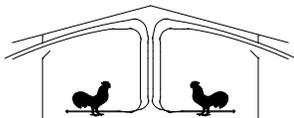




The University of Georgia

College of Agricultural and Environmental Sciences
Cooperative Extension



Poultry Housing Tips

Variable Speed Tunnel Fans Can Result in Dramatic Power Savings

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Figure 1. Skov 55" variable speed BlueFan.



Figure 2. Traditional 1990's 48" slant-wall fan.

The amount of electricity used by an exhaust fan is not determined by the size of the motor but rather how fast the fan blades are rotating. The faster a fan spins, the greater the amount of air moved, and the greater the power consumed. As a result you can modify both the amount of air moved and the power consumed by a tunnel fan by simply increasing or decreasing the size of the motor pulley, which would change the speed at which the fan blades rotate.

$$\begin{aligned} \text{Cfm}_2 &= \text{Fan blade speed}_2 / \text{Fan blade speed}_1 \times \text{Cfm}_1 \\ &= 480 / 400 \times 20,000 \\ &= 1.2 \times 20,000 \text{ cfm} \\ &= 24,000 \text{ cfm} \end{aligned}$$

Interestingly though the air moving capacity of a fan increases proportionally with fan speed, power usage increases exponentially with fan speed. If fan speed is increased by 20%, the air moving capacity of the fan will increase by roughly 20%. For example, if you have a fan that moves 20,000 cfm that is rotating at 400 rpm and you increase the fan speed to 480 rpm by installing a larger motor pulley the air moving capacity of the fan will increase 20% increase to 24,000 cfm.

$$\begin{aligned} \text{Power}_2 &= (\text{Fan blade speed}_2 / \text{Fan blade speed}_1)^3 \times \text{Power}_1 \\ &= (480 / 400)^3 \times 1,000 \text{ watts} \\ &= 1.73 \times 1,000 \text{ watts} \\ &= 1,730 \text{ watts} \end{aligned}$$

The fact that power usage increases exponentially with fan speed means that relatively small increases in fan speed can result in very large increases in the amount of power used by a fan. For example, if we have a fan that is spinning at 400 rpm (moving 20,000 cfm) using 1,000 watts of power and we increase the size of the motor pulley so the fan is spinning at 480 rpm (20% increase), power usage will not increase 20%, but rather would nearly double to 1,730 watts! This is the reason producers should not replace their existing fan motor pulleys with larger ones to increase the air moving capacity of their fans. Though it may be initially less expensive to replace motor pulleys than to install additional fans, the nearly doubling of fan power usage for a 20% increase in air moving capacity/air speed would be far more costly in the long run.

Though increasing fan speed is not typically a wise investment, the converse can result in substantial power savings. For instance, reducing fan speed by 20% will result in the air moving capacity of the fan in the above example decreasing from 20,000 cfm to 16,000 cfm, but the amount of power used by the fan would be roughly cut in half to 512 watts. The greater the reduction in fan speed, the more dramatic reduction in fan power usage.

