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BIOGAS UPGRADING
TECHNOLOGY OVERVIEW

Cash Cow:
The Future of RNG as a Transportation Fuel

Washington Clean Cities

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Agenda

- Who is Robinson Group
- Market Review
- Technology overview
- Insights

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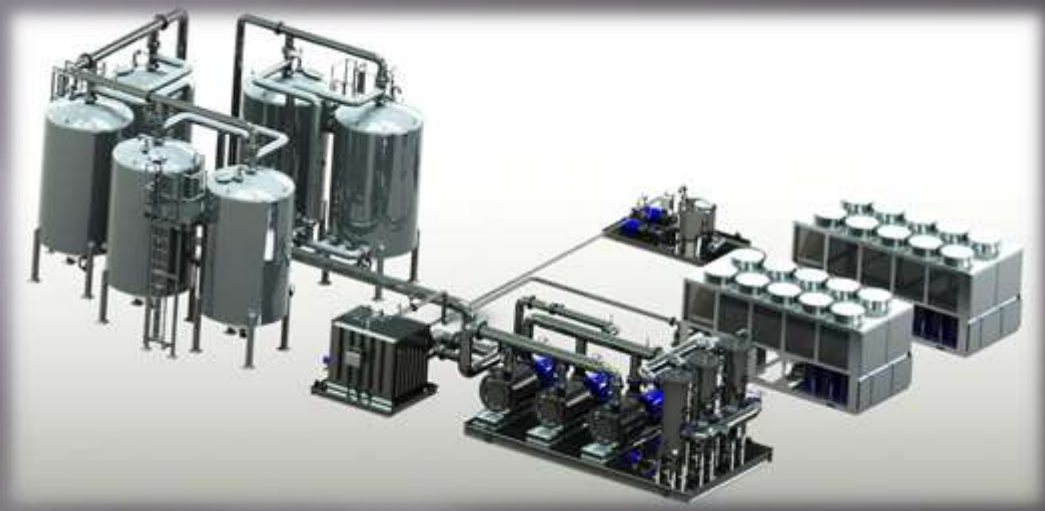
Who is Robinson Group?



Robinson Group LLC custom designs, installs, fine-tunes and operates biogas-to-energy systems for manufacturers, consultants, municipalities and energy companies. We are recognized as a market leader in conditioning and recouping waste stream biogas – including chilling; compressing; and removal of sulfur, carbon dioxide and siloxane – with the end goal for our customers of clean power generation and a stronger bottom line.

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RG Capabilities

- Moisture and dew point modification
- Non methane volatiles removal
- Co Generation Engines and Turbines
- System Operations
- Heat recovery
- Long Term Service Support
- Build/Own/Operate

- Project feasibility analysis
- System design and supply
- Total Integrated Gas Processing and Use
- Process Review
- Gas testing and analysis
- Siloxane removal
- Sulfur Removal
- Compression

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Landfills

The United States Environment Protection Agency currently reports 576 Operation BioGas projects in the US that are based on Landfill Gas Production. Existing Projects represent 1,762 Megawatts of electrical production. The EPA also shows 510 landfills sites that are candidates for commercial energy production. Those 510 sites represent a potential production of 1,155 Megawatts.

WWTPs Analyzed	Facilities Evaluated	Candidate Facilities	Potential Capacity
Gas Currently Used Non-CHP	203	88	74
Not Utilizing Gas	1,148	574	186
TOTALS		**662**	**260**

WWTP Plants

As of June 2011 CHP was in place at 133 Waste Water Treatment Plants in 30 states representing 437 megawatts of electricity production.

The U.S. Environmental Protection Agency Combined Heat and Power Partnership suggested in an October 2011 report there are 662 additional facilities that would be good candidates representing 260 Megawatts of electrical production.

Agricultural

USDA estimates 8,200 U.S. dairy and swine operations could support biogas recovery systems. Biogas recovery systems at these facilities have the potential to collectively generate more than 13 million megawatt-hours (MWh) per year and displace about 1,670 megawatts (MW) of fossil fuel-fired generation. In addition, biogas recovery systems are also feasible at some poultry operations.

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Sales Channel

- Eastern and Western Regional Sales Managers
- 19 Rep Groups with 126 Sales Reps

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Biogas Upgrading Processes

- **PSA, Pressure Swing Adsorption**
- **MGA, Membrane Gas Adsorption**
- **CL, Cryogenic, CO_2 Liquefaction**

Membrane system
•Low energy consumption
•Highest energy recovery
•Lowest methane slip
•0-100% flow flexibility

• **Adsorption by moleculair sieves/ carbon**
• N2 removal possible
• Batch operation - 3 or 4 vessels
• High methane loss

• **Selective Membrane diffusion**
•Compact
•Some methane loss
•Low power Consumption

• **Liquifying of CO_2**
•Complex technique

•High towers

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Choice for biogas upgrading?

