CHAPTER 6. MANUFACTURING COST ASSESSMENT

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CHAPTER 6. MANUFACTURING COST ASSESSMENT

6.1 INTRODUCTION

Manufacturing cost is used by all the remaining stages of the water heater analysis process. The manufacturing cost assessment quantifies the current manufacturing costs of producing water heaters based on (1) data provided by GAMA, (2) data provided by independent contractors, and (3) publicly available sources. The final results provide detailed manufacturing cost estimates in a way that preserves required confidentiality.

6.2 ASSUMPTIONS

6.2.1 Baseline Definition

The typical baseline unit represents the most common size water heater of each fuel type with an efficiency rating equal to the minimum allowed by existing energy-efficiency standards. The general characteristics of the baseline models are described in detail in the Engineering Analysis (Chapter 8).

Baseline units differ according to fuel type and size. The existing baseline models we selected for electric water heaters have 1.5 inches of HCFC-141b foam insulation, while baseline models for gas-fired (natural gas and LPG)[a] and oil-fired water heaters have 1 inch of HCFC-141b foam insulation. The most widely distributed sizes for electric water heaters have a rated volume of 50 gallons. For gas-fired and oil-fired water heaters, the most common rated volumes are 40 and 32 gallons, respectively.[1]

The cost of specific models (or individual manufacturers) will vary from this baseline, depending on elements such as the product's precise characteristics, actual manufacturing processes, and the product mix in the factory (baseline water heater models with specific design, i.e., jacket insulation thickness, availability of heat traps). However, using incremental manufacturing cost estimates for design options reduces the impact of model-specific characteristics.

6.2.2 Conventions for Manufacturing Cost Estimates

The cost categories used to summarize the manufacturing costs parallel the cost categories used in the data request form sent to manufacturers (see Appendix C-1). Direct material, direct labor, transportation and overhead (including investment depreciation) comprise the variable production cost, which is sometimes called the full production cost. The overhead component of the variable production cost includes indirect labor, indirect material, investment depreciation, income

[a] Water heaters fueled by natural gas and LPG are considered as one product class from the point of view of energy efficiency characteristics. They are treated separately with respect to manufacturing cost, markup, retail price, and fuel price in the Life-Cycle Cost and subsequent analyses.

taxes, cost of miscellaneous supplies, payroll benefit costs, supervision costs, utilities, and insurance related to assets. Other cost elements are the capital expenses and product development. R&D costs are associated with efforts to find new or improved products or production processes, which are grouped under the fixed cost category, sometimes called non-production costs. The fixed cost may also include sales, general and administration (costs of service units and corporate costs, i.e., computers, etc.), interest (cost of borrowing money) and selling (marketing, advertising, sales persons, logistics). Together these costs make up the full cost of the product, as shown in Figure 6.1. The manufacturing cost assessment estimates the full production cost.

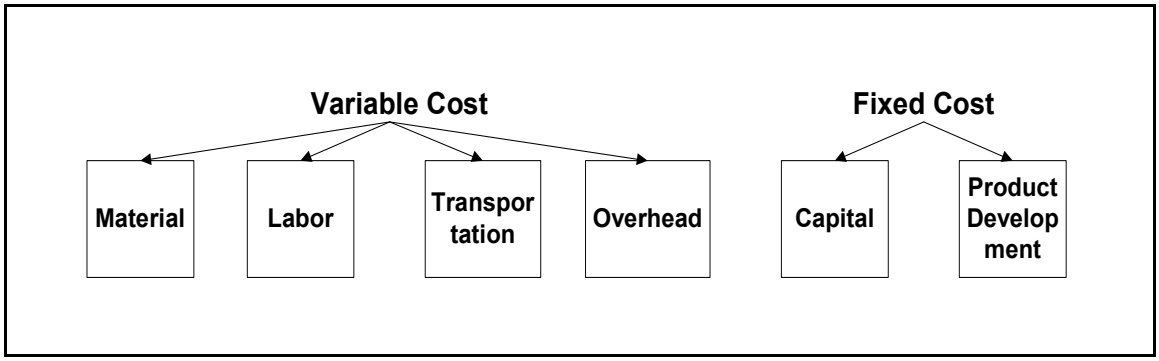

Figure 6.1 Full Production Cost

6.3 APPROACH

The manufacturing cost assessment is a detailed technique for calculating the manufacturing cost of a product (direct materials, direct labor and some overhead costs). It is a slightly shortened version of a manufacturing cost evaluation approach widely accepted and applied by manufacturers to products at various stages of development, from early R&D to production. Figure 6.2 shows the three major steps in generating a baseline manufacturing cost.

