Genifuel Hydrothermal Processing for Renewable Natural Gas

UCR | College of Engineering- Center for Environmental Research & Technology

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Overview of Hydrothermal Processing

- **Hydrothermal Processing (HTP) uses temperature and pressure to convert wet organic matter to biocrude oil and natural gas**
- **Process mimics the way fossil fuels were formed, but in 45 minutes rather than millions of years**
- **Can produce all oil, all methane, or combination**
  - Hydrocarbons are produced in single continuous process
- **Highly efficient—captures more than 86% of feedstock energy and uses only 14% for process**
  - Energy yield app. 2x biological processes

Photo of An Operating HTP System

How HTP Works

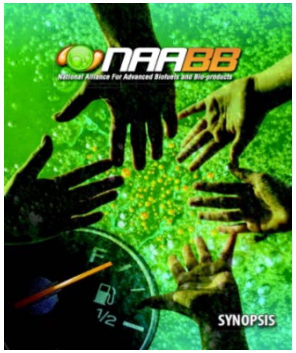
- **Uses subcritical water and pressure (no solvents) to convert wet organics into crude oil and methane**
  - 350°C and 200 bar, built from stainless steel
  - Temperature much lower than syngas processes
- **Feedstock is completely converted—no solids left and no char**
- **Water is conserved and effluent is clean and sterile**
- **Plant nutrients are recovered as fertilizer**
- **High efficiency, solids elimination, nutrient recovery, and small size makes systems economical**

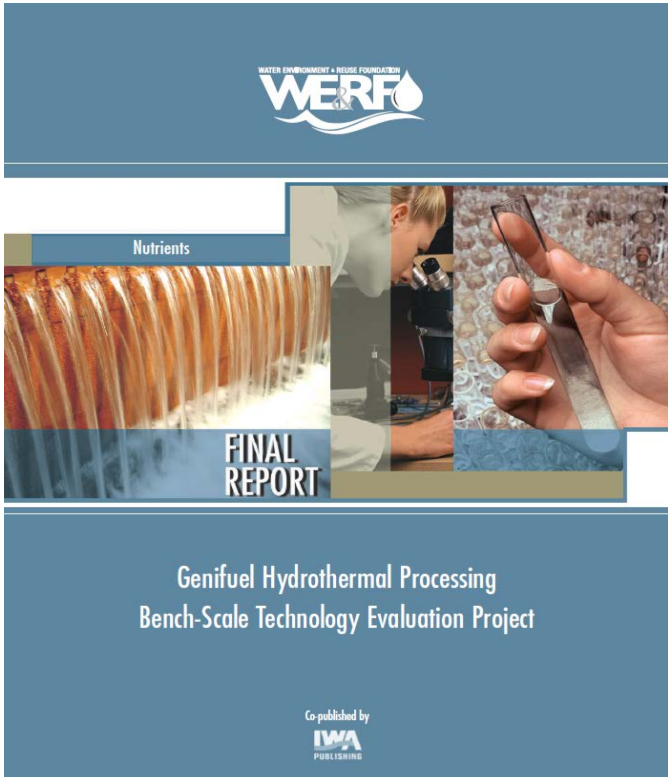
Outputs of Hydrothermal Processing

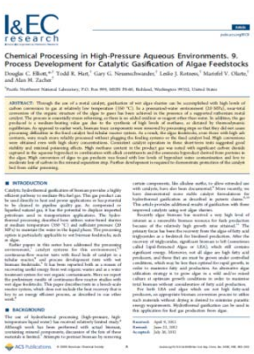
- **Can produce biocrude oil, RNG (methane), or both together**
  - Greatest energy output is from producing both together
  - If oil is produced, can be processed in existing refineries into finished fuels (gasoline, kerosene, diesel)
- **Gas output is 65% methane, 35% carbon dioxide**
  - Need to strip CO_2 for pipeline—easily done
  - Reminder: This is methane, not syngas ($CO + H_2$)
- **Gas is clean and needs no further cleanup—major advantage over biogas from landfill or AD**

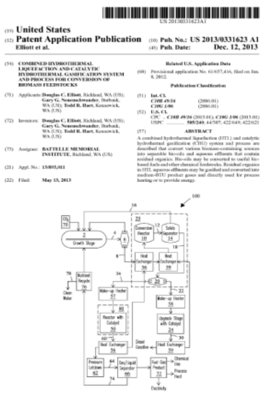
Developed by US DOE Over 40 Years Together with Genifuel Over Last 10 Years

- **Published in dozens of journals, reports, patents, etc.**
- **Thousands of successful tests and now successful pilot plants**
- **One of the best-documented new processes ever**









