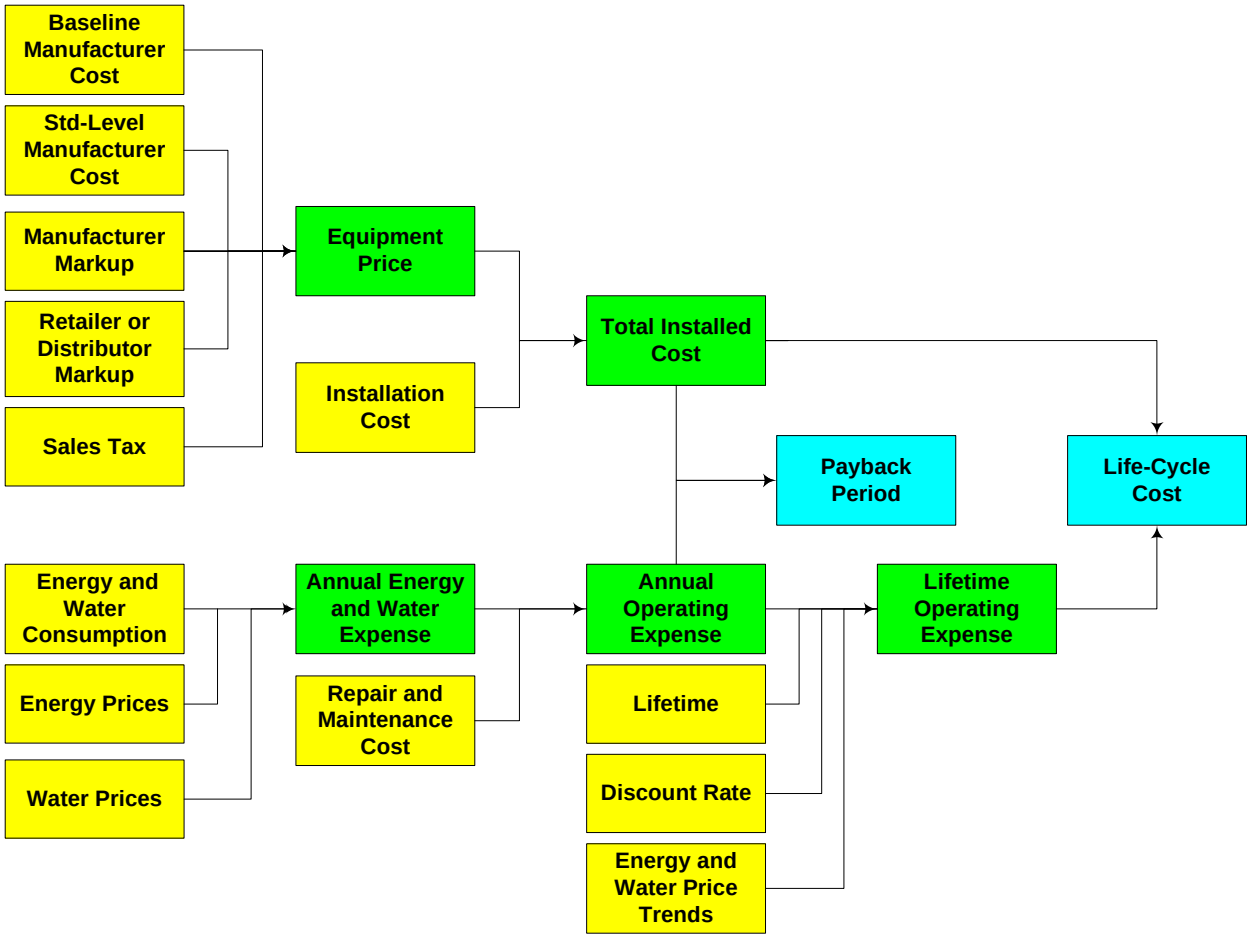

Figure 8.1.1 Flow Diagram of Inputs for the Determination of LCC and PBP

Table 8.1.1 summarizes the input values that DOE used to calculate the LCC and PBP. Each table summarizes the total installed cost inputs and the operating cost inputs including the lifetime, discount rate, and energy and water price trends. DOE characterized all of the total cost inputs with single-point values, but characterized several of the operating cost inputs with probability distributions that capture the input's uncertainty and/or variability. For those inputs characterized with probability distributions, the values provided in the following tables are the average or typical values. Also listed in the following tables is the section of the technical support document (TSD) where more detailed information on the inputs can be found.

Table 8.1.1 LCC and PBP Input Summary

Input	Product Class	Average or Typical Value	Characterization	TSD Section Reference
Total Installed Cost Inputs				
Baseline Manufacturer Cost	Top-Loading	1.26 MEF/9.50 WF = $296.30	Single-Point Value	8.2.1.2
	Front-Loading	1.72 MEF/8.00 WF = $611.02	Single-Point Value	
Standard-Level Manufacturer Cost Increase	Top-Loading	1.42 MEF/9.50 WF = $77.60 1.60 MEF/8.50 WF = $134.99	Single-Point Value	8.2.1.3
	Front-Loading	1.80 MEF/7.50 WF = $0.00 2.00 MEF/5.50 WF = $14.21 2.20 MEF/5.10 WF = $39.34 2.35 MEF/4.40 WF = $66.16	Single-Point Value	
Manufacturer Markup	Both	1.26	Single-Point Value	7.4
Distributor Markup	Both	Baseline = 1.43 Incremental = 1.18	Single-Point Value	7.5
Sales Tax	Both	1.0690	Single-Point Value	7.6
Installation Cost	Both	$190.00	Single-Point Value	8.2.1.5
Operating Cost Inputs				
Usage	Both	Multi-Family = 3.4 cycles/day Laundromat = 6 cycles/day	Uniform distribution: Multi-Family = 1.5 to 6.4 cyc/day Laundromat = 3 to 8 cyc/day	6.3, 6.4
Annual Energy Use*	Top-Loading	Baseline use**: Multi-Family = 2769 kWh Laundromat = 4867 kWh	Variability based on usage	6.3
	Front-Loading	Baseline use**: Multi-Family = 2028 kWh Laundromat = 3565 kWh	Variability based on usage	
Annual Water Use	Top-Loading	Baseline use**: Multi-Family = 33.1 10^3 gallon Laundromat = 58.3 10^3 gallon	Variability based on usage	6.3
	Front-Loading	Baseline use**: Multi-Family = 27.9 10^3 gallon Laundromat = 49.1 10^3 gallon	Variability based on usage	
Energy Prices	Both	Elec = 10.8 ¢/kWh Gas = 11.89 $/MMBtu	Single-Point Value	8.2.2.2
Water and Wastewater Prices	Both	Water = 2.29 $/$10^3$ gallon Wastewater = 2.97 $/$10^3$ gallon	Singe-Point Value	8.2.2.2
Repair and Maintenance Costs	Both	Annualized repair cost = ½ Equipment price / Lifetime	Single-Point Value	8.2.2.4
Lifetime	Both	Multi-Family = 11.25 years Laundromat = 7.125 years	Weibull distribution	8.2.3
Discount Rate	Both	5.7%	Custom distribution	8.2.4
Energy Price Trend	Both	AEO 2009 Reference Case	Two sensitivities: High & Low Growth Cases	8.2.2.3
Water and Wastewater Price Trend	Both	Bureau of Labor Statistics: Water and sewerage CPI	Single forecast	8.2.2.3

* Annual use based on electric water heating and electric clothes drying.

** Annual use provided for baseline product only. Annual use decreases with increased product efficiency.

8.2 LIFE-CYCLE COST INPUTS

Life-cycle cost is the total customer expense over the life of an appliance, including purchase expense and operating costs (including energy expenditures). DOE discounts future operating costs to the time of purchase, and sums them over the lifetime of the equipment. DOE defines LCC by the following equation:

$$LCC = IC + \sum_{t=1}^{N} \frac{OC_t}{(1+r)^t}$$

where:

LCC =	Life-cycle cost in dollars,
IC =	Total installed cost in dollars,
∑ =	Sum over the lifetime, from year 1 to year N,
N =	Lifetime of appliance in years,
OC =	Operating cost in dollars,
r =	Discount rate, and
t =	Year for which operating cost is being determined.

DOE expresses dollar values in 2008$.

The following sections discuss total installed cost, operating cost, lifetime, and discount rate.

8.2.1 Total Installed Cost Inputs

DOE defines the total installed cost using the following equation:

$$\boldsymbol{IC = EQP + INST}$$

where:

EQP =	Equipment price (i.e., customer price for the equipment only), expressed in dollars, and
INST =	Installation cost or the customer price to install equipment (i.e., the cost for labor and materials), also in dollars.

The equipment price is based on how the consumer purchases the equipment. As discussed in Chapter 7, Markups for Equipment Price Determination, DOE defined markups and sales taxes for converting manufacturing costs into consumer equipment prices.

Table 8.2.1 summarizes the inputs for the determination of total installed cost.

Table 8.2.1 Inputs for Total Installed Cost

Baseline Manufacturer Cost
Standard-Level Manufacturer Cost
Manufacturer Markup
Retailer or Distributor Markup
Sales Tax
Installation Cost

The *baseline manufacturer cost* is the cost incurred by the manufacturer to produce equipment meeting existing minimum efficiency standards. *Standard-level manufacturer cost increases* are the change in manufacturer cost associated with producing equipment at a standard level. *Markups and sales tax* convert the manufacturer cost to a consumer equipment price. The *installation cost* is the cost to the consumer of installing the equipment and represents all costs required to install the equipment other than the marked-up consumer equipment price. The installation cost includes labor, overhead, and any miscellaneous materials and parts. Thus, the total installed cost equals the consumer equipment price plus the installation cost. DOE calculated the total installed cost for baseline products based on the following equation:

$$\begin{aligned} IC_{BASE} &= EQP_{BASE} + INST_{BASE} \\ &= COST_{MFG} \times MU_{OVERALL\_BASE} + INST_{BASE} \end{aligned}$$

where:

IC_{BASE} = Baseline total installed cost,
EQP_{BASE} = Consumer equipment price for baseline models,
$INST_{BASE}$ = Baseline installation cost,
$COST_{MFG}$ = Manufacturer cost for baseline models, and
$MU_{OVERALL\_BASE}$ = Baseline overall markup (product of manufacturer markup, baseline retailer or distributor markup, and sales tax).

DOE calculated the total installed cost for standard-level products based on the following equation:

$$\begin{aligned} IC_{STD} &= EQP_{STD} + INST_{STD} \\ &= \left(EQP_{BASE} + \Delta EQP_{STD}\right) + \left(INST_{BASE} + \Delta INST_{STD}\right) \\ &= \left(EQP_{BASE} + INST_{BASE}\right) + \left(\Delta EQP_{STD} + \Delta INST_{STD}\right) \\ &= IC_{BASE} + \left(\Delta COST_{MFG} \times MU_{OVERALL\_INCR} + \Delta INST_{STD}\right) \end{aligned}$$

where:

IC_{STD} = Standard-level total installed cost,
EQP_{STD} = Consumer equipment price for standard-level models,
$INST_{STD}$ = Standard-level installation cost,
EQP_{BASE} = Consumer equipment price for baseline models,
ΔEQP_{STD} = Change in equipment price for standard-level models,
$INST_{BASE}$ = Baseline installation cost,
$\Delta INST_{STD}$ = Change in installation cost for standard-level models,
IC_{BASE} = Baseline total installed cost,
$\Delta COST_{MFG}$ = Change in manufacturer cost for standard-level models, and
$MU_{OVERALL\_INCR}$ = Incremental overall markup (product of manufacturer markup, incremental retailer or distributor markup, and sales tax).

The remainder of this section provides information about each of the above input variables that DOE used to calculate the total installed cost for cooking products, dishwashers, dehumidifiers, and commercial clothes washers.

8.2.1.2 Baseline Manufacturer Cost

DOE used residential clothes washer data from AHAM's 2005 Fact Book to develop the baseline manufacturer costs for top-loading commercial clothes washers.[3] According to the AHAM 2005 Fact Book, in the year 2005, total clothes washer sales equaled $3,373,042 million while total industry shipments equaled 9,394 million. DOE divided total sales by total shipments to arrive at an average manufacturer price of $359.06. Based on a manufacturer markup of 1.26, as determined in section 7.2 of Chapter 7, Markups for Equipment Price Determination, DOE arrived at a baseline manufacturer cost of $284.97 in 2006$. As detailed in Chapter 5, Engineering Analysis, DOE estimated the cost difference between top-loading and front-loading washers to arrive at the baseline manufacturer cost for front-loading washers. Table 8.2.2 presents the baseline manufacturer cost as well as the associated baseline modified energy factor and water factor.

Table 8.2.2 Commercial Clothes Washers: Baseline Manufacturer Costs

Product Class	Baseline Modified Energy Factor (cu.ft./kWh/cyc)	Baseline Water Factor (gal/cu.ft.)	Baseline Manufacturer Cost (2008$)
Top-Loading	1.26	9.50	$296.30
Front-Loading	1.72	8.00	$611.02

Source: AHAM 2005 Fact Book.

8.2.1.3 Standard-Level Manufacturer Cost Increases

DOE used a combination of cost data submitted by AHAM and a reverse engineering analysis to develop commercial clothes washer manufacturer cost increases associated with increases in product standard levels. Refer to Chapter 5, Engineering Analysis, for details. Tables 8.2.3 and 8.2.4 present the standard-level manufacturer cost increases as well as the

associated modified energy factors and water factors for top-loading and front-loading washers, respectively.

Table 8.2.3 Top-Loading Commercial Clothes Washers: Standard-Level Manufacturer Cost Increases

Standard Level	Modified Energy Factor (cu.ft./kWh/cyc)	Water Factor (gal/cu.ft.)	Standard-Level Manufacturer Cost Increase (2008$)
Baseline	1.26	9.50	-
1	1.42	9.50	$77.60
2	1.60	8.50	$134.99

Table 8.2.4 Front-Loading Commercial Clothes Washers: Standard-Level Manufacturer Cost Increases

Standard Level	Modified Energy Factor (cu.ft./kWh/cyc)	Water Factor (gal/cu.ft.)	Standard-Level Manufacturer Cost Increase (2008$)
Baseline	1.72	8.00	-
1	1.80	7.50	$0.00
2	2.00	5.50	$14.21
3	2.20	5.10	$39.34
4	2.35	4.40	$66.16

8.2.1.4 Overall Markup

The overall markup is the value determined by multiplying the manufacturer and retailer markups and the sales tax together to arrive at a single markup value. Table 8.2.5 shows the overall baseline and incremental markups for commercial clothes washers. Refer to Chapter 7, Markups for Equipment Price Determination, for details.

