Anaerobic Digestion Basics and Best Practices

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WHAT WE'LL SEE TODAY

1. Overview of AgSTAR Program
2. Anaerobic Digestion Basics and Best Practices
   - Explore AgSTAR Project Development Handbook
3. Questions and Answers

How AgSTAR Works

PARTNERSHIP PROGRAM

Collaborative program sponsored by EPA and USDA.

1 Promote Anaerobic Digestion

Advancing economically and environmentally sound livestock manure management.

2 Strong Ties

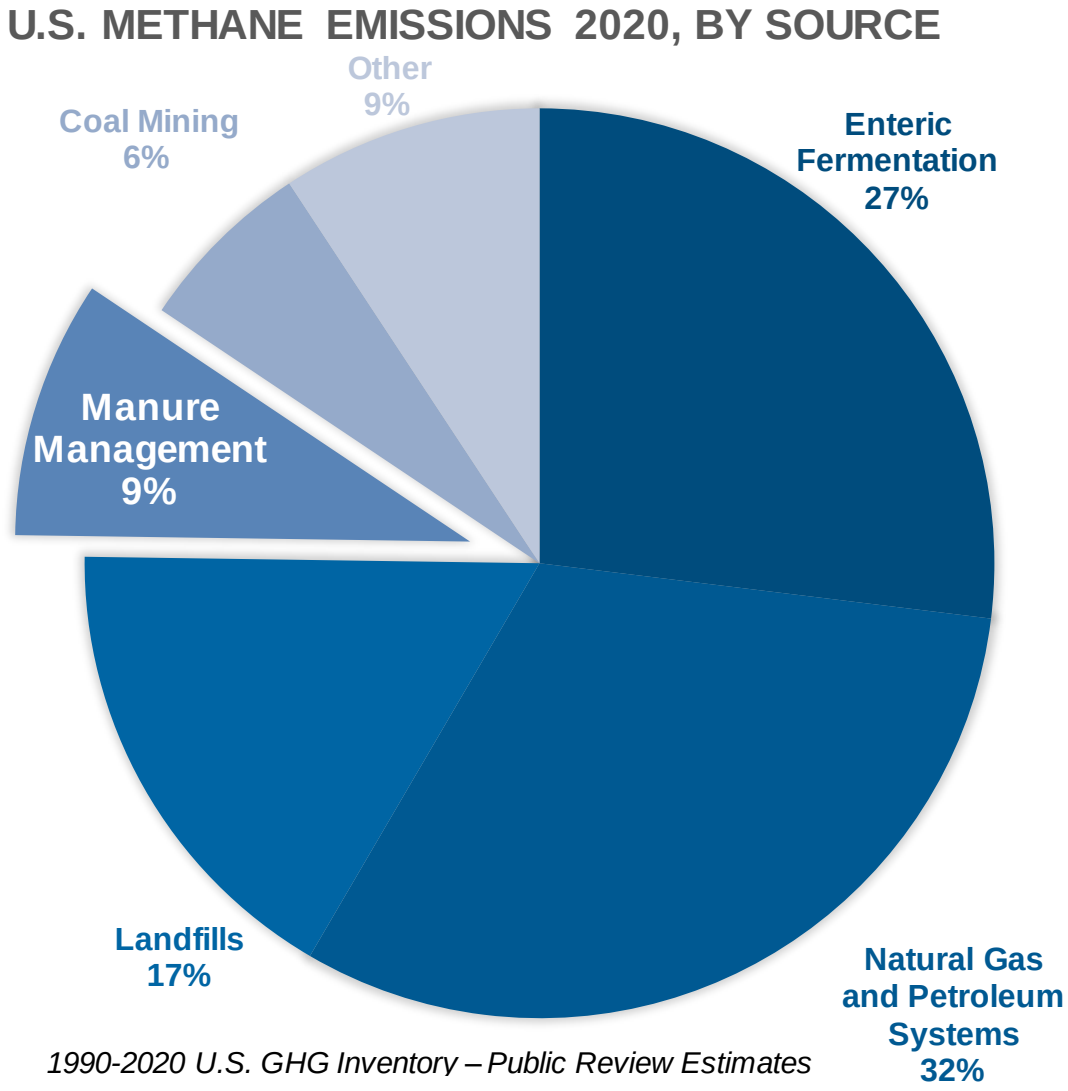
Working with industry, government, NGOs and university stakeholders.

3 Helping Hand

Assisting those who enable, purchase, or implement farm anaerobic digestion projects.

Manure is an important source of U.S. methane emissions

- Livestock (dairy, beef, swine, poultry) manure contributes ~9% of US methane emissions, or 59.6 MMTCO2e
- US methane emissions from livestock manure increased 71% between 1990 to 2020
- Other environmental issues are associated with manure management: water, soil health, air quality



1990-2020 U.S. GHG Inventory – Public Review Estimates

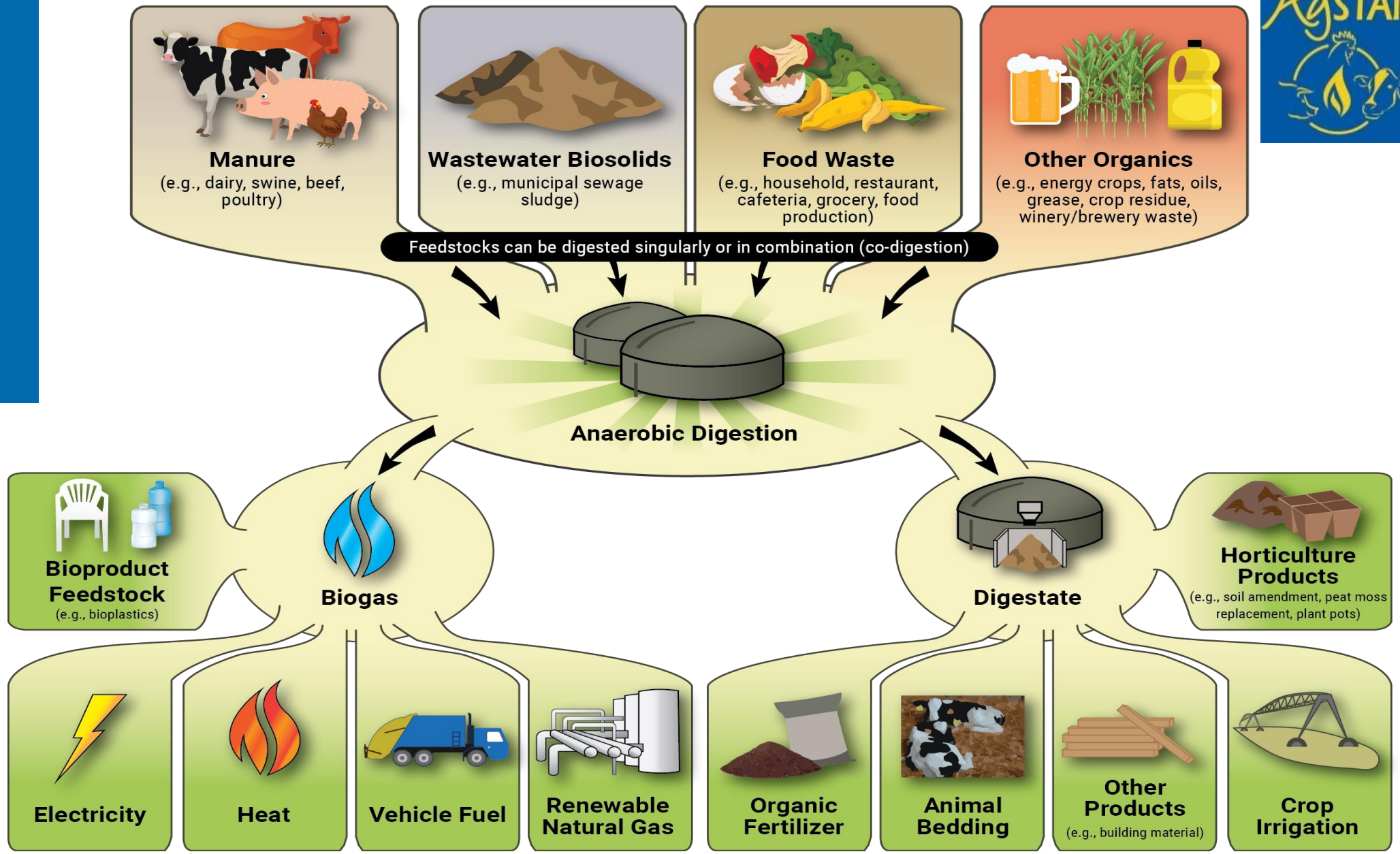
Anaerobic Digesters are a tool to improve manure management

How does anaerobic digestion work?