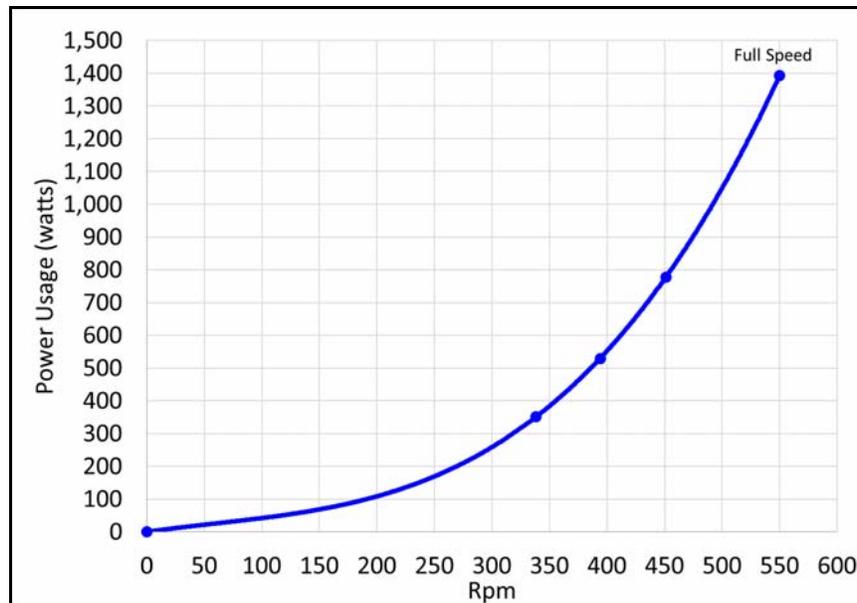


Figure 3. Fan power usage vs Fan speed.

Figure 3 provides an example of how power usage varies with fan speed for a 55", variable speed, tunnel fan (Skov BlueFan - DA1700-5). When operating at full speed the fan uses 1,400 watts of power. When the fan speed is reduced from 550 rpm to 450 rpm, a reduction of approximately 20%, fan power usage is nearly cut in half to 780 watts. But even more dramatic power savings can be realized by reducing fan speed from 550 rpm to 340 rpm. The 38% reduction in fan speed reduces fan power usage by 65% to only 350 watts...about the same amount of power used by a 1/3 hp - 18" circulation fan.

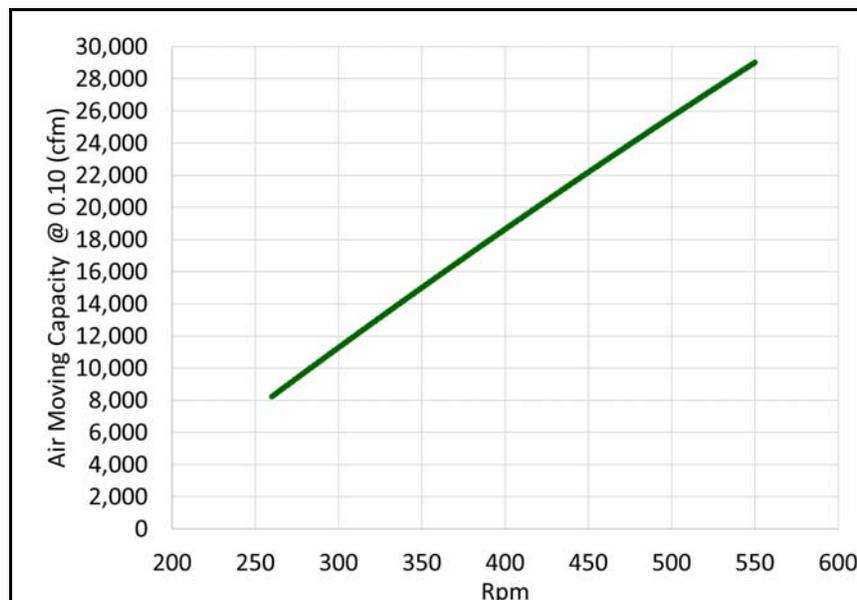


Figure 4. Fan air moving capacity vs. Fan speed.

Figure 4 illustrates the general linear relationship between fan speed and air moving capacity for the Skov BlueFan. At 550 rpm and a static pressure of 0.10" the 55" fan moves approximately 29,000 cfm. When the speed is reduced by 20%, air moving capacity of the fan decreases to approximately 22,000 cfm (24 % reduction). Reducing the fan speed from 550 to 340 rpm, a 38% reduction in speed, decreases the air moving capacity the fan to approximately 14,000 cfm (52% reduction). The actual reduction in air moving capacity of the fans in this instance is not directly proportional to fan speed because of the fan is moving air under a static pressure of 0.10" and not zero. One important characteristic of a variable speed fan is that as fan speed is reduced, its ability to move air under a high static pressure is significantly reduced. As a result you could have a case where fan speed is reduced 20% but because it is moving air under a high static pressure situation (i.e. 0.15"), the air moving capacity of the fan could be reduce 50% or more . In fact, if fan speed is reduced too much, a variable speed fan may not even be able to generate enough pressure to open its own shutter. For this reason it is generally recommended that variable speed exhaust fans not operate at less than 60% of their indicated "full" speed.

