



**HEARTLAND**  
WATER TECHNOLOGY

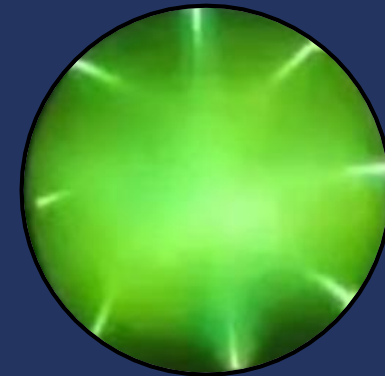


**NYWEA**  
LEADING THE WAY IN  
WATER QUALITY MANAGEMENT



**NEWEA**  
WORKING FOR WATER QUALITY

**Ultra-High Temperature Ionic Gasification for  
Biosolids Management, PFAS Destruction,  
and Hydrogen Production**



# Residuals Management Challenges



## ENVIRONMENTAL STEWARDSHIP

- Beneficial reuse essential to any long-term solution
- Cannot compromise Environmental, Operational, or Commercial viability
- Sustainable residuals management practices key to community acceptance



## DISPOSAL UNCERTAINTY

- Land application **increasingly limited**, if not **prohibited**
- Landfills are **declining** residuals
- **Regulatory uncertainty increases risk**



## RISING COSTS

- **Disposal options more constrained and distant**
- **Inflation:** trucking, disposal, chemicals, and energy
- **Reactionary environment** undermines long-term planning



## OPERATIONAL UNCERTAINTY

- Utilities forced to adopt pro-active **PFAS** mitigation strategy
- New in-plant technology inevitable
- Uncertainty related to staffing, training, retention and results

# Ultra-High Temperature Ionic Gasification

## REGULATORY COMPLIANCE

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**Assured PFAS destruction** believed possible via complete molecular dissociation

## COST CERTAINTY

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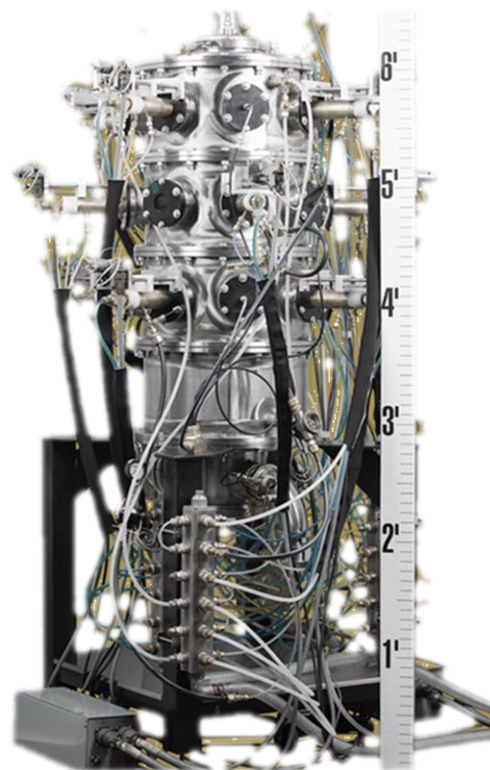
Offered exclusively as a *service*, Generator's costs are confirmed well-beyond traditional commercial terms

## ENVIRONMENTAL STEWARDSHIP

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Local feedstock conversion can eliminate hauling to offsite disposal reducing risk and greenhouse gasses

## HELIOSTORM™



## DISPOSAL CERTAINTY

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Formerly contaminated materials are reformed into innocuous Char and Syngas and eligible for beneficial reuse

## OPERATIONAL EXCELLENCE

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HelioStorm™ will be operated exclusively by certified Heartland personnel ensuring performance and reliability

# Ultra-High Temperature Ionic Gasification

## OPERATING TEMPERATURE

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3,000 to 10,000°C Plasma Arc  
Electrically driven

## SCALABLE

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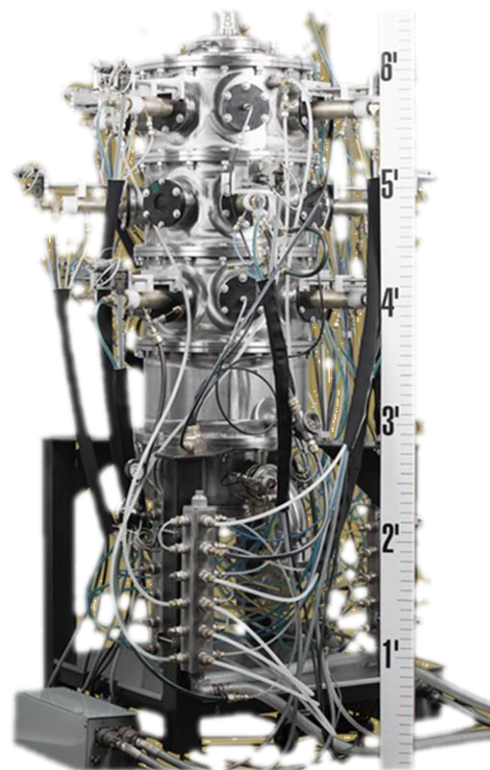
Small individual footprint  
Multiple units combine to satisfy specific and  
changing plant outputs

## TAR-FREE SYNGAS

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Tar-free syngas is used to generate electricity  
for the needs of HelioStorm™ without the  
need for a thermal oxidizer

## HELIOSTORM™



## MODULAR

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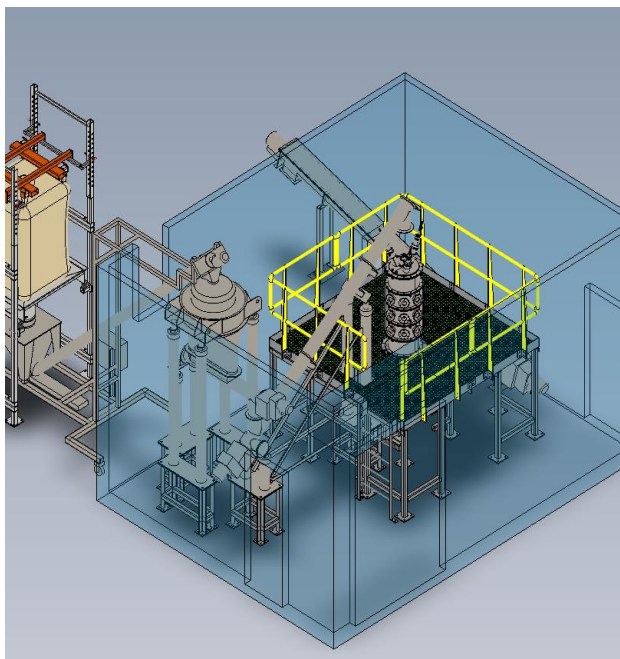
Custom design accommodates varying  
feedstock characteristics

