

# *Exhaust Air Heat Recovery System Assessment*

*49<sup>th</sup> Tobacco Workers' Conference*  
*Grant Ellington, Justin Macialek, Kyle Bostian*

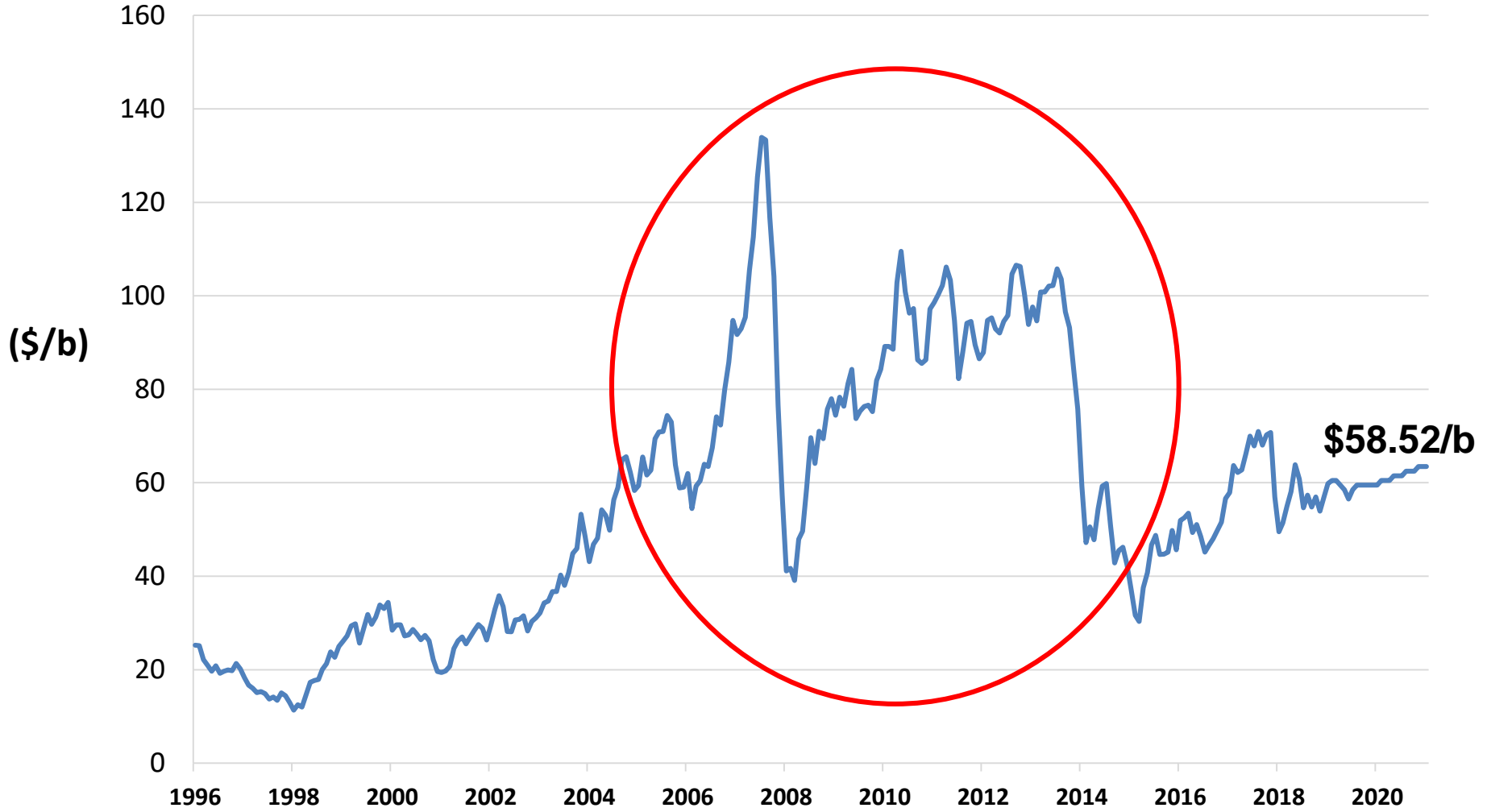


**“We Bring  
Engineering  
to Life”**



# Monthly Cushing, Oklahoma West Texas Intermediate (WTI) Spot Price FOB

(Dollars per barrel)