Table 8.2.5 Overall Markups

Markup	Baseline	Incremental
Manufacturer	1.26	
Distributor	1.43	1.18
Sales Tax	1.0690	
Overall	1.93	1.59

8.2.1.5 Installation Cost

DOE derived baseline installation costs for commercial clothes washers from data in the *RS Means Mechanical Cost Data, 2008*.[4] This book provides estimates on the labor required to install commercial clothes washers. Table 8.2.6 summarizes the nationally representative

average costs associated with the installation of a four-cycle, coin operating, commercial clothes washer as presented in *RS Means Mechanical Cost Data*. Table 8.2.6 provides both bare costs (i.e., costs before O&P) and installation costs including O&P. DOE determined that installation costs would not be impacted with increased standard levels.

Table 8.2.6 Commercial Clothes Washers: Baseline Installation Costs

	Bare Costs (2005$)			Including Overhead & Profit (2005$)		
Installation Type	**Material**	**Labor**	**Total**	**Total**	**Material***	**Labor****
Average	$1,100	$125	$1,225	$1,400	$1,210	$190
					Average (2008$)	**$190**

* Material costs including O&P equal bare costs plus 10% profit.

** DOE derived labor cost including O&P by subtracting material with O&P from total with O&P.

Source: RS Means, *Mechanical Cost Data, 2008.*

8.2.1.6 Total Installed Cost

The total installed cost is the sum of the consumer equipment price and the installation cost. Refer back to section 8.2.1 to see the equations that DOE used to calculate the total installed cost for baseline and standard-level products.

Tables 8.2.7 and 8.2.8 present the consumer equipment price, installation costs, and total installed costs for top-loading and front-loading washers, respectively. Prices and costs are presented at the baseline level and each standard level.

Table 8.2.7 Top-Loading Commercial Clothes Washers: Consumer Equipment Prices, Installation Costs, and Total Installed Costs

Standard Level	Modified Energy Factor (cu.ft./kWh/cyc)	Water Factor (gal/cu.ft.)	Equipment Price (2008$)	Installation Cost (2008$)	Total Installed Cost (2008$)
Baseline	1.26	9.50	$570.71	$190.00	$760.71
1	1.42	9.50	$694.05	$190.00	$884.05
2	1.60	8.50	$785.26	$190.00	$975.26

Table 8.2.8 Front-Loading Commercial Clothes Washers: Consumer Equipment Prices, Installation Costs, and Total Installed Costs

Standard Level	Modified Energy Factor (cu.ft./kWh/cyc)	Water Factor (gal/cu.ft.)	Equipment Price (2008$)	Installation Cost (2008$)	Total Installed Cost (2008$)
Baseline	1.72	8.00	$1,176.90	$190.00	$1,366.90
1	1.80	7.50	$1,176.90	$190.00	$1,366.90
2	2.00	5.50	$1,199.48	$190.00	$1,389.48
3	2.20	5.10	$1,239.43	$190.00	$1,429.43
4	2.35	4.40	$1,282.05	$190.00	$1,472.05

8.2.2 Operating Cost Inputs

DOE defines the operating cost by the following equation:

$$OC = EC + WC + RC + MC$$

where:

EC = Energy expenditure associated with operating the equipment,
WC = For dishwashers and commercial clothes washers, the water expenditure associated with operating the equipment,
RC = Repair cost associated with component failure, and
MC = Service cost for maintaining equipment operation.

Table 8.2.9 shows the inputs for determining the operating costs. The inputs listed in Table 8.2.9 are also necessary for determining lifetime operating expenses, which include the energy price trends (and water price trends), product lifetime, discount rate, and effective date of the standard.

Table 8.2.9 Inputs for Operating Cost

Annual Energy (and Water) Consumption
Energy and Water Prices
Repair and Maintenance Costs
Energy and Water Price Trends
Product Lifetime
Discount Rate
Effective Date of Standard

The *annual energy consumption* is the site energy use associated with operating the equipment. The *annual water consumption*, which is applicable to commercial clothes washers, is the site water use associated with operating the equipment. The annual energy (and water)

consumption vary with the product efficiency. That is, the energy and water consumption associated with standard-level equipment (i.e., equipment with efficiencies greater than baseline equipment) are less than the consumptions associated with baseline equipment. *Energy and water prices* are the prices paid by consumers for energy (i.e., electricity, gas, or oil) and water. Multiplying the annual energy and water consumption by the energy and water prices yields the annual energy cost and water cost, respectively. *Repair costs* are associated with repairing or replacing components that have failed. *Maintenance costs* are associated with maintaining the operation of the equipment. DOE used *energy and water price trends* to forecast energy and water prices into the future and, along with the product lifetime and discount rate, to establish the lifetime energy and water costs. The *product lifetime* is the age at which the equipment is retired from service. The *discount rate* is the rate at which DOE discounted future expenditures to establish their present value. DOE calculated the operating cost for baseline products based on the following equation:

$$\begin{aligned} OC_{BASE} &= EC_{BASE} + WC_{BASE} + RC_{BASE} + MC_{BASE} \\ &= AEC_{BASE} \times PRICE_{ENERGY} + AWC_{BASE} \times PRICE_{WATER} + RC_{BASE} + MC_{BASE} \end{aligned}$$

where:

OC_{BASE} =	Baseline operating cost,
EC_{BASE} =	Energy expenditure associated with operating the baseline equipment,
WC_{BASE} =	For commercial clothes washers, the water expenditure associated with operating the baseline equipment,
RC_{BASE} =	Repair cost associated with component failure for the baseline equipment,
MC_{BASE} =	Service cost for maintaining baseline equipment operation,
AEC_{BASE} =	Annual energy consumption for baseline equipment,
$PRICE_{ENERGY}$ =	Energy price,
AWC_{BASE} =	Annual water consumption for baseline equipment, and
$PRICE_{WATER}$ =	Water price.

DOE calculated the operating cost for standard-level products based on the following equation:

$$\begin{aligned} OC_{STD} &= EC_{STD} + WC_{STD} + RC_{STD} + MC_{STD} \\ &= AEC_{STD} \times PRICE_{ENERGY} + AWC_{STD} \times PRICE_{WATER} + RC_{STD} + MC_{STD} \\ &= \left(AEC_{BASE} - \Delta AEC_{STD}\right) \times PRICE_{ENERGY} + \left(AWC_{BASE} - \Delta AWC_{STD}\right) \times PRICE_{WATER} \\ &\quad + \left(RC_{BASE} + \Delta RC_{STD}\right) + \left(MC_{BASE} + \Delta MC_{STD}\right) \end{aligned}$$

where:

OC_{STD} =	Standard-level operating cost,
EC_{STD} =	Energy expenditure associated with operating standard-level equipment,

WC_{STD} = For commercial clothes washers, the water expenditure associated with operating standard-level equipment,
RC_{STD} = Repair cost associated with component failure for standard-level equipment,
MC_{STD} = Service cost for maintaining standard-level equipment operation,
AEC_{STD} = Annual energy consumption for standard-level equipment,
$PRICE_{ENERGY}$ = Energy price,
AWC_{STD} = Annual water consumption for standard-level equipment,
$PRICE_{WATER}$ = Water price,
ΔAEC_{STD} = Change in annual energy consumption caused by standard-level equipment,
ΔAWC_{STD} = Change in annual water consumption caused by standard-level equipment,
ΔRC_{STD} = Change in repair cost caused by standard-level equipment, and
ΔMC_{STD} = Change in maintenance cost caused by standard-level equipment.

The remainder of this section provides information about each of the above input variables that DOE used to calculate the operating costs for cooking products, dishwashers, dehumidifiers, and commercial clothes washers.

8.2.2.1 Annual Energy and Water Consumption

Chapter 6, Energy and Water Use Determination, details how DOE determined the annual energy and water consumption for baseline and standard-level products.

DOE characterized the variability of commercial clothes washer usage based on several studies. For multi-family product applications, DOE equally weighted each study to establish the variability. For laundromat applications, DOE used a range of values varying from three to eight cycles per day. Refer back to Chapter 6, section 6.4 to review how DOE characterized commercial clothes washer usage variability.

The tables presented below are based on the energy and water use determination analysis described in Chapter 6. Keep in mind that the annual energy and water consumption values in the tables below are averages. DOE captured the variability in energy (and water) consumption when it conducted its LCC and PBP analysis.

Tables 8.2.10 and 8.2.11 provide the average annual energy and water consumption by efficiency level for top-loading commercial clothes washers. Tables 8.2.12 and 8.2.13 provide the average annual energy and water consumption by efficiency level for front-loading commercial clothes washers. DOE presents annual consumption based on two applications: multi-family housing and laundromats. The tables below are similar to Tables 6.3.2 through 6.3.5 in section 6.3 from Chapter 6 with the exception that, in the tables below, the electric and gas water heating and drying consumptions take into account the percentage of buildings in the U.S. that use electric and gas water heaters and dryers. In others words, the electric and gas water heating and drying consumption in Tables 8.2.10 through 8.2.13 are weighted by the share

of buildings that use electric and gas water heaters and dryers. Based on data from the Consortium for Energy Efficiency (CEE),[5] the shares of electric and gas water heating and drying in multi-family applications are: 20 percent and 80 percent electric and gas water heating, respectively, and 40 percent and 60 percent electric and gas drying, respectively. Also based on CEE data, 100 percent of laundromats use gas water heating and drying.

Table 8.2.10 Top-Loading Commercial Clothes Washers, Multi-Family Application: Annual Energy and Water Use by Efficiency Level

Standard Level	MEF	WF	Annual Energy Use*					Annual Water Use
			Water Heating**		Drying***		Machine	
			Electric	Gas	Electric	Gas		
	cu.ft./kWh/cyc	*gal/cu.ft.*	*kWh/yr*	*MMBtu/yr*	*kWh/yr*	*MMBtu/yr*	*kWh/yr*	*1000 gal/year*
Baseline	1.26	9.50	204	3.71	633	3.63	166	33.1
1	1.42	9.50	158	2.87	601	3.45	166	33.1
2	1.60	8.50	125	2.27	566	3.24	142	29.7
3	1.76	8.30	101	1.84	534	3.06	142	29.0

* Annual usage based on 3.4 cycles per day (1241 cycles per year).

****** Electric and gas water heating based on water heater efficiencies of 100% for electric and 75% for gas. Water heater consumption is weighted by the share of buildings with electric (20%) and gas (80%) water heaters.

******* Dryer consumption is weighted by the share of buildings with electric (40%) and gas (60%) dryers.

Table 8.2.11 Top-Loading Commercial Clothes Washers, Laundromat Application: Annual Energy and Water Use by Efficiency Level

Standard Level	MEF	WF	Annual Energy Use*					Annual Water Use
			Water Heating**		Drying***		Machine	
			Electric	Gas	Electric	Gas		
	cu.ft./kWh/cyc	*gal/cu.ft.*	*kWh/yr*	*MMBtu/yr*	*kWh/yr*	*MMBtu/yr*	*kWh/yr*	*1000 gal/year*
Baseline	1.26	9.50	0	8.16	0	10.63	291	58.3
1	1.42	9.50	0	6.30	0	10.10	291	58.3
2	1.60	8.50	0	4.99	0	9.50	250	52.1
3	1.72	8.00	0	4.04	0	8.96	250	50.9

* Annual usage based on 6 cycles per day (2190 cycles per year).

****** Electric and gas water heating based on water heater efficiencies of 100% for electric and 75% for gas. Water heater consumption is weighted by the share of buildings with electric (0%) and gas (100%) water heaters.

******* Dryer consumption is weighted by the share of buildings with electric (0%) and gas (100%) dryers.

Table 8.2.12 Front-Loading Commercial Clothes Washers, Multi-Family Application: Annual Energy and Water Use by Efficiency Level

Standard Level	MEF	WF	Annual Energy Use*					Annual Water Use
			Water Heating**		Drying***		Machine	
			Electric	Gas	Electric	Gas		
	cu.ft./kWh/cyc	*gal/cu.ft.*	*kWh/yr*	*MMBtu/yr*	*kWh/yr*	*MMBtu/yr*	*kWh/yr*	*1000 gal/year*
Baseline	1.72	8.00	106	1.94	542	3.11	142	27.9
1	1.80	7.50	96	1.75	526	3.01	142	26.2
2	2.00	5.50	77	1.41	486	2.79	142	19.2
3	2.20	5.10	66	1.19	446	2.56	142	17.8
4	2.35	4.40	60	1.10	417	2.39	142	15.4

* Annual usage based on 3.4 cycles per day (1241 cycles per year).

****** Electric and gas water heating based on water heater efficiencies of 100% for electric and 75% for gas. Water heater consumption is weighted by the share of buildings with electric (20%) and gas (80%) water heaters.

******* Dryer consumption is weighted by the share of buildings with electric (40%) and gas (60%) dryers.

Table 8.2.13 Front-Loading Commercial Clothes Washers, Laundromat Application: Annual Energy and Water Use by Efficiency Level

Standard Level	MEF	WF	Annual Energy Use*					Annual Water Use
			Water Heating**		Drying***		Machine	
			Electric	Gas	Electric	Gas		
	cu.ft./kWh/cyc	*gal/cu.ft.*	*kWh/yr*	*MMBtu/yr*	*kWh/yr*	*MMBtu/yr*	*kWh/yr*	*1000 gal/year*
Baseline	1.72	8.00	0	4.25	0	9.10	250	49.1
1	1.80	7.50	0	3.85	0	8.83	250	46.0
2	2.00	5.50	0	3.10	0	8.16	250	33.7
3	2.20	5.10	0	2.62	0	7.49	250	31.3
4	2.35	4.40	0	2.41	0	6.99	250	27.0

* Annual usage based on 6 cycles per day (2190 cycles per year).

****** Electric and gas water heating based on water heater efficiencies of 100% for electric and 75% for gas. Water heater consumption is weighted by the share of buildings with electric (0%) and gas (100%) water heaters.

