Energy Usage in Swine Production Systems

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U of MN, St. Paul, MN
Energy Use in Swine Production

• Direct (Fossil Fuel) Energy
  – Primarily Propane and Electricity
  – 2 to 5% of pig production cost (U of MN Farm Financial Management)

• Indirect (Feed) Energy
  – Feed efficiency, rate of gain
  – Estimated to be 60 to 70% of pig production costs
Economic Energy Impact significant for Contract Growers

- Due to business model used in modern production system (integrators/contract growers), fossil fuel energy represents a higher % of the “out of pocket” cost for the contract grower than the reported 2 to 5 % for producing a pig from birth to slaughter.
Present Cost of Fossil Fuel Energy

• **Electricity**
  – Average Midwest ≈ $0.10 /kWh
  – Variable costs due to location and generation source, plus demand-side programs available

• **Propane**
  – Average Midwest ≈ $1.50/gal
  – Highly volatile costs due to demand / location

• **Diesel (off road)**
  – Average estimate in US = $2.50/gal
  – Much less volatile costs than propane or electricity
Areas of Electrical Energy Usage

- Electrical
  - Ventilation exhaust fans plus mixing fans and curtain controllers in natural ventilation barns
  - Creep heat for young piglets
  - Lighting in buildings
  - Power Washing - disinfecting surfaces
  - Feed and Water delivery
Larger Usage of Electrical Energy

• Electrical
  – Ventilation fans - even if natural ventilation some electrical energy needed for control
Moderate Usage of Electrical Energy

- Electrical
  - Creep heat for young piglets
  - Lighting

LED lights
Smaller usage of electrical energy

- Feed and Water delivery
Areas of Propane Energy Usage

- Propane or Natural Gas
  - Space heating to maintain room temps
  - Creep heating for surface temp control
  - Water heating for cleaning and washing
  - Incineration for mortality disposal
Major Usage of Propane Energy

• Propane or Natural Gas
  – Space heating to maintain room temps
  – Radiant heaters for zone heating
Midwestern Pig Finishing Barns
90+% are either CS or TV with Deep Pits

- Curtain Sided (CS)
- Tunnel Ventilated (TV)
## Annual Electrical & Propane Energy Use for 2400 head Tunnel Ventilated, wean-to-finish barn (MN)

<table>
<thead>
<tr>
<th>Year</th>
<th>Elect kWh</th>
<th>Usage</th>
<th>$</th>
<th>$/unit</th>
<th>Propane Gal</th>
<th>kWh-Propane Gal / pig space</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>Elect kWh</td>
<td>65,000</td>
<td>5,054</td>
<td>0.0778</td>
<td>5,115</td>
<td>27.1</td>
</tr>
<tr>
<td></td>
<td>Propane Gal</td>
<td>5,115</td>
<td>7,876</td>
<td>1.54</td>
<td>2.1</td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td>Elect kWh</td>
<td>68,740</td>
<td>5,694</td>
<td>0.0828</td>
<td>4,344</td>
<td>28.6</td>
</tr>
<tr>
<td></td>
<td>Propane Gal</td>
<td>4,344</td>
<td>7,773</td>
<td>1.79</td>
<td>1.8</td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td>Elect kWh</td>
<td>72,760</td>
<td>6,607</td>
<td>0.0908</td>
<td>4,915</td>
<td>30.3</td>
</tr>
<tr>
<td></td>
<td>Propane Gal</td>
<td>4,915</td>
<td>7,650</td>
<td>1.56</td>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>Elect kWh</td>
<td>70,040</td>
<td>6,911</td>
<td>0.0987</td>
<td>5,450</td>
<td>29.2</td>
</tr>
<tr>
<td></td>
<td>Propane Gal</td>
<td>5,450</td>
<td>9,021</td>
<td>1.66</td>
<td>2.3</td>
<td></td>
</tr>
</tbody>
</table>

Bill Crawford, PCM, Fairmont, MN
# AVERAGE Annual Electrical & Propane Energy Use for Various Swine Finishing Facilities in Iowa*

<table>
<thead>
<tr>
<th>Type of Barn</th>
<th>kWh/ pig space</th>
<th>Propane, gal/ pig space</th>
<th># of Barns</th>
<th>Years of data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hybrid (fans with side wall curtains)</td>
<td>22.6</td>
<td>0.67</td>
<td>4</td>
<td>1 to 5 years</td>
</tr>
<tr>
<td>Tunnel, grow-to-finish</td>
<td>28.6</td>
<td>-</td>
<td>2</td>
<td>1 year</td>
</tr>
<tr>
<td>Tunnel, wean-to-finish</td>
<td>30.1</td>
<td>2.8</td>
<td>5</td>
<td>0.8 to 2.9 years</td>
</tr>
</tbody>
</table>

*Hanna, Harmon, & Schweitzer, 2014 (ASABE)
Areas of Diesel Energy Usage

• Diesel Fuel Use
  – Backup Generators
  – Use of skid-steer, front end tractor loaders, trucks to transport feed and pigs
  – Tractors/trucks to load and spread manure
Diesel Powered Backup Generator
Estimated Energy Usage of 3000 sow operation
Electrical Energy Usage of 3000 sow operation