Genifuel HTP Status of Implementation

	Name	Description	Year	Size (wet)	Cost	Funding	Feedstock
1	PNNL Bench Scale 1	First bench-scale unit, oil and gas	1991	36 L/d	$225K	100% DOE	Various
2	PNNL Mobile System	Trailer-mounted gas only	1993	100 L/d	$325K	100% DOE	Various
3	PNNL Bench Scale 2	Updated test unit, oil only	2014	50 L/d	$500K	100% DOE	Various
4	Pilot System (HPPS)	Combined oil and gas	2015	1,500 L/d	$4 million (installed)	25% DOE 75% Reliance	Algae
5	PNNL Modular HTL System	Engineering HTL system	2016	300L/d	$2M (installed)	100% DOE	Various
6	CEC System (Containerized)	HTL + CHG demonstration	2017	50-100 L/d	$650K	CEC and SoCalGas	Dairy Cow Manure
7	Metro Vancouver Pilot System	Install in Canada for WWTP	2017 (Planned)	10,000 L/d	$8 million (est. installed)	50% MV, 50% Canada	Wastewater Solids
8	HYPOWERS	Install in USA, next scale-up	2019 (Planned)	15,000 L/d	$15 million (est.)	50% DOE	Wastewater Solids

RNG Output from Low-Hanging Feeds

Feedstock	Millions of dry metric t/y	Methane, billions of cu. ft./y
Dairy Cow Manure	19.3	340.7
Organic Portion of MSW	13.0	229.5
Wastewater Solids	12.4	218.9
Food Processing Waste	10.9	192.4
Non-Dairy Cattle Manure	10.8	190.6
Pig Manure	9.4	165.9
TOTALS	75.8	1,338
Total US Natural Gas Use, 2016		27,497
As % Total US Use*		4.9%

*Note: With addition of agricultural waste and wood, could supply more than 20% of total US gas

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Next HTP Pilots Planned in Vancouver and Northern California (Contra Costa)

HTP Compared to AD (Wastewater)

MEASURE	HTP (USD $000)	AD (USD $000)
Capital Expense	$4,560	$5,346
Operating Expense	$215/y	$388/y (inc. sludge)
Revenue	$131/y	$26/y
20-Year Net Cost	$5,532	$10,136

- *Specific case is for a wastewater treatment plant*
- *In this example, HTP 20-yr NPV cost is 55% of AD*

* Interest = 7%; OpEx Annual Increase = 3%; Oil and Gas Annual Price Increase = 4%

Equipment Installation

- **HTP system is skid-mount and factory-built**
  - Shipped to site by truck
  - May be containerized for sea shipment
- **Site installation requires pad, utilities (electricity, water, drain), and cover (roof or building)**
- **Best to install at feedstock site to reduce transportation of wet feedstocks**
- **Ideal location is near gas pipeline for insertion into pipeline; oil can be trucked to refinery if oil is made**

Project Structures

- **Project can be owned by feedstock provider (e.g. wastewater plant) or can be investor-owned**
- **If project is investor-owned, then investor will provide a turnkey system**
  - Feedstock owner provides long-term supply contract Investor sells outputs (oil, gas, electricity)
- **Investor could be strategic—e.g. oil or gas company, water treatment equipment company, etc.**

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Economic Factors

- **Economics driven by four factors**
  - Feedstock cost (should be negative)
  - Price of oil and gas
  - Government Incentives
  - CapEx—dropping fast but more reduction planned
- **Examples of government incentives:**
  - US Federal Renewable Fuel Standard RINs
  - Federal and state tax incentives (compare to wind/solar)
  - California Low Carbon Fuel Standard (LCFS)
  - Similar Canadian programs current or future
- **Preliminary analysis shows will qualify for D3 (Cellulosic) RINs and be carbon-negative**

Why Do This?

- **IP, R&D, and initial scaling already proven**
- **Feedstock is there—For Example, 16,000 wastewater utilities in North America, with solid waste issues**
- **Regulatory environment supportive worldwide**
- **Government incentives can provide large benefits**
- **Significant contribution to GHG reduction targets**

Major Triple-Bottom-Line Benefits—Economic, Social, and Environmental

What Is Needed to Accelerate Adoption

- **Hydrothermal Processing is in classic gap between pilot systems and full-scale commercial adoption**
  - Funding needed to bridge gap and accelerate uptake
- **Many potential customers are in "Show-Me" mode**
- **Funding is non-traditional**
  - Does not fit typical Venture Capital model
  - Most funding so far has been government
  - SoCalGas is first commercial entity to provide significant support
- **Most likely investment is from project finance, energy companies, or equipment companies**

What Are Roadblocks?

- **Need much greater interest from refiners and gas companies to understand the process and the high quality of the outputs**
  - Process and outputs are unfamiliar to refiners and gas companies
  - Often confused with pyrolysis oil and syngas, which are quite different
  - Provide technical resources to test HTP oil and gas and how to insert into existing facilities and processes
- **Ensure that government support and regulations are not biased toward existing processes**

Contact

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Thank you!

Appendix

Genifuel Worldwide Partners

Pacific Northwest
NATIONAL LABORATORY

U.S. DEPARTMENT OF
ENERGY

NAABB
National Alliance For Advanced Biofuels and Bio-products

360 ip
A Battelle Company

Reliance
Industries Limited

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

leidos

SoCalGas
A Sempra Energy utility

STATE OF CALIFORNIA
ENERGY COMMISSION

metrovancouver

SF
SPRINGS FAB

WERF
Water Environment Research Foundation
Collaboration. Innovation. Results.

Water Environment
Federation®
the water quality people™

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