The Economics of Anaerobic Digestion

John H. Martin, Jr.
Hall Associates
Georgetown, DE

Economically, a decision to invest in anaerobic digestion is a rational investment decision if it provides :

- An competitive rate of return to the capital investment required, or
- A least cost solution to odor and/or other environmental quality problems.

Options for evaluating return on investment :

- Simple payback
- Equivalent uniform annual cash flow
- Present worth (net present value)
- Prospective rate of return

Simple Payback

- Only appropriate for under financed business ventures
- Ignores the time value of money
- Does not consider long-term consequences

Equivalent Uniform Cash Flow and Present Worth

- Trial and error methods to determine if an investment meets a given standard for attractiveness based on expected annual gross income.
- Require stipulation of a minimum rate of return that is attractive or an estimate of the cost of borrowed capital.

Prospective Rate of Return

- Eliminates trial and error calculations.
- Allows the direct determination if the rate of return is adequate to repay the cost of borrowed capital and provide an attractive rate of return to equity capital invested.

When properly applied, equivalent uniform cash flow, present worth, and prospective rate of return methods can provide equally valid results.

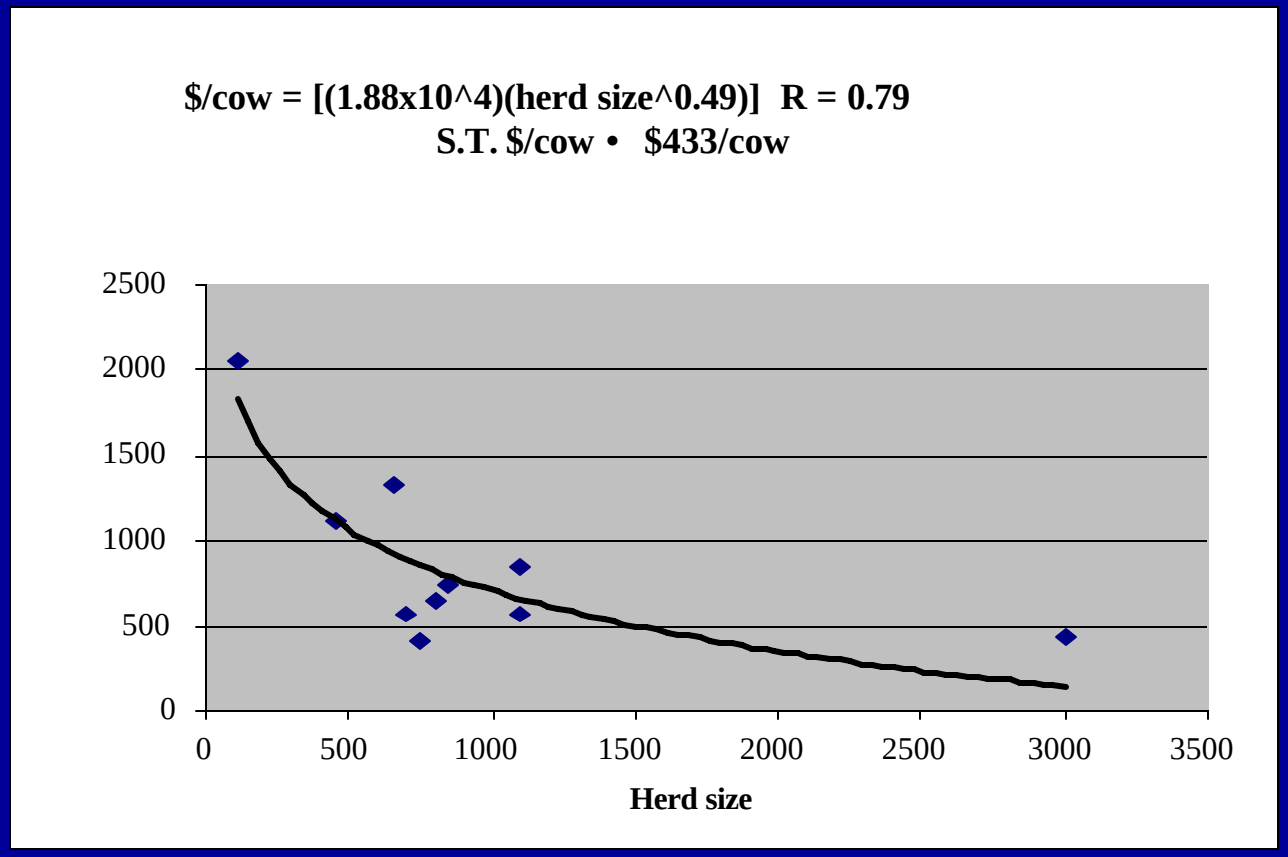
What do we know about the economics of anaerobic digestion?