Though it may be difficult to grasp at first, the fan laws tell us that from a power savings standpoint it is better to operate more fans at lower speed, than fewer fans at high speed. It is not the number of fans operating that will determine your power bills but the speed at which they are operating. For instance, operating at full speed three BlueFans will move a total of 87,000 cfm (29,000 cfm @ 0.10 X 3) and consume 4,200 watts (1,400 watts X 3). But, operating five fans at 375 rpm (68%) will move the same amount of air and only use a total of 2,250 watts of power (450 watts X 5), a savings of nearly 50%! More fans, but lower power bills.

Recently a study has begun to examine the use of variable speed tunnel fans to reduce fan operating cost. The study is being conducted on a two-house broiler-breeder farm in Northwest Georgia. The 40' X 500' curtain-sided houses were constructed in the mid 1990's and were equipped with eight 48" slant wall fans and two 36" side wall exhaust fans (Figure 2). In one of the houses, six 55" variable speed Skov BlueFans were installed and four of the original 48" fans were left in the place for back-up purposes (Figure 1). Each of the fans was equipped with a "speed controller" that allows the speed of the fans to be adjusted between 60 and 100% (Figure 5). Fan operation was controlled through the house's Choretime C2 environmental controller which sent on/off signals to a Skov "control box" which in turn activated each fan's speed controller as needed (Figure 6).



Figure 5. Variable speed 55" fans equipped with speed controllers (above fans).



Figure 6. Choretime controller with Skov fan interface (blue box) and power meters (left)

The initial speed of each of the six 55" fans was set so the fans would move the same amount of air as one of the existing 48" fans (340 rpm or 62%). This was done so that when the controller in the house with the variable speed fans turned on a "tunnel" fan it moved the same amount of air as the 48" fans in the adjacent house. When the controller asked for a seventh tunnel fan the speed of the six variable speed fans was increased to match the air moving capacity of seven 48" fans (395 rpm or 71%). Likewise, when the controller asked for an eighth tunnel fan the speed of the variable speed fans was increased to match the air moving capacity of eight 48" fans (450 rpm or 82%).

The air speed in the scratch area of both houses, the conventional house with all eight fans operating and the test house with the six 55" fans operating at 82%, was approximately 480 ft/min with the air speed on the slats near the side of 300 ft/min. Though the six 55" fans were capable of moving roughly 30% more air when operating at 100%, the environmental controller was set only to allow this in the case of excessive house temperatures. It is important to note that the objective of the study was not to increase the air speed in the house with the new fans, but to match the air moving capacity of the existing ventilation system with much more energy efficient fans.

