NEWTRIENT™
INNOVATIVE SOLUTIONS IN RESOURCE RECOVERY

Methane, Dairies and Livestock, and Renewable Natural Gas in California

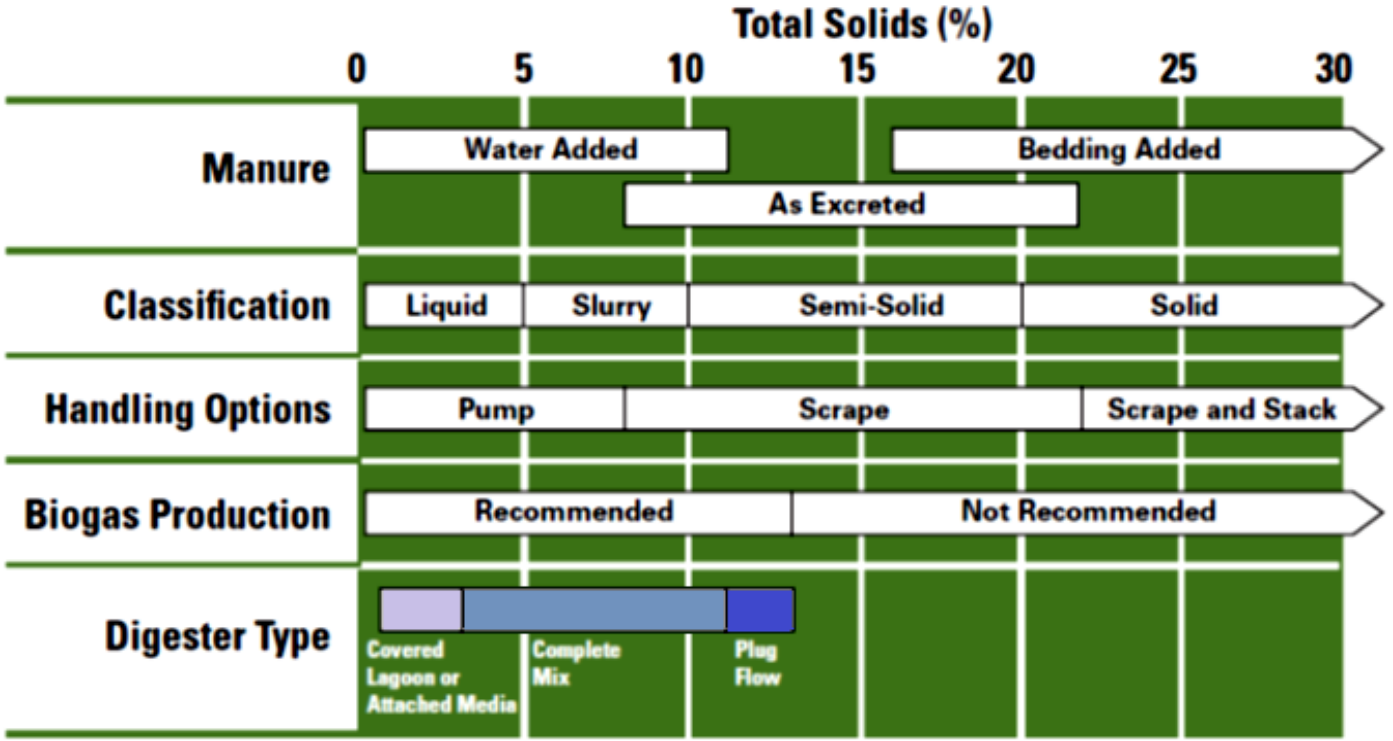
Newtrient Manure Treatment Technology Evaluation

April 4, 2022

Developing Manure Management Strategies

- No single source to identify best technologies
- Technology types should be sorted by impact on specific operational and environmental critical indicators
- Assist the dairy industry in making decisions in area of specific concern
- So Newtrient is expanding its Technology Catalog

