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

Newtrient Manure Treatment Technology Evaluation
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

https://www.newtrient.com/newtrient-solutions-catalog/
Focus: Technologies That Impact GHG

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

https://www.newtrient.com/newtrient-solutions-catalog/
Where to Find Information

## Manure Treatment Estimated Reduction of GHG

<table>
<thead>
<tr>
<th>Technology Type</th>
<th>% GHG Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active Solids Drying</td>
<td>67-95</td>
</tr>
<tr>
<td>Aeration</td>
<td>67-95</td>
</tr>
<tr>
<td>Ammonia Stripping</td>
<td>0</td>
</tr>
<tr>
<td>Anaerobic Digestion*</td>
<td>40-80</td>
</tr>
<tr>
<td>Centrifuge</td>
<td>33-67</td>
</tr>
<tr>
<td>Chemical Flocculation</td>
<td>80</td>
</tr>
<tr>
<td>Complete Membrane Systems</td>
<td>0</td>
</tr>
<tr>
<td>Composting</td>
<td>33-67</td>
</tr>
<tr>
<td>Evaporation</td>
<td>67-95</td>
</tr>
<tr>
<td>Gasification / Pyrolysis / Torrefaction*</td>
<td>95</td>
</tr>
<tr>
<td>Hydrothermal Processing*</td>
<td>95</td>
</tr>
<tr>
<td>Nitrification Denitrification</td>
<td>67-95</td>
</tr>
<tr>
<td>Rotary Screen</td>
<td>33</td>
</tr>
<tr>
<td>Sand Separation</td>
<td>0</td>
</tr>
<tr>
<td>Screw Press</td>
<td>33</td>
</tr>
<tr>
<td>Slope Screen</td>
<td>33</td>
</tr>
<tr>
<td>Struvite Crystallization</td>
<td>0</td>
</tr>
<tr>
<td>Vermifiltration</td>
<td>20-40</td>
</tr>
</tbody>
</table>

*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

![NEAT MATRIX](https://www.newtrient.com/technology-type-active-solids-drying/)
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

![NEAT Matrix](https://www.newtrient.com/technology-type/anaerobic-digestion/)
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 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.

### NEAT Matrix

<table>
<thead>
<tr>
<th>Metric</th>
<th>Negative</th>
<th>Positive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen Recovery</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>Phosphorus Recovery</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>Storage Reduction</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>GHG Reduction</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>Odor Control</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>Pathogen Reduction</td>
<td>D</td>
<td>D</td>
</tr>
</tbody>
</table>

- P: Peer Reviewed
- D: Documented
- E: Expert Opinion

[https://www.newtrient.com/technology-type/chemical-flocculation/](https://www.newtrient.com/technology-type/chemical-flocculation/)
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, phosphorus recovery, storage reduction, GHG reduction, odor control and pathogen reduction

https://www.newtrient.com/technology-type/evaporative-technologies/
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 phosphorus recovery, storage reduction, GHG reduction, odor control and pathogen reduction
- This technology loses nitrogen to the atmosphere

![NEAT Matrix](image.png)
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.

[NEAT MATRIX Diagram]

https://www.newtrient.com/technology-type/hydrothermal-carbonization/
Where to Find Information

Technology Strengths, Weaknesses and Critical Indicators

Overall Summary

Primary Application
- Daily farms with over 500 cows or farms with meaningful owners for co-digestion.
- Animal manure and human waste from small to medium farms.
- Education and no investment considerations
- Economic viability of the project is demonstrated by the low cost of ownership and operational costs.
- Industry uptake
- Over 200 dairy farms and biogas facilities world-wide.
- Technology maturity
- Refined, standard designs available from multiple technology providers.

Primary Benefits
- Higher reduction (50% to 70%)
- Increased organic matter reduction - 30%
- Renewable energy production - 1.500 KWh per cow per year.
- Pathogen reduction - 95% elimination of harmful organisms as a potential indicator pathogens.
- Greenhouse gas emissions reduction - amounts vary by location and farm specific, but reductions can be large, in the order of 47%.
- Nitrogen preservation transformation - key crop nutrients in manure are not consumed by 4D and the nutrient form is more plant available than when not digested.
- Contributes to society’s goal for organic landfills - co-digestion avoids enhanced enriching above benefits.

Secondary Benefits
- Pre-treatment to treat methane like ammonia stripping.
- Post-treatment to waste separation can produce adequate recycled manure or solids for bedding livestock.
- Sustainable energy production - 1.500 Kilowatts per cow per year.
- Nutrients covered for a more plant available form.
- Increased crop yields possible.
- Possible reduction of input 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 (28.8 °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 beds and/or when manure is not substantially diluted. Pre-treatment to remove bedding sand is required with tank-baffled units.
- Pre-treatment may be used to remove excess moisture from influent from farms 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 manure containing bedding sand.
- Does not work with high dry solids due to cost and heat demands for a large vessel.

Other Considerations
- Dairy farms are more managed.
- More consistent results may be achieved by dedicated operators.
- Adding organic material will increase the nutrient content of the digester and will need to be addressed in the nutrient management plan.
- A portion of the nutrients are converted from organic to inorganic. Some nutrients are available immediately by crops. Nutrient management plans should be updated to reduce the potential for water quality concerns.

Technology Providers in order of 9-Point Scoring System

DVO, Inc. - Linear Vertex Digester
DVO is the U.S. market leader for anaerobic digestion engineering, providing reliable, proven solutions and services to industry and agriculture. DVO has installed over 200 of its patented Sharp Vortex Mixed Digesters across the nation, producing 60 MW of electricity. DVO also has expanded internationally, with...

Mass Energy Works - Covered Lagoon Digester
Mass Energy Works is the most successful developer owner-operators of dairy manure digesters on the West Coast. The motto is simple. “Renewable Energy That Works.” Mile hundreds of thousands of operating hours in three states and processing the manure on nearly 20 farms. Mass Energy Works looks here to build and run successfully.

California Bioenergy (CalBio) - Covered Lagoon Digester
California Bioenergy (CalBio) converts biomass at dairy farms into a clean and reliable renewable energy source with suitable co-products and its benefits. CalBio partners with California dairy farmers to finance, develop and operate projects that turn dairy manure into energy - electricity, bioheat or both. The projects generate multiple benefits for...
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
