Estimating Reductions in Energy Consumption During Tobacco Curing as a Result of Improved Tobacco Barn Maintenance

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ABSTRACT

CURING costs can be reduced by effective management and regular maintenance of flue-cured tobacco barns. A survey was implemented to examine flue-cured tobacco barns for their state of maintenance and to interview farmers on their curing techniques, with the objective of identifying possible ways of improving energy efficiency during bulk tobacco curing on the farm. With improved tobacco barn maintenance, survey results indicate possible average savings of $300 per curing season for 70% of the tobacco barns examined. Savings for the flue-cured tobacco belt are projected to be as much as $15 million per year if similar improvements were to be implemented on all bulk tobacco barns.

INTRODUCTION

Curing tobacco is an art as much as it is a science. The biological nature of the leaf makes each crop, even each priming, different from the last in the way that it should be cured. It is this variability that makes curing management so important in preparing tobacco for the market. During 1983, it was estimated that six to seven percent of the total market value of the Georgia flue-cured tobacco crop could be accounted for in curing expenses alone (Georgia Tobacco Research - Extension Report, 1983). Thus, in the face of vigorous international competition, United States tobacco farmers are looking for ways of reducing production expenses.

There are approximately 75,000 flue-cured bulk tobacco barns in operation during the curing season in the various tobacco producing states. All these barns have an air circulation fan powered by electricity and a petroleum or wood fuel source. During the national concern for energy conservation of recent years, attention has been drawn to the possibility of improving the energy efficiency of existing bulk tobacco barns. Using Georgia as an example, the equivalent of 68 million L (liters) of LP-gas may be consumed in one season for heating the air circulated through the tobacco. There are approximately 10,000 bulk tobacco barns in the state. Based upon 1984 costs of $0.21/L this is equivalent to $14.3 million.

The question of how much the agricultural industry could contribute to a nationwide drive on energy conservation was raised during the last "energy crisis". Tobacco curing was identified as a possible area where conservation measures could be implemented, but the extent was unknown. A research project was implemented to estimate the reduction in energy consumption during flue-cured bulk tobacco curing as a result of improved tobacco barn maintenance and curing management. This manuscript describes the procedure and reports the results of the described project. The project was conducted in Georgia, yet the results are extrapolated to give indications of the potential for energy conservation throughout the flue-cured tobacco region.

PROCEDURE

Agricultural engineers on the project invited county extension agents to inquire in their county as to which tobacco farmers would be willing to participate in an examination of their tobacco bulk curing barns and curing management techniques with the understanding that subsequent recommendations by the engineers be implemented on their farm. The involvement of the Extension service was of prime importance for the success of the survey. Then, in the presence of the local county extension agent, three or four engineers visited each participating tobacco farmer and discussed with him curing practices and the condition of his tobacco barns. A visual inspection was also conducted of the farmer's tobacco barns, using an established procedure to ensure consistency among the inspections.

The information gathered from each farm was later entered into a computer for analysis by a special computer program developed and verified at North Carolina State University. (Hunt*, 1982). Following analysis of the on farm information a package of results and recommendations was then mailed to each farmer within a few days of the farm visit. Extension records have been kept for state and national analysis.

A typical procedure began with an on-site interview with the farmer. Some of the items in the interview were as follows. The estimated annual fuel expenses per barn were noted, including electricity costs. The number of

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cures per barn per year and the average weight of tobacco in each cure were determined. The farmer was asked what barn controls were used and specifically whether or not a wet-bulb thermometer was used. The farmer was asked what type of insulation, if any, lay under the pad of the tobacco barn.

While the farmer was being interviewed, the other team members inspected the tobacco barns for brand, model and physical condition. A number of standard barn configurations were already stored in a permanent data file in the computer and were accessible by the computer during execution of the program. If the barns being inspected were of this category, simple barn identification was all that was needed to establish a full set of dimensions for analysis. However, any unusual tobacco barn design had to be correctly measured and the construction materials determined. The presence of any unusual insulation modifications were noted to update the existing stored data. The physical condition of each bulk tobacco barn was evaluated from the outside with respect to surface damage, obstruction of the fan screens, a tightly sealed pad and barn foundation, and tightly sealed door gaskets, walls, corners and roof line. Each barn was considered individually.

