# Generate Fuel on-site

## Convert Trash to Fuel

**Simplified Small System**

- 30lb/hr of Waste (wet)
- Fuels 5kW Sterling Engine
- <3,000lb weight

**Medium Sized Systems**

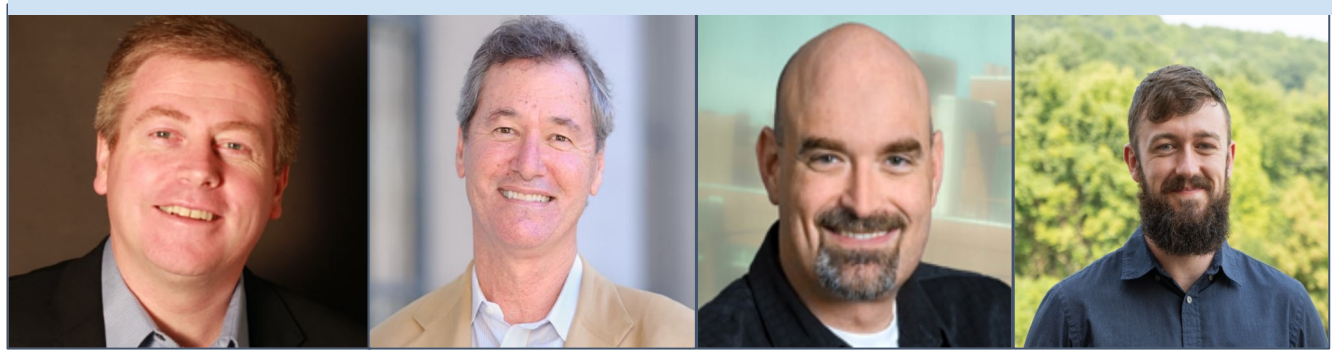
- 140lb/hr of Waste (wet)
- Fuels 60kW AMMPS Generator
- <10,000lb weight


**Large Processing System**

- 720lb/hr of Waste (wet)
- Optional AMMPS or Turbine Generator
- Energy Storage using fuel

# The Team

## Leadership Team



| Kieran Mitchell<br>Co-founder & CEO | Dr. David Holst<br>Chief Economist | Dr. Blake Simmons<br>Co-founder & CTO | David Connolly<br>Chief Engineer |
|---|---|---|---|
| MBA in Strategic Leadership 25+ years' experience | Professor Resource Economics | Division Director Lawrence Berkeley National Lab | ME in Energy Systems Engineering, |
| Sales/BD | Technical Expert | Technical Expert | Manufacturing |

## Partner -The State University of New York (SUNY)


A team of 10 Engineers and PHD's at Joint facilities at SUNY

# Problem Statement

- **Burn pits cause cancer and lung disease. Since the $5 Billion PACT Act 2022, DOD Policy now prohibits the open air burning of trash.**

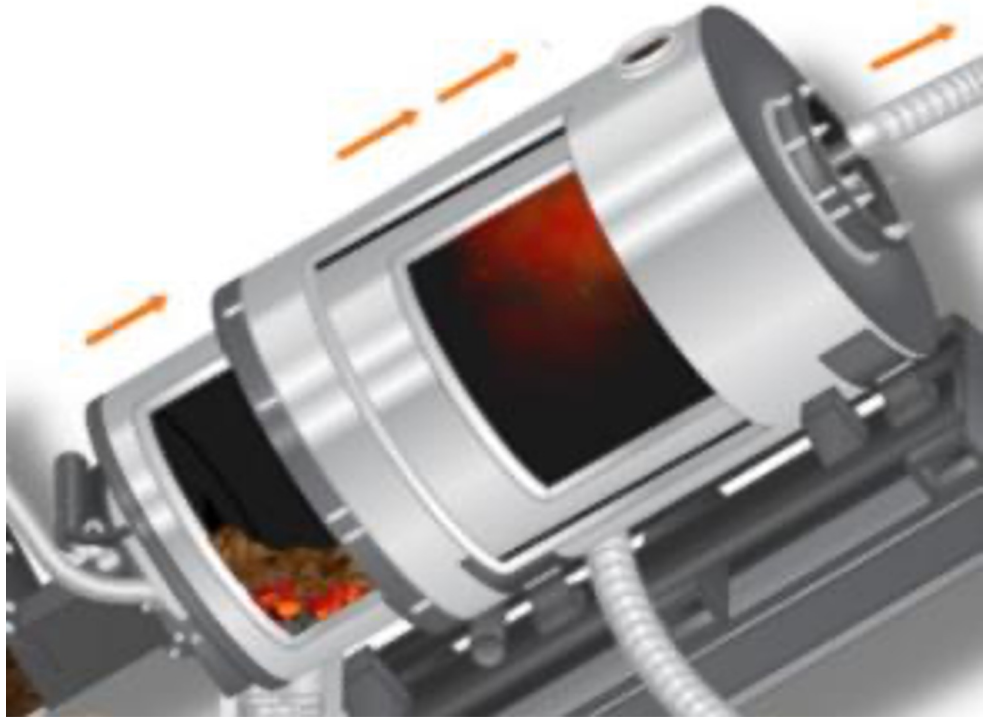
- **Contested logistics present a huge issue with fuel transportation if we get into a war.**


