ACTUATED ATTIC INLETS

A Progress Report

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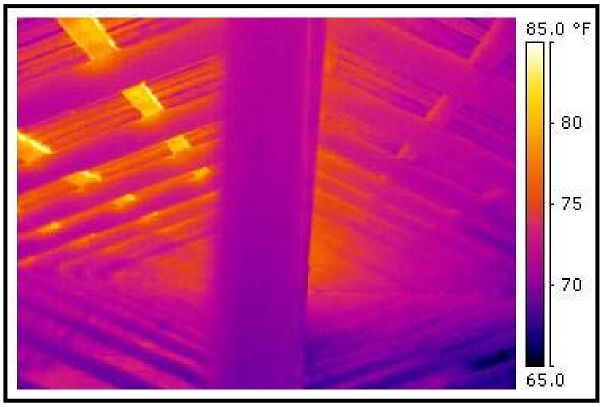
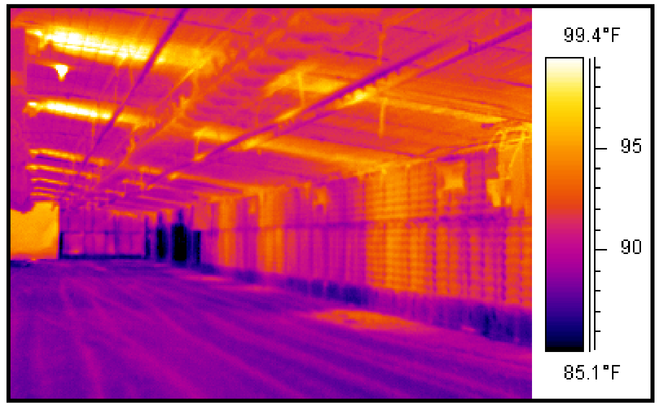


Thermal picture of solar heated attic



Solar heated attic air entering bird chamber

The cost of fuel for poultry house heating has increased so dramatically in the past five years growers are exploring every imaginable alternative to reduce energy costs. Good poultry house energy management starts with a tight, well sealed and insulated poultry house and a properly managed ventilation system. But after the structure has been made energy efficient, reducing the fuel costs must rely on utilization of an alternate heat source. A possible alternate heat source that is being examined by Auburn University Extension Engineers, Poultry Scientists and Economists is the recovery of solar heat from the attic of poultry houses to reduce the amount of heating fuel necessary for brooding and growing.

Using free solar heat will help reduce fuel costs for brooding and growing but an added benefit will be the use of free attic heat to help lower relative humidity and reduce litter moisture content. Growers tend to look at the reduction in fuel costs as the only major advantage of using attic inlets. However, the improvements in litter moisture and in-house conditions have been very significant in some of the houses that we have examined. Additionally, using attic heat for preheating prior to chick placement is also a major benefit.

The first question to answer with regard to using attic heat is, “How much heat is available and will it affect my gas consumption?” In general the large roof areas of dropped ceiling poultry houses make very good solar collectors. Recovery of solar heat is not new to agricultural buildings. During the energy crisis of the 1970's several studies using solar heating were conducted at Auburn University and at other locations across the poultry belt. The conclusions that were drawn from these studies are the same as we conclude today. There is a large amount of heat readily available in the attic of a poultry house.

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The amount of heat available varies greatly from winter to summer, and the amount of heat we need for brooding also varies greatly throughout the year. Having an east-west roof ridge orientation is best. Time of year, time of day, amount of cloud cover, number of attic inlets installed, and the ventilation rate will all have a direct bearing on how much energy can be recovered from the attic.

Data shared with Auburn University by the USDA-ARS Poultry Research Unit at Mississippi State University is used in this report to characterize attic, outdoor, and indoor temperatures during winter and summer months in the Poultry Belt. This published research data is consistent with the field observations we have made in several houses that have attic inlets. The USDA data indicates that the temperature was at least 10.8 degrees Fahrenheit warmer than the outside air temperature for at least 86% of the time during the first two weeks of a particular winter grow out. Chart 1 presents a histogram of just how much solar attic heat is available as a percentage of the total time for the first week of brood during a wintertime flock. This chart shows that 83.4 percent of the time the attic temperature was at least 6 degrees higher than outside air. (All charts and tables are located following the text.)

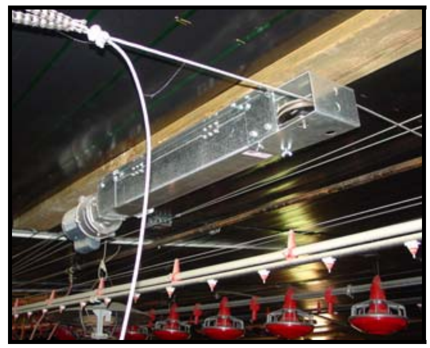
Auburn data often found attic temperatures in winter to be at least 15-20 degrees higher than outside air temperatures during the middle of the day. Chart 2 shows the difference between attic temperature and outside temperature for the first week of the wintertime flock. Chart 3 shows a sunny wintertime day where the attic temperature is at least 15 degrees greater than the outside temperature for at least 6 hours. Note that attic temperature remains about 10 degrees above the outside temperature for the remaining 18 hours of the day. Chart 4 shows a cloudy wintertime day. Note that the attic temperature remains about 7 degrees above the outside temperature for the entire 24 hour period.

