Unison Solutions, Inc. Overview

- Company founded on January 1, 2000
- Located in Dubuque, Iowa
- 38 Employees (10 Engineers)
- 45,000 sq. ft. Manufacturing Facility
- 243 systems sold worldwide, 150+ in Operation
- Biogas Conditioning System Design and Fabrication
- Custom System Design and Fabrication

Leaders in Biogas Technology
Unison Solutions, Inc. Overview

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Traditional Biogas Conditioning System
Process Flow Diagram

- Digester or Landfill
- Hydrogen Sulfide Removal
- Gas Compression/Moisture Removal
- Siloxane/VOC Removal

MicroTurbines
IC Engines
Boilers
Digester or Landfill → Hydrogen Sulfide Removal → Gas Compression/Moisture Removal → Siloxane/VOC Removal

MicroTurbines → IC Engines → Boilers
Why Hydrogen Sulfide Removal?

- Equipment Damage from Corrosion (Hydrosulfuric Acid)
- SOx Emissions
- Health and Safety Issues (1000ppm will cause an individual to lose consciousness)
- Odor Control
- Causes fouling of Siloxane Removal Media

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Hydrogen Sulfide Removal Technologies

- SulfaTreat Systems
- Iron Sponge Systems
- Biological/Iron Sponge Systems
- Biological Systems
Biogas containing Hydrogen sulfide (H₂S)

Media:
Sulfatreat or Iron Sponge

Water to Drain

Biogas free of Hydrogen Sulfide (H₂S)

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Features

- Inert substrate clay base coated with iron oxide.
- Uniform in size and shape. This helps distribute the media in the vertical vessel.
- Requires saturated gas
- Typically used on applications with $\text{H}_2\text{S}$ levels $<3,000\text{ppmv}$
- Easy to handle and environmentally safe in both its unreacted and reacted forms.
Iron Sponge Systems

- **Features**
  - Hydrated iron oxide on a wood shavings and chips carrier.
  - Forms stable iron pyrite, a solid, which removes the hydrogen sulfide from the gas stream.
  - Requires saturated gas
  - Typically used on applications with $\text{H}_2\text{S}$ levels $<3,000\text{ppmv}$
  - Safety concerns are an issue when changing media.
Biological/Iron Sponge Systems

Features

- Hydrated iron oxide on a wood shavings and chips carrier.
- Water is re-circulated through the system.
- Oxygen is injected into the system.

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Biological Systems

Typically used on applications with high $\text{H}_2\text{S}$ levels
Gas Compression/Moisture Removal System

Digester or Landfill → Hydrogen Sulfide Removal → Gas Compression/Moisture Removal → Siloxane/VOC Removal

MicroTurbines → IC Engines → Boilers
Complete System Process Flow Diagram

Equipment | Mounting     | Electrical Classification
--------- |-------------|-------------------------
Hydrogen Sulfide Removal System | Standalone    | Class I, Division 1
Gas Blower/Moisture Removal System | Skid Mounted  | Class I, Division 1
Siloxane Removal System       | Standalone    | Class I, Division 1
Glycol Chiller                | Standalone    | Unclassified
Electrical Control Panel      | Standalone    | Unclassified

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Gas Blower Systems
Generation Supported

- Internal Combustion Engines
  - Caterpillar
  - GE Jenbacher
  - GE Waukesha
  - Cummins
  - MWM
  - Liebherr
  - MAN
  - Guascor

- Direct Use Boiler

- Fuel Cells

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Gas Blower Systems
Design Specifications

- Inlet Pressure
  - -90”WC to 5 PSIG

- Inlet Temperature
  - 32°F to 100°F

- Discharge Pressure
  - 15 PSIG Max.

- Discharge Temperature
  - Typically 80°F with temperatures up to 140°F

- Discharge Flow
  - Up to any flow

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Gas Blower Systems
Major Components

Gas Blower Inlet
Moisture/Particulate Filter

Rotary Lobe Positive Displacement Blower

OR
Multistage Centrifugal Blower

Forced Air To Gas Heat Exchanger (Optional)

Dual Core Heat Exchanger

Glycol Chiller

Leaders in Biogas Technology
Gas Blower Systems
Skid Mounted Equipment

Rotary Lobe Positive Displacement Blower System

Multistage Centrifugal Blower System

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Gas Compressor Systems
Generation Supported

- Turbines
  - Capstone
  - Solar
- Direct Use Boiler
- Direct Use Pipeline
- Fuel Cells

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Gas Compressor Systems
Design Specifications

- **Inlet Pressure**
  - -5 PSIG to any positive pressure

- **Inlet Temperature**
  - 32°F to 140°F

- **Discharge Pressure**
  - 200 PSIG +

- **Discharge Temperature**
  - Typically 80°F with temperatures up to 200°F

- **Discharge Flow**
  - Up to any flow

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Gas Compressor Systems
Major Components

