

# Electric and Thermal Energy Consumption in Commercial Swine Facilities

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# WCROC Renewable Energy

- Modern production ag relies heavily on fossil-fuels
  - Electricity, propane, natural gas, diesel, gasoline
- **Consumers are demanding products with less environmental impacts**

## Goals of WCROC RE Program:

- Increase utilization of renewable energy in production agriculture
- Research and demonstrate large/small scale systems
  - Are these systems feasible, applicable, and economical for producers?
  - Share our findings



# Greening of Ag Initiative

- Goal is to reduce fossil-fuel consumption in ag production systems:
  - Renewable energy generation
  - Energy conservation
  - Energy optimization
- Perform research to develop results for producers to use as a guide
- Three focus areas:
  - Crop production
  - Dairy production
  - **Swine production**
- Funded through Xcel Energy's Renewable Development Fund, the Legislative-Citizen Commission on Minnesota Resources (LCCMR)



# Modern Pork Production Systems

- Pork production systems have changed dramatically
- Most farms were farrow to finish, now specialize for each life cycle stage:
  - Breed-to-wean
    - Bred/lactating sows and piglets from farrow to weaning (~12#)
  - Nursery
    - Pigs from weaning (~12#) to feeder weight (~50#)
  - Finishing
    - Feeder pigs from ~50# to market weight (~280#)
- Each type of unit has differing environmental requirements
  - Differing uses of electricity
  - Differing amounts of fuel



# Commercial Swine Barn Energy Monitoring

- First study of its kind to monitor **specific** electric loads
- Unique in that it parcels out usage past the utility meter
- Baseline data collection and analysis
  - Electricity
  - Fuel (propane and natural gas)
  - Pig production
  
- Big questions:
  - Where is energy being used in commercial swine production units?
    - What areas of energy use have potential to be reduced?
  - How much electric and thermal energy goes into producing one pig?

# Commercial Swine Barn Energy Monitoring

- Six units within an hour of Morris, MN
- Production units representative of Midwest pork production systems:
  - Two breed-to-wean barns
  - Two nursery barns
  - Two finishing barns



- Where is electric energy being used within these units?

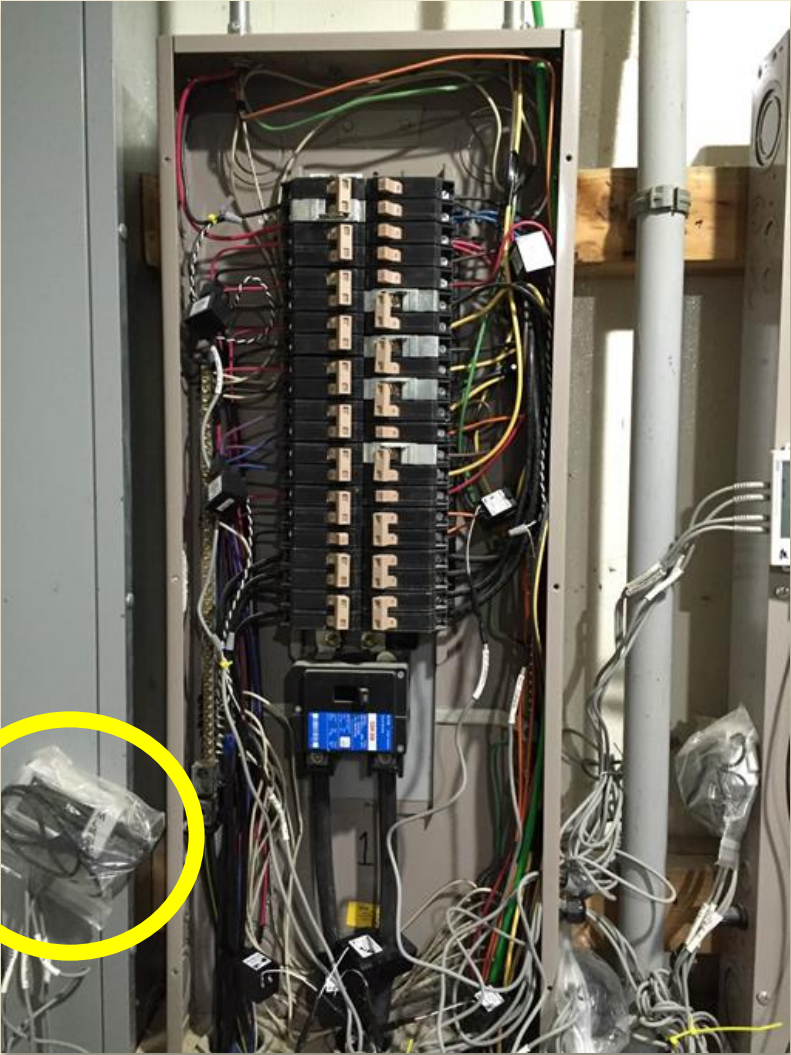
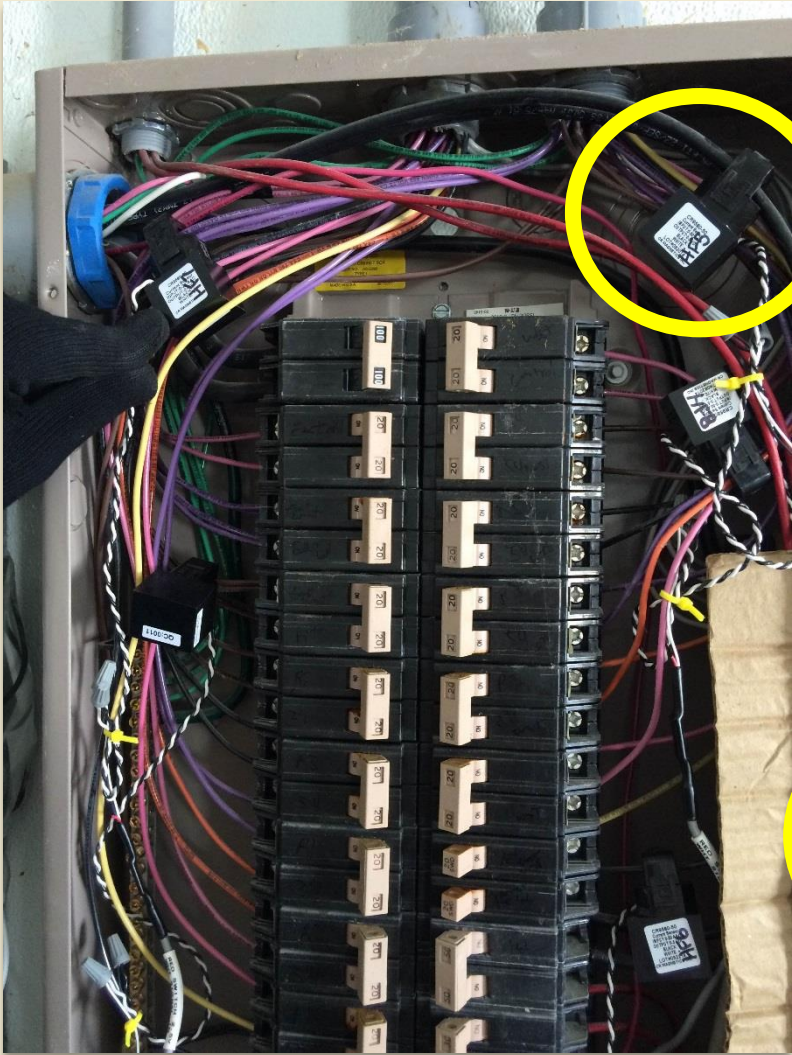
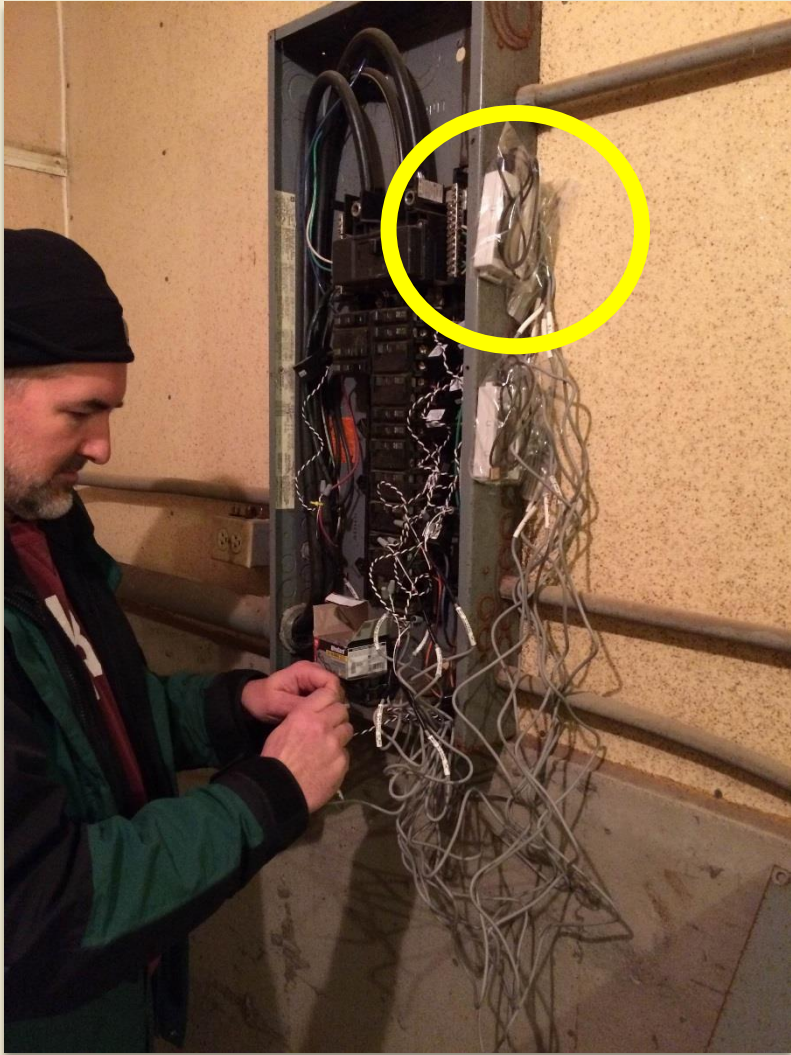