******* Dryer consumption is weighted by the share of buildings with electric (0%) and gas (100%) dryers.

8.2.2.2 Energy and Water Prices

DOE derived energy prices for 13 geographic areas in the U.S. and derived water prices for the four Census regions. Using these data, DOE analyzed the variability of energy and water prices at the regional level for cooking products and commercial clothes washers.

DOE characterized energy and water price regional variability with probability distributions. It based the probability associated with each regional energy and water price on the population weight of each region.

The methodology that DOE used for deriving the energy and water prices is presented below. Included are tables that summarize the regional energy and water prices for each product.

Energy Prices

DOE derived average energy prices from data from EIA. DOE calculated prices for each of 13 geographic areas: the nine U.S. Census divisions, with four large States (New York, Florida, Texas, and California) treated separately. For Census divisions containing one of these large States, DOE calculated the regional average values leaving out data for the large State—for example, the Pacific region average does not include California, and the West South Central does not include Texas.

Commercial Electricity Prices

DOE estimated electricity prices for commercial consumers in each of the above geographic areas using EIA Form 861 data.[6] These data are published annually and include annual electricity sales in kilowatt hours (kWh), revenues from electricity sales, and number of consumers, for the residential, commercial, and industrial sectors, for every utility serving final consumers. The calculation of an average residential electricity price proceeds in two steps:

1. For each utility, estimate an average residential price by dividing the residential revenues by residential sales.
2. Calculate a regional average price, weighting each utility with customers in a region by the number of residential consumers served in that region.

Table 8.2.14 shows the results for each geographic region.

Table 8.2.14 Average Commercial Electricity Prices in 2007

Geographic Area	Average Price (2007$/kWh)
New England	$0.148
Middle Atlantic (excludes NY)	$0.107
East North Central	$0.088
West North Central	$0.072
South Atlantic (excludes FL)	$0.082
East South Central	$0.083
West South Central (excludes TX)	$0.082
Mountain	$0.081
Pacific (excludes CA)	$0.091
New York	$0.163
Florida	$0.131
Texas	$0.115
California	$0.098

Source: EIA Form 861.

Table 8.2.15 shows the national average commercial electricity prices for commercial clothes washers based on the relative residential consumer weight of each geographic area. DOE used 2006 population estimates from the U.S. Census as a proxy to estimate how the national saturation of commercial clothes washers was distributed over the 13 geographic areas.[7] Because DOE conducted the LCC and PBP analysis in 2008$, all electricity prices are in 2008$. To perform the necessary monetary conversion, DOE used the GDP to convert the electricity prices from 2007$ to 2008$.

Table 8.2.15 Average Commercial Electricity Prices for Commercial Clothes Washers in 2008

Geographic Area	Average Price (2008$/kWh)**	Saturations*
New England	$0.156	4.8%
Middle Atlantic (excludes NY)	$0.114	7.1%
East North Central	$0.093	15.5%
West North Central	$0.076	6.7%
South Atlantic (excludes FL)	$0.087	13.0%
East South Central	$0.088	5.9%
West South Central (excludes TX)	$0.087	3.6%
Mountain	$0.085	7.0%
Pacific (excludes CA)	$0.096	4.0%
New York	$0.172	6.4%
Florida	$0.139	6.0%
Texas	$0.121	7.9%
California	$0.104	12.2%
National Average Price (2008$/kWh)	**$0.108**	-

* Saturations based on 2006 population estimates from Census.

** Converted to 2008$ by multiplying costs in 2007$ by the ratio of 2008 GDP (1.1981) to 2007 GDP (1.1727). Converted the price for year 2007 to the price in 2008 by multiplying the 2007 price by the ratio of the average AEO electricity price in 2008 (29.06 $/MMBtu) to average AEO electricity price in 2007 (28.03 $/MMBtu).

Commercial Natural Gas Prices

DOE obtained the data for the natural gas price calculation from the EIA publication *Natural Gas Monthly*.[8] This publication includes a compilation of monthly natural gas delivery volumes and average consumer prices by State, for residential, commercial, and industrial customers. The Department used the complete annual data for 2007 to calculate an average annul price for each area. The calculation of average prices proceeds in two steps:

1. Calculate the annul price for each State using a simple average over the appropriate months.
2. Calculate a regional price, weighting each State in a region by its population.

This method differs from the method used to calculate electricity prices because EIA does not provide consumer- or utility-level data on gas consumption and prices. The commercial price units in Table 8.2.16 are in dollars per thousand cubic feet ($/tcf).

Table 8.2.16 Average Commercial Natural Gas Prices in 2007

Geographic Area	Average Price (2007$/tcf)
New England	$14.12
Middle Atlantic (excludes NY)	$12.49
East North Central	$10.86
West North Central	$10.89
South Atlantic (excludes FL)	$12.94
East South Central	$12.64
West South Central (excludes TX)	$11.21
Mountain	$10.47
Pacific (excludes CA)	$13.91
New York	$11.39
Florida	$10.17
Texas	$9.99
California	$13.04

Source: EIA *Natural Gas Monthly*.

Table 8.2.17 shows the national average commercial natural gas prices for commercial clothes washers based on the relative commercial consumer weight of each geographic area. DOE used 2006 population estimates from the U.S. Census as a proxy to estimate how the national saturation of commercial clothes washers was distributed over the 13 geographic areas. Because DOE conducted the LCC and PBP analysis in 2008$, all natural gas prices are in 2008$. To perform the necessary monetary conversion, DOE used the GDP to convert the gas prices from 2007$ to 2008$.

Table 8.2.17 Average Commercial Natural Gas Prices for Commercial Clothes Washers in 2008

Geographic Area	Average Price (2008$/MMBtu)**	Saturations*
New England	$14.43	4.8%
Middle Atlantic (excludes NY)	$12.77	7.1%
East North Central	$11.10	15.5%
West North Central	$11.14	6.7%
South Atlantic (excludes FL)	$13.23	13.0%
East South Central	$12.92	5.9%
West South Central (excludes TX)	$11.46	3.6%
Mountain	$10.70	7.0%
Pacific (excludes CA)	$14.22	4.0%
New York	$11.64	6.4%
Florida	$10.39	6.0%
Texas	$10.21	7.9%
California	$13.33	12.2%
National Average Price (2008$/MMBtu)	**$11.89**	**-**

* Saturations based on 2005 population estimates from U.S. Census.

** 1 tcf gas = 1.03 MMBtu; Converted to 2008$ by multiplying costs in 2007$ by the ratio of 2008 GDP (1.1981) to 2007 GDP (1.1727). Converted the price for year 2007 to the price in 2008 by multiplying the 2007 price by the ratio of the average AEO gas price in 2008 (11.34 $/MMBtu) to average AEO gas price in 2007 (10.99 $/MMBtu).

Water Prices

DOE obtained water price data from the year 2006 from the *Water and Wastewater Rate Survey* conducted by Raftelis Financial Consultants and the American Water Works Association.[9] The survey covers approximately 216 water utilities and 153 wastewater utilities, with each industry analyzed separately. The water survey includes, for each utility, the cost to consumers of purchasing a given volume of water. In this case, the data include a division of the total consumer cost into fixed and volumetric charges. The calculations use only the volumetric charge to calculate water prices, since only this charge would be affected by a change in water consumption. Including the fixed charge in the average would lead to a slightly higher water price.

The *Water and Wastewater Rate Survey* provides prices separately for residential and non-residential customers. For wastewater utilities, the format is similar, but the cost refers to the cost of treating a given volume of wastewater. In both surveys, the non-residential sector is divided into four sub-sectors based on the average monthly volume of water delivered or, equivalently, the size of the delivery pipe. The sub-sectors are named non-manufacturing, commercial, industrial 1, and industrial 2. DOE's analysis uses the commercial category to estimate prices for commercial consumers.

A sample of 216 utilities is not large enough to calculate regional prices for all U.S. Census divisions and large States (for comparison, the EIA Form 861 data include more than 3000 utilities). For this reason, DOE calculated regional values at the Census region level (Northeast, South, Midwest, and West). The calculation of average per-unit-volume prices proceeds in three steps:

1. For each utility, calculate the per-unit-volume price by dividing the total volumetric cost by the volume delivered.
2. Calculate a State-level average price by weighting each utility in a given State by the number of consumers it serves (either residential or commercial).
3. Calculate a regional average by combining the State-level averages, weighting each by the population of that State. This third step helps reduce any bias in the sample that may occur due to relative under-sampling of large States.

The results of the calculation for the commercial sector are presented in Table 8.2.18. The price units in the table are dollars per thousand gallons ($/tg).

Table 8.2.18 Average Per-Unit-Volume Water Prices in 2006

	Commercial	
Region	**2005$/tg Water**	**2005$/tg Wastewater**
Northeast	$2.03	$3.06
Midwest	$1.62	$2.30
South	$2.00	$2.27
West	$2.00	$2.54

Table 8.2.19 shows the national average commercial water and wastewater prices for commercial clothes washers based on the relative commercial consumer weight of each region. DOE used 2006 population estimates from the U.S. Census as a proxy to estimate how the national saturation of commercial clothes washers was distributed over the four regions. Because DOE conducted the LCC and PBP analysis in 2008$, it needed to convert all water prices into 2008$. To perform the necessary monetary conversion, DOE used the GDP to convert the water and wastewater prices from 2005$ to 2008$.

Table 8.2.19 Average Per-Unit-Volume Water Prices for Commercial Clothes Washers in 2008

Region	2008$/tg Water**	2008$/tg Wastewater**	Saturations*
Northeast	$2.42	$3.65	18.3%
Midwest	$1.93	$2.75	22.1%
South	$2.39	$2.71	36.4%
West	$2.39	$3.03	23.2%
National	$2.29	$2.97	-

* Saturations based on 2006 population estimates from Census.

** Converted to 2008$ by multiplying costs in 2005$ by the ratio of 2008 GDP (1.1981) to 2004 GDP (1.1193). Converted the price for year 2006 to the price in 2008 by multiplying the 2006 price by the ratio of the average water CPI in 2008 (331.33) to average water CPI in 2006 (297.20).

8.2.2.3 Energy and Water Price Trends

DOE used price forecasts by the EIA to estimate the trends in natural gas, oil, and electricity prices. To arrive at prices in future years, it multiplied the average prices described in the preceding section (section 8.2.2.2) by the forecast of annual average price changes in EIA's *AEO 2009* updated to reflect the American Recovery and Reinvestment Act (*AEO 2009 ARRA*).[10] To estimate the trend after 2030, DOE followed past guidelines provided to the Federal Energy Management Program (FEMP) by EIA and used the average rate of change during 2020–2030.

The Department set up its analysis to calculate LCC and PBP using three separate projections: Reference, Low Economic Growth, and High Economic Growth. These three cases reflect the uncertainty of economic growth in the forecast period. The high and low growth cases show the projected effects of alternative growth assumptions on energy markets. The *AEO 2009 ARRA* provides only forecasts for the Reference Case. Therefore, DOE used the high-growth case and low-growth forecasts from the *AEO 2009* March release to estimate high and low growth price trends.[11] Figures 8.2.1 and 8.2.2 show the commercial electricity and natural gas price trends, respectively, based on the three projections. For the LCC results presented in section 8.4, DOE used only the energy price forecasts from the *AEO 2009 ARRA* Reference Case.

