Energy in Agriculture
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Farm Methane Anaerobic Digester Systems

Robert Foster

OVERVIEW

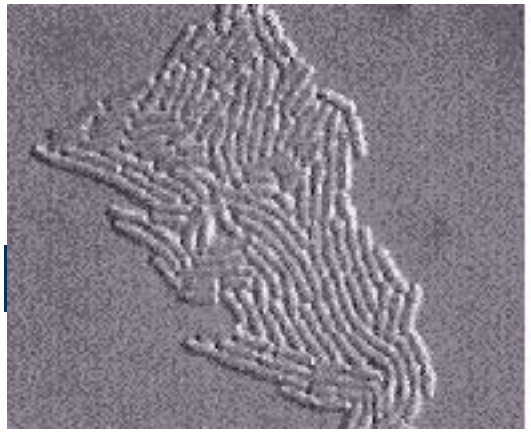
- Farm Anaerobic Digesters
- Project Success Factors
- Farm AD Project Finances
- Environmental Markets as a Financing Mechanism
- The Vermont Cow Power™ Experience
- The AgRefresh™ Model
- Why Farm AD Projects Are Beneficial
- Conclusions

Farm Anaerobic Digesters

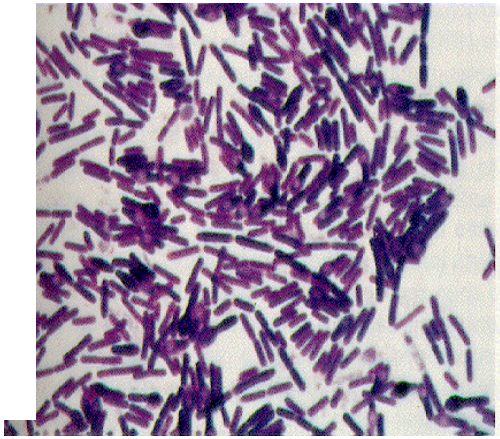
- What is Anaerobic Digestion?
- Feed Stocks
- Types of Digesters
- Integrated Approaches

The Work Horses of the Digester

- Methane production depends on methanogenic bacteria



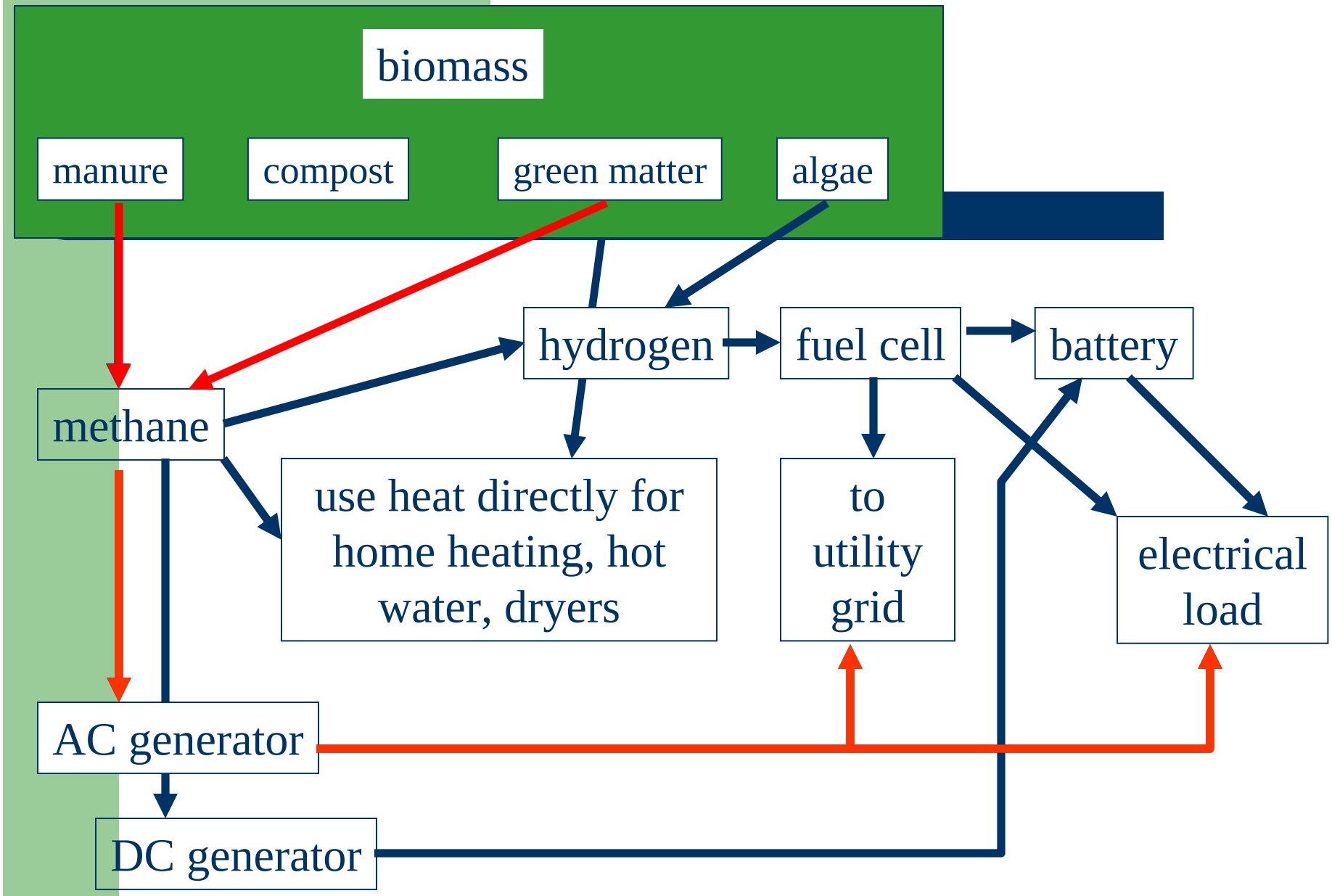
- Optimum growth temperature occurs mesophilic range (90-120 deg F}
- If temps rise to around 140 - 160 deg F, then thermophilic bacteria take over with quicker and greater gas production
- However at ~ 120-130 deg F, foaming may occur causing problems



Gas Values

- Biogas from digester is typically about 50 - 60%
  Pure methane has a heating value of ~1 000 BTU/ft^3
- methane
- The rest is CO_2, H_2S, and small amounts other gases
- Of these, only methane has heating value
- Therefore heating value of raw biogas tends to be about 500 BTU/ft^3

