Reducing Climate Change with Waste To Energy

Solving Some of the World's Climate and Waste Problems by Converting Waste Materials into Renewable Hydrogen

Dan Madden, PE
CEO
Eco Energy International
pdmadden@ecoenergyinternational.com

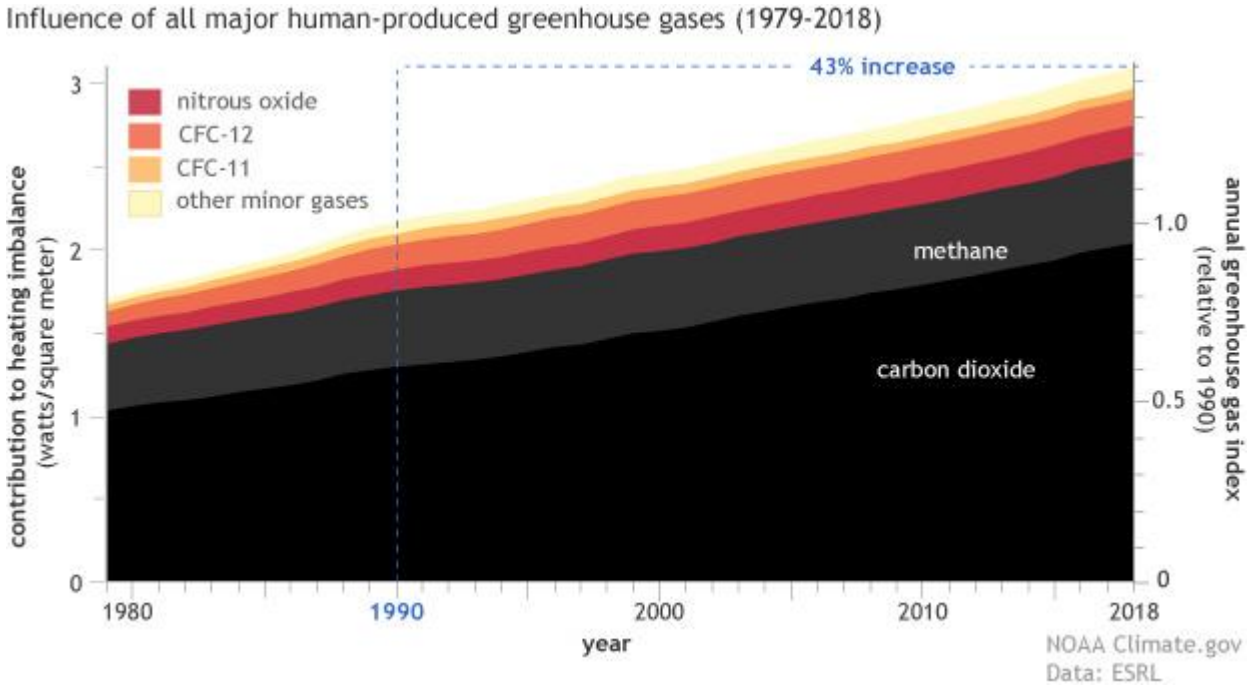
PROBLEM/OPPORTUNITY 1

Global climate change is one of the world's biggest challenges.

- Climate change is recognized as a major issue worldwide. The rising atmospheric temperatures and rising ocean levels are largely attributed to increases in greenhouse gas emissions.

- Greenhouse gasses in the atmosphere mostly consist of carbon dioxide and methane.

- Earth's land and ocean surfaces are continuously warmed by sunlight that radiates thermal infrared energy (heat). The greenhouse gases absorb that heat and release it gradually over time. Increasing greenhouse gases traps additional heat and raises the Earth's average temperature.

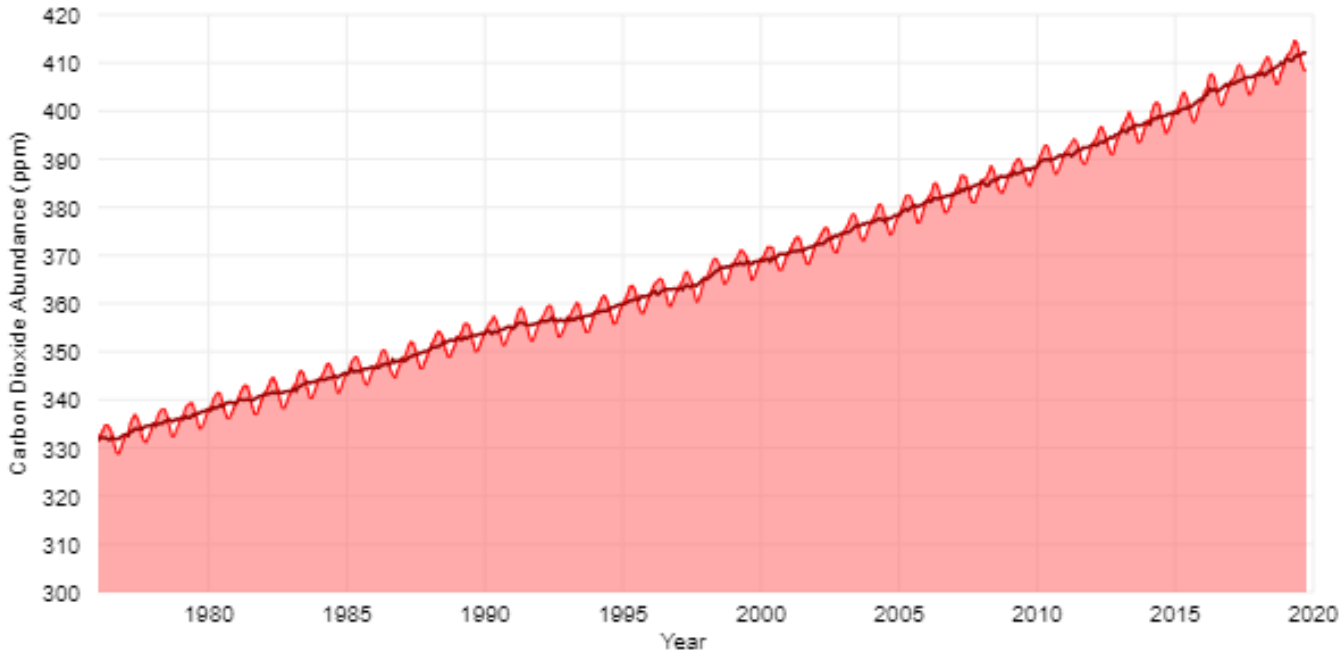


PROBLEM/OPPORTUNITY 1 (continued)

Global climate change is one of the world's biggest challenges.

- Carbon dioxide concentrations are rising mostly because of the combustion of carbon based fossil fuels used to produce energy. This includes coal and natural gas fired power plants, gasoline and diesel powered vehicles, residential and commercial building heating systems, etc.

- Some of this carbon dioxide is dissolved into ocean water. The ocean has absorbed enough carbon dioxide from the atmosphere to lower the ocean's pH by 0.1 units, a 30% increase in acidity, which is impacting some sea life.



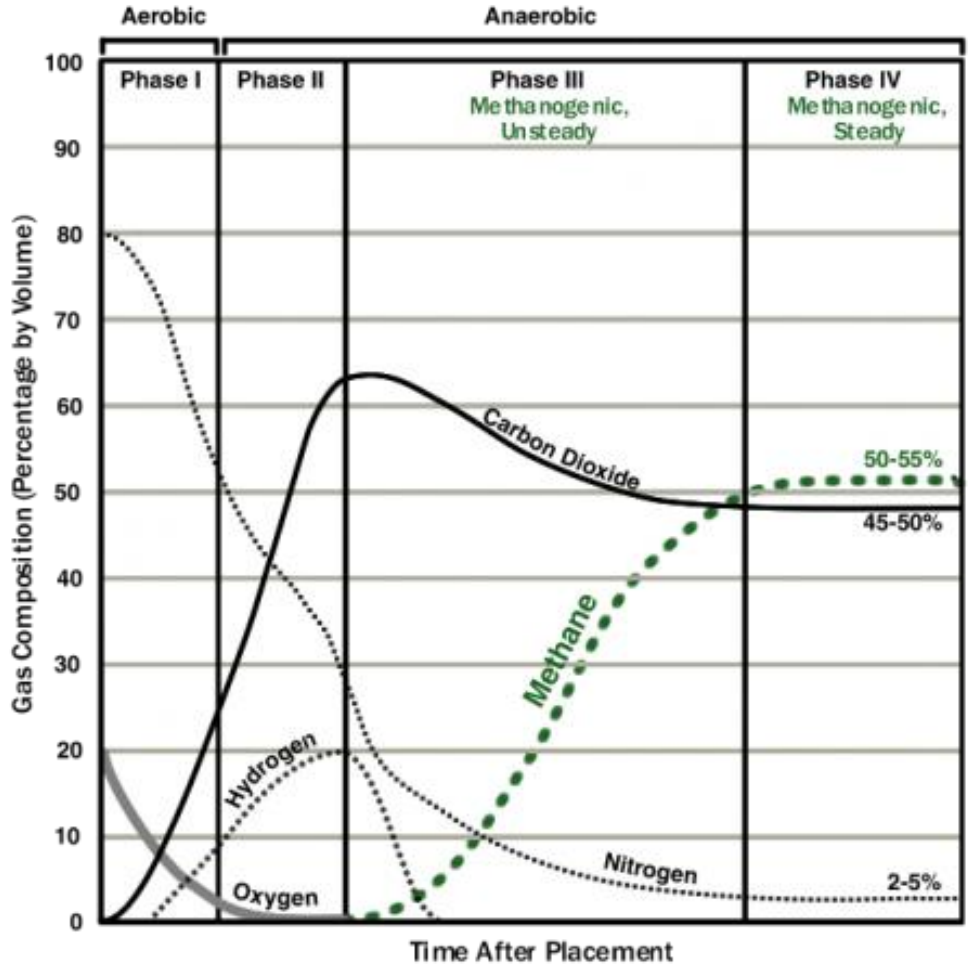
PROBLEM/OPPORTUNITY 1 (continued)

Global climate change is one of the world's biggest challenges.

