



# ***INENTEC***<sup>®</sup>

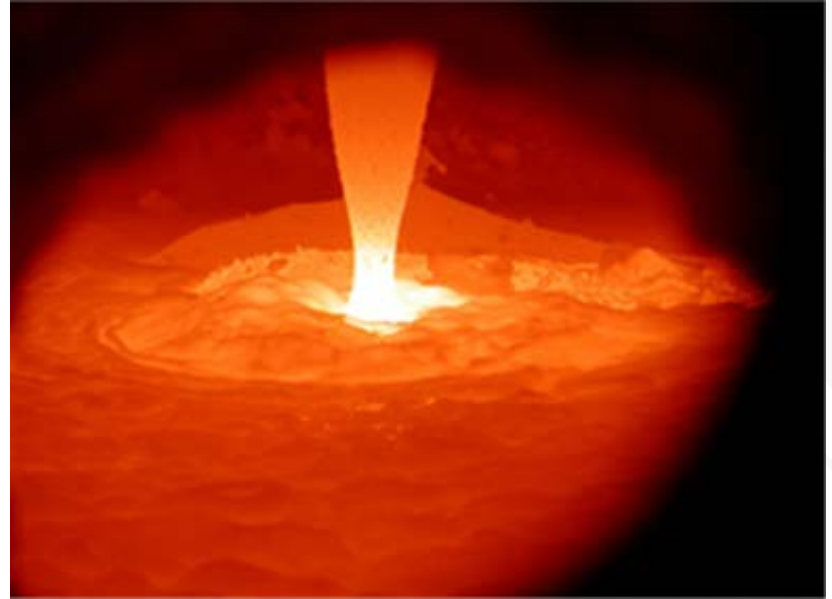
Today's waste, tomorrow's clean energy<sup>SM</sup>

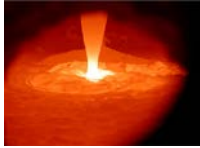
**Plasma Gasification Technology for  
Efficient Conversion of Waste into  
Chemical and Energy Products**

November 2020  
[www.inentec.com](http://www.inentec.com)

## OUTLINE

- Introduction to InEnTec Inc.
- Technology Overview
- Example InEnTec Facilities
- Summary





# Introduction to InEnTec

## OVERVIEW

- Founded in 1995, based in Washington State, USA
- InEnTec owns proprietary **plasma gasification technology** that converts waste into renewable chemicals and energy
- Technology based \$300 million R&D funding (US Department of Energy), developed in collaboration with MIT and Battelle National Laboratory
- Technology has very low environmental impact



**Battelle**  
*The Business of Innovation*

**INENTEC®**

# 55+ PATENTS AROUND THE WORLD

## (12) United States Patent

Cohn et al.

(10) Patent No.: US 10,273,414 B2

(45) Date of Patent: \*Apr. 30, 2019

(54) RENEWABLE ELECTRICITY CONVERSION OF LIQUID FUELS FROM HYDROCARBON FEEDSTOCKS

(58) Field of Classification Search  
CPC ..... C01B 3/24  
(Continued)

(71) Applicant: INENTEC INC., Richland, WA (US)

(72) Inventors: Daniel R. Cohn, Cambridge, MA (US);  
Jeffrey E. Surma, Richland, WA (US);  
Leslie Bromberg, Sharon, MA (US)

(56) References Cited  
U.S. PATENT DOCUMENTS  
4,341,069 A 7/1982 Bell et al.  
5,713,195 A 2/1998 Bronicki et al.  
(Continued)

(73) Assignee: InEnTec, Inc., Bend, OR (US)

(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 254 days.  
This patent is subject to a terminal disclaimer.

