CHAPTER 3. ENGINEERING ANALYSIS

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CHAPTER 3. ENGINEERING ANALYSIS

3.1 INTRODUCTION

This engineering analysis establishes the relationship between the cost and the energy efficiency. This relationship serves as the basis for cost-benefit calculations for individual consumers, manufacturers, and the Nation. The engineering analysis identifies the representative baseline equipment, which is the starting point for analyzing possible energy efficiency improvements. The engineering analysis also identifies higher efficiency levels and the corresponding increase in price associated with achieving those higher efficiency levels. Using this cost-efficiency relationship and the results of the downstream analysis (mark-up analysis, life-cycle costs, payback period analysis), DOE can estimate customer prices resulting from amended energy conservation standards. DOE then examines the costs and benefits associated with each increased efficiency level.

For this rulemaking, DOE only performed an engineering analysis on computer room air conditioners because the other equipment classes either had no models on the market or a very low potential energy savings at higher efficiency levels than those in ASHRAE Standard 90.1-2010. For equipment classes for which DOE performed a potential energy savings analysis and the energy savings results, please see chapter 4. This chapter will only focus on computer room air conditioners.

To develop the engineering analysis for computer room air conditioners (the only ASHRAE equipment class DOE analyzed in the engineering analysis), DOE used an efficiency-level approach in conjunction with a pricing survey to develop the price-efficiency relationships. DOE discusses the equipment classes it analyzed; the identification of representative capacities for analysis, baseline efficiency levels, and the efficiency levels above the baseline; the process for collecting pricing data; and the methodology for developing the price-efficiency results. The engineering analysis produces a set of price-efficiency results that represents the average incremental contractor cost of increasing energy efficiency levels above the baseline for computer room air conditioners.

3.2 EQUIPMENT CLASSES ANALYZED

As mentioned in chapter 2 of this TSD (Market Assessment), computer room air conditioners were previously an uncovered product by DOE, but newly covered under ASHRAE Standard 90.1-2010; therefore, DOE undertook this analysis to determine whether to adopt the ASHRAE standards or more stringent standards as DOE standards. ASHRAE Standard 90.1-2010 separates computer room air conditioners into 30 equipment classes based upon its heat rejection method (air-cooled, water-cooled, or glycol-cooled), sensible cooling capacity (<65,000 Btu/h, ≥65,000 Btu/h and <240,000 Btu/h, or ≥240,000 Btu/h and <760,000 Btu/h), orientation (upflow or downflow), and whether or not a fluid economizer is used. However, due to a lack of data for certain equipment classes, DOE could not analyze each of the 30 equipment classes. DOE instead focused its efforts on the equipment classes with the most efficiency data available and extrapolated that analysis to the other equipment classes. Table 3.3.1 of the 30 equipment classes for computer room air conditioners is generated below. The following paragraphs discuss how DOE selected equipment classes for its analysis.

Table 3.3.1 Equipment Classes for Computer Room Air Conditioners and Their ASHRAE Standard 90.1-2010 Efficiency Level

Equipment Class	Size Category (Sensible Capacity[1])	Upflow SCOP	Downflow SCOP
Air-Cooled	<65,000 Btu/h	2.20	2.09
	≥65,000 Btu/h and <240,000 Btu/h	2.10	1.99
	≥240,000 Btu/h and <760,000 Btu/h	1.90	1.79
Water-Cooled	<65,000 Btu/h	2.60	2.49
	≥65,000 Btu/h and <240,000 Btu/h	2.50	2.39
	≥240,000 Btu/h and <760,000 Btu/h	2.40	2.29
Water-Cooled with a Fluid Economizer	<65,000 Btu/h	2.55	2.44
	≥65,000 Btu/h and <240,000 Btu/h	2.45	2.34
	≥240,000 Btu/h and <760,000 Btu/h	2.35	2.24
Glycol Cooled	<65,000 Btu/h	2.50	2.39
	≥65,000 Btu/h and <240,000 Btu/h	2.15	2.04
	≥240,000 Btu/h and <760,000 Btu/h	2.10	1.99
Glycol Cooled with a Fluid Economizer	<65,000 Btu/h	2.45	2.34
	≥65,000 Btu/h and <240,000 Btu/h	2.10	1.99
	≥240,000 Btu/h and <760,000 Btu/h	2.05	1.94

