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

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


15,000 head
Image modified from Google Earth

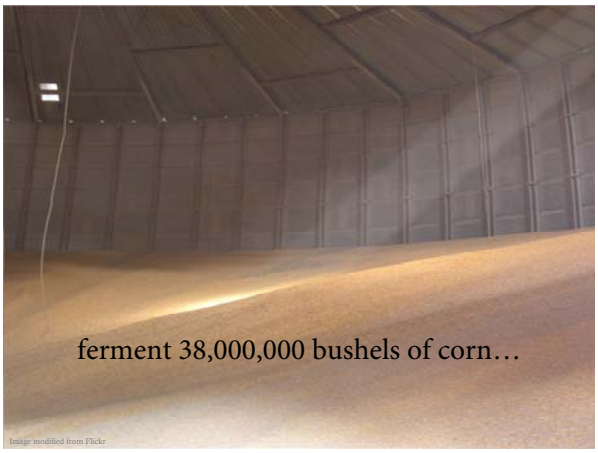

35,000 head
Image modified from Google Earth


42,000 head
Image modified from Google Earth


45,000 head
Image modified from Google Earth

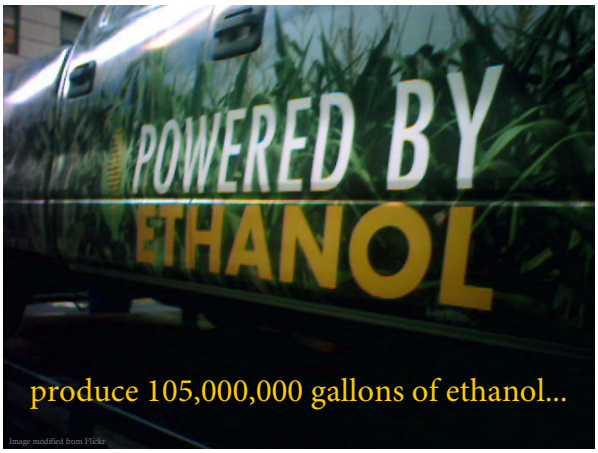

Ethanol Plant
Image by Emalee Buttrey


Each year,
the ethanol plant will:
burn 1,000,000,000 pounds of manure…



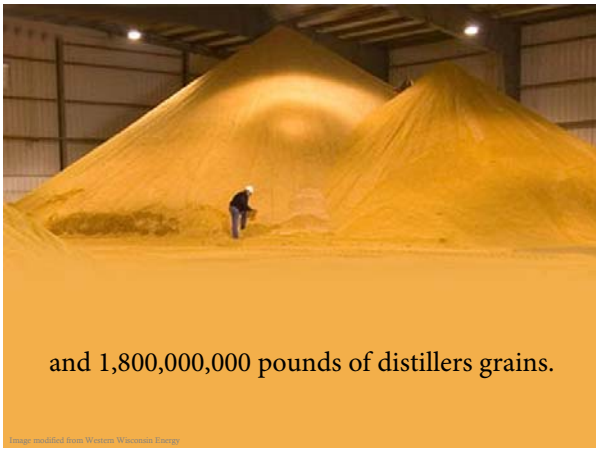
ferment 38,000,000 bushels of corn…

Image modified from Flickr



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

Image modified from Flickr



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

Image modified from Western Wisconsin Energy

Annual Ethanol Production 105 Million Gallons

Billion Pounds – Dry Matter Basis

Corn	WDGS	Manure	Ash
1.8	0.63	0.65	0.23

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:

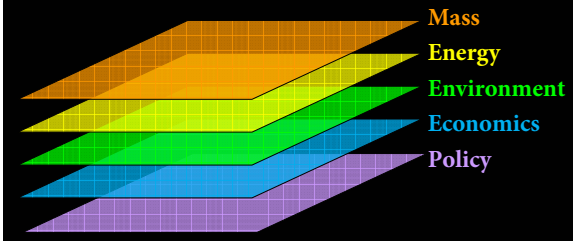
What are the implications of using fuelstocks other than manure?

