A Systems Approach to Evaluating Manure-Based Fuel in Ethanol Production

Sharon Preece, Emalee Buttrey, Kevin Heflin, Gary Marek
Dr. Brent Auvermann, Dr. Robert DeOtte

West Texas A&M University
Texas AgriLife Extension Service
Texas AgriLife Research

Where We Come From

Image modified from Google Maps

5,166,000

Image modified from Google Earth

5,000 head

Image modified from Google Earth
Each year, the ethanol plant will:

burn 1,000,000,000 pounds of manure...
ferment 38,000,000 bushels of corn…

produce 105,000,000 gallons of ethanol...

and 1,800,000,000 pounds of distillers grains.

Annual Ethanol Production
105 Million Gallons

Billion Pounds – Dry Matter Basis

<table>
<thead>
<tr>
<th></th>
<th>Corn</th>
<th>WDGS</th>
<th>Manure</th>
<th>Ash</th>
</tr>
</thead>
<tbody>
<tr>
<td>Billion</td>
<td>1.8</td>
<td>0.63</td>
<td>0.65</td>
<td>0.23</td>
</tr>
</tbody>
</table>

Q:
Under what conditions is the production of ethanol using a manure-based fuel economically viable?

Q:
What are the implications of using feedstocks other than corn?
Q: **What are the implications of using fuelstocks other than manure?**

META Q: **How do we build a modeling tool to answer these and similar questions?**

_A systems approach…_

**EtOH**

**Integrated System Aspects**

- Mass
- Energy
- Environment
- Economics
- Policy

- natural gas (ng)
- electricity
- water
- corn
- manure (m)
- fossil fuel
- distillers’ grains (dg)
- ethanol
- gases
- water
- ash
Contracted
Independent

Fyd

Local Corn
Distal Corn

Local Other
Distal Other

LMU

EtOH

ash

EtOH
dg

water
ng
cattle

LMU

seed

corn
\[ q = q_1 + q_2 + \Delta s_1 \]

where: \( q_i = \Psi \cdot q_{i\text{max}}, \quad [0 \leq \Psi \leq 1] \)

**Factors Affecting \( q_i \)**
- Time of Year (T)
- Storage capacity (s)
- Collection radius (r)
- Price of fossil fuel (\( P_{\text{f}} \))
- Manure production rate (\( q_{m,FYD} \))
- Price of chemical fertilizer (\( P_{\text{cf},i} \))
- Fertilizer Value (\( FV_{\text{NPK}} \))
- Fuel Value (\( Q_{\text{HHV}} \))
- Agronomic Rate (\( q_{m,LMU} \))
- HHV Demand (\( D_{\text{HHV}} \))
- NPK Demand (\( D_{\text{NPK}} \))
Determining Maximum $q_1$

Fertilizer Value = $F_{VNPK}$

- Determined by nutrient concentration = $min (F_{VN}, F_{VP}, F_{VK})$
- NPK demand = $(D_{NPK})$
- Agronomic rate = $q_{aLMU}$
- Range (% db)
  - $0 \leq F_{VN} \leq 2.7$
  - $0 \leq F_{VP} \leq 0.9$
- Demand (% db)
  - $D_{nP} = 2$ tons/acre/yr

Determined by:

\[
q_1 = f(q_{aLMU}, F_{VNPK}, q_{m,LMU}, D_{NPK})
\]

Determining Maximum $q_2$

Fuel Value = $V_{HHV}$

- Determined by percent moisture = $O_m$
- Percent ash = 0
- Range (BTU/lb)
  - $2758 \leq Q_{HHV} \leq 8500$
- Demand $Q_{HHV} = 8.25 \times 10^9$ BTU/day

\[
q_2 = f(q_{aLMU}, Q_{HHV}, D_{HHV})
\]

Heating Value of Manure

- Minimum Acceptable HV = 2,758 BTU/lb
- Arbitrary Target HHV = 3,500 BTU/lb
- Arbitrary Target HHV = 4,500 BTU/lb

Influence of HHV on Manure Throughput
Influence of HHV on Manure Throughput
Acknowledgements

Graham Hartmann
Jeff Merrell
Glen Green
Dr. Lance Baker
Dr. Bob Stewart

References


Auvermann, B.W., et al. 2007. An operational framework for systems modeling of animal feeding operations and associated agricultural activities. Texas Agricultural Experiment Station, College Station, TX. CREES Multistate Committee S-1032, working draft.