FOREIGN PATENT DOCUMENTS  
WO 2004071947 8/2004

### OTHER PUBLICATIONS

(21) Appl. No.: 15/267,021

(22) Filed: Sep. 15, 2016

(65) Prior Publication Data  
US 2017/0002271 A1 Jan. 5, 2017

### Related U.S. Application Data

(63) Continuation of application No. 14/077,094, filed on Nov. 11, 2013, now Pat. No. 9,469,533, which is a (Continued)

(51) Int. Cl.  
C10G 2/00 (2006.01)  
C01B 3/24 (2006.01)  
(Continued)

(52) U.S. Cl.  
CPC ..... C10G 2/32 (2013.01); C01B 3/24 (2013.01); C01B 3/36 (2013.01); C01B 13/0229 (2013.01);  
(Continued)

20 Claims, 8 Drawing Sheets

Bartholomy, "Renewable Hydrogen From Wind in California", Proceedings, National Hydrogen Association, 20 pages (Mar. 2005).  
(Continued)

Primary Examiner — Nina Bhat  
(74) Attorney, Agent, or Firm — Dorsey & Whitney LLP

### (57) ABSTRACT

A method for converting renewable energy source electricity and a hydrocarbon feedstock into a liquid fuel by providing a source of renewable electrical energy in communication with a synthesis gas generation unit and an air separation unit. Oxygen from the air separation unit and a hydrocarbon feedstock is provided to the synthesis gas generation unit, thereby causing partial oxidation reactions in the synthesis gas generation unit in a process that converts the hydrocarbon feedstock into synthesis gas. The synthesis gas is then converted into a liquid fuel.

## (12) United States Patent

Bromberg et al.

(10) Patent No.: US 10,316,262 B2

(45) Date of Patent: Jun. 11, 2019

(54) REGENERATOR FOR SYNGAS CLEANUP AND ENERGY RECOVERY IN GASIFIER SYSTEMS

(56) References Cited  
U.S. PATENT DOCUMENTS

## (12) United States Patent

Cohn et al.

(10) Patent No.: US 10,273,414 B2

(45) Date of Patent: \*Apr. 30, 2019

(54) RENEWABLE ELECTRICITY CONVERSION OF LIQUID FUELS FROM HYDROCARBON FEEDSTOCKS

(58) Field of Classification Search  
CPC ..... C01B 3/24  
(Continued)

## (12) United States Patent

Surma et al.

(10) Patent No.: US 9,994,474 B2

(45) Date of Patent: \*Jun. 12, 2018

(54) COMBINED GASIFICATION AND VITRIFICATION SYSTEM

2300/16 (2013.01); C10J 2300/1634 (2013.01); C10J 2300/1846 (2013.01); Y02P 40/58 (2015.11)

## (12) United States Patent

Surma et al.

(10) Patent No.: US 9,914,890 B2

(45) Date of Patent: \*Mar. 13, 2018

(54) GASIFICATION SYSTEM

(56) References Cited

## (12) United States Patent

Batdorf et al.

(10) Patent No.: US 9,771,532 B2

(45) Date of Patent: Sep. 26, 2017

(54) PRESSURIZED PLASMA ENHANCED REACTOR AND METHODS FOR CONVERTING ORGANIC MATTER TO GAS PRODUCTS

2200/12; C10J 2300/1238; C10J 2300/1884; C10J 3/66; C10J 2200/156; C10J 2300/0906; C10J 2300/0946; C10J 2300/0959; C10J 2300/0976; C10J

# INENTEC®

# AWARDS

## *#1 Waste-to-Value Project in the World*

- Biofuels Digest

## *Technology Innovation Award – Energy*

- The Wall Street Journal

## *One of the “25 Companies to Watch in Energy Tech”*

- BusinessWeek

## *Top Innovator*

- Seattle Business Magazine

## *One of “20 Ways to Build a Cleaner, Healthier, Smarter World”*

- Scientific American

## *“Award of Excellence in Sustainable Technology”*

- Platts Global Energy Awards

The Carbon Rescuers: 20 Top Waste projects and breakthroughs that capture used carbon from the waste pile for new uses

June 4, 2018 | Jim Lane

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#1 Commercial time: Aemetis embarks on \$158 million cellulosic ethanol project in California

So, it's big news this week that Aemetis completed its operation of an integrated demonstration unit for more than 120 days of continuous operations with 94% uptime, meeting the requirements for a federal USDA 9003 Biorefinery Assistance Program guaranteed loan.

