# T2C-ENERGY

Biogas to Diesel

Hinkley Center for Solid and Hazardous Waste Management

Funding 2011

CLEANTECH Intelligent Innovations

Funding 2016-Present

GlobalVenture Challenge™ 2010

Winner 2010

MegaWatt VENTURES

Winner 2012

CLEAN TECH OPEN SOUTHEAST

Winner 2013

U.S. DEPARTMENT OF ENERGY

Funding 2016-Present

FESC Florida Energy Systems Consortium

Universities Addressing Florida's Energy Needs

Funding 2008

tbtf Tampa Bay Technology Forum

Innovation of the Year 2013

Forbes

30 Under 30 2014

USF UNIVERSITY OF SOUTH FLORIDA

20 VENTUREWELL™ 20 years of idea to impact

Funding 2014

# Problem/Opportunity

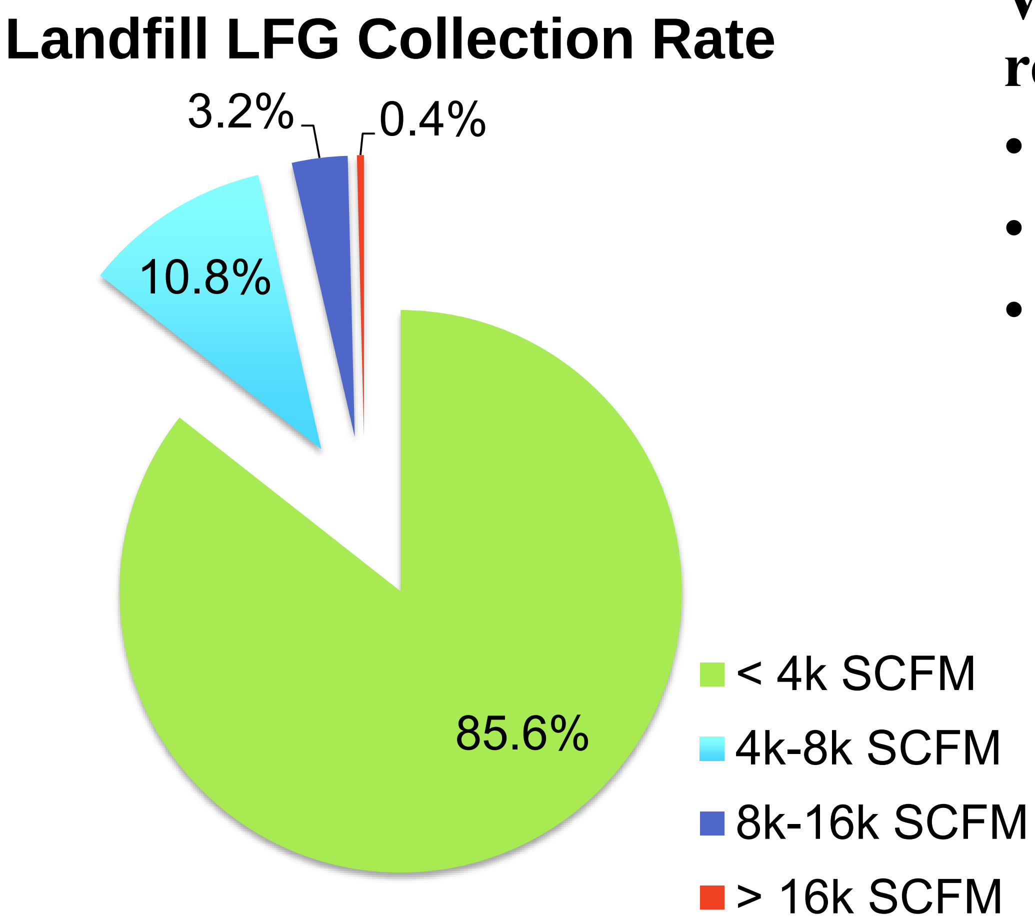
$CH_4$ & $CO_2$

**234 MM tons/year of Garbage**

- 2,450 Landfills in US
- 20% of Human Source of Methane
- Requirement to Capture and Mitigate
- RFS Increase in RVO
- Waste Industry Consumes ~ 4% US Diesel consumption
- Ag Industry Consumes ~3% US Diesel Consumption
- AD Technology Advancements (~1,500 projects operating in US)

