Is a Circulator's Efficiency as Important as a Boiler's?

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The heating industry has been focusing on improving the combustion efficiency of the boiler, and every boiler manufacturer has a modulating/condensing boiler in its product offering. The number of mod/con boiler installations has been growing every year and will continue to grow. Some of the boilers, when installed in the right application, are achieving efficiencies in the 95%+ range.

Some in the industry are under the impression that, with thermal efficiencies this high, there isn't any room left to improve a hydronic heating system. Their thinking would be correct if combustion efficiency was the only goal. However, there is another efficiency that the industry is starting to look at—*hydraulic efficiency* of the distribution system. We should be looking at overall system efficiency, which includes how efficient the boiler plant converts fuel into heated system water *and* how efficiently this heated water is delivered to the building.

Definitions

Let's first define what Distribution Efficiency is:

> EFFICIENCY = Desired OUTPUT quantity/ Necessary INPUT quantity

In basic terms…how much energy is needed to get the desired output? When we apply the definition of distribution efficiency to a heating system, it looks like this:

> DISTRIBUTION EFFICIENCY = Rate of heat delivery/ Rate of energy use by distribution equipment.

If a heating system provides 120,000 British Thermal Units/hour (BTU/H) at outdoor design conditions, and they have four circulators that consume 90 watts each, the Distribution Efficiency for that system is:

> **DE =** *120,000 BTU/H/ 360 watts = 333 BTU/H / watt*

Compare that to a warm air furnace where the blower motor consumes 1,050 watts while delivering 110,000 BTU/H through the duct system. The Distribution Efficiency for that system would be:

> **DE =** *110,000 BTU/H / 1,050 watts = 105 BTU/H/ watt*

The hydronic system has a higher Distribution Efficiency than the warm air furnace because the physical properties of water are much better for conveying heat than air.

Even though hydronic systems generally have a higher Distribution Efficiency than air systems, when the number of pumped zones increases, the Distribution Efficiency can quickly dissolve. For example, I recently visited a very large home that had 34 zones, all with water-lubricated circulators consuming 90 watts each. The house had a design load of 350,000 BTU/H. When you run the numbers to determine the Distribution Efficiency:

> **DE =** *350,000 BTU/H / 34 x (90 watts) = 114 BTU/H / watt*

As you can see, a hydronic system, when taken to the extreme, can become an inefficient distribution system. These systems have been installed for years with no real concern for operating costs. However, with energy costs continuing to rise, not only has it has impacted both fuel costs for transportation and heating homes, but electrical costs are also impacted.

Electrical power plants need to use some source of energy. The majority of plants have used coal for years, but through legislation, many are being closed down or converted to natural gas. This is putting tremendous pressure on the power plants to manufacture electricity. The result? Higher electric bills!

Over in Europe, where they have experienced higher fuel and electric costs, they have been forced to come up with better and more efficient ways to heat water and *deliver* the heated water to the heating terminal units. One of the technologies

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they have embraced for years is electronically commutated magnetic motors (ECM).

The majority of residential homes in Europe use hot water heating to warm their homes. To achieve higher Distribution Efficiencies, they have incorporated ECM technology into their circulators. In fact, nowadays, only ECM circulators are allowed to be installed in Europe.

The pump manufacturers in Europe have combined their efforts to improve the efficiency of the circulators they offer for hot water heating systems. They came up with an efficiency index that all pump manufacturers had to reach called the Energy Efficiency Index (EEI). The European community created legislation to adopt this EEI standard and manufacturers quickly realized they could not achieve the necessary efficiency points with induction motor technology. It just proved to be too inefficient, so they moved to ECM technology.

Back in the Northeast

Utilities in the Northeast are providing rebate incentives for residential ECM circulators. It seems they are very interested in having the hydronic industry move away from the old, inefficient induction motors and move towards ECM technology. Plumbing and heating wholesale distributors have signed up and became part of the utility's high-performance circulator program. This allows them to offer a $100 discount off the price of any of the participating ECM residential circulators.

Why would they provide such a generous incentive? It has to do with energy costs and energy consumption. As energy costs continue to rise, the impact affects everyone. As production costs go up, distribution costs go up, and the net result is higher utility bills for end-users.

If we were to re-examine our Distribution Efficiency formula while incorporating the new ECM circulators that *can* consume considerably fewer watts, the Distribution Efficiency can be markedly improved. If we go back to that large home that had 34 water-lubricated zone pumps and replaced them with the ECM pumps with speed control (which allows the pump to be set for the zone's actual load) the formula would look something like this:

DE = *350,000 BTU/H / 34 x (20 watts) = 515 BTU/H / watt*

If you have any questions or comments, e-mail *gcarey@fiainc.com*; call 1-800-423-7187 or follow *@Ask_Gcarey* on Twitter. **ICM**