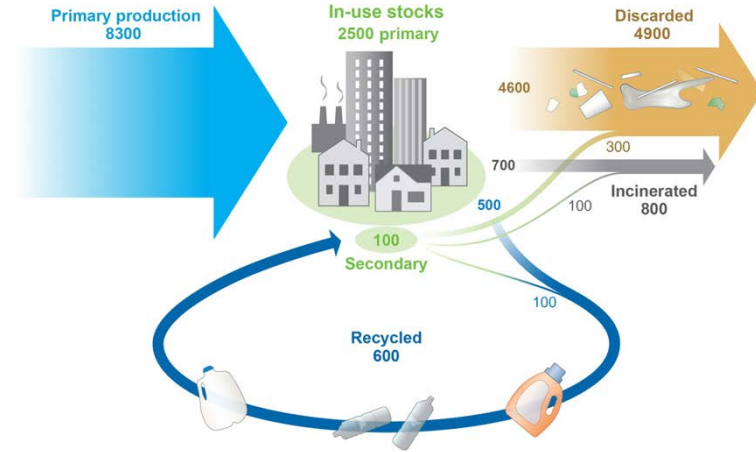
In partnership with its key technology providers InEnTec and LanzaTech, Aemetis successfully optimized the integration of an advanced arc furnace and gas fermentation technologies to convert waste biomass into low carbon, renewable cellulosic ethanol and fish meal. The unit was built at the InEnTec Technology Center in Richland, Washington and demonstrated the fully integrated system, including biomass handling, gasification, gas clean up, waste treatment and distillation systems.



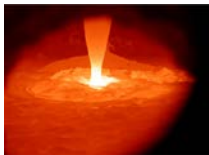
# INENTEC®

## INENTEC'S BUSINESS FOCUS

- Waste Plastic and Plastics Circularity
- Distributed Hydrogen
- High Value Waste (Medical, Hazardous, Chemical and Industrial)
- Municipal Solid Waste to Energy Products
- Biomass to fuels



Roland Geyer et al. Sci Adv 2017;3:e1700782

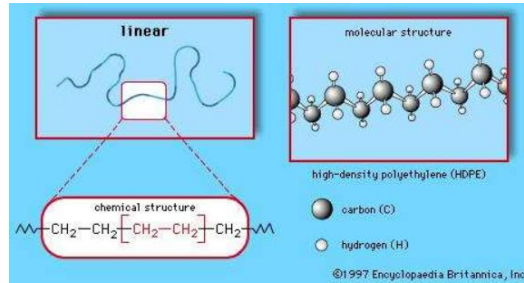


# Technology Overview



# WHAT IS GASIFICATION?

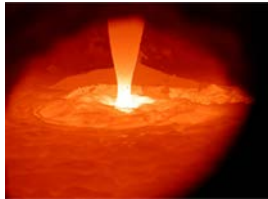
- Elemental recycling: Gasification cracks feedstocks into their atoms and reforms those atoms into simple molecules.
- Example: Post-Consumer High Density Polyethylene (HDPE)



## Certificate of Analysis

Date Received: July 1, 2020

Sample Date & Time:	Lab #:	Carbon	Hydrogen	Nitrogen	Oxygen	Sulfur	Heating Value	
		D5291 Moist. Free wt%	D5291 Moist. Free wt%	Moist. Free wt%	Calculated Moist. Free wt%	D4239 Moist. Free wt%	E711 As Received BTU/lb	E711 Moist. Free BTU/lb
6/26/20 0825	T2001063-001	85.56	14.5	<0.1	<0.01	<0.03	19,637	19,639
6/26/20 0830	T2001063-002	85.86	14.4	<0.1	<0.01	<0.03	20,047	20,047
6/26/20 0835	T2001063-003	85.16	14.2	<0.1	<0.01	<0.03	19,762	19,762