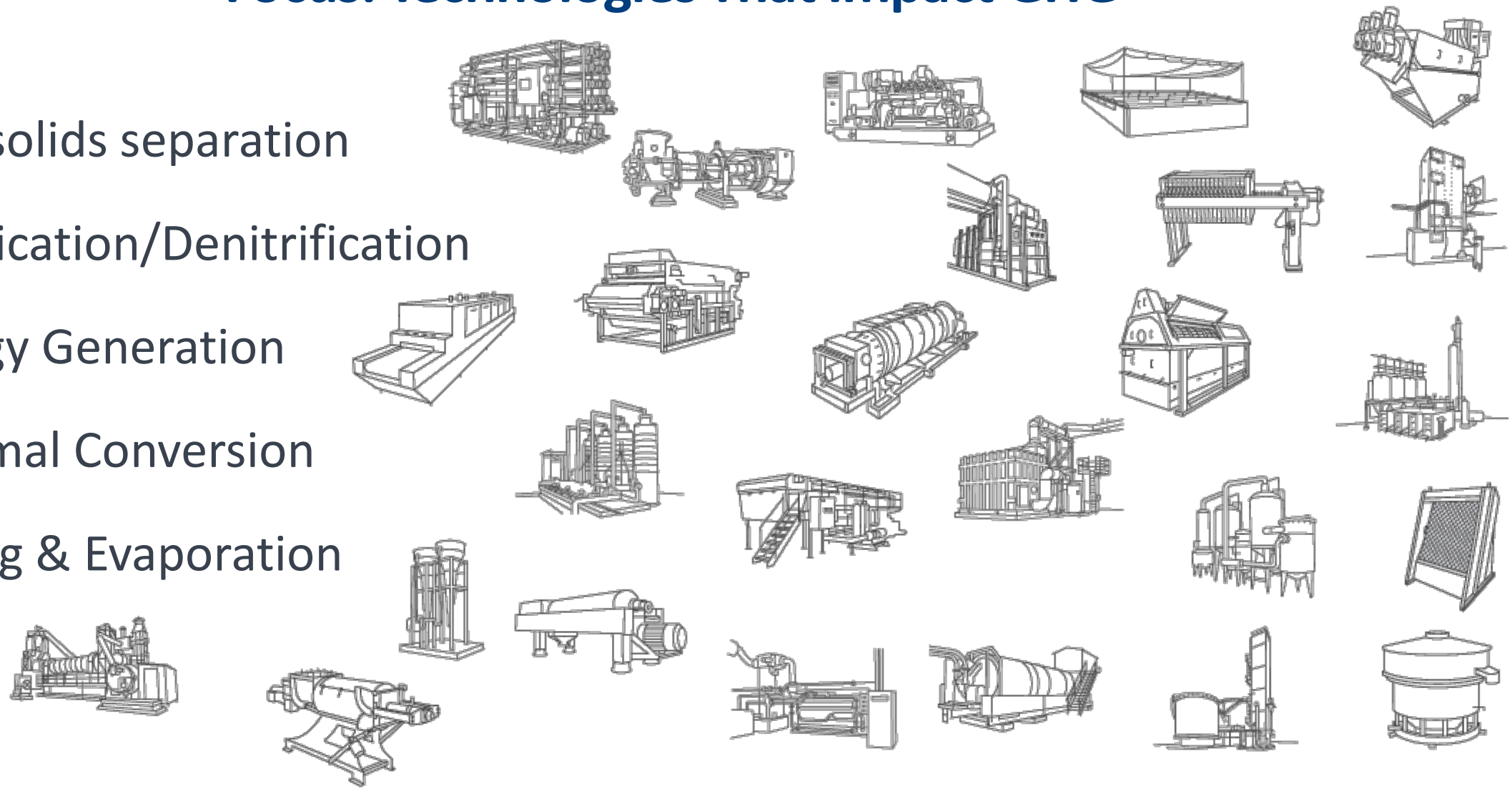
Figure 2. Manure Handling Practices Affect the Feasibility and Choice of Digester Systems



https://www.newtrient.com/newtrient-solutions-catalog/

Focus: Technologies That Impact GHG

- Fine solids separation
- Nitrification/Denitrification
- Energy Generation
- Thermal Conversion
- Drying & Evaporation



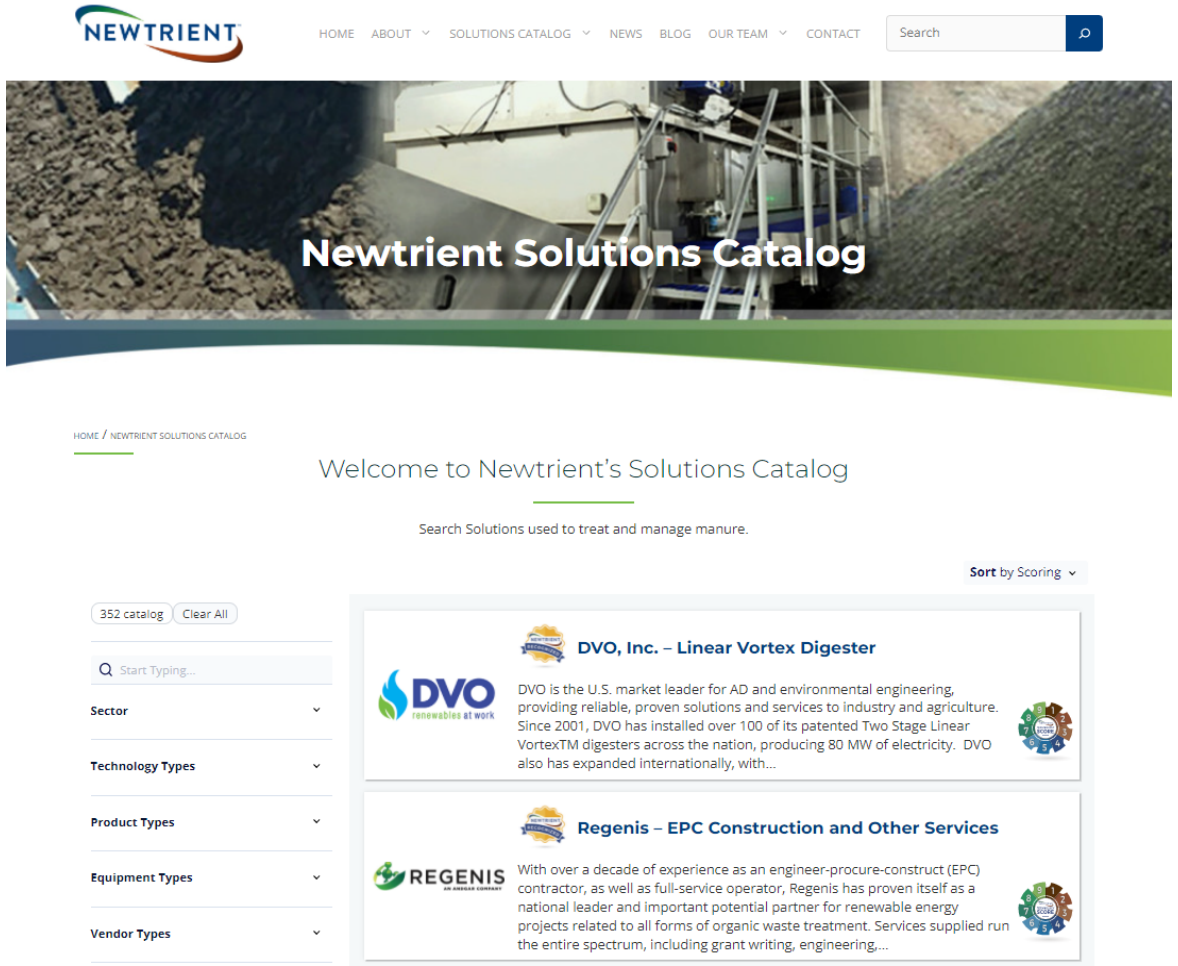
Expanded Newtrient Solutions Catalog

In 2022, Newtrient will increase on-farm evaluations to include:

- Conservation Practices
- Feed Additives
- Manure Additives

And develop packaged evaluations on key topics including:

- Conservation Practices
- Feed and Manure Additives
- Manure Management Technologies
- Energy Efficiency
- Renewable Energy (fuel, electricity, substrates)
- Water and Carbon Trading
- Corporate Sponsored Programs



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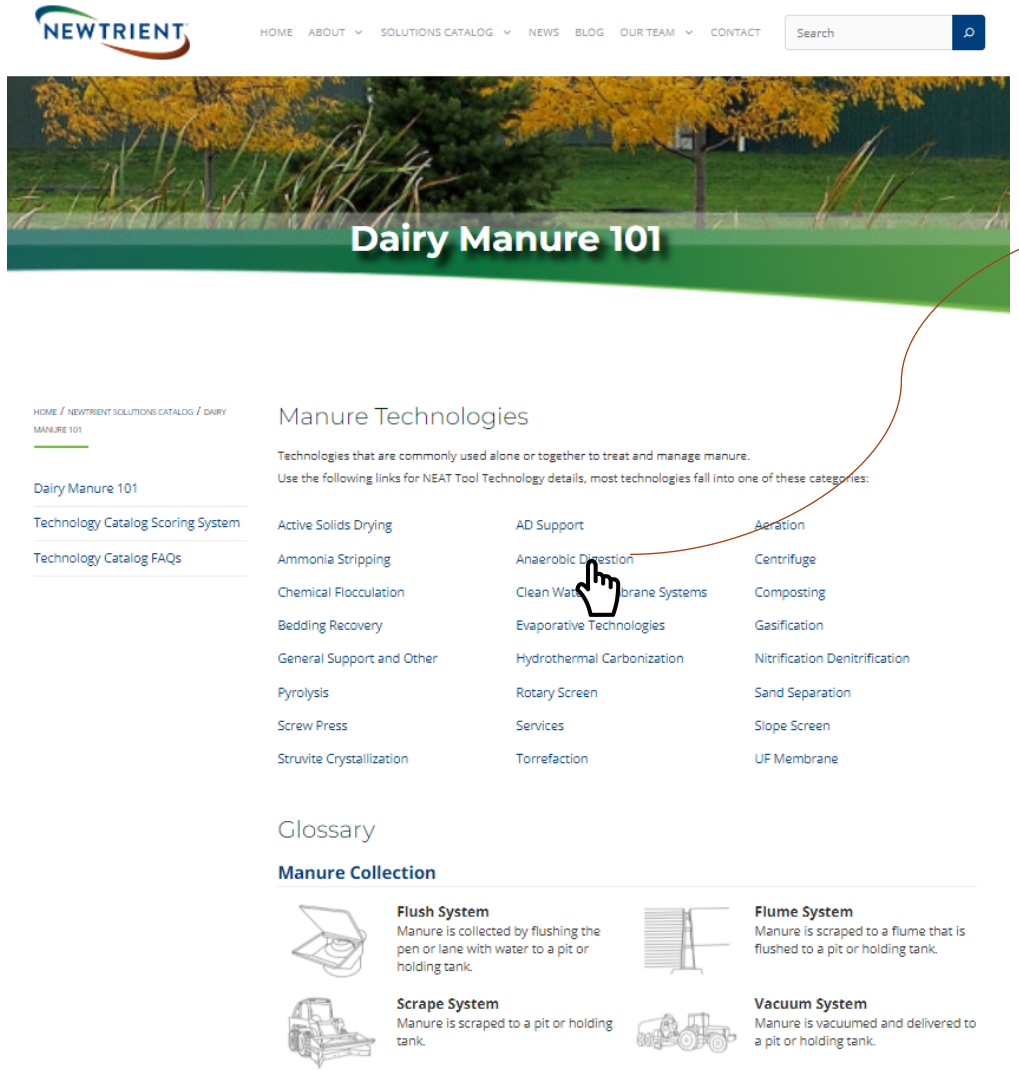
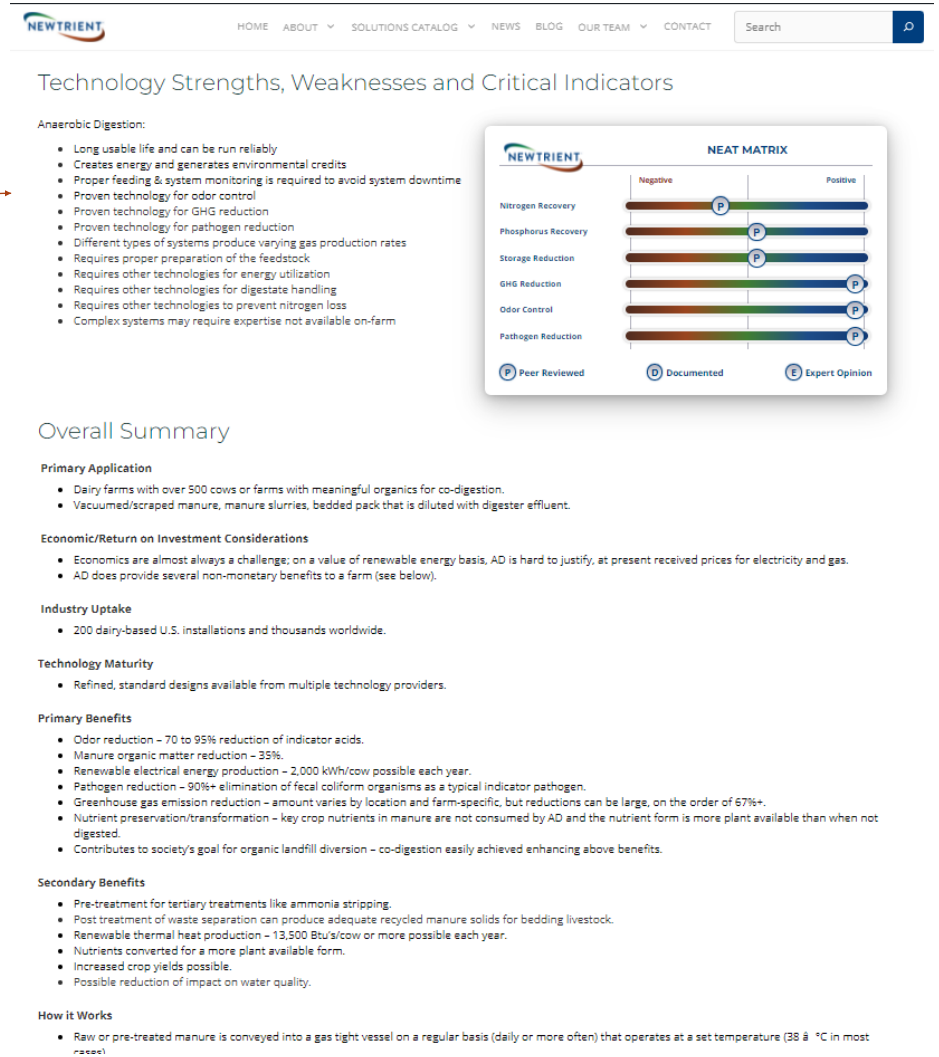
Where to Find Information





