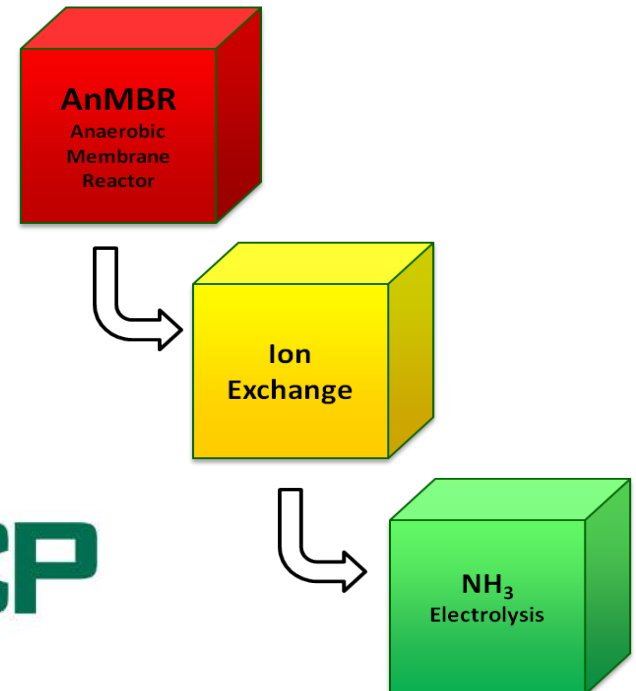


Distributed Low-Energy Wastewater Treatment (D-LEWT) for Fuel Generation and Water Reuse

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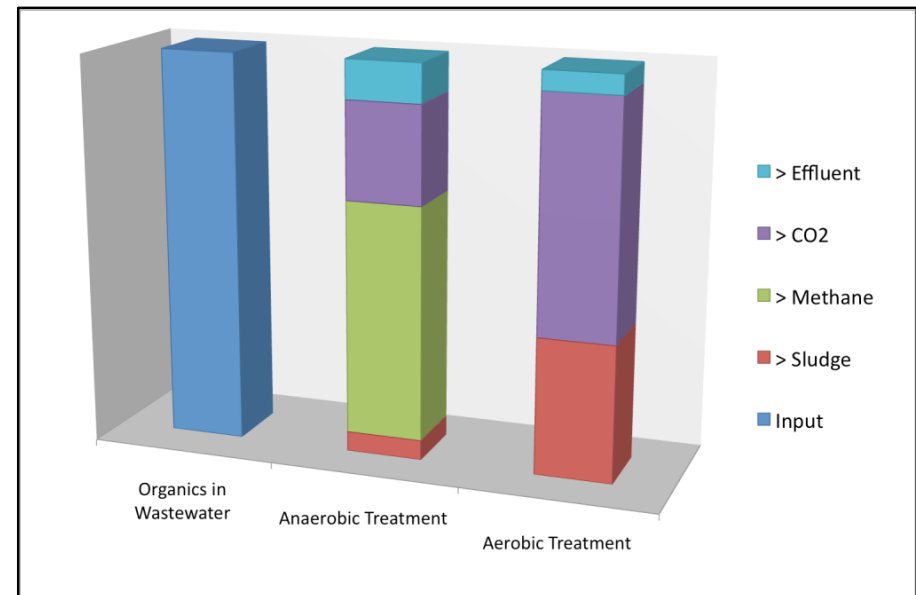


Project Team

Member	Role	Organization
Dr. Kathryn Guy	Principal Investigator	ERDC-CERL
Shane Hirschi	Project Manager	ERDC-CERL
Nicholas Josefik	Industrial Engineer	ERDC-CERL
Tapan Patel	Mechanical Engineer	ERDC-CERL
Nathan Peterson	Electrical Engineer	ERDC-CERL
Dr. Dawn Morrison	Information Specialist	ERDC-CERL
Dr. Lance Schideman	Environmental Engineer	U of Illinois-UC
Dr. Ana Martin	Environmental Engineer	U of Illinois-UC
Danicza Lopez	Environmental Engineer	Mountain Home AFB