- A substantial capital investment is required
- There are operation and maintenance costs
- Gross income depends on a several site specific factors

The capital investment required varies depending on:

- Site specific conditions (existing infrastructure, etc. that can be used),
- Scale (larger operations have lower unit capital costs), and
- The demand for digesters.

Capital cost of plug-flow anaerobic digesters as a function of herd size



Operation and maintenance costs

We need better information to accurately characterize their significance as a component of total annual cost.

Income depends on:

- What sources of income are included (biogas and ??),
- Available options for biogas utilization, and
- Marketing options.

Additional Sources of Income—A Boundary Condition Issue

- Primary and trace plant nutrients?
- Weed seed destruction?
- Separated solids?

Value of Biogas Depends on the Conventional Energy Source Replaced

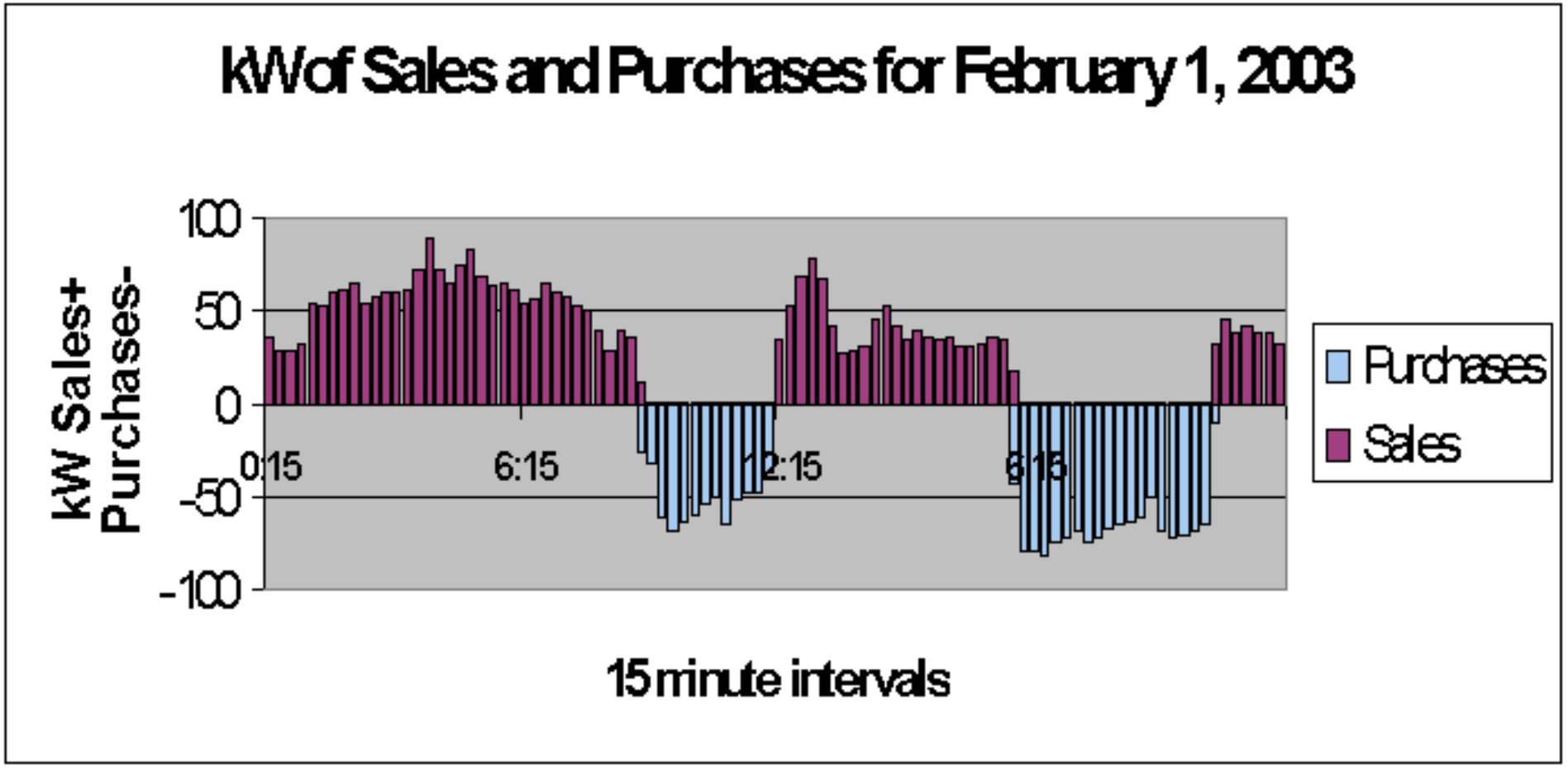
- No. 2 fuel oil @ \$0.97/gal—\$4.22/1,000 ft^3
- Propane @ \$1.10/gal—\$7.29/ 1,000 ft^3
- Nat. gas @ \$6.64/10^6 Btu—\$4.02/ 1,000 ft^3
- Electricity @\$0.05/kWh—\$2.66/1,000 ft^3