Meta Q:

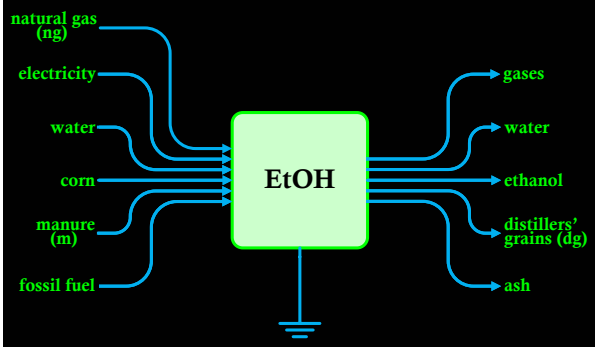
How do we build a modeling tool to answer these and similar questions?

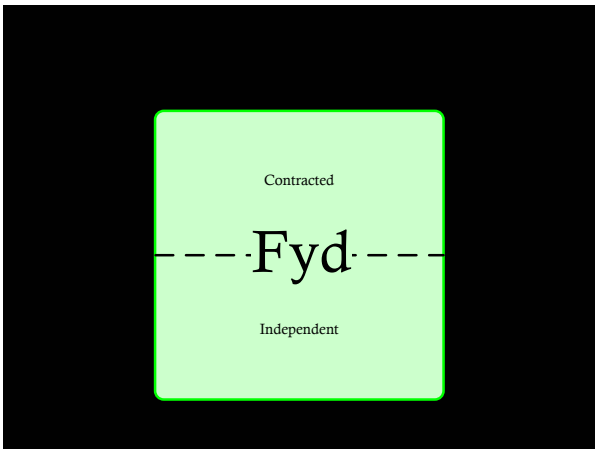
A systems approach…

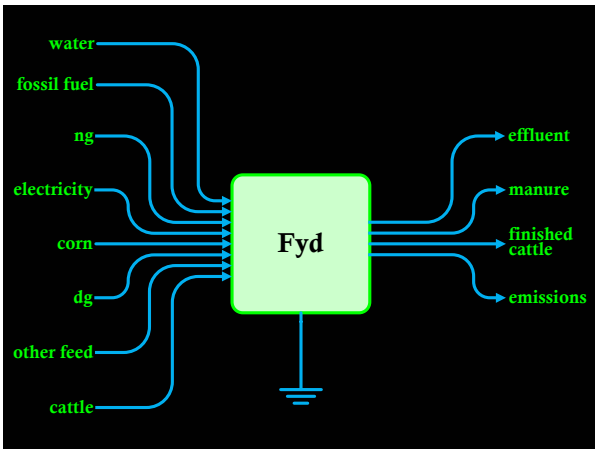
Integrated System Aspects

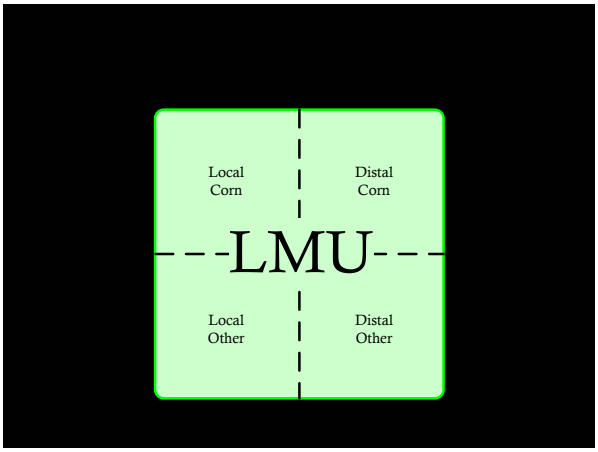


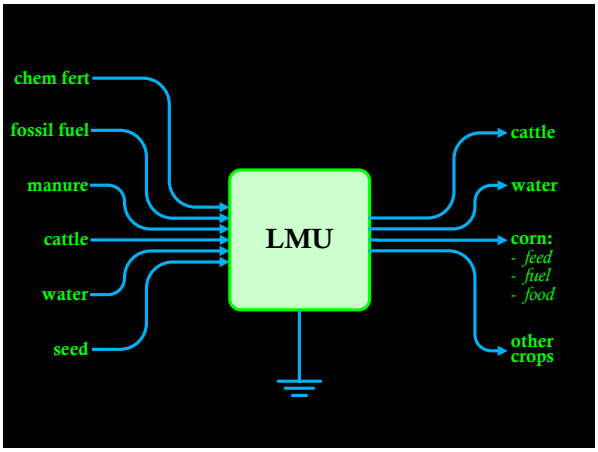
EtOH

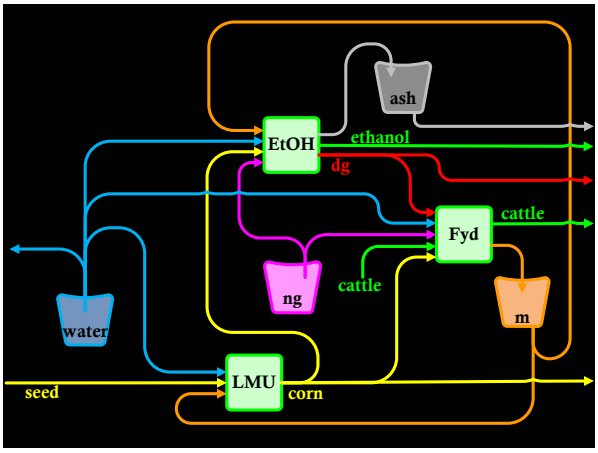


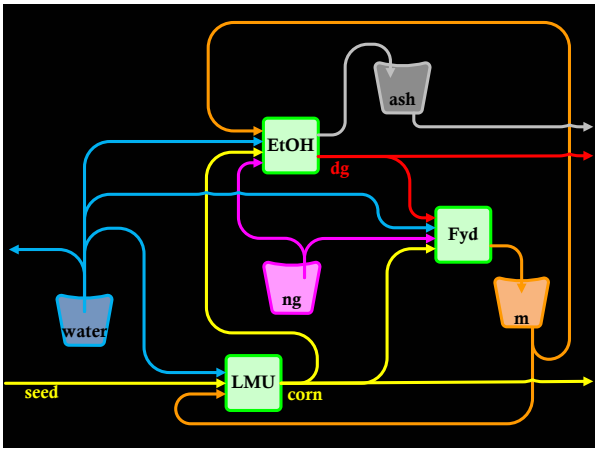

Contracted
Fyd
Independent

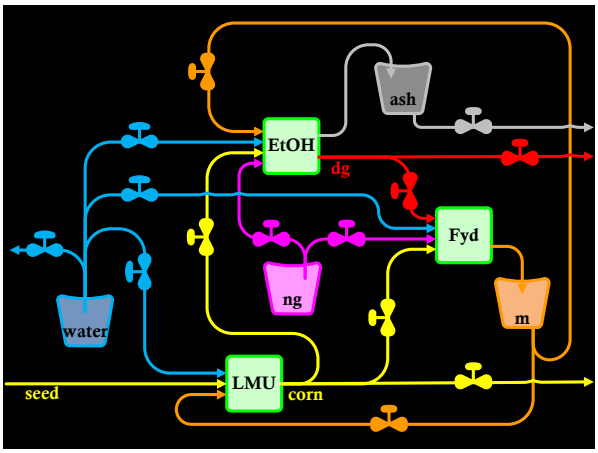

water
fossil fuel
ng
electricity
corn
dg
other feed
cattle
Fyd
effluent
manure
finished cattle
emissions