# 52% of casualties come from resupplying troops


**Multiple studies identify that air and ground delivery of liquid fuel comes at a significant cost in terms of lives and dollars. Approximately 18,700 casualties, or 52% of the approximately 36,000 total U.S. casualties over a nine-year period during Operation Iraqi Freedom and Operation Enduring Freedom occurred from hostile attacks during land transport missions, mainly associated with resupplying fuel and water.**

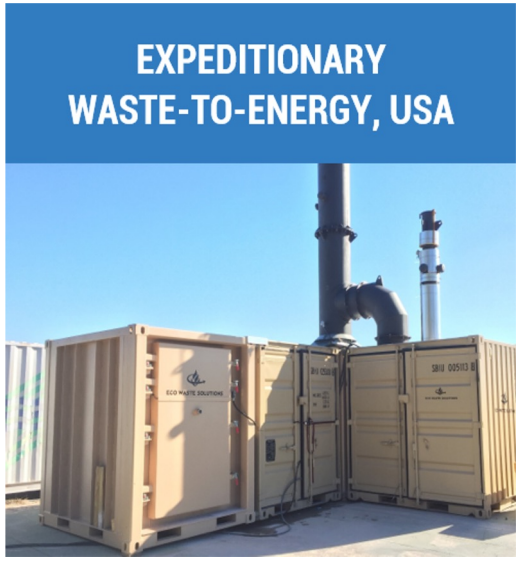
# Gasification

- Gasification is a thermal process that converts all volatiles to gaseous fuel
- Inert items (metals, glass, stones) discharge from the bottom of the rotating gasifier with the dense ash
- Very low emissions relative to combustion/incineration
- Self-sustaining and energy positive
- Excess carbon discharges with ash as biochar



# Trash Options


**Burn Pits**




**Incenerators**


**Gasifier**

# Current Option – An Incenerator using fuel

PM FS²

UNITED STATES ARMY
PRODUCT MANAGER
FORCE SUSTAINMENT SYSTEMS

**EXPEDITIONARY SOLID WASTE DISPOSAL SYSTEM (ESWDS)**

**CAPABILITIES:**

Capable of on-site disposal of 1000 pounds of non-hazardous, mixed solid waste per day for approximately 92% volume reduction. Supports the 150-person module of the Force Provider Expeditionary product by providing safer alternative to open burn pits and backhauling of waste. ESWDS is designed to be easily set up and operated by MOS-nonspecific soldiers using the Army's All Terrain 10K forklift.

**DESCRIPTION:**

The primary chamber of the ESWDS is manually loaded to capacity through a large front door. After loading, the door is sealed shut and electronically locked to avoid unsafe access during operation. The Operator uses simple push-button controls to start the system. The entire operation does not require attendance or operator input after the system is loaded and started. All key operating parameters are controlled by the PLC contained within the ESWDS control panel. The full batch burn cycle consists of a 5 hour burn time followed by a 5 hour cool-down. Pollution is controlled by automatically maintaining the secondary burn chamber at an average of 1600ºF. After cool down, the operator removes the ash using provided rakes, shovels, etc. Eye protection and dust masks are also furnished.

- **Power requirements:** Operates on 208VAC,3 phase. Average power draw: 2.5 KW Peak power draw: 5 KW
- **Fuel requirements:** Uses an average of 60 gallons per day of Diesel or F-34 fuel. One 500-gallon fuel storage bladder is furnished.
- **Size (LxWxH):** 20'x8'x8' (Three Triple Containers (TRICON) joined together). Stack Height from grade is 20 feet.
- **Weight:** Approximately 9500 pounds per TRICON.
- **Status/Availability:** Development completed. Production decision contingent on funding.
- **Transportability:** Being developed for air, land, and sea
- **Supportability:** Operator and maintainer technical manuals under development
- **NSN:** XXXX-XX-XXX-XXXX
- **LIN:** XXXXXX

**INFORMATION CONTACT:**

**Field Services & Field Feeding Equipment**
DSN 256-5543/(508) 233-5543

REV 04-05-19 • UNCLASSIFIED

***Uses 60 Gallons a day***

***Converts trash and generates 120 Gallons of fuels a day***

***Very important if a base gets cut off and needs to maintain operations.***
***"Contested Logistics"***

# A Machine that Turns Trash into Fuel for Generators

Trash

IRG Machine
Converts to fuel

Army Generator

APRIL 24, 2023

FEDERAL BUDGET IQ

# U.S. Military Increases Focus on Contested Logistics

By Becky Leggieri • Defense

According to Army budget materials, the FY24 funding for distributed logistics in a contested environment, specifically Indo- Pacific, totals $1.4 billion (See Chart I)

| Army Distributed Logistics Investments | |
|---|---|
| **Fiscal Year 2024** | |
| Composite watercraft units and modernized platforms | $180 million |
| Investment in force projection/strategic lift | $96 million |
| Army prepositioned stocks | $858 million |
| Fuel distribution systems, bridging and other enablers | $262 million |
| **Total** | **$1.396 billion** |

*You will not find it difficult to prove that battles, campaigns, and even wars have been won or lost primarily because of logistics.*