In the market assessment, DOE noted that upflow and downflow units were treated as the same in the California Energy Commission's (CEC) database and in most manufacturers' product literatures. DOE found that all upflow models in its database also had a corresponding downflow model in which the interior components were arranged in a different manner within the same exterior shell. DOE assumed that because both orientations have the same major components, the prices and incremental costs for increasing efficiency for both orientations would be the same. Therefore, to lower the number of equipment classes analyzed, DOE only analyzed downflow units in this engineering analysis because more data were available for these equipment classes. Since DOE assumed that the prices and incremental costs for increasing

[1] Note that ASHRAE Standard 90.1-2010 uses sensible cooling capacity rather than total cooling capacity for their size categories.

efficiency for the upflow models would be the same as for the downflow models, DOE did not extrapolate the downflow results to the upflow equipment class in the engineering analysis.

For the 15 downflow equipment classes analyzed in the engineering analysis, DOE focused the analysis on the four equipment classes where the largest number of models was available on the market and where DOE received enough pricing information to generate a trend:

1) small (*i.e.*, sensible capacity <65,000 Btu/h) air-cooled computer room air conditioners
2) large (*i.e.*, sensible capacity ≥65,000 Btu/h and <240,000 Btu/h) air-cooled computer room air conditioners
3) small water-cooled computer room air conditioners
4) large water-cooled computer room air conditioners

For the other 11 downflow equipment classes, DOE extrapolated the results from these four primary equipment classes. An explanation of how the results were extrapolated to the equipment classes that were not directly analyzed is in section 3.3.4 below.

3.3 METHODOLOGY OVERVIEW

This section describes the analytical methodology DOE used in the engineering analysis. The results of the engineering analysis are a set of price-efficiency relationships, which are used as the basis for the cost-benefit analyses.

3.3.1 Approach

DOE typically structures its engineering analysis around one of three methodologies. These are: (1) the design-option approach, which calculates the incremental costs of adding specific design options to a baseline model; (2) the efficiency-level approach, which calculates the relative costs of achieving increases in energy efficiency levels, without regard to the specific design options used to achieve such increases; and/or (3) the reverse engineering or cost-assessment approach, which involves a “bottom-up” manufacturing cost assessment based on a detailed bill of materials derived from teardowns of the product being analyzed. Deciding which methodology to use for the engineering analysis depends on the product, the design options under study, and any historical data that DOE can draw on.

For analyzing computer room air conditioners, DOE used an efficiency-level approach with a pricing survey in order to estimate the cost of achieving different sensible coefficient of performance (SCOP) levels. With the efficiency level approach, DOE could focus on the relative price difference of the units at different SCOP ratings but still capture a variety of design options available on the market. The efficiency levels used in the engineering analysis were representative of computer room air conditioners available on the market at the time of this analysis. DOE obtained pricing data from equipment distributors of three[2] major computer room air conditioner manufacturers, which was used to develop the price-efficiency relationship for computer room air conditioners.

3.3.2 Selection of Representative Sensible Cooling Capacities

Equipment prices can vary significantly depending upon differences in sensible cooling capacity. To help limit the variation in equipment prices from cooling capacity, DOE analyzed a range of sensible cooling capacities for each equipment class that was representative of that class. Using a representative sensible cooling capacity allows DOE to analyze specific equipment in detail that can provide information representative of the entire equipment class and also allows DOE to perform analysis at the baseline efficiency level as well as higher efficiency levels. The baseline units are discussed further in section 3.3.5 of this analysis.

DOE chose a representative capacity for analysis within each of the three size categories of computer room air conditioners in ASHRAE Standard 90.1-2010 (*i.e.*, <65,000 Btu/h, ≥65,000 Btu/h and <240,000 Btu/h, and ≥240,000 Btu/h and <760,000 Btu/h). DOE selected the representative capacity in each equipment class using the average sensible capacity of all the models DOE found on the market in a given equipment size class, rounded to the nearest ton of cooling. This representative capacity also generally corresponded to the mode of sensible cooling capacities (the highest number of models) with efficiency information for that equipment class. Table 3.3.2 shows the computer room equipment classes and the representative sensible cooling capacities at which DOE collected information for the engineering analysis.

