Chapter 1 – SUMMARY OF PHES RESULTS

Contents:

A. INTRODUCTION

The goal of the poultry house evaluation service (PHES) was to identify areas where there may be potential to reduce energy costs and, in some cases, increase income to the producer through improved production. It is most advantageous for a producer to focus on those features that have the best potential for generating a positive return from any improvements that may be made. This focus will vary from farm to farm.

At each farm, the PHES team looked at various features and components of the poultry houses that may affect energy costs. Upon completion of the on-site evaluation, a written report was prepared for each participating grower. The report identified items that may contribute to excessive energy use; suggested possible improvements; estimated the cost of improvements and the associated energy savings; and provided an estimated cost recovery/payback period for each of the suggested improvements.

Although the evaluations were done on a few selected farms from each complex, the participating farms were chosen so that they represented the different housing systems used by all the growers supplying the same complex. As a result, many of the areas of improvement noted in the houses evaluated by the Poultry House Evaluation Service are applicable to similar houses managed by other growers.

Table 1.1 – Overview of the improvement options recommended
Note: Estimated savings will vary from farm to farm and, because of interactions, are not necessarily cumulative

ITEM	ESTIMATED COST	ESTIMATED SAVINGS	PAYBACK (years)
Insulate sidewall curtain	$4,000	800 gal	2.5
Insulate ceiling	$2,800	450 gal	3.1
Add attic inlets	$1,800	600 gal	1.5
Tunnel inlet doors	$5,800	500 gal	5.8
Mixing fans	$ 500	100 gal	2.5
Radiant tube heaters	$7,000	500 gal	7.0
Cold cathode lights	$1,000	11,000 kWh	0.8

B. CURRENT ENERGY USAGE

The purpose of the Poultry House Evaluation Service was to provide growers with options to reduce energy usage in their poultry houses. In order to evaluate the magnitude of any reduction it is important to know the current energy usage. There was a wide range in the amount of energy used by the different farms sampled. It should be noted that the level of energy use by a farm does not appear to be correlated with the level of production efficiency on that farm. **The economic impacts of any recommended modifications, therefore, will vary from farm to farm and be farm-specific**.

The level of propane and electricity used by the farms evaluated are shown in Figures 1.1 and 1.2, respectively. The usage was converted to a weight basis (i.e., per 1,000 lbs of broilers sold) to allow for comparisons between farms. Due to differences in data availability between farms, the same farm number designations were not used for the farms in Figures 1.1 and 1.2.

Figure 1.1 – The amount of propane used by 14 farms evaluated

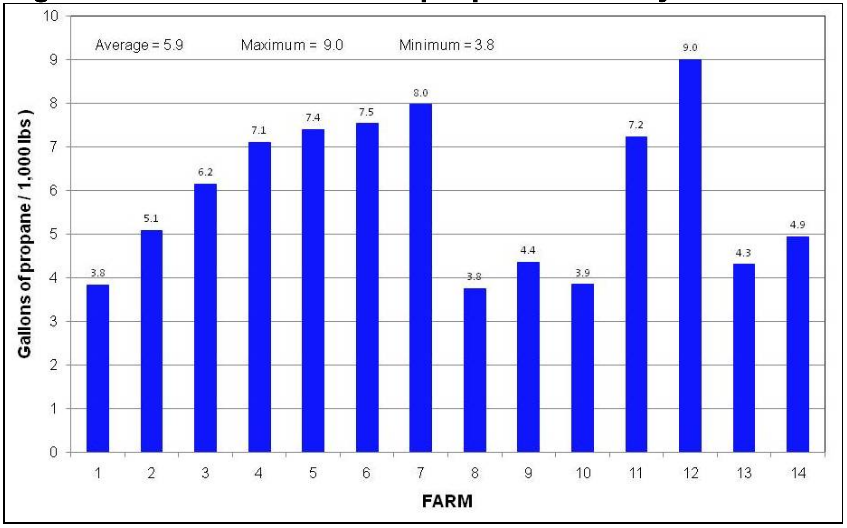
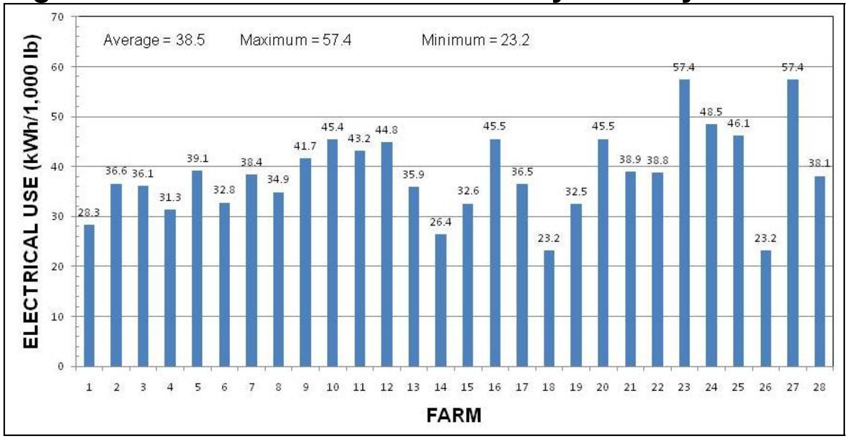


Figure 1.2 – The amount of electricity used by 21 farms evaluated



C. RECOMMENDATIONS BASED ON LIGHTING

One energy-saving recommendation is to **change *from* incandescent lights *to*** cold cathode or compact fluorescents. Replacing incandescent bulbs with compact fluorescents or dimmable cold cathode bulbs **can save 8,000 to 12,000 Kilowatt house/house/year, with a payback period of a few months to two years**.

Compact fluorescent lights

When you make the change from incandescent light bulbs to energy-efficient compact fluorescent light bulbs, you get **similar light levels for about a quarter of the energy and cost**. Retrofitting your poultry houses with money-saving, energy-efficient compact fluorescent lighting really is as simple as changing a light bulb. Dimmable compact fluorescents are available, usually made with “cold cathode” technology.

When comparing compact fluorescent lights to incandescent lights, consider these facts:

- Traditional incandescent bulbs typically last about 1,000 hours and about 90% of their energy generates heat.
- Compact fluorescent bulbs (CFLs) on the other hand, will use up to 67% less energy with no loss in light, and last eight to ten times longer.

Figure 1.3 – Examples of compact fluorescent light bulbs

Figure 1.4 – Incandescent light bulb

It is important with whichever light source you use that the bulbs be kept clean so that all the light they produce can pass through – see Figures 1.5 and 1.6.

Figure 1.5 – Clean compact fluorescent bulb

Figure 1.6 – Examples of dirty compact fluorescent bulbs

It is **very important to recycle CFLs** as they contain small amounts of mercury. If breathed and absorbed by the body, mercury can cause neurological damage. A compact fluorescent light bulb contains an average of 5 mg of mercury – about one-fifth the amount of mercury in an average watch battery, and one-hundredth the amount of mercury in an amalgam dental filling. No mercury is released when CFLs are intact or in use.

It is against the law to dispose of any items containing mercury in the regular solid waste trash. **Compact fluorescent light bulbs must be disposed of in the same way as paint, batteries, thermostats, and other hazardous items**. The Kentucky Division of Waste Management provides an online list of solid waste coordinators in Kentucky (http://www.waste.ky.gov/). For questions, call 502-564-6716.

CFLs versus Incandescent bulbs

A recent study reported in Popular Mechanics tested seven CFLs against the classic incandescent bulb and noted the following:

- Overall the incandescent bulb was rated the lowest.
- The incandescent bulb was labeled as a 75 watt bulb but 78.2 watts were observed. The CFLs on the other hand used only 1 extra watt than what was stated on the label, or actually used less.
- All of the CFLs were rated better than the incandescent bulb.
- Replacing all of the bulbs in your home would save about $180 a year. [*Note: Since more bulbs are used in poultry houses, greater savings are expected.*]

Why use CFLs?

- CFLs can last up to nine years.
- A high quality 24 watt CFL can produce the same brightness as a 150 watt incandescent bulb.
- The CFL bulbs are much better for the environment and your wallet.

Figure 1.7 – Cold cathode light bulb

Cold Cathode lights (see Figure 1.7) are another potential energy saver for poultry houses. The name may sound strange, but cold cathode lights are really just another type of fluorescent light. They have been used extensively in signs and other applications where a curved tube-style light is needed, but are only recently being used as screw-in bulbs.

Anyone who has used a laptop computer has benefited from cold-cathode fluorescent lighting since this technology is used to provide the back-lights of computers. In conventional CFLs a hot cathode made of tungsten wire emits electrons which pass through mercury vapor and generate ultraviolet light. It doesn’t take much energy to release these electrons, but the lamp takes a minute or two to reach full brightness. By contrast, with a cold-cathode lamp it takes a much greater voltage drop—and hence more energy—to release the electrons in the unheated cathode. As with all fluorescent lamps, mercury vapor is used to produce the light, so used lamps **should be properly disposed** of.

The biggest **advantage** of cold cathode lighting is that they can be dimmed with most light dimmers, including those currently used in poultry houses to dim incandescent light bulb. The lights are capable of a full range of dimming from 100% to near zero. Cold cathode lights also start at low temperatures; can be cycled on and off without significant bulb life reduction; and are flicker free when dimmed.

