Gas Furnace Electricity Usage

Background

A low-rise apartment complex in upstate New York undertook energy improvements through the NYSERDA Multifamily Performance Program, with replacement of gas furnaces in each apartment as one of the major improvements. Post-construction, substantial gas savings were found to have been delivered, but a significant increase in electricity use was also observed.

This led to an evaluation of the impact of condensing furnace replacements on blower motor power, with a focus on whether condensing furnaces have higher electricity usage than non-condensing furnaces. We measured the electric power draw of several furnaces of each of three different types:

- Non-condensing furnaces with permanent-split-capacitor (PSC) blower motors
- Condensing furnaces with PSC blower motors
- Condensing furnaces with brushless permanent magnet (BPM) blower motors

Motor Types

The majority of furnaces use PSC motors — estimates vary between 75% and 95% — likely because these motors are more affordable than BPM motors. Most of these motors have multiple speed taps, one of which is chosen and set by the installer. So, in normal operation, these motors generally run at a constant speed.

BPM motors are direct current (DC), variable speed motors that are significantly more efficient than PSC motors, even at low speeds. The Electronically Commutated Motor (ECM) is a registered trademark of General Electric and is the most common brand of BPM motor.

Testing and Analysis

A power meter was used to record the instantaneous power draw of the furnaces tested. Each unit's total power use was measured, including stand-by power and power drawn by the inducer motor, igniter, and condensate pump. Long-term monitoring was not performed.

For furnaces with BPM motors, measurements were taken at both high and low speed. Even though the motors can run at many speeds, they typically run either at high speed or at low speed.

Annual projections were performed using a bin analysis to estimate usage based on furnace runtime calculated for a building with UA = 547 btu/h-°F at each of a number of different outdoor temperatures.

Results

There is a significant increase in electricity usage when replacing a non-condensing furnace with a condensing furnace having a PSC motor, with the average electricity usage increasing by approximately 50%.

When a non-condensing furnace is replaced with a condensing furnace with a BPM motor, the blower electricity use increases slightly at high fire. But because a typical dual-stage furnace fires on low fire so much of the time, the annual electricity usage for a BPM condensing furnace is slightly lower than for a non-condensing furnace.

Tables 1, 2, and 3 on the next page show the complete test results.

Secondary Sources of Electricity Usage

Secondary sources of electricity usage include standby energy, draft inducers, igniters, and when installed, condensate pumps. Taken together, these can add from 5% to 20% to the annual electricity usage, with 10% being typical. The majority of the added annual electric use is the electricity the furnace uses while on standby, presumably for controls.

Added Construction Cost

Furnaces with BPM motors were found to cost $200 to $800 more than those with PSC motors, with an average cost difference of $400.

Modeling

For usage in energy modeling, such as TREAT, the following estimates are recommended, on the basis of annual heating usage:

Non-condensing furnace	6 kWh/MMBtu
Condensing furnace with PSC motor	9 kWh/MMBtu
Condensing furnace with BPM motor	5 kWh/MMBtu

Example
Assume that a multifamily building consumes 1,300 MMBtu per year for heating and is heated with non-condensing furnaces having an AFUE of 81%.

Annual electric usage can be calculated as follows:

$$0.81 \times \frac{1{,}300\ MMBtu}{year} \times \frac{6\ kWh}{MMBtu} = \frac{\mathbf{6{,}318\ kWh}}{\mathbf{year}}$$

Table 1 – Non-Condensing Furnaces with PSC blowers

Furnace	Furnace Output (Btu/hr)	Blower Power (W/kBtuh)	Total Annual kWh	Total Electric Usage (kWh/MMBtu)
A	80,000	7.8	920	10
B	88,000	5.5	640	7
C	95,000	5.7	700	7
D	100,000	8.3	880	9
E	100,000	2.6	300	3
F	108,000	1.3	260	3
G	160,000	3.0	360	4
Average	**104,429**	**4.9**	**580**	**6**

Definitions

Blower power

Instantaneous blower power used per furnace heat output. For dual-stage furnaces, there are separate values for the blower power on high fire and on low fire.

Total Annual kWh

The estimated annual energy usage of each furnace if installed in a building requiring 46,500 Btuh to heat at -18°F.

Total electric usage

The average electricity, in watt-hours, per kBtu of heat supplied to the building, In addition to blower motor electricity, this includes secondary sources of electricity usage.

Table 2 – Condensing Furnaces with PSC blowers

Furnace	Furnace Output (Btu/hr)		Blower Power (W/kBtuh)		Total Annual kWh	Total Electric Usage (kWh/MMBtu)
	(high)	(low)	(high)	(low)		
H	46,500		9.6		1,100	11
I	54,000		9.2		1.080	11
J	67,500		7.3		880	9
K	73,000		4.1		460	5
L	75,000		6.1		700	7
M	90,000		7.2		940	10
N	93,000		8.4		980	10
O	93,200	63,716	6.8	8.4	920	10
P	114,000		5.1		560	6
Average	**78,467**	**63,716**	**7.1**	**8.4**	**847**	**9**

Table 3 – Condensing Furnaces with BPM blowers

Furnace	Furnace Output (Btu/hr)		Blower Power (W/kBtuh)		Total Annual kWh	Total Electric Usage (kWh/MMBtu)
	(high)	(low)	(high)	(low)		
Q	60,000	24,000	6.6	3.7	440	5
R	67,500	45,900	6.7	6.3	700	7
S	74,000	30,000	4.5	3.1	380	4
T	78,000	31,200	8.4	5.2	560	6
Average	**69,875**	**32,775**	**6.5**	**4.6**	**520**	**5**