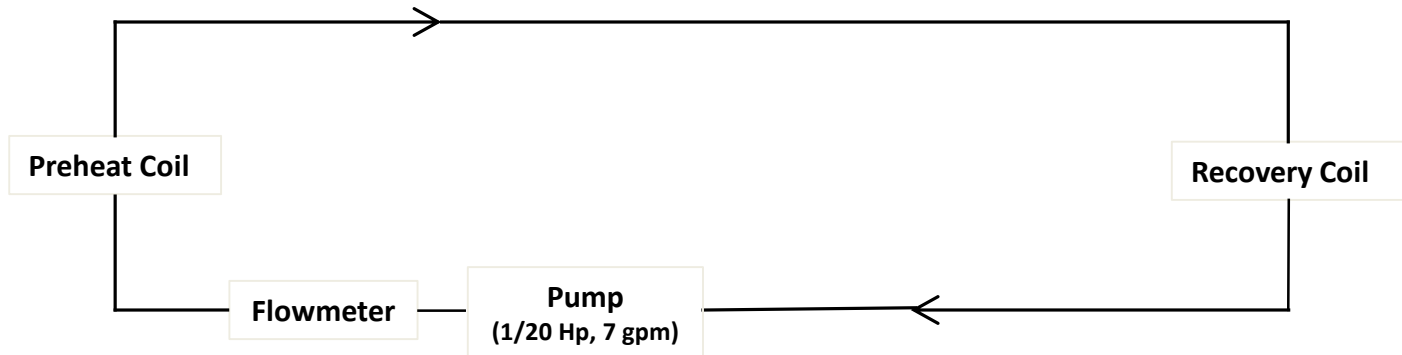
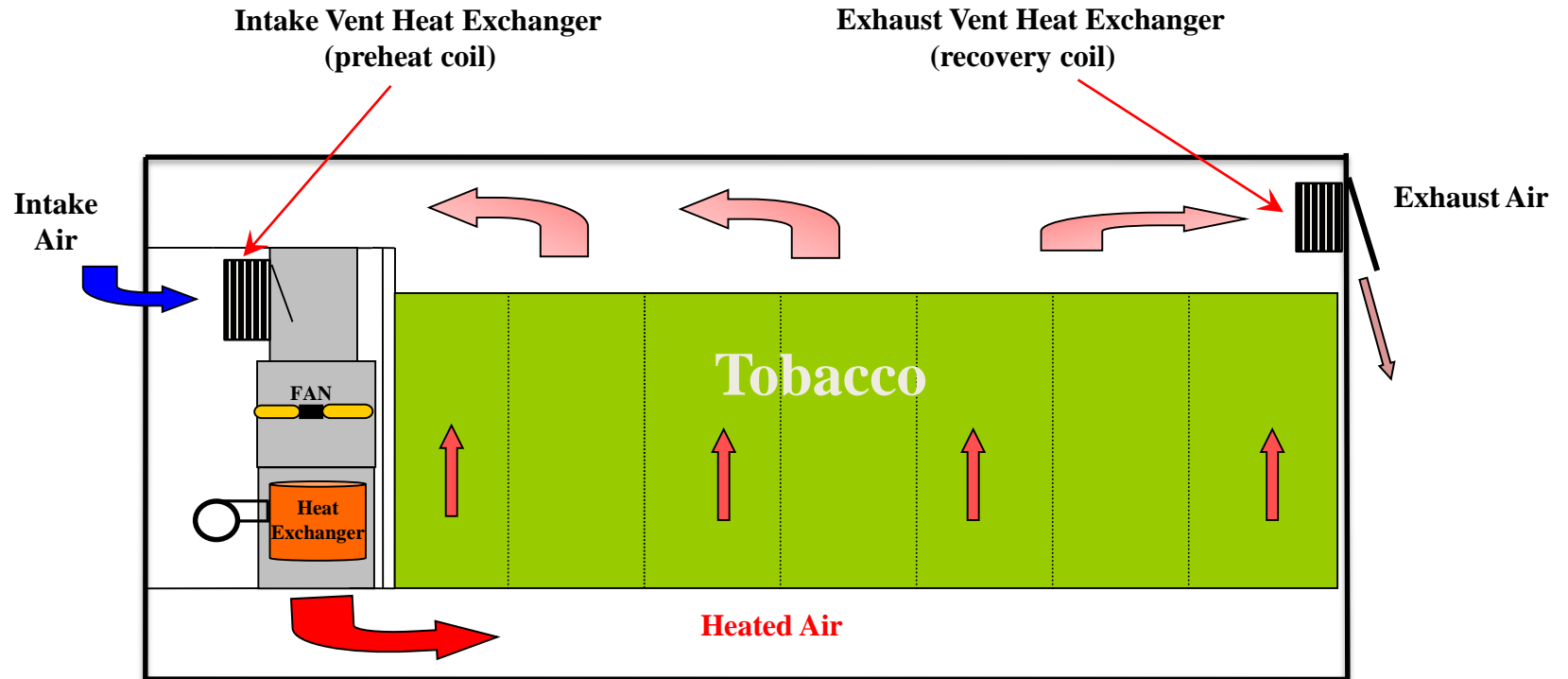


