Reducing Fossil Fuel Use in Swine Production - One Piece at a Time

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Greening of Ag Project

- Consumer supply chains are asking for reduced environmental impacts
- Modern production agriculture uses significant fossil fuel resources
  - Fertilizer, crop protection products, diesel, electricity, heating fuels
- Is there a way to reduce the use of these fuels without compromising or maybe improving production?

Greening of Ag Project - Swine

Approaches to reduce carbon footprint of pork

- Monitor fossil-based energy use on farms
- Conservation practices
- Renewable energy generation
- Enhanced pig performance with RE?
- Estimate LCA of production systems

ENERGY CONSERVATION

Lowering Energy Consumption by Reduction of Temperature in Swine Facilities

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Heating Fuel and Electricity Costs to Produce Pigs

Phase of production	Heating fuel ($/pig)	Electricity ($/pig)	Total cost ($/pig)
Farrow-to-finish	1.37	2.30	195.91
Wean-to-finish	1.92	0.76	181.97
Feeder-to-finish	1.42	1.23	184.97

MnSCU Adult Farm Business Mgt. (2014)

Current Practice in Swine Nurseries

- Room temperature on arrival about 85+ °F
- Constant room temperature day and night
- "Ramping" set to gradually reduce room temperature

Pigs Prefer Cooler Nights

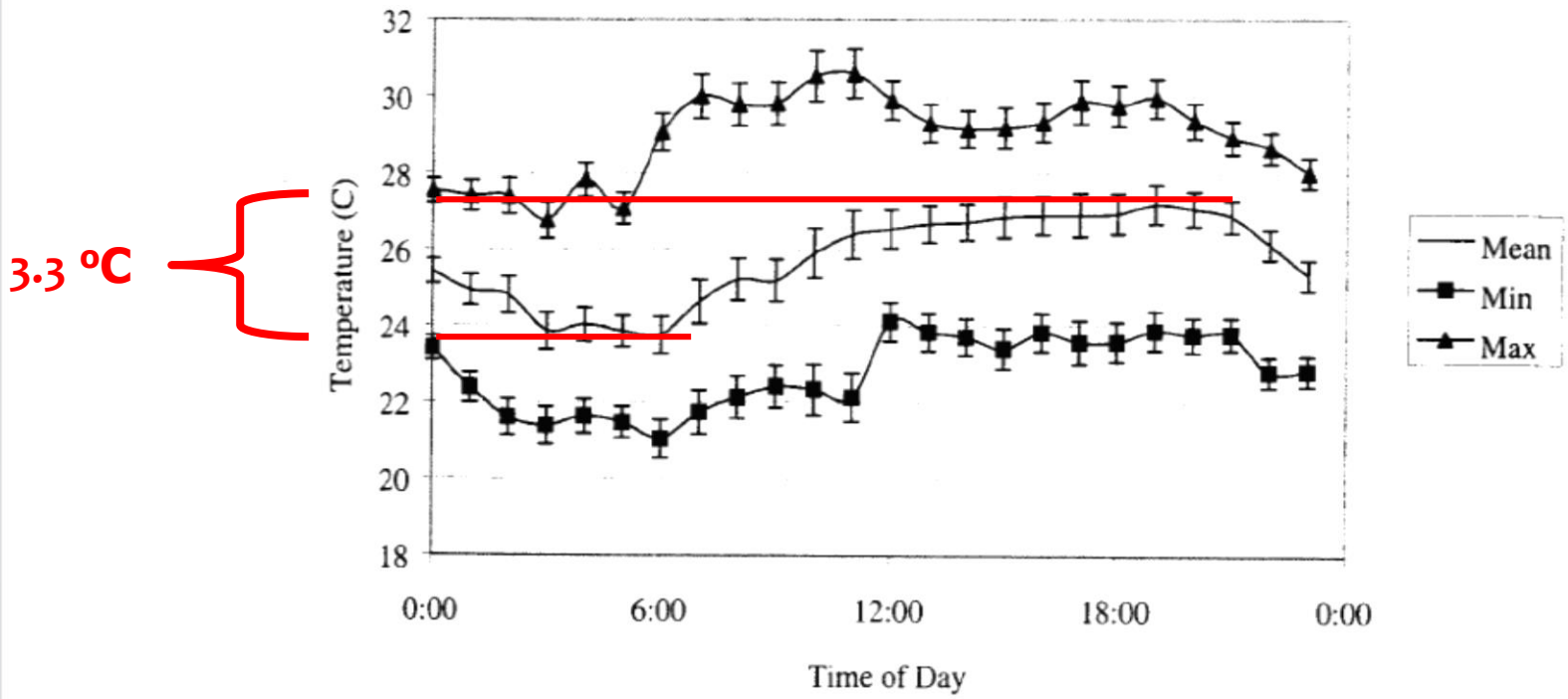


Fig. 1. Mean preferred temperatures (± SE), selected by early-weaned pigs, for a 24-h circadian cycle (averaged for all replicates; $P < 0.001$). P value represents differences in mean temperature data per hour of the day.

Bench and Gonyou, 2007

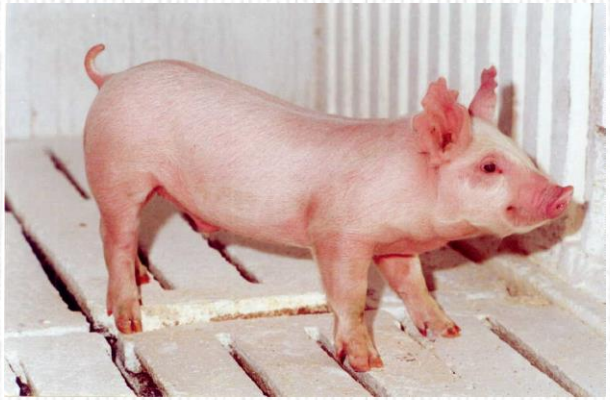
Thermo-Regulatory Behavior of Pigs

So Why Evaluate RNT Now?

- Commercial implementation of RNT was impractical in the 1990's
- Design of nursery facilities has improved
- Heating costs can be significant (remember $7 propane?)
- Heat production of pigs has increased
  - 60 Btu/h at 15 lb bodyweight
  - 137 Btu/h at 24 lb
  - 240 Btu/h at 48 lb

Objectives (XP 1)

- To determine if a RNT regimen:
  - Influences pig performance
  - Decreases consumption of fossil fuels



