NJWEA 109th Annual Conference
Session: Air Pollution & GHG
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PONCH-H2O - Advanced Wastewater Resource Recovery for Enhanced Carbon Reduction at WRRFs

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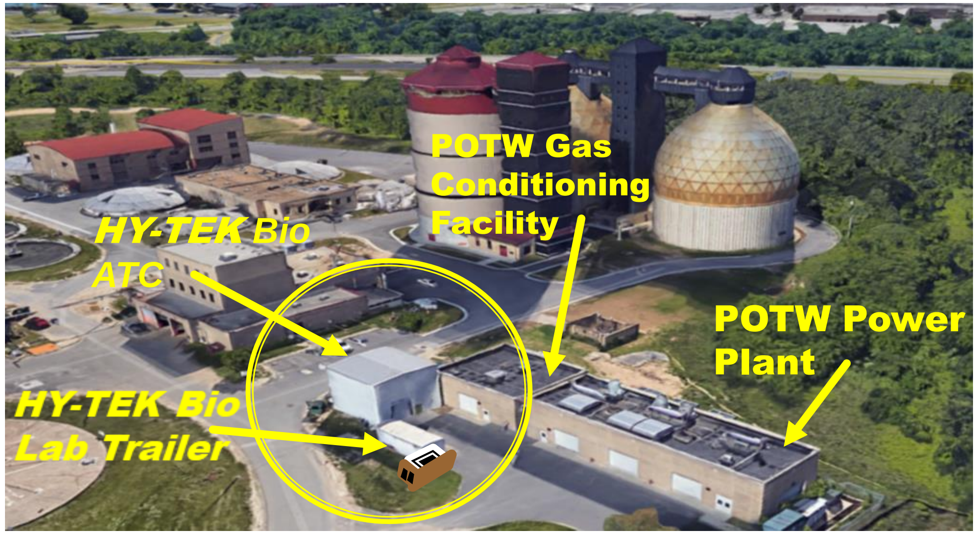
Presentation Outline

- Meet **PONCH-H_2O** (**P**hosphorus, **O**xygen, **N**itrogen, **C**arbon, **H**ydrogen for enhanced **H_2O** & air quality)
- Focus on **C**arbon Capture & Utilization and Nutrient **N-Nitrate** Recovery/Reuse as Ammonia for **Hydrogen**
- GHG **C**O_2 Biogas Reduction Driven by Microalgae
- **PONCH-H_2O** Outcomes, Key Takeaways

WRRF CO_2 Capture and Reuse Project
C, N & P, O_2 , H_2

Mass Cultivation of Microalgae in Photobioreactors – Net Negative C Operations



$$106CO_2 + 16HNO_3 + H_3PO_4 + 78\ H_20 \rightleftarrows C_{106}H_{175}O_{42}N_{16}P + 150O_2$$

Carbon Reuse via Microalgae

- **Biofuels**
  - Biodiesel, Renewable Diesel, and SAF
- **Bioproducts**
  - *Carotenoids –> Pigments, <u>Nutraceuticals</u>*
  - Proteins
  - Sugars/Starches
  - *Soil amendment/fertilizer - <u>Biochar</u>*

CO_2 Emissions Sources

- Raw Biogas/Landfill Gas Feedstock – 35% - 65% CO_2

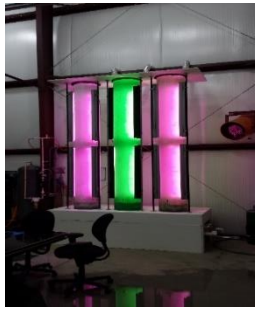
- Biogas **CHP** - 8% - 12% CO_2
- Biogas/NG Industrial Steam **Boiler** - 5% - 6% CO_2
- Biogas **Sludge Drying** - 8% - 10% CO_2

- Purified Biogas **RNG** - 97% - 99% CO_2

- Solar **Sludge Drying** - 400 ppm – 1000 ppm CO_2

Waste Heat Recovery

- **Optimum Algae Cultivation = ~ 85° F;** Engine Exhaust = ~1000° F



- **Three Choices of WHRUs**
  - ORC (Electric Power) → Offset LED Lighting
  - Waste Heat Chiller (Cooling) → Gas Cooling or Chilled Water
  - Waste Heat Boiler (Heating) → Drying or Pyrolysis of Wet Algae