USDA data also indicate that in summer there is a very large supply of available heat in the attic of a poultry house. Chart 5 shows the difference between attic temperature and outside temperature for the first week of the summertime flock. Attic temperature typically exceeds outside temperature by 30-35 degrees. Chart 6 shows a clear, sunny summertime day. Note that attic temperature is 25-35 degrees higher than outside temperature for 6 hours and more than 10 degrees higher for 11-12 hours. However, note that attic and outside temperatures are almost equal during nighttime. Chart 7 shows a cloudy summertime day. Note that attic temperature is at least 10 degrees higher than outside temperature for 10 hours and more than 20 degree higher for 7 hours.

It is important to understand that the amount of fuel that may be saved by using solar assist and attic inlets is highly dependent on the time of year and the weather conditions. A typical grower who is growing a small bird size might grow seven flocks per year. Two of these flocks will be brooded in very cold weather, four will be brooded in moderate weather and one will be brooded in very hot summertime conditions. See Table 1 for a conservative estimate of the breakout of gas data usage by time of year for a small bird grower. A typical grower who is growing a large bird size might grow only five flocks per year. One of these flocks will be brooded in very cold weather, three will be brooded in moderate weather and one will be brooded in very hot summertime conditions. See Table 2 for a conservative estimate of the breakout of gas data usage by time of year for a large bird grower.

Our initial tests utilized actuated attic inlets.   They were installed on a new four-house farm in Central Alabama. These houses were 42 ft x 510 ft houses, dropped ceiling, tunnel ventilated and center brooded. Twelve actuated bi-flow clam shell inlets (Cumberland, model #ACI-4000GP) were installed in the brood chambers of these houses during the final stages of construction. The inlets were connected to a single ball screw-type inlet machine that was controlled by the poultry house controller. The house had perimeter ceiling inlets installed for minimum ventilation. The original idea of the test was to utilize attic solar heat during the first three weeks of the grow-out and then at the point of the grow-out where it became necessary to cool the house, the perimeter ceiling inlets would be used and attic inlet use would be discontinued.

Bi-Flow Actuated Attic Inlet



Typical Actuator

During the first test in cold weather the two houses equipped with attic inlets used 17% less gas than the two control houses that were ventilated using only perimeter ceiling inlets. Litter conditions were much drier in the attic inlet houses and, in general, the humidity levels in these houses were noticeably lower. It became obvious that there was a definite advantage to having the solar preheating of air in wintertime.

At the conclusion of the first test, it was decided that placement of attic inlets only in a brood chamber was not the best approach.   The house was then modified by repositioning the inlets and having a total of sixteen inlets placed in the house, equally spaced. Inlets were rated at 3,000 CFM each, meaning that approximately 48,000 CFM of minimum ventilation air could be drawn through the attic inlets. A second test was then initiated using the new attic inlet configuration. Inlets in the off end were closed with the exception of one on each side of the brood curtain (center brood). At flock turn out, attic inlets were opened in both off ends of the house. When bird age and weather conditions dictated that we would be in a cooling mode, attic inlets were discontinued (approximately three weeks of age).

In the second test during a mild weather flock, heating fuel usage in the test houses was 35% less than in the control houses. Houses were heated with natural gas and meters were on all houses. Hot weather test data is not available at this time but the input from growers throughout the Poultry Belt supports expecting up to a 50% fuel savings during hot weather brooding conditions.

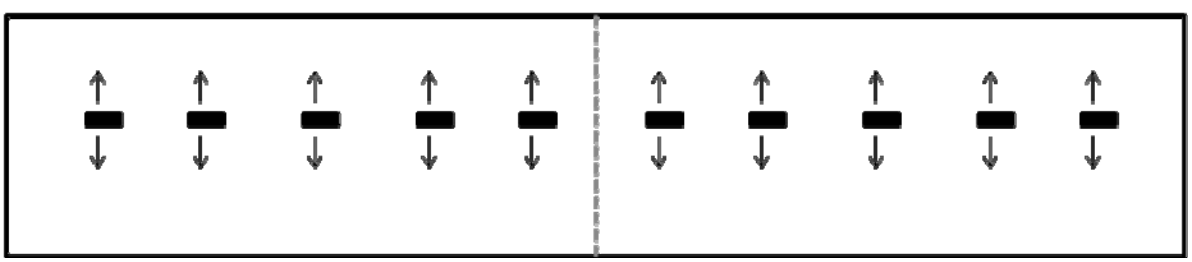
We have had so many inquiries as to the value and use of solar assisted heating using actuated attic inlets that we have listed below the most frequently asked questions and their answers.

Frequently Asked Questions about Actuated Attic Inlets

1. **How many actuated bi-flow attic inlets should be installed?** Attic inlet systems need to be large enough to handle the needs of the minimum ventilation fans when birds are in the whole house mode. In our first test houses that were 42 ft x 510 ft dropped ceiling broiler houses we decided we would never run more than 48,000 CFM in timer fan ventilation. A good rule of thumb for the capacity of the attic inlet system should be about 2 CFM per square foot of house. Inlets on the market today with which we are familiar are generally rated at 2,000 CFM (gravity type), and 2,500 and 3,000 CFM (actuated types). The bi-flow clam shell inlets that we used were rated at 3,000 CFM. In our first whole house test we installed sixteen inlets rated at 3,000 CFM. This was done partially because the house was a center brooded house and in the final stages of minimum ventilation we might be running two 48-inch fans, one in each of the two non-brood chambers. Several houses have been installed based on handling three 36-inch fans or one 36-inch and one 48-inch fan. Be sure to install enough attic inlets to handle the air flow of the maximum number of minimum ventilation fans that will be used.