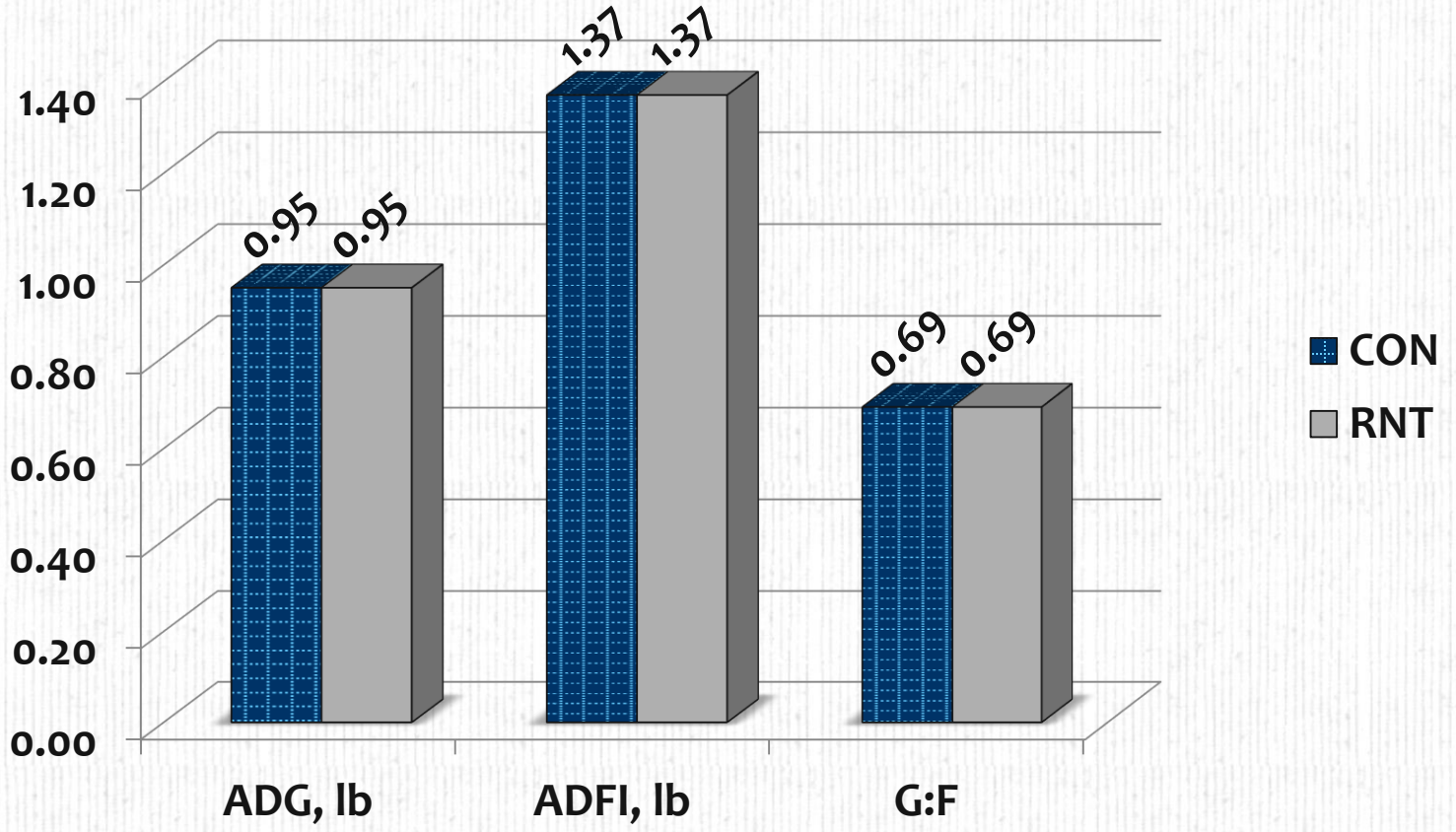
Room Treatments

- Control
  - 86 °F at pig height
  - Lowered temperature 3.5 °F per week (5-6 wk)
- RNT
  - Same as Control in week 1
  - Beginning week 2, reduced temperature 10 °F 1900 to 0700 hours daily
  - Reduced daytime temperature 3.5 °F per week

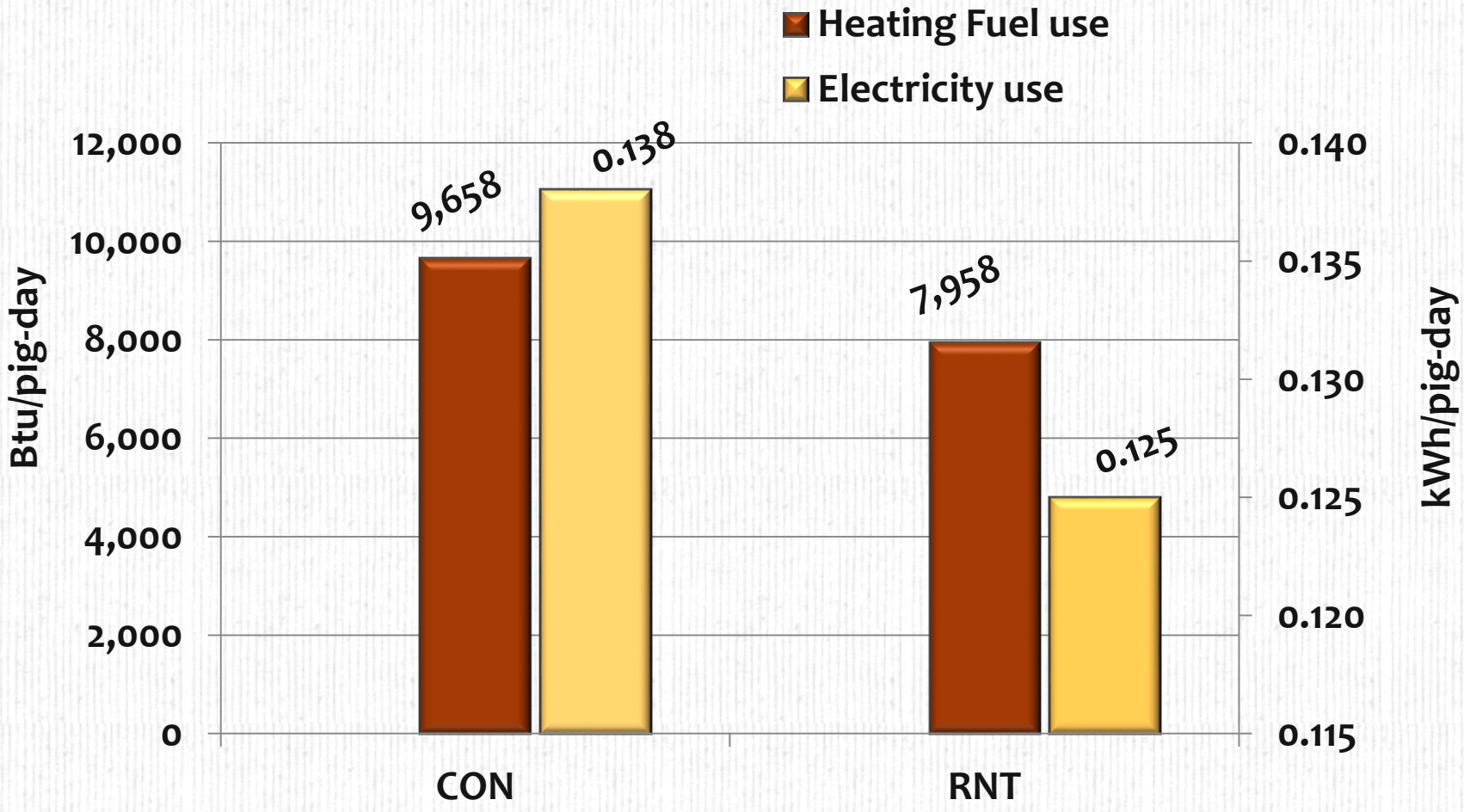
Procedures

- Animals
  - 1,638 weaned pigs weighing 13.7 lb
  - Trial lasted 35 to 42 days
- Facilities
  - Mirror-image nursery rooms used at each site
  - 6 trials conducted at 3 stations
    - NE (2 trials; 238 pigs)
    - MO (2 trials; 480 pigs)
    - MN (2 trials; 920 pigs)
- Measurements
  - Pig performance
  - Weekly heat/electricity use by room

Overall Pig Performance (XP 1)



Use of Heating Fuel and Electricity (XP 1)



Summary (XP1)

- The RNT regimen imposed:
  - Had no effect on pig performance
  - Had no effect on morbidity or mortality of pigs
  - Numerically reduced heating fuel and electricity use by 18 and 9%, respectively.

Objectives (XP 2)

- To determine if an aggressive RNT regimen:
  - Influences pig performance
  - Increases magnitude of fossil fuel savings