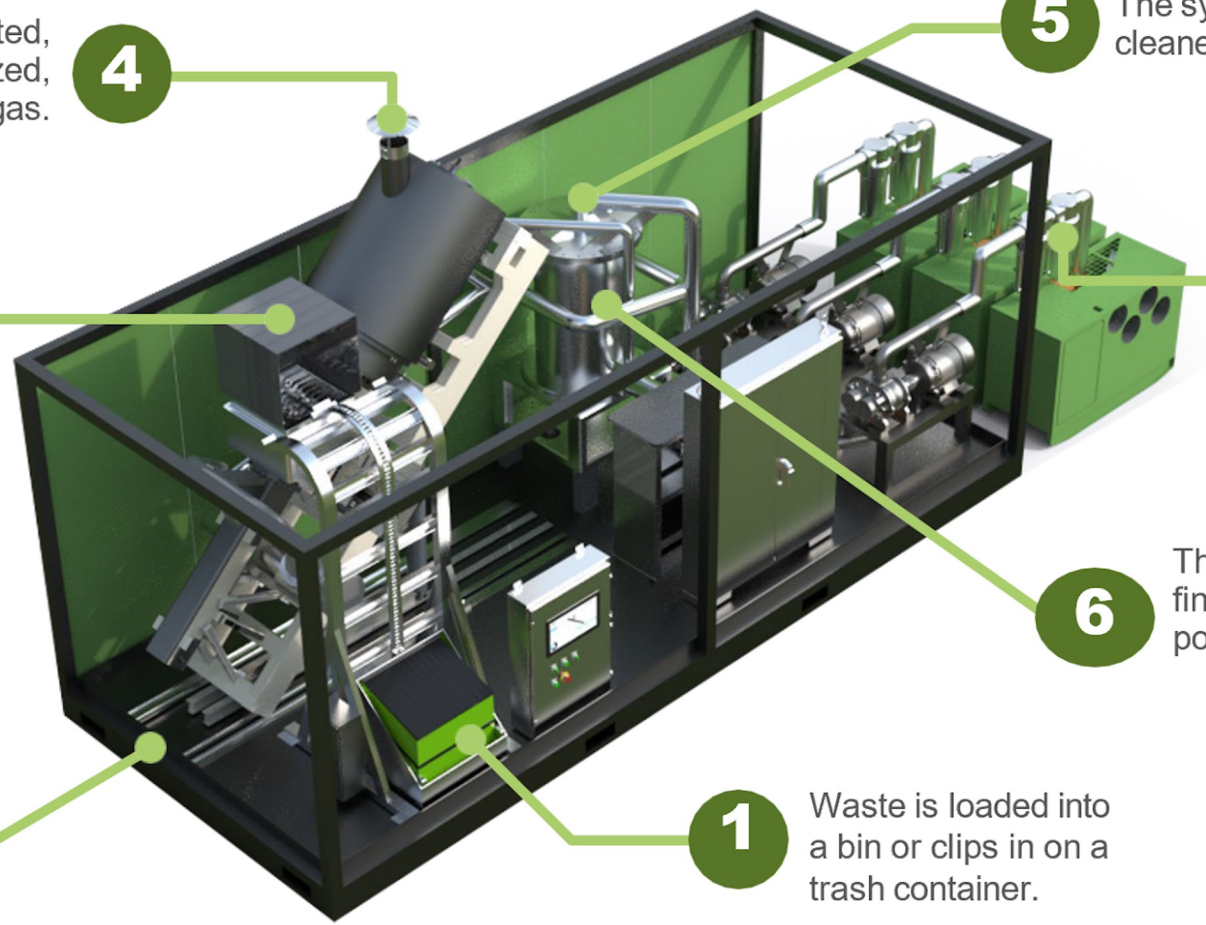
General Dwight D. Eisenhower

https://federalbudgetiq.com/insights/u-s-military-increases-focus-on-contested-logistics/

# Completed Program - ESTCP Systems

- Fuels 60kW AMMPS Generator
- Co-Fueled at 65% syngas, 35% diesel
- Operates on FOB waste
- 2 x 20ft shipping container footprint

# Current Generation IRG



4 In the reactor the material is heated, and the material devolatilized, which releases the sygas.

2 The door is closed and the IRG activates and lifts the trash or bin where it is loaded into the shredder, which has a ballistic shroud.

3 The shredded material is then hydraulically pushed into the reactor.

1 Waste is loaded into a bin or clips in on a trash container.

5 The syngas is cooled and cleaned in the quencher.

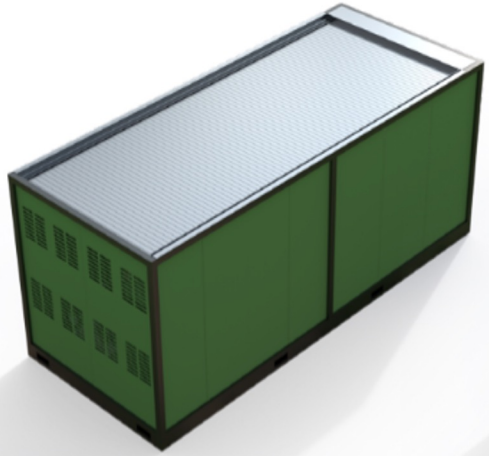
7 The syngas is then pumped into the AMMPs Generator.