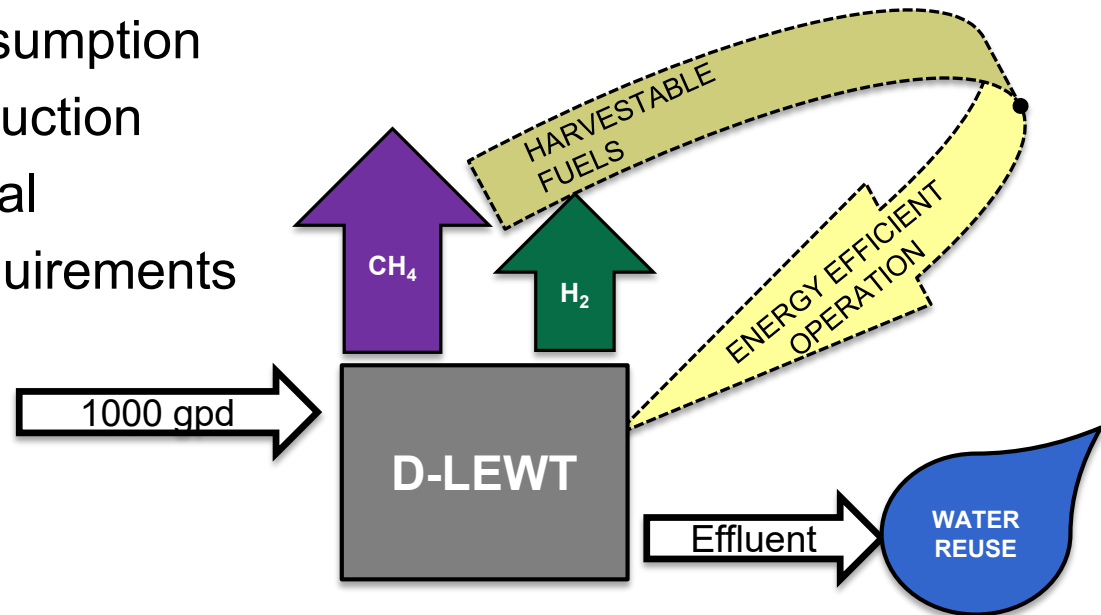
Problem Statement

- Current wastewater treatment options:
 - ◆ Energy intensive to operate
 - DoD \$250M/yr treatment (>50% aeration)
 - ◆ Miss energy generation opportunities
 - ◆ Discharge permit focused
 - ◆ Expansive infrastructure
- Over 100 installations with onsite water treatment
- Mandates and regulations
 - ◆ EO 13514
 - ◆ EPACT 2005
 - ◆ EISA 2007



Technical Objectives

- Demonstrate
 - ◆ Decentralized waste water treatment (1000 gpd)
 - ◆ Harvestable fuel generation (H_2 & CH_4)
- Validate
 - ◆ Reduced energy consumption
 - ◆ Reduced sludge production
 - ◆ Effluent reuse potential
 - ◆ Low maintenance requirements