- **Pressurized Water Scrubbing**
  - Low investment and operational cost
  - Low methane slip 0.8 %
  - High energy efficiency >96%
  - Proven technology
  - Robust system
  - Flexible system
  - No chemicals

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Choice for biogas upgrading?

- **Membrane separation**
  - Low investment and operational cost
  - Low methane slip <0.5%
  - Highest energy efficiency >98%
  - Highest operational uptime
  - Pretreatment required
  - Compact
  - Simple on/off
  - No chemicals and/ or water

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Choice for biogas upgrading?

- **Pressure Swing Adsorption**
  - Requires catalytic oxidizer
  - Requires pretreatment
  - Can remove O_2 and N_2
  - Heating required
  - Large methane loss

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Choice for biogas upgrading?

- **Pressurized Water Scrubbing**
  - DMT
  - Econet
  - Greenlane Biogas
  - Malmberg Water
  - RosRoca
- **Pressure Swing Adsorption**
  - Acrona-systems
  - CarboTech
  - Cirmac
  - ETW Energietechnik
  - Guild
  - Strabag
  - Xebec
  - Mahler
- **Membrane Separation**
  - Air Liquide
  - Cirmac
  - DMT
    Envitec Biogas
  - Haffmans
  - Gastechnik Himmel
  - Mainsite Technologies
  - Memfoact
  - MT-Biomethan

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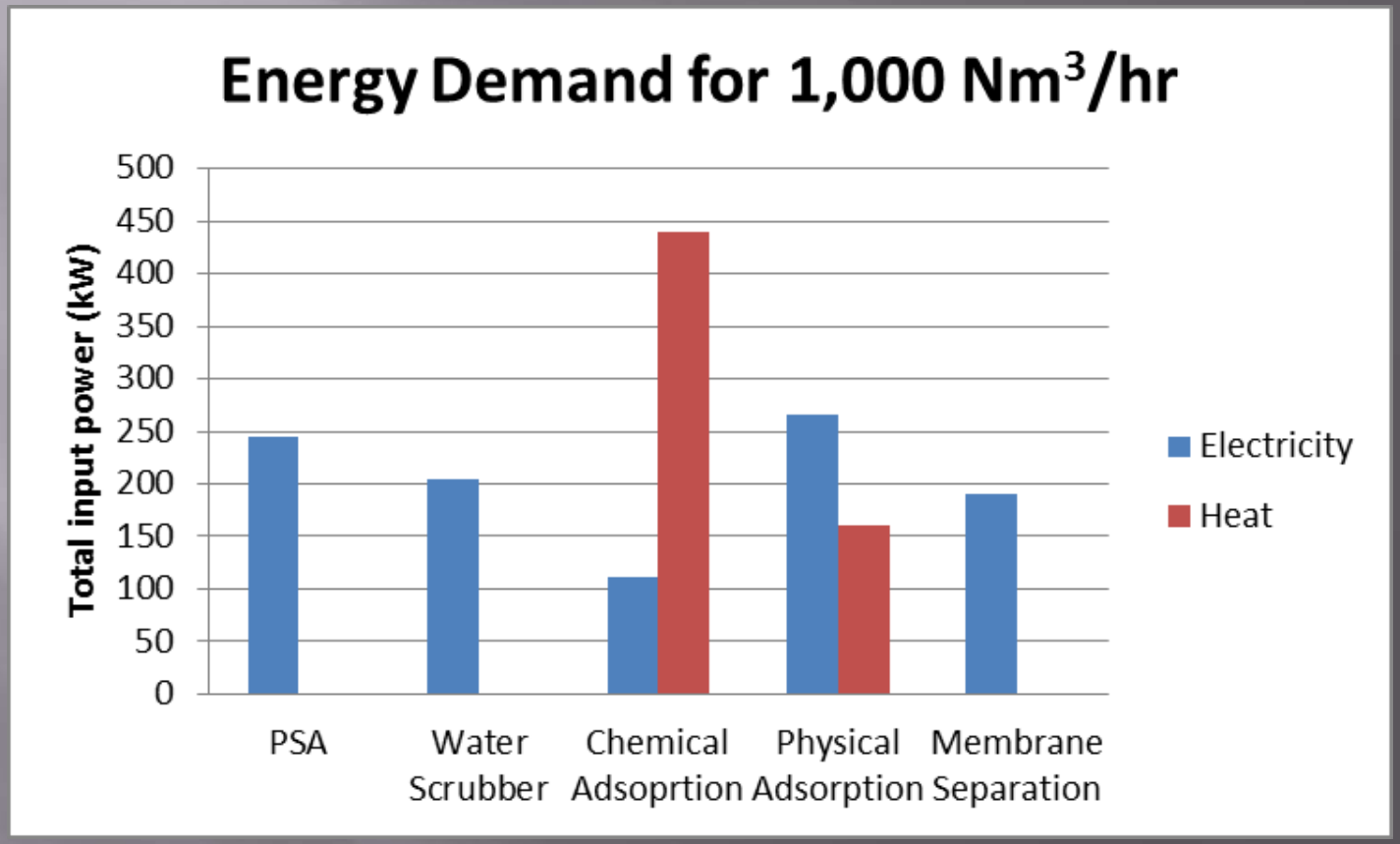