Just add:

1. Organic Feedstock
2. Heat
3. Bacterial consortium
4. Time

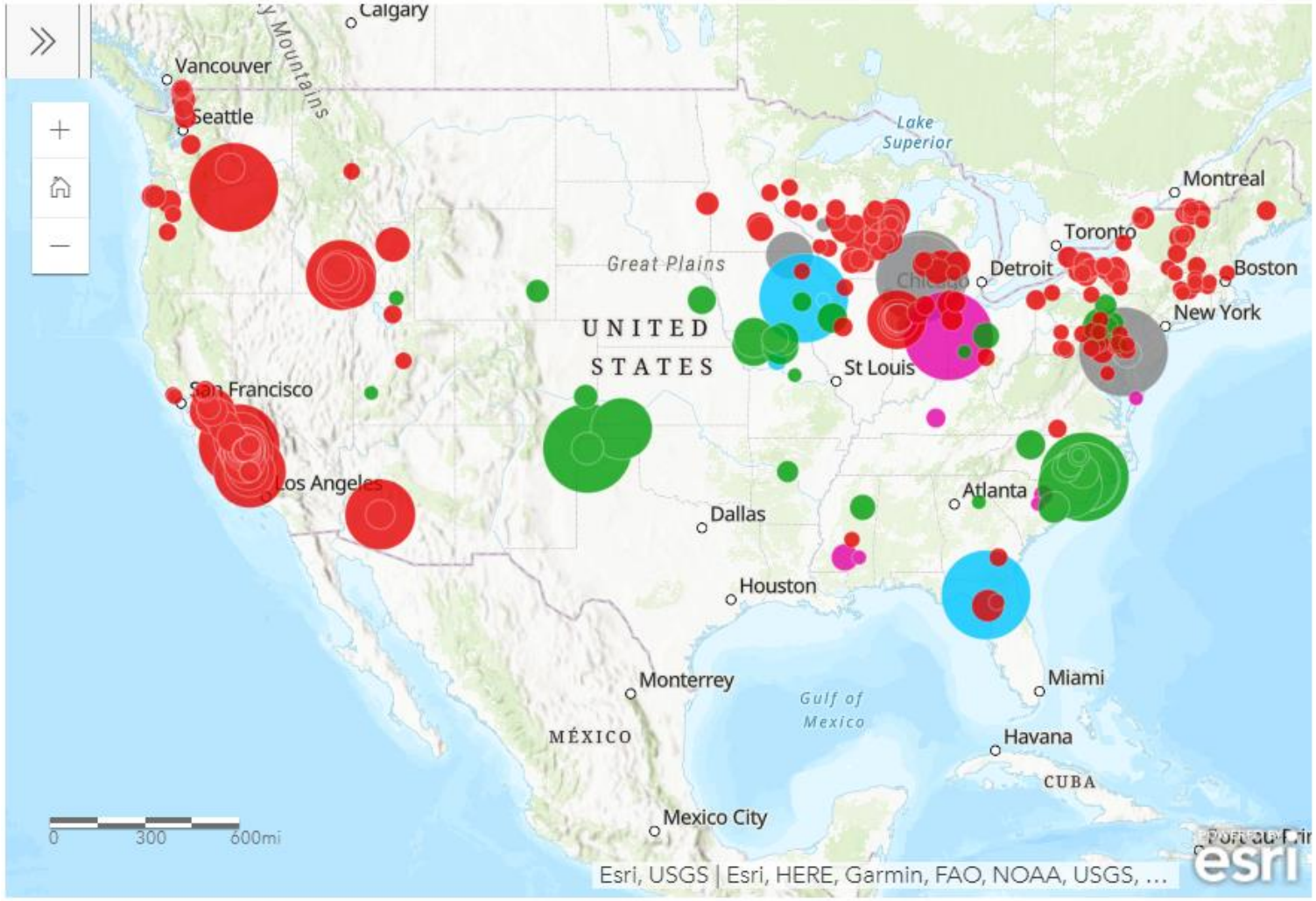
And eliminate oxygen



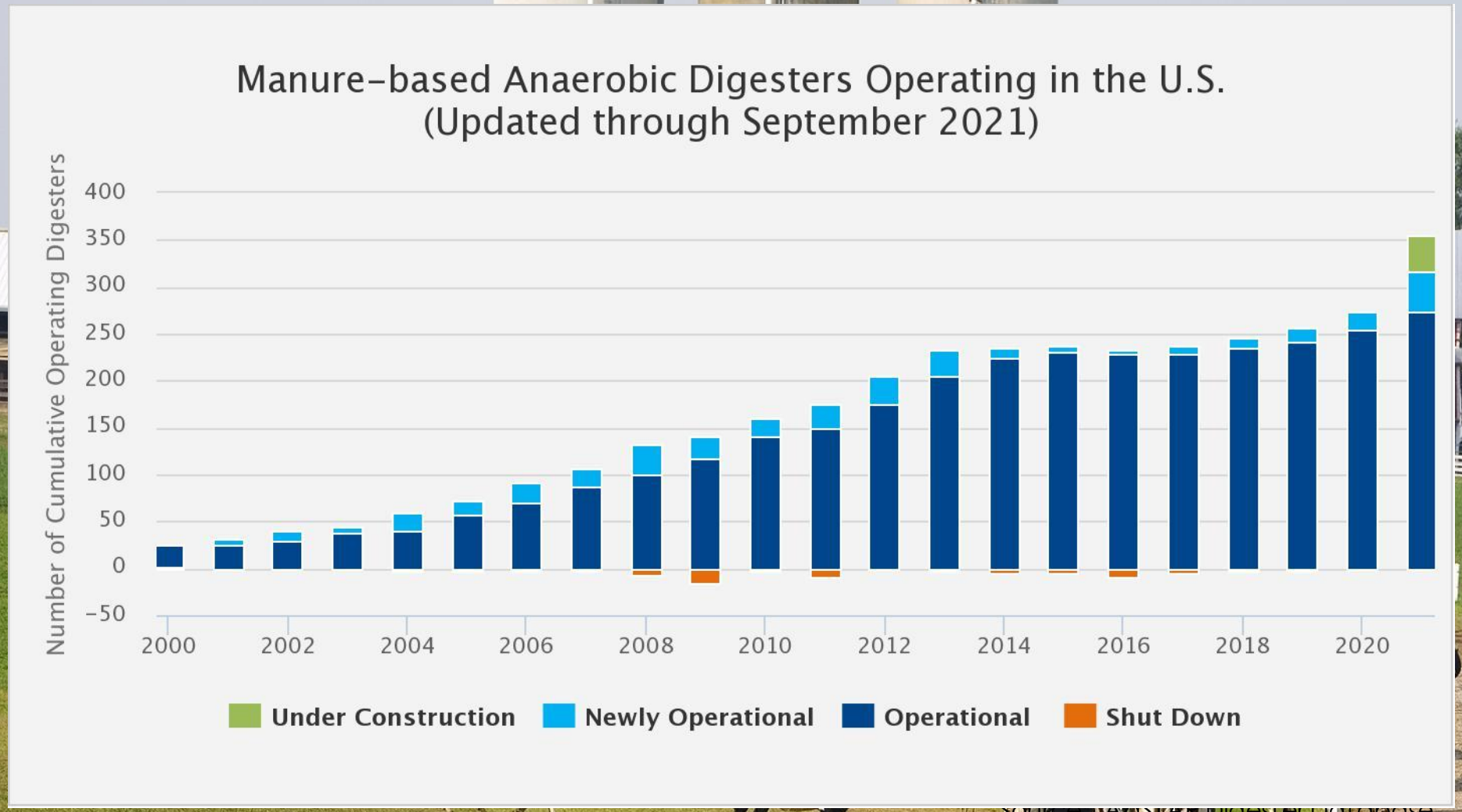
Benefits of Anaerobic Digester Systems

- **Environmental**
  - **Air Quality:** reduction in methane emissions, a powerful GHG and precursor to ground-level ozone; reduced odors
  - **Water Quality:** reduced pathogens and nutrients from leaching into surface and groundwaters
  - **Soil Health:** land application of digestate recycles nutrients and is shown to increase crop yields
- **Energy**
  - Renewable energy production; energy independence; and displacement of fossil fuels
- **Economic**
  - Diversified farm revenue through sale of energy and co-products; opportunity to create new local jobs; partnerships with local businesses

Where are digesters found?



Farm Digester Market Growth



315 Current Digesters

Growth projected to exceed 500 digesters in next 3 years

Potential for over 8,000* digesters on farms in U.S.

Source: AgSTAR Digester Database

