# APPENDIX 8-D. INSTALLATION, MAINTENANCE, REPAIR COST DETERMINATION FOR FURNACE FANS

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# APPENDIX 8-D. INSTALLATION, MAINTENANCE, REPAIR COST DETERMINATION FOR FURNACE FANS

## 8-D.1 INTRODUCTION

This appendix provides further details about the derivation of installation, maintenance and repair costs for furnace fans. The installation cost is the price to the consumer of labor and materials (other than the cost of the actual product) needed to install a furnace product.

The Department of Energy (DOE) estimated installation, maintenance, and repair costs for furnaces based on RS Means, a well known and respected construction cost estimation method, as well as manufacturer literature and information from expert consultants. Table 8-D.1.1 offers an example of the cost calculation method. All labor costs are derived using the latest residential 2012 RS Means labor costs by crew type.[1] Replacement installation, maintenance, and repair cost tables include a trip charge, which is often charged by contractors and calculated to be equal to one half hour of labor per crew member. Labor hours (or person-hours) are based on RS Means data, expert data, or engineering judgment. Bare costs are all the costs without any markups. Material costs are based on RS Means data, expert data, or internet sources. The total includes overhead and profit (O&P), which is calculated using labor and material markups from RS Means. Values reported in this appendix are based on national average labor costs. The labor costs shown in the tables in this appendix are the national average values. In its analysis, DOE used regional labor costs to more accurately estimate installation costs by region. Section 8-D.5 describes the derivation of regional labor costs. DOE then applied the appropriate regional labor cost to each RECS sample household. The total costs include O&P. (Note that the unit "L.F." in the tables means "linear foot.")

**Table 8-D.1.1 Example Cost Table**

| Description | Crew | Labor Hours | Unit | Bare Costs *(2011$)* | | | Quantity | Total incl. O&P |
|---|---|---|---|---|---|---|---|---|
| | | | | Material | Labor | Total | | |
| Trip Charge | CREW1 | 0.5 | - | 0.00 | 23.00 | 23.00 | 1 | 35.00 |
| Description of Installation Item | CREW1 | 0.5 | Ea. | 15.00 | 23.00 | 48.00 | 1 | 51.50 |
| Total | | 1.0 | | 15.00 | 46.00 | 71.00 | | **86.50** |

## 8-D.2 INSTALLATION COST DETERMINATION

Because the furnace fan is installed in the furnace in the factory, there is generally no additional installation cost at the home. However, ECM furnace fan design may require additional installation costs. DOE assumed that a fraction of the ECM furnace fan installations will require up to an hour of extra labor at startup to check and adjust airflow. DOE believes this additional installation cost is above and beyond the regular basic installation cost calculated in DOE's furnace rulemaking for a baseline non-ECM furnace. This cost is only applied to the replacement cases, where contractors would be switching from the old PSC motor to the new ECM. In the new construction case DOE assumes that the installer would already make any required adjustments with no additional cost.

ECMs have a very different airflow curve compared to PSC motors. The ECM airflow curve as described in chapter 7 of this TSD is pretty much flat with increasing static pressure (ECMs maintain constant airflow in this range). In the meantime PSC motors decrease airflow with increasing static pressure. If an ECM is installed in a household with a previous PSC motor without checking or adjusting the airflow there is a likelihood that the ECM could operate at undesirable operating conditions. Installers familiar with ECMs will take the time to check and adjust airflow. Those that don't often get callbacks, particularly on systems with tight ducts. Since the motor continues to deliver rated airflow, it generates objectionable noise and often noticeable additions to power consumption, thus requiring a callback to reduce airflow and reassure the customer all is well. DOE assumes that X13 motors don't require much extra time to set up, although some will require additional adjustment over a PSC due to the steeper fan curve delivering more air at high static. Therefore, DOE assumed that for X13 motors the additional installation cost is one fourth that of the ECM.

The additional labor hours required for an ECM are calculated using a triangular distribution with a range from 0 hours to 1 hour and a most likely value of 0 hours (See Figure 8-D.2.1). The average value from this distribution is 0.33 hours.