[2] Of the five major manufacturers of computer room air conditioners, DOE found that efficiency information needed to estimate the SCOP rating was only available from three of the manufacturers. Thus, DOE obtained pricing information for all manufacturers where efficiency information was available.

Table 3.3.2 Equipment Classes Analyzed in the Engineering Analysis and Their Representative Capacities

Equipment Class	Size Category (Btu/h)	Representative Sensible Cooling Capacity (Btu/h)
Air-Cooled	Small (<65,000)	36,000
	Large (≥65,000 and <240,000)	132,000
	Very Large (≥240,000 and <760,000)	288,000
Water-Cooled	Small	36,000
	Large	132,000
	Very Large	288,000
Water-Cooled with a Fluid Economizer	Small	36,000
	Large	132,000
	Very Large	288,000
Glycol Cooled	Small	36,000
	Large	132,000
	Very Large	288,000
Glycol Cooled with a Fluid Economizer	Small	36,000
	Large	132,000
	Very Large	288,000

For the small and large product classes, DOE focused its data collection efforts on units near the representative capacity. For the very large product class, there were only five units in the database that had efficiency information at this size so DOE collected data for all five of these units. Due to the limited amount of data available for the very large equipment DOE did not analyze them explicitly but rather extrapolated the analysis from the large equipment classes to apply it to the very large classes, as explained in section 3.3.4.

3.3.3 Selection of Baseline Efficiency Levels

In the next step of the engineering analysis, DOE selected baseline efficiency levels as reference points for each equipment class, against which it measured changes resulting from potential amended energy conservation standards. DOE defined the baseline efficiency levels for computer room air conditioners in the engineering analysis as reference points to compare the energy savings and cost of equipment with higher energy efficiency levels. Typically, units at the baseline efficiency level just meet Federal energy conservation standards and provide basic consumer utility. However, computer room air conditioners are newly covered equipment by DOE and, therefore, have no Federal energy conservation standards. But, since EPCA directs that DOE must adopt amended energy conservation standards at the new efficiency levels in ASHRAE Standard 90.1, unless clear and convincing evidence supports a determination that the adoption of a more stringent level would produce significant additional energy savings and be technologically feasible and economically justified (42 U.S.C. 6313(a)(6)(A)(ii)), DOE cannot consider any energy conservation standards below the efficiency levels specified in ASHRAE Standard 90.1-2010. Therefore, for the engineering analysis DOE set the baseline efficiency level for each equipment class of computer room air conditioners equal to the efficiency level in ASHRAE. Table 3.3.3 shows the baseline efficiency level for each equipment class of computer room air conditioners.

Table 3.3.3 Baseline SCOP Efficiency Levels for Computer Room Air Conditioners

Equipment Class[1]	**Size Category (Btu/h)**	**ASHRAE Standard 90.1-2010 Efficiency Level (SCOP)**
Air-Cooled	<65,000	2.2
	≥65,000 and <240,000	2.1
	≥240,000 and <760,000	1.9
Water-Cooled	<65,000	2.6
	≥65,000 and <240,000	2.5
	≥240,000 and <760,000	2.4
Water-Cooled with a Fluid Economizer	<65,000	2.55
	≥65,000 and <240,000	2.45
	≥240,000 and <760,000	2.35
Glycol Cooled	<65,000	2.5
	≥65,000 and <240,000	2.15
	≥240,000 and <760,000	2.1
Glycol Cooled with a Fluid Economizer	<65,000	2.45
	≥65,000 and <240,000	2.1
	≥240,000 and <760,000	2.05

[1] As noted in Section 3.2, DOE focused its analysis on downflow only models.

