Life Cycle Assessment of Commodity and Niche Swine Production Systems

What is Life Cycle Assessment (LCA) and why is it important as a research tool?
Life cycle assessment is a biophysical accounting framework that has been standardized by the International Organization for Standardization (ISO) to
• Compile an inventory of the material and energy inputs and outputs at each stage of a product life cycle, and
• Quantify how these flows contribute to specific resource use and emissions-related environmental impacts.

LCA research is being used to examine material and energy use, greenhouse gases, and other emissions associated with various livestock and crop production systems across the globe. To ensure sustainability in crop and livestock production systems, we must understand how current systems contribute to emissions, deplete resources, and affect waste streams. The authors chose to use LCA to examine various swine production systems in the Upper Midwest given its prevalent use world-wide as an eco-efficiency tool.

What was the role of the Leopold Center and ISU in this study?
Leopold Center Associate Director Rich Pirog began working with lead investigator Nathan Pelletier in 2008 using LCA to compare beef production systems. At the time Pelletier was completing an interdisciplinary Ph.D. in ecological economics at Dalhousie University in Nova Scotia, Canada. He also was working for a company he started, Global Ecologic Environmental Consulting and Management Services. Given the availability of swine performance data for both commodity and deep-bedded niche in the Upper Midwest, Pirog and Pelletier decided in late 2008 to conduct a similar comparison of swine production systems. Pirog engaged Pete Lammers, then an Animal Science doctoral student at Iowa State University, and ISU Extension swine specialist Dave Stender, given their experience and research in energy use and swine production efficiency. This team worked with Pelletier to
• design and review assumptions used in the study,
• provide Pelletier with swine production and energy use data appropriate to Iowa and the Midwest for the analysis, and
• co-write the paper with Pelletier after he ran the LCA model on the pork production systems.

Work began on this project in early 2009. In January 2010, a draft paper with research findings was submitted to the journal Agricultural Systems for peer review; the paper was accepted for publication in July 2010.

What was studied in this research?
We used LCA to measure impacts in two different pork production systems for two resource-use and two emissions-related impact categories:
• Cumulative energy use
• Ecological footprint
• Greenhouse gas emissions (primarily carbon dioxide, methane and nitrous oxide)
• Eutrophying emissions (excess phosphate and nitrate emissions that may contribute to poor water quality)

What were the major assumptions?
We wished to compare performance in these four environmental impact categories across commodity and deep-bedded niche swine production systems. We also compared the most and least profitable (per unit live-weight production) 20 percent of Upper Midwest farms in both systems for which we were able to access standardized data.

Commodity system assumptions: 2,400-sow unit producing 40-50,000 weaned pigs annually in climate-controlled, slatted-floor barns. Manure is handled as slurry in a central collection pit beneath the finishing barn before being applied to agricultural lands.
Deep-bedded niche system assumptions: 60-sow unit producing 650 weaned pigs annually in hoop buildings with cornstalk bedding and phase-specific space allowance guidelines; farrowing crates, gestation stalls, and sub-therapeutic antibiotics were not used. Manure is handled as a solid, and is scraped and stockpiled within 300 meters (about 980 feet) from the barn before being applied to agricultural lands.

Additional assumptions reflect conditions and systems in the Upper Midwest, including the following:
- Both commodity and niche systems use the same feeds.
- Manure volume is calculated on estimated daily manure rates and cleaning water use (based on previous ISU research). In-barn material and energy use was based on Lammers’ 2009 ISU research.
- Data on crop yields, fertilizer inputs and pesticide use come from NASS and ISU Extension publications or other statistical bulletins from Midwestern land-grant universities.
- Impacts were calculated for producing individual piglets and finished pigs in each system, as well as per kilogram of total live-weight production.

What were the key findings?
Feed use was consistently higher for low-profitability systems, both commodity and niche, except for lactation feed in the commodity system. Feed use also was consistently higher in niche compared to commodity production systems. There are larger differences in feed consumption between high- and low-profitability niche systems than in corresponding commodity systems. Deep-bedded niche pigs finish at slightly higher weights than commodity pigs and have substantially longer finishing times.