House Size	Minimum Vent CFM	2000 CFM Inlets	2500 CFM Inlets	3000 CFM Inlets
40x400	30,000	15	12	10
40x500	40,000	20	16	13
50x500	48,000	24	19	16
60x600	72,000	36	29	24

Actuated Bi-Flow Attic Inlets/House Size



Typical Layout of Bi-Flow Attic Inlets in a 40x400 Poultry House

2. **Should attic inlets be used during nighttime?** Our attic temperature data showed that almost always at night there was an advantage to drawing in attic air. Attic inlets are less affected by wind than side wall inlets. We saw no disadvantage to using attic inlets at night.

3. **If attic heat is free, should I then increase minimum ventilation run-time?** We have learned that we can get more benefit from installed attic inlets if we move more air through the house during periods of high attic temperatures in the middle of the day. The key thing to understand is that if the heat is free then minimum ventilation does not need to be minimum anymore. More fan run time is better when we can do it with warmer air that we are not spending gas to heat. More warm air and more ventilation decreases relative humidity and dries out the litter in the house, making it easier for us to withstand periods of really cold weather or high humidity when we do have to go back to the stingy minimum time clock ventilation. Drier litter allows us to approach really cold or rainy weather in much better shape than if we are running the bare minimum of time on our timer fans to conserve heating fuel.

4. **Do we need to monitor attic temperature either with a controller sensor or with a stand alone thermometer?** Well the answer to this is yes and no. Certainly in our tests we were keeping up with attic temperatures but the fact of the matter is, with the simplest attic heating assist regimens there was almost always some benefit from drawing preheated air from the attic. So, if you are set up to use attic heat and don't monitor attic air temperature there is probably nothing wrong with it. However, use of actuated attic inlets in hot summer conditions must be monitored very closely to insure that bird chamber overheating does not occur. We have learned that to get more benefit from installed attic inlets we need to move more air through the house during periods of high attic temperatures in the middle of the day. Again, the hardest concept to get your mind around with attic heat recovery is that if the heat is free then the minimum ventilation does not need to be minimum anymore. For actuated attic inlets, the best way to get maximum benefit is for the controller to operate the inlets based on the temperature of the attic. If heat is available and needed, the inlets are used. If heat is not needed, perimeter inlets are used. No grower intervention is necessary. If attic inlets are not on a controller, it is probably best to not use them in very hot conditions or house overheating can occur.

5. **What type of air flow was observed?** At a static pressure of .07, warm air was directed all the way to the side walls of the test houses. An initial observation on attic inlet houses is that high static pressures are not necessary to get good airflow, since the ventilation air is coming into the house at the warmest place in the house (that is high and in the center of the ceiling). Air velocities at the inlet were 700 to 800 feet per minute and in the range of 200 feet per minute at the side wall.

6. **Do I need to modify the house so that I can pull air into the attic?** Much of the work that has been done with respect to attic inlets has utilized only running minimum ventilation fans to draw air into the attic. Most poultry houses have not been designed with attic ventilation in mind but up until this point in time we have not seen any difficulties in bringing minimum ventilation air through the ridge cap, corrugation openings and slots above the bird board on the eave. We are recommending to growers building new houses that they consider having their builder lower the bird board by at least three quarters of an inch from where it meets the tin on the roof so that there will be ample space for additional attic air entry. As we learn more about attic inlet ventilation in broiler houses it is possible that additional roof vents and or gable vents will be needed to insure we have adequate air entry square footage to feed outside air into the attic for preheating.

7. **How much management is required for using attic inlets?** The theory behind the actuated inlets is that the Poultry House Controller will utilize attic inlets when needed and will utilize perimeter side wall or ceiling inlets when needed. Basically we will have two inlet systems in the poultry house, one for low level ventilation during cold weather and one for moderate ventilation during mild weather and during the middle of the flock before tunnel ventilation. While actuated attic inlets can be run manually, integration of the two inlet machines into the poultry house controller is highly desirable. Most controller companies now have software in their units to allow attic inlets to be used when beneficial and not used when they would be detrimental.

8. **How will using the attic of a poultry house as a solar collector affect the useful life of the building?** If attic inlets remain fully closed when no ventilation is taking place, then it would be impossible for air that is in the bird chamber to find its way into the attic. If poultry houses have attic inlets that remain hung open during a period of non-use, warm moist air from the bird chamber will chimney its way into the attic. This could be very detrimental to the building. Warm moist air contacting cold roof tin in the attic will cause condensation, sweating, wetting of timbers, wetting of insulation and, over time, will lead to structural damage of the building. A caution to any grower considering any type of attic inlet would be that the attic inlets must be managed closely and under no circumstances should they be allowed to hang in the open position or leak air into the attic.