# Electrical usage data collection

- Collect electric use of specific loads
  - Ex. pit fans, vent fans, heat lamps, pressure washers, lights, heaters, feedline augers, etc.
- Data loggers and sensors
  - Record and store electrical use
  - Data collected from each barn on a monthly basis



# Data Loggers and Sensors





# Thermal (fuel) usage data collection

- Propane tank fills collected from producer
- Natural gas usage collected from NG utility



# Breed-to-Wean Results

- Breed-to-Wean Barn A

- ~2,500 sows
- Average 58,420 weaned pigs produced per year
- South Gestation unit curtain-sided
- North Gestation, farrowing rooms power-ventilated

- Electrical use (2015-2016)

- Average use 62,000 kWh/month
- **Average of 11.32 kWh per weaned pig**

- Breed-to-Wean Barn B

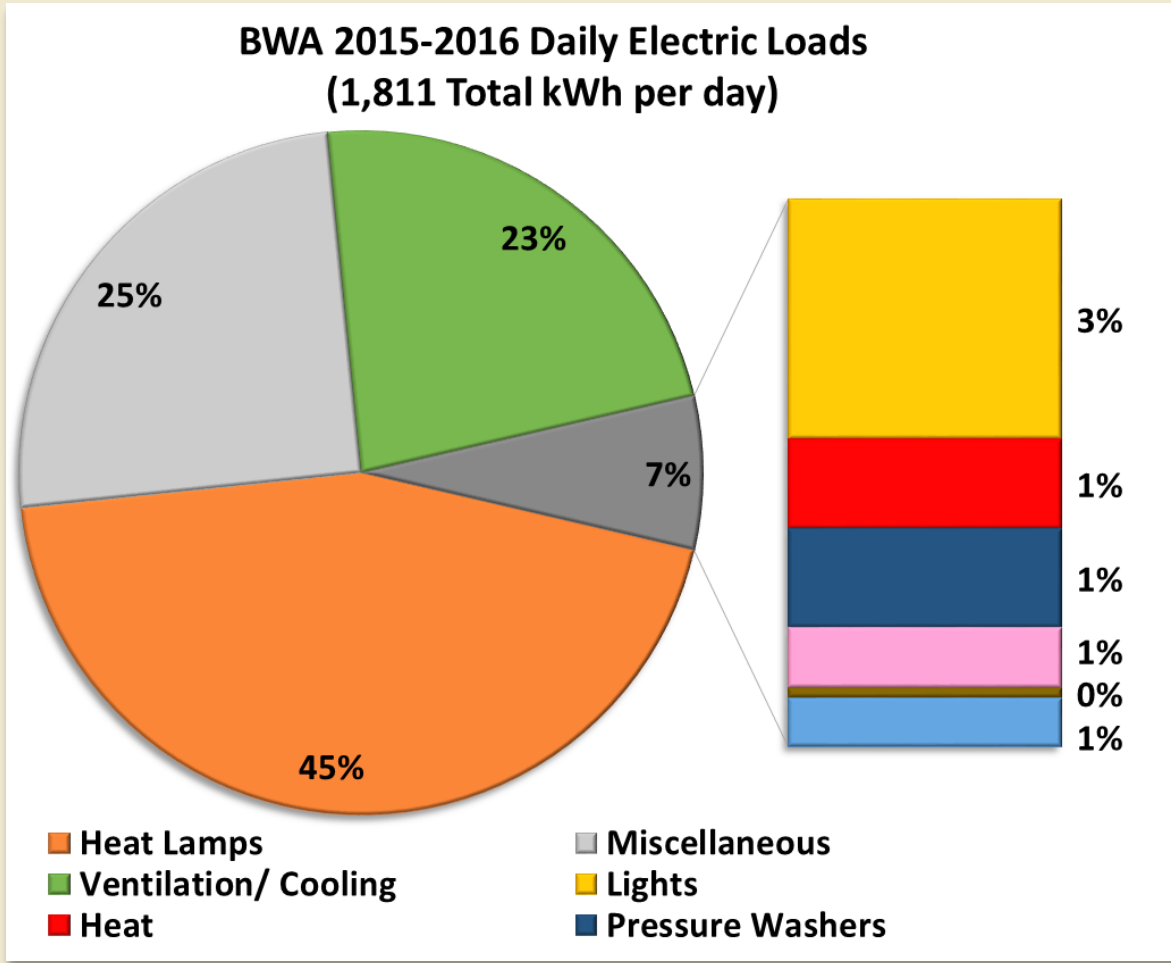
- ~3,300 sows
- Average 87,670 weaned pigs produced per year
- Gestation unit cross-ventilated
- Farrowing rooms power-ventilated

- Electrical use (2015-2016)