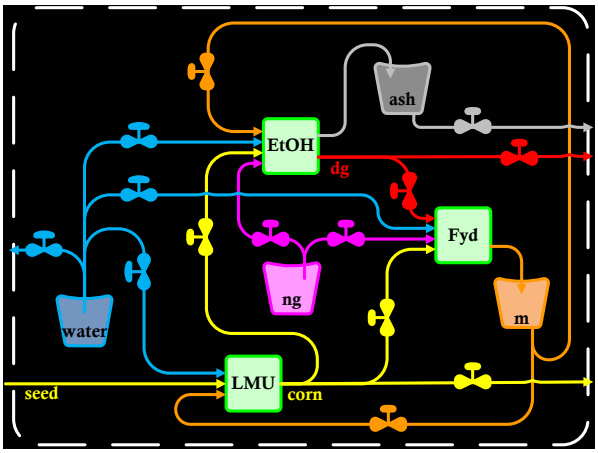

Local Corn
Distal Corn
LMU
Local Other
Distal Other

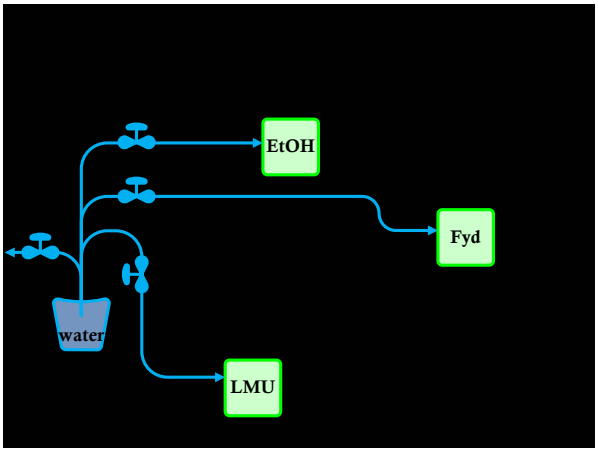

chem fert
fossil fuel
manure
cattle
water
seed
LMU
cattle
water
corn:
- feed
- fuel
- food
other crops