3.3.4 Identification of Efficiency Levels for Analysis

After selecting the baseline efficiency levels, DOE identified higher efficiency levels for each equipment class based on an extensive review of the data DOE compiled from the CEC database and manufacturers' product literature. DOE converted the EER information provided in these sources (which was determined using the ASHRAE 127-2001 test procedure) into the new SCOP metric used in the updated ASHRAE 127-2007 test procedure. DOE used the "rule of thumb" formula described in ASHRAE 127-2007 to convert from the ASHRAE 127-2001 EER rating to the ASHRAE 127-2007 SCOP rating, as described in chapter 2 of this TSD. As previously noted in section 3.2, DOE only had enough data to directly analyze four equipment classes, small air-cooled, large air-cooled, small water-cooled, and large water-cooled. For each of these four equipment classes, DOE identified the baseline efficiency level (see section 3.3.3) and the market max tech efficiency level on the market and chose three additional evenly spaced efficiency levels in between the baseline and the market max-tech levels for a total of five efficiency levels. For the other eleven equipment classes where DOE did not have enough market efficiency data, DOE selected efficiency levels based on the efficiency differences between the SCOP of the different equipment classes as specified by ASHRAE Standard 90.1-2010 in the same manner which DOE extrapolated price-efficiency curves (see section 3.3.6 and Figure 3.3.1). DOE analyzed the efficiency levels in Table 3.3.3, which span the entire efficiency range of computer room air conditioner efficiency levels found in DOE's database. Table 3.3.4 below shows the SCOP efficiency levels for each of the 15 equipment classes DOE analyzed in the engineering analysis.

Table 3.3.4 Efficiency Levels for Analysis of Computer Room Air Conditioners

Equipment Class		**Efficiency Levels (SCOP)**				
		Baseline Level	**Level 1**	**Level 2**	**Level 3**	**Level 4**
Air-Cooled	<65,000 Btu/h	2.20	2.40	2.60	2.80	3.00
	≥65,000 Btu/h and <240,000 Btu/h	2.10	2.35	2.60	2.85	3.10
	≥240,000 Btu/h and <760,000 Btu/h	1.90	2.15	2.40	2.65	2.90
Water-Cooled	<65,000 Btu/h	2.60	2.80	3.00	3.20	3.40
	≥65,000 Btu/h and <240,000 Btu/h	2.50	2.70	2.90	3.10	3.30
	≥240,000 Btu/h and <760,000 Btu/h	2.40	2.60	2.80	3.00	3.20
Water-Cooled with a Fluid Economizer	<65,000 Btu/h	2.55	2.75	2.95	3.15	3.35
	≥65,000 Btu/h and <240,000 Btu/h	2.45	2.65	2.85	3.05	3.25
	≥240,000 Btu/h and <760,000 Btu/h	2.35	2.55	2.75	2.95	3.15
Glycol-Cooled	<65,000 Btu/h	2.50	2.70	2.90	3.10	3.30
	≥65,000 Btu/h and <240,000 Btu/h	2.15	2.35	2.55	2.75	2.95
	≥240,000 Btu/h and <760,000 Btu/h	2.10	2.30	2.50	2.70	2.90
Glycol-Cooled with a Fluid Economizer	<65,000 Btu/h	2.45	2.65	2.85	3.05	3.25
	≥65,000 Btu/h and <240,000 Btu/h	2.10	2.30	2.50	2.70	2.90
	≥240,000 Btu/h and <760,000 Btu/h	2.05	2.25	2.45	2.65	2.85

3.3.5 Pricing Data

Next, DOE selected units for which it would obtain pricing information. The units selected represent a variety of technologies and SCOP ratings but were limited to models for which DOE could estimate the SCOP rating. DOE collected pricing data for all units near the representative capacity. To simulate a typical request from a contractor that would install computer room air conditioners, DOE requested the pricing information for individual models in quantities of 10 to be shipped to Oakland, California. DOE chose Oakland as the shipping destination for a central location. Although the shipping cost was not broken out as a separate aspect of the purchase price (*i.e.*, all price quotes were total price that included shipping) and since all three manufactures are based in California, DOE assumed that shipping prices would be similar between the manufacturers. DOE received pricing information for 32 models: 6 small air-cooled units, 6 large air-cooled units, 2 very large air-cooled units, 5 small water-cooled units, 7 large water-cooled units, 1 very large water-cooled unit, 2 small glycol-cooled units, 1 large glycol-cooled unit, and 2 very large glycol-cooled units (one with a fluid economizer and one without one). DOE only received pricing information for one unit with a fluid economizer because that was the only unit with efficiency information that was near the representative capacity. DOE then used this pricing information along with the estimated SCOP information (derived from EER as described in chapter 2) to build price-efficiency curves.

