Anaerobic Digestion and Nutrient Recovery

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Our Company

- Located In Ferndale, Washington
  - Established in 1935
- Specialize In All Facets Of Construction And Project Management
  - Over 150 Skilled and Experienced Men and Women Spread Over Seven Construction Trades
- Proven To Be A Leader In Specialty General Contracting (SGC)
  - Teamed Up With DVO Inc. In 2001 To Market, Construct, and General Contract their Two-Stage Mixed Plug Flow™ Digesters
  - In The Business Of Turning Animal Waste And Other Organic Wastes Into Profits For The Owner.
- Our First Digester
  - Vander Haak Dairy - Lynden, Washington – November 2004
DVO Inc.

- Located In Chilton, Wisconsin
  - Established in 1989
- Founded by Steve Dvorak, Professional Engineer
  - Packerland Digester in 1985 – Still operational
- DVO Inc. First Digester
  - Gordondale Farms, Chilton, Wisconsin – September 2001
- By The End Of 2014 Andgar Corporation And DVO Inc. Combined Will Have 80+ Digesters Constructed And Operational In The United States
  - Digesters in 17 States and 3 Countries
  - Installed Electrical Generation Capacity of 72,840 kWh
Anaerobic Digestion
Patented Digester

MIXED + PLUG-FLOW

- Advantages
  - For Waste Streams Between 3% and 15% Total Solids
  - Solids And Liquids In Suspension
  - Less Stratification And Settling Issues

- Advantages
  - Guaranteed Retention Time
    - Pathogen Destruction
    - Gas Production
  - High Solids Content
Performance Data

- 55 – 60% Methane (CO₂ – 40%)
- 110 ft³ Of Bio-Gas/Cow/Day (Manure only projects)
- 4 – 5 Cows = 1 kWh/day (Manure only projects)
- Gen-Set Provides Electricity And Waste Heat
  - Waste Heat Is Utilized To Maintain Digester Temperature And Provide The Farm With Hot Water For The Parlor, Radiant Heat, And Etc.
- Low Parasitic Load: Average <10% (Entire System)
- Reliable: ENGINE Run-Time Average Of 92%
- Small Amounts Of H₂S (50-2,500 ppm)
- Excess Bio-gas Is Flared
Biological System

- **Manure/Waste Collection System**
  - Dairies (Flush, Scrape, And Vacuum)
  - Poultry Farms: 1.2M Layer poultry farm
  - Other Animal Waste
  - Substrates: Food Processing, Bio-Fuels, And Etc.

- **Digester Vessel**
  - Two-Stage Mixed Plug Flow™
  - First In, First Out

- **Digester Mixing**
  - Bio-Gas Recirculation

- **Digester Temperature**
  - Mesophilic - 101 F
Substrates

- DVO Design is Ideal for Co-Digestion
  - 2006 WSU Co-Digestion study at Vander Haak Dairy
    - Examined the performance/economic model of Co-Digestion
    - Solidified the Co-Digestion model across the U.S.
    - Vander Haak Digester operating well after a decade of consistent Co-Digestion

- Other Organic Wastes Added To Our Digesters
  - Restaurant/Casino/Institution Grease
  - Cheese Whey And Milk
  - Grain Distillers
  - Activated Sewer Sludge
  - Cannery Waste (Vegetable And Fruit)
  - Waste From Ravioli Sauce Plant
  - Silage Spoilage
  - DAF From Chicken Processing Plant
  - Artificial Crab Meat And Fish Trimmings
  - Grass Clippings
  - Inedible Eggs
  - Fish Patty Breading
Project: Vander Haak Dairy
Location: Lynden, Washington
Description: Finishing The Manure Piping From The Collection Pit To The Digester Vessel
Project: Vander Haak Dairy
Location: Lynden, Washington
Description: Finished Digester Vessel And Mechanical Building
Project: Vander Haak Dairy
Location: Lynden, Washington
Description: Caterpillar 425 kWh Bio-Gas Generator Producing Renewable Electricity
Project: Vander Haak Dairy
Location: Lynden, Washington
Description: Guascor 600kWh Bio-Gas Generator Producing Renewable Electricity
Project: Double A Dairy  
Location: Jerome, Idaho  
Description: Setting Separation Equipment and Finishing Digester Construction.
Project: Double A Dairy
Location: Jerome, Idaho
Description: Completed Mechanical Building
Project: Double A Dairy
Location: Jerome, Idaho
Description: Completed Digester Vessel and Piping
Project: Edaleen Cow Power
Location: Lynden, WA
Description: Completed Digester
A typical DVO installation.
Digester Benefits

- **Renewable Energy**
  - Electricity
  - CNG

- **Greenhouse Gas Emission Reduction**
  - Eligible For Carbon Credits And Renewable Energy Credits

- **Odor Reduction**

- **Pathogen Reduction**

- **Separated Solids**
  - High Quality Cow Bedding
    - Pathogen Reduction – Due To Plug Flow Retention Time
    - Somatic Cell Count/Herd Health
    - Clean Cows
  - Fertilizer
    - Peat Moss Replacement
Digester Benefits Continued

- **Waste Heat**
  - Many valuable uses on sites

- **Liquid Fertilizer – Primarily Organic**
  - 2 – 3% Solids
  - Irrigation VS. Trucking
  - PH Increase From 6.8 To 8
  - Applied directly to growing crops
    - Increased crop yield
  - Lessens likelihood of leaching or runoff

- **Nutrient Recovery**
  - Having a digester allows you to add on Nutrient Recovery Technology
  - Waste heat available for NR
  - Digestion increases the amount of CO2 in the manure.
  - Digestion stabilizes manure/substrates
  - Nutrients in the digester are changed from organic to in-organic
    - Nitrogen to Ammonia Nitrogen
Nutrient Recovery
Why Nutrient Recovery? - Phosphorus

- Estimated 100 years of supply.
- Remaining reserves of poor quality ($, heavy metals).
- 90% and 50% of ingested P is excreted by human and animal.
- Agricultural/hydrologic systems serve as sink for P release.