Possible Biomass Energy Paths



Types of Anaerobic Digesters

Covered Lagoon

- Low biogas output.
- Minimal change to manure handling

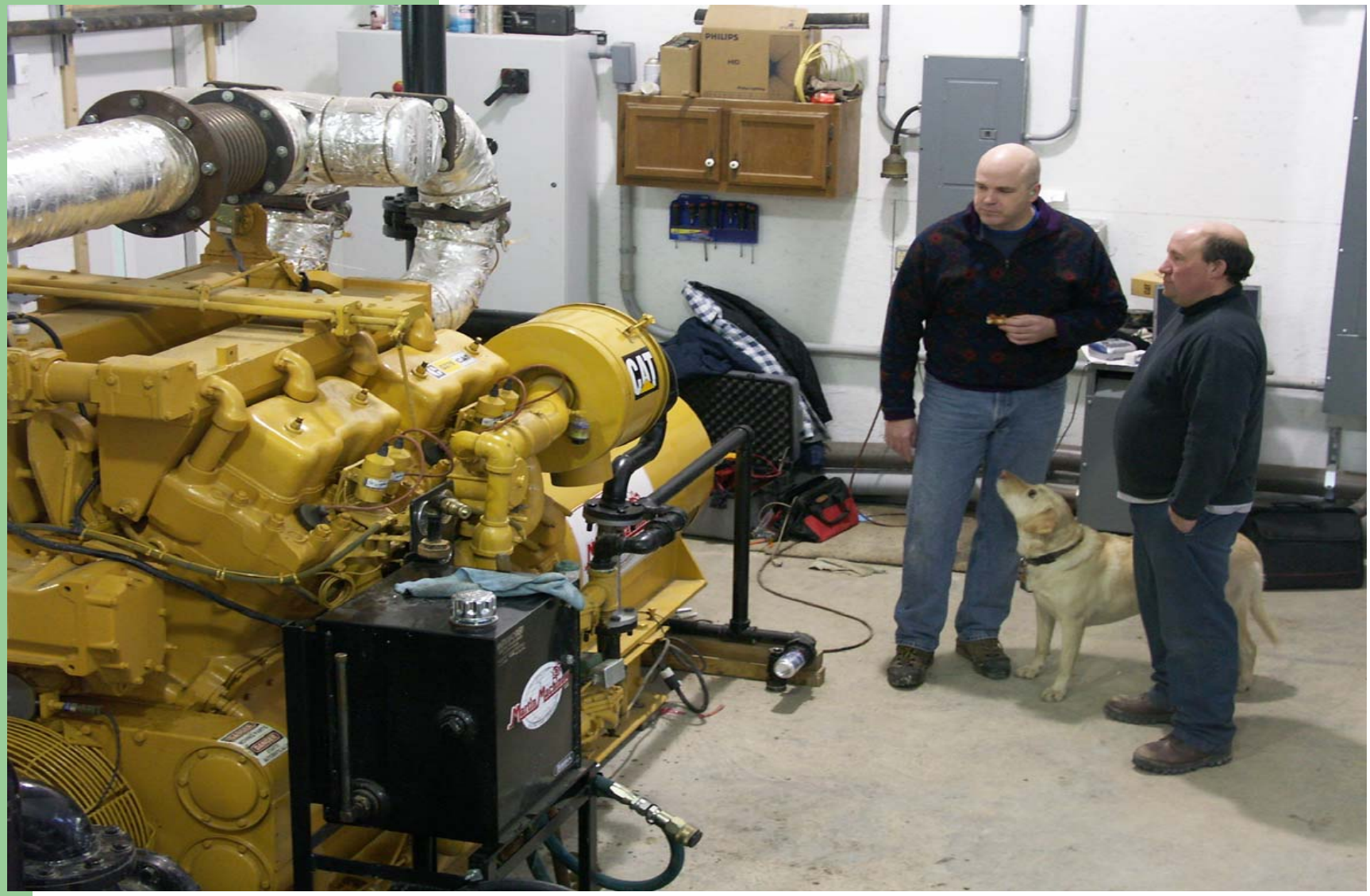
Plug Flow

- Handles manure slurries.
- Lower efficiency & longer retention of materials

Fixed Film

- Typically requires separation before digestion.
- Higher throughput of materials.
- Higher efficiency of VS conversion.