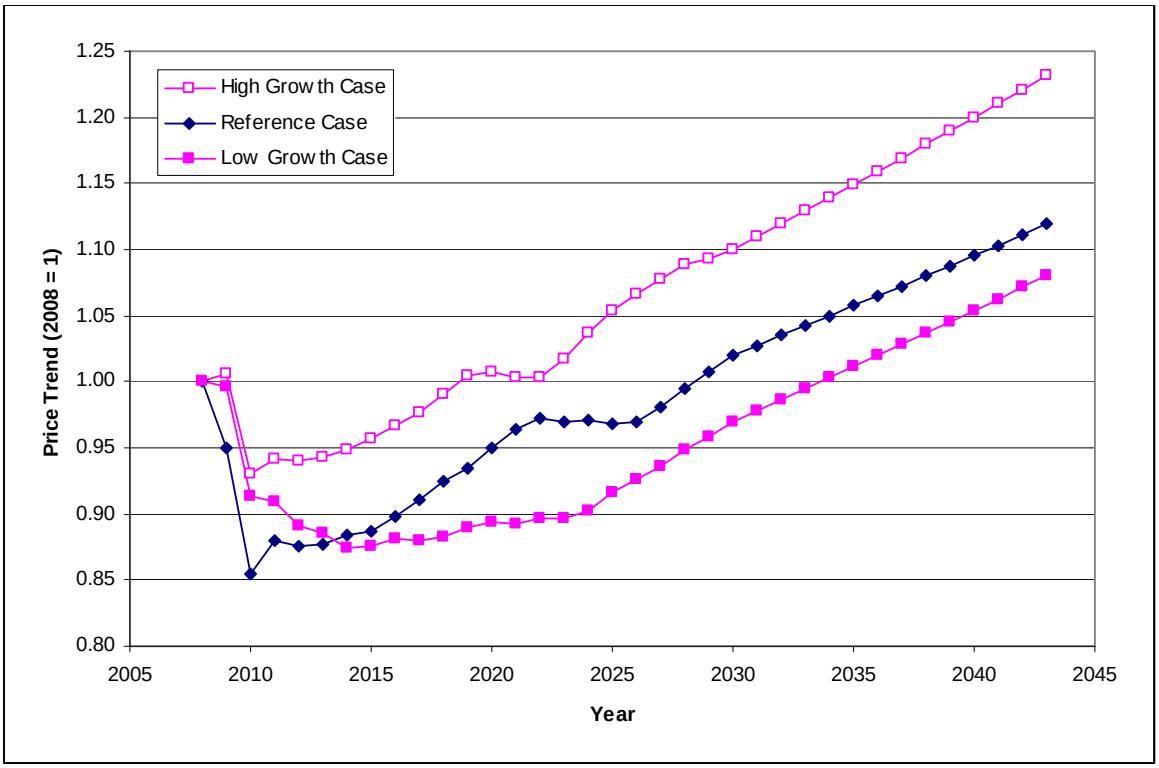

Figure 8.2.1 Electricity Price Trends

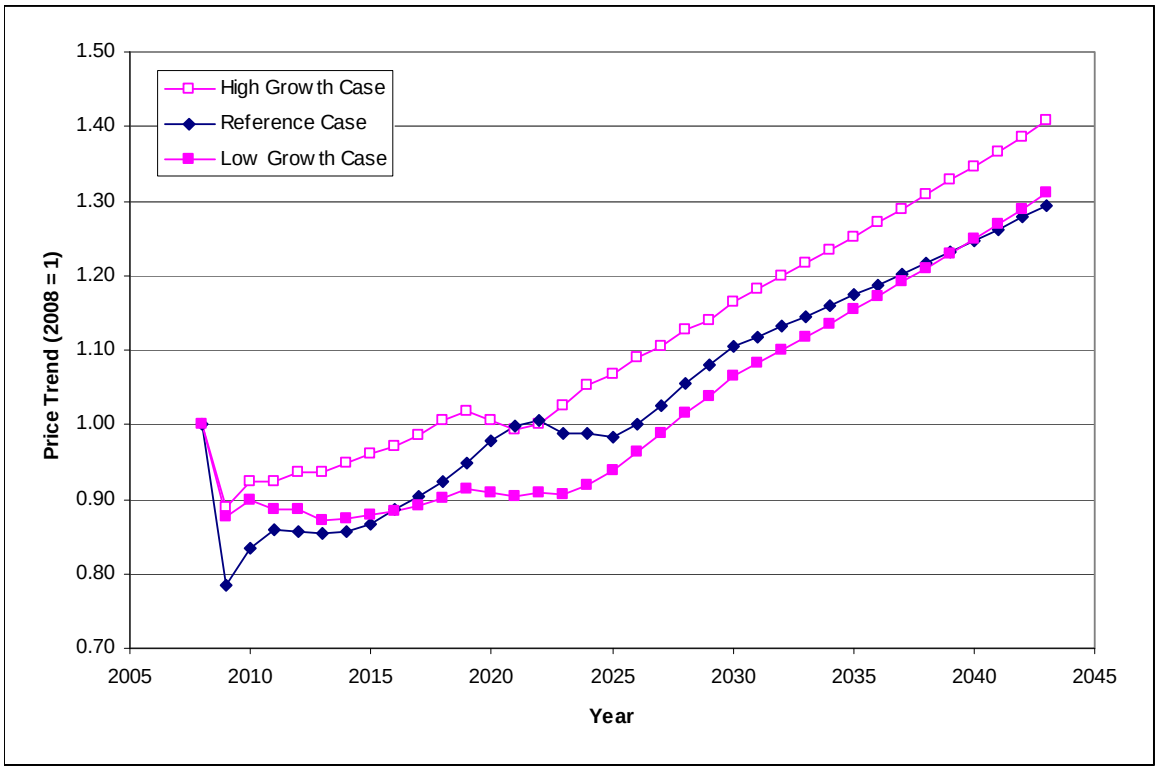

Figure 8.2.2 Natural Gas Price Trends

To estimate the future trend for water and wastewater prices, DOE used data on the historic trend in the national water price index (U.S. city average) from 1970 through 2008.[12] DOE extrapolated the future trend based on the linear growth from 1970 to 2008. But rather than use the extrapolated trend to forecast the prices for the four years after 2008, DOE pinned the annual price to the value in 2008. Otherwise, forecasted prices for this four-year time period would have been up to eight percent lower than the price in 2008. Beyond the four-year time period, DOE used the extrapolated trend to forecast prices out to the year 2043. Figure 8.2.3 shows the historical and projected water price trend data. DOE used the forecasted data to estimate water and wastewater prices for commercial clothes washers.

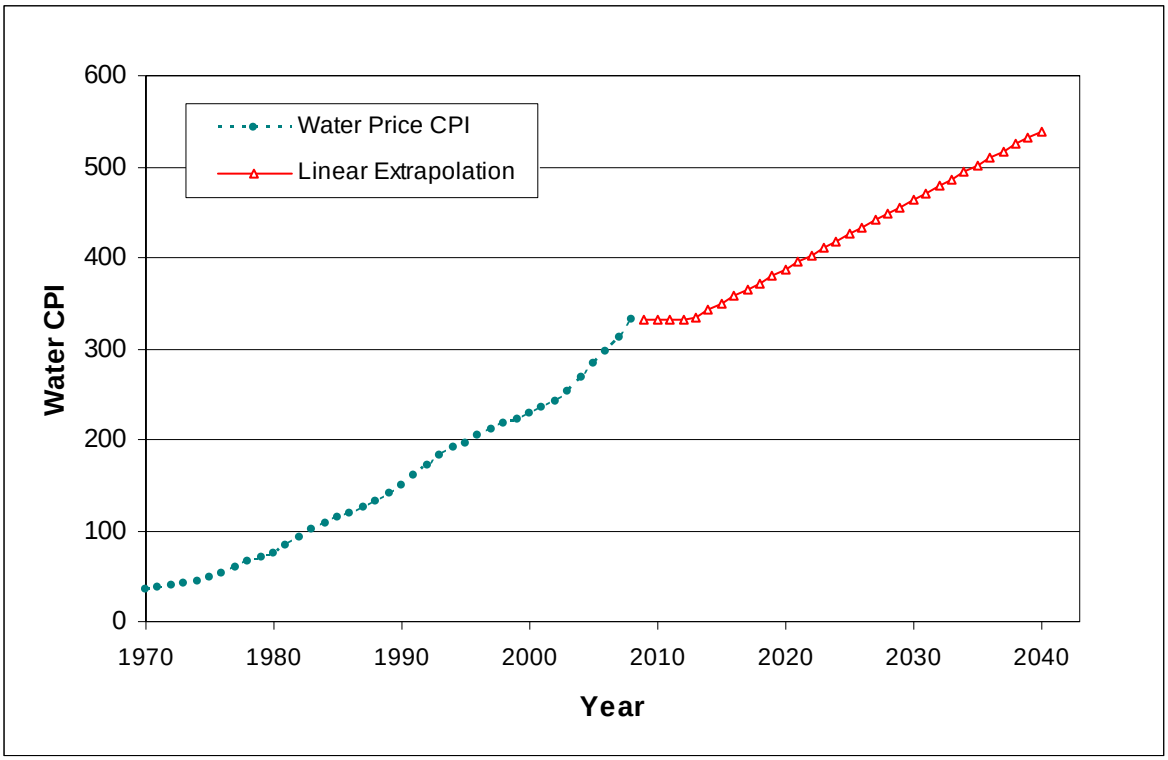

Figure 8.2.3 Water Price Trend

8.2.2.4 Repair and Maintenance Costs

Typically, small incremental changes in product efficiency incur no, or only very small, changes in repair and maintenance costs over baseline products. However, equipment with efficiencies that are significantly higher than the baseline are more likely to incur higher repair and maintenance costs because its higher complexity and higher part count typically increases the cumulative probability of failure.

The Whirlpool Corporation estimates that the unit shipments of horizontal-axis commercial clothes washers are less than half that of vertical-axis machines while their in-warranty repair costs are double that of vertical-axis machines.[13] This suggests that the repair of

horizontal-axis machines is four times as costly as that of vertical-axis machines. Because in-warranty repair costs, based on Whirlpool's experience, are greater for horizontal-axis machines that vertical-axis machines, DOE estimated that commercial clothes washer repair costs would increase as a function of equipment efficiency. DOE utilized an algorithm developed for central air conditioners and heat pumps to estimate repair cost increases.[14] This algorithm calculates annualized repair costs by dividing the half the equipment retail price by the equipment lifetime as show in the expression below:

$$RC_{ANNUAL} = \frac{0.5 \times EQP}{LIFE}$$

where:

RC_{ANNUAL} = Annualized repair cost associated with equipment,
EQP = Consumer equipment price, and
$LIFE$ = Product lifetime.

Tables 8.2.20 and 8.2.21 show for each product class and each product application (multi-family buildings and laundromats) the annualized repair costs for the commercial clothes washer baseline and efficiency levels. Annualized repair costs for each product application differ because commercial clothes washer lifetime is different for each application. (Product lifetimes are presented below is section 8.2.3.) The tables also present the consumer equipment prices for the baseline level and each efficiency level.

Table 8.2.20 Top-Loading Commercial Clothes Washer Annualized Repair Costs

Level	Modified Energy Factor (cu.ft./kWh/cyc)	Water Factor (gal/cu.ft.)	Equipment Price (2008$)	Annualized Repair Cost (2008$)	
				Multi-Family*	Laundromat*
Baseline	1.26	9.50	$570.71	$25.36	$40.05
1	1.42	9.50	$694.05	$30.85	$48.71
2	1.60	8.50	$785.26	$34.90	$55.11

* Average product lifetime: Multi-family = 11.3 years; Laundromat = 7.1 years.

Table 8.2.21 Front-Loading Commercial Clothes Washer Annualized Repair Costs

Level	Modified Energy Factor (cu.ft./kWh/cyc)	Water Factor (gal/cu.ft.)	Equipment Price (2008$)	Annualized Repair Cost (2008$)	
				Multi-Family*	Laundromat*
Baseline	1.72	8.00	$1176.90	$52.31	$82.59
1	1.80	7.50	$1176.90	$52.31	$82.59
2	2.00	5.50	$1199.48	$53.31	$84.17
3	2.20	5.10	$1239.43	$55.09	$86.98
4	2.35	4.40	$1282.05	$56.98	$89.97

* Average product lifetime: Multi-family = 11.3 years; Laundromat = 7.1 years.

8.2.3 Product Lifetime

DOE used only primary sources of data to estimate product lifetimes. DOE considered the sources listed in Table 8.2.22 to estimate product lifetime.

Table 8.2.22 Commercial Clothes Washers: Product Lifetime Estimates and Sources

Lifetime (years)	Source
7 to 10	CEE (1998) [5]
Top-Loading (12 to 14 lbs.): 5 to 8* Front-Loading (18 to 50 lbs.): 10 to 15**	CLA [15]
8 to 9***	ACEEE (2001) [16]
5 (high-use)* to 13 (low-use)**	Southern California Edison (2000) [17]
15** †	CALMAC (2000) [18]

* Used to establish laundromat lifetime only.

** Used to establish multi-family lifetime only.

*** Depending on the usage rate, the life can be shorter.

† Based on engineering judgment.

Because DOE conducted the LCC analysis based on analyzing two product applications—multi-family and laundromats—it established separate lifetimes for each product application. Because clothes washers in multi-family applications are used less frequently than in laundromats, DOE decided to use only those sources that indicated lifetimes of seven years or greater for multi-family applications. For laundromats applications, where clothes washers receive heavier use, DOE decided to use only those sources that indicated lifetimes of 10 years or less. DOE then took an average of the lifetime estimates that met the above criteria. For multi-family applications the average lifetime turned out to be 11.3 years, while the average lifetime for laundromats was 7.1 years. DOE used the low estimate for the above applicable sources to establish the minimum product lifetime for each product application. For multi-family applications the minimum estimate is 7 years and for laundromats it is 5 years. To establish the maximum product lifetime, DOE took the difference between the minimum and average values (4.3 years for multi-family and 2.1 years for laundromats) and added it to the average product lifetime. The minimum, average, and maximum lifetime estimates for each product application are shown in Table 8.2.23.

Table 8.2.23 Commercial Clothes Washers: Average, Minimum, and Maximum Product Lifetimes

Product	Minimum *years*	Average *years*	Maximum *years*
Multi-Family	7.0	11.3	15.5
Laundromats	5.0	7.1	9.3

DOE characterized the clothes washer product lifetimes for each product application with Weibull distributions. Appendix 8C presents the Weibull distributions for commercial clothes washers that DOE used in the LCC and PBP analysis.

8.2.4 Discount Rates

DOE derived the discount rates for the LCC and PBP analysis from estimates of the finance cost of purchasing the considered products. Following financial theory, the finance cost of raising funds to purchase appliances can be interpreted as: (1) the financial cost of any debt incurred to purchase equipment, or (2) the opportunity cost of any equity used to purchase equipment. For the residential products, the purchase of equipment for new homes entails different finance costs for consumers than the purchase of replacement equipment. Thus, DOE used different discount rates for new construction and replacement installations.

For commercial clothes washers, DOE derived the discount rate from the cost of capital of publicly traded firms in the sectors that purchase commercial clothes washers.[19] These companies typically finance equipment purchases through debt and equity capital. DOE estimated the cost of capital of these firms as the weighted average of the cost of equity financing and the cost of debt financing.

The costs of debt and equity financing are usually obtainable from publicly available data about the following types of companies in the sectors that purchase commercial clothes washers:

- personal services (including laundromats),
- educational services (which buy washers for dormitories),
- hotels, and
- real estate investment trusts (REITs) (i.e., building owners, including owners of apartment complexes).

Damodaran Online is a widely used source of information about company debt and equity financing for most types of firms, and was the source of data for this analysis on educational services, hotels, and REITs.[20] Since Damodaran Online does not include data for firms in the personal services sector (SIC 7200), DOE used data from Ibbotson's Associates for this sector.[21] Ibbotson Associates is a leading authority on asset allocation with expertise in capital market expectations and portfolio implementation.

DOE estimated the cost of equity using the capital asset pricing model (CAPM).[22] The CAPM assumes that the cost of equity (k_e) for a particular company is proportional to the systematic risk faced by that company, where high risk is associated with a high cost of equity and low risk is associated with a low cost of equity. The systematic risk facing a firm is determined by several variables: the risk coefficient of the firm (β), the expected return on risk-free assets (R_f), and the equity risk premium (*ERP*). The risk coefficient of the firm indicates the risk associated with that firm relative to the price variability in the stock market. The expected return on risk-free assets is defined by the yield on long-term government bonds. The *ERP* represents the difference between the expected stock market return and the risk-free rate. The

cost of equity financing is estimated using the following equation, where the variables are defined as above:

$$k_e = R_f + (\beta \times ERP)$$

where:

k_e = Cost of equity,
R_f = Expected return on risk-free assets,
β = Risk coefficient of the firm, and
ERP = Equity risk premium.

The cost of debt financing (k_d) is the interest rate paid on money borrowed by a company. The cost of debt is estimated by adding a risk adjustment factor (R_a) to the risk-free rate. This risk adjustment factor depends on the variability of stock returns represented by standard deviations in stock prices. So for firm *i*, the cost of debt financing is:

$$k_{di} = R_f + R_{ai}$$

where:

k_d = Cost of debt financing for firm, *i*,
R_f = Expected return on risk-free assets, and
R_{ai} = Risk adjustment factor to risk-free rate for firm, *i*.

