Commercial Equipment Cost Database

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MASTER

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Summary

The passage of the 1992 Energy Policy Act (EPAc) (42 USC 13201) brings commercial equipment under the scope of federal energy efficiency regulations for the first time. Categories of equipment covered by these regulations include commercial package heating and air-conditioning equipment, warm air furnaces, packaged boilers, and hot water heaters. In setting standards for these equipment categories, minimum efficiency levels are based on voluntary standards promoted by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) in the document entitled *Energy Code for Commercial and High-Rise Residential Building* (ASHRAE/IES 90.1-1989) (ASHRAE 1993). EPAc further requires that if the ASHRAE standards are amended, the Secretary of Energy shall establish an amended national standard at the minimum level specified in the amended ASHRAE standard, unless a more stringent standard can be shown to result in significant additional energy savings, and is both technologically feasible and economically justified. A revised ASHRAE standard is currently under development, and in compliance with EPAc, the U.S. Department of Energy (DOE) has undertaken an evaluation of the standards development process.

This report, prepared for DOE, Office of Codes and Standards, as part of the Commercial Equipment Standards Program at Pacific Northwest Laboratory, specifically addresses the equipment cost estimates used to evaluate the economic impacts of revised standards. A database including commercial equipment list prices and estimated contractor costs was developed, and through statistical modeling, estimated contractor costs are related to equipment parameters including performance. These models are then used to evaluate cost estimates developed by the ASHRAE 90.1 Standing Standards Project Committee, which is in the process of developing a revised ASHRAE 90.1 standard. The database will also be used to support further evaluation of the manufacturer and consumer impacts of standards. Cost estimates developed from the database will serve as inputs to economic modeling tools, which will be used to estimate these impacts.

Preliminary results suggest that list pricing is a suitable measure from which to estimate contractor costs for commercial equipment. Models developed from these cost estimates accurately predict estimated costs. The models also confirm the expected relationships between equipment characteristics and cost. Cost models were developed for gas-fired and electric water heaters, gas-fired packaged boilers, and warm air furnaces for indoor installation. Because of industry concerns about the use of the data, information was not available for the other categories of EPAc-covered equipment. These concerns must be addressed to extend the analysis to all EPAc equipment categories.

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1.0 Introduction

If the economic impacts of commercial equipment efficiency standards are to be fully evaluated, all costs that are incurred in purchasing and operating the equipment over its assumed life must be estimated. This report primarily addresses equipment purchased cost estimates for both low- and high-efficiency units and the appropriate performance measure(s) for the equipment. When the equipment cost data were developed, other information relevant to the life-cycle equipment costs was also available. Where appropriate, this information is discussed, especially when it relates to equipment purchased costs and equipment operating costs.

The analysis relies primarily on a database of equipment cost and performance information. A partial version of this database is included in Appendix A, with manufacturer-specific information and some cost data excluded to protect the proprietary interests of the manufacturers. This database was developed from list price information supplied by manufacturers of commercial equipment; catalog data on the features and characteristics of the equipment; and performance information derived from a variety of sources including the manufacturers, equipment catalogs, equipment directories, and other databases. In addition, the manufacturers were asked to supply estimated multipliers for converting list prices to wholesale prices, allowing price comparisons between companies. Contractor pricing is estimated from wholesale prices assuming a dealer markup of 10%. Finally, consumer costs are estimated assuming a contractor markup of 25%, which does not include the cost of labor for equipment installation or the peripheral equipment necessary to install the equipment. The two cost measures held in the database are list price and estimated contractor price.

The database is used to develop estimates of the baseline contractor costs for standard-efficiency equipment as well as the incremental costs for high-efficiency equipment. Because the database relies on information about existing equipment, it reflects costs associated with the actual features and characteristics of both standard- and high-efficiency equipment currently available on the market. As such, the data may not cover the entire spectrum of technologically achievable performance. The results also reflect market factors that affect equipment costs beyond the actual costs that are associated with the production and distribution of the equipment. The cost estimates are used to evaluate cost information generated by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) in the development of a revised ASHRAE Standard 90.1.

The database in Appendix A includes information on water heaters, hot water storage tanks, packaged boilers, and warm air furnaces. Information was requested from manufacturers of heating, ventilating, and cooling (HVAC) equipment; however, there was an extreme reluctance to provide these data, especially among the major manufacturers. A formal request for data was presented through the Air Conditioning and Refrigeration Institute (ARI) to its members, which include most of the manufacturers of commercial HVAC equipment. This request was turned down. The Gas Appliance Manufacturers Association (GAMA) also formally requested that the U.S. Department of Energy (DOE) desist from current cost data collection efforts until after the ASHRAE analysis is completed. As a result,

data were not collected from several major boiler manufacturers. The analysis was completed using the boiler information available, but sufficient data does not currently exist on HVAC equipment to warrant inclusion in the database.

Baseline and incremental cost information that was collected in this study is also intended for use in evaluating the consumer and manufacturer impacts of efficiency standards. This work is being conducted by the Commercial Equipment Standards Program at Pacific Northwest Laboratory,^(a) under contract to DOE, Office of Codes and Standards. The cost data will serve as inputs to economic models that are used to evaluate the impacts of revised standards.

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2.0 Background

Several potential sources of cost and performance information are available for commercial equipment. The following chapter discusses some of the strengths and weaknesses of these information sources and also discusses how the data can be used to relate equipment costs to equipment characteristics.

2.1 Evaluation of Cost Data

Accurately evaluating average commercial equipment costs is difficult. Competitive pricing at the wholesale, dealer, and contractor levels leads to wide variation in consumer costs for a particular piece of equipment. Comparing equipment prices between manufacturers requires that a consistent measure of cost be identified.

2.1.1 Market Effects on Cost Data Consistency

At the manufacturing level, costs are typically measured as "standard costs," which reflect the estimated cost (not including sales and general administration costs) to produce a typical model. A change in standard costs over a given time period is referred to as variance, where a positive variance represents average production costs above the expected standard cost. If the variance is generally small with respect to standard cost and the standard cost is consistently defined across a given sector of the manufacturing industry, the standard cost would be an appropriate measure of manufactured cost. Unfortunately, manufactured cost information is very closely guarded. This is partly due to the fact that a manufacturer's competitors can obtain detailed information about its products simply by purchasing them. Therefore, production cost information remains one of the few competitive secrets that can be maintained. Even if standard costs are a consistent measure of equipment costs between companies, this information is difficult to obtain.

Manufactured costs can also be expected to fluctuate substantially as a result of short-term market conditions. Equipment manufacturers rely to a varying extent on suppliers to provide components for the equipment. As demand for equipment rises, the manufacturers may turn to secondary suppliers of components to meet short-term demands. This may, in turn, result in higher component costs, though the essential characteristics of the equipment remain unchanged. In a competitive market, these costs may not be passed on to the consumer and may not be reflected in retail equipment prices.

Difficulties also occur in the collection of consistent cost information at a defined point in the equipment distribution chain. This happens primarily because of the variety and complexity of distribution mechanisms found in the commercial equipment market. As an example, consider two extreme cases of different marketing systems. In one system, equipment is marketed through distributors who purchase the equipment based on a published price list. The actual price paid for the equipment is discounted from the published price based on the dollar volume of sales, the number of models stocked by the distributor, and the terms of the sale (cash paid in a specific time frame after shipment). Also,

these published prices may vary by region. In another system, a small company that manufactures a low volume of high-efficiency equipment may market that same equipment directly to consumers. Identifying a consistent cost measure for comparing equipment from these two types of companies is difficult.

Because consumer costs for equipment are in many cases the desired measure, it is also possible to try to collect this information directly. However, commercial equipment is typically not sold at a retail level, making consumer cost difficult to collect. Commercial equipment is usually purchased and installed by a contractor who charges the consumer for the cost of the equipment plus some markup to cover overhead and profit for the project. Contractors base this markup on the characteristics of the project and the relationship to the customer. In general, the greater the level of competition in an area and the lower the level of risk involved in the project, the less the equipment will be marked up. Estimated markups can range from less than 15% to greater than 50%, thus heavily impacting the actual consumer cost for the equipment. Because of the factors involved in project bidding, it is generally difficult to obtain equipment cost estimates from contractors without specifying the exact details of the project.

Other potential sources of consumer cost data for commercial equipment are utility rebate programs that offer incentives to customers based on the cost of the equipment. If sufficient information is recorded in these programs, it would serve as a source of data on actual equipment costs at the consumer level. An evaluation of this data source suggests, however, that the quality and quantity of commercial equipment cost data available through rebate programs is limited and, in many cases, may be considered proprietary.

Finally, equipment distributors can provide cost information for equipment at the contractor level. These costs will reflect all of the variations found in the distribution chain, including regional factors that affect price. Estimating national average values, however, makes it necessary to request data from a wide number of distributors. Collecting information from distributors also has other limitations. First, prices charged by a given distributor may vary depending on the relationship with an individual contractor. Second, contractor cost information may be considered proprietary to disguise the variable rate structure between clients. Third, the collection of large quantities of information through this method would be difficult because no published contractor costs are available. Thus, while distributor pricing may be the best information available for estimating consumer costs, it would be difficult to develop a large data set based on this source.

The primary cost data source used in this analysis was manufacturer-supplied list pricing. Because list prices are not necessarily comparable between manufacturers, list price information was converted to estimated wholesale price where wholesale price is defined as the price paid by a distributor for the equipment. Two methods were used to convert list prices to wholesale prices. When possible, equipment manufacturers were asked to provide a multiplier for calculating wholesale price from list price. Lacking manufacturer estimates, dealers were contacted for actual contractor price quotes, and these quotes were averaged to identify the relationship between list prices and contractor pricing. Estimated

average dealer and contractor markups were then used to convert these costs to consumer costs. A similar multiplier can be used to estimate manufacturer costs.

2.1.2 Specificity of Equipment Characterization

Accurately measuring the cost of comparable pieces of equipment requires a detailed specification of the properties of that equipment. Without the ability to control for equipment features, any between-company comparison of equipment costs is impossible.

As an example, consider some common features of commercial electric water heaters. Frequently, these units can be purchased with either immersion or surface thermostats. The cost premium for an immersion thermostat model may be as much as an additional 30% over the cost of a surface thermostat model. Without knowledge of the thermostat type, it is clearly risky to compare the costs of two otherwise similar units. When incremental cost estimates are made from costs for existing equipment, it is important to understand the features associated with the equipment.

Baseline equipment cost estimates also affect the outcome of life-cycle cost calculations. As first costs for equipment escalate, the impact of fuel savings on the life-cycle cost diminishes. An accurate assessment of average baseline equipment costs requires not only an understanding of common equipment features and costs, but also an understanding of the market penetration of these features.

2.2 Evaluation of Performance Data

Performance information plays an integral role in the estimation of life-cycle consumer costs for commercial equipment. In this type of analysis, incremental costs for high-efficiency equipment are essentially weighed against the value of fuel savings over the life of the equipment. If the present value of fuel savings is greater than the present value of increased capital or other costs, then the life-cycle cost is lower at higher levels of efficiency, justifying a more stringent standard. While life-cycle cost minimization is only one of many possible decision rules in any life-cycle cost assessment, the actual life-cycle performance of the equipment has an important effect on the estimation of life-cycle cost.

Standard measures of performance have been developed for commercial equipment by a variety of groups and agencies, including DOE, ASHRAE, American National Standards Institute (ANSI), and Underwriters Laboratories (UL). These standards describe a detailed test situation in which the performance of a specific piece of equipment is measured in the laboratory. The standards are designed to ensure consistent ratings of equipment produced by different manufacturers. Performance testing for commercial equipment primarily focuses on the steady-state performance, however, which typically does not reflect the actual seasonal performance of the equipment. Thus, evaluation of life-cycle costs based on steady-state performance measures does not accurately reflect the actual fuel consumption and fuel costs associated with equipment operation.

This issue is particularly pertinent when evaluating high-efficiency equipment. Achieving such high efficiencies makes it necessary to depart radically from conventional design parameters.

Examples of such types of equipment include modulating condensing water heaters and boilers, pulse combustion furnaces and boilers, and direct contact water heaters. Standard test procedures applied to these types of equipment may grossly underestimate or overestimate the annual fuel consumption, and thus fuel costs.

As an example, consider the modulating water heater referred to above. Under steady-state conditions at maximum-rated capacity, the tested thermal efficiency (ANSI Z21.10.3) is 93%. This efficiency goes up as input decreases, approaching 99% efficiency at 10:1 turndown ratio. In this case, the seasonal performance of the unit, because of part load operation, is most likely higher than the steady-state, full-fire efficiency. Evaluating life-cycle costs for this equipment based on rated input efficiency will overestimate fuel consumption and costs.

Conversely, many types of equipment operate less efficiently under part load conditions. In a report that evaluated seasonal performance of conventional steam boilers, the results of three studies covering 13 boilers were analyzed. The steady-state efficiencies of this equipment ranged from 70% to 85.4%, while the seasonal-efficiency estimates for the same equipment ranged from 56.6% to 73.7% (Hewett and Lobenstein 1992). Estimating fuel consumption based on steady-state performance is clearly inaccurate.

High-efficiency equipment may also require higher levels of maintenance than conventional equipment. This adds additional operating costs and, in the absence of sufficient maintenance, may add additional fuel costs as performance degrades. As an example, consider a boiler with a heat reclaimer added to the boiler stack to recover energy. Because of the added complexity to the system, a more sophisticated tuning process is required to achieve the expected peak performance. Properly tuned, the unit may operate at four percentage points above the conventional design. Without proper tuning, carbon may soot up the tube bundles and boiler, possibly reducing performance below that of a standard model.

Performance measures in this report are based on current test procedures. When life cycle costs are evaluated, it is important to remember the limitations of this type of performance information.

2.3 Availability of Cost and Performance Data

Manufacturers, manufacturer representatives, and dealers are frequently reluctant to release cost information. Even when a potential provider of information is identified, several contacts may be required before the information is released. Many manufacturers were contacted in this data collection effort, and repeated attempts were made to ensure the confidentiality of the information. However, in some cases, limited or no data were available. In the case of the HVAC equipment manufacturers, a further effort will be required to evaluate equipment costs. Because of the sensitivity of cost data in this report, specific manufacturers are not identified with regard to any cost information. Also, equipment parameters such as volume and input were rounded to further disguise the data.

While performance data are more readily available, some types of performance information are difficult to collect and may be of poor quality. Though water heater performance data for most manufacturers are collected in the California Energy Commission (CEC) equipment database, thermal-efficiency data are missing for many fuel-fired water heaters. Standby loss information is also missing for a significant fraction of storage-type water heaters. Some information of this type is available from the manufacturers, but it is often only a general estimate used in sales literature. The CEC database does not include unfired hot water storage tanks, and no other source of tested standby loss performance for this equipment was identified.

The CEC database also includes thermal-efficiency data for warm air furnaces and combustion efficiency data for boilers. An additional source of boiler efficiency information is the Hydronics Institute, which publishes ratings for Institute-certified equipment (Hydronics Institute 1994). A comparison of data from the two sources revealed only a few discrepancies in the efficiency measures. Where possible, information from the CEC database was used, as it provides the broadest coverage. Other sources were used to supplement these data.

2.4 Model Development

With consistent measures of cost and performance identified, statistical models can be developed relating costs to equipment parameters. When these models are developed, many subjective decisions must be made about the form of the models and the data to be included in the analysis. When residual plots and other statistical measures of goodness of fit are evaluated, it is possible to eliminate some models from consideration. In many cases, however, there are still several possible ways in which the data can be modeled. If outliers are eliminated, more accurate models can be developed for the remaining data. When there is little basis for excluding any particular data, however, other than the difficulty in modeling it, an attempt is made to revise the model to account for these data, either by including dummy variables or by regrouping the data into separate categories.

Model validity can also be measured by the extent to which parameter estimates reflect the expected relationships between equipment characteristics and cost. Because many of the explanatory variables used to characterize equipment are correlated, it is often difficult to account for the effect of each variable independently. If these correlations are understood, however, it is possible to choose a set of variables that, in general, reflect the most important parameters that affect cost.

Models are reported along with the R-squared value for the model. This is not meant to imply that a high R-squared value alone can be used as a measure of the validity of the model. In fact, R-squared values are a poor measure of model validity, and comparisons of R-squared values between models are only useful in certain limited circumstances. In order to assess model validity other methods were used including the evaluation of t-statistics and standard errors, direct evaluation of predicted versus actual values, and the evaluation of tests for general model misspecification. In this way it is possible to choose models which are both statistically valid, and which reflect the most important characteristics which affect cost.

It is also extremely important to understand the bounds of model validity. Any attempt to apply the model to equipment with characteristics outside of the bounds of the data set is invalid, and is likely to lead to poor estimates of cost, especially for models involving power and logarithmic functions. These bounds have generally been noted when estimating equipment costs, and any attempt to produce additional cost estimates using these models should only be carried out after a thorough examination of the relevant data set.

3.0 Definition of Equipment Categories

EPAct standards only apply to certain categories of equipment, and these standards also vary between equipment subcategories. The following chapter describes the equipment categories found in EPAct.

3.1 Water Heaters

In EPAct, commercial water-heating equipment is divided into six categories. These categories are presented in Table 3.1.

The minimum input ratings for small-input fuel-fired storage water heaters and fuel-fired instantaneous water heaters with greater than 10-gal storage are different for gas and oil models. Minimum oil inputs are given in parenthesis. Because no significant difference was found in costs for large-input, fuel-fired storage water heaters and for fuel-fired instantaneous water heaters with greater than 10-gal storage volume, these two categories are treated as one in this report and are referred to as fuel-fired storage water heaters. The remaining small-storage instantaneous units are referred to as tankless water heaters. The characteristics of these equipment types are discussed further in Section 6.1 of this report.

3.2 Packaged Boilers

Commercial packaged boilers are defined in EPAct as units that are "...shipped complete with heating equipment, mechanical draft equipment, and automatic controls; usually shipped in one or more sections." This includes all equipment with rated capacity of 300,000 Btu/hr or more and includes oil- and gas-fired units and water and steam boilers. Separate standards exist for each fuel type, so they were examined separately.

3.3 Warm Air Furnaces

A warm air furnace is defined in EPAct as "...a self-contained oil- or gas-fired furnace designed to supply heated air through ducts to spaces that require it and includes combination warm air furnace/ electric air conditioning units but does not include unit heaters and duct furnaces." Commercial equipment includes all units with rated capacity of 225,000 Btu/hr or more. The ASHRAE analysis is based on outdoor-type warm air furnaces. Because few data were available from manufacturers of this type of equipment, baseline cost estimates were limited to warm air furnaces for indoor installation.

Table 3.1. Water Heater Categories

Type	Input Rating	Storage Volume	Input-to-Storage Volume Ratio	Standard
Storage Electric	> 12 kW	All	All	$\leq 0.3 + 27/\text{Vol.}$
Fuel-Fired Storage	> 75 (105) kBtu/hr ≤ 155 kBtu/hr	All	All	$\geq 78\%$ efficiency $\leq 1.3 + 114/\text{Vol.}$
Fuel-Fired Storage	> 155 kBtu/hr	≥ 10 gal	< 4,000 Btu/hr	$\geq 78\%$ efficiency $\leq 1.3 + 95/\text{Vol.}$
Fuel-Fired Instantaneous	> 200 (210) kBtu/hr	< 10 gal	$\geq 4,000$ Btu/hr	$\geq 80\%$ efficiency
Fuel-Fired Instantaneous	> 155 kBtu/hr	≥ 10 gal	$\geq 4,000$ Btu/hr	$\geq 77\%$ efficiency $\leq 2.3 + 67/\text{Vol.}$
Unfired Storage Tanks	N/A	All	N/A	≤ 6.5 Btu/hr/ft ²

4.0 Description of ASHRAE Cost Analysis Methodology

When evaluating the cost of commercial equipment, ASHRAE relied on two primary types of information: estimated contractor cost for typical equipment and estimated incremental cost for high-efficiency equipment. Contractor pricing for the baseline units was developed by an engineering consultant who contacted equipment distributors and asked them for equipment costs (by size) for up to four separate models and different sizes in each category. These estimates were inflated by 25% to account for contractor markup and then averaged. Incremental costs above this baseline were estimated based on information supplied by manufacturers through associations such as GAMA and ARI. The manufacturers were asked in a survey to estimate the incremental cost, as a percentage, to produce equipment at varying levels of efficiency above an assumed baseline. These incremental cost percentages were then multiplied by the baseline costs to develop equipment costs at each of the desired efficiency levels. The specific details of the cost collection exercise varied for each of the major equipment categories and are described below.

4.1 Water Heaters

Cost estimates for water heater equipment were made for 10 specific equipment types and sizes. Only gas-fired equipment was considered in this analysis.

4.1.1 Baseline Cost Estimates

Baseline cost estimates are presented in Table 4.1. These costs are for equipment only and include an estimated 25% contractor markup. The contractor markup does not include labor costs to install the equipment. The first four entries are gas-fired water heaters with storage tanks. Based on the ASHRAE water heater classifications, the first three models are storage water heaters, having an input-to-volume ratio of less than 4,000 Btu/hr/gal. The fourth model, based on this ratio, is an instantaneous water heater with greater than a 10-gal storage volume. The second set of equipment, labeled instantaneous water heaters, are of copper finned-tube design. These units have no storage volume other than the quantity of water held in the tubing of the equipment. These units are essentially equivalent to hydronic-heating models, which are classified as boilers. Finally, four sizes of unfired hot water storage tanks with insulation are included.

4.1.2 Incremental Cost Estimates

ASHRAE incremental cost estimates are based on manufacturer responses to a commercial water heater survey conducted by GAMA. The survey included three levels of thermal efficiency and two levels of standby efficiency, combined for a total of 20 cost levels in five categories of equipment. Incremental cost estimates were made for only 14 levels. This information is presented in Table 4.2.

Table 4.1. ASHRAE Water Heater Baseline Cost Estimates

Category	Capacity	MFR "A"	MFR "B"	MFR "C"	MFR "D"	Average
75-gal Storage	120 kBtu/hr	\$2,478	\$7,785	\$1,683	\$2,625	\$3,665
100-gal Storage	199 kBtu/hr	\$3,323	\$8,200	\$2,142	\$3,500	\$4,291
100-gal Storage	360 kBtu/hr	\$5,337	\$9,712	\$2,830	\$5,000	\$5,720
100-gal Storage	500 kBtu/hr	\$12,722	\$11,250	\$3,947	\$7,375	\$8,824
Instantaneous	400 kBtu/hr	\$4,402	\$4,125	\$2,897	\$2,483	\$3,477
Instantaneous	1000 kBtu/hr	\$6,250	\$6,000	\$4,785	\$4,806	\$5,460
Unfired Storage Tank	120 gal	\$2,265	\$2,500	\$1,673	\$1,250	\$1,922
Unfired Storage Tank	200 gal	\$3,545	\$3,125	\$2,371	\$3,750	\$3,198
Unfired Storage Tank	500 gal	\$9,656	\$4,187	\$10,351	\$7,937	\$8,033
Unfired Storage Tank	1000 gal	\$17,808	\$5,662	\$16,025	\$13,125	\$13,155

4.2 Boilers

Baseline and incremental boiler cost estimates were made for gas-fired units only.

4.2.1 Baseline Cost Estimates

Baseline costs for commercial packaged boilers were developed from dealer quotes for both atmospheric and power burner cast-iron and steel boilers. Information was collected for 10 size categories in the range of 200 kBtu/hr up to 4,000 kBtu/hr. No information was collected on copper or copper/nickel alloy boilers. Baseline cost information is presented in Tables 4.3 through 4.6.

Baseline cost estimates were developed from these data for four size categories: 300 to 400 kBtu/hr, 400 to 1,000 kBtu/hr, 1,000 to 2,500 kBtu/hr, and 2,500 to 4,000 kBtu/hr. Only a small number of the costs listed in Tables 4.3 through 4.6 are actually used. The baseline cost for a 300- to 400-kBtu/hr hot water boiler was estimated from the average cost for 400-kBtu/hr atmospheric and power burner cast-iron boilers. Similarly, the other size categories were estimated from the average costs of power and atmospheric cast-iron boilers of 800-, 1500-, and 3,000-kBtu/hr sizes. These baseline costs were also used for the steam boiler analysis. None of the steel boiler cost data were used.

Table 4.2. ASHRAE Water Heater Incremental Cost Estimates

Water Heater Type	Technology Level	Thermal Efficiency	Standby Loss Requirement	Cost Increase
< 155 kBtu/hr	1	78%	$\leq 1.3 + 114/\text{Vol.}$	3%
	2	80%	$\leq 1.3 + 114/\text{Vol.}$	10%
	3	86%	$\leq 1.0 + 67/\text{Vol.}$	60%
≥ 155 kBtu/hr	1	78%	$\leq 1.3 + 95/\text{Vol.}$	3%
	2	80%	$\leq 1.3 + 95/\text{Vol.}$	10%
	3	86%	$\leq 1.0 + 67/\text{Vol.}$	70%
≥ 4000 Btu/hr/gal Vol. < 10 gal	1	80%	N/A	0%
	2	83%	N/A	24%
	3	86%	N/A	85%
≥ 4000 Btu/hr/gal Vol. ≥ 10 gal	1	77%	$\leq 2.3 + 67/\text{Vol.}$	3%
	2	80%	$\leq 2.3 + 67/\text{Vol.}$	13%
	3	86%	$\leq 1.0 + 50/\text{Vol.}$	81%
Unfired Storage Tank	1	N/A	< 13.6 Btu/hr/ft ²	3%
	2	N/A	< 6.5 Btu/hr/ft ²	10%

4.2.2 Incremental Cost Estimates

Incremental cost estimates for high-efficiency packaged boilers were supplied by GAMA in the form of curves of cost versus efficiency for four size categories and two types of boilers (steam and water). When analyzing life-cycle costs, ASHRAE assumed that baseline costs for hot water and steam boilers were roughly equivalent. To test this assumption, ASHRAE repeated life-cycle cost calculations with water boiler cost estimates increased by 10% to account for the slightly higher cost of steam boilers. Minimum life-cycle costs occurred at the same efficiency levels in both cases, so the assumption was deemed acceptable. Cost increments supplied by GAMA are presented in Tables 4.7 and 4.8.

Table 4.3. ASHRAE Atmospheric Burner Cast-Iron Boiler Baseline Cost Estimates

Capacity	MFR "A"	MFR "B"	MFR "C"	Average
200 kBtu/hr	\$1,951	\$2,025	\$2,500	\$2,159
400 kBtu/hr	\$2,565	\$3,200	\$3,200	\$2,988
600 kBtu/hr	\$4,476	\$4,100	\$4,200	\$4,259
800 kBtu/hr	\$4,915	\$5,000	\$5,300	\$5,072
1,000 kBtu/hr	\$5,824	\$6,100	N/A	\$5,962
1,500 kBtu/hr	\$7,713	\$8,200	N/A	\$7,957
2,000 kBtu/hr	\$9,602	\$10,000	N/A	\$9,801
2,500 kBtu/hr	\$11,463	\$13,800	N/A	\$12,632
3,000 kBtu/hr	\$13,054	\$16,600	N/A	\$14,827
4,000 kBtu/hr	N/A	\$19,200	N/A	\$19,200

Table 4.4. ASHRAE Power Burner Cast-Iron Boiler Baseline Cost Estimates

Capacity	MFR "A"	MFR "B"	Average
200 kBtu/hr	\$1,603	\$10,000	\$5,802
400 kBtu/hr	\$3,684	\$10,400	\$7,042
600 kBtu/hr	\$4,670	\$10,800	\$7,735
800 kBtu/hr	\$5,342	\$11,000	\$8,171
1,000 kBtu/hr	\$6,434	\$12,300	\$9,367
1,500 kBtu/hr	\$7,518	\$13,600	\$10,559
2,000 kBtu/hr	\$10,063	\$14,900	\$12,482
2,500 kBtu/hr	\$11,781	\$16,200	\$13,991
3,000 kBtu/hr	\$13,121	\$17,100	\$15,111
4,000 kBtu/hr	\$15,918	\$17,500	\$16,709

Table 4.5. ASHRAE Steel Water-Tube Boiler Baseline Cost Estimates

Capacity	MFR "A"	MFR "B"	MFR "C"	MFR "D"	Average
200 kBtu/hr	N/A	N/A	N/A	\$16,000	\$16,000
400 kBtu/hr	\$3,357	\$4,676	\$3,900	\$16,500	\$7,108
600 kBtu/hr	\$5,571	\$4,840	\$4,250	\$17,000	\$7,915
800 kBtu/hr	\$7,235	\$5,521	\$4,600	\$17,500	\$8,714
1,000 kBtu/hr	\$7,682	\$6,278	\$5,100	\$18,600	\$9,415
1,500 kBtu/hr	\$9,012	\$7,282	\$6,120	\$19,400	\$10,454
2,000 kBtu/hr	\$10,936	\$8,127	\$7,510	\$15,000	\$10,393
2,500 kBtu/hr	\$11,978	\$9,623	\$8,950	\$16,000	\$11,638
3,000 kBtu/hr	\$15,559	\$10,496	\$10,300	\$17,000	\$13,339
4,000 kBtu/hr	\$18,907	\$12,565	\$13,400	\$18,000	\$15,718

Table 4.6. ASHRAE Steel Fire-Tube and Scotch Marine Boiler Baseline Cost Estimates

Capacity	MFR "A"	MFR "B"	MFR "C"	MFR "D"	Average
200 kBtu/hr	N/A	\$7,684	N/A	\$16,000	\$11,842
400 kBtu/hr	\$7,026	\$7,684	N/A	\$16,500	\$10,403
600 kBtu/hr	\$7,191	\$9,170	\$6,100	\$17,300	\$9,940
800 kBtu/hr	\$7,344	\$9,431	\$6,800	\$18,100	\$10,419
1,000 kBtu/hr	N/A	\$9,618	\$6,800	\$18,900	\$11,839
1,500 kBtu/hr	\$8,782	\$11,714	\$8,360	\$22,200	\$12,764
2,000 kBtu/hr	\$10,132	\$13,514	\$10,265	\$24,200	\$14,438
2,500 kBtu/hr	N/A	N/A	\$11,670	\$27,800	\$19,735
3,000 kBtu/hr	\$13,994	\$17,466	\$12,500	\$30,000	\$18,490
4,000 kBtu/hr	\$17,681	\$18,937	\$19,170	\$34,000	\$22,447

Table 4.7. ASHRAE Hot Water Boiler Incremental Cost Estimates

Thermal Efficiency	300 to 400 kBtu/hr	400 to 1,000 kBtu/hr	1,000 to 2,500 kBtu/hr	2,500 to 4,000 kBtu/hr
75%	0%	0%	0%	0%
75%	6%	-	-	-
76%	10%	10%	10%	10%
77%	15%	35%	40%	15%
78%	22%	35%	40%	15%
79%	44%	90%	110%	30%
80%	114%	90%	110%	40%
82%	121%	210%	255%	73%
84%	261%	210%	255%	100%
88%	450%	450%	350%	300%

The first level of incremental costs for the 300 to 400 kBtu/hr size category represents a change from pilot to electronic ignition, not affecting the combustion efficiency. The pilot is assumed to use energy at a rate of 1,000 Btu/hr.

4.3 Warm Air Furnaces

The cost estimates for ASHRAE warm air furnaces are based on outdoor gas-fired models. Warm air furnaces for indoor installation are covered by EPAct but were not considered in the ASHRAE analysis.

4.3.1 Baseline Cost Estimates

Information on the cost of baseline equipment was developed by a consultant. A summary of this information is provided in Table 4.9. This represents the cost for stripped-down units with no accessories, such as economizers and curbs. ASHRAE subsequently revised the cost for the 250 kBtu/hr unit upward by 5% to an average cost of \$5,133. This estimate was used in the analysis.