Audet’s Blue Spruce Farm Plug Flow Digester



Methane Powered Engine/Generator at Audets

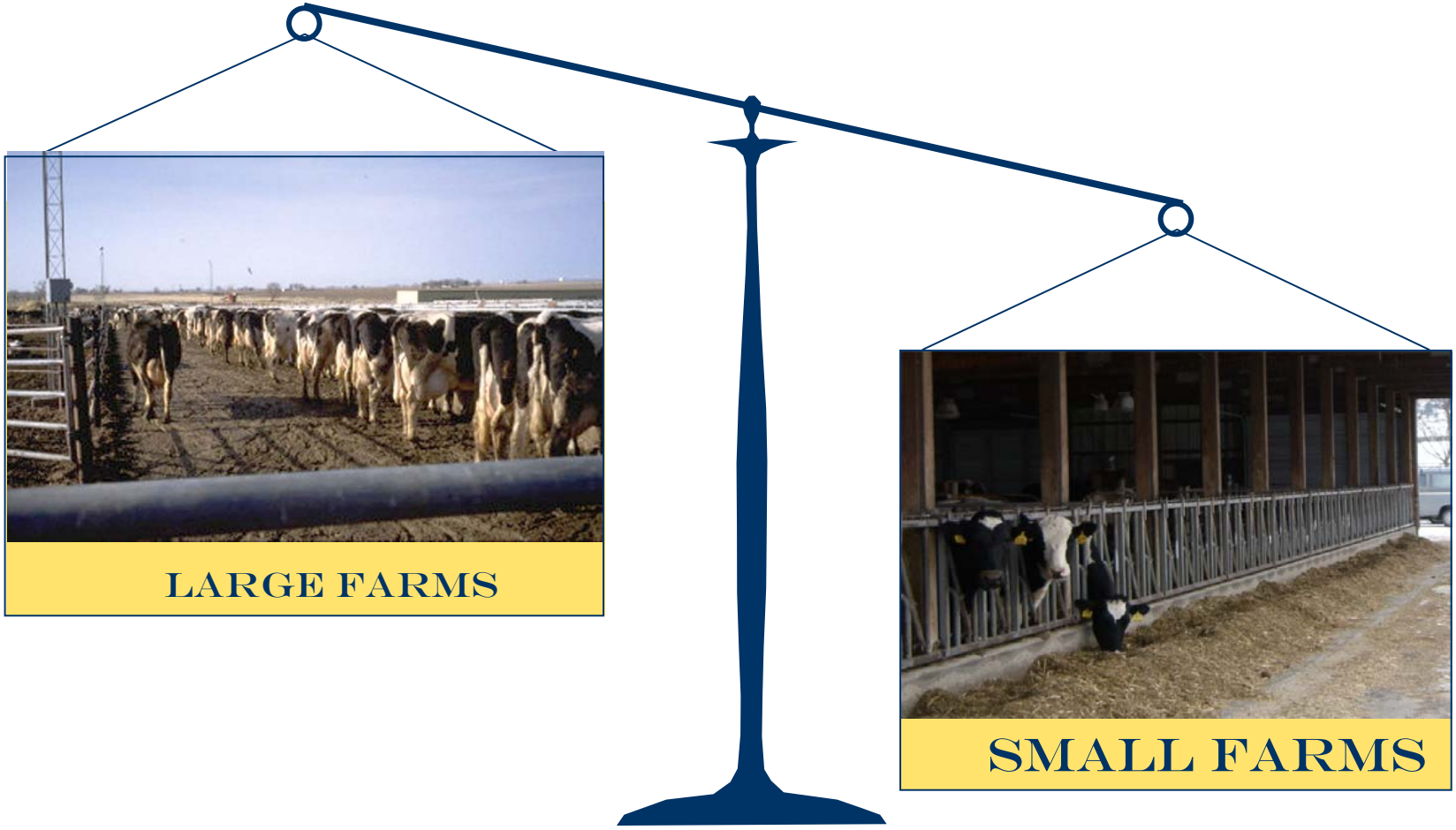
Austrian Crop Digester –Medium Size

Austrian 6 Partner Crop Digester/Power System

Large Austrian Corn Silage Fed Anaerobic Digester

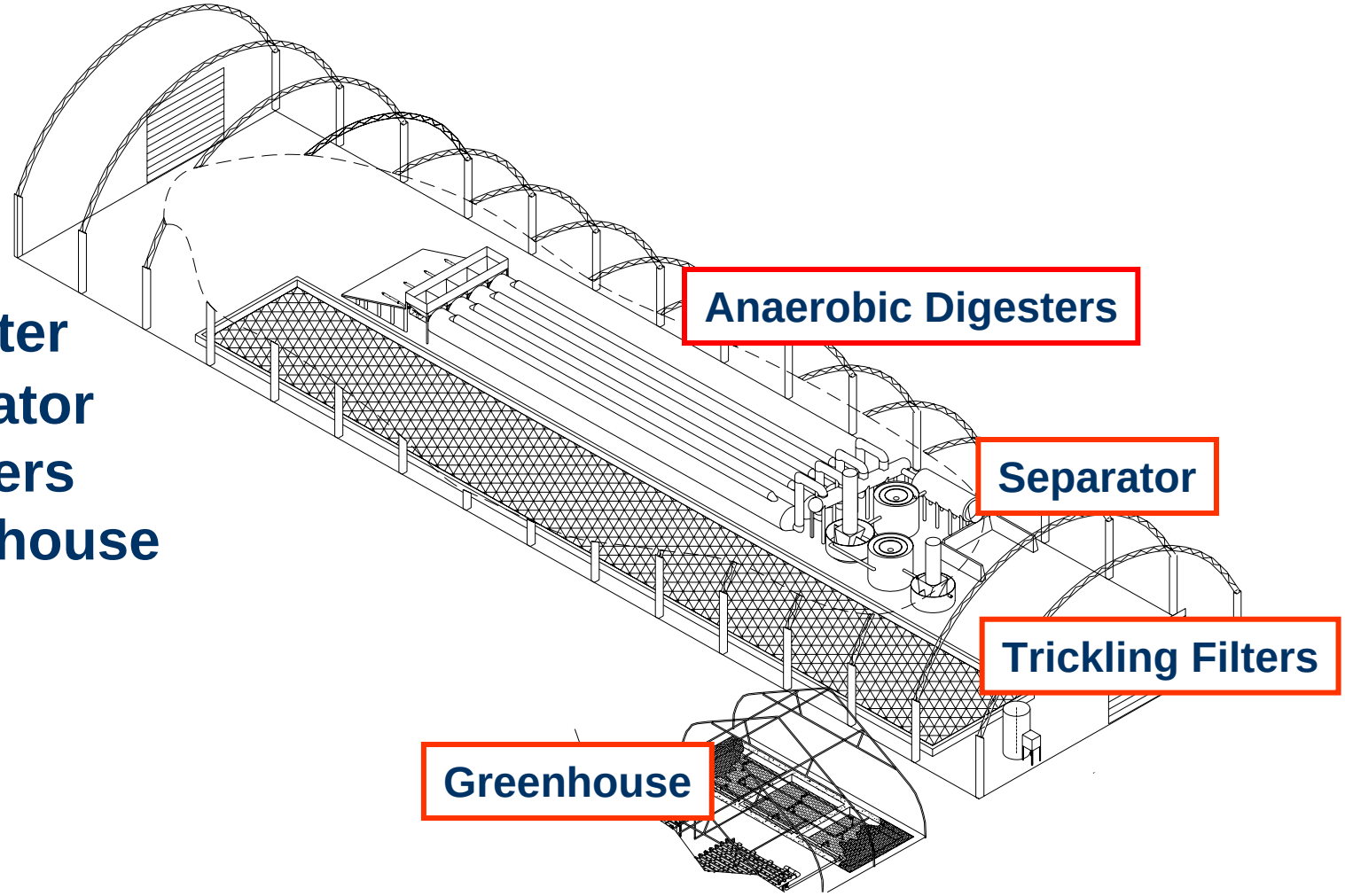
Small Farms *outweigh* Large Farms

…in animals, acres, & number of farms.