6 The syngas has a final cleaning in the polisher.

**At the end of the day the small remaining solids are removed.**

# System Ruggized and Mobile

Soldier-Safe Isolated Operation



Standard ISO Shipping Container Footprint

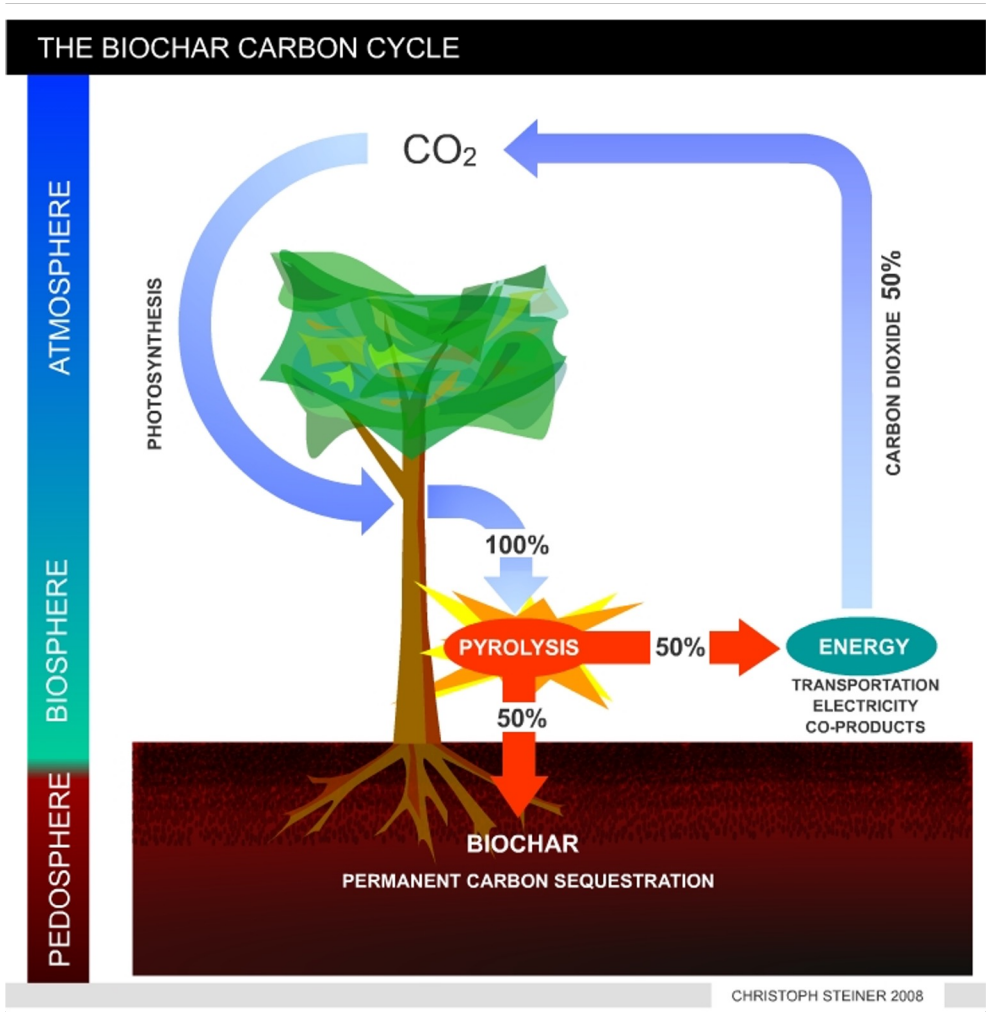
Strategic Mobility Advantages at <10,000lbs

Steel Frame with removeable panels for easy maintenance

# The process is carbon negative

**Gas or Liquid Biofuel or electricity**
**Sell & Earn Carbon Credits**

**Sequestered Carbon**
**Sell for fertilizer, asphalt or Composites**



# Birth of the Technology

**Generate electrical power from raw wet waste on Forward Operating Bases (FOB)**

**Reduce JP-8 (diesel) fuel consumption**

- Fuel deliveries require military escort
- Estimated delivered cost to FOB $350 to $800 per gallon

**Eliminate burn pits**

- Smoke and pollutants
- Health risks

Image: JULIANNE SHOWALTER/U.S. AIR FORCE
HTTP://WWW.STRIPES.COM/NEWS/FEDERAL-COURT-TO-WEIGH-LAWSUIT-ALLEGING-LUNG-DISEASES-FROM-IRAQ-AFGHANISTAN-BURN-PITS-1.386711 -