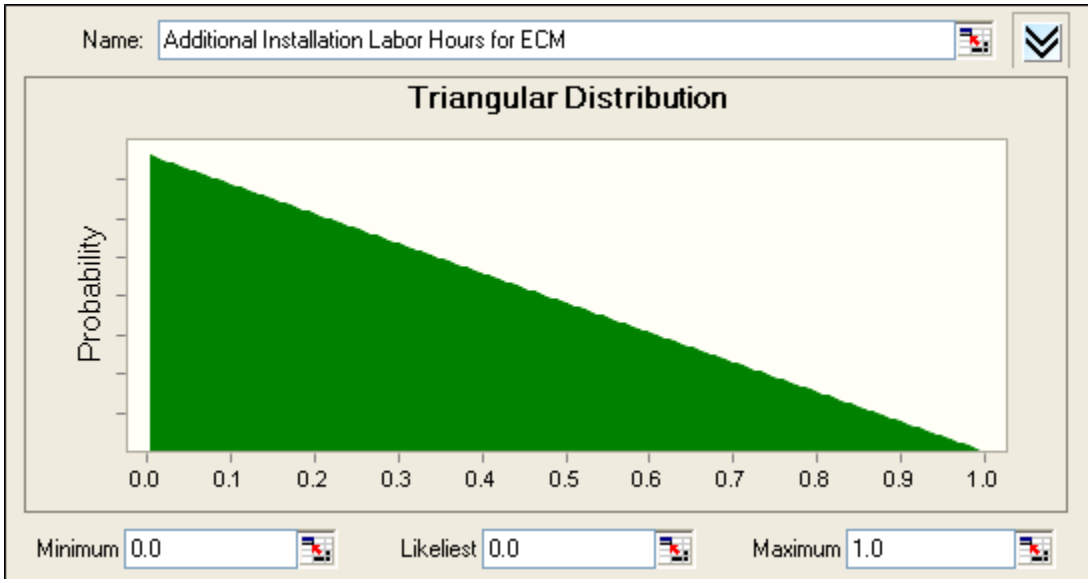


**Figure 8-D.2.1 Additional Installation Labor Hours Distribution for ECMs**

Table 8-D.2.1 shows the installation costs using RS Means.

**Table 8-D.2.1 Additional Installation Cost Calculation for ECM (National Average)**

| Description | Crew | Labor Hours | Unit | Bare Costs *(2011$)* | | | Total incl. O&P |
|---|---|---|---|---|---|---|---|
| | | | | Material | Labor | Total | |
| Check blower airflow for ECM | Q1 | 0.33 | Ea. | $0.00 | $10.51 | $10.51 | $17.16 |

### 8-D.2.2 Summary of Furnace Fan Installation Costs

Table 8-D.2.2 and Table 8-D.2.3 show the average total installation costs used in the analysis.

**Table 8-D.2.2 Installation Costs for Furnace Fans Used in HVAC Products Other than Hydronic Air Handlers (2011$)**

| Key Product Class | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| | Baseline PSC | Improved PSC | PSC w/ Controls | X13 | ECM | ECM + Backward-curved Impeller |
| Non-weatherized, Non-condensing Gas Furnace Fan | $0 | $0 | $0 | $3 | $10 | $10 |
| Non-weatherized, Condensing Gas Furnace Fan | $0 | $0 | $0 | $3 | $13 | $13 |
| Weatherized Gas Furnace Fan | $0 | $0 | $0 | $2 | $10 | $10 |
| Oil Furnace Fan | $0 | $0 | $0 | $4 | $17 | $17 |
| Electric Furnace / Modular Blower Fan | $0 | $0 | $0 | $2 | $9 | $9 |
| Manufactured Home Non-weatherized, Non-condensing Gas Furnace Fan | $0 | $0 | $0 | $2 | $6 | $6 |
| Manufactured Home Non-weatherized, Condensing Gas Furnace Fan | $0 | $0 | $0 | $2 | $8 | $8 |
| Manufactured Home Electric Furnace / Modular Blower Fan | $0 | $0 | $0 | $1 | $6 | $6 |

**Table 8-D.2.3 Installation Costs for Furnace Fans Used in Hydronic Air Handlers (2011$)**

| Key Product Class | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| | Baseline PSC | Improved PSC | PSC w/ Controls | X13 | ECM | ECM + Backward-curved Impeller | Switching Mode Power Supply | Toroidal Transformer |
| Hydronic Air Handler Fan (Heat/Cool) | $0 | $0 | $0 | $3 | $12 | $12 | $12 | $12 |

## 8-D.3 MAINTENANCE COST FOR FURNACE FANS

The maintenance cost is the routine annual cost to the consumer of maintaining equipment operation. It is the cost associated with general maintenance. The regular furnace maintenance generally includes checking the furnace fan. DOE assumes that this maintenance cost is the same at all efficiency levels.