- Pre-Cooler
- Gas Compressor Inlet Moisture/Particulate Filter
- Oil Flooded Twin Screw Compressor
- Oil/Gas Separator
- Gas To Gas Heat Exchanger
- Gas To Glycol Heat Exchanger
- Glycol Chiller
- Moisture Separator

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Gas Compressor Systems
Skid Mounted Equipment

Oil Flooded Twin Screw Compressor System

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Siloxane/VOC Removal System

Digester or Landfill → Hydrogen Sulfide Removal → Gas Compression/Moisture Removal → Siloxane/VOC Removal

- MicroTurbines
- IC Engines
- Boilers
Siloxanes and Other VOC’s

Products That Contribute Siloxanes

- Detergents & Soap Products
- Cosmetics
- Hair Care

Products That Contribute Other VOC’s

- Industrial Solvents & Cleaners
- Tires/Rubber Products
- Paint & Thinner

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BTEX Compounds

- **Benzene**
  - Found after volcano’s erupt, smoke off forest fires and in some plants and animals

- **Toluene**
  - Found in crude oil and in soil after forest fires
  - Used in the manufacture of other BTEX compounds

- **Ethylbenzene**
  - Found in coal tar and petroleum
  - Used to manufacture styrene

- **Xylene**
  - Found in petroleum, coal tar and wood tar

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Siloxanes

- What is a Siloxane?
- Silica and organic compounds are combined (Organosilicon)
- Used in many consumer and industrial products (*Listed as Silicones as the ingredient on products*)
  - Shampoo
  - Conditioner
  - Deodorant
  - Dry Cleaning Solutions
  - Windshield Cleaning Products
  - RTV Silicone Cleaner
- Siloxanes break down in landfills and digesters, and combine with the methane gas

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Siloxanes

- When methane gas is used as a fuel, the siloxanes form SiO$_2$ Silicon Dioxide and precipitate to a hard deposit on surfaces.

- Significant impact on electrical generation systems, i.e. turbines, IC engines:
  - Increased down time for maintaining equipment
  - Increased costs for components, i.e. spark plugs, valve seals
  - Engine rebuild time is more frequent

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Siloxane Impact on Boilers

New

After operation with biogas containing siloxanes

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Siloxane Impact on Engines

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Siloxane Impact on Flares

After operation with biogas containing siloxanes

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Biogas with siloxanes and other VOC’s

Through adsorption organics are attracted to the surface and pores of the carbon media

Methane gas free of siloxanes

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Siloxane and VOC Removal

Carbon Media - Type is determined based on siloxane levels

Methane gas with siloxanes - H₂S has been removed

Methane gas - ready for use

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# How Long Will The Media Last? Why VOC Data Is Important

## VOC Adsorption with Activated Carbon (Computer Estimate)

**System Designed For:** St. Landry BioCNG  

**Design Basis:**  
- **Flow (SCFM):** 50  
- **Temp (°F):** 80  
- **Carbon Type:**  
- **Coal:** 25  
- **Operating Hrs/Day:** 24  
- **System Press (PSIA):** 114.7  
- **Carbon Bed (LBS):** 135  

## Compounds to Be Removed:

<table>
<thead>
<tr>
<th>VOC</th>
<th>Conc. (ppm)</th>
<th>Mol. Wt.</th>
<th>Boiling Point (°C)</th>
<th>Refractive Index</th>
<th>Part. Press (psia)</th>
<th>GAC Loading* (wt%)</th>
<th>GAC Use Rate* (lb/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetone</td>
<td>3.9</td>
<td>58</td>
<td>56.2</td>
<td>1.3591</td>
<td>0.000447</td>
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<td></td>
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<tr>
<td>Toluene</td>
<td>4.6</td>
<td>92</td>
<td>110.6</td>
<td>1.4969</td>
<td>0.000528</td>
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<td></td>
</tr>
<tr>
<td>Ethyl Benzene</td>
<td>1.3</td>
<td>106</td>
<td>136.2</td>
<td>1.4983</td>
<td>0.000149</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M-Xylene</td>
<td>2.4</td>
<td>106</td>
<td>139.1</td>
<td>1.4972</td>
<td>0.000275</td>
<td></td>
<td></td>
</tr>
<tr>
<td>O-Xylene</td>
<td>0.62</td>
<td>106</td>
<td>144.4</td>
<td>1.5054</td>
<td>7.1E-05</td>
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<td></td>
</tr>
<tr>
<td>Siloxane-D4</td>
<td>1.7</td>
<td>297</td>
<td>347</td>
<td>na</td>
<td>0.000195</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydrogen Sulfide</td>
<td>0.1</td>
<td>34</td>
<td>na</td>
<td>na</td>
<td>1.15E-05</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>14.62</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*GAC Loading and Use Rate presume saturation capacity

