Economics of Agricultural Anaerobic Digestion

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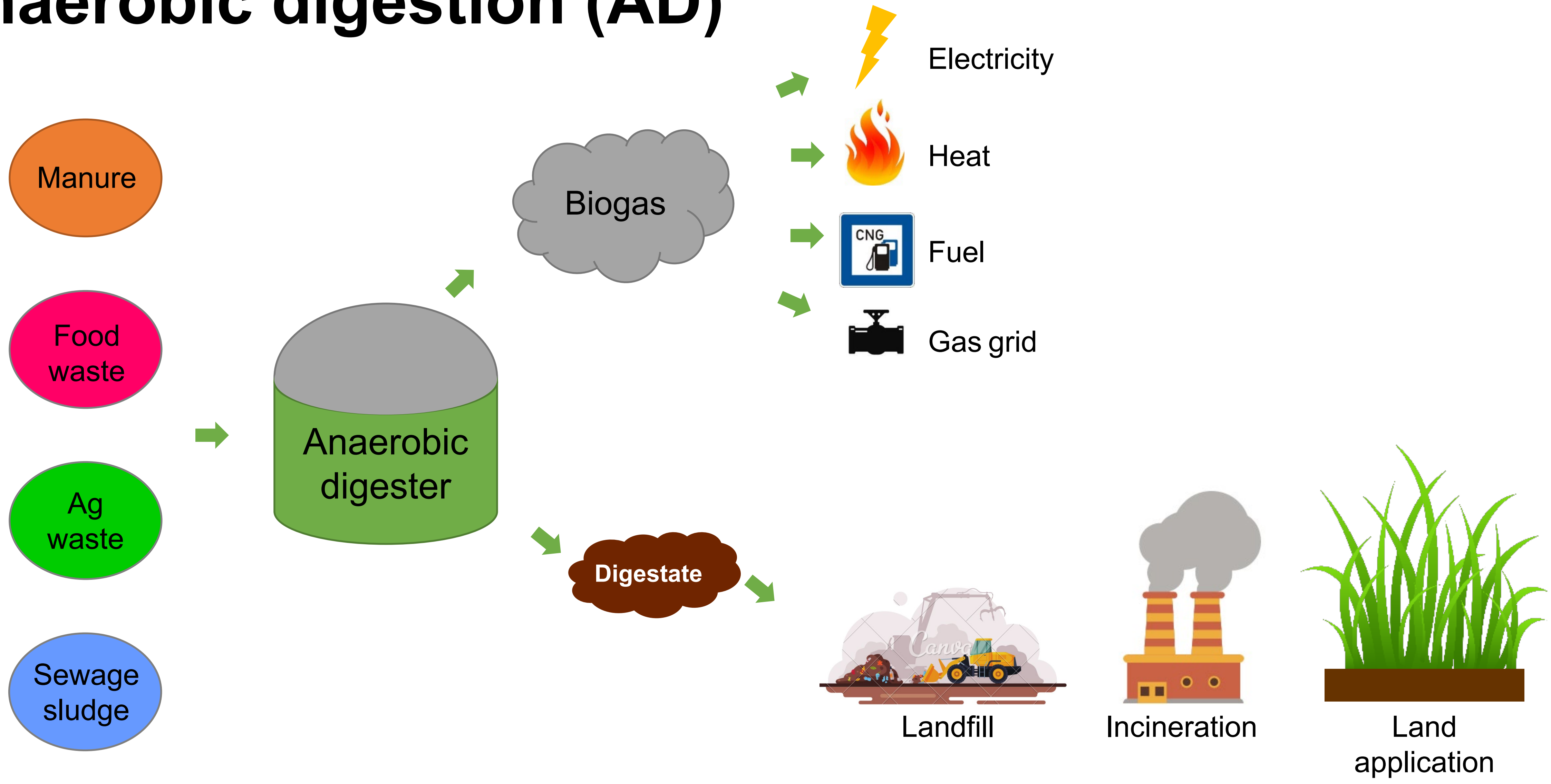
Anaerobic digestion (AD)

