Pipeline RNG Project

John Welch, P. E.

Director

Dane County Dept of Waste & Renewables

Dane County Waste & Renewables

- 1 Active landfill & 2 closed landfills
  - 250,000 tons/yr
- C&D MRF
- Clean Sweep
- Compost
- LFGTE
- RNG system
- Tours, recycling events, sharps program, etc

Renewable Natural Gas

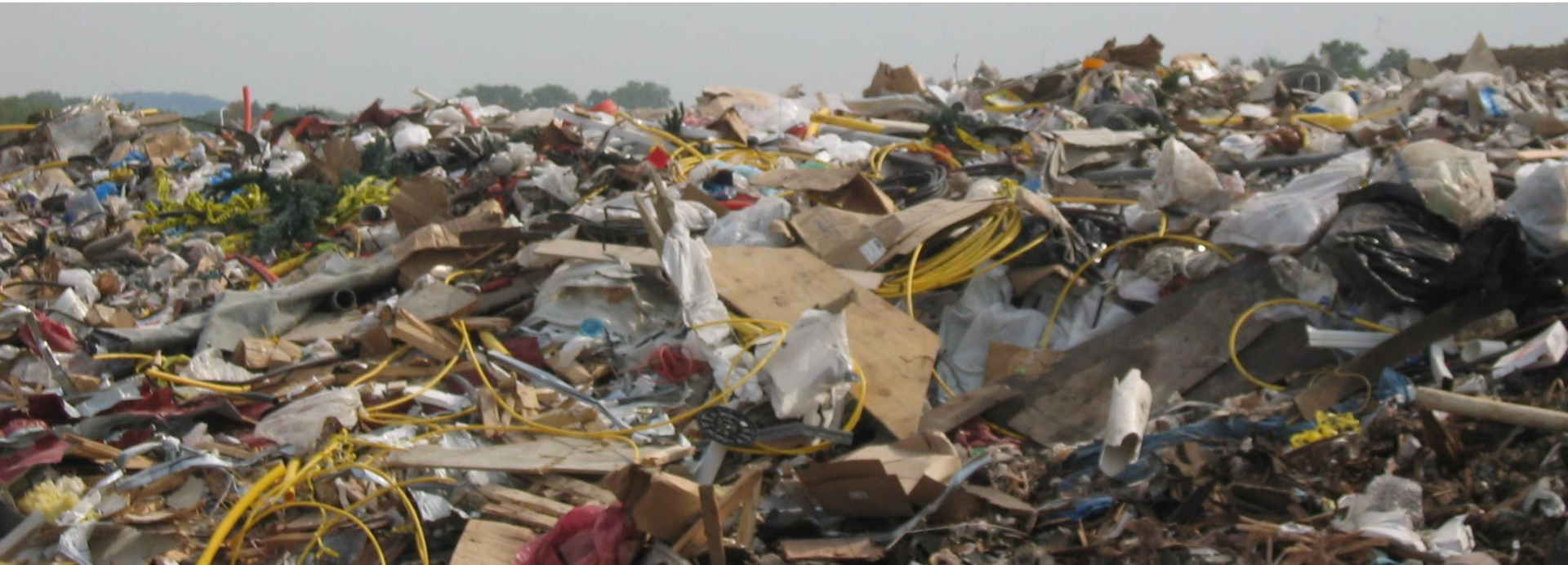
Dane County Biogas Projects

- Landfill Gas to Energy (LFGTE)
- Waste heat – multiple buildings
- Manure digester projects
- Evaluated food waste digester
- RNG fueling station – Pilot system & expansion
- High BTU pipeline grade gas
- CO2 Sequestration Pilot Project
- Food waste feasibility with City of Madison