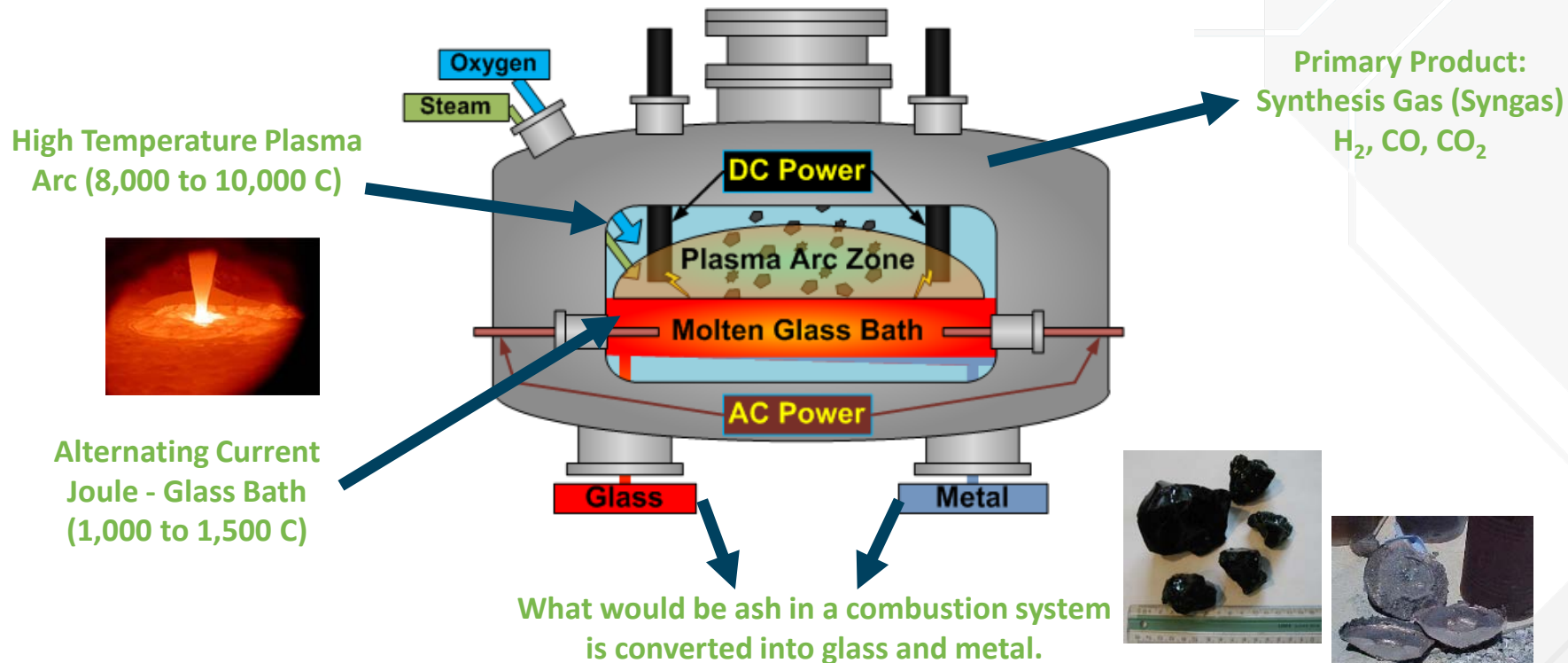


Gasification with optimized mix of steam and oxygen:  
$$\text{C}_x\text{H}_y\text{O}_z + \text{H}_2\text{O} \longrightarrow x\text{CO} + y\text{H}_2$$



Synthesis Gas:  
Simple Molecules  
 $\text{H}_2$ ,  $\text{CO}$ ,  $\text{CO}_2$ ,  $\text{H}_2\text{O}$