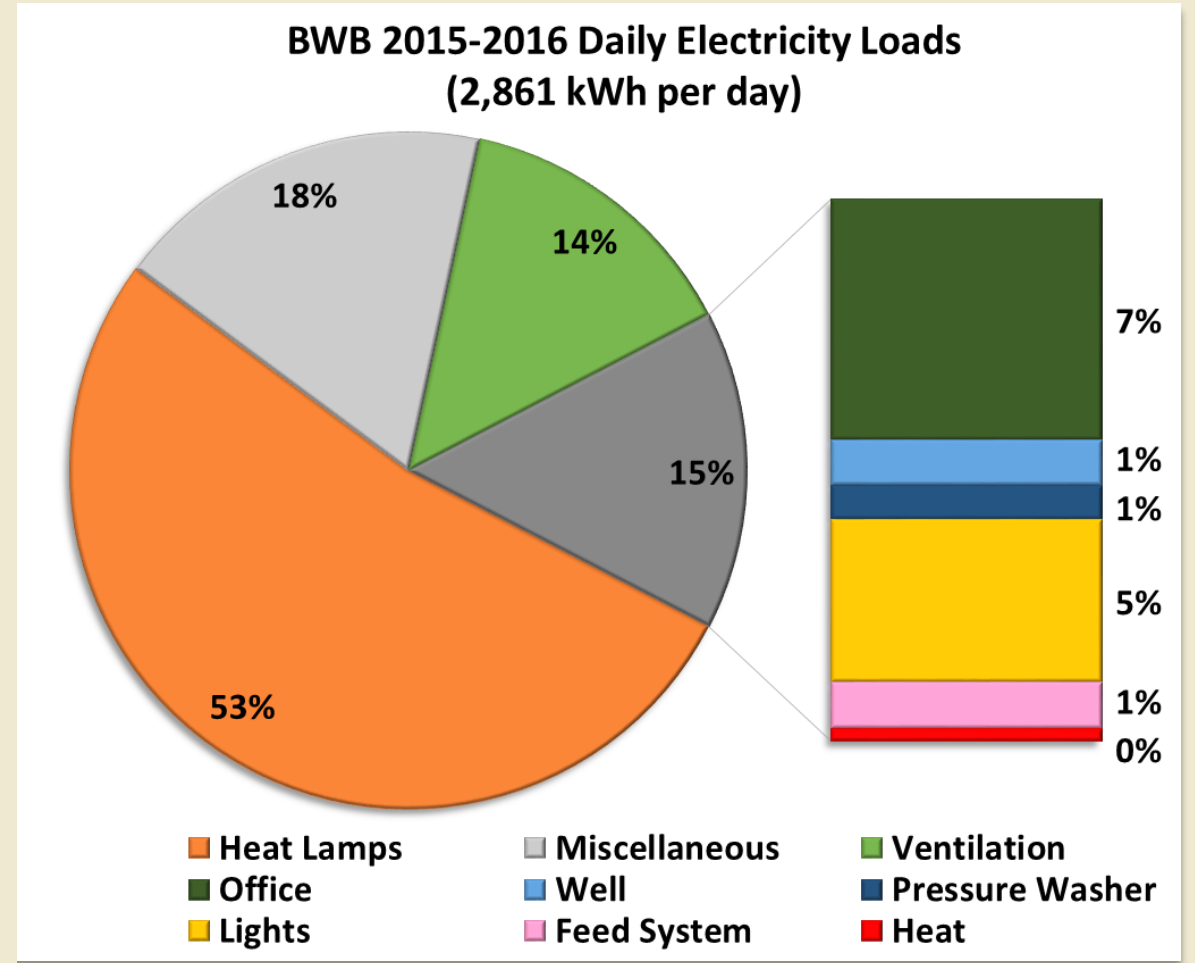
- Average use 97,700 kWh/month
- **Average of 11.92 kWh per weaned pig**