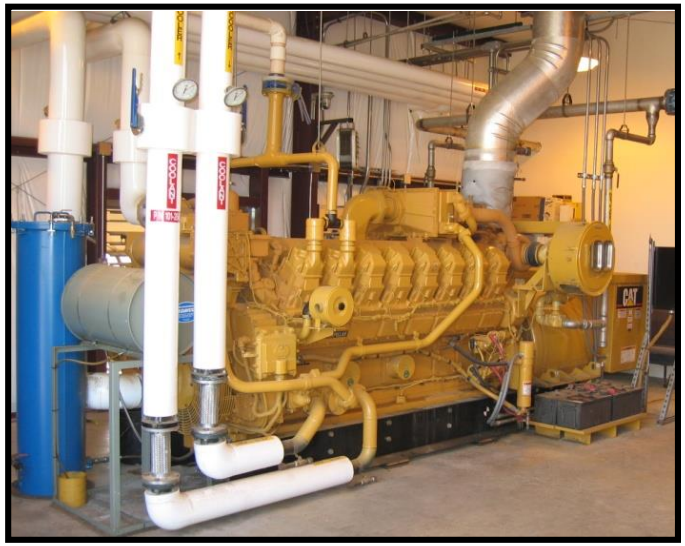
Decomposing Waste Produces Landfill Gas

- Landfill Gas Components
  - Methane – 50-55% ← Energy!!!
  - Carbon Dioxide – 40-45%
  - Nitrogen – 5-10%

  } Added Value?
  - Oxygen – Less than 0.5%
  - VOCs, H2S, Siloxanes, H2O, etc
- Gas Temperature 80-120 F



Use of Biogas Resource



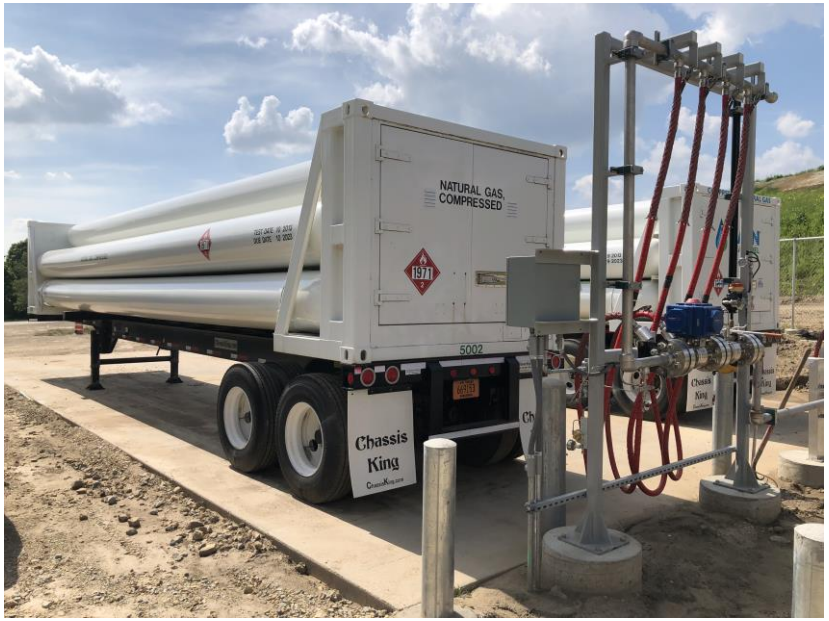
Dane County LFG History

- LFGTE Plants at 2 landfills – started 1995
- 4MW per year – 4,000 homes of renewable electricity
- Net $2.5-3.0 million/yr in profit
- High PPA for electricity…until the markets shifted

Dane County's Future – High BTU

Dane County's Future – RNG

- Biogas from landfill and off-site biogas sources
- Gas is cleaned up
- Pipeline injection
- Off-load station – clean lakes
- Started project January 2017
- Construction started July 2018
- Construction completed 2019