Each barn was assigned an exfiltration factor ranging from 1.0 to 1.2. This factor was a multiplier to adjust the amount of heat lost by hot air escaping through leaks in the barn according to the size of the hole (Hunt and Graham, 1984). The estimation of an exfiltration factor was made by one team member being closed inside the tobacco barn, viewing all the light entering the barn through cracks. Then, from the inside, attention was again given to the seal around loading doors, eaves, roof ridge, foundation pad and the furnace room wall. An exfiltration factor of 1.0 was considered a good tight barn and 1.2 a leaky barn.

Next, the farmer was taken on a tour of his own tobacco barns and shown barn maintenance or repair which was needed to improve curing efficiency. Such maintenance items included cleaning screens above the fan, changing the wick on the wet-bulb controller or thermometer, repairing missing or broken door gaskets and repairing external barn damage. If the particle barn was equipped with weights on the return air dampers above the furnace, it was suggested to the farmer that they be removed. Even different types of thermometers and thermal insulation were discussed. Often, the farmer was taken inside the tobacco barn to observe light entering through cracks, suggesting the possible location of hot air leaks during curing.

The data collected during the examination was taken back to the project headquarters on the university campus and entered into the computer. The computer program calculated the approximate cost for insulating each tobacco barn, estimated annual savings in fuel costs and estimated a payback period for a return on financial investment in major repairs and insulation. Estimates of cost savings in petroleum fuel through insulation were based upon the farmer using 13 mm of polyurethane spray foam to insulate the walls, ceilings and doors and 25 mm of polystyrene board insulation on the pad as was found to be a typical example. In some cases insulation of the pad after construction was not recommended because the design of the tobacco barn floor made it difficult to install. A list of recommendations and explanations was combined with the analysis printout and delivered to each participating farmer. Drawings for constructing a homemade wet-bulb thermometer were included where appropriate.

In related studies, on-farm tests were conducted at two different locations to determine actual fuel savings in fuel experienced when tobacco barn maintenance and curing management were implemented under controlled conditions by the agricultural engineers themselves. For example in Colquitt County, Georgia, two 156 rack bulk curing tobacco barns were selected for a comparative test. One of the tobacco barns was insulated using approximately 13 mm of polyurethane foam (R value = 2.4 $m^2 \cdot K/W/cm$) sprayed on the inside of the barn. The other barn, left uninsulated, was used as a check in the experiment. Electricity and petroleum fuel meters were installed on both tobacco barns to record energy use. Both barns were loaded with tobacco having had the same treatments and having been primed from the same field at the same time during the season.

A follow up of the on-farm examination was later conducted to estimate the farmer's reaction to the usefulness of the recommendations to his particular farm (the results have not been published in order to preserve confidentiality). Furthermore, estimates of the effectiveness of conservation measures, extrapolated over the entire tobacco producing region, were calculated.

RESULTS AND DISCUSSION

During 1982-1984, a total of 437 curing barns were inspected on 109 tobacco farms. Energy savings were calculated for each barn inspected based upon thermal conductivity equations for the composite structure of the tobacco barn, considering walls, roof, pad and additional structures in the barn. Estimates of energy savings were calculated based upon costs for materials, labor and fuel appropriate at the date of examination.

The results are listed by county and then for the total number of counties visited (Table 1). Seventy percent of the barns inspected qualified for a complete barn overhaul including the application of full insulation. A complete overhaul included upgrading the barns back to the original structural soundness. For these barns average savings were estimated at $303 in fuel costs per year with our estimated insulation installation cost of $761. On twenty four percent of the remaining barns only a thorough caulking of cracks and an application of insulation to the pad was needed. Average savings for these barns were estimated at $104 per year with an estimated installation cost of $154. The remaining barns in the study (in Clinch, County) were found to be satisfactory. The cost of insulation estimate was based upon the application of polyurethane spray foam at an average cost of $\$5/m^2$ for the walls, roof and doors and polystyrene sheet at an average cost of $\$3.55/m^2$ for the pad.