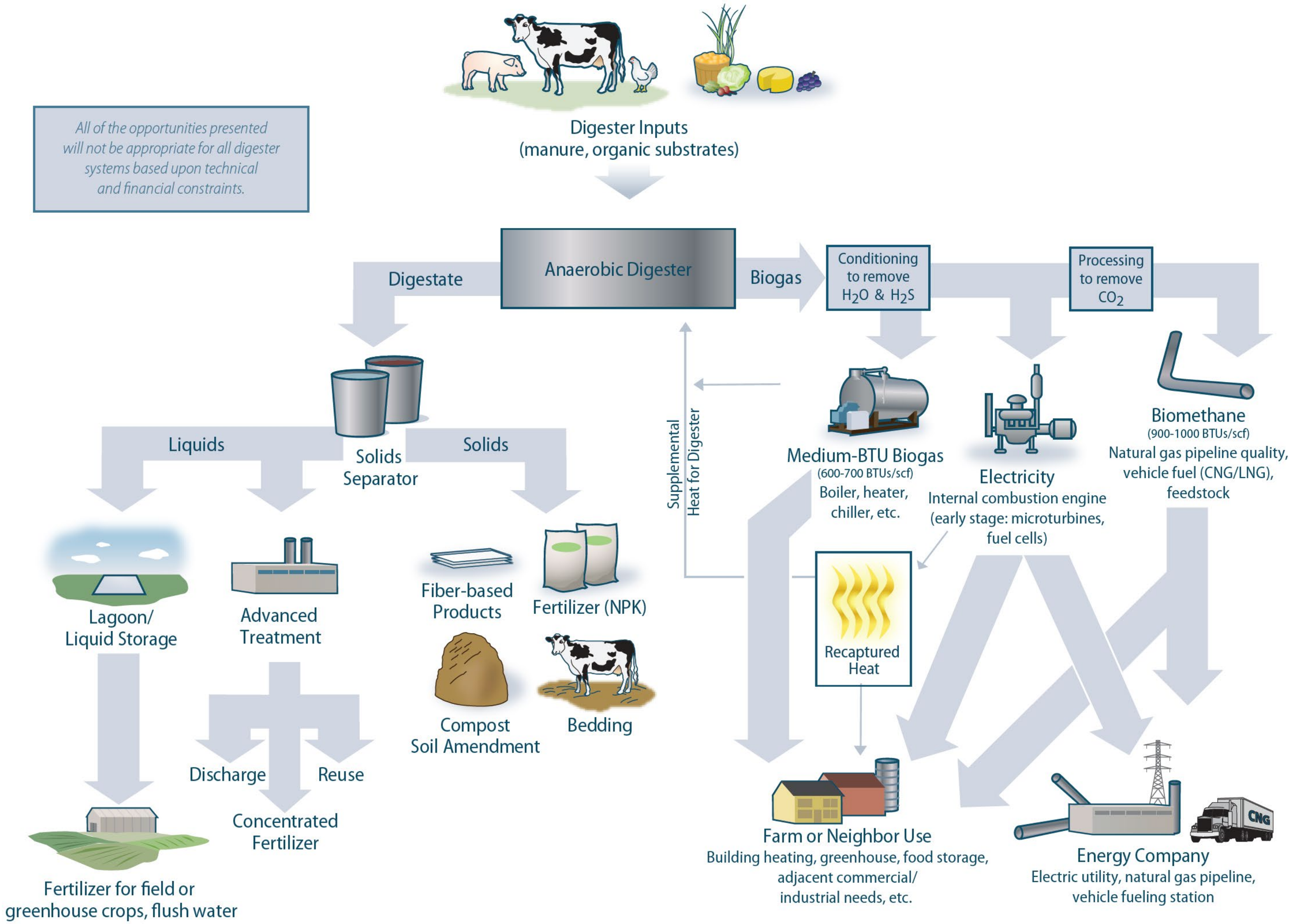


Types of digesters

Stand-alone

On farm

WWTP



All of the opportunities presented will not be appropriate for all digester systems based upon technical and financial constraints.
Digester Inputs
(manure, organic substrates)
Anaerobic Digester
Digestate
Biogas
Conditioning to remove H_2O & H_2S
Processing to remove CO_2
Solids Separator
Liquids
Solids
Supplemental Heat for Digester
Medium-BTU Biogas
(600-700 BTUs/scf)
Boiler, heater, chiller, etc.
Electricity
Internal combustion engine (early stage: microturbines, fuel cells)
Biomethane
(900-1000 BTUs/scf)
Natural gas pipeline quality, vehicle fuel (CNG/LNG), feedstock
Lagoon/ Liquid Storage
Advanced Treatment
Fiber-based Products
Fertilizer (NPK)
Compost Soil Amendment
Bedding
Recaptured Heat
Discharge
Reuse
Concentrated Fertilizer
Fertilizer for field or greenhouse crops, flush water
Farm or Neighbor Use
Building heating, greenhouse, food storage, adjacent commercial/ industrial needs, etc.
Energy Company
Electric utility, natural gas pipeline, vehicle fueling station
CNG