The **output** of cold cathode lighting, measured as lumens per watt, is a little less than compact fluorescent lights. For example, an 8-watt cold cathode light has a rated initial lumen output of about 40 lumens per watt. A 10-watt compact fluorescent light provides about 52 lumens per watt. Incandescent bulbs produce only 12-15 lumens per watt. The **expected life** of cold cathode bulbs is over two times that of a compact fluorescent bulb. An 8-watt cold cathode bulb has a rated life of 18,000 hours, whereas the rated life of a 10-watt compact fluorescent bulb is 8,000 hours.

One **disadvantage** at the present time is that cold cathode bulbs with a screw-in base that fits standard light fixtures are only available in 5-watt and 8-watt sizes. A simple replacement of incandescent lights with cold cathode bulbs may not supply sufficient light intensity for brooding young chicks. One solution is to install an additional lighting circuit in the brood half of the barn. On this new circuit, compact fluorescent lighting can be installed in between the cold cathode lights and turned off when no longer needed. In poultry houses that only have lights over the feed lines, an additional row of cold cathode bulbs could be installed in the center of the house.

An 8-watt cold cathode bulb costs about $10, approximately four times the cost of compact fluorescent bulbs. As already indicated, cold cathode bulbs do have a longer life expectancy, but the initial cost is still substantially higher at the present time. **Cold cathode bulbs are most cost effective when replacing incandescent lights.** The energy savings from replacing compact fluorescent lighting to cold cathode light is not sufficient to offset the initial set up costs.

THERMAL IMAGING

Infrared (IR) imaging in poultry houses is used to measure thermal energy emitted from objects (walls, ceilings, doors, curtains etc). Thermal or infrared energy is not visible because its wavelength is too long to be detected by the human eye (see Figure 1.8 below). Infrared energy can be perceived as heat and is emitted from objects in proportion to their temperature. In other words, the higher an object's temperature, the greater the IR radiation emitted.

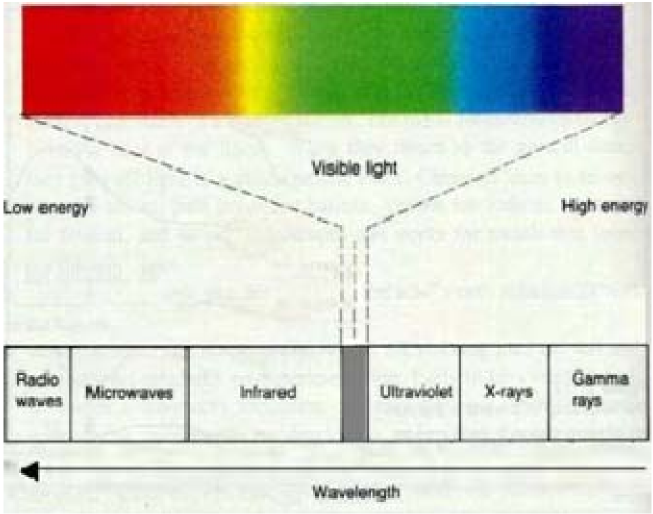


Figure 1.8 – Electromagnetic spectrum

Infrared imaging allows us to see what our eyes cannot. Infrared thermography cameras produce images of invisible infrared or "heat" radiation and provide non-contact temperature measurement capabilities. This can help growers to identify places of air leakage, deteriorated insulation, and other cold areas in the house.

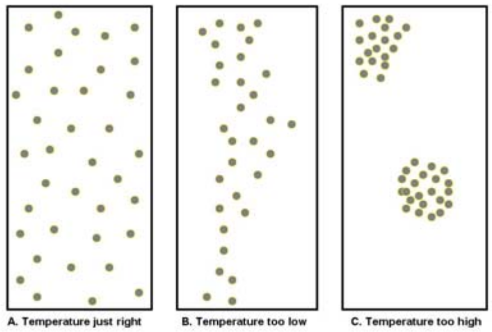
Although different surface temperatures are shown in the pictures, it is important to know that there is not an ideal temperature for the walls and other objects (doors, curtains etc). Both, outside and inside air temperature will influence the surface temperatures. Thus, two equally well insulated structures can have different surface temperatures, depending on the visiting day conditions. However, for the same visiting day and same surface, some temperatures can be compared. For instance: An image of a well insulated wall, for constant outside inside air temperatures, should show almost the same temperatures in all parts of its surface and should be close to air temperature inside the barn. But if there is any problem with the insulation inside the wall, its surface temperature will vary in proportion to the amount of insulation present.

How to interpret thermal images: The camera images basically display surface temperatures as varying shades of different colors. Some photos are shown in the original color palette but may have a slightly adjusted temperature scale. When comparing pictures, it is important to note the temperature scale that appears alongside the image. Air leaks appear as darker colored streaks, usually around doors, fans, corners, curtains, in damaged surfaces, and around holes or cracks. Reduced insulation sites appear as shaded and/or darker colored areas that follow the condition of the insulation in the wall.

D. RECOMMENDATIONS BASED ON THERMAL IMAGING

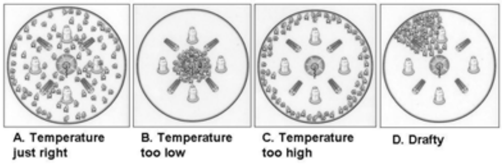
People depend on vision for 90% of their sensory information and this is true whether watching a TV show or managing a poultry house. When inspecting a poultry house, growers typically look to see that the drinkers are at the proper height and not leaking; the litter is in good shape; the feeders are at the proper height and filling properly; and that chick behavior indicates that they are comfortable (see Figures 1.9 and 1.10).

Figure 1.9 – Typical chick behavior under whole house brooding



A. Temperature just right
B. Temperature too low
C. Temperature too high

Figure 1.10 – Typical chick behavior under spot brooding



A. Temperature just right
B. Temperature too low
C. Temperature too high
D. Drafty

If the chicks are stressed, it is not always possible to **see the source of the problem** since we can't see temperature. While a few thermometers strategically placed in a house give an indication of the temperatures at those points, you still don't get the full picture of the overall thermal environment within the house. This is where thermal imaging comes into play.

Infrared (thermal imaging) cameras record different colors for different temperatures. All objects that are warmer than absolute zero emit infrared light/heat that is invisible to the human eye. Infrared cameras measure the amount of "invisible" energy emitted and converts it to a temperature. Software within the camera then converts the temperatures to a color so you end up with a picture where each color represents a specific temperature.

As part of the PHES, thermal images were taken of various locations in the poultry house with chickens in place. These images were used to identify areas of the house where heat is being lost. For example, thermal images of walls and ceiling can be used to identify areas of poor insulation or air leakage and thermal images of walls, ceiling, and other surfaces show possible air leaks, areas in need of insulation, and warm/cold areas on the floor.

Insulation is any material that reduces the heat transfer from a place to another. Usually, the materials used as insulation present a high resistance to heat flow. This insulation resistance is quantified by an “R-value.” Well insulated components have higher R-values and lower heat flow through the material than poorly insulated components. As a general reference, R-values for poultry houses could be described as follows:

R = less than 2	Very Low R-value;
R = 2 to 5	Low R-value;
R = 6 to 9	Moderate R-value;
R = 10 to 15	High R – value;
R = 16 or more	Very High R-value

Some quick facts about R-value are:

- One type of insulation maybe thicker or thinner than another, but if the R-value is the same they should insulate equally.
- R-value performance testing is done in a 70°F environment with no air movement. Ironically enough, when you need insulation the most you're generally not in these ideal temperatures or conditions. This can result in the actual effective R-value being lower than the rated R-value.
- The R-value of insulation is substantially lowered when there are any air or water/moisture leaks.
- The standard R-value required for poultry house insulation varies based on climate and temperature

Based on the thermal images taken at all the poultry houses, the following **common areas for improvement** were identified:

1. Insulate the attic
2. Insulate and cover the sidewall curtain opening
3. Re-insulate the sidewall below the curtain opening
4. Seal cracks
    a. between the bottom of the sidewall and the top of the concrete foundation wall
    b. along the ceiling line at the ends of the barn
    c. around end wall doors
5. Cover and seal tunnel curtain inlets (commercial tunnel inlet doors is one option)

A selection of **insulation materials** is available. All of these are based on standard principles of thermal insulation. Materials used to reduce heat transfer by conduction, radiation, or convection is employed in varying combinations to achieve the desired outcome (usually thermal comfort with low energy consumption). Usually a combination of materials is required to achieve an optimum solution for a poultry house over a range of climatic conditions. There are also some products which combine different types of insulation in one product.