9. **Are manual (gravity type) attic inlets better than actuated inlets?** Our feeling at this time is there is a place for both types of attic inlets. The major advantage of the gravity type inlet is lower initial cost and the major advantage of the actuated inlet will be that it will not be necessary for any grower intervention for management. Gravity inlets require more intervention from time to time. We have striven for years to automate poultry houses and do not need to regress to systems that place more demands on growers. Our feeling is that in the long run the actuated inlet will become very popular.

10. **Are there any poultry houses that attic inlets should not be installed in?** For attic inlets to provide real benefits, the house needs to be adequately tight. If a house can not achieve at least a 0.10” of static pressure (a 0.13” pressure would be desirable) during a standard static pressure test, it will most likely be too loose to get much of a benefit from attic inlets. The tighter the house, the higher the percentage of air that is drawn into the house comes from the attic. Attic vents do not belong in Class C poultry houses.

Preliminary Economic Analysis

Specific fuel savings will vary by prevailing weather conditions and number of flocks per year. Fuel savings used to develop Tables 1 and 2 were estimated from actual in-house observations made by University staff, growers, and service technicians at several locations across the Poultry Belt. They are conservative estimates based on flock type and time of year. The coldest weather flocks show the lowest percentage in fuel reduction, while the hottest weather flocks show the greatest percentage in fuel reduction.

Table 1 calculates the estimated fuel savings resulting from operating actuated heat recovery attic vents for a small bird (7 flocks/year) operation. It was assumed that 5,200 gallons of propane were used prior to attic vent installation. Annual fuel usage resulting from incorporating attic ventilation was estimated to be reduced by 19.6 percent, or 1,019 gallons. With a propane price level of $2.00 per gallon, annual fuel savings are estimated to be $2,038. If the initial cost of installing attic vents in a 40 ft X 500 ft poultry house is assumed to be $3,600, the initial investment will be recovered in slightly less than 2 years, just from fuel savings alone. However, additional value is likely to result from maintaining drier litter, extending the in-house life of litter, and from slight increases in flock performance (e.g. average weight, livability, paw quality, and feed conversion) from maintaining a more uniform brood environment.

Table 2 calculates the estimated fuel savings resulting from operating actuated heat recovery attic vents for a large bird (5 flocks/year) operation. It was assumed that 4,100 gallons of propane were used prior to attic vent installation. Annual fuel usage resulting from incorporating attic ventilation was estimated to be reduced by 19.4 percent, or 794 gallons. With a propane price level of $2.00 per gallon, annual fuel savings are estimated to be $1,588. If the initial cost of installing attic vents in a 40 ft X 500 ft poultry house is assumed to be $3,600, the initial investment will be recovered in approximately 2.5 years, just from fuel savings alone. Increases in value attributable to improved litter conditions and longevity and flock performance similar to those realized in the small bird operation would be expected in a large bird program, as well.

Conclusions

The ultimate decision to use attic inlet systems should be based on several factors. Projected fuel savings during preheating, brooding and growing and initial cost will greatly influence the decision. Other factors, such as the value of maintaining drier litter, warming the house between flocks, minimizing the need to clean out, and reduction in the need for purchasing more new bedding material all have economic values that are hard to quantify and vary from one location to another. There will also be some additional time requirements associated with the management and maintenance of an attic ventilation system.

The major possible negative consequences of operating an attic ventilation system would result from system mismanagement. Any attic inlet system that is mismanaged will allow warm moist bird chamber air to enter the attic of a poultry house and that air will, over time, damage the poultry house. The attic insulation will become less effective, the underside of the metal roof will corrode more quickly, and the structural members will be adversely affected, as well. The management and maintenance of attic ventilation systems are responsibilities that must be taken very seriously. Attic heat recovery appears to be a powerful emerging tool in reducing fuel usage and costs in modern dropped ceiling poultry houses. As more data is collected and more work is conducted, that additional information will be made available.

Thanks are extended to the integrated companies, equipment companies, service technicians, and growers who have helped us in our initial work with attic vents. We are also appreciative of the input made from the University of Arkansas. Finally, we are grateful to the USDA-ARS Southeast US Poultry Research Laboratory in Starkville, Mississippi for their willingness to share data and collaborate with us on this study.