# Compact and flexible system

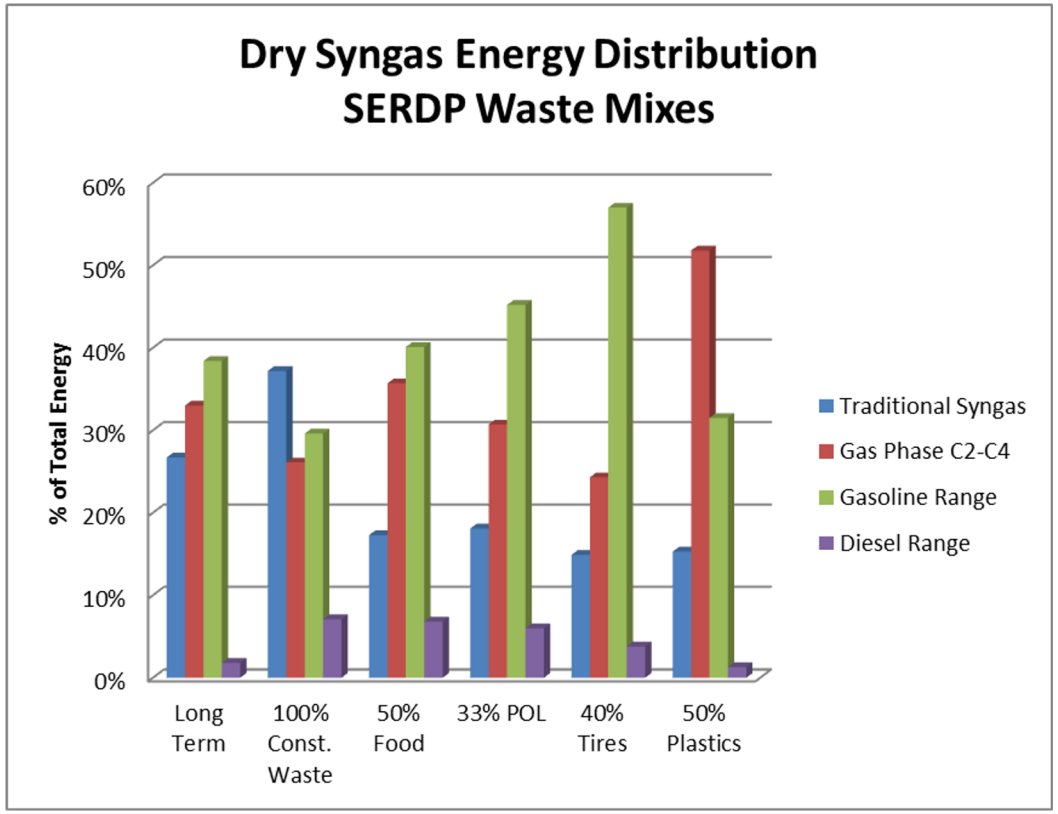
- Low parasitic load
- Simple and light weight
- Small reactor and process vessels
- Minimal or no feedstock preparation
- Process dripping wet feedstock
- Able to process soil, stones, glass, and metals mix with feedstock
- Safe (low hydrogen production)
- High energy syngas from cracking heavy oil into gasoline and diesel.

# Wet Feedstock

- Able to process dripping wet feedstock
- Ram feeder uses compression to dewater feedstock to < 50% moisture content (WB)
- Unique heat recovery and management allows gasifier to operate on wet feedstock
- Moisture evaporates into the syngas and passes thru the engine as superheated steam (invisible gas)

# Choice of liquid or gaseous fuel

- Produces a liquid fuel similar to gasoline or a clean syngas.
- Simple thermal process
- De-volatilization – NOT incineration
- Accelerates what naturally occurs in the earth over thousands of years to less than 20 minutes
- Fuels can be upgraded to Sustainable Aviation Fuels.



# Emissions

- Low NOx
  - Based on engine type and sizing
  - Syngas is naturally a low NOx fuel
  - Catalytic NOx reduction, as required
- Very low or undetectable SOx
  - Sulfur captured as synthetic gypsum with ash
- Unburnt hydrocarbons – exhaust catalyst
- Particulate matter – removed from fuel gas prior to combustion
- No odor from complete and controlled combustion

# A Machine that Turns Trash into Fuel for Generators

- Perfect for co-fueling with syngas
- Can operate reliably at 75% gaseous fueled
- No efficiency loss > 40% is possible
- No engine or ECU modifications are required
- Direct injection of syngas into intake manifold
- Any 60 kW AMMPS can be modified for use in an hour

DOD AMMPS Generator

# Safety

1. Suppresses Hydrogen production, which can be an incendiary gas

1. Operates slightly under atmospheric pressure

1. Operates on air, not dangerous oxygen or high voltage electricity

1. Removable side panels provide operator protection and maintenance access

# Emissions

U.S. EPA has set National Ambient Air Quality Standards (NAAQS) for six pollutants, including ozone and particulate matter. These are referred to as the “criteria” pollutants.

- Particulate Matter (PM10 and PM2.5)
- Ozone ($O_3$), Nitrogen Oxides ($NO_X$)
- Sulfur Oxides ($SO_X$), Carbon Monoxide (CO)
- Lead

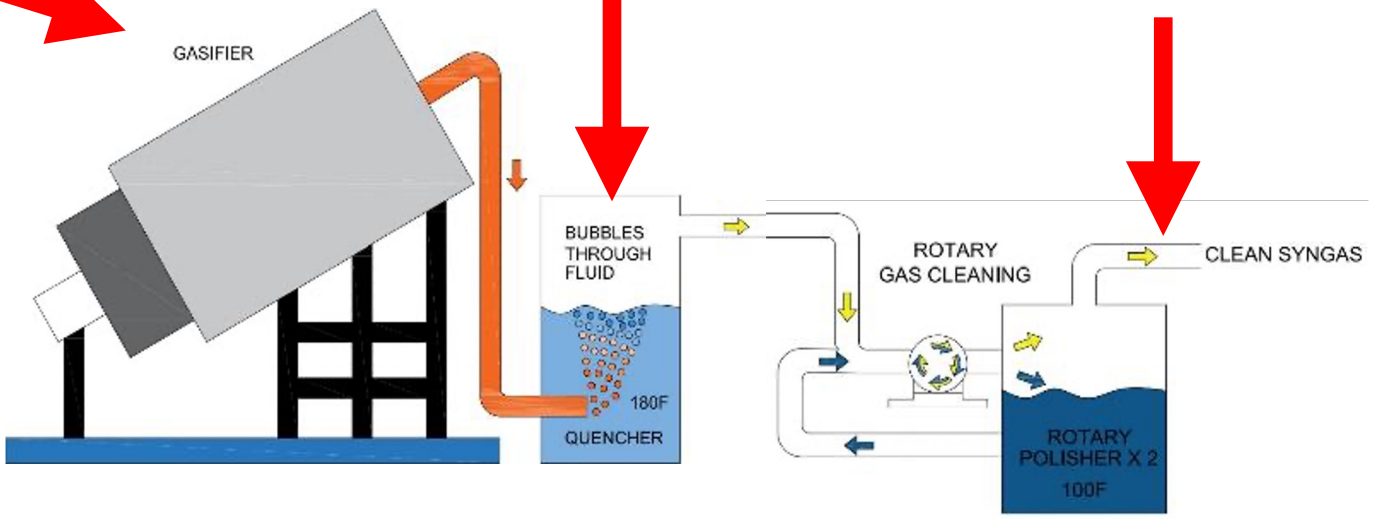
2,000 Degrees F “baked not burned”
Kills all pathogen’s converts most substances to inert material