Benefits of AD

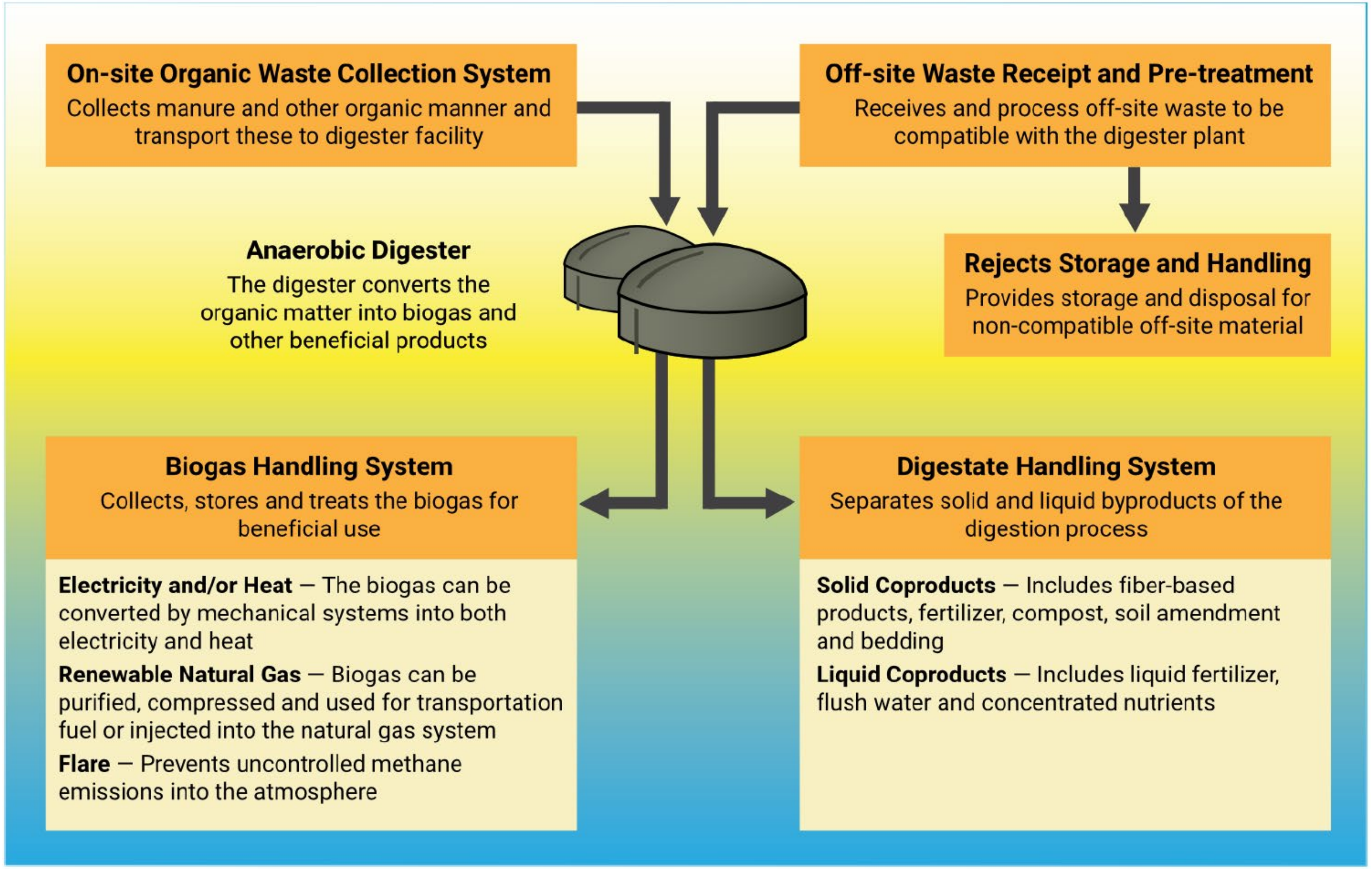
Benefits	Outcome
Economic and Financial	New revenues from AD/biogas systems can significantly diversify farm income.
Environmental and Socio-Economic	Waste products that are considered a liability are converted into a beneficial resource. AD/biogas systems create circular use of materials such that waste products are recycled into beneficial use products.
Energy Generation	Biogas from digestion can be used to provide usable energy, such as thermal energy, electrical power, pipeline-quality natural gas, and/or RNG. Electrical power from biogas can be used as baseload and/or dispatchable power generation (i.e., generation of power at peak periods, as dictated by the utilities). These are two of several significant advantages over wind and solar renewable energy generation, which require energy storage to be added to meet these power demands.
Transportation Fuel	When RNG is used as a vehicle fuel, emissions meet the most stringent GHG pollution laws. For example, as defined by the State of California, RNG is the most carbon negative transportation fuel available.
Stabilized Digestate	Digestate can be used as a nutrient-rich fertilizer and as a soil amendment to improve soil health and crop production, both on farm and off farm.
Climate Change Mitigation	Emissions are reduced by capturing methane (CH_4) that may have been lost to the atmosphere and utilization of that CH_4 as a renewable fuel, offsetting the use of fossil fuels.
Overall General Benefits	The implementation of on farm AD/biogas systems increases overall sustainability, reduces pathogens, and improves overall efficiency of natural resources.
Bio-Products	The primary and secondary products of AD/biogas systems can be the foundation for renewable bio-based products, such as bio-based plastics. This is something no other renewable technology can provide.