The choice and degree of insulation is based on a number of factors:

- Prevailing climate
- Ease of installation (e.g. some materials cannot be retrofitted due to issues of accessibility or toxicity)
- Durability – resistance to compression, moisture, degradation
- Cost – which is generally related to durability and effectiveness
- The mode of heat transfer – bulk insulators are most useful in cold conditions where significant convective / conductive losses occur; they are less useful in hot conditions where solar radiation is the source of heat gain
- The orientation of the surface and direction of heat flow determine how effective a radiant barrier will be – radiant barriers work best at stopping downward heat transfer from or to horizontal surfaces
- Toxic effects / Off gassing
- Environmental impact and sustainability

A range of material can be employed in the manufacture and construction of insulation products:

- Synthetic polymers e.g. polystyrene, polyicynene, polyurethane, polyisocyanurate
- Aerogel
- Mineral wools (insulation) - e.g. Fiber-glass, rockwool, slagwool
- Minerals - Vermiculite, Perlite
- Natural plant materials - Cellulose insulation, cork, hemp, cotton, straw
- Animal fibers - wool

Other unusual materials or of historic interest:

- Natural plant materials – corn cobs, sawdust, wood chips, sawdust, redwood bark, hemlock fiber, or balsa wood

Insulation can be installed in a number of forms:

- Non-structural

- Batts (insulation) - e.g. fiber-glass, mineral wool
- Blankets (insulation)
- Loose-fill (insulation) e.g. cellulose (may also be wet-sprayed), vermiculite
- Spray foams (insulation) e.g. synthetic polymers
- Reflective Insulation (insulation) e.g. foil-foam-foil

- Structural

- Rigid Panels (insulation)
- Structured panels (insulation)
- Straw bale

Table 1.2 – R-values (hr ft^2 °F/Btu) for different insulation materials that can be used in poultry houses

INSULATION TYPE	**R-value per inch (hr ft^2 °F/Btu)**	
	Range	**Average**
Fiber glass or batt	2.9 - 3.8	3.2
Hi perf fiberglass/batt	3.7 - 4.3	3.8
Loose-fill fiberglass	2.3 - 2.7	2.5
Loose-fill rock wool	2.7 - 3.0	2.8
Loose-fill cellulose	3.4 – 3.7	3.5
Perlite/Vermiculite	2.4 – 3.7	2.7
Expanded polystyrene board	3.6 – 4.0	3.8
Extruded polystyrene board	4.5 – 5.0	4.8
Polyisocyanurate board, unfaced	5.6 – 6.3	5.8
Polyisocyanurate board, foil-faced		7.0
Spray polyurethane foam	5.6 – 6.3	5.9

Source: http://www.insulation-r-values.com

Attic insulation

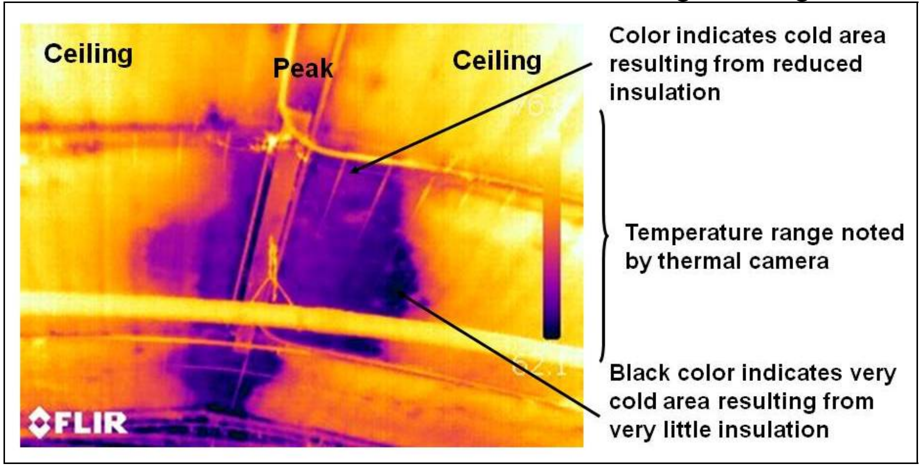
Having quality ceiling insulation is of significant benefit to poultry producers year round. During cold weather, hot air produced by the brooders, furnaces and the chickens quickly rises towards the ceiling. If the ceiling is not properly insulated this valuable heat will pass through it, resulting in lower house temperatures and higher heating costs. Conversely, during summertime ceiling insulation keeps the amount of heat entering the house through the ceiling to a minimum.

On a hot summer day, attic temperatures in dropped-ceiling houses can easily exceed 130°F. If a ceiling is not properly insulated, heat from the attic space will enter the house, leading to higher house temperatures and lower bird performance. A minimum R-value of ceiling insulation is R-12, while R-19 is preferred. Attic insulation should be checked yearly to verify a sufficient level and proper distribution of insulating material.

The most common form of insulation used in dropped ceilings is blown-in cellulose, which settles and shifts over time. A poultry house built in the 1980s probably had 5-6 inches of insulation when new but by 2008 this same house often has less than two inches of insulation due to settlement and compaction (see Figure 1.11). The area around ceiling fans (see Figure 1.12) is particularly prone to compaction caused by the pulsing on and off of the fan.

Attic insulation should be checked yearly to identify any areas damaged by rodents or water leaks (see Figure 1.13) and corrective measures taken as needed.

Figure 1.11 – Thermal image of a ceiling showing missing insulation: The insulation has shifted off center of the ceiling leaving cold areas

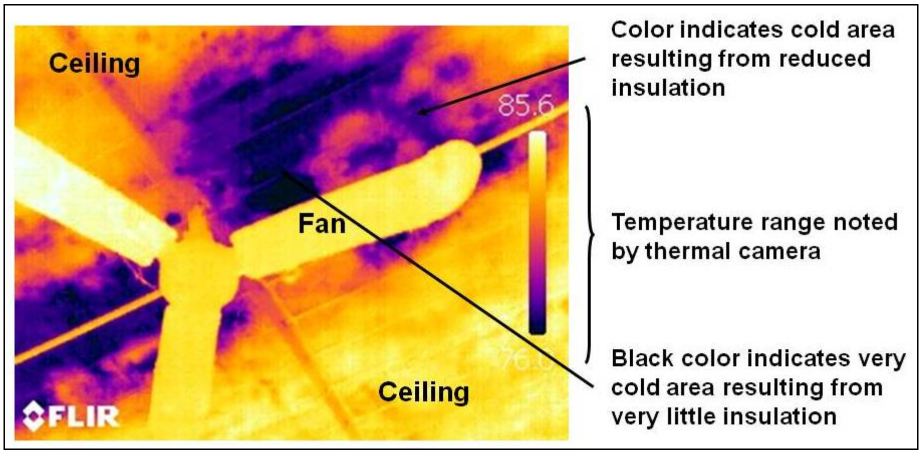


Color indicates cold area resulting from reduced insulation

Temperature range noted by thermal camera

Black color indicates very cold area resulting from very little insulation

Figure 1.12 – Thermal image showing missing insulation around a ceiling fan

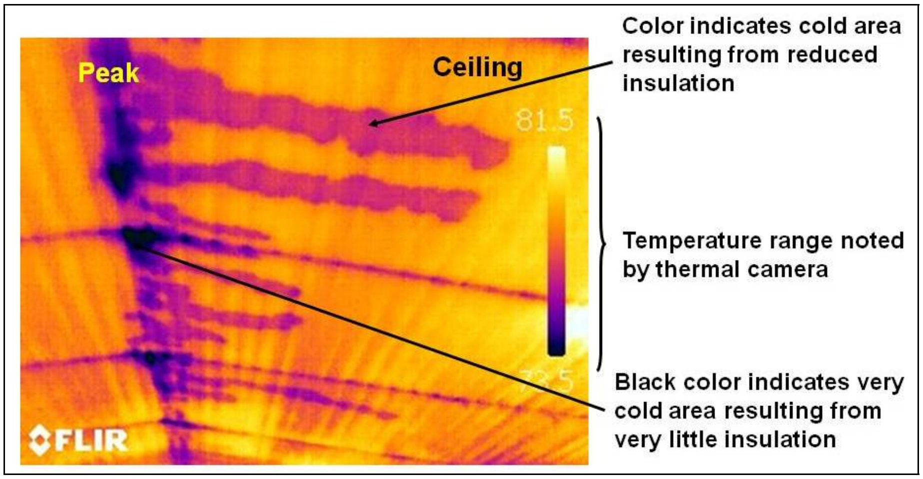


Color indicates cold area resulting from reduced insulation

Temperature range noted by thermal camera

Black color indicates very cold area resulting from very little insulation

Figure 1.13 – Thermal image showing damaged ceiling insulation caused by roof leaks



Color indicates cold area resulting from reduced insulation

Temperature range noted by thermal camera

Black color indicates very cold area resulting from very little insulation

HOW MUCH ATTIC INSULATION?

Energy savings in broiler production can be done in many ways, including attic insulation, closing curtain-sided buildings, and using fluorescent light bulbs and more energy efficient fans (higher cfm/watt ratings). In principal, this savings can directly translate into improved profitability for your operation, right? Well, not exactly.

Simple Payback

If the cost of housing modifications is free, then all the money saved is money earned. However, most modifications will have materials and labor costs. How do you decide whether the cost will be a good investment? A simple approach often used is to determine the simple payback, in years, of how long before the savings you realize have paid off the initial investment. “Simple” payback is so-called because we neglect depreciation and time-value of money. It is a gross estimate to let you decide if you are on the right track.

Information required for calculations

To determine how much additional attic insulation is appropriate, you need the following information:

- Dimensions of your building, separated into brooding and growing areas
- Type and quantity of insulation currently in your attic (and its R-value — see Table 1.2)
- Base the estimate on three winter flocks per year
- The temperature difference between the house and attic (For Kentucky conditions: a reasonable estimate is 35°F difference for 10 days during brooding and 27°F for 12 days during growout)
- What is the cost of the additional insulation you are considering?

Example calculation

- 40’ x 500’ broiler house with half house brooding
- Currently have 2 inches of loose-fill cellulose (R value of 3.5 per inch - see Table 1.2)
- Three winter flocks per year
- Brood for 10 days with supplemental heat for an additional 12 days of the growout period
- Cost of blown-in cellulose estimated to be 4.3¢/ft^2 for each inch of depth added

Square feet of brooding area = (40 x 500)/2 =		10,000
Temperature difference between house and attic during brooding	X	35
Brooding time (24 hr/day x 10 day x 3 flocks/year) =	X	720
Current insulation value (hr ft^2 °F/Btu) = 3.5 x 2 inches	/	7
Convert Btu to gallons LPG	/	85,560

SUBTOTAL = 421 gallons LPG / year

Square feet of growout area = (40 x 500) =		20,000
Temperature difference between house and attic during growout	X	27
Time with supplemental heat (24 hr/day x 12 day x 3 flocks/year) =	X	864
Current insulation value (hr ft^2 °F/Btu) = 3.5 x 2 inches	/	7
Convert Btu to gallons LPG	/	85,560

SUBTOTAL = 779 gallons LPG / year

Total current propane use = 1,200 gallons LPG/year

Next, repeat the calculations above using the final height of insulation. For example, doubling insulation from 2 to 4 inches cuts fuel use in half. The fuel savings would be 1,200 - 600 = 600 gallons. At $2/gal, this would be savings of $1,200 per year.