- Methane is considered 25 times more detrimental to the atmosphere than carbon dioxide and is produced from a number of sources.

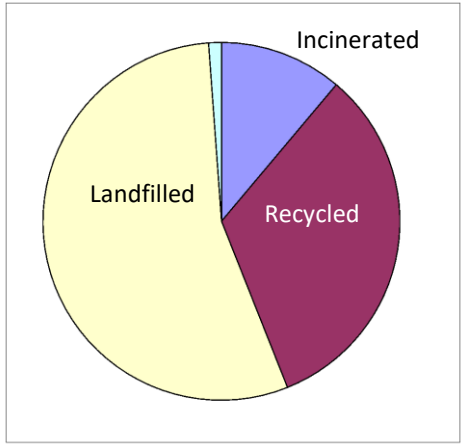
- One major source is the decaying of organic matter in municipal and agricultural landfills. This decomposition produces methane and carbon dioxide as a byproducts.

- Bacteria decomposes landfill and agricultural waste in four phases. Gas composition changes with each phase and waste in a landfill may be undergoing several phases of decomposition at once. The time after placement scale (total time and phase duration) varies with landfill conditions.



PROBLEM/OPPORTUNITY 2

Municipal Solid Waste (MSW) management is one of the world's biggest challenges.



- The world is drowning in trash, and the waste generation rates are only increasing, according to the World Bank.

- Worldwide, the total MSW generated is ***2,017 million tons per year*** and projected to be 3,400 million tons per year by 2050

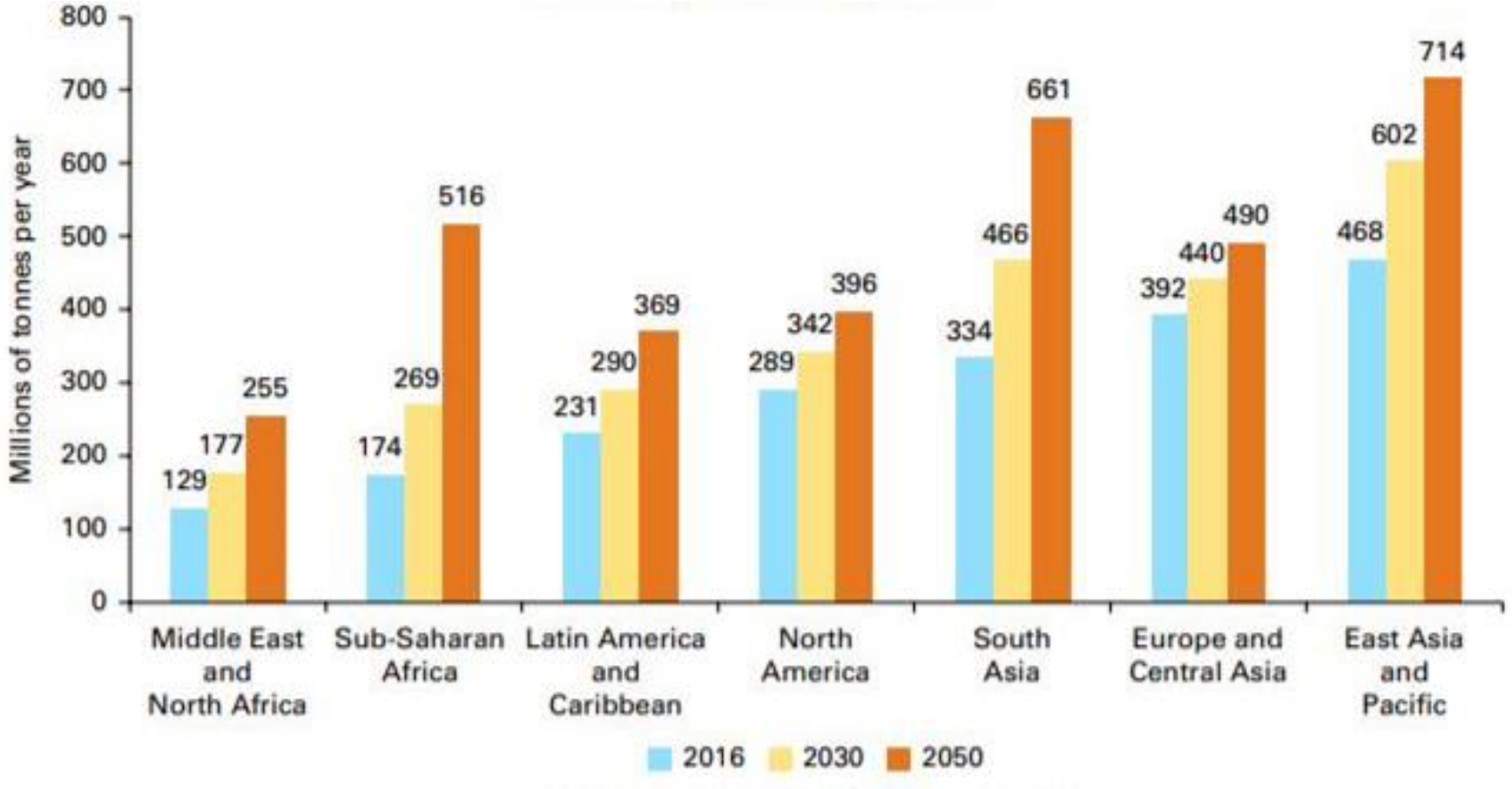
- In 2017, the USA produced over **268 million tons** of MSW,
  - 13% was Incinerated to produce energy
  - 34% was Recycled (mostly paper, glass, and metals and some plastic)
  - 53% was Landfilled. Over 139 million tons per year were deposited into 1,738 existing operating landfills in the US.

PROBLEM/OPPORTUNITY 2 (continued)

Municipal Solid Waste (MSW) management is one of the world's biggest challenges.

- The world is drowning in trash, and the waste generation rates are only increasing, according to the World Bank.

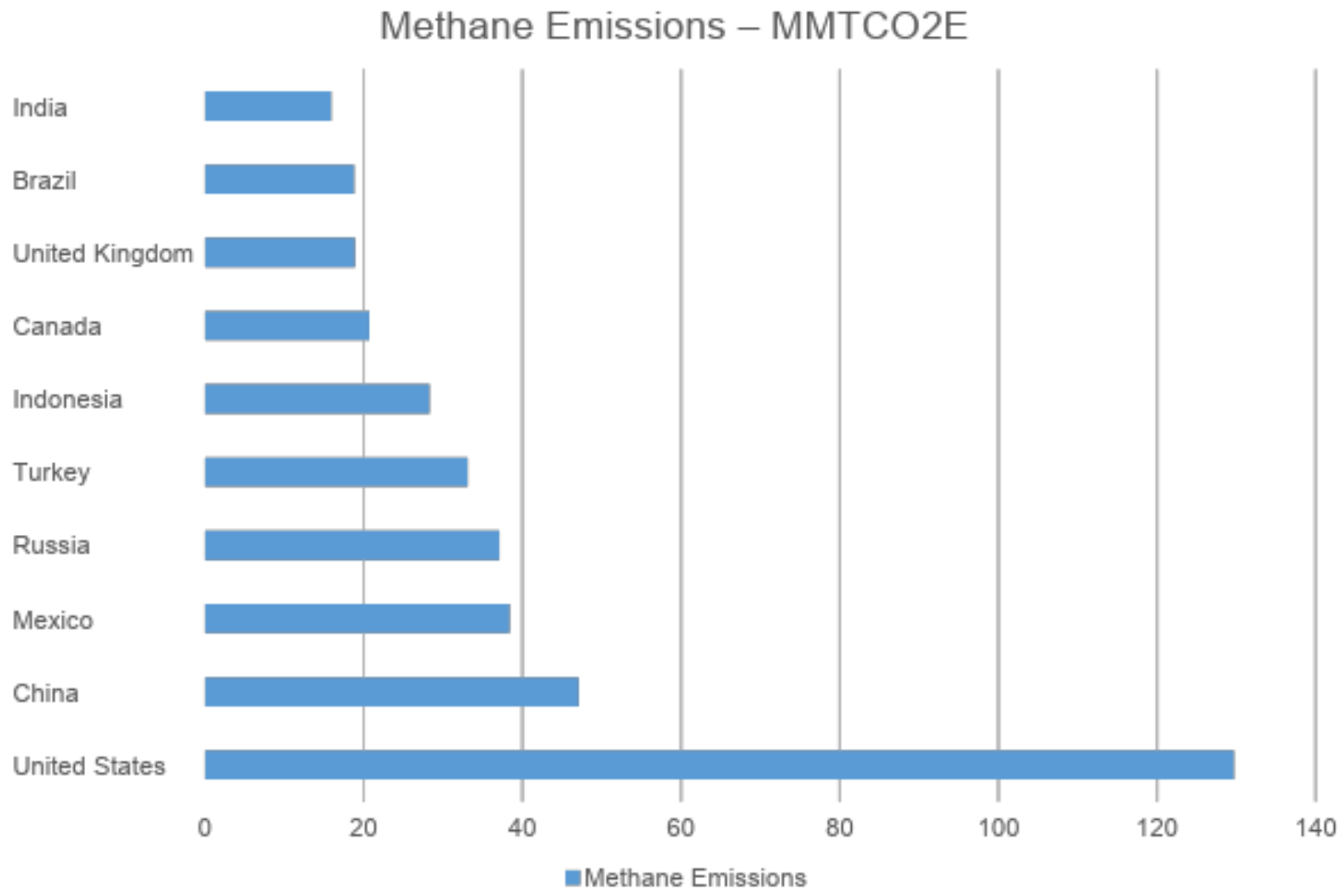
PROJECTED MSW WASTE GENERATED BY REGION



PROBLEM/OPPORTUNITY 2 (continued)

Municipal Solid Waste (MSW) management is one of the world's biggest challenges.