# Current Issues

## Total US Biogas Generation Rate ~ 800,000 SCFM




**What's the best use of this energy resource?**

- Electricity generation
- Biomethane
- Gas to Liquids

**Key Factors**

Economics

Infrastructure

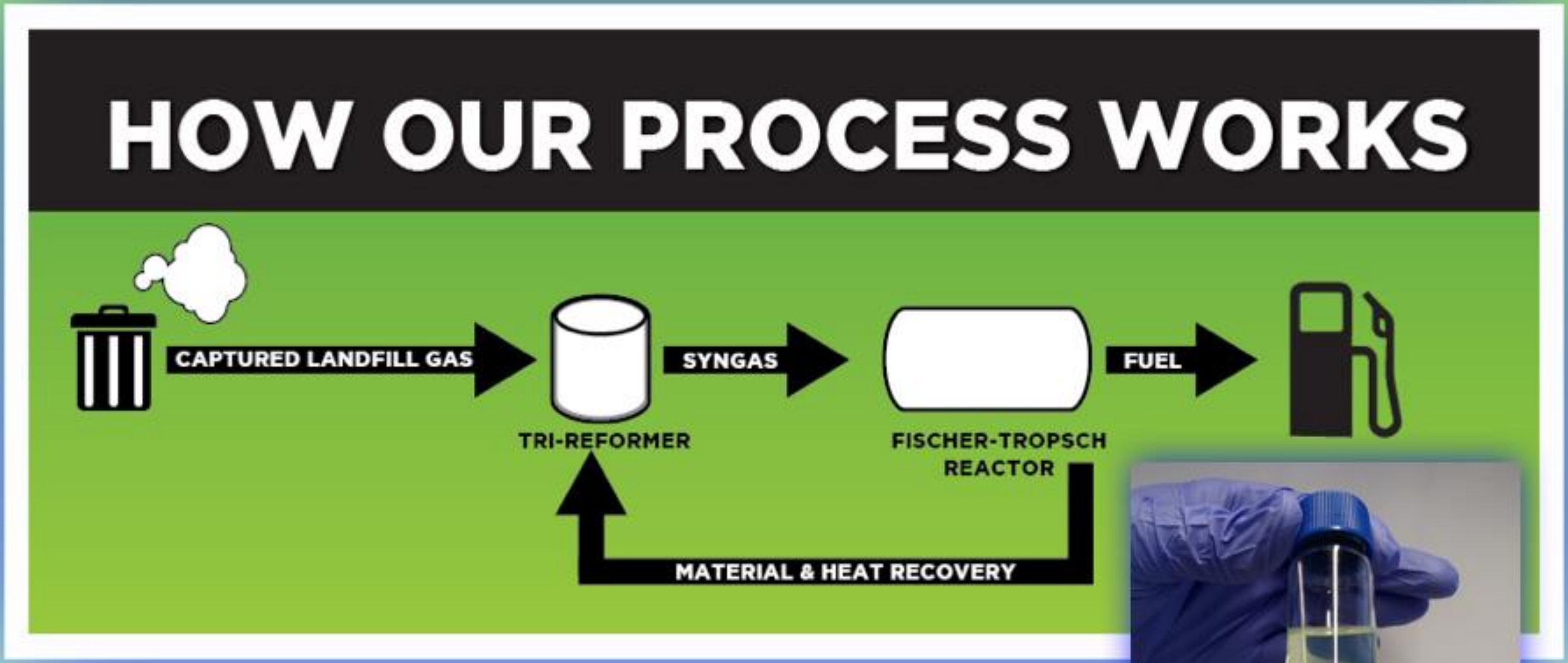
Location

Efficiency

Policy

# Focus and Technology

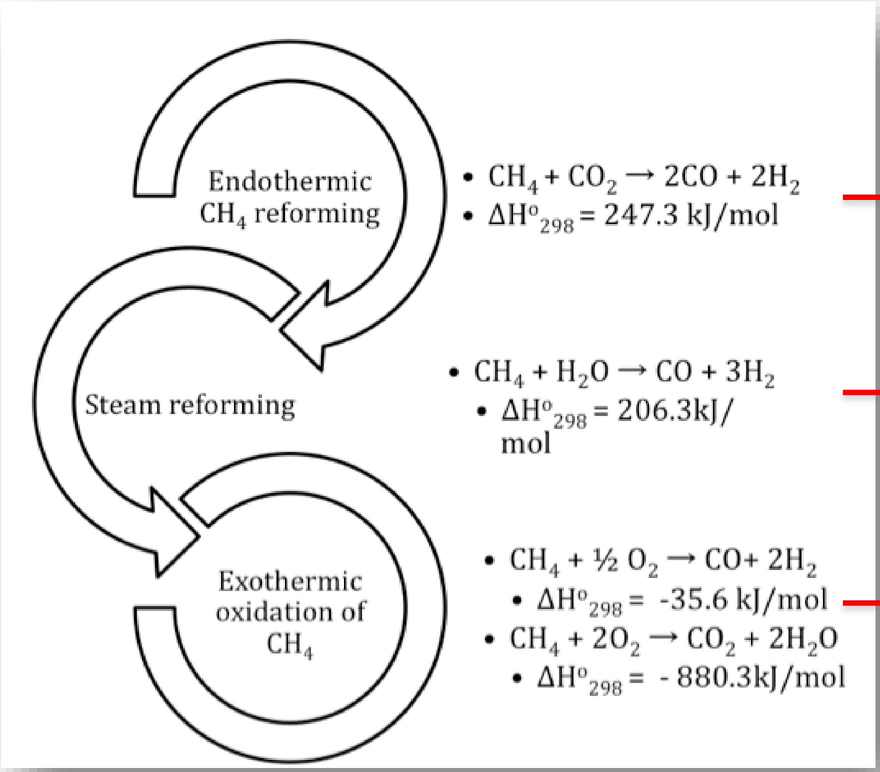
**Demonstrate small scale GTL in economical and profitable manner**




# Project Overview

## Tri-reforming:

- Minimize cleanup and pretreatment process
- Less energy consumption
- Produce high quality syngas ($H_2$:CO ~ 2)




→ **Utilize 100% of biogas as feedstock**

→ **Control H2 and CO selectivity**

→ **Generate heat in-situ**

# Project Overview

## Tri-reforming of LFG

| Catalyst Bed temp. (°C) | GHSV (h$^{-1}$) | $CH_4$ conv. (%) | $CO_2$ conv. (%) | $H_2$:CO |
|---|---|---|---|---|
| 770-810 | 30,000 | 92-99 | 52-72 | 1.70-2.23 |