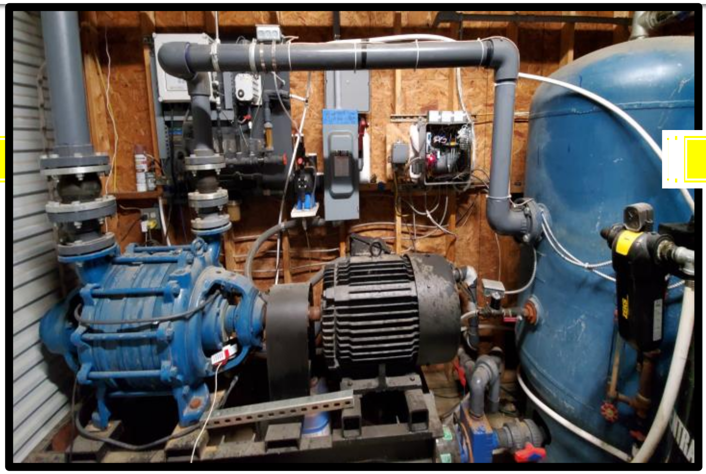
Algal System Technology/Flue Gas Conditioning

FLUE GAS

Flue gas is captured using a slipstream and cooled using Waste Heat Recovery Units (not shown)

FLUE GAS FILTRATION

A simple H_2O quench trap cools the water to 85F and traps any particulates



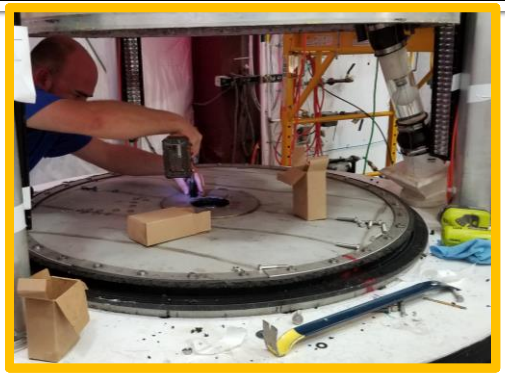
FLUE GAS COMPRESSION

Flue gas is fed to a Liquid Ring Compressor to minimize heat of compression. The water is separated from the flue gas which is then directed to the photobioreactors (PBRs)

WATER CONDITION

Compressor recirculating water is neutralized to pH 7, nutrient and makeup water added and cooled to <70F for re-use through the compressor.

Microalgae Cultivation Technology/Process



FLUE GAS INJECTION

A special gas sparger was developed in-house to ensure rapid transfer of gas chemistry to the culture using micro-bubbles that increase light penetration and enhance tall column mixing throughout

GROWTH ENHANCEMENT

Advanced LED lighting technology developed in-house to enhance growth and nutritional value of the algae via proprietary lighting strategies that “photo-stress” the algae and reduce energy consumption

CULTURE HARVEST

When the algae gets too dense for light penetration, the automation drains 10% of the tank to thin out the culture to get more light

CULTURE HOLDING

Harvested algae is centrifuged (not shown) to concentrate the algae into paste product for conversion. Centrate is recirculated to the PBRs.

Why Algae? - Host of Bioproducts

- Algae and algae oil is used in the following products (partial list)
  - ✓ **Nutraceutical products,** eye nutrients, Omega-3 Fatty Acids
  - ✓ Skin conditioners
  - ✓ Cosmetic and paint thickeners

  - ✓ Bioplastics

  - ✓ Animal and numan food supplements - **PROTEINS**
  - ✓ The HY-TEK Bio algae *s.HTB-1* can bring as much as **$40/lb** from an algae brokerage house

  - ✓ 90-95% **Oxygen** from photosynthesis is a reusable marketable commodity
  - ✓ Direct replacement for Palm Oil

  - ✓ **Biochar Soil Amendment**

THE BUSINESS PLAN

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CLIENTS

INVESTORS

PONCH-H2O Facilities

Rent/Lease Space; Electric Bills, PROJECT CREDITS (RECs, RINs, Carbon Credits, Tax Credits)

O&M

PROFIT

s.HTB1
ALGAE

ONCE THE INVESTOR IS PAID BACK, THE PONCH-H2O FACILITY IS TURNED OVER TO THE CLIENT AT NO COST ALONG WITH % OF THE REVENUE STREAM FROM THE SALE OF THE ALGAE TO PAY FOR O&M PLUS CONTINUED REVENUE STREAMS THAT MAXIMIZE RETURN and ENABLE MULTIPLE COMMUNITY BENEFITS