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Charts and Tables

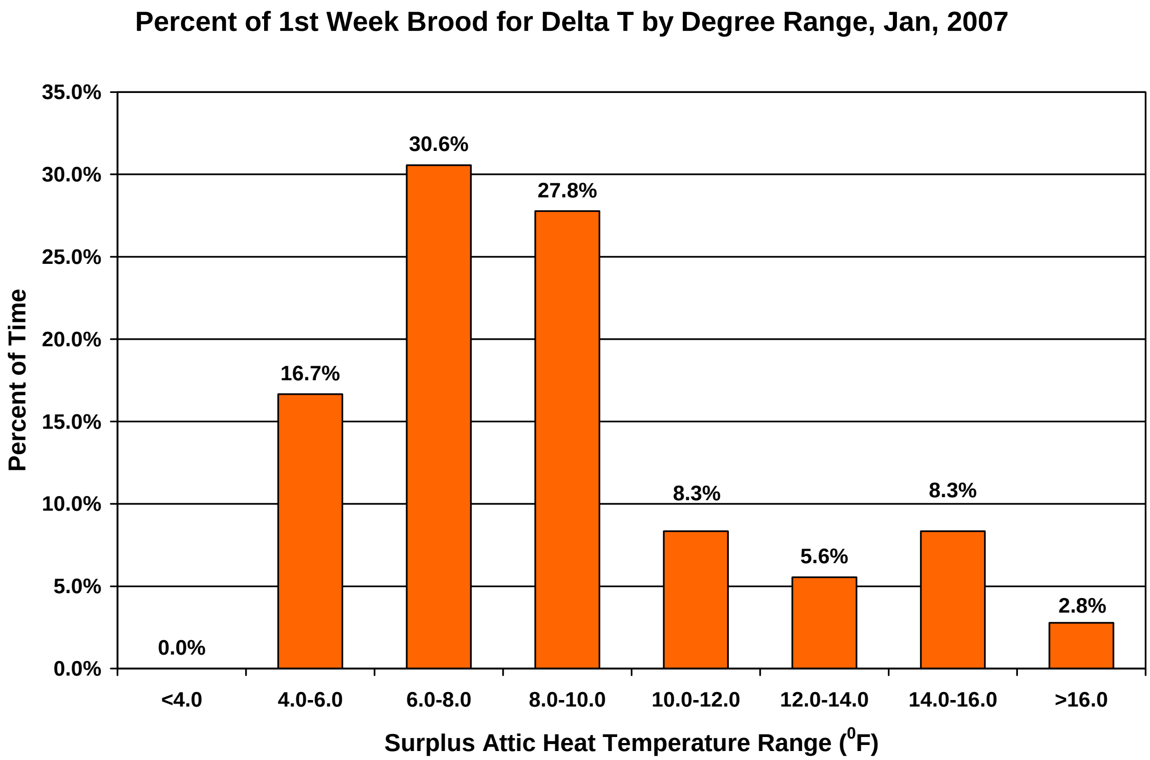

Chart 1. Histogram showing percentage of time Delta T is in a given temperature range.

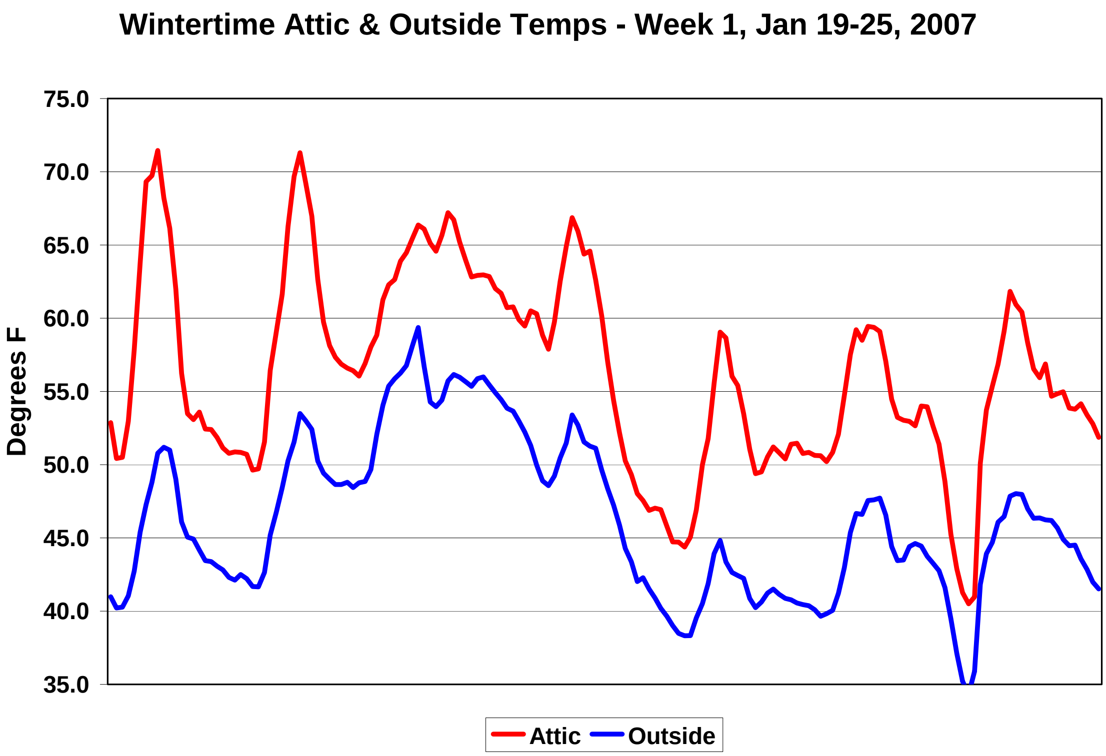

Chart 2. First week of wintertime brooding.