DOE estimated labor hours and costs for annual maintenance was estimated using RS Means data (See Table 8-D.3.1).

**Table 8-D.3.1 Maintenance Cost Calculation for Furnace Fans (National Average)**

| Description | Crew | Labor Hours | Unit | Bare Costs *(2011$)* | | | Total incl. O&P |
|---|---|---|---|---|---|---|---|
| | | | | Material | Labor | Total | |
| Check blower | Q1 | 0.042 | Ea. | $0.00 | $1.34 | $1.34 | $2.10 |

The frequency with which the maintenance occurs was derived from a 2008 consumer survey[2] on the frequency with which owners of different types of furnaces perform maintenance.

**Table 8-D.3.2 Maintenance Fractions based on 2008 American Home Comfort Survey**

| Frequency of Maintenance | Assumed Frequency for Analysis | Fraction of Households | |
|---|---|---|---|
| | | Oil Furnaces | Other Furnaces |
| Last maintenance within a year | Annual | 71% | 53% |
| Last maintenance within two years | Biannual | 17% | 17% |
| Last maintenance over 2 years | Every 5 years | 7% | 15% |
| Never | Never | 5% | 14% |

## 8-D.4 REPAIR COST FOR FURNACE FANS

The repair cost is the cost to the consumer for replacing or repairing components in the furnace fan that have failed.

DOE included motor replacement as a repair cost for a fraction of furnace fans. To estimate rates of fan failure, DOE developed a distribution of fan motor lifetime (expressed in operating hours) by motor size using data from DOE's analysis for small electric motors.[a] See Figure 8-D.4.1 for the furnace motor Weibull distribution, which indicates 30,000 hours as the mean operating hours. DOE then paired these data with the calculated number of annual operating hours for each sample furnace.

[a] http://www1.eere.energy.gov/buildings/appliance_standards/commercial/sem_finalrule_tsd.html

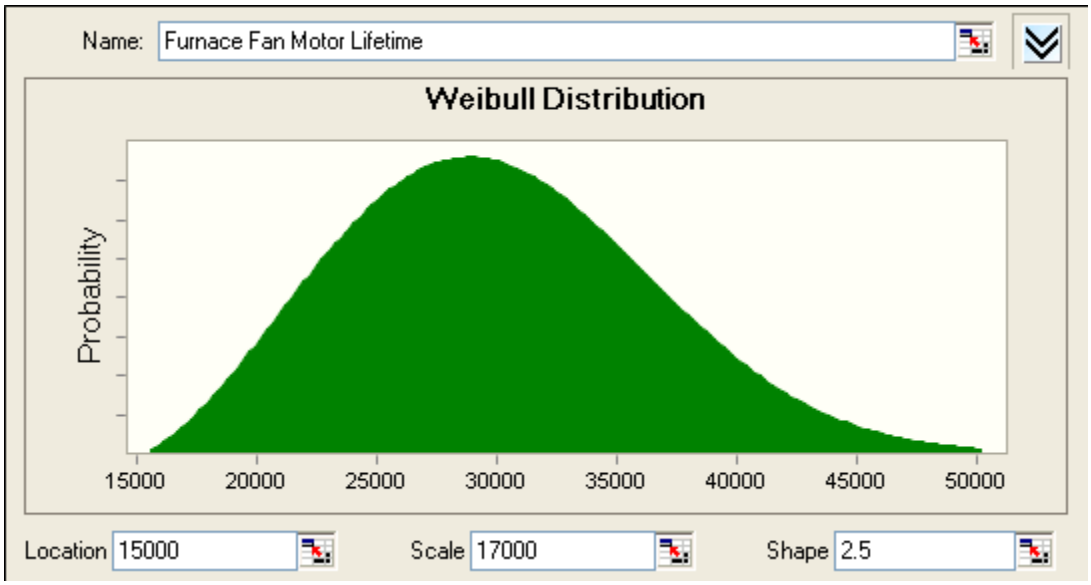


**Figure 8-D.4.1 Furnace Fan Lifetime Distribution in Operating Hours**

Motor costs were based on costs developed in the engineering analysis and marked up using the replacement markups developed in the markup analysis. DOE assumed that the motor cost does not apply if motor failure occurs during the furnace warranty period or if a service contract covers parts. Table 8-D.4.1 shows the warranty period assumptions based on manufacturer product literature. Table 8-D.4.2 shows the service contract assumptions based on a 2008 consumer survey.[2]

