

## Alternative Heating Systems

Michael Czarick  
The University of Georgia



## Propane...



- ▶ With very high propane prices in the recent past...
- ▶ Promises of equally high (if not higher) propane prices in the future...
- ▶ Potential for legislative actions to limit "green house gas emissions"...
- ▶ Many producers/poultry companies are wondering is there another alternative to propane...
- ▶ A cost effective alternative.



## Alternative heating systems

- ▶ An automated heating system that burns something other than fossil fuels.
- ▶ Requires approximately the same amount of time as traditional heating systems



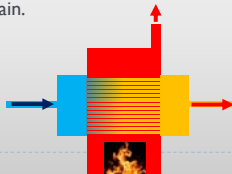
## Alternative heating systems

- ▶ There are basically two types of alternative heating systems
  - ▶ Hydronic - Hot water systems
  - ▶ Hot air systems



## Hydronic systems

- ▶ A group of houses is heated using a central boiler that burns some type of low cost fuel to heat water to a temperature of between 150°F – 200°F:
  - ▶ The heated water is circulated to the houses on the farm.
  - ▶ Some type of heat exchangers are then used to heat the air/floor in the houses
  - ▶ The slightly cooler water (-20°F) is then returned to boiler to be heated again.



## Boilers themselves are fairly similar...

- ▶ Biggest difference between these systems is the type of heat exchanger used.
- ▶ There are primarily four types of hydronic heat exchangers used in poultry houses



Types of hot water heat exchangers:

- ▶ **Black steel pipe**
  - ▶ Typically installed on the side walls



1 1/2" black steel pipe



Black steel pipe heat exchangers:

- ▶ Each foot of pipe is capable of adding a specific amount of heat to a house (more pipe more heat):
  - ▶ 1 1/2" black steel pipe = 150 Btu's/hr per foot
  - ▶ 2" black steel pipe = 170 Btu's/hr per foot
- ▶ If you wanted to add up to 500,000 Btu's/hr of heat to a house...
  - ▶ 1 1/2" black steel pipe = 150 Btu's/hr per foot
    - ▶  $500,000 / 150 = 3,300'$
  - ▶ 2" black steel pipe = 170 Btu's/hr per foot
    - ▶  $500,000 / 170 = 2,900'$



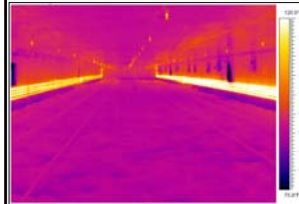
Black steel pipe installed on side wall



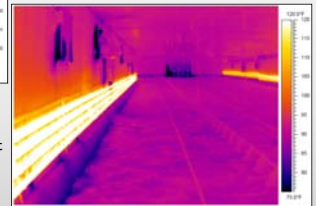
2" black steel pipe



Thermal image of hot water radiator pipes on side walls



Basically a hot air heating system (furnaces producing warm air)



Don't produce a substantial amount of radiant heat compared to conventional/radiant brooders



Cost?

- ▶ 2" black steel pipe = 170 Btu's/hr per foot
  - ▶  $500,000 / 170 = 2,900'$
  - ▶ \$3 per foot = \$8,700



Types of hot water heat exchangers

- ▶ **Black steel pipe**
- ▶ **Finned tube**
  - ▶ More surface area
  - ▶ More heating produced per foot
  - ▶ Less pipe required



Finned tubes have greater surface area  
(approx. five times the heat output per foot)

- ▶ 1 1/2" finned tube = 750 Btu's/hr per foot (150 bsp)
- ▶ 2" finned tube = 850 Btu's/hr per foot (170 bsp)
  
- ▶ If you wanted to add up to 500,000 Btu's/hr of heat to a house...
- ▶ 1 1/2" finned tube
  - ▶  $500,000/750 = 670'$
- ▶ 2" finned tube
  - ▶  $500,000/850 = 590'$



### Finned tubes

- ▶ Traditionally installed in vicinity of air inlets to warm cold incoming air.