3.3.6 Construction of Price-Efficiency Curves

Once DOE aggregated all the pricing information with their corresponding efficiency information, DOE normalized the prices to the representative capacity for each equipment class by calculating the price per Btu/h of sensible cooling capacity and adjusting it to the representative capacity. Then, DOE did an initial assessment of the normalized pricing information for the equipment classes where it was able to collect data.

From the initial assessment, DOE noticed that the prices for ceiling mount units were usually lower than floor mount units with a similar sensible cooling capacity; so in order for the analysis to compare as similar units as possible, DOE omitted the pricing data for the 5 ceiling mount units it had gathered (1 small air-cooled unit, 2 small water-cooled units, and 2 large water-cooled units). Then, DOE took the remaining 27 data points for floor mount units and plotted them on graphs of their corresponding equipment class and used an exponential regression analysis to fit a curve that best defined the data trend. DOE used an exponential regression curves because typically the price-efficiency relationship for appliances follows an exponential fit; and in this case, DOE found that an exponential-curve fit best represented the data that was collected. DOE only had enough data points to adequately form exponential regression curve for four equipment classes: small air-cooled, large air-cooled, small-water cooled, and large-water cooled. For the remaining 11 equipment classes, DOE extrapolated the analysis based on results, SCOP differences in ASHRAE Standard 90.1-2010, and price differences from the four primary equipment classes. DOE used the SCOP differences in ASHRAE because there was not enough SCOP data in DOE's database to determine the changes in SCOP between equipment classes. DOE assumed that the differences in the SCOP levels in ASHRAE Standard 90.1-2010 approximated the industry-average SCOP differences between equipment classes.

For the very large air-cooled and water-cooled equipment classes, DOE did not have enough data to develop the price-efficiency relationship and extrapolated the results from the price-efficiency curves for the large air-cooled and large water-cooled equipment classes. For very large air-cooled equipment, DOE shifted the large air-cooled price-efficiency curve down by 0.20 SCOP (the difference in SCOP levels between large and very large air-cooled equipment in ASHRAE Standard 90.1-2010). Then, DOE calculated the average percent increase in price between large air-cooled and very large air-cooled units in the same model line. DOE found that the average price difference of models for which data was collected was a 44 percent increase in price for the very large air-cooled equipment class from the large air-cooled equipment class. Thus, DOE multiplied the prices in the price-efficiency curve by 1.44 to approximate the average increase in price between the large and very large air-cooled equipment class. For the very large water-cooled equipment class, DOE used the same methodology as for air-cooled units. DOE shifted the large price-efficiency curve down by 0.10 SCOP (the difference in SCOP as noted by ASHRAE Standard 90.1-2010) and multiplied the prices in the large water-cooled equipment class price-efficiency curve by 1.90 to estimate the average price-efficiency relationship for the very large water-cooled equipment class.

For the small, large, and very large glycol-cooled equipment classes, DOE was unable to obtain enough price and efficiency data to generate a price-efficiency relationship; as a result, DOE extrapolated the price-efficiency relationship for these equipment classes based on the results from the water-cooled equipment class. From the pricing survey, DOE found that in both of the instances where DOE had pricing information for a model that was optionally water-cooled or glycol-cooled (large and very large sizes), the glycol-cooled unit was the same exact price as its corresponding water-cooled unit. (For the remaining three glycol-cooled models for which DOE had obtained pricing information, DOE did not have pricing information for a similar model water-cooled unit for comparison and could not draw any conclusions) Based on this information, DOE assumed that the price for glycol units would be the same as the price for water-cooled units at the same representative capacity. Next, DOE shifted the SCOP rating of glycol-cooled units down by 0.1 for the small class, 0.35 for the large class, and 0.3 for the very large class (which were the SCOP differences according to ASHRAE Standard 90.1-2010).