Vaccari 2009; Cornell et al, 2009; Jonsson et al 2004; Smil 2000
Why Nutrient Recovery?

- Samish Bay Watershed
  - High in Fecal Coliform
  - Nutrient Loading

- Chesapeake Bay Watershed
  - Nutrient Loading

- Yakima Valley
  - Nitrogen in groundwater/air

- All list Agriculture as a contributor.
Andgar can install any combinations of systems to meet the project and/or Farmers individual needs.
Nutrient Recovery – DVO/WSU/Andgar System

Figure: Demonstration Sites
A—1,500-cow dairy, Lynden WA
B—1,500-cow dairy, Enumclaw WA
C—2,400-cow dairy, Chilton WI
D—1.5 M Layer Chicken Farm

<table>
<thead>
<tr>
<th>Unit Operations</th>
<th>Production</th>
<th>N Removal (%)</th>
<th>P Removal (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AD</td>
<td>110 ft$^3$ of biogas cow$^{-1}$ day$^{-1}$</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Fiber/Peat</td>
<td>9-10 yards fiber cow$^{-1}$ y$^{-1}$</td>
<td>15-20</td>
<td>12-18</td>
</tr>
<tr>
<td>Ammonia $^a$</td>
<td>1/4 dry ton AS cow$^{-1}$ y$^{-1}$</td>
<td>40-50</td>
<td>---</td>
</tr>
<tr>
<td>$^2$ Solids/P $^b$</td>
<td>1/2 dry tons solid cow$^{-1}$ y$^{-1}$</td>
<td>10-15</td>
<td>60-70</td>
</tr>
<tr>
<td>Total System $^c$</td>
<td>---</td>
<td>---</td>
<td>65-85</td>
</tr>
</tbody>
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$^a$ Ammonia removal
$^b$ Phosphorus removal
$^c$ Total system

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Nutrient Recovery

Poultry Project
Nutrient Recovery – DVO/WSU/Andgar System

Poultry Litter
25-65% DM

8-9%

Dilution

NR Strip creates Ammonium Sulfate, & H₂S removal medium

NR Scrub removes H₂S & enriches the biogas

Biologs Separator

Bedding
Fertilizer (NPK)

Digestate Recycle

Recaptured Heat

Hot Water for farm use

Off-site Sales
Owner Usage

Electricity, CNG, DME

Anaerobic Digester

Digestate

Biosolids Separator

Courtesy of DVO, Inc.
Litter is belt-collected and falls into a collection auger.
The partially air-dried litter is transported from the barns via conveyor, to a nearby manure storage/staging building.
Inside the building litter collects in a pile. Periodically a loader scoops it up and brings it to the digester’s waste reception pit.
The loader feeds the fresh litter to the digester, where it is mixed with processed digestate to provide the desired dilution for the AD system.
Nutrient Recovery – DVO/WSU/Andgar System

BIOSOLIDS SEPARATION

- CentriFlo “fine solids” separator, followed by Modified Dissolved Air Floatation (M-DAF)

- 85-90% P reductions for < $0.002 USD/gal processed.

Courtesy of DVO, Inc.
Nutrient Recovery

– DVO/WSU/Andgar System

Digested, dried biosolids:
• No flies
• No feathers
• A saleable fertilizer product
NR: Ammonia-laden gas leaves the NR processing tank and is piped to the capture section.
Nutrient Recovery – DVO/WSU/Andgar System

- Ammonium sulfate (nitrogen) is temporarily stored in poly tank (s) until sold from the farm.
Heat exchangers increase recovery efficiency by conserving Btus.
Project: Rainier Biogas
Location: Enumclaw, Washington
Description: Primary Separation
Project: Rainier Biogas
Location: Enumclaw, Washington
Description: Secondary Separation
Project: Rainier Biogas
Location: Enumclaw, Washington
Description: Settling Weir
Project: Rainier Biogas
Location: Enumclaw, Washington
Description: Ammonia Removal
Project: Rainier Biogas
Location: Enumclaw, Washington
Description: Ammonia Stripping and Short – term Fertilizer Storage
Project: Vander Haak Dairy
Location: Lynden, Washington
Description: Nutrient Recovery System
Nutrient Recovery – Value Added Products

- **Nitrogen Fertilizer – Ammonium Sulfate**
  - 8:0:0:9 NPKS Concentration

- **Phosphorus Fertilizer**
  - Fine Solids from Secondary Separation
  - Fine Solids from DAF/Weir

- **Sell Fertilizers to Third Party**
  - Gets nutrients off the farm
  - Generates $

- **Use Fertilizer on Farm**
  - Lower/Eliminate use of commercial fertilizer
  - Get nutrients where they need to be
    - More efficient use of nutrients
    - Lower trucking costs

- **Nutrient Trading**
  - Generate income by trading nutrients
  - Like Carbon Credits
Nutrient Recovery – Other benefits.

- More Animals?
- More Substrates?
- Less Land?
- Stay in Business?
  - Increased regulations.
Nutrient Recovery – What’s next?

- Ammonia sulfate crystallization
- More efficient and effective ammonia removal
Questions?

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