**Catalyst Optimization**

Thermally Stable

High Surface Area

Coke Resistant

High OSC

Excellent Redox Properties

High Dispersion

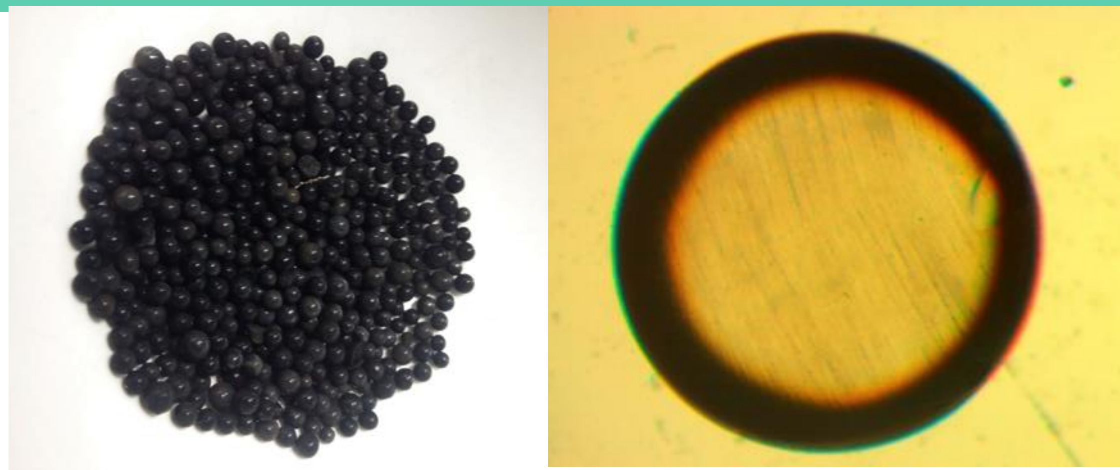
Excellent Selectivity

High Activity

Economical

Low Pressure Drop

# Project Overview



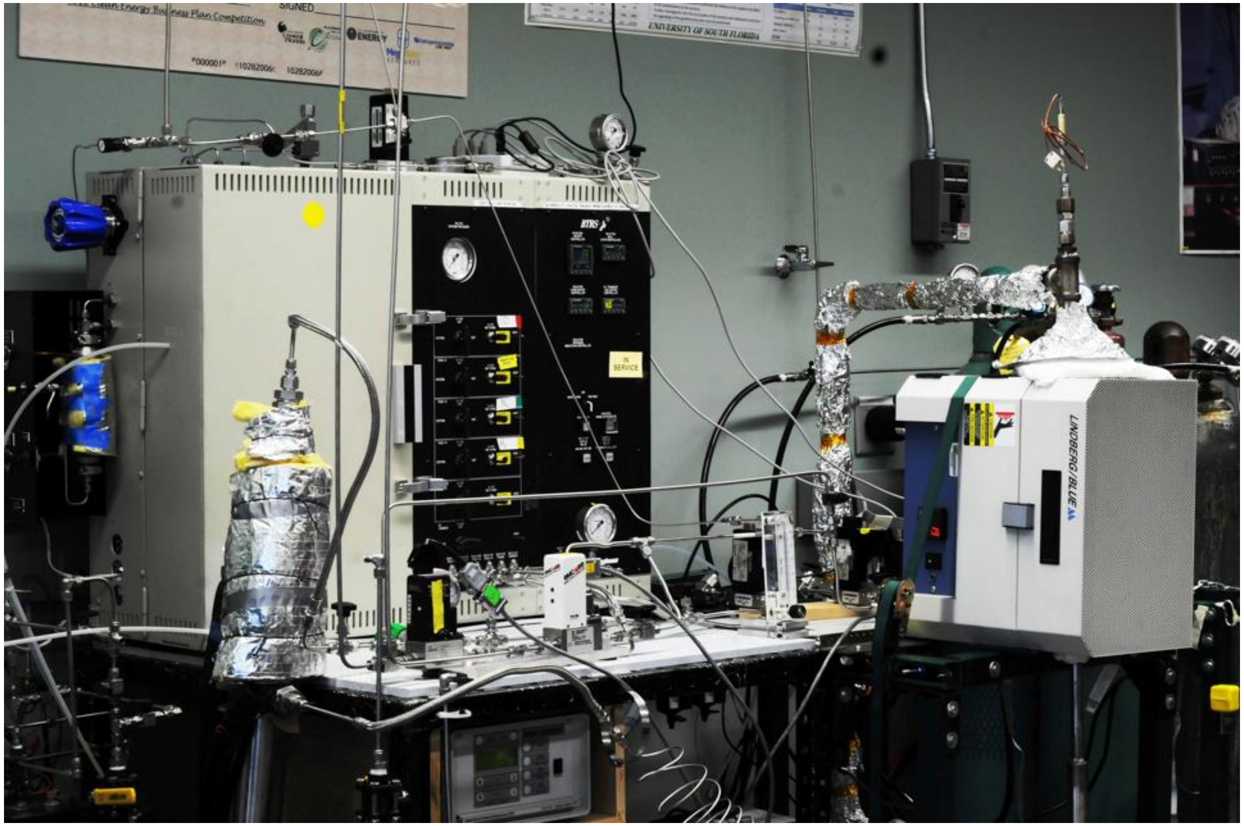
**FTS Eggshell Catalyst**

- Overcome mass and heat transfer limitations
- Selective product distribution in middle distillate region
- Avoid wax production

| CO % Conv | LFG Energy Recovery In Liq Fuel (%) | Selectivity (%) | | |
|---|---|---|---|---|
| | | $C_{1-4}$ | $CO_2$ | $C_{5+}$ |
| 71 | 40 | 43.7 | 1.4 | 55.0 |