**Table 8-D.4.1 Warranty Period Assumptions**

| Warranty Period | Fraction of Households |
|---|---|
| One year Labor and Parts | 100% |
| 5 years parts only | 90% |
| 10 year parts only | 10% |

**Table 8-D.4.2 Service Contract Assumptions**

| Service Contract Types | Fraction of Households | |
|---|---|---|
| | Oil Furnaces | Other Furnaces |
| Total Package (Labor and Parts) | 27% | 15% |
| Annual Cleaning | 11% | 6% |
| None | 62% | 79% |

DOE estimated repair costs at each considered level, based on *2012 RS Means Facility Repair and Maintenance Data*.[3] DOE accounts for regional differences in labor costs. DOE estimated labor hours and costs for annual maintenance using RS Means data (See Table 8-D.4.3). DOE assumed that the labor cost does not apply if motor failure occurs during the furnace warranty periods first year or if a service contract covers labor.

**Table 8-D.4.3 Repair Cost Calculation (Labor Only) for Furnace Fans (National Average)**

| Description | Crew | Labor Hours | Unit | Bare Costs *(2011$)* | | | Total incl. O&P |
|---|---|---|---|---|---|---|---|
| | | | | Material | Labor | Total | |
| Check blower | Q-1 | 1 | Ea. | $0.00 | $31.85 | $31.85 | $52.01 |
| Remove fan motor | Q-1 | 0.976 | Ea. | $0.00 | $31.09 | $31.09 | $50.76 |
| Replace fan motor | Q-1 | 1.951 | Ea. | $0.00 | $62.14 | $62.14 | $101.47 |
| Total | | | | | | | **$204.25** |

## 8-D.4.2 Summary of Furnace Fan Repair Costs

Table 8-D.4.4 and Table 8-D.4.5 show the average annualized repair costs used in the analysis.

**Table 8-D.4.4 Annualized Repair Cost for Furnace Fans Used in HVAC Products Other than Hydronic Air Handlers (2011$)**

| Key Product Class | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| | Baseline PSC | Improved PSC | PSC w/ Controls | X13 | ECM | ECM + Backward -curved Impeller |
| Non-weatherized, Non-condensing Gas Furnace Fan | $13 | $13 | $14 | $14 | $18 | $19 |
| Non-weatherized, Condensing Gas Furnace Fan | $13 | $14 | $14 | $15 | $18 | $19 |
| Weatherized Gas Furnace Fan | $15 | $15 | $16 | $17 | $21 | $23 |
| Oil Furnace Fan | $14 | $14 | $14 | $15 | $18 | $19 |
| Electric Furnace / Modular Blower Fan | $14 | $14 | $15 | $16 | $19 | $21 |
| Manufactured Home Non-weatherized, Non-condensing Gas Furnace Fan | $12 | $12 | $13 | $14 | $17 | $18 |
| Manufactured Home Non-weatherized, Condensing Gas Furnace Fan | $13 | $13 | $14 | $15 | $17 | $18 |
| Manufactured Home Electric Furnace / Modular Blower Fan | $13 | $13 | $14 | $15 | $19 | $21 |

**Table 8-D.4.5 Annualized Repair Cost for Furnace Fans Used in Hydronic Air Handlers (2011$)**

| Key Product Class | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| | Baseline PSC | Improved PSC | PSC w/ Controls | X13 | ECM | ECM + Backward -curved Impeller | Switching Mode Power Supply | Toroidal Transformer |
| Hydronic Air Handler Fan (Heat/Cool) | $16 | $16 | $17 | $18 | $21 | $23 | $23 | $24 |

## 8-D.5 REGIONAL MATERIAL AND LABOR COSTS

DOE used regional material and labor costs to more accurately estimate installation, maintenance, and repair costs by region. RS Means provides average national labor costs for different trade groups as shown in Table 8-D.5.1. Bare costs are given in RS Means, while labor

costs including overhead and profit (O&P) are the bare costs multiplied by the RS Means markups by trade shown in Table 8-D.5.2.