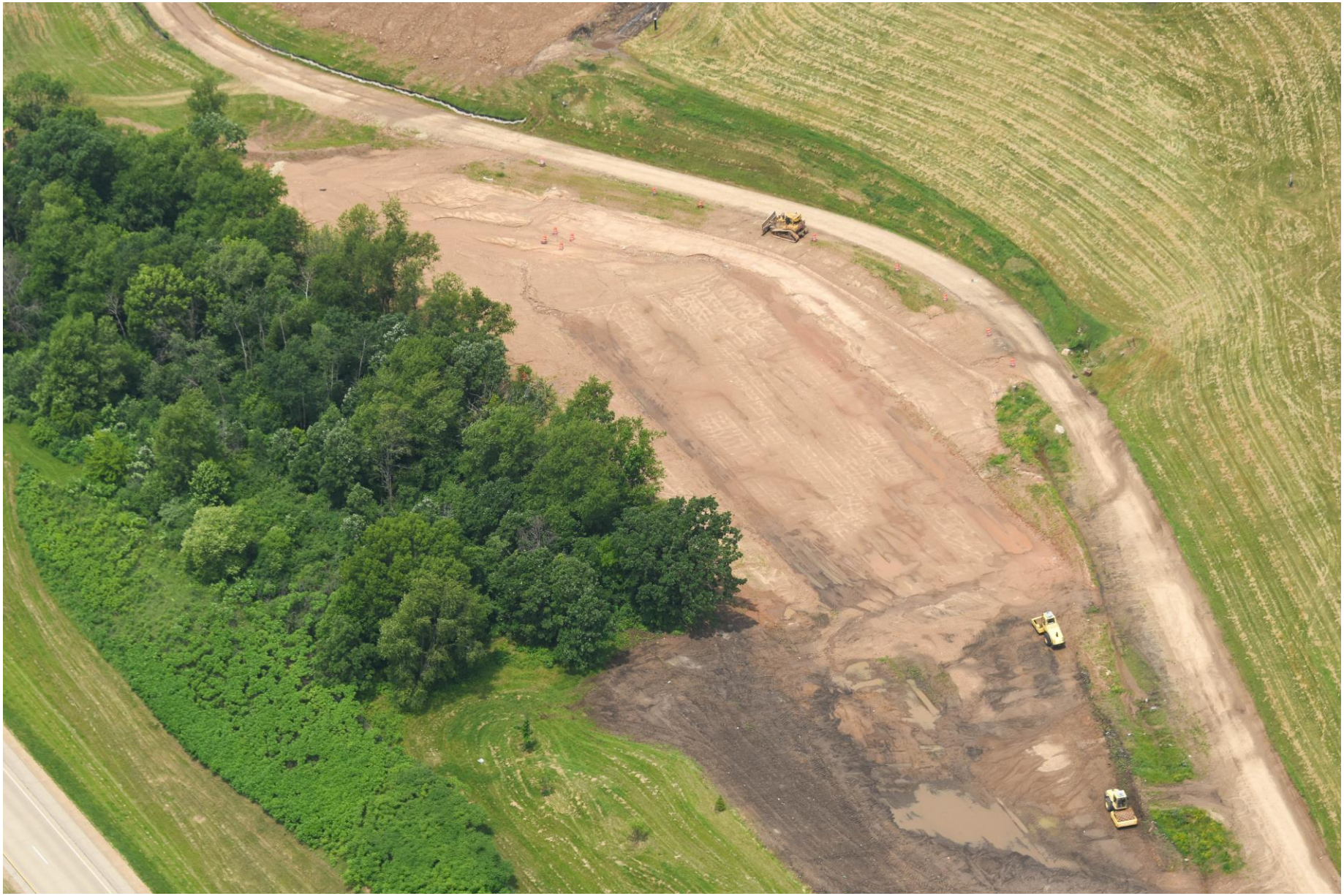
Dane County's RNG Project

- County ownership
- Private O&M for first 3 years
- $29M capital
- Quick pay back – RIN markets fluctuate
- Revenue streams
  - Gas – compared to frac gas
  - RINs (Renewable Identification Number)
    - Federal program: Renewable Fuels Standard (RFS)
  - ~~LCFS (Low Carbon Fuels Standard)~~
    - ~~California program~~