# Breed-to-Wean Results

## Breed-to-Wean Barn A

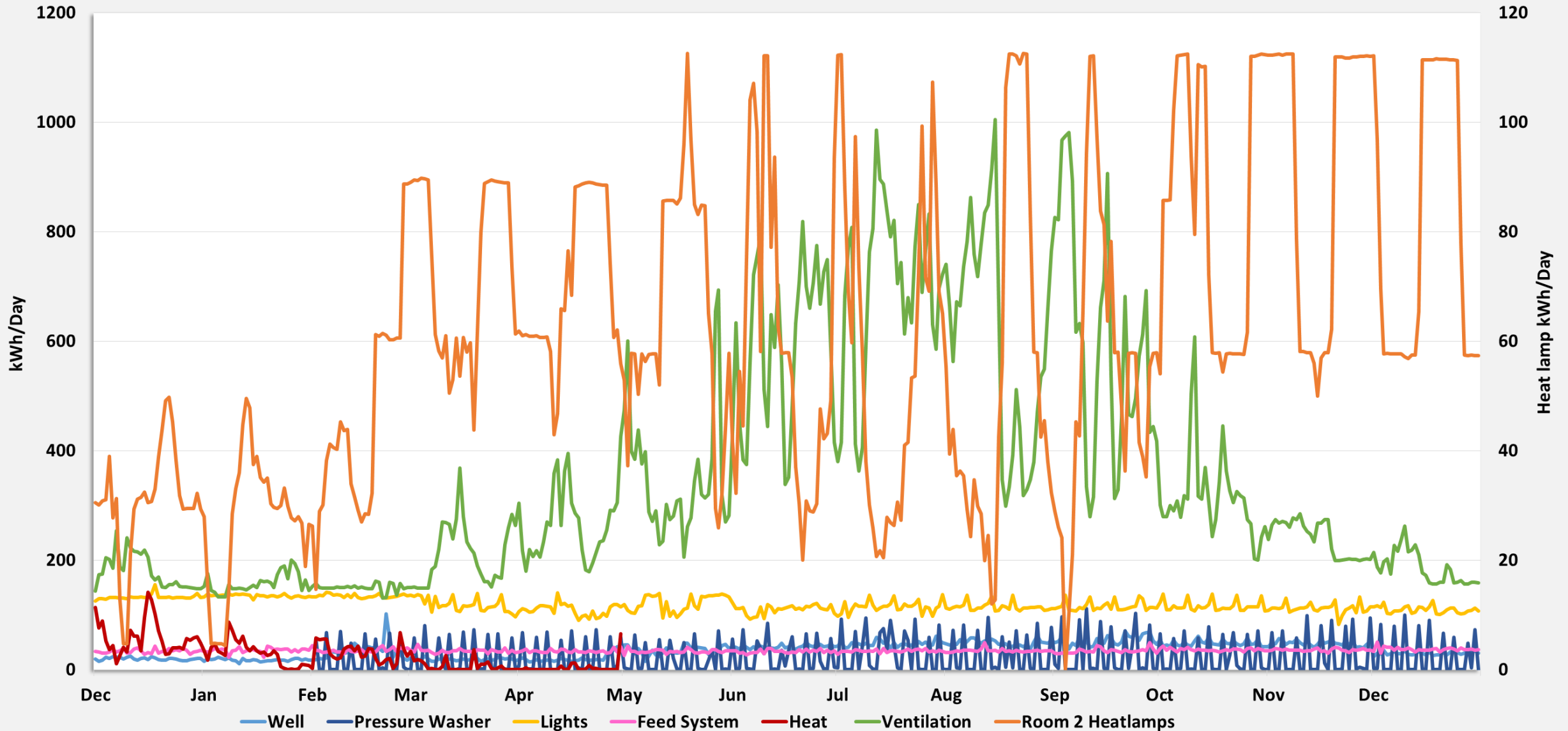


## Breed-to-Wean Barn B



# Breed-to-Wean Barn B Electricity

Breed-to-Wean Barn B Daily Electricity Use December 2014-December 2015



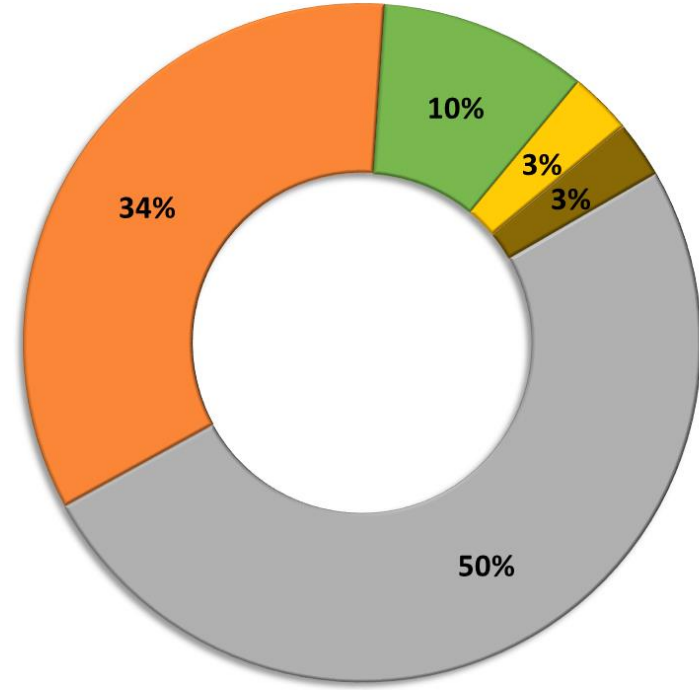
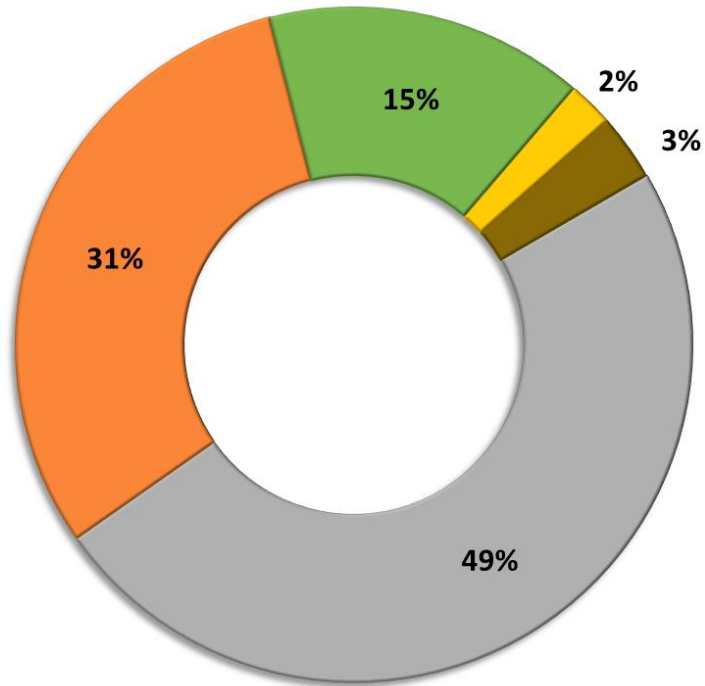
# Breed-to-Wean Results

## Breed-to-Wean Barn A

## Breed-to-Wean Barn B

BWA Yearly Average Total Energy Use (3,285 MMBtu)

BWB Yearly Average Total Energy Use (4,916 MMBtu)



■ Heating Fuel ■ Heat Lamps ■ Ventilation ■ Lights ■ Misc.

■ Propane ■ Heat Lamps ■ Ventilation ■ Lights ■ Misc.



# Nursery Results

## •Nursery Barn A

- ~3,000 head
- Average 19,100 feeder pigs produced per year
- Nursery rooms power-ventilated

## •Electrical use (2015-2016)

- Average use 3,900 kWh/month
- **Average of 2.38 kWh per feeder pig**

## •Nursery Barn B

- ~12,000 head
- Average 71,650 feeder pigs produced per year
- Nursery rooms power-ventilated

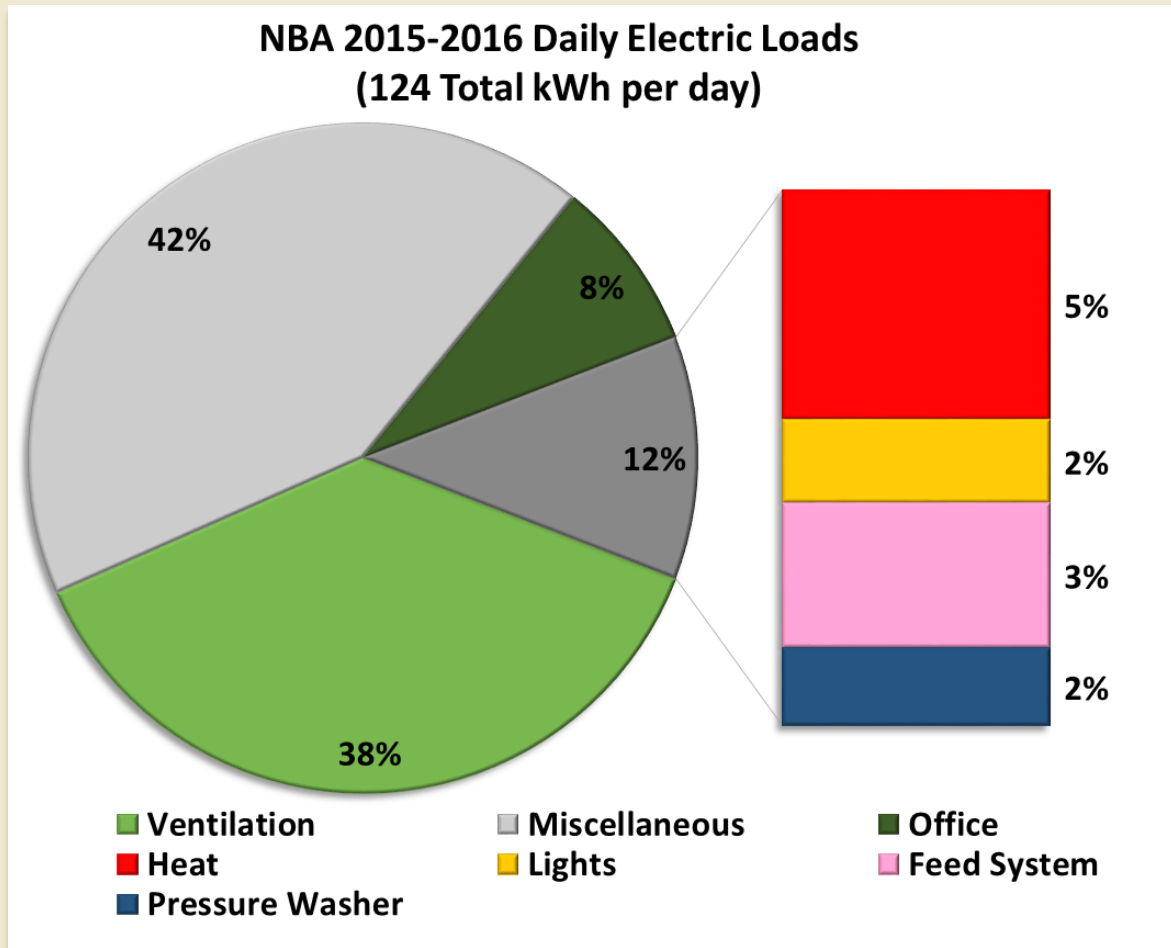
## •Electrical use (2015-2016)