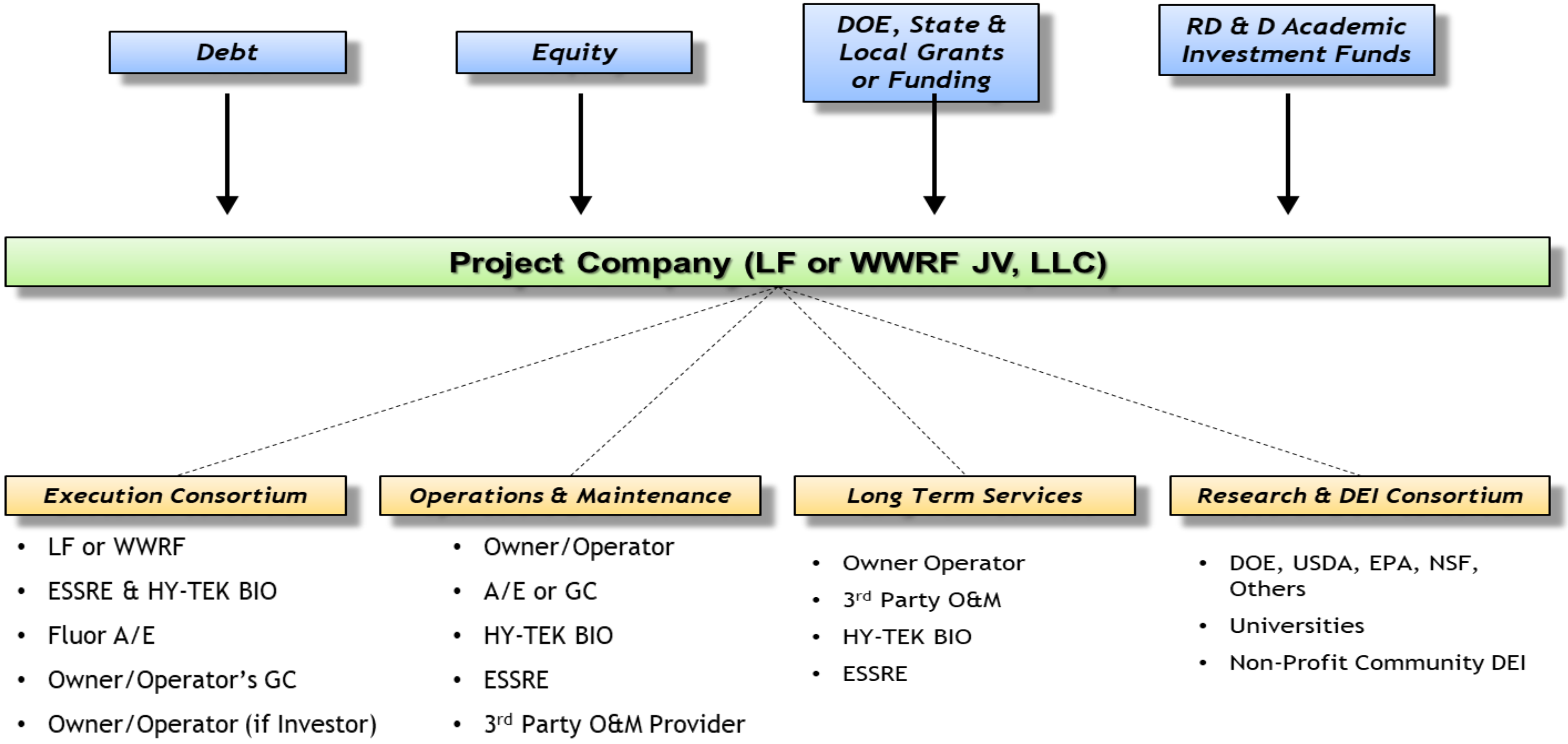
10-Year Algae Production & Financial Projections

- EXAMPLE: Containerized Algae Facility Adjacent to Biogas Engine Room
- PRODUCTION: *1149* Tons Algae p.a.
- DETAILS: 10 PBRs; Capital Initial Investment $4.375M;
  Breakeven Payback by Yr. 3 of operation;
  Total 10-Yr Revenue ~ $39M
  NPV ~$6.25M; IRR% 40.7
- INVESTOR OUTCOME: If 15% of Capital Cost, Investor net profit ~$2.8M
- CLIMATE OUTCOME: Total Carbon Dioxide Removed, 2095 Tons, p.a

Note: Assume a system availability factor of 75% during year one, otherwise 90% availability factor