RNG Project Timeline

- 9/2016 – Project Budgeted
- 1/2017 – RFP to hire EcoEngineers
- Mid-2017 – RFP to hire BIOFerm
- 2017 – Equipment design – offload station added
- Late 2017 – RFP to hire TetraTech
- Early 2018 – Issue RFB for construction
- **Early 2018 – Pipeline Interconnect Discussions**
- Mid 2018 – RFP for RINs marketing – BlueSource
  - No LCFS
- July 2018 – Construction starts – multiple contractors
- April 2019 – Injected first gas
- Today – negotiating offload agreements

Dane County's RNG Facility Construction



Dane County's RNG Facility Construction

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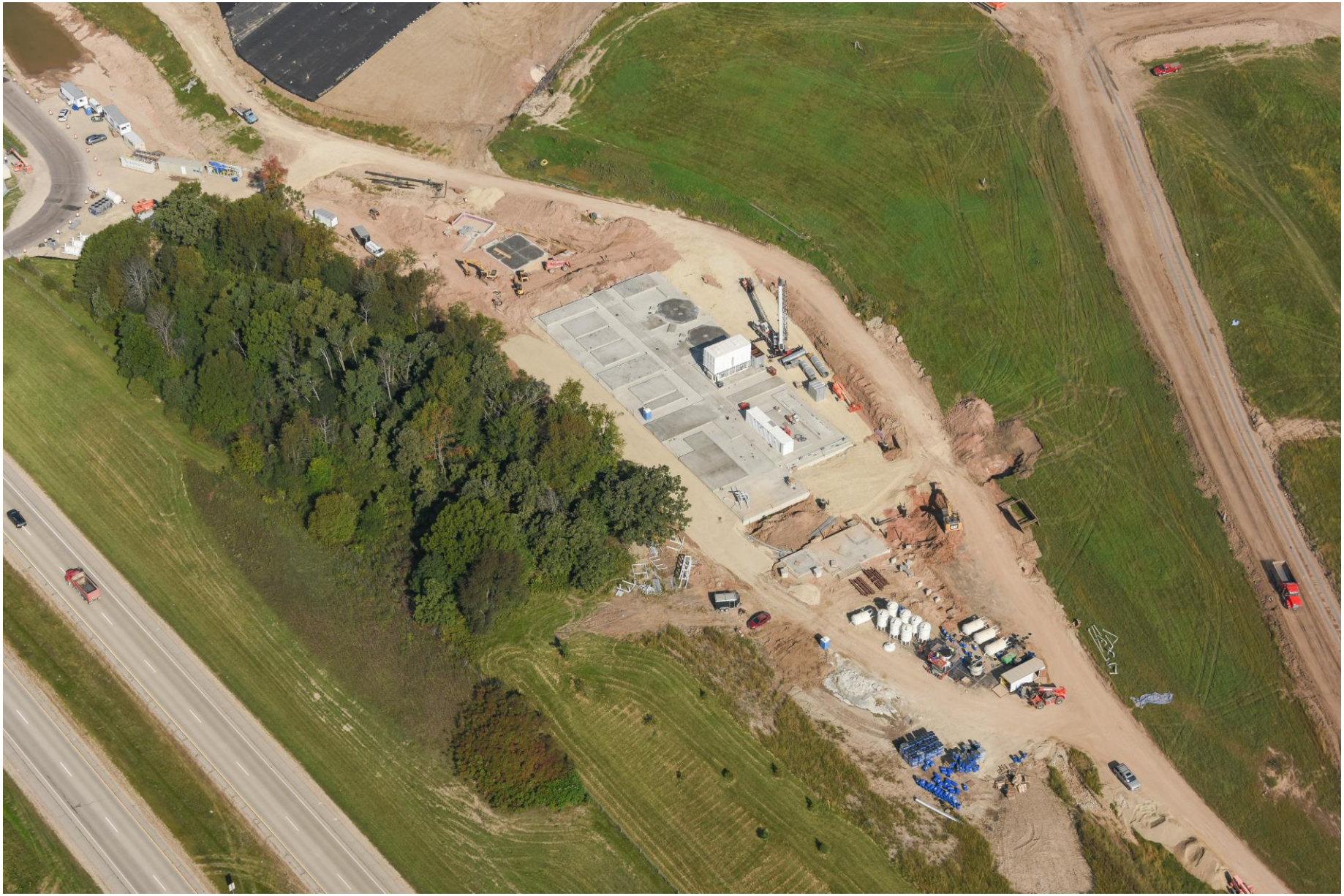