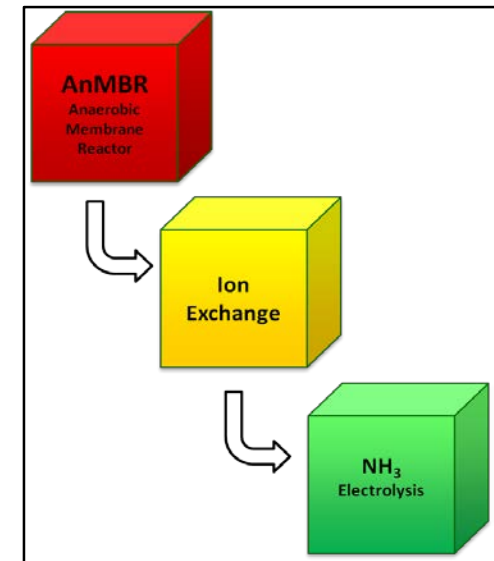


Expected Benefits

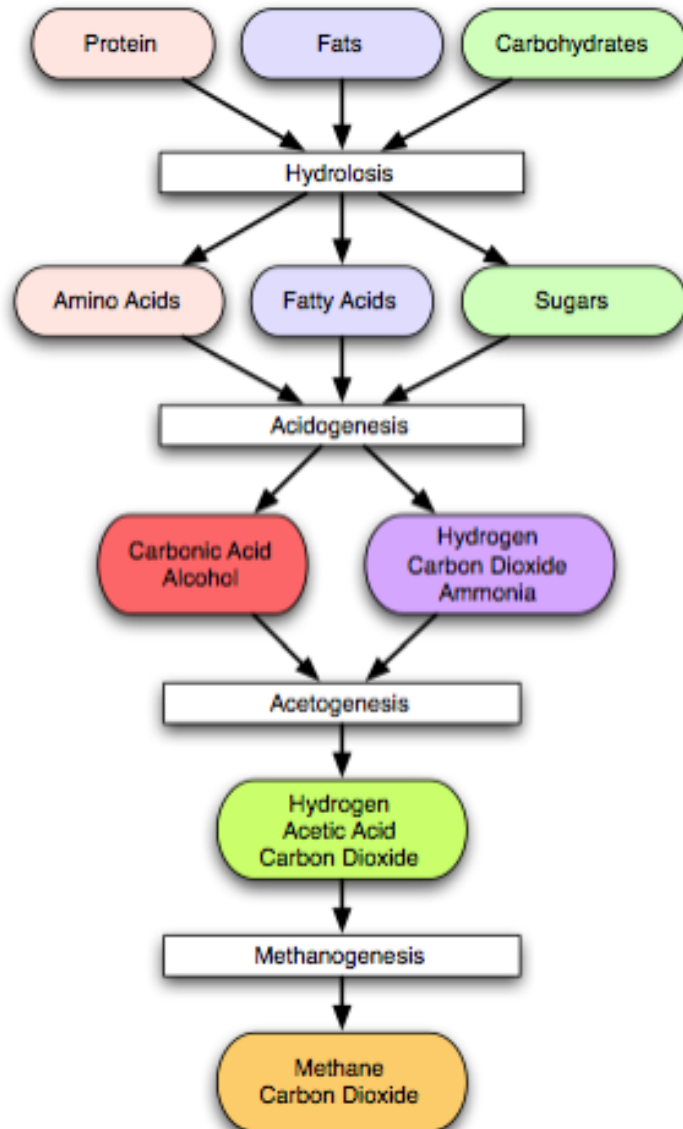
- D-LEWT system
 - ◆ Energy efficient operation while generating harvestable fuels (*potential 80% energy reduction*)
 - ◆ Treated water available for reuse applications (*>85% reuse*)
 - ◆ Segregated waste streams based on building function (simplified/consistent)
- Supports Army Net-Zero water, energy, and waste goals
- Opportunities for D-LEWT implementation
 - ◆ >100 existing on-site treatment facilities across DoD
 - ◆ New decentralized construction
 - ◆ Contingency basing applications
 - ◆ Disaster relief efforts

Technology/Methodology Description

- AnMBR
 - ◆ Degrades organics and generates CH_4
 - ◆ CH_4 can be harvested for electrical and thermal energy
- Clinoptilolite ion exchange
 - ◆ Captures NH_3
 - ◆ Generates feedstock for NH_3 electrolysis
- NH_3 electrolysis
 - ◆ Converts the NH_3 into N_2 and H_2 gases
 - ◆ H_2 can be harvested for electrical and thermal energy generation

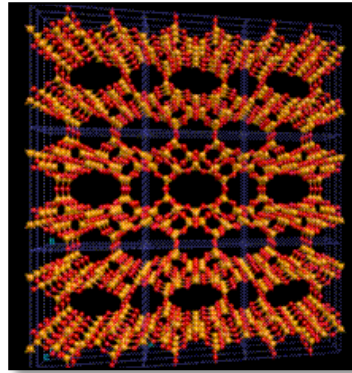
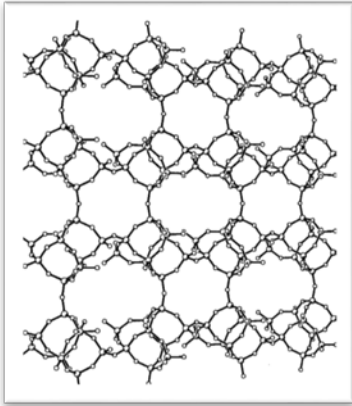


Technical Background - AnMBR



- Anaerobic biological processes remove organics from wastewater
- Organics are converted into harvestable methane gas with low sludge production
 - Approximately 90% less sludge produced compared to aerobic treatment
- Anaerobic bioreactors work well for high organic loadings (i.e., wastewater plus food wastes)
- High rate anaerobic membrane bioreactors (AnMBRs) allow for retention of particulates with shorter hydraulic retention times

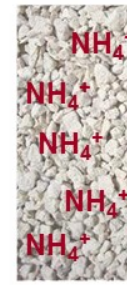
Technical Background - Clinoptilolite



- Clinoptilolite is a naturally occurring high-siliceous, ion exchanging zeolite (Si:Al ~5.7)

- Open channel framework with high surface area carrying a distributed negative charge
- Cations such as Na^+ are loosely held in extraframework positions
- Integration of clinoptilolite ion exchange into integrated wastewater systems has been limited due to additional brine disposal or treatment requirements