PONCH-H2O PROJECT ORGANIZATIONAL STRUCTURE

Commercial Demonstration Project (Alpha, Beta, etc.) Structure Overview



PONCH-H_2O Review

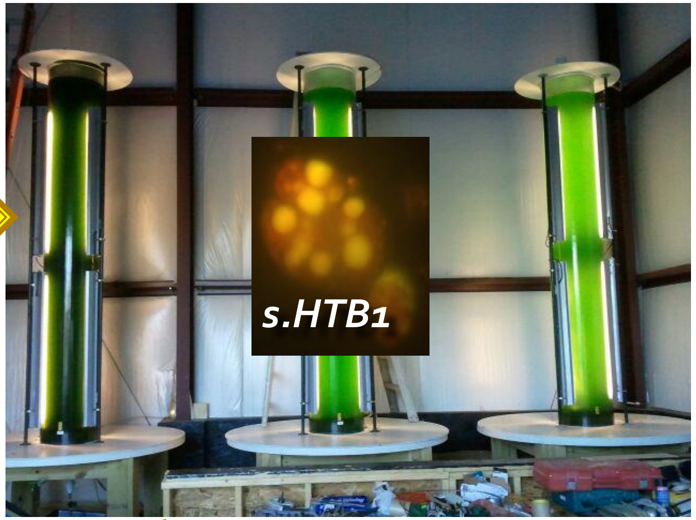
Digesters/Landfills

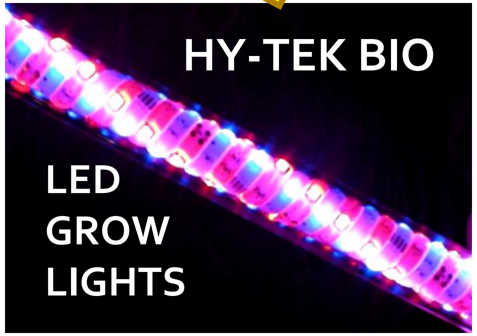
Biogas Engine Exhaust

LFG Engine Exhaust

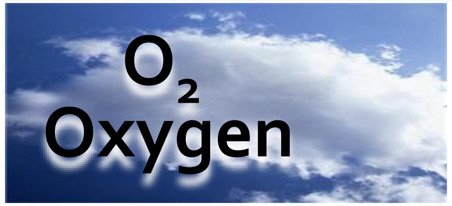
RNG Waste CO_2 Tail Gas

500 L Pilot Scale Photobioreactors





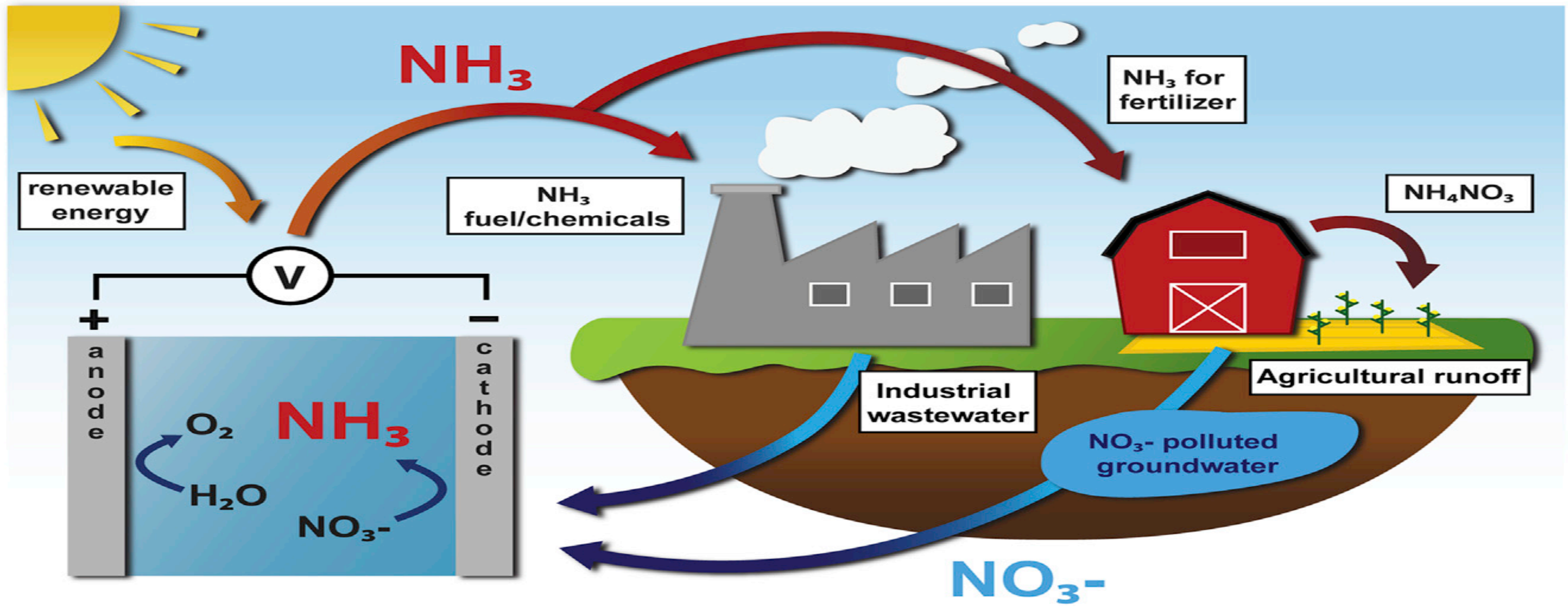
Recycled N &P from Manure, Wastewater, Digestate or Landfill



Net Negative C Ops

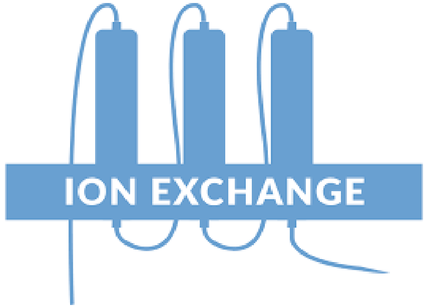
Zero CO_2 Emissions; Non-Detect NOx Emissions