Project Example: 3rd Party Owned/ Operated

BAR-WAY FARM

Deerfield, MA

7,700 MWh

Annual energy output.

5,500 lbs

Daily offset of CO2 emissions.

Farm Facts

- 600-acres
- 250 cows milked daily

Digester Facts

- Built in 2016
- 660,000-gallon capacity
- Owned, operated and maintained by Vanguard Renewables

Annual Digester Input

- 9,200 tons of manure
- 30,000 tons of food waste

Project Example: Creating Value from Coproducts

FREUND FARM

East Canaan, Connecticut

- Small Family-owned farm
- Horizontal plug flow digester
- 300 dairy cows feeding digester

Displace unsustainable peat moss and plastic planters.

Biodegradable planter pots made from digested manure solids.

Project Example: Renewable Natural Gas to Vehicle Fuel

CALIFORNIA BIOENERGY'S KERN CLUSTER

Kern County, California

Capacity for 5 million gallons diesel equivalent per year

Leverages CA Dept. of Food and Ag grant incentives for digesters

Combines compressed natural gas and electricity production

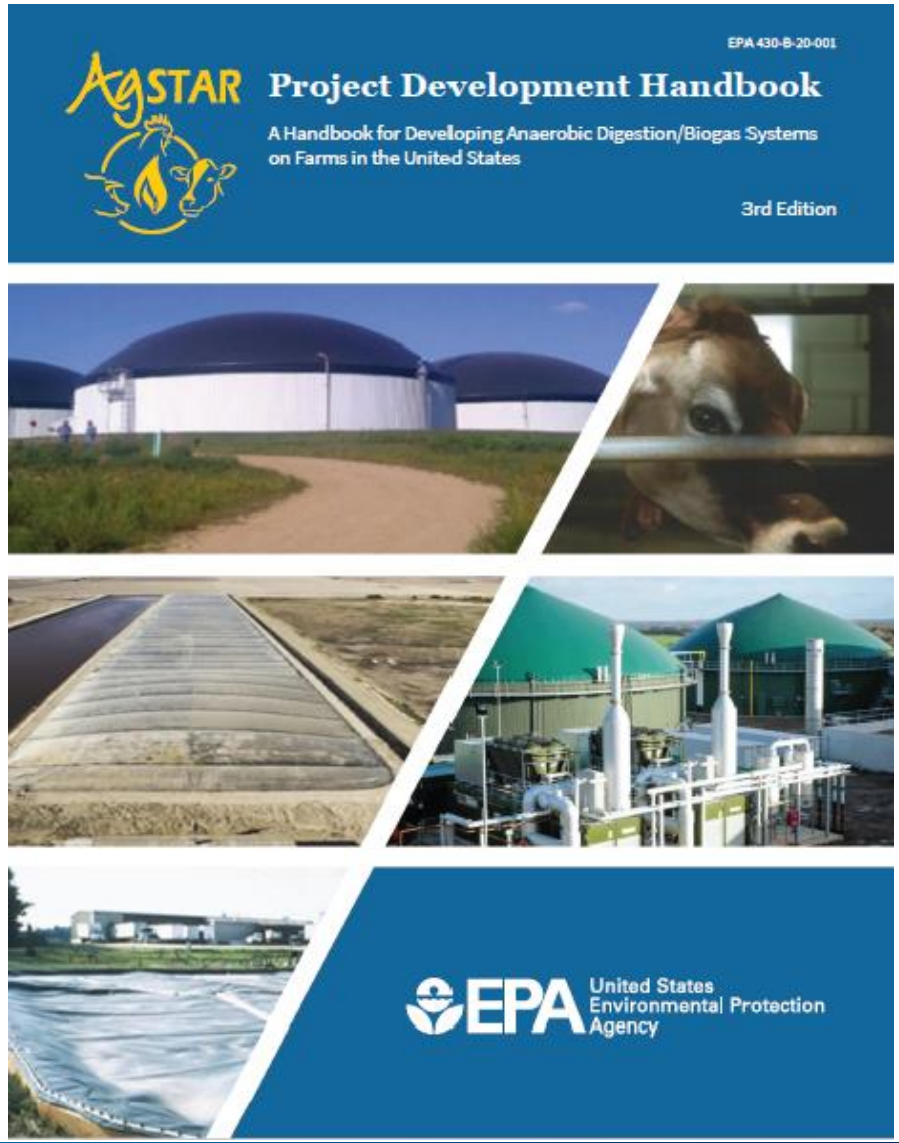
15 large dairies participating in the cluster