## PROPRIETARY PEM® TECHNOLOGY



# GLASS

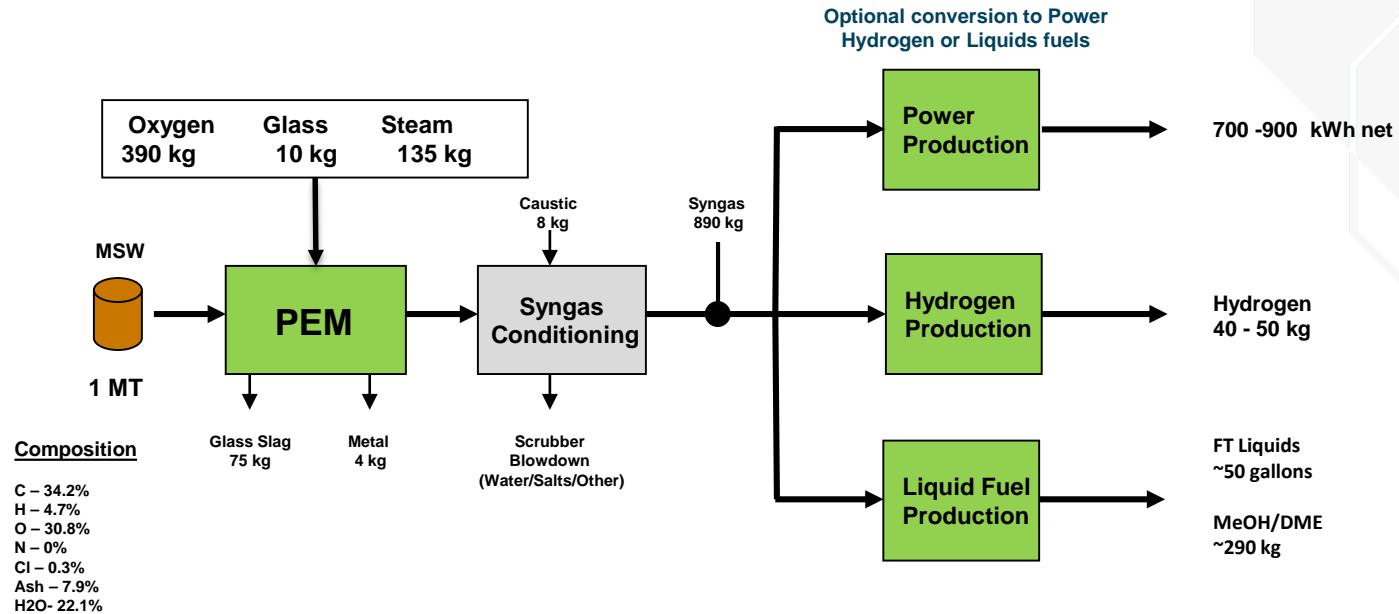
- Non leachable, not a hazardous waste
- Large volume reduction (95+%) from original feedstock stream
- Can be used to make products



ITEM	METAL (including compounds)	USEPA TCLP Test Limit (ppm)	UNI 10802_2002 Test Limit (mg/l)	Analyzed Leachate (mg/l)
1	pH			9.83
2	Tot. Dis. Solids		400	100
3	D. Org. Carbon		50	< 1
4	Phenol Index	Not Applicable	0.1	< 0.01
5	Arsenic (As)	5.0	0.05	< 0.001
6	Barium (Ba)	100.0	2	0.05
7	Boron (B)	Not Applicable	Not Applicable	
8	Cadmium (Cd)	1.0	0.004	< 0.001
9	Chromium (Cr)	5.0	0.05	0.001
10	Copper (Cu)	Not Applicable	0.2	0.003
11	Lead (Pb)	5.0	0.05	0.002
12	Mercury (Hg)	0.2	0.001	< 0.001
13	Molybdenum (Mo)	Not Applicable	0.05	< 0.001
14	Nickel (Ni)	Not Applicable	0.04	0.001
15	Antimony (Sb)	Not Applicable	0.006	< 0.001
16	Selenium (Se)	1.0	0.01	< 0.001
17	Silver (Ag)	5.0	Not Applicable	
18	Thallium (Tl)	Not Applicable	Not Applicable	
19	Zinc (Zn)	Not Applicable	0.4	0.01
20	Chlorides (Cl)	Not Applicable	80	3.4
21	Fluorides (F)	Not Applicable	1	< 0.1
22	Sulphates (SO4)	Not Applicable	100	< 1

Sample results reported with "<" represent results below the detection limit specified.