Economic and financial benefits of AD

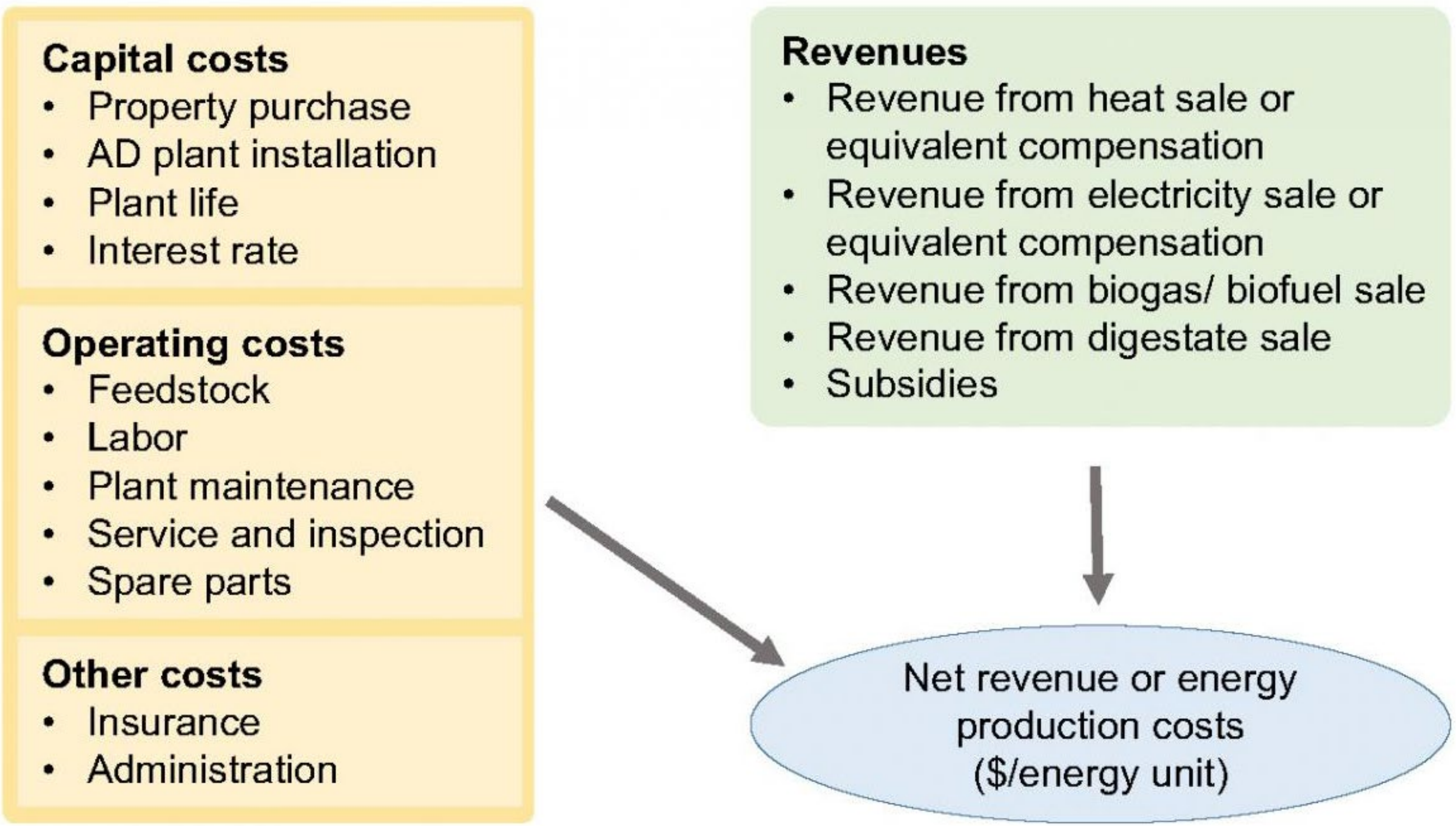
New sources of income:

- Selling biogas-based renewable energy
- Receipt of tipping fees for co-digestion feedstocks.
- Digestate-derived products..
- Create new opportunities for rural economic growth