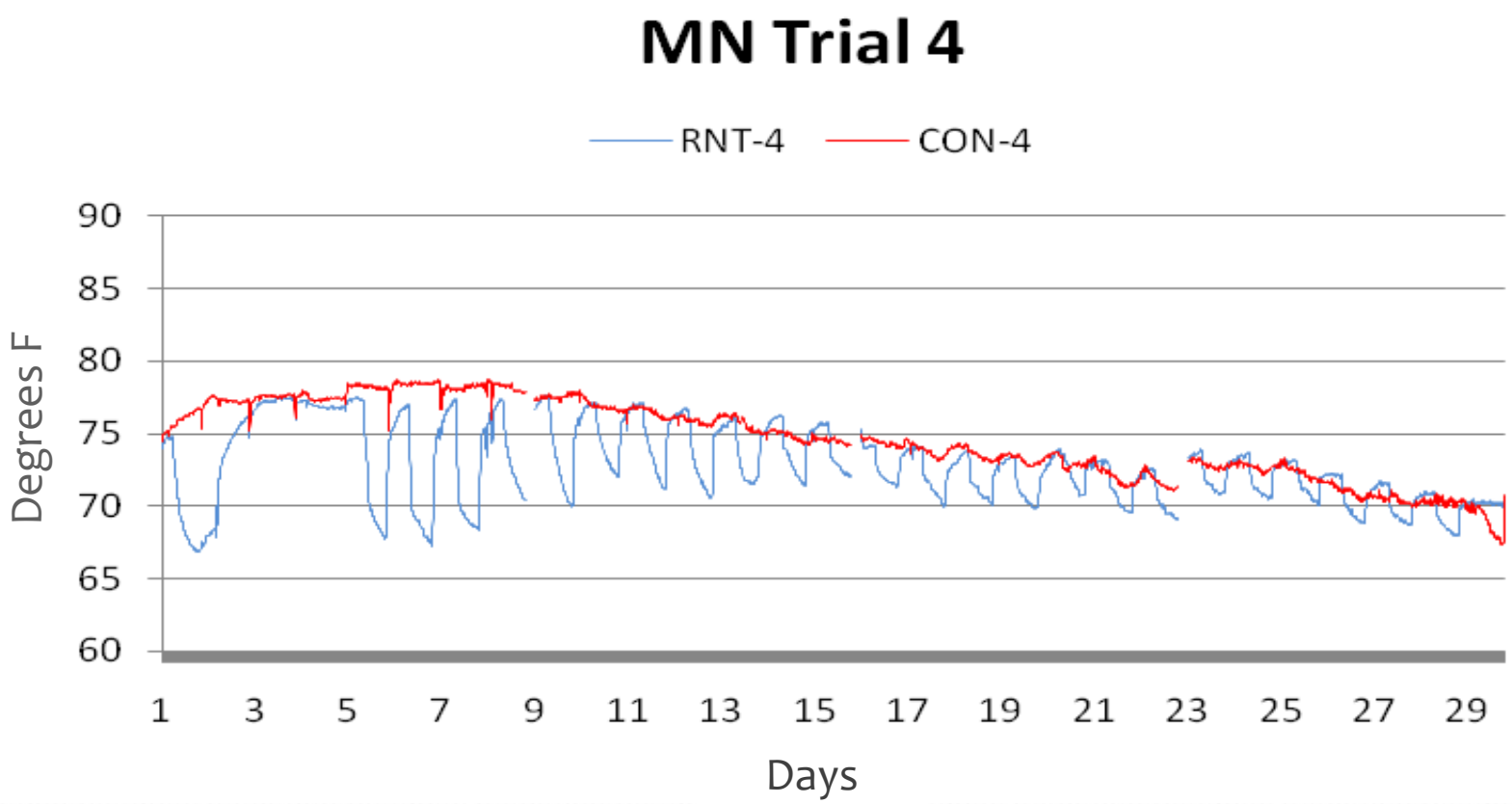
Cooperating Universities

South Dakota State University

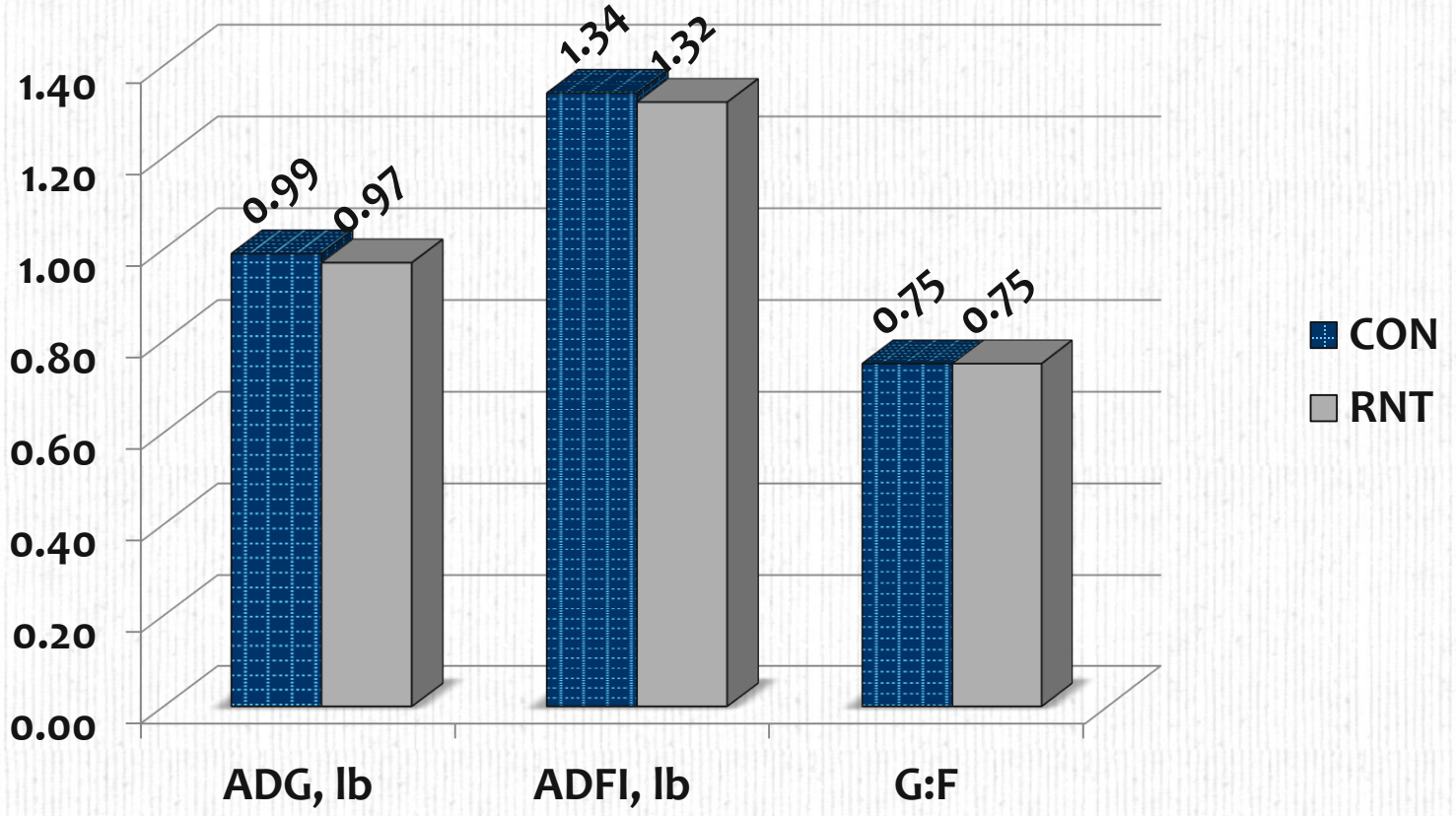
Room Treatments (XP 2)

- Control
  - 86 °F at pig height
  - Lowered temperature 3.5 °F per week (5-6 wk)
- RNT
  - Same as Control during days 1 to 4
  - Beginning day 5, reduced temperature 15 °F 1900 to 0700 hours daily
  - Reduced daytime temperature 3.5 °F per week

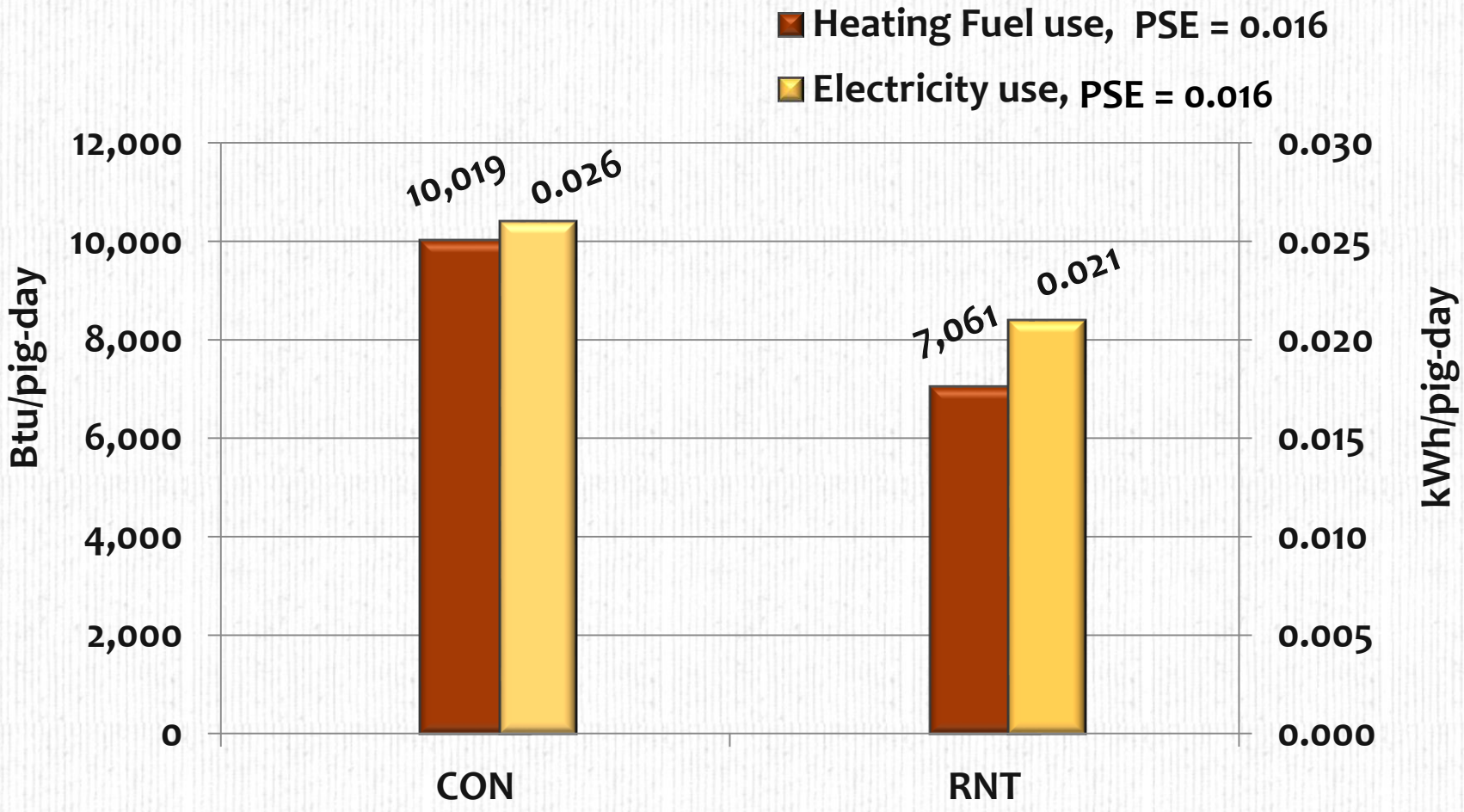
Example Temperature Profile in a MN Nursery Room (XP 2)