## EXAMPLE MASS BALANCE - PER TON FEED



## ULTRA-CLEAN SYNGAS HAS MANY USES . . .

### ***Wide Range of Feedstocks:***

- Municipal solid waste
- Post-consumer plastic
- Medical waste
- Hazardous waste
- Biomass
- Construction and Demolition
- Auto shredder residue
- Tires
- Commercial and Industrial Waste
- Liquids and Solids



### ***Ultra-Clean Syngas:***

A basic building block  
of chemical and  
plastics production

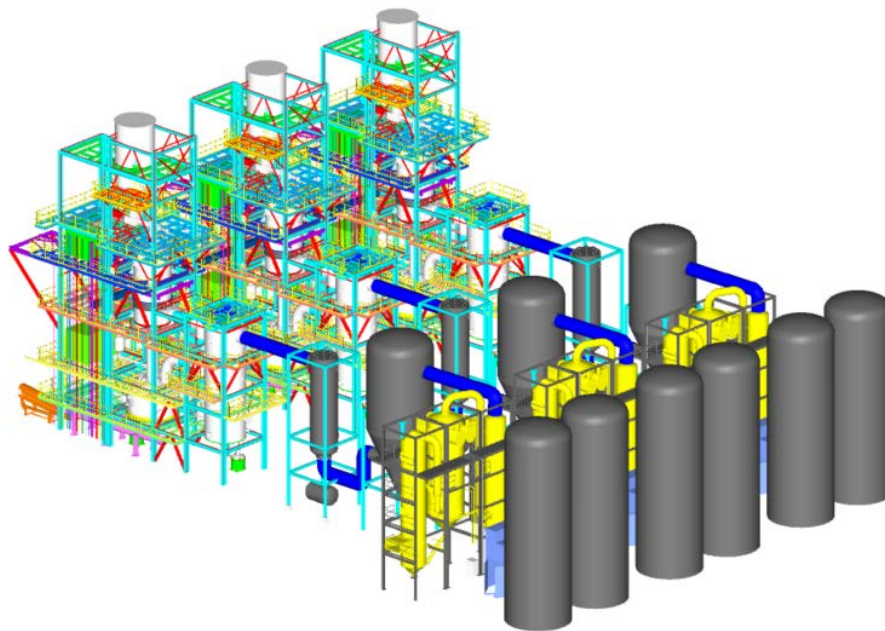


### ***Wide Range of Products:***

- “Chemical-grade” syngas for input to chemical and plastic production
- Ethanol
- Methanol
- Hydrogen
- Electricity
- Others

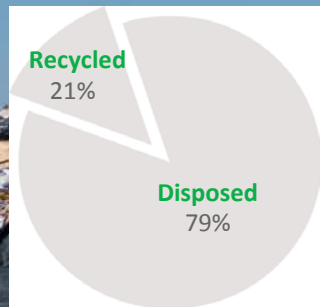
## MODULAR, SKID-MOUNTED SYSTEM

125 - 150 TPD  
PEM Module





## REUSE EXISTING CARBON



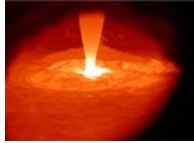
**2 Billion tpy  
2016**

**3.4 Billion tpy  
2050**

**Potential Energy:**

US: 280 million barrels of oil equivalent

Worldwide: 3,000 to 5,000 million barrels



## Example Facilities



## OREGON HYDROGEN PRODUCTION

- Feedstock: Industrial and Medical Waste
- Product: Hydrogen
- Status: Restarted in August October 2020; commercial operation expected in 1Q 2021



## KAWASAKI HEAVY INDUSTRIES, JAPAN

- PCB Destruction
- 5 ton/day demonstration system



## GLOBAL PLASMA, TAIWAN

- Processed medical waste and batteries



## DOW CORNING CORPORATION, MICHIGAN

- Feedstock: Hazardous waste with high quantities of chlorine
- Products: Aqueous HCl and Syngas used as Boiler Fuel