Cost of adding the additional 2 inches of blown-in cellulose = 2 inches x $0.043/inch x 20,000 ft^2 = $1,714

Simple payback, in years = Cost of insulation / Annual fuel savings = $1,714 / $1,200 = 1.43 years (about 17 months). By calculating the fuel costs for the different levels of insulation, you can use this method to help decide how much insulation is appropriate.

Table 1.3 on the next page shows some estimated simple payback values for adding insulation to an attic that initially has either 2” or 4” of blown-in cellulose insulation and is increased to 4” to 18”. Of immediate interest is that, for these assumptions, if you already have 4” of insulation in the attic and you double it to 8” it will take over 5 years to payback the cost! However, if you have 2” and increase to 6” (R-21 if using cellulose), the payback is 2.14 years.

Continued ….

HOW MUCH ATTIC INSULATION? *Continued from previous page*

Table 1.3 – Estimated simple payback values for addition of loose-fill cellulose attic insulation based on an installation cost of 4.3¢/ft^2 per inch of added insulation

Initial depth of 2 inches		**Initial depth of 4 inches**	
Final depth (inches)	**Payback (years)**	**Final depth (inches)**	**Payback (years)**
4	1.43	4	0
6	2.14	6	4.29
8	2.86	8	5.72
10	3.57	10	7.14
12	4.29	12	8.57
14	5.00	14	10.00
16	5.72	16	11.43
18	6.43	18	12.86

Cellulose insulation was introduced into the poultry house market in the mid-1970s. When installed properly, it does a relatively good job. In the late 1990s, most of the poultry companies started requiring tunnel ventilation which meant the houses had to be much tighter. The result was much more vibration on the ceilings. This can result in the cellulose shifting out of the peak and sliding down the truss. It can also cause the cellulose to settle much more than it had in previous years. In the winter, air cools as it moves toward the outside, and moisture condenses in the walls and attic. This makes the insulation wet, causing it to get heavy and compress, which in turn reduces the effectiveness of the insulation. This moisture will also eventually cause structural problems. Unless you have a vapor barrier, the recommendation is that you do not use fiberglass, mineral wool, and cellulose insulation.

To minimize the impact of high winds blowing ceiling insulation away from the side walls, eave openings should be no more than one inch high. Do not totally close off the eaves, however, because fresh air is needed to help remove moisture from the attic space as well as help minimize attic temperatures during hot weather.

Blown-in cellulose type insulation has an average R-value of 3.2 per inch. To obtain the suggested R-19, a minimum of 6 inches is required. Most of the houses evaluated as part of the PHES had only 2-4 inches of insulation, which is insufficient for controlling temperature loss in the winter and temperature increase in summer. **Adding insulation can save 300 to 600 gal LP/house/year**. The payback for this investment is 2.5 to 5 years.

There are steps that can be taken when installing blown-in cellulose insulation that will help to minimize the shifting of insulation from the peak of the house. Before blowing the insulation, install a four-foot swath of 3½ inch fiberglass batt at the peak of the ceiling. Cellulose insulation is then blown on top of the fiberglass batt, minimizing the possibility that the peak of the ceiling will be left uninsulated. An additional intervention can be the installation of 1 inch x 4 inch insulation stops between the lower cords of the trusses before blowing in the cellulose. The insulation stops act as dams keeping the insulation from sliding toward the side walls and away from the peak.

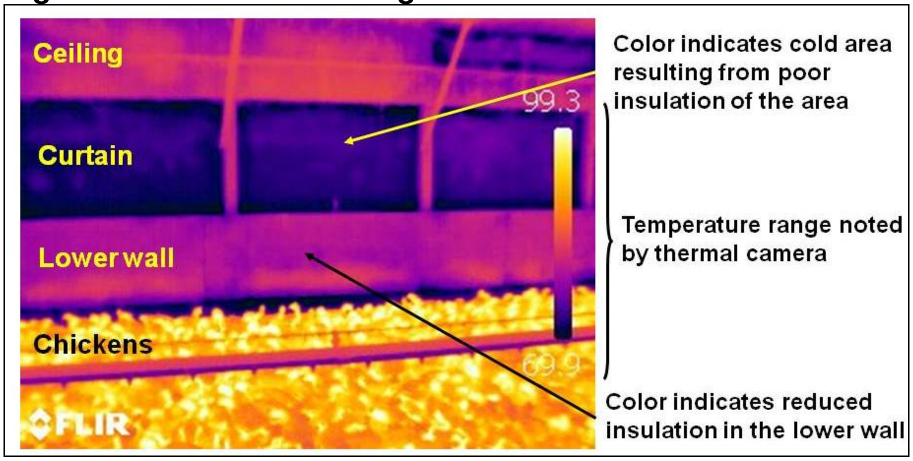
Other ceiling insulation can be batt or blanket insulation (see Figure 1.14), which is installed in different thicknesses. A 3½- to 4-inch batt of fiberglass has an R-value of approximately 11 and a 6-inch batt of fiberglass has an R-value of approximately 19.

Figure 1.14 – Fiberglass insulation

Insulation of side and end walls

There can be 6,000 to 8,000 square feet of side and end wall area in a typical commercial broiler house. Each square foot of uninsulated wall has the potential to transfer a large amount of heat energy to the cold outside. How fast heat is lost through a wall will depend on its R-value as well as how big a temperature difference there is between the inside and outside.

Figure 1.15 – Thermal image of an uninsulated sidewall curtain



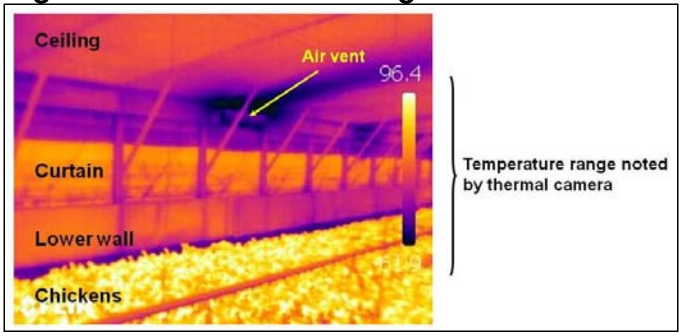
Color indicates cold area resulting from poor insulation of the area

Temperature range noted by thermal camera

Color indicates reduced insulation in the lower wall

Figure 1.15 is a thermal image of an uninsulated sidewall curtain. There is no insulation of the curtains in this house and the color detected by the thermal camera indicates cold areas of the walls. The lower wall also shows indications of insulation settling out. By comparison, Figure 1.16 is a thermal image of an insulated sidewall. Bubble wrap was placed behind the curtain. The yellow color for the sidewall curtains indicates good insulation. The black color around the air vent indicates cold air is coming in.

Figure 1.16 – Thermal image of a sidewall curtain insulated with bubble wrap



Insulation of broiler houses should provide a minimum thermal resistance (R-value) of R8 in exposed walls. It is recommended that the sidewall curtains be closed and insulated. These modifications **could save 600 – 1,000 gal LP/house/year**, with a payback of two to four years.

The R-value of most insulation materials decreases drastically when moistened. Installing a **vapor barrier** on the insulation's warm side protects against moisture saturation. **Seal tears and damage to exposed vapor barriers**.

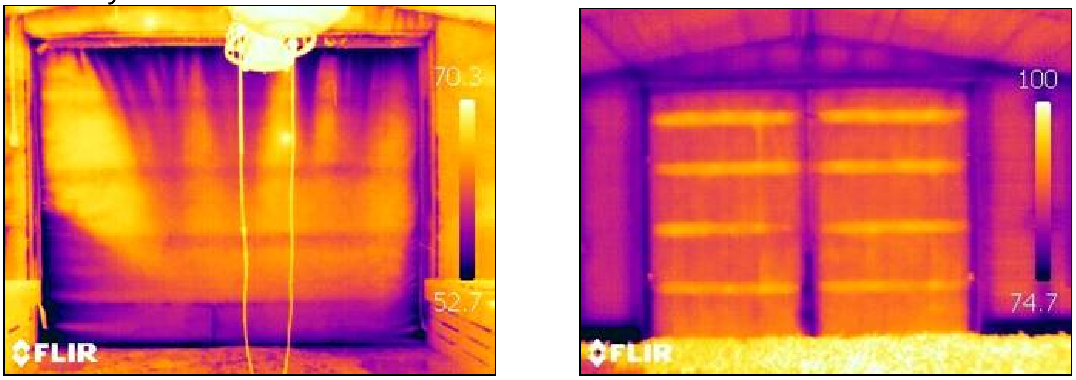
Many different types of wall construction are used in broiler houses. Some of the older houses use board-type insulation underneath the tin, but the modern trend is to build a wall that is approximately 3½ inches thick, which is insulated with batt-type insulation.