Particulates, heavy metals, Other contaminants caught & filtered

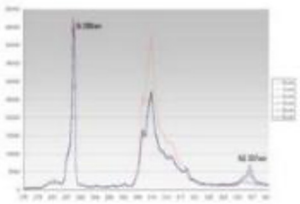
Gas Cleaning process

Clean gas used by generator in dual-fuel mode

Real time emissions monitoring




Feedstock ->



# IRG at the Pentagon (Fort Myers)

**Convert trash generated by forward operating bases to a carbon negative gas for a generator.**

**Mr. Kramer**

**Meeting with Assistant Secretary of Defence for Energy, Installation and Environment.**

**On site in Washington with The Pentagon Operational Energy Team**

# The Air Force & Pentagon Site Visit in NY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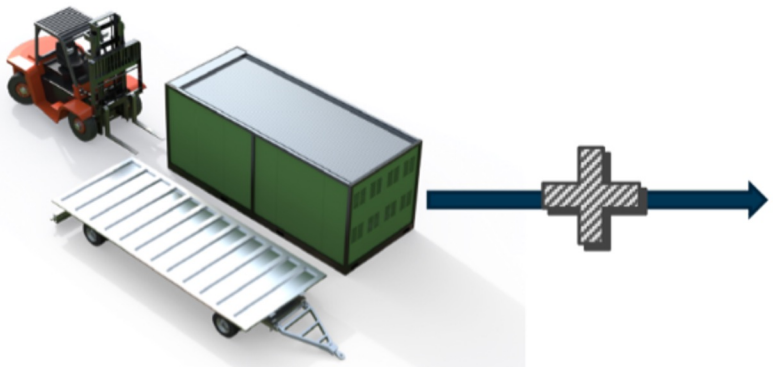
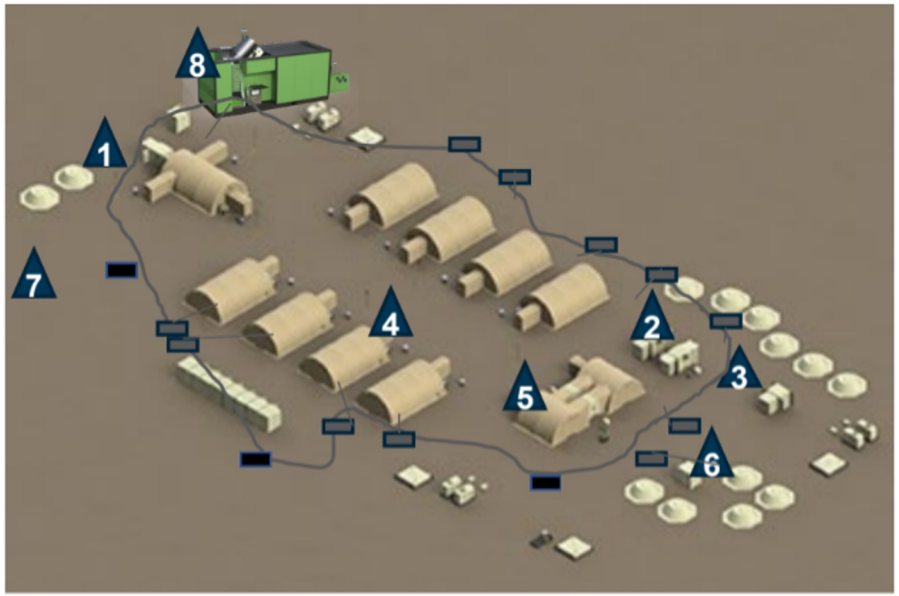
# Add to Operation Base Package

**Force Provide 150 Soldier Camp Modules consist of:**

- Two latrine systems (2)
- Two shower systems (5)
- One kitchen system (1)
- One laundry system (3)
- One refrigerated container
- Six 60-kW generators (7)
- Eight modular personnel tents (4)
- Two 400,000 BTU water heaters (6)
- One improved fuel distribution system
- **One Waste to Energy Unit (8)**



*Waste To Energy Expeditionary System*




This is an example of how the Waste to Energy System integrates into the to the Army's Base Camp Program of Record (POR) called Force Provider. The Force Provider Module has evolved from a 550 Soldier camp with limited flexibility in deployment capability into an Expeditionary Base Camps designed to support 150 Soldiers with billeting facilities, administration facilities, dining facilities, water and fuel storage, and distribution systems, and wastewater collection.