15 MW base load (30 MW peak) electricity production

Best Practices for Anaerobic Digester Systems

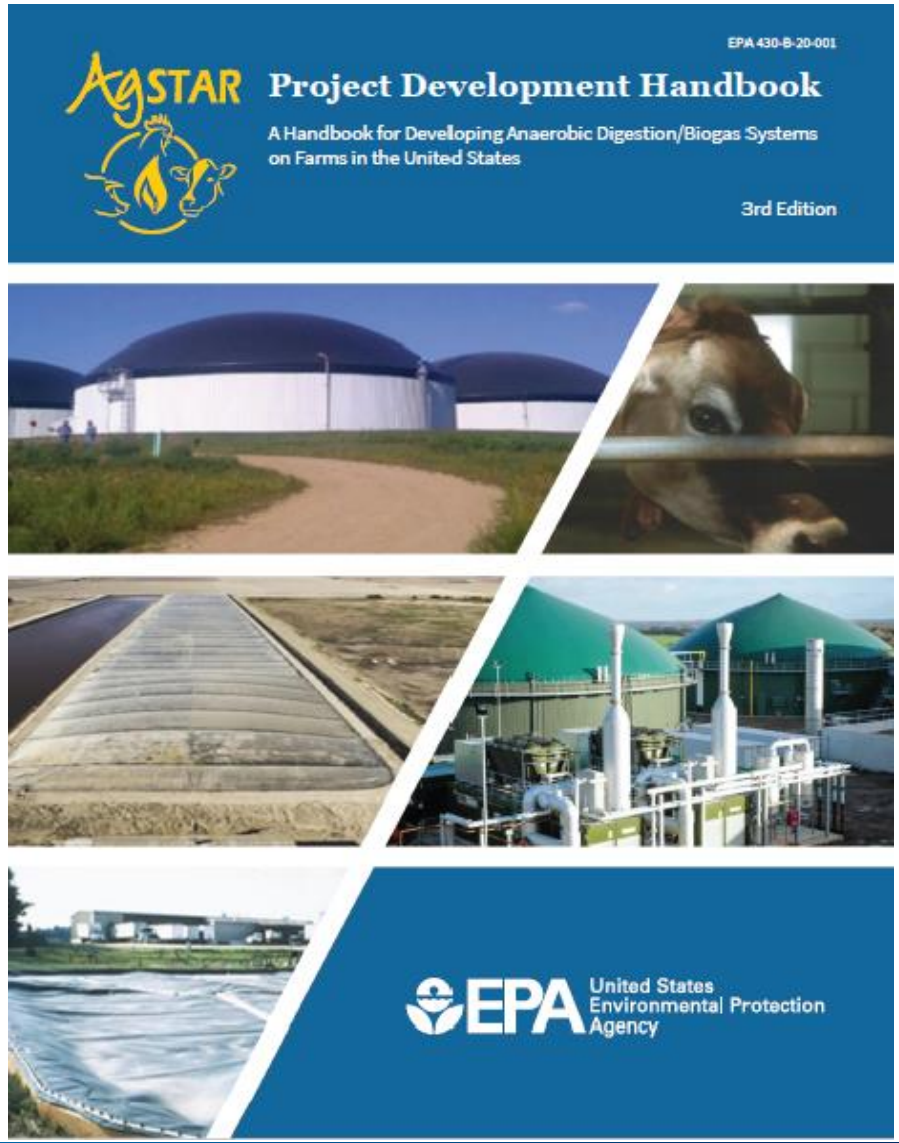
AgSTAR's Anaerobic Digester Handbook

- The latest knowledge in the industry on best practices for anaerobic digestion (AD)/ biogas systems.
- Goal: ensure long-term success for AD/ biogas systems by providing a framework for project development.
- Audience: Anyone interested in AD/biogas systems as a farm manure management option
  - Policy makers
  - Farmers
  - Financiers/ investors
  - Private Developers



Handbook Overview

- 11 Chapters that outline key considerations for farm-based digester projects
  - ✓ Process Fundamentals
  - ✓ Digester Feedstocks
  - ✓ Products and Equipment - Energy and Digestate
  - ✓ Economic and Financial Factors
  - ✓ Screening and Feasibility Assessments
  - ✓ Business Relationships
  - ✓ Permitting
  - ✓ Public and Community Outreach
  - ✓ Safety, Operations and Maintenance



Good Planning to Avoid Disappointment

A reputable company can avoid pitfalls, such as:

- Inappropriate application of a technology
- Inadequate designs
- Inexperience of the practitioner
- A lack of understanding of basic process fundamentals
- Underestimated maintenance requirements
- Overestimated performance and uptime
- Inadequate operator training
- De-prioritization of operation and maintenance activities
- Inadequate operations, logistics, and financial planning

Key Design Concepts

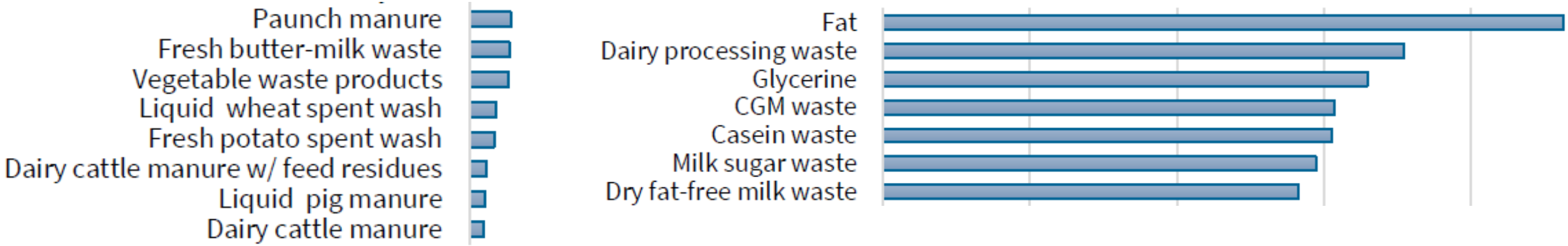
Clearly Define:

- Project goals
  - Integration into business
  - Financial goals
  - Long-term vision of the business
- Feedstock characteristics
  - Moisture content
  - Total and dissolved solids
  - Chemical composition
- System complexity
  - Heating
  - Mixing
- Biogas and Digestate Utilization