Table 4.8. ASHRAE Steam Boiler Incremental Cost Estimates

Thermal Efficiency	300 to 400 kBtu/hr	400 to 1,000 kBtu/hr	1,000 to 2,500 kBtu/hr	2,500 to 4,000 kBtu/hr
72%	0%	0%	0%	0%
72%	5%	-	-	-
73%	10%	10%	10%	10%
74%	10%	10%	10%	10%
75%	10%	10%	10%	10%
76%	26%	35%	40%	10%
77%	47%	45%	50%	15%
78%	50%	45%	50%	15%
79%	52%	45%	50%	30%
80%	100%	60%	60%	60%
81%	114%	125%	125%	-

Table 4.9. ASHRAE Outdoor Furnace Baseline Cost Estimates

Furnace Size	MFR "A"	MFR "B"	MFR "C"	MFR "D"	Average
250 kBtu/hr	\$4,932	\$4,875	\$5,000	\$4,750	\$4,889
400 kBtu/hr	\$6,702	\$6,250	\$7,875	\$7,500	\$7,082
1,000 kBtu/hr	\$22,700	\$19,750	\$27,500	\$27,000	\$24,236

4.3.2 Incremental Cost Estimates

Incremental cost estimates for high-efficiency outdoor gas furnaces were provided by GAMA, based on manufacturer responses to a warm air furnace survey. Each efficiency level is associated with a specific burner type and ignition system. These estimates are presented in Table 4.10.

Table 4.10. ASHRAE Outdoor Furnace Incremental Cost Estimates

Burner Type	Combustion Efficiency	Ignition System	250 kBtu/hr	400 kBtu/hr	1000 kBtu/hr
Atmospheric	78%	Pilot	0.0%	0.0%	0.0%
Atmospheric	80%	IID ^(a)	1.5%	1.5%	1.5%
Atmospheric, Vent Cap	80%	IID ^(a)	3.5%	3.5%	4.5%
Power	80%	IID ^(a)	6.0%	6.0%	6.0%
Power	82%	IID ^(a)	7.0%	6.0%	7.0%
Power, Condensing	88%	IID ^(a)	50.0%	51.0%	55.0%
(a) IID = Intermittent Ignition Device.					

5.0 Database Description

The equipment database in Appendix A includes six tables containing data on equipment with similar characteristics. To protect the confidentiality of the cost information, all manufacturer-specific data were excluded. In addition, some cost information was deleted where equipment characteristics were unique to a particular manufacturer. The remaining fields include descriptors of the equipment and its characteristics that affect cost. The following sections describe the tables and the data that they contain.

5.1 Common Variables

Four common variables exist in each table of the database: record number (REC), cost type (CTYPE), list cost (LCOST), and estimated contractor cost (CCOST). List costs were provided by manufacturers, usually in the form of published price sheets. These price sheets represent either a retail list price, which reflects retail pricing, or a distributor list price, which reflects distributor pricing. Neither price measures actual average retail or distributor costs for the equipment. Instead they are used as a basis for actual pricing, using some percentage discount or markup.

The published list prices are included in the equipment database, along with a price-type descriptor (CTYPE) (either retail [R] or distributor [D]). This variable measures the approximate level of the list price. Another cost measure, CCOST, is used to represent the estimated contractor price for the equipment. Where possible, CCOST was developed from list cost on the basis of manufacturer-supplied estimates of the wholesale discount from list price. An additional 10% is added to estimated wholesale price to account for dealer markup. Some manufacturers offer a discount off of list price in a complicated fashion, making estimates of the wholesale price from the list price difficult to calculate. When no estimate of the list price average discount was available, equipment dealers were contacted for contractor pricing. Average contractor costs were then used to arrive at a multiplier to estimate contractor costs from the list price. The variable CCOST is used in the statistical analysis.

The values of CCOST must also be modified to arrive at consumer cost. Commercial equipment is typically purchased by a contractor who then charges some markup in addition to the purchase price. This markup does not reflect labor costs for installing the equipment but instead covers overhead and profit. Contractor markup may vary from less than 15% to more than 50% depending on the characteristics of the job. Because a precise method for evaluating average contractor markups for commercial equipment does not exist, a midrange value of 25% was used. This estimate is consistent with the contractor markup that is used by ASHRAE. Costs developed from the statistical models presented below must be marked up by 25% to arrive at estimated consumer cost. The remaining database variables are described below.

5.2 Water Heaters

Water-heating equipment is separated into four different categories: fuel-fired storage water heaters, tankless water heaters, electric storage water heaters, and unfired hot water storage tanks.

5.2.1 Fuel-Fired Storage Water Heaters

FUEL is a character variable that describes the fuel type used by the equipment, either gas (G) or oil (O).

VOL is a numerical variable that describes the water heater tank volume in gallons. This is the nominal volumetric capacity of the water heater, as reported by the manufacturer. Nominal volume typically varies from actual volume by up to 3% but is the more commonly available measure.

INPUT is a numerical variable that describes the fuel input capacity in kBtu/hr, as reported by the manufacturer.

EFF is a numerical variable that describes the thermal efficiency of the water heater defined by ANSI Standard Z21.10.3 (AGA 1993). Where possible, this information is taken from the California Energy Commission (CEC) equipment database. Manufacturer-provided information is used to supplement the CEC data when actual test results are available.

STBY is a numerical variable that describes the standby loss rating of the water heater in percent per hour, based on ANSI Standard Z21.10.3. Where possible, this information is taken from the CEC equipment database. Manufacturer-provided information is used to supplement the CEC data when actual test results are available.

TANK is a character variable that describes the tank construction, either standard (S) or American Society of Mechanical Engineering (ASME) code (A), as provided by the manufacturer.

BURN is a character variable that describes the burner type, either atmospheric (A) or power (P), taken from the CEC database or manufacturer literature.

WARR is a numerical variable that indicates the length (in years) of the manufacturer warranty on the equipment.

5.2.2 Tankless Water Heaters

FUEL is a character variable that describes the fuel type used by the equipment, either gas (G) or oil (O).

INPUT is a numerical variable that describes the fuel input capacity in kBtu/hr, as reported by the manufacturer.

EFF is a numerical variable that describes the thermal efficiency of the water heater, defined by ANSI Standard Z21.10.3. Where possible, this information is taken from the CEC equipment database. Manufacturer-provided information is used to supplement the CEC data when actual test results are available.

EXCH is a character variable that describes the heat exchanger material type (steel [S], cast iron [I], copper [C], or copper-nickel alloy [N]). One line of water heaters of the direct contact type has EXCH = D to identify it from other conventional models. Heat exchange actually occurs in a stainless steel mesh material.

WARR is a numerical variable that indicates the length (in years) of the manufacturer warranty on the equipment.

5.2.3 Electric Storage Water Heaters

VOL is a numerical variable that describes the water heater tank volume in gallons. This is the nominal volumetric capacity of the water heater, as reported by the manufacturer. Nominal volume typically varies from actual volume by up to 3% but is the more commonly available measure.

INP is a numerical variable that describes the energy input capacity in kilowatts, as reported by the manufacturer.

STBY is a numerical variable that describes the standby loss rating of the water heater in percent per hour. Where possible, this information is taken from the CEC equipment database. Manufacturer-provided information is used to supplement the CEC data when actual test results are available.

VOLT is a numerical variable that indicates the supply voltage for the equipment, as provided by the manufacturer.

TANK is a character variable that describes the tank construction, either standard (S) or ASME code (A), as provided by the manufacturer.

RVAL is a numerical variable that describes the R-value of insulation on the water heater, as provided by the manufacturer or estimated from the insulation thickness and type.

WARR is a numerical variable that indicates the length (in years) of the manufacturer warranty on the equipment.

THERM is a character variable that indicates the thermostat type, either immersion (I) or surface (S).

5.2.4 Unfired Hot Water Storage Tanks

VOL is a numerical variable that describes the storage tank volume in gallons. This is the nominal volumetric capacity of the storage tank, as reported by the manufacturer. Nominal volume typically varies from actual volume by up to 3% but is the more commonly available measure.

RVAL is numerical variable that describes the R-value of insulation on the tank, as provided by the manufacturer or estimated from the insulation thickness and type.

TANK is a character variable that describes the tank construction, either standard (S) or ASME code (A), as provided by the manufacturer.

LIN is a character variable that describes the material used to line the water tank (glass [G], epoxy [E], cement or stone [S], or nickel [N]), as provided by the manufacturer.

ORIENT is a character variable that describes the tank orientation, either vertical (V) or horizontal (H), as provided by the manufacturer.

PRESS is a numerical variable that describes the pressure rating of the storage tank (in psig) as provided by the manufacturer.

WARR is a numerical variable that indicates the length (in years) of the manufacturer warranty on the equipment.

5.3 Packaged Boilers

TYPE is a character variable for the boiler type, either steam (S) or water (W).

FUEL is a character variable that describes the fuel type used by the equipment, either gas (G) or oil (O).

INPUT is a numerical variable that describes the fuel input capacity in kBtu/hr, as reported by the manufacturer.

EFF is a numerical variable that describes the combustion efficiency of the furnace, defined as 100% minus flue losses. Where possible, this information is taken from the CEC equipment database. Manufacturer-provided information is used to supplement the CEC data when actual test results are available.

EXCH is a character variable that describes the heat exchanger type (copper [C], copper-nickel alloy [N], cast-iron [I], or steel [S]), as provided by the manufacturer.

IGN is a character variable that describes the ignition type, either electronic (E) or pilot (P).

BURN is a character variable that describes the burner type (power [P], atmospheric [A], or pulse [L]).

VENT is a character variable that describes whether the unit has a vent damper (Y) or does not (N).

5.4 Warm Air Furnaces

FUEL is a character variable that describes the fuel type used by the equipment, either gas (G) or oil (O).

INPUT is a numerical variable that describes the fuel input capacity in kBtu/hr, as reported by the manufacturer.

EFF is a numerical variable that describes the thermal efficiency of the furnace, defined as 100% minus flue losses. Where possible, this information is taken from the CEC equipment database. Manufacturer-provided information is used to supplement the CEC data when actual test results are available.

6.0 Estimate of Baseline Consumer Costs

The consumer cost for commercial equipment is assumed to be the price paid by the consumer to a contractor for the equipment, not including installation. As discussed previously, estimating contractor markup for equipment is difficult because it varies as a function of the customer, the job size, and other factors. The baseline cost estimates that ASHRAE uses for equipment are developed from contractor cost estimates and an estimated 25% contractor markup, not including labor. This estimate is consistent with reported values and is used in this report. The statistical models are reported in terms of contractor costs, and they are multiplied by 1.25 to arrive at estimated consumer cost.

6.1 Water Heaters

Water heater information was provided by 16 manufacturers. The database includes more than 1,500 individual water heater records, which are divided into four categories: fuel-fired water heaters, fuel-fired tankless water heaters, electric storage water heaters, and unfired hot water storage tanks.

6.1.1 Fuel-Fired Storage Water Heaters

Fuel-fired storage water heaters include three subcategories of equipment: models with input ratings $\leq 155,000$ Btu/hr, models with input ratings $> 155,000$ Btu/hr and an input-to-storage volume ratio less than 4,000 Btu/hr, and models with input ratings $> 155,000$ Btu/hr and an input-to-storage volume ratio of 4,000 Btu/hr/gallon or more (labeled instantaneous in ASHRAE definitions). The lower input bound for commercial models is also divided by fuel type: 105,000 Btu/hr for oil-fired storage models and 75,000 Btu/hr for gas-fired storage models. The lower bound for instantaneous models is 210,000 Btu/hr for oil-fired units and 200,000 Btu/hr for gas-fired units. These categories are summarized in Table 6.1. This categorization results in the anomaly that a 160,000 Btu/hr water heater is classified as a residential instantaneous water heater if the tank volume is less than 40 gal, or a commercial storage water heater if the tank volume is greater than or equal to 40 gal.

Despite the complexity of this subcategorization, fuel-fired water heaters with storage tanks are a fairly homogenous product. The designation of instantaneous water heaters with greater than 10-gallon storage capacity attempts to capture the effect on standby losses of increased flue area at high-input-to-volume ratios; however, units falling just below and above 4,000 Btu/hr input-to-volume ratio are very similar. The separate designation of units above and below 155,000 Btu/hr input also is directed at capturing differences in standby loss performance, as reflected in the standard.

Table 6.1. Fuel-Fired Storage Water Heater Categories

Type	Input Rating	Volume	Input-to-Volume Ratio	Standard
Storage Gas	> 75 and ≤ 155 kBtu/hr	All	All	78% efficiency 1.3 + 114/Vol.
Storage Oil	> 105 and ≤ 155 kBtu/hr	All	All	78% efficiency 1.3 + 114/Vol.
Storage	> 155 kBtu/hr	≥ 10 gal	< 4,000 Btu/hr	78% efficiency 1.3 + 95/Vol.
Tankless Gas	> 200 kBtu/hr	< 10 gal	≥ 4,000 Btu/hr	77% efficiency 2.3 + 67/Vol.
Tankless Oil	> 210 kBtu/hr	< 10 gal	≥ 4,000 Btu/hr	77% efficiency 2.3 + 67/Vol.

These trends in performance are verified by testing for differences in efficiency and standby losses between equipment subcategories. As expected, no significant differences exist in thermal efficiency between any of the size categories. However, standby losses are significantly lower for large-input storage water heaters (input/volume < 4,000 Btu/hr/gal) than for instantaneous water heaters that fall in the same size range. This is reflected in the standard, which is less restrictive for water heaters that are classified as instantaneous.

Baseline costs for these equipment categories were modeled as a function of the primary characteristics of the equipment: input, warranty, tank construction, and efficiency. Information was provided by seven manufacturers of storage water heaters totaling 295 units. The database contains information for 33 units with input of 155,000 Btu/hr or less, all of which are gas-fired. Four of these units were not used in the model because the records were incomplete. The remaining 29 units were used to develop the model ($R^2 = 0.99$), which is given below, with t-statistics for each parameter given in parenthesis.

$$\text{CCOST} = 14.6 \cdot \text{INPUT} + 121.6 \cdot \text{WARR} + 22.1 \cdot \text{EFF} + 5,895 \cdot \text{OUT} - 2,317$$

(0.0001) (0.0028) (0.0046) (0.0001) (0.0013)

where INPUT is in kBtu/hr, WARR is the length of the warranty (usually 3 or 5 years), EFF is efficiency as a whole number (88% = 88), and OUT is a dummy variable used to account for several large-volume water heaters (OUT = 1 if Vol. ≥ 140 gal, otherwise OUT = 0) included in the database for which the model otherwise underpredicts costs. CCOST was not significantly correlated with tank volume at the 5% level. No ASME construction tanks were included in the database for this size range.

Only one unit in this size range is considered in the ASHRAE analysis. ASHRAE and modeled baseline cost estimates are compared in Table 6.2. The baseline efficiency is assumed to be 78%, the warranty, 3 years, and the outlier dummy variable is set to 0.

Modeled baseline costs are only about half of ASHRAE estimates, primarily because of one extremely high cost estimate for this category of water heater (Table 4.1). While the cost of this unit is more in line with costs for large-volume equipment represented by the OUT dummy variable, the ASHRAE analysis was based on a 75-gallon unit and thus does not account for the discrepancy.

Units above 155,000 Btu/hr were modeled as two groups to account for these same large-volume water heaters (> 140 gallons). In both cases, CCOST was not found to be significantly correlated with efficiency. A total of 176 units were used to develop the model for the small-volume units (R-squared = 0.96). The model is given below.

$$\text{CCOST} = 5.80 \cdot \text{INPUT} + 129 \cdot \text{WARR} + 486 \cdot \text{TANK} + 910 \cdot \text{BURN} + 468$$

(0.0001) (0.0001) (0.0001) (0.0001) (0.0001)

where INPUT is in kBtu/hr, WARR is the length of the warranty in years, TANK is an indicator variable for the type of tank construction (TANK = 1 if ASME; 0 if standard), and BURN is an indicator variable for power burners (BURN = 1 if power, 0 if atmospheric). Because oil-fired equipment is under-represented in the database, oil-fired units were excluded from the analysis. The model is thus valid for gas-fired equipment and can be used for comparison to ASHRAE-developed cost estimates. A comparison of ASHRAE and modeled cost estimates is given in Table 6.3, where the warranty is 3 years and BURN = 0 for the standard models and BURN = 1 for ASME models.

Table 6.2. Comparison of ASHRAE and Modeled Baseline Cost Estimates for Low-Input Fuel-Fired Storage Water Heaters

Size	ASHRAE	Model	Difference
120 kBtu/hr	\$3,665	\$1,900	-48%

Table 6.3. Comparison of ASHRAE and Modeled Baseline Cost Estimates for High-Input Fuel-Fired Storage Water Heaters

Input	ASHRAE	Model (Standard)	Model (ASME)
199 kBtu/hr	\$4,291	\$2,512	\$4,257
360 kBtu/hr	\$5,720	\$3,679	\$5,424
500 kBtu/hr	\$8,824	\$4,693	\$6,438

ASHRAE cost estimates for the 199,000 Btu/hr and the 360,000 Btu/hr units are at the high end of modeled cost estimates. For the 500,000 Btu/hr unit, ASHRAE cost estimates are much higher than modeled cost estimates. Several large-volume models (140 or more gallons) were left out of the data set in developing this model. These units, a total of 38, can be modeled separately to account for the equipment. The resulting model ($R\text{-squared} = 0.85$) is given below.

$$\text{CCOST} = 2.81 \cdot \text{INPUT} + 29.9 \cdot \text{VOL} + 5,358$$

(0.0008) (0.0001) (0.0001)

where INPUT is in kBtu/hr and VOL is the volume in gallons. Because the ASHRAE analysis does not include any equipment with greater than 100-gal storage capacity, this model was not used for comparison with ASHRAE results. As before, the model was developed using only data from gas-fired units.

6.1.2 Tankless Water Heaters

Low-volume instantaneous (tankless) water heaters are designated in ASHRAE 90.1-1989 as water heaters having an input-to-volume ratio of 4,000 Btu/gal/hr or more, less than 10 gal of water storage volume, and inputs >200,000 Btu/hr for gas-fired units and inputs greater than 210,000 Btu/hr for oil-fired units. Five manufacturers of gas fired equipment provided data. Several manufacturers of oil-fired boilers offer options that allow them to be used as tankless water heaters. However, because these units are marketed as boilers, and because the ASHRAE analysis does not consider oil-fired equipment in this category, they were not evaluated.

Input ratings for gas-fired equipment range from 225,000 Btu/hr to 21,000,000 Btu/hr. Performance data for all 108 units were available from the CEC equipment database. The majority of the units fall in the combustion-efficiency range of 80 to 82% and are of copper finned-tube design. High-performance copper finned-tube units range to higher than 88% efficiency. One company manufactures a single modulating-input condensing model, which achieves efficiencies from 93% to 99% as input ranges from maximum-rated capacity to a 10:1 turndown ratio. A complete line of high-input direct-contact models also exist, reaching 99% efficiency. In this design, the cold inlet water comes in direct contact with the hot products of combustion, allowing virtually all of the thermal energy to be transferred to the water.

Using the efficiency at maximum-rated input for the modulating condensing unit (93%), regression analysis using all of the data yields a cost model of input and efficiency with a very high $R\text{-squared}$ value (0.99). This may not be the best model for estimating equipment costs for two reasons. First, the ASHRAE analysis is limited to consideration of efficiencies from 80% to 86%, so including high-efficiency models may diminish the validity at lower efficiencies. Second, the direct-contact models are very large (1 to 21 million Btu/hr), so they do not represent typical units in the 80% to 86% efficiency range.

Regression analysis of CCOST using only units with 93 % efficiency or less (96 units) suggests models with input and efficiency as the explanatory variables. Evaluating residual plots reveals that a straight line model cannot account for the incremental cost of high-efficiency equipment. Introducing a squared term on efficiency improves the R-squared value from 0.81 to 0.90. The model below is used to estimate cost.

$$\text{CCOST} = 2.35 \cdot \text{INPUT} - 7,872 \cdot \text{EFF} + 49.5 \cdot \text{EFF}^2 + 314,743$$

(0.0001) (0.0001) (0.0001) (0.0001)

where INPUT is in kBtu/hr and EFF is efficiency as a whole number (88 % = 88). The ASHRAE analysis is based on two sizes of equipment (400 kBtu/hr and 1,000 kBtu/hr) and an estimated baseline efficiency of 80%. Model and ASHRAE estimates are presented in Table 6.4.

Table 6.4. Comparison of ASHRAE and Modeled Baseline Cost Estimates for Tankless Water Heaters

Size	ASHRAE	Model	Difference
400 kBtu	\$3,477	\$3,291	-5.3 %
1000 kBtu	\$5,460	\$5,058	-7.4 %

When evaluating the life-cycle cost for this equipment, ASHRAE only used the 400 kBtu/hr model. Thus, modeled costs are 5.3 % lower than ASHRAE-developed costs.

6.1.3 Electric Storage Water Heaters

Electric storage water heaters make up less than 20% of commercial water heater shipments according to data covering the first 7 months of 1994 (Appliance Manufacturer 1994, p. 15). At this time, ASHRAE has not evaluated the life-cycle costs for baseline and high-efficiency electric storage water heaters. Data for electric storage water heaters are included in the database, so a model was developed for this equipment.

The database contains about 1,000 records for electric storage units produced by nine companies, with tank volumes ranging from 50 to 1,000 gallons and input ratings ranging from 13.5 to 480 kW. When the data were analyzed, it was found that no simple model adequately characterized costs in the different size classes. Instead, separate models were developed for common size classes; in this case, 50, 80, and 120 gal of storage volume. These units have a vertical cylindrical configuration and are similar to residential electric water heaters, but they have a heavier construction. Costs were also found to be a function of the number of thermostats and fuses used in the heater. Because this number typically varies as a function of input size classes, the effect can be captured by further segregating the

heaters into three input categories: less than 20 kW, between 20 and 40 kW, and above 40 kW. These categories will be referred to in this report as class 1, 2, and 3, respectively (input alone did not capture these effects). The resulting models are presented below.

$$\text{Cost}(50) = 365 + 400*\text{THERM} + 338*\text{TANK} + 175*\text{WARR} + 481*\text{C2} + 1075*\text{C3}$$

$$(0.001) \quad (0.0001) \quad (0.0001) \quad (0.0001) \quad (0.0001) \quad (0.0001)$$

$$\text{Cost}(80) = 628 + 446*\text{THERM} + 366*\text{TANK} + 164*\text{WARR} + 488*\text{C2} + 1057*\text{C3}$$

$$(0.0001) \quad (0.0001) \quad (0.0001) \quad (0.0001) \quad (0.0001) \quad (0.0001)$$

$$\text{Cost}(120) = 877 + 485*\text{THERM} + 371*\text{TANK} + 162*\text{WARR} + 392*\text{C2} + 1002*\text{C3}$$

$$(0.0001) \quad (0.0001) \quad (0.0001) \quad (0.0001) \quad (0.0001) \quad (0.0001)$$

where THERM is a dummy variable for the thermostat type (surface=0, immersion=1), TANK is a dummy variable for tank construction (standard=0, ASME=1), WARR is the length of the warranty in years, C2 is a dummy variable for class 2 (1 if the input rating is between 20 and 40 kW), and C3 is a dummy variable for class 3 (1 if the input rating is above 40 kW). R-squared values for the three models are 0.85, 0.87, and 0.89, respectively.

6.1.4 Unfired Hot Water Storage Tanks

Cost information for unfired hot water storage tanks was collected from eight manufacturers for a total of 143 units. A cursory examination of the data suggests that equipment costs are a function of several factors, including the tank size; tank construction (standard or ASME); tank lining; and, for large-volume tanks, the tank orientation (vertical or horizontal). Storage tanks also come with different warranty lengths, insulation types, and pressure ratings. Modeling cost as a function of these parameters revealed four significant parameters: tank size, lining, orientation, and construction. Examination of cost plots as a function of each of these variables also revealed some nonstraight-line relationships in the data. A variety of models involving logs of the dependent and independent variables were tested to account for these relationships. The resulting model (R-squared = 0.93), based on 123 units, is given below.

$$\text{Ln}(\text{CCOST}) = 0.823*\text{Ln}(\text{VOL}) + 0.955*\text{TANK} + 0.235*\text{ORIENT} + .201*\text{LIN} + 2.519$$

$$(0.0001) \quad (0.0001) \quad (0.0001) \quad (0.0002) \quad (0.0001)$$

where VOL is the volume in gallons, and TANK, ORIENT, and LIN are indicator variables (TANK = 1 for ASME, 0 for standard; ORIENT = 1 for horizontal, 0 for vertical; and LIN = 1 for glass, 0 for other).

In the ASHRAE analysis, cost information was gathered for four tank sizes: 120, 200, 500, and 1,000 gal. ASHRAE-developed costs are compared against the range of modeled costs, based on equipment characteristics (with the three dummy variables all set to either 0 or 1). This comparison is presented in Table 6.5.

Table 6.5. Comparison of ASHRAE and Modeled Baseline Cost Estimates for Unfired Hot Water Storage Tanks

Tank Volume	ASHRAE	Model
120 gal	\$1,922	\$799-3,209
200 gal	\$3,198	\$1,216-4,887
500 gal	\$8,033	\$2,586-10,390
1,000 gal	\$13,155	\$4,575-18,385

For tanks in the 120- and 200-gal size ranges, an option for horizontal orientation typically does not exist. Glass-lined tanks are also by far the most commonly offered models. Table 6.6 compares ASHRAE costs with modeled costs for vertical glass-lined storage tanks of both standard and ASME construction.

The ASHRAE-developed estimates fall between modeled cost estimates for glass-lined vertical standard and ASME models. A detailed understanding of shipment quantities, by type, for hot water storage tanks is necessary to accurately assess the baseline costs for this equipment.

6.2 Packaged Boilers

This equipment category includes a wide variety of boiler types, including copper finned-tube, cast-iron, and steel boilers. These boiler types have either atmospheric or forced draft combustion and output of either hot water or steam. Though ASHRAE collected cost data for both steel and iron boilers,

Table 6.6. Comparison of ASHRAE and Modeled Baseline Cost Estimates for Standard and ASME Construction Hot Water Storage Tanks

Tank Volume	ASHRAE	Model Standard	Model ASME - Vertical	Model ASME - Horizontal
120 gal	\$1,922	\$977	\$2,538	N/A
200 gal	\$3,198	\$1,487	\$3,865	N/A
500 gal	\$8,033	\$3,162	\$8,218	\$10,390
1,000 gal	\$13,155	\$5,595	\$14,541	\$18,385

the baseline cost estimate was derived from costs for iron boilers only and was the average of estimated costs for atmospheric-type and power-burner-type boilers. ASHRAE considered only gas-fired boilers in the analysis.

Because energy efficiency regulations are insensitive to boiler type, boiler costs in this study were modeled pooled into two categories based on fuel type. Explanatory variables for the boiler types are then used to characterize cost differences between boiler types. The database contains nearly 700 boiler records, of which about 570 are gas-fired and 115 are oil-fired.

Gas-fired boilers are modeled as a function of input and efficiency, with dummy variables included to account for the cost increment for the following types of models:

- steam boilers (STEAM = 1; otherwise = 0)
- units with vent dampers (VENT=1; otherwise = 0)
- units with electronic ignition (IGN=1; otherwise = 0)
- cast-iron boilers (IRON=1; otherwise = 0)
- steel boilers (STEEL=1; otherwise = 0)
- power-burner-type units (BURN=1; otherwise = 0)
- line of units offered by one manufacturer for which the model otherwise consistently underestimates costs (OUT=1; otherwise = 0).

A total of 577 units were used to develop the model (R-squared = 0.94) given below.

$$\begin{aligned} \text{CCOST} = & 3.23 \cdot \text{INPUT} + 2.64 \cdot \text{EFF}^2 + 931 \cdot \text{IRON} + 2,927 \cdot \text{STEEL} + 1,009 \cdot \text{BURN} + \\ & (0.0001) \quad (0.0001) \quad (0.0001) \quad (0.0001) \quad (0.0001) \\ & 563 \cdot \text{IGN} + 1,116 \cdot \text{STEAM} + 6,518 \cdot \text{OUT} - 17,249 \\ & (0.0153) \quad (0.0001) \quad (0.0001) \quad (0.0001) \end{aligned}$$

where INPUT is in kBtu/hr and efficiency (EFF) is a whole number (80% = 80). Evaluation of the high-cost outliers revealed that they represent a line of high-input units, but the evaluation does not reveal a simple characteristic that explains their high cost.

The model shown above is used to estimate costs for baseline efficiency equipment. Model-developed costs and ASHRAE cost estimates for cast-iron hot water boilers are presented in Table 6.7. The

Table 6.7. Comparison of ASHRAE and Modeled Baseline Cost Estimates for Cast-Iron Hot Water Boilers

Size	ASHRAE	Model (Atm)	Model (Power)
400 kBtu/hr	\$5,015	\$2,336	\$3,599
800 kBtu/hr	\$6,621	\$4,655	\$5,917
1,500 kBtu/hr	\$9,258	\$7,481	\$8,743
3,000 kBtu/hr	\$14,969	\$13,538	\$14,799

ignition is assumed to be the pilot for the smallest size category and electronic for the remaining categories. The dummy variables STEEL, STEAM, and OUT are set to zero. The baseline efficiency of the equipment is 80%.

Modeled cost estimates for power-burner equipped boilers are similar to ASHRAE cost estimates, which are an average of atmospheric and power boilers, for the 800, 1,500 and 3,000 kBtu/hr size ranges. Modeled cost estimates for the 400 kBtu/hr size are significantly lower than ASHRAE cost estimates, which is primarily due to one extremely high power boiler cost estimate (Table 4.4). Model estimates are similar to the other four estimates used in this average. The cost difference between power and atmospheric boilers also narrows at larger-input ranges. This trend is apparent in the ASHRAE data as well.

The average combustion efficiency for cast-iron units in the database is 81%. ASHRAE cost estimates are developed from units with either 80% or 81% efficiency. The baseline costs are then assumed to represent units with a thermal efficiency of 75%. This reflects the fact that combustion efficiency is considered to be a poor measure of actual performance because it neglects jacket losses. ASHRAE is currently planning to move to a thermal efficiency standard, so the analysis is based on estimated cost increments as a function of thermal efficiency.

ASHRAE has not, at this point, evaluated oil-fired boilers. A preliminary analysis of the data for oil-fired boilers also suggests that there is insufficient information to adequately characterize the equipment. For this reason, baseline cost estimates for oil-fired equipment are not included here.

6.3 Warm Air Furnaces

Space heating in commercial establishments is provided by several distinct types of equipment. These include duct heaters, unit heaters, outdoor furnaces, indoor furnaces, and vertical air turnover (VATO) furnaces. EPart specifically exempts both unit heaters and duct heaters from energy efficiency regulations. VATO furnaces are also excluded from EPart standards, which cover only furnaces that supply heated air through ducts. The VATO operates by picking up cool air at floor level and discharging it at the top of the furnace. These units are primarily used in warehouses and other

large storage areas. Of the remaining two furnace types, commercial indoor warm air furnaces represent a relatively small equipment class. In applications requiring indoor furnaces, one or more units may be used with capacities falling in the residential equipment range (below 225,000 Btu/hr). Roof-top combination heating and air-conditioning units make up the remainder of the market, accounting for about 14% of commercial and industrial energy use for space heating (Hewett and Lobenstein 1992, p. 41).

Cost information was provided only by manufacturers of indoor warm air furnaces. Baseline efficiencies for this equipment are 80% for gas-fired units and 81% for oil-fired units. The best fit model, based on all 57 data points, gives cost as a function of fuel type and input. This model ($R^2 = 0.82$) is given below.

$$\text{CCOST} = 7.65 \cdot \text{INPUT} - 1,182 \cdot \text{FUEL} + 937$$

(0.0001) (0.0001) (0.007)

where INPUT is in kBtu/hr and FUEL is a dummy variable for the fuel type (FUEL = 1 for oil; 0 for gas). There is only a small range of efficiencies for the units in the database, and no significant correlation was found between cost and efficiency.