- Total landfill methane emissions in 2010 was 799 million metric tonnes of carbon dioxide equivalents ($MMTCO_2E$)



ANALYSIS OF CLIMATE and WASTE PROBLEMS

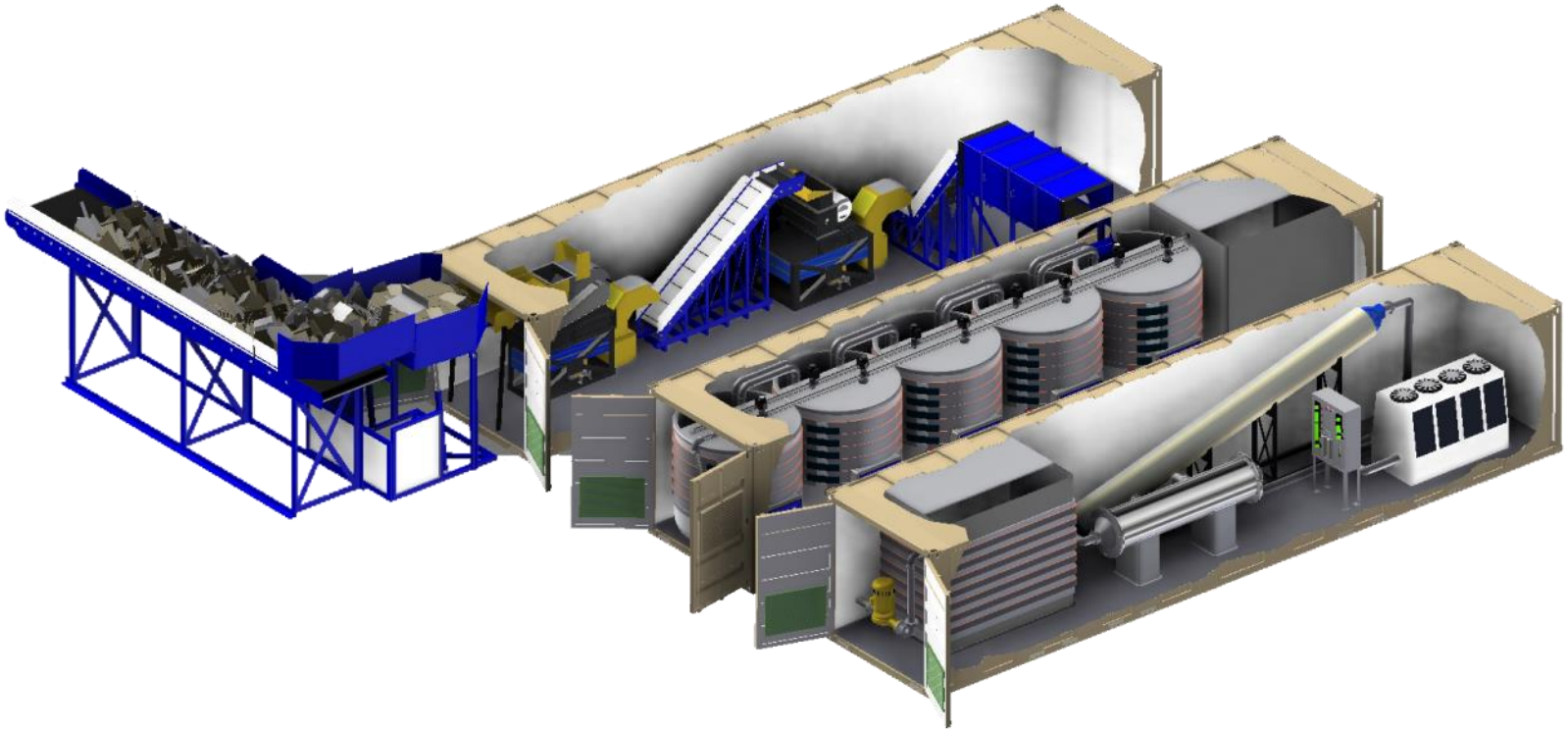
- Need to reduce the amount of carbon dioxide released into the atmosphere by reducing sources of carbon dioxide production as a waste byproduct.
  - Reduce sources of carbon dioxide emissions, i.e. eliminate organic wastes going to landfills
  - Displace carbon based fuels with alternative fuels or energy, i.e. hydrogen fuel cells
  - Stop using steam methane reformation to produce the hydrogen since the process produces 11 times as much carbon dioxide as hydrogen

- Need to reduce the amount of methane released into the atmosphere by reducing sources of methane production as a waste byproduct.
  - Reduce sources of methane emissions, i.e. eliminate organic wastes going to landfills

PROPOSED SOLUTION TO THESE PROBLEMS

Eco Energy International (EEI) now offers a breakthrough technology that can take each of these Problems and turn them into Opportunities.

Base Facilitated Reformation (BFR)



PROPOSED SOLUTION

Utilize EEI's Base Facilitated Reformation (BFR)

- Eco Energy International has developed a revolutionary technology to convert any organic material directly into pure hydrogen.

- This proprietary process is scalable allowing it to meet the needs of a given application, large or small.

- The equipment is modular, allowing it to be located nearer end users; reducing or eliminating expensive transportation costs and their associated emissions.

- When applied to municipal or agricultural waste, this process eliminates organic waste going into the landfill; thus avoiding the production of greenhouse gases (methane and carbon dioxide) from decomposition of the waste.

PROPOSED SOLUTION (continued)

Utilize EEI's Base Facilitated Reformation (BFR)

- Consequently, since the organic wastes do not go to the landfill, it also reduces the need for additional landfill real estate and costly methane abatement.

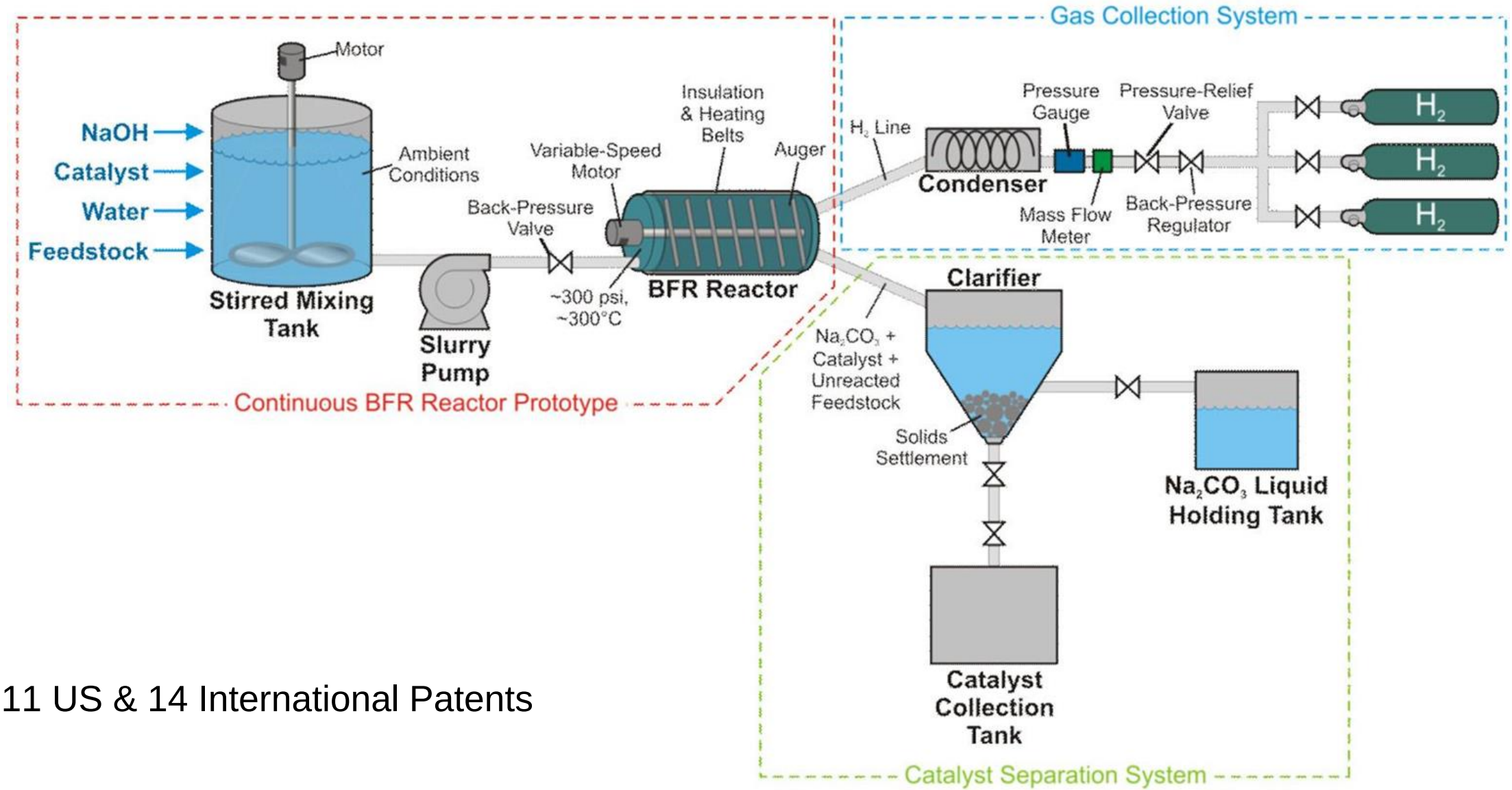
- With this technology, all the carbon from the waste feedstock is sequestered. This means that no greenhouse gases are produced. Conversely, the standard hydrogen technology, steam methane reformation, produces 11 times as much carbon dioxide as the hydrogen produced.