Endwalls are often insulated with fiberglass batts, and in some cases with board-type insulation. Common board-type insulation can be either polyurethane or polystyrene. Polystyrene R-values range from 3 to 5 per inch of thickness. Polyurethane has an average R-value of 6 per inch of thickness. Figure 1.17 shows thermal images comparing sealed and leaky endwalls.

In retrofitting or redoing an older house, board-type insulation can be extremely helpful in keeping up the R-value when trying to modernize a poultry house. Board-type insulation is often the only type of insulation available for insulating high ceiling or open-truss houses. It is particularly valuable in insulating end doors. One of the disadvantages of using board-type insulation in broiler houses is that it is often worked on by rats, darkling beetles, wild birds, and other varmints, and over a period of time may not hold up as well as batt or blown-in insulation.

The use of solid side walls is another option. In general, a solid sidewall house will use less energy than a curtain-sided house. Comparing the fuel requirement during cold weather for an old 5-foot curtain-sided house to a solid sidewall house, it is possible save as much as 40% on the fuel in the solid sidewall house. Similarly, comparing a solid sidewall house to a curtain house with 24-inch curtain openings, curtain flaps and insulation above and below the curtains, only a 15% fuel savings may be realized.

Figure 1.14 – Thermal images of a leaky and well-sealed end door


A. Leaky B. Sealed door

Just because a broiler house has solid **side walls does not mean that it is air tight** (see Figure 1.18), which is a requirement for most ventilation systems. All carpentry **joints must be sealed**, either with regular caulk, expanding foam, or foam tape.

Options for totally enclosing a curtain-sided house included:

- -In a traditional stud-wall house: Place metal sheeting on the outside; fill the wall with fiberglass batt insulation; install an interior vapor barrier; then cover the interior with plywood. Estimated cost: $10,000+
- -Close up curtain openings using lumber or polystyrene board insulation and sheet metal siding. Estimated cost: $5,000 - $10,000
- -Spray polyurethane insulation. Estimated cost: $1.00+ per square foot
- -Heavy duty polypropylene-faced fiberglass batt insulation in 50-foot long rolls. Therm-All[1] is the most commonly used form of this insulation product. Therm-All consists of a 1.5 mill black polypropylene facing reinforced with tri-directional fiberglass/polyester scrim with a 0.5 metalized polyester film backing for added strength and to act as a radiant barrier. Attached to the metalized polyester film is a 3½ inch fiberglass batt this is specifically designed to recover its original thickness after it is unrolled.

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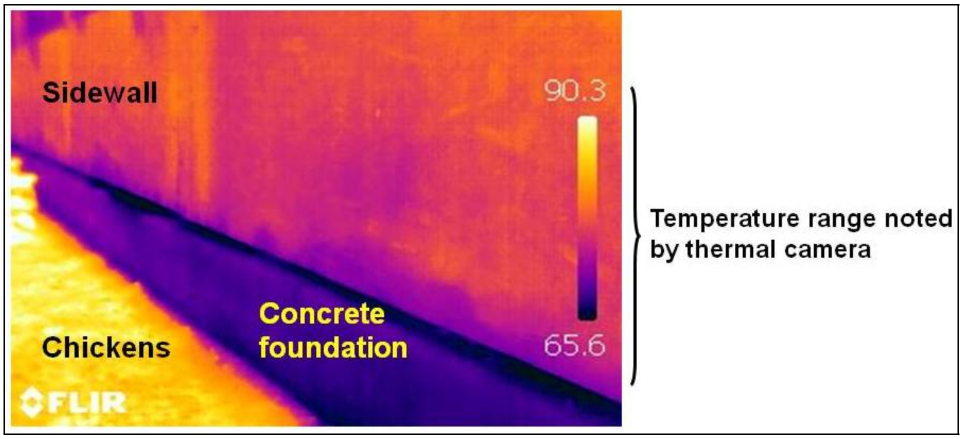
[1] Trade and brand names are used for information only and does not imply approval of any product to the exclusion of others that may also be suitable.

Figure 1.18 – Thermal image of a solid sidewall above a concrete foundation



Insulating tunnel inlets

One of the challenges facing many poultry growers during cold weather is keeping the tunnel curtain ends of their houses warm and dry. There are a number of reasons for this:

- Tunnel inlets are loose end wall doors
- The tunnel curtain is often larger than the remainder of the side wall curtains (5 feet high for tunnel curtains versus 3 feet high for side wall curtains). Since curtains have a very low insulation value (R-value around 1.5) this two foot difference in height can result in the brooders/furnaces having to run 30% more than those in the remainder of the house.
- The tunnel curtain has to be free to open and close as needed so it is often looser than the remainder of the side wall curtains in the poultry house. Air leaking from around the tunnel curtain can further increase heating costs.

Figure 1.19 compares thermal images for uninsulated and well insulated tunnel doors. Figure 1.20 has two views of a commercial tunnel inlet door. Insulating tunnel inlets **can save 400-600 gal LP/house/year** and have a payback period of 5-8 years.

Figure 1.19 – Thermal images – leaky versus well insulated tunnel inlets

A. Tunnel inlet leakage B. Well insulated tunnel doors

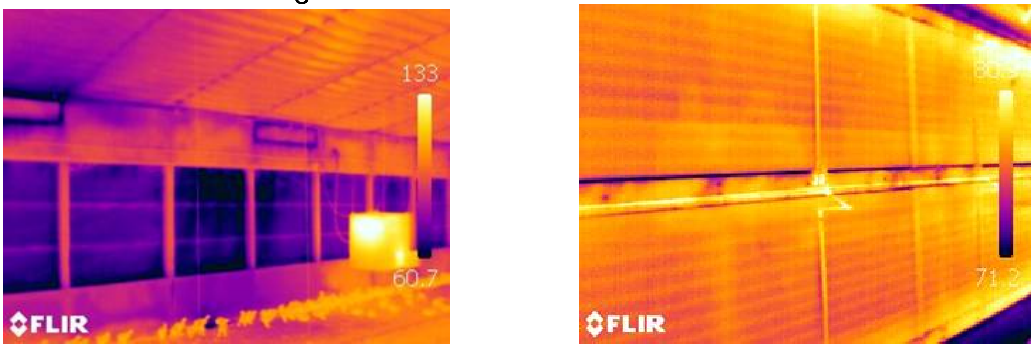


Figure 1.20 – Photograph of tunnel doors

Additional problems identified with thermal images

Thermal imaging can also be used to identify and electrical problems. For example, Figure 1.21 shows overheating in a breaker due to a poor contact. Similarly, Figure 1.22 shows overheating in a relay due to a poor connection.

Figure 1.21 – Thermal image showing overheating due to a poor relay breaker contact

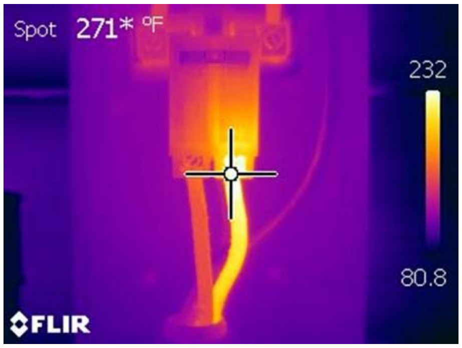
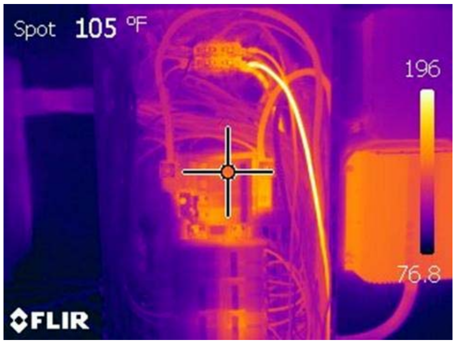


Figure 1.22 – Thermal image showing overheating due to a problem with a connection



E. RECOMMENDATIONS BASED ON EVALUATION OF VENTILATION SYSTEMS

As will be discussed in subsequent chapters in this binder, ventilation systems depend on **static pressure**. To maximize energy efficiency for ventilation, the poultry house must be sufficiently 'tight'. Figure 1.23 shows the level of house tightness measured in the broiler farms evaluated. The static pressure with one fan running was measured and ranged from 0.04 to 0.21 inches of water. Those houses with lower static pressure measurements will require fans to run longer to achieve the same level of ventilation, increasing energy costs per house.

Air leakage (Figure 1.24) is another measurement of **house tightness**. Measurements of air leakage were completed at twelve of the fourteen broiler farms participating in the PHES evaluations and ranged from 11,469 to 28,098 CFM. Farm 6, which has the highest level of house leakage, is losing the equivalent of almost two fans through the leaks in the house.