Finned tubes on ceiling near side wall inlets



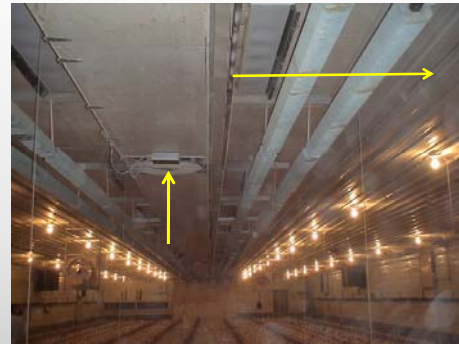
Finned tubes on side wall below inlets



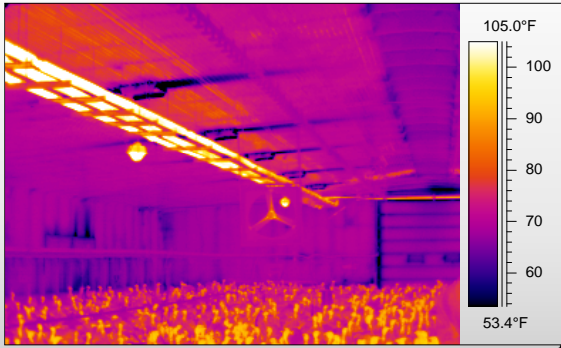
Finned tubes on side wall and ceiling



Finned tubes install next to two way attic inlet/circulator



Finned tubes installed below attic inlets



Cost?

- ▶ 2" finned tube = 750 Btu's/hr per foot
- ▶  $500,000/850 = 590'$
- ▶ \$15 per foot = \$8,900 (\$8,700 bsp)

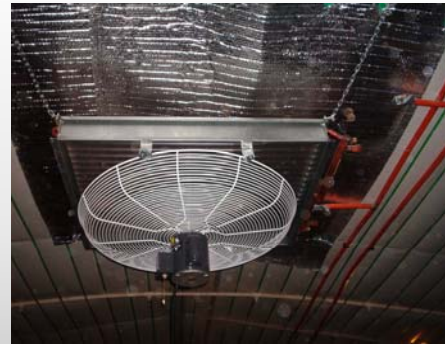


Types of hot water heat exchanger:

- ▶ Fin pipes
- ▶ Black steel pipe
- ▶ Individual radiators with blower fans
  - ▶ Lower cost option
  - ▶ Similar to forced air furnaces but air produced is not as hot.



Radiator with blower fan located next to ceiling



Cost?



- ▶ Btu/hr output = 225,000 to 150,000 Btu's/hr
- ▶ \$1,000 per unit.
- ▶ 500,000 Btu's/hr system would require 3 possible 4 exchangers
  - ▶ \$3,000 - \$4,000

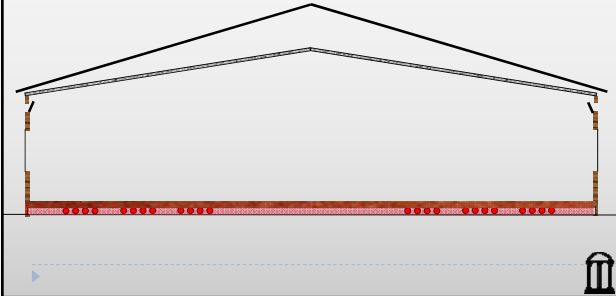
Types of hot water heat exchanger:

- ▶ Black steel pipe
- ▶ Finned tubes
- ▶ Individual radiators with blower fans
- ▶ Floor heating
  - ▶ Very expensive



## Floor heating systems

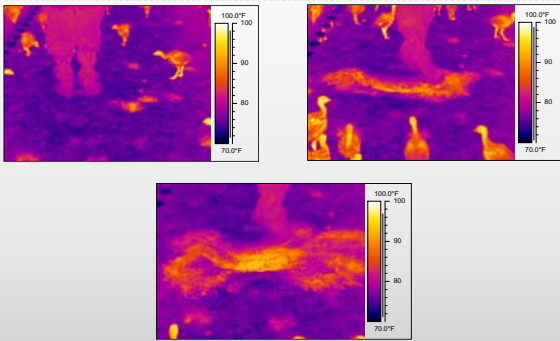
- ▶ Concrete floor with pipes running through it



## Floor heating systems

- ▶ Concrete floor is required adding substantial cost to a house.
- ▶ Litter depth has to be carefully controlled because litter is a very good insulating material.
  - ▶ Most of these systems are installed in houses that clean out after each flock.