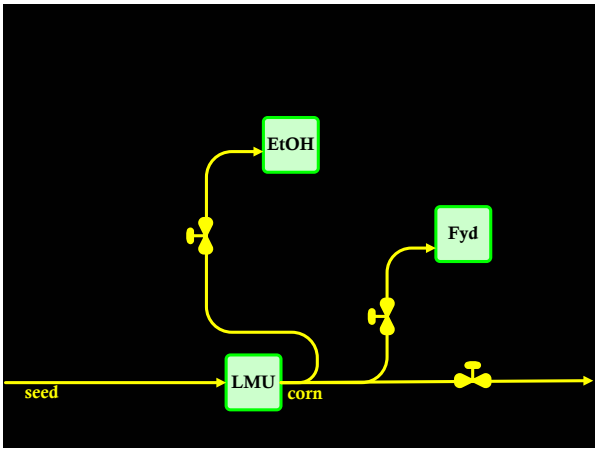

ash
EtOH
ethanol
dg
Fyd
cattle
ng
cattle
m
water
LMU
seed
corn

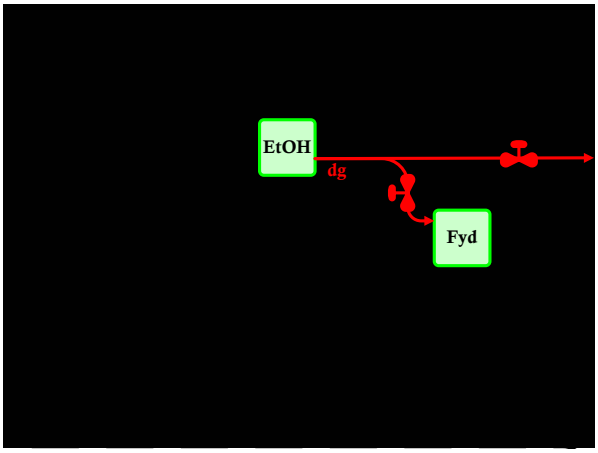

ash
EtOH
dg
Fyd
ng
m
water
LMU
seed
corn

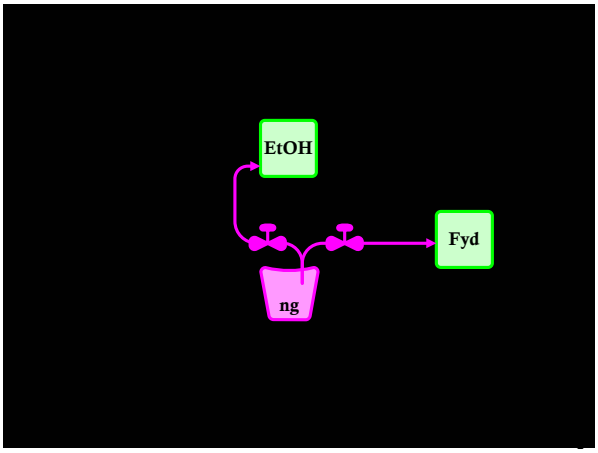

ash
EtOH
dg
Fyd
ng
m
water
LMU
seed
corn

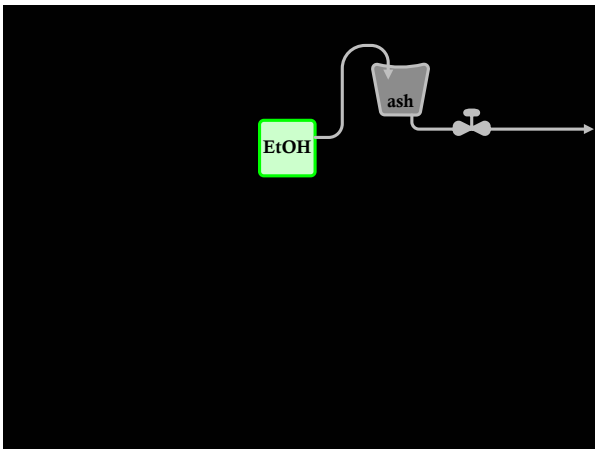

ash
EtOH
dg
Fyd
ng
m
water
LMU
seed
corn

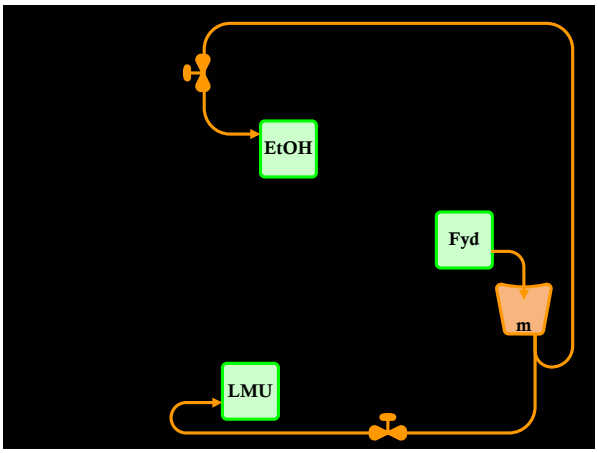

EtOH
Fyd
water
LMU

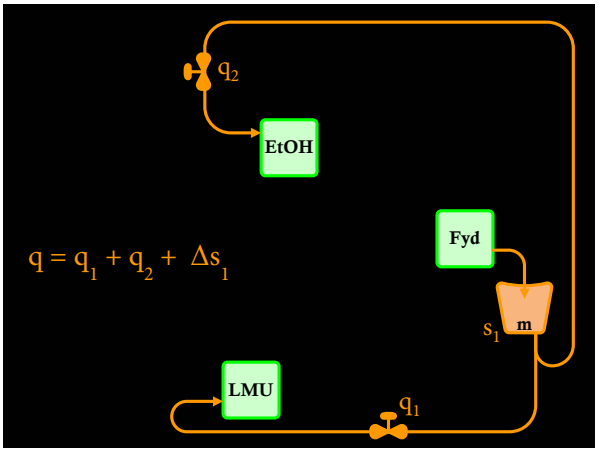

EtOH
Fyd