Figure 1.23 – Average house tightness of the fourteen farms participating in the PHES evaluations: The values were determined with a single tunnel fan running

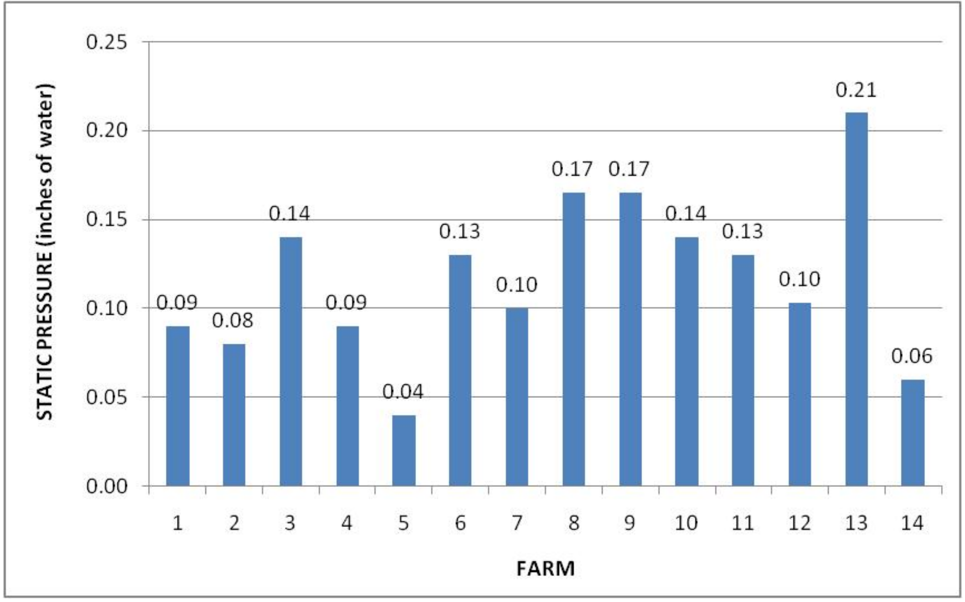
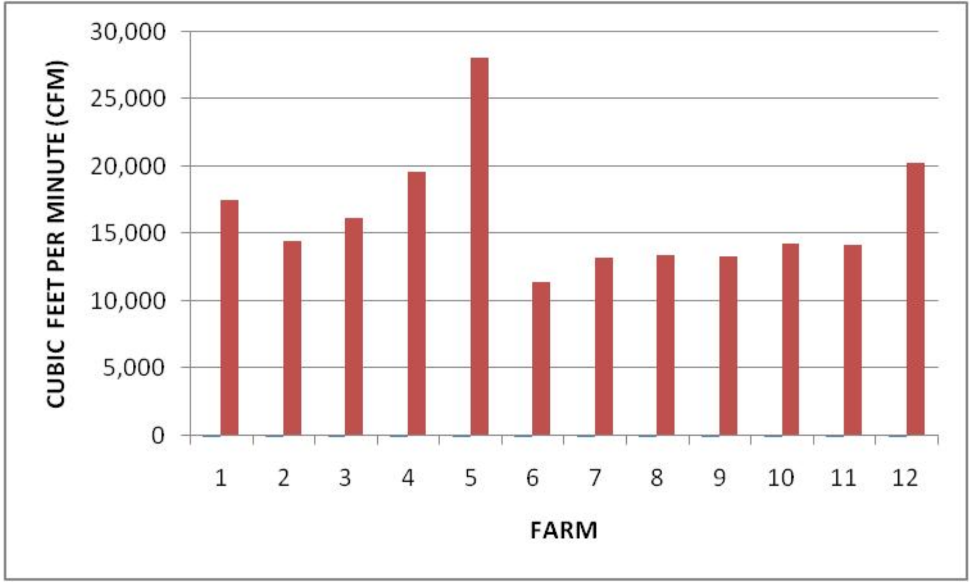


Figure 1.24 – Average air leakage at 0.1 inches of water static pressure for twelve of the fourteen farms participating in the PHES evaluations

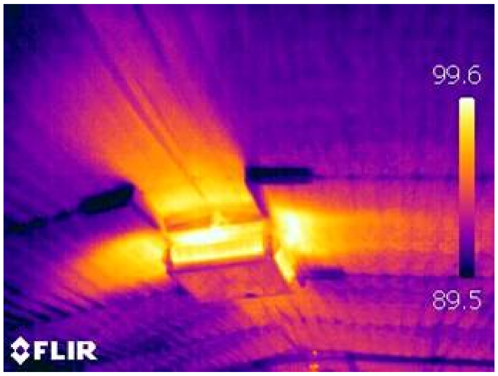


Attic inlets

Attic inlets (see Figure 1.25) are used to **recover solar heat from the attic** of poultry houses. The large roof areas of dropped ceiling poultry houses make very good solar collectors, so there is a large amount of heat readily available in the attic (see the thermal image in Figure 1.26). This free solar heat can also help to lower the relative humidity in the house and reduce litter moisture. So in addition to reducing fuel costs, attic inlets also have the potential to improve in-house conditions because of the reduced litter moisture.

Figure 1.25 – Photograph of an attic inlet

Figure 1.26 – Thermal image of an attic inlet



The amount of fuel that may be saved by using attic inlets is strongly dependent on the time of year and the weather conditions. Addition of attic inlets in the houses evaluated can **save an average of 400 – 800 gal LP/house/yr**. The payback period depends on the type of attic inlets installed. The less expensive option is the **gravity inlet** and has a payback period of 2 to 4 years. This type of inlet is more dependent on having a tight house in order to be functional as designed. The gravity inlet is manually operated which can be time consuming when it is necessary to close all the inlets. The **controlled inlets** are more expensive but house tightness is not as critical for proper functioning. There may be more energy savings than with the gravity inlets, but because of the higher cost of installation, the payback period is increased to 5 to 10 years.

The **number of attic inlets** needed in a given poultry house is determined by the maximum CFM that will be utilized in minimum ventilation when the whole house is filled. This is typically about 2 CFM per square foot of house. Inlets currently on the market are generally rated at 2000, 2500 or 3000 CFM.

Mixing/circulation fans

One option available to producers with leaky houses is the installation of mixing or circulating fans (see Figure 1.27). To avoid hot spots, it is important that hot air be mixed with room air. Mixing in most poultry facilities is accomplished by appropriate placement of fresh air inlets. If inlet air mixing is not adequate, **stratification** occurs, with warmest, air near the ceiling rather than at broiler level. **Mixing fans** can be hung from the ceiling to blow air in a racetrack pattern around the house in a horizontal direction or slightly canted upward toward the ceiling. Installing mixing fans **can save 100 gal LP/house/yr**, with a payback period of 2-4 years. Ceiling fans can also be used (see Figure 1.28)

Figure 1.27 – Mixing/circulating fan

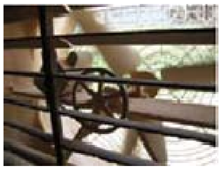
Figure 1.28 – Ceiling fan

F. RECOMMENDATIONS BASED ON FAN EVALUATIONS

Figure 1.29 – Equipment used in the fan evaluations during PHES farm visits

The Fans Assessment Numeration System (FANS) unit (see Figure 1.29) uses a horizontal array of five propeller anemometers (the instrument used for measuring wind speed) to obtain real-time airflow measurements as the array is moved up and down along the fan. With the aid of a computer, approximately 1.8 million air speed readings are obtained in the three minutes it takes for the instruments to move up or down across the fan. The average speed is multiplied by the effective cross-section area of the FANS unit to obtain the mean air flow rate.

To test a fan, the FANS unit is positioned in front of the fan and sealed to the wall using duct tape. Measurements are taken at six static pressures ranging from free air to approximately 0.20 inches of H2O.



Fan revolutions per minute (RPMs) and air movement (Cubic feet per minute – CFMs; and velocity) are directly related. For example, a fan turning 10% slower in RPMs moves 10% less air. Similarly, a fan turning 15% slower moves 15% less air than normal. Proper fan installation and maintenance is required to maintain house conditions that are optimal for bird growth and feed conversion.

Fan performances varied from house to house as well as within a poultry house (see figures 1.30 and 1.31). Nine fans of different brands and models were compared to the test results from the BioEnvironmental and Structural Systems (BESS) lab at the University of Illinois. The results are shown in Figure 1.32

Figure 1.30 – Performance for five 54-inch tunnel fans in a single broiler house

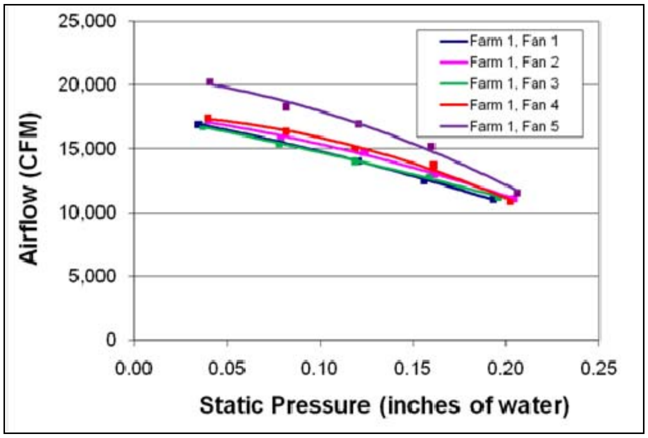


Figure 1.31 – Performance of four 48-inch fans from a single broiler house

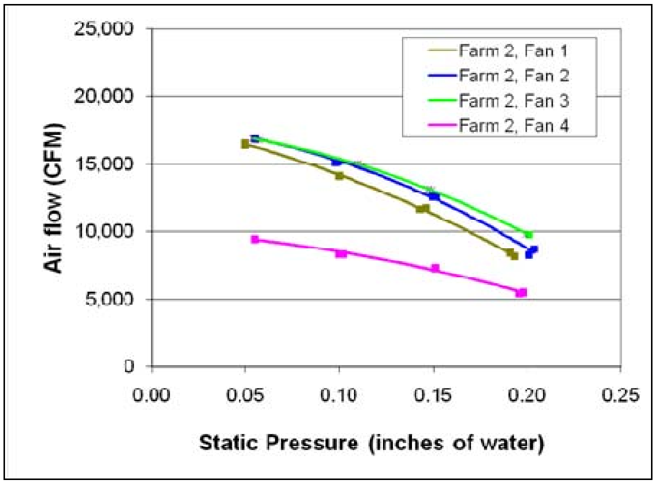


Figure 1.32 – Comparison of the fan performance results from the PHES study with data evaluated used