Overall Pig Performance (XP 2)



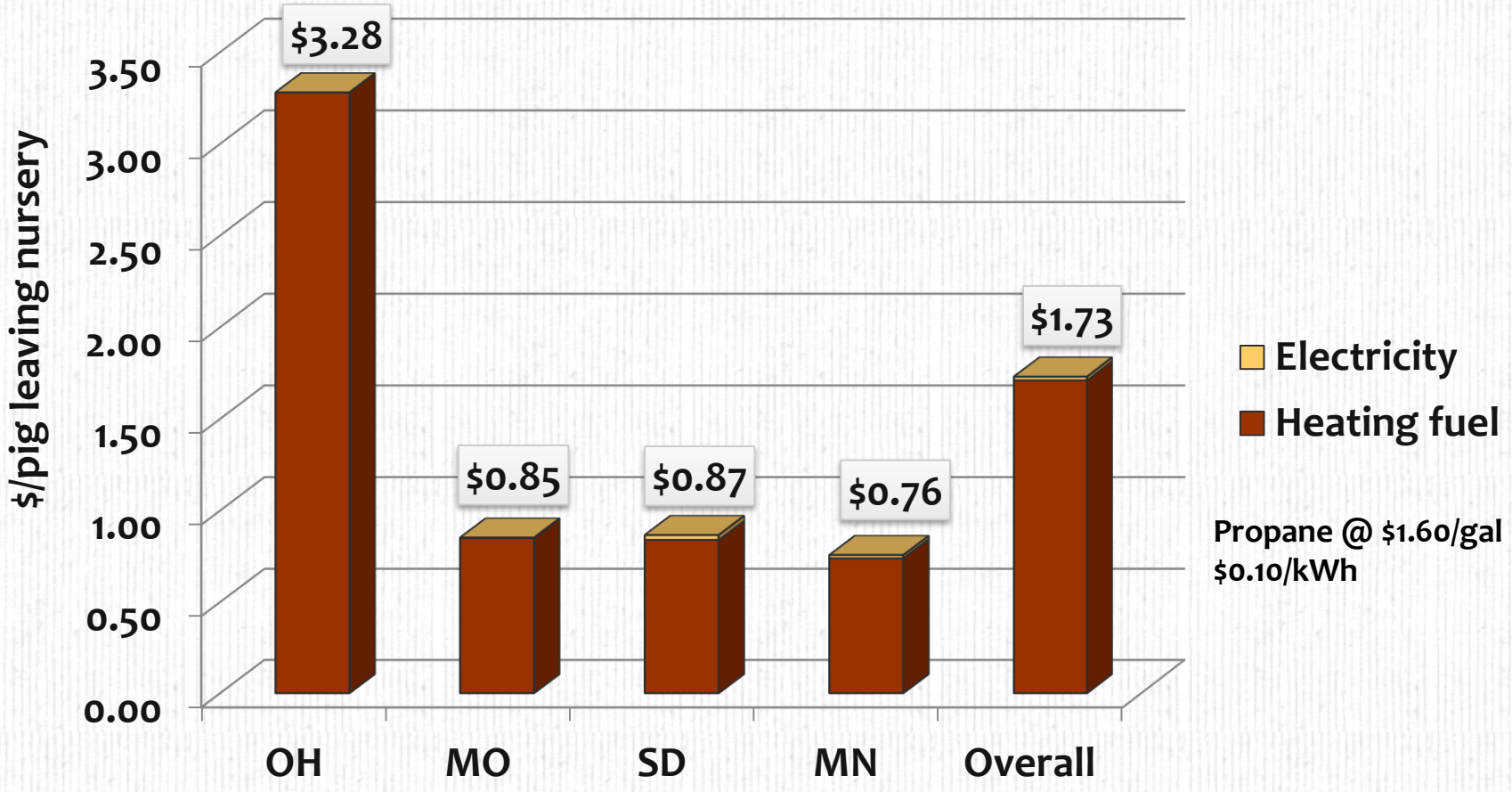
Use of Heating Fuel and Electricity (XP 2)



Use of Heating Fuel and Electricity Across all Stations (XP 2)

	Trait			
	Heating fuel (Btu/pig-day)		Electrical use (kWh/pig-day)	
Station	CON	RNT	CON	RNT
OH	14,307	8,943	-	-
MO	14,104	12,030	0.020	0.019
SD	7,935	5,714	0.043	0.036
MN	3,009	1,557	0.032	0.026

RNT Cost Savings in Heating Fuel and Electricity



Estimated Reduction in GHG Emissions

- Propane
  - 2,958 Btu/pig/d saved x 35 d = 103,530 Btu saved
  - 103,530 Btu = 1.13 gallons saved
  - 15.2 lb CO_2 equivalents saved/pig
- Electricity
  - 0.005 kWh/pig/d saved x 35 = 0.175 kWh saved
  - 0.3 lb CO_2 equivalents saved/pig
- Total: 15.5 lb CO_2 equivalents saved/pig

Conclusions

- Reducing room temperature furnace set point by 15 °F at night beginning the 5th day after arrival:
  - Did not influence pig performance or health
  - Reduced heating fuel and electrical use by 29 and 19%, respectively
  - Reduced GHG emissions by 15.5 lb CO_2 -e

Future Research Questions

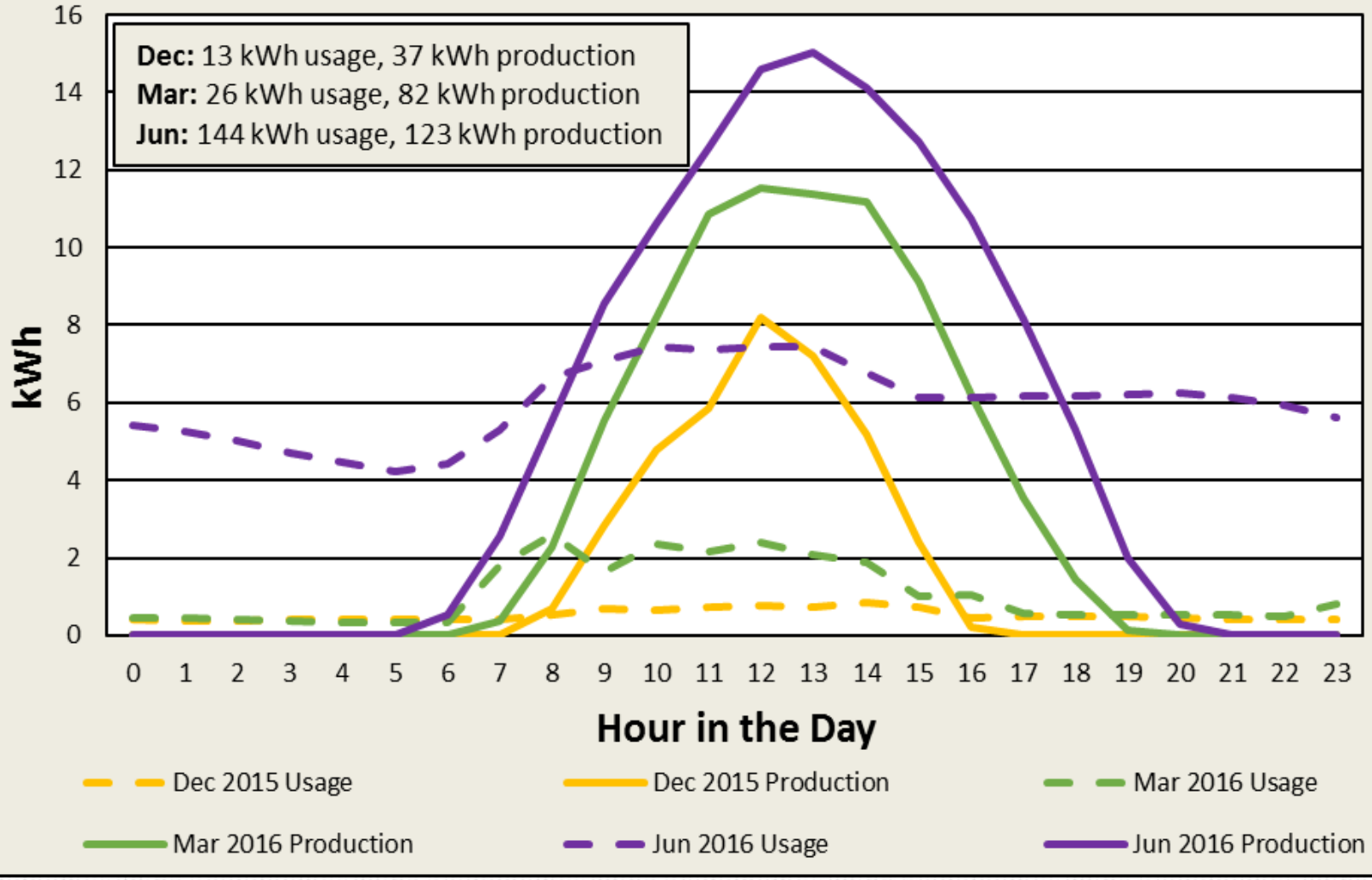
- Will RNT work in wean-to-finish barns?
- Does RNT have utility in early finishing?
- Do we need to re-evaluate pigs' thermal requirements?