## FLEXIBLE

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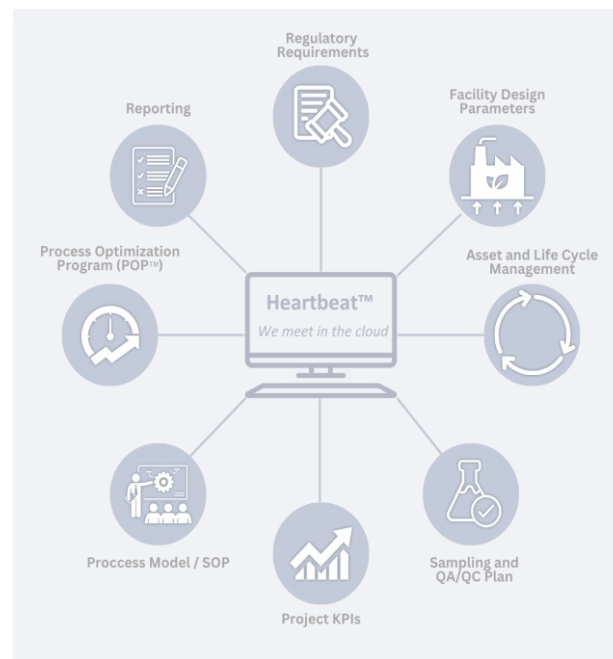
HelioStorm™ can accept a range of feedstocks  
and generate multiple materials eligible for  
beneficial reuse

# Heartland Water Technology



## HelioStorm™ Gasifier

Ultra-high temperature ionic gasifier  
20 years in development at Idaho National Labs  
Launching for Residuals in 2023  
Provides Assured PFAS Destruction™



## Heartbeat™ Intelligence Platform

Process automation and control  
Dynamic reporting™ and alerts  
Process model w/digital twin  
Content management



## Heartland Concentrator™

Two decades of proven performance  
Award-winning, globally recognized solution  
**COVAP:** Cogen using waste-heat from engines  
**ROVAP:** Evaporating RO concentrate

# Gasification

Converts carbonaceous materials into gases, achieved by reacting the feedstock material at high temperatures (typically  $>700\text{ }^{\circ}\text{C}$ ) *without combustion*, by controlling the amount of oxygen in the reaction

## SYNGAS

Carbon Monoxide (CO) and Hydrogen (H<sub>2</sub>)



Used as a source of hydrogen as well as *renewable energy* if the gasified compounds were obtained from biomass feedstock

## CHAR

Lightweight black residue, made of carbon and ash, remaining after the gasification of biomass



Thousands of uses including agriculture, excellent "*carbon sink*"

# Technology Heritage



*Historical Gasification*



*USS Gerald R. Ford*

*Modern Gasification*

# Technology Heritage

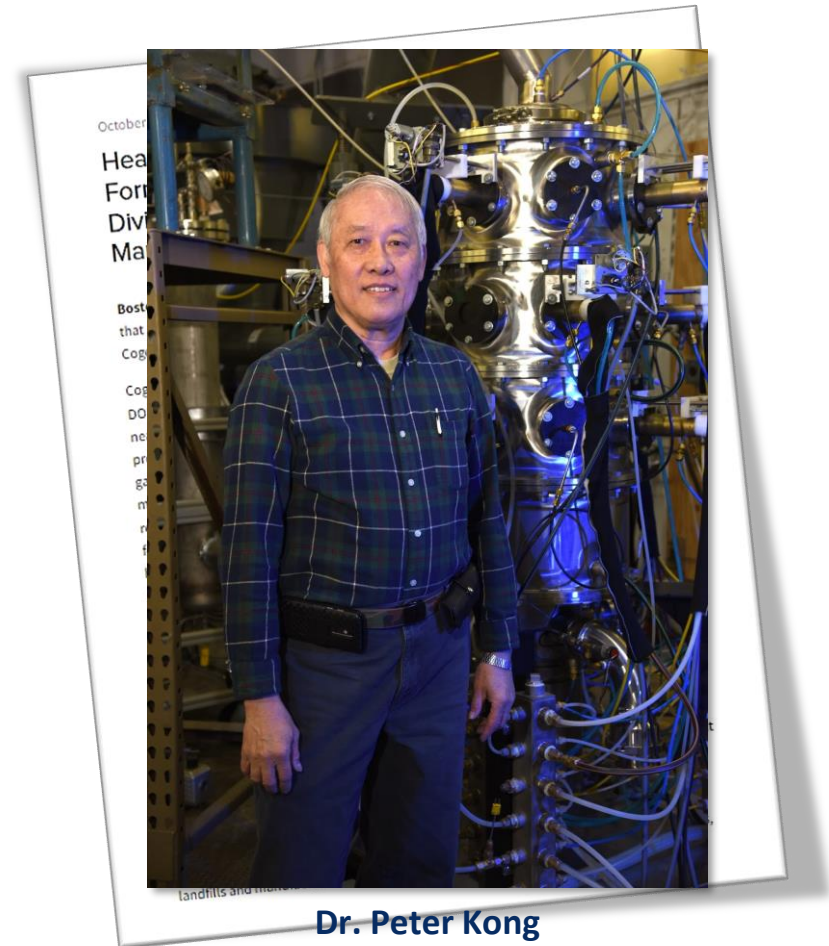
**40+ years** in thermal plasma technology research and development.

Retired from **Idaho National Laboratory (INL)** after 22+ years of service.

Distinguished Staff Scientist with the Laboratory and the Technical Lead for the **Plasma Processing Group**.

**53+ published articles** in plasma technology, materials synthesis, and nuclear waste remediation.

Holder of **37 US patents**.