DOE estimates the weighted-average cost of capital (WACC) using the following equation:

$$WACC = k_e \times w_e + k_d \times w_d$$

where:

$WACC$ = Weighted average cost of capital,
w_e = Proportion of equity financing, and
w_d = Proportion of debt financing.

The values of the parameters used in the calculations are shown in Table 8.2.24 below.

Table 8.2.24 Data for the Calculation of Weighted-Average Cost of Capital for Sectors that Purchase Commercial Clothes Washers

Sector	β	R_f	ERP	R_a	w_e	w_d
Personal Services	0.53	5.2%	5.1%	0.8%	67.4%	32.6%
Educational Services	1.09	5.2%	5.1%	2.0%	97.5%	2.5%
Hotels	0.82	5.2%	5.1%	2.0%	73.7%	26.3%
REIT	0.67	5.2%	5.1%	0.5%	92.6%	7.4%

Based on the procedure described above and the data in Table 8.2.24, Table 8.2.25 shows the WACC for each of the four sectors that purchase commercial washers.

Table 8.2.25 Weighted Average Cost of Capital for Sectors that Purchase Commercial Clothes Washers

Sector	Weighted-Average Cost of Capital
Personal Services	6.9%
Educational Services	10.6%
Hotels	8.5%
REIT	8.4%

The WACC provides an estimate of the nominal cost of capital for firms that purchase commercial clothes washers. The real WACC is calculated by adjusting the cost of capital by the expected rate of inflation using the following formula:

$$WACC_r = \frac{1 + WACC}{1 + r} - 1$$

where:

$WACC_r$ = Real weighted-average cost of capital,
$WACC$ = Weighted-average cost of capital, and
r = Inflation rate.

DOE applied this formula to the costs of capital shown in Table 8.2.25 which yielded the discount rates for each of the sectors given in Table 8.2.26. For the calculation of the discount rates, DOE assumed an inflation rate of 2.5 percent (the average of inflation rates over the 2001–2005 time period).[23] Because DOE performed the discount rate calculation on companies or firms that typically purchase commercial clothes washers, a distribution of discount rates were generated within each sector. The standard deviation of the distribution for each sector is provided in Table 8.2.26. To obtain an average discount rate value for the entire commercial clothe washer industry, DOE analyzed additional data from the CEE. The CEE estimates that there are up to 3,000,000 commercial clothes washers in use in the United States, 2,000,000 of these in multi-family housing and 420,000 in laundromats.[5] DOE assumed that the remaining 580,000 washers are used in universities and educational institutions. Using these proportions, DOE derived weights of 14 percent, 19.4 percent, and 66.6 percent for personal services, educational services, and REIT, respectively. In the absence of any data regarding hotels, DOE assumed the weight for educational services was applicable to hotels as well. Weighting each sector by its market share, DOE estimated the average discount rate for companies that purchase commercial washers to be 5.7 percent, assuming an inflation rate of 2.5 percent (the average of inflation rates over the 2001–2005 time period).[22]

Table 8.2.26 Discount Rates for Commercial Clothes Washers

	Discount Rate		
Sector	**Average**	**Std Deviation**	**Share**
Personal Services	4.3%	1.8%	14.0%
Educational Services	7.9%	5.7%	9.7%
Hotels	5.8%	2.0%	9.7%
REIT	5.7%	2.2%	66.6%
Average	**5.7%**	**-**	**100%**

To account for variation in the discount rates within each of the sectors, DOE used the average values and standard deviations in the table above to characterize the discount rates for each sector with a normal probability distribution. Because the use of the above standard deviations yield distributions with negative values, DOE truncated the lower end of the normal distribution at a discount rate of zero. DOE also truncated the higher end of the normal distribution in equal proportion to the truncation at the lower end to maintain the average discount rates shown above in Table 8.2.26.

8.2.5 Effective Date of Standard

The effective date is the future date when a new standard becomes operative. Based on DOE's implementation report for energy conservation standards activities submitted pursuant to Section 136 of the Energy Policy Act of 2005, a final rule for the commercial clothes washers being considered for this standards rulemaking is scheduled for completion no later than January 1, 2010. Therefore, the effective date of any new energy efficiency standards for these products will be three years after the final rule is published, which is January 1, 2013. The Department calculated the LCC for all consumers as if they each would purchase a new piece of equipment in the year the standard takes effect.

8.2.6 Equipment Assignment for the Base Case

For purposes of conducting the LCC analysis, DOE analyzed standard levels relative to a baseline efficiency level. However, some consumers already purchase products with efficiencies greater than the baseline levels. Thus, to accurately estimate the percentage of consumers that would be affected by a particular standard level, DOE took into account the distribution of product efficiencies currently in the marketplace. In other words, rather than analyzing the impacts of a particular standard level assuming that all consumers are currently purchasing products at the baseline level, DOE conducted the analysis by taking into account the full breadth of product efficiencies that consumers purchase under the base case (i.e., the case without new energy efficiency standards).

DOE took into account the mix of commercial clothes washer efficiencies by characterizing the current mix of product efficiencies as a probability distribution. In other

words, as DOE performed the Monte Carlo simulation, each standard level analyzed was evaluated against the distribution of product efficiencies in the base case.

Rather than providing market share data, AHAM provided shipment-weighted efficiencies of all commercial clothes washers.[24] That is, shipment-weighted efficiencies were not provided separately for the top-loading and front-loading product classes. For the year 2005, the shipment-weighted efficiencies of commercial clothes washers are 1.41 modified energy factor (MEF) and 10.91 water factor (WF). Based on the shipment-weighted efficiency data, DOE was able to derive the market share of each product class. DOE assumed a bi-modal market share distribution consisting of only top-loading equipment meeting current minimum efficiency standards of 1.26 MEF/9.5 WF and top-loading equipment with an efficiency of 2.00 MEF/5.5 WF. Thus, by using a shipment-weighted efficiency of 1.41 MEF, DOE determined that the market share of 1.26 MEF/9.5 WF washers is 79.7 percent and the market share of 2.00 MEF/5.5 WF washers is 20.3 percent.[a] DOE interprets this result as indicating that in the year 2005, 79.7 percent of the market consists of top-loading washers while 20.3 percent is comprised of front-loading washers.

Subsequent to 2005, energy efficiency tax incentives in the Energy Policy Act of 2005 and extensions as well as new provisions in the Economic Stabilization Act of 2008 have resulted in more front-loading washers being produced by manufacturers. DOE reviewed the U.S. Securities and Exchange Commission (SEC) 10K report of the low volume manufacturer (LVM) of commercial clothes washers and determined that manufacturer tax credits in this recent federal legislation have resulted in significantly increased sales of the front-loading washers for the LVM. When accounting for the LVM's market share, the increase in front-loading sales results in a current market share of 30 percent for front-loading washers. Although tax credits are set to expire after 2010, DOE estimates that the tax credits would permanently transform the market so that front-loading washers would continue to comprise 30 percent of the market over the entire forecast period.

Knowing the market share of each product class does not provide the distribution of equipment efficiencies within each class. Therefore, DOE relied on anther data source—the California Energy Commission (CEC).[25] As discussed in Section 3.14.3 of Chapter 3, Market and Technology Assessment, the CEC publishes the MEFs and WFs of commercial clothes washers sold in California. Although the range in efficiencies is relatively wide, the distribution is based on the number of available models being sold rather than the percent of shipments being sold. Without any other data available, DOE assumed that the distribution of available models in the CEC data were representative of actual shipments sold in the U.S. Tables 8.2.27 and 8.2.28 present the market shares of the efficiency levels in the base case for top-loading and front-loading washers, respectively. The tables represent the equipment that establishments would have purchased in the year 2013 in the absence of new standards.

[a] DOE did not consider the shipment-weighted average WF of 10.91 in performing the market share calculation.

Table 8.2.27 Top-Loading Commercial Clothes Washers: Base Case Market Shares

Standard Level	MEF	WF	Market Share
Baseline	1.26	9.50	64.8%*
1	1.42	9.50	33.8%**
2	1.60	8.50	1.4%***

* Represents units with the following MEF and WF ratings: 1.26 ≤ MEF < 1.42; 9.5 ≥ WF > 8.5.

** Represents units with the following MEF and WF ratings: 1.42 ≤ MEF < 1.60; 9.5 ≥ WF > 8.5.

*** Represents units with the following MEF and WF ratings: MEF ≥ 1.60; WF ≤ 8.5.

Table 8.2.28 Front-Loading Commercial Clothes Washers: Base Case Market Shares

Standard Level	MEF	WF	Market Share
Baseline	1.72	8.00	3.5%*
1	1.80	7.50	0.0%**
2	2.00	5.50	73.7%***
3	2.20	5.10	22.8%†
4	2.35	4.40	0.0%††

* Represents units with the following MEF and WF ratings: 1.72 ≤ MEF < 1.80; 8.0 ≥ WF > 7.5.

** Represents units with the following MEF and WF ratings: 1.80 ≤ MEF < 2.00; 7.5 ≥ WF > 5.5.

*** Represents units with the following MEF and WF ratings: 2.00 ≤ MEF < 2.20; 5.5 ≥ WF > 5.1.

† Represents units with the following MEF and WF ratings: 2.20 ≤ MEF < 2.35; 5.1 ≥ WF > 4.4.

†† Represents units with the following MEF and WF ratings: MEF ≥ 2.35; WF ≤ 4.4.

8.3 PAYBACK PERIOD INPUTS

The payback period is the amount of time it takes the consumer to recover the assumed higher purchase expense of more energy-efficient equipment as a result of lower operating costs. Numerically, the PBP is the ratio of the increase in purchase expense (i.e., from a less efficient design to a more efficient design) to the decrease in annual operating expenditures. This type of calculation is known as a "simple" payback period, because it does not take into account changes in operating expense over time or the time value of money; i.e., the calculation is done at an effective discount rate of zero percent.

The equation for PBP is:

$$PBP = \frac{\Delta IC}{\Delta OC}$$

where:

ΔIC = Difference in the total installed cost between the more efficient standard level and the baseline design, and

ΔOC = difference in annual operating expenses.

Payback periods are expressed in years. Payback periods greater than the life of the product mean that the increased total installed cost is not recovered in reduced operating expenses.

The data inputs to PBP are the total installed cost of the equipment to the consumer for each efficiency level and the annual (first year) operating expenditures for each standard level. The inputs to the total installed cost are the equipment price and the installation cost. The inputs to the operating costs are the annual energy (and water) cost, the annual repair cost, and the annual maintenance cost. The PBP uses the same inputs as the LCC analysis as described in section 8.2, except that energy (and water) price trends and discount rates are not required. Since the PBP is a "simple" payback, the required energy price is only for the year in which a new standard is to take effect—in this case, the year 2013. The energy price DOE used in the PBP calculation was the price projected for that year. Discount rates are also not required for the simple PBP calculation.

8.4 LIFE-CYCLE COST AND PAYBACK PERIOD RESULTS

This section presents the LCC and PBP results for commercial clothes washers. DOE's approach for conducting the LCC analysis relied on characterizing the uncertainty and variability of many of the inputs to the analysis with probability distributions. DOE used a Monte Carlo simulation technique to perform the LCC calculations. DOE calculated the average LCC and LCC savings and the median and average PBP for each of the candidate standard levels. These standard levels are also referred to as candidate standard levels (CSL).

DOE calculated LCC savings and PBPs relative to the base case equipment that it assigned to commercial consumers. As discussed in section 8.2.6, DOE assigned base case equipment that is more efficient than some of the CSLs. For that reason, the average LCC impacts are not equal to the difference between the LCC of a specific and the LCC of the baseline equipment.

In the subsections below, DOE presents figures showing the distribution of LCCs in the base case for each product class. Also presented below for a specific are figures showing the distribution of LCC impacts and the distribution of PBPs. The figures are presented as frequency charts that show the distribution of LCCs, LCC impacts, and PBPs with their corresponding probability of occurrence. DOE generated the figures for the distributions from a Monte Carlo simulation run based on 10,000 samples. The LCC and PBP calculations were performed 10,000 times by sampling from the probability distributions that DOE developed to characterize many of the inputs.

Based on the Monte Carlo simulations that DOE performed, for each standard-level, DOE calculated the share of commercial consumers with a net LCC benefit, with a net LCC cost, and with no impact. DOE considered a commercial user to receive no impact at a given if DOE assigned it base case equipment that is the same as or has higher efficiency than the CSL. To

illustrate the range of LCC and PBP impacts among the commercial clothes washer users, the sections below present figures that provide such information for each product class.

8.4.1 Base Case LCC Distributions

Figures 8.4.1 and 8.4.2 show the frequency charts for the base case LCC for both product applications of top-loading commercial clothes washers. Figures 8.4.3 and 8.4.4 show the frequency charts for the base case LCC for both product applications of top-loading commercial clothes washers.The figures below show the mean LCC of the base case distribution as well as the full range of LCCs.