Force Provider is currently using command approved burn pits for waste management. The PM-FSS is examining the use of a waste to energy design that could be added as a module and quickly integrated into the existing Force Provider provisioning. Force Provider includes power generation and distribution, fuel support, water and wastewater systems. The Waste To Energy System would be added as a standard module to address the elimination of the burn pits, but also provide for operational energy from the waste removal.

This diagram illustrates the addition of the Waste To Energy module as a standard containerized, highly deployable capability. By integrating the module into the Tactical microgrid, the Force Provider POR not only addresses Improved Waste Handling, but also provides supplemental power to the basecamp infrastructure. This reduces contested logistics such as generator transport and fueling and has the propensity to reduce fueling and power requirements in support of billets, showers, latrines, and laundry, kitchen and their support equipment.

# Manufacturing Partnership - Flory Industries

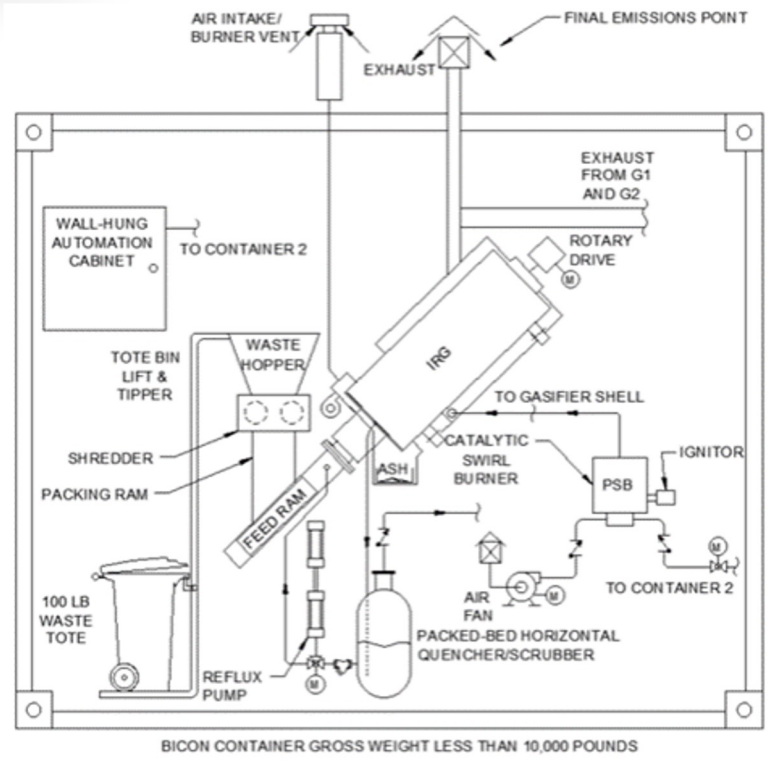
Largest Agricultural Machinery Manufacturer in California.

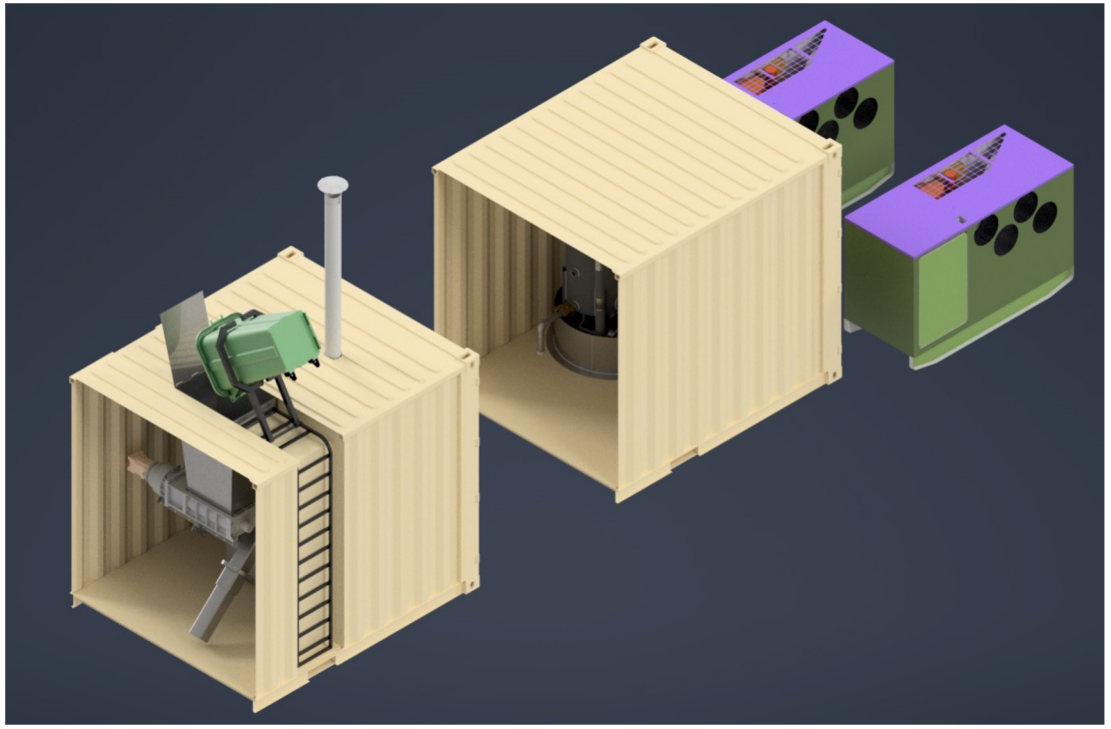

To be deployed at Flory

- Testing
- Design for manufacture
- Large Scale Production

Flory Industries, Salida, CA

# Newest Form Factor



# Future Project

- A liquid fuel can be stored easily
- A liquid fuel can be transported
- Disconnect the IRG from the generator