Operating Ventilation Exhaust Fans in winter and summer
Electrical Energy Usage of 3000 sow operation

• Heat Mats and Lamps in farrowing crates
Options for creep heaters

- Conventional 250 watt heat lamps
- Energy Efficient 175 watt heat lamps
- Electric heating mats with temp. control
- Propane or Natural Gas fired radiant heater with temperature control
Electrical Energy Usage of 3000 sow operation

- Lighting

Fluorescent lights
Comparison of various lighting options in livestock housing

<table>
<thead>
<tr>
<th>Lamp Type</th>
<th>Power use in watts</th>
<th>Light output in lumens</th>
<th>Lumens/watts</th>
<th>Lamp or bulb life in hours</th>
<th>Cost per lamp or bulb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incandescent</td>
<td>100</td>
<td>1,530</td>
<td>15</td>
<td>750</td>
<td>$1.20</td>
</tr>
<tr>
<td>Halogen</td>
<td>72</td>
<td>1,490</td>
<td>21</td>
<td>1,000</td>
<td>$1.75</td>
</tr>
<tr>
<td>Compact Fluorescent (CFL)</td>
<td>26</td>
<td>1,550</td>
<td>60</td>
<td>8,000</td>
<td>$6.50</td>
</tr>
<tr>
<td>Light Emitting Diodes (LED)</td>
<td>22</td>
<td>1,700</td>
<td>81</td>
<td>25,000</td>
<td>$55.00</td>
</tr>
<tr>
<td>screw-in</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4-ft T8 fluorescent</td>
<td>68</td>
<td>5,600</td>
<td>81</td>
<td>20,000</td>
<td>$3.50</td>
</tr>
<tr>
<td>4-ft LED tube</td>
<td>46</td>
<td>4,600</td>
<td>100</td>
<td>100,000</td>
<td>$70.00</td>
</tr>
</tbody>
</table>

From Lighting Technology: LED Lamps for Home, Farm, & Small Business; Scott Sanford, UW Madison July 2014
Estimated Annual *Electrical* Energy Usage of 3000 sow operation

- **Electrical Energy**
  - Ventilation fans ≈ 250,000 kWh (winter ≈ 70,000 kWh; summer ≈ 180,000 kWh)
  - Creep Heat ≈ 250,000 kWh (use of 125 watt heat lamps in farrowing)
  - Lighting ≈ 170,000 kWh (gestation ≈ 110,000; farrowing ≈ 60,000)
Estimated Annual *Electrical* Energy Usage of 3000 sow operation

- Power Washing $\approx 10,000$ kWh (20 hours of washing per week)

- Feed & Water delivery $\approx 5,000$ kWh

**Electrical Subtotal $\approx 685,000$ kWh**
Estimated Annual Propane Energy Usage of 3000 sow operation

- Propane Usage
  - Space Heating ≈ 3 billion BTUs (33,000 gal of Propane)
  - Water Heating ≈ 300 million BTUs (3,500 gal of Propane or 90,000 kWh)

Propane Subtotal ≈ 37,000 gals
Estimated Annual Total Energy Usage of 3000 sow operation

- Total Estimated Electrical Energy Usage
  \[ \approx 700,000 \text{ kWh} \text{ or } 230 \text{ kWh/sow space} \]

- Total Estimated Propane Energy Usage
  \[ \approx 37,000 \text{ gals} \text{ or } 12.3 \text{ gals/sow space} \]
Control Direct Energy Costs

• Heated buildings in cold/cool weather
  – Precise control of ventilation rates
  – Exhaust Fan efficiency
  – Building Insulation and leaks
  – Environmental Controllers (e.g. temperature setpoints and heater on-off time)
Energy Efficient Exhaust Fans

- High CFM/watt rating for fans (especially for fans that run a greater percentage of the time)
## Exhaust Fan Test Data

<table>
<thead>
<tr>
<th>Static pressure</th>
<th>Speed</th>
<th>Airflow</th>
<th>Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>in. H$_2$O</td>
<td>rpm</td>
<td>cfm</td>
<td>cfm/W</td>
</tr>
<tr>
<td>0.00</td>
<td>1,642</td>
<td>2,150</td>
<td>9.2</td>
</tr>
<tr>
<td>0.05</td>
<td>1,638</td>
<td>2,020</td>
<td>8.5</td>
</tr>
<tr>
<td>0.10</td>
<td>1,635</td>
<td>1,840</td>
<td>7.7</td>
</tr>
<tr>
<td>0.15</td>
<td>1,653</td>
<td>770</td>
<td>3.5</td>
</tr>
<tr>
<td>0.20</td>
<td>1,641</td>
<td>650</td>
<td>2.8</td>
</tr>
</tbody>
</table>
All 24” exhaust fans are not the same!