Source: U.S. Energy Information Administration

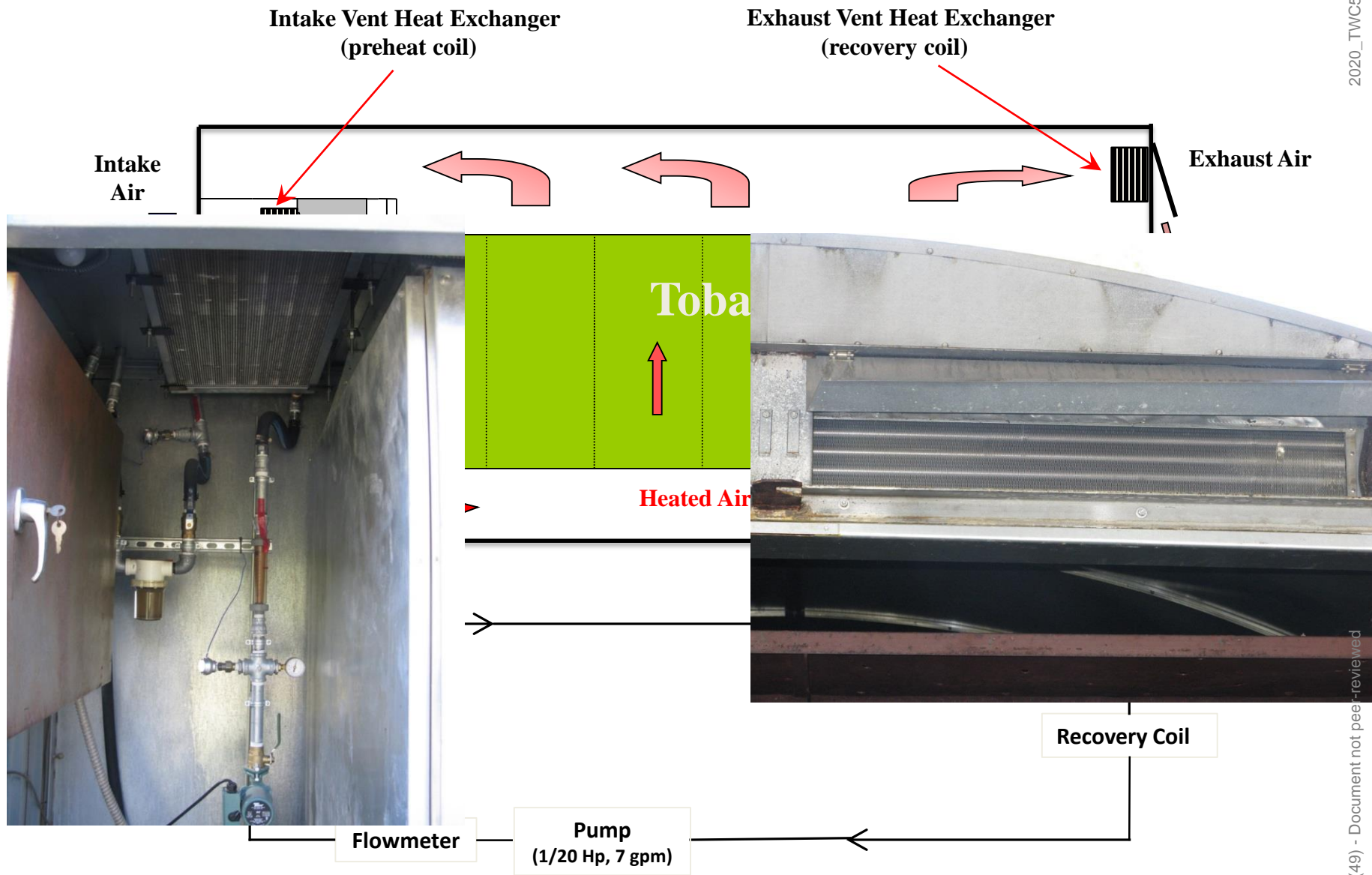
# Exhaust Air Heat Recovery System

- Significant amounts of energy can be recovered from a barn exhaust air stream
  - *Strategy was evaluated with curing tobacco in the 1980s*
- Performance information collected on initial system in 2014 (Johnston County)
  - *DeCloet, 20% (52 gal) averaged over the season – 10 cures*
- Systems added in Wilson, Nash, Edgecombe, Pamlico, Vance, Sampson, Guilford, Surry, and Dinwiddie VA.
- Multiple barn manufacturers, varying age
  - *Taylor (8 & 10-box), Long (8 & 10-box), DeCloet (13-box), Tytun (18-box), Powell (9-box), World (10-box), Long (126-rack)*
- Commercially available components used and can be installed on any make barn
- Main objective to collect system performance information
  - *Fuel consumption and kWh usage (initially)*
  - *Pump flowrate, heat exchanger (coil) inlet and exit temperatures*
  - *Green and cured leaf weights*
  - *Cure duration*
  - *Grower feedback on cured leaf quality differences*