For the six equipment classes with a fluid economizer (*i.e.*, small, large, and very large water-cooled and small, large, and very large glycol-cooled), DOE translated the price-efficiency curves from the corresponding water-cooled and glycol-cooled equipment classes without a fluid economizer. Because a fluid economizer adds additional static pressure for the blower to overcome, DOE believes that these units require more fan energy and thus have a lower SCOP rating then those models without a fluid economizer. Thus, DOE shifted the price-efficiency curves down by 0.05 SCOP, which was the difference as specified in ASHRAE Standard 90.1-2010 between units with and without a fluid economizer. As noted in section 3.3.5, DOE was only able to collect pricing data for one unit with a fluid economizer (a very large glycol-cooled unit). DOE compared the price of this unit with the fluid economizer to the price of the same unit without the fluid economizer to determine the price increase associated with the addition of a fluid economizer. DOE found that the percentage difference in the price of a model with a fluid economizer versus the price of a model without a fluid economizer was 5.82 percent. DOE assumed that this percentage difference of adding a fluid economizer would hold true for the small and large equipment classes, so DOE multiplied the prices in the price-efficiency curves for those classes without a fluid economizer by 1.0582 to generate the corresponding price-efficiency curves for the equipment classes with a fluid economizer.

Figure 3.3.1 shows a visual summary of how DOE extrapolated the data. The boxes in green are the four primary equipment classes which DOE had enough data to analyze directly, and the boxes in blue are the equipment classes to which DOE extrapolated the data. The arrows connecting the boxes show how the price-efficiency data was extrapolated to the equipment classes in the blue boxes. The arrows have equations next to them to show how the SCOP and the price were adjusted for each extrapolation.