- The BFR process is economical. Production costs are competitive with existing large scale hydrogen facilities including steam methane reformation.

- Plus, this method generates revenue via the sale of clean, renewable hydrogen.

BFR Flow Diagram

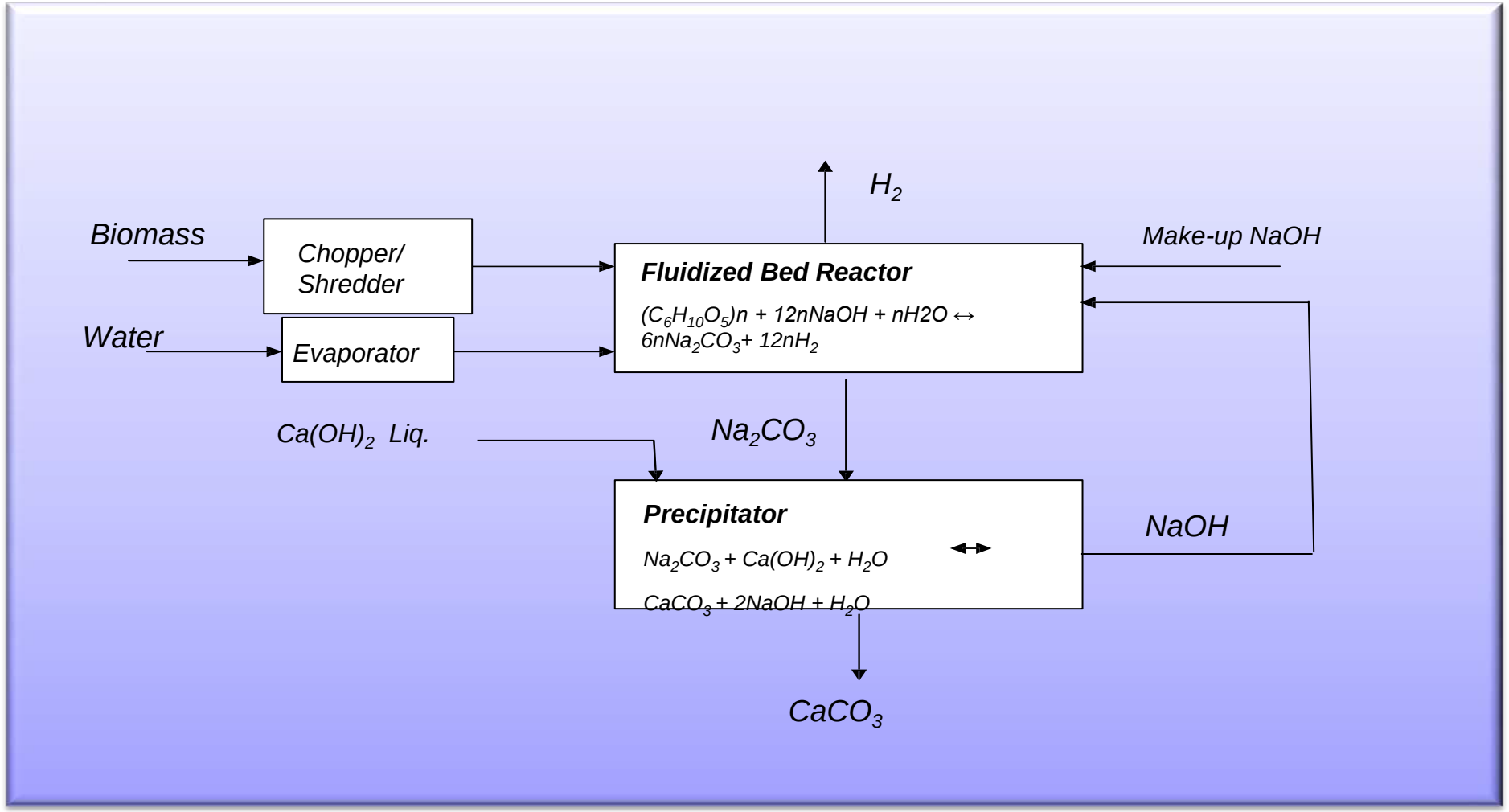
Base Facilitated Reformer generates clean Hydrogen



* 11 US & 14 International Patents

Base Facilitated Reformation of Biomass

Flow Diagram



BFR FEEDSTOCKS

Examples of Renewable and Non-Renewable Feedstocks Successfully Reformed into Hydrogen by BFR Process







Cardboard (Biomass): Grass, Grain, Crops, Algae, Sawdust, Cellulose, Hemicelluloses, Lignin, etc
Municipal Solid Waste (MSW): Paper Products, Wood, Food Waste and Yard Waste and other Organic Materials
Agricultural Solid Waste (ASW): Animal Waste, Crop Waste and other Agricultural Organic Wastes
Coal Industry Waste (CIW): Anthracite, Bituminous and Lignite Coals including Waste Coal, Coal Fines, Coal Slurry, etc
Food Industry Waste (FIW): Food Processing, Meat Processing and Food Service Wastes; i.e. Fryer Oils, Potato Peels
Lumber Industry Waste (LIW): Forest Slash Piles, Woodchips, Sawdust, etc
Alcohols: Methanol, Ethanol, Crude Ethanol, E95, Ethylene Glycol, Glycerol (byproduct of biodiesel production)
Sugars and Starches: Glucose, Fructose, Corn Starch, Potato Starch, etc
Fossil Fuels: Methane (Natural Gas, Landfill Gas, Bio-Gas, Flare Gas)

BFR REACTIONS - SUMMARY

Bio Reforming of Cellulose (i.e. Municipal Solid Waste)

$$(C_6H_{10}O_5)_n + 12nNaOH + nH_2O \leftrightarrow 6nNa_2CO_3 + 12nH_2$$

Bio Reforming of Glycerol (i.e. Excess Byproduct from Biodiesel Production)

$$C_3H_5(OH)_3 + 6NaOH \leftrightarrow 3Na_2CO_3 + 7H_2$$

Bio Reforming of Methane (i.e. Landfill Gas/Biogas)

$$CH_4 + 2NaOH + H_2O \leftrightarrow Na_2CO_3 + 4H_2$$

Bio Reforming of Coal (i.e. Coal Fines, Lignite, etc)