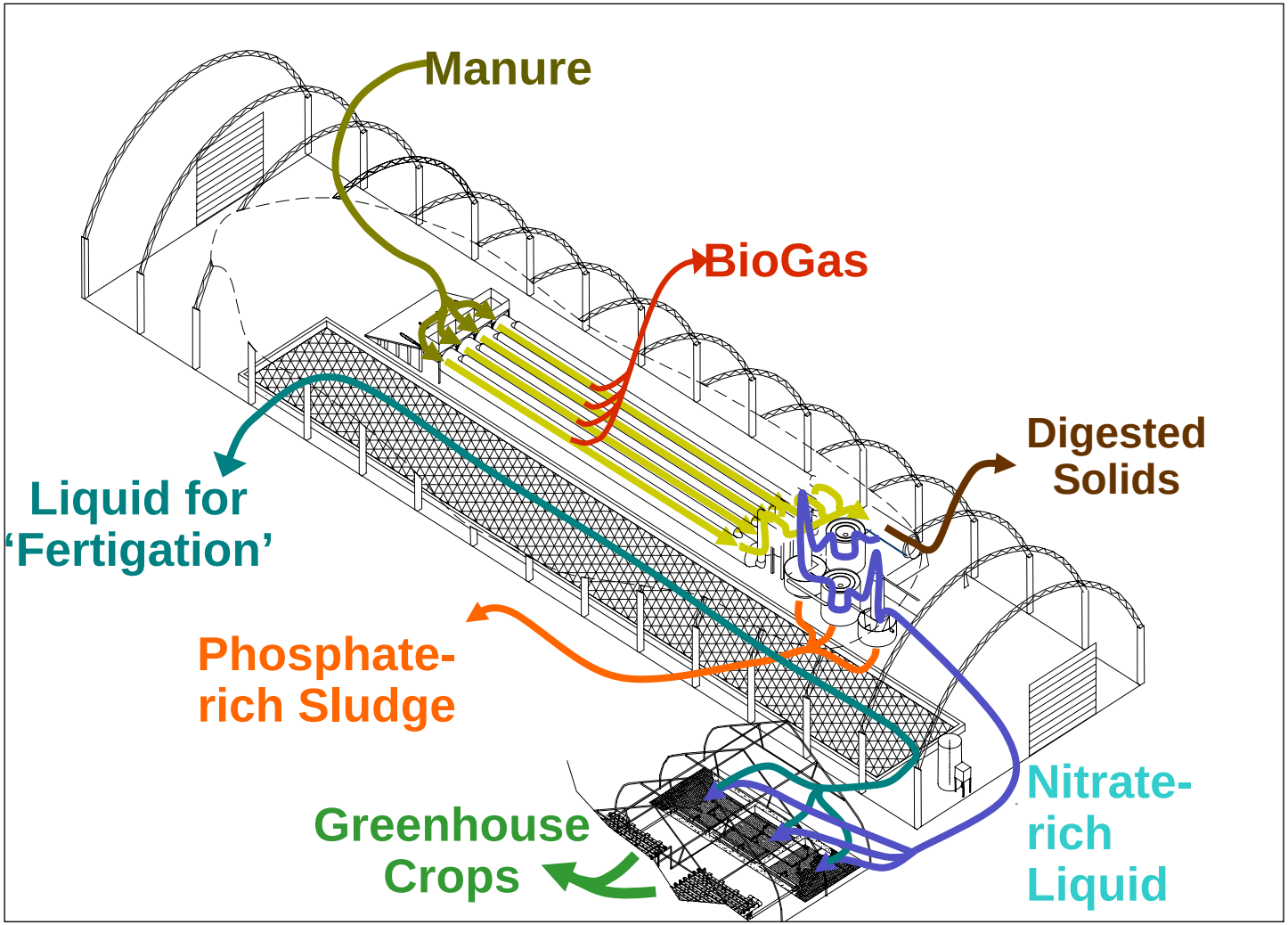


Avatar's Small Scale Integrated Digester System

- Digester
- Separator
- Biofilters
- Greenhouse

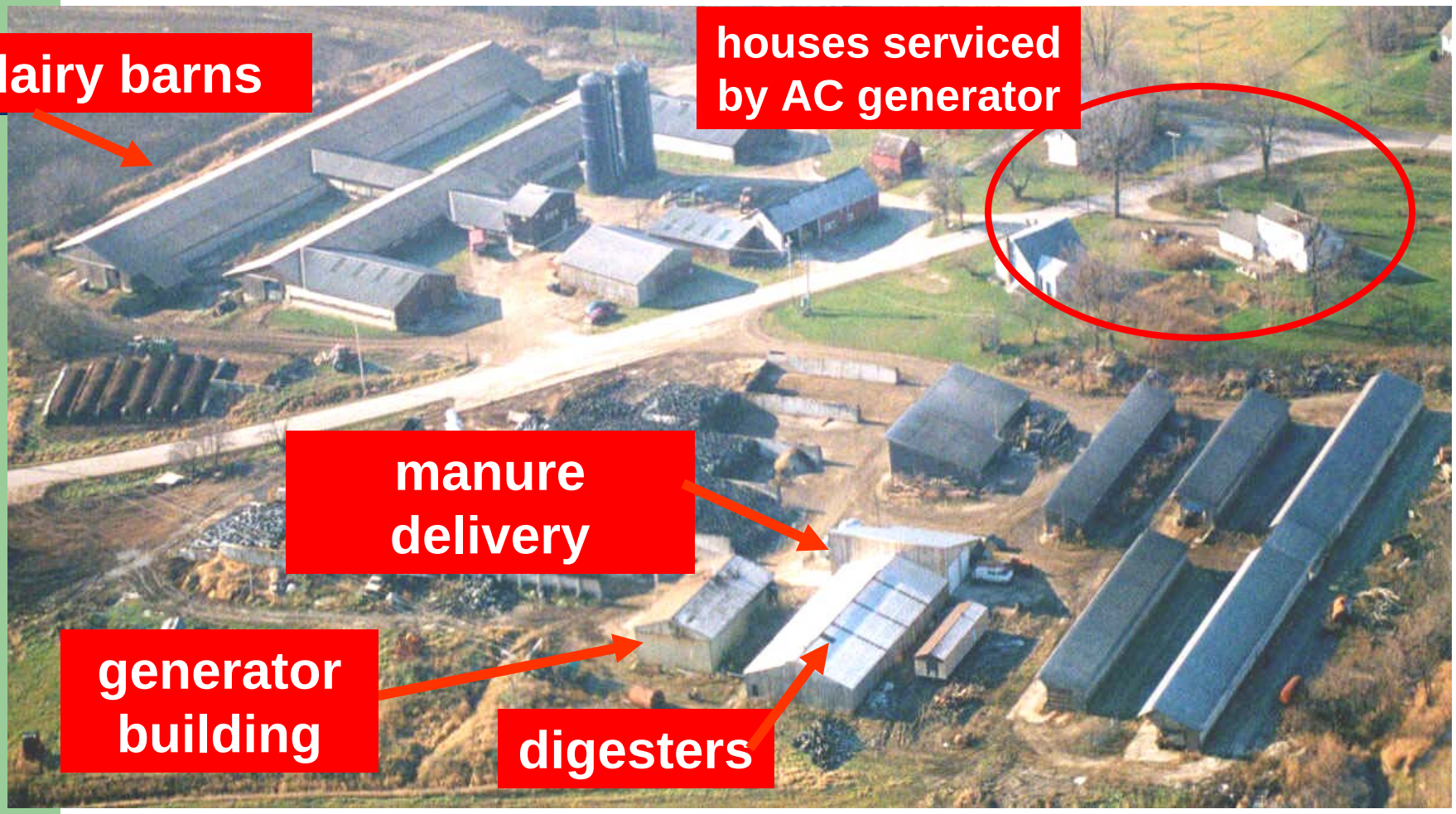