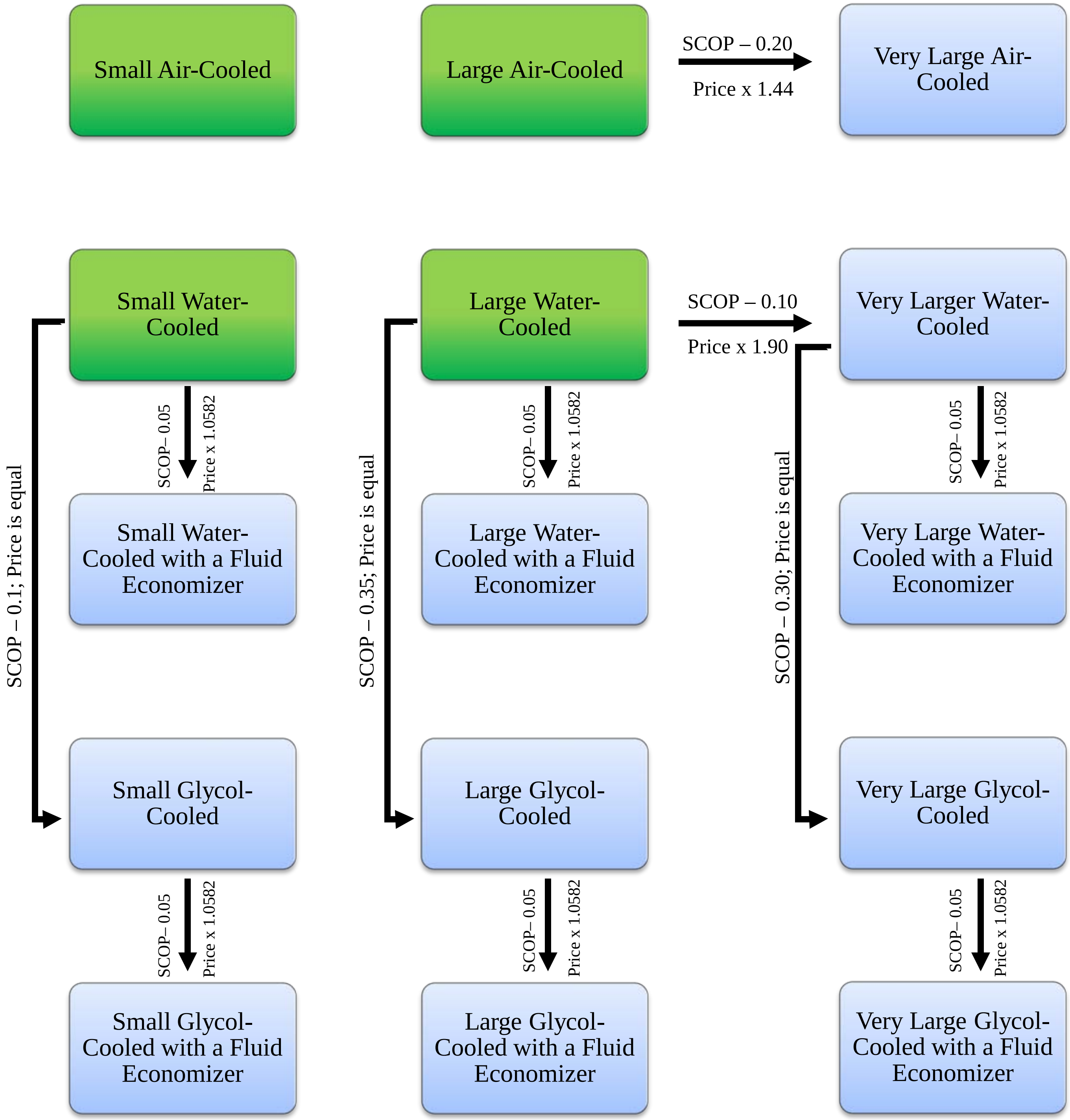

Figure 3.3.1 Extrapolation Flow Chart of the Price-Efficiency Curves for Computer Room Air Conditioner Classes

3.4 ENGINEERING ANALYSIS SUMMARY OF RESULTS

The result of the engineering analysis is a set of price-efficiency relationships. Creating the price-efficiency relationship involved four steps: (1) plotting the distributor prices versus SCOP for the four equipment classes that were directly analyzed, (2) using a regression analysis to fit a curve that best defines the aggregated data, (3) extrapolating the results to the other eleven equipment classes, and (4) calculating the price at each efficiency level for analysis. Table 3.4.1 through Table 3.4.5 show the price-efficiency results in the form of total price of the unit versus SCOP efficiency. Note that the only equipment classes in which DOE had enough information to run a regression analysis were the small air-cooled class, the large air-cooled class, the small water-cooled class, and the large water-cooled class. In the rulemaking process, the results from the engineering analysis are used in the life-cycle cost (LCC) analysis to determine customer prices for computer room air conditioners.

Table 3.4.1 Price-Efficiency Points for Air-Cooled Computer Room Air Conditioners

Small (<65,000 Btu/h)		Large (≥65,000 Btu/h and <240,000 Btu/h)		Very Large (≥240,000 Btu/h and <760,000 Btu/h	
Efficiency Level (SCOP)	**Price**	**Efficiency Level (SCOP)**	**Price**	**Efficiency Level (SCOP)**	**Price**
2.20	$6,681	2.10	$22,621	1.90	$32,575
2.40	$7,854	2.35	$24,383	2.15	$35,112
2.60	$9,232	2.60	$26,282	2.40	$37,847
2.80	$10,852	2.85	$28,329	2.65	$40,794
3.00	$12,756	3.10	$30,536	2.90	$43,972

Table 3.4.2 Price-Efficiency Points for Water-Cooled Computer Room Air Conditioners

Small (<65,000 Btu/h)		Large (≥65,000 Btu/h and <240,000 Btu/h)		Very Large (≥240,000 Btu/h and <760,000 Btu/h	
Efficiency Level (SCOP)	**Price**	**Efficiency Level (SCOP)**	**Price**	**Efficiency Level (SCOP)**	**Price**
2.60	$14,233	2.50	$12,883	2.40	$24,453
2.80	$11,528	2.70	$17,315	2.60	$32,864
3.00	$9,337	2.90	$23,272	2.80	$44,166
3.20	$7,562	3.10	$31,279	3.00	$59,357
3.40	$6,125	3.30	$42,040	3.20	$79,771