Digester Feedstocks

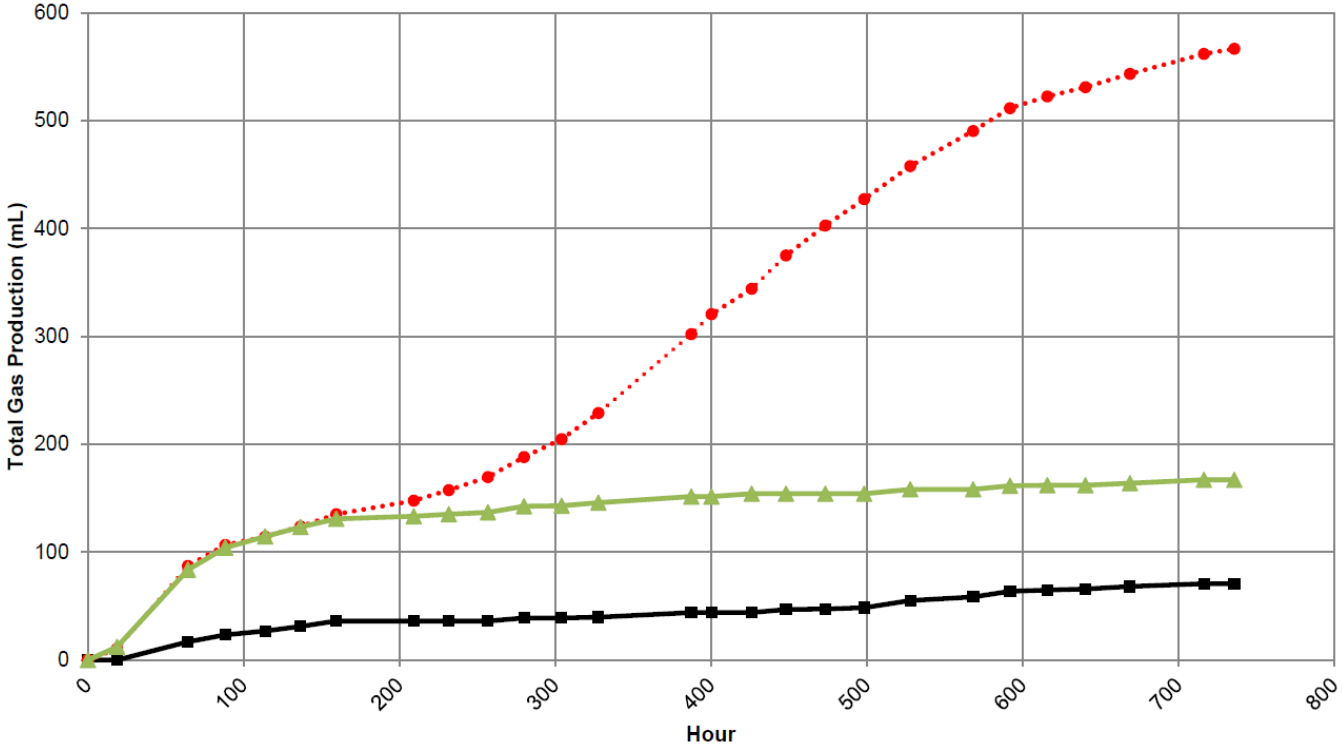
Feedstocks Provide Stability & Energy

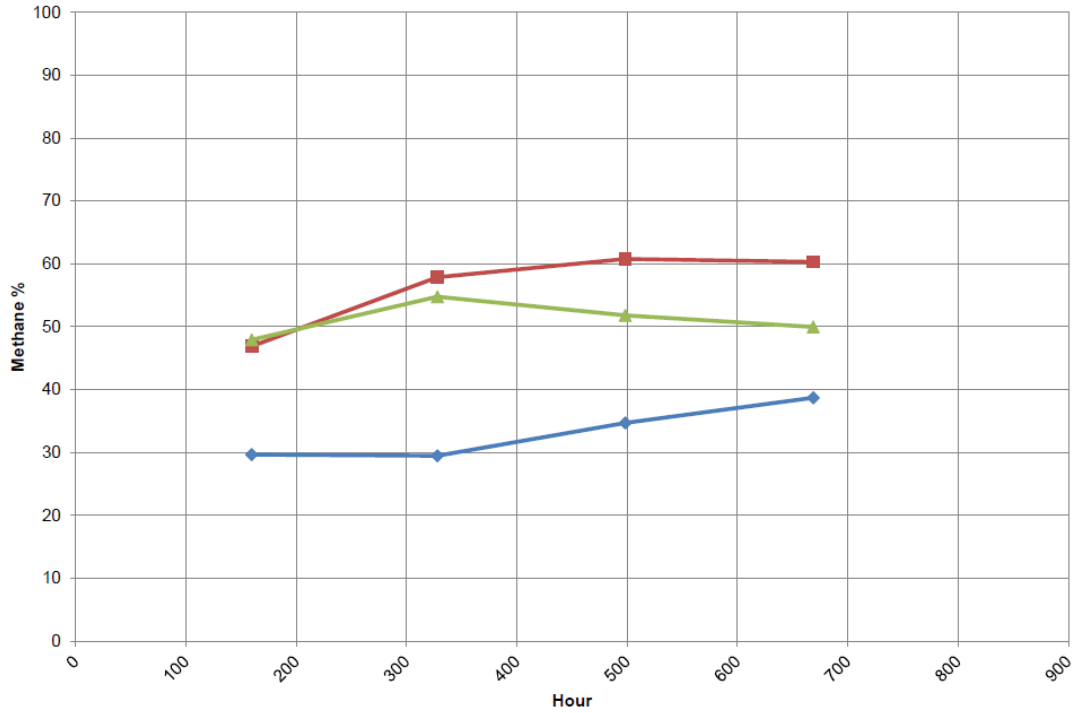
- Manures
  - Lower energy potential
  - Microbial population
  - Alkalinity
  - Nutrients
- Other Feedstocks
  - Higher energy potential
  - Limited buffering
  - Missing key nutrients



Bar chart shows methane potential per ton of feedstock (Figure 4.1)