**Est Carbon Bed Life Till Breakthrough:** 13 Days

**Prepared For:** Reference - KMT  

**Date:** 5/31/2012

**VOC Clarification:**  
- D4 - Includes L2, D3, L3, Tetramethylsilane & Trimethylsilanol  
- D6 - Includes L4 & L5

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**Grandville Clean Water Plant**

- Design Flow: 10.0 MGD
- DGTS: 85 scfm
  - Compression & Moisture Removal
  - Siloxane Removal
- IC Engine & Direct Use Boiler

System mechanical and electrical connections completed
November 2012

**Leaders in Biogas Technology**
Delhi Charter Township

- Design Flow: 4.87 MGD
- DGTS: 60scfm
  - Compression & Moisture Removal
  - Siloxane Removal
- (2) CR65 – 65kW Microturbines

System mechanical and electrical connections completed
August 2009

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What is BioCNG™?

Unison Solution’s new product which is a patent pending system to convert biogas to a gaseous vehicle fuel.

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Alternative Fuels: Looking Ahead to the Future

Leaders in Biogas Technology
Carbon Intensity for Fuels and Renewable Substitute (gCO2/MJ)

- Diesel: 95
- CNG: 75
- RNG-Landfill: 13
- RNG-Dry AD: -15
- RNG-Wet AD: 48
- RNG-WWTP*: -65

Fuel Type and Pathway

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**Top five countries with CNG Vehicles:**
- Iran (18.82%)
- Pakistan (18.76%)
- Argentina (12.50%)
- Brazil (11.15%)
- India (7.24%)

**CNG Vehicle Fun Facts**
- Approximately 142,000 CNG vehicles are on U.S. roads today and more than 15.2 million worldwide
- 50 different manufacturers produce 100 models of light-, medium-, and heavy-duty vehicles and engines
- More than 50% of new Refuse Trucks sold are CNG
- CNG vehicles offset the use of more than 400 million gallons of gasoline in 2013
- 20% of Municipal Buses in the US are CNG
- **U.S. (>1%) - 17th**
Key Definitions

- **CNG** - Compressed Natural Gas
- **LNG** - Liquified Natural Gas
- **RNG** - Renewable Natural Gas (BioCNG™)
- **GGE** - Gasoline Gallon Equivalent, 120,000 BTU/Gal
- **DGE** - Diesel Gallon Equivalent, 140,000 BTU/Gal
- **Biogas** - Methane (CH$_4$) and carbon dioxide (CO$_2$) produced from the breakdown of waste by bacteria in wastewater treatment facilities and landfills
- **RIN** - A Renewable Identification Number is a serial number assigned to a batch of biofuel for the purpose of tracking its production, use, and trading

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A RIN credit is a serial number assigned to each gallon of renewable fuel as it is introduced into U.S. commerce.

- Federally Mandated program is until 2022.
- Only biogas used as renewable transportation fuel can generate RINs.
- RIN Agents - similar to Carbon Credit Exchange brokers.

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Compressed Natural Gas Vehicle Types

There are three types of NGVs:

- **Dedicated**: These vehicles are designed to run only on natural gas
- **Bi-fuel**: These vehicles have two separate fueling systems that enable them to run on either natural gas or gasoline.
- **Dual-fuel**: These vehicles are traditionally limited to heavy-duty applications, have fuel systems that run on natural gas, and use diesel fuel for ignition assistance.
Compressed Natural Gas Vehicles

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Vehicle Fueling Stations - “Time Fill”

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Vehicle Fueling Stations - “Fast Fill”

Compression and Storage

Fast Fill

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“Fast Fill” CNG Fueling Process

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NGV Resources

- ngvamerica.org
- US Department of Energy
  - http://www.eere.energy.gov/cleancities/
  - http://www.afdc.energy.gov/fuels/naturalgas.html
- US EPA - Renewable Fuel Standards

Leaders in Biogas Technology
## BioCNG™ Models

<table>
<thead>
<tr>
<th>Model</th>
<th>Biogas Inlet Flow (scfm)</th>
<th>Fuel Production (GGE/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BioCNG™ 50</td>
<td>50</td>
<td>200 - 275</td>
</tr>
<tr>
<td>BioCNG™ 100</td>
<td>100</td>
<td>375 - 550</td>
</tr>
<tr>
<td>BioCNG™ 200</td>
<td>200</td>
<td>775 - 1100</td>
</tr>
</tbody>
</table>