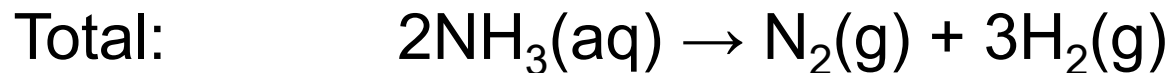
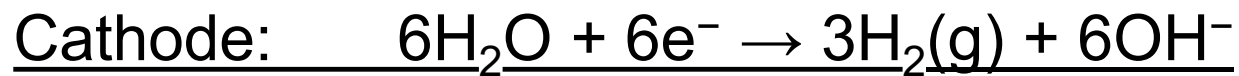
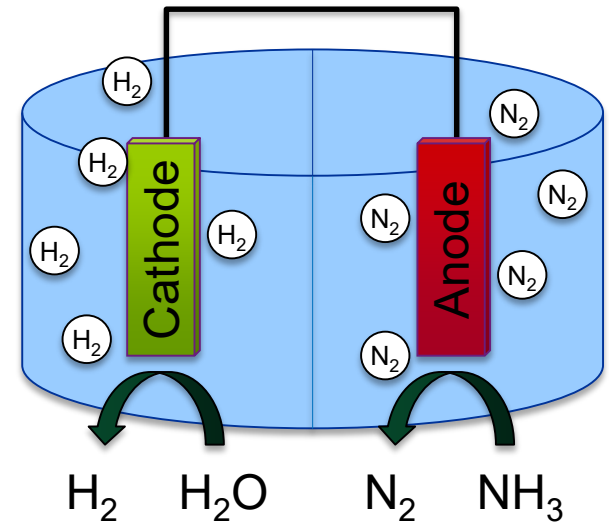
Caustic Sodium Solution



Concentrated Ammonia Brine

Technical Background – NH₃ Electrolysis

- Ammonia electrolysis breaks down ammonia into nitrogen and hydrogen gases
- Clean hydrogen can be captured for use in fuel cells
- Requires significantly less energy input than water electrolysis
 - ~95% less based on theoretical calculations
- Operates most efficiently at high pH with high NH₃ concentrations



Technology/Methodology Maturity

- Successful demonstration of D-LEWT technology at bench scale under SERDP ER-2218
 - ◆ Individual component technologies of the wastewater treatment system have been optimized for batch processes
 - ◆ All subsystems are COTS available technologies or assemblies of COTS materials
 - ◆ SERDP results indicate technology is mature enough to pursue demonstration and validation
- D-LEWT project focuses on automation, subsystem linkages, and balance of plant to achieve operational autonomy