<table>
<thead>
<tr>
<th>Fan</th>
<th>Airflow cfm @ 0.10 In. H₂O</th>
<th>Efficiency cfm/W</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fan 1</td>
<td>7,270</td>
<td><strong>12.4</strong></td>
</tr>
<tr>
<td>Fan 2</td>
<td>7,000</td>
<td><strong>16.6</strong></td>
</tr>
<tr>
<td>Fan 3</td>
<td>6,060</td>
<td>16.1</td>
</tr>
<tr>
<td>Fan 4</td>
<td>4,150</td>
<td>11.1</td>
</tr>
</tbody>
</table>
Fan Selection Matters

• 24” fans @ 0.05” H₂O (5,000 hrs per year)
• Most efficient (Fan # 2)
  – 16.6 cfm/W, 7000 cfm
  – $211 per year @ $0.10 /KwH
• Less efficient (Fan # 1)
  – 12.4 cfm/W, 7,270 cfm
  – $293 per year @ $0.10 /KwH
Large Exhaust Fans – Belt Driven
In place Air Flow measurement of Belt-Driven Fans
Belt-Driven Exhaust Fan Maintenance

![Graph showing airflow (cfm) vs. static pressure (Pa) for BESS lab, airflow before belt adj., and airflow after belt adj.](image-url)
Ventilation Exhaust Fan Maintenance

• Dirty/Dusty fan shutters and grills can result in up to 40% reductions in airflow rates
Ventilation Exhaust Fan
Attachments also important

Comparison of 24” fans

- Shutter & guard only
- + Wind hood
- + Discharge cone

Source: BESS Lab data
Nursery Barn example to show importance of Room Temperature on Propane use

- 1000 Head Nursery
- 41’ by 84’
- R – 11 in Walls
- R – 30 in Ceiling
- 2.5 cfm airflow/hd minimum
- 76 F average Room Temp
- Estimated Propane
  - 995 gallons/yr
  - ≈ $2,000 /yr
- $2.00/gallon of propane
## Fuel Cost comparison

<table>
<thead>
<tr>
<th>Average Barn Temp</th>
<th>Gallons LP</th>
<th>Annual Cost</th>
<th>Difference from Base</th>
</tr>
</thead>
<tbody>
<tr>
<td>72 F</td>
<td>712 gal</td>
<td>$1,424</td>
<td>- $576</td>
</tr>
<tr>
<td>74 F</td>
<td>837 gal</td>
<td>$1,674</td>
<td>- $326</td>
</tr>
<tr>
<td>76 F</td>
<td>995 gal</td>
<td>$2,000</td>
<td>Base</td>
</tr>
<tr>
<td>78 F</td>
<td>1154 gal</td>
<td>$2,308</td>
<td>+ $308</td>
</tr>
<tr>
<td>80 F</td>
<td>1361 gal</td>
<td>$2,722</td>
<td>+ $722</td>
</tr>
</tbody>
</table>
Use of Radiant Heater so can operate lower barn air temperatures

- Radiant heaters heat surface without direct heating the air

- Less expensive to zone heat (surface temp of 80+ F) rather than heat the entire building to that temperature (room temp maybe 70 F)
Adding Insulation??

• Does it pay?

  – Recommendation for Midwest (MWPS)
    • R 33 in ceiling
    • R 20 in walls
    • Perimeter Insulation (R 6.5)
Adding Insulation ??

• Improving from R 30 to R 40 in ceiling
  – Example savings of $94 per year
• Improving from R 10 to R 30 in ceiling
  – Example savings of $782 per year

Adding Insulation is most beneficial when it is poorly insulated. Making good insulation better rarely pays.
Uninsulated Concrete Kneewall

70 F Room

0 F Outdoors

34 F Surface
Condensation occurs above 25 % RH

6 inch Concrete
R= 1.33

Heat Flow
Insulated Concrete Kneewall

Heat Flow

70 F Room

6 inch Concrete + 1 inch Rigid insulation

R= 6.33

62 F Surface
Condensation only occurs above 75% RH

0 F Outdoors
Sealing Curtain Openings
Bubble wrap “insulation for winter

Mike Brumm, Brumm Consultancy Inc.
Controller Set-Point Temperature

- Target temperature for controller
  - **NOT the average room temperature**
- Other controller settings are based on set-point temperature
2 Variable-Speed Fans & 2 Single-Speed Fans

Airflow rate

Set Point

Temperature

Minimum

Bandwidth 1

Offset

Bandwidth 2

Differential 1

Differential 3

Differential 4

Stage 1

Stage 2

Stage 3

Stage 4

Jay Harmon, Iowa State Univ.
Heater Control

Heater On

Differential

Heater Offset

Continues Heating to X Degrees ???

Set Point

Temperature

Heat output
Heater offset of at least 1.5 F helps to Prevent Heater “Overshoot”
Setpoint = 70 F

Furnace on at 69 F and off at 70 F
VS Fans increase at 70.5 F

Recommendation:
Furnace on at 67 & off at 68.5
VS Fans increase at 72 F
“Blue Valve” – reduces heater output to 65% of maximum
Questions??