## Hydronic floor heating systems

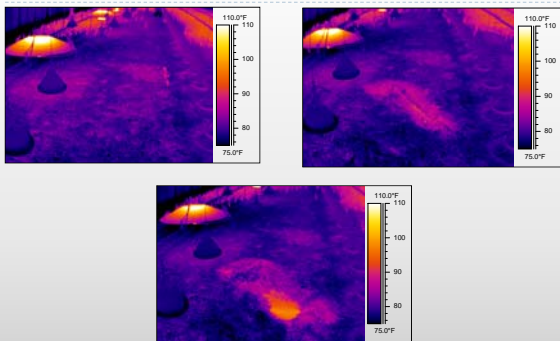


## Often houses with floor heating systems also have a secondary heating system

- ▶ **Floor heating:**
  - ▶ Primarily designed to provide background heat
  - ▶ Tends to have a very slow response time



## Supplemental brooders in turkey brooding barn

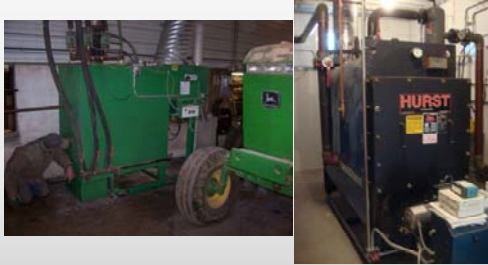


## Often houses with floor heating systems also have another heating system

- ▶ **Floor heating:**
  - ▶ Primarily designed to provide background heat
  - ▶ Tends to have a very slow response time
- ▶ Yes, the litter tends to be dry but this tends to be true with any hydronic system
- ▶ Not a very common type hydronic heating system – cost

All Hydronic systems require a substantial initial investment

► First, there is the boiler...



Fuel storage...



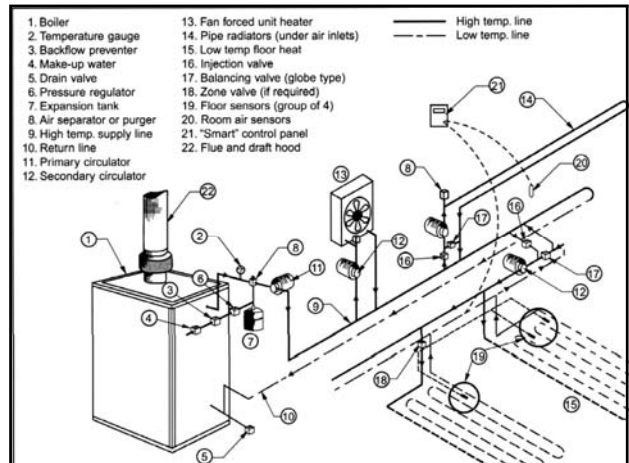
Pumps...



Hot water delivery system...

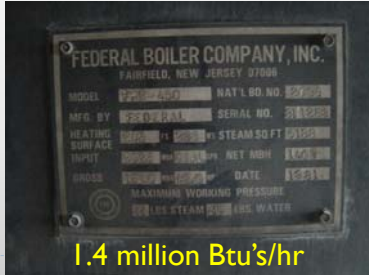


and of course there are the heat exchangers...



To reduce initial cost hydronic systems tend to be total farm heating systems

- ▶ The boiler is the largest single cost and the cost difference between a boiler to do a single house and multiple houses is not substantially greater.



To reduce initial cost hydronic systems tend to be total farm heating systems

- ▶ The boiler is the largest single cost and the cost difference between a boiler to do a single house and multiple houses is not substantially greater.
- ▶ In some areas of the country the entire farm (poultry houses, dwelling houses, farm shop, etc) is heated using a single boiler.



### Hydronic systems

- ▶ Typically looking at \$40,000 to \$50,000 per house
- ▶ +\$100,000 per farm
- ▶ This of course could change but this is what it has traditionally cost.



### Are they a good investment?

- ▶ If the fuel is inexpensive enough...
- ▶ and your energy usage is high enough...
- ▶ They could be...