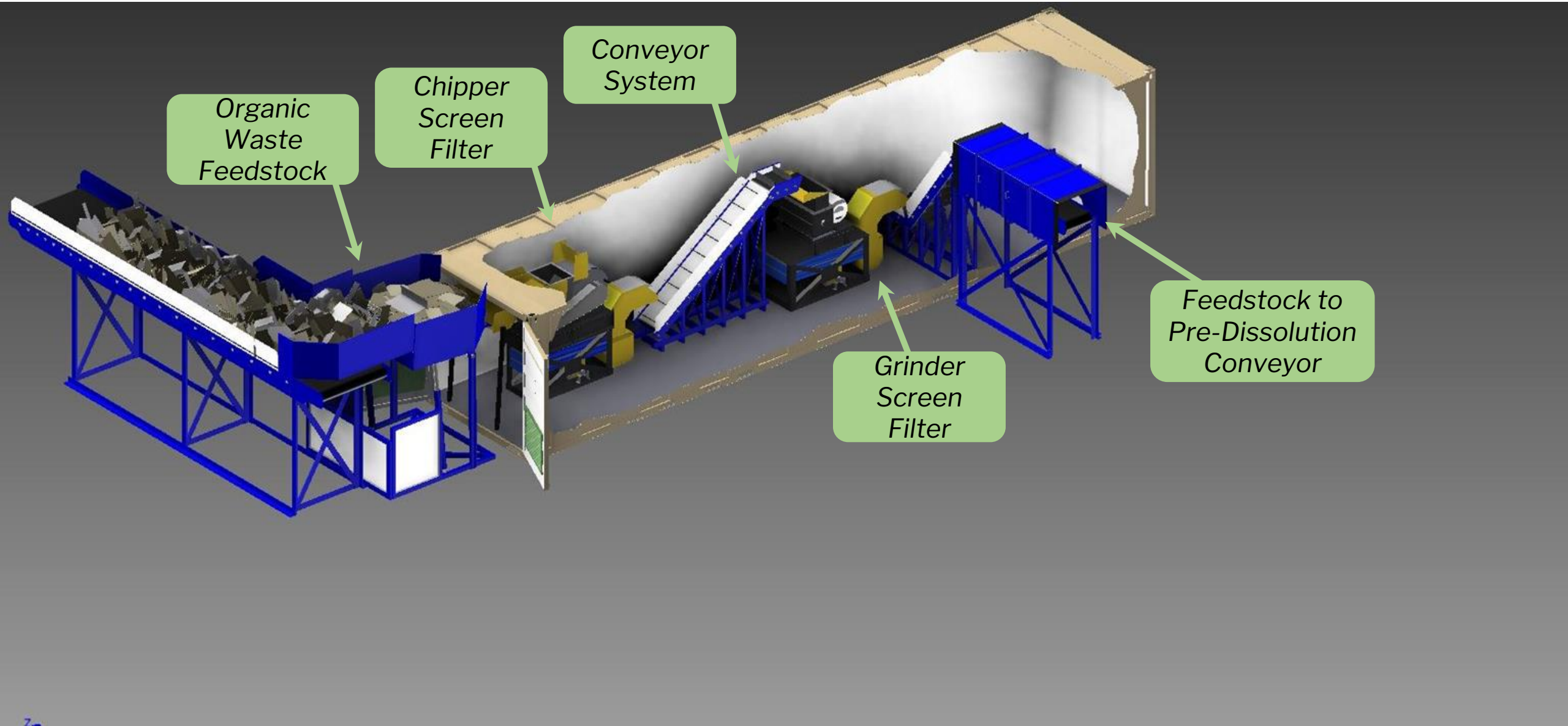
$$C + 2NaOH + H_2O \leftrightarrow Na_2CO_3 + 2H_2$$

Bio Reforming of Ethanol (i.e. Produced from Corn as Gasoline Supplement)

$$C_2H_5OH + 4NaOH + H_2O \leftrightarrow 2Na_2CO_3 + 6H_2$$

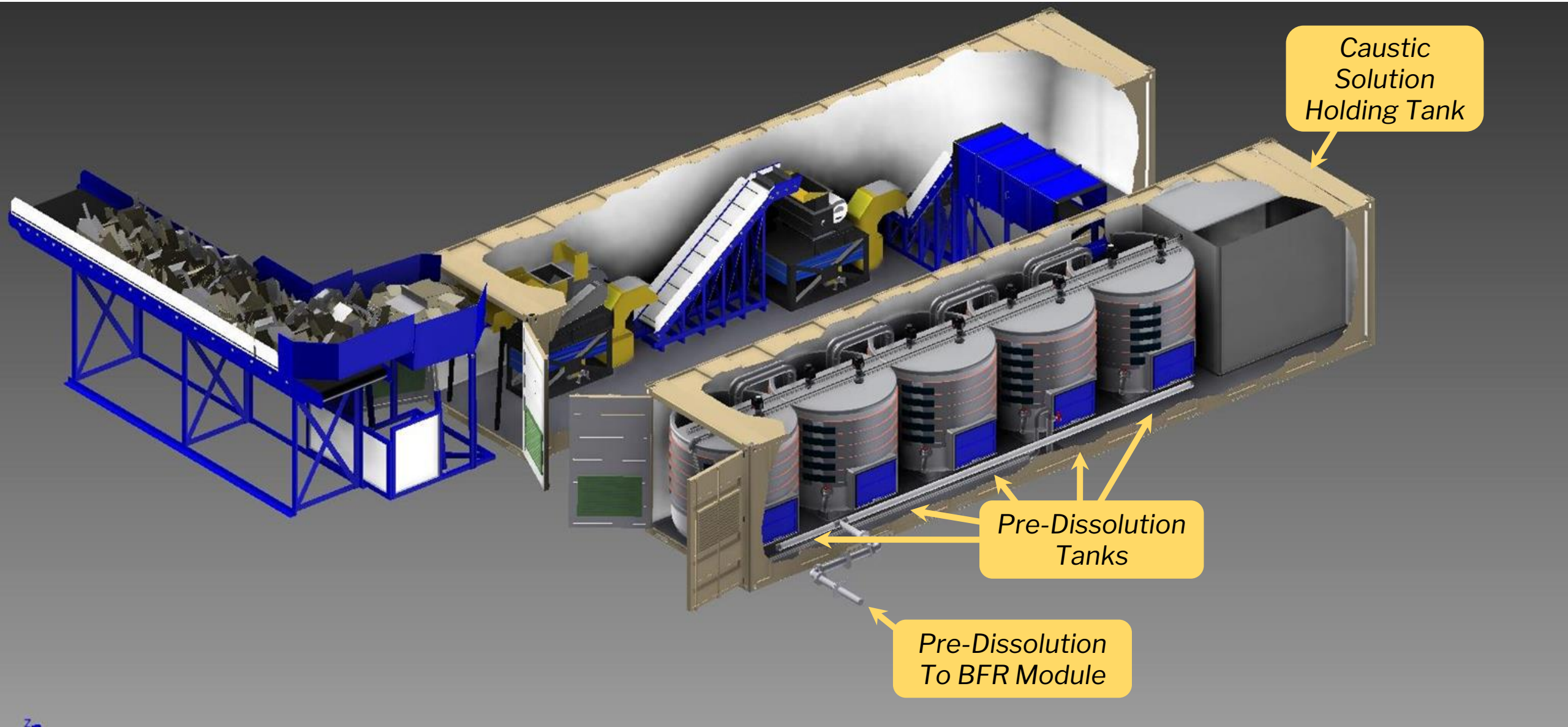
APPLICATION EXAMPLE: Using BFR for Hydrogen Generation

Feedstock Preparation Module



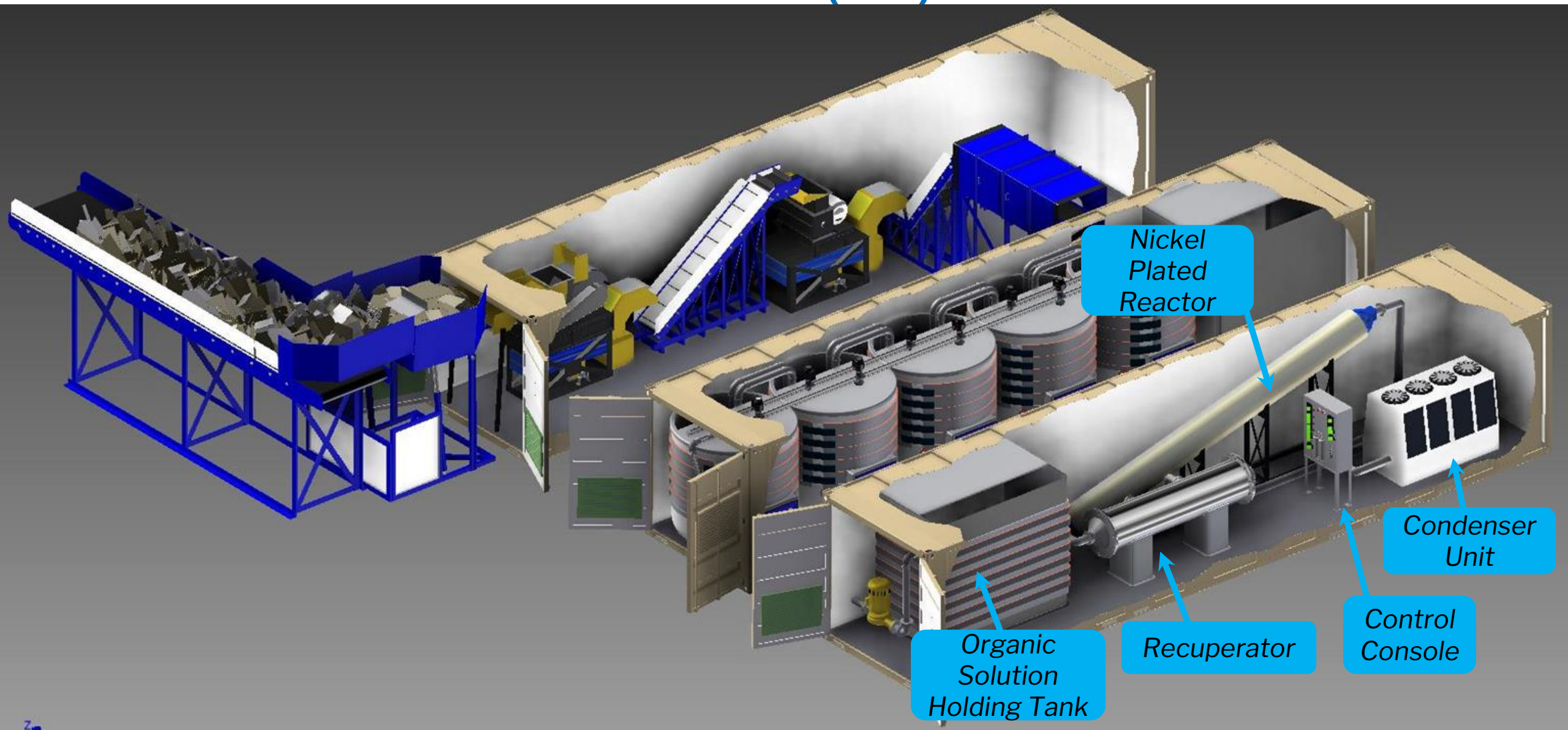
APPLICATION EXAMPLE: Using BFR for Hydrogen Generation