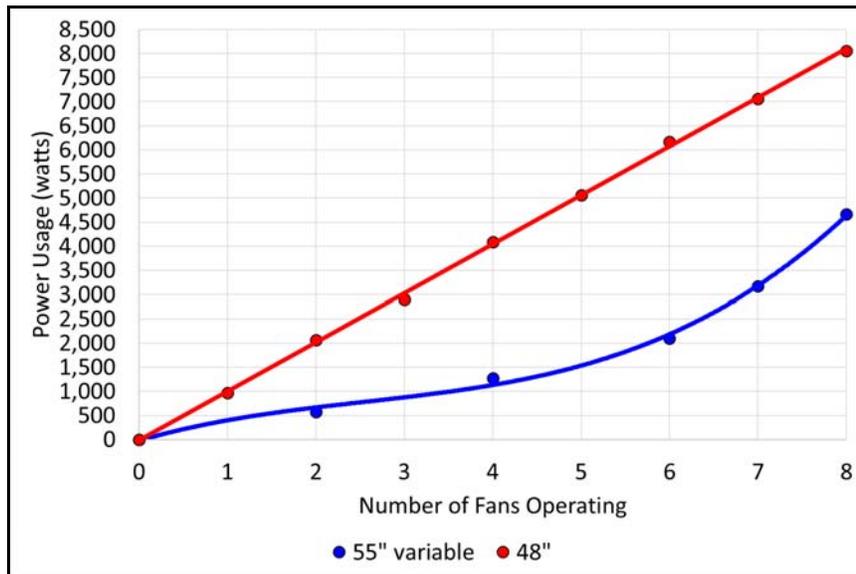


Figure 5. Total fan power usage vs. Number of fans operating.

Figure 5 illustrates total power usage of the tunnel fans as function of the number of fans operating in each house. Each of the eight 48" fans in the control house uses approximately 1,000 watts of power regardless of whether it is first fan or the eighth fan to come on. In the house with the variable speed fans the situation is a little more complex. When the first six variable speed fans are turned on they are set to operate at 68% of full speed to match the air moving capacity of the 48" fans in the adjacent house and as a result will only use roughly 350 watts compared to the 1,000 watts consumed by the 48" fans in the adjacent house (65% reduction in power usage). When the controller calls for a seventh fan, each of the six variable speed fans speed up a little to match the total air moving capacity of seven 48" fans and power usage of each fan increases to 530 watts. When the controller calls for an eighth fan, the speed of the six fans increases again and power usage of each fan increases to 740 watts. Though the power usage of each of the variable speed tunnel fans increases as the controller calls for the seventh and eighth tunnel fan, it is important to keep in mind that there are only six fans using 530 and 740 watts, respectively, which results in a significant reduction in total fan power usage. When the controller is calling for seven fans in the house equipped with the variable speed fans, total power usage will be 3,180 watts, compared to 7,000 watts in the house with the 48" fans, a 55 % reduction. When the controller calls for eight fans in the house equipped with the variable speed fans, the fans consume a total of 4,320 watts compared to the 8,000 watts required to drive eight 48" fans, a 46% reduction.

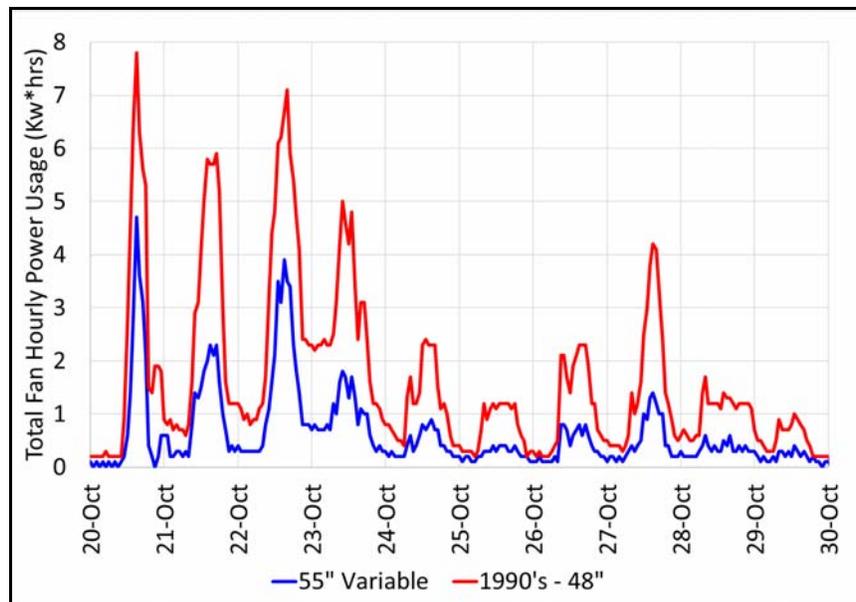


Figure 6. Hourly fan power usage.