ONE WATER Goal: Nitrate Polluted Water/Wastewater Closed-loop Transformation into Reuseable Ammonia Based Products

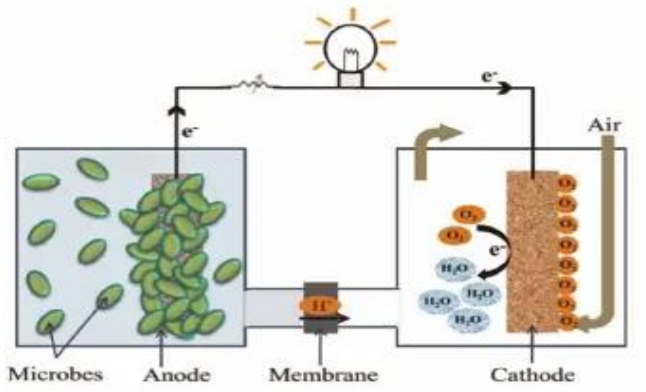


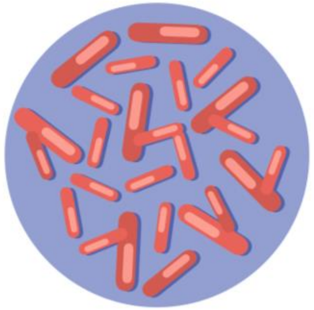
Electrochemical membrane treatment alternative to denitrification or Nitrate selective Ion Exchange processes, which respectively transforms pollutant nutrient N ammonia gas or liquid ammonium salt fertilizer solution. The built environment N cycle image shows two distinct opportunities: 1) Concentrated nitrate wastewater from industry and 2) Dilute nitrate waters from farm runoff or drainage and treated POTW effluent (not shown)

N-Nitrate Removal "Pain Points"



Cons: Frequent regeneration Nitrate is only concentrated and then T&D'ed Costly Brine Waste Disposal; No resource recovery





Biological Denitrification

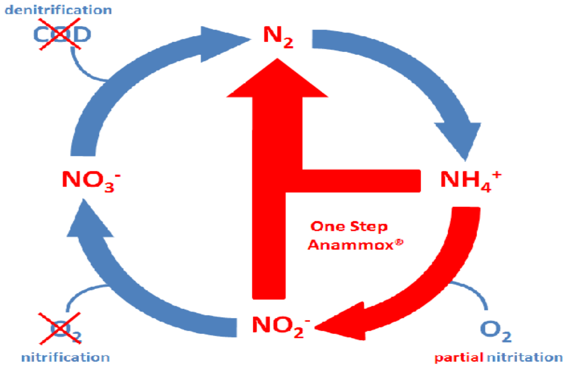
Cons: Long hydraulic retention times. Additional carbon source. No resource recovery – inert N_2 gas emitted

Bio-Electrochemical Systems (BES)

Cons: Several Hybrid cases (MFC, MEC) in development with removal of COD and production of energy as the primary outcomes