Pre-Dissolution Module



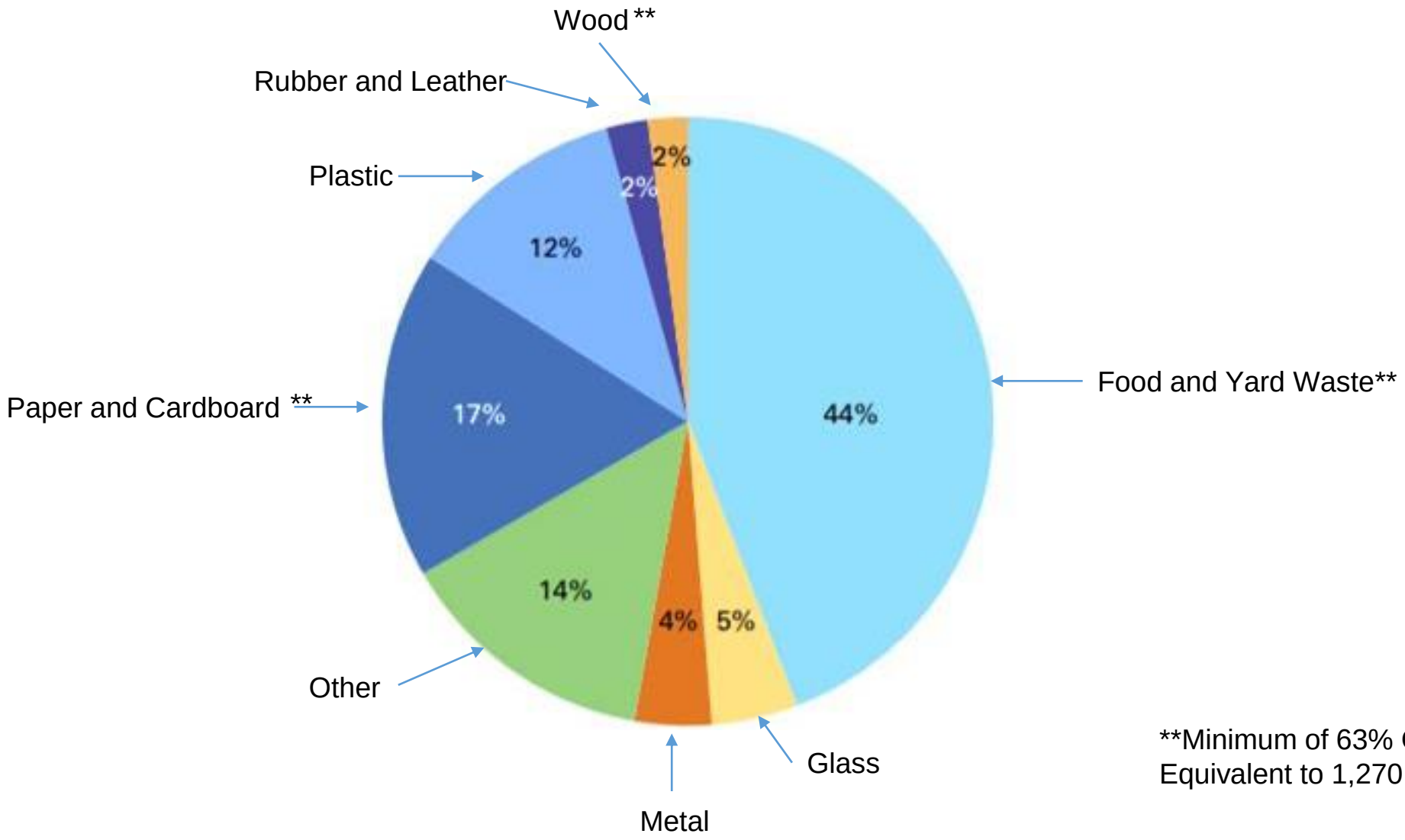
APPLICATION EXAMPLE: Using BFR for Hydrogen Generation

Base Facilitated Reformer (BFR) Reactor Module



GLOBAL MSW COMPOSITION BY PERCENTAGE

Total Global MSW Generated by Material 2016
(2,017 million tons)



**Minimum of 63% Organics
Equivalent to 1,270 million tons/yr

HYDROGEN PRODUCTION RATES (PER GLOBAL MIX)

Converting Various MSW Feedstocks to Hydrogen

	Max Theoretical H_2 Production ($g\ H_2$ / g feedstock)	Expected H_2 Yield (% of max theoretical)	Target Feedstock to H_2 Conversion ($g\ H_2$ / g feedstock)	Percent Content in MSW per EPA (% of total intake)	H_2 Conversion ($ton\ H_2$ / ton feedstock)
Paper Waste	0.148	90%	0.1332	17.0%	0.0226
Food Scraps and					
Yard Trimmings	0.148	90%	0.1332	44.0%	0.0586
Wood Waste	0.148	80%	0.1184	2.0%	0.0024
MSW Total Mix					0.0832**

*** equates to 8.32 tons of hydrogen produced for every 100 tons of unsorted MSW globally*

APPLICATION EXAMPLE: Municipal Solid Waste from MRF

ECO ENERGY INTERNATIONAL

Material Recovery Facility

Recycling

All Organic Wastes

BFR

Hydrogen

Merchant Market

Fuel Cells

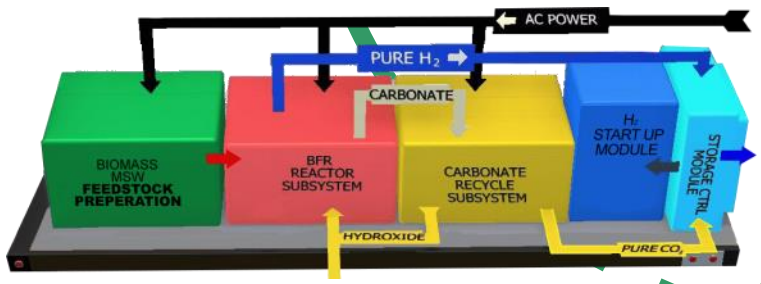
APPLICATION EXAMPLE: Locating at Distribution Centers

ECO ENERGY INTERNATIONAL

Distribution Centers

Walmart Save money. Live better. LOWE'S amazon

Cardboard & other Waste



BFR

Hydrogen Storage & Filling Station

*Fuel Cell Forklifts**

*Walmart and Amazon are in the process of converting all of their distribution center forklifts to fuel cells power. Both have significant cardboard wastes that can be used as feedstock.

Base Facilitated Reformation of Agricultural Solid Waste (ASW)

Batch Reactor – % Yield @ 340ºC

Feedstock	Hydrogen Yield (%)*	H_2 (%)	CH_4 (%)
Flax shives, non- milled, non-delignified	87	98	2
Hemp Hurds, non- milled, non-delignified	85	98	2
Hemp Hurds, milled, non-delignified	93	97	3
Barely hulls, milled, non-delignified	90	98	2
Hemp bast fibers, milled, non-delignified	87	98	2
Mixed hemp, milled, non-delignified	87	97	3
Mixed hemp, milled, delignified	88	98	2
Wood, milled, delignified	95	98	2
Wood, non-milled, delignified (dried)	95	98	2
DDGS, non-milled	66	98	2
Whole stillage (liquid, 14% solid)	75	98	2

**** H_2 yield (%): (liter gas obtained/gr-solid)*H_2(%)/1.8*** *(1.8 liter-H_2/gr-cellulose, theoretical)*

APPLICATION EXAMPLE: Locating at or near Farms and Ranches

- Agricultural waste includes both crop and animal wastes. This means that it is almost entirely organic. (Municipal waste is typically only 63% organic waste)

- Typically there is as much or more agricultural waste and there is municipal waste by weight.

- These two facts result in agricultural waste contributing far more to greenhouse gas emissions than municipal waste.