Why we always seem to end up using biogas to generate electricity:

- Demand for boiler fuels varies seasonally diurnally, and
- Surplus engine-generator set waste heat is available.

Value of Biogas Used to Generate Electricity Depends On:

- Local electricity rates and on-site demand
- Type of energy contract
  - Sell all-Buy all
  - Surplus sale
  - Net metering


kW of Sales and Purchases for February 1, 2003
kW Sales+ Purchases-
100
50
0
-50
-100
0:15
6:15
12:15
6:15
Purchases
Sales
15 minute intervals

The effect of type of energy contract on gross income per kWh of electricity generated using biogas

Assuming the following for a 550 cow digester:

- Generating capacity = 51,000 kWh/month
- On-site energy requirement = 34,500 kWh/month
- Electricity used on-site = 65% of generating capacity
- Peak demand = 70 kW @ $9.15/kW
- Price from grid = $0.085/kWh
- Price to grid = $0.05/kWh

Gross income per kWh generated

- Sell all-buy all—$0.050
- Surplus sale with no demand reduction—$0.065
- Surplus sale with 50% demand reduction—$0.072
- Net metering with no demand reduction—$0.074
- Net metering with 50% demand reduction—$0.080

Gross income per month

- Sell all-buy all—$2,550
- Surplus sale with no demand reduction—$3,335
- Surplus sale with 50% demand reduction—$3,655
- Net metering with no demand reduction—$3,768
- Net metering with 50% demand reduction—$4,087

Standby Charges!

Centralized Digestion

- Advantages
  - Economy of scale
  - Additional financing options
  - Greater leverage in negotiating an energy contract
- Disadvantage
  - Cost of transporting manure

What is the maximum average distance that manure can be transported?

Depends on:

- Income derived from digestion
- Unit transportation cost

Consider the following:

- One ton of dairy manure ~ 69 kWh,
- At $0.05/kWh, one ton of dairy manure ~ $3.45, and
- Truck transportation costs between $1.20 and $1.40 per ton-mile.

Conclusion:

The maximum average manure transportation distance for centralized digestion at $0.05/kWh appears to be less than one mile unless there is a tipping fee or some other source of income.