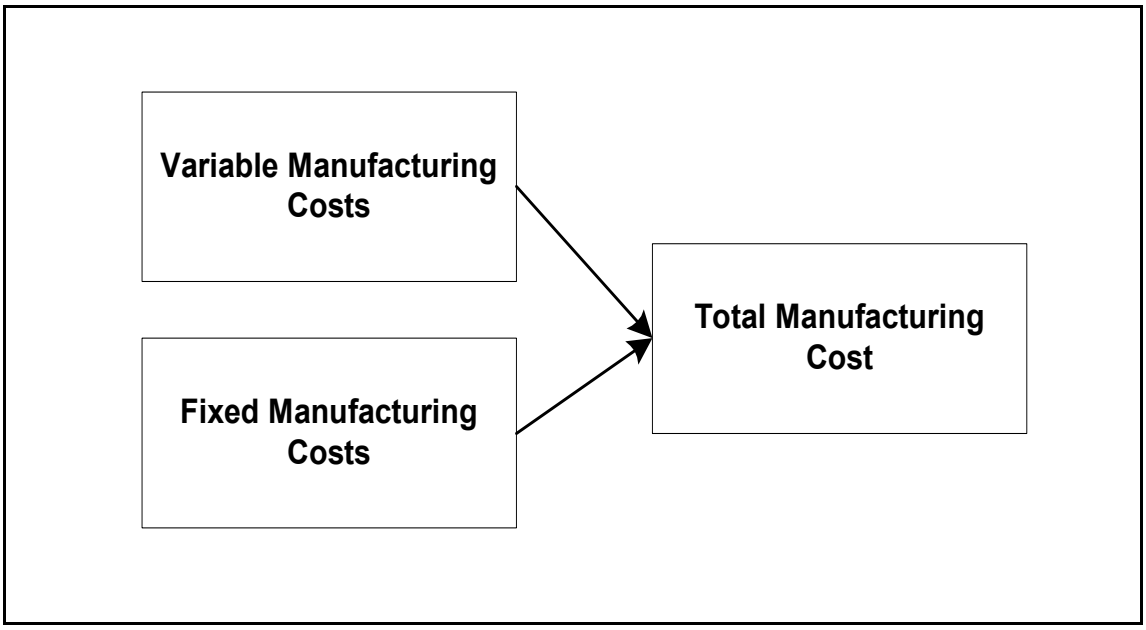

Figure 6.2 Manufacturing Cost Assessment Approach

6.4 MANUFACTURER COST DATA

The primary source of manufacturer cost data used in this analysis was the Gas Appliance Manufacturers' Association (GAMA), which collected data from water heater manufacturers for baseline water heater models and for models incorporating some of the design options considered in the analysis. GAMA did not provide data for four of the design options being considered (2.5" and 3" Jacket Insulation, Plastic Tank and Side Arm Heater). No data were supplied for oil-fired or LPG water heaters, which are also covered in this analysis. The missing data were obtained from estimates provided by independent consultants recommended by GAMA. The detailed data from GAMA and from the consultants are provided in Appendices C-2 and C-3.

6.4.1 Electric Water Heaters Manufacturing Cost Estimates

The total variable cost estimates of the existing baseline model are based on data collected from GAMA.[2] A comparable data set developed by an independent consultant was used for comparison only.[3] As mentioned before, the baseline model represents a typical existing 50-gallon rated volume electric water heater with 1.5-inch HCFC-141b foam insulation. No fixed cost is associated with the existing baseline model.