- Average use 12,650 kWh/month
- **Average of 2.10 kWh per feeder pig**

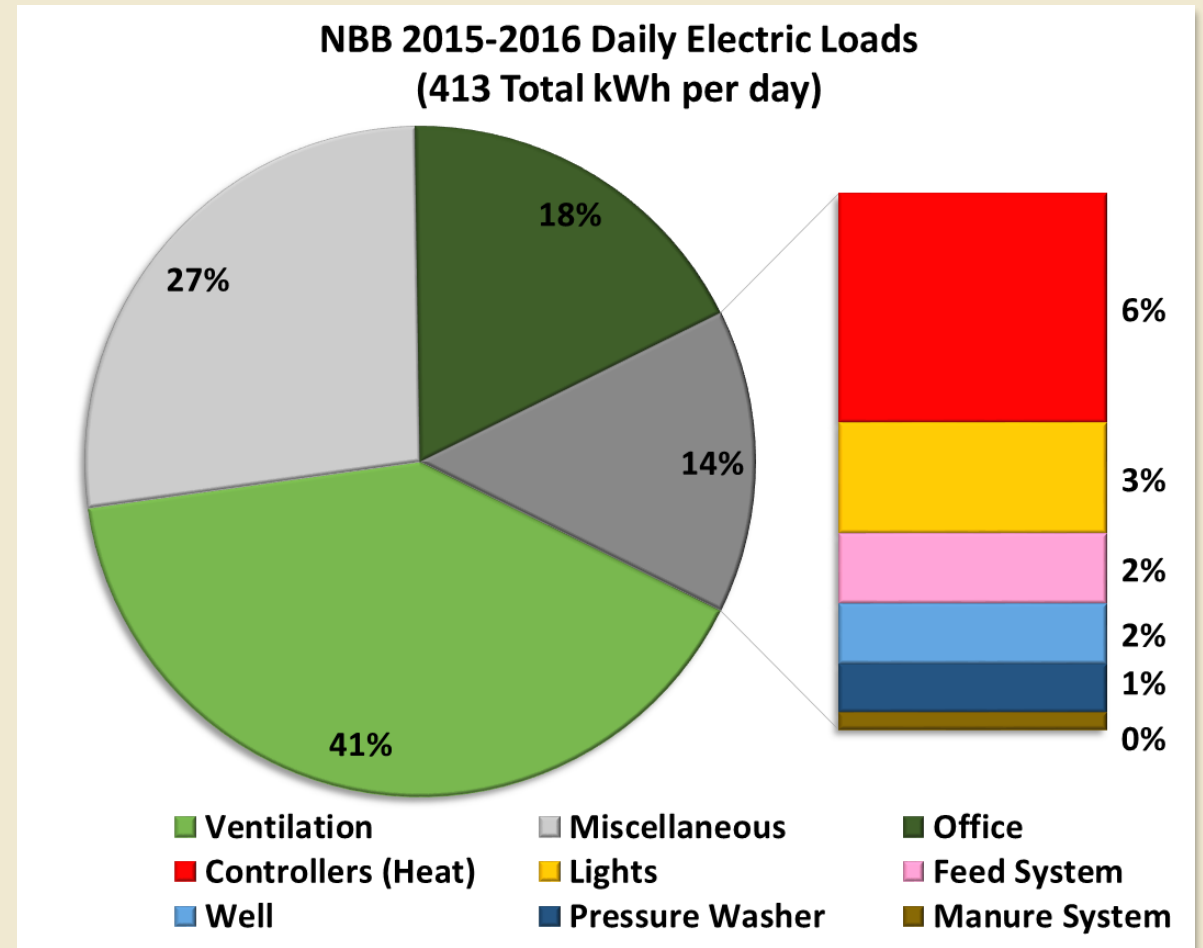


# Nursery Results Cont'd

## Nursery Barn A

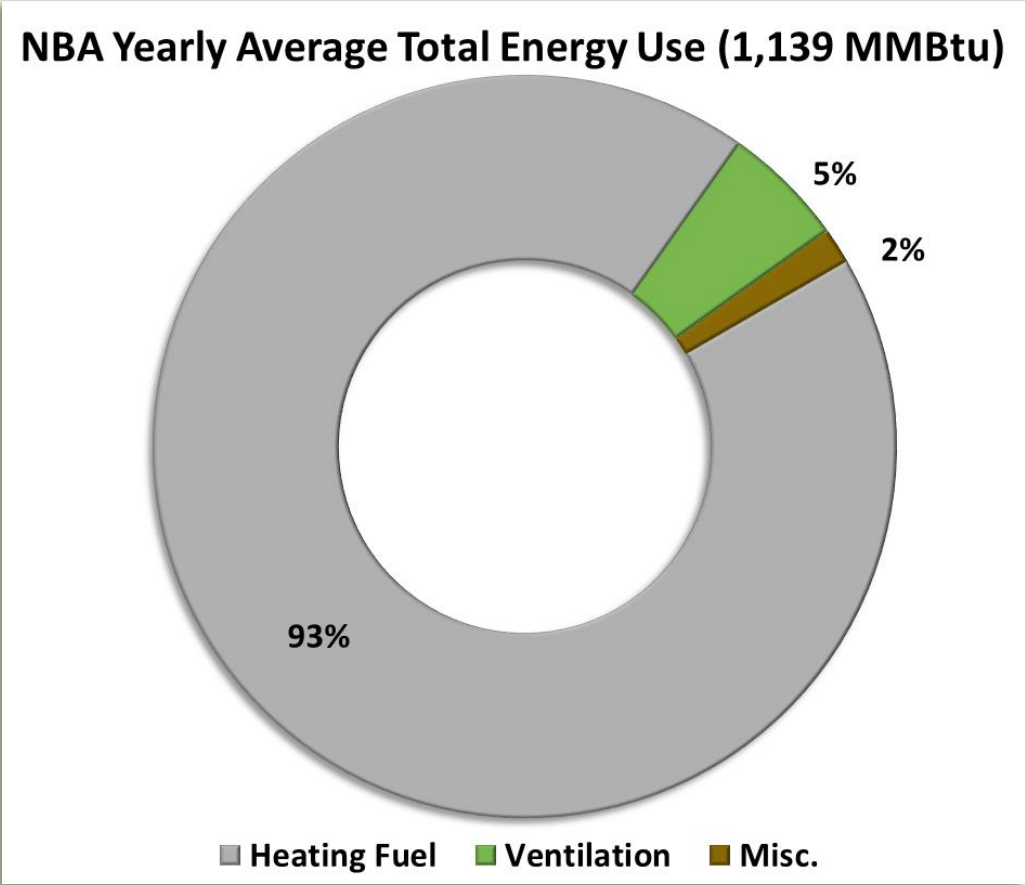


## Nursery Barn B

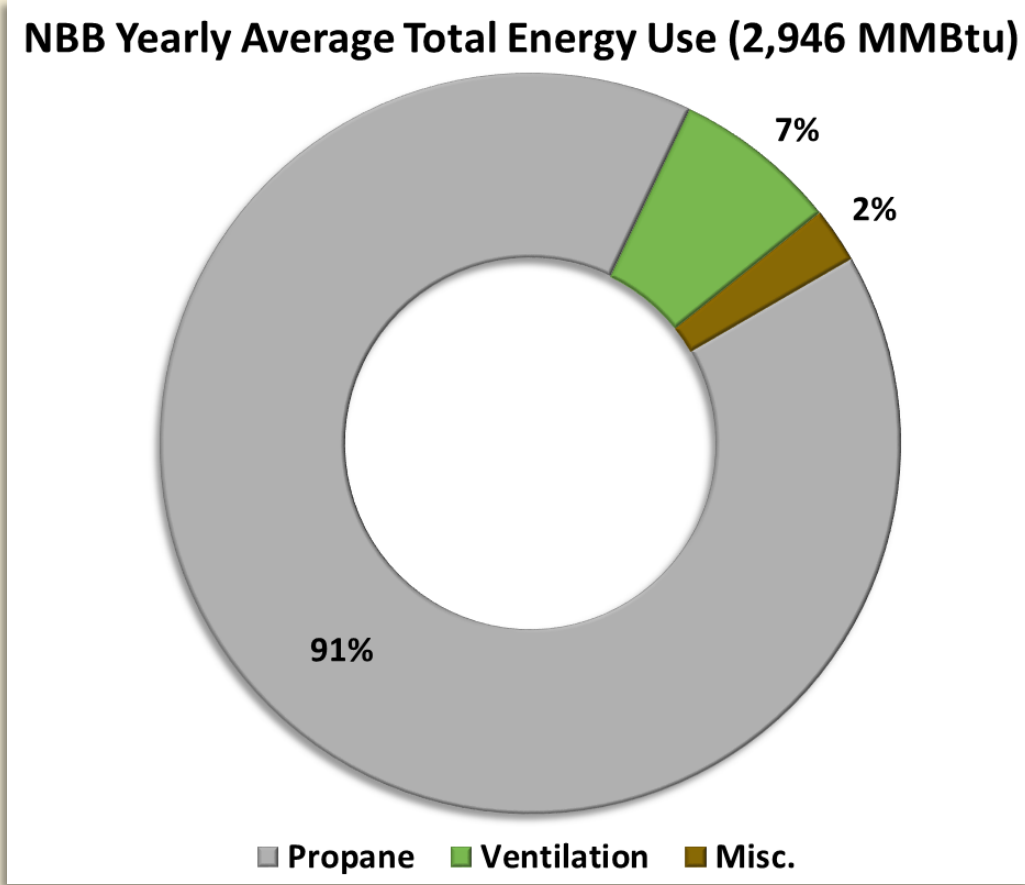


# Nursery Results Cont'd

## Nursery Barn A



## Nursery Barn B





# Finishing Results

- Finishing Barn A