7.0 Estimate of High-Efficiency Incremental Cost

The statistical models described in Chapter 6.0 are used to estimate the incremental costs for high-efficiency equipment. When model-developed incremental cost estimates are compared to ASHRAE-developed cost estimates, an understanding of the data from which the models were developed is critical. The models should not be used to estimate incremental costs for equipment that has characteristics that are outside the range of the data set from which they were developed.

7.1 Water Heaters

As with baseline costs, incremental costs for water-heating equipment were developed for four categories: fuel-fired storage water heaters, fuel-fired tankless water heaters, electric storage water heaters, and unfired hot water storage tanks.

7.1.1 Fuel-Fired Storage Water Heaters

The incremental cost associated with low-input high-efficiency storage water heaters can be estimated from the model described in Section 6.1.1. This model was developed from data for equipment up to 84% thermal efficiency and, therefore, cannot be extended to ranges with higher efficiency. Two 100,000 Btu/hr high-efficiency condensing models are offered, however, and by using manufacturer estimates of the added cost for these models, a cost increment can be estimated to reach the condensing regime (approximately 86% for gas fired equipment). The results are presented in Table 7.1 and are valid only for gas-fired equipment.

In the ASHRAE analysis, GAMA manufacturers estimated a 3% cost increase to achieve current standard levels. Based on the thermal efficiency, only 14 of 254 gas-fired units in the database do not meet the current standard. The ASHRAE incremental cost estimate to the 86% efficiency level also includes a reduction in standby losses. While this reduction can be expected to result in additional costs, it should be noted that the high-efficiency models that are the basis for this estimate achieve standby loss ratings of 1%, well below the assumed standard level. Manufacturers have also indicated

Table 7.1. Comparison of ASHRAE and Modeled Incremental Cost Estimates for High-Efficiency Fuel-Fired Storage Water Heaters

Efficiency	ASHRAE	Model
78%	3%	0%
80%	10%	3%
86%	60%	(50%)

that, though high-efficiency units are technologically achievable, other issues such as premature equipment failure have hindered the production of high-efficiency equipment, a fact that is mirrored in the limited number of such units on the market. An accurate assessment of the incremental costs for high-efficiency equipment must account for any decline in other performance aspects, something that is not done in analyses that assume the same level of nonefficiency-related performance across all efficiency levels.

The data for units with input greater than 155,000 Btu/hr did not reveal a statistically significant correlation between cost and efficiency, possibly because little variation in efficiency exists for this equipment. The results for units with input less than 155,000 Btu/hr were extrapolated to this size range. This is consistent with GAMA-supplied cost increment estimates, which are very similar for the two categories of equipment (Table 4.2).

7.1.2 Tankless Water Heaters

In the GAMA survey of commercial water heater manufacturers, incremental cost estimates for low-volume instantaneous (tankless) water heaters were provided for three levels of efficiency: 80% (baseline), 83%, and 86%. These estimates, along with estimates based on the model presented in Section 6.1.2, are given below in Table 7.2.

The GAMA-developed estimates are almost identical to modeled incremental costs for the 400 kBtu/hr size category and somewhat higher than for the 1,000 kBtu/hr size category. The model also suggests that as rated input increases, the incremental cost for high-efficiency equipment decreases. This trend is confirmed by looking at equipment of various efficiency levels produced by a single manufacturer. This has important implications for life-cycle cost estimates because larger equipment will also have greater fuel input, thus weighting the impact of fuel savings on life-cycle cost. Because the ASHRAE analysis is based on a 400 kBtu/hr model, which is relatively small, the life-cycle cost estimates for larger high-efficiency equipment may be inflated.

Table 7.2. Comparison of ASHRAE and Modeled Incremental Cost Estimates for Tankless Water Heaters

Efficiency	GAMA	Model (400 kBtu)	Model (1000 kBtu)
80% (Baseline)	0%	0%	0%
83%	24%	27%	19%
86%	85%	85%	57%

7.1.3 Electric Storage Water Heaters

No ASHRAE analysis has been conducted on the incremental costs for high-efficiency electric storage water heaters. Current standards apply only to standby losses, because thermal efficiencies are near 100% for this equipment. The existing standby loss performance standard for commercial electric water heaters is given as a function of water storage volume, in gallons, and must be less than $0.30 + 27/\text{Vol}$. The standard is related to storage volume to account for the relationship between storage volume and the surface area for tanks of different sizes. As volume increases, the surface-area-to-volume ratio for tanks with equal relative proportions decreases. For tanks with equal effective insulation, standby losses decrease when the volume increases. This finding is reflected in the standard.

Commercial electric storage water heaters in the 50- to 120-gal size range are currently manufactured almost exclusively with about 3 in. of foam insulation. This results in standby loss performance that is near the current ASHRAE standard, as can be seen by examining standby loss data for these models listed in the database. These models are marketed as having R-values of 24 or 25. However, reaching such high levels of R-value has become more difficult because of an Environmental Protection Agency ban on the use of chlorofluorocarbon (CFC)-based foaming agents, such as CFC R-11, with an R-value of about 8 per inch. A replacement non-CFC foaming agent, HCFC 141b, is estimated to have an R-value of about 7.5/in., effectively requiring more than 3-1/8 in. of foam to reach R-24. Manufacturers have also improved on the effective insulation value by increasing the amount of insulation on top of the tank, decreasing the surface area of nonfoam insulation around the controls and heating elements, and improving the insulation (typically fiberglass) below the tanks.

Incremental material costs for increasing the insulation level to 4 in. can be calculated from tank dimensions and estimated costs for foam insulation (\$1.50/lb at 2.2 lb/ft³) and 20-gauge steel-jacketing material (\$0.32 lb at 1.5 lb/ft²). Cost increases range from \$11 for a 50-gal model to \$18 for a 120-gal model. Based on a manufacturer markup of about 53.8% (gross margin of 65%), 10% dealer markup, and 25% contractor markup, this would add \$23 to \$38 in additional material costs at the consumer level. This equates to about a 2% increase in costs for non-ASME surface thermostat models.

Other considerations, such as the overall size of the water heater, limit the potential for increasing insulation levels. Incremental energy savings also become extremely small as insulation levels increase, partly because energy "leaks" around the piping and fittings begin to outweigh losses through the insulation. Greater potential for energy savings exists through substitution of alternative water-heating mechanisms. Solar water heaters can potentially save large quantities of energy, but because their performance depends on climate, they are perhaps not suitable for inclusion in a national standard. Fuel-fired water heaters also reduce overall energy consumption when electricity generation losses are accounted for. Heat pump water heaters offer the potential for large energy savings, but their performance is highly dependent on ambient conditions. While the baseline cost model in Section 6.1.3 cannot be extrapolated to such low-input ranges, light commercial electric water heaters with 120-gal storage capacity and 4.5 kW input (recovery of 20 gal/hr at 90°F rise) typically cost about \$1,000. A commercial heat pump water heater that provides the same level of service costs approximately \$3,600, an increase of 260% compared to an electric water heater.

7.1.4 Unfired Hot Water Storage Tanks

Little information is available on the standby loss performance of unfired hot water storage tanks, and little variability exists in the level of insulation used by different manufacturers on similar models. Reported R-values typically range from 13 to 16.7; however, these may only be rough approximations based on the estimated performance of the particular type of insulation used. The incremental costs associated with improving the standby loss performance of storage tanks can be estimated by examining the types, quantities, and qualities of insulation used with these tanks.

Several water heater manufacturers and insulation manufacturers were contacted on the thermal performance of insulation. Estimates of the k-value for fiberglass water heater insulation ranged from 0.22 to 0.3, with an average of 0.27 (the units on k are Btu-in./hr/ft²/F). This translates to an R-value of about 3.7/in. or R-14.8 for 4 in. of insulation. The theoretical heat loss for a planar surface insulated to this level, combined with a temperature difference of 80°F, is 5.4 Btu/hr*ft². By comparison, foam insulation has k-values in the range of 0.11 to 0.14. The first value is typical of foams such as CFC R-11, and the latter value is typical of non-CFC foams, such as HCFC 141b. Using an estimate of the insulating capability of non-CFC foam gives an R-value of 7.5/in. Thus, 2 in. of foam insulation, which is common on storage tanks in the 120- to 200-gal size, yields an R-value of 15 and a theoretical heat loss rate of 5.3 Btu/hr*ft².

Both of these values are below the current standard of 6.5 Btu/hr*ft², though actual losses for storage tanks insulated to these levels would be higher. Heat loss from a hot water storage tank will differ from this based on the shape of the tank, and the number and extent of "leaks" around the insulation caused by inlet and outlet pipes, and other extrusions such as pressure relief valves. Free convection of heat can also occur if heat traps are not used to control migration of hot water into the cool pipes. Despite these considerations, it is possible to estimate the incremental material cost to increase the quantity of insulation, based on the estimated cost of the additional materials used. Cost increments, as a percentage of baseline costs, are presented in Table 7.3.

In the GAMA commercial water heater survey, manufacturers were asked to estimate the incremental cost to improve the thermal performance of storage tanks from a maximum of 13.6 Btu/hr*ft² to 6.5 Btu/hr*ft². This represents a 52% increase in the effective insulation value. Estimates are that achieving 13.6 Btu/hr/ft² would cost an additional 3%, and achieving 6.5 Btu/hr/ft² would cost an additional 10% over an assumed baseline. These estimates include non-material-related cost increases and can be expected to be higher than estimates based only on incremental material costs.

Table 7.3. Incremental Material Cost Estimates for Highly Insulated Hot Water Storage Tanks

Tank Volume	120 Gal	200 Gal	500 Gal	1,000 Gal
2-in. Fiberglass	0%	0%	0%	0%
2-in. Foam	2%	2%	1%	1%
3-in. Foam	6%	5%	4%	3%

7.2 Packaged Boilers

The incremental costs for high-efficiency packaged boilers can be estimated from the model developed in Section 6.2. This model is based on combustion efficiencies and is therefore not directly comparable to ASHRAE-developed incremental cost estimates, which are based on thermal efficiency. The results for an 800 kBtu/hr atmospheric cast-iron boiler are presented in Table 7.4.

For this size class, incremental cost estimates are similar for small incremental-efficiency improvements, but the model results are much smaller for larger incremental-efficiency improvements. However, the model should not be used to extrapolate beyond the range of the data set. For cast-iron boilers, the range of efficiencies is only 80% to 83.3%. Above this level, the model is only valid for copper- or copper/nickel-type boilers. Because efficiency standards are not equipment-type dependent, the model can be used to evaluate cost increments that are independent of equipment type. The model can similarly be used to evaluate incremental costs for other boiler size classes.

7.3 Warm Air Furnaces

The ASHRAE furnace analysis is based on outdoor furnaces, a category of equipment manufactured primarily by large HVAC equipment companies. Because these manufacturers have declined to provide information, it is not possible to evaluate the ASHRAE incremental cost estimates at this time. Furthermore, there is little variability in efficiency between indoor-type warm air furnaces, so no incremental cost estimates can be made for high-efficiency furnaces based on the available data.

Table 7.4. Comparison of ASHRAE and Modeled Incremental Cost Estimates for Packaged Atmospheric Hot Water Boilers (800 kBtu/hr)

Thermal Efficiency	ASHRAE	Combustion Efficiency	Model
75%	0%	80%	0%
76%	10%	81%	11%
77%	15%	82%	23%
78%	22%	83%	35%
79%	44%	84%	47%
80%	114%	85%	(58%)
82%	121%	87%	(83%)
84%	261%	89%	(108%)
88%	450%	91%	(133%)

8.0 Conclusions

The purpose of this work is to support an evaluation of the economic impact of revised commercial equipment standards. A database of commercial equipment costs was created, and information from this database was used to develop models for baseline and high-efficiency equipment costs. In some cases, sufficient data were not available on high-efficiency equipment to accurately evaluate the incremental costs for this equipment. Where possible, other means were used to evaluate these costs. Also, information was not available for heat pumps, air conditioners, and outdoor warm air furnaces. Further data collection will be required to analyze costs for these types of equipment.

The problems encountered in the cost data collection effort highlight the difficulty in making accurate assessments of equipment costs. Not only is cost information considered sensitive and is thus difficult to collect, but the wide variability of cost estimates also makes an accurate evaluation of costs extremely difficult. There is no single correct cost that can be associated with a given piece of equipment. However, by collecting a large quantity of data, it is possible to average out extreme values, identifying factors that affect costs. Statistical tools can also be employed to quantify the quality of the data and to reveal relationships between equipment parameters and cost.

Some consideration of the primary measure used in this study, list price, is appropriate. List price figures, in themselves, do not specifically measure the actual cost of the equipment at the wholesale, contractor, or consumer level. Also, list prices may not accurately reflect the relationship of prices between products manufactured by the same company. However, within a given product line, it is assumed that list prices, to some extent, reflect the manufactured cost associated with the size and features of each piece of equipment and that these costs will, on the whole, be passed on to the consumer. Through statistical analysis of relative costs as a function of equipment parameters, models that relate cost to these parameters can be developed.

The results of this study show some of the strengths and weaknesses of this approach. For baseline cost estimates, the models provide a useful tool for evaluating the important equipment characteristics that affect cost. From this understanding of the relationship between equipment characteristics and cost, an informed baseline cost estimate can be made that precisely defines the attributes of the assumed baseline model. For incremental cost estimates, the models also provide a method for estimating the incremental costs for high-efficiency equipment. In some cases, however, no significant relationship was found between performance and cost. This was primarily due to the fact that for some equipment categories there was little range in efficiency for equipment currently being marketed. These categories include electric storage water heaters, unfired hot water storage tanks, and warm air furnaces for indoor installation.

When the modeled baseline cost estimates are compared to ASHRAE-developed cost estimates, two important conclusions can be drawn. First, ASHRAE baseline cost estimates do not contain sufficient information about the assumed characteristics of the equipment to accurately estimate costs. The model results highlight the wide range of possible costs based on equipment features that are typically offered

with commercial equipment. Second, a comparison of ASHRAE and modeled cost estimates revealed that a small number of extremely high cost estimates used by ASHRAE heavily impacted the average cost estimates. Thus, ASHRAE baseline cost estimates were generally similar to or higher than modeled baseline cost estimates. High baseline cost estimates will tend to diminish the importance of energy savings on life-cycle costs for high-efficiency equipment, shifting the minimum life-cycle cost towards lower efficiency levels.

Two important conclusions can also be drawn when comparing the modeled incremental cost estimates to ASHRAE-developed incremental cost estimates. First, in some cases, ASHRAE estimates are not size specific. The modeled results suggest that equipment size does affect incremental costs. This is clear in the incremental cost estimates for tankless water heaters, which differ significantly between size ranges. For the size range used by ASHRAE, modeled and ASHRAE incremental cost estimates are almost identical. For larger-sized equipment, the model predicts a smaller cost increment, highlighting the importance of equipment size on the results. Second, the ASHRAE incremental cost estimates are often equipment-type specific, which affects the magnitude of incremental costs. In the case of packaged boilers, model results were developed as a function of equipment type. In this way, incremental costs can be independently estimated for these equipment types. This may be of value because EPA standards are not equipment-type dependent.

Several categories of equipment were not included in the analysis because of lack of data. These include all categories of heat pumps and air conditioners, warm air furnaces for outdoor installation, and several types of oil-fired equipment. Additional data collection will be required to evaluate baseline and incremental costs for this equipment. The results of this study suggest, however, that list price information can be used to estimate these costs, with other information used to supplement list price data where necessary.

9.0 References

American Gas Association. 1993. *American National Standard: Gas Water Heater Volume III: Storage with Input Ratings Above 75,000 Btu per hour, Circulating and Instantaneous Water Heaters*. ANSI Z21.10.3, AGA. Cleveland, Ohio.

American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. 1993. *Energy Code for Commercial and High-Rise Residential Buildings*. Codification of ASHRAE/IES 90.1-1989, Energy Efficient Design of New Buildings Except Low-Rise Residential Buildings, Atlanta, Georgia.

Appliance Manufacturer. 1994. "Environmental Comfort Shipments." *Appliance Manufacturer* 10-94:15.

Energy Policy Act of 1992. Public Law 102-486 as amended, 42 USC 13201.

Hewett, M. J., and M. S. Lobenstein. 1992. *Commercial Gas Space Heating Equipment: Opportunities to Increase Energy Efficiency*. Report to Minnegasco, Inc. by the Center for Energy and the Urban Environment, CEUE/TR91-3-CM, Minneapolis, Minnesota.

Hydronics Institute. 1994. *I=B=R Ratings for Boilers, Baseboard Radiation and Finned Tube (Commercial) Radiation*. The Hydronics Institute, January 1, 1994, Berkeley Heights, New Jersey.

Appendix A

Equipment Database Tables

The commercial equipment database is presented in the following six tables. Field definitions for each of these tables are given in Chapter 5.0. Some data have been deleted from these tables to protect the proprietary interests of the manufactures. This is represented by an asterisk (*) in the tables. These missing values are left blank, and represent information that was unavailable. Every effort has been made to ensure the accuracy of this data; however, in the course of data collection and data entry, some errors are inevitable.

Table A.1. Fuel-Fired Storage Water Heaters

REC	FUEL	VOL	INPUT	EFF	STBY	TANK	BURN	WARR	CTYPE	LCOST	CCOST
1,000	G	20	150	80		A	A	5	R	2,103	2,103
1,001	G	20	120	80		A	A	5	R	2,069	2,069
1,002	G	30	180	80		A	A	5	R	2,244	2,244
1,003	G	30	240	80		A	A	5	R	2,311	2,311
1,004	G	30	150	81	4.2	S	A	3	D	1,747	1,939
1,005	G	30	150	81	4.2	S	A	5	D	1,887	2,095
1,006	G	30	200	79	4.7	S	A	3	D	1,775	1,970
1,007	G	30	200	79	4.7	S	A	5	D	1,917	2,128
1,008	G	30	230	77	4.7	A	A	3	D	2,285	2,536
1,009	G	30	230	77	4.7	A	A	5	D	2,468	2,739
1,010	G	30	230	77	4.7	S	A	3	D	1,828	2,029
1,011	G	30	230	77	4.7	S	A	5	D	1,974	2,191
1,012	G	30	100	94	1.0	S	P	3	D	1,424	1,581
1,013	G	40	150	80		S	A	3	R	2,691	1,776
1,014	G	40	300	80		A	A	5	R	2,444	2,444
1,015	G	40	150	78	3.2	S	A	3	D	1,747	1,939
1,016	G	40	150	78	3.2	S	A	3	D	1,747	1,939
1,017	G	40	160	79	3.5	S	A	3	D	1,711	1,899
1,018	G	50	100	80	3.0	S	A	3	D	1,282	1,423
1,019	O	50	190	78	3.1	S	P	1	D	850	935
1,020	G	50	100	94	1.0	S	P	3	D	1,569	1,742
1,021	G	70	360	84	2.8	A	A	3	D	2,968	3,294
1,022	G	70	360	84	2.8	S	A	3	D	2,509	2,785
1,023	G	70	370	81	2.7	A	A	3	D	2,963	3,289
1,024	G	70	370	81	2.7	A	A	3	D	2,963	3,289
1,025	G	70	370	80	0.0	A	A	3	R	5,072	3,348
1,026	G	70	370	81	2.7	S	A	3	D	2,506	2,782
1,027	G	70	370	81	2.7	S	A	3	D	2,506	2,782
1,028	G	70	370	80	0.0	S	A	3	R	4,364	2,880
1,029	G	70	400	80	2.9	A	A	3	D	3,245	3,602
1,030	G	70	400	80	2.9	A	A	3	D	3,235	3,591
1,031	G	70	400	80	2.9	S	A	3	D	3,033	3,367
1,032	G	70	400	80	2.9	S	A	3	D	2,787	3,094
1,033	G	70	630	82	2.1	A	A	3	D	4,110	4,562
1,034	G	70	630	82	2.1	A	A	3	D	4,680	5,195
1,035	G	70	630	80	0.0	A	A	3	R	7,191	4,746
1,036	G	70	630	82	2.1	S	A	3	D	3,570	3,963
1,037	G	70	630	82	2.1	S	A	3	D	4,269	4,739
1,038	G	70	630	80	0.0	S	A	3	R	6,834	4,510
1,039	G	70	120	79	2.9	S	A	3	D	1,420	1,576
1,040	G	70	370	80	3.2	A	A	3	D	2,966	3,292
1,041	G	70	370	80	3.2	S	A	3	D	2,508	2,784
1,042	G	70	500			A	A	3	D	3,956	4,391
1,043	G	70	500			S	A	3	D	3,487	3,871
1,044	G	70	540			A	P	3	D	4,168	4,626

Table A.1. Fuel-Fired Storage Water Heaters (contd)

REC	FUEL	VOL	INPUT	EFF	STBY	TANK	BURN	WARR	CTYPE	LCOST	CCOST
1,045	O	70	700	80	3.2	A	P	3	D	5,118	5,681
1,046	G	70	700	80	3.2	A	P	3	D	4,704	5,221
1,047	O	70	700	80	3.2	S	P	3	D	4,024	4,467
1,048	O	70	250	78	3.0	S	P	1	D	1,000	1,100
1,049	G	70	360	82	2.5	A	A	3	D	2,963	3,289
1,050	G	70	360	82	2.5	A	A	5	D	3,200	3,552
1,051	G	70	360	82	2.5	S	A	3	D	2,506	2,782
1,052	G	70	360	82	2.5	S	A	5	D	2,706	3,004
1,053	G	70	140	82	2.0	S	A	3	D	1,762	1,956
1,054	G	70	410	80		A	A	5	R	4,167	4,167
1,055	G	80	80	79	2.3	S	A	3	D	754	837
1,056	G	80	80	83	2.8	S	A	3	D	753	836
1,057	G	80	80	80	0.0	S	A	3	R	1,313	867
1,058	G	80	90			S	A	3	D	1,003	1,113
1,059	G	80	120	79	2.5	S	A	3	D	1,460	1,621
1,060	G	80	120	79	2.5	S	A	5	D	1,577	1,750
1,061	G	80	120	79	2.2	S	A	3	D	1,417	1,573
1,062	G	80	130	83	1.9	S	A	3	D	1,460	1,621
1,063	G	80	130	80	0.0	S	A	3	R	2,529	1,669
1,064	G	80	130	83	1.9	S	A	3	D	1,417	1,573
1,065	G	80	140	78	2.6	S	A	3	D	1,787	1,984
1,066	G	80	140	78	2.6	S	A	5	D	1,930	2,142
1,067	G	80	160	80	0.0	S	A	3	R	2,797	1,846
1,068	G	80	160	78	2.1	S	A	3	D	1,787	1,984
1,069	G	80	160	78	2.1	S	A	3	D	1,787	1,984
1,070	G	80	190			S	A	3	D	1,873	2,079
1,071	G	80	250	81	2.0	A	A	3	D	2,428	2,695
1,072	G	80	250	81	2.0	A	A	5	D	2,622	2,910
1,073	G	80	250			A	A	3	D	2,585	2,869
1,074	G	80	250	81	2.4	S	A	3	D	1,972	2,189
1,075	G	80	250	81	2.4	S	A	5	D	2,130	2,364
1,076	G	80	250			S	A	3	D	2,049	2,274
1,077	G	80	300	79	2.2	A	A	3	D	2,648	2,939
1,078	G	80	300	79	2.2	A	A	5	D	2,860	3,175
1,079	G	80	300	81	1.9	A	A	3	D	2,648	2,939
1,080	G	80	300	81	1.9	A	A	3	D	2,648	2,939
1,081	G	80	300	80	0.0	A	A	3	R	4,791	3,162
1,082	G	80	300	81	1.9	S	A	3	D	2,191	2,432
1,083	G	80	300	79	2.2	S	A	3	D	2,191	2,432
1,084	G	80	300	79	2.2	S	A	5	D	2,366	2,626
1,085	G	80	300	81	1.9	S	A	3	D	2,191	2,432
1,086	G	80	300	80	0.0	S	A	3	R	3,936	2,598
1,087	G	80	310	80	2.8	A	A	3	D	2,650	2,942
1,088	G	80	310	80	2.8	S	A	3	D	2,193	2,434
1,089	G	80	370			A	P	3	D	3,830	4,251

Table A.1. Fuel-Fired Storage Water Heaters (contd)

REC	FUEL	VOL	INPUT	EFF	STBY	TANK	BURN	WARR	CTYPE	LCOST	CCOST
1,090	G	80	370			S	P	3	D	2,956	3,281
1,091	O	80	390	80	3.1	A	P	3	D	3,703	4,110
1,092	O	80	390	80	3.1	S	P	3	D	2,796	3,104
1,093	G	80	400	77	2.9	A	A	3	D	3,245	3,602
1,094	G	80	400	77	2.9	S	A	3	D	3,033	3,367
1,095	O	80	460	78	3.1	A	P	3	D	4,273	4,743
1,096	O	80	460	78	3.1	S	P	3	D	3,269	3,629
1,097	G	80	500	80		A	A	5	R	5,102	5,102
1,098	G	80	180	80	2.0	S	A	3	D	1,835	2,037
1,099	G	80	200	82	2.6	S	A	3	D	1,899	2,108
1,100	G	80	500	82	3.1	A	A	3	D	3,900	4,329
1,101	G	80	500	82	3.1	S	A	3	D	3,429	3,806
1,102	G	80	600	79		A	A	3	D	4,110	4,562
1,103	G	80	600	79		S	A	3	D	3,570	3,963
1,104	G	80	180	79	2.0	S	A	3	D	1,835	2,037
1,105	G	80	180	79	2.0	S	A	5	D	1,982	2,200
1,106	G	80	180	81	2.3	S	A	3	D	1,835	2,037
1,107	G	80	180	80		S	A	3	R	3,187	2,103
1,108	G	80	180	81	2.3	S	A	3	D	1,835	2,037
1,109	G	80	200	79	2.0	S	A	3	D	1,848	2,051
1,110	G	80	200	79	2.0	S	A	5	D	1,996	2,216
1,111	G	80	200	82	2.3	S	A	3	D	1,848	2,051
1,112	G	80	200	80		S	A	3	R	3,207	2,117
1,113	G	80	200	82	2.3	S	A	3	D	1,848	2,051
1,114	G	80	250	80	2.3	A	A	3	D	2,428	2,695
1,115	G	80	250	80	2.3	A	A	3	D	2,428	2,695
1,116	G	80	250	80	2.3	S	A	3	D	1,972	2,189
1,117	G	80	250	80	2.3	S	A	3	D	1,972	2,189
1,118	G	80	400	80	2.8	A	A	3	D	3,481	3,864
1,119	G	80	400	80		A	A	3	R	5,370	3,544
1,120	G	80	400	80	2.8	S	A	3	D	3,033	3,367
1,121	G	80	400	80		S	A	3	R	4,812	3,176
1,122	G	80	430	82	1.6	A	A	3	D	3,650	4,052
1,123	G	80	430	82	1.6	A	A	3	D	3,653	4,055
1,124	G	80	430	82	1.6	S	A	3	D	3,187	3,538
1,125	G	80	430	82	1.6	S	A	3	D	3,205	3,558
1,126	G	80	500	77	2.7	A	A	3	D	3,950	4,385
1,127	G	80	500	77	2.7	A	A	5	D	4,266	4,735
1,128	G	80	500	77	2.7	S	A	3	D	3,493	3,877
1,129	G	80	500	77	2.7	S	A	5	D	3,772	4,187
1,130	G	80	510	81	2.3	A	A	3	D	3,900	4,329
1,131	G	80	510	78	2.0	A	A	3	D	3,950	4,385
1,132	G	80	510	81	2.3	S	A	3	D	3,430	3,807
1,133	G	80	510	78	2.0	S	A	3	D	3,493	3,877
1,134	G	80	510	80	3.0	A	A	3	D	3,950	4,385

Table A.1. Fuel-Fired Storage Water Heaters (contd)

REC	FUEL	VOL	INPUT	EFF	STBY	TANK	BURN	WARR	CTYPE	LCOST	CCOST
1,135	G	80	510	80		A	A	3	R	6,047	3,991
1,136	G	80	510	80	3.0	S	A	3	D	3,493	3,877
1,137	G	80	510	80		S	A	3	R	5,255	3,468
1,138	G	80	730	80	1.7	A	A	3	D	4,704	5,221
1,139	G	80	730	78	2.5	A	A	3	D	4,872	5,408
1,140	G	80	730	78	2.5	A	A	5	D	5,262	5,841
1,141	G	80	730	80	1.7	A	A	3	D	4,872	5,408
1,142	G	80	730	80		A	A	3	R	8,173	5,394
1,143	G	80	730	80	1.7	S	A	3	D	4,414	4,900
1,144	G	80	730	78	2.5	S	A	3	D	4,414	4,900
1,145	G	80	730	78	2.5	S	A	5	D	4,767	5,291
1,146	G	80	730	80	1.7	S	A	3	D	4,414	4,900
1,147	G	80	730	80		S	A	3	R	7,307	4,823
1,148	G	80	160	80	2.3	S	A	3	D	1,793	1,990
1,149	G	80	200	79	2.0	S	A	3	D	1,873	2,079
1,150	O	80	320	80	2.8	A	P	3	D	3,195	3,546
1,151	O	80	320	80	2.8	S	P	3	D	2,373	2,634
1,152	G	90	200	79	2.1	S	A	3	D	1,848	2,051
1,153	G	90	400	83	2.6	A	A	3	D	3,245	3,602
1,154	G	90	400	83	2.6	S	A	3	D	3,049	3,384
1,155	G	90	140			A	P	3	D	3,466	3,847
1,156	G	90	140			S	P	3	D	2,300	2,553
1,157	G	90	180	80	2.5	S	A	3	D	1,837	2,039
1,158	G	90	200			A	P	3	D	3,519	3,906
1,159	O	90	200	81	2.8	S	P	3	D	2,192	2,433
1,160	G	90	200			S	P	3	D	2,376	2,637
1,161	O	90	250	82	2.8	S	P	3	D	2,245	2,492
1,162	G	90	250	83	2.4	A	A	3	D	2,571	2,854
1,163	G	90	250	83	2.4	S	A	3	D	2,107	2,339
1,164	G	90	270			A	P	3	D	3,572	3,965
1,165	G	90	270			S	P	3	D	2,670	2,964
1,166	G	90	150	78	2.5	S	A	3	D	1,789	1,986
1,167	G	90	590	80		A	A	5	R	5,585	5,585
1,168	G	90	200	83	2.1	S	A	3	D	1,910	2,120
1,169	G	90	300	81	2.4	A	A	3	D	2,650	2,942
1,170	G	90	300	82	2.4	S	A	3	D	2,196	2,438
1,171	G	100	180	81	2.2	S	A	3	D	1,837	2,039
1,172	G	100	200	81	1.7	S	A	3	D	1,897	2,106
1,173	G	100	200	80	0.0	S	A	3	R	3,238	2,137
1,174	G	100	200	81	1.7	S	A	3	D	1,897	2,106
1,175	G	100	250	80	1.7	A	A	3	D	2,560	2,842
1,176	G	100	250	80	1.7	A	A	3	D	2,560	2,842
1,177	G	100	250	80	1.7	S	A	3	D	2,104	2,335
1,178	G	100	250	80	0.0	S	A	3	R	3,491	2,304
1,179	G	100	250	80	1.7	S	A	3	D	2,026	2,249

Table A.1. Fuel-Fired Storage Water Heaters (contd)