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Manure Treatment Estimated Reduction of GHG

Technology Type	% GHG Reduction
Active Solids Drying	67-95
Aeration	67-95
Ammonia Stripping	0
Anaerobic Digestion*	40-80
Centrifuge	33-67
Chemical Flocculation	80
Complete Membrane Systems	0
Composting	33-67
Evaporation	67-95

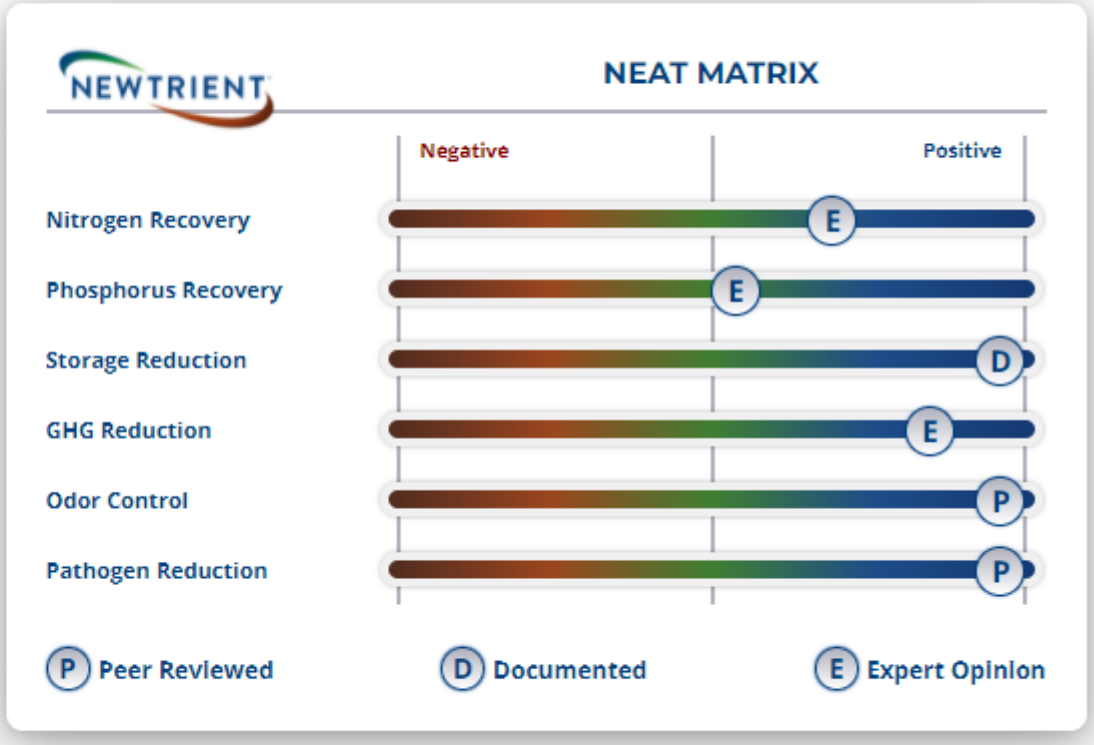
Technology Type	% GHG Reduction
Gasification / Pyrolysis / Torrefaction*	95
Hydrothermal Processing*	95
Nitrification Denitrification	67-95
Rotary Screen	33
Sand Separation	0
Screw Press	33
Slope Screen	33
Struvite Crystallization	0
Vermifiltration	20-40

*These technologies not only reduce on-farm emissions but produce renewable energy and replace fossil fuel usage

Active Solids Drying

Active Drying Technologies:

- Produce a marketable product, dry manure solids, and reduce transportation costs
- Require energy to reduce water content and dry manure solids, purchased energy cost are an issue
- Require operator attention in excess of other systems due to the risk of combustion
- Other compounds are released with the water (i.e. ammonia, hydrogen sulfide), and require additional treatment
- Potential loss of ammonia nitrogen due to volatilization
- Proven technology for storage reduction, odor control, GHG reduction and pathogen reduction