### Is your demand high enough?

- ▶ Most of these systems are in very cold climates
  - ▶ Northern tier U.S, Canada, Northern Europe.
- ▶ Many have access to very inexpensive fuel...coal



### Coal heat cost heating comparison

- ▶ 1,000 gallons of propane
  - ▶ 93 Millions Btu's of heat
  - ▶ Cost = \$1,500 @ \$1.50 per gallon
  - ▶ Cost per million Btu's = \$16
- ▶ Delivered cost of coal = \$150 per ton
  - ▶ Btu's in a pound of coal = 10,000 Btu's
  - ▶ 93 million Btu's of heat = 9,300 lbs of coal
  - ▶ Cost = \$700
  - ▶ Cost per million Btu's = \$7.50
  - ▶ Roughly half as much



### Litter burning systems?

- ▶ Many of the proposed systems are hydronic.
- ▶ Fuel is very cheap...but the systems tend to be very expensive.
  - ▶ Litter is a difficult fuel



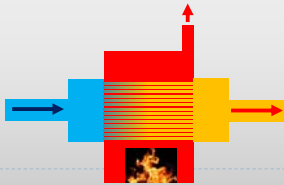
### Hot air systems tend to be much more affordable

- ▶ Lower initial cost...
- ▶ Lower risk...you can try it out on a single house.



### Hot air systems

- ▶ Each house has its own heating unit that burns some type of low cost fuel:
  - ▶ Air is drawn from the house,
  - ▶ Runs over the burning chamber/heat exchanger,
  - ▶ Returned to the house where it is distributed using either duct system and/or circulation fans



### Hot air systems

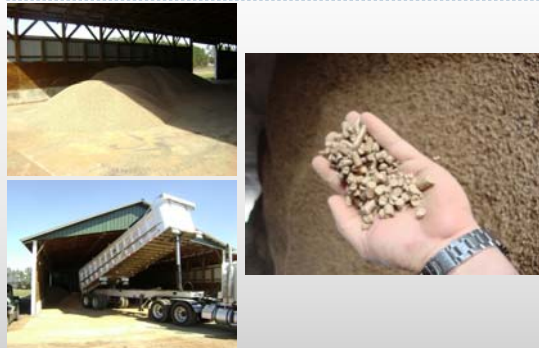
- ▶ Simpler systems and as a result tend to be less expensive
  - ▶ \$15,000 to \$30,000



### Our experiences with a hot air alternative heating system



### Capable of burning wood pellets



or fine wood chips



Operation was fairly straight forward...



Loading of unit  
(typically once every other day during high use)



Automated fuel feeding system

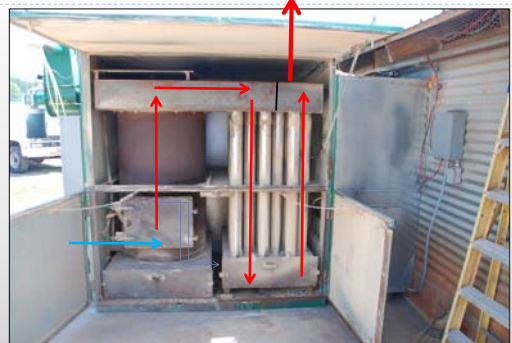


Heating unit operation

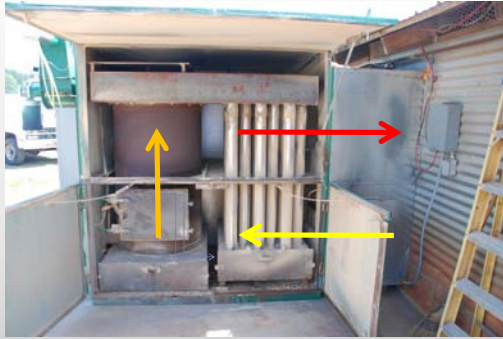
- ▶ House environmental controller would call for heat
- ▶ Fuel is fed and then ignited
- ▶ When unit comes up to temperature, a large blower comes on to deliver heat air to the house.