# Heat Recovery System Schematic



# Heat Recovery System Schematic



# Sampson County, 10-box Taylor

*2014 Taylor*

*Late 90s Taylor*



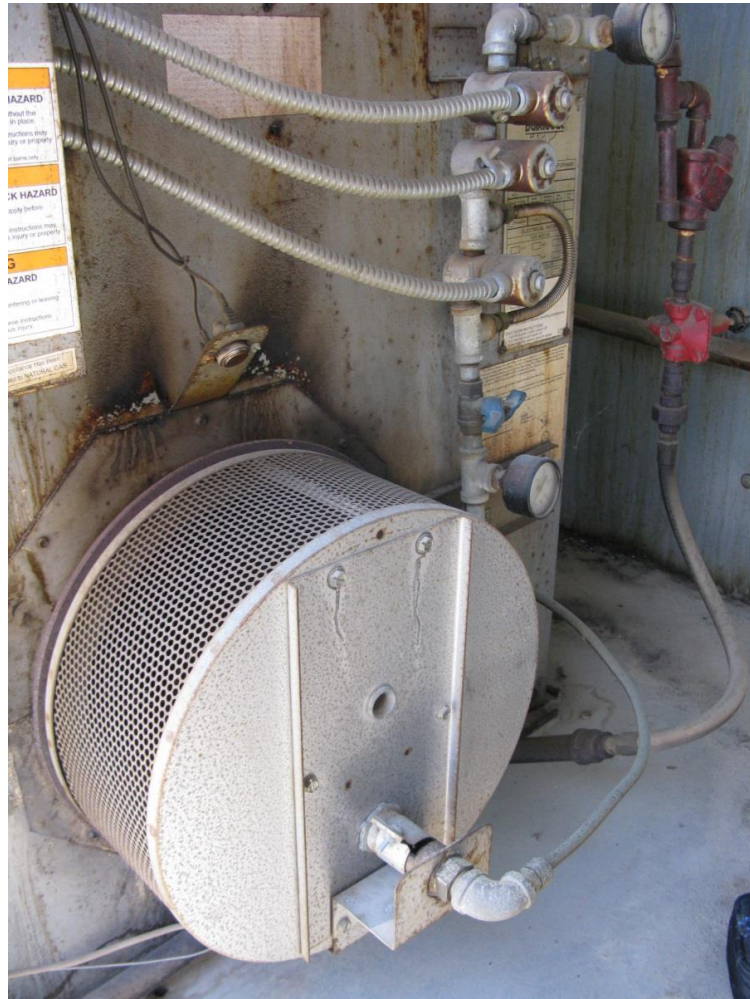


# Dinwiddie County VA, 18-box Tytun



# Vance