ANAEROBIC DIGESTION | Wastewater Treatment

Over the next 10 years, wastewater treatment plants (WWTP) will undergo profound changes.

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ANAEROBIC DIGESTION

About quasar energy group

Quasar is a U.S.-based renewable energy company.

- Aggregation of the best anaerobic digestion technology available
- Provide complete full service, turnkey anaerobic digestion solutions for our customers
- Produce energy for use as combined heat, power and fuel from organic sources
- Operate laboratory and engineering facilities on OSU-OARDC campus
- Dedicated to building systems based on U.S. components and U.S. suppliers
- One system under construction in Ohio and two in New York

Anaerobic digestion is a natural process where microorganisms break down organic biomass in the absence of oxygen.

Inputs:
- Agricultural biomass (manure, crop residuals, energy crops)
- Food processing residuals and FOG (fats, oils and grease)
- Municipal wastewater (biosolids)
- Ethanol and biodiesel processing residuals
- Expired, damaged or off-spec consumer goods

Outputs:
- Renewable energy – natural gas, electricity, motor vehicle fuel (CNG/LNG)
- Animal bedding, peat alternative and compost
- Concentrated fertilizer with capacity for (P) separation
- Reduced greenhouse gas emissions, cleaner water, soil and cleaner air

Which types of biomass are best for a digester?

Biomass recipes will differ based on the type and quantity of feedstock available in the region. Quasar's laboratory on the OSU-OARDC campus validates biomass recipes to guarantee a system's energy potential.
Germany, which has the largest installed base of solar and the third largest installed base of wind gets more renewable energy from organic materials than wind and solar combined.

In 2011, Germany had approximately 6,800 biogas facilities generating 2,300 MW of electricity. That’s the equivalent of 307,300 gge per hour. 1.7 billion gallons of renewable fuel per year!

Germany is approximately the size of Montana.

REFERENCES:
1. Renewable Energy World: Integrating Anaerobic Digestion into our Culture Part 2
2. Assumptions: 3,412,142 BTU=1MW, Standard Electric Generator Efficiency – 33.2%, 114,000 BTU = 1gge

U.S. INDUSTRY

• 152 anaerobic digester systems are operating at commercial livestock farms in the United States.
• These systems have the ability to generate more than 66 MW of electricity each hour.
• The average U.S. system creates enough biogas to operate a 350 kW rated generator.
• The U.S. AD industry is about 3% the size of the German industry.

REFERENCES:
1. AgSTAR Website: Operating Anaerobic Digestion Projects
Note: The AgSTAR database only tracks agricultural anaerobic digestion projects.

COLUMBUS, OH

Placed in Service: 2010
Annual Tons: 50,000 wet tons
Fuel per day: 1,800 GGE

FRENCH CREEK, OH

Operational: April 2012
Annual Tons: 50,000 wet tons
Fuel per day: 1,800 GGE

ANAEORBIC DIGESTERS in Ohio

Operational or Under Construction:
- Ashley (under construction)
- Cleveland
- Columbus
- Haviland
- North Ridgeville
- Norton
- Wooster
- City of Wooster
- Zanesville
- Zanesville Expansion – iADs

Ohio Projects Scheduled in 2013:
- Celina
- Dayton
- Findlay
- Mansfield
- Muskingum
- Worthington
- Willard
- Wooster II
HAVILAND, OH
Placed in Service: 2012
Annual Tons: 50,000 wet tons
Fuel per Day: 1,800 GGE

RUTLAND, MA
Placed in Service: 2011
Annual Tons: 15,000 wet tons
Fuel per Day: 450 GGE

WOOSTER, OH
Placed in Service: 2010
Annual Tons: 25,000 wet tons
Fuel per Day: 825 GGE

ZANESVILLE, OH
Placed in Service: 2010
Annual Tons: 50,000 wet tons
Fuel per Day: 1,800 GGE

ZANESVILLE, OH
Operational:
Summer 2012
Annual Tons: 8,000 iADs
Plant Expansion Tons: 100,000
Fuel per Day: 7,550 GGE

The Integrated Anaerobic Digestion System (iADs) is patent pending technology developed at The Ohio State University.

ASHLEY, OH
Under Construction: 2013
Annual Tons: 50,000 wet tons
Fuel per Day: 1,800 GGE
Transit buses equipped with model year 2004 CNG engines compared to model year 2004 diesel engines:
- CNG buses produced 49% lower nitrogen oxides emissions
- CNG buses produced 84% lower particulate matter emissions

In a study of UPS delivery trucks running on CNG compared to diesel trucks of a similar age:
- CNG trucks produced 75% lower carbon monoxide emissions
- CNG trucks produced 49% lower nitrogen oxides emissions
- CNG trucks produced 95% lower particulate matter emissions

REFERENCES:
1. U.S. Department of Energy: UPS CNG Truck Fleet: Final Results
2. SWACO Truck Fueling in Columbus
3. Zanesville Station
4. 2012 SWACO Emerald Award
5. quasar natural gas
6. the future of energy is renewable fuel
7. quasar has introduced our new brand of alternative motor vehicle fuel—CNG (or quasar natural gas).
8. Fueling stations are already operational at our Corporate Headquarters and at our Columbus, Zanesville and Wooster plants and will be coming soon to Cleveland, North Ridgeville and Raveland.
9. quasar will continue installing fueling stations at our anaerobic digester systems, helping to build the infrastructure necessary to reduce transportation costs of goods and services to Americans.

quasar’s process generates two products: renewable energy and nutrient rich fertilizer alternative. equate can be applied to farm fields for agronomic benefit.
- high organic matter: Adding organic matter to fields increases their ability to hold water in drought years and helps clay soils drain more effectively.
- eco-friendly alternative: equate is an eco-friendly alternative to traditional fertilizer options such as land application of manure or chemical fertilizers.
- odor management: odor causing solids are naturally reduced during anaerobic digestion by converting volatile solids into biogas – resulting in a less odorous product.