Note that the existing baseline model cost was used to calculate the manufacturing cost of the 2003 baseline model in the Engineering Analysis, which is based on HFC-245fa-blown insulation. Table 6.1 shows the calculation of the total foam cost for HFC-141b and HFC-245fa insulation based on component cost estimates.[4]

Table 6.1 Foam Components Cost Estimate

Foam Components	Fraction (in foam)	Component Cost	Total Cost (141b)	Total Cost (245fa)
	%	*$/lb*	*$/lb*	*$/lb*
HCFC-141b	13.00	1.50	0.20	-
HFC-245fa	13.00	4.00	-	0.52
Isocyanurate	51.00	0.75	0.38	0.38
Polyols	31.00	0.65	0.20	0.20
Catalysts, refractants, etc.	5.00	4.50	0.23	0.23
Total	**100.00**		**1.00**	**$1.32**

Variable and fixed incremental manufacturer cost estimates for heat traps are also based on data collected from GAMA.[2] In addition, data provided by two independent consultants[3,5] and from the heat trap manufacturer Perfection, Inc.[6] were available. All the cost estimates were similar.

Variable and fixed incremental manufacturer cost data to increase the jacket insulation from 1.5 inch to 2 inches of HCFC-141b-based insulation were provided by GAMA.[2] Data provided by a consultant were used to calculate ratios of variable and fixed costs for 2.5-inch and 3-inch insulation.[3] GAMA's costs for upgrading to 2-inch insulation, modified for HFC-245fa, were multiplied by those ratios to develop the variable and fixed costs for 2.5-inch and 3-inch insulation used in the Engineering Analysis. The incremental manufacturer costs for insulating tank bottoms are based on data from the two consultants.

The incremental manufacturer costs for a plastic tank electric water heater design are based on data provided by one of the independent consultants.[3] The plastic tank design fixed costs were provided as the "lump sum" amount required to convert baseline production to the new design and converted to a per unit cost.

The full cost of the product to a large extent is a function of the production volume. For the electric water heaters, the cost estimated by the consultants is based on 40,000 units/year. However, the volume of production for a specific product typically includes families of products based on the same basic design and size. The impact of production volume is particularly significant on fixed costs. It is very difficult to interpolate the data regarding fixed costs to a meaningful cost for the given model. We assume the data provided by the manufacturers includes this effect. Design changes that consist of attachments or connected components have a lesser effect.

We assumed that all fixed costs have been amortized over a five-year period. Table 6.2 summarizes the electric water heater manufacturers' cost used in the Engineering Analysis.

Table 6.2 Manufacturing Costs: Electric Water Heaters (50-gal)

	Design Options	Variable Costs					Fixed Costs		
		Material	Labor	Transp.	Overhead	Total	Capital	Product Design	Total
		$	$	$	$	$	$	$	$
1	Baseline	62.16	10.57	10.11	38.89	121.73	0.00	0.00	0.00
2	Heat Trap	2.59	0.19	0.00	0.82	3.60	0.15	0.24	0.39
3	Increased Insulation*	8.23	0.50	1.44	2.26	12.43	-	-	4.61
4	Bottom Insulation	2.28	0.12	0.00	0.36	2.76	-	-	1.15
5	Plastic Tank	5.25	0.80	0.00	3.20	9.25	15.00	3.00	18.00

* from 1.5" to 2" of HCFC-141b-blown insulation

6.4.2 Gas-Fired Water Heaters Manufacturing Cost Estimates

The total variable cost estimates of the existing baseline gas-fired model as presented in Table 6.3 are based on data collected from GAMA. As mentioned before, the baseline model represents a typical existing 40-gallon rated volume gas-fired water heater with 1-inch HCFC-141b foam insulation. No fixed costs are associated with the existing baseline models.

Manufacturing cost data for the existing baseline LPG water heater is provided as an incremental cost compared to a baseline natural gas water heater and is added in Table 6.3. The total incremental manufacturing cost for 40-gal water heater is $14.82. This incremental cost includes variable manufacturer material cost and fixed cost as well as the allocations for product failure and liability. Appendix C-3 contains the details of the derivation of these incremental manufacturer costs to manufacture an LPG water heater.