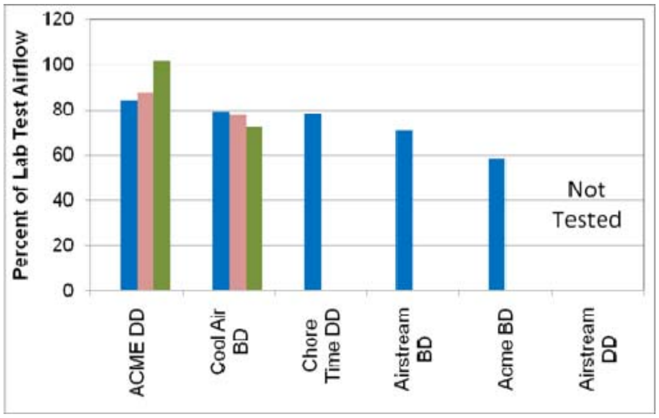
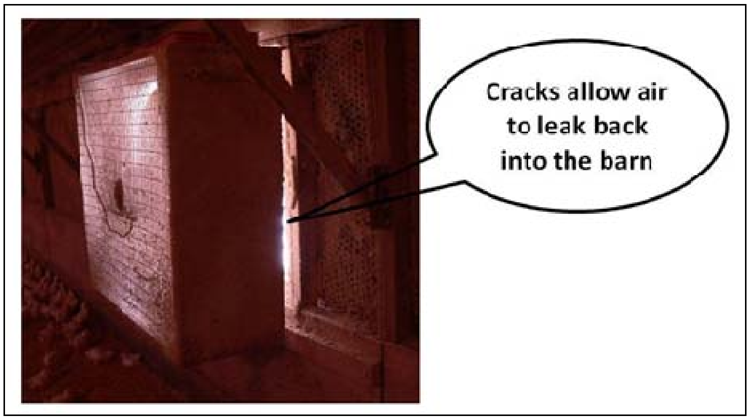


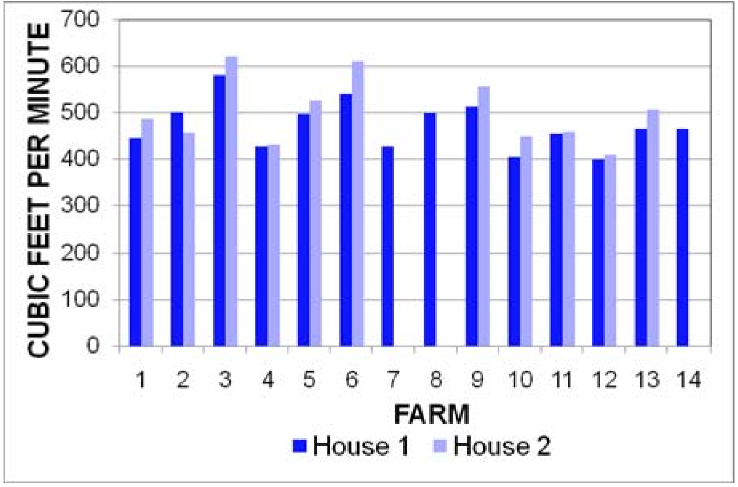
Figure 1.33 – Example of an improperly installed fan



Proper installation of the fans is very important for maximum fan performance. Figure 1.33 is an example of an improperly installed fan. There is a crack between the fan and the poultry house wall allowing air to circumvent the flow through the fan decreasing the efficiency of the fan.

Both fan performance and house tightness influence the air speed that can be achieved with tunnel ventilation. For most of the farms participating in the PHES, two fans were evaluated for their ability to achieve the air speed required for tunnel ventilation. The recommended speed for tunnel ventilation of broilers is 500-600 feet per minute. The average air speed with all the fans running was measured at broiler height, 23 m (~75.5 ft) upstream from the tunnel fans. Air speeds achieved varied from 398 to 620 CFM (see Figure 1.34). Sixteen of the 25 houses evaluated had air speeds below the target 500 CFM. Several factors influence fan efficiency, as discussed below.

Figure 1.34 – The average air speed measured at broiler level with all tunnel fans running.

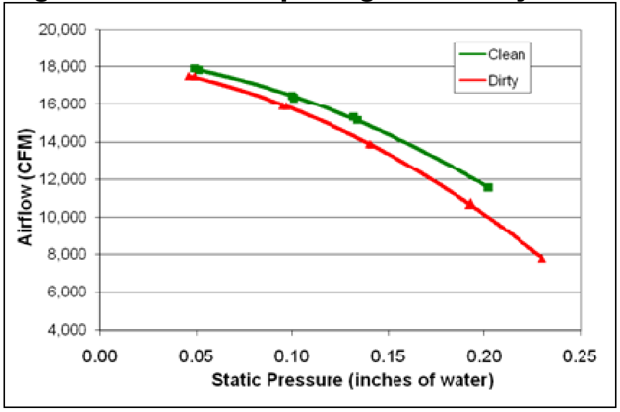


Clean shutters & fans

Fan blades and shutters should be checked on a weekly basis. Previous research has shown that if shutters and blades are allowed to become caked with dust, fan performance can be cut by as much as 30%.This means that a fan delivering 400 RPMs when clean may deliver only 280 RPMs when dirty.

During the PHES evaluations of some of the sample broiler houses, the efficiency of fans while clean and dirty was measured. As shown in Figure 1.35, the amount of air moved by a fan at any given static pressure is less when the fan is dirty.

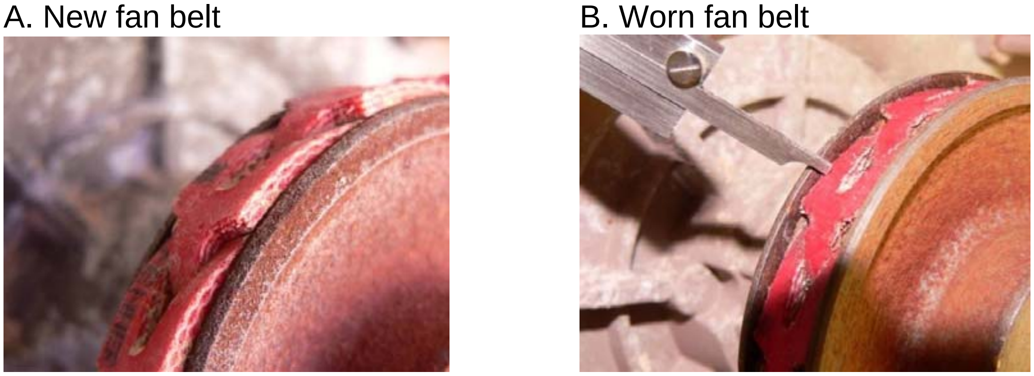
Figure 1.35 – Comparing efficiency of clean versus dirty fans



Replace worn fan belts

It is the fan belt and pulley that determine the RPBs of a fan. As a fan belt wears, it becomes thinner and rides deeper in the pulley than when new (see Figure 1.36). The effect is exactly the same as installing a small motor pullet: the fan RPM speed is reduced. Tightening a worn belt does not cure the problem, it needs to be replaced. As shown in Figure 1.37, the amount of air moved by a fan at any given static pressure is less when the fan belt is worn.

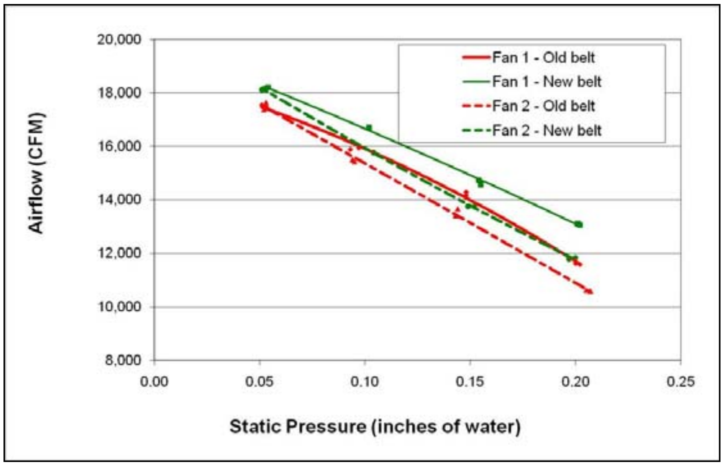
Figure 1.36 – Comparing new versus worn fan belts



A. New fan belt

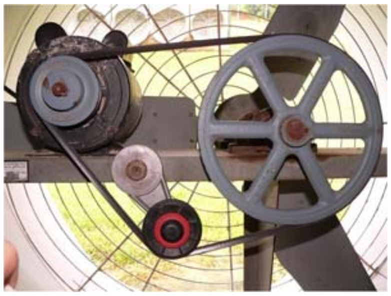
B. Worn fan belt

Figure 1.37 – Comparing the airflow performance of fans with new and worn V-belts



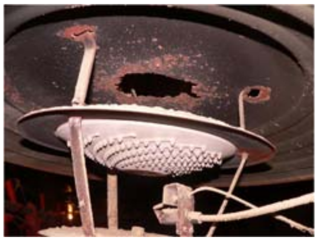
Check all fans to ensure that the motor has the correct size drive pulley

In order to maximize belt life and fan performance it is important that the motor and fan hub pullet are in line with one another. If the motor pulley and fan hub pulley are not in perfect alignment the belt will twist causing the belt to wear unevenly. The accelerated belt wear not only leads to reduced air moving capacity but also increases costs due to a shorter functional life – a belt that might have lasted well over a year may need replacing in as little as a few months if not properly installed. One way to check to see if the motor pulley is in the proper position is to simply place a long straight edge (such as a ruler or piece of angle iron) across the fan hub pullet so that it extends down to the motor pullet. Position the motor pullet unit the outside edges of both pulleys are in line.



