Central Air Conditioner and Heat Pump Engineering Analysis: Production Costs

U.S. Department of Energy
August, 1999

What is production cost?

Production cost is the cost a manufacturer incurs to produce a saleable product. It includes the costs of:

- *Direct Materials*— purchased components and raw materials that go directly into the product (compressors, wires, sheet metal)
- *Direct Labor*—wages and fringe benefits of workers that fabricate and assemble the product

and overhead items such as:

- *Indirect Materials*—materials indirectly associated with producing the product (strapping, process computers)
- *Indirect Labor*—wages and fringe benefits of workers that supervise and support the production process
- *Maintenance*—labor and materials associated with maintaining the production facility
- *Utilities*—primarily electricity used to power production equipment and support plant services
- *Depreciation*—amortized cost of buildings and equipment associated with production
- *Taxes*—property taxes on plant and equipment
- *Insurance*—hazard insurance for plant and equipment.

We do not include non-production costs such as sales, administration, and research.

Outbound freight is typically considered a sales cost, and therefore not a production cost. We included it in our analysis, however, to capture the effect of higher equipment efficiency (larger, heavier equipment) on shipping charges.

What is the DOE production cost workbook (*CAC Cost v24.xls*)?

CAC Cost contains the results of the reverse engineering production cost estimates for each of the four classes of residential central air conditioners defined by NAECA:

- split system air conditioners,
- single packaged air conditioners,
- split system heat pumps,
- single packaged heat pumps.

For split air conditioners, costs are estimated for indoor units with and without air handlers. Each estimate represents equipment with a nominal three ton cooling capacity (33,000 through 39,000 BTU/hr).

The workbook allows you to see a representative breakdown of production costs, in 1998 dollars, for equipment under each class at each efficiency level. You can also see the costs of equipment at each efficiency level relative to the baseline equipment under the current NAECA standard (10 SEER for split systems and 9.7 SEER for packaged systems.) This can illustrate how individual items tend to change as system efficiency increases.

Note that the production costs assume that each efficiency level is the minimum efficiency standard established by DOE. Consequently, the component labor, material and overhead costs are *not necessarily representative* of current production costs for equipment efficiencies that exceed the current SEER 10 standard (9.7 SEER for packaged equipment).

In addition to letting you view the cost estimates, *CAC Cost* lets you adjust them to see the effects on the overall relative cost relationship. You can change a cost element by 1) replacing it with a new value, 2) adding or subtracting a fixed percentage, or 3) adding or subtracting a fixed dollar amount. This feature will let you identify and correct apparent problems, adjust for inflation or deflation of component or material prices, and model the potential impacts of new technologies.

Why do production costs change as the equipment efficiency changes?

Generally, more efficient equipment is larger, heavier, and more complex and uses more expensive components. All of these contribute to higher production costs.

What do each of the cost elements represent?

Manufacturers have different philosophies about exactly how to increase the efficiency of their equipment. For example, some may prefer to install a more efficient compressor and some may prefer to increase the size of the outdoor heat exchanger (outdoor coil). ***We assume that manufacturers in a competitive environment will incur close to the same incremental production cost at a given efficiency level, even when they use different design approaches***.

The equipment we sampled displayed a diversity of designs. The results in *CAC Cost* represent the cost of each of those approaches averaged together. This can reveal design trends, but not exact costs. For example, if a compressor cost is listed as $155, it may represent several models that use $155 compressors, or some models that use $150 compressors with larger heat exchangers and come that use $160 compressors with smaller heat exchangers. The same is true for the other items. We presented the information this way to protect the confidentiality of the underlying information. This is also consistent with the *efficiency level* approach that we adopted for the engineering analysis.

How were the cost estimates developed?

The reverse engineering process estimated the cost of air conditioners by examining the products both directly and indirectly.

We initially disassembled and inspected three 3-ton units to determine the designs, components, materials, and processes used to produce them. The units were 1) a 10 SEER split air conditioner with fancoil, 2) a 10 SEER packaged heat pump, and 3) a 12 SEER split air conditioner condenser. In addition to the three tear down units, we collected design, material, and component information on another 68 models. This information came directly from equipment manufacturers and from product literature.

Once the information was gathered, we estimated materials and component pricing, fabrication and assembly costs, and factory overhead. We obtained pricing information from various sources.

We estimated the production cost for each of the 71 models analyzed. The results in *CAC Cost* represent the averages of those results at each efficiency level. Some efficiency levels represent average results from multiple equipment models and some from only a single model.

What are the key assumptions that drive the cost estimates?

We assumed that each unit at a given efficiency level represents a typical unit that would be produced if DOE established a minimum efficiency standard at that level. Some important assumptions include:

1. High-volume production (125,000 units per year for split air conditioners and 25,000 units per year for split heat pumps and packaged systems)
2. Elimination of "premium" features like sound attenuation and aesthetic enhancements
3. Production processes and cabinet configurations similar to the two disassembled 10 SEER units
4. Greenfield production facility
5. No price reductions in components due to economies of scale or technological advance
6. No technologies or processes that were not widely applied in 1998

The Technical Support Document published with the Advanced Notification of Proposed Rulemaking will explain further these and other assumptions.

Why do values in *CAC Cost v2.4* differ from those presented in the Lifecycle Cost analysis?

CAC Cost v2.4 differs in two respects from the costs used in the lifecycle cost analysis. First, the *CAC Cost v2.4* calculates outbound freight in an updated manner (fixed rate based on cabinet volume). Second, for ease of use, the values presented in *CAC Cost v2.4* have not been subjected to a Monte Carlo uncertainty analysis. Hence, they represent "most likely" rather than "mean" estimates. The

lifecycle cost analysis uses the more appropriate “mean” cost estimates. The differences are usually subtle.

How do I use the workbook?

From the Menu screen, select which equipment class you would like to view and what adjustment you would like to make. The workbook will take you to the correct worksheet. To make adjustments, enter values in the white boxes. If you only want to view the costs without making adjustments, you can select any sheet.

To return to the Menu screen, select the button near the top left corner of the cost table on the worksheet you are currently using.

Can I modify the workbook?

Each worksheet is protected to prevent you from accidentally entering values in the wrong area or deleting important information. However, you can make deliberate alterations after removing the protection. No password is required. Refer to MS Excel™ help for instructions on protecting worksheets.

To remove and reestablish protection for all worksheets at once, select the *unprotect* or *protect* macros from the list of macros available. Refer to MS Excel™ help for instructions on running macros.