Facilitating a Hydrogen Fuel Cell Infrastructure in Support of Tactical Micro Grids®

- Fuel cells are becoming more prevalent in micro-grids
- The lack of hydrogen infrastructure is impeding growth
- Base Facilitated Reformation (BFR) is a potential solution
Topics Covered Here:

- Micro Grid Configuration
- Base Facilitated Reformation (BFR)
- Multiple Feedstocks
- Total Recovery System
- BFR Configurations
- Distribution Opportunities
System of Systems Architecture Based on Modular Micro Cell Design
Military Eco Energy Micro Grid Installations
Hybrid Powered Base

- DC from Tactical Vehicles
- Micro Grid Controller Module
- Wind Turbine
- Large Scale Solar Array
- Solar Panel Awnings
- UPS
- Fuel Cell Power Plant
- Hydrogen Fuel Reformer
- UPS

H2 Infrastructure
**PROPOSED SOLUTION TO H2 INFRASTRUCTURE**

**Base Facilitated Reformation**
Simple One Step, Energy Efficient Process to High Purity Hydrogen

Feedstock (JP8, Diesel, Cellulose, MSW)

- **BFR Reactor**
  - NaOH (Sodium Hydroxide)
  - H$_2$O
  - Catalyst

- **H$_2$**
  - Fuel Cell or H2 Storage

**Carbonate recycling**
Sodium Bi-Carbonate is formed as a by-product

Alkaline material is used as a reactant in the reformation process.
This system is a low cost direct conversion of feedstock into pure hydrogen (H2) without producing greenhouse gas emissions (no CO and CO2).

The BFR process is modular and scalable allowing hydrogen production near the point of use, minimizing transportation costs.

The H2 produced through this process is delivered directly to fuel cells or stored in vessels.
BFR ADVANTAGES

- One step reaction – making reformer design simpler
- Bio-waste / biogenic materials can be converted directly into H2
- No CO or CO₂ gases formed – Water gas shift and PSA not necessary
- **Greener process** – CO₂ sequestered as a carbonate (i.e. Na₂CO₃)
- Pure hydrogen is formed
- Batch or continuous operation possible
- Lower operating temperatures
- Can be used to reform variety of feedstocks, a major advantage.
- Minimizes / eliminates waste storage/transport
- Minimizes / eliminates the need for waste incineration
- Modular and scalable, allowing for application at point of H2 use
Examples of Renewable and Non-Renewable Feedstocks Successfully Reformed into Hydrogen by BFR Process

Fossil Fuels: JP8, Diesel, Methane (Natural Gas, Landfill Gas, Bio-Gas, Flare Gas), Coal
Agricultural Solid Waste (ASW): Animal, Crop and other Agricultural Organic Wastes
Food Industry Waste (FIW): Food Processing, Meat Processing and Food Service Wastes, i.e. Fryer Oils, Potato Peels
Biomass: Grass, Algae, Sawdust, Woodchips, Corn, Cellulose
Alcohols: Methanol, Ethanol, Crude Ethanol, E95, Ethylene Glycol, Glycerol
Sugars and Starches: Glucose, Fructose, Starch (Corn Starch, Potato Starch)
INTEGRATING BFR INTO TOTAL RECOVERY SYSTEM

- Reformation units producing H2 from dissolved organic feedstocks
- Dryer units producing engineered fuel from plastics and other undissolved feedstocks
- Organics are dissolved in lye or caustic soda solution
Example of First Article Container And Demonstration System

Scalable up to 2000 Kg of H2 Per Day

FOB Point of Use

Depot Point of Use

Scalable up to 2000 Kg of H2 Per Day
H2 Infrastructure

Module Layout of BFR Container

Examples of Materials Reformed by the ETI Bio-Reformer

<table>
<thead>
<tr>
<th>Category</th>
<th>Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biomass</td>
<td>Grass, Sawdust, Woodchips, Corn, Potato Peels, Cellulose, Hemicelluloses (Fibers from Beachwood), Lignin (Cegrass)</td>
</tr>
<tr>
<td>Municipal Solid Waste</td>
<td>Paper, yard waste, food waste</td>
</tr>
<tr>
<td>Sugars / Starch</td>
<td>Glucose, Fructose, Starch (Cornstarch, Potato starch)</td>
</tr>
<tr>
<td>Alcohols</td>
<td>Methanol, Ethanol, Crude Ethanol, E95, Ethylene Glycol, Glycerol (from bio-diesel plants)</td>
</tr>
<tr>
<td>Fossil Fuels</td>
<td>Methane, Coal</td>
</tr>
</tbody>
</table>
Distribution of H2 Storage Module to Mobile Refueling Vehicle & Permanent Station
Specialized H2 Distribution/Fueling Trucks to deliver H2 to other forward locations
What to do with carbonate byproducts?

• Recausticize back to NaOH (common name: lye or caustic soda) for use as makeup to the input of the process

• Disposal of carbonate in block form
Our Base Facilitated Reformation (BFR) process has been successfully demonstrated using a wide variety of renewable feedstocks.

Reformation of municipal and agricultural wastes, biogases and other organic materials produces clean energy, helps solve environmental issues.

Using the Total Recovery System can convert over 80% of waste to useful energy.

BFR approach solves fuel cell H2 infrastructure issues

Scalable technology allows application at FOB, Depot & support facilities.

H2 can be utilized directly or stored

Flexible feedstocks including, JP8, Diesel, MSW and Cellulose,
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