Note that the existing baseline model cost was used to calculate the manufacturing cost of the 2003 baseline model in the Engineering Analysis, which uses HFC-245fa-blown insulation (see Table 6.1).

The incremental manufacturer costs to account for the price impact of a change in the flue diameter from 4" to 3" design for baseline 30-gal and 40-gal gas-fired water heater were provided by a consultant. This cost data is used solely to adjust the retail mark-up based on gas-fired water heaters with 4" diameter flue. The cost increment is based solely on the impact of a change in the flue diameter. The total incremental manufacturing cost for the 30-gal water heater is $3.64 and for 40-gal water heater is $3.40. Appendix C-3 contains the details of the derivation of the incremental manufacturer costs to switch from 3" to 4"flue diameter.

Variable and fixed incremental manufacturer cost estimates for heat traps are also based on data from GAMA. Note that the manufacturer cost provided by GAMA for heat traps is not identical for gas-fired water heaters and electric water heaters. As in the case of electric water heaters, the cost data provided by two independent consultants and from the heat trap manufacturer Perfection, Inc. were used for comparison only.

Variable and fixed incremental manufacturer cost data to increase the jacket insulation from 1 inch to 2 inches of HCFC-141b-based insulation were provided by GAMA. Data provided by a consultant were used to calculate ratios of variable and fixed costs for 2.5-inch and 3-inch insulation. GAMA's costs for upgrading to 2-inch insulation, modified for HFC-245fa-blown foam, were multiplied by those ratios to develop the variable and fixed costs for 2.5 inches and 3 inches of insulation used in the Engineering Analysis.[3]

The incremental manufacturer costs for the improved flue baffle design were provided by GAMA. The costs were based on a design that increased the RE to 78%. Our consultant estimated that the manufacturing cost to increase the RE from the baseline to 80% is the same as the manufacturing cost to increase RE to 78%. Note the largest component of the manufacturing cost increase is product design.

The incremental manufacturer costs for electronic ignition are for replacing a standing pilot with an intermittent pilot ignition device. The cost of the electronic ignition system is from GAMA.

The incremental manufacturer costs for including an electromechanical flue damper with a gas-fired water heater were from GAMA. Because electromechanical flue dampers are analyzed only in conjunction with electronic ignition systems, the incremental manufacturer costs associated with this design option always include the incremental manufacturer costs of electronic ignition.

The incremental manufacturer costs for a plastic tank electric water heater design are based on data provided by the independent consultant. The plastic tank design fixed costs were provided as the "lump sum" amount required to convert baseline production to the new design and converted to a per unit cost.

The incremental manufacturer costs for the side arm heater for a gas-fired water heater design were based on estimates provided by the independent consultant. We considered the manufacturer costs for designs that use a metal tank or a plastic tank. Plastic tanks cannot be considered as a stand-alone design option for standard center-flue gas-fired water heaters due to the high temperature of combustion. Thus, plastic tanks are only considered with a side arm heater. The cost of metal and plastic tanks differs by the cost of the plastic tank design option as explained in Section 6.4.1. Because side arm heaters are analyzed only in conjunction with electronic ignition systems, the incremental manufacturer costs include the electronic ignition design.

The full cost of the product to a large extent is a function of the production volume. For the gas-fired water heaters, the cost estimated by the consultants is based on a production volume of 50,000 units/year. It is assumed that all fixed costs have been amortized over a five-year period.

Table 6.3 summarizes the gas-fired water heater manufacturers' costs used in the analysis.

Table 6.3 Manufacturing Costs: Gas-Fired Water Heaters (40-gal)

	Design Options	Variable Costs					Fixed Costs		
		Material	Labor	Transp.	Overhead	Total	Capital	Product Design	Total
		$	$	$	$	$	$	$	$
1	Baseline - Natural Gas	75.02	10.74	9.671	38.35	133.76	0.00	0.00	0.00
1	Baseline - LPG	9.20	-	-	-	142.96	0.00	0.00	5.62
2	Heat Trap	2.75	0.16	0.00	0.19	3.10	0.07	0.13	0.20
3	Increased Insulation*	8.51	0.59	2.56	2.40	15.16	0.84	0.59	1.43
4	Improved Flue Baffle	0.97	1.25	0.00	1.38	3.60	1.14	1.70	2.84
5	Electronic Ignition	43.78	2.60	4.84	7.55	58.77	2.05	1.44	3.49
6	Electromech. Flue Damper	85.05	3.29	7.17	9.49	105.00	3.41	2.00	5.41
7	Side Arm w/ Metal Tank	24.50	2.10	2.50	11.80	40.90	0.80	2.00	2.80
8	Side Arm w/ Plastic Tank	29.75	2.90	4.90	13.60	51.15	3.80	2.60	6.40