REC	FUEL	VOL	INPUT	EFF	STBY	TANK	BURN	WARR	CTYPE	LCOST	CCOST
1,180	G	100	80	80	3.5	S	A	3	D	932	1,035
1,181	G	100	90	82	2.4	S	A	3	D	931	1,033
1,182	G	100	90	80		S	A	3	R	1,624	1,072
1,183	G	100	100			S	A	3	D	1,181	1,311
1,184	G	100	200	80	2.2	S	A	3	D	1,899	2,108
1,185	G	100	200	81	2.2	S	A	3	D	1,897	2,106
1,186	G	100	200	81	2.2	S	A	5	D	2,049	2,274
1,187	G	100	200	80	1.7	S	A	3	D	1,899	2,108
1,188	G	100	200	80	1.9	S	A	3	D	1,897	2,106
1,189	G	100	200	80	1.8	S	A	3	D	1,897	2,106
1,190	G	100	200	79	2.0	S	A	3	D	1,897	2,106
1,191	G	100	200	80		S	A	3	R	3,238	2,137
1,192	G	100	240	80	2.2	A	A	3	D	2,562	2,844
1,193	G	100	240	80	2.2	S	A	3	D	2,026	2,249
1,194	G	100	250	82	1.9	A	A	3	D	2,560	2,842
1,195	G	100	250	80	0.0	A	A	3	R	4,490	2,963
1,196	G	100	250	81	1.8	A	A	3	D	2,560	2,842
1,197	G	100	250	82	1.9	S	A	3	D	2,104	2,335
1,198	G	100	250			S	A	3	D	2,106	2,338
1,199	G	100	250	81	1.8	S	A	3	D	2,026	2,249
1,200	G	100	260	79	2.2	A	A	3	D	2,560	2,842
1,201	G	100	260	79	2.2	A	A	5	D	2,765	3,069
1,202	G	100	260	79	2.2	S	A	3	D	2,104	2,335
1,203	G	100	260	79	2.2	S	A	5	D	2,272	2,522
1,204	G	100	270	82	2.3	A	A	3	D	2,614	2,902
1,205	G	100	270	80	1.8	A	A	3	D	2,560	2,842
1,206	G	100	270	82	2.3	S	A	3	D	2,160	2,398
1,207	G	100	270	80	1.8	S	A	3	D	2,104	2,335
1,208	G	100	280	82	1.7	S	A	3	D	2,170	2,409
1,209	G	100	300	81	1.7	A	A	3	D	2,648	2,939
1,210	G	100	300	81	1.7	S	A	3	D	2,196	2,438
1,211	G	100	400			A	A	3	D	3,329	3,695
1,212	G	100	400			S	A	3	D	3,050	3,386
1,213	G	100	400	78	2.0	A	A	3	D	3,491	3,875
1,214	G	100	400	78	2.0	A	A	5	D	3,770	4,185
1,215	G	100	400	78	2.0	S	A	3	D	3,033	3,367
1,216	G	100	400	78	2.0	S	A	5	D	3,276	3,636
1,217	G	100	680	80		A	A	5	R	6,234	6,234
1,218	G	120	810	80		A	A	5	R	6,955	6,955
1,219	G	140	140	80		A	P	5	D	*	8,220
1,220	O	140	140	80		A	P	5	D	*	7,777
1,221	G	140	200	81		A	P	5	D	*	8,498
1,222	O	140	200	80		A	P	5	D	*	8,044
1,223	G	140	260	81		A	P	5	D	*	8,745
1,224	O	140	260	80		A	P	5	D	*	8,277

Table A.1. Fuel-Fired Storage Water Heaters (contd)

REC	FUEL	VOL	INPUT	EFF	STBY	TANK	BURN	WARR	CTYPE	LCOST	CCOST
1,225	G	140	270	81		A	P	5	D	*	10,805
1,226	O	140	270	80		A	P	5	D	*	10,225
1,227	G	140	400	81		A	P	5	D	*	11,080
1,228	O	140	400	80		A	P	5	D	*	10,485
1,229	G	140	540	80		A	P	5	D	*	11,595
1,230	O	140	540	80		A	P	5	D	*	10,970
1,231	G	140	720	79		A	P	5	D	*	11,807
1,232	O	140	720	80		A	P	5	D	*	11,174
1,233	G	140	1,170	80		A	A	5	R	*	7,632
1,234	G	140	990	80		A	A	5	R	*	7,356
1,235	G	180	1,350	80		A	A	5	R	*	8,882
1,236	G	200	1,500	80	2.4	A	P	5	D	*	19,707
1,237	G	210	1,250	80	2.4	A	P	5	D	*	18,124
1,238	G	220	1,750	80		A	A	5	R	*	9,455
1,239	G	220	300			A	P	5	D	*	15,615
1,240	O	220	300	80		A	P	5	D	*	14,777
1,241	G	220	600			A	P	5	D	*	15,955
1,242	O	220	600	80		A	P	5	D	*	16,477
1,243	G	220	800			A	P	5	D	*	16,475
1,244	O	220	800	80		A	P	5	D	*	15,591
1,245	G	220	1,000	80	2.4	A	P	5	D	*	16,886
1,246	O	220	1,000	80		A	P	5	D	*	15,980
1,247	O	220	1,250	80		A	P	5	D	*	17,152
1,248	O	220	1,500	80		A	P	5	D	*	18,649
1,249	G	300	300	79		A	P	5	D	*	16,278
1,250	G	300	600	79		A	P	5	D	*	16,601
1,251	G	300	800	80		A	P	5	D	*	17,096
1,252	G	300	1,000	78		A	P	5	D	*	17,489
1,253	G	300	1,250	79		A	P	5	D	*	18,667
1,254	G	300	1,500	79		A	P	5	D	*	20,174
1,255	G	380	2,500	80		A	P	5	D	*	27,187
1,256	G	390	2,250	80		A	P	5	D	*	26,178
1,257	G	400	2,000	80		A	P	5	D	*	25,484
1,258	G	400	1,750	80		A	P	5	D	*	23,554
1,259	G	410	600			A	P	5	D	*	19,906
1,260	O	410	600	80		A	P	5	D	*	18,837
1,261	G	410	800			A	P	5	D	*	19,946
1,262	O	410	800	80		A	P	5	D	*	18,876
1,263	G	410	1,000			A	P	5	D	*	21,061
1,264	O	410	1,000	80		A	P	5	D	*	19,930
1,265	G	410	1,250			A	P	5	D	*	21,550
1,266	O	410	1,250	80		A	P	5	D	*	20,393
1,267	G	410	1,500			A	P	5	D	*	22,971
1,268	O	410	1,500	80		A	P	5	D	*	21,737
1,269	O	410	1,750	80		A	P	5	D	*	22,288

Table A.1. Fuel-Fired Storage Water Heaters (contd)

REC	FUEL	VOL	INPUT	EFF	STBY	TANK	BURN	WARR	CTYPE	LCOST	CCOST
1,270	O	410	2,000	80		A	P	5	D	*	24,116
1,271	O	410	2,250	80		A	P	5	D	*	24,772
1,272	O	410	2,500	80		A	P	5	D	*	25,726
1,273	O	580	2,250	80		A	P	5	D	*	26,449
1,274	G	580	2,500	80		A	P	5	D	*	29,048
1,275	O	580	2,500	80		A	P	5	D	*	27,486
1,276	G	590	2,250			A	P	5	D	*	27,948
1,277	G	590	720			A	P	5	D	*	23,726
1,278	O	590	720	80		A	P	5	D	*	22,453
1,279	G	590	1,000			A	P	5	D	*	24,897
1,280	O	590	1,000	80		A	P	5	D	*	23,161
1,281	G	590	1,250			A	P	5	D	*	25,159
1,282	O	590	1,250	80		A	P	5	D	*	23,878
1,283	G	590	1,500			A	P	5	D	*	25,851
1,284	O	590	1,500	80		A	P	5	D	*	24,463
1,285	G	590	1,750			A	P	5	D	*	26,560
1,286	O	590	1,750	80		A	P	5	D	*	25,135
1,287	G	590	2,000			A	P	5	D	*	27,319
1,288	O	590	2,000	80		A	P	5	D	*	25,847

Table A.2. Tankless Water Heaters

REC	FUEL	INPUT	EFF	EXCH	WARR	CTYPE	LCOST	CCOST
1,289	G	230	80	C	5	R	1,942	1,282
1,290	G	230	80	C	5	D	1,531	1,684
1,291	G	250	88	C	5	R	7,462	4,925
1,292	G	260	82	C	5	R	3,682	2,025
1,293	G	270	80	C	5	R	2,358	1,556
1,294	G	300	82	C	5	D	2,064	2,270
1,295	G	300	85	C	5	R	3,998	2,639
1,296	G	320	80	C	5	R	2,883	1,903
1,297	G	330	82	C	5	D	2,724	2,996
1,298	G	330	82	C	5	D	2,615	2,877
1,299	G	330	82	C	5	R	4,035	2,219
1,300	G	360	80	C	5	R	2,991	1,974
1,301	G	400	82	C	5	D	2,866	3,152
1,302	G	400	80	C	5	R	3,312	2,186
1,303	G	400	81	C	5	D	2,516	2,768
1,304	G	400	82	C	5	D	2,762	3,038
1,305	G	400	82	C	5	R	4,166	2,291
1,306	G	400	85	C	5	R	5,325	3,515
1,307	G	420	82	C	5	D	2,516	2,768
1,308	G	500	80	C	5	R	3,917	2,585
1,309	G	500	85	C	5	R	6,011	3,967
1,310	G	500	88	C	5	R	9,942	6,562
1,311	G	500	88	C	5	D	6,604	7,264
1,312	G	510	82	C	5	D	3,543	3,898
1,313	G	510	82	C	5	D	3,404	3,745
1,314	G	510	82	C	5	R	5,644	3,104
1,315	G	520	82	C	5	D	2,895	3,185
1,316	G	630	82	C	5	D	3,826	4,208
1,317	G	630	82	C	5	D	3,686	4,054
1,318	G	630	82	C	5	R	6,131	3,372
1,319	G	650	85	C	5	R	6,390	4,217
1,320	G	670	80	C	5	R	4,687	3,093
1,321	G	670	75	C	5	D	3,309	3,640
1,322	G	720	82	C	5	D	2,835	3,119
1,323	G	730	82	C	5	D	4,085	4,494
1,324	G	730	82	C	5	D	3,920	4,312
1,325	G	730	82	C	5	R	6,539	3,596
1,326	G	750	85	C	5	R	6,639	4,382
1,327	G	750	88	C	5	R	10,950	7,227
1,328	G	750	88	C	5	D	7,097	7,807
1,329	G	750	99	D		R	*	*
1,330	G	760	80	C	5	R	4,851	3,202
1,331	G	830	82	C	5	D	4,380	4,818
1,332	G	830	82	C	5	D	4,217	4,639
1,333	G	830	82	C	5	R	7,049	3,877

Table A.2. Tankless Water Heaters (contd)

REC	FUEL	INPUT	EFF	EXCH	WARR	CTYPE	LCOST	CCOST
1,334	G	840	82	C	5	D	3,060	3,366
1,335	G	930	82	C	5	D	4,596	5,056
1,336	G	940	80	C	5	R	5,469	3,610
1,337	G	960	82	C	5	D	3,195	3,515
1,338	G	960	82	C	5	D	4,617	5,078
1,339	G	960	82	C	5	R	7,380	4,059
1,340	G	990	85	C	5	R	7,728	5,100
1,341	G	1,000	88	C	5	R	11,692	7,717
1,342	G	1,000	88	C	5	D	7,426	8,169
1,343	G	1,000	93	N	5	R	14,000	*
1,344	G	1,080	82	C	5	D	3,375	3,713
1,345	G	1,080	82	C	5	D	4,956	5,451
1,346	G	1,120	82	C	5	D	4,771	5,248
1,347	G	1,120	82	C	5	R	7,734	4,254
1,348	G	1,180	82	C	5	D	5,273	5,800
1,349	G	1,200	99	D		R	*	*
1,350	G	1,210	80	C	5	R	6,206	4,096
1,351	G	1,210	82	C	5	D	3,600	3,960
1,352	G	1,220	82	C	5	D	5,086	5,595
1,353	G	1,220	82	C	5	R	8,720	4,796
1,354	G	1,240	80	C	5	D	6,046	6,651
1,355	G	1,260	85	C	5	R	9,037	5,964
1,356	G	1,290	82	C	5	D	5,443	5,987
1,357	G	1,340	82	C	5	D	5,443	5,987
1,358	G	1,340	82	C	5	R	9,621	5,292
1,359	G	1,340	76	C	5	D	6,519	7,171
1,360	G	1,350	82	C	5	D	3,960	4,356
1,361	G	1,410	82	C	5	D	5,822	6,404
1,362	G	1,440	85	C	5	R	9,790	6,461
1,363	G	1,470	82	C	5	D	5,822	6,404
1,364	G	1,470	82	C	5	R	10,137	5,575
1,365	G	1,480	82	C	5	D	4,095	4,505
1,366	G	1,540	80	C	5	R	7,366	4,862
1,367	G	1,570	82	C	5	D	6,086	6,695
1,368	G	1,610	82	C	5	D	4,322	4,754
1,369	G	1,630	82	C	5	D	6,086	6,695
1,370	G	1,630	82	C	5	R	11,629	6,396
1,371	G	1,690	80	C	5	R	7,987	5,271
1,372	G	1,760	82	C	5	D	6,606	7,266
1,373	G	1,800	85	C	5	R	10,405	6,867
1,374	G	1,810	82	C	5	D	4,950	5,445
1,375	G	1,830	82	C	5	D	6,606	7,266
1,376	G	1,830	82	C	5	R	10,329	5,681
1,377	G	2,000	99	D		R	*	*
1,378	G	2,000	80	C	5	R	9,757	6,440

Table A.2. Tankless Water Heaters (contd)

REC	FUEL	INPUT	EFF	EXCH	WARR	CTYPE	LCOST	CCOST
1,379	G	2,070	85	C	5	R	13,553	8,945
1,380	G	2,100	82	C	5	R	12,666	6,966
1,381	G	2,310	80	C	5	R	10,191	6,726
1,382	G	2,500	82	C	5	R	13,528	7,440
1,383	G	2,620	80	C	5	R	11,319	7,471
1,384	G	3,000	82	C	5	R	16,115	8,863
1,385	G	3,000	99	D		R	*	*
1,386	G	3,080	80	C	5	R	12,435	8,207
1,387	G	3,500	82	C	5	R	17,517	9,634
1,388	G	4,000	82	C	5	R	18,921	10,407
1,389	G	4,500	99	D		R	*	*
1,390	G	5,500	99	D		R	*	*
1,391	G	7,000	99	D		R	*	*
1,392	G	9,000	99	D		R	*	*
1,393	G	12,000	99	D		R	*	*
1,394	G	15,000	99	D		R	*	*
1,395	G	18,000	99	D		R	*	*
1,396	G	21,000	99	D		R	*	*

Table A.3. Electric Storage Water Heaters

REC	VOL	INP	STBY	VOLT	TANK	RVAL	WARR	THERM	CTYPE	LCOST	CCOST
1,397	10	15		120	S		3	I	D	813	902
1,398	10	18		120	S		3	I	D	845	938
1,399	10	24		120	S		3	I	D	1,159	1,286
1,400	10	27		120	S		3	I	D	1,222	1,356
1,401	10	30		120	S		3	I	D	1,230	1,365
1,402	10	36		120	S		3	I	D	1,274	1,414
1,403	10	45		120	S		3	I	D	1,433	1,591
1,404	10	54		120	S		3	I	D	1,569	1,742
1,405	20	15	1.1	240	A	16	3	I	D	1,267	1,406
1,406	20	18	1.1	240	A	16	3	I	D	1,306	1,450
1,407	30	15		240	A	16	3	I	D	1,289	1,431
1,408	30	18		240	A	16	3	I	D	1,353	1,502
1,409	30	24		240	A	16	3	I	D	1,725	1,915
1,410	40	15		240	A	16	3	I	D	1,342	1,490
1,411	40	18		240	A	16	3	I	D	1,385	1,537
1,412	40	24		240	A	16	3	I	D	1,759	1,952
1,413	40	30		240	A	16	3	I	D	1,910	2,120
1,414	40	36		240	A	16	3	I	D	2,069	2,297
1,415	50	14	0.9	240	S	24	3	I	D	1,150	1,277
1,416	50	14	0.9	240	S	24	3	S	D	846	939
1,417	50	15	0.8	240	A	24	3	I	D	1,434	1,591
1,418	50	15		240	A	16	3	I	D	1,430	1,587
1,419	50	15	0.8	240	A	24	3	S	D	1,132	1,256
1,420	50	15	0.8	240	S	24	3	I	D	1,145	1,271
1,421	50	15	0.9	240	S	24	3	I	D	1,150	1,277
1,422	50	15		240	S			I	R	1,257	1,068
1,423	50	15		240	S		5	I	R	1,163	989
1,424	50	15	0.9	240	S	25	3	I	D	1,145	1,271
1,425	50	15	0.8	240	S	24	3	S	D	843	936
1,426	50	15	0.9	240	S	24	3	S	D	846	939
1,427	50	15	0.9	240	S	25	3	S	D	843	936
1,428	50	18	0.8	240	A	24	3	I	D	1,439	1,597
1,429	50	18		240	A	16	3	I	D	1,467	1,628
1,430	50	18	0.8	240	A	24	3	S	D	1,143	1,268
1,431	50	18	0.8	240	S	24	3	I	D	1,150	1,277
1,432	50	18	0.9	240	S	24	3	I	D	1,158	1,285
1,433	50	18	0.9	240	S	25	3	I	D	1,150	1,277
1,434	50	18	0.8	240	S	24	3	S	D	854	948
1,435	50	18	0.9	240	S	24	3	S	D	854	948
1,436	50	18	0.9	240	S	25	3	S	D	854	948
1,437	50	20		240	S			I	R	1,265	1,075
1,438	50	20		240	S		5	I	R	1,171	995
1,439	50	24	0.8	240	A	24	3	I	D	1,789	1,986
1,440	50	24		240	A	16	3	I	D	1,906	2,116
1,441	50	24	0.8	240	A	24	3	S	D	1,528	1,696

Table A.3. Electric Storage Water Heaters (contd)

REC	VOL	INP	STBY	VOLT	TANK	RVAL	WARR	THERM	CTYPE	LCOST	CCOST
1,442	50	24	0.8	240	S	24	3	I	D	1,500	1,665
1,443	50	24	0.9	240	S	24	3	I	D	1,514	1,681
1,444	50	24		240	S			I	R	1,588	1,350
1,445	50	24		240	S		5	I	R	1,494	1,270
1,446	50	24	0.9	240	S	25	3	I	D	1,500	1,665
1,447	50	24	0.8	240	S	24	3	S	D	1,239	1,375
1,448	50	24	0.9	240	S	24	3	S	D	1,237	1,373
1,449	50	24	0.9	240	S	25	3	S	D	1,239	1,375
1,450	50	27	0.8	240	A	24	3	I	D	1,829	2,030
1,451	50	27	0.8	240	A	24	3	S	D	1,545	1,715
1,452	50	27	0.8	240	S	24	3	I	D	1,540	1,709
1,453	50	27	0.9	240	S	24	3	I	D	1,548	1,718
1,454	50	27	0.9	240	S	25	3	I	D	1,540	1,709
1,455	50	27	0.8	240	S	24	3	S	D	1,256	1,394
1,456	50	27	0.9	240	S	24	3	S	D	1,255	1,393
1,457	50	27	0.9	240	S	25	3	S	D	1,255	1,393
1,458	50	30	0.8	240	A	24	3	I	D	1,879	2,085
1,459	50	30		240	A	16	3	I	D	2,022	2,244
1,460	50	30	0.8	240	A	24	3	S	D	1,565	1,737
1,461	50	30	0.8	240	S	24	3	I	D	1,590	1,765
1,462	50	30	0.9	240	S	24	3	I	D	1,595	1,770
1,463	50	30		240	S			I	R	1,654	1,406
1,464	50	30		240	S		5	I	R	1,560	1,326
1,465	50	30	0.9	240	S	25	3	I	D	1,590	1,765
1,466	50	30	0.8	240	S	24	3	S	D	1,276	1,416
1,467	50	30	0.9	240	S	24	3	S	D	1,275	1,415
1,468	50	30	0.9	240	S	25	3	S	D	1,276	1,416
1,469	50	35		240	S			I	R	1,824	1,550
1,470	50	35		240	S		5	I	R	1,730	1,471
1,471	50	36	0.8	240	A	24	3	I	D	1,929	2,141
1,472	50	36		240	A	16	3	I	D	2,081	2,310
1,473	50	36	0.8	240	A	24	3	S	D	1,588	1,762
1,474	50	36	0.8	240	S	24	3	I	D	1,640	1,820
1,475	50	36	0.9	240	S	24	3	I	D	1,642	1,823
1,476	50	36	0.9	240	S	25	3	I	D	1,640	1,820
1,477	50	36	0.8	240	S	24	3	S	D	1,299	1,442
1,478	50	36	0.9	240	S	24	3	S	D	1,295	1,437
1,479	50	36	0.9	240	S	25	3	S	D	1,296	1,439
1,480	50	40		240	S			I	R	1,833	1,558
1,481	50	40		240	S		5	I	R	1,739	1,478
1,482	50	45	0.8	240	A	24	3	I	D	2,309	2,563
1,483	50	45		240	A	16	3	I	D	2,463	2,734
1,484	50	45	0.8	240	S	24	3	I	D	2,020	2,242
1,485	50	45	0.9	240	S	24	3	I	D	2,010	2,231
1,486	50	45		240	S			I	R	1,833	1,558

Table A.3. Electric Storage Water Heaters (contd)

REC	VOL	INP	STBY	VOLT	TANK	RVAL	WARR	THERM	CTYPE	LCOST	CCOST
1,487	50	45		240	S		5	I	R	1,739	1,478
1,488	50	45	0.9	240	S	25	3	I	D	2,010	2,231
1,489	50	45	0.9	240	S	24	3	S	D	1,668	1,851
1,490	50	45	0.9	240	S	25	3	S	D	1,317	1,462
1,491	50	48		240	S			I	R	2,481	2,109
1,492	50	48		240	S		5	I	R	2,387	2,029
1,493	50	54	0.8	240	A	24	3	I	D	2,379	2,640
1,494	50	54	0.8	240	S	24	3	I	D	2,090	2,320
1,495	50	54	0.9	240	S	24	3	I	D	2,084	2,313
1,496	50	54		240	S			I	R	2,499	2,124
1,497	50	54		240	S		5	I	R	2,405	2,044
1,498	50	54	0.9	240	S	25	3	I	D	2,083	2,312
1,499	50	54	0.9	240	S	24	3	S	D	1,683	1,868
1,500	50	54	0.9	240	S	25	3	S	D	1,339	1,486
1,501	50	58		240	S			I	R	2,508	2,132
1,502	50	58		240	S		5	I	R	2,414	2,052
1,503	50	14		240	S	16	5	I	D	1,375	1,526
1,504	50	14		240	S	16	3	I	D	1,150	1,277
1,505	50	14	0.9	240	S	20	3	I	D	1,156	1,283
1,506	50	14		240	S	16	5	S	D	1,071	1,189
1,507	50	14		240	S	16	3	S	D	846	939
1,508	50	14	0.9	240	S	20	3	S	D	843	936
1,509	50	15		240	S	16	5	I	D	1,375	1,526
1,510	50	15		240	S	16	3	I	D	1,150	1,277
1,511	50	15	0.9	240	S	20	3	I	D	1,151	1,278
1,512	50	15		240	S	16	5	S	D	1,071	1,189
1,513	50	15		240	S	16	3	S	D	846	939
1,514	50	15	0.9	240	S	20	3	S	D	843	936
1,515	50	18		240	S	16	5	I	D	1,383	1,535
1,516	50	18		240	S	16	3	I	D	1,158	1,285
1,517	50	18	0.9	240	S	20	3	I	D	1,159	1,286
1,518	50	18		240	S	24	3	I	R	1,884	1,198
1,519	50	18		480	S	24	3	I	R	2,077	1,321
1,520	50	18		240	S	16	5	S	D	1,079	1,198
1,521	50	18		240	S	16	3	S	D	854	948
1,522	50	18	0.9	240	S	20	3	S	D	854	948
1,523	50	18		240	S	24	3	S	R	1,456	926
1,524	50	18		480	S	24	3	S	R	1,574	1,001
1,525	50	24	0.9	240	S	20	3	I	D	1,514	1,681
1,526	50	24	0.9	240	S	20	3	S	D	1,239	1,375
1,527	50	27		240	S	16	5	I	D	1,773	1,968
1,528	50	27		240	S	16	3	I	D	1,548	1,718
1,529	50	27	0.9	240	S	20	3	I	D	1,549	1,719
1,530	50	27		240	S	24	3	I	R	2,673	1,700
1,531	50	27		480	S	24	3	I	R	2,808	1,786

Table A.3. Electric Storage Water Heaters (contd)

REC	VOL	INP	STBY	VOLT	TANK	RVAL	WARR	THERM	CTYPE	LCOST	CCOST
1,532	50	27		240	S	16	5	S	D	1,480	1,643
1,533	50	27		240	S	16	3	S	D	1,255	1,393
1,534	50	27	0.9	240	S	20	3	S	D	1,256	1,394
1,535	50	27		240	S	24	3	S	R	2,206	1,403
1,536	50	27		480	S	24	3	S	R	2,272	1,445
1,537	50	30		240	S	16	5	I	D	1,820	2,020
1,538	50	30		240	S	16	3	I	D	1,595	1,770
1,539	50	30	0.9	240	S	20	3	I	D	1,596	1,772
1,540	50	30		240	S	16	5	S	D	1,500	1,665
1,541	50	30		240	S	16	3	S	D	1,275	1,415
1,542	50	30	0.9	240	S	20	3	S	D	1,276	1,416
1,543	50	36		240	S	16	5	I	D	1,867	2,072
1,544	50	36		240	S	16	3	I	D	1,642	1,823
1,545	50	36	0.9	240	S	20	3	I	D	1,643	1,824
1,546	50	36		240	S	24	3	I	R	2,929	1,863
1,547	50	36		480	S	24	3	I	R	3,043	1,935
1,548	50	36		240	S	16	5	S	D	1,520	1,687
1,549	50	36		240	S	16	3	S	D	1,295	1,437
1,550	50	36	0.9	240	S	20	3	S	D	1,296	1,439
1,551	50	36		240	S	24	3	S	R	2,238	1,423
1,552	50	36		480	S	24	3	S	R	2,330	1,482
1,553	50	41	0.9	240	S	20	3	I	D	2,020	2,242
1,554	50	45		240	S	16	5	I	D	2,235	2,481
1,555	50	45		240	S	16	3	I	D	2,010	2,231
1,556	50	45	0.9	240	S	20	3	I	D	2,020	2,242
1,557	50	54		240	S	16	5	I	D	2,308	2,562
1,558	50	54		240	S	16	3	I	D	2,083	2,312
1,559	50	54	0.9	240	S	20	3	I	D	2,092	2,322
1,560	50	81		240	S	16	5	I	D	3,648	4,049
1,561	50	81		240	S	16	3	I	D	3,423	3,800
1,562	70	15		240	A	16	3	I	D	1,591	1,766
1,563	70	18		240	A	16	3	I	D	1,613	1,790
1,564	70	24		240	A	16	3	I	D	2,069	2,297
1,565	70	30		240	A	16	3	I	D	2,182	2,422
1,566	70	36		240	A	16	3	I	D	2,244	2,491
1,567	70	45		240	A	16	3	I	D	2,612	2,899
1,568	70	54		240	A	16	3	I	D	2,658	2,950
1,569	80	14	0.7	240	S	24	3	I	D	1,362	1,512
1,570	80	14	0.8	240	S	20	3	I	D	1,364	1,514
1,571	80	14	0.7	240	S	24	3	S	D	1,058	1,174
1,572	80	14	0.8	240	S	20	3	S	D	1,060	1,177
1,573	80	15		240	A	16	3	I	D	1,756	1,949
1,574	80	15	0.7	240	S	24	3	I	D	1,399	1,553
1,575	80	15		240	S		5	I	R	1,387	1,179
1,576	80	15		240	S		5	I	R	1,293	1,099

Table A.3. Electric Storage Water Heaters (contd)

REC	VOL	INP	STBY	VOLT	TANK	RVAL	WARR	THERM	CTYPE	LCOST	CCOST
1,577	80	15	0.7	240	S	25	3	I	D	1,380	1,532
1,578	80	15	0.8	240	S	20	3	I	D	1,400	1,554
1,579	80	15	0.7	240	S	24	3	S	D	1,058	1,174
1,580	80	15		240	S		5	S	R	1,232	1,047
1,581	80	15		240	S		5	S	R	1,138	967
1,582	80	15	0.7	240	S	25	3	S	D	1,058	1,174
1,583	80	15	0.8	240	S	20	3	S	D	1,060	1,177
1,584	80	18		240	A	16	3	I	D	1,767	1,961
1,585	80	18	0.7	240	S	24	3	I	D	1,404	1,558
1,586	80	18		240	S		5	I	D	1,123	1,348
1,587	80	18	0.7	240	S	25	3	I	D	1,390	1,543
1,588	80	18	0.8	240	S	20	3	I	D	1,405	1,560
1,589	80	18	0.7	240	S	24	3	S	D	1,074	1,192
1,590	80	18	0.7	240	S	25	3	S	D	1,073	1,191
1,591	80	18	0.8	240	S	20	3	S	D	1,073	1,191
1,592	80	20		240	S		5	I	R	1,403	1,192
1,593	80	20		240	S		5	I	R	1,309	1,113
1,594	80	24		240	A	16	3	I	D	2,213	2,456
1,595	80	24	0.7	240	S	24	3	I	D	1,757	1,950
1,596	80	24		240	S		5	I	R	1,726	1,467
1,597	80	24		240	S		5	I	R	1,632	1,387
1,598	80	24		240	S		5	I	D	1,236	1,483
1,599	80	24	0.7	240	S	25	3	I	D	1,745	1,937
1,600	80	24	0.8	240	S	20	3	I	D	1,762	1,956
1,601	80	24	0.7	240	S	24	3	S	D	1,347	1,495
1,602	80	24	0.7	240	S	25	3	S	D	1,350	1,499
1,603	80	24	0.8	240	S	20	3	S	D	1,350	1,499
1,604	80	27	0.7	240	S	24	3	I	D	1,806	2,005
1,605	80	27	0.7	240	S	25	3	I	D	1,800	1,998
1,606	80	27	0.8	240	S	20	3	I	D	1,815	2,015
1,607	80	27	0.7	240	S	24	3	S	D	1,477	1,639
1,608	80	27	0.7	240	S	25	3	S	D	1,476	1,638
1,609	80	27	0.8	240	S	20	3	S	D	1,476	1,638
1,610	80	30		240	A	16	3	I	D	2,324	2,580
1,611	80	30	0.7	240	S	24	3	I	D	1,844	2,047
1,612	80	30		240	S		5	I	R	1,792	1,523
1,613	80	30		240	S		5	I	R	1,698	1,443
1,614	80	30		240	S		5	I	D	1,311	1,573
1,615	80	30	0.7	240	S	25	3	I	D	1,835	2,037
1,616	80	30	0.8	240	S	20	3	I	D	1,845	2,048
1,617	80	30	0.7	240	S	24	3	S	D	1,485	1,648
1,618	80	30	0.7	240	S	25	3	S	D	1,485	1,648
1,619	80	30	0.8	240	S	20	3	S	D	1,487	1,651
1,620	80	35		240	S		5	I	R	1,962	1,668
1,621	80	35		240	S		5	I	R	1,868	1,588

Table A.3. Electric Storage Water Heaters (contd)