ENERGY GENERATION

WCROC Solar PV Installation

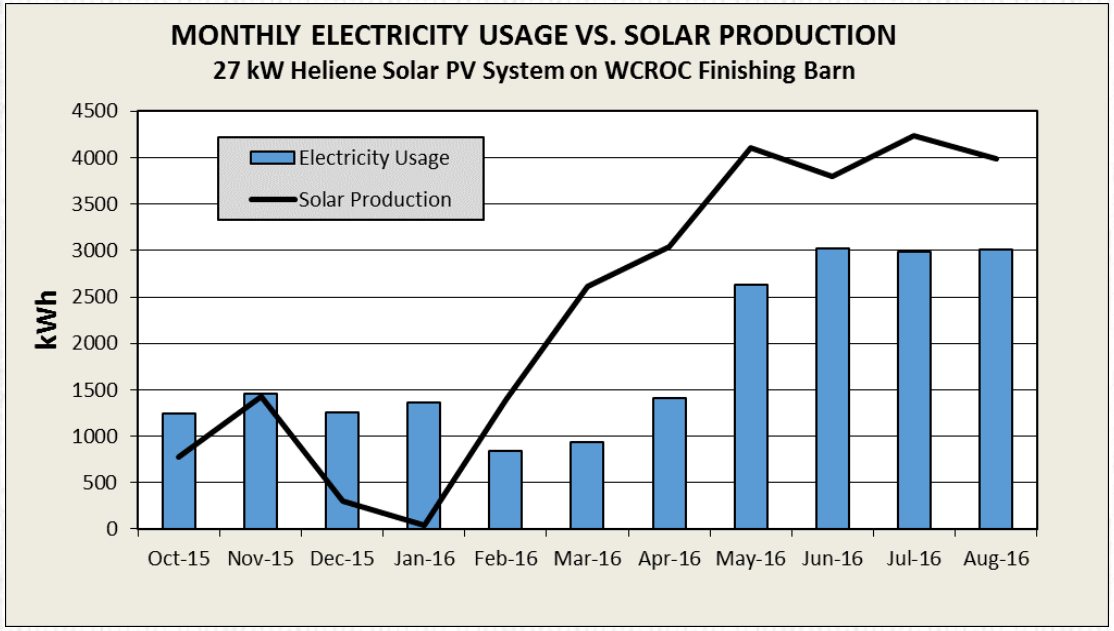
Total Electricity Usage vs. Solar PV Production

by the WCROC Finishing Barn



Swine Barn Energy Systems

- Morris Example (finishing barn roof)
  - Use PVwatts to predict performance (easy)
    - Predicted annual production = 35,480 kWh
    - Cost = $86,000 ($3.20/Watt)



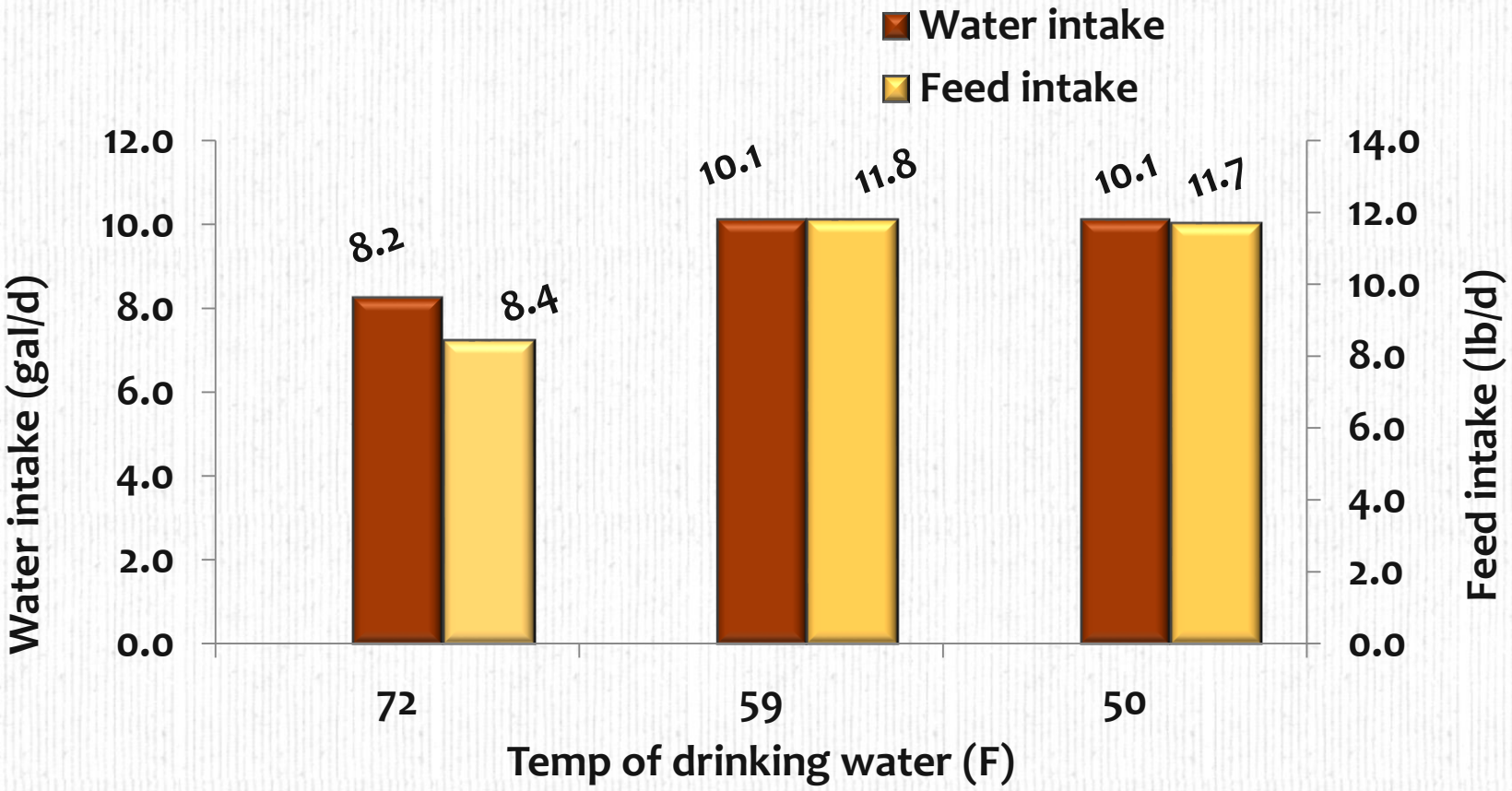
Over 25 years

- 9.7¢/kWh (no incentives)
- 6.8¢/kWh (fed tax credit)
- 1.6¢/kWh (FTC & MiM)