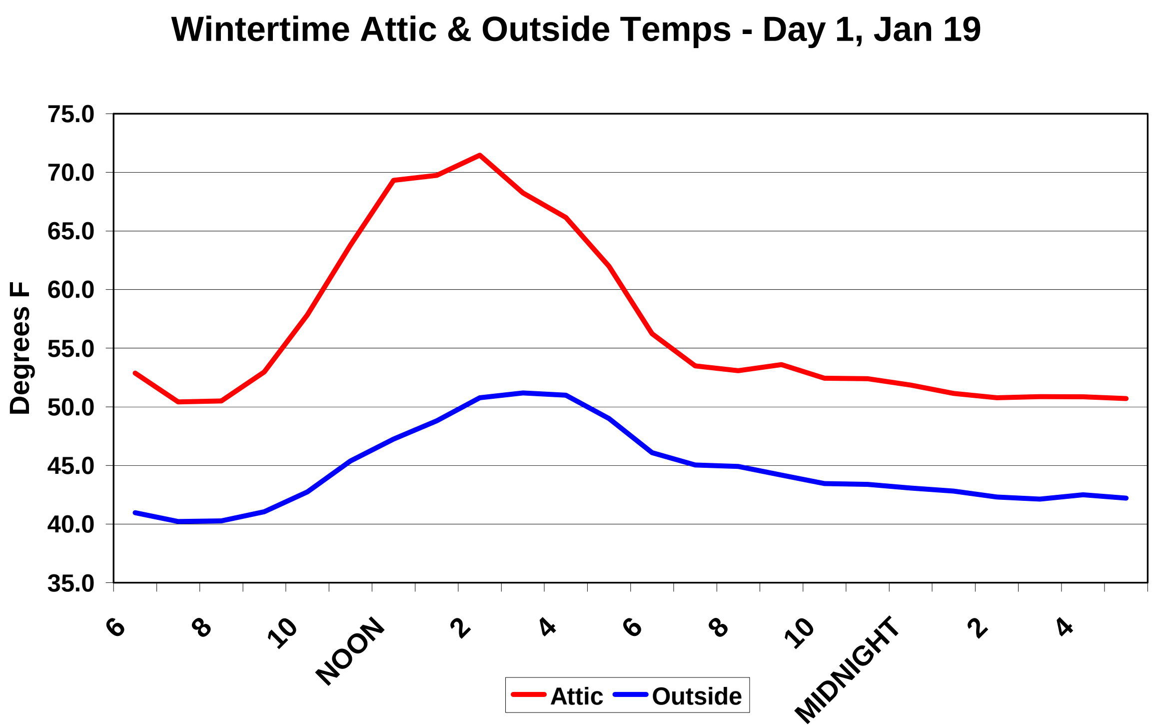

Chart 3. Typical sunny day during brood in wintertime.