Taking into account interest on invested capital, the average payback period for those barns recommended to have full insulation and a complete overhaul was slightly more than three years or three tobacco curing seasons. No insulation was recommended for installation if the payback period exceeded five years.

Recommendations to the farmer were made according to the needs of each tobacco barn on his farm. All were identified as to the need for insulation, caulking, door

TABLE 1. ESTIMATED COSTS AND SAVINGS FOR INSULATING BULK CURING BARNS.

County	Number of tobacco barns audited	Average cost pad, $/barn	Average savings pad, $/barn	Average cost complete, $/barn	Average savings complete, $/barn	Average payback, years†
Appling	7	95	107	374	226	2.0
Atkins	27	162	113	814	362	3.2
Bacon	11	160	108	866	392	2.8
Ben Hill	6	132	76	756	212	4.9
Brantley	7	91	103	631	277	3.3
Clinch	10	*	*	*	*	*
Coffee	21	160	68	924	334	3.7
Colquitt	20	130	80	842	323	3.1
Emanuel	22	128	98	558	255	2.8
Evans	60	139	82	734	300	3.1
Irwin	19	136	61	769	251	3.6
Jeff Davis	25	156	120	828	279	3.6
Laurens	15	171	130	824	356	2.8
Long	12	92	109	618	279	2.8
Montgomery	8	135	113	865	304	3.4
Tattnall	41	138	74	620	275	2.9
Tift	13	137	78	761	251	3.9
Ware	57	203	123	823	302	3.7
Wheeler	18	160	113	832	355	3.0
Worth	38	170	119	838	320	3.3
TOTAL	437	154	104	761	303	3.2

*These barns had a curing efficiency such that the savings incurred by added insulation would not justify its cost.
†The average payback is only computed for those barns where insulation of both pad and superstructure was recommended in the county.

gaskets, external repairs and any other specific needs. Special note was made of the seal between the tobacco barn foundation and the pad. An asphalt type sealant was recommended to reduce air leaks around the base of the barn. Recommendations were also made for an annual overhaul of the fuel burners. Where a farmer was not using a wet-bulb thermometer or controller it was recommended that he do so. Tobacco curing is dependent not only upon the dry-bulb temperature but also upon the humidity in the barn at different stages of the cure. Design drawings were made available for a home built wet-bulb thermometer and also an alternate hinge which allows the doors of a particular manufacturer's tobacco barn to swing open to protect the door gaskets from damage during loading. A curing guide was also given to the farmer to assist in choosing the correct temperature settings at different stages of the cure.

Considering the on-farm fuel trials conducted in Colquitt County, Georgia, 965 liters of LP-gas were saved by using an insulated barn over five cures. This amounts to approximately $200. Energy savings calculated for inspected barns were based on a season of six cures.

Extrapolating the acquired results on a statewide and then on a national basis, we calculate the following energy savings per year. If 70 percent of the total 10,000 tobacco barns in the state of Georgia were fully insulated and overhauled, to the specifications noted earlier, approximately $2 million could be saved per year in petroleum fuel for the state, a savings of 14 percent of the estimated annual petroleum fuel consumption for tobacco curing. Similar projections over the total estimated 75,000 flue-cured tobacco barns indicate a nationwide savings of $15 million per year.

SUMMARY AND CONCLUSIONS

Research has been conducted to estimate the potential reduction in energy consumption during flue-cured bulk tobacco curing as a result of improved tobacco barn maintenance and curing management. Tobacco farmers have been visited in Georgia to establish criteria for calculating possible energy savings on a barn, state and a national basis.

Results based upon the 437 curing barns inspected on 109 tobacco farms in 20 Georgia counties indicate that approximately $300 of fuel per barn could be saved per season on 70% of those barns inspected. Extrapolated to a state wide basis, this amounts to over $2 million per year in Georgia alone or $15 million per year for the flue-cured tobacco belt as a whole.

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