County, 8-box Long

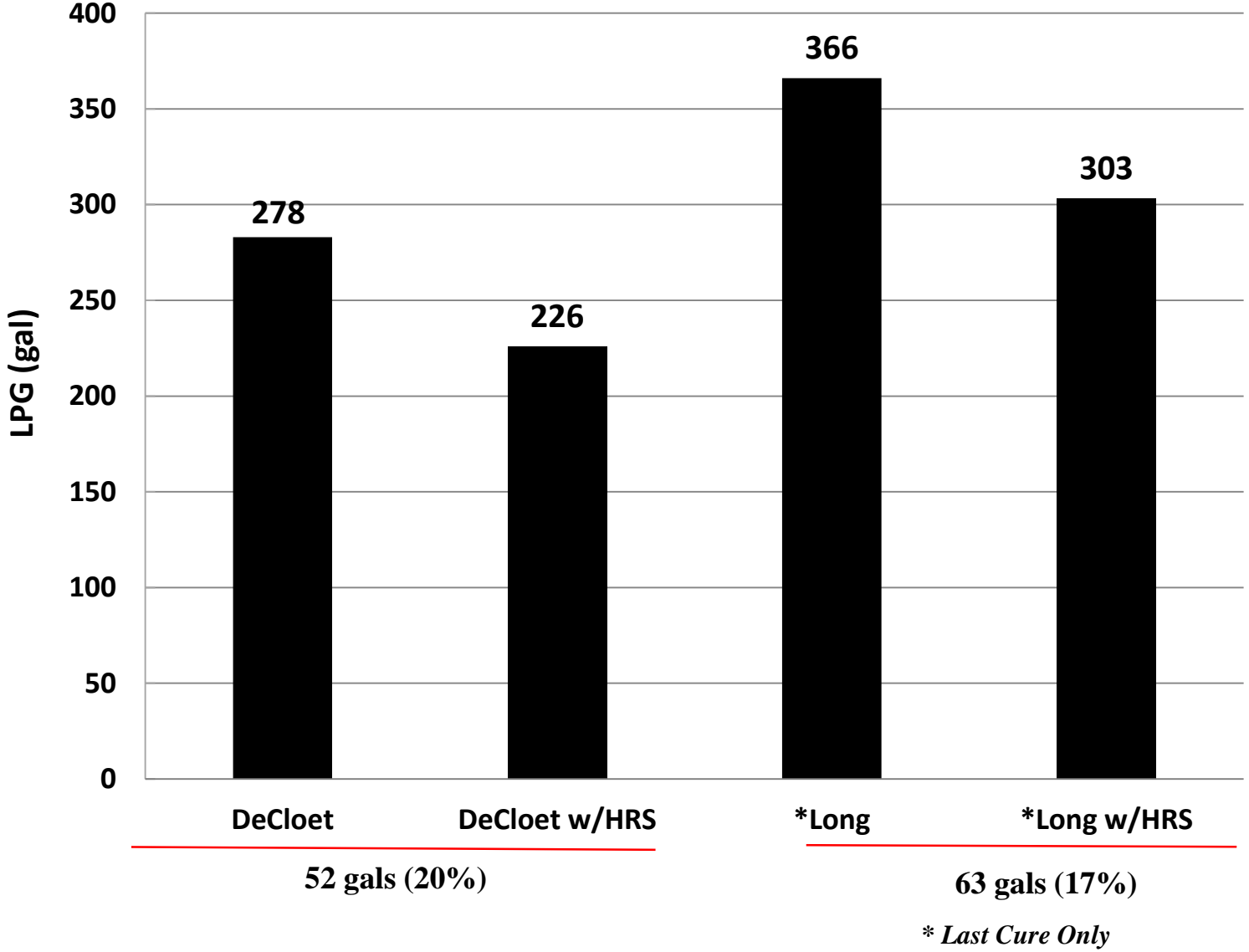
Heat Exchanger Housing





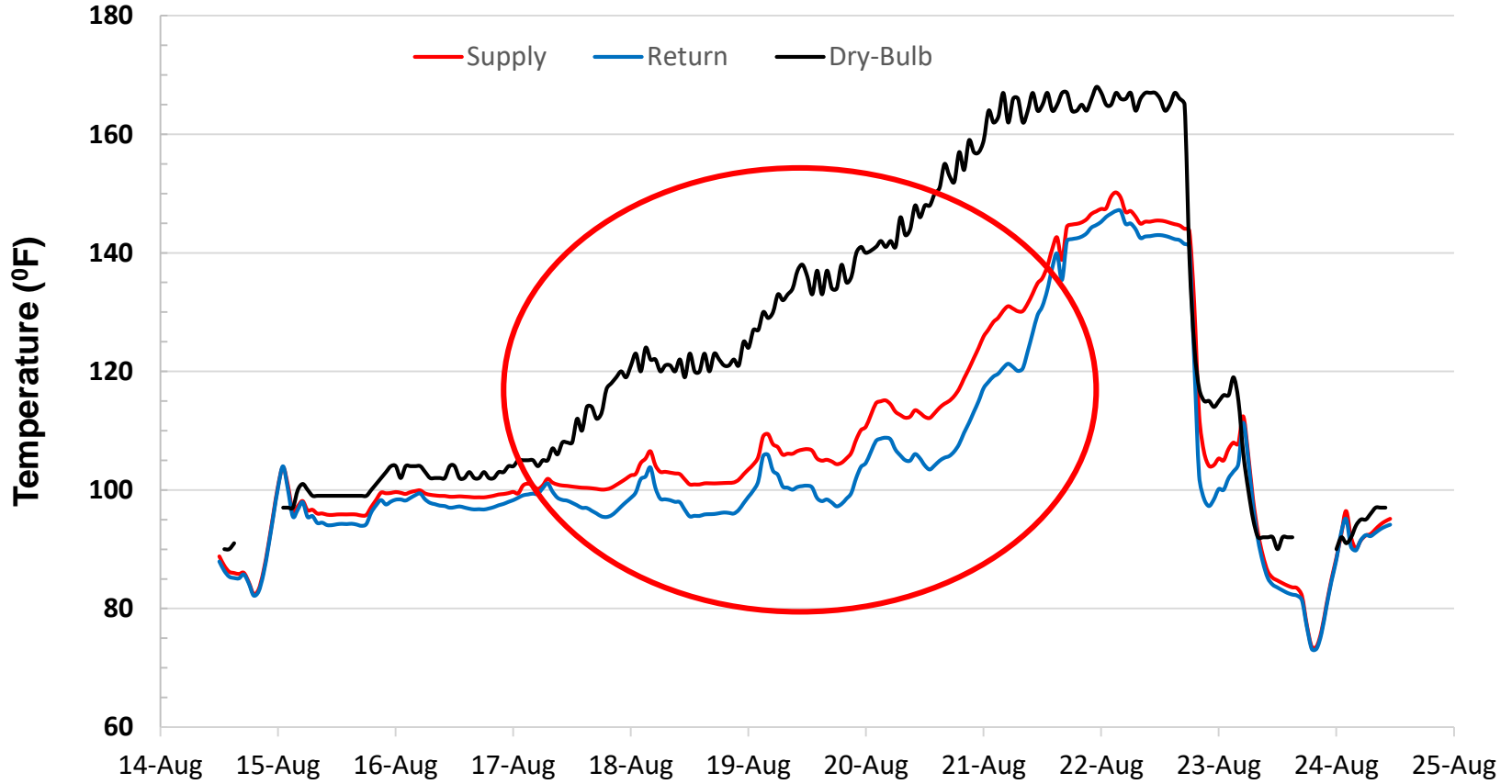
# Heat Recovery System Average Fuel Savings – 2014

(DeCloet Barns – 10 Cures; Long Barns – 1 Cure)