REC	VOL	INP	STBY	VOLT	TANK	RVAL	WARR	THERM	CTYPE	LCOST	CCOST
1,622	80	36		240	A	16	3	I	D	2,389	2,652
1,623	80	36	0.7	240	S	24	3	I	D	1,890	2,098
1,624	80	36		240	S		5	I	D	1,432	1,718
1,625	80	36	0.7	240	S	25	3	I	D	1,881	2,088
1,626	80	36	0.8	240	S	20	3	I	D	1,891	2,099
1,627	80	36	0.7	240	S	24	3	S	D	1,496	1,661
1,628	80	36	0.7	240	S	25	3	S	D	1,795	1,992
1,629	80	36	0.8	240	S	20	3	S	D	1,496	1,661
1,630	80	40		240	S		5	I	R	1,971	1,675
1,631	80	40		240	S		5	I	R	1,877	1,595
1,632	80	41	0.8	240	S	20	3	I	D	2,254	2,502
1,633	80	41	0.8	240	S	20	3	S	D	1,879	2,086
1,634	80	45		240	A	16	3	I	D	2,761	3,065
1,635	80	45	0.7	240	S	24	3	I	D	2,252	2,500
1,636	80	45		240	S		5	I	R	2,619	2,226
1,637	80	45		240	S		5	I	R	2,525	2,146
1,638	80	45	0.7	240	S	25	3	I	D	2,244	2,491
1,639	80	45	0.8	240	S	20	3	I	D	2,254	2,502
1,640	80	45	0.7	240	S	24	3	S	D	1,877	2,083
1,641	80	45	0.7	240	S	25	3	S	D	1,877	2,083
1,642	80	45	0.8	240	S	20	3	S	D	1,879	2,086
1,643	80	48		240	S		5	I	D	1,455	1,746
1,644	80	52		240	S		5	I	D	1,501	1,801
1,645	80	54		240	A	16	3	I	D	2,797	3,105
1,646	80	54	0.7	240	S	24	3	I	D	2,322	2,577
1,647	80	54	0.7	240	S	25	3	I	D	2,314	2,569
1,648	80	54	0.8	240	S	20	3	I	R	2,324	2,580
1,649	80	54	0.7	240	S	24	3	S	D	1,890	2,098
1,650	80	54	0.7	240	S	25	3	S	D	1,889	2,097
1,651	80	54	0.8	240	S	20	3	S	R	1,889	2,097
1,652	80	14		240	S	16	5	I	D	1,587	1,762
1,653	80	14		240	S	16	3	I	D	1,362	1,512
1,654	80	14		240	S	16	5	S	D	1,283	1,424
1,655	80	14		240	S	16	3	S	D	1,058	1,174
1,656	80	15		240	S	16	5	I	D	1,624	1,803
1,657	80	15		240	S	16	3	I	D	1,399	1,553
1,658	80	15		240	S	16	5	S	D	1,283	1,424
1,659	80	15		240	S	16	3	S	D	1,058	1,174
1,660	80	18		240	S	16	5	I	D	1,629	1,808
1,661	80	18		240	S	16	3	I	D	1,404	1,558
1,662	80	18		240	S	24	3	I	R	2,452	1,559
1,663	80	18		480	S	24	3	I	R	2,530	1,609
1,664	80	18		240	S	16	5	S	D	1,299	1,442
1,665	80	18		240	S	16	3	S	D	1,074	1,192
1,666	80	18		240	S	24	3	S	R	1,840	1,170

Table A.3. Electric Storage Water Heaters (contd)

REC	VOL	INP	STBY	VOLT	TANK	RVAL	WARR	THERM	CTYPE	LCOST	CCOST
1,667	80	18		480	S	24	3	S	R	1,949	1,240
1,668	80	27		240	S	16	5	I	D	2,031	2,254
1,669	80	27		240	S	16	3	I	D	1,806	2,005
1,670	80	27		240	S	24	3	I	R	3,232	2,056
1,671	80	27		480	S	24	3	I	R	3,310	2,105
1,672	80	27		240	S	16	5	S	D	1,702	1,889
1,673	80	27		240	S	16	3	S	D	1,477	1,639
1,674	80	27		240	S	24	3	S	R	2,651	1,686
1,675	80	27		480	S	24	3	S	R	2,734	1,739
1,676	80	30		240	S	16	5	I	D	2,069	2,297
1,677	80	30		240	S	16	3	I	D	1,844	2,047
1,678	80	30		240	S	16	5	S	D	1,710	1,898
1,679	80	30		240	S	16	3	S	D	1,485	1,648
1,680	80	36		240	S	16	5	I	D	2,115	2,348
1,681	80	36		240	S	16	3	I	D	1,890	2,098
1,682	80	36		240	S	24	3	I	R	3,408	2,167
1,683	80	36		480	S	24	3	I	R	3,495	2,223
1,684	80	36		240	S	16	5	S	D	1,721	1,910
1,685	80	36		240	S	16	3	S	D	1,496	1,661
1,686	80	36		240	S	24	3	S	R	2,708	1,722
1,687	80	36		480	S	24	3	S	R	2,785	1,771
1,688	80	45		240	S	16	5	I	D	2,477	2,749
1,689	80	45		240	S	16	3	I	D	2,256	2,504
1,690	80	45		240	S	24	3	I	R	3,832	2,437
1,691	80	45		480	S	24	3	I	R	3,939	2,505
1,692	80	45		240	S	16	5	S	D	2,102	2,333
1,693	80	45		240	S	16	3	S	D	1,877	2,083
1,694	80	45		240	S	24	3	S	R	3,283	2,088
1,695	80	45		480	S	24	3	S	R	3,396	2,160
1,696	80	54		240	S	16	5	I	D	2,547	2,827
1,697	80	54		240	S	16	3	I	D	2,322	2,577
1,698	80	54		240	S	24	3	I	R	3,721	2,367
1,699	80	54		480	S	24	3	I	R	3,792	2,412
1,700	80	54		240	S	16	5	S	D	2,115	2,348
1,701	80	54		240	S	16	3	S	D	1,890	2,098
1,702	80	54		240	S	24	3	S	R	3,333	2,120
1,703	80	54		480	S	24	3	S	R	3,439	2,187
1,704	80	81		240	S	16	5	I	D	3,888	4,316
1,705	80	81		240	S	16	3	I	D	3,663	4,066
1,706	90	15	0.6	240	A	24	3	I	D	1,721	1,910
1,707	90	15	0.6	240	A	24	3	S	D	1,405	1,560
1,708	90	15	0.6	240	S	24	3	I	D	1,380	1,532
1,709	90	15	0.6	240	S	24	3	S	D	1,064	1,181
1,710	90	18	0.6	240	A	24	3	I	D	1,731	1,921
1,711	90	18	0.6	240	A	24	3	S	D	1,422	1,578

Table A.3. Electric Storage Water Heaters (contd)

REC	VOL	INP	STBY	VOLT	TANK	RVAL	WARR	THERM	CTYPE	LCOST	CCOST
1,712	90	18	0.6	240	S	24	3	I	D	1,390	1,543
1,713	90	18	0.6	240	S	24	3	S	D	1,081	1,199
1,714	90	24	0.6	240	A	24	3	I	D	2,086	2,315
1,715	90	24	0.6	240	A	24	3	S	D	1,700	1,887
1,716	90	24	0.6	240	S	24	3	I	D	1,745	1,937
1,717	90	24	0.6	240	S	24	3	S	D	1,359	1,508
1,718	90	27	0.6	240	A	24	3	I	D	2,141	2,377
1,719	90	27	0.6	240	A	24	3	S	D	1,817	2,017
1,720	90	27	0.6	240	S	24	3	I	D	1,800	1,998
1,721	90	27	0.6	240	S	24	3	S	D	1,476	1,638
1,722	90	30	0.6	240	A	24	3	I	D	2,176	2,415
1,723	90	30	0.6	240	A	24	3	S	D	1,826	2,027
1,724	90	30	0.6	240	S	24	3	I	D	1,835	2,037
1,725	90	30	0.6	240	S	24	3	S	D	1,485	1,648
1,726	90	36	0.6	240	A	24	3	I	D	2,222	2,466
1,727	90	36	0.6	240	A	24	3	S	D	1,835	2,037
1,728	90	36	0.6	240	S	24	3	I	D	1,881	2,088
1,729	90	36	0.6	240	S	24	3	S	D	1,494	1,659
1,730	90	45	0.6	240	A	24	3	I	D	2,585	2,869
1,731	90	45	0.6	240	A	24	3	S	D	2,221	2,465
1,732	90	45	0.6	240	S	24	3	I	D	2,244	2,491
1,733	90	45	0.6	240	S	24	3	S	D	1,880	2,087
1,734	90	54	0.6	240	A	24	3	I	D	2,655	2,947
1,735	90	54	0.6	240	A	24	3	S	D	2,231	2,476
1,736	90	54	0.6	240	S	24	3	I	D	2,314	2,569
1,737	90	54	0.6	240	S	24	3	S	D	1,890	2,098
1,738	100	15	0.6	240	A	16	3	I	D	1,932	2,145
1,739	100	18	0.6	240	A	16	3	I	D	1,976	2,193
1,740	100	18		240	S		5	I	D	1,123	1,348
1,741	100	24	0.6	240	A	16	3	I	D	2,315	2,570
1,742	100	24		240	S		5	I	D	1,236	1,483
1,743	100	30	0.6	240	A	16	3	I	D	2,433	2,701
1,744	100	30		240	S		5	I	D	1,311	1,573
1,745	100	36	0.6	240	A	16	3	I	D	2,489	2,763
1,746	100	36		240	S		5	I	D	1,432	1,718
1,747	100	45	0.6	240	A	16	3	I	D	2,872	3,188
1,748	100	48		240	S		5	I	D	1,455	1,746
1,749	100	52		240	S		5	I	D	1,501	1,801
1,750	100	54	0.6	240	A	16	3	I	D	2,912	3,232
1,751	120	20		240	S		5	I	R	1,608	1,367
1,752	120	20		240	S		5	I	R	1,470	1,250
1,753	120	24		240	S		5	I	R	1,931	1,642
1,754	120	24		240	S		5	I	R	1,793	1,524
1,755	120	30		240	S		5	I	R	1,997	1,698
1,756	120	30		240	S		5	I	R	1,859	1,580

Table A.3. Electric Storage Water Heaters (contd)

REC	VOL	INP	STBY	VOLT	TANK	RVAL	WARR	THERM	CTYPE	LCOST	CCOST
1,757	120	35		240	S		5	I	R	2,167	1,842
1,758	120	35		240	S		5	I	R	2,029	1,725
1,759	120	40		240	S		5	I	R	2,023	1,719
1,760	120	40		240	S		5	I	R	2,038	1,732
1,761	120	45		240	S		5	I	R	2,824	2,401
1,762	120	45		240	S		5	I	R	2,686	2,283
1,763	120	54		240	S		5	I	R	2,843	2,417
1,764	120	54		240	S		5	I	R	2,705	2,299
1,765	120	15	0.4	240	A	25	3	I	D	1,969	2,186
1,766	120	15	0.4	240	A	25	3	S	D	1,529	1,697
1,767	120	15	0.4	240	S	25	3	I	D	1,665	1,848
1,768	120	15	0.4	240	S	25	3	S	D	1,229	1,364
1,769	120	18	0.4	240	A	25	3	I	D	1,997	2,217
1,770	120	18	0.4	240	A	25	3	S	D	1,546	1,716
1,771	120	18	0.4	240	S	25	3	I	D	1,695	1,881
1,772	120	18	0.4	240	S	25	3	S	D	1,246	1,383
1,773	120	20		208	S	17	3	S	D	1,230	1,365
1,774	120	24	0.4	240	A	25	3	I	D	2,130	2,364
1,775	120	24	0.4	240	A	25	3	S	D	1,896	2,105
1,776	120	24	0.4	240	S	25	3	I	D	1,880	2,087
1,777	120	24		240	S	17	3	S	D	1,230	1,365
1,778	120	24	0.4	240	S	25	3	S	D	1,601	1,777
1,779	120	27	0.4	240	A	25	3	I	D	2,263	2,512
1,780	120	27	0.4	240	A	25	3	S	D	1,910	2,120
1,781	120	27	0.4	240	S	25	3	I	D	1,960	2,176
1,782	120	27	0.4	240	S	25	3	S	D	1,609	1,786
1,783	120	30	0.4	240	A	25	3	I	D	2,308	2,562
1,784	120	30	0.4	240	A	25	3	S	D	1,922	2,133
1,785	120	30	0.4	240	S	25	3	I	D	2,000	2,220
1,786	120	30		208	S	17	3	S	D	1,520	1,687
1,787	120	30		208	S	17	3	S	D	1,600	1,776
1,788	120	30	0.4	240	S	25	3	S	D	1,620	1,798
1,789	120	36	0.4	240	A	25	3	I	D	2,344	2,602
1,790	120	36	0.4	240	A	25	3	S	D	1,932	2,145
1,791	120	36	0.4	240	S	25	3	I	D	2,039	2,263
1,792	120	36		240	S	17	3	S	D	1,520	1,687
1,793	120	36		240	S	17	3	S	D	1,600	1,776
1,794	120	36		480	S	17	3	S	D	1,620	1,798
1,795	120	36	0.4	240	S	25	3	S	D	1,629	1,808
1,796	120	45	0.4	240	A	25	3	I	D	2,754	3,057
1,797	120	45	0.4	240	A	25	3	S	D	2,383	2,645
1,798	120	45	0.4	240	S	25	3	I	D	2,450	2,720
1,799	120	45		208	S	17	3	S	D	1,700	1,887
1,800	120	45		208	S	17	3	S	D	1,950	2,165
1,801	120	45	0.4	240	S	25	3	S	D	2,083	2,312

Table A.3. Electric Storage Water Heaters (contd)

REC	VOL	INP	STBY	VOLT	TANK	RVAL	WARR	THERM	CTYPE	LCOST	CCOST
1,802	120	54	0.4	240	A	25	3	I	D	2,820	3,130
1,803	120	54	0.4	240	A	25	3	S	D	2,399	2,663
1,804	120	54	0.4	240	S	25	3	I	D	2,520	2,797
1,805	120	54		240	S	17	3	S	D	1,700	1,887
1,806	120	54		240	S	17	3	S	D	1,950	2,165
1,807	120	54		480	S	17	3	S	D	2,090	2,320
1,808	120	54	0.4	240	S	25	3	S	D	2,099	2,330
1,809	120	14	0.4	240	A	24	3	I	D	1,923	2,135
1,810	120	14	0.4	240	A	24	3	S	D	1,529	1,697
1,811	120	14		240	S	16	5	I	D	1,848	2,051
1,812	120	14		240	S	16	3	I	D	1,623	1,802
1,813	120	14	0.4	240	S	24	3	I	D	1,623	1,802
1,814	120	14	0.6	240	S	20	3	I	D	1,624	1,803
1,815	120	14		240	S	16	5	S	D	1,454	1,614
1,816	120	14		240	S	16	3	S	D	1,229	1,364
1,817	120	14	0.4	240	S	24	3	S	D	1,229	1,364
1,818	120	14	0.6	240	S	20	3	S	D	1,237	1,373
1,819	120	15	0.4	240	A	24	3	I	D	2,059	2,285
1,820	120	15	0.4	240	A	24	3	I	D	1,969	2,186
1,821	120	15	0.6	240	A	16	3	I	D	2,124	2,358
1,822	120	15	0.4	240	A	24	3	S	D	1,628	1,807
1,823	120	15	0.4	240	A	24	3	S	D	1,529	1,697
1,824	120	15		240	S	16	5	I	D	1,894	2,102
1,825	120	15		240	S	16	3	I	D	1,669	1,853
1,826	120	15	0.4	240	S	24	3	I	D	1,665	1,848
1,827	120	15	0.4	240	S	24	3	I	D	1,669	1,853
1,828	120	15	0.6	240	S	20	3	I	D	1,670	1,854
1,829	120	15		240	S	16	5	S	D	1,454	1,614
1,830	120	15		240	S	16	3	S	D	1,229	1,364
1,831	120	15	0.4	240	S	24	3	S	D	1,234	1,370
1,832	120	15	0.4	240	S	24	3	S	D	1,229	1,364
1,833	120	15	0.6	240	S	20	3	S	D	1,230	1,365
1,834	120	18	0.4	240	A	24	3	I	D	2,089	2,319
1,835	120	18	0.4	240	A	24	3	I	D	1,997	2,217
1,836	120	18		240	A	24	3	I	R	3,867	2,459
1,837	120	18		480	A	24	3	I	R	3,924	2,496
1,838	120	18	0.6	240	A	16	3	I	D	2,185	2,425
1,839	120	18	0.4	240	A	24	3	S	D	1,644	1,824
1,840	120	18	0.4	240	A	24	3	S	D	1,546	1,716
1,841	120	18		240	A	24	3	S	R	6,048	3,847
1,842	120	18		480	A	24	3	S	R	3,171	2,017
1,843	120	18		240	S	16	5	I	D	1,922	2,133
1,844	120	18		240	S	16	3	I	D	1,697	1,884
1,845	120	18	0.4	240	S	24	3	I	D	1,695	1,881
1,846	120	18	0.4	240	S	24	3	I	D	1,697	1,884

Table A.3. Electric Storage Water Heaters (contd)

REC	VOL	INP	STBY	VOLT	TANK	RVAL	WARR	THERM	CTYPE	LCOST	CCOST
1,847	120	18		240	S		5	I	D	1,123	1,348
1,848	120	18	0.6	240	S	20	3	I	D	1,699	1,886
1,849	120	18		240	S	24	3	I	R	3,017	1,919
1,850	120	18		480	S	24	3	I	R	3,074	1,955
1,851	120	18		240	S	16	5	S	D	1,471	1,633
1,852	120	18		240	S	16	3	S	D	1,246	1,383
1,853	120	18	0.4	240	S	24	3	S	D	1,250	1,387
1,854	120	18	0.4	240	S	24	3	S	D	1,246	1,383
1,855	120	18	0.6	240	S	20	3	S	D	1,246	1,383
1,856	120	18		240	S	24	3	S	R	2,198	1,398
1,857	120	18		480	S	24	3	S	R	2,321	1,476
1,858	120	24	0.4	240	A	24	3	I	D	2,274	2,524
1,859	120	24	0.4	240	A	24	3	I	D	2,183	2,423
1,860	120	24	0.6	240	A	16	3	I	D	2,417	2,683
1,861	120	24	0.4	240	A	24	3	S	D	1,995	2,214
1,862	120	24	0.4	240	A	24	3	S	D	1,903	2,112
1,863	120	24	0.4	240	S	24	3	I	D	1,880	2,087
1,864	120	24	0.4	240	S	24	3	I	D	1,883	2,090
1,865	120	24		240	S		5	I	D	1,236	1,483
1,866	120	24	0.6	240	S	20	3	I	D	1,889	2,097
1,867	120	24	0.4	240	S	24	3	S	D	1,601	1,777
1,868	120	24	0.4	240	S	24	3	S	D	1,603	1,779
1,869	120	24	0.6	240	S	20	3	S	D	1,604	1,780
1,870	120	27	0.4	240	A	24	3	I	D	2,354	2,613
1,871	120	27	0.4	240	A	24	3	I	D	2,263	2,512
1,872	120	27		240	A	24	3	I	R	4,379	2,785
1,873	120	27		480	A	24	3	I	R	4,486	2,853
1,874	120	27	0.4	240	A	24	3	S	D	2,002	2,222
1,875	120	27	0.4	240	A	24	3	S	D	1,910	2,120
1,876	120	27		240	A	24	3	S	R	3,790	2,410
1,877	120	27		480	A	24	3	S	R	3,843	2,444
1,878	120	27		240	S	16	5	I	D	2,188	2,429
1,879	120	27		240	S	16	3	I	D	1,963	2,179
1,880	120	27	0.4	240	S	24	3	I	D	1,960	2,176
1,881	120	27	0.4	240	S	24	3	I	D	1,963	2,179
1,882	120	27	0.6	240	S	20	3	I	D	1,965	2,181
1,883	120	27		240	S	24	3	I	R	3,529	2,244
1,884	120	27		480	S	24	3	I	R	3,636	2,312
1,885	120	27		240	S	16	5	S	D	1,835	2,037
1,886	120	27		240	S	16	3	S	D	1,610	1,787
1,887	120	27	0.4	240	S	24	3	S	D	1,608	1,785
1,888	120	27	0.4	240	S	24	3	S	D	1,610	1,787
1,889	120	27	0.6	240	S	20	3	S	D	1,611	1,788
1,890	120	27		240	S	24	3	S	R	2,940	1,870
1,891	120	27		480	S	24	3	S	R	2,993	1,904

Table A.3. Electric Storage Water Heaters (contd)

REC	VOL	INP	STBY	VOLT	TANK	RVAL	WARR	THERM	CTYPE	LCOST	CCOST
1,892	120	30	0.4	240	A	24	3	I	D	2,394	2,657
1,893	120	30	0.4	240	A	24	3	I	D	2,308	2,562
1,894	120	30	0.6	240	A	16	3	I	D	2,534	2,813
1,895	120	30	0.4	240	A	24	3	S	D	2,014	2,235
1,896	120	30	0.4	240	A	24	3	S	D	1,922	2,133
1,897	120	30		240	S	16	5	I	D	2,233	2,479
1,898	120	30		240	S	16	3	I	D	2,008	2,229
1,899	120	30	0.4	240	S	24	3	I	D	2,000	2,220
1,900	120	30	0.4	240	S	24	3	I	D	2,008	2,229
1,901	120	30		240	S		5	I	D	1,311	1,573
1,902	120	30	0.6	240	S	20	3	I	D	2,010	2,231
1,903	120	30		240	S	16	5	S	D	1,847	2,050
1,904	120	30		240	S	16	3	S	D	1,622	1,800
1,905	120	30	0.4	240	S	24	3	S	D	1,620	1,798
1,906	120	30	0.4	240	S	24	3	S	D	1,622	1,800
1,907	120	30	0.6	240	S	20	3	S	D	1,623	1,802
1,908	120	36	0.4	240	A	24	3	I	D	2,433	2,700
1,909	120	36	0.4	240	A	24	3	I	D	2,344	2,602
1,910	120	36		240	A	24	3	I	R	4,461	2,837
1,911	120	36		480	A	24	3	I	R	4,624	2,941
1,912	120	36	0.6	240	A	16	3	I	D	2,594	2,879
1,913	120	36	0.4	240	A	24	3	S	D	2,023	2,245
1,914	120	36	0.4	240	A	24	3	S	D	1,932	2,145
1,915	120	36		240	A	24	3	S	R	3,835	2,439
1,916	120	36		480	A	24	3	S	R	3,899	2,480
1,917	120	36		240	S	16	5	I	D	2,269	2,519
1,918	120	36		240	S	16	3	I	D	2,044	2,269
1,919	120	36	0.4	240	S	24	3	I	D	2,039	2,263
1,920	120	36	0.4	240	S	24	3	I	D	2,044	2,269
1,921	120	36		240	S		5	I	D	1,432	1,718
1,922	120	36	0.6	240	S	20	3	I	D	2,046	2,271
1,923	120	36		240	S	24	3	I	R	3,611	2,297
1,924	120	36		480	S	24	3	I	R	3,774	2,400
1,925	120	36		240	S	16	5	S	D	1,857	2,061
1,926	120	36		240	S	16	3	S	D	1,632	1,812
1,927	120	36	0.4	240	S	24	3	S	D	1,629	1,808
1,928	120	36	0.4	240	S	24	3	S	D	1,632	1,812
1,929	120	36	0.6	240	S	20	3	S	D	1,634	1,814
1,930	120	36		240	S	24	3	S	R	2,985	1,898
1,931	120	36		480	S	24	3	S	R	3,049	1,939
1,932	120	41	0.6	240	S	20	3	I	D	2,456	2,726
1,933	120	41	0.6	240	S	20	3	S	D	2,089	2,319
1,934	120	45	0.4	240	A	24	3	I	D	2,844	3,157
1,935	120	45	0.4	240	A	24	3	I	D	2,754	3,057
1,936	120	45		240	A	24	3	I	R	5,138	3,268

Table A.3. Electric Storage Water Heaters (contd)

REC	VOL	INP	STBY	VOLT	TANK	RVAL	WARR	THERM	CTYPE	LCOST	CCOST
1,937	120	45		480	A	24	3	I	R	5,173	3,290
1,938	120	45	0.6	240	A	16	3	I	D	2,949	3,273
1,939	120	45	0.4	240	A	24	3	S	D	2,478	2,750
1,940	120	45	0.4	240	A	24	3	S	D	2,383	2,645
1,941	120	45		240	A	24	3	S	R	4,574	2,909
1,942	120	45		480	A	24	3	S	R	4,618	2,937
1,943	120	45		240	S	16	5	I	D	2,679	2,974
1,944	120	45		240	S	16	3	I	D	2,454	2,724
1,945	120	45	0.4	240	S	24	3	I	D	2,450	2,720
1,946	120	45	0.4	240	S	24	3	I	D	2,454	2,724
1,947	120	45	0.6	240	S	20	3	I	D	2,456	2,726
1,948	120	45		240	S	24	3	I	R	4,288	2,727
1,949	120	45		480	S	24	3	I	R	4,323	2,749
1,950	120	45		240	S	16	5	S	D	2,308	2,562
1,951	120	45		240	S	16	3	S	D	2,083	2,312
1,952	120	45	0.4	240	S	24	3	S	D	2,084	2,313
1,953	120	45	0.4	240	S	24	3	S	D	2,083	2,312
1,954	120	45	0.6	240	S	20	3	S	D	2,084	2,313
1,955	120	45		240	S	24	3	S	R	3,724	2,368
1,956	120	45		480	S	24	3	S	R	3,768	2,396
1,957	120	48		240	S		5	I	D	1,455	1,746
1,958	120	52		240	S		5	I	D	1,501	1,801
1,959	120	54	0.4	240	A	24	3	I	D	2,916	3,236
1,960	120	54	0.4	240	A	24	3	I	R	2,820	3,130
1,961	120	54		240	A	24	3	I	R	5,225	3,323
1,962	120	54		480	A	24	3	I	R	5,294	3,367
1,963	120	54	0.6	240	A	16	3	I	D	2,985	3,313
1,964	120	54	0.4	240	A	24	3	S	D	2,494	2,768
1,965	120	54	0.4	240	A	24	3	S	R	2,399	2,663
1,966	120	54		240	A	24	3	S	R	4,612	2,933
1,967	120	54		480	A	24	3	S	R	4,676	2,974
1,968	120	54		240	S	16	5	I	D	2,745	3,047
1,969	120	54		240	S	16	3	I	D	2,520	2,797
1,970	120	54	0.4	240	S	24	3	I	D	2,522	2,799
1,971	120	54	0.4	240	S	24	3	I	D	2,520	2,797
1,972	120	54	0.6	240	S	20	3	I	D	2,522	2,799
1,973	120	54		240	S	24	3	I	R	4,375	2,783
1,974	120	54		480	S	24	3	I	R	4,444	2,826
1,975	120	54		240	S	16	5	S	D	2,324	2,580
1,976	120	54		240	S	16	3	S	D	2,099	2,330
1,977	120	54	0.4	240	S	24	3	S	D	2,100	2,331
1,978	120	54	0.4	240	S	24	3	S	D	2,099	2,330
1,979	120	54	0.6	240	S	20	3	S	D	2,100	2,331
1,980	120	54		240	S	24	3	S	R	3,762	2,393
1,981	120	54		480	S	24	3	S	R	3,826	2,433

Table A.3. Electric Storage Water Heaters (contd)

REC	VOL	INP	STBY	VOLT	TANK	RVAL	WARR	THERM	CTYPE	LCOST	CCOST
1,982	120	81		240	S	16	5	I	D	4,085	4,534
1,983	120	81		240	S	16	3	I	D	3,860	4,285
1,984	130	15	0.6	240	A	12		I	D	5,532	6,141
1,985	130	15	0.6	480	A	12		I	D	5,467	6,068
1,986	130	24	0.6	240	A	12		I	D	5,906	6,556
1,987	130	24	0.6	480	A	12		I	D	5,667	6,290
1,988	130	30	0.6	240	A	12		I	D	6,104	6,775
1,989	130	30	0.6	480	A	12		I	D	5,824	6,465
1,990	130	36	0.6	240	A	12		I	D	6,400	7,104
1,991	130	36	0.6	480	A	12		I	D	5,929	6,581
1,992	130	45	0.6	240	A	12		I	D	6,661	7,394
1,993	130	45	0.6	480	A	12		I	D	6,084	6,753
1,994	130	60	0.6	240	A	12		I	D	6,897	7,656
1,995	130	60	0.6	480	A	12		I	D	6,508	7,224
1,996	130	75	0.6	240	A	12		I	D	7,536	8,365
1,997	130	75	0.6	480	A	12		I	D	7,042	7,817
1,998	130	90	0.6	240	A	12		I	D	7,906	8,776
1,999	130	90	0.6	480	A	12		I	D	7,267	8,066
2,000	130	105	0.6	240	A	12		I	D	8,499	9,434
2,001	130	105	0.6	480	A	12		I	D	7,834	8,696
2,002	130	120	0.6	240	A	12		I	D	8,865	9,840
2,003	130	120	0.6	480	A	12		I	D	8,056	8,942
2,004	150	15	0.6	240	A	16	3	I	R	9,417	5,989
2,005	150	15	0.5	240	A	12		I	D	6,222	6,906
2,006	150	15	0.5	480	A	12		I	D	6,151	6,828
2,007	150	15	0.6	240	A	16	3	S	R	9,104	5,790
2,008	150	18	0.6	240	A	16	3	I	R	9,877	6,282
2,009	150	18	0.6	240	A	16	3	S	R	9,392	5,973
2,010	150	24	0.6	240	A		3	I	D	6,640	7,370
2,011	150	24	0.6	480	A		3	I	D	6,453	7,163
2,012	150	24	0.5	240	A	12		I	D	6,541	7,261
2,013	150	24	0.5	480	A	12		I	D	6,364	7,064
2,014	150	30	0.6	240	A	16	3	I	R	10,080	6,411
2,015	150	30	0.5	240	A	12		I	D	6,671	7,405
2,016	150	30	0.5	480	A	12		I	D	6,502	7,217
2,017	150	30	0.6	240	A	16	3	S	R	9,580	6,093
2,018	150	36	0.6	240	A		3	I	D	7,090	7,870
2,019	150	36	0.6	480	A		3	I	D	6,733	7,474
2,020	150	36	0.6	240	A	16	3	I	R	10,580	6,729
2,021	150	36	0.5	240	A	12		I	D	6,987	7,756
2,022	150	36	0.5	480	A	12		I	D	6,632	7,362
2,023	150	36	0.6	240	A	16	3	S	R	10,054	6,394
2,024	150	45	0.6	240	A	16	3	I	R	10,774	6,852
2,025	150	45	0.5	240	A	12		I	D	7,129	7,913
2,026	150	45	0.5	480	A	12		I	D	6,897	7,656

Table A.3. Electric Storage Water Heaters (contd)