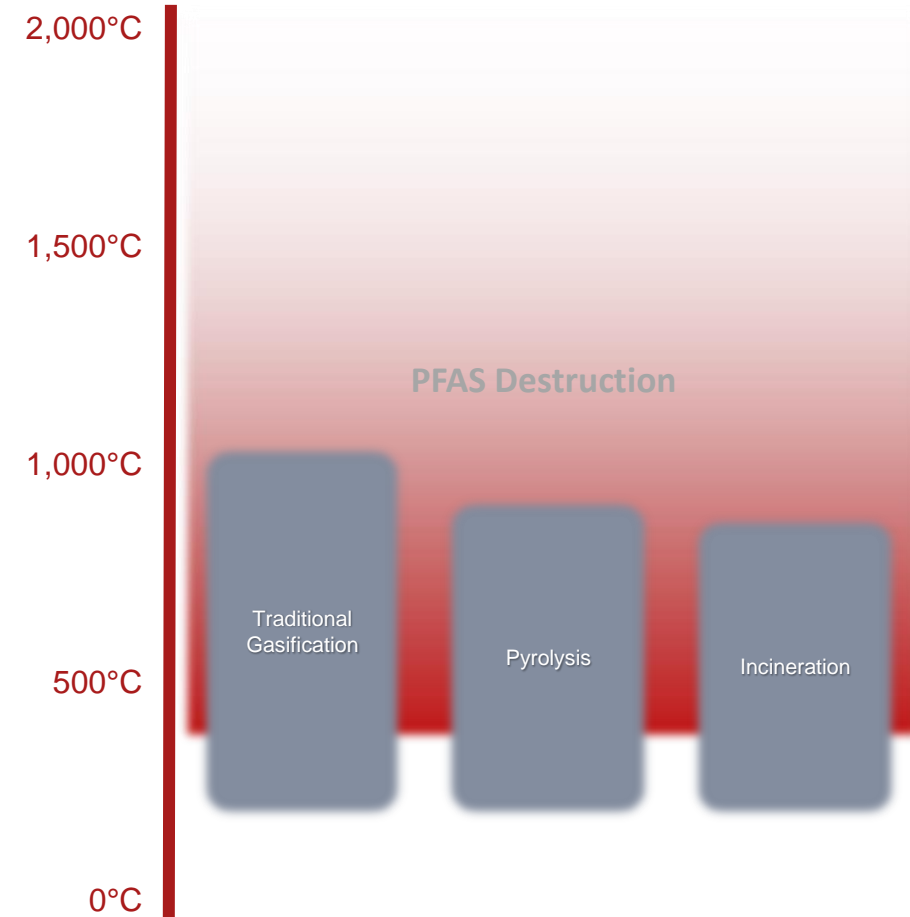
**Dr. Peter Kong**  
Chief Scientist



# PFAS Destruction

## ULTRA HIGH TEMPERATURE IONIC GASIFICATION

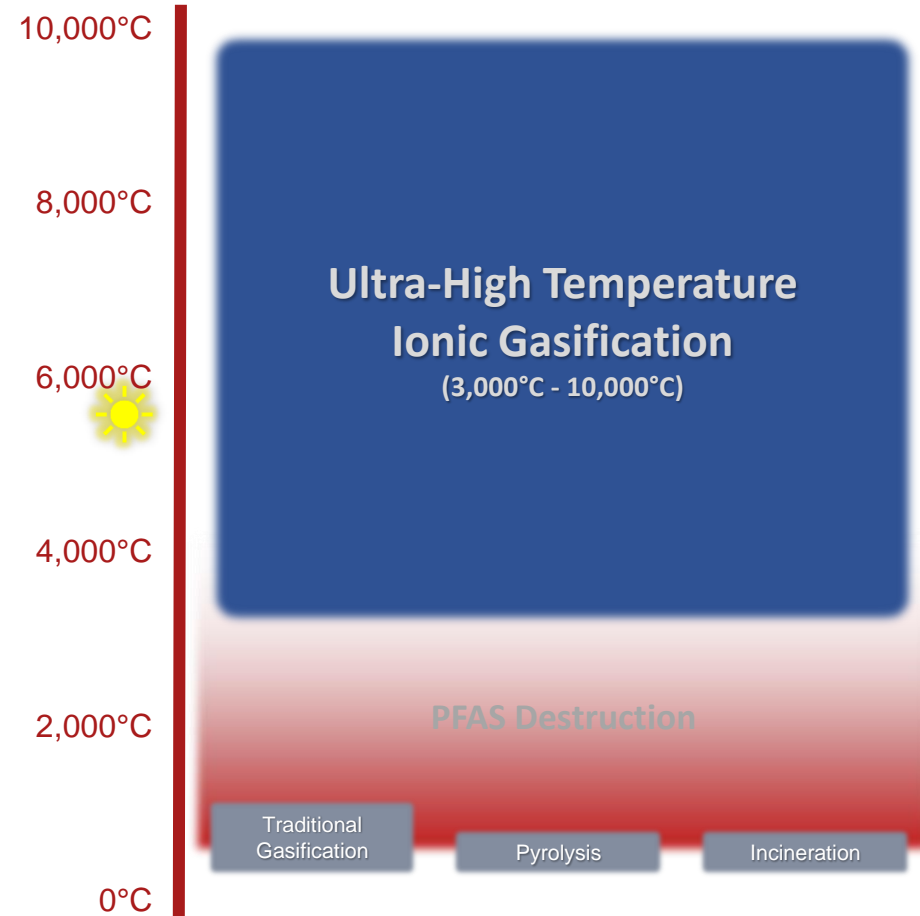
- Entire interior of the processor is an ultra-high temperature reaction zone
- Processing zone contains hyper-energetic gaseous ions, accelerating conversion process
- Vaporizes all feedstock, including carbon
- Transforms water into high-energy oxygen and hydrogen radicals and ions, rather than lower-energy steam
- Waste completely breaks down to individual atoms and ions generating a consistent tar-free syngas with no by-products or toxin production