Combustion air flow through heating unit



House air flow through heating unit



House from air flowing into and out of heating unit



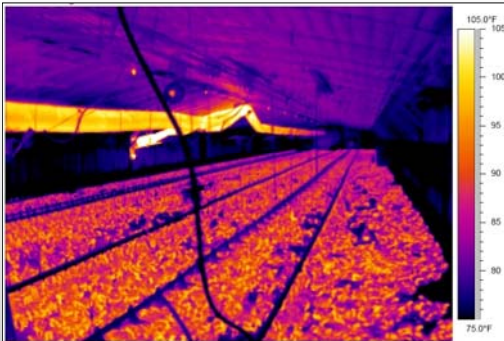
We studied two hot air distribution systems...



Perforated duct



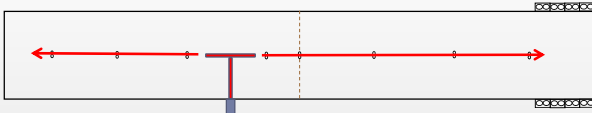
Perforated plastic duct ran the length of the house



Short duct – with circulation fans



### Circulation fan distribution system



### Circulation fans moving heated air towards the brooding end wall.



### Circulation fans moving heated air towards the brooding curtain



### Circulation fan in half house curtain to move heated air to nonbrooding end



### Operation challenges with hot air systems:

- ▶ What would happen in your existing houses if all the furnaces/brooders were wired together to operate as a single unit?
- ▶ If every area of the house required the same amount heat there wouldn't be a problem...
- ▶ But when was the last time you saw all the furnaces/brooders operating the same amount of time each day?

### Heat distribution

- ▶ With these systems they need to be operated off an average of house temperature (hydronic systems can be zone controlled to some extent).
  - ▶ If you have a warm spot, it will tend to get warmer.
  - ▶ If you have a cold spot, it will tend to stay cool
- ▶ The cool spots were "fixed" by utilizing the houses existing heating system (radiant brooders/furnaces).
  - ▶ If the temperature dropped too low (3°F below desired) they would come on.
- ▶ The hot spots can become problematic because they can cause exhaust fans to come on to cool the house while you are trying to heat it.

### Heat distribution

- ▶ Hot and cold spots tend to reduce the savings associated with these systems.
  - ▶ Cold spots cause an increase in propane usage.
  - ▶ Hot spots cause an increase in ventilation which results in an increase in alternative fuel usage.
- ▶ The more uniform the producer can make the heat demand of the house the greater their savings will be.
  - ▶ Keep birds spread out
  - ▶ Make sure all inlets open the same amount
  - ▶ Keep tunnel curtains tight and tunnel fan shutters covered
  - ▶ Etc.



In general these systems are best suited for totally enclosed houses

- ▶ Heat demand tends to be more uniform than in loose curtain sided houses.



### Heat distribution

- ▶ These systems typically provide the producer little ability to modify heat delivery.

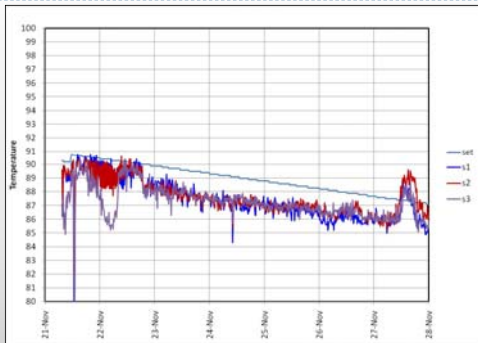


Heating system response time is another challenge

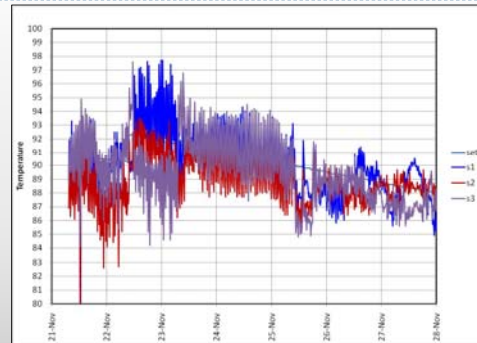
- ▶ Traditional propane systems produce very hot air, very quickly.
  - ▶ Propane = +500°F, in seconds
  - ▶ Alternative hot air heating systems = 150°F – 180°F in minutes
- ▶ As a result house temperatures will tend to drift more than in propane heated houses.