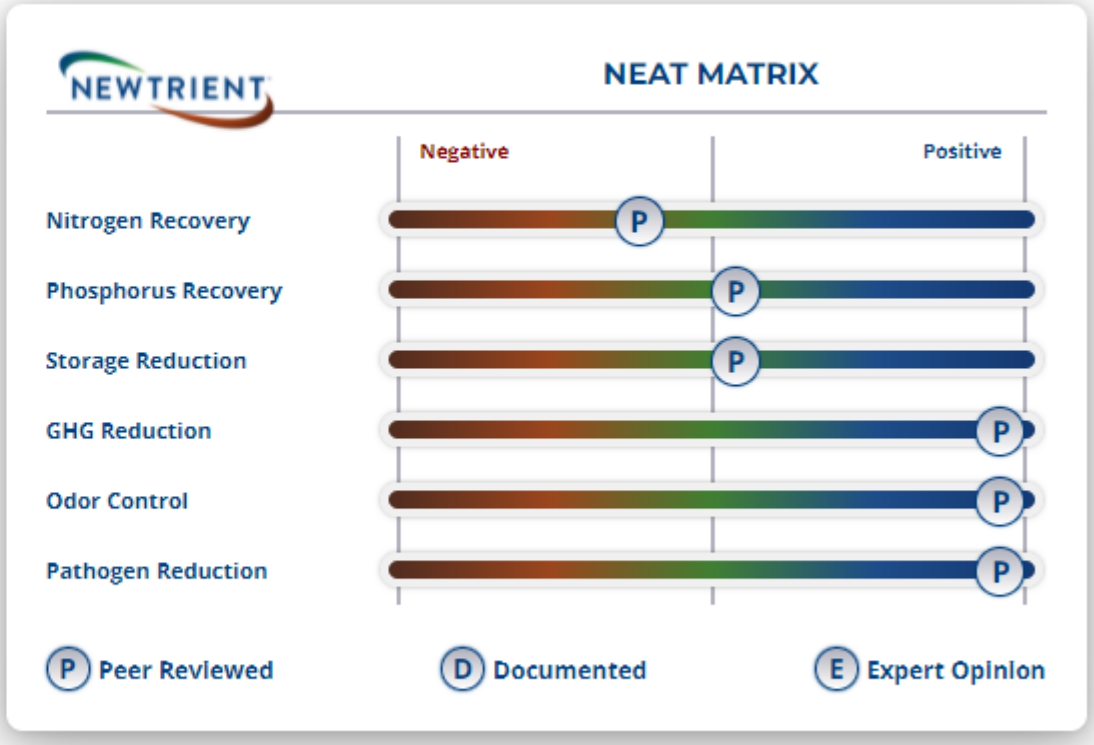


https://www.newtrient.com/technology-type/active-solids-drying/

Anaerobic Digestion

Anaerobic Digestion:

- Long usable life and can be run reliably
- Creates energy and generates environmental credits
- Proper feeding & system monitoring is required to avoid system downtime
- Proven technology for odor control
- Proven technology for GHG reduction
- Proven technology for pathogen reduction
- Different types of systems produce varying gas production rates
- Requires proper preparation of the feedstock
- Requires other technologies for energy utilization
- Requires other technologies for digestate handling
- Requires other technologies to prevent nitrogen loss
- Complex systems may require expertise not available on-farm

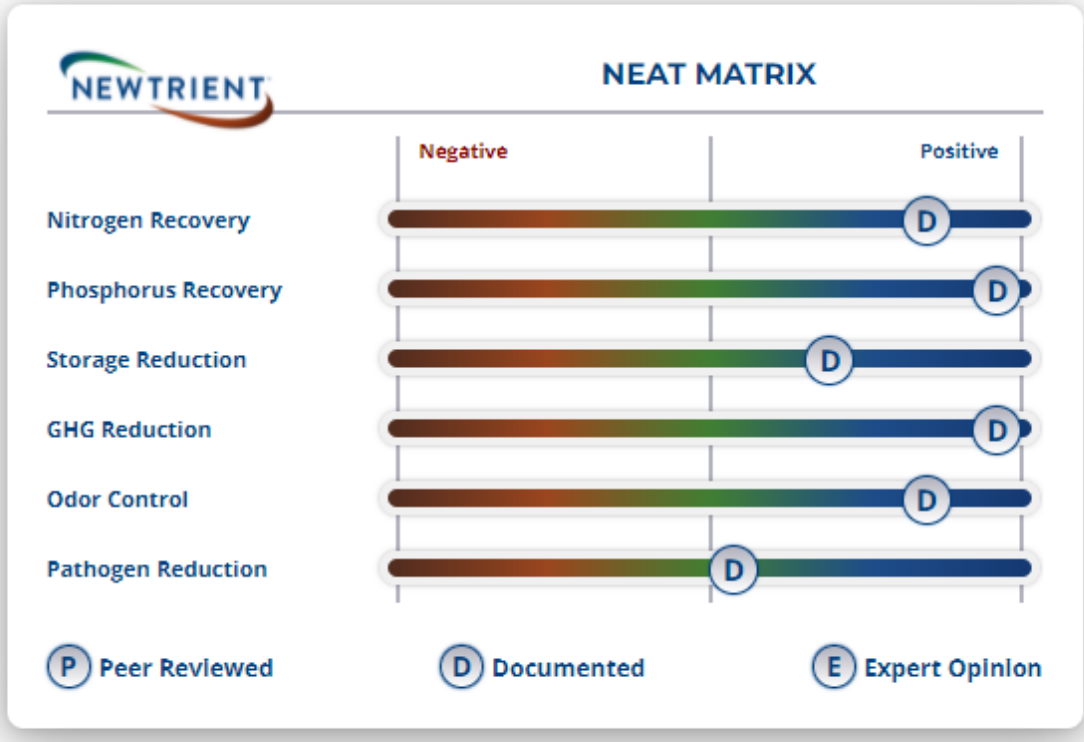


https://www.newtrient.com/technology-type/anaerobic-digestion/

Chemical Flocculation

Chemical flocculation technologies remove the non-dissolved particles from the waste stream typically resulting in irrigation quality "tea water":

