Electric and Thermal Energy Consumption in Commercial Swine Facilities


University of Minnesota
West Central Research and Outreach Center
2019 Midwest Farm Energy Conference
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 Agriculture 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 and the Minnesota Environment and Natural Resources Trust Fund
Modern Pork Production

• 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 for heating/ washing
Commercial Swine Barn Energy Monitoring

• First study of its kind to monitor **specific** electric loads
• Unique in that it parses 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 barns?
    • 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

- Collected electric use of specific loads
  - Ex. pit fans, ventilation fans, heat lamps, pressure washers, lights, heaters, feedline augers, etc.

- Data loggers and sensors
  - Recorded and stored electrical use
  - Data were 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 natural gas utility
Breed-to-Wean Results (2015-2016)

• 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
  • Average use 62,000 kWh/month
  • Average of 11.36 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
  • Average use 97,700 kWh/month
  • Average of 11.91 kWh per weaned pig
Breed-to-Wean Electricity Use

Breed-to-Wean A
(663,371 kWh/yr)

- Heat Lamps: 58%
- Pressure Washers: 4%
- Well: 3%
- Other: 10%

Breed-to-Wean B
(1,044,265 kWh/yr)

- Heat: 61%
- Lights: 14%
- Feed System: 16%
- Miscellaneous: 5%
- Other: 4%
Breed-to-Wean Barn B Electricity

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

- kWh/Day
- Heat lamp kWh/Day

Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

- Well
- Pressure Washer
- Lights
- Feed System
- Heat
- Ventilation
- Room 2 Heatlamps
Breed-to-Wean Total Energy Use

**Breed-to-Wean Barn A**
- 35%: Other
- 42%: Heat Lamps
- 18%: Lights
- 2%: Ventilation
- 3%: Propane/Natural Gas

**Breed-to-Wean Barn B**
- 39%: Other
- 45%: Heat Lamps
- 10%: Lights
- 3%: Ventilation
- 3%: Propane/Natural Gas
Nursery Results (2015-2016)

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

• Electrical use:
  • 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
  • Average use 12,650 kWh/month
  • Average of 2.10 kWh per feeder pig
Nursery Electricity Use

Nursery A
(45,391 kWh/yr)

- 7% Ventilation
- 4% Heat
- 33% Miscellaneous
- 51% Well

Nursery B
(150,598 kWh/yr)

- 8% Ventilation
- 4% Heat
- 31% Miscellaneous
- 50% Well

Other categories:
- Lights
- Pressure Washers
- Manure System
- Feed System
Nursery Barn Total Energy Use

Nursery Barn A (1,154 MMBtu/yr)
- Propane/Natural Gas: 92%
- Ventilation: 2%
- Other: 6%

Nursery Barn B (3,018 MMBtu/yr)
- Propane/Natural Gas: 88%
- Ventilation: 9%
- Other: 3%

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Driven to Discover
Finishing Results (2015-2016)

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

• Electrical use
  • Average use 7,300 kWh/month
  • Average of 14.40 kWh per finished pig

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

• Electrical use
  • Average use 900 kWh/month
  • Average of 4.12 kWh per finished pig
Finishing Results

Finishing Barn A
(91,140 kWh/yr)

- Ventilation: 72%
- Well: 10%
- Feed System: 4%
- Other: 12%

Finishing Barn B
(11,591 kWh/yr)

- Ventilation: 81%
- Well: 13%
- Feed System: 6%

Legend:
- Ventilation
- Well
- Feed System
- Other
- Miscellaneous
Finishing Barn Total Energy Use

Finishing Barn A (477 MMBtu/yr)
- Propane: 47%
- Ventilation: 43%
- Other: 10%

Finishing Barn B (163 MMBtu/yr)
- Propane: 20%
- Ventilation: 4%
- Other: 76%
Total Energy Use

- Total MMBtu/yr:
  - BWB, 5,539
  - NBB, 3,018
  - BWA, 3,285
  - FBA, 477
  - FBB, 163

Bar chart showing energy use categories for each location:
- BWB
- NBB
- NBA
- FBA
- FBB

Legend:
- Heating Fuel
- Heat Lamps
- Ventilation
- Other Measured
## Results

<table>
<thead>
<tr>
<th>Barn</th>
<th>kWh/pig</th>
<th>Gallons of propane/pig</th>
<th>Therms of natural gas/pig</th>
<th>Total energy cost/pig</th>
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<tbody>
<tr>
<td>BWA</td>
<td>11.36</td>
<td>0.21</td>
<td>0.08</td>
<td>$1.46</td>
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<tr>
<td>BWB</td>
<td>11.91</td>
<td>0.31</td>
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<td>$1.57</td>
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<tr>
<td>NBA</td>
<td>2.38</td>
<td>0.33</td>
<td>0.26</td>
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Discussion and Conclusions

• Results comparable to other industry measures:
  • Production system with 70,000 sows
    • Avg across all sows of 9.7 kWh/weaned pig (11.6 kWh/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 feeder pig (2.2 kWh/pig)
    • ~0.31 gal propane per feeder pig (0.37 gal propane/pig)

  • Tunnel-vented finisher (personal communication)
    • 11.2 kWh per finished pig (14.4 kWh/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
Application of Data

• Energy modeling of energy efficiency measures
  • LED lighting
  • Heat lamp controllers
  • Night temperature setbacks
  • Daylight harvesting (windows and light sensors)
• Life Cycle Assessment (LCA) input

• Producers have the tools to reduce fossil energy use:
  • More efficient piglet heating systems
  • Proper maintenance of ventilation systems
  • Reduced nocturnal temperatures (Johnston et al.)
  • Higher efficiency lighting
  • Renewables
Acknowledgements

• Participating producers

• Funding provided by the MN Environment and Natural Resources Trust Fund as recommended by the Legislative Citizen Commission on Minnesota Resources
Questions?
References


• LIFE Magazine. Kansas Farm Boy Dan Gardner feeding a mixture of his and his father's hogs skim milk.© Time Inc. Wallace Kirkland


• Nursery Pigs- http://www.gannett-cdn.com/-mm-/f3981d96801cb5500d5b417c93e5db606650b4a5/c=134-0-2366-1678&r=x404&c=534x401/local/-/media/2016/03/10/INGroup/Muncie/635932257715051033-pigs.jpg