Liquid Fuel

Easy to move

# Points Of Contact

Caribou Biofuels

NORTHROP GRUMMAN

Caribou Biofuels

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# Waste-To-Energy (WtE) Inclined Rotary Gasifier

Protecting and Sustaining the Warfighter in Contested Environments

## Warfighter Safety

The safety of America's warfighters remains paramount in all we do. The Administration's passing of the 2022 PACT ACT to eliminate open burning of waste solidifies this mindset. As such, Northrop Grumman has partnered with our small business associate Caribou Biofuels, supported by the State University of New York-Cobleskill, to deliver ground-breaking technology that eliminates open burning while creating surplus energy and eliminating hazardous airborne pathogens.

## Warfighter Security

Logistics in contested environments is a concern to all Services no matter the Area of Responsibility. Imagine being able to generate electric power for your troops from trash, reducing reliance on host nation trash removal while also reducing the need for vulnerable and life-threatening fuel convoys. In the end, this is exactly what our WtE systems bring to the fight.

## The Technology

In this design, waste material is inserted to a user-friendly bin where it is first shredded, and then pushed into a rotating steel drum which is rapidly heated to approximately 1,000 degrees C. The steel drum is oxygen starved so the trash does not burn…this is ***NOT*** an incinerator. Anything that can turns into syngas and is devolatilized. Any non-converted waste is discharged as a safe charcoal/ash called biochar, typically in very small amounts. Soda cans, glass, and similar inert materials pass through and are discharged with the biochar. The environmentally-friendly syngas that is produced is then used to run ancillary generator(s).

## Environmental Resilience

Our waste-to-energy solution not only makes the battlefield safer for our warfighters, but it is also environmentally friendly. Gasification is a proven, eco-friendly, carbon sequestering technology that has ultra low emissions compared to other processes such as burning. When coupled to an AMMPS generator, the IRG provides a fuel savings of 65% and has proven as high as 80% in testing.

## A Winning Team

Northrop Grumman has teamed with our small business partner Caribou Biofuels to develop and commercialize this ground-breaking technology. Caribou is the sole-licensee to the foundational technology developed and patented by the State University of New York (SUNY) in Cobleskill. Both Caribou and SUNY round out a robust and motivated team of professionals dedicated to furthering these technologies for the protection of our warfighters and the environment.

northropgrumman.com


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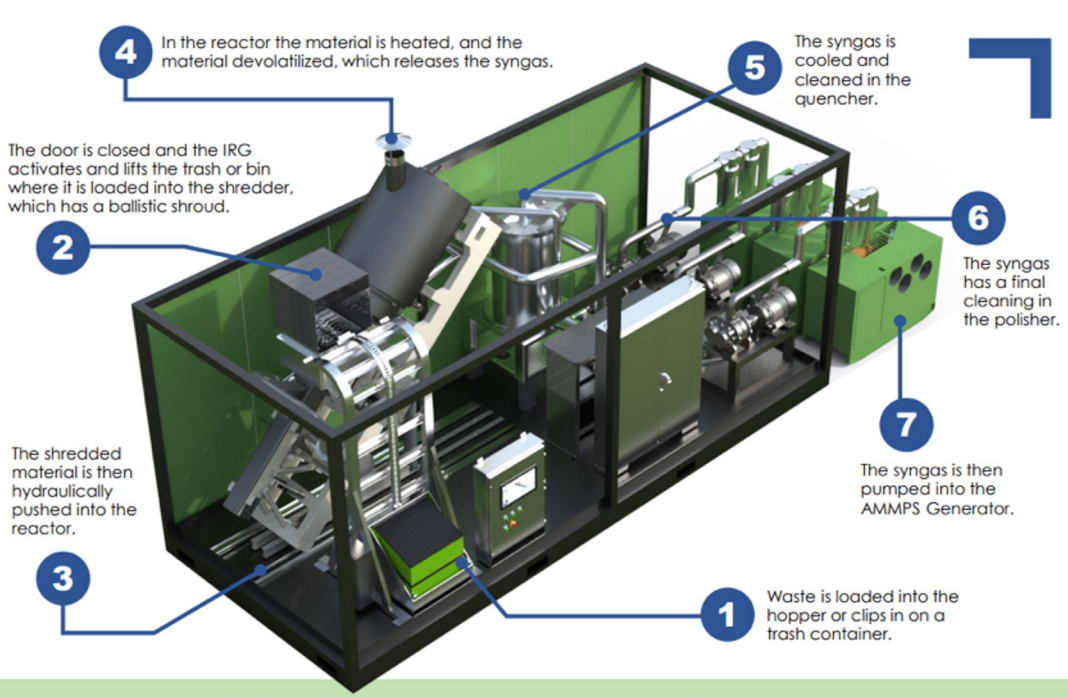


When the day is done, any remaining small, non-toxic solids are removed and safely discarded

## POINTS OF CONTACT

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