REC	VOL	INP	STBY	VOLT	TANK	RVAL	WARR	THERM	CTYPE	LCOST	CCOST
2,027	150	45	0.6	240	A	16	3	S	R	10,230	6,506
2,028	150	54	0.6	240	A	16	3	I	R	11,318	7,198
2,029	150	54	0.6	240	A	16	3	S	R	10,767	6,848
2,030	150	60	0.5	240	A	12		I	D	7,499	8,324
2,031	150	60	0.5	480	A	12		I	D	7,108	7,890
2,032	150	72	0.6	240	A	16	3	I	R	12,250	7,791
2,033	150	72	0.6	240	A	16	3	S	R	11,643	7,405
2,034	150	75	0.6	240	A		3	I	D	8,253	9,161
2,035	150	75	0.6	480	A		3	I	D	7,759	8,612
2,036	150	75	0.5	240	A	12		I	D	8,125	9,019
2,037	150	75	0.5	480	A	12		I	D	7,643	8,484
2,038	150	90	0.6	240	A	16	3	I	R	12,806	8,145
2,039	150	90	0.5	240	A	12		I	D	8,499	9,434
2,040	150	90	0.5	480	A	12		I	D	7,879	8,746
2,041	150	90	0.6	240	A	16	3	S	R	12,169	7,739
2,042	150	105	0.6	240	A		3	I	D	9,250	10,268
2,043	150	105	0.6	480	A		3	I	D	8,563	9,505
2,044	150	105	0.5	240	A	12		I	D	9,107	10,109
2,045	150	105	0.5	480	A	12		I	D	8,431	9,358
2,046	150	108	0.6	240	A	16	3	I	R	13,738	8,737
2,047	150	108	0.6	240	A	16	3	S	R	13,050	8,300
2,048	150	120	0.6	240	A		3	I	D	9,621	10,679
2,049	150	120	0.6	480	A		3	I	D	8,779	9,745
2,050	150	120	0.5	240	A	12		I	D	9,474	10,516
2,051	150	120	0.5	480	A	12		I	D	8,644	9,595
2,052	150	144	0.6	240	A	16	3	I	R	14,294	9,091
2,053	150	144	0.6	240	A	16	3	S	R	13,582	8,638
2,054	150	150	0.6	240	A		3	I	D	10,559	11,720
2,055	150	150	0.6	480	A		3	I	D	9,437	10,475
2,056	150	150	0.5	240	A	12		I	D	10,395	11,538
2,057	150	150	0.5	480	A	12		I	D	9,291	10,313
2,058	200	15	0.6	240	A	16	3	I	R	10,304	6,553
2,059	200	15	0.6	240	A	16	3	S	R	10,154	6,458
2,060	200	18	0.6	240	A	16	3	I	R	10,336	6,574
2,061	200	18	0.6	240	A	16	3	S	R	9,841	6,259
2,062	200	30	0.5	240	A		3	I	D	6,931	7,693
2,063	200	30	0.5	480	A		3	I	D	6,810	7,559
2,064	200	30	0.5	240	A		3	I	D	7,726	8,576
2,065	200	30	0.5	480	A		3	I	D	7,605	8,442
2,066	200	30	0.6	240	A	16	3	I	R	10,349	6,582
2,067	200	30	0.6	240	A	16	3	S	R	9,999	6,359
2,068	200	36	0.6	240	A	16	3	I	R	10,770	6,850
2,069	200	36	0.6	240	A	16	3	S	R	10,230	6,506
2,070	200	45	0.6	240	A	16	3	I	R	10,805	6,872
2,071	200	45	0.6	240	A	16	3	S	R	10,267	6,530

Table A.3. Electric Storage Water Heaters (contd)

REC	VOL	INP	STBY	VOLT	TANK	RVAL	WARR	THERM	CTYPE	LCOST	CCOST
2,072	200	54	0.6	240	A	16	3	I	R	11,879	7,555
2,073	200	54	0.6	240	A	16	3	S	R	11,286	7,178
2,074	200	60	0.5	240	A		3	I	D	7,955	8,830
2,075	200	60	0.5	480	A		3	I	D	7,554	8,385
2,076	200	60	0.5	240	A		3	I	D	8,750	9,713
2,077	200	60	0.5	480	A		3	I	D	8,349	9,267
2,078	200	72	0.6	240	A	16	3	I	R	12,993	8,264
2,079	200	72	0.6	240	A	16	3	S	R	12,343	7,850
2,080	200	90	0.5	240	A		3	I	D	9,116	10,119
2,081	200	90	0.5	480	A		3	I	D	8,482	9,415
2,082	200	90	0.5	240	A		3	I	D	9,911	11,001
2,083	200	90	0.5	480	A		3	I	D	9,277	10,297
2,084	200	90	0.6	240	A	16	3	I	R	13,549	8,617
2,085	200	90	0.6	240	A	16	3	S	R	12,875	8,189
2,086	200	105	0.5	240	A		3	I	D	9,725	10,795
2,087	200	105	0.5	480	A		3	I	D	9,039	10,033
2,088	200	105	0.5	240	A		3	I	D	10,520	11,677
2,089	200	105	0.5	480	A		3	I	D	9,834	10,916
2,090	200	108	0.6	240	A	16	3	I	R	14,482	9,211
2,091	200	108	0.6	240	A	16	3	S	R	13,743	8,741
2,092	200	120	0.5	240	A		3	I	D	10,091	11,201
2,093	200	120	0.5	480	A		3	I	D	9,253	10,271
2,094	200	120	0.5	240	A		3	I	D	10,886	12,083
2,095	200	120	0.5	480	A		3	I	D	10,048	11,153
2,096	200	144	0.6	240	A	16	3	I	R	15,045	9,569
2,097	200	144	0.6	240	A	16	3	S	R	14,281	9,083
2,098	200	180	0.5	240	A		3	I	D	11,592	12,867
2,099	200	180	0.5	480	A		3	I	D	10,518	11,675
2,100	200	180	0.5	240	A		3	I	D	12,387	13,750
2,101	200	180	0.5	480	A		3	I	D	11,313	12,557
2,102	250	15	0.5	240	A	16	3	I	R	10,580	6,729
2,103	250	15	0.5	240	A	16	3	S	R	10,612	6,749
2,104	250	18	0.5	240	A	16	3	I	R	10,642	6,768
2,105	250	18	0.5	240	A	16	3	S	R	11,372	7,233
2,106	250	30	0.5	240	A		3	I	D	7,185	7,975
2,107	250	30	0.5	480	A		3	I	D	7,049	7,824
2,108	250	30	0.5	240	A		3	I	D	7,980	8,858
2,109	250	30	0.5	480	A		3	I	D	7,844	8,707
2,110	250	30	0.5	240	A	16	3	I	R	10,692	6,800
2,111	250	30	0.5	240	A	16	3	S	R	10,217	6,498
2,112	250	36	0.5	240	A	16	3	I	R	11,231	7,143
2,113	250	36	0.5	240	A	16	3	S	R	10,668	6,785
2,114	250	45	0.5	240	A	16	3	I	R	11,693	7,437
2,115	250	45	0.5	240	A	16	3	S	R	11,106	7,063
2,116	250	54	0.5	240	A	16	3	I	R	12,442	7,913

Table A.3. Electric Storage Water Heaters (contd)

REC	VOL	INP	STBY	VOLT	TANK	RVAL	WARR	THERM	CTYPE	LCOST	CCOST
2,117	250	54	0.5	240	A	16	3	S	R	11,813	7,513
2,118	250	60	0.5	240	A		3	I	D	8,287	9,199
2,119	250	60	0.5	480	A		3	I	D	7,943	8,817
2,120	250	60	0.5	240	A		3	I	D	9,082	10,081
2,121	250	60	0.5	480	A		3	I	D	8,738	9,699
2,122	250	72	0.5	240	A	16	3	I	R	13,406	8,526
2,123	250	72	0.5	240	A	16	3	S	R	12,881	8,192
2,124	250	90	0.5	240	A		3	I	D	9,371	10,402
2,125	250	90	0.5	480	A		3	I	D	8,730	9,690
2,126	250	90	0.5	240	A		3	I	D	10,166	11,284
2,127	250	90	0.5	480	A		3	I	D	9,525	10,573
2,128	250	90	0.5	240	A	16	3	I	R	14,007	8,908
2,129	250	90	0.5	240	A	16	3	S	R	13,313	8,467
2,130	250	108	0.5	240	A	16	3	I	R	14,419	9,170
2,131	250	108	0.5	240	A	16	3	S	R	14,106	8,971
2,132	250	120	0.5	240	A		3	I	D	10,344	11,482
2,133	250	120	0.5	480	A		3	I	D	9,513	10,559
2,134	250	120	0.5	240	A		3	I	D	11,139	12,364
2,135	250	120	0.5	480	A		3	I	D	10,308	11,442
2,136	250	144	0.5	240	A	16	3	I	R	15,407	9,799
2,137	250	144	0.5	240	A	16	3	S	R	14,645	9,314
2,138	250	180	0.5	240	A		3	I	D	11,823	13,124
2,139	250	180	0.5	480	A		3	I	D	10,753	11,936
2,140	250	180	0.5	240	A		3	I	D	12,618	14,006
2,141	250	180	0.5	480	A		3	I	D	11,548	12,818
2,142	250	240	0.5	240	A		3	I	D	14,033	15,577
2,143	250	240	0.5	480	A		3	I	D	12,042	13,367
2,144	250	240	0.5	240	A		3	I	D	14,828	16,459
2,145	250	240	0.5	480	A		3	I	D	12,837	14,249
2,146	300	15	0.4	240	A	16	3	I	R	11,274	7,170
2,147	300	15	0.4	240	A	16	3	S	R	12,442	7,913
2,148	300	18	0.4	240	A	16	3	I	R	11,693	7,437
2,149	300	18	0.4	240	A	16	3	S	R	11,111	7,067
2,150	300	30	0.4	240	A	16	3	I	R	11,730	7,460
2,151	300	30	0.4	240	A	16	3	S	R	11,148	7,090
2,152	300	36	0.4	240	A	16	3	I	R	11,768	7,484
2,153	300	36	0.4	240	A	16	3	S	R	11,180	7,110
2,154	300	45	0.4	240	A		3	I	D	8,140	9,035
2,155	300	45	0.4	480	A		3	I	D	7,884	8,751
2,156	300	45	0.4	240	A		3	I	D	8,935	9,918
2,157	300	45	0.4	480	A		3	I	D	8,679	9,634
2,158	300	45	0.4	240	A	16	3	I	R	12,118	7,707
2,159	300	45	0.4	240	A	16	3	S	R	11,518	7,325
2,160	300	54	0.4	240	A	16	3	I	R	12,956	8,240
2,161	300	54	0.4	240	A	16	3	S	R	12,312	7,830

Table A.3. Electric Storage Water Heaters (contd)

REC	VOL	INP	STBY	VOLT	TANK	RVAL	WARR	THERM	CTYPE	LCOST	CCOST
2,162	300	72	0.4	240	A	16	3	I	R	13,919	8,852
2,163	300	72	0.4	240	A	16	3	S	R	13,218	8,407
2,164	300	90	0.4	240	A		3	I	D	9,725	10,795
2,165	300	90	0.4	480	A		3	I	D	9,087	10,087
2,166	300	90	0.4	240	A		3	I	D	10,520	11,677
2,167	300	90	0.4	480	A		3	I	D	9,882	10,969
2,168	300	90	0.4	240	A	16	3	I	R	14,482	9,211
2,169	300	90	0.4	240	A	16	3	S	R	13,750	8,745
2,170	300	108	0.4	240	A	16	3	I	R	15,546	9,887
2,171	300	108	0.4	240	A	16	3	S	R	14,631	9,305
2,172	300	144	0.4	240	A	16	3	I	R	15,957	10,149
2,173	300	144	0.4	240	A	16	3	S	R	15,163	9,644
2,174	300	150	0.4	240	A		3	I	D	11,516	12,783
2,175	300	150	0.4	480	A		3	I	D	10,535	11,694
2,176	300	150	0.4	240	A		3	I	D	12,311	13,665
2,177	300	150	0.4	480	A		3	I	D	11,330	12,576
2,178	300	210	0.4	240	A		3	I	D	13,457	14,937
2,179	300	210	0.4	480	A		3	I	D	11,833	13,135
2,180	300	210	0.4	240	A		3	I	D	14,252	15,820
2,181	300	210	0.4	480	A		3	I	D	12,628	14,017
2,182	300	240	0.4	240	A		3	I	D	14,331	15,907
2,183	300	240	0.4	480	A		3	I	D	12,522	13,899
2,184	300	240	0.4	240	A		3	I	D	15,126	16,790
2,185	300	240	0.4	480	A		3	I	D	13,317	14,782
2,186	300	300	0.4	240	A		3	I	D	16,050	17,816
2,187	300	300	0.4	480	A		3	I	D	14,000	15,540
2,188	300	300	0.4	240	A		3	I	D	16,845	18,698
2,189	300	300	0.4	480	A		3	I	D	14,795	16,422
2,190	350	60	0.4	240	A		3	I	D	9,022	10,014
2,191	350	60	0.4	480	A		3	I	D	8,627	9,576
2,192	350	60	0.4	240	A		3	I	D	9,817	10,897
2,193	350	60	0.4	480	A		3	I	D	9,422	10,458
2,194	350	90	0.4	240	A		3	I	D	10,047	11,152
2,195	350	90	0.4	480	A		3	I	D	9,409	10,444
2,196	350	90	0.4	240	A		3	I	D	10,842	12,035
2,197	350	90	0.4	480	A		3	I	D	10,204	11,326
2,198	350	120	0.4	240	A		3	I	D	11,021	12,233
2,199	350	120	0.4	480	A		3	I	D	10,170	11,289
2,200	350	120	0.4	240	A		3	I	D	11,816	13,116
2,201	350	120	0.4	480	A		3	I	D	10,965	12,171
2,202	350	180	0.4	240	A		3	I	D	12,524	13,902
2,203	350	180	0.4	480	A		3	I	D	11,448	12,707
2,204	350	180	0.4	240	A		3	I	D	13,319	14,784
2,205	350	180	0.4	480	A		3	I	D	12,243	13,590
2,206	350	240	0.4	240	A		3	I	D	14,654	16,266

Table A.3. Electric Storage Water Heaters (contd)

REC	VOL	INP	STBY	VOLT	TANK	RVAL	WARR	THERM	CTYPE	LCOST	CCOST
2,207	350	240	0.4	480	A		3	I	D	12,835	14,247
2,208	350	240	0.4	240	A		3	I	D	15,449	17,148
2,209	350	240	0.4	480	A		3	I	D	13,630	15,129
2,210	350	300	0.4	240	A		3	I	D	17,154	19,041
2,211	350	300	0.4	480	A		3	I	D	14,327	15,903
2,212	350	300	0.4	240	A		3	I	D	17,949	19,923
2,213	350	300	0.4	480	A		3	I	D	15,122	16,785
2,214	400	15	0.4	240	A	16	3	I	R	13,207	8,400
2,215	400	15	0.4	240	A	16	3	S	R	14,994	9,536
2,216	400	18	0.4	240	A	16	3	I	R	14,094	8,964
2,217	400	18	0.4	240	A	16	3	S	R	13,232	8,416
2,218	400	30	0.4	240	A	16	3	I	R	14,200	9,031
2,219	400	30	0.4	240	A	16	3	S	R	13,487	8,578
2,220	400	36	0.4	240	A	16	3	I	R	14,237	9,055
2,221	400	36	0.4	240	A	16	3	S	R	13,525	8,602
2,222	400	45	0.4	240	A	16	3	I	R	14,294	9,091
2,223	400	45	0.4	240	A	16	3	S	R	13,582	8,638
2,224	400	54	0.4	240	A	16	3	I	R	15,032	9,560
2,225	400	54	0.4	240	A	16	3	S	R	14,294	9,091
2,226	400	72	0.4	240	A	16	3	I	R	15,994	10,172
2,227	400	72	0.4	240	A	16	3	S	R	15,200	9,667
2,228	400	75	0.4	240	A		3	I	D	10,746	11,928
2,229	400	75	0.4	480	A		3	I	D	10,243	11,370
2,230	400	75	0.4	240	A		3	I	D	11,541	12,811
2,231	400	75	0.4	480	A		3	I	D	11,038	12,252
2,232	400	90	0.4	240	A	16	3	I	R	16,520	10,507
2,233	400	90	0.4	240	A	16	3	S	R	15,694	9,981
2,234	400	108	0.4	240	A	16	3	I	R	17,445	11,095
2,235	400	108	0.4	240	A	16	3	S	R	16,583	10,547
2,236	400	120	0.4	240	A		3	I	D	12,101	13,432
2,237	400	120	0.4	480	A		3	I	D	11,273	12,513
2,238	400	120	0.4	240	A		3	I	D	12,896	14,315
2,239	400	120	0.4	480	A		3	I	D	12,068	13,395
2,240	400	144	0.4	240	A	16	3	I	R	18,038	11,472
2,241	400	144	0.4	240	A	16	3	S	R	17,147	10,905
2,242	400	210	0.4	240	A		3	I	D	14,964	16,610
2,243	400	210	0.4	480	A		3	I	D	13,237	14,693
2,244	400	210	0.4	240	A		3	I	D	15,759	17,492
2,245	400	210	0.4	480	A		3	I	D	14,032	15,576
2,246	400	300	0.4	240	A		3	I	D	17,243	19,140
2,247	400	300	0.4	480	A		3	I	D	15,775	17,510
2,248	400	300	0.4	240	A		3	I	D	18,038	20,022
2,249	400	300	0.4	480	A		3	I	D	16,570	18,393
2,250	400	330	0.4	240	A		3	I	D	18,298	20,311
2,251	400	330	0.4	480	A		3	I	D	15,909	17,659

Table A.3. Electric Storage Water Heaters (contd)

REC	VOL	INP	STBY	VOLT	TANK	RVAL	WARR	THERM	CTYPE	LCOST	CCOST
2,252	400	330	0.4	240	A		3	I	D	19,093	21,193
2,253	400	330	0.4	480	A		3	I	D	16,704	18,541
2,254	400	390	0.4	240	A		3	I	D	20,406	22,651
2,255	400	390	0.4	480	A		3	I	D	17,472	19,394
2,256	400	390	0.4	240	A		3	I	D	21,201	23,533
2,257	400	390	0.4	480	A		3	I	D	18,267	20,276
2,258	500	15	0.3	240	A	16	3	I	R	16,207	10,308
2,259	500	15	0.3	240	A	16	3	S	R	16,857	10,721
2,260	500	18	0.3	240	A	16	3	I	R	16,233	10,324
2,261	500	18	0.3	240	A	16	3	S	R	15,419	9,806
2,262	500	30	0.3	240	A	16	3	I	R	16,357	10,403
2,263	500	30	0.3	240	A	16	3	S	R	15,531	9,878
2,264	500	36	0.3	240	A	16	3	I	R	16,809	10,691
2,265	500	36	0.3	240	A	16	3	S	R	15,606	9,925
2,266	500	45	0.3	240	A	16	3	I	R	16,464	10,471
2,267	500	45	0.3	240	A	16	3	S	R	15,651	9,954
2,268	500	54	0.3	240	A	16	3	I	R	17,083	10,865
2,269	500	54	0.3	240	A	16	3	S	R	16,219	10,315
2,270	500	72	0.3	240	A	16	3	I	R	18,008	11,453
2,271	500	72	0.3	240	A	16	3	S	R	17,107	10,880
2,272	500	75	0.4	240	A		3	I	D	12,016	13,338
2,273	500	75	0.4	480	A		3	I	D	11,531	12,799
2,274	500	75	0.4	240	A		3	I	D	12,811	14,220
2,275	500	75	0.4	480	A		3	I	D	12,326	13,682
2,276	500	90	0.3	240	A	16	3	I	R	18,557	11,802
2,277	500	90	0.3	240	A	16	3	S	R	17,936	11,407
2,278	500	108	0.3	240	A	16	3	I	R	19,871	12,638
2,279	500	108	0.3	240	A	16	3	S	R	18,871	12,002
2,280	500	120	0.4	240	A		3	I	D	13,537	15,026
2,281	500	120	0.4	480	A		3	I	D	12,785	14,191
2,282	500	120	0.4	240	A		3	I	D	14,332	15,909
2,283	500	120	0.4	480	A		3	I	D	13,580	15,074
2,284	500	144	0.3	240	A	16	3	I	R	20,234	12,869
2,285	500	144	0.3	240	A	16	3	S	R	19,221	12,225
2,286	500	210	0.4	240	A		3	I	D	16,567	18,389
2,287	500	210	0.4	480	A		3	I	D	14,976	16,623
2,288	500	210	0.4	240	A		3	I	D	17,362	19,272
2,289	500	210	0.4	480	A		3	I	D	15,771	17,506
2,290	500	300	0.4	240	A		3	I	D	19,370	21,501
2,291	500	300	0.4	480	A		3	I	D	17,398	19,312
2,292	500	300	0.4	240	A		3	I	D	20,165	22,383
2,293	500	300	0.4	480	A		3	I	D	18,193	20,194
2,294	500	390	0.4	240	A		3	I	D	22,575	25,058
2,295	500	390	0.4	480	A		3	I	D	19,718	21,887
2,296	500	390	0.4	240	A		3	I	D	23,370	25,941

Table A.3. Electric Storage Water Heaters (contd)

REC	VOL	INP	STBY	VOLT	TANK	RVAL	WARR	THERM	CTYPE	LCOST	CCOST
2,297	500	390	0.4	480	A		3	I	D	20,513	22,769
2,298	500	480	0.4	240	A		3	I	D	25,025	27,778
2,299	500	480	0.4	480	A		3	I	D	21,867	24,272
2,300	500	480	0.4	240	A		3	I	D	25,820	28,660
2,301	500	480	0.4	480	A		3	I	D	22,662	25,155
2,302	600	15	0.3	240	A	16	3	I	R	17,845	11,349
2,303	600	15	0.3	240	A	16	3	S	R	16,857	10,721
2,304	600	18	0.3	240	A	16	3	I	R	18,946	12,050
2,305	600	18	0.3	240	A	16	3	S	R	17,983	11,437
2,306	600	30	0.3	240	A	16	3	I	R	18,971	12,066
2,307	600	30	0.3	240	A	16	3	S	R	18,021	11,461
2,308	600	36	0.3	240	A	16	3	I	R	19,009	12,090
2,309	600	36	0.3	240	A	16	3	S	R	18,057	11,484
2,310	600	45	0.3	240	A	16	3	I	R	19,046	12,113
2,311	600	45	0.3	240	A	16	3	S	R	18,096	11,509
2,312	600	54	0.3	240	A	16	3	I	R	19,084	12,137
2,313	600	54	0.3	240	A	16	3	S	R	18,132	11,532
2,314	600	72	0.3	240	A	16	3	I	R	19,859	12,630
2,315	600	72	0.3	240	A	16	3	S	R	18,869	12,001
2,316	600	90	0.3	240	A	16	3	I	R	20,609	13,107
2,317	600	90	0.3	240	A	16	3	S	R	19,571	12,447
2,318	600	108	0.3	240	A	16	3	I	R	21,710	13,808
2,319	600	108	0.3	240	A	16	3	S	R	20,634	13,123
2,320	600	144	0.3	240	A	16	3	I	R	22,091	14,050
2,321	600	144	0.3	240	A	16	3	S	R	20,984	13,346
2,322	700	15	0.3	240	A	16	3	I	R	19,946	12,686
2,323	700	15	0.3	240	A	16	3	S	R	18,871	12,002
2,324	700	18	0.3	240	A	16	3	I	R	19,960	12,695
2,325	700	18	0.3	240	A	16	3	S	R	18,908	12,025
2,326	700	30	0.3	240	A	16	3	I	R	19,970	12,701
2,327	700	30	0.3	240	A	16	3	S	R	18,946	12,050
2,328	700	36	0.3	240	A	16	3	I	R	19,871	12,638
2,329	700	36	0.3	240	A	16	3	S	R	18,958	12,057
2,330	700	45	0.3	240	A	16	3	I	R	19,896	12,654
2,331	700	45	0.3	240	A	16	3	S	R	18,976	12,069
2,332	700	54	0.3	240	A	16	3	I	R	20,047	12,750
2,333	700	54	0.3	240	A	16	3	S	R	19,046	12,113
2,334	700	72	0.3	240	A	16	3	I	R	20,972	13,338
2,335	700	72	0.3	240	A	16	3	S	R	19,928	12,674
2,336	700	90	0.3	240	A	16	3	I	R	21,434	13,632
2,337	700	90	0.3	240	A	16	3	S	R	20,365	12,952
2,338	700	108	0.3	240	A	16	3	I	R	21,910	13,935
2,339	700	108	0.3	240	A	16	3	S	R	20,816	13,239
2,340	700	144	0.3	240	A	16	3	I	R	23,211	14,762
2,341	700	144	0.3	240	A	16	3	S	R	22,035	14,014

Table A.3. Electric Storage Water Heaters (contd)

REC	VOL	INP	STBY	VOLT	TANK	RVAL	WARR	THERM	CTYPE	LCOST	CCOST
2,342	800	15	0.3	240	A	16	3	I	R	21,559	13,712
2,343	800	15	0.3	240	A	16	3	S	R	19,716	12,539
2,344	800	18	0.3	240	A	16	3	I	R	21,586	13,729
2,345	800	18	0.3	240	A	16	3	S	R	20,504	13,041
2,346	800	30	0.3	240	A	16	3	I	R	21,604	13,740
2,347	800	30	0.3	240	A	16	3	S	R	20,523	13,053
2,348	800	36	0.3	240	A	16	3	I	R	21,660	13,776
2,349	800	36	0.3	240	A	16	3	S	R	20,572	13,084
2,350	800	45	0.3	240	A	16	3	I	R	21,710	13,808
2,351	800	45	0.3	240	A	16	3	S	R	20,628	13,119
2,352	800	54	0.3	240	A	16	3	I	R	22,135	14,078
2,353	800	54	0.3	240	A	16	3	S	R	21,023	13,371
2,354	800	72	0.3	240	A	16	3	I	R	22,197	14,117
2,355	800	72	0.3	240	A	16	3	S	R	21,091	13,414
2,356	800	90	0.3	240	A	16	3	I	R	22,411	14,253
2,357	800	90	0.3	240	A	16	3	S	R	21,290	13,540
2,358	800	108	0.3	240	A	16	3	I	R	23,161	14,730
2,359	800	108	0.3	240	A	16	3	S	R	21,991	13,986
2,360	800	144	0.3	240	A	16	3	I	R	24,299	15,454
2,361	800	144	0.3	240	A	16	3	S	R	23,086	14,683
2,362	1,000	15	0.3	240	A	16	3	I	R	23,622	15,024
2,363	1,000	15	0.3	240	A	16	3	S	R	22,366	14,225
2,364	1,000	18	0.3	240	A	16	3	I	R	23,586	15,001
2,365	1,000	18	0.3	240	A	16	3	S	R	22,411	14,253
2,366	1,000	30	0.3	240	A	16	3	I	R	23,617	15,020
2,367	1,000	30	0.3	240	A	16	3	S	R	22,435	14,269
2,368	1,000	36	0.3	240	A	16	3	I	R	23,649	15,041
2,369	1,000	36	0.3	240	A	16	3	S	R	22,467	14,289
2,370	1,000	45	0.3	240	A	16	3	I	R	23,723	15,088
2,371	1,000	45	0.3	240	A	16	3	S	R	22,535	14,332
2,372	1,000	54	0.3	240	A	16	3	I	R	23,747	15,103
2,373	1,000	54	0.3	240	A	16	3	S	R	22,573	14,356
2,374	1,000	72	0.3	240	A	16	3	I	R	23,854	15,171
2,375	1,000	72	0.3	240	A	16	3	S	R	22,660	14,412
2,376	1,000	90	0.3	240	A	16	3	I	R	23,949	15,232
2,377	1,000	90	0.3	240	A	16	3	S	R	22,741	14,463
2,378	1,000	108	0.3	240	A	16	3	I	R	24,498	15,581
2,379	1,000	108	0.3	240	A	16	3	S	R	23,273	14,802
2,380	1,000	144	0.3	240	A	16	3	I	D	25,631	16,301
2,381	1,000	144	0.3	240	A	16	3	S	R	23,585	15,000

Table A.4. Unfired Hot Water Storage Tanks

REC	VOL	RVAL	TANK	LIN	ORIENT	PRESS	WARR	CTYPE	LCOST	CCOST
2,382	40		S	S	V	150	10	D	235	282
2,383	40	16	S	S	V	150	10	D	272	326
2,384	40		S	S	V		5	R	576	490
2,385	80	16	S	G	V	150	5	R	654	432
2,386	80		A	G	V	160	5	D	992	1,091
2,387	80	13	A	G	V	125	5	D	990	1,089
2,388	80	16	A	E	V	160	5	R	1,100	605
2,389	80		S	S	V	150	10	D	345	414
2,390	80	16	S	S	V	150	10	D	380	456
2,391	80	16	S	G	V		5	D	524	576
2,392	80		S	G	V	160	5	D	550	605
2,393	80		S	S	V		5	R	873	742
2,394	80		S	G	V	150	5	D	550	605
2,395	90	16	S	G	V	150	5	R	962	635
2,396	120	16	A	E	V	160	5	R	2,300	1,265
2,397	120	16	A	G	V	150	5	R	1,881	1,241
2,398	120	16	S	G	V		5	D	604	664
2,399	120	16	S	G	V	150	5	R	962	635
2,400	120	16	S	G	V	150	5	R	2,116	1,397
2,401	120	16	A	G	V		5	D	1,339	1,473
2,402	120		A	G	V	160	5	D	1,036	1,140
2,403	120	13	A	G	V	125	5	D	1,165	1,282
2,404	120		S	S	V	150	5	D	462	554
2,405	120	16	S	S	V	150	5	D	516	619
2,406	120		S	G	V	160	5	D	565	622
2,407	120		S	S	V		5	R	1,100	935
2,408	120		S	G	V	150	5	D	571	628
2,409	140	13	A	G	V	125	5	D	1,637	1,801
2,410	180		A	G	V	160	5	D	1,513	1,664
2,411	180	16	A	E	V	160	5	R	2,550	1,403
2,412	180		S	G	V	160	5	D	1,039	1,143
2,413	200	13	A	G	H	125	5	D	3,063	3,369
2,414	200	16	A	G	V		5	D	1,897	2,087
2,415	200	13	A	G	V	125	5	D	1,823	2,005
2,416	200	16	A	G	V	150	5	R	3,106	2,050
2,417	220	16	A	G	V	125	5	R	6,741	4,449
2,418	220	16	A	G	V	150	5	R	7,703	5,084
2,419	220	16	A	E	V	125	5	R	6,409	4,230
2,420	220	16	A	E	V	150	5	R	6,879	4,540
2,421	230		A	E	V			R	1,975	1,086
2,422	260	16	A	G	V	125	5	R	7,932	5,235
2,423	260	16	A	G	V	150	5	R	8,275	5,462
2,424	260	16	A	E	V	125	5	R	7,342	4,846
2,425	260	16	A	E	V	150	5	R	7,812	5,156
2,426	300	16	A	G	H	125	5	R	10,201	6,733

Table A.4. Unfired Hot Water Storage Tanks (contd)

REC	VOL	RVAL	TANK	LIN	ORIENT	PRESS	WARR	CTYPE	LCOST	CCOST
2,427	300	16	A	G	H	150	5	R	10,996	7,257
2,428	300	16	A	E	H	125	5	R	9,826	6,485
2,429	300	16	A	E	H	150	5	R	10,408	6,869
2,430	320	16	A	E	V	125	5	R	4,981	3,287
2,431	320	16	A	G	V	125	5	R	8,227	5,430
2,432	320	16	A	G	V	150	5	R	9,236	6,096
2,433	320	16	A	E	V	125	5	R	7,678	5,067
2,434	320	16	A	E	V	150	5	R	8,262	5,453
2,435	330		A	E	V			R	2,265	1,246
2,436	350	13	A	G	H	125	5	D	3,732	4,105
2,437	350	13	A	G	V	125	5	D	3,416	3,758
2,438	400	13	A	G	H	125	5	D	4,416	4,858
2,439	400	16	A	G	H	125	5	R	11,176	7,376
2,440	400	16	A	G	H	150	5	R	12,030	7,940
2,441	400	16	A	E	H	125	5	R	10,574	6,979
2,442	400	16	A	E	H	150	5	R	11,161	7,366
2,443	400	13	A	G	V	125	5	D	3,874	4,261
2,444	430	16	A	E	V	125	5	R	5,915	3,904
2,445	430	16	A	G	V	125	5	R	11,429	7,543
2,446	430	16	A	G	V	150	5	R	12,506	8,254
2,447	430	16	A	E	V	125	5	R	9,192	6,067
2,448	430	16	A	E	V	150	5	R	9,888	6,526
2,449	500	13	A	G	H	125	5	D	5,667	6,234
2,450	500	13	A	G	H	125	5	D	5,864	6,450
2,451	500	16	A	G	H	125	5	R	15,988	10,552
2,452	500	16	A	G	H	150	5	R	16,813	11,097
2,453	500	16	A	E	H	125	5	R	12,860	8,488
2,454	500	16	A	E	H	150	5	R	13,568	8,955
2,455	500	13	A	G	V	125	5	D	5,327	5,860
2,456	500	13	A	G	V	125	5	D	5,517	6,069
2,457	500	16	A	E	V	125	5	R	6,144	4,055
2,458	500	16	A	G	V	125	5	R	11,830	7,808
2,459	500	16	A	G	V	150	5	R	12,784	8,437
2,460	500	16	A	E	V	125	5	R	9,629	6,355
2,461	500	16	A	E	V	150	5	R	10,333	6,820
2,462	530		A	E	V			R	2,665	1,466
2,463	600	16	A	G	H	125	5	R	17,752	11,716
2,464	600	16	A	G	H	150	5	R	18,644	12,305
2,465	600	16	A	E	H	125	5	R	13,429	8,863
2,466	600	16	A	E	H	150	5	R	14,141	9,333
2,467	700	16	A	G	H	125	5	R	18,243	12,040
2,468	700	16	A	G	H	150	5	R	19,227	12,690
2,469	700	16	A	E	H	125	5	R	14,311	9,445
2,470	700	16	A	E	H	150	5	R	15,013	9,909
2,471	750	13	A	G	H	125	5	D	7,468	8,215