Avatar's: Materials Flow

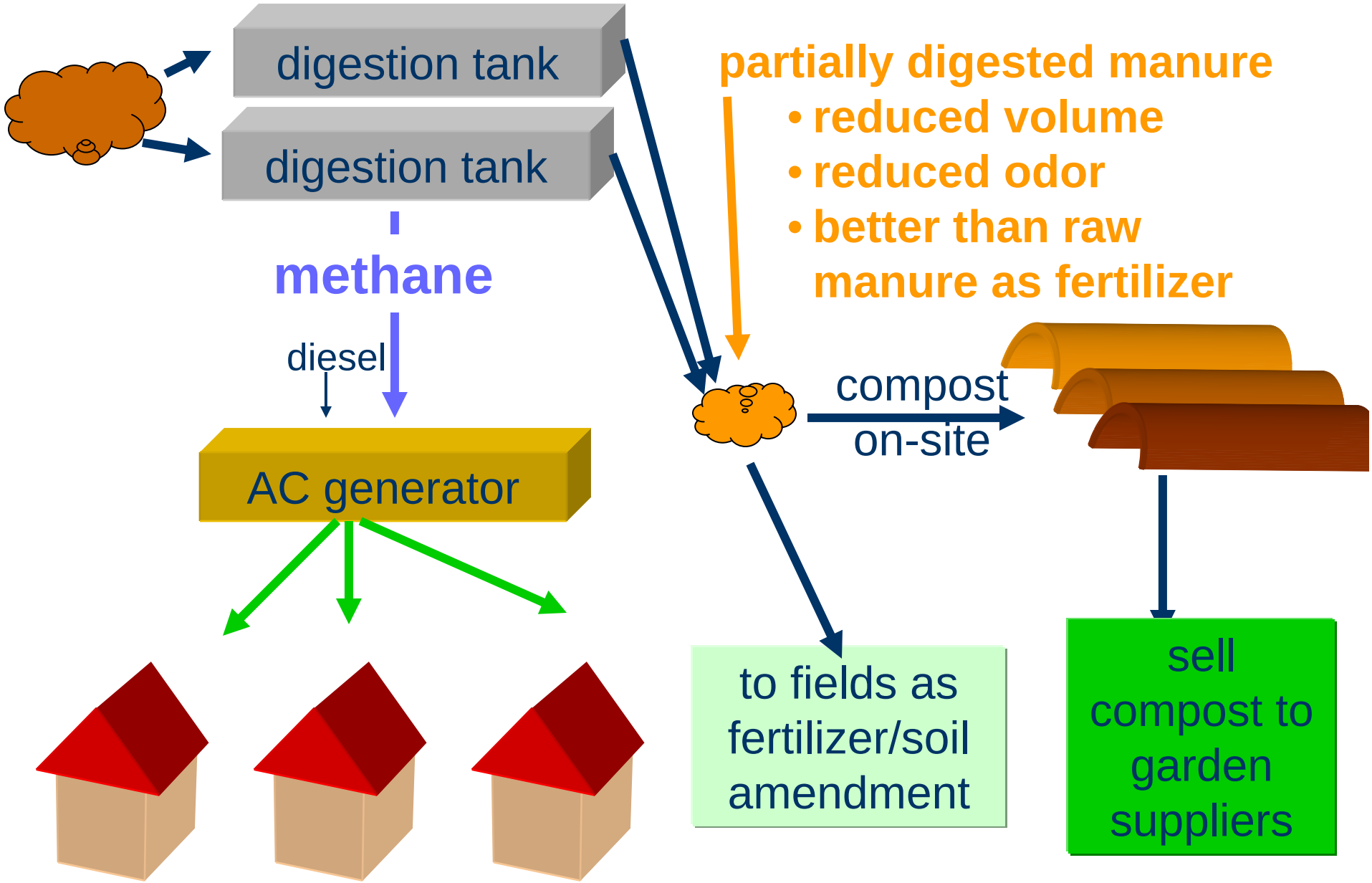


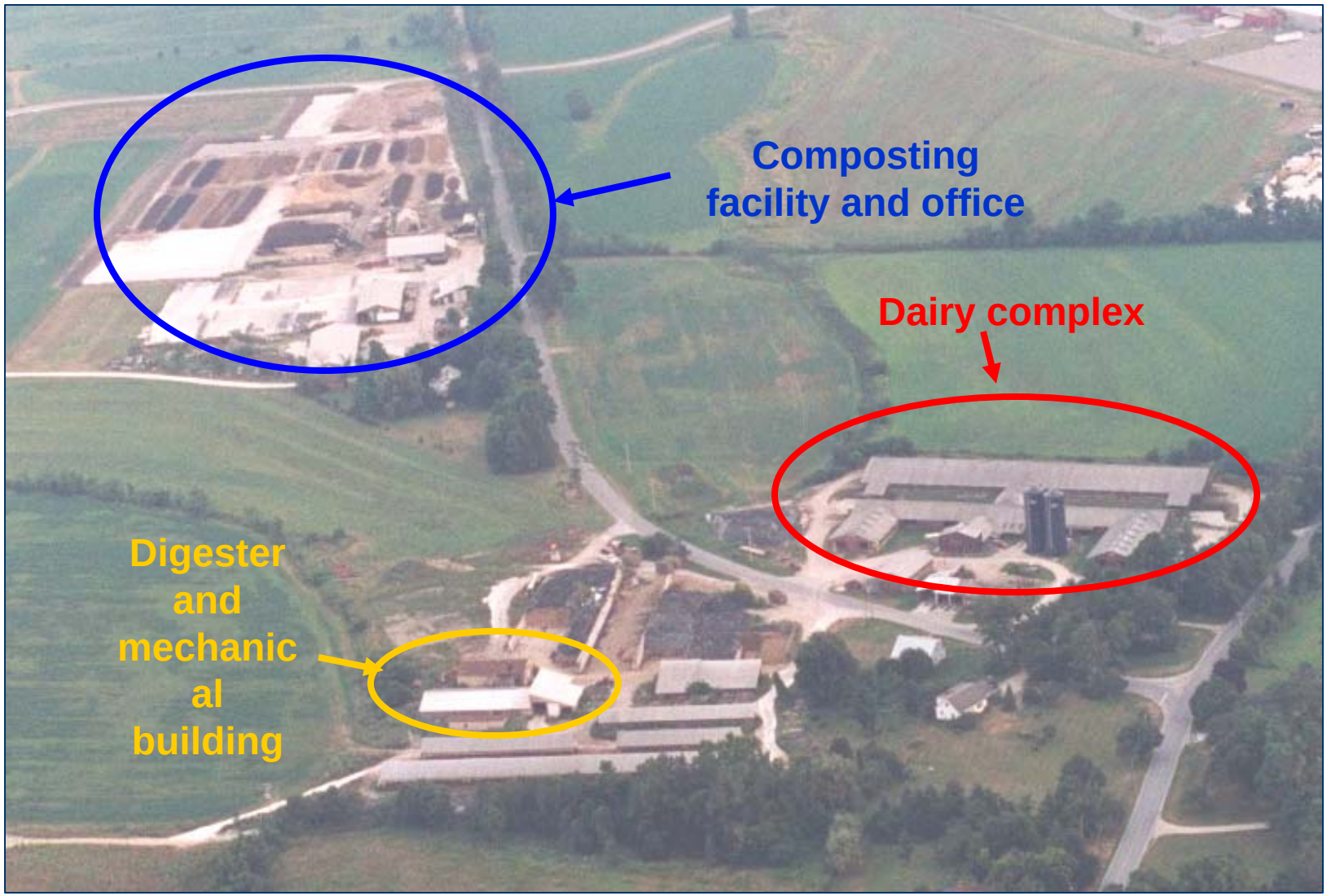
Our Integrated Dairy, Digester, and Composting Facility