It does not take a lot of tension to keep belts from slipping. Typically only about five pounds of tension are required to keep a fan belt from slipping. If a fan motor is not firmly affixed to the fan supports, excessive belt tensioning can cause the fan motor to be lifted/pulled down out of its proper orientation. As a result, even though the pulleys may be in line with one another the fan motor pulley may be twisted five degrees or more out of alignment.

G. RECOMMENDATIONS BASED ON EVALUATION OF HEATING SYSTEMS



When it is time to replace worn out pancake brooders, consider installing radiant tube or ‘Quad’ heaters. This would reduce the number of units to maintain. If the house air temperature is lowered, there will also be an energy saving. It is possible to save 300-600 gal LP/house/yr, with a payback period of 6-10 years.

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Poultry Housing Tips

Basic Attic Inlet Operational Guidelines

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Balancing air/litter quality with propane usage during cold weather has always been a challenge for poultry producers. But now, with the price of propane climbing to over two dollars a gallon, what before was a challenge, for many now seems to be nearly impossible. Attic inlets are looked upon by many as a possible partial solution to this dilemma. Though attic inlets do have the potential to decrease the cost of heating a poultry house, their most significant impact has been that by pulling 5°F to 30°F warmer air out of the attic during the day, poultry producers are able to ventilate their houses 20% to 100% more without **increasing** heating costs. The higher daytime ventilation rates have significantly improved both house air and litter quality.

Though there are still a number of questions as to the best way to use attic inlets, the following are some operational guidelines to consider. These guidelines have been developed to help users of attic inlets to take full advantage of the warm air in their attics.

Basic Attic Inlet Operational Guidelines

Ideally, houses equipped with attic inlets should have an attic temperature sensor. This can either be a spare temperature sensor from a house's environmental controller or a standalone thermometer such as a digital thermometer with an external temperature sensor which can be placed in the attic (i.e. Radioshack #63-1087). An attic temperature sensor allows the producer/controller to know how warm the air is in the attic so adjustments can be made to minimum ventilation fan settings to take full advantage of the warmer attic air.

Between flocks:

Close up the house except for the attic inlets. Set three 36" fans or a 48" and a 36" fan on a timer operating a few minutes out of 30 minutes. Any other fans should be turned off as well as the side wall inlet machine. When the attic temperature reaches a minimum of 60°F the fans should run continuously. If there is a controller temperature sensor in the attic this can be done automatically by setting the timer fans to operate off of the attic temperature instead of house temperature and setting the controller to maintain a temperature of 60°F. Using the attic inlets between flocks will pull warm air to the house during the day which should help to "burn-off" some ammonia as well as help to remove moisture from the litter.

Prior to chick placement:

1) During cold weather it is generally best to close the attic inlets on the non-brooding end (if you want to leave open one or two for moisture control on the non-brooding ends that is also permissible). Keep in mind that though during the day the attic air is warmer than outside air, at night there is little to no difference between outside and attic air temperature. So if it is 30°F at night you will be pulling 30°F air into the non-brooding end of the house every time the minimum ventilation fans operate.

2) Set side wall inlet controller to maintain a static pressure between 0.09" and 0.12". This will generally keep the side wall inlets closed during minimum ventilation and allow all the fresh air brought in by the minimum ventilation fans to enter the house through the attic inlets. Make sure the side wall inlet machine is set to operate if the static pressure rises above 0.12" so that if the house heats up too much, and additional fans do come on, the side wall inlets will open to meet the needs of the additional fans.

3) Set one 36" fan on the brooding end and one 36" on the non-brooding end to operate as your minimum ventilation timer fans.

4) Turn on the two 36" fans manually and check the static pressure. Typically it will run between 0.05" and 0.10". If it is lower than 0.05", your house needs to be tightened and/or you may need to use three 36" fans for minimum ventilation. It is important to realize that with attic inlets it is not always necessary to have as high of a static pressure as one might typically target in a house with side wall inlets. First, we don't have to throw the incoming air all the way to the center of the house to hopefully mix with the warmest air near the peak of the ceiling because it is already there. Secondly, due to fact that the attic inlet sits on the ceiling and is designed to direct air along the ceiling, you will often find that a relatively low static pressure will do a good job of mixing of the cool incoming air with the hot air near the ceiling. Last but not least, for a good portion of the day the attic air is warmer/lighter than outside air and therefore a slightly lower static pressure and the resulting lower inlet air velocity are not problematic. The net result is that you will tend to find that attic inlets function very well at a static pressures as low as 0.05" or 0.06".

After chick placement:

1) Set your timer fans as you have in the past. Monitor house relative humidity. The ideal relative humidity is around 50%. If the relative humidity is above 70%, timer fan settings should be increased to avoid litter moisture problems.

2) Monitor attic temperature. When the attic temperature rises above 70°F, consider increasing minimum ventilation fan runtime 50% or more. If the attic temperature rises to 80°F+ consider increasing runtime by 100% or more. If the attic temperature rises to 90°F+ runtime should be increased 200% or more. It is important to realize that if you don't increase your minimum ventilation rates during the day you may not pull enough warm air out of the attic to make a difference in house condition. What you will often find is that by increasing the minimum ventilation fan run time during the day, you will pull enough warm air out of the attic to cause the minimum ventilation fans to operate constantly, which will result in significantly improved air and litter quality. At night, minimum ventilation fan settings can be reduced back to what they were in the morning, keeping in mind that the ideal relative humidity is around 50% (70% maximum).

3) If the house warms up enough that additional fans (other than your timer fans) come on and the static pressure rises above 0.12", the side wall inlets should open automatically. If you feel you are pulling too much warm air from the attic, just decrease the static pressure setting on your side wall inlet machine (typically only an issue during warmer weather). The lower static pressure setting will cause the side wall attic inlets to open more and less air will enter through the attic inlets, lowering the house warming effect produced by the attic inlets.

4) Some environmental controllers have the ability to change the side wall inlet machine's static pressure setting

with house temperature. This can be a useful method of reducing the effect of the attic inlets if you feel the house is getting a little too warm. For instance, if a 48" fan turns on and the side wall inlets begin to open, you can set the environmental controller to decrease the side wall inlet static pressure setting from a 0.06 to 0.09". This will not only reduce the effect of the attic inlets but typically cause the side wall inlets to open enough (an inch or more) to get the air to the center of the house.

Turning the birds out into the entire house:

1) You may want to consider switching to a 48" fan for minimum ventilation to help pull the warm air from the brooding end into the non-brooding end of the house.

2) As the birds spread to the non-brooding end, open the attic inlets on the non-brooding end. Generally an additional 36" fan will be required once all the attic inlets are opened to be able to maintain a static pressure of at least 0.05".

Full house operation:

1) Consider decreasing the temperature offset of your minimum ventilation fans to one degree above your target temperature. The lower temperature offset will tend to cause the minimum ventilation fans to switch to constant operation earlier in the day, thus taking greater advantage of the warmer attic air to help dry out the house.

2) Don't worry if the attic inlets are causing the house to run a degree or two warmer. Watch your birds. Do they look like they are too warm? Most of the time the slightly higher house temperatures produced by the attic inlets will just cause another fan or two to operate and the cooling effect produced by the additional air movement will tend to offset the slightly higher house temperatures.

3) Don't be concerned if the house humidity drops well below 50% during the day. The lower humidity will not harm the birds and will lead to accelerated moisture removal from the litter, which in turn will often lead to lower house relative humidity and improved air quality at night.

4) Some environmental controllers have the ability to increase minimum ventilation settings based off a single or group of temperature sensors. Using an attic temperature sensor by itself or in combination with inside house temperature sensors can at times help increase minimum ventilation fan runtime. Caution should be used when using attic temperature to control minimum ventilation fan settings. For instance, some controllers can be programmed to use a temperature sensor to automatically increase timer fan settings if the temperature indicated by the sensor rises above the desired house temperature. So, if during the day it is 40°F outside and 65°F in the attic, the controller would not increase minimum ventilation fan settings if the desired temperature was 75°F, even though doing so would help to improve air quality and not necessarily result in increased fuel usage.

5) Don't worry about the attic inlets causing a significant increase in electricity usage. Even if the attic inlets caused a 48" fan to run for an additional six hours a day, this would typically increase electricity usage by less than $0.50 per day.

6) When walking your houses, always be on the lookout for side and end wall leakage. The tighter you make your house, the greater the percentage of the air that will enter through the attic inlets, and the better job the attic inlets will do at keeping your litter dry and your air fresh.

7) Don't feel you have to close the attic inlets if you happen to have a warm day or two and the house goes into tunnel ventilation. At lower levels of tunnel ventilation that one may experience during the cooler times of year, the static pressure will tend to be very low (less than 0.05"). The low static pressure will cause the

attic inlets to close all or most of the way, thereby limiting their effect (keep in mind that the static pressure has to exceed 0.04" for the attic inlets to even open). Even if they remain open when tunneling, the hot air they do introduce will be relatively minimal when compared to the amount of air entering through the tunnel curtain and will tend to stay next to the ceiling, resulting in a minimum effect on house temperature (a degree or less).

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