- Produces a clay like cake which is high in phosphorus and with significant amounts of organic nitrogen.
- Supported technologies include belt presses, centrifuges, dissolved air flotation systems and others; all requiring flocculants to achieve high rates of solids removal
- There is significant variation of chemical and energy use depending on site and by technology
- There is significant variation of operational intensity depending on site and by technology
- There is significant variation of cost depending on site and by technology
- Proven technology for nitrogen recovery, phosphorous recovery, storage reduction, GHG reduction, and odor control



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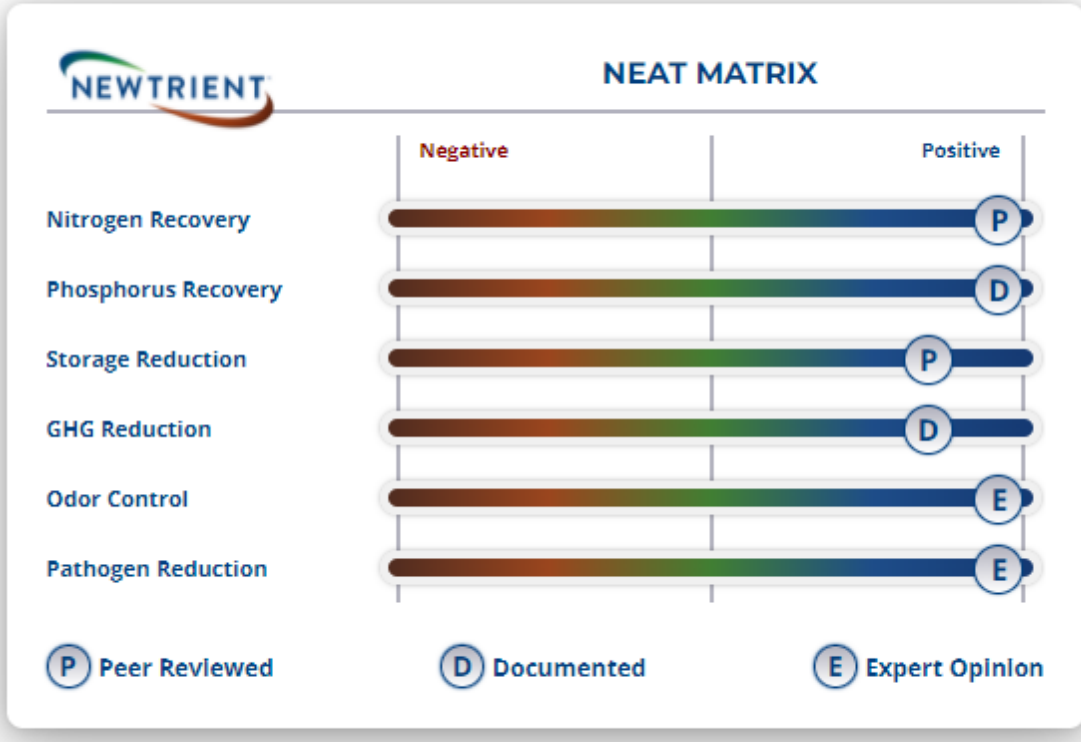
Evaporation

Evaporation Technologies:

- Use heat to produce either manure with less water or dried manure solids
- Reduce water in manure using a series of evaporators or recompressed process generated steam to evaporate water from liquid slurries—energy is supplied either by purchased fuel and/or waste heat from other processes
- Systems that dry separated solids use either a belt or drum to evaporate water from separated solids—energy is supplied either by purchased fuel, electricity and/or waste heat from other processes
- Compounds are released as the water is driven off (i.e. ammonia, hydrogen sulfide), this often requires additional treatment such as condensation of the water and/or scrubbing of the chemicals
- Requires purchased energy and costs are a significant concern leading to a trade-off between input costs and gains in liquid concentration and transportation/market of by-products
- Proven technology for nitrogen recovery, phosphorous recovery, storage reduction, GHG reduction, odor control and pathogen reduction