AD System Process Components



Economics of an AD project

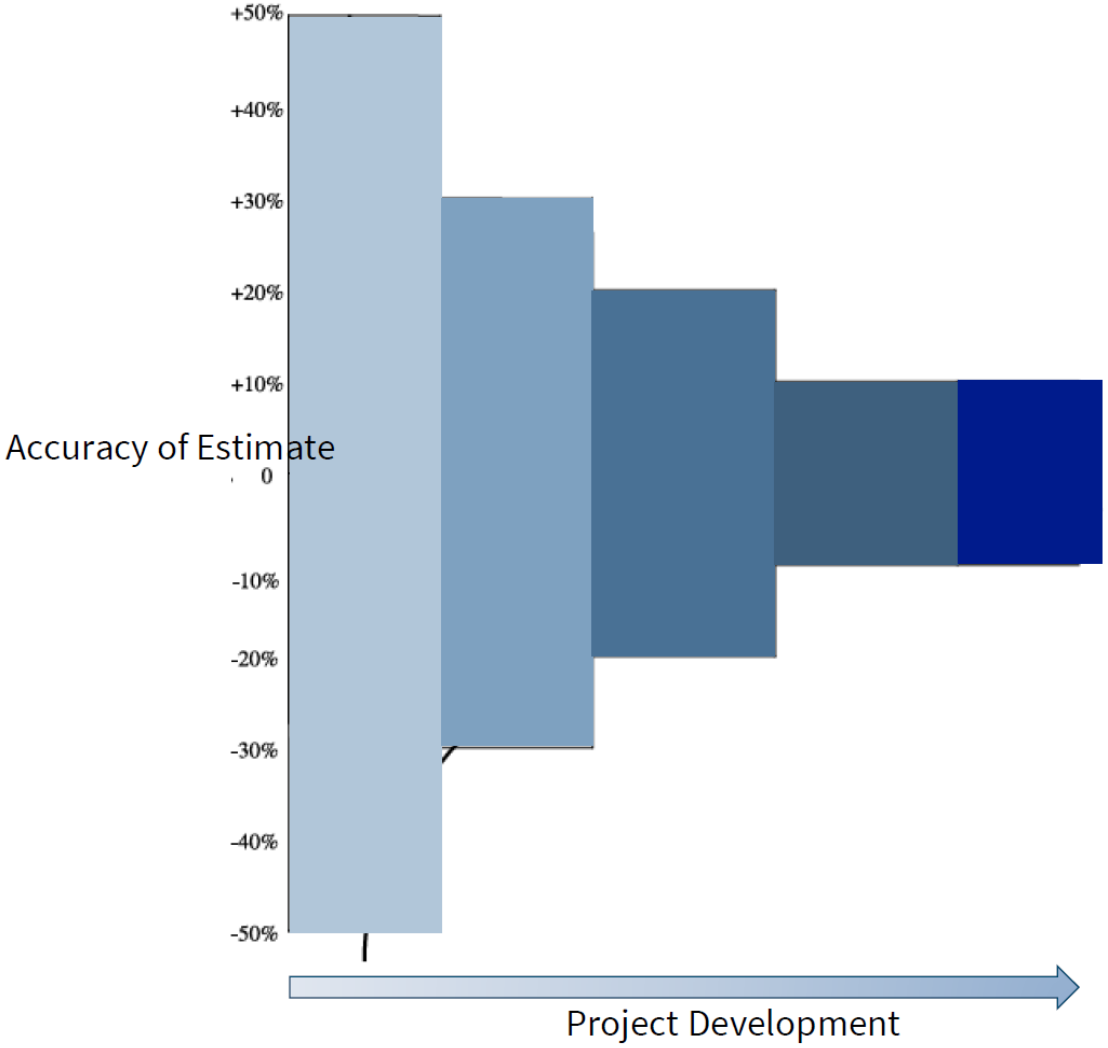


Capital investment

- Land acquisition;
- Site development;
- Civil works (earthwork, site work, etc.);
- Structure (buildings, tanks, etc.);
- Equipment (mixers, pumps, generator, relays, etc.);
- Equipment installation;
- Conveyance systems;
- Project controls;
- Interconnection;
- Permitting fees;
- Project management;
- Consulting and legal;
- Contractor overhead and profit; and
- Developer costs for process design and engineering services.