Determining Feedstock Productivity





Digester Types


Covered lagoon


Agricultural complete mix

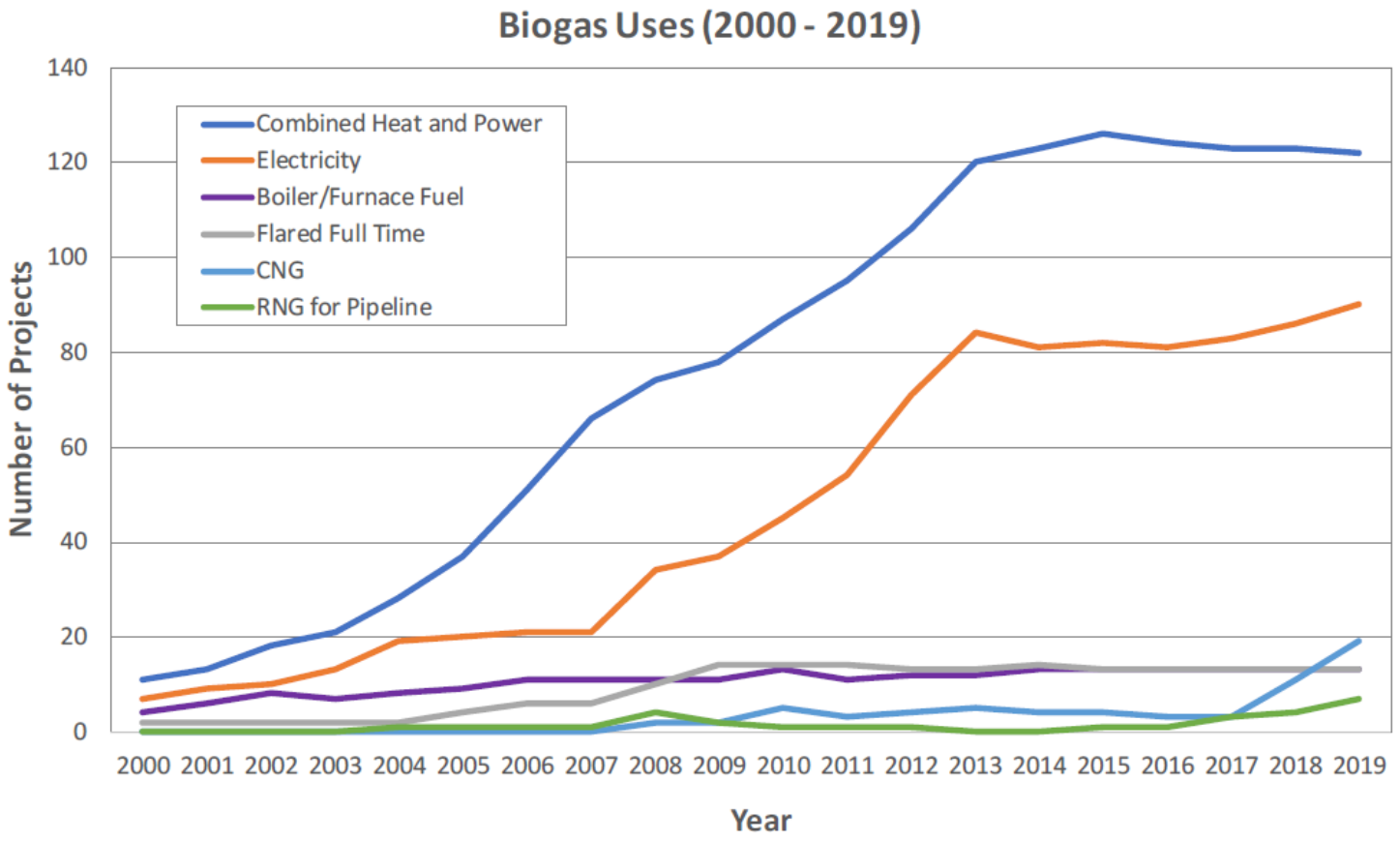

Fixed film


Municipal complete mix


Plug Flow

Biogas Uses

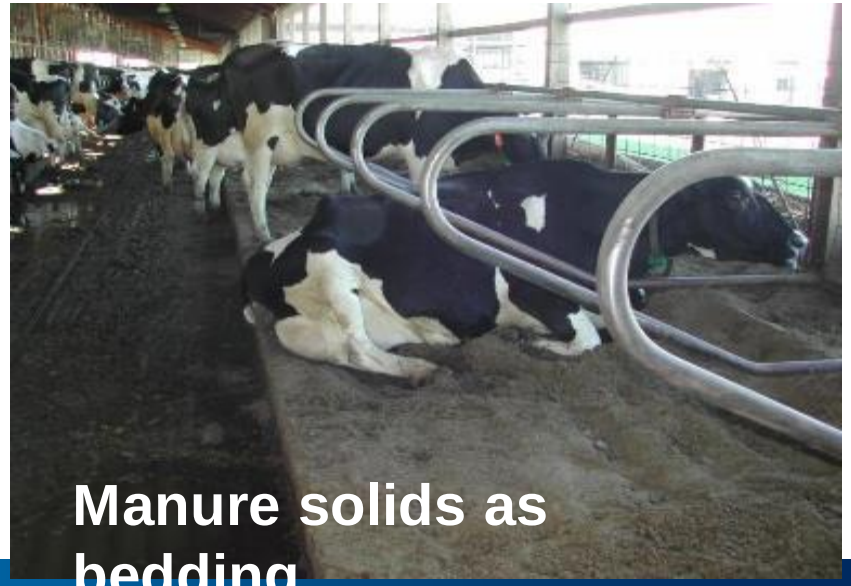
- Biogas utilization
  - Electrical generation
  - Combine heat & power
  - Direct use
  - Flare
  - Renewable natural gas (RNG)



Digestate

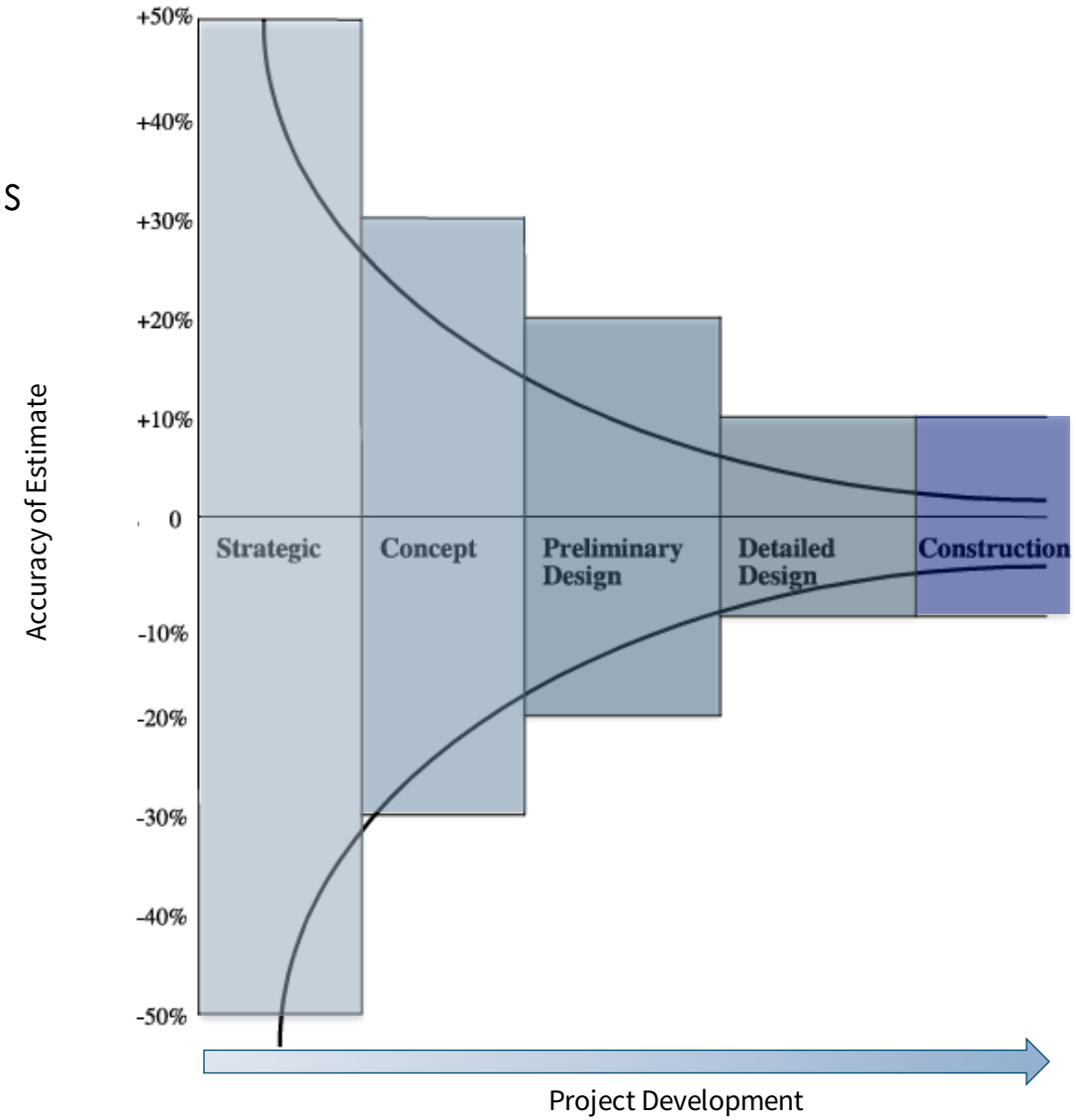
- Digestate utilization (manure)
  - Bedding
  - Whole digestate
  - Solid/liquid separation
  - Nutrient partitioning


Compost


Manure solids as bedding

Economic & Financial Factors

- Capital Investment
  - A first step in evaluating financial viability is to assess capital investment needed
  - A business plan is essential
  - Capital Investment includes 2 items:
    - Construction budget
    - Owner's budget
  - Numerous items to consider when developing an AD/biogas system
  - Graph illustrates technical and cost estimating refinement through a project cycle



Modified by Tetra Tech as of 2019 based on the "Estimating the Cost of Capital Projects". Canadian Journal of Civil Engineering, 2002, 29, 653-661.