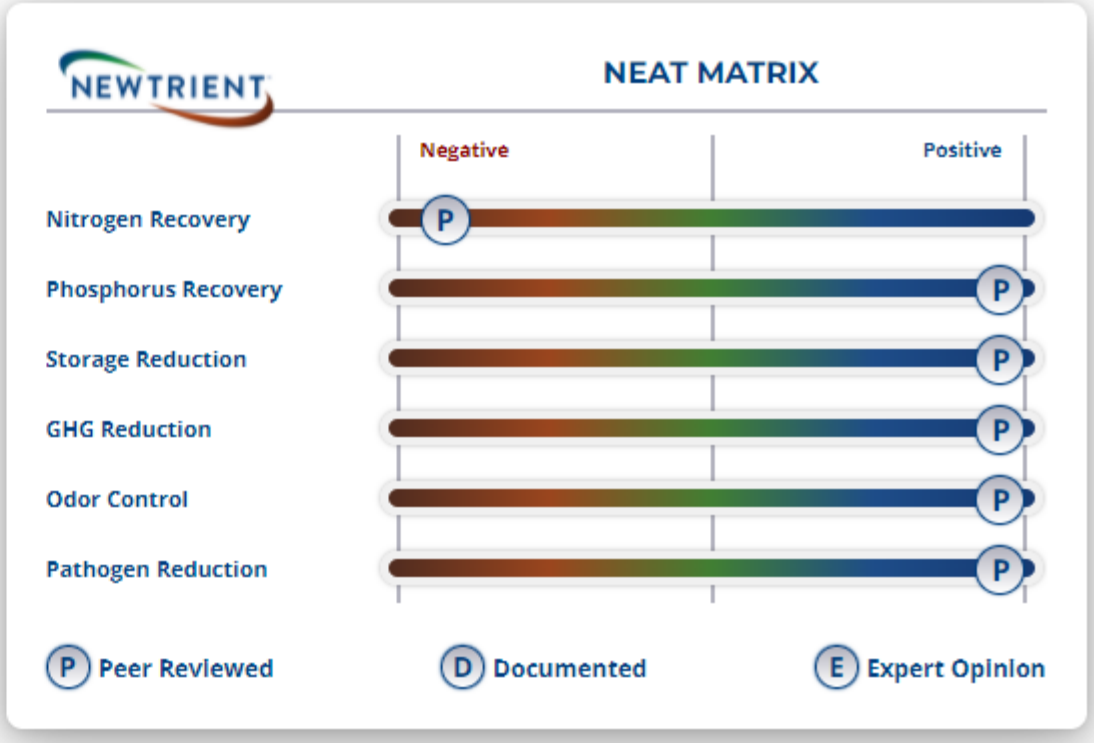


https://www.newtrient.com/technology-type/evaporative-technologies/

Gasification / Pyrolysis / Torrefaction

Gasification:

- Produces a soil amendment in the form of biochar
- Biochar does not yet have an established, stable commercial market
- There is significant variation in energy use and recovery depending on feedstock
- There is significant variation of operational intensity by site and by technology, many technologies require pairing with other technologies to offer a comprehensive manure management solution
- There is significant variation of cost depending on site and by technology
- Proven technology for phosphorous recovery, storage reduction, GHG reduction, odor control and pathogen reduction
- This technology loses nitrogen to the atmosphere

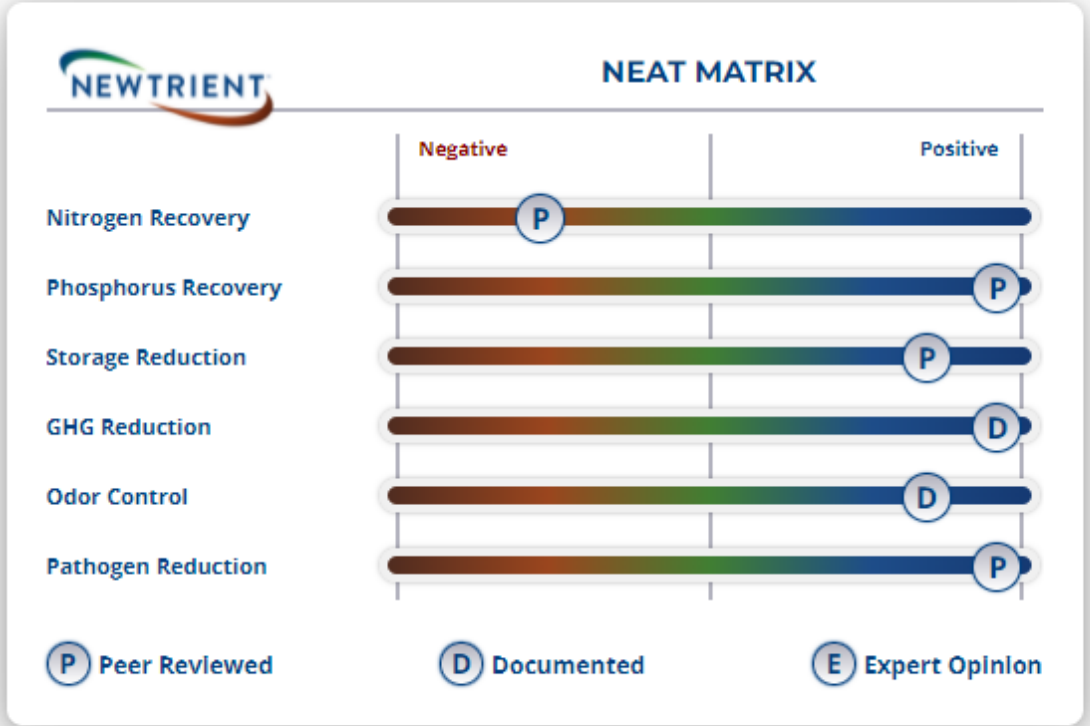


https://www.newtrient.com/technology-type/gasification/

Hydrothermal Processing

Hydrothermal Carbonization:

- May produce a salable product in the form of hydrochar, a product similar to biochar
- Hydrochar does not yet have an established, stable commercial market in the United States
- There is variation of operational intensity by site and by technology, many technologies require pairing with other technologies to offer a comprehensive manure management solution
- There is significant variation of cost depending on site and by technology
- Proven technology for phosphorous recovery, storage reduction, GHG reduction, odor control and pathogen reduction but not widely adopted
- This technology may lose nitrogen to the atmosphere



https://www.newtrient.com/technology-type/ hydrothermal-carbonization/

Where to Find Information

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Technology Strengths, Weaknesses and Critical Indicators

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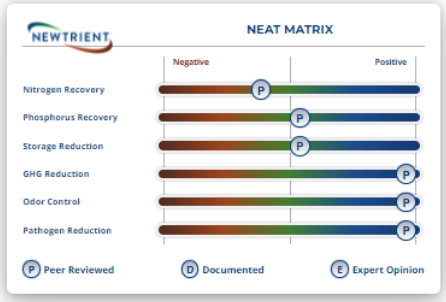

Overall Summary

Primary Application

- Dairy farms with over 500 cows or farms with meaningful organics for co-digestion.
- Vacuumed/scraped manure, manure slurries, bedded pack that is diluted with digester effluent.