Might have maintenance costs with inverters

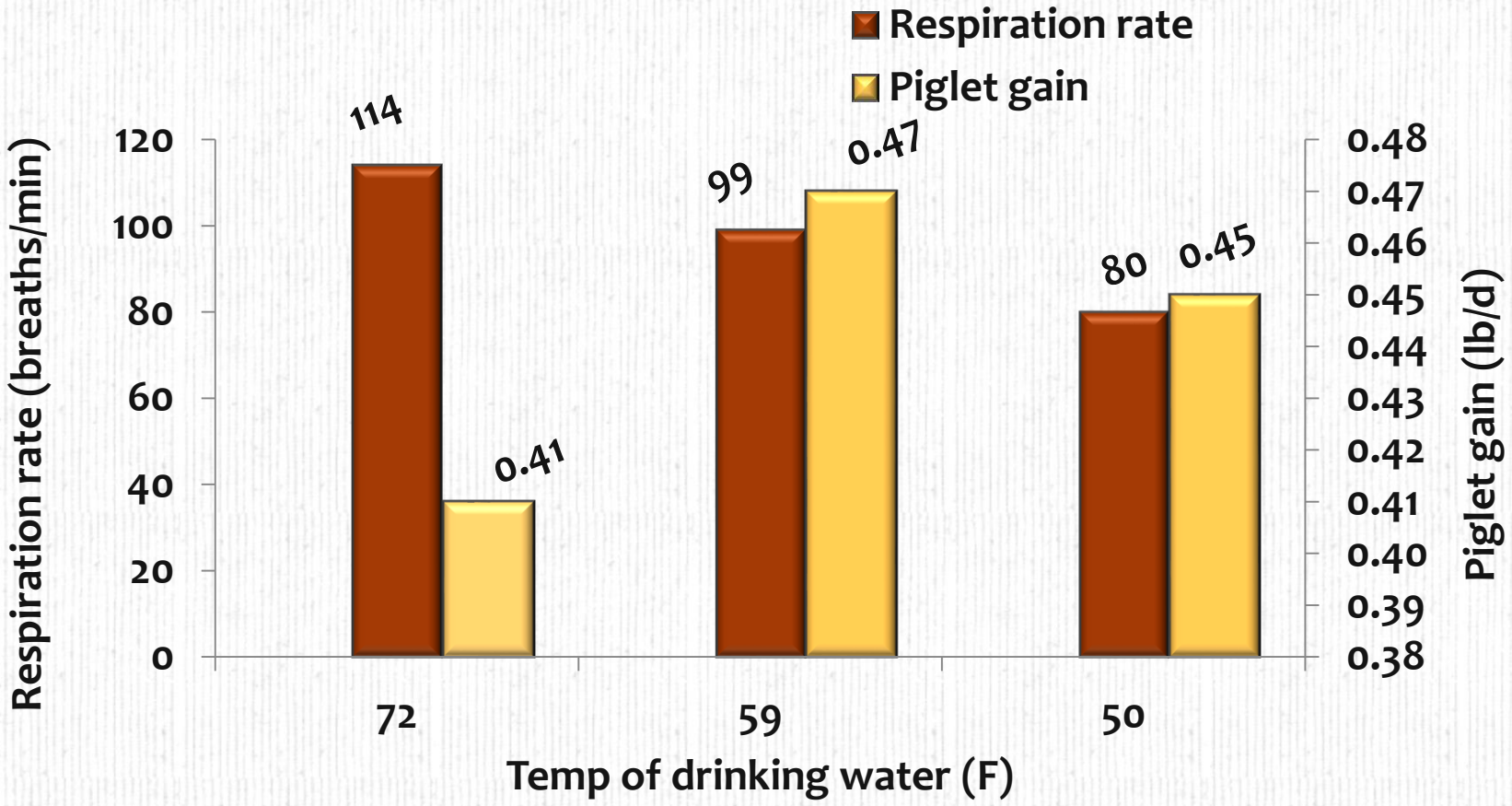
ENHANCED PIG PERFORMANCE WITH RENEWABLE ENERGY ?

Effect of Water Temperature on Performance of Lactating Sows



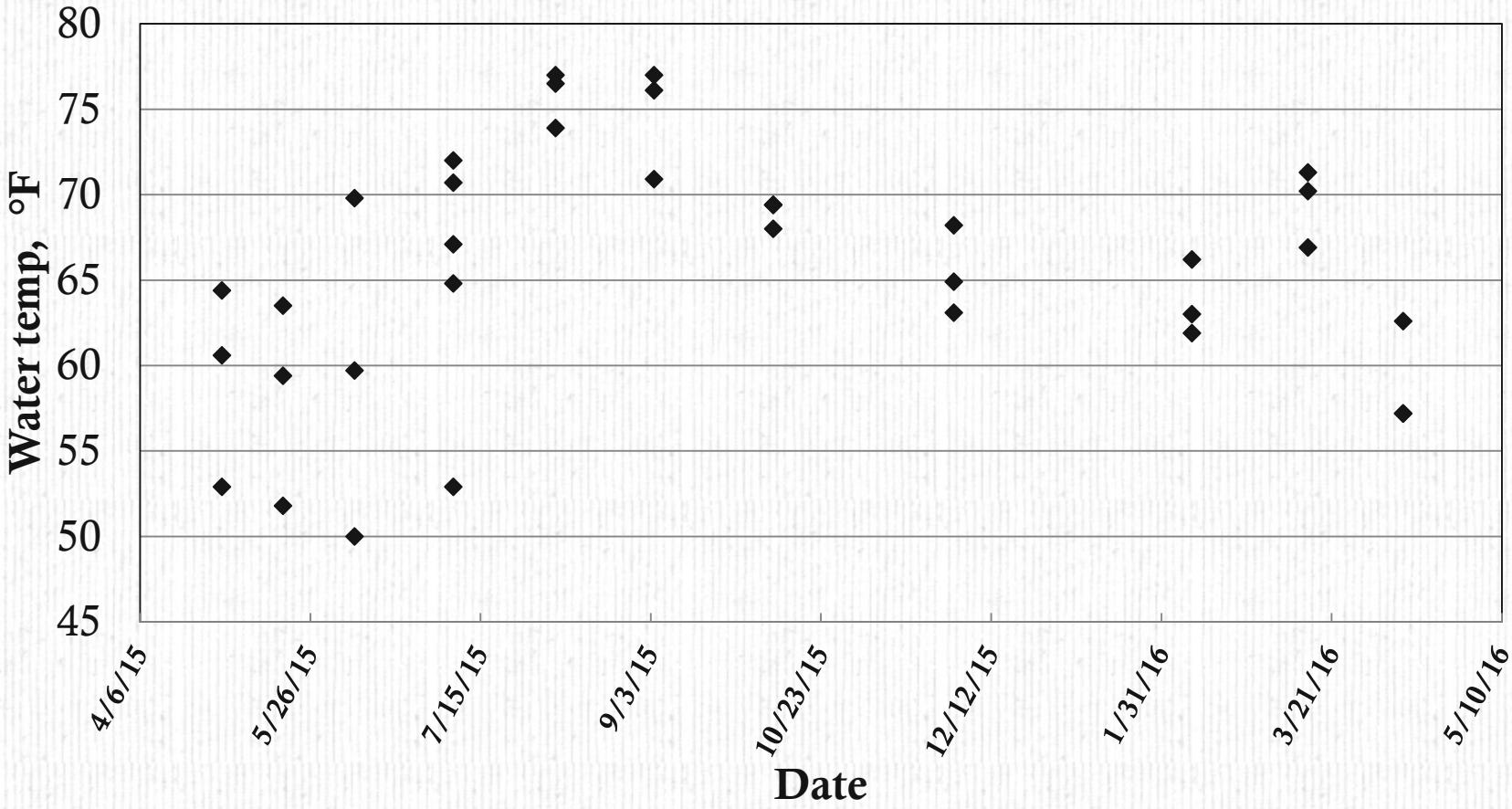
Jeon et al. (2006)

Effect of Water Temperature on Performance of Lactating Sows



Jeon et al. (2006)

Water Temperature in Farrowing Stall Water Cups



Johnston et al. unpublished

Cooling Sows with Solar Energy?