*average concentrations and values listed above are based on laboratory tests of representative samples. Treatment values may vary slightly.

Composting is an excellent way to manage organic waste while generating a valuable byproduct. quasar’s q-bio is where composting meets energy—organic residuals are diverted from landfills and processed in an anaerobic digester that produces renewable energy. The nutrient rich liquid byproduct is mixed with q-bio adsorption powder and used to inoculate woody biomass (yard waste and crop waste).

The result is a nutrient rich compost product which can be sold to regional landscape supply companies.

Anaerobic digestion impacts America’s food processing companies, waste water treatment plants, farmers, manufacturing plants, public and private vehicle fleets, electric and natural gas utilities, and consumers who benefit from all of these activities. Anaerobic digestion is the starting point for sustainable solutions with economic benefits that will affect every American.
Characteristics of Some Wastewaters from the Food Processing Industry

<table>
<thead>
<tr>
<th>Industry</th>
<th>BOD (mg/L)</th>
<th>TSS (mg/L)</th>
<th>pH</th>
</tr>
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<tbody>
<tr>
<td>Brewery</td>
<td>850</td>
<td>90</td>
<td>4 – 6</td>
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<tr>
<td>Cannery</td>
<td>2,000</td>
<td>7,000</td>
<td>ACID</td>
</tr>
<tr>
<td>Diary</td>
<td>600 – 1,000</td>
<td>200 – 400</td>
<td>ACID</td>
</tr>
<tr>
<td>Potato Processing</td>
<td>2,000</td>
<td>2,500</td>
<td>11 – 13</td>
</tr>
<tr>
<td>Sugar Beet</td>
<td>450 – 2,000</td>
<td>800 – 1,000</td>
<td>7 – 8</td>
</tr>
<tr>
<td>Slaughter House</td>
<td>1,500</td>
<td>800</td>
<td>7</td>
</tr>
<tr>
<td>Silage</td>
<td>2,500 – 50,000</td>
<td>Low</td>
<td>ACID</td>
</tr>
</tbody>
</table>

Wastewater contains 10 times more energy than is needed to treat it. 30% - 60% of a city’s energy bill is from water and wastewater treatment. Food waste produces three times more methane than wastewater solids.

Why Wastewater Treatment Plants?

- Wastewater contains 10 times more energy than is needed to treat it.
- 30% - 60% of a city’s energy bill is from water and wastewater treatment.
- Food waste produces three times more methane than wastewater solids.

Streams

Input
- Organic Carbon (OC)
- Organic Nitrogen (ON)
- Organic Phosphorous (OP)
- Ammonia nitrogen ($NH_4^+$)
- Sulfate ($SO_4^{2-}$)
- Phosphate ($PO_4^{3-}$)

Gaseous output
- CH$_4$, CO$_2$, NH$_3$, H$_2$, N$_2$

Liquid output
- $NH_4^+$
- $PO_4^{3-}$
- $SO_4^{2-}$
- HS$^-$/H$_2$S

Solids output

Energy

Gasoline Gallon Equivalents (gge)

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Unit of Measure</th>
<th>BTUs/Unit</th>
<th>gge</th>
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<tbody>
<tr>
<td>Gasoline (regular)</td>
<td>Gallon</td>
<td>114,100</td>
<td>1.00 gallon</td>
</tr>
<tr>
<td>Diesel #2</td>
<td>Gallon</td>
<td>129,500</td>
<td>0.88 gallons</td>
</tr>
<tr>
<td>Ethanol (E85)</td>
<td>Gallon</td>
<td>81,800</td>
<td>1.39 gallons</td>
</tr>
<tr>
<td>Compressed Natural Gas</td>
<td>Cubic foot</td>
<td>900</td>
<td>126.67 cu. ft.</td>
</tr>
<tr>
<td>Liquid Natural Gas</td>
<td>Gallon</td>
<td>75,000</td>
<td>1.52 gallons</td>
</tr>
</tbody>
</table>

Working on sustainable, renewable transportation solutions:
- Recycling automotive oils
- Alternative fuel vehicles (CNG)
- Supporting local auto industry and infrastructure
Most organic waste is ≈90% water
- Water weighs about 8.3 lbs. per gallon and is typically twice as heavy as regular waste
- By removing organic waste, you are removing up to 90% of the total weight of trash
- The highest % of companies’ trash bill is based on weight

Reduced waste volume and weight = reduced costs

*Water analysis based on averages of typical food-oriented businesses. Remaining waste is presumed to be packaging, paper, plastic and miscellaneous waste with densities lower than water
Depackaging equipment presents a new opportunity to capture organic materials from products with recyclable packaging such as:

- wax-coated cardboard
- glass bottles
- aluminum cans
- plastic bottles, wrappers & containers

Quasar has been actively conducting depackaging trials at our Wooster and Zanesville anaerobic digestion facilities since 2010.