Table A.4. Unfired Hot Water Storage Tanks (contd)

REC	VOL	RVAL	TANK	LIN	ORIENT	PRESS	WARR	CTYPE	LCOST	CCOST
2,472	750	13	A	G	V	125	5	D	7,059	7,765
2,473	750	16	A	G	V	125	5	R	16,166	10,670
2,474	750	16	A	G	V	150	5	R	17,034	11,242
2,475	750	16	A	E	V	125	5	R	12,385	8,174
2,476	750	16	A	E	V	150	5	R	12,790	8,441
2,477	800	16	A	G	H	125	5	R	21,261	14,032
2,478	800	16	A	G	H	150	5	R	22,629	14,935
2,479	800	16	A	E	H	125	5	R	15,552	10,264
2,480	800	16	A	E	H	150	5	R	15,984	10,549
2,481	940	16	A	G	V	125	5	R	18,314	12,087
2,482	940	16	A	G	V	150	5	R	19,379	12,790
2,483	940	16	A	E	V	125	5	R	13,518	8,922
2,484	940	16	A	E	V	150	5	R	13,925	9,191
2,485	1,000	13	A	G	H	125	5	D	9,691	10,660
2,486	1,000	16	A	G	H	125	5	R	22,717	14,993
2,487	1,000	16	A	G	H	150	5	R	23,795	15,705
2,488	1,000	16	A	E	H	125	5	R	16,420	10,837
2,489	1,000	16	A	E	H	150	5	R	17,555	11,586
2,490	1,000	13	A	G	V	125	5	D	9,161	10,077
2,491	1,250	16	A	G	H	125	5	R	27,926	18,431
2,492	1,250	16	A	G	H	150	5	R	29,318	19,350
2,493	1,250	16	A	E	H	125	5	R	17,150	11,319
2,494	1,250	16	A	E	H	150	5	R	17,624	11,632
2,495	1,250	16	A	G	V	125	5	R	24,207	15,977
2,496	1,250	16	A	G	V	150	5	R	25,953	17,129
2,497	1,250	16	A	E	V	125	5	R	15,503	10,232
2,498	1,250	16	A	E	V	150	5	R	15,976	10,544
2,499	1,500	16	A	G	H	125	5	R	30,617	20,207
2,500	1,500	16	A	G	H	150	5	R	35,344	23,327
2,501	1,500	16	A	E	H	125	5	R	19,367	12,782
2,502	1,500	16	A	E	H	150	5	R	19,886	13,125
2,503	1,500	16	A	G	V	125	5	R	26,096	17,223
2,504	1,500	16	A	G	V	150	5	R	30,954	20,430
2,505	1,500	16	A	E	V	125	5	R	17,054	11,256
2,506	1,500	16	A	E	V	150	5	R	17,580	11,603
2,507	2,000	16	A	G	H	125	5	R	37,790	24,941
2,508	2,000	16	A	E	H	125	5	R	23,395	15,441
2,509	2,000	16	A	E	H	150	5	R	24,195	15,969
2,510	2,000	16	A	G	V	125	5	R	36,231	23,912
2,511	2,000	16	A	G	V	150	5	R	36,231	23,912
2,512	2,000	16	A	E	V	125	5	R	20,329	13,417
2,513	2,000	16	A	E	V	150	5	R	21,125	13,943
2,514	2,500	16	A	G	H	125	5	R	44,524	29,386
2,515	2,500	16	A	E	H	125	5	R	24,859	16,407
2,516	2,500	16	A	E	H	150	5	R	25,936	17,118

Table A.4. Unfired Hot Water Storage Tanks (contd)

REC	VOL	RVAL	TANK	LIN	ORIENT	PRESS	WARR	CTYPE	LCOST	CCOST
2,517	2,500	16	A	G	V	125	5	R	38,580	25,463
2,518	2,500	16	A	G	V	150	5	R	38,580	25,463
2,519	2,500	16	A	E	V	125	5	R	23,352	15,412
2,520	2,500	16	A	E	V	150	5	R	24,436	16,128

Table A.5. Packaged Boilers

REC	TYPE	FUEL	INPUT	EFF	EXCH	IGN	BURN	VENT	CTYPE	LCOST	CCOST
2,521	W	G	120	80	C	E	A		D	4,102	4,553
2,522	W	G	250	88	C	E	P	N	R	6,390	4,217
2,523	W	G	300	84	C	E	P	N	R	3,133	2,068
2,524	W	G	300	84	C	E	P	N	R	3,373	2,226
2,525	W	G	300	82	C	E	A	N	D	2,064	2,291
2,526	W	G	320	81	C	E	A	N	R	2,211	1,459
2,527	W	G	320	81	C	E	A	N	R	2,361	1,558
2,528	W	G	320	80	C	E	A		D	1,920	2,131
2,529	W	G	320	80	C	E	A		D	2,014	2,236
2,530	W	G	330	82	C	E	A		R	3,195	1,757
2,531	W	G	360	81	C	E	A	N	R	2,320	1,531
2,532	W	G	360	81	C	E	A	N	R	2,492	1,645
2,533	W	G	360	80	C	E	A		D	1,986	2,204
2,534	W	G	360	80	C	E	A		D	2,090	2,320
2,535	W	G	400	80	C	E	A	N	R	3,082	2,034
2,536	W	G	400	80	C	E	A	N	R	3,295	2,175
2,537	W	G	400	81	C	E	A	N	D	2,516	2,793
2,538	W	G	400	82	C	E	A		R	3,326	1,829
2,539	W	G	400	84	C	E	P	N	R	4,202	2,773
2,540	W	G	400	84	C	E	P	N	R	4,482	2,958
2,541	W	G	410	83	C	E	A	Y	R	7,720	5,790
2,542	W	G	420	82	C	E	A	N	D	2,516	2,793
2,543	W	G	480	80	C	E	A		D	2,777	3,082
2,544	W	G	480	80	C	E	A		D	2,923	3,245
2,545	W	G	490	83	C	E	A	Y	R	7,815	5,861
2,546	W	G	500	80	C	E	A	N	R	3,676	2,426
2,547	W	G	500	84	C	E	P	N	R	5,013	3,309
2,548	W	G	500	88	C	E	P	N	R	8,537	5,634
2,549	W	G	500	80	C	E	A	N	R	3,950	2,607
2,550	W	G	500	84	C	E	P	N	R	5,403	3,566
2,551	W	G	500	88	C	E	P	N	D	5,274	5,854
2,552	W	G	510	82	C	E	A		R	4,804	2,642
2,553	W	G	520	82	C	E	A	N	D	2,895	3,213
2,554	W	G	570	80	C	E	A		D	3,205	3,558
2,555	W	G	570	80	C	E	A		D	3,371	3,742
2,556	W	G	600	83	C	E	A	Y	R	8,002	6,002
2,557	W	G	630	82	C	E	A		R	5,291	2,910
2,558	W	G	650	84	C	E	P	N	R	5,280	3,485
2,559	W	G	650	84	C	E	P	N	R	5,720	3,775
2,560	W	G	670	80	C	E	A	N	R	3,851	2,542
2,561	W	G	670	80	C	E	A	N	R	4,203	2,774
2,562	W	G	670	80	C	E	A		D	3,310	3,674
2,563	W	G	670	80	C	E	A		D	3,502	3,887
2,564	W	G	670	75	C	E	A	N	D	3,309	3,673
2,565	W	G	700	83	C	E	A	Y	R	8,109	6,082

Table A.5. Packaged Boilers (contd)

REC	TYPE	FUEL	INPUT	EFF	EXCH	IGN	BURN	VENT	CTYPE	LCOST	CCOST
2,566	W	G	720	82	C	E	A	N	D	2,385	2,647
2,567	W	G	730	82	C	E	A		R	5,699	3,134
2,568	W	G	750	84	C	E	P	N	R	5,451	3,598
2,569	W	G	750	88	C	E	P	N	R	9,315	6,148
2,570	W	G	750	84	C	E	P	N	R	4,901	3,235
2,571	W	G	750	88	C	E	P	N	D	5,766	6,400
2,572	W	G	760	80	C	E	A	N	R	3,998	2,639
2,573	W	G	760	80	C	E	A	N	R	4,382	2,892
2,574	W	G	760	80	C	E	A		D	3,422	3,798
2,575	W	G	760	80	C	E	A		D	3,630	4,029
2,576	W	G	810	83	C	E	A	Y	R	8,670	6,503
2,577	W	G	830	82	C	E	A		R	6,209	3,415
2,578	W	G	840	82	C	E	A	N	D	2,520	2,797
2,579	W	G	860	80	C	E	A		D	3,728	4,138
2,580	W	G	860	80	C	E	A		D	3,962	4,398
2,581	W	G	940	80	C	E	A	N	R	4,866	3,212
2,582	W	G	940	80	C	E	A	N	R	5,333	3,520
2,583	W	G	940	80	C	E	A		D	3,845	4,268
2,584	W	G	940	80	C	E	A		D	4,105	4,557
2,585	W	G	950	83	C	E	A	Y	R	9,052	6,789
2,586	W	G	960	82	C	E	A	N	D	2,700	2,997
2,587	W	G	960	82	C	E	A		R	6,540	3,597
2,588	W	G	990	84	C	E	P	N	R	6,756	4,459
2,589	W	G	990	84	C	E	P	N	R	7,226	4,769
2,590	W	G	1,000	88	C	E	P	N	R	10,104	6,669
2,591	W	G	1,000	88	C	E	P	N	D	6,150	6,827
2,592	W	G	1,080	82	C	E	A	N	D	2,880	3,197
2,593	W	G	1,110	83	C	E	A	Y	R	9,472	7,104
2,594	W	G	1,120	80	C	E	A		D	4,404	4,888
2,595	W	G	1,120	82	C	E	A		R	6,894	3,792
2,596	W	G	1,210	80	C	E	A	N	R	5,829	3,847
2,597	W	G	1,210	80	C	E	A	N	R	6,425	4,241
2,598	W	G	1,210	80	C	E	A		D	4,346	4,824
2,599	W	G	1,210	80	C	E	A		D	4,674	5,188
2,600	W	G	1,210	82	C	E	A	N	D	3,060	3,397
2,601	W	G	1,220	82	C	E	A		R	7,420	4,081
2,602	W	G	1,240	80	C	E	A	N	D	6,046	6,711
2,603	W	G	1,260	84	C	E	P	N	R	8,092	5,341
2,604	W	G	1,260	84	C	E	P	N	R	8,692	5,737
2,605	W	G	1,300	83	C	E	A	Y	R	9,900	7,425
2,606	W	G	1,340	82	C	E	A		R	8,321	4,577
2,607	W	G	1,340	76	C	E	A	N	D	6,519	7,236
2,608	W	G	1,350	80	C	E	A		D	4,847	5,380
2,609	W	G	1,350	80	C	E	A		D	5,216	5,790
2,610	W	G	1,350	82	C	E	A	N	D	3,465	3,846

Table A.5. Packaged Boilers (contd)

REC	TYPE	FUEL	INPUT	EFF	EXCH	IGN	BURN	VENT	CTYPE	LCOST	CCOST
2,611	W	G	1,440	84	C	E	P	N	R	8,243	5,440
2,612	W	G	1,440	84	C	E	P	N	R	8,983	5,929
2,613	W	G	1,470	82	C	E	A		R	8,837	4,860
2,614	W	G	1,480	82	C	E	A	N	D	3,645	4,046
2,615	W	G	1,520	83	C	E	A	Y	R	10,417	7,813
2,616	W	G	1,540	80	C	E	A	N	R	6,382	4,212
2,617	W	G	1,540	80	C	E	A	N	R	7,150	4,719
2,618	W	G	1,540	80	C	E	A		D	5,137	5,702
2,619	W	G	1,540	80	C	E	A		D	5,553	6,164
2,620	W	G	1,610	82	C	E	A	N	D	3,960	4,396
2,621	W	G	1,630	82	C	E	A		R	9,436	5,190
2,622	W	G	1,690	80	C	E	A	N	R	6,812	4,496
2,623	W	G	1,690	80	C	E	A	N	R	7,638	5,041
2,624	W	G	1,690	80	C	E	A		D	5,561	6,173
2,625	W	G	1,690	80	C	E	A		D	6,013	6,674
2,626	W	G	1,770	83	C	E	A	Y	R	10,770	8,078
2,627	W	G	1,800	84	C	E	P	N	R	8,759	5,781
2,628	W	G	1,800	84	C	E	P	N	R	9,679	6,388
2,629	W	G	1,810	82	C	E	A	N	D	4,320	4,795
2,630	W	G	1,830	82	C	E	A		R	10,329	5,681
2,631	W	G	1,880	83	C	E	A	Y	R	14,033	10,524
2,632	W	G	2,000	80	C	E	A	N	R	8,784	5,797
2,633	W	G	2,000	80	C	E	A	N	R	9,746	6,432
2,634	W	G	2,000	80	C	E	A		D	6,769	7,514
2,635	W	G	2,000	80	C	E	A		D	7,289	8,091
2,636	W	G	2,070	84	C	E	P	N	R	11,292	7,453
2,637	W	G	2,070	84	C	E	P	N	R	12,282	8,106
2,638	W	G	2,100	82	C	E	A		R	12,666	6,966
2,639	W	G	2,200	83	C	E	A	Y	R	14,918	11,188
2,640	W	G	2,310	80	C	E	A	N	R	9,193	6,067
2,641	W	G	2,310	80	C	E	A	N	R	10,281	6,785
2,642	W	G	2,310	80	C	E	A		D	7,077	7,855
2,643	W	G	2,310	80	C	E	A		D	7,670	8,514
2,644	W	G	2,500	82	C	E	A		R	13,528	7,440
2,645	W	G	2,570	83	C	E	A	Y	R	15,908	11,931
2,646	W	G	2,620	80	C	E	A	N	R	10,201	6,733
2,647	W	G	2,620	80	C	E	A	N	R	11,417	7,535
2,648	W	G	2,620	80	C	E	A		D	7,835	8,697
2,649	W	G	2,620	80	C	E	A		D	8,501	9,436
2,650	W	G	3,000	83	C	E	A	Y	R	18,630	13,973
2,651	W	G	3,000	82	C	E	A		R	16,115	8,863
2,652	W	G	3,080	80	C	E	A	N	R	11,608	7,661
2,653	W	G	3,080	80	C	E	A	N	R	13,024	8,596
2,654	W	G	3,080	80	C	E	A		D	8,598	9,544
2,655	W	G	3,080	80	C	E	A		D	9,373	10,404

Table A.5. Packaged Boilers (contd)

REC	TYPE	FUEL	INPUT	EFF	EXCH	IGN	BURN	VENT	CTYPE	LCOST	CCOST
2,656	W	G	3,490	83	C	E	A	Y	R	19,770	14,828
2,657	W	G	3,500	82	C	E	A		R	17,517	9,634
2,658	W	G	4,000	82	C	E	A		R	18,921	10,407
2,659	W	G	4,000	83	C	E	A	Y	R	20,580	15,435
2,660	S	G	100	80	I	E	A	N	R	7,287	4,372
2,661	W	G	300	83	I	E	P	N	R	4,752	2,614
2,662	W	G	300	80	I	E	A	N	R	3,608	1,984
2,663	S	G	300	80	I	E	A	N	R	3,908	2,149
2,664	W	G	300	80	I	P	A	N	R	2,209	1,336
2,665	W	G	300	80	I	E	A	Y	R	2,494	1,509
2,666	W	G	300	80	I	E	A	N	R	2,330	1,410
2,667	W	G	300	80	I	P	A	N	R	2,641	1,664
2,668	S	G	300	80	I	P	A	N	R	2,751	1,733
2,669	W	G	300	80	I	E	A	N	R	2,953	1,772
2,670	S	G	300	80	I	E	A	N	R	3,122	1,873
2,671	W	G	310	81	I	E	A	N	R	1,922	1,518
2,672	W	G	310	81	I	P	A	N	R	1,810	1,430
2,673	W	G	330	80	I	P	A	N	R	2,428	1,469
2,674	W	G	330	80	I	E	A	Y	R	2,712	1,641
2,675	W	G	330	80	I	E	A	N	R	2,549	1,542
2,676	W	G	340	80	I	E	P	N	R	5,223	3,656
2,677	S	G	340	80	I	E	P	N	R	5,212	3,648
2,678	S	G	350	82	I	E	P	Y	R	5,224	3,657
2,679	W	G	350	82	I	E	P	Y	R	5,224	3,657
2,680	W	G	350	80	I	P	A	N	R	2,606	1,577
2,681	W	G	350	80	I	E	A	Y	R	2,892	1,750
2,682	W	G	350	80	I	E	A	N	R	2,727	1,650
2,683	S	G	350	80	I	E	A	N	R	2,764	2,184
2,684	W	G	350	80	I	E	A	N	R	2,561	2,023
2,685	S	G	350	80	I	P	A	N	R	2,639	2,085
2,686	W	G	350	80	I	P	A	N	R	2,433	1,922
2,687	W	G	370	81	I	E	A	N	R	2,324	1,836
2,688	W	G	370	81	I	P	A	N	R	2,210	1,746
2,689	W	G	370	83	I	E	P	N	R	5,096	2,803
2,690	W	G	380	80	I	P	A	N	R	2,802	1,695
2,691	W	G	380	80	I	E	A	Y	R	3,088	1,868
2,692	W	G	380	80	I	E	A	N	R	2,922	1,768
2,693	W	G	400	80	I	P	A	N	R	3,050	1,922
2,694	S	G	400	80	I	P	A	N	R	3,163	1,993
2,695	W	G	400	80	I	E	A	N	R	4,079	2,243
2,696	S	G	400	80	I	E	A	N	R	4,380	2,409
2,697	W	G	400	80	I	P	A	N	R	3,050	1,922
2,698	S	G	400	80	I	P	A	N	R	3,163	1,993
2,699	W	G	400	80	I	E	A	N	R	3,568	2,141
2,700	S	G	400	80	I	E	A	N	R	3,738	2,243

Table A.5. Packaged Boilers (contd)

REC	TYPE	FUEL	INPUT	EFF	EXCH	IGN	BURN	VENT	CTYPE	LCOST	CCOST
2,701	S	G	400	80	I	E	A	N	R	3,012	2,379
2,702	W	G	400	80	I	E	A	N	R	2,809	2,219
2,703	S	G	400	80	I	P	A	N	R	2,888	2,282
2,704	W	G	400	80	I	P	A	N	R	2,682	2,119
2,705	W	G	420	80	I	E	P	N	R	7,132	4,992
2,706	S	G	420	80	I	E	P	N	R	6,943	4,860
2,707	W	G	430	81	I	E	A	N	R	2,711	2,142
2,708	W	G	450	83	I	E	P	N	R	5,520	3,036
2,709	S	G	450	80	I	E	A	N	R	3,401	2,687
2,710	W	G	450	80	I	E	A	N	R	3,198	2,526
2,711	S	G	490	82	I	E	P	Y	R	6,091	4,264
2,712	W	G	490	82	I	E	P	Y	R	6,091	4,264
2,713	W	G	500	80	I	E	A	N	R	4,550	2,503
2,714	S	G	500	80	I	E	A	N	R	4,860	2,673
2,715	W	G	500	80	I	P	A	N	R	3,602	2,269
2,716	S	G	500	80	I	P	A	N	R	3,717	2,342
2,717	W	G	500	80	I	E	A	N	R	4,039	2,423
2,718	S	G	500	80	I	E	A	N	R	4,209	2,525
2,719	S	G	500	80	I	E	A	N	R	3,621	2,861
2,720	W	G	500	80	I	E	A	N	R	3,418	2,700
2,721	S	G	550	80	I	E	A	N	R	3,872	3,059
2,722	W	G	550	80	I	E	A	N	R	3,669	2,899
2,723	W	G	560	80	I	E	P	N	R	8,069	5,648
2,724	W	G	560	83	I	E	P	N	R	7,644	4,204
2,725	S	G	570	80	I	E	P	N	R	7,900	5,530
2,726	W	G	600	83	I	E	P	N	R	9,504	5,227
2,727	W	G	600	80	I	E	A	N	R	6,149	3,382
2,728	S	G	600	80	I	E	A	N	R	6,458	3,552
2,729	W	G	600	80	I	P	A	N	R	4,469	2,815
2,730	S	G	600	80	I	P	A	N	R	4,646	2,927
2,731	W	G	600	80	I	E	A	N	R	4,917	2,950
2,732	S	G	600	80	I	E	A	N	R	5,097	3,058
2,733	S	G	640	82	I	E	P	Y	R	6,622	4,635
2,734	W	G	640	82	I	E	P	Y	R	6,622	4,635
2,735	W	G	650	81	I	E	A	N	R	6,347	5,014
2,736	S	G	650	81	I	E	A	N	R	6,545	5,171
2,737	W	G	680	83	I	E	P	N	R	8,280	4,554
2,738	W	G	700	80	I	E	A	N	R	6,667	3,667
2,739	S	G	700	80	I	E	A	N	R	6,932	3,813
2,740	W	G	700	80	I	P	A	N	R	4,896	3,084
2,741	S	G	700	80	I	P	A	N	R	5,047	3,180
2,742	W	G	700	80	I	E	A	N	R	5,552	3,331
2,743	S	G	700	80	I	E	A	N	R	5,704	3,422
2,744	W	G	700	80	I	E	P	N	R	8,717	6,102
2,745	S	G	700	80	I	E	P	N	R	8,550	5,985

Table A.5. Packaged Boilers (contd)

REC	TYPE	FUEL	INPUT	EFF	EXCH	IGN	BURN	VENT	CTYPE	LCOST	CCOST
2,746	W	G	750	83	I	E	P	N	R	10,192	5,606
2,747	W	G	780	81	I	E	A	N	R	6,970	5,506
2,748	S	G	780	81	I	E	A	N	R	7,168	5,663
2,749	S	G	790	82	I	E	P	Y	R	7,575	5,303
2,750	W	G	790	82	I	E	P	Y	R	7,575	5,303
2,751	W	G	800	80	I	E	A	N	R	7,138	3,926
2,752	S	G	800	80	I	E	A	N	R	7,421	4,082
2,753	W	G	800	80	I	P	A	N	R	5,304	3,342
2,754	S	G	800	80	I	P	A	N	R	5,455	3,437
2,755	W	G	800	80	I	E	A	N	R	6,175	3,705
2,756	S	G	800	80	I	E	A	N	R	6,340	3,804
2,757	W	G	840	81	I	E	P	N	R	9,220	6,454
2,758	S	G	840	81	I	E	P	N	R	9,274	6,492
2,759	W	G	860	83	I	E	P	N	R	10,828	5,955
2,760	W	G	900	83	I	E	P	N	R	11,040	6,072
2,761	W	G	900	80	I	E	A	N	R	7,660	4,213
2,762	S	G	900	80	I	E	A	N	R	7,943	4,369
2,763	W	G	900	80	I	P	A	N	R	6,315	3,978
2,764	S	G	900	80	I	P	A	N	R	6,477	4,081
2,765	W	G	900	80	I	E	A	N	R	6,641	3,985
2,766	S	G	900	80	I	E	A	N	R	6,811	4,087
2,767	W	G	910	81	I	E	A	N	R	7,683	6,070
2,768	S	G	910	81	I	E	A	N	R	7,909	6,248
2,769	W	G	940	83	I	E	P	N	R	12,740	7,007
2,770	S	G	940	82	I	E	P	Y	R	8,233	5,763
2,771	W	G	940	82	I	E	P	Y	R	8,233	5,763
2,772	S	G	1,000	82	I	E	P	N	R	9,840	6,888
2,773	W	G	1,000	82	I	E	P	N	R	9,840	6,888
2,774	W	G	1,000	80	I	E	A	N	R	8,132	4,473
2,775	S	G	1,000	80	I	E	A	N	R	8,415	4,628
2,776	W	G	1,000	80	I	P	A	N	R	6,720	4,234
2,777	S	G	1,000	80	I	P	A	N	R	6,887	4,339
2,778	W	G	1,000	80	I	E	A	N	R	7,115	4,269
2,779	S	G	1,010	82	I	E	P	N	R	9,840	6,888
2,780	W	G	1,010	82	I	E	P	N	R	9,840	6,888
2,781	W	G	1,040	81	I	E	A	N	R	8,258	6,524
2,782	S	G	1,040	81	I	E	A	N	R	8,484	6,702
2,783	S	G	1,080	82	I	E	P	Y	R	9,124	6,387
2,784	W	G	1,080	82	I	E	P	Y	R	9,124	6,387
2,785	W	G	1,090	83	I	E	P	N	R	13,588	7,473
2,786	W	G	1,100	80	I	E	A	N	R	9,827	5,405
2,787	S	G	1,100	80	I	E	A	N	R	10,057	5,531
2,788	W	G	1,100	80	I	P	A	N	R	7,125	4,489
2,789	S	G	1,100	80	I	P	A	N	R	7,286	4,590
2,790	W	G	1,100	80	I	E	A	N	R	8,237	4,942

Table A.5. Packaged Boilers (contd)

REC	TYPE	FUEL	INPUT	EFF	EXCH	IGN	BURN	VENT	CTYPE	LCOST	CCOST
2,791	S	G	1,100	80	I	E	A	N	R	8,376	5,026
2,792	W	G	1,120	83	I	E	P	N	R	15,288	8,408
2,793	W	G	1,170	81	I	E	A	N	R	8,968	7,085
2,794	S	G	1,170	81	I	E	A	N	R	9,163	7,239
2,795	W	G	1,200	80	I	E	A	N	R	10,295	5,662
2,796	S	G	1,200	80	I	E	A	N	R	10,523	5,788
2,797	W	G	1,200	80	I	P	A	N	R	7,554	4,759
2,798	S	G	1,200	80	I	P	A	N	R	7,696	4,848
2,799	W	G	1,200	80	I	E	A	N	R	8,852	5,311
2,800	S	G	1,200	80	I	E	A	N	R	8,991	5,395
2,801	S	G	1,230	82	I	E	P	Y	R	9,650	6,755
2,802	W	G	1,230	82	I	E	P	Y	R	9,650	6,755
2,803	W	G	1,260	81	I	E	P	N	R	10,273	7,191
2,804	S	G	1,260	81	I	E	P	N	R	10,333	7,233
2,805	W	G	1,300	80	I	E	A	N	R	11,052	6,079
2,806	S	G	1,300	80	I	E	A	N	R	11,312	6,222
2,807	W	G	1,300	80	I	P	A	N	R	8,562	5,394
2,808	S	G	1,300	80	I	P	A	N	R	8,703	5,483
2,809	W	G	1,300	80	I	E	A	N	R	9,179	5,507
2,810	S	G	1,300	80	I	E	A	N	R	9,318	5,591
2,811	W	G	1,300	81	I	E	A	N	R	9,567	7,558
2,812	S	G	1,300	81	I	E	A	N	R	9,762	7,712
2,813	W	G	1,350	83	I	E	P	N	R	16,560	9,108
2,814	S	G	1,360	82	I	E	P	N	R	10,816	7,571
2,815	W	G	1,360	82	I	E	P	N	R	10,816	7,571
2,816	S	G	1,380	82	I	E	P	Y	R	10,219	7,153
2,817	W	G	1,380	82	I	E	P	Y	R	10,219	7,153
2,818	W	G	1,400	80	I	E	A	N	R	11,524	6,338
2,819	S	G	1,400	80	I	E	A	N	R	11,751	6,463
2,820	W	G	1,400	80	I	P	A	N	R	8,976	5,655
2,821	S	G	1,400	80	I	P	A	N	R	9,113	5,741
2,822	W	G	1,400	80	I	E	A	N	R	9,795	5,877
2,823	S	G	1,400	80	I	E	A	N	R	9,934	5,960
2,824	W	G	1,430	81	I	E	A	N	R	10,149	8,018
2,825	S	G	1,430	81	I	E	A	N	R	10,344	8,172
2,826	W	G	1,500	80	I	E	A	N	R	11,996	6,598
2,827	S	G	1,500	80	I	E	A	N	R	12,241	6,733
2,828	W	G	1,500	80	I	P	A	N	R	9,374	5,906
2,829	S	G	1,500	80	I	P	A	N	R	9,526	6,001
2,830	W	G	1,500	80	I	E	A	N	R	10,268	6,161
2,831	S	G	1,500	80	I	E	A	N	R	10,417	6,250
2,832	S	G	1,530	82	I	E	P	Y	R	10,838	7,587
2,833	W	G	1,530	82	I	E	P	Y	R	10,838	7,587
2,834	W	G	1,560	81	I	E	A	N	R	10,937	8,640
2,835	S	G	1,560	81	I	E	A	N	R	11,189	8,839

Table A.5. Packaged Boilers (contd)

