Integrated Resource Management Tool to Mitigate the Carbon Footprint of Swine Produced in the U.S.
A Research, Extension, and Class Room Teaching Project

Project Rationale

• Agriculture strives to increase productivity, decrease costs and minimize environmental impacts.
• Climate change is a complex issue with large cost/benefit uncertainties.
• Climate change has highly uncertain impacts.
• The livestock revolution – global increase demand for animal protein.
• Gaps in understanding exist, impairing our ability to make fully informed decisions.

Project Goals and Objectives

• Project Goal:
  – To produce a fully integrated process-based systems analysis and decision support tool (LCA and LCC) for on-farm use, education, outreach, and policy support.

• Objectives:
  1. Experimentally evaluate the effectiveness of select strategies:
     – Dietary (reduced nitrogen, growth enhancers).
     – Health status (viral exposure).
     – Manure management (solids separation, algal nutrient removal, thermoconversion).
  2. Expand and enhance LCA model providing a tool to identify economic production options which minimize GHG emissions and increase sustainability.
  3. Implement education and outreach programs linking life cycle analysis, climate and swine science, to foster life cycle thinking in agriculture: understanding the system.

Roles of Contributing University PIs

- **University of Arkansas:**
  - Model development; nitrogen reduction study; manure treatment technologies (ATS, gasification, separation); REU home; extension coordination.

- **Virginia Tech:**
  - Health status experimental work; manure treatment simulation; animal physiology modeling (with UA).

- **Purdue University:**
  - Full-scale, fully instrumented experimental trials on nitrogen reduction and effects of health status on GHG emissions.

- **DNDC Applications, Research and Training:**
  - DNDC development and integration (with UA)

- **Livestock Poultry Environmental Learning Center:**
  - Multi-state extension and education

Expected Benefits of Project Efforts

- Create a decision support tool for farmers and consultants.

- Assist in determination of economic and environmental effects of alternate management scenarios.
  - Help analyze cost optimization of GHG mitigation strategies.
  - Help produce benchmark reductions in GHG emissions, including comparative economic evaluation.

- Create a research, education and policy support tool
  - Economic projection may guide policymakers and farmers in driving adoption rates of new technology.

This Project Builds on

- Based on LCA and CF model
  - University of Arkansas
  - National Pork Board

- Released at 2011 World Pork Expo

- Available at [www.pork.org](http://www.pork.org)

Overview of the Model

- The model lists GHG emissions by type and source to enable comparisons of variations in facilities and operations.
- For use by the producer and consultants using known or easily determined inputs.
- A “predictive model”, to estimate how much feed, electricity, gas, and propane are used and how much manure is produced.
- Model improvements supported by this project
  - Updating the GHG emissions model (LCA).
  - Adding an Economic evaluation portion (LCC).
  - Converting program language to C# to enable integration with DeNitrification and DeComposition (DNDC).

Model Information Flow

Inputs
Location
Size of Operation
# pigs, culling, delivery
Barn characteristics
Type of Manure System
 treatment, spreading
Types of Feed
Heating/Cooling System
Water Consumption

Farm Model Predicts
Pig Population Profile
age, weight, farrowing
Feed Consumed
Manure Produced
Electricity Used
Fuels Used

GHG Model Calculates
CO₂, N₂O, and CH₄ Emissions
by source in farm

Cost of Reduced Emissions
$ / kg CO₂ reduced emission

LCA–LCC Modeling Overview

- Conduct differential cost analyses ($ per kg GHG reduction)
  - Estimate the cost of reducing GHG emissions associated with multiple portions of barn and farms simultaneously.
- Focal Points:
  - Linking of economic analytical tools with GHG emissions model to identify costs and benefits of adopting swine management practices that reduce GHGs.
  - Use optimization models and sensitivity analyses to search for production management practices that minimize GHG emissions and production costs.
  - Evaluate how volatility in input costs can impact estimates of costs, and benefits of adopting different management practices.
- Current Status:
  - Ongoing development of economic portions of the model:
    - Manure component operational costs, labor costs.
    - Integration of feed component data from initial N-mitigation studies results.
  - Developing economic linkages with the demographic portions of the model.

**DNDC Model Overview**

- DNDC consists of two components:
  - Component one involves three sub-models and converts primary drivers (i.e., climate, soil, vegetation and anthropogenic activity) to soil environmental factors (i.e., temperature, moisture, pH, Eh and substrate concentration gradient).
  - Component two consists of nitrification, denitrification and fermentation sub-models.
    - Simulates production/consumption of N\(_2\)O, NO, N\(_2\), NH\(_3\), and CH\(_4\) driven by the modeled soil environmental conditions.

- **Focal Points:**
  - Perform model validation for each mitigation option within the scope of the LCA-LCC model.

- **Current Status:**
  - Ongoing implementation of merging Manure-DNDC with existing model.
  - Manure-DNDC to replace the current manure system to enable quantification of regional GHG reduction opportunities by mitigation option.