**Table 8-D.5.1 RS Means 2011 National Average Labor Costs by Crew (Standard Union)**

| Crew Type | Crew Description | Laborers per Crew | Cost per Labor-Hour | |
|---|---|---|---|---|
| | | | Bare Costs | Incl. O&P* |
| **1 Plum** | 1 Plumber | 2 | $35.40 | $57.81 |
| **1 Elec** | 1 Electrician | 1 | $33.70 | $54.63 |
| **Q1** | 1 Plumber, 1 Plumber Apprentice | 2 | $31.85 | $52.01 |
| **1 Carp** | 1 Carpenter | 1 | $30.15 | $50.47 |

* Q&P includes markups in Table 8-A.8.2

**Table 8-D.5.2 RS Means Labor Costs Markups by Trade (Residential)**

| Trade | Workers Comp. | Aver Fixed Overhead | Overhead | Profit | Total |
|---|---|---|---|---|---|
| Plumber | 7.0% | 16.3% | 30.0% | 10.0% | 63.3% |
| Electrician | 5.8% | 16.3% | 30.0% | 10.0% | 62.1% |
| Carpenter | 16.1% | 16.3% | 25.0% | 10.0% | 67.4% |

RS Means also provides material and labor cost factors for 295 cities and towns in the U.S. To derive average labor cost values by state, DOE weighted the price factors by city or town population size using 2009 census data. DOE used the material and labor cost factors for cost associated with fire suppression, plumbing, and HVAC. Table 8-D.5.3 shows the final regional material and labor price factors used in the analysis by geographical area. The distribution of each RECS 2005 product class sample is different, so the average labor cost weighted by RECS 2005 sample weights is different from the RS Means national average (i.e., labor cost factor of 1.00).

## Table 8-D.5.3 Material and Labor Cost Factors by Geographical Area

| Geographical Area | Material | Labor |
|---|---|---|
| Connecticut, Maine, New Hampshire, Rhode Island, Vermont | 0.99 | 0.94 |
| Massachusetts | 1.00 | 1.18 |
| New York | 1.00 | 1.57 |
| New Jersey | 1.00 | 1.21 |
| Pennsylvania | 0.98 | 1.12 |
| Illinois | 1.00 | 1.26 |
| Indiana, Ohio | 0.99 | 0.88 |
| Michigan | 1.00 | 1.00 |
| Wisconsin | 0.99 | 0.93 |
| Iowa, Minnesota, North Dakota, South Dakota | 0.99 | 0.90 |
| Kansas, Nebraska | 0.99 | 0.72 |
| Missouri | 0.99 | 0.95 |
| Virginia | 0.99 | 0.69 |
| Delaware, District of Columbia, Maryland, West Virginia | 0.99 | 0.88 |
| Georgia | 0.99 | 0.68 |
| North Carolina, South Carolina | 0.99 | 0.41 |
| Florida | 1.00 | 0.63 |
| Alabama, Kentucky, Mississippi | 0.99 | 0.63 |
| Tennessee | 1.00 | 0.65 |
| Arkansas, Louisiana, Oklahoma | 0.99 | 0.58 |
| Texas | 1.03 | 0.56 |
| Colorado | 0.99 | 0.79 |
| Idaho, Montana, Utah, Wyoming | 1.00 | 0.69 |
| Arizona | 1.00 | 0.73 |
| Nevada, New Mexico | 1.00 | 0.90 |
| California | 0.99 | 1.20 |
| Oregon, Washington | 1.00 | 1.00 |
| Alaska | 1.00 | 1.03 |
| Hawaii | 1.02 | 0.60 |

## REFERENCES


1. RS Means Company Inc., *RS Means Residential Cost Data*. 31st Annual Edition ed. 2012: Kingston, MA

2. Decision Analysts, *2008 American Home Comfort Study: Online Database Tool*, 2009. Arlington, Texas. <http://www.decisionanalyst.com/Syndicated/HomeComfort.dai>

3. RS Means Company Inc., *Means Facilities Maintenance & Repair Cost Data*. 2012. Kingston, MA.