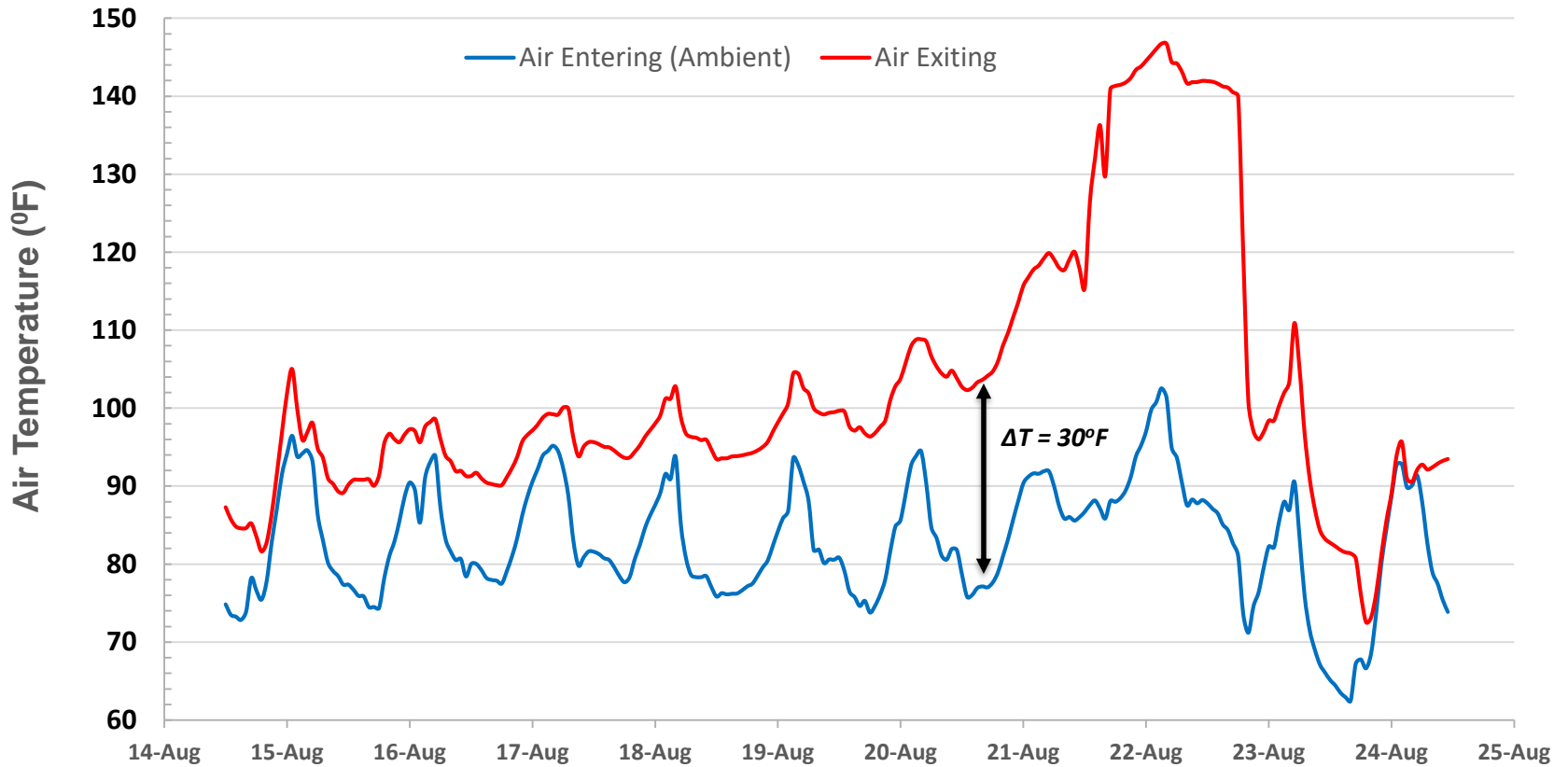
# Preheat Coil Water Temperature Profiles

(Wilson County, Cure 5 – 2018)



# Preheat Coil Air Temperature Profiles

(Wilson County, Cure 5 – 2018)



## 2018 System Performance Summary

Location	Barn Make	Cures	Avg. Savings (gal)	% Savings
Wilson	Long 10-box	7	46.6	15.9
Dinwiddie, VA	Tytun 18-box	6	47.8	12.9
Sampson	Taylor (new) 10-box	6	29.1	9.6
Sampson	Taylor (older) 10-box	4	21.1	5.8
Pamlico	Powell 9-box	4	-7.3	-2.4
Vance*	Long 8-box	4	26.1	8.3
Edgecombe	Taylor 8-box	5	6.4	2.3

\* Natural gas (Therms)



# 2019 System Performance Summary

Location	Barn Make	Cures	Avg. Savings (gal)	% Savings
Wilson	Long 10-box	4	37	12.7
Dinwiddie, VA	Tytun 18-box	2	46	14.3
Sampson	Taylor (new) 10-box	6	20	6.52
Sampson	Taylor (old) 10-box	2	30	8.7
†Guilford	Long (rack barn)	6	12	9.0
*Vance	Long 8-box	2	16	5.19
Edgecombe	Taylor 8-box	3	15	6.3

\* Natural gas (Therms)

† Fuel Oil

## World Box Barn Application Drying Sweet Potatoes

Drying Cycles	Barn	Total Therms	Avg. Savings (therms)	(%) Savings
33 (11/7/18 - 6/24/19)	Heat Recovery	3363	37	22.4
33 (11/7/18 - 6/24/19)	Control	4287		
<b>Total Difference</b>		<b>924</b>		