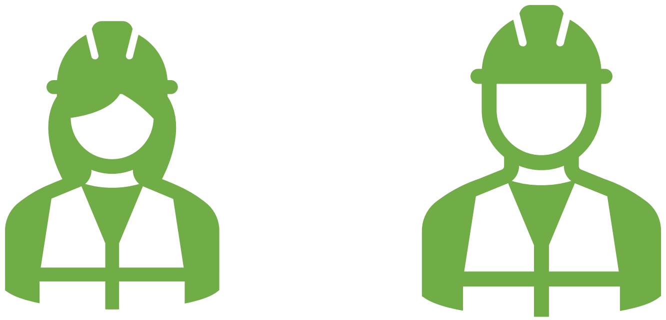
Other costs

- Working capital
- Contingency

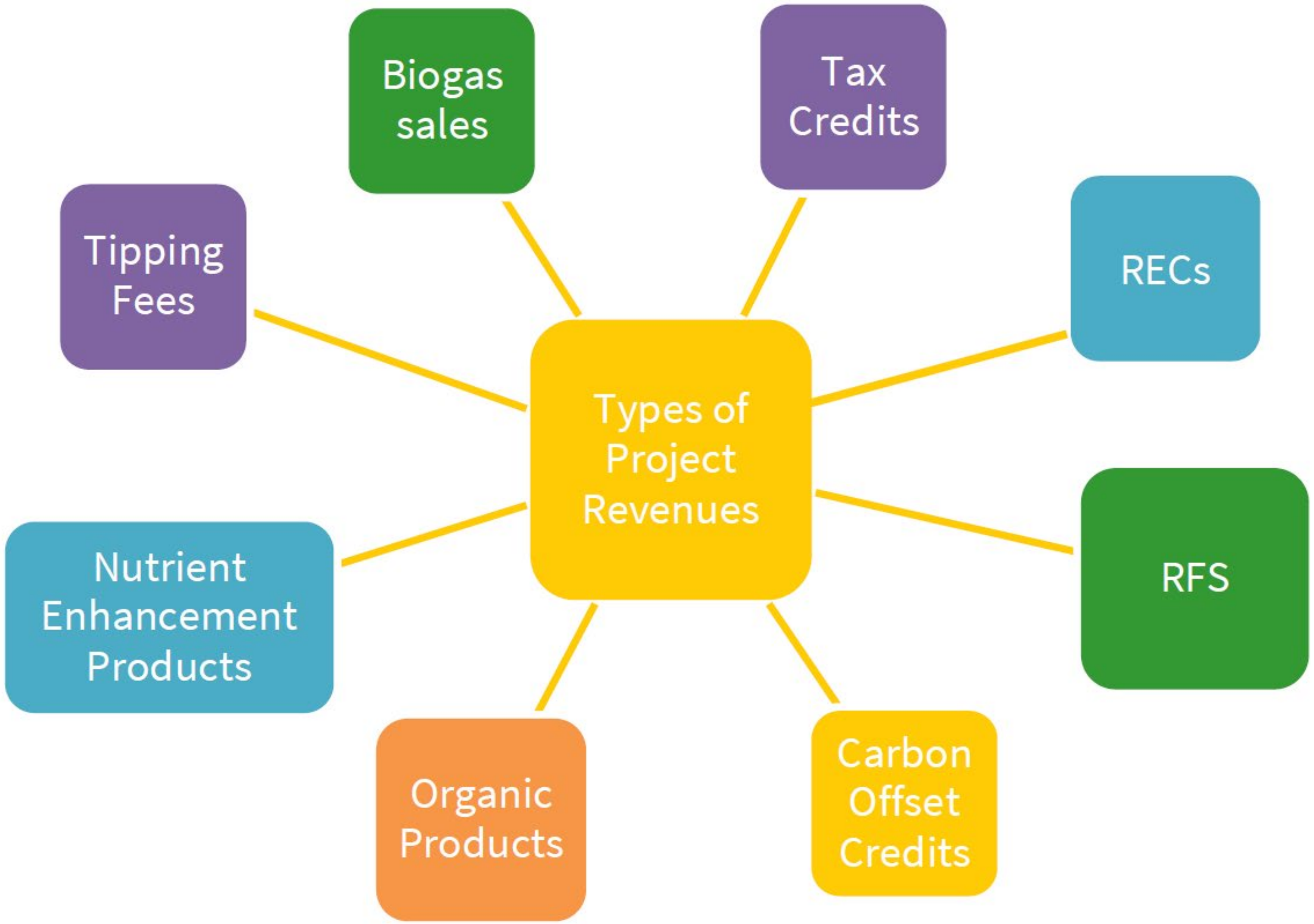


Operating expenses

- Daily operating labor;
- Purchased utilities;
- Mechanical systems maintenance;
- Chemicals and consumables;
- Digestate disposal;
- Regulatory compliance;
- Insurance;
- Miscellaneous; and
- Property taxes.



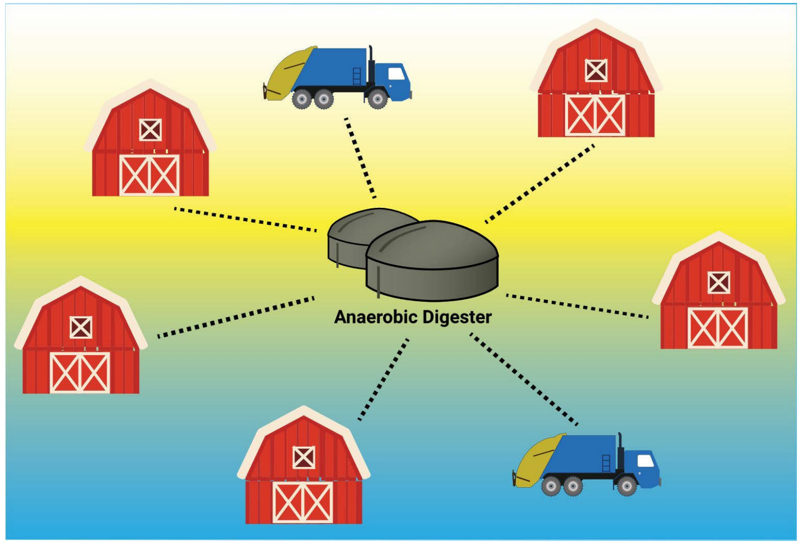
Revenues

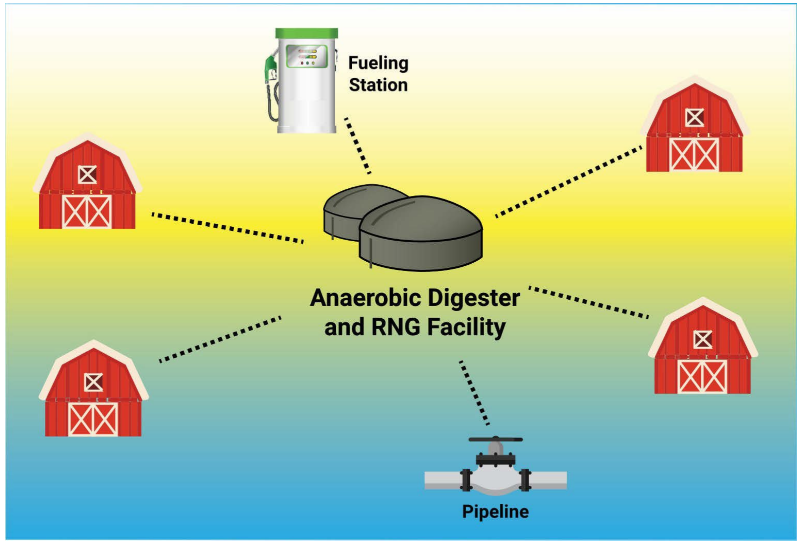

Biogas sales
Tax Credits
Tipping Fees
RECs
Types of Project Revenues
RFS
Nutrient Enhancement Products
Organic Products
Carbon Offset Credits