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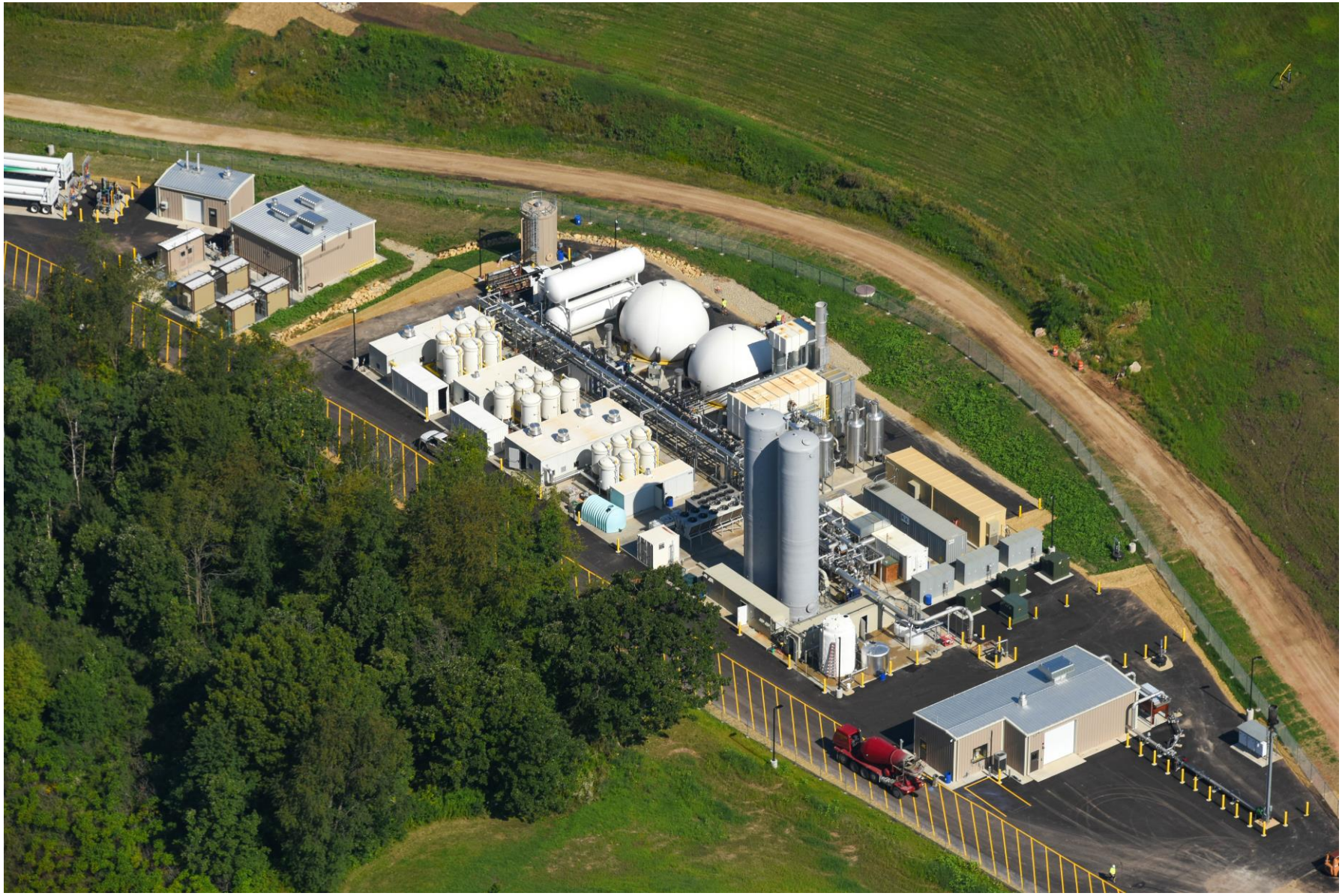
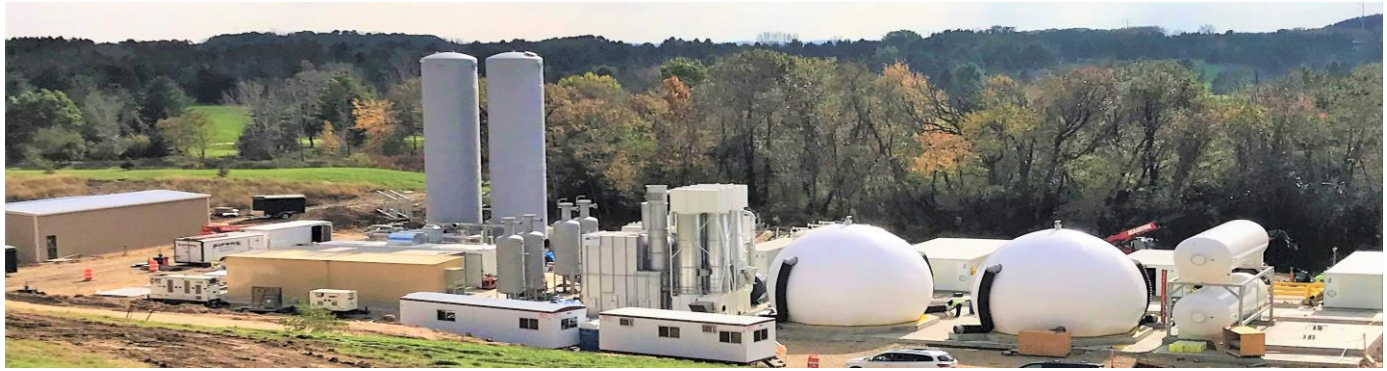