Table 3.4.3 Price-Efficiency Points for Water-Cooled Computer Room Air Conditioners with a Fluid Economizer

Small (<65,000 Btu/h)		Large (≥65,000 Btu/h and <240,000 Btu/h)		Very Large (≥240,000 Btu/h and <760,000 Btu/h	
Efficiency Level (SCOP)	**Price**	**Efficiency Level (SCOP)**	**Price**	**Efficiency Level (SCOP)**	**Price**
2.55	$15,062	2.45	$13,633	2.35	$25,878
2.75	$12,199	2.65	$18,324	2.55	$34,778
2.95	$9,881	2.85	$24,628	2.75	$46,739
3.15	$8,003	3.05	$33,101	2.95	$62,814
3.35	$6,482	3.25	$44,489	3.15	$84,417

Table 3.4.4 Price-Efficiency Points for Glycol-Cooled Computer Room Air Conditioners

Small (<65,000 Btu/h)		Large (≥65,000 Btu/h and <240,000 Btu/h)		Very Large (≥240,000 Btu/h and <760,000 Btu/h	
Efficiency Level (SCOP)	**Price**	**Efficiency Level (SCOP)**	**Price**	**Efficiency Level (SCOP)**	**Price**
2.50	$14,233	2.15	$12,870	2.10	$24,453
2.70	$11,528	2.35	$17,297	2.30	$32,864
2.90	$9,337	2.55	$23,245	2.50	$44,166
3.10	$7,562	2.75	$31,240	2.70	$59,357
3.30	$6,125	2.95	$41,985	2.90	$79,771

Table 3.4.5 Price-Efficiency Points for Glycol-Cooled Computer Room Air Conditioners with a Fluid Economizer

Small (<65,000 Btu/h)		Large (≥65,000 Btu/h and <240,000 Btu/h)		Very Large (≥240,000 Btu/h and <760,000 Btu/h	
Efficiency Level (SCOP)	**Price**	**Efficiency Level (SCOP)**	**Price**	**Efficiency Level (SCOP)**	**Price**
2.45	$15,062	2.10	$13,620	2.05	$25,878
2.65	$12,199	2.30	$18,304	2.25	$34,778
2.85	$9,881	2.50	$24,599	2.45	$46,739
3.05	$8,003	2.70	$33,060	2.65	$62,814
3.25	$6,482	2.90	$44,430	2.85	$84,417

These results represent the average industry price for achieving certain efficiency levels and do not take into account the cost for specific design improvements. The prices in the tables above do not represent any single manufacturer. DOE found that among individual manufacturers there was no discernable relationship between pricing and efficiency; however, when manufacturer prices were aggregated, trends between price and efficiency appeared.

Namely, the aggregate data indicated that there are manufacturers who sell lower price, less efficient units and manufacturers who sell higher price, more efficient units.

DOE observed that the results for small water-cooled computer room air conditioners with and without a fluid economizer and small glycol-cooled computer room air conditioners with and without a fluid economizer have a negative correlation between price and efficiency (*i.e.*, as the efficiency of the unit increases, the price for that unit decreases). This result is counter-intuitive because DOE typically finds that an increase in efficiency will also result in an increase in manufacturer costs, which are then reflected in increased customer prices. DOE believes that more data points could reveal a different trend than resulted from its pricing analysis.

DOE also found no common trend when looking at results from individual manufacturers within each product class. Oftentimes, the most efficient unit offered by a particular manufacturer also happened to be the manufacturer's least expensive model. DOE believes that it is likely that manufacturers base the pricing of their units on factors other than energy efficiency. For example, factors such as how competitive the market is for certain equipment could cause manufacturers to apply different markups to different product lines. As a result, more-popular equipment might have a lower price (either due to lower markup or higher manufacturing volumes) and less-popular equipment might be more expensive. Additionally, manufacturers may charge a premium for other factors that are unrelated to efficiency, such as longer warranties, improved user controls, or a myriad of other factors. Accordingly, it follows that an alternative approach, such as a reverse-engineering or design option approach which estimates the equipment cost at the point of manufacturer (rather than the purchase price from the distributor) might yield different results from those presented in this analysis.