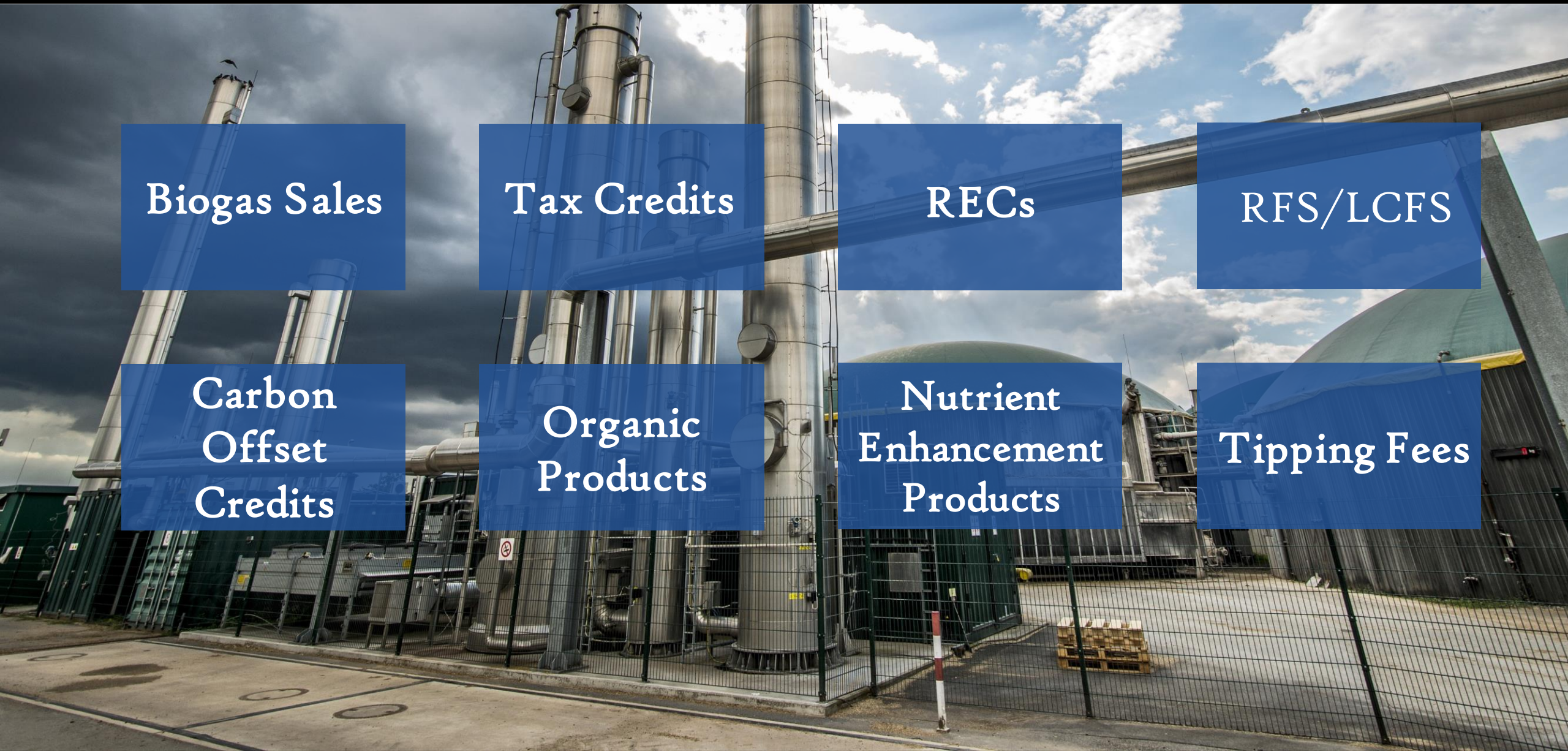
Economic & Financial Factors

- Operating Expenses
  - Cost examples table shows lists of many of the operating expenses that are applicable to projects
  - Operational labor is frequently underestimated, which can significantly damage project economics.
  - Because the farm's primary purpose is to generate a product, often digester O&M becomes secondary to traditional farm responsibilities.
  - Key to assess all expenses to achieve success in project performance

Examples of Operating Expenses

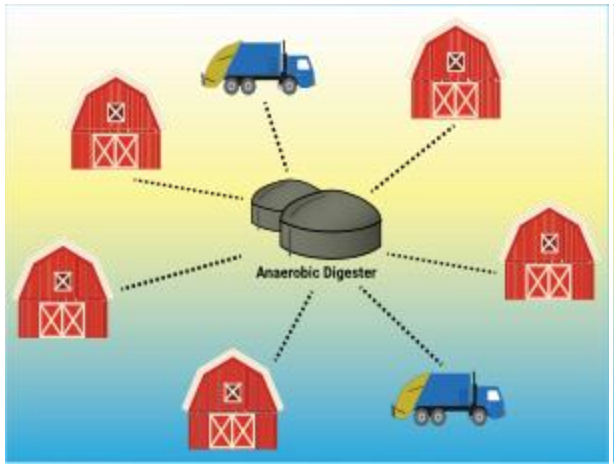
Expense	Units
Daily Labor, if needed	$/hour
Engine O&M	¢/kWh
AD/Biogas System O&M	$/day
H_2S Removal	$/year
Insurance	$/year
Outside Engineering & Other Services	$/year
Filtrate Management	¢/gallon

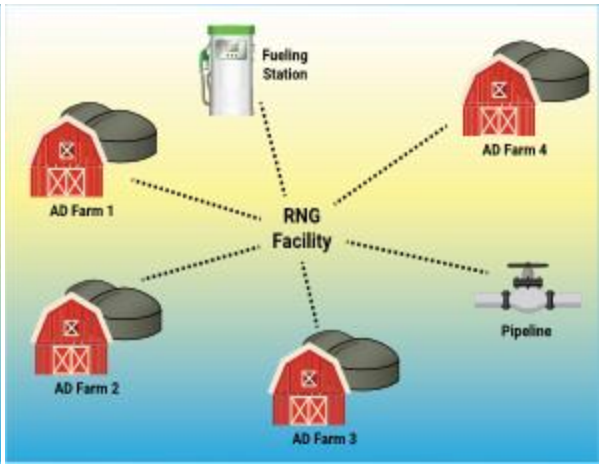
Types of Project Revenues

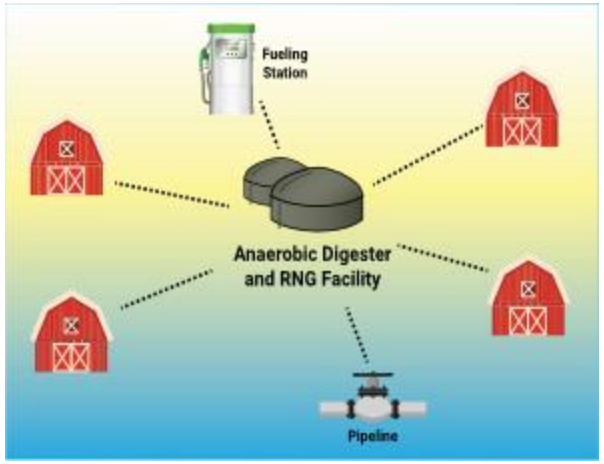


Owner & Operator Models

- Successful business models:
  - Involve partners along with value chain, such as co-ops, customers, suppliers, and processors;
  - Draw on strengths, such as marketing, contracting, permitting, energy, design, or operations;
  - Common goals (e.g., financial, public relations, or market expansion);
  - 3rd party investment, ownership, and operations;
  - Look to traditional cooperative models for use with manure solids, nutrients, energy, or fuel.
- General types of business model structures:
  - Farmer owned & operated
  - 3rd party owned & operated
  - 3rd party operated
  - Hub & Spoke (see figures)