- ~2,400 head
- Average 6,300 market hogs produced per year
- Rooms are tunnel-ventilated

- Electrical use (2015-2016)

- Average use 7,300 kWh/month
- **Average of 14.48 kWh per finished pig**

- Finishing Barn B

- ~1,060 head
- Average 2,800 market hogs produced per year
- Rooms are curtain-sided

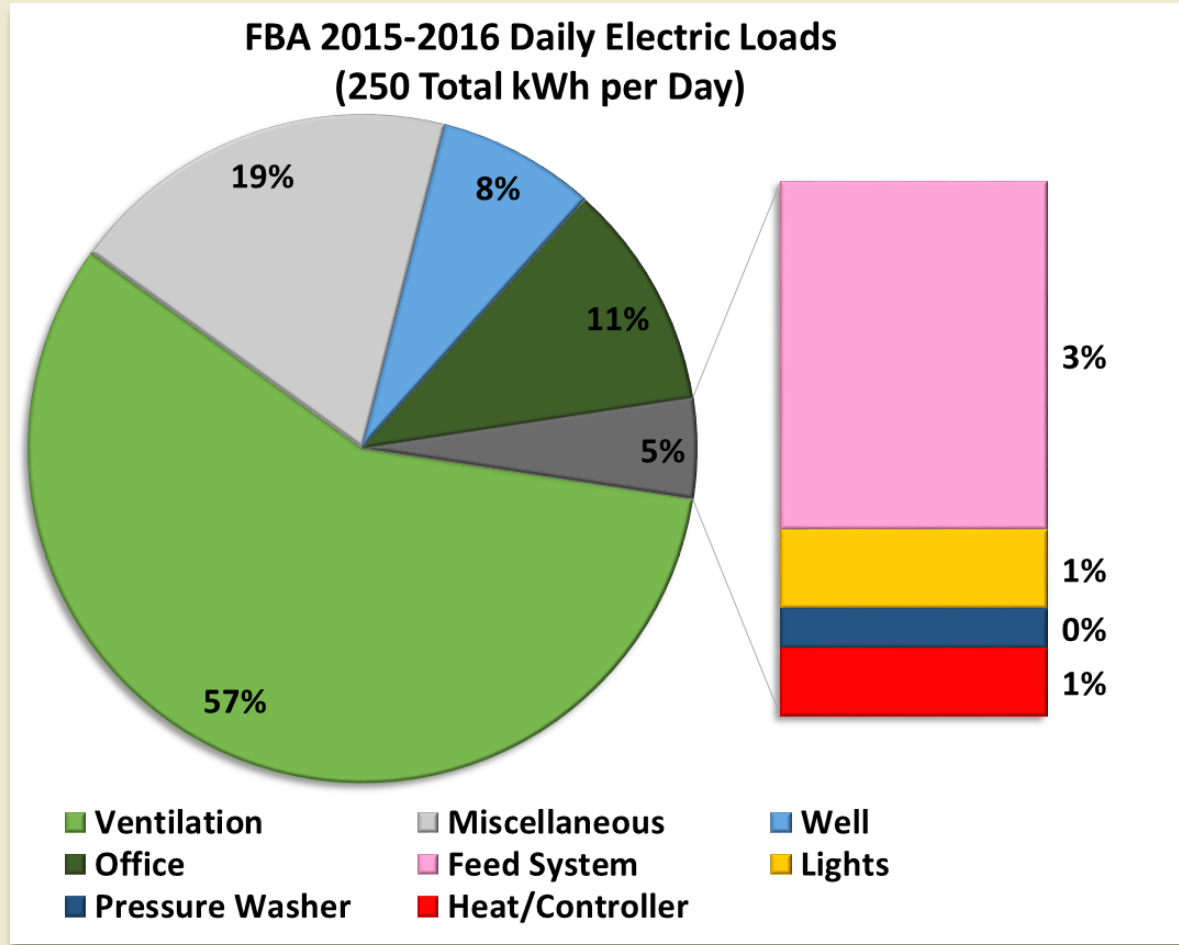
- Electrical use (2015-2016)