### BioCNG™ Models

<table>
<thead>
<tr>
<th>Model</th>
<th>Ford F-150</th>
<th>Waste Hauler</th>
<th>School Bus</th>
</tr>
</thead>
<tbody>
<tr>
<td>BioCNG™ 50</td>
<td>16</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>BioCNG™ 100</td>
<td>32</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>BioCNG™ 200</td>
<td>64</td>
<td>20</td>
<td>16</td>
</tr>
</tbody>
</table>

* Assumes 1 fill per day per vehicle

**Leaders in Biogas Technology**
Suitability Factors For Potential Sites

- CNG or Dual Fuel Vehicles on site, or in future budget?
  - How many vehicles?
  - What type of vehicles?
  - How often do you need to fill up?
  - Time Fill or Fast Fill?

- Is biogas available under positive pressure from the digester?

- Is CNG available on site?

- Sufficient biogas flow, minimum 50 scfm

- Suitable inlet biogas quality
Suitability Factors for Potential Sites: Inlet Biogas Quality

<table>
<thead>
<tr>
<th>Biogas Constituents</th>
<th>Inlet Biogas (Typical)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methane (CH$_4$)</td>
<td>&gt;50%</td>
</tr>
<tr>
<td>Carbon Dioxide (CO$_2$)</td>
<td>&lt;50%</td>
</tr>
<tr>
<td>Nitrogen (N$_2$)</td>
<td>&lt;5%</td>
</tr>
<tr>
<td>Oxygen (O$_2$)</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Hydrogen Sulfide (H$_2$S)</td>
<td>&lt;1,000 ppmv</td>
</tr>
<tr>
<td>Siloxanes and Volatile Organic Compounds</td>
<td>&lt;2,000 ppbv</td>
</tr>
</tbody>
</table>
BioCNG™ Models

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BioCNG™ Site Layout

Leaders in Biogas Technology
BioCNG™ System

Main Components
- Skid Enclosure
- Interconnection Kit
- Electrical Control Panel
- Skid Mounted Glycol Chiller & Electrical Control Panel

Options
- H₂S Removal
- BioCNG™ Compression, Moisture, Siloxane/VOC, & CO₂ Removal
- Heat Trace & Insulation
- Electrical Distribution Panel
- Glycol Chiller
City of Janesville, WI WWTF

- Founded in 1835
- Located on the Rock River, in southeast Wisconsin
- Area: 33 sq. miles
- Population: 63,500

Leaders in Biogas Technology
City of Janesville, WI WWTF

- Design flow - 17.75 MGD
- Current average flow - 12.5 MGD
- Digesters produce 100,000 ft$^3$/day of biogas
- Janesville WWTF currently has 4-65kW Capstone Turbines
- The first commercial BioCNG™ hybrid system

Leaders in Biogas Technology
City of Janesville, WI WWTF

Vehicles on site using BioCNG™:
1 - Dixie Chopper (lawn mower)
1 - Ford, F-250 truck
2 - Ford, F-150 trucks
1 - Ford Fusion sedan
St. Landry Parish Landfill, Washington, LA

- Population: 83,000
- Area: 900 sq. miles
- Fleet: 15 sheriff and public works vehicles
- Vehicles are bi-fuel, gasoline as back up to CNG fueling

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St. Landry Parish Landfill, Washington, LA

- Solid waste landfill disposal rate - 275 tons/day
- 300 scfm biogas is collected from site
- Onsite flare is used continuously
- BioCNG™ - 50 scfm
- Air & Gas fueling station - fast fueling with a single compressor

Leaders in Biogas Technology
System includes H₂S, Moisture, VOC/Siloxane, and CO₂ Removal, Compression, Storage and Fueling Station.
BioCNG™ Installations

- St. Landry Parish, LA Landfill - BioCNG™ 50, Operational since March 2012
- Janesville WWTF, WI - BioCNG™ 50, Operational since April 2012
- Rodefeld Landfill, Dane County, WI - BioCNG™ 50, Operational since June 2012
- Sacramento, CA - BioCNG™ 100, food waste digester, Operational since May 2013
- Riverview Landfill, MI - BioCNG™ 100, Operational since May 2013
- South San Francisco, CA - BioCNG™ 100, food waste digester, Q4 2013
- Sacramento, CA - BioCNG™ 200, Q1 2014

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What Was Learned From These Projects

- BioCNG™ is a reliable vehicle fuel to meet SAE J1616
- Gas testing showed equivalent to CNG
- The BioCNG™ system has been easy to operate and service
- BioCNG™ fuel production costs - $0.65/GGE to $1.15/GGE
- Operators have not noticed a performance difference between gasoline and BioCNG™
- Oil testing on biogas fueled vehicles at St. Landry indicated oil condition matched that of unleaded gas
Contact Information

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