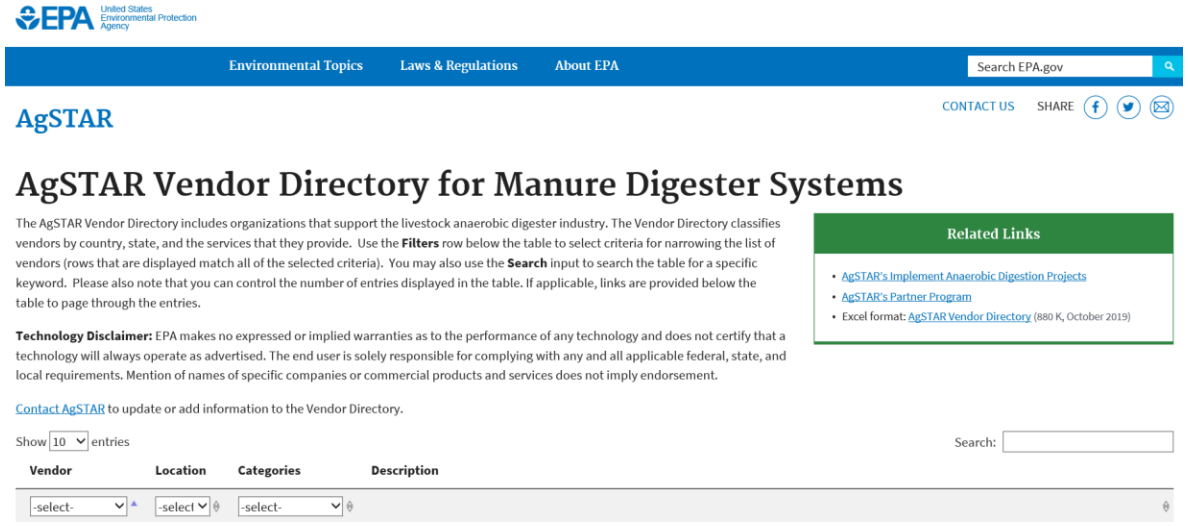


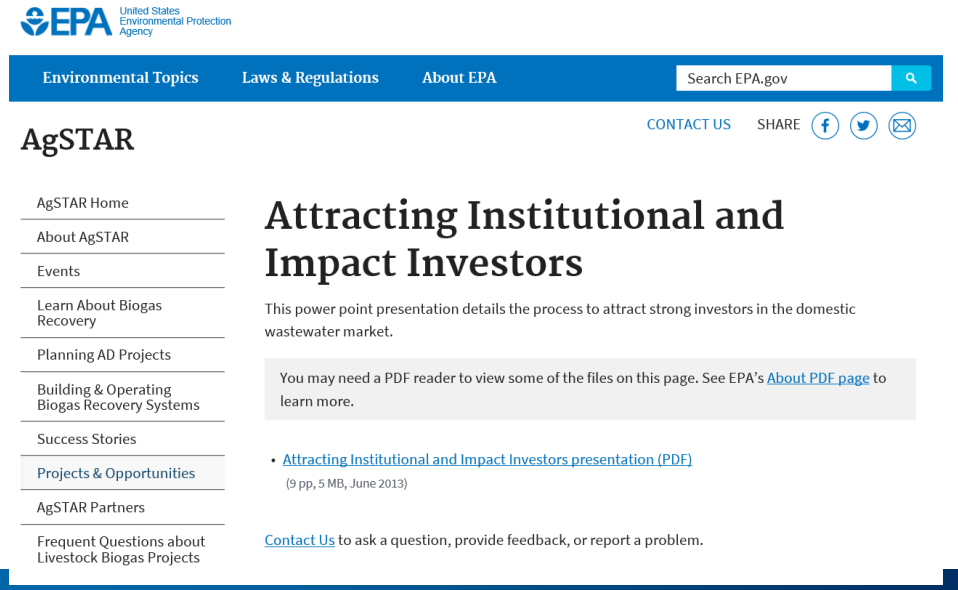




Project Finance & Assistance

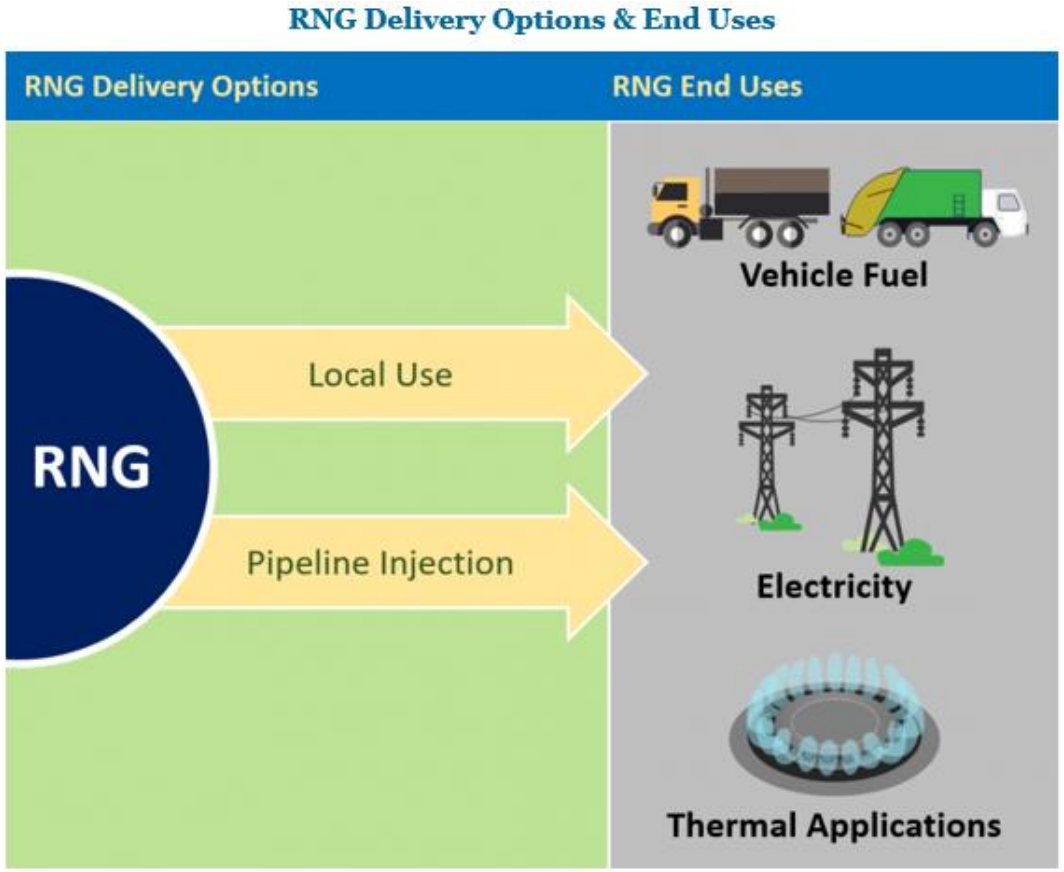
- Owner Equity Financing vs. Debt & Equity Financing
- Financial Assistance Methods:
  - Grants
  - Cost-Sharing
  - Loan Guarantees
  - Industrial Revenue Bonds
  - AgSTAR website
    - AgSTAR Vendor Directory
    - Attracting Institutional & Impact Investors





Business Relationships

- Interconnection Guidelines
  - Elements of Agreements
  - AD/Biogas System Utility Benefits
  - Energy Contracts
- Renewable Natural Gas (RNG)
- Organics Contracts
- Project Finance
- Construction Contracts
- Operational Contracts



EPA Landfill Methane Outreach Program, Renewable Natural Gas, https://www.epa.gov/lmop/renewable-natural-gas (accessed March 2020).

Permitting


Air Quality
Additional Permitting
Water Quality
AD/Biogas Permitting Requirements
Co-Digestion Feedstock
Water Supply
Land Use
Solid Waste

Public & Community Outreach

- Advent of RNG and codigestion has brought in new players and new activity beyond the farmer. Leads to new truck traffic and new faces. Very important to build trust between these individuals and neighboring farms, local businesses, lenders, and community leaders.

Crescent Farm, Haverhill, MA. Project developer is Vanguard Renewables

Public & Community Outreach Needs

- In some cases, need critical mass of manure. Again speaks to need to build trust, positive relationships and clear business deals.

- May need changes in zoning, so educate early and often — and have a line item in budget for outreach. Same goes for regulators. Consider having Lunch ‘n Learns.

- Off-site wastes may need to be stored for period of time before (or after) blending with manure and prior to AD. Make sure tanks are airtight so don’t have fugitive odors.

- Establish an odor management and response plan. Share with potentially impacted neighbors and local officials who may receive complaints.

- Similarly, establish a spill response plan — idea is to have protocols in place for any possible community nuisance.

- Communicate community benefits. And have tours once all systems are in place.

CHECK OUT THE HANDBOOK ON AGSTAR'S WEBSITE!

www.epa.gov/agstar

Contact:

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Connect:

- www.epa.gov/agstar
- Subscribe to our newsletter
- Technical information and resources

Appendix

AgSTAR is a Resource Center for the Agriculture Sector

www.epa.gov/agstar

Market Trends

- National data for anaerobic digester projects
- Market Opportunities Report

Technical Information

- Biogas Toolkit
- Updated 3rd Edition Project Development Handbook
- Operators Guidebook
- AD Risk Analysis Checklist

Success Stories

- Project profiles
- Interviews with operators

Collaboration

- Webinars
- Industry events & trainings - virtual