The Actual Dairy Farmstead and Anaerobic Digester Complex

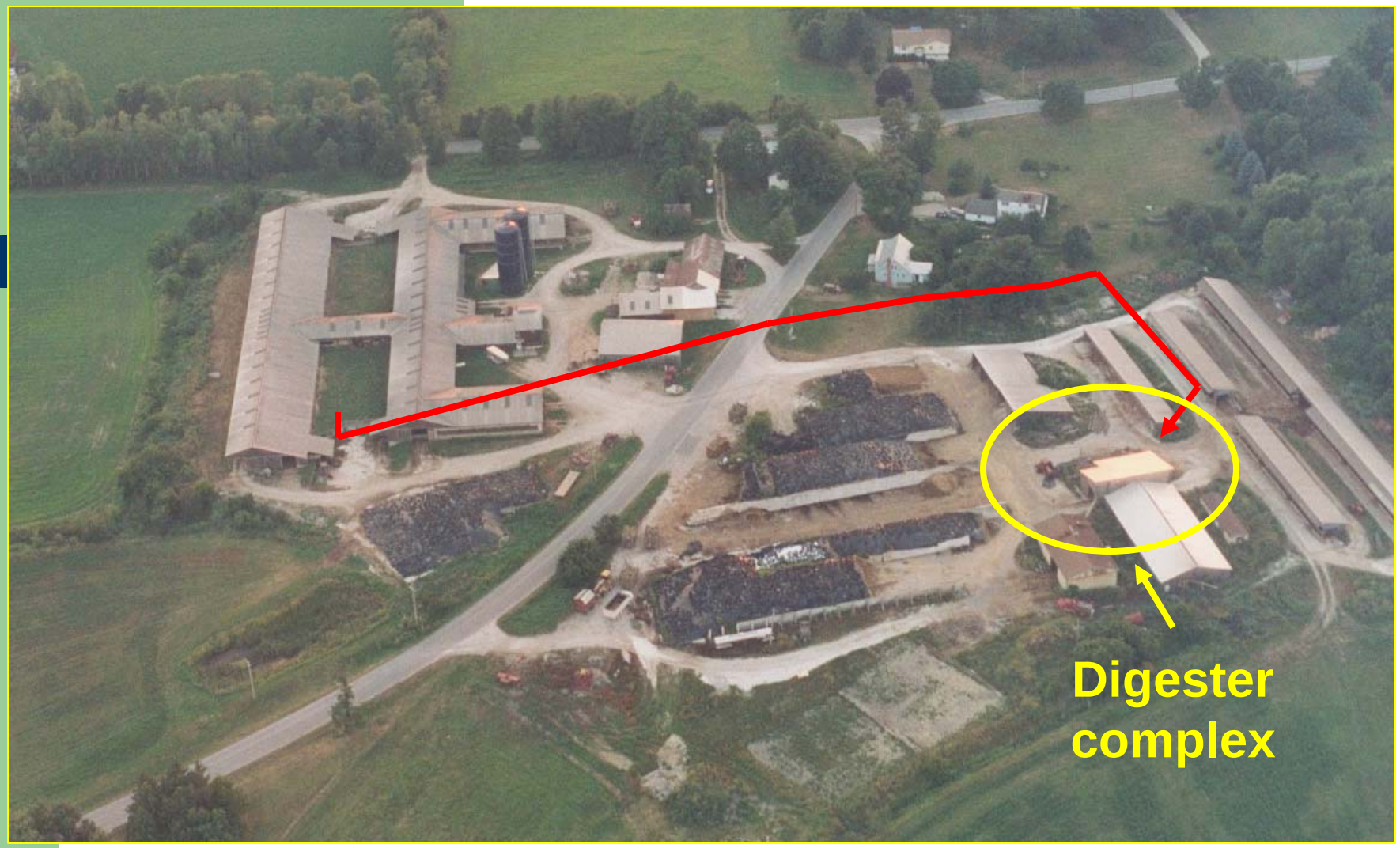


Conceptual Diagram of the Our System

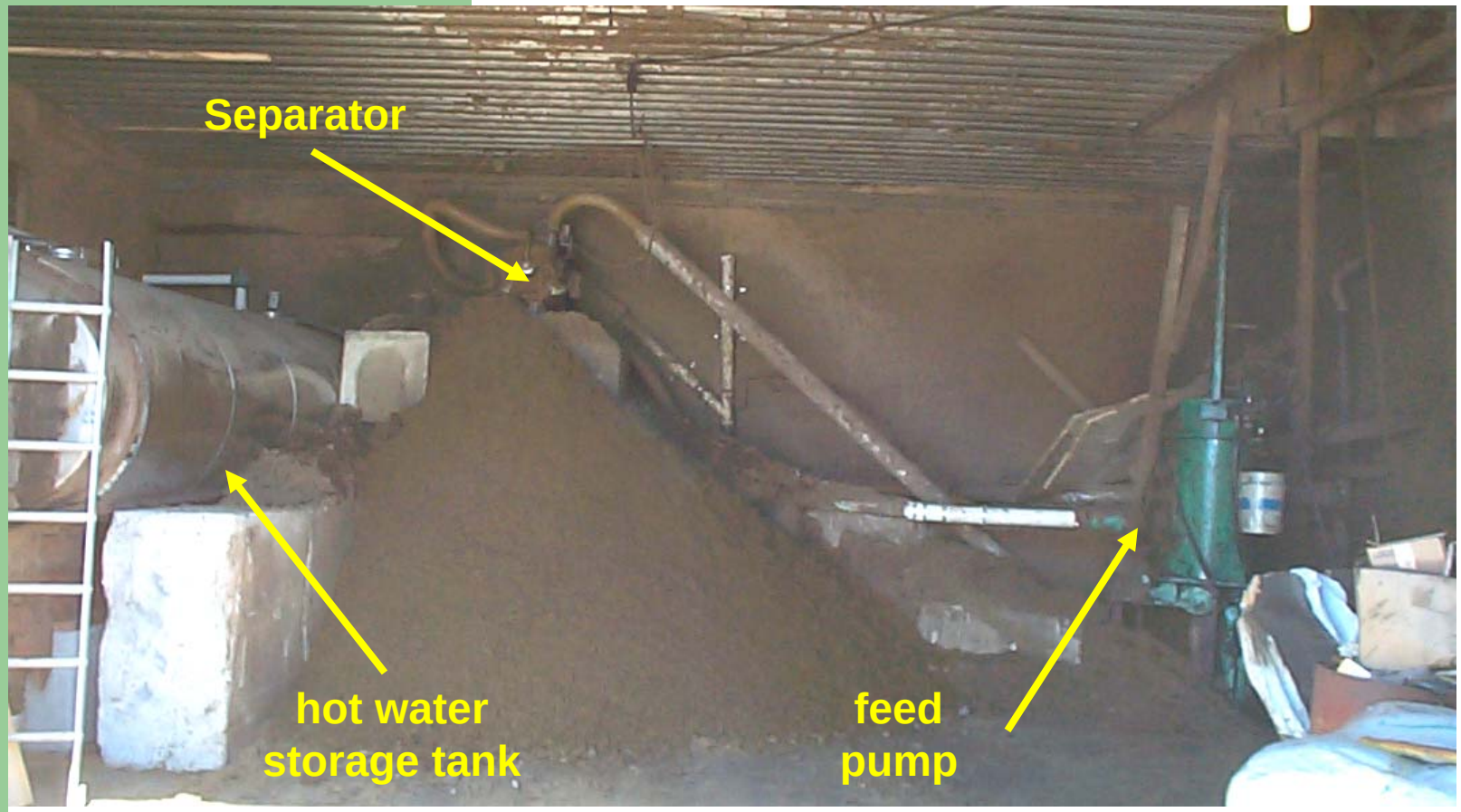




Flows from Red to Yellow to Blue

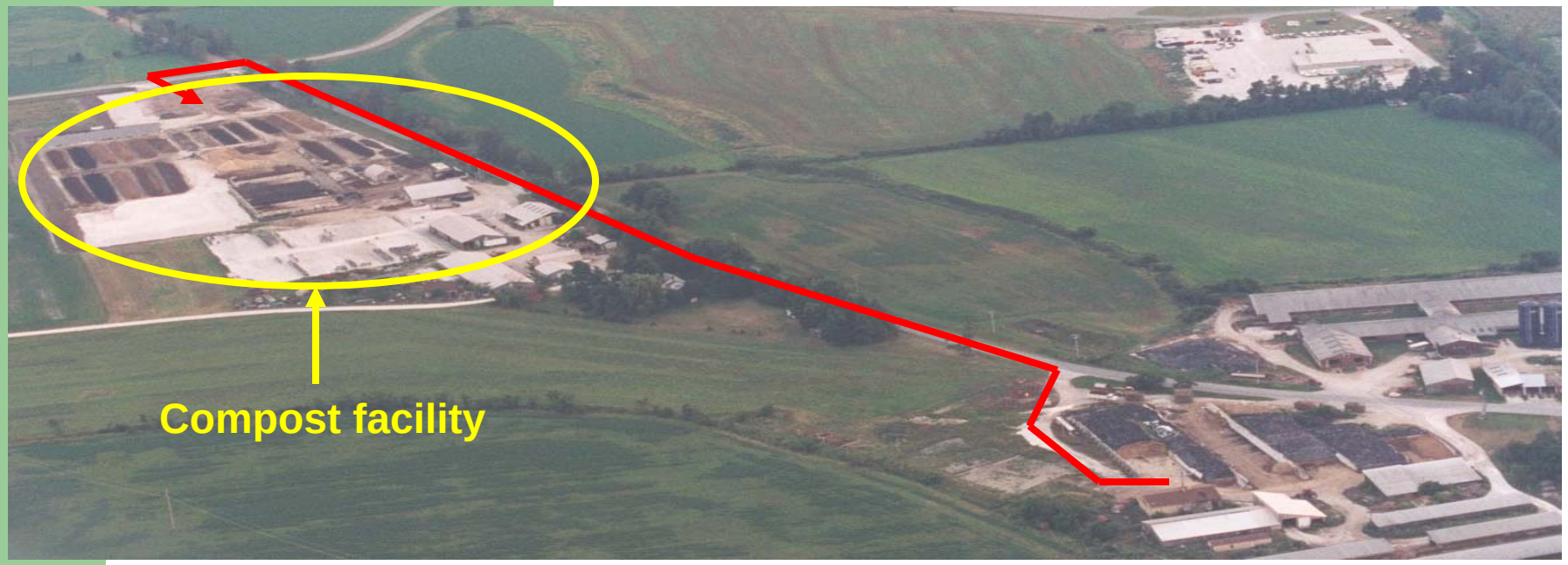


Typical Transport Route of Manure to the Digester



Separator Room

Feed Stock for Composting



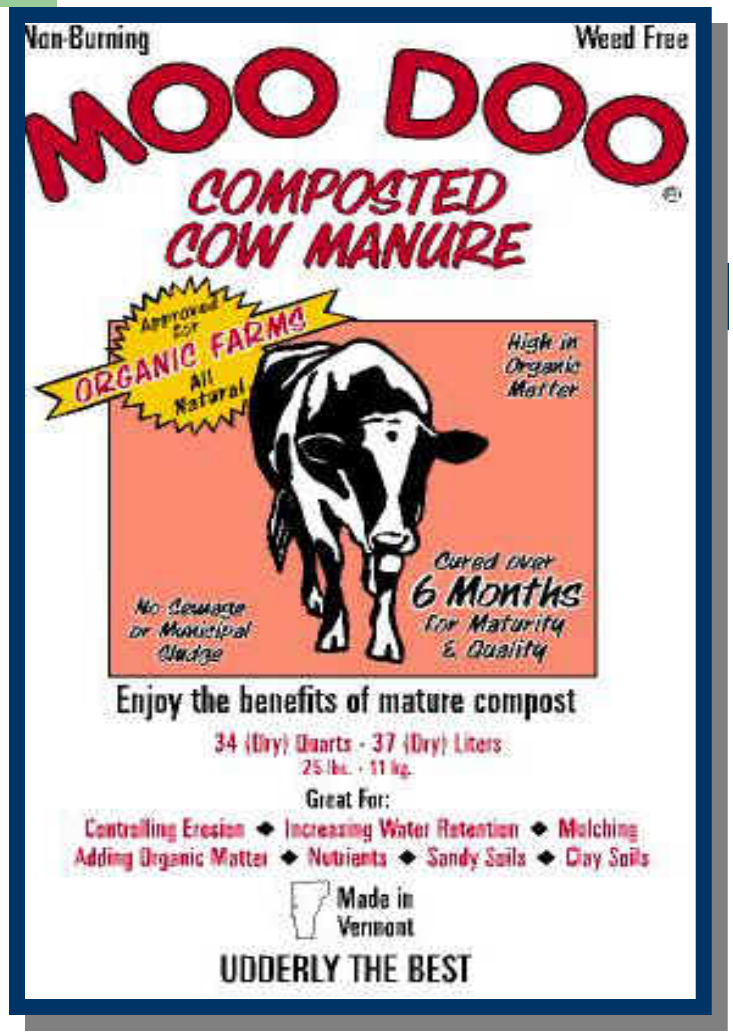
Separated Solid are Transported to Compost Facility

Ingredient Stock Piles

Compost Windrows and Pad

Form, Fill and Seal Bagging Line

Finished Product Awaiting Shipment



Premier Composted Cow Manure

Project Success Factors

- Technology
- Financial
- Management

Technology

- Appropriate Application
- Minimize Complexity
- Anticipate Change
- Incorporate Flexibility
- Learn From Others

Farm AD Project Finances

Northeastern Dairy Experience

- **Capital Hurdles**
  - greater than $1k per head