BIOFerm™ Gas Upgrading Technology at

DANE COUNTY LANDFILL BUP



Project Gas Upgrading Specifications

Two Stage PSA: BUP2500i
Plant Footprint: 24,000 ft2
Gas Utilization: Pipeline Injection
Energy Content: >967 BTU/scf
Pipeline Requirements: Exceeds ANR pipeline specs
Raw Gas Capacity: 2,500 scfm
Raw Gas: 56% CH4, 34% CO2, 6.6% N2, >430 ppm H2S
Product Gas: 1,340 scfm

Skid-Ready PSA Installation Includes:

>Fully Integrated Control System
>Landfill Gas Filtration
>Biological Sulfur Removal Unit
>Landfill Gas Compressor
>VOC and H2S Removal
>Thermal Oxidizer
>Gas Chilling
>Booster Blower
>RNG Compressor

Two Stage PSA Process Steps

1. Raw biogas is compressed
2. Cooling system removes condensed water vapor
3. Activated carbon removes trace components such as H2S, VOCs, and siloxanes
4. Conditioned biogas is channeled through PSA adsorbers filled with carbon molecular sieves for adsorption
5. First stage of adsorption removes CO2, H2O, NH3, and parts of O2 and N2
6. Second stage removes remaining O2 and N2
7. RNG is injected into the grid, or upgraded to CNG

Key Features

>Typical CH4 recovery >92-96%
>High N2 Rejection
>Meets stringent pipeline requirements
>No increased CH4 losses overtime
>High processing efficiency

www.biofermenergy.com
info@biofermenergy.com
608.467.5523

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BIOGAS RNG SOLAR

RNG Project Development

RNG Project Considerations

- Industry direction right now
  - RINS/LCFS
  - Electric Buyback Rates – due to wind, solar, & frac gas
- Stringent gas requirements
  - BTU, moisture, CO_2, H_2S, nitrogen, others
  - Expensive treatment – high capital and O&M
- Lacking industry wide interconnection standards
- Complex projects
- Proximity to CNG markets and/or a pipeline?