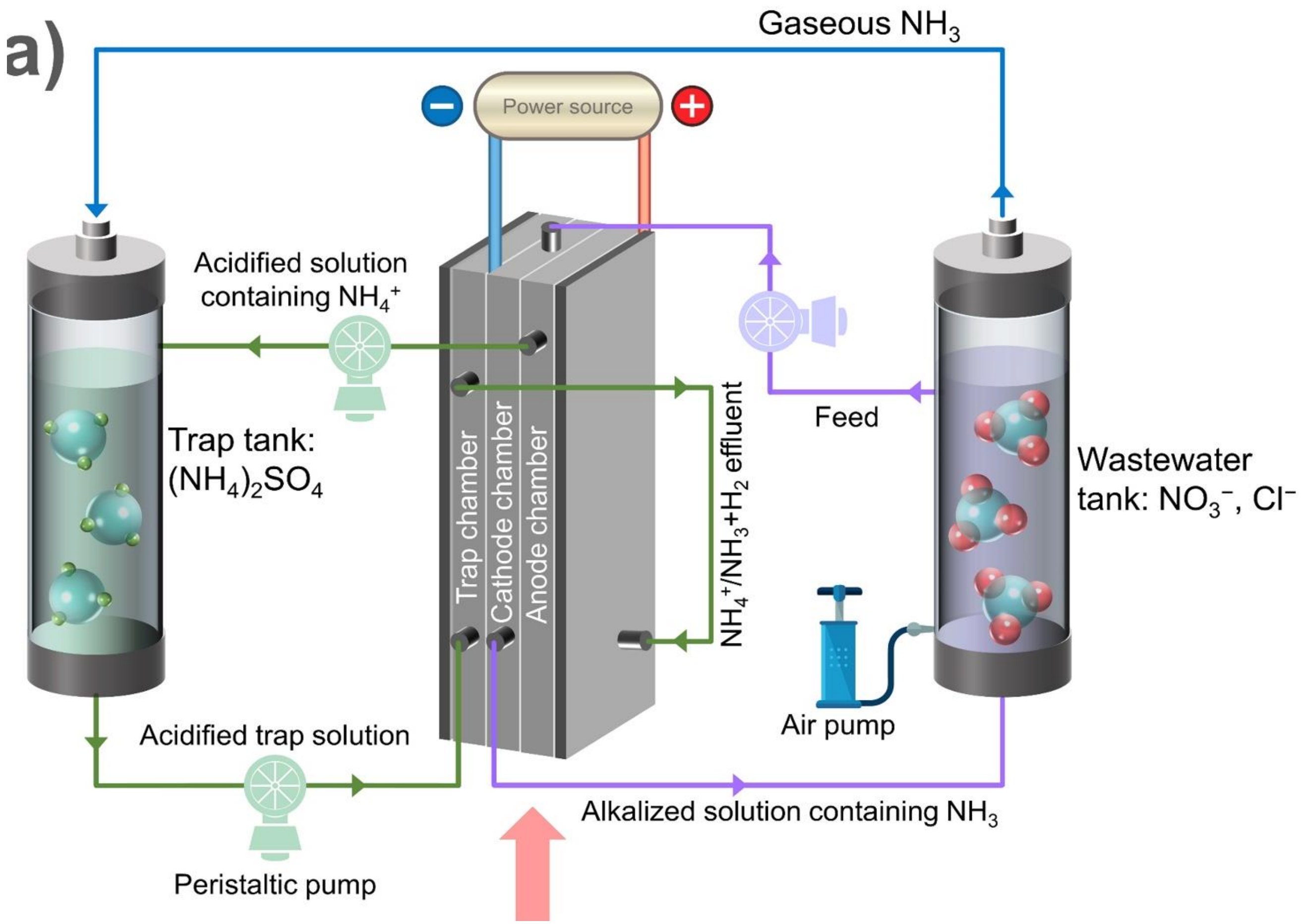
Physical Membrane Separation

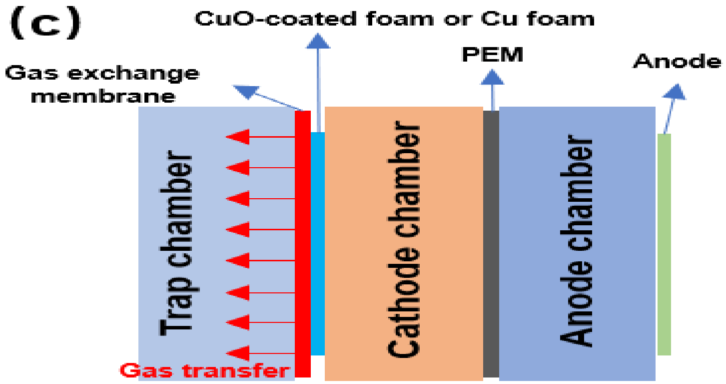
Cons: Prone to fouling, frequent cleaning; Concentrate Disposal; Energy intensive; High Capex cost; no resource recovery



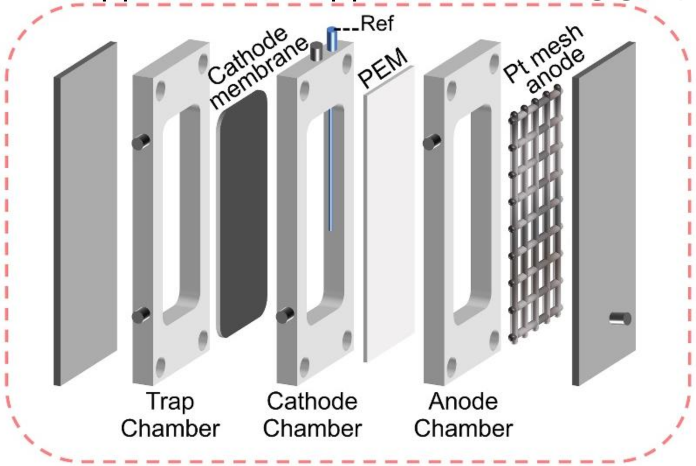
Partial Denitrification Anammox; SND; Alternative C Sources