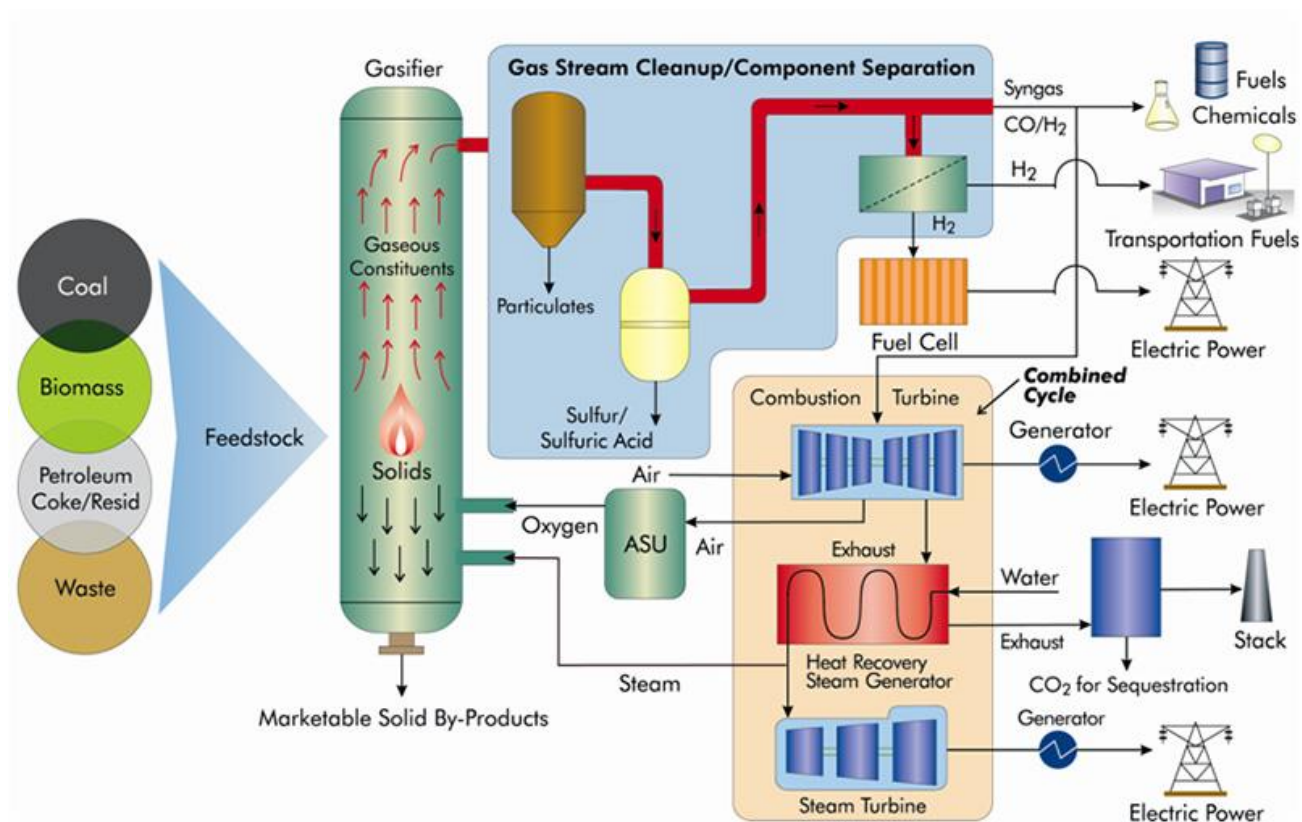
# HELIOSTORM™

## ULTRA HIGH TEMPERATURE IONIC GASIFICATION

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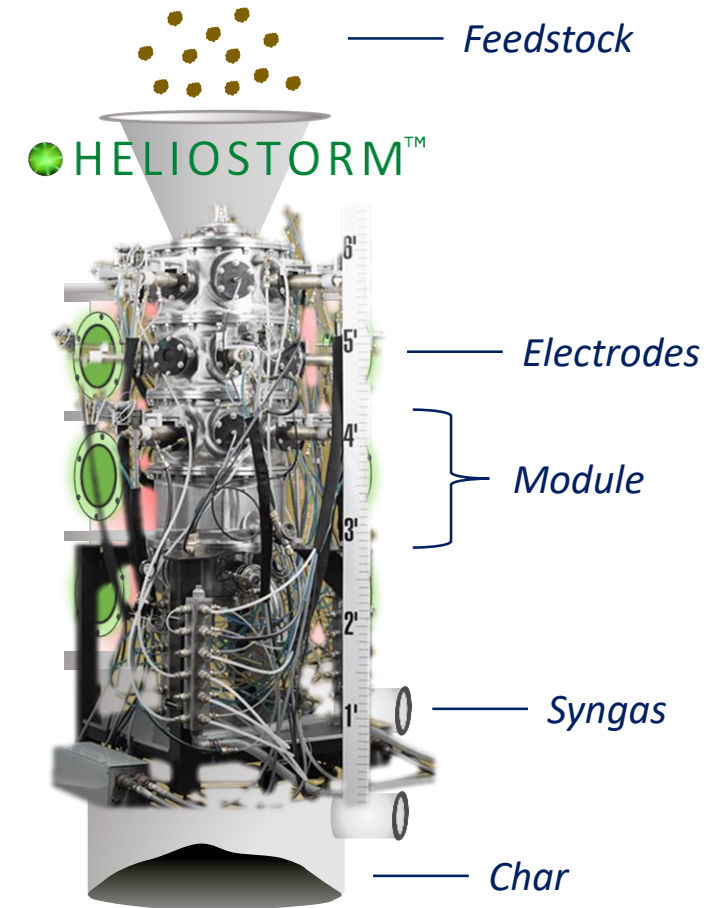
# Gasification



# ● HELIOSTORM™

A **modular, multi-purpose, ultra-high-temperature** electric driven gasifier with key features and operations:

- Ionic field created by paired electrodes that produce an electric arc. Multiple electrode pairs per module create an ultra-high temperature electric field.
- Multiple modules can be stacked for optimized production.
- Ionic field fills the entire internal volume of the gasifier.
- Feedstock falls through, fully immersed into an ultra-high-temperature reaction zone, disassociating into individual atoms and ions.
- Design of stacked modules creates a cascade of energy that reduces total input power.



# HELIOSTORM™

The HelioStorm™ ‘free-burning’ arc system is importantly different from other systems that all rely on a conventional plasma torch method.

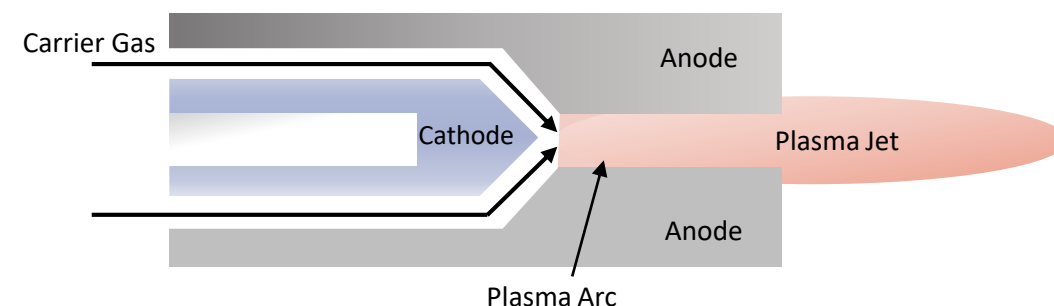
The arc generated between our electrodes is unconfined, extending through the entire diameter of the reaction cylinder inside. This type of arc is live, it has a measurable voltage and carries current.

The ultra-high temperature is created by the arc itself, bringing feedstock into direct contact with the hybrid plasma.

- The plasma and its associated gas created by these electrodes operates at temperatures between 3,000 and 10,000°C.
- Unlike conventional plasma torches, the free-burning arcs do not experience cooling loss to the metal body around the electrode.
- Since the arc is continuously heating the gas surrounding it, the temperature of the plasma in a free-burning arc is significantly higher than that of a plasma jet emanating from a conventional plasma torch.