Economic/Return on Investment Considerations

- Economics are almost always a challenge; on a value of renewable energy basis, AD is hard to justify, at present received prices for electricity and gas.
- AD does provide several non-monetary benefits to a farm (see below).

Industry Uptake

- 200 dairy-based U.S. installations and thousands worldwide.

Technology Maturity

- Refined, standard designs available from multiple technology providers.

Primary Benefits

- Odor reduction – 70 to 95% reduction of indicator acids.
- Manure organic matter reduction – 35%.
- Renewable electrical energy production – 2,000 kWh/cow possible each year.
- Pathogen reduction – 90%+ elimination of fecal coliform organisms as a typical indicator pathogen.
- Greenhouse gas emission reduction – amount varies by location and farm-specific, but reductions can be large, on the order of 67%+.
- Nutrient preservation/transformation – key crop nutrients in manure are not consumed by AD and the nutrient form is more plant available than when not digested.
- Contributes to society's goal for organic landfill diversion – co-digestion easily achieved enhancing above benefits.

Secondary Benefits

- Pre-treatment for tertiary treatments like ammonia stripping.
- Post treatment of waste separation can produce adequate recycled manure solids for bedding livestock.
- Renewable thermal heat production – 13,500 Btu's/cow or more possible each year.
- Nutrients converted for a more plant available form.
- Increased crop yields possible.
- Possible reduction of impact on water quality.

How it Works

- Raw or pre-treated manure is conveyed into a gas tight vessel on a regular basis (daily or more often) that operates at a set temperature (38 â °C in most cases).
- Naturally occurring microbes in manure break solids down into energy-rich biogas.
- Biogas is used to fuel engine-generators to make electricity or is cleaned to make a natural gas replacement.
- Some of the produced gas, or heat produced by an engine-generator set is used to heat the digester making it a net energy production system.

Pre-treatment and/or Post-treatment Required

- Pre-treatment not required when organic material is used to bed stalls and/or when manure is not substantially diluted. Pre-treatment to remove bedding sand is required with sand-bedded stalls.
- Pre-treatment may be used to remove excess moisture from influent from barns where hydraulic flushing is used.
- Post-treatment not required but may be employed based on overall goals of the manure treatment system.

Limitations

- Does not reduce volume.
- Does not work well with raw manure containing bedding sand.
- Does not work with highly diluted manure due to cost and heat demands for a large vessel.

Other Considerations

- Currently, most systems are farmer managed, more consistent results may be achieved by dedicated operators.
- Adding co-digestible material will increase the nutrient content of the digestate and will need to be addressed in the nutrient management plan.
- A portion of nutrients are converted from organic to inorganic. More nutrients are available for immediate update by crops, so nutrient management plans should be updated to reduce the potential for water quality concerns.

Technology Providers in order of 9-Point Scoring System

Sort by Score

DVO, Inc. – Linear Vortex Digester

DVO is the U.S. market leader for [illegible] environmental engineering, providing reliable, proven solutions and services to industry and agriculture. Since 20[illegible] VO has installed over 100 of its patented Two Stage Linear VortexTM digesters across the nation, producing 80 MW of electricity. DVO also has expanded internationally, with…

Maas Energy Works – Covered Lagoon Digester

Maas Energy Works is the most successful developer-owner-operator of dairy manure digesters on the West Coast. Their motto is simple, "Renewable Energy that Works." After hundreds of thousands of operating hours in three states and processing the manure on nearly 20 farms, Maas Energy Works knows how to build and run successful…

California Bioenergy (CalBio) – Covered Lagoon Digester

California Bioenergy (CalBio) converts biomass at dairy farms into a clean and storable renewable energy source with valuable co-products and co-benefits. CalBio partnera with California dairy farmers to finance, develop and operate projects that turn dairy manure into energy – electricity, biomethane or fuel. The projects generate multiple benefits for…

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Increased Information and Resources

Credible resources to help:

- evaluating and comparing options
- the dairy community better understand the greatest opportunities for environmental improvement
- increase knowledge to drive incentives and investments from policymakers or investors

Types of resources:

- ***Snapshots*** to introduce emerging or existing solutions
- ***Project Profiles*** to build understanding of and interest in existing on-farm solutions
- ***Expert Evaluations*** to provide credible, in-depth evaluations of solutions

What California Has Done…

- Created a market to support GHG reduction projects nationwide
- Created an incentive program to leverage private investment to support GHG reduction projects in California
  - Dairy Digester Research & Development Program (DDRP) = $2.11 Private / $1.00 Public
  - Alternative Manure Management Program (AMMP) = $0.15 Private / $1.00 Public
- Created a model program that is being followed by other states
- Reduced GHG emissions an estimated 2.333 MMTCO2e/year
  - DDRDP funded projects = 2.112 MMTCO2e
  - AMMP funded projects = 0.221 MMTCO2e
- Established a plan to the 40% reduction target by 2030 with continued investment
- Created a program that works with California industries to ensure success
- Created a program that provides benefits to all Californians

Source: https://ww2.arb.ca.gov/sites/default/files/2022-03/draft-2030-dairy-livestock-sb1383-analysis.pdf

Contact Information

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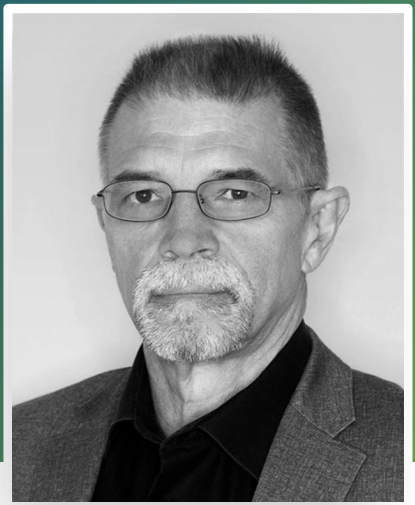

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