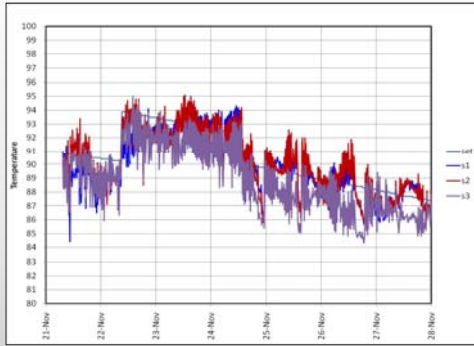
### Traditional propane heating system



### Duct heat delivery system



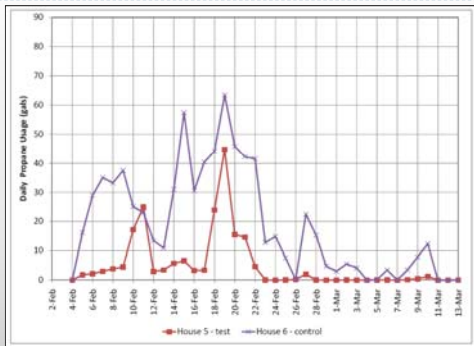
### Circulation fan heat distribution



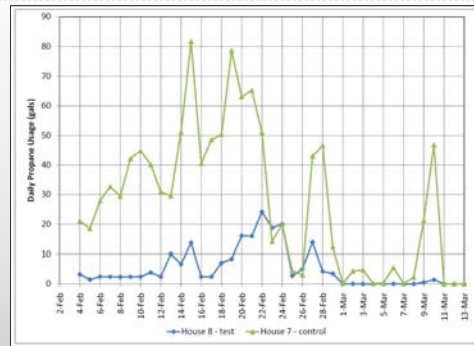
With a little effort most of these issues were handled:

- ▶ Generally, we reduced our propane usage in our test houses by 80% or more over the conventional propane heating system houses.

### Reduced daily propane usage +80%



### Reduced daily propane usage +80%



### Study results – Late fall flock

November 21 - December 28, 2008

	House 5 wood chips	House 6 propane	House 7 propane	House 8 wood pellets
Propane (gallons)	113	441	583	36
Propane cost @ \$2/gal				
Total wood fuel used (pounds)				
Total wood fuel used (cubic feet)				
Wood cost @ \$50 per ton of wood chips @ \$150 per ton of wood pellets				
Peak 24 hour wood usage (pounds) ½ house				
Peak 24 hour wood usage (pounds) full house				

### Study results – Late fall flock

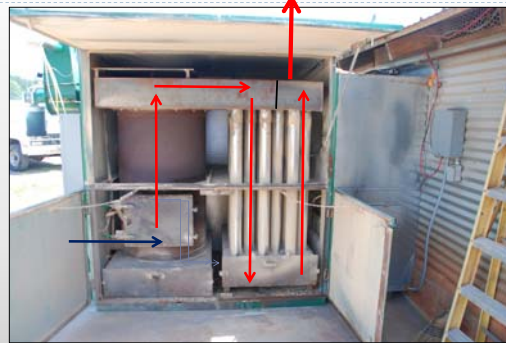
Total heating cost	\$526	\$882	\$1,166	\$1,362
Corrected heating cost				
Savings				
% Savings				
Downtime (total hours)				
Downtime (incidences)				
Approximate overall heating system efficiency				

### Heating system efficiency

- ▶ Propane has a heating system efficiency of approximately 100%
- ▶ Alternative heating systems have a lower system efficiency due to a couple of reasons.

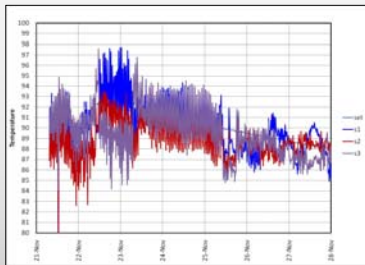


At least 15% of the Btu's go out the stack



### Shut down loss

- ▶ Brooders stop burning fuel the instant they shut off...
- ▶ Alternative heating systems do not.