## CONVENTIONAL PLASMA TORCH

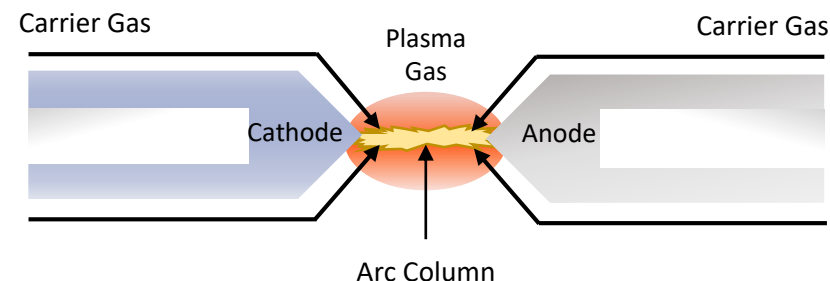
*(Significant heat loss to the Plasma Torch Body)*



## FREE-EXPANDING ARC

### The HelioStorm™ Ionic Gasifier

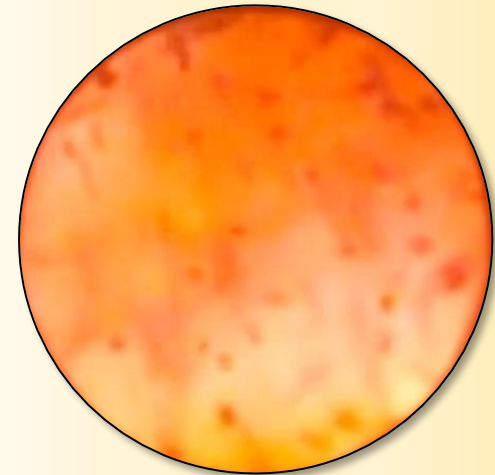
*(No Torch Body means no heat loss to the Arc Body or Column)*



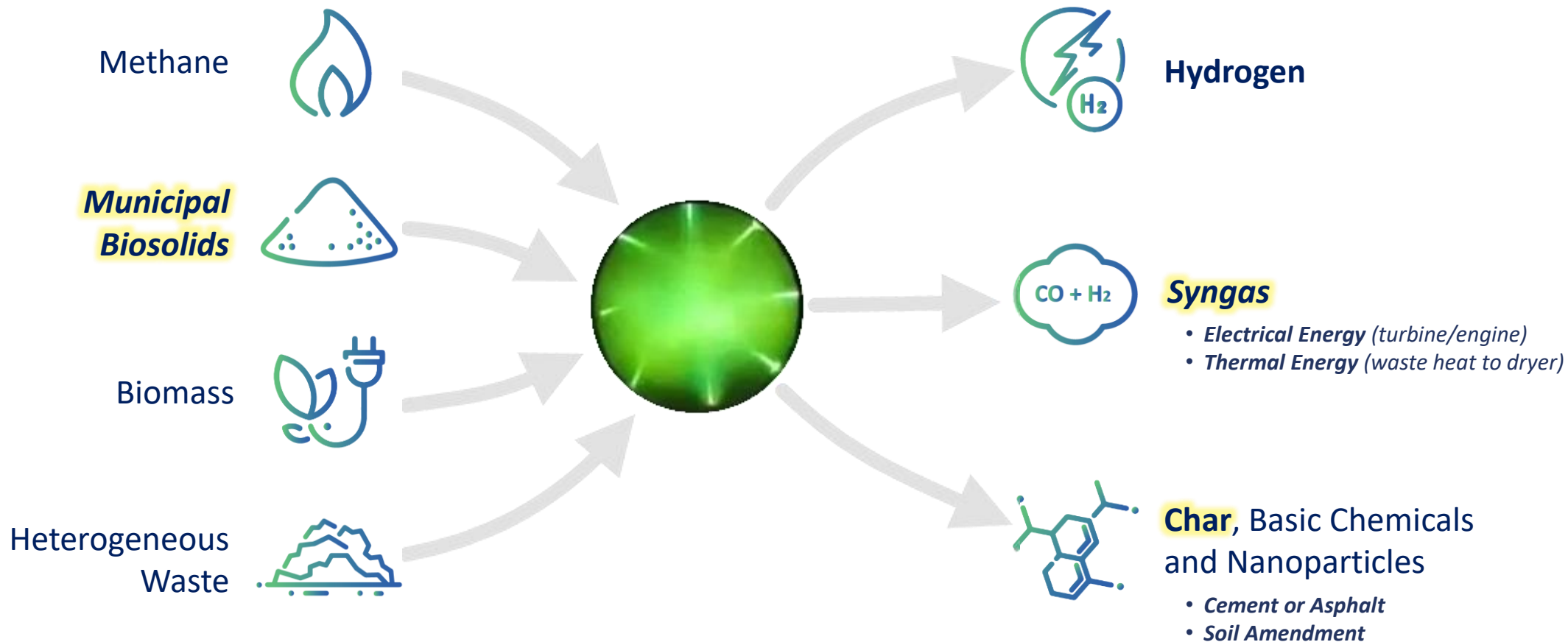
# ● HELIOSTORM™

Heartland's breakthrough HelioStorm™ gasification technology enables efficient, cost effective and environmentally friendly residuals disposal and value recovery