LMU
seed
corn

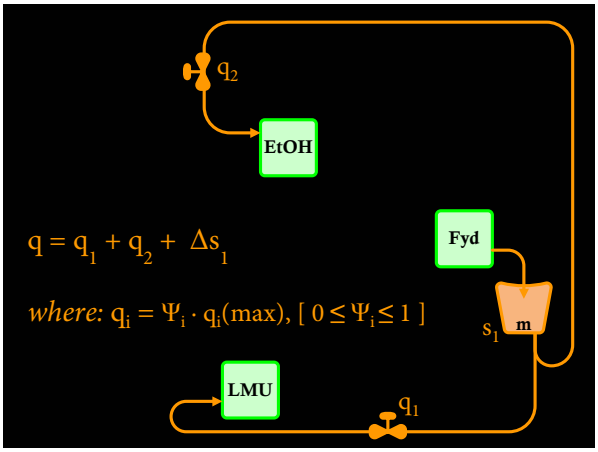

EtOH
dg
Fyd


EtOH
Fyd
ng



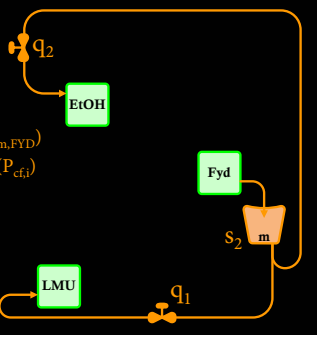






Factors Affecting q_i

- Time of Year (T)
- Storage capacity (s)
- Collection radius (r)
- Price of fossil fuel (P_{ff})
- Manure production rate ($q_{m,FYD}$)
- Price of chemical fertilizer ($P_{cf,i}$)
- Fertilizer Value (FV_{NPK})
- Fuel Value (Q_{HHV})
- Agronomic Rate ($q_{m,LMU}$)
- HHV Demand (D_{HHV})
- NPK Demand (D_{NPK})