- Average use 900 kWh/month
- **Average of 4.19 kWh per finished pig**

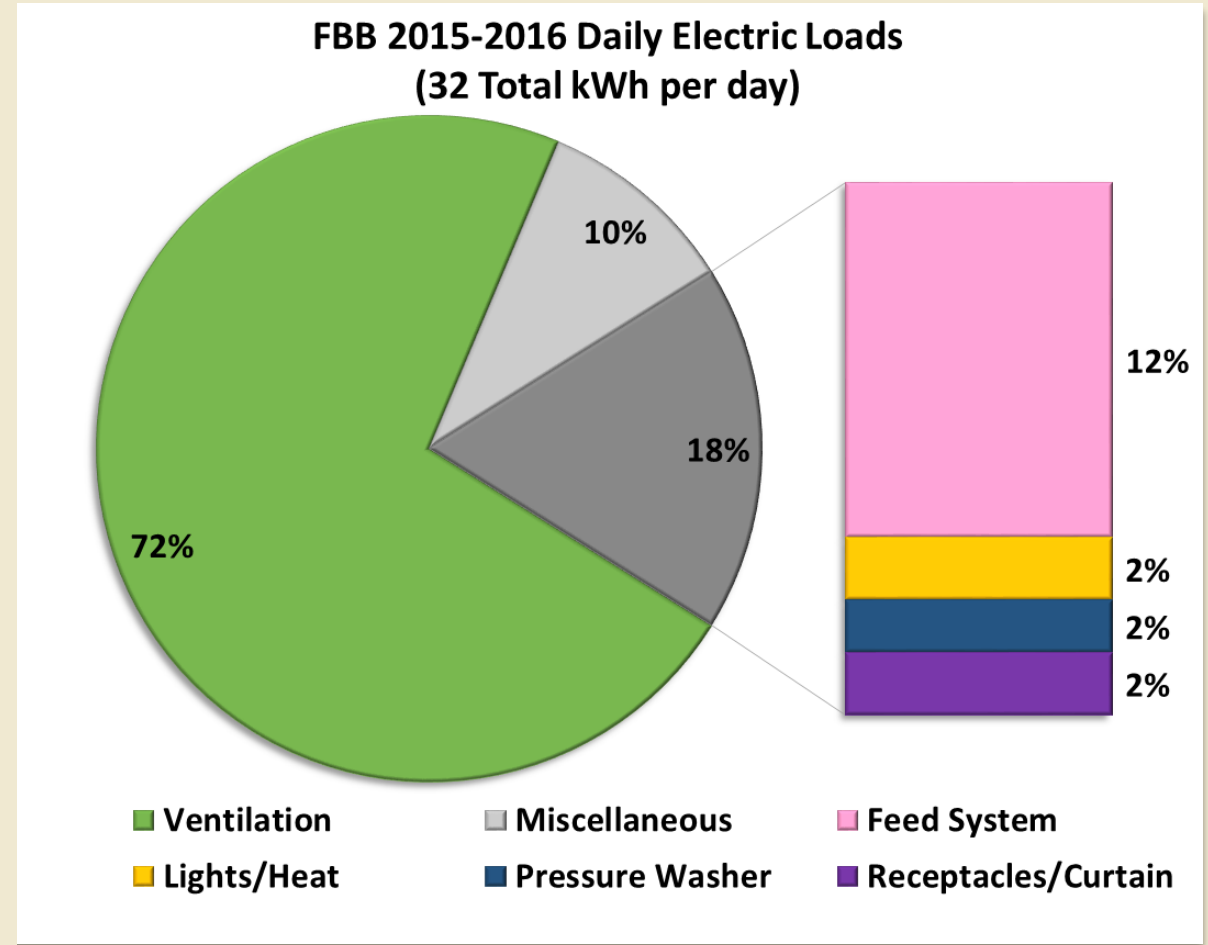


# Finishing Results Cont'd

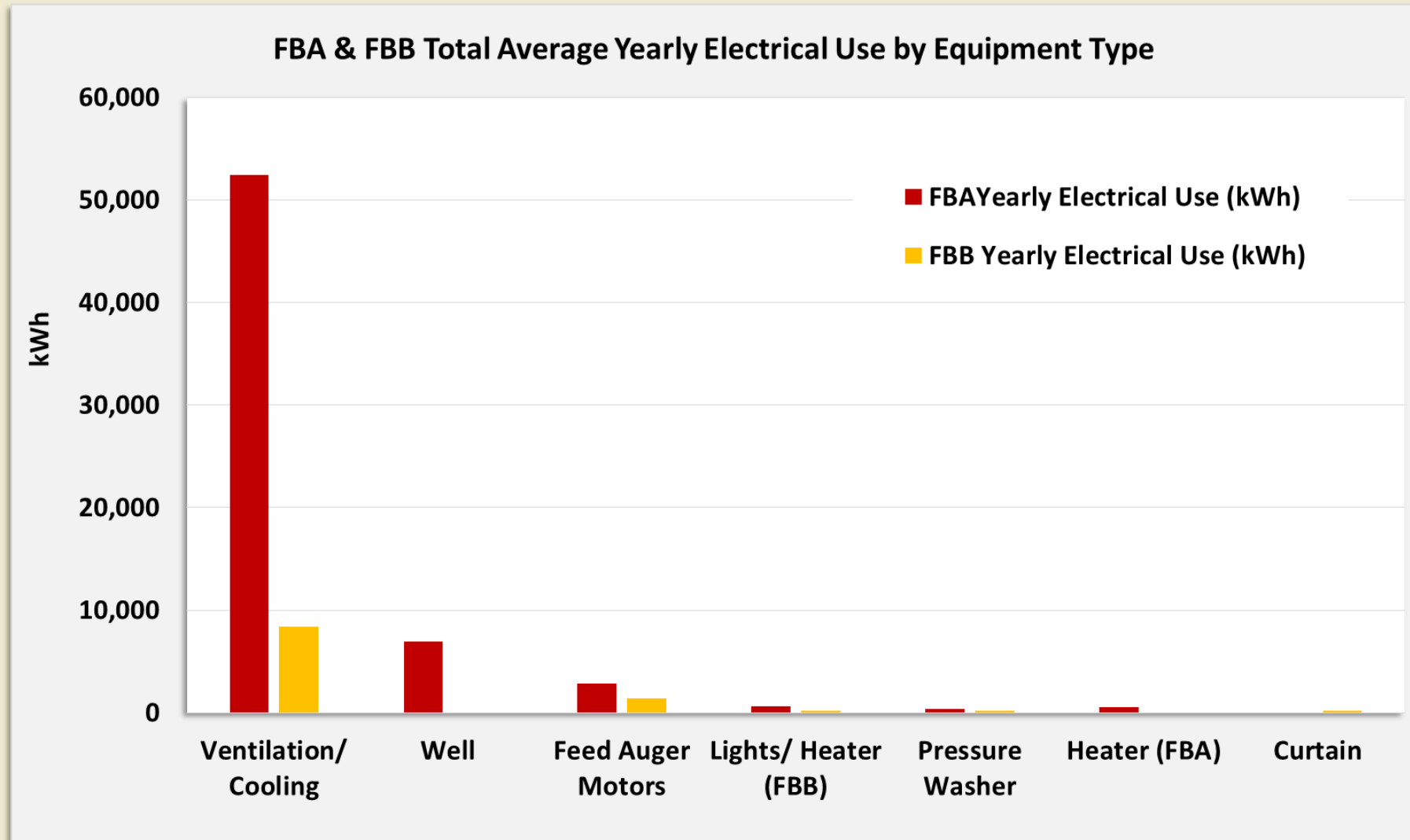
## Finishing Barn A



## Finishing Barn B



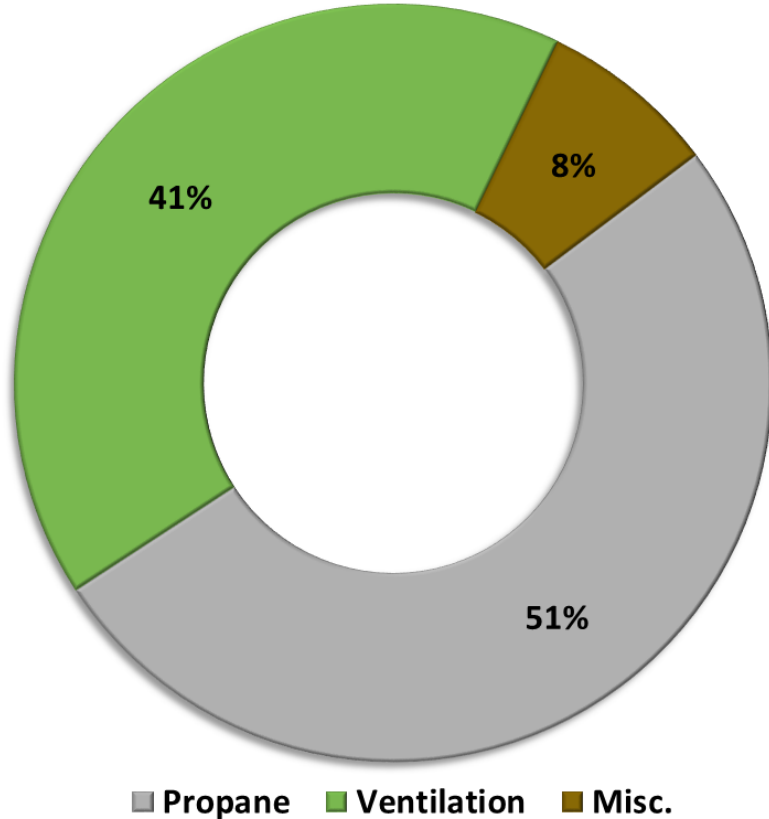
# Finishing Results Cont'd



# Finishing Results Cont'd

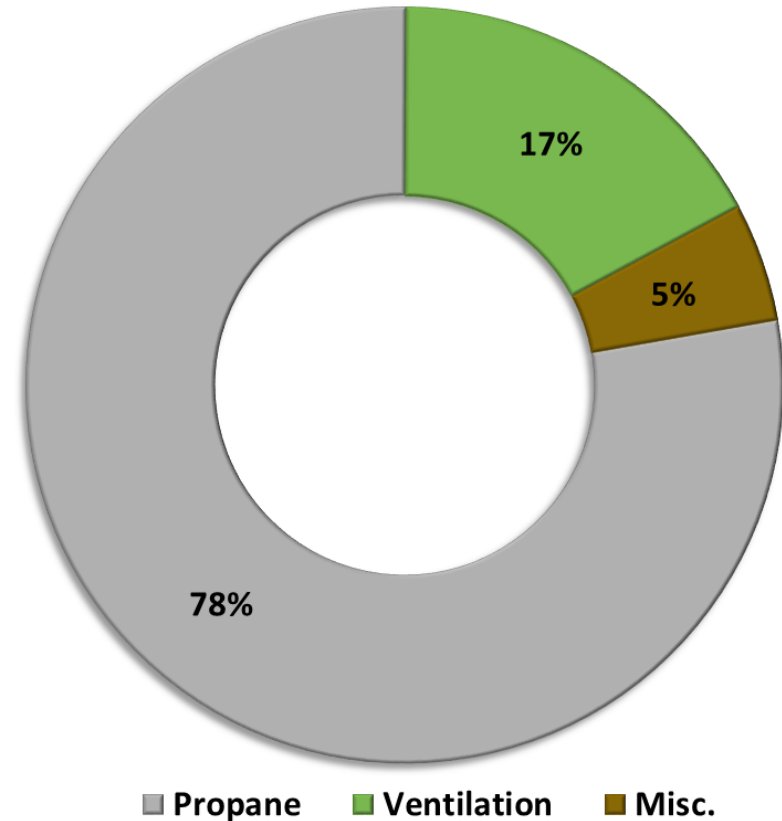
## Finishing Barn A

FBA Yearly Average Total Energy Use (397 MMBtu)



## Finishing Barn B

FBB Yearly Average Total Energy Use (158 MMBtu)



# Conclusions

- Results comparable to other industry measures:

- Production system with 70,000 sows
  - Avg across all sows of 9.7 kWh/weaned pig
  - Units within system ranged from 5-12 kWh/weaned pig
  - 5 kWh/weaned pig system very efficient

- Nursery (Brumm, 2015)
  - ~1.8 kWh per weaned pig
  - ~0.31 gal propane per feeder pig

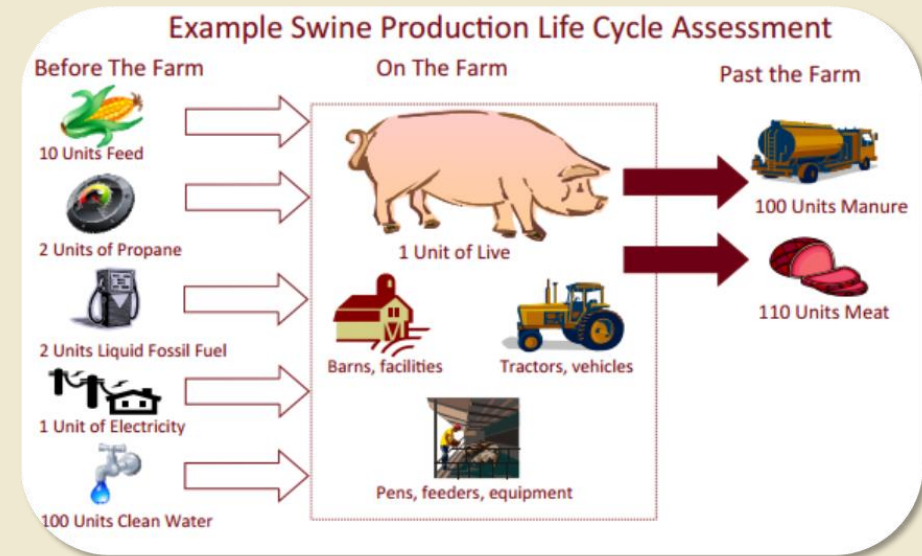
- Tunnel-vented finisher
  - 11.2 kWh per finished pig

- Bottom line- confident our findings capture an accurate depiction of Midwest production units
- Findings point to areas within barns where there is potential to reduce usage

Electric and Thermal Cost to Produce 1 Pig				
Barn	kWh/pig	Gallons of propane/pig	Therms of natural gas/pig	Total energy cost/pig
<b>BWA</b>	11.32	0.21	0.08	\$1.42
<b>BWB</b>	11.92	0.31	X	\$1.56
<b>NBA</b>	2.38	0.33	0.26	\$0.75
<b>NBB</b>	2.10	0.41	X	\$0.70
<b>FBA</b>	14.48	0.34	X	\$1.86
<b>FBB</b>	4.19	0.49	X	\$1.01

# Application of data

- Energy modeling firm AKF to model energy efficiency measures
  - LED lighting
  - Heat lamp controllers
  - Night temperature setbacks
  - Daylight harvesting (windows and light sensors)
  - Earth tube pre-conditioning
  - Solar chimney
- Primarily being used as Life Cycle Assessment (LCA) input
- Replacing heat lamps with heat mats
  - Now that we know how much energy heat lamps use...
  - Heat lamp electric usage versus water-heated mats
  - Starting June 12<sup>th</sup>, 2017 (WCROC Farrowing Barn)



# Acknowledgements

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- Funders:
  - The Legislative-Citizen Commission on Minnesota Resources (LCCMR)



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# Breed-to-Wean Results

**Table X.** Electric and thermal consumption and total costs per weaned pig produced across both BWA and BWB in 2015 and 2016.

Year	Barn	Total pigs weaned	Total electricity used by facility (kWh)	kWh/pig	\$ electricity / pig	Total propane used by facility (gal.)	Gal. propane/pig	\$ propane/pig	Total therms natural gas used by facility	Therms natural gas/pig	\$ natural gas/pig	Total energy cost/pig
2015	BWA	57,965	658,558	11.36	\$1.14	19,668	0.34	\$0.41	X	X	X	\$1.55
	BWB	85,874	1,045,541	12.18	\$1.22	27,016	0.31	\$0.38	X	X	X	\$1.60
2016	BWA	58,872	663,751	11.27	\$1.13	4,168	0.07	\$0.09	4,774	0.08	\$0.07	\$1.29
	BWB	89,469	1,043,038	11.66	\$1.17	27,008	0.30	\$0.36	X	X	X	\$1.53



# Nursery Results

**Table X.** Electric and thermal consumption and total costs per feeder pig produced across both NBA and NBB in 2015 and 2016.

Year	Barn	Total feeders produced	Total electricity used by facility (kWh)	kWh/pig	\$ electricity / pig	Total propane used by facility (gal.)	Gal. propane/ pig	\$ propane/ pig	Total therms natural gas used by facility	Therms natural gas/ pig	\$ natural gas/ pig	Total energy cost/pig
2015	NBA	19,596	44,354	2.26	\$0.23	8,434	0.43	\$0.52	X	X	X	\$0.75
	NBB	71,522	157,313	2.20	\$0.22	31,175	0.44	\$0.53	X	X	X	\$0.75
2016	NBA	18,609	46,428	2.49	\$0.25	4,192	0.23	\$0.27	4,830	0.26	\$0.24	\$0.76
	NBB	71,778	143,882	2.00	\$0.20	26,975	0.38	\$0.45	X	X	X	\$0.65



# Finishing Results

**Table X.** Electric and thermal consumption and total costs per finished pig produced across both FBA and FBB in 2015 and 2016.

Year	Barn	Total feeders produced	Total electricity used by facility (kWh)	kWh/pig	\$ electricity / pig	Total propane used by facility (gal.)	Gal. propane/pig	\$ propane/pig	Total energy cost/pig
2015	FBA	5,837	90,048	15.43	\$1.54	1,440	0.25	\$0.30	\$1.84
	FBB	2,970	9,282	3.13	\$0.31	996	0.34	\$0.41	\$0.72
2016	FBA	6,819	92,231	13.53	\$1.35	2,990	0.44	\$0.53	\$1.88
	FBB	2,655	13,928	5.25	\$0.52	1,695	0.64	\$0.77	\$1.29