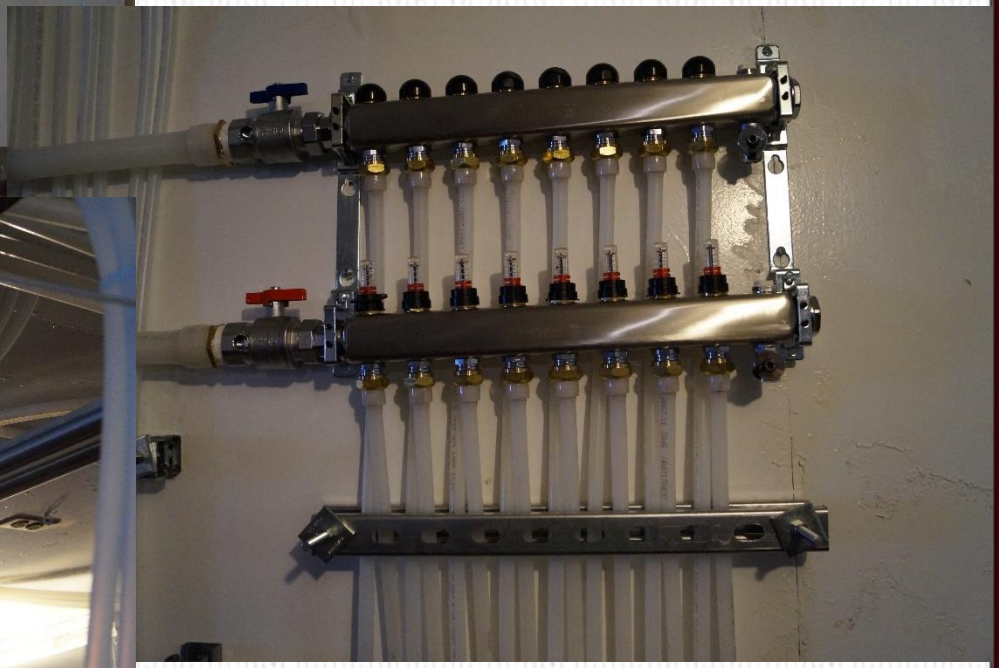
- Solar PV panels installed to power systems in WCROC farrowing barn
- Use air-source heat pumps to cool water
- Circulate water under sow flooring for cooling
- Supply cooled drinking water to sows

Cooling Sows with Solar Energy

Nooyen Manufacturing, Netherlands

Cool Sow flooring installed at WCROC

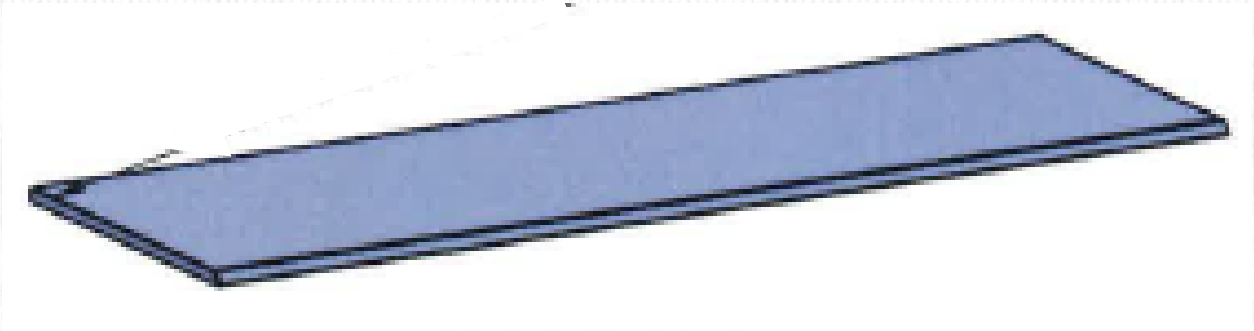
A plumber’s dream/nightmare??

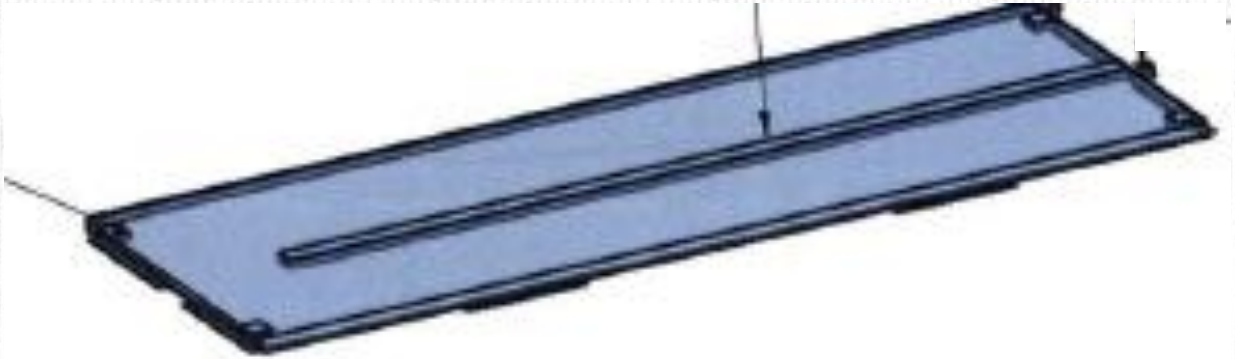


Water-Heated Creep Mats

Rotecna, Spain

Water-Heated Creep Mats





LIFE CYCLE ANALYSIS OF LIVESTOCK PRODUCTION - WCROC



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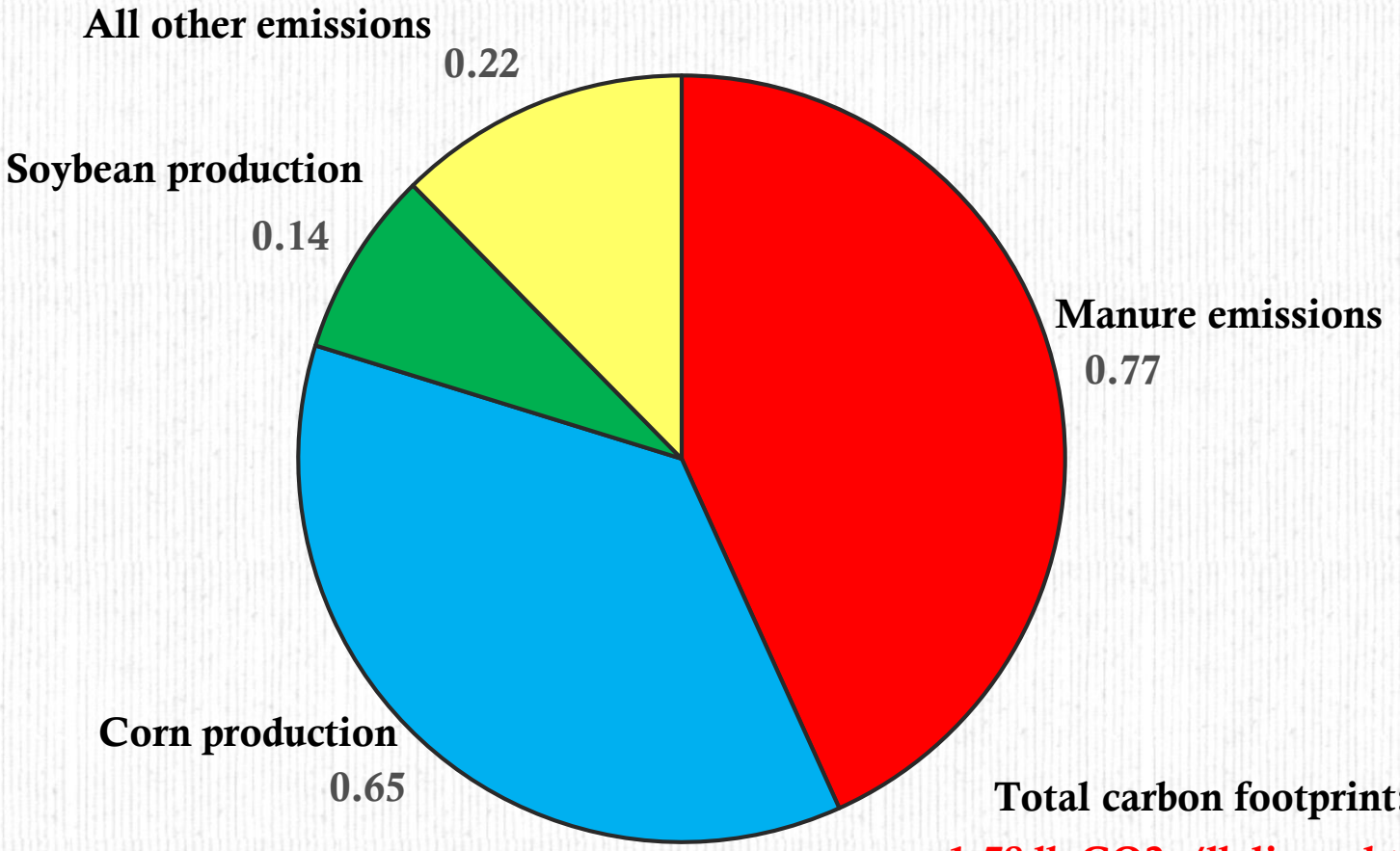
Life Cycle Assessment

- A comprehensive look at a product or process to evaluate inputs and outputs of interest for their impacts on the environment.
- Many different impacts can be examined:
  - Resource depletion
  - Eutrophication potential
  - Global warming
  - Water use
- Our work examines fossil fuel depletion and global warming
  - MJ of fossil energy
  - Equivalents of CO_2

Carbon Footprint of WCROC Pig Production (lb CO2e/lb live mkt pig)