## System Performance Summary, 2016 – 2019

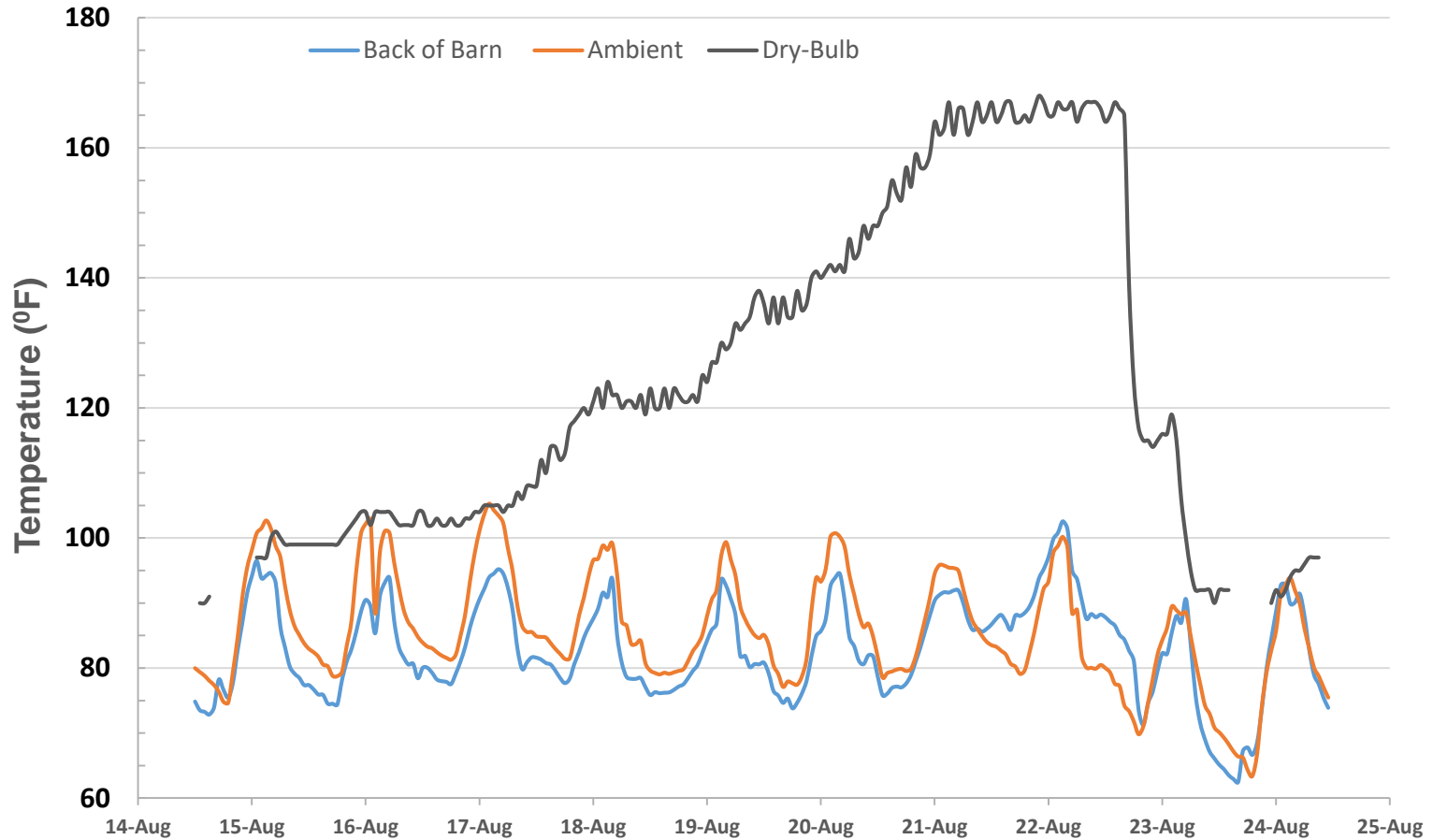
Location	Barn Type	Cures	(gal)	(%)
Wilson	Long, 10-box	27	43	14.5
Sampson	Taylor, 10-box (90s)	15	21	5.8
Sampson	Taylor, 10-box (New)	23	27	8.9
Dinwiddie, VA	Tytun, 18-box	18	51	13.3