High-profitability operations have consistently lower environmental impacts across all four categories in both commodity and niche systems. On a per pig basis (both weaned and finished), environmental impacts in all four categories were lowest in the high-profit commodity system. Greenhouse gas emissions were lower in the high-profit niche system than in the low-profit commodity system. On a live-weight basis (per kilogram finished), the high-profit commodity system had the lowest environmental impacts across all four categories. However, because niche pigs finish slightly heavier, the high-profit niche system had lower greenhouse gas emission and cumulative energy use impacts than the low-profit commodity system. The difference in GHG emissions per kilogram live weight production between the high profit commodity and niche production systems was small, however.

Are these findings applicable anywhere in the United States or Canada? Why or why not?
No, study results reflect only the upper Midwest and results SHOULD NOT be applied to other regions. We used data and analysis from studies in the Upper Midwest, primarily Iowa and Minnesota. No full LCAs comparing different U.S. pork production technologies have been reported to date.

How could swine production systems be improved so that environmental impacts are lower?
It is important to note that the commodity system of producing high volumes of pigs has, in part, increased efficiencies due to significant and longer-term investment in research and education; the deep-bedded niche system represents a relatively recent system that has not been similarly optimized. For example, the data set we used to analyze the deep-bedded system represents the first extensive effort to analyze niche production efficiencies in the Upper Midwest. For the niche system, Improving swine herd productivity, optimizing diet formulation, and reducing losses from manure storage are critical, especially the niche system. In particular, the niche system diet should have the appropriate balance of amino acids to energy consumed since pigs in this system devote more feed energy to thermoregulation than do pigs in climate-controlled buildings in the commodity system. Greenhouse gas emissions may be reduced in the commodity system by managing manure as a solid and/or the use of methane digesters; using naturally ventilated hog buildings also will decrease energy use.

Did this study examine animal health or meat quality attributes between the systems?
The study did not examine these attributes. In addition, we did not examine variables such as biodiversity, quality of life of farmers and their neighbors, or job creation.
What else was learned from this study?
We were able to make good comparisons because one of the co-authors, through collaboration with the Pork Niche Market Working Group and the Iowa Pork Industry Center, collected extensive records on niche swine performance and efficiency. Much of the previous Iowa-based work on deep-bedded niche swine systems was made possible through funds from the Leopold Center in collaboration with ISU, Practical Farmers of Iowa, and other partners. To do LCA comparisons in other livestock or crops will require more funding and collaborative research on the alternative systems to produce similar robust data sets.

What other related LCA work on livestock production systems has been recently conducted?
The Leopold Center cooperated with the same lead author to conduct a LCA of beef production systems. The resultant paper, titled “Comparative life cycle environmental impacts of three beef production strategies in the Upper Midwestern United States” also was published in the journal, Agricultural Systems, and can be found at the Leopold Center website or on the journal’s website: Go to http://dx.doi.org and enter doi:10.1016/j.agsy.2010.03.009.

The Leopold Center also funded an Iowa State University Department of Economics graduate student to conduct LCA comparisons of dairy production systems, including grass-based. The work has been completed, but a paper has not been submitted yet for peer review and publication.

Where can I find other research on deep-bedded niche production systems for swine?
Numerous Iowa project reports on swine production using hoops can be found at the following websites:
- Leopold Center www.leopold.iastate.edu
- ISU Hoop Group: www3.abe.iastate.edu/hoop_structures/index.html
- Agricultural Marketing Resource Center: www.agmrc.org/commodities__products/livestock/pork/production_research_on_economics_and_profitability.cfm
- Pork Niche Market Working Group: www.leopold.iastate.edu/marketing/pork_niche_market

Where can I find this report?
A PDF of the Agricultural Systems journal article is on the Leopold Center website at: www.leopold.iastate.edu/ecology/resources.

You also can view the article: “Life cycle assessment of high- and low-profitability commodity and deep-bedded niche swine production systems in the Upper Midwestern United States” on the Agricultural Systems journal website: Go to http://dx.doi.org and enter doi:10.1016/j.agsy.2010.07.001.

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