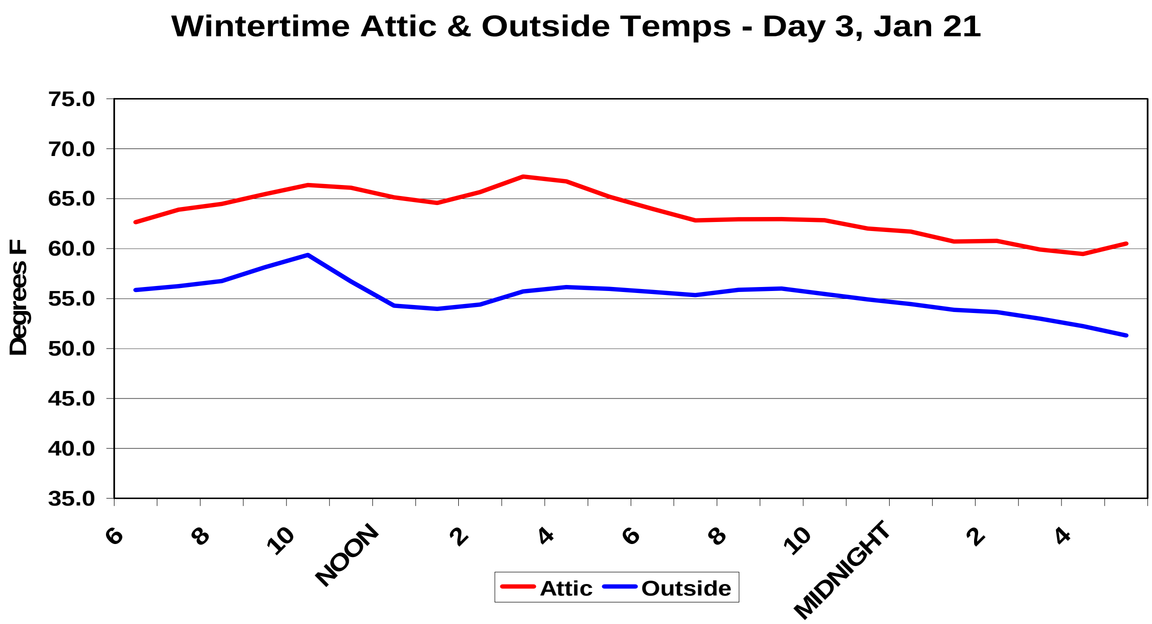

Chart 4. Typical cloudy day during brood in

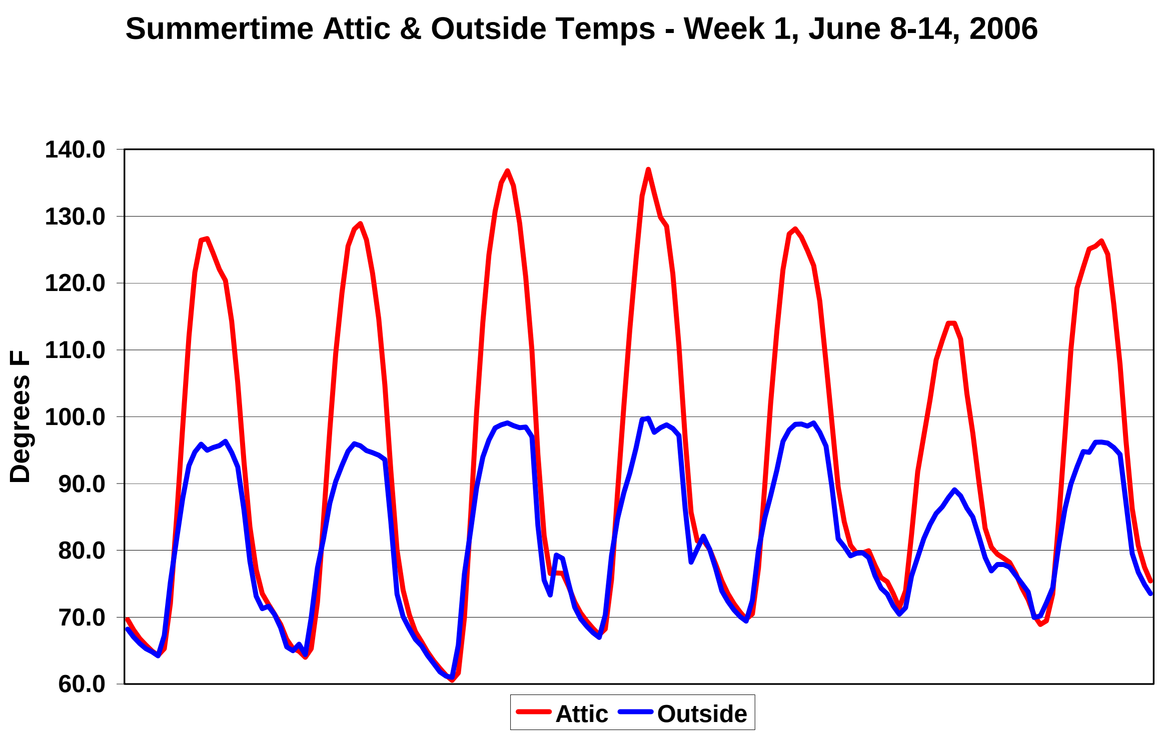

Chart 5. First week of summertime brooding.

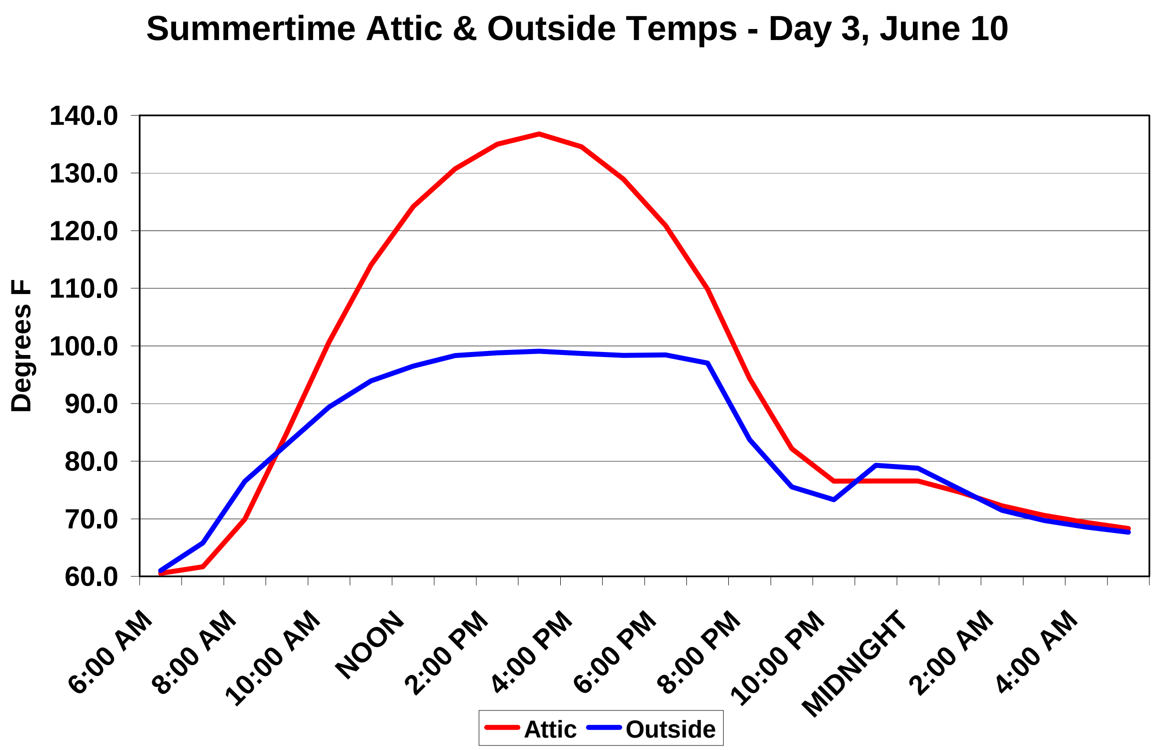

Chart 6. Typical sunny day during brood in summertime.