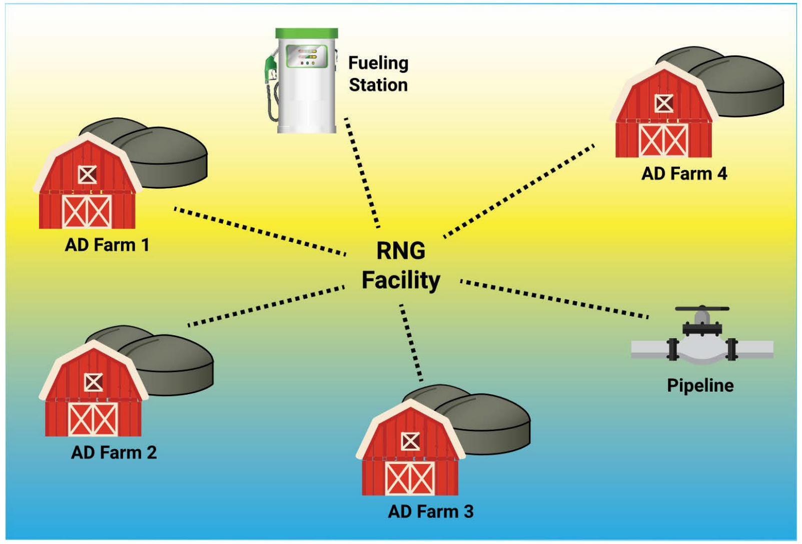
Owner and Operator Models

- Farm owned and operated
- Third party owned and operated
- Third party operated
- Hub and spoke

Hub and Spoke Systems







Feasibility studies

Opportunities for Smaller Farm-based AD/Biogas Systems

The success of farm-based systems is usually enhanced with a larger herd size. However, there are exceptions that create opportunities for smaller farms, including:

- Environmental issues
- Odor issues
- Energy production incentives
- Grant funding
- Farm location
- Manure collection practices
- AD/biogas system design
- Farm owner's goals

One exception, for example, is the ability of smaller farms to use co-digestion feedstocks to produce significantly more biogas than a manure-based system alone. Plus, the co-digestion feedstocks also provide new revenues from the tipping fees.

For example, the Bar-Way Farm in Deerfield, MA operates an AD/biogas system using the manure from only 250 dairy cows (see Figure 7.1). The project is successful because it annually co-digests 30,000 tons of food waste in addition to the 9,200 tons of manure produced by the dairy cattle.