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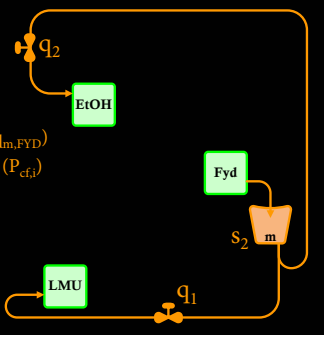
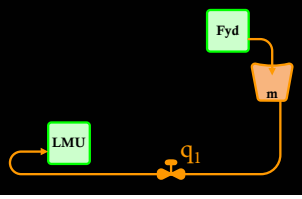


Determining Maximum q_1

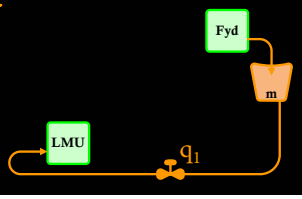
Fertilizer Value = FV_{NPK}

- Determined by
  - nutrient concentration = min (FV_N, FV_P, FV_K)
  - NPK demand = (D_{NPK})
  - agronomic rate = $q_{m,LMU}$
- Range (% db)
  - $0 \le FV_N \le 2.7$
  - $0 \le FV_P \le 0.9$
- Demand (db)
  - $D_P \approx 2$ tons/acre/yr



q_1

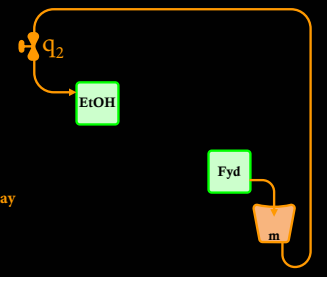
$q_1 = f$ { T, s, r, P_{ff}, $q_{m,FYD}$, FV_{NPK}, $q_{m,LMU}$, D_{NPK}, t }



Determining Maximum q_2

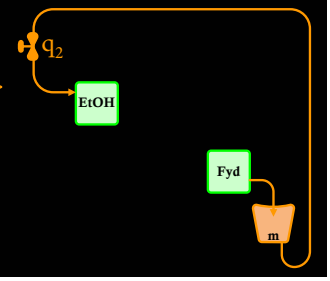
Fuel Value = V_{HHV}

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

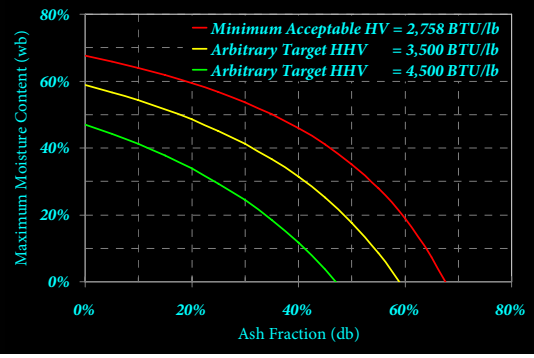


q_2

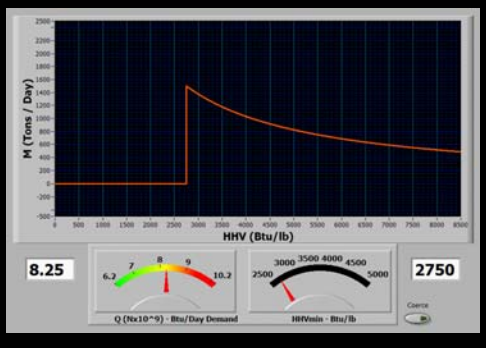
$q_2 = f$ { T, s, r, P_{ff}, $q_{m,FYD}$, Q_{HHV}, D_{HHV}, t }