Schematics of an ElectroChemical Membrane (ECM) Cell and System



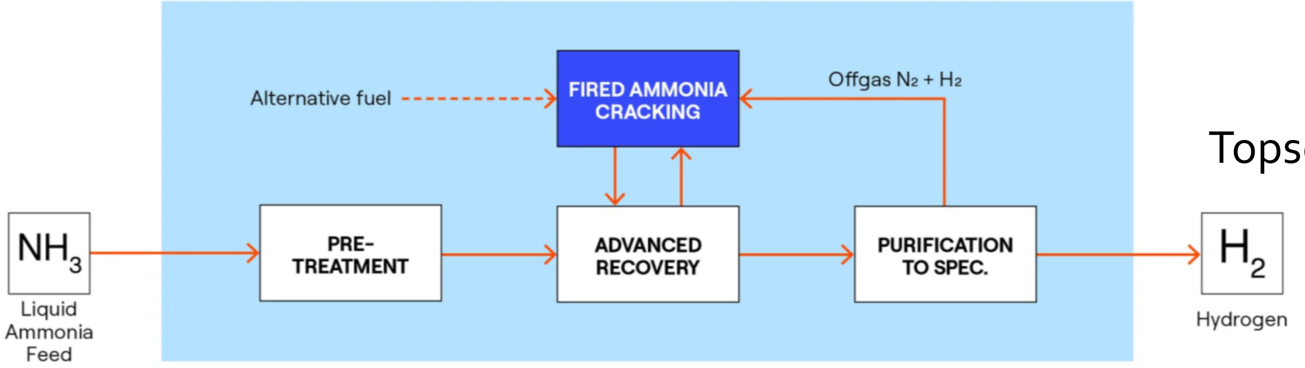


US patent application#: application No. 63/340,193



Ammonia "Cracking" for Hydrogen

Ammonia is emerging as a clear front runner for transporting Hydrogen because it has a much higher density and the gas can be readily liquefied at room temperature and low pressure for high volume, safer transport.



Topsoe H_2Retake™

Once delivered to the H2 use site, the ammonia is "cracked" (decomposed) to release the H2 gas. It can then be used as a zero Carbon fuel or as a raw material in industrial processes (e.g., oil refineries).

Ammonia vs. H2 vs. Battery Storage

Energy storage comparison

30,000 gallon underground tank contains 200 MWh (plus 600 MMBTU CHP heat

Capital cost ~$100K

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204 MWh NGK battery in Japan