### Heat distribution loss

- ▶ Tend to overheat some areas of a house.



### Energy content of various fuels

- ▶ Propane 93,000 Btu's/gal
- ▶ Natural gas 100,000 Btu's/therm
- ▶ Used motor oil 140,000 Btu's/gal
- ▶ Coal 10,000 Btu's/lb
- ▶ Wood pellets 8,000 Btu's/lb
- ▶ Hardwood 7,000 Btu's/lb
- ▶ Corn 7,000 Btu's/lb

**Most systems would have a more realistic overall heating system efficiency of 50 to 70%**



### Study results – Winter flock

January 26 - March 4, 2009				
	House 5 wood chips	House 6 propane	House 7 propane	House 8 wood pellets
Propane (gallons)	76	467	389	80
Propane cost @ \$2/gal				
Total wood fuel used (pounds)				
Total wood fuel used (cubic feet)				
Wood cost @ \$50 per ton of wood chips @ \$150 per ton of wood pellets				
Peak 24 hour wood usage (pounds) 1/3 house				
Peak 24 hour wood usage (pounds) full house				
Total heating cost				



### Study results – Winter flock

Savings	\$579			\$127
% Savings				
Downtime (hours)				
Downtime (incidences)				
Approximate overall heating system efficiency				



### Maintenance issues

- ▶ Ignition problems
- ▶ Auger problems
- ▶ Cleaning once a flock



### Ash



### Ash

- ▶ Wood pellets
  - ▶ 1 - 3% ash
  - ▶ 6000 lbs pellets = 120 lbs
  - ▶ Couple of 5 gallon buckets at the end of the flock.
- ▶ Wood chips
  - ▶ Very similar to pellets



### Study results – Winter flock

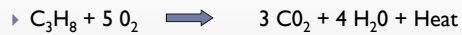
Savings	\$579			\$127
% Savings	62%			16%
Downtime (hours)	20			13
Downtime (incidences)	2			2
Approximate overall heating system efficiency	65 - 70%			60 - 65%



### Other differences...



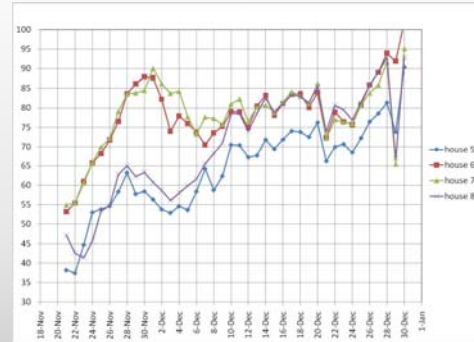
### Burning propane adds moisture to a house



- ▶ Burning one gallon of propane
- ▶ Consumes:
  - ▶ oxygen in 850 ft<sup>3</sup> of air
- ▶ Produces:
  - ▶ 92,000 Btu's/hr of heat
  - ▶ 108 ft<sup>3</sup> of carbon dioxide
  - ▶ 6.8 lbs of water (approximately 0.8 gals)



### Lower relative humidity



### Drier litter – less ammonia



### The other reason is that the fuel is inexpensive



### Cost?

- ▶ Installed \$25,000 - \$30,000
- ▶ Eligible for 25% USDA REAP cost share program
- ▶ Green energy rebates?
- ▶ It must be view as a long term investment!



### Factors to consider with any type of alternative heating system:

- ▶ Must be able to burn multiple types of fuels
  - ▶ Fuels that have little value and are local
- ▶ Considering what these systems cost...what kind of track record does the heating system have?
- ▶ Make sure the system is designed to heat the entire house.
- ▶ Most importantly...



Have you done everything else to reduce your heat demand?

- ▶ Totally enclosed side walls
- ▶ Circulation fans
- ▶ Modern controller
- ▶ Tunnel doors
- ▶ Attic inlets
- ▶ Etc...
- ▶ Alternative heating system is the last thing a producer should consider!

mczarick@engr.uga.edu  
706 542-9041



**The University of Georgia**  
**Cooperative Extension Service**  
College of Agriculture / Athens, Georgia

[www.poultryventilation.com](http://www.poultryventilation.com)