*Why is the system performance not similar at all locations?*

# Intake and Exhaust Coil Size Comparison

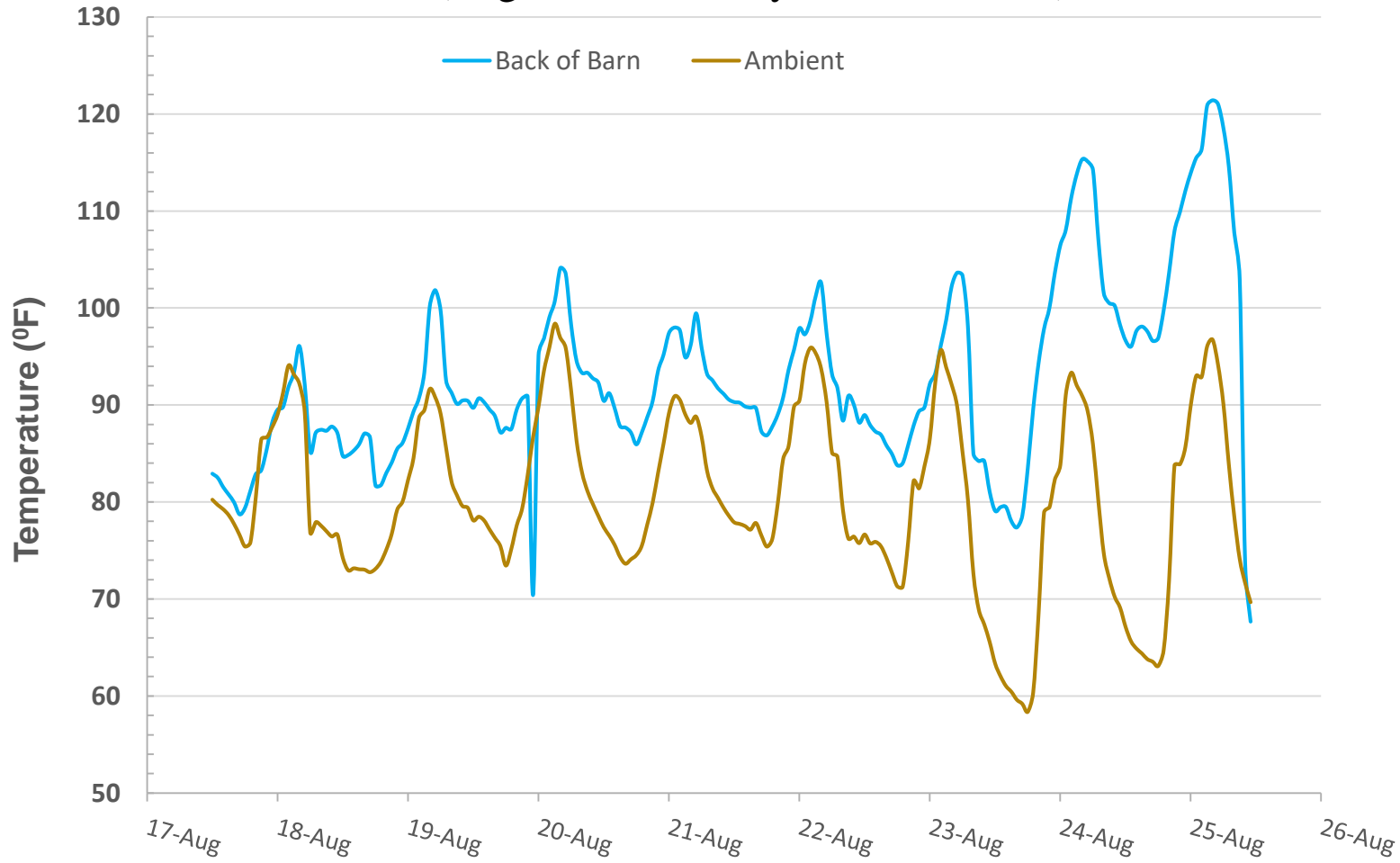
Location	Barn Make	Intake Coil		Exhaust Coil	
		Finned Area (in <sup>2</sup> )	Fin Density (fins/in)	Finned Area (in <sup>2</sup> )	Fin Density (fins/in)
Wilson	Long	630	14	646	14
Dinwiddie, VA	Tytun	720	14	680	14
Sampson	Taylor (new)	468	14	901	14
Sampson	Taylor (older)	630	14	646	14
Pamlico	Powell	400	10	901	14
Vance	Long	720	14	680	14
Nash	World	938	14	1060	14
Guilford	Long (rack)	828	10	901	10
Edgecombe	Taylor	720	14	680	14

# Intake Air and Ambient Temperature Profiles (Wilson County, Cure 5 – 2018)





# Intake Air and Ambient Temperature Profiles (Edgecombe County, Cure 4 – 2018)



## System Cost – 2014 thru 2017

Item	Cost (\$)
Recovery coil	510
Preheat coil	554
Pump	85
Plumbing	655
Labor	300*
<b>Total</b>	<b>\$2,104</b>

*\*25 man hours @ \$12 per hour*

***2019 System Cost, \$3,000 – \$3,500!***

# Heat Recovery System Summary

- Season average fuel savings varied zero to 16% per cure across all locations
- Multiple factors contribute to differences in fuel savings measured
  - *Barn design limits preheat coil size and installation options*
  - *Variations in temperature differences between incoming air temperature and preheat coil water temperature*
  - *May restrict airflow excessively, especially on lower-stalk cures and barns with centrifugal fans, resulting in darker cured leaf*
- Limited differences, if any, in the cured leaf quality and cure duration with barns with tube-axial fans
  - *Curing management modified at some locations, especially lower-stalk tobacco*
- 2019 system cost approximately \$2,800 installed
- Simple payback period for the best fuel savings measured (45 gal/cure, \*\$432 / season) is 6+ years at current infrastructure and fuel costs
  - \*(\$1.20/gal, 8 cures per season)

# Acknowledgements

- Vick Family Farms, Wilson County
- R&R Farms, Dinwiddie County, VA
- Drake Farm, Edgecombe County
- Clapp Farms, Guilford County
- Whitford Farms, Pamlico County
- Stainback Farms, Vance County
- Lake Wendell Farming, Johnston County
- Warren Farming Partnership, Sampson County
- N.C. Tobacco Research Commission
- R.J. Reynolds Tobacco Company
- Japan Tobacco International
- Universal Leaf North America
- Alliance One International