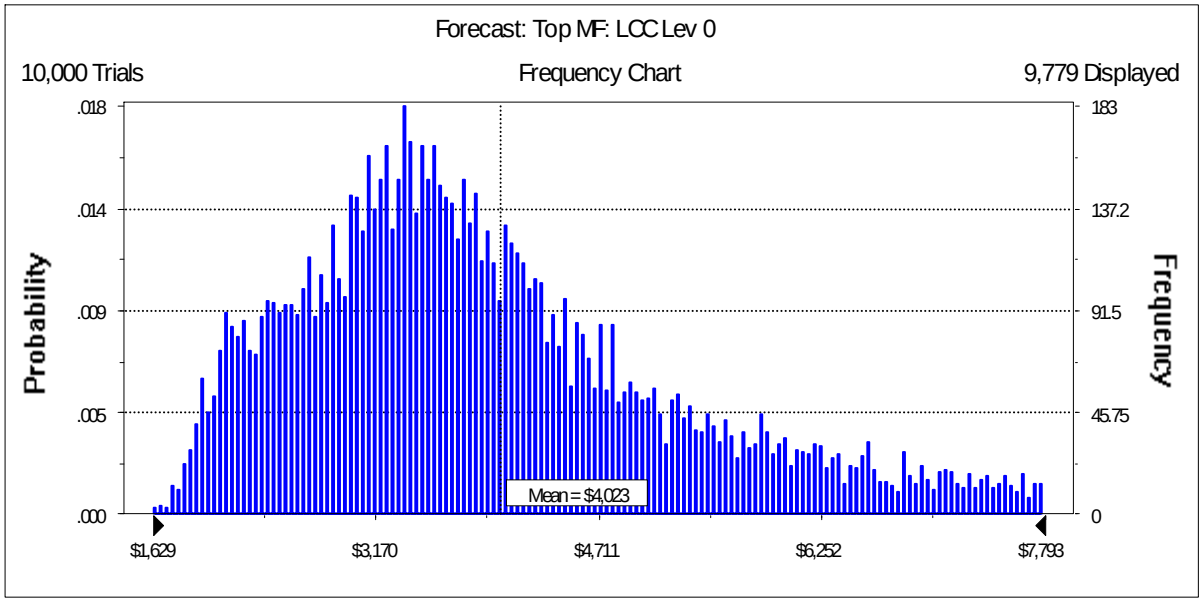

Figure 8.4.1 Top-Loading Commercial Clothes Washers, Multi-Family Application: Base Case LCC Distribution

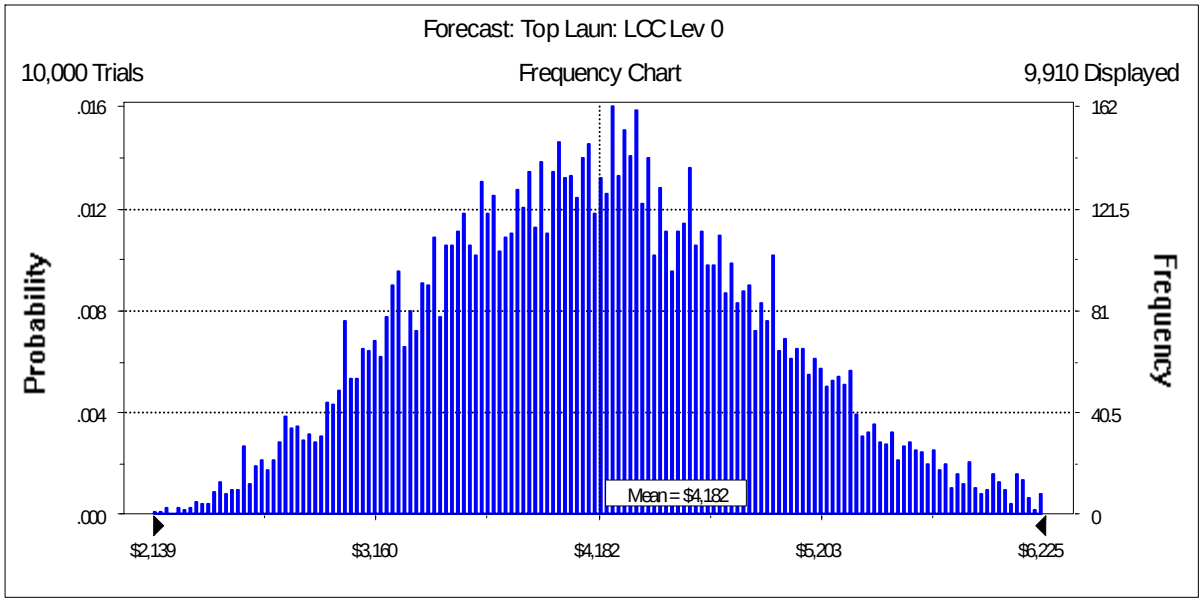

Figure 8.4.2 Top-Loading Commercial Clothes Washers, Laundromat Application: Base Case LCC Distribution

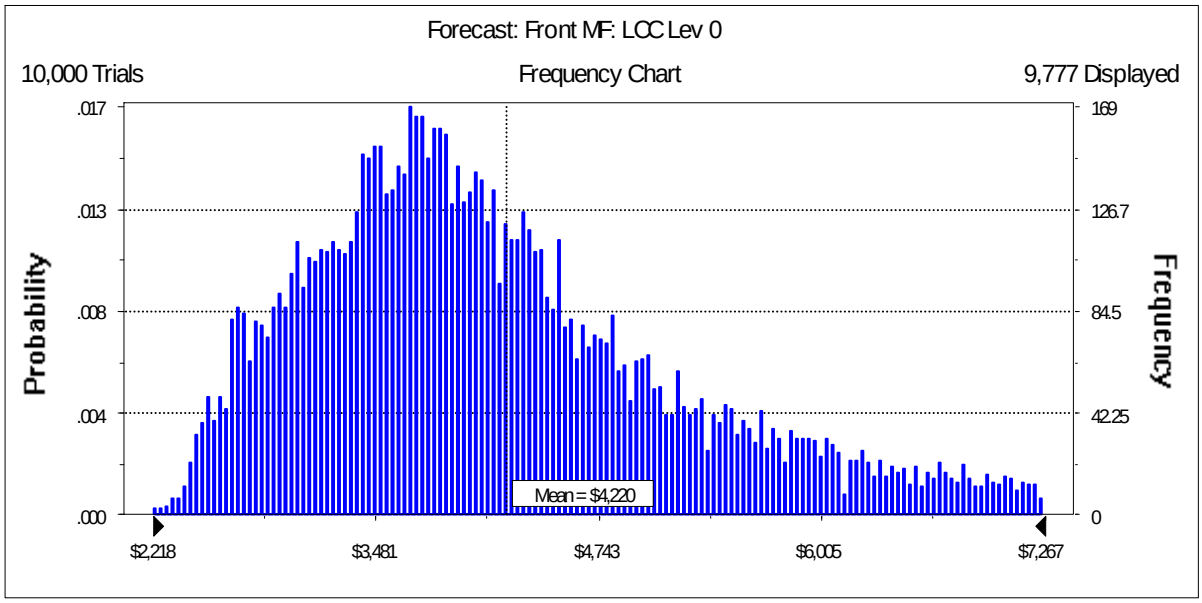

Figure 8.4.3 Front-Loading Commercial Clothes Washers, Multi-Family Application: Base Case LCC Distribution

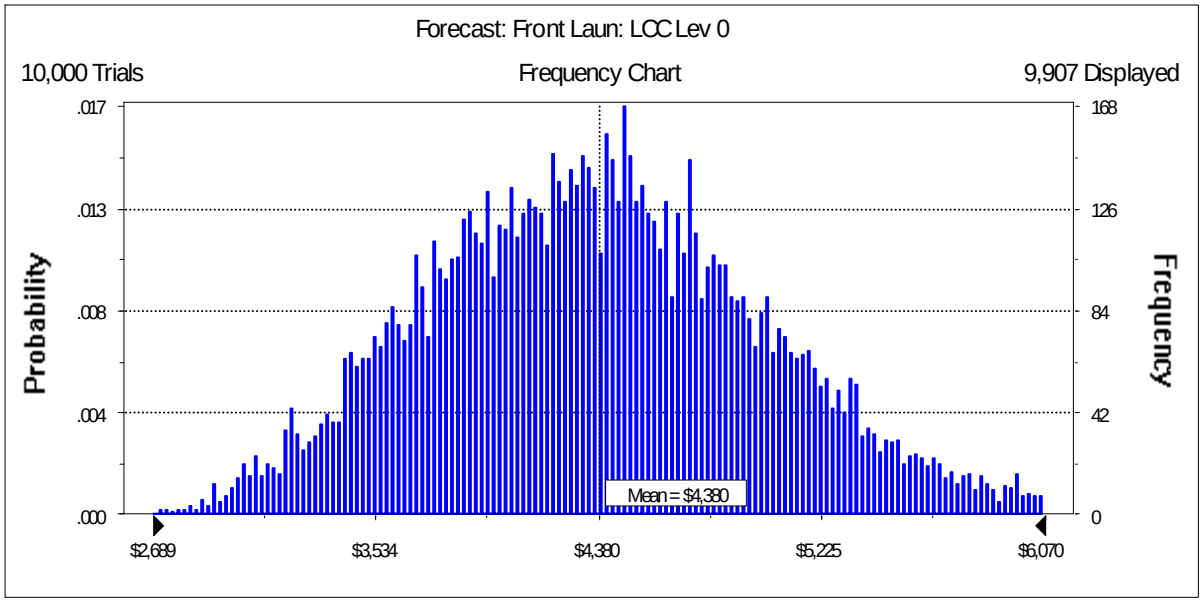

Figure 8.4.4 Front-Loading Commercial Clothes Washers, Laundromat Application: Base Case LCC Distribution

8.4.2 Standard-Level Distributions of LCC Impacts

Figure 8.4.5 is an example of a frequency chart showing the distribution of LCC differences for the case of CSL 2 for top-loading washers, multi-family product application. In the figure, a text box next to a vertical line at that value on the x-axis shows the mean change in LCC (a savings of $179 in the example here). The note, "Certainty is 86.34% from $0 to +Infinity," means that 86.34 percent of consumers using clothes washers will have LCC savings or not be impacted due to the CSL compared to the base case. The large 'spike' in Figure 8.4.5 represents the percentage of consumers that are not impacted by an increase in the CSL, i.e., consumers that already use commercial clothes washers with efficiencies greater than or equal to the CSL. Refer back to section 8.2.6 on the distribution of product efficiencies under the base case. DOE can generate a frequency chart like the one shown in Figure 8.4.5 for every CSL and each product application.

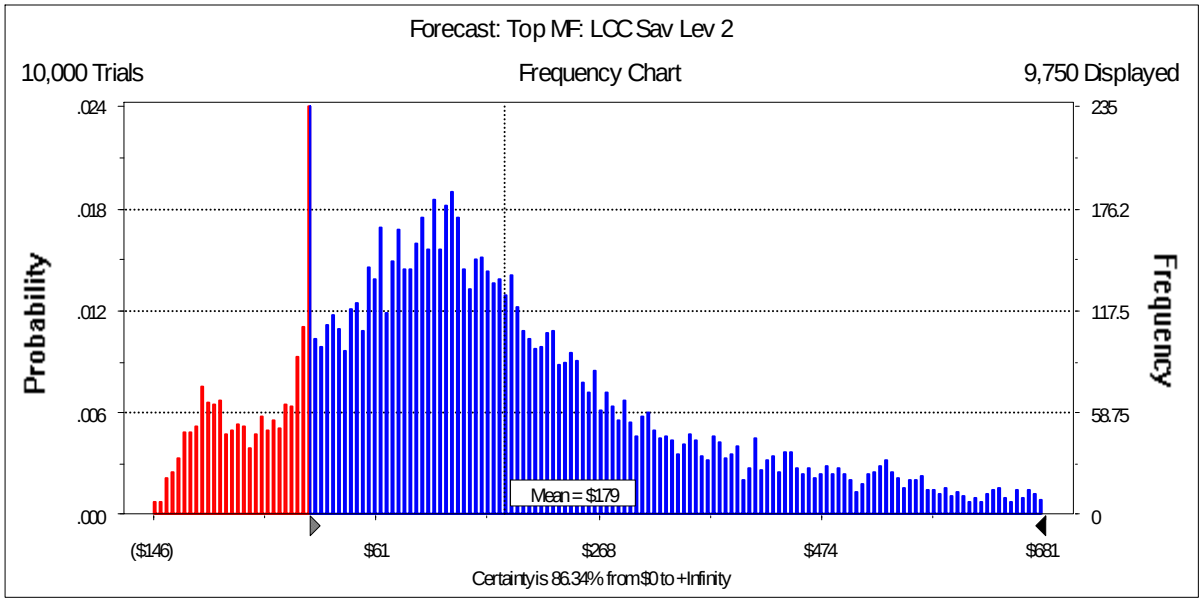

Figure 8.4.5 Top-Loading Commercial Clothes Washers, Multi-Family Application: Distribution of LCC Impacts for CSL 2

8.4.3 Standard-Level PBP Distributions

Figure 8.4.6 is an example of a frequency chart showing the distribution of payback periods of CSL 2 for top-loading washer, multi-family product application. The large 'spike' at the PBP value of -2.00 indicates the percentage of consumers using commercial clothes washers that are not impacted by an increase in the CSL, i.e., consumers that already use top-loading commercial clothes washers with efficiencies equal to or greater than then CSL. Refer back to section 8.2.6 on the distribution of product efficiencies under the base case. DOE can generate a frequency chart like the one shown in Figure 8.4.6 for every CSL and each product application.

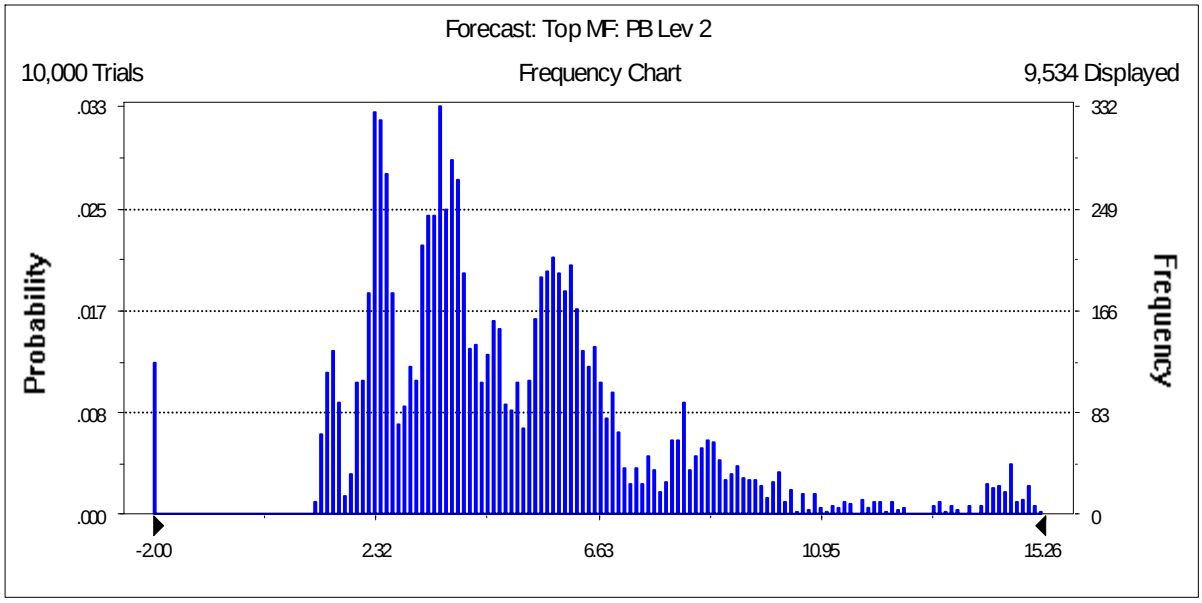

Figure 8.4.6 Commercial Clothes Washers, Multi-Family Application: Distribution of PBPs for CSL 3

8.4.4 LCC and PBP Results

Tables 8.4.1 and 8.4.2 show the LCC and PBP results for both product applications of top-loading commercial clothes washers. Tables 8.4.3 and 8.4.4 show the LCC and PBP results for both product applications of front-loading commercial clothes washers. For example, in the case of the front-loading washer, multi-family application, CSL 2 (2.00 MEF/5.50 WF) shows an average LCC savings of $19.5. Note that for CSL 2, approximately 96 percent of consumers in 2013 are assumed to already be using a commercial clothes washer in the base case at CSL 2 and thus have zero savings due to the standard. If one compares the LCC of the base case at 1.72 MEF/8.00 WF to the standards case at 2.00 MEF/5.50 WF, then the average LCC savings are $530. But since the base case includes a significant number of consumers that are not impacted by the standard, the average savings over all of the consumers is $19.5. With regard to the PBPs shown below, DOE determined the median and average values by excluding the percentage of households not impacted by the standard. For example, in the case of CSL 2 for front-loading washers, about 96 percent of the consumers did not factor into the calculation of the median and average PBP.