REC	TYPE	FUEL	INPUT	EFF	EXCH	IGN	BURN	VENT	CTYPE	LCOST	CCOST
2,836	W	G	1,600	80	I	E	A	N	R	13,662	7,514
2,837	S	G	1,600	80	I	E	A	N	R	13,842	7,613
2,838	W	G	1,600	80	I	P	A	N	R	9,782	6,163
2,839	S	G	1,600	80	I	P	A	N	R	9,934	6,258
2,840	W	G	1,600	80	I	E	A	N	R	11,578	6,947
2,841	S	G	1,600	80	I	E	A	N	R	11,694	7,016
2,842	S	G	1,670	82	I	E	P	Y	R	11,458	8,021
2,843	W	G	1,670	82	I	E	P	Y	R	11,458	8,021
2,844	W	G	1,680	81	I	E	P	N	R	12,449	8,714
2,845	S	G	1,680	81	I	E	P	N	R	12,494	8,746
2,846	W	G	1,690	81	I	E	A	N	R	11,561	9,133
2,847	S	G	1,690	81	I	E	A	N	R	11,754	9,286
2,848	W	G	1,700	80	I	E	A	N	R	14,132	7,773
2,849	S	G	1,700	80	I	E	A	N	R	14,312	7,872
2,850	W	G	1,700	80	I	P	A	N	R	10,821	6,817
2,851	S	G	1,700	80	I	P	A	N	R	10,945	6,895
2,852	W	G	1,700	80	I	E	A	N	R	11,913	7,148
2,853	S	G	1,700	80	I	E	A	N	R	12,029	7,217
2,854	S	G	1,700	81	I	E	P	N	R	12,357	8,650
2,855	W	G	1,700	81	I	E	P	N	R	12,357	8,650
2,856	W	G	1,800	80	I	E	A	N	R	14,605	8,033
2,857	S	G	1,800	80	I	E	A	N	R	14,783	8,131
2,858	W	G	1,800	80	I	P	A	N	R	11,230	7,075
2,859	S	G	1,800	80	I	P	A	N	R	11,351	7,151
2,860	W	G	1,800	80	I	E	A	N	R	12,528	7,517
2,861	S	G	1,800	80	I	E	A	N	R	12,644	7,586
2,862	W	G	1,900	80	I	E	A	N	R	15,076	8,292
2,863	S	G	1,900	80	I	E	A	N	R	15,256	8,391
2,864	W	G	1,900	80	I	P	A	N	R	11,629	7,326
2,865	S	G	1,900	80	I	P	A	N	R	11,752	7,404
2,866	W	G	1,900	80	I	E	A	N	R	12,999	7,799
2,867	S	G	1,900	80	I	E	A	N	R	13,115	7,869
2,868	W	G	1,960	80	I	E	P	N	R	13,177	9,224
2,869	S	G	1,960	80	I	E	P	N	R	13,231	9,262
2,870	W	G	2,000	80	I	E	A	N	R	15,546	8,550
2,871	S	G	2,000	80	I	E	A	N	R	15,726	8,649
2,872	W	G	2,000	80	I	P	A	N	R	12,041	7,586
2,873	S	G	2,000	80	I	P	A	N	R	12,458	7,849
2,874	W	G	2,000	80	I	E	A	N	R	13,473	8,084
2,875	S	G	2,000	80	I	E	A	N	R	13,589	8,153
2,876	S	G	2,050	81	I	E	P	N	R	13,922	9,745
2,877	W	G	2,050	81	I	E	P	N	R	13,922	9,745
2,878	W	G	2,100	80	I	E	A	N	R	17,265	9,496
2,879	S	G	2,100	80	I	E	A	N	R	17,445	9,595
2,880	W	G	2,100	80	I	P	A	N	R	13,046	8,219

Table A.5. Packaged Boilers (contd)

REC	TYPE	FUEL	INPUT	EFF	EXCH	IGN	BURN	VENT	CTYPE	LCOST	CCOST
2,881	S	G	2,100	80	I	P	A	N	R	13,462	8,481
2,882	W	G	2,100	80	I	E	A	N	R	14,420	8,652
2,883	S	G	2,100	80	I	E	A	N	R	14,536	8,722
2,884	W	G	2,200	80	I	E	A	N	R	17,739	9,756
2,885	S	G	2,200	80	I	E	A	N	R	17,918	9,855
2,886	W	G	2,200	80	I	P	A	N	R	13,458	8,479
2,887	S	G	2,200	80	I	P	A	N	R	13,871	8,739
2,888	W	G	2,200	80	I	E	A	N	R	15,180	9,108
2,889	S	G	2,200	80	I	E	A	N	R	15,295	9,177
2,890	W	G	2,300	80	I	E	A	N	R	18,209	10,015
2,891	S	G	2,300	80	I	E	A	N	R	18,388	10,113
2,892	W	G	2,300	80	I	P	A	N	R	13,850	8,726
2,893	S	G	2,300	80	I	P	A	N	R	14,276	8,994
2,894	W	G	2,300	80	I	E	A	N	R	15,651	9,391
2,895	S	G	2,300	80	I	E	A	N	R	15,766	9,460
2,896	S	G	2,400	81	I	E	P	N	R	15,214	10,650
2,897	W	G	2,400	81	I	E	P	N	R	15,214	10,650
2,898	W	G	2,400	80	I	E	A	N	R	18,680	10,274
2,899	S	G	2,400	80	I	E	A	N	R	18,859	10,372
2,900	W	G	2,400	80	I	P	A	N	R	14,267	8,988
2,901	S	G	2,400	80	I	P	A	N	R	14,732	9,281
2,902	W	G	2,400	80	I	E	A	N	R	16,122	9,673
2,903	S	G	2,400	80	I	E	A	N	R	16,238	9,743
2,904	S	G	2,480	81	I	E	P	N	R	16,355	11,449
2,905	W	G	2,480	81	I	E	P	N	R	16,355	11,449
2,906	W	G	2,500	80	I	E	A	N	R	19,151	10,533
2,907	S	G	2,500	80	I	E	A	N	R	19,412	10,677
2,908	W	G	2,500	80	I	P	A	N	R	15,277	9,625
2,909	S	G	2,500	80	I	P	A	N	R	15,740	9,916
2,910	W	G	2,500	80	I	E	A	N	R	16,593	9,956
2,911	S	G	2,500	80	I	E	A	N	R	16,760	10,056
2,912	W	G	2,520	82	I	E	P	N	R	16,986	11,890
2,913	S	G	2,520	82	I	E	P	N	R	17,148	12,004
2,914	S	G	2,540	81	I	E	P	N	R	24,651	17,256
2,915	W	G	2,540	81	I	E	P	N	R	24,651	17,256
2,916	W	G	2,600	80	I	E	A	N	R	20,749	11,412
2,917	S	G	2,600	80	I	E	A	N	R	21,012	11,557
2,918	W	G	2,600	80	I	E	A	N	R	17,576	10,546
2,919	S	G	2,600	80	I	E	A	N	R	17,743	10,646
2,920	W	G	2,700	80	I	E	A	N	R	21,223	11,673
2,921	S	G	2,700	80	I	E	A	N	R	21,485	11,817
2,922	W	G	2,700	80	I	E	A	N	R	18,114	10,868
2,923	S	G	2,700	80	I	E	A	N	R	18,359	11,015
2,924	S	G	2,710	81	I	E	P	N	R	16,754	11,728
2,925	W	G	2,710	81	I	E	P	N	R	16,754	11,728

Table A.5. Packaged Boilers (contd)

REC	TYPE	FUEL	INPUT	EFF	EXCH	IGN	BURN	VENT	CTYPE	LCOST	CCOST
2,926	W	G	2,800	80	I	E	A	N	R	21,694	11,932
2,927	S	G	2,800	80	I	E	A	N	R	21,957	12,076
2,928	W	G	2,800	80	I	E	A	N	R	18,807	11,284
2,929	S	G	2,800	80	I	E	A	N	R	18,974	11,384
2,930	S	G	2,890	81	I	E	P	N	R	17,913	12,539
2,931	W	G	2,890	81	I	E	P	N	R	17,913	12,539
2,932	S	G	2,890	81	I	E	P	N	R	26,586	18,610
2,933	W	G	2,890	81	I	E	P	N	R	26,586	18,610
2,934	W	G	2,900	80	I	E	A	N	R	22,166	12,191
2,935	S	G	2,900	80	I	E	A	N	R	22,427	12,335
2,936	W	G	2,900	80	I	E	A	N	R	19,278	11,567
2,937	S	G	2,900	80	I	E	A	N	R	19,445	11,667
2,938	W	G	3,000	80	I	E	A	N	R	22,636	12,450
2,939	S	G	3,000	80	I	E	A	N	R	22,898	12,594
2,940	W	G	3,000	80	I	E	A	N	R	19,749	11,849
2,941	S	G	3,000	80	I	E	A	N	R	19,916	11,950
2,942	S	G	3,100	81	I	E	P	N	R	17,940	12,558
2,943	W	G	3,100	81	I	E	P	N	R	17,940	12,558
2,944	S	G	3,250	81	I	E	P	N	R	28,403	19,882
2,945	W	G	3,250	81	I	E	P	N	R	28,403	19,882
2,946	S	G	3,390	81	I	E	P	N	R	19,431	13,602
2,947	W	G	3,390	81	I	E	P	N	R	19,431	13,602
2,948	S	G	3,610	81	I	E	P	N	R	30,225	21,158
2,949	W	G	3,610	81	I	E	P	N	R	30,225	21,158
2,950	S	G	3,750	81	I	E	P	N	R	20,620	14,434
2,951	W	G	3,750	81	I	E	P	N	R	20,620	14,434
2,952	S	G	3,970	81	I	E	P	N	R	32,094	22,466
2,953	W	G	3,970	81	I	E	P	N	R	32,094	22,466
2,954	S	G	4,110	81	I	E	P	N	R	21,944	15,361
2,955	W	G	4,110	81	I	E	P	N	R	21,944	15,361
2,956	S	G	4,330	81	I	E	P	N	R	33,914	23,740
2,957	W	G	4,330	81	I	E	P	N	R	33,914	23,740
2,958	S	G	4,470	81	I	E	P	N	R	23,031	16,122
2,959	W	G	4,470	81	I	E	P	N	R	23,031	16,122
2,960	S	G	4,690	81	I	E	P	N	R	36,084	25,259
2,961	W	G	4,690	81	I	E	P	N	R	36,084	25,259
2,962	S	G	4,760	81	I	E	P	N	R	24,122	16,885
2,963	W	G	4,760	81	I	E	P	N	R	24,122	16,885
2,964	S	G	4,980	81	I	E	P	N	R	25,267	17,687
2,965	W	G	4,980	81	I	E	P	N	R	25,267	17,687
2,966	S	G	5,050	82	I	E	P	N	R	37,747	26,423
2,967	W	G	5,050	82	I	E	P	N	R	37,747	26,423
2,968	S	G	5,120	81	I	E	P	N	R	25,378	17,765
2,969	W	G	5,120	81	I	E	P	N	R	25,378	17,765
2,970	S	G	5,410	82	I	E	P	N	R	39,377	27,564

Table A.5. Packaged Boilers (contd)

REC	TYPE	FUEL	INPUT	EFF	EXCH	IGN	BURN	VENT	CTYPE	LCOST	CCOST
2,971	W	G	5,410	82	I	E	P	N	R	39,377	27,564
2,972	S	G	5,490	81	I	E	P	N	R	26,951	18,866
2,973	W	G	5,490	81	I	E	P	N	R	26,951	18,866
2,974	S	G	5,770	82	I	E	P	N	R	40,864	28,605
2,975	W	G	5,770	82	I	E	P	N	R	40,864	28,605
2,976	S	G	5,850	81	I	E	P	N	R	28,041	19,629
2,977	W	G	5,850	81	I	E	P	N	R	28,041	19,629
2,978	S	G	6,130	82	I	E	P	N	R	42,456	29,719
2,979	W	G	6,130	82	I	E	P	N	R	42,456	29,719
2,980	S	G	6,500	82	I	E	P	N	R	44,699	31,289
2,981	W	G	6,500	82	I	E	P	N	R	44,699	31,289
2,982	S	G	6,860	82	I	E	P	N	R	46,604	32,623
2,983	W	G	6,860	82	I	E	P	N	R	46,604	32,623
2,984	S	G	7,220	82	I	E	P	N	R	47,570	33,299
2,985	W	G	7,220	82	I	E	P	N	R	47,570	33,299
2,986	W	G	250	88	N	E	P	N	R	6,627	4,374
2,987	W	G	300	96	N	S	L		R	6,500	5,850
2,988	W	G	500	88	N	E	P	N	R	8,954	5,910
2,989	W	G	500	95	N	S	L		R	7,895	7,106
2,990	S	G	500	87	N	S	L		R	9,450	8,505
2,991	W	G	750	88	N	E	P	N	R	9,891	6,528
2,992	W	G	750	94	N	S	L		R	8,925	8,033
2,993	S	G	750	87	N	S	L		R	11,235	10,112
2,994	W	G	1,000	88	N	E	P	N	R	10,840	7,154
2,995	W	G	1,000	93	N	E	P	N	R	14,000	12,796
2,996	W	G	1,000	93	N	S	L		R	9,975	8,978
2,997	W	G	300	80	S	E	A	N	R	2,088	1,879
2,998	W	G	300	83	S	E	A	N	R	4,178	3,760
2,999	S	G	300	83	S	E	A	N	R	5,980	5,382
3,000	S	G	300	80	S	E	A	N	R	3,690	3,321
3,001	W	G	400	80	S	E	A	N	R	2,511	2,260
3,002	W	G	400	83	S	E	A	N	R	4,601	4,141
3,003	S	G	400	83	S	E	A	N	R	7,140	6,426
3,004	S	G	400	80	S	E	A	N	R	4,680	4,212
3,005	S	G	400	86	S	E	P	N	R	10,854	9,769
3,006	S	G	430	83	S	E	A	N	R	7,340	6,606
3,007	S	G	430	80	S	E	A	N	R	4,880	4,392
3,008	W	G	490	80	S	E	A	N	R	2,772	2,495
3,009	W	G	490	83	S	E	A	N	R	4,862	4,376
3,010	S	G	520	86	S	E	P	N	R	12,069	10,862
3,011	W	G	530	80	S	E	P	N	R	7,596	6,836
3,012	W	G	600	80	S	E	A	N	R	2,970	2,673
3,013	W	G	600	83	S	E	A	N	R	5,280	4,752
3,014	S	G	650	83	S	E	A	N	R	9,200	8,280
3,015	S	G	650	80	S	E	A	N	R	6,030	5,427

Table A.5. Packaged Boilers (contd)

REC	TYPE	FUEL	INPUT	EFF	EXCH	IGN	BURN	VENT	CTYPE	LCOST	CCOST
3,016	W	G	670	80	S	E	P	N	R	7,866	7,079
3,017	S	G	690	86	S	E	P	N	R	12,069	10,862
3,018	W	G	760	80	S	E	A	N	R	3,375	3,038
3,019	W	G	760	83	S	E	A	N	R	6,405	5,765
3,020	S	G	860	83	S	E	A	N	R	11,080	9,972
3,021	S	G	860	80	S	E	A	N	R	7,470	6,723
3,022	W	G	860	80	S	E	P	N	R	8,388	7,549
3,023	S	G	950	86	S	E	P	N	R	14,733	13,260
3,024	W	G	970	80	S	E	A	N	R	4,527	4,074
3,025	W	G	970	83	S	E	A	N	R	7,497	6,747
3,026	W	G	1,010	80	S	E	P	N	R	9,396	8,456
3,027	S	G	1,080	83	S	E	A	N	R	11,530	10,377
3,028	S	G	1,080	80	S	E	A	N	R	7,920	7,128
3,029	W	G	1,140	80	S	E	A	N	R	4,797	4,317
3,030	W	G	1,140	83	S	E	A	N	R	7,767	6,990
3,031	S	G	1,260	83	S	E	A	N	R	13,968	12,571
3,032	S	G	1,260	80	S	E	A	N	R	10,358	9,322
3,033	S	G	1,260	86	S	E	P	N	R	16,542	14,888
3,034	W	G	1,300	80	S	E	P	N	R	11,934	10,741
3,035	W	G	1,460	80	S	E	A	N	R	6,480	5,832
3,036	W	G	1,460	83	S	E	A	N	R	9,890	8,901
3,037	W	G	1,540	80	S	E	P	N	R	12,537	11,283
3,038	S	G	1,680	83	S	E	A	N	R	15,140	13,626
3,039	S	G	1,680	80	S	E	A	N	R	11,610	10,449
3,040	S	G	1,680	86	S	E	P	N	R	18,414	16,573
3,041	W	G	1,730	80	S	E	A	N	R	6,750	6,075
3,042	W	G	1,730	83	S	E	A	N	R	10,160	9,144
3,043	W	G	1,920	80	S	E	P	N	R	13,941	12,547
3,044	S	G	2,000	83	S	E	A	N	R	16,740	15,066
3,045	S	G	2,000	80	S	E	A	N	R	13,410	12,069
3,046	W	G	2,000	80	S	E	A	N	R	7,695	6,926
3,047	W	G	2,000	83	S	E	A	N	R	11,025	9,923
3,048	S	G	2,100	83	S	E	A	N	R	16,740	15,066
3,049	S	G	2,100	80	S	E	A	N	R	13,410	12,069
3,050	S	G	2,100	86	S	E	P	N	R	20,475	18,428
3,051	W	G	2,160	80	S	E	A	N	R	7,695	6,926
3,052	W	G	2,160	83	S	E	A	N	R	11,025	9,923
3,053	W	G	2,300	80	S	E	P	N	R	15,597	14,037
3,054	W	G	2,490	80	S	E	A	N	R	7,695	6,926
3,055	W	G	2,490	83	S	E	A	N	R	11,025	9,923
3,056	W	G	2,600	80	S	E	A	N	R	9,180	8,262
3,057	W	G	2,600	83	S	E	A	N	R	13,160	11,844
3,058	W	G	2,640	80	S	E	P	N	R	18,018	16,216
3,059	S	G	2,940	83	S	E	A	N	R	20,900	18,810
3,060	S	G	2,940	80	S	E	A	N	R	16,920	15,228

Table A.5. Packaged Boilers (contd)

REC	TYPE	FUEL	INPUT	EFF	EXCH	IGN	BURN	VENT	CTYPE	LCOST	CCOST
3,061	S	G	2,940	86	S	E	P	N	R	25,020	22,518
3,062	W	G	2,970	80	S	E	A	N	R	9,648	8,683
3,063	W	G	2,970	83	S	E	A	N	R	13,628	12,265
3,064	W	G	3,120	80	S	E	P	N	R	19,674	17,707
3,065	W	G	3,460	80	S	E	P	N	R	20,655	18,590
3,066	W	G	3,600	80	S	E	A	N	R	11,133	10,020
3,067	W	G	3,600	83	S	E	A	N	R	14,893	13,404
3,068	S	G	3,780	83	S	E	A	N	R	24,360	21,924
3,069	S	G	3,780	80	S	E	A	N	R	19,260	17,334
3,070	S	G	3,780	86	S	E	P	N	R	28,656	25,790
3,071	W	G	3,900	80	S	E	A	N	R	11,673	10,506
3,072	W	G	3,900	83	S	E	A	N	R	16,773	15,096
3,073	W	G	4,030	80	S	E	P	N	R	22,761	20,485
3,074	W	G	4,600	80	S	E	A	N	R	13,365	12,029
3,075	W	G	4,600	83	S	E	A	N	R	18,465	16,619
3,076	S	G	4,830	83	S	E	A	N	R	27,240	24,516
3,077	S	G	4,830	80	S	E	A	N	R	22,140	19,926
3,078	S	G	4,830	86	S	E	P	N	R	32,040	28,836
3,079	W	G	5,000	80	S	E	P	N	R	26,298	23,668
3,080	W	G	5,700	80	S	E	A	N	R	16,263	14,637
3,081	W	G	5,700	83	S	E	A	N	R	24,233	21,810
3,082	W	G	6,250	80	S	E	P	N	R	28,953	26,058
3,083	S	G	6,300	83	S	E	A	N	R	35,780	32,202
3,084	S	G	6,300	80	S	E	A	N	R	27,810	25,029
3,085	S	G	6,300	86	S	E	P	N	R	38,853	34,968
3,086	W	G	6,800	80	S	E	A	N	R	18,018	16,216
3,087	W	G	6,800	83	S	E	A	N	R	25,988	23,389
3,088	W	G	1,470	80	I	E	P	N	R	16,399	9,019
3,089	W	G	1,740	80	I	E	P	N	R	17,424	9,583
3,090	W	G	2,010	80	I	E	P	N	R	18,903	10,397
3,091	W	G	2,280	80	I	E	P	N	R	19,866	10,926
3,092	W	G	2,550	80	I	E	P	N	R	22,391	12,315
3,093	W	G	2,820	80	I	E	P	N	R	23,240	12,782
3,094	W	G	3,090	80	I	E	P	N	R	24,261	13,344
3,095	W	G	3,360	80	I	E	P	N	R	25,237	13,880
3,096	W	G	3,630	80	I	E	P	N	R	26,978	14,838
3,097	W	G	3,900	80	I	E	P	N	R	27,955	15,375
3,098	W	O	330	83	I	P	P	N	R	2,374	1,436
3,099	S	O	340	85	I	E	P	Y	R	3,938	2,757
3,100	W	O	340	85	I	E	P	Y	R	3,938	2,757
3,101	W	O	340	80	I	E	P	N	R	5,037	3,526
3,102	S	O	340	80	I	E	P	N	R	5,030	3,521
3,103	S	O	360	82	I	P	P	N	R	2,903	1,756
3,104	W	O	400	82	I	P	P	N	R	2,695	1,630
3,105	W	O	420	80	I	E	P	N	R	5,641	3,949

Table A.5. Packaged Boilers (contd)

REC	TYPE	FUEL	INPUT	EFF	EXCH	IGN	BURN	VENT	CTYPE	LCOST	CCOST
3,106	S	O	420	80	I	E	P	N	R	5,451	3,816
3,107	S	O	430	82	I	P	P	N	R	3,112	1,883
3,108	W	O	470	81	I	P	P	N	R	2,896	1,752
3,109	S	O	480	85	I	E	P	Y	R	4,894	3,426
3,110	W	O	480	85	I	E	P	Y	R	4,894	3,426
3,111	W	O	560	80	I	E	P	N	R	6,575	4,603
3,112	S	O	560	80	I	E	P	N	R	6,409	4,486
3,113	S	O	620	84	I	E	P	Y	R	5,431	3,802
3,114	W	O	620	84	I	E	P	Y	R	5,431	3,802
3,115	W	O	700	80	I	E	P	N	R	7,224	5,057
3,116	S	O	700	80	I	E	P	N	R	7,057	4,940
3,117	S	O	770	84	I	E	P	Y	R	6,348	4,444
3,118	W	O	770	84	I	E	P	Y	R	6,348	4,444
3,119	W	O	840	81	I	E	P	N	R	7,468	5,228
3,120	S	O	840	81	I	E	P	N	R	7,640	5,348
3,121	S	O	910	84	I	E	P	Y	R	7,125	4,988
3,122	W	O	910	84	I	E	P	Y	R	7,125	4,988
3,123	S	O	970	84	I	E	P	N	R	8,992	6,294
3,124	W	O	970	84	I	E	P	N	R	8,992	6,294
3,125	S	O	980	84	I	E	P	N	R	8,992	6,294
3,126	W	O	980	84	I	E	P	N	R	8,992	6,294
3,127	S	O	1,050	84	I	E	P	Y	R	7,489	5,242
3,128	W	O	1,050	84	I	E	P	Y	R	7,489	5,242
3,129	S	O	1,190	84	I	E	P	Y	R	8,019	5,613
3,130	W	O	1,190	84	I	E	P	Y	R	8,019	5,613
3,131	W	O	1,260	81	I	E	P	N	R	9,125	6,388
3,132	S	O	1,260	81	I	E	P	N	R	9,189	6,432
3,133	S	O	1,320	84	I	E	P	N	R	10,130	7,091
3,134	W	O	1,320	84	I	E	P	N	R	10,130	7,091
3,135	S	O	1,340	84	I	E	P	Y	R	8,539	5,977
3,136	W	O	1,340	84	I	E	P	Y	R	8,539	5,977
3,137	W	O	1,470	80	I	E	P	N	R	14,788	8,133
3,138	S	O	1,480	84	I	E	P	Y	R	9,072	6,350
3,139	W	O	1,480	84	I	E	P	Y	R	9,072	6,350
3,140	S	O	1,620	84	I	E	P	Y	R	9,812	6,868
3,141	W	O	1,620	84	I	E	P	Y	R	9,812	6,868
3,142	S	O	1,650	84	I	E	P	N	R	11,565	8,096
3,143	W	O	1,650	84	I	E	P	N	R	11,565	8,096
3,144	W	O	1,680	81	I	E	P	N	R	10,579	7,405
3,145	S	O	1,680	81	I	E	P	N	R	10,626	7,438
3,146	W	O	1,740	80	I	E	P	N	R	15,813	8,697
3,147	W	O	1,960	80	I	E	P	N	R	12,185	8,530
3,148	S	O	1,960	80	I	E	P	N	R	12,240	8,568
3,149	S	O	1,990	84	I	E	P	N	R	12,873	9,011
3,150	W	O	1,990	84	I	E	P	N	R	12,873	9,011

Table A.5. Packaged Boilers (contd)

REC	TYPE	FUEL	INPUT	EFF	EXCH	IGN	BURN	VENT	CTYPE	LCOST	CCOST
3,151	W	O	2,010	80	I	E	P	N	R	17,002	9,351
3,152	W	O	2,280	80	I	E	P	N	R	17,965	9,881
3,153	S	O	2,320	84	I	E	P	N	R	14,050	9,835
3,154	W	O	2,320	84	I	E	P	N	R	14,050	9,835
3,155	S	O	2,410	84	I	E	P	N	R	15,301	10,711
3,156	W	O	2,410	84	I	E	P	N	R	15,301	10,711
3,157	S	O	2,450	84	I	E	P	N	R	23,342	16,339
3,158	W	O	2,450	84	I	E	P	N	R	23,342	16,339
3,159	W	O	2,520	82	I	E	P	N	R	14,777	10,344
3,160	S	O	2,520	82	I	E	P	N	R	14,943	10,460
3,161	W	O	2,550	80	I	E	P	N	R	20,484	11,266
3,162	S	O	2,630	84	I	E	P	N	R	15,357	10,750
3,163	W	O	2,630	84	I	E	P	N	R	15,357	10,750
3,164	S	O	2,800	84	I	E	P	N	R	16,516	11,561
3,165	W	O	2,800	84	I	E	P	N	R	16,516	11,561
3,166	S	O	2,800	84	I	E	P	N	R	25,153	17,607
3,167	W	O	2,800	84	I	E	P	N	R	25,153	17,607
3,168	W	O	2,820	80	I	E	P	N	R	21,333	11,733
3,169	S	O	3,010	84	I	E	P	N	R	16,985	11,890
3,170	W	O	3,010	84	I	E	P	N	R	16,985	11,890
3,171	W	O	3,090	80	I	E	P	N	R	22,354	12,295
3,172	S	O	3,150	84	I	E	P	N	R	27,208	19,046
3,173	W	O	3,150	84	I	E	P	N	R	27,208	19,046
3,174	S	O	3,290	84	I	E	P	N	R	18,255	12,779
3,175	W	O	3,290	84	I	E	P	N	R	18,255	12,779
3,176	W	O	3,360	80	I	E	P	N	R	23,330	12,832
3,177	S	O	3,500	84	I	E	P	N	R	29,029	20,320
3,178	W	O	3,500	84	I	E	P	N	R	29,029	20,320
3,179	W	O	3,630	80	I	E	P	N	R	24,373	13,405
3,180	S	O	3,640	84	I	E	P	N	R	19,445	13,612
3,181	W	O	3,640	84	I	E	P	N	R	19,445	13,612
3,182	S	O	3,850	84	I	E	P	N	R	30,840	21,588
3,183	W	O	3,850	84	I	E	P	N	R	30,840	21,588
3,184	W	O	3,900	80	I	E	P	N	R	25,350	13,943
3,185	S	O	3,990	84	I	E	P	N	R	20,636	14,445
3,186	W	O	3,990	84	I	E	P	N	R	20,636	14,445
3,187	S	O	4,200	84	I	E	P	N	R	32,657	22,860
3,188	W	O	4,200	84	I	E	P	N	R	32,657	22,860
3,189	S	O	4,340	84	I	E	P	N	R	22,045	15,432
3,190	W	O	4,340	84	I	E	P	N	R	22,045	15,432
3,191	S	O	4,550	84	I	E	P	N	R	35,078	24,555
3,192	W	O	4,550	84	I	E	P	N	R	35,078	24,555
3,193	S	O	4,620	84	I	E	P	N	R	23,086	16,160
3,194	W	O	4,620	84	I	E	P	N	R	23,086	16,160
3,195	S	O	4,900	84	I	E	P	N	R	36,678	25,675

Table A.5. Packaged Boilers (contd)

REC	TYPE	FUEL	INPUT	EFF	EXCH	IGN	BURN	VENT	CTYPE	LCOST	CCOST
3,196	W	O	4,900	84	I	E	P	N	R	36,678	25,675
3,197	S	O	4,970	84	I	E	P	N	R	24,298	17,009
3,198	W	O	4,970	84	I	E	P	N	R	24,298	17,009
3,199	S	O	5,250	84	I	E	P	N	R	37,933	26,553
3,200	W	O	5,250	84	I	E	P	N	R	37,933	26,553
3,201	S	O	5,320	84	I	E	P	N	R	25,770	18,039
3,202	W	O	5,320	84	I	E	P	N	R	25,770	18,039
3,203	S	O	5,600	84	I	E	P	N	R	39,420	27,594
3,204	W	O	5,600	84	I	E	P	N	R	39,420	27,594
3,205	S	O	5,670	83	I	E	P	N	R	26,859	18,801
3,206	W	O	5,670	83	I	E	P	N	R	26,859	18,801
3,207	S	O	5,950	84	I	E	P	N	R	41,085	28,760
3,208	W	O	5,950	84	I	E	P	N	R	41,085	28,760
3,209	S	O	6,300	84	I	E	P	N	R	43,785	30,650
3,210	W	O	6,300	84	I	E	P	N	R	43,785	30,650
3,211	S	O	6,650	84	I	E	P	N	R	45,511	31,858
3,212	W	O	6,650	84	I	E	P	N	R	45,511	31,858
3,213	S	O	7,000	84	I	E	P	N	R	46,828	32,780

Table A.6. Warm Air Furnaces

REC	FUEL	INPUT	EFF	CTYPE	LCOST	CCOST
3,214	G	250	80	D	3,700	5,180
3,215	G	280	80	D	1,920	2,688
3,216	G	280	80	D	1,920	2,688
3,217	G	280	80	D	1,920	2,688
3,218	G	350	80	D	2,250	3,150
3,219	G	350	80	D	2,250	3,150
3,220	G	350	80	D	2,250	3,150
3,221	G	500	80	D	4,800	6,720
3,222	G	560	80	D	3,450	4,830
3,223	G	560	80	D	3,450	4,830
3,224	G	560	80	D	3,450	4,830
3,225	G	560	80	D	3,500	4,900
3,226	G	560	80	D	3,500	4,900
3,227	G	560	80	D	3,500	4,900
3,228	G	1,000	80	D	6,400	8,960
3,229	O	250	83	R	2,535	1,293
3,230	O	250	83	R	2,535	1,293
3,231	O	250	83	R	2,485	1,267
3,232	O	250	83	R	2,485	1,267
3,233	O	250	83	R	2,535	1,293
3,234	O	250	84	D	1,040	1,352
3,235	O	250	84	D	1,088	1,414
3,236	O	250	84	D	1,130	1,469
3,237	O	250	80	D	3,000	4,200
3,238	O	250	80	R	3,678	2,023
3,239	O	250	80	R	3,780	2,079
3,240	O	280	80	D	1,640	2,296
3,241	O	280	80	D	1,640	2,296
3,242	O	280	80	D	1,640	2,296
3,243	O	280	80	D	1,376	1,789
3,244	O	310	80	R	4,222	2,322
3,245	O	310	80	R	4,324	2,378
3,246	O	320	82	R	3,515	1,793
3,247	O	320	82	R	3,515	1,793
3,248	O	320	82	R	3,425	1,747
3,249	O	320	82	R	3,425	1,747
3,250	O	320	82	R	3,515	1,793
3,251	O	350	80	D	2,000	2,800
3,252	O	350	80	D	2,000	2,800
3,253	O	350	80	D	2,000	2,800
3,254	O	350	81	D	1,988	2,584
3,255	O	350	86	D	1,958	2,545
3,256	O	390	81	D	1,988	2,584
3,257	O	400	80	R	4,538	2,496
3,258	O	400	80	R	4,640	2,552

Table A.6. Warm Air Furnaces (contd)

REC	FUEL	INPUT	EFF	CTYPE	LCOST	CCOST
3,259	O	420	81	D	1,988	2,584
3,260	O	490	82	D	2,331	3,030
3,261	O	500	80	D	3,900	5,460
3,262	O	560	80	D	2,530	3,542
3,263	O	560	80	D	2,530	3,542
3,264	O	560	80	D	2,530	3,542
3,265	O	560	80	D	2,550	3,570
3,266	O	560	80	D	2,550	3,570
3,267	O	560	80	D	2,550	3,570
3,268	O	630	83	D	3,150	4,095
3,269	O	1,000	80	D	6,100	8,540

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