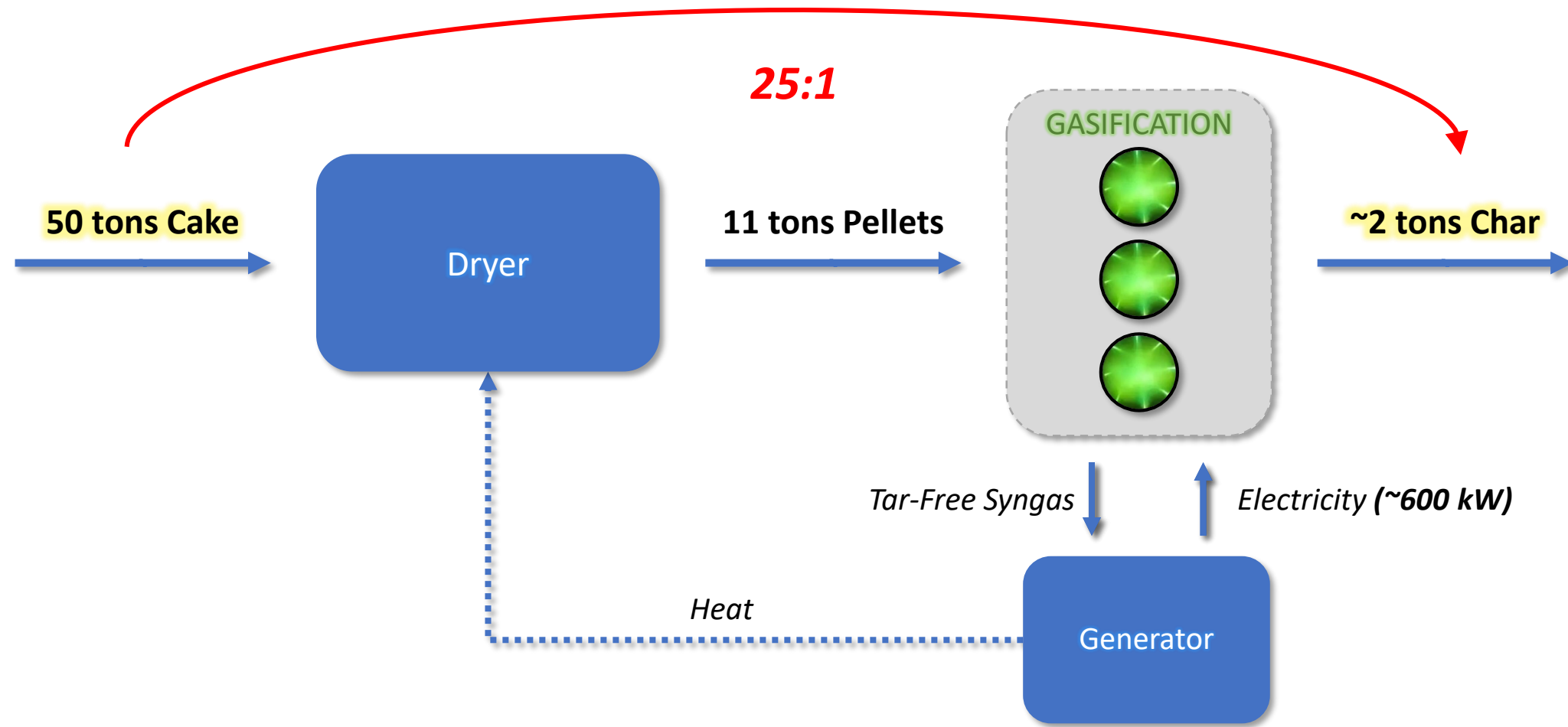
- Efficiently processes relatively small volumes (1-4 dt/d)
- Operates at ultra-high temperatures reaching 3,000 - 10,000 °C
- Produces a clean syngas with no tars (CO and H<sub>2</sub>)
- Syngas can be used on site to support a dryer
- No greenhouse gas or toxic emissions from the gasifier core
- Minimizes transportation costs
- Replaces traditional disposal options



# HELIOSTORM™

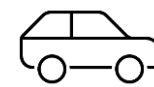
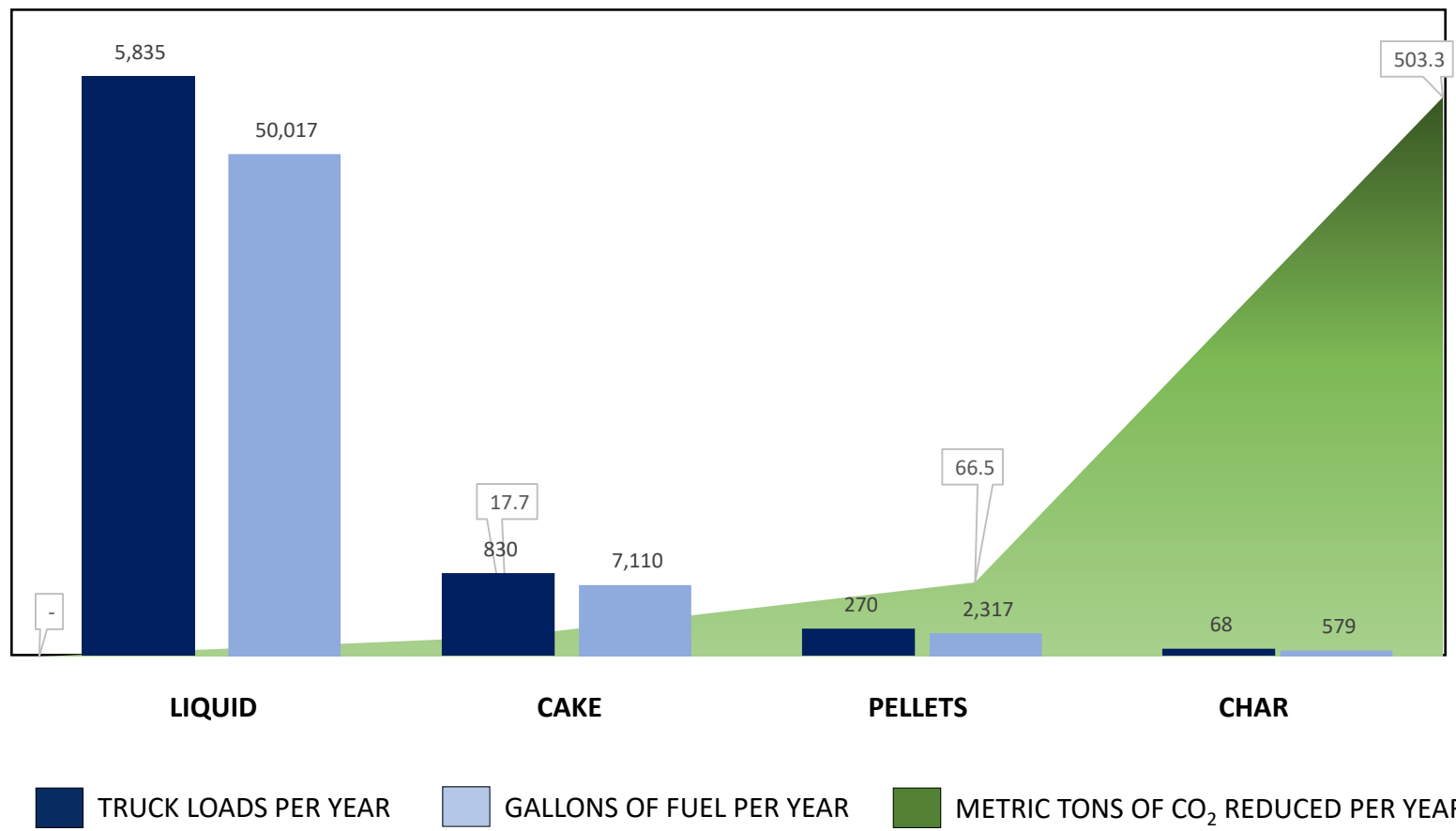