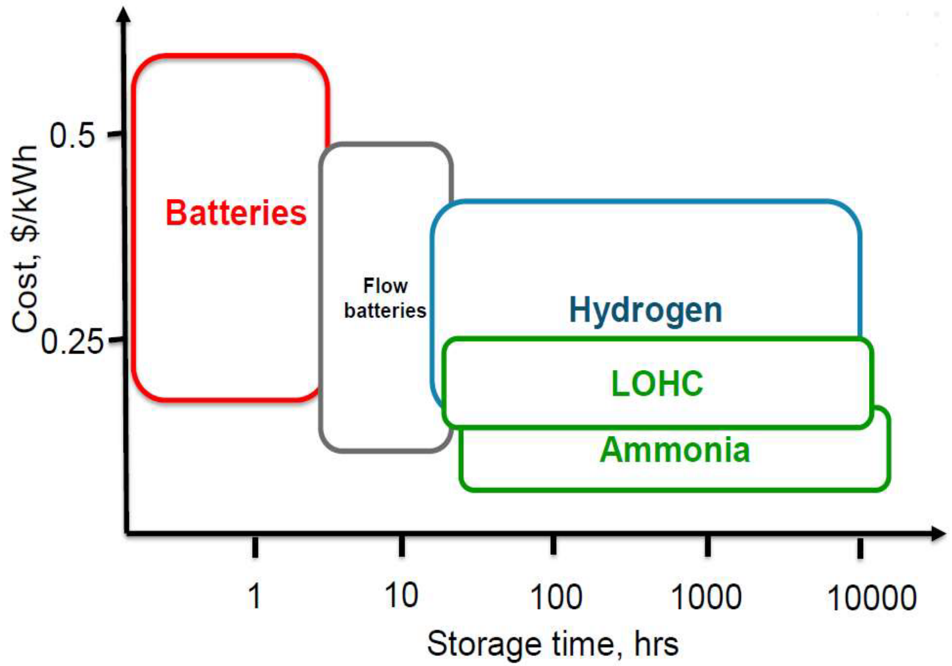
or

40 x

5 MWh A123 battery in Chile

Capital cost $50,000 - 100,000K

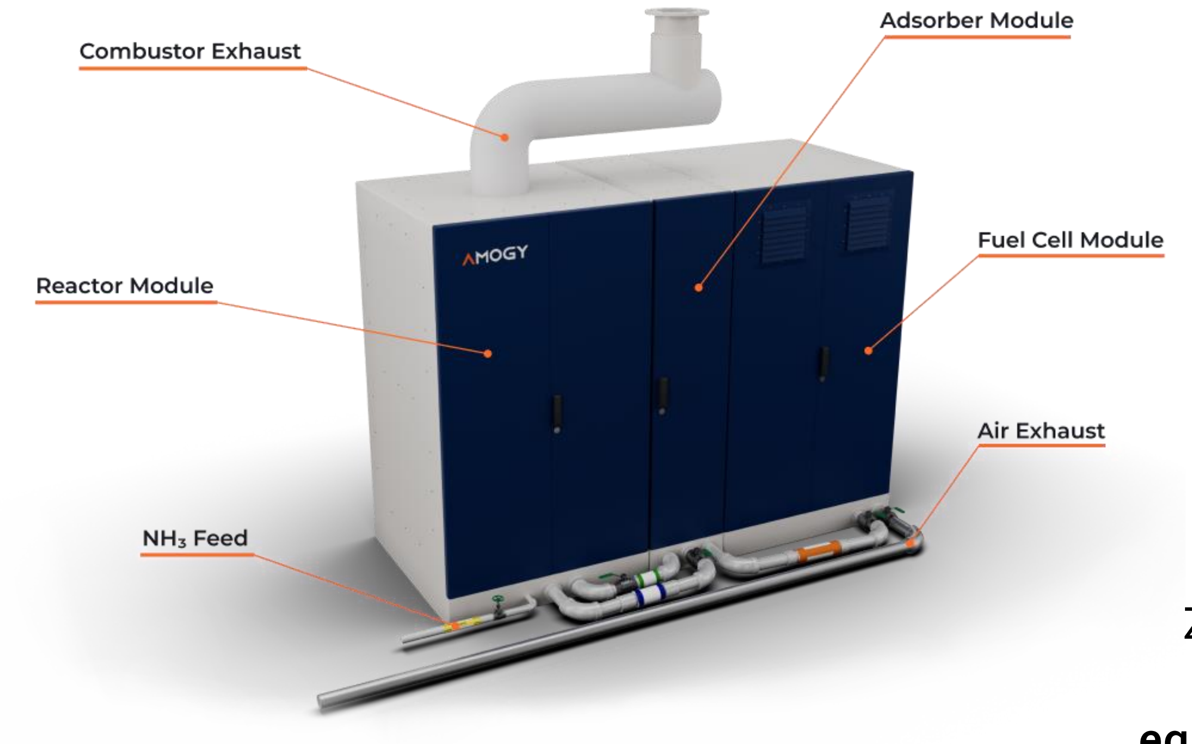
Levelized cost of energy storage



Source: Soloveichik, NH_3 Fuel Conference 2016

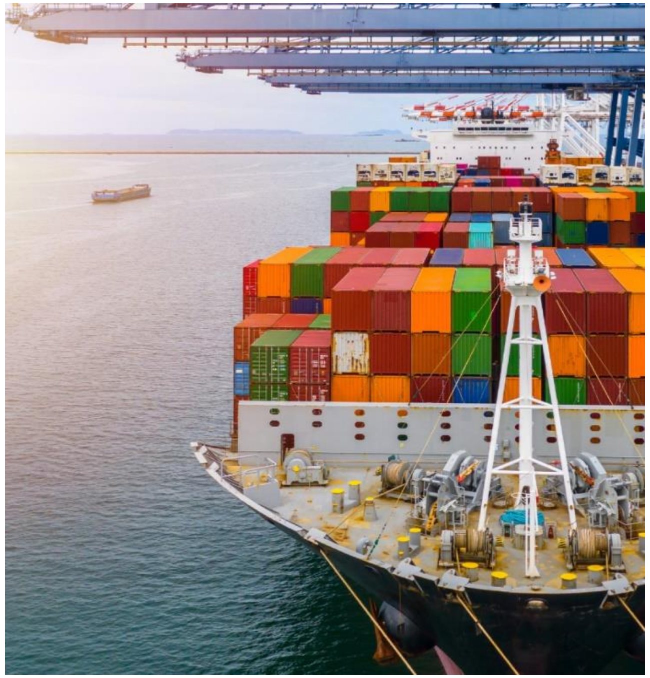
Ammonia to Power

Amogy Ammonia Fuel Cell



Zero-C power replaces polluting diesel generators for backup power at **WRRFs**

Zero-C power for **cargo & heavy duty handling equipment,** maritime vessels, EV charging stations, and **data centers**



Key Take Aways

- PONCH-H_2O = WRRF & Industrial Decarbonization
  - Complete CO_2 removal from Biogas, LFG Utilization while maximizing returns
  - Net Negative Carbon, O_2 reuse, and Novel Nitrate Transformation to Ammonium Salt Nutrients for Microalgae or Ammonia/H_2 for fuel at WRRFs and elsewhere

- Regenerative Ag - Carbon Markets
  - PONCH-H_2O: Transfers Atmospheric CO_2 and Sequesters C as Biochar onto Soil for Maximum Dual Impact on Climate Change

- Net Zero GHG Emissions
  - ESG Scope 1, 2 or 3 Emissions wherever fossil fuel is combusted

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Questions