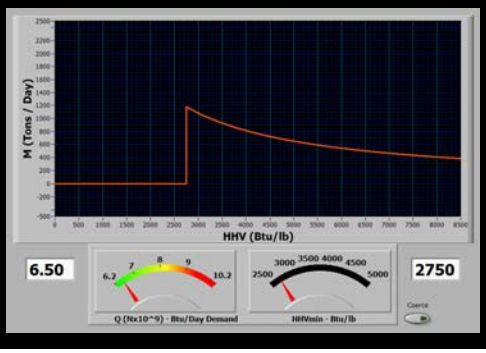
Heating Value of Manure



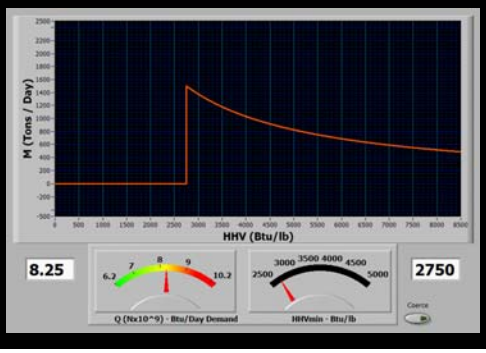
Influence of HHV on Manure Throughput



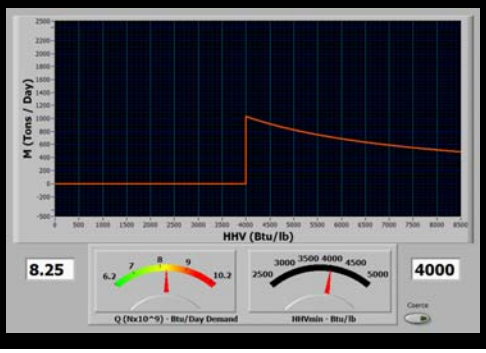
Influence of HHV on Manure Throughput

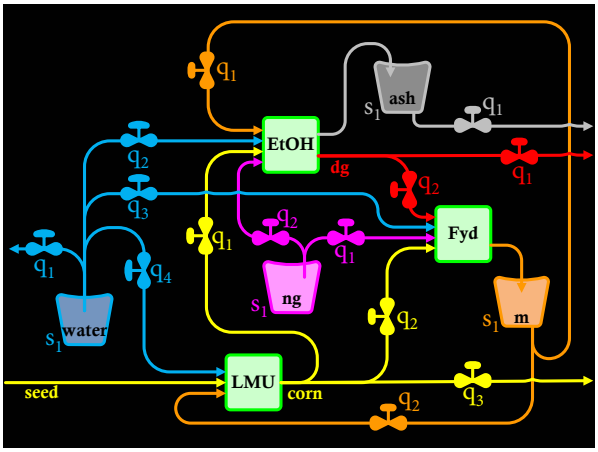


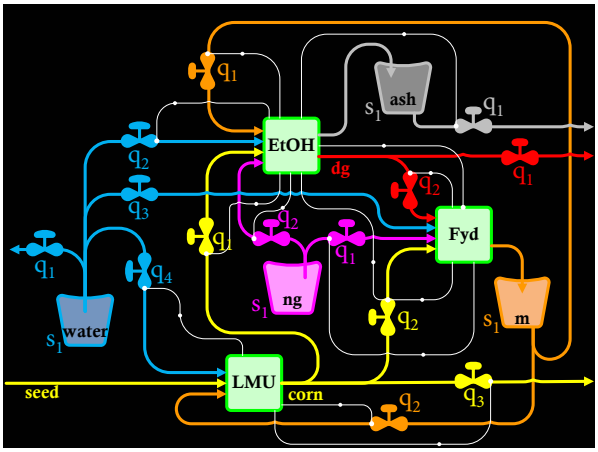
Influence of HHV on Manure Throughput

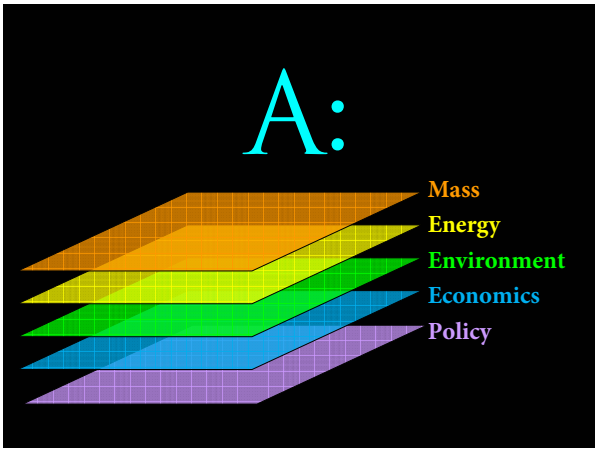


Influence of HHV on Manure Throughput









Acknowledgements

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

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