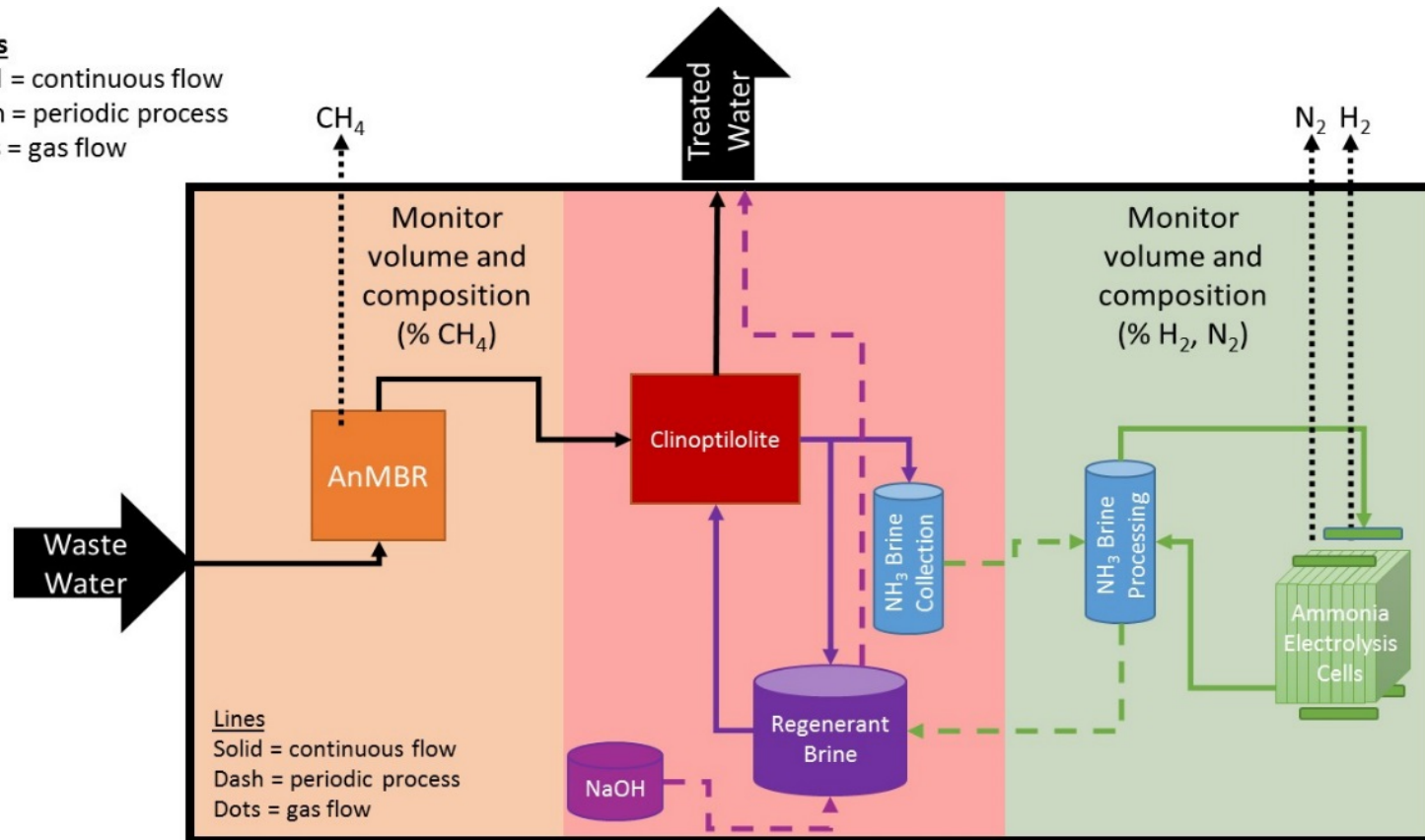
Test Design – Integrated System

Lines

Solid = continuous flow

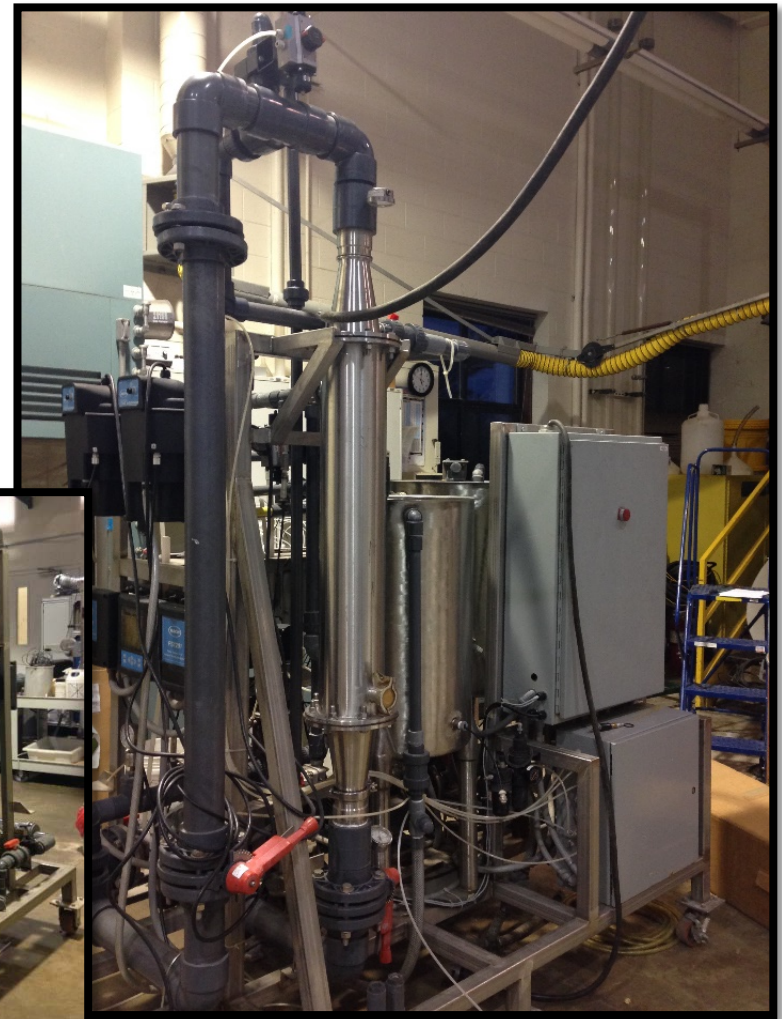
Dash = periodic process

Dots = gas flow

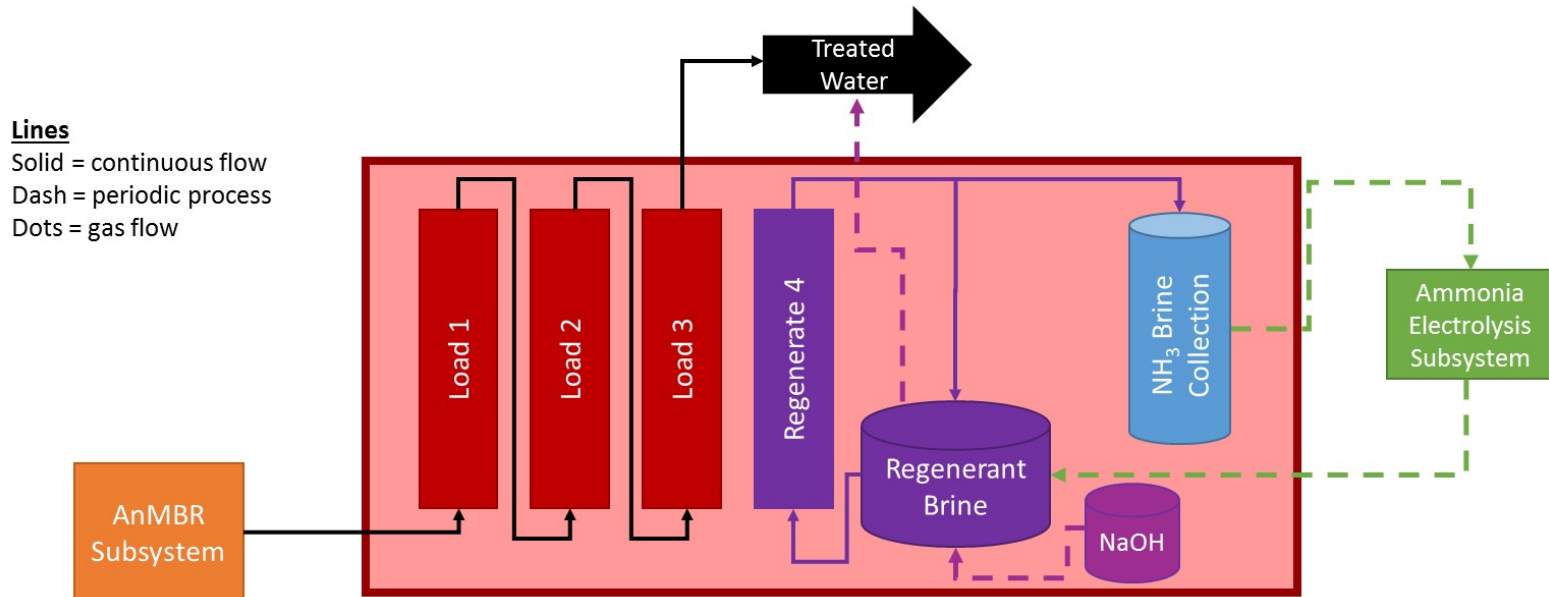


Test Design - AnMBR

- Partnership with AnMBR experts
- AnMBR provided as cost share with University of Illinois at Urbana-Champaign
- Treats 750-1000 gpd



Test Design – Ion Exchange



Loading

- Columns in positions 1-3
- Influent flows serially through all three columns
- Flow for all columns is bottom up

Switching

- After a user defined period of time, all columns switch functional positions
- Column 1 → Column 4
- Column 2 → Column 1
- Column 3 → Column 2
- Column 4 → Column 3