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**Nitrogen Mitigation Studies Overview**

- Maximizing crystalline amino acid use and reducing dietary crude protein in swine diets has been shown to dramatically reduce nitrogen excretion in both nursery and growing/finishing swine.

- **Focal Points:**
  - The wean-to-finish facilities are housing a 3 phase nursery, and a 5 phase grow/finish feeding program (U of A).
    - Feed trials consist of a Ractopamine supplement during the final 3-week phase.
      - Identify diets that maximize use of crystalline amino acids.
      - Minimize crude protein without negatively impacting gain, carcass composition or quality.

- **Current Status:**
  - Awaiting carcass data for use in building model data relative to carcass basis.
  - Nursery N-excretion trials preparing to commence.
    - Output data will be used to validate and adjust NRC equations and estimate GHG emissions.

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**Health Status Overview**

- Our working hypothesis is that immune activation, from clinical and subclinical disease, reduces growth performance, increases nutrient excretion, and increases GHG emissions from manure management.

- **Focal Points:**
  - Test the effect of vaccination on pig growth and GHG emissions through conducting full-scale trials at the Swine Environmental Research Building (SERB) at Purdue University.
    - Validate results of pilot studies at Arkansas and Virginia Tech.
    - Evaluate the impact of low CP, amino acid supplemented diets on GHG emissions.
    - Evaluate the effects of health status on GHG emissions.

- **Current Status:**
  - The Salmonella portion of health status experiments is expected to begin in late August 2012.
Animal Physiological Model Overview

- Prediction of GHG emissions from swine manure requires knowledge of N and volatile solids content.
- Focal Points:
  - Enhance the NRC swine model (1998) with equations to predict fecal flow of volatile solids and N and urinary N output.
  - Enhance the NRC Growth and N retention models through inclusion of results from this project’s concurrent studies on Ractopamine (U of A); and health status effects on growth and rates of excretion (Purdue).
- Current Status:
  - Equation development for nutrient inputs/outputs for DNDC model.

Algal Turf Scrubber Overview

- Algal biomass offers many advantages over traditional energy crops:
  - Generates higher yields and requires smaller land area than other energy crops.
  - Algal growth systems can also act as tertiary treatment systems for wastewater.
  - Dramatically reduce nitrogen and phosphorus from wastewater.
- Focal Points:
  - Wastewater Treatment Process: Removal of Nutrients
  - Biomass Energy Feedstock Production: Reduce Carbon Footprint
- Current Status:
  - Recently completed installation of:
    - Water pumping system
    - Raceway control panel
    - Analog control systems
  - Presently conducting testing on pumping systems and calibrating flow-way water levels in preparation for trial-scale operations in the coming weeks.

Solids Separation Overview

- Focal Points:
  - Quantify the effect of various solid separation approaches on the chemical composition of the manure generated by the feed trials (U of A).
  - Generate the necessary manure solids for the thermo-chemical conversion.
  - Determine overall characteristics for the feed trial manure samples to provide additional validation data for the animal physiology sub-model.
- Current Status:
  - Completing ongoing construction of pilot scale mobile solids separation system:
    - Unit contains systems to allow for various combinations of mechanical screen and filter bag separation.
    - Features separation with and without chemical treatment.

Thermo-Chemical Conversion Overview

- An auger gasification system developed in the University of Arkansas, Bioenergy Laboratory at the Rice Research and Extension Center (RREC), may help to simplify the air gasification process for this type of biomass.
  - Algal biomass was gasified using the auger system during preliminary tests, bringing about system improvements to ensure smooth operation.
- Current Status:
  - Gasification trials utilizing the separated swine manure and algal biomass from concurrent sub-projects are slated to begin during the coming weeks, with emphasis placed on:
    - Monitoring BTUs of yielded producer gases
    - Monitoring changes in Carbon input and output ratios
- Long-term Goal:
  - To provide technology to convert swine manure and/or algal biomass to biofuel via a continuous gasification process.

Extension Overview

- Focal Points:
  - Deliver project yielded developments and outputs through sustained independent/collaborative information dissemination and educational/outreach efforts.
    - Arkansas Extension Technician coordinates with project PIs to translate research outputs into lay terminology.
    - Convey the resulting products to LPELC for posting in the appropriate venues.
      - LPELC developed web-pages with cross links to eXtension sites.
      - Project Web-page overseen by University of Arkansas.
  - Two state-level Extension efforts:
    - Arkansas
    - Indiana
- Additional Activities:
  - Regional professional meetings
  - 2012 World Pork Expo

REU Program Overview

- Focal Points:
  - This project’s REU program is a 10 week summer research program for undergraduate students, with a research focus on carbon footprint mitigation from agriculture.
    - Ongoing for the duration of this project.
    - The expected outcomes include:
      - Inspiring students to continue their education through graduate school.
      - Fostering an interest and competency in agricultural research.
  - REU Program Features:
    - Participating in skills development workshops.
    - Conducting project assignments with guidance from U of A faculty mentors.
    - Reporting of project results in dynamic presentation format.
    - Dorm-living
    - Extracurricular Activities
      - ‘Trips and Outings

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