Each of the tunnel fans in both the houses were equipped with a power meter connected to a data logging system set to record power usage every 15 minutes. Figure 6 illustrates the total hourly fan power usage over the first ten days of the recently

placed broiler-breeder flock. Figure 7 illustrates the daily cost of operating the fans in each of the houses assuming a power cost of \$0.10 Kw*hr. As expected, the variable speed tunnel fans reduced fan power usage between 46% and 65% depending on the number fans operating over the course of the day. Though we are at the very beginning of the year long study, this initial window into the potential power savings in using variable speed fans does illustrate why there is increasing interest in to this concept.

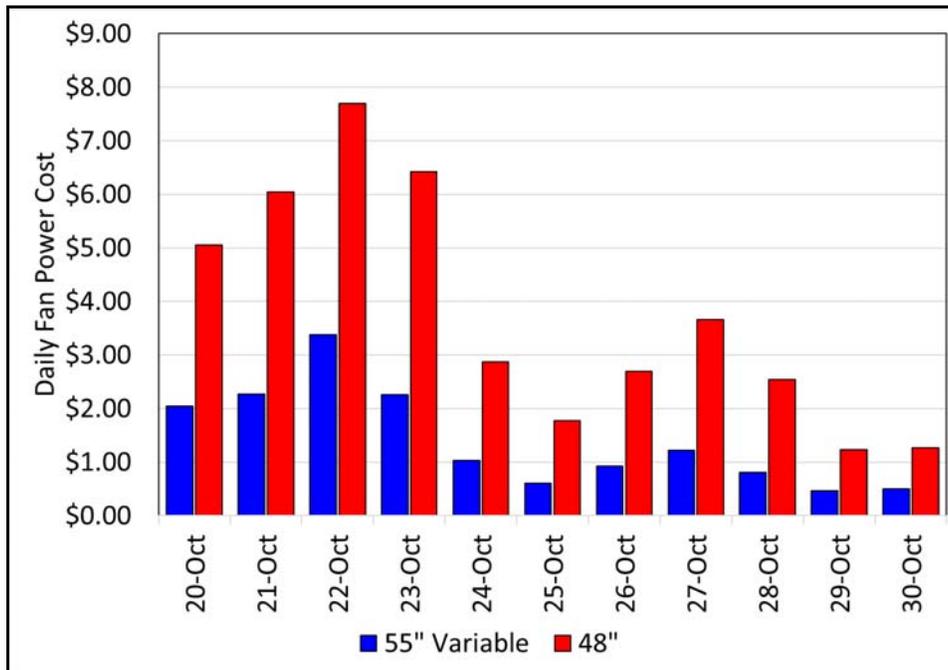


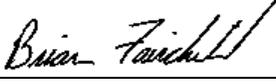
Figure 7. Daily fan power cost @ \$0.10 per Kw*hr.

Due to the potential for significant power savings there is little doubt that in the future poultry houses will use variable speed tunnel fans. But before they become commonplace there are a number of questions that must first be answered:

- 1) Economics. Currently variable speed fans and associated controls are two to three times more expensive than traditional fixed speed fans.
- 2) Longevity/Reliability. Variable speed fans require electronic speed controllers which if they fail makes it essentially impossible to operate the fan.
- 3) Control. Currently not all poultry house environmental controllers can be easily modified to properly control large numbers of variable speed fans.
- 4) What is the optimal number of variable speed fans to install? When variable speed fans operate at full speed they tend to be not that much more energy efficient than many fixed speed fans. The key to saving energy is installing enough fans. The more fans installed, the fewer hours they will operate at 100%, the greater the power savings, but the higher the initial cost.
- 5) Power savings compared to modern fans. This current study is examining the replacement of old tunnel fans with lower energy efficiency ratings than most modern tunnel fans. Studies need to be conducted comparing the same or similar modern fan with and without variable speed technology.

The answer to these questions and more will be addressed in future as testing continues on this farm and others where we are currently testing this new and promising technology.


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