* from 1" to 2" HCFC-141b-blown insulation.

6.4.3 Oil-Fired Water Heaters Manufacturing Cost Estimates

GAMA did not supply manufacturer cost data for oil-fired water heaters. These data were provided by independent consultants.

The total variable cost estimates of the existing baseline model are based on estimates provided by an independent consultant.[3] Manufacturers of oil-fired water heaters use both fiberglass and foam insulation in their baseline models. The existing baseline costs are assumed to be equivalent for models with fiberglass or foam. Since the base for the design option evaluations is a model with HCFC141b foam, an additional calculation of the volume of foam and shell material for the baseline model was made independently of the data supplied by the consultant. This cost information was used to determine the cost impact of increasing insulation thickness on oil-fired water heaters. Section 8.5.3 of the Engineering Analysis contains the calculation details.

The incremental manufacturer cost estimates for heat traps are based on data gathered by two independent consultants, Max Minniear and Eugene West.[3,5] The estimates were very similar. The estimates for the variable costs are from Minniear and are used here because they are slightly higher cost, therefore conservative, and were broken down into material, labor, and overhead costs. Fixed conversion costs to incorporate heat traps were developed from product design cost estimates provided by John Grahm at R. W. Beckett Corporation[7] and Eugene West.[5]

The incremental manufacturer costs to increase insulation from 1 inch to 2 inches were estimated based on a nominal 1-inch increase in foam on both the top and side walls of the tank. The estimates were provided by the independent consultant Eugene West.

Variable costs for improved flue baffles were estimated as $3.75 for material, $0.55 for labor, and $1.00 per unit for overhead costs based on data from GAMA. Fixed costs for improving the flue baffle design are estimated at $300,000 for production improvements and $500,000 for product design based on data from Minniear.[3]

Variable costs to incorporate interrupted ignition circuitry in oil burners were estimated at $16.50 material costs. Discussions with a burner manufacturer indicated that the manufacturers' cost differential for interrupted versus intermittent controls was presently between $10 and $15 and that typically ignition controls are installed by burner manufacturers[7]. These data confirm the initial estimate and were used as a reference only. No additional overhead or labor costs are anticipated if interrupted ignition controls replace intermittent ignition controls. No fixed capital costs are anticipated for interrupted ignition. Design costs for water heater manufacturers are mostly for water heater testing and certification. These costs are estimated at $25,000, based on similar product testing costs for increased insulation and heat traps.[5]

Variable costs for increasing heat exchanger surface area were estimated at $17.25/unit for material costs, $1.75/unit for labor costs, and $4.25/unit in overhead. Fixed conversion costs for this design option were estimated at $1,500,000 for production improvements and $500,000 for product design.[3] The fixed cost estimates are based on Bock's Turboflue model.

Table 6.4 Manufacturing Costs: Oil-Fired Water Heaters (32-gal)

	Design Options	Variable Costs				Fixed Costs		
		Material	Labor	Overhead	Total	Capital	Product Design	Total
		$	$	$	$	$	$	$
1	Baseline	85.00	18.25	36.00	139.25	0.00	0.00	0.00
2	Heat Trap	3.97	0.15	0.05	4.17	-	-	1.52
3	Increased Insulation	5.68	0.29	3.19	8.10	-	-	1.52
4	Improved Flue Baffle	3.75	0.55	1.00	5.30	-	-	32.00
5	Interrupted Ignition	16.50	0.00	0.00	16.50	-	-	0.20
6	Increase Heat Exchange Surface	17.25	1.75	4.25	23.25	-	-	80.00

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