APPLICATION EXAMPLE: Locating at or near Farms and Ranches

ECO ENERGY INTERNATIONAL

Farming Industry

Crop Waste

Animal Waste

Municipal Waste

BFR

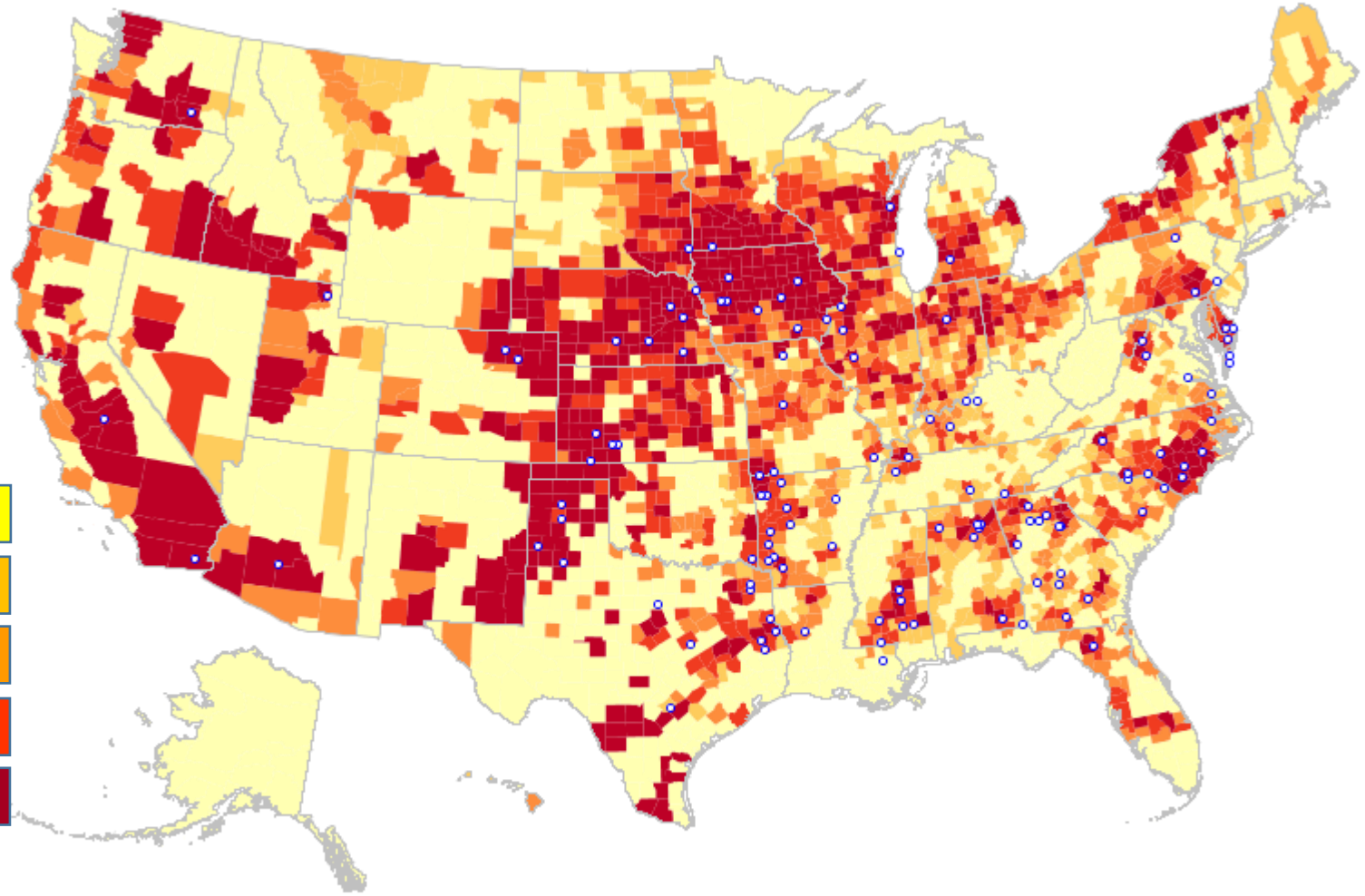
Hydrogen

Farm to Market Transport

Merchant Market

Other Fuel Cells

USA FARMS: DISTRIBUTION MAP



Map Key

Density Level

- None
- Moderate
- High
- Severe
- Extreme
- Meat Plants

1	California	1,709,918
2	Idaho	525,104
3	Wisconsin	412,427
4	Texas	376,152
5	New Mexico	315,183
6	New York	270,123
7	Washington	219,536
8	Michigan	205,660
9	Arizona	192,079
10	Minnesota	131,729
11	Colorado	118,952
12	Florida	109,121
13	Kansas	104,387
14	Oregon	90,356
15	Indiana	88,525
16	Ohio	82,144
17	Iowa	79,960
18	Pennsylvania	67,566
19	Utah	66,370
20	South Dakota	64,896
21	Vermont	52,186
22	Georgia	49,000
23	Nebraska	32,769
24	Oklahoma	27,699
25	Nevada	26,006
26	Missouri	20,119
27	North Carolina	17,536
28	Virginia	17,249
29	Illinois	16,588
30	Maryland	9,498
31	North Dakota	7,694
32	Maine	7,309
33	Kentucky	6,848
34	Tennessee	6,280
35	South Carolina	5,295
36	Connecticut	3,937
37	Wyoming	*3,620
38	Louisiana	3,338
39	Hawaii	*3,322
40	Montana	2,882
41	Alabama	1,851
42	Mississippi	*1,139
43	New Hampshire	*819
44	New Jersey	*553
45	Delaware	*513

APPLICATION EXAMPLE: Locating at Biodiesel Plants

- Biodiesel is made through a chemical process called transesterification whereby the glycerin is separated from the fat or vegetable oil. The process leaves behind two products – biodiesel and glycerol.

- Biodiesel production across the US has grown to more than 3 billion gallons per year. This results in 300 million gallons of crude glycerol as a byproduct. The market fluctuates on crude glycerol value, from low value to waste product. This crude glycerol is an excellent feedstock for direct conversion to hydrogen using the BFR process.

- The plant waste after extracting the oils, is all organic and an excellent BFR feedstock.

APPLICATION EXAMPLE: Locating at Biodiesel Plants

Bio Diesel Plant

Biodiesel

Glycerol* Byproduct

Lignin & Other Spent Materials

BFR

Hydrogen

Merchant Market

Fuel Cells

*10 pounds of crude glycerol byproduct are produced for every 100 pounds of biodiesel produced.

USA BIODIESEL PLANTS: DISTRIBUTION MAP

APPLICATION EXAMPLE: Locating near Logging Camps

Logging Industry

Slash Piles
Wood Waste

BFR

Hydrogen

Merchant Market

Fuel Cells

APPLICATION EXAMPLE: Locating at Lumber Mills

Lumber Industry Plant

Sawdust

Wood Waste

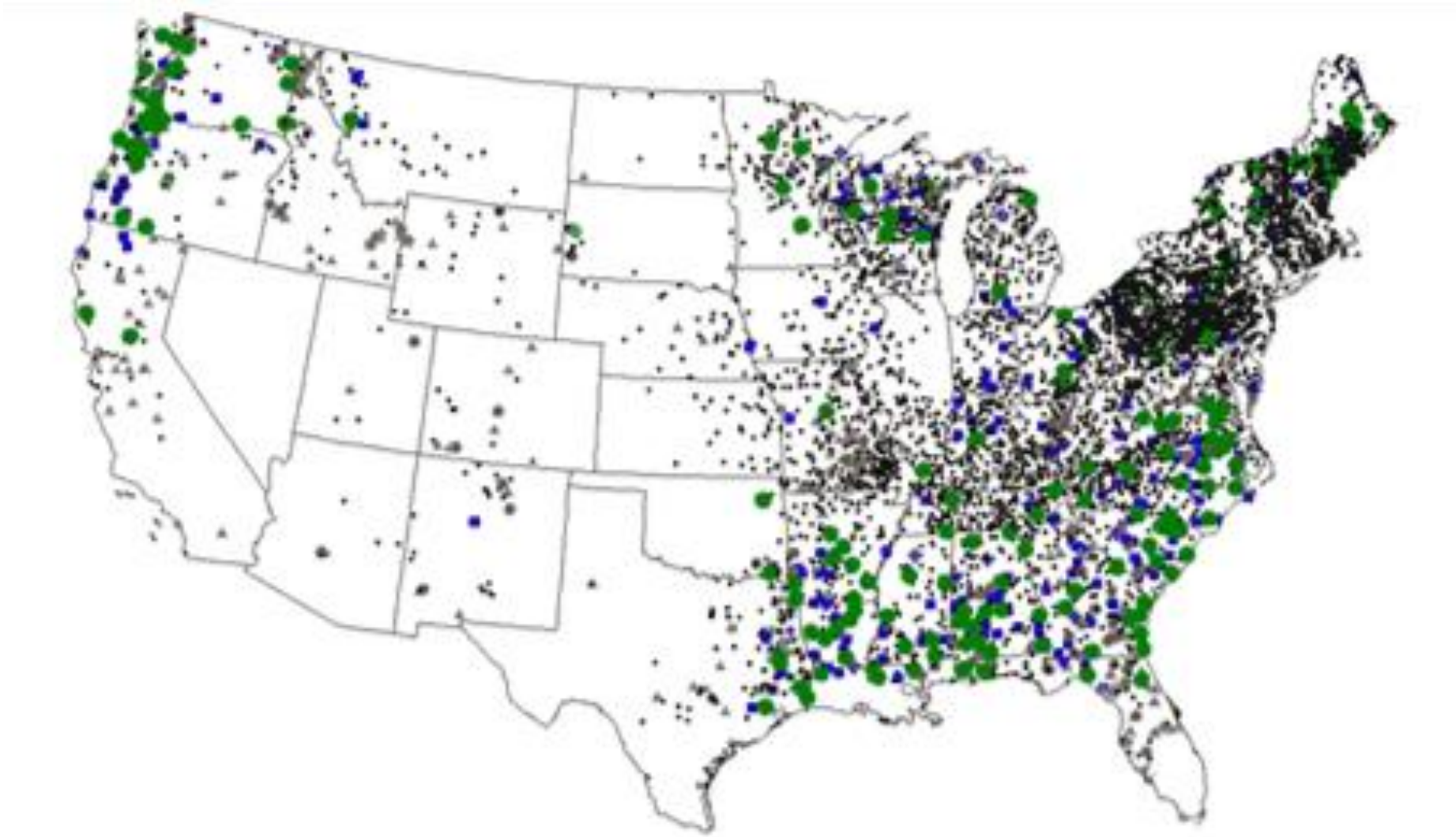
BFR

Hydrogen

Merchant Market

Fuel Cells

USA LUMBER MILLS: DISTRIBUTION MAP



APPLICATION EXAMPLE: Locating at Breweries

- The waste materials from the brewing process include spent grain, spent yeast and trub. Trub is slurry consisting of wort, hop particles, and unstable colloidal proteins coagulated during the wort boiling.