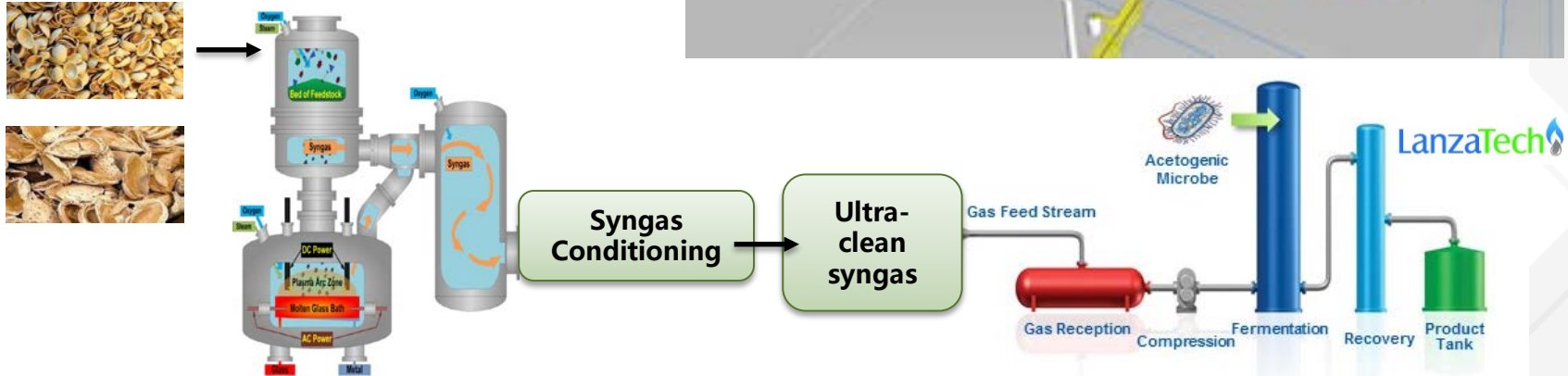
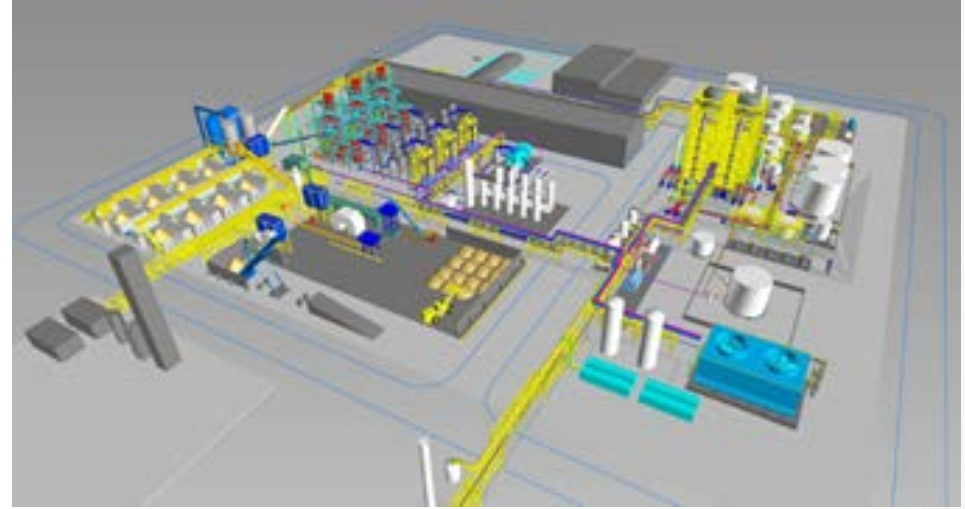




## MOBILE PEM SYSTEM



- Feedstock: 450 ton/day orchard waste
- Product: 12 million gallons/year cellulosic ethanol
- Extremely low or negative carbon intensity under California rules



## INENTEC SUMMARY



- Commercially proven proprietary technology
- Wide range of potential feedstocks
- Ultra-clean “chemical grade” syngas can be used to produce many products
- Modular and scalable
- Environmental beneficial, low impact

## CONTACTS

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