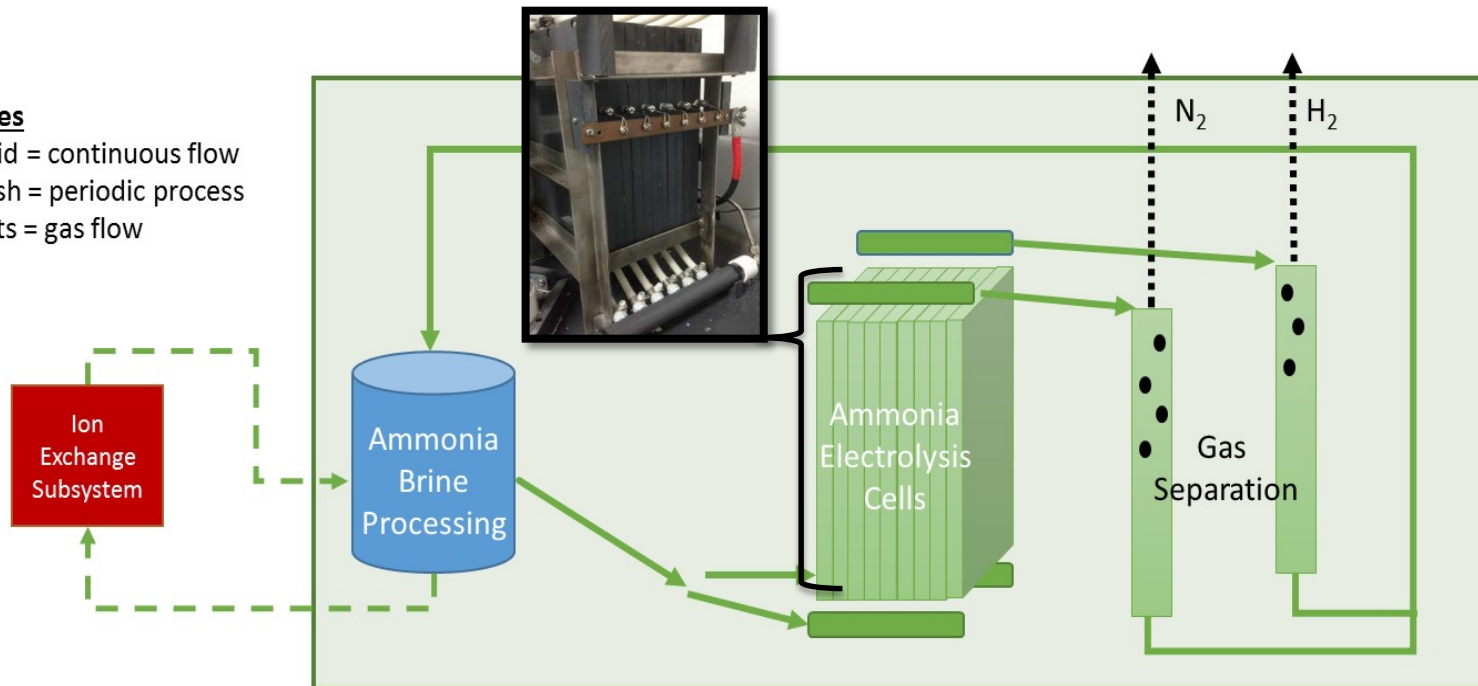
Regeneration

- Simultaneous with loading
- Column in position 4
- Regenerant brine introduced in a flow-hold-flow pattern with user defined time periods
- Two effluent options (Regenerant Brine, NH_3 Brine Collection) switched at user defined times

Test Design – Ammonia Electrolysis

Lines

Solid = continuous flow
 Dash = periodic process
 Dots = gas flow



- Ammonia brine generated from multiple clinoptilolite regeneration cycles treated in batches
- Solution must be heated to 40-70°C based on user input
- Solution recycled back to ammonia brine processing tank following electrolysis until user defined time to discharge to regenerant brine tank
- User defined adjustable flow (100-500 mL/min) to both sides of electrolysis cells
- Maximum 0.925 Volts applied across each cell
- Flow enters and exits cells through manifolds
- Cells provided as GFE
- Hydrogen and nitrogen gasses are separated from the brine solution
- Composition, purity, and volume of gas generated is measured
- Vented outside of the container unit
- Degassed brine returned to ammonia brine processing tank

Technical Approach

Pre-validation Testing

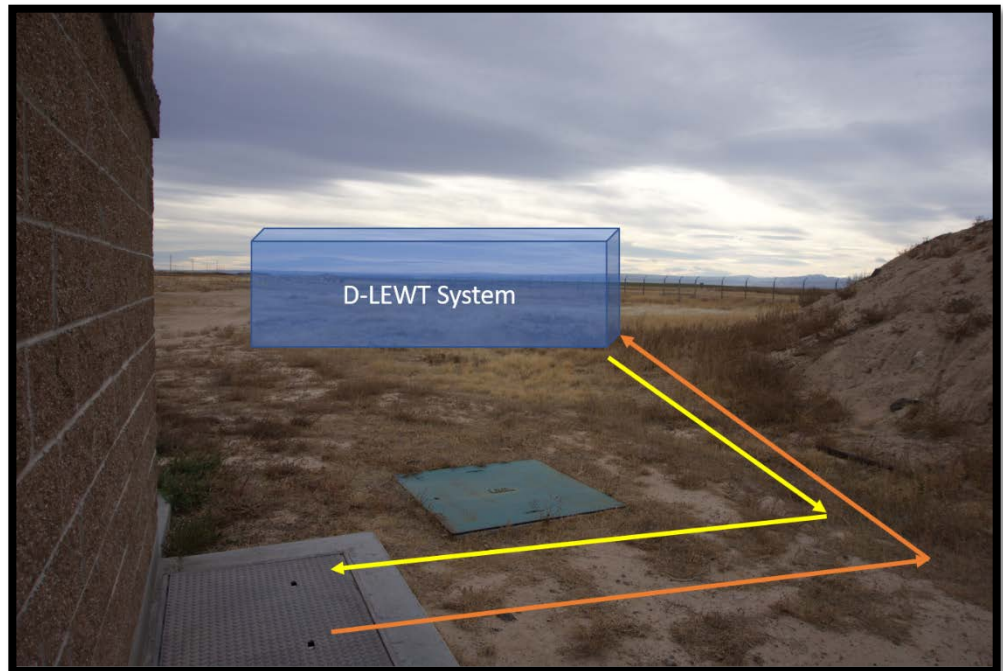
- ◆ Performed at ERDC-CERL
- ◆ Based upon the performance objectives:
 - Energy consumption
 - Energy production potential
 - Effluent water quality and water reuse potential
 - Sludge mass
 - Maintenance requirements
- ◆ Performance metrics verified to minimize risks associated with onsite demonstration and validation