# Volume Reduction & Carbon Conversion





# Gasification Yields Greatest GHG Reduction



**1,290,234 miles driven**  
by an average gasoline-powered passenger vehicle



**97.9 homes'**  
electricity use for one year

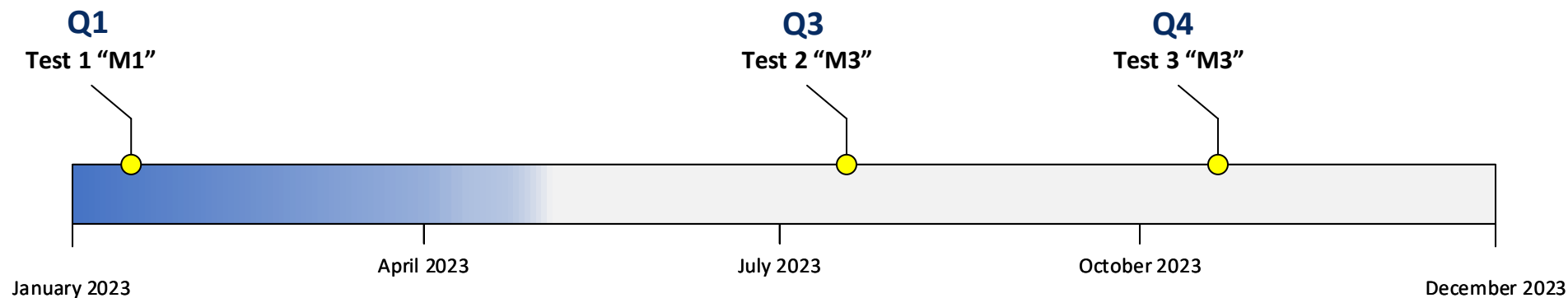


**97.9 acres of U.S. forests**  
sequestering CO<sub>2</sub> for one year

EPA Greenhouse Gas Equivalencies Calculator

\*50 wt/day, 30-mile 1-way haul

# Performance Validation – Fate of PFAS



- Undertaking a prescriptive, multi-stage analytical protocol to demonstrate PFAS destruction
- First test round completed Q1 on single module “M1” – *results exceeded expectations*
- Subsequent tests scheduled Q2 and Q3 on “M3” commercial-scale platform
- Extended performance testing
- Hosting clients now

# Heartland Technology Center

**HEARTLAND**  
ROBERT E. CAWTHORN  
TECHNOLOGY CENTER



Murfreesboro, TN

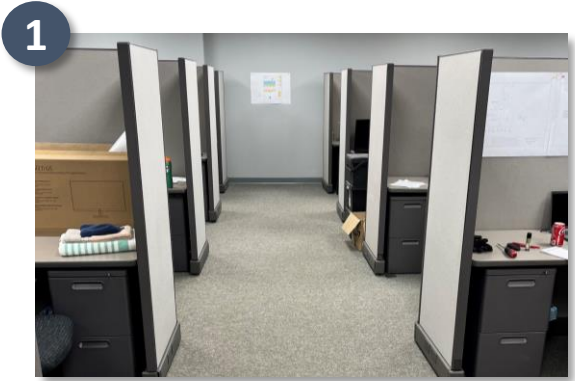
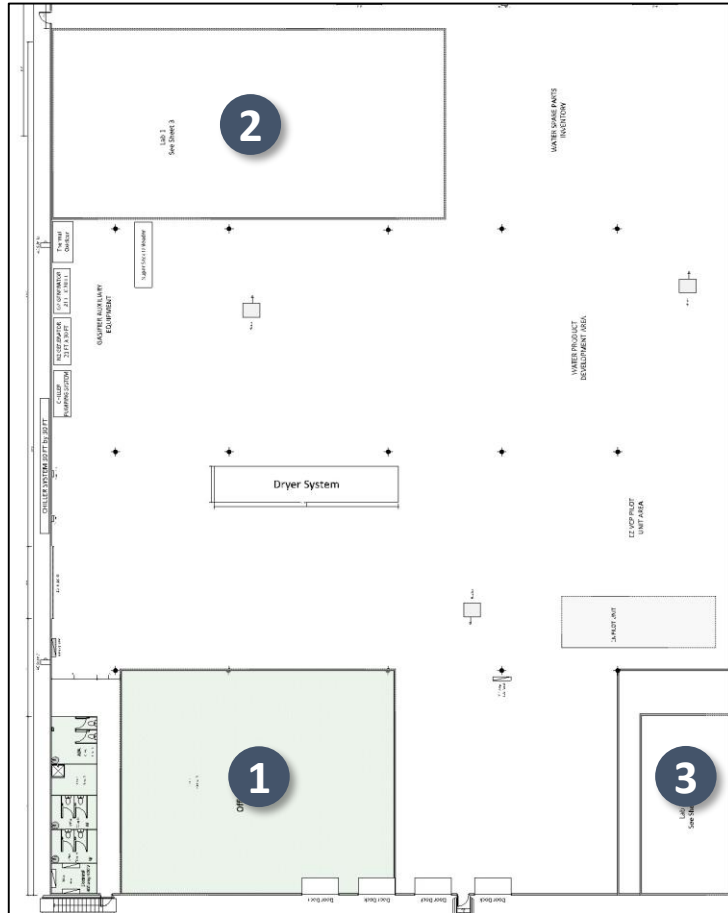


30,000 ft<sup>2</sup> Facility

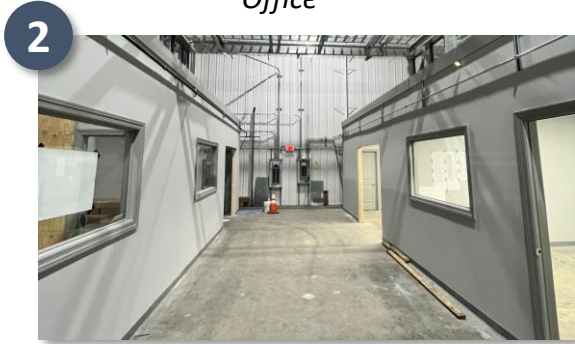


**Commercial-scale Gasifier:**

- ✓ Facilitates client feedstock evaluation
- ✓ Delivers complete analytical data capture to assess performance against Utility KPIs
- ✓ Validates performance at a commercial scale