- **Sources & Uses**
  - range of possibilities
  - grant funding sweet spot: 60% debt; 40% grants; minimal equity; for example: 25% USDA plus 15% State or Other
- **Operating Margins**
  - highly favorable if: high energy price, high prices for green attributes, CHP utilization, monetization of solids

Environmental Markets as a Finance Mechanism

- Carbon Credit Markets
- REC markets
- Innovative Combinations

Central Vermont Public Service
ENERGIZING VERMONT FOR 75 YEARS

CVPS Cow Power

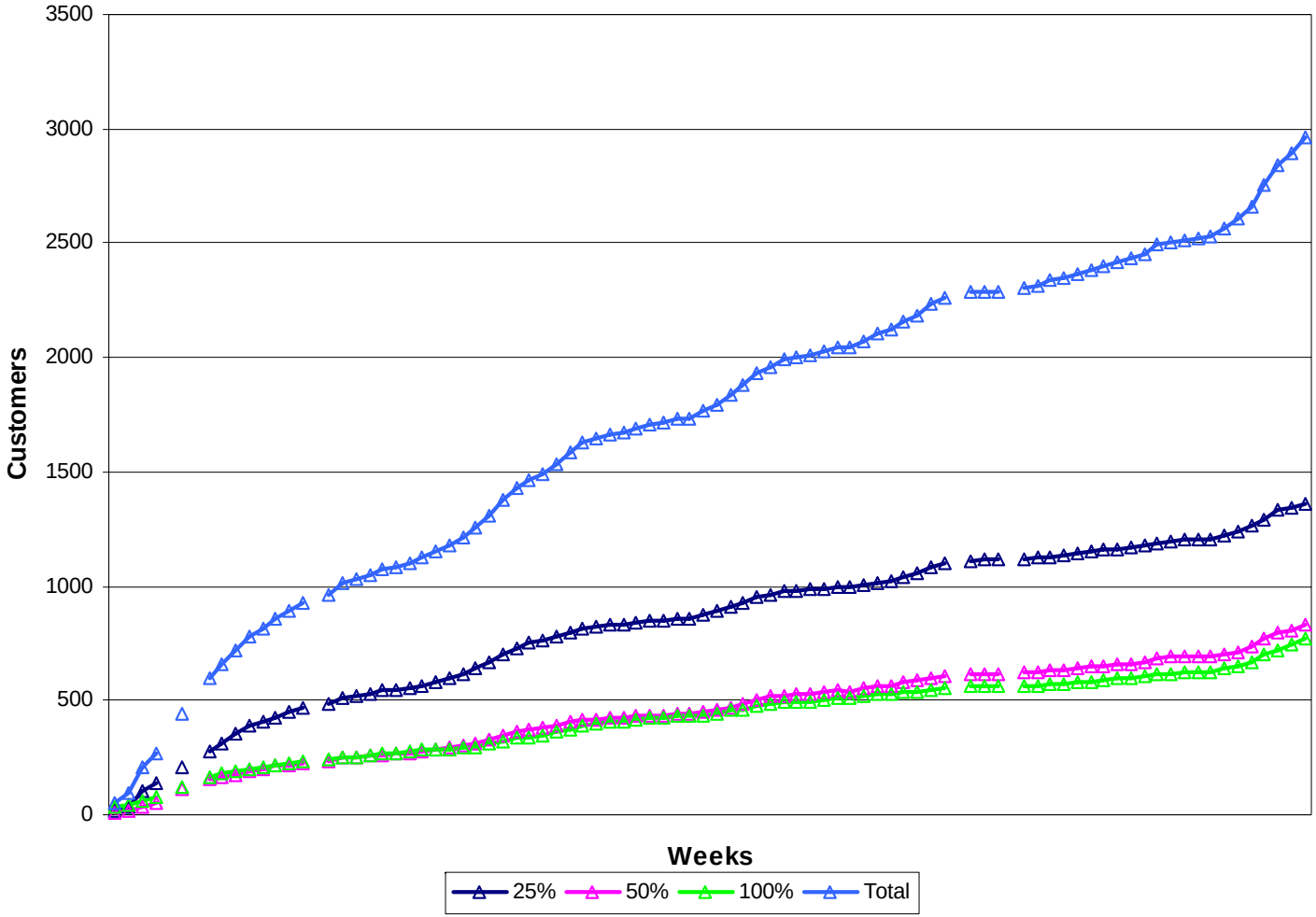
A renewable energy program directly linking farm based renewable energy produced from agricultural waste with retail electric customer choice.

- Provides customers a renewable choice.
- Provides Vermont dairy farmers with a new revenue stream and new manure management options.
- Provides Vermont with new tool to protect the environment.