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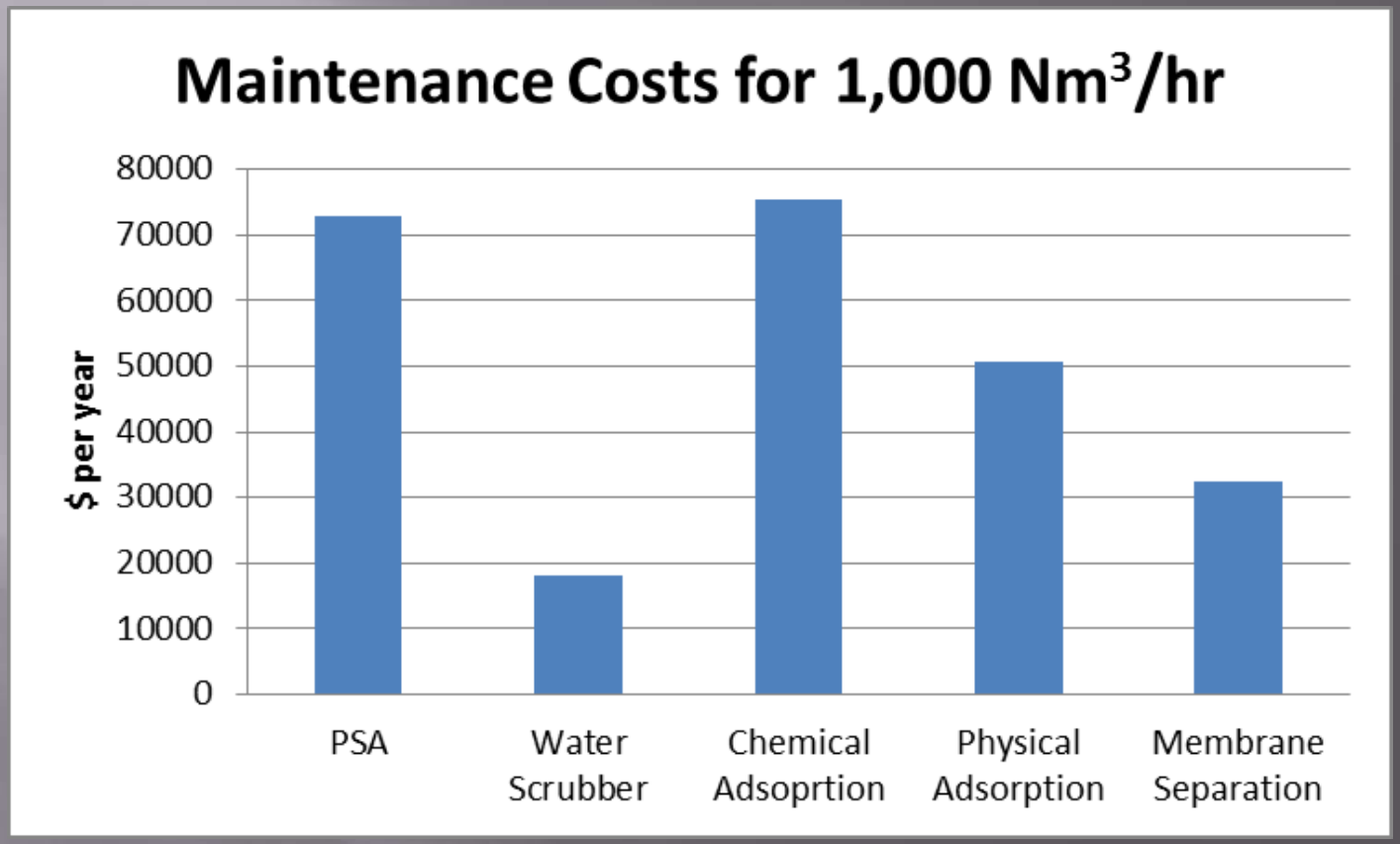