Design Considerations

- Gas quality and processing needs (Siloxanes, H2S, nitrogen, H2O)
- Plan for future gas quantities/qualities
- Regulatory and Permitting Compliance
- Status of Technology; Reliability; Types of Technologies
- Ease of Operation
- Redundancy
- Safety Issues
- Aesthetics/Nuisances

Development Steps

1. Find a good biogas site
2. Determine project roles
   - Developer, Tech Provider, Owner, Operator, etc
3. Perform financial pro forma
   - Capital, O&M, Revenue
4. **Obtain pipeline access**
5. Find marketer and end users of the fuel
6. Design, bid, and construct plant
7. Obtain RIN and/or LCFS certifications
8. O&M

Our Interconnect

1. ANR
2. ~2,000 LF pipe installed by ANR
3. Duplicate flow meter and gas chromatograph
4. Tariff gas quality standards

Parameter	ANR Pipeline Specifications
Heating Value (BTU/ft^3)	967 - 1,200
Hydrogen Sulfide (ppmv)[1]	< 4
Total Sulfur (ppmv)[2]	< 320
Oxygen (% by volume)	< 1
Carbon Dioxide (% by volume)	< 2
Nitrogen (% by volume)	< 3
Water Vapor (lb./1x10^6 ft^3)	< 7
Temperature (deg. F)	40 < T < 120
Hydrocarbon Dewpoint (deg. F)[3]	> 15
Pressure (psig)[4]	600 - 975