Technical Approach

Field Demonstration

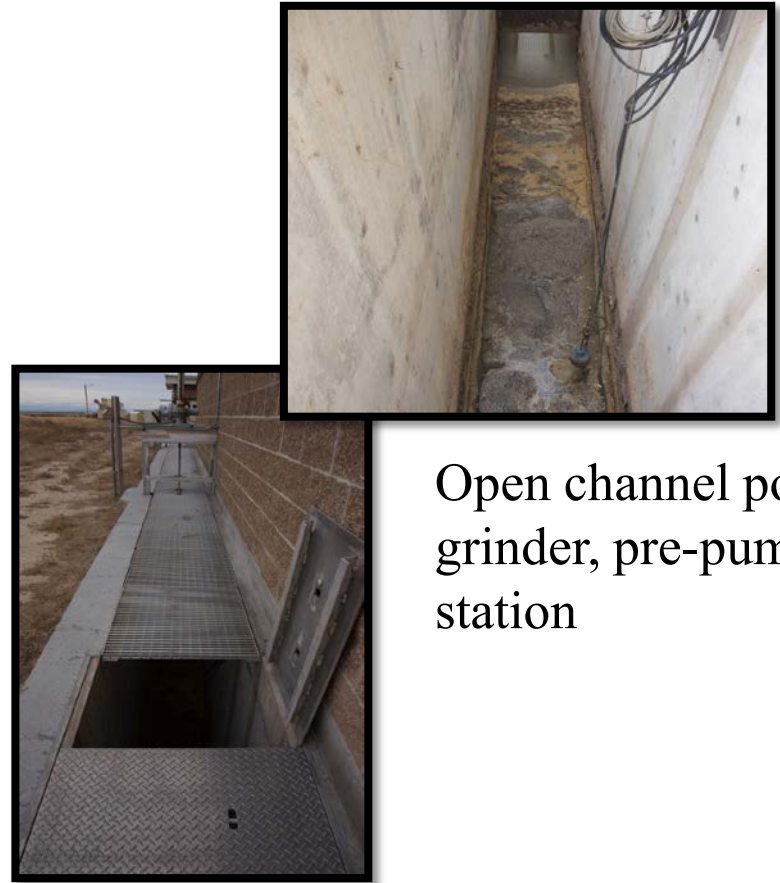
- ◆ Mountain Home Air Force Base (MHAFB)
- ◆ Parallel integration with the existing wastewater treatment infrastructure at headworks
- ◆ Bypass valve to minimize risk in the event of system shutdown
- ◆ Minimal ancillary onsite infrastructure improvements required



Site Description (MHAFB)



MHAFB headworks buildings—inlet & grate (A), grinder & pumping station (B)



Open channel post grinder, pre-pump station

Technical Approach

Performance Objectives

Parameter	Objective
Capacity	1000 gpd
Energy Consumption	≤ 4.45 kWh/kgal
H ₂ Yield	≥ 0.017 kg/kgal
CH ₄ Yield	≥ 0.026 kg/kgal
Net Energy Consumption Reduction	≥ 6.0 kWh/kgal
Sludge Reduction	$> 60\%$
Water Re-Use Potential	$> 85\%$
BOD	< 30 mg/l
COD	< 30 mg/l
NH ₃	< 5 mg/l

Current Status

- AnMBR
 - ◆ University of Illinois updating AnMBR with new piping and a second membrane module
 - ◆ Upgrading controls to enable integration with the parent D-LEWT system
 - ◆ Conditioning sludge for seeding the AnMBR
- Clinoptilolite
 - ◆ Subsystem designed by Highland Engineering
 - ◆ Assembly is underway with a completion date of March 2018
- Ammonia Electrolysis
 - ◆ Electrolysis cells assembled with improved catalyst
 - ◆ Received 2/5/2018



Ceramic membrane module
for AnMBR



Assembled clinoptilolite column

Next Steps

- Integrated system complete – July 2018
- Pre-validation testing complete – January 2019
- Install at MHAFB – February 2019
- Field demonstration complete – March 2020
- Final report – April 2020

Key Points

- Decentralized waste water treatment system that generates useful methane and hydrogen fuels
- Reduced energy consumption and sludge production compared to aerated systems
- Effluent water available for reuse
- Containerized system suitable for decentralized use and deployed applications
- Supports water, energy, and waste Net-Zero goals

Questions?