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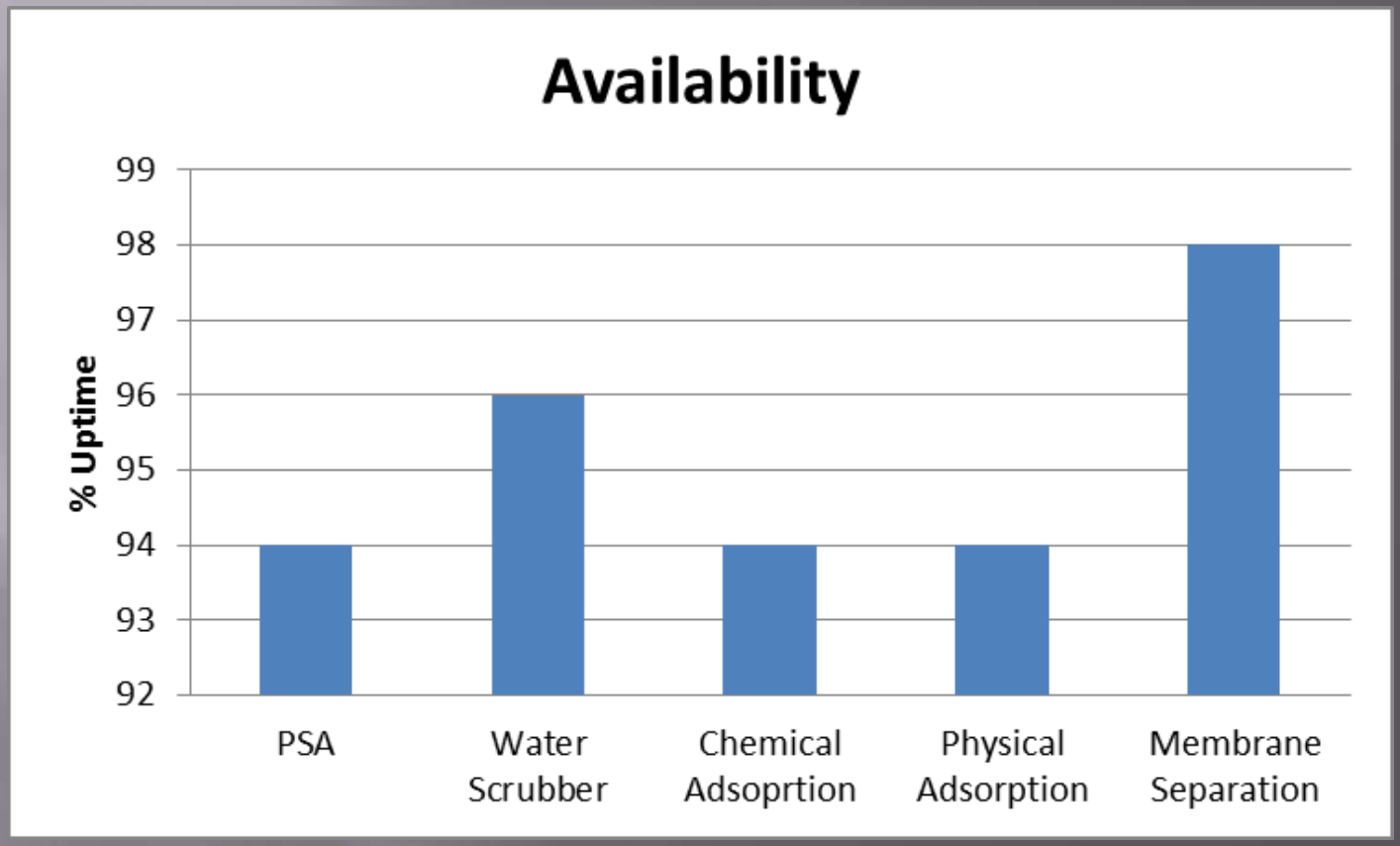

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Project Hurdles

- Storage
- Grid Injection
- Contracting
  - Feedstock
  - Offtaker

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Thank You!

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