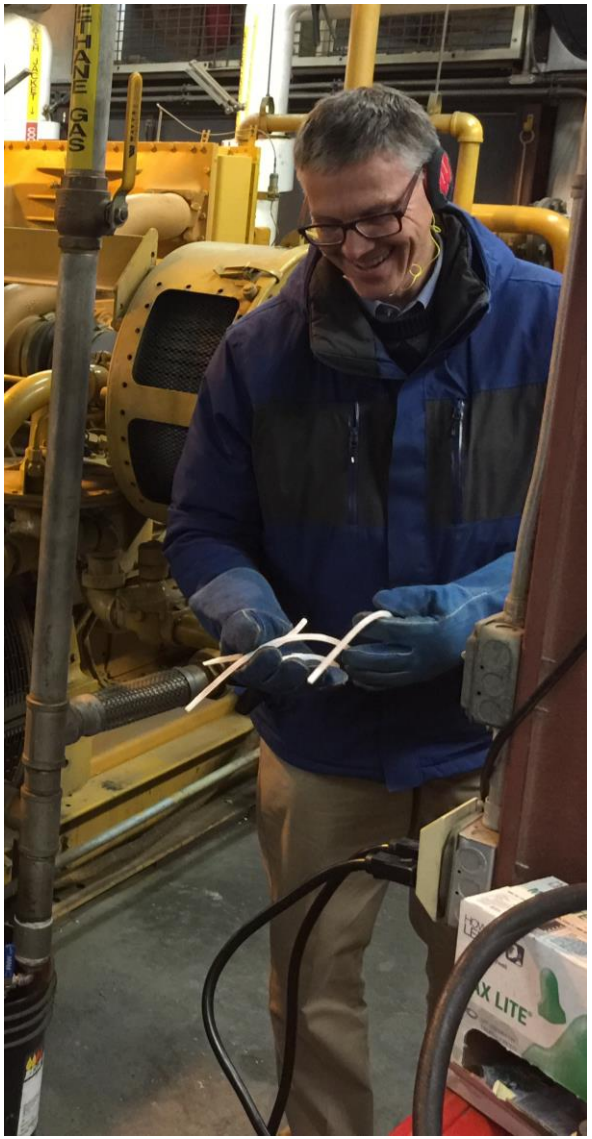
How Utilities Can Help

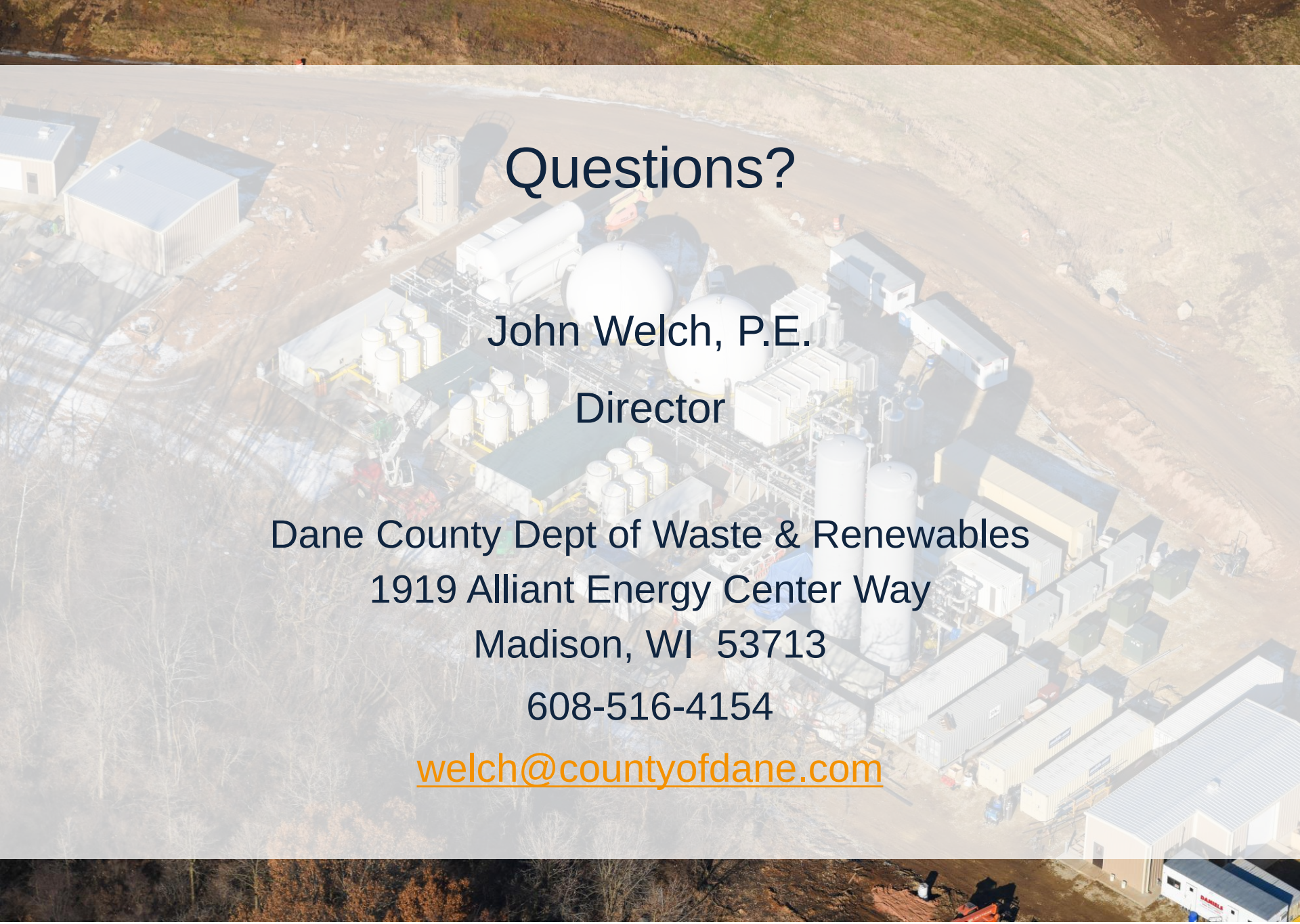
- Interconnect standards
- Interconnect costs
- Gas quality requirements
  - N2, CO2, total balance gas, O2
- Shut-in assistance – equipment design & staffing
- Voluntary carbon reduction programs
  - Decarbonize your gas using RNG

What's Next?

Possible future add-on options:

- Waste heat capture
- Grow local CNG network
- CO2 capture
- Onsite electric production





Questions?

John Welch, P.E.

Director

Dane County Dept of Waste & Renewables

1919 Alliant Energy Center Way

Madison, WI 53713

608-516-4154

welch@countyofdane.com