*Office*

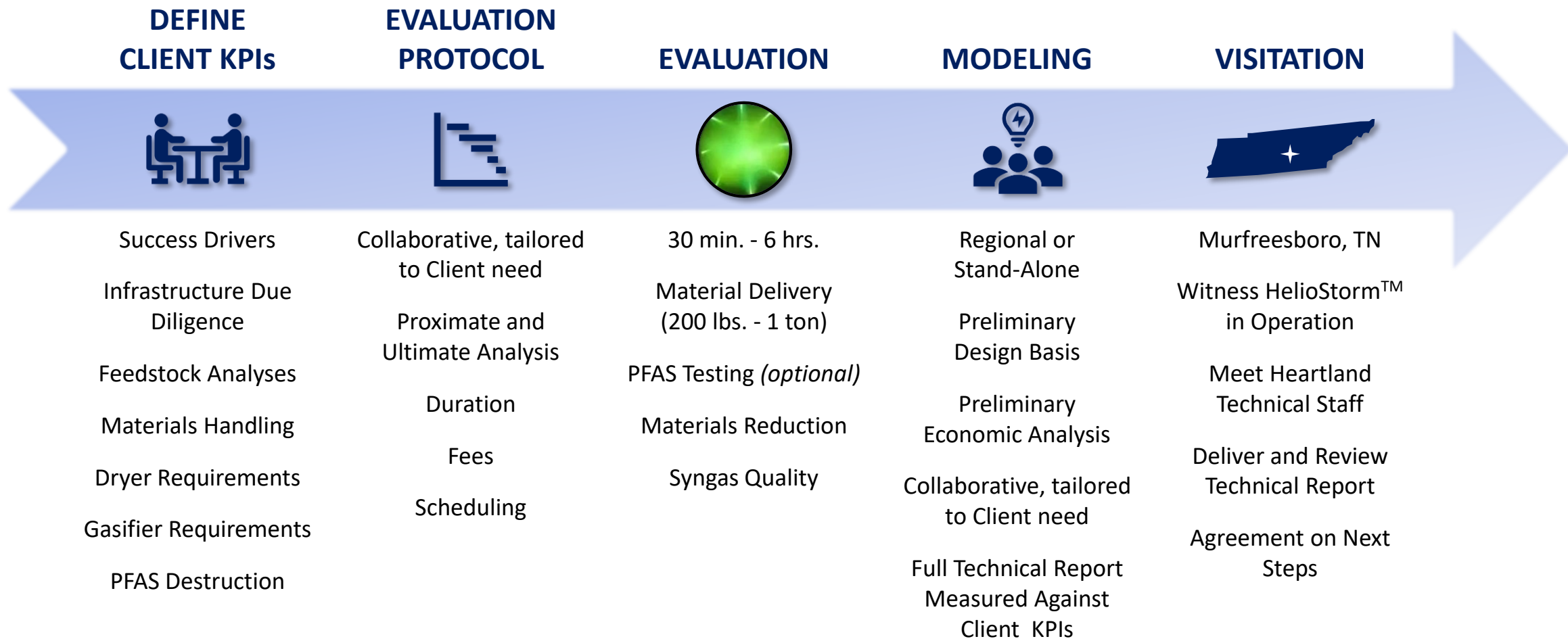


*Gasification Lab*



*Water Lab*

# Feedstock Evaluation

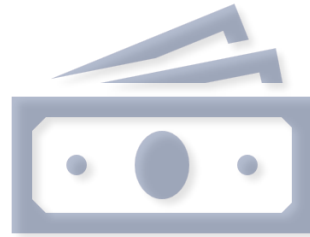


# Project Delivery



## **BUILD**

Full Project Development  
Tailored to Customer KPIs  
Heartland Team  
Permitting  
Construction  
Commissioning



## **OWN**

*NO* Client Capital  
Long-term Cost Guarantee  
Cradle-to-Grave  
responsibility

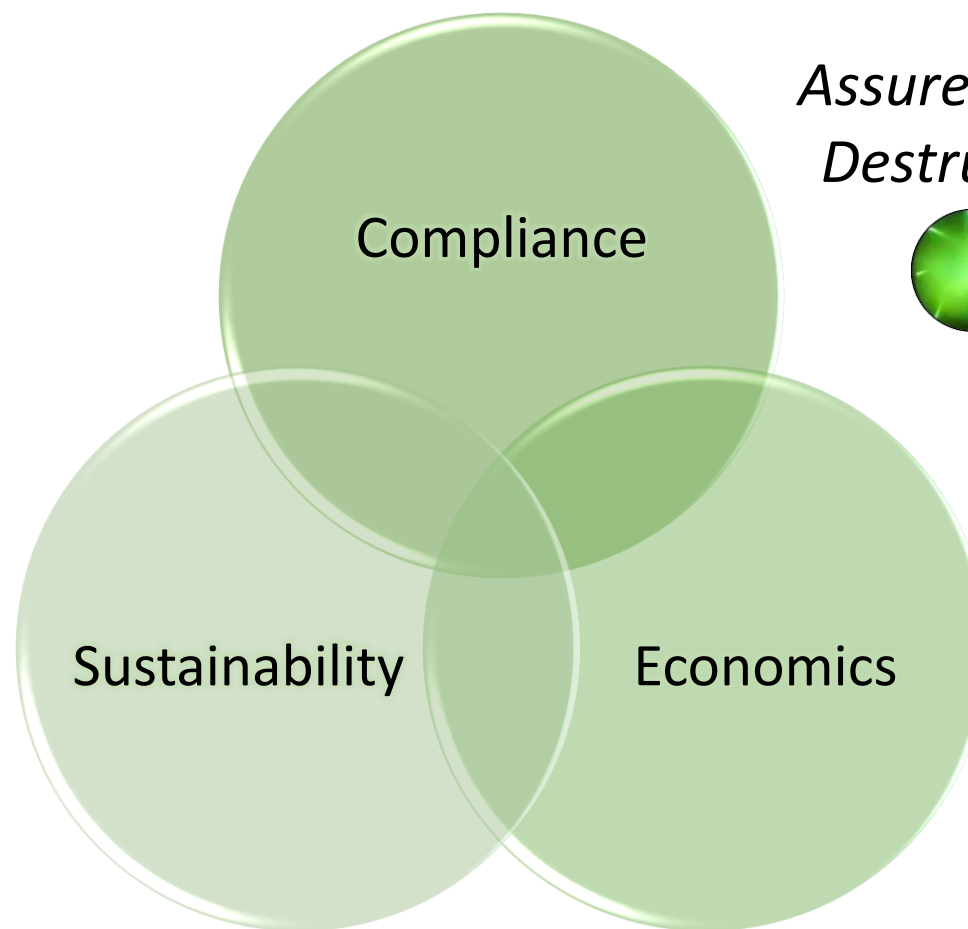


## **OPERATE**

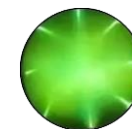
*NO* Client Staffing  
*NO* Client Training  
Assured PFAS Destruction  
Heartland Personnel  
Optimal O&M

# Case for Gasification

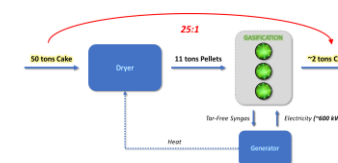
*Minimal Energy  
Valuable Products*



*Assured PFAS  
Destruction*



*25:1 Volume  
Reduction*





THANK YOU

**Jim Henderson**

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