Table 8.4.1 Top-Loading Commercial Clothes Washers, Multi-Family Application: LCC and PBP Results

CSL	MEF/WF	Life-Cycle Cost			Life-Cycle Cost Savings				Payback Period (years)	
		Average Installed Price	Average Operating Cost	Average LCC	Average Savings	Households with			Median	Average
						Net Cost	No Impact	Net Benefit		
Baseline	1.26/9.50	$760	$3,263	$4,023	-	-	-	-	-	-
1	1.42/9.50	$883	$3,153	$4,036	-$8.1	43.3%	35.3%	21.5%	11.7	17.3
2	1.60/8.50	$974	$2,873	$3,847	$178.6	13.8%	1.2%	85.0%	4.6	5.6

Table 8.4.2 Top-Loading Commercial Clothes Washers, Laundromat Application: LCC and PBP Results

CSL	MEF/WF	Life-Cycle Cost			Life-Cycle Cost Savings				Payback Period (years)	
		Average Installed Price	Average Operating Cost	Average LCC	Average Savings	Households with			Median	Average
						Net Cost	No Impact	Net Benefit		
Baseline	1.26/9.50	$760	$3,422	$4,182	-	-	-	-	-	-
1	1.42/9.50	$883	$3,326	$4,209	-$17.7	51.4%	35.3%	13.3%	7.9	9.1
2	1.60/8.50	$974	$3,025	$3,999	$190.0	2.9%	1.2%	95.9%	2.8	3.0

Table 8.4.3 Front-Loading Commercial Clothes Washers, Multi-Family Application: LCC and PBP Results

CSL	MEF/WF	Life-Cycle Cost			Life-Cycle Cost Savings				Payback Period (years)	
		Average Installed Price	Average Operating Cost	Average LCC	Average Savings	Households with			Median	Average
						Net Cost	No Impact	Net Benefit		
Baseline	1.72/8.00	$1,365	$2,855	$4,220	-	-	-	-	-	-
1	1.80/7.50	$1,365	$2,855	$4,091	$4.7	0.0%	96.3%	3.7%	0.0	0.0
2	2.00/5.50	$1,388	$2,726	$3,690	$19.5	0.0%	96.3%	3.7%	0.4	0.4
3	2.20/5.10	$1,428	$2,302	$3,596	$91.5	1.4%	23.1%	75.5%	3.0	3.2
4	2.35/4.40	$1,470	$2,168	$3,484	$202.7	1.1%	0.0%	98.9%	2.9	3.1

Table 8.4.4 Front-Loading Commercial Clothes Washers, Laundromat Application: LCC and PBP Results

CSL	MEF/WF	Life-Cycle Cost			Life-Cycle Cost Savings				Payback Period (years)	
		Average Installed Price	Average Operating Cost	Average LCC	Average Savings	Households with			Median	Average
						Net Cost	No Impact	Net Benefit		
Baseline	1.72/8.00	$1,365	$2,014	$4,380	-	-	-	-	-	-
1	1.80/7.50	$1,365	$3,014	$4,240	$5.2	0.0%	96.3%	3.7%	0.0	0.0
2	2.00/5.50	$1,388	$2,874	$3,787	$22.0	0.0%	96.3%	3.7%	0.2	0.2
3	2.20/5.10	$1,428	$2,400	$3,695	$93.4	0.0%	23.1%	76.9%	1.8	1.9
4	2.35/4.40	$1,470	$2,267	$3,572	$216.1	0.0%	0.0%	100.0%	1.6	1.7

Figures 8.4.7 and 8.4.8 show the range of LCC savings for the CSLs for both product applications of top-loading commercial clothes washers. Figures 8.4.9 and 8.4.10 show the range of LCC savings for the CSLs for both product applications of front-loading commercial clothes washers. For each CSL, the top and the bottom of the box indicate the 75^{th} and 25^{th} percentiles, respectively. The bar at the middle of the box indicates the median; 50 percent of the households have LCC savings above this value The 'whiskers' at the bottom and the top of the box indicate the 5^{th} and 95^{th} percentiles. The small box shows the average LCC savings for each CSL.

Figures 8.4.11 and 8.4.12 show the range of PBPs for top-loading commercial clothes washers. Figures 8.4.13 and 8.4.14 show the range of PBPs for front-loading commercial clothes washers. In these figures, households which are not impacted by an increase in the standard are not included (this situation applies to all CSLs except CSL 4 for front-loading washers).

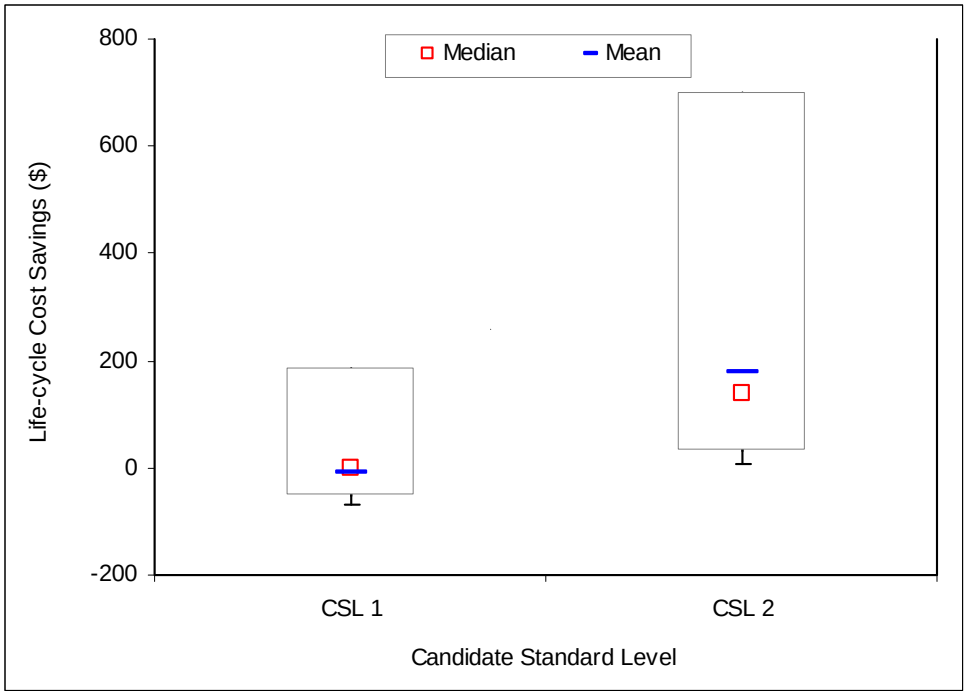

Figure 8.4.7 Range of LCC Savings for Top-Loading Commercial Clothes Washers, Multi-Family

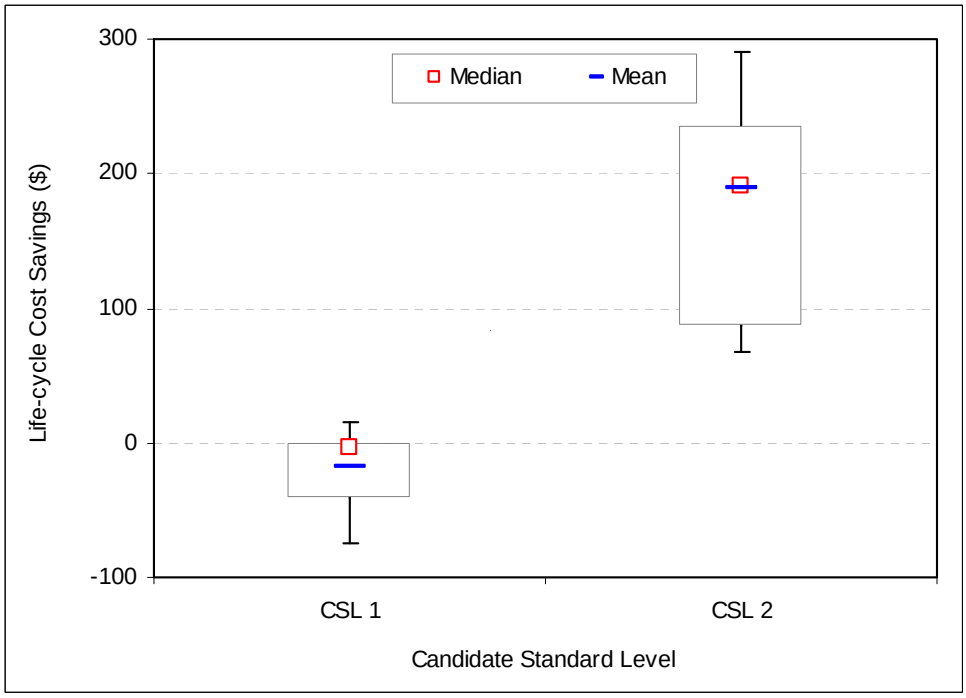

Figure 8.4.8 Range of LCC Savings for Top-Loading Commercial Clothes Washers, Laundromat

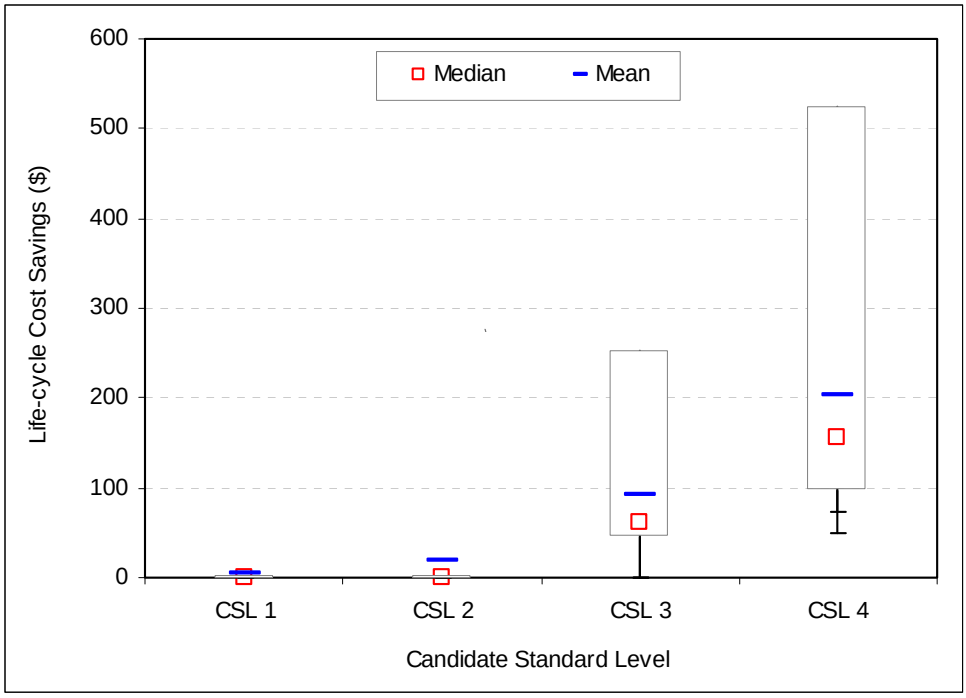

Figure 8.4.9 Range of LCC Savings for Front-Loading Commercial Clothes Washers, Multi-Family

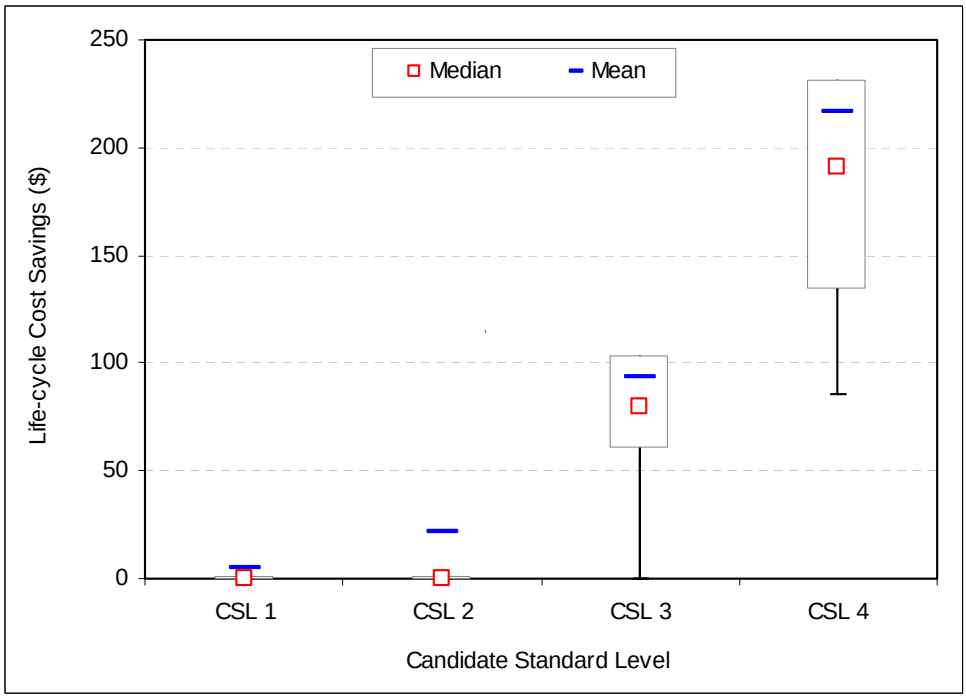

Figure 8.4.10 Range of LCC Savings for Front-Loading Commercial Clothes Washers, Laundromat