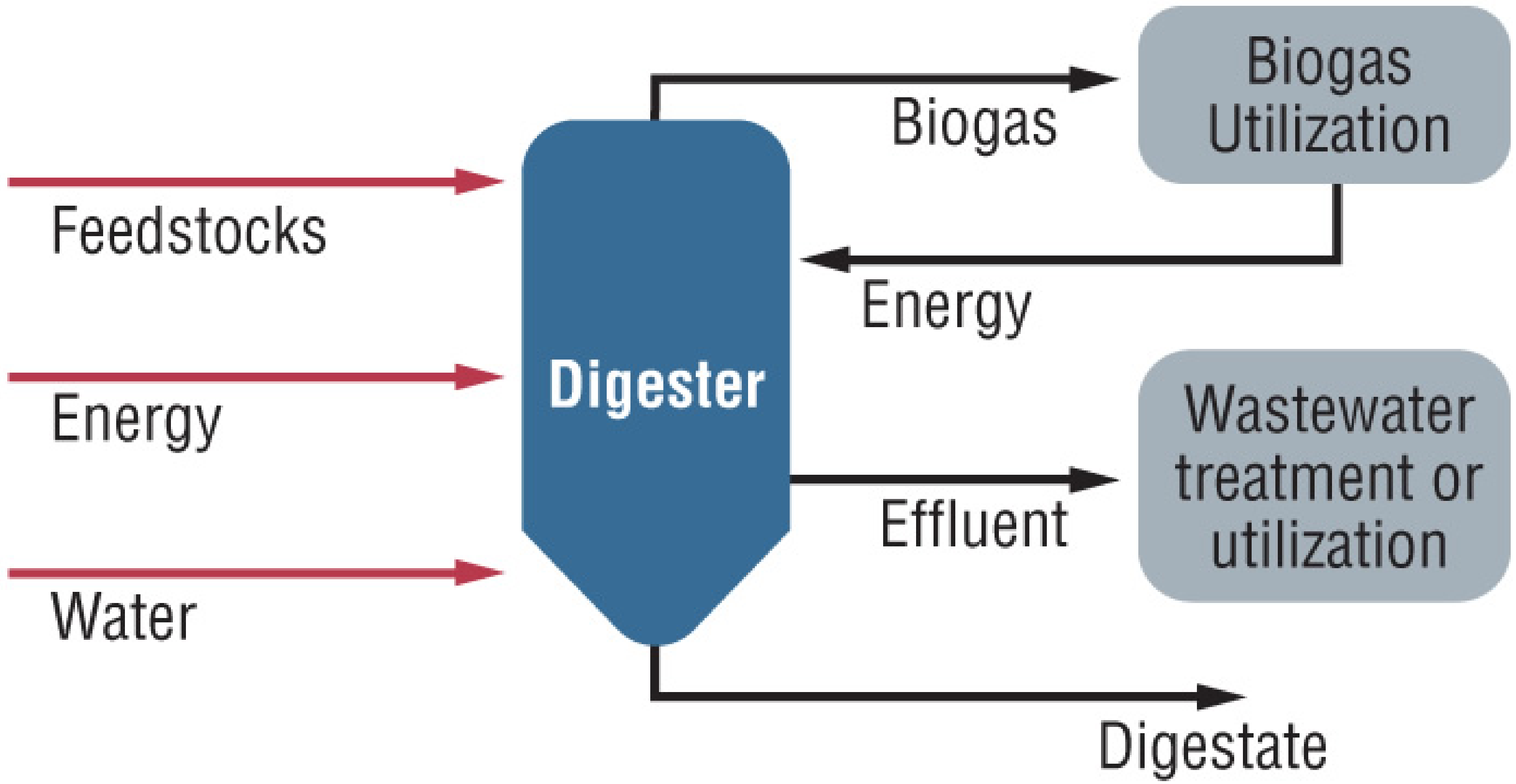
Pre-feasibility

- Concentrated animal feeding operation (CAFO) status;
- Animal type and number of animals
  - For dairy farms - lactating, dry and heifers, layers
  - For swine farms - sow, nursery, finishing, and the stocking plan for the finishing operation
  - For poultry farms – turkey or chicken, and for chicken layers or broilers;
- Barn type, including for example, free stall, open corral, slatted floor, cross ventilated;
- The amount of time livestock spend in barns as summarized on daily and yearly averages;
- Manure removal practices on the farm, including for example, flush, vacuum, scrape, pit, pull plug, deep pit manure management practices;
- Manure collection frequency;
- Water sources and amounts entering manure stream (e.g., parlor wash, manure flushing, and rainwater management on farm);
- Current manure handling practices (e.g., separation, lagoon, land application practices);
- Current energy uses (e.g., the cost and quantity of electricity, fuel oil, propane, natural gas, electricity service, single- or three-phase);
- Siting available and configuration;
- Co-digestion feedstocks, if any

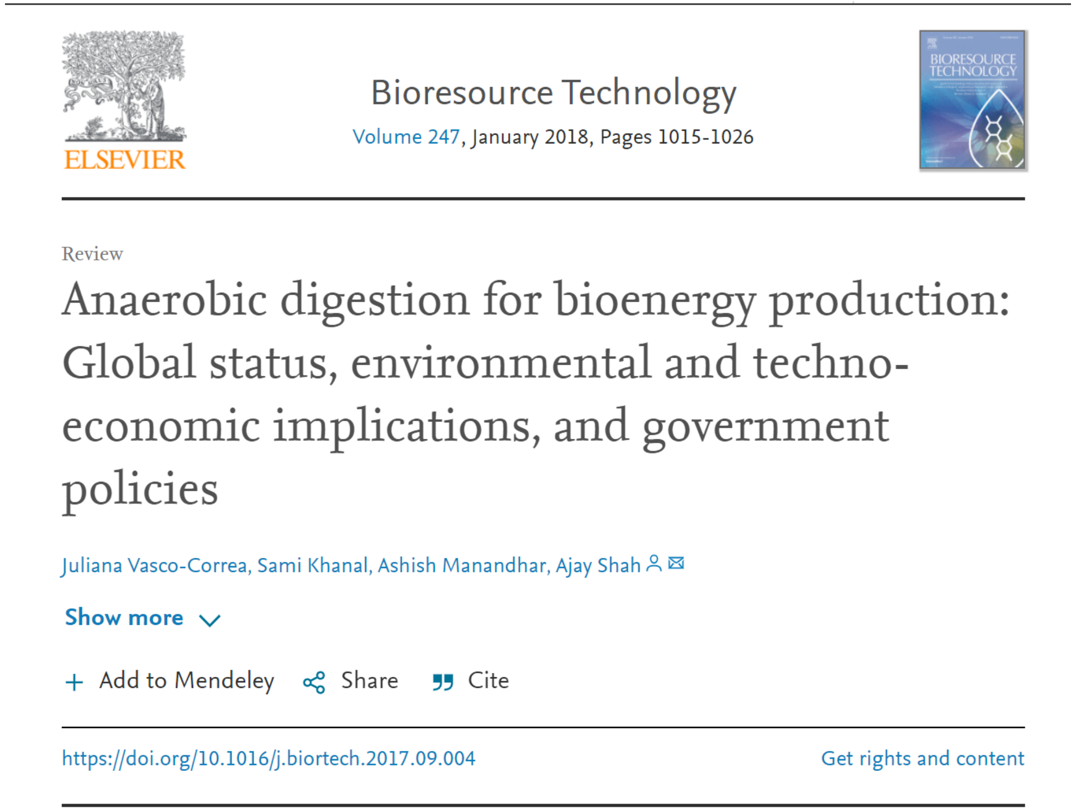
Feasibility

- Feedstock definition
- Recoverable products definition
- Preliminary technology definition
- Mass and energy balance
- Capital cost estimate
- Operating costs estimate
- Revenues estimate
- Economic and financial projections

Mass and energy balances



Sources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Review

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Thank you

Questions?

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