- These waste materials are usually in aqueous form and pose a challenge for local waste water treatment facilities.

- Having these organic wastes in an solution is perfect since the BFR aqueous process.

- Anheuser-Busch Breweries have ordered 800 Nikola Fuel Cell Class 8 Trucks. If they have a BFR on site, they can refill these trucks from brewery waste.

APPLICATION EXAMPLE: Anheuser-Busch Breweries

Anheuser Busch Breweries

Spent Grain, Spent Yeast & Trub Waste*

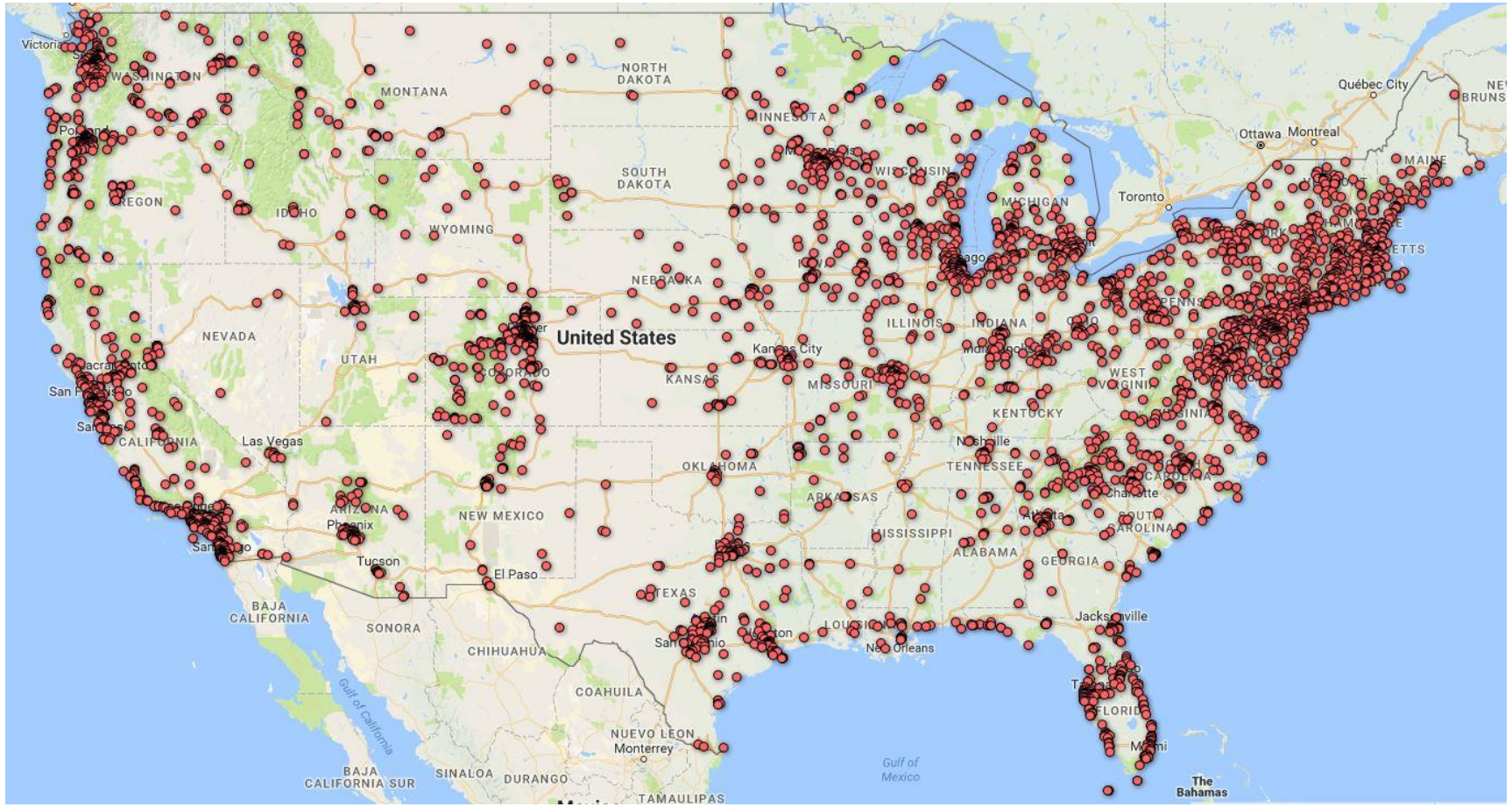
BFR

Hydrogen

800 Nikola Fuel Cell Class 8 Trucks

*wort, hop particles, and unstable colloidal proteins

USA BREWERIES: PLANT LOCATION MAP



Evaluation by Major Hydrogen Plant EPC

TechnipFMC, with headquarters in Paris, France and Houston, TX is an international EPC* and chemicals company with $13 billion in annual sales and 37,000 employees. As part of their business operations, they design and build major hydrogen plants around the world with a 35% market share.
https://www.technipfmc.com/en/what-we-do/onshore-offshore/Onshore-capabilities/Hydrogen

Technip has reviewed our technology in detail and has declared in a letter to us that ***"…this technology will revolutionize hydrogen production."***

Technip will guarantee the performance of the EEI facilities in which they perform the EPC.

* EPC- Engineering, Procurement and Construction

Technip

September 13, 2016

Mr. Steve Racoosin
Bio Carbon Fuels

3849 Pal Mesa Dr.
Fallbrook, CA 92028

Dear Steve:

Technip Stone & Webster Process Technology, Inc. (Technip) has agreed to work with Bio Carbon Fuels in order to develop, design and construct large scale renewable energy facilities on a global basis. This letter is intended to identify the scope of the work, and the collaboration between our two companies.

Technip is a corporation organized and existing under the laws of Delaware whose place of business is located 555 West Arrow Highway, Claremont, CA 91711, USA. Technip is considered a premier project engineering, design and construction firm with global capability and a world leader in emerging technologies for Alternative Energy Production Capability.

Technip will offer consulting, studies, project management, risk management, as well as engineering, preliminary and detailed design, procurement, construction, construction management and pre-commissioning start-up services up to mechanical completion, by way of engineering services, engineering and procurement or EPC contracts for any project.

On global projects, Technip will collaborate with the other Technip entities, to ensure local content, and maximizing the use of local experience within the Technip group.

Technip will guarantee the maximum performance achievable, based on industry standards, for the EPC performance to satisfy the project lenders requirements, and be subject to the contract between Technip and Bio Carbon Fuels for that project. The technology of Base Facilitated Reforming of Hydrogen from renewable waste is extremely interesting to Technip. After completion of the engineering process, this technology will revolutionize hydrogen production.

Technip will assist Bio Carbon Fuels with information required for local permitting and government requirements. Technip agrees to be market competitive and work on an open book basis during front end loading (FEL) / front end engineering design (FEED), activities for the project.

Technip agrees to "stand by" Bio Carbon Fuels in certain project presentations and in certain financial negotiations to add its global credibility to the overall proposals.

Sincerely,

Jeroen Snijder

SUMMARY

- The Hydrogen Merchant Market has been forecast to grow twenty fold by 2030.
- Our Base Facilitated Reformation (BFR) process has been successfully demonstrated using a wide variety of renewable feedstocks.
- Using the BFR technology can convert over 90% of organic waste to useful energy, thus reducing landfill space requirements along with the resultant long term methane and carbon dioxide emissions from the landfills proportionately.
- Reformation of municipal wastes, agricultural waste, biomass and other organic materials, produces clean energy, helps solve environmental and social issues; all while making a profit.

SUMMARY (continued)

- As shown in the previous maps, organic waste feedstocks are readily available across the USA, affording the opportunity to economically produce hydrogen in most regions and thus forming a hydrogen infrastructure with minimal transportation costs.

- Similarly, these same organic waste feedstock opportunities exist worldwide facilitating the creation of a global hydrogen infrastructure.

- With the BFR, each 300 metric ton/day of MSW (typical facility) can produce 24 metric ton/day of pure Hydrogen. The top 1/3 of the landfills (581 sites) in the USA process a total of 200,458 tons of MSW per day, which could produce 16,036 million kgs of hydrogen per day or 5,616* **million** kgs per year.

** Allowing for 2 weeks of maintenance*

SUMMARY (continued)

- Technip will guarantee the maximum performance achievable for BFR plants that they do the EPC (Engineer, Procure and Construct). This guarantee also helps secure financing for these projects.

- Eco Energy International reformation can be the bridge to the hydrogen economy, providing immediate cost and distribution advantages to present and future hydrogen users by enabling a low cost hydrogen production and distribution infrastructure all while reducing the environmental impact of municipal, agricultural and other biogenic waste streams.

THANK YOU

Dan Madden, PE
CEO
Eco Energy International

cell: (714) 336-6666
pdmadden@ecoenergyinternational.com

www.EcoEnergyInternational.com