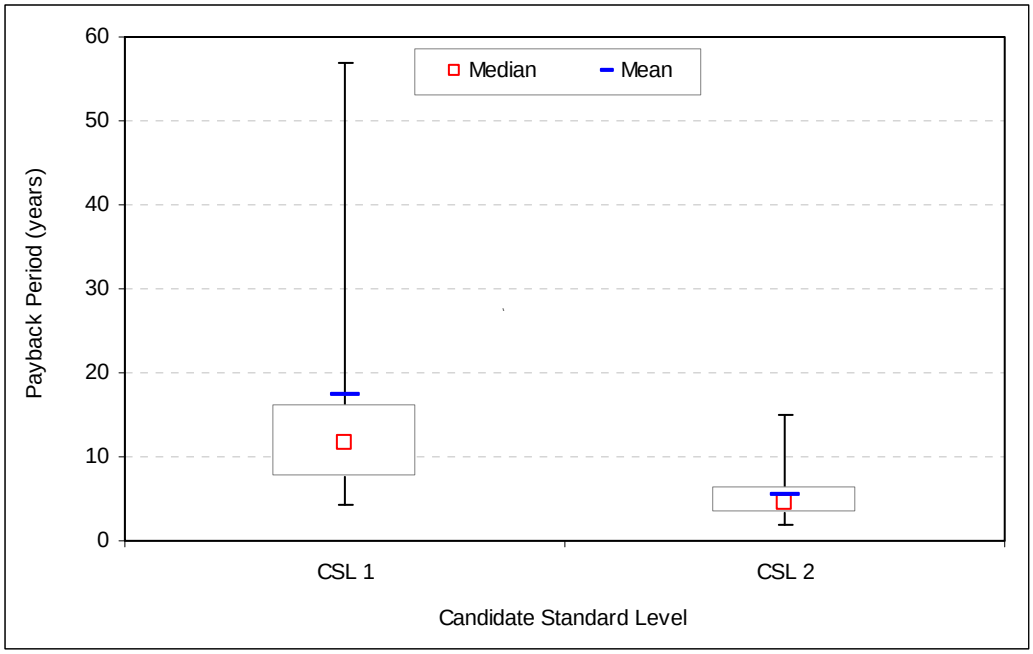

Figure 8.4.11 Range of Payback Periods for Top-Loading Commercial Clothes Washers, Multi-Family

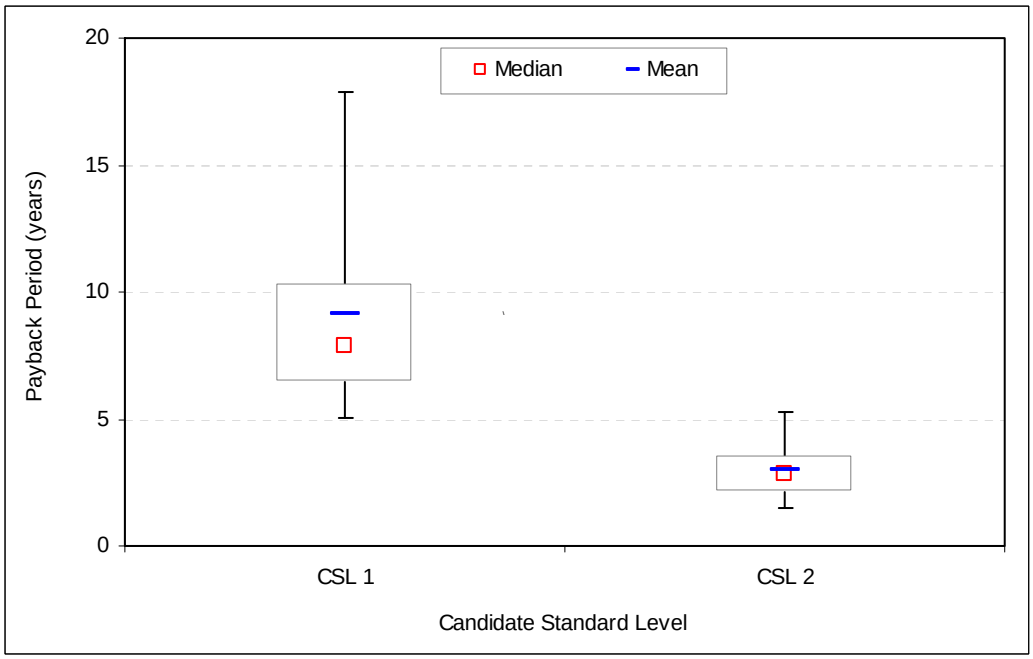

Figure 8.4.12 Range of Payback Periods for Top-Loading Commercial Clothes Washers, Laundromat

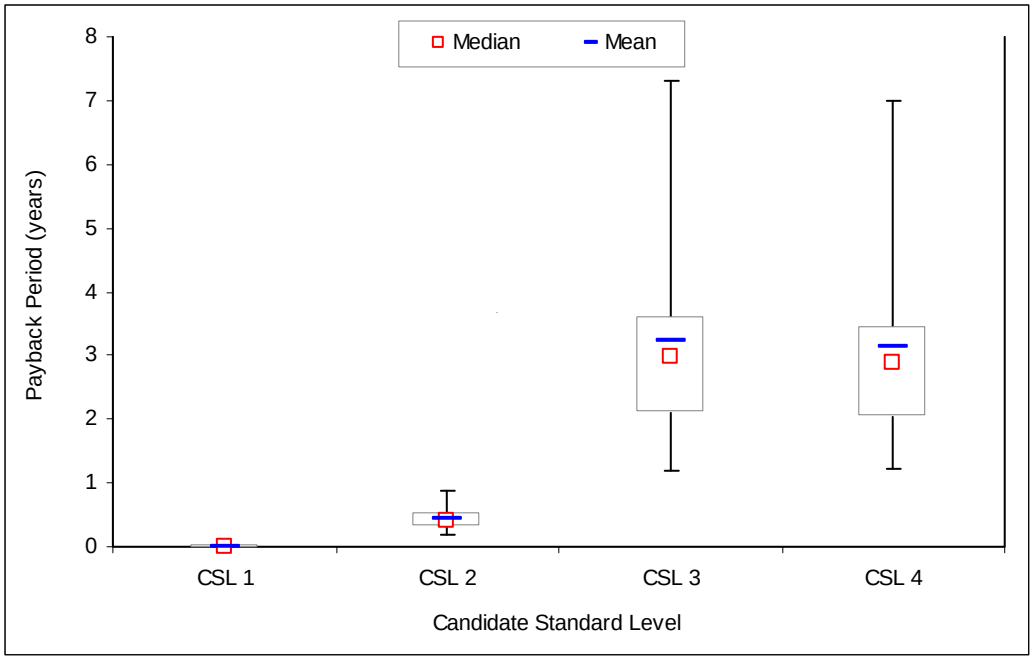

Figure 8.4.13 Range of Payback Periods for Front-Loading Commercial Clothes Washers, Multi-Family

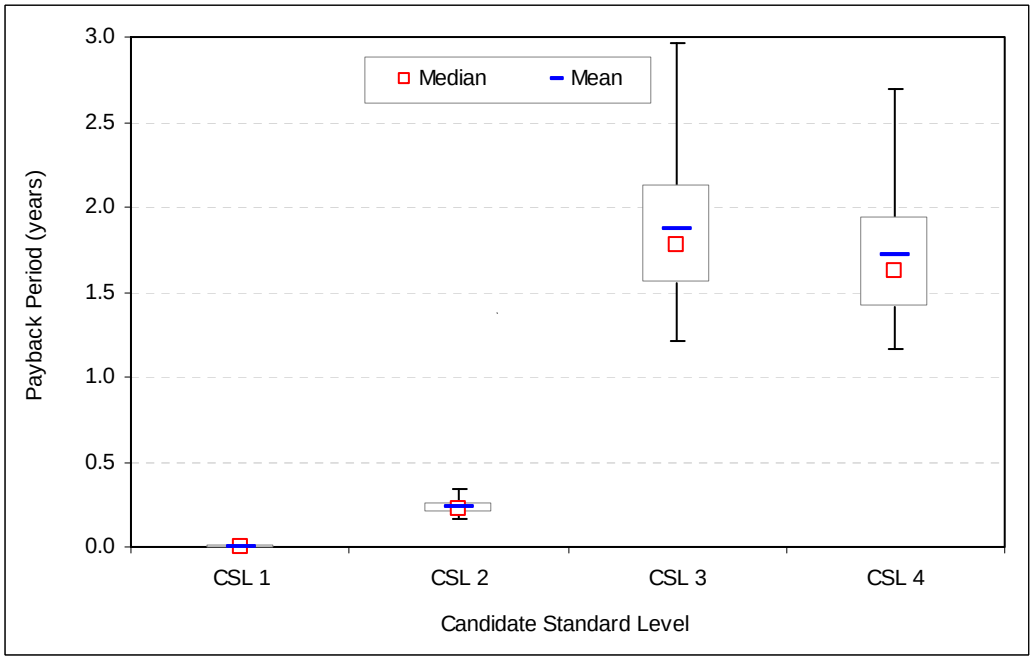

Figure 8.4.14 Range of Payback Periods for Front-Loading Commercial Clothes Washers, Laundromat

8.5 REBUTTABLE PAYBACK PERIOD

DOE presents rebuttable PBPs to provide the legally established rebuttable presumption that an energy efficiency standard is economically justified if the additional product costs attributed to the standard are less than three times the value of the first-year energy cost savings. (42 U.S.C. §6295 (o)(2)(B)(iii))

8.5.1 Metric

The basic equation for rebuttable PBP is the same as that shown in section 8.3, Payback Period Inputs. Unlike the analyses described in sections 8.2 and 8.3, however, the rebuttable PBP is not based on the use of household samples and probability distributions. Rather than distributions, the rebuttable PBP is based on discrete single-point values. For example, while DOE uses a probability distribution of regional energy prices in the distributional payback period analysis, it uses only the national average energy price from the probability distribution to determine the rebuttable PBP.

Other than the use of single-point values, the most notable difference between the distribution PBP and the rebuttable PBP is the latter's reliance on the DOE test procedure to determine a product's annual energy and water consumption. The following identifies the differences between the annual energy and water consumptions determined for the distribution PBP and the rebuttable PBP.

DOE based the annual energy and water consumption values that it used to determine the rebuttable PBP on the number of cycles per year specified in the DOE test procedure.[26] The commercial clothes washer test procedure cites the residential clothes washer test procedure to establish efficiency ratings as well as annual energy and water consumption. As a result, the annual number of use cycles, 392 cycles per year, for determining the annual energy and water consumption of commercial clothes washers is representative of residential use, not commercial use. Because residential use is significantly lower than the average usage for commercial applications—1241 cycles per year in multi-family buildings and 2190 cycles per year in laundromats—the average annual energy and water consumption used to determine rebuttable PBP will be significantly less than the consumption associated with actual usage. As a result, the rebuttable PBP will be significantly longer than the distribution PBPs for both multi-family and laundromat applications.

8.5.2 Inputs

Inputs for the rebuttable PBP differ from the distribution PBP in that the calculation uses discrete values, rather than distributions, for inputs. Note that for the calculation of distribution PBP, because inputs for the determination of total installed cost were based on single-point values, only the variability and/or uncertainty in the inputs for determining operating cost contributed to variability in the distribution PBPs. The following summarizes the single-point values that DOE used in the determination of the rebuttable PBP.

- Manufacturing costs, markups, sales taxes, and installation costs were all based on the single-point values used in the distributional LCC and PBP analysis.

- As described in section 8.5.1, annual energy and water consumption is based on the DOE test procedure.

- Energy and water prices are based on national average values for the year that new standards are assumed to take effect.

- An average discount rate or lifetime is not required in the rebuttable PBP calculation.

- The effective date of the standard is assumed to be 2013.

8.5.3 Results

DOE calculated rebuttable PBPs for each CSL relative to the distribution of product efficiencies assumed for the base case (refer back to section 8.2.6 for more details on the base case efficiency distributions for each product). In other words, DOE did not determine the rebuttable PBP relative to the baseline efficiency level, but relative to the current distribution of product efficiencies DOE determined for the base case (i.e., the case without new standards). The following sections present the results for the sets of products being analyzed for this standards rulemaking.

Tables 8.5.1 and 8.5.2 present the rebuttable PBPs for top-loading commercial clothes washers under both product applications; multi-family buildings and laundromats. Tables 8.5.3 and 8.5.4 present the rebuttable PBPs for front-loading commercial clothes washers under both product applications; multi-family buildings and laundromats.

Table 8.5.1 Top-Loading Commercial Clothes Washers, Multi-Family Application: Rebuttable Payback Periods

CSL	MEF	WF	PBP *years*
Baseline	1.26	9.50	-
1	1.42	9.50	895
2	1.60	8.50	24

Table 8.5.2 Top-Loading Commercial Clothes Washers, Laundromat Application: Rebuttable Payback Periods

CSL	MEF	WF	PBP *years*
Baseline	1.26	9.50	-
1	1.42	9.50	Infinity
2	1.60	8.50	226

Table 8.5.3 Front-Loading Commercial Clothes Washers, Multi-Family Application: Rebuttable Payback Periods

CSL	MEF	WF	PBP *years*
Baseline	1.72	8.00	-
1	1.80	7.50	0
2	2.00	5.50	1.2
3	2.20	5.10	9.4
4	2.35	4.40	10.0

Table 8.5.4 Front-Loading Commercial Clothes Washers, Laundromat Application: Rebuttable Payback Periods

CSL	MEF	WF	PBP *years*
Baseline	1.72	8.00	-
1	1.80	7.50	0
2	2.00	5.50	1.3
3	2.20	5.10	17.3
4	2.35	4.40	17.6

REFERENCES

1 U.S. Department of Energy-Office of Energy Efficiency and Renewable Energy, Energy Conservation Standards for Certain Consumer Products (Dishwashers, Dehumidifiers, Microwave Ovens, and Electric and Gas Kitchen Ranges and Ovens) and for Certain Commercial and Industrial Equipment (Commercial Clothes Washers); Final Rule. *Federal Register*, 2009. 74(66): pp. 16040-16096.

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