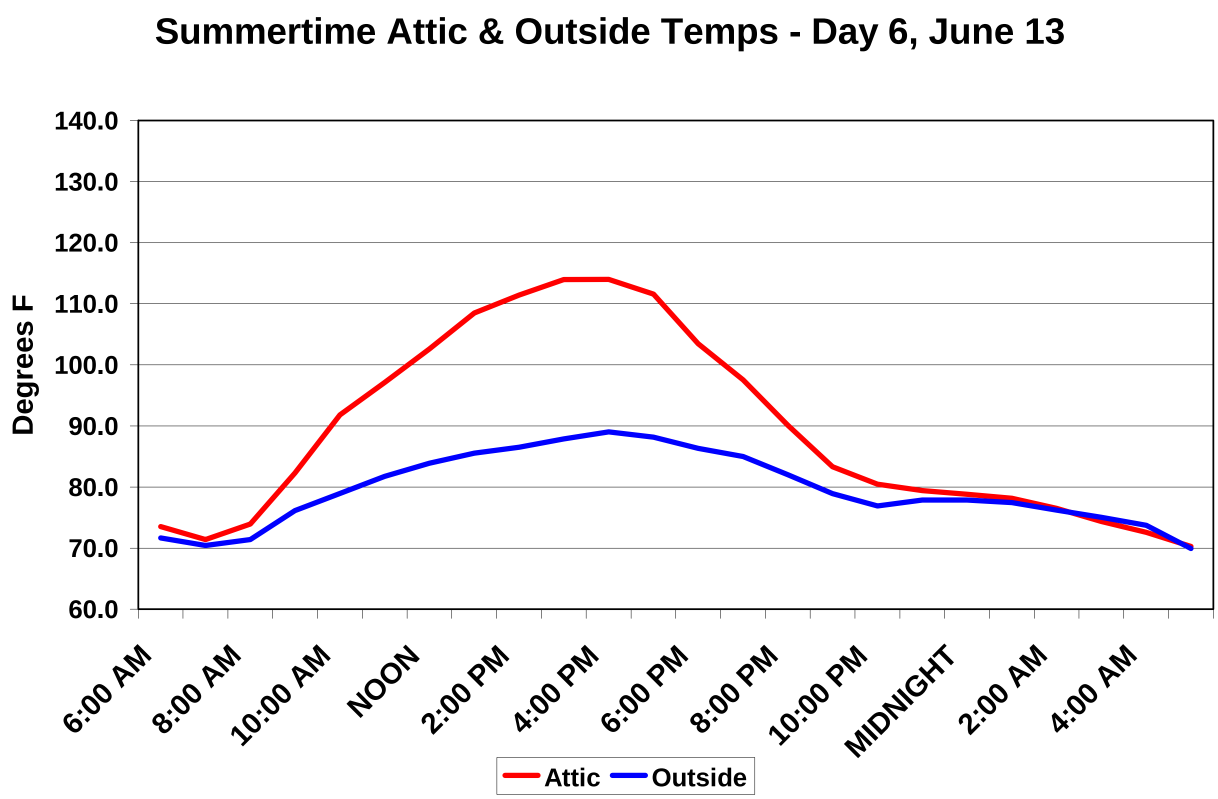

Chart 7. Typical cloudy day during brood in summertime.

Utilizing Solar Heated Attic Ventilation Inlets for Fuel Savings

Table 1. Estimated Gas Savings Example for Small Bird Grow Out (7 flocks/year)
Annual Gas Usage 5,200 gallons/year – Improved Housing – North Alabama Conditions

Flock No.	Weather	% of Annual Consumption	Gallons	Projected % of Fuel Savings	Gallons Saved	@ $2.00 / Gallon Propane
1	Cold	24	1,248	15	187	374.00
2	Cool	15	780	20	156	312.00
3	Hot	8	416	25	104	208.00
4	Very Hot	6	312	40	125	250.00
5	Hot	8	416	25	104	208.00
6	Cool	15	780	20	156	312.00
7	Cold	24	1,248	15	187	374.00
Summary	-	100	5,200	-	1,019	2,038.00

Estimated Savings: 1,019 gal / 5,200 gal = 19.6% of fuel saved on average per year

Table 2. Estimated Gas Savings Example for Large Bird Grow Out (5 flocks/year)
Annual Gas Usage 4,100 gallons/year – Improved Housing – North Alabama Conditions

Flock No.	Weather	% of Annual Consumption	Gallons	Projected % of Fuel Savings	Gallons Saved	@ $2.00 / Gallon Propane
1	Cold	40	1,640	15	246	492.00
2	Cool	34	1,394	18	251	502.00
3	Warm	13	533	23	123	246.00
4	Hot	8	328	28	92	184.00
5	Very Hot	5	205	40	82	164.00
Summary	-	100	4,100	-	794	1,588.00

Estimated Savings: 794 gal / 4,100 gal = 19.4% of fuel saved on average per year

Notes for Tables 1 and 2

1. **Estimated gas savings are based on actual Auburn University data and grower reports from several locations across the poultry belt.**
2. **In this economic analysis, conservative estimates of fuel savings have been applied to account for highly variable weather conditions that might occur during the preheating and brooding periods. No additional values have been applied for additional benefits related to the utilization of attic inlets.**
3. **Calculations assume improved housing (solid insulated walls, dropped ceiling, etc.) that pulls at least 0.13 inches of water column on static pressure test.**