Central Vermont Public Service

ENERGIZING VERMONT FOR 75 YEARS

CVPS Cow Power Tariff Participants



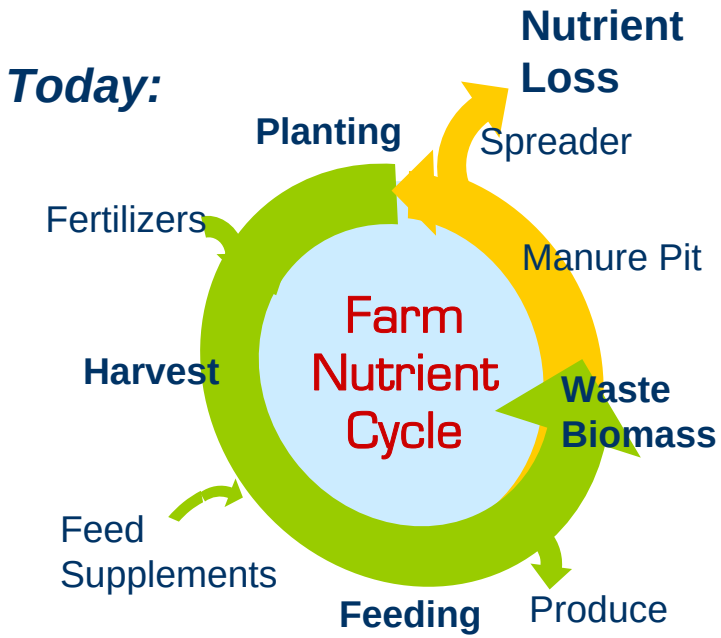
Critical Issues in Dairy Agriculture

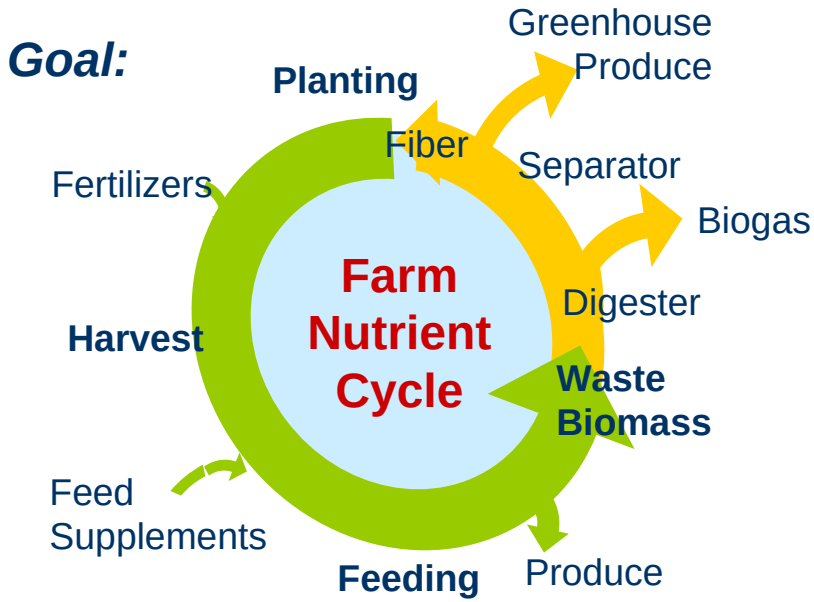
Economic Risks

- Unstable Milk Market
- Liability for Odors & Pollution
- Nutrient Loss
- Energy Costs

Answers

- Value-Added Production
- Digestion & Bio-filtration
- Nutrient recovery
- Odor reduction





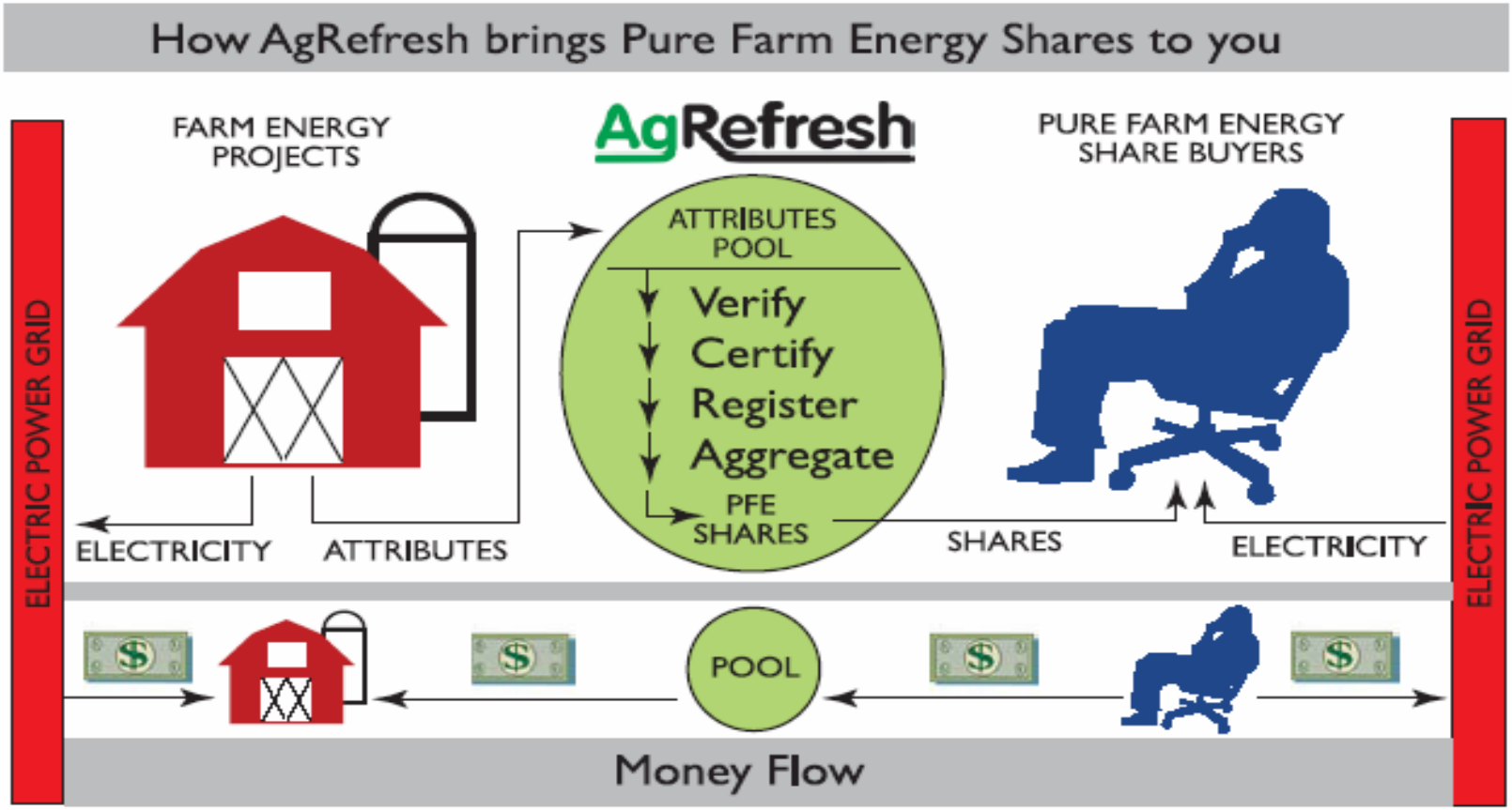
Why Farm AD Projects Are Beneficial

- Renewable Energy
- Provides a Basis for Integration
- Environmental Benefits
- Social and Economic Benefits

AgRefresh™

Pure Farm Energy Plus, Plus™

AgRefresh™ Financial Flow Diagram



Management

- Digesters are Alive
- Know Your Resources
- Know Your Market
- Understand Potential Interconnect Issues and Opportunities
- Develop a Comprehensive Business Plan
- Build on Others Experiences
- Requires a Commitment to Succeed

CONCLUSIONS

- Digesters Can Benefit the Farm, the Community, and the Environment
- Capital Funds Needs and Availability Vary
- Financial Mechanism's are Being Developed via Emerging Environmental Markets such as Cow Power™ and AgRefresh™
- Good Models Provide for Increasing Farm Energy
- Provide a Value-Added Component for a More Sustainable Systems through Integration

One final thought, in reality, all of us in agriculture are in the solar collection and distribution business.

Contact Information

Robert Foster
moodoovt@sover.net

802.388.1137

www.agrefresh.org
www.avatarenergy.com
www.cvps.com/cowpower
www.moodoo.com