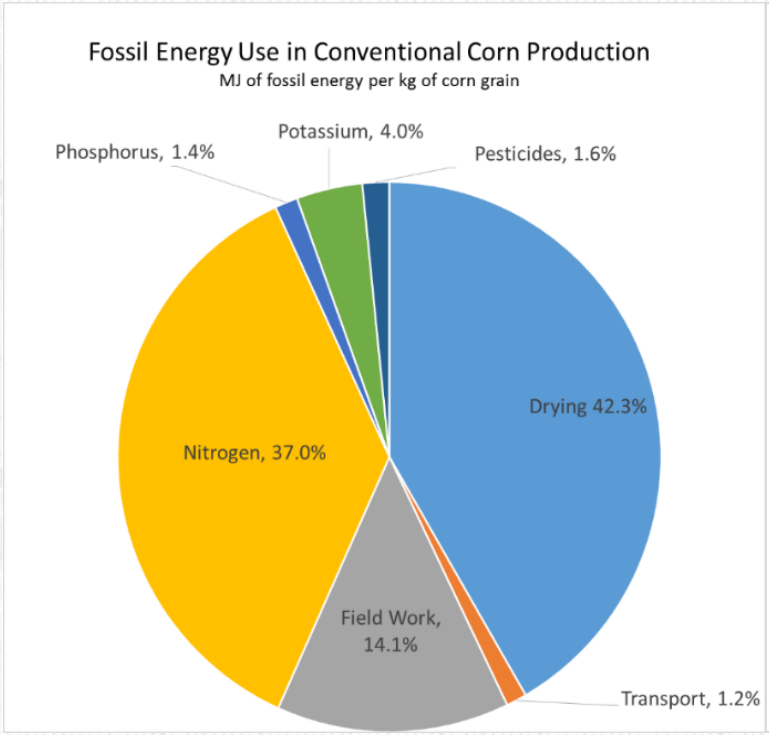


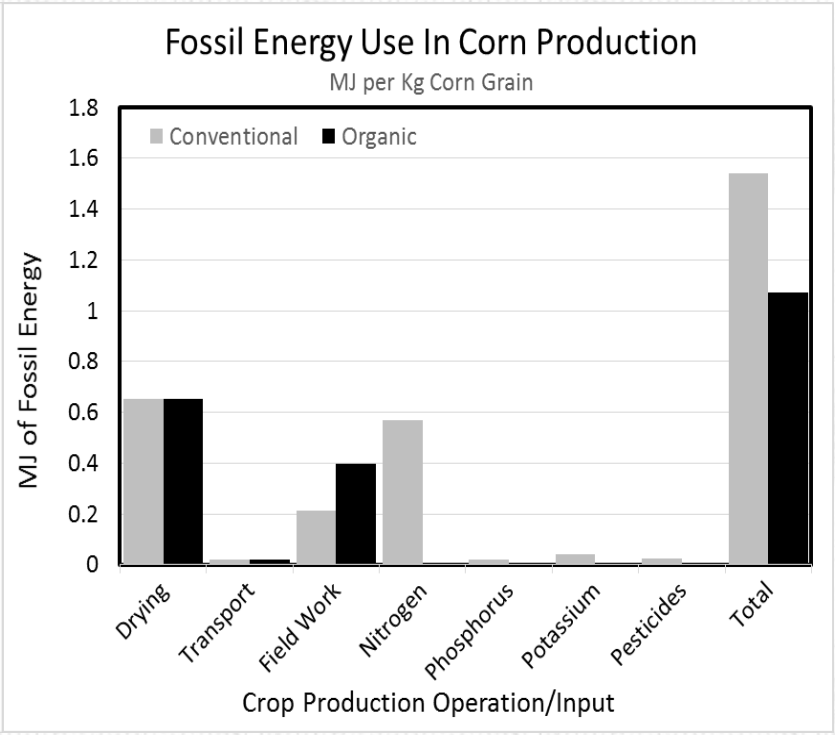
Total carbon footprint:

1.78 lb CO2e/lb live mkt pig

Preliminary estimate as of Jan. 2017

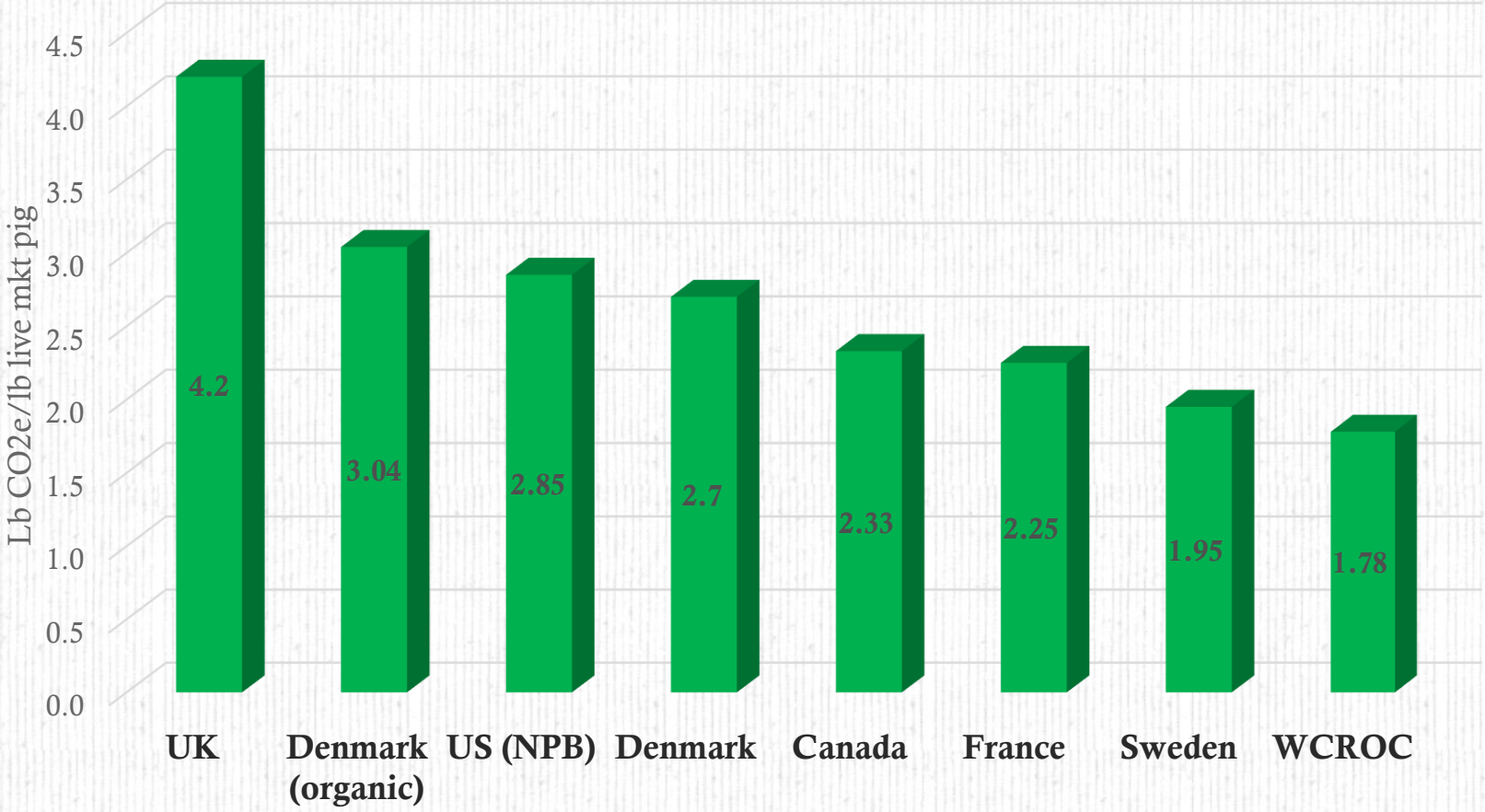
Fossil Energy Use





Preliminary data- current as of Fall 2015

Comparison of Carbon Footprints for Market Pigs



Summary

- Consumers and market chains will likely continue demanding:
  - Reduced carbon footprint
  - More environmental sustainability
- Producers have tools to reduce fossil fuel use without compromising animal performance and comfort
- Changes will likely be driven more by consumer demands than economic benefit to producers

Summary

- Possible approaches for producers to meet consumer demands:
  - More efficient piglet heating systems
  - Improved ventilation systems
  - Higher efficiency lighting
  - Reduced nocturnal temperature regimens
  - Capture “waste” heat (sows, exhaust air)
  - Generate electricity on-farm

Acknowledgements

- Swine: Adrienne Hilbrands, Mark Smith, farm staff
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  - Excel Energy
  - UM Institute on the Environment
  - UM Rapid Ag Response Fund
  - MN Environment and Natural Resource Trust Fund through the Legislative Citizen's Commission on MN Resources