# Project Overview

## Benchscale TRIFTS Unit



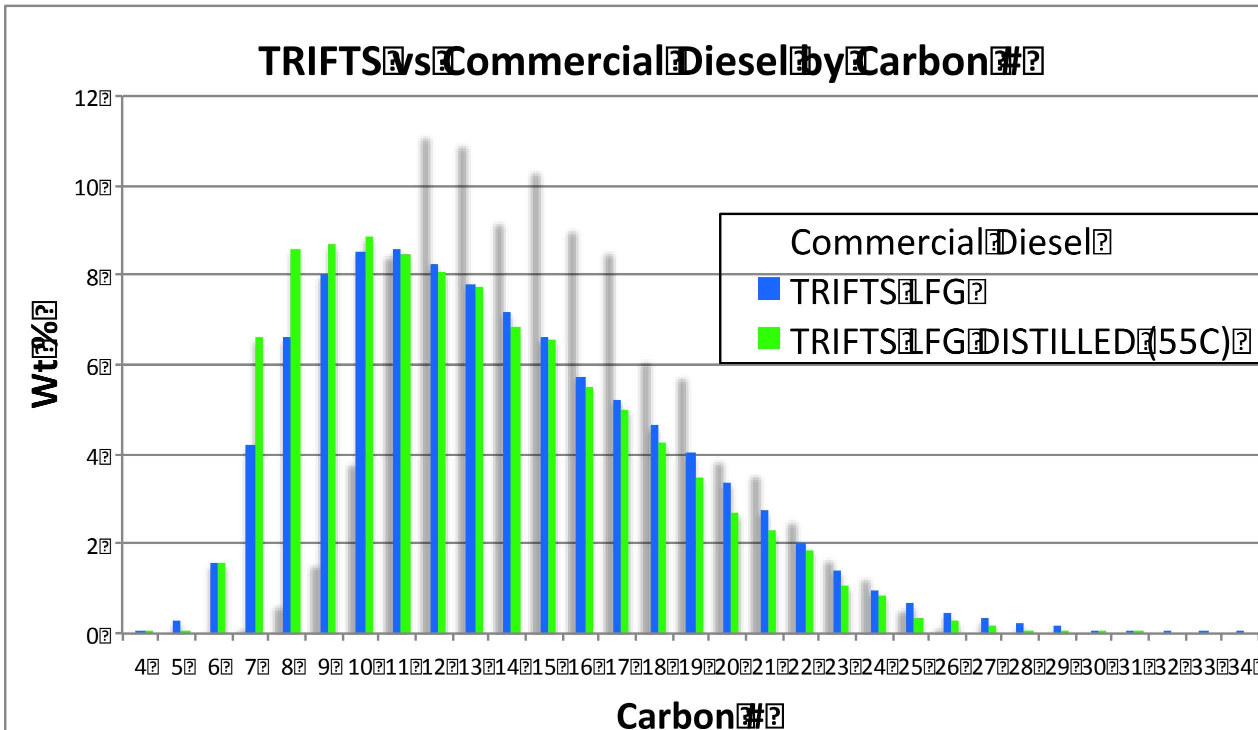
- **Optimize process conditions**
- **Facilitate Pilot/Demonstration Design**
- **Plug bench data into ASPEN**
- **Update full scale techno-economic analysis**

# Project Overview

## Fuel Analysis

- Low aromatics improve net heat of combustion and reduce soot
- Isomers improve cold temp properties
- Further reduce olefin content w/ addition of catalyst promoters
- Excellent middle distillate boiling point distribution
- Control phase separation temp to fractionate light ends
- Final boiling point aligns with commercial diesel

| Hydrocarbon Family | T2C-E (H2:CO=1.7) | Commercial Diesel |
|---|---|---|
| Paraffins | 67.164 | 19.95 |
| Isomers | 28.243 | 31.6 |
| Olefins | 4.323 | 0.92 |
| Aromatics | 0.02 | 39.48 |
| Cyclics | 0.25 | 8.05 |



# Project Overview

## ASTM D975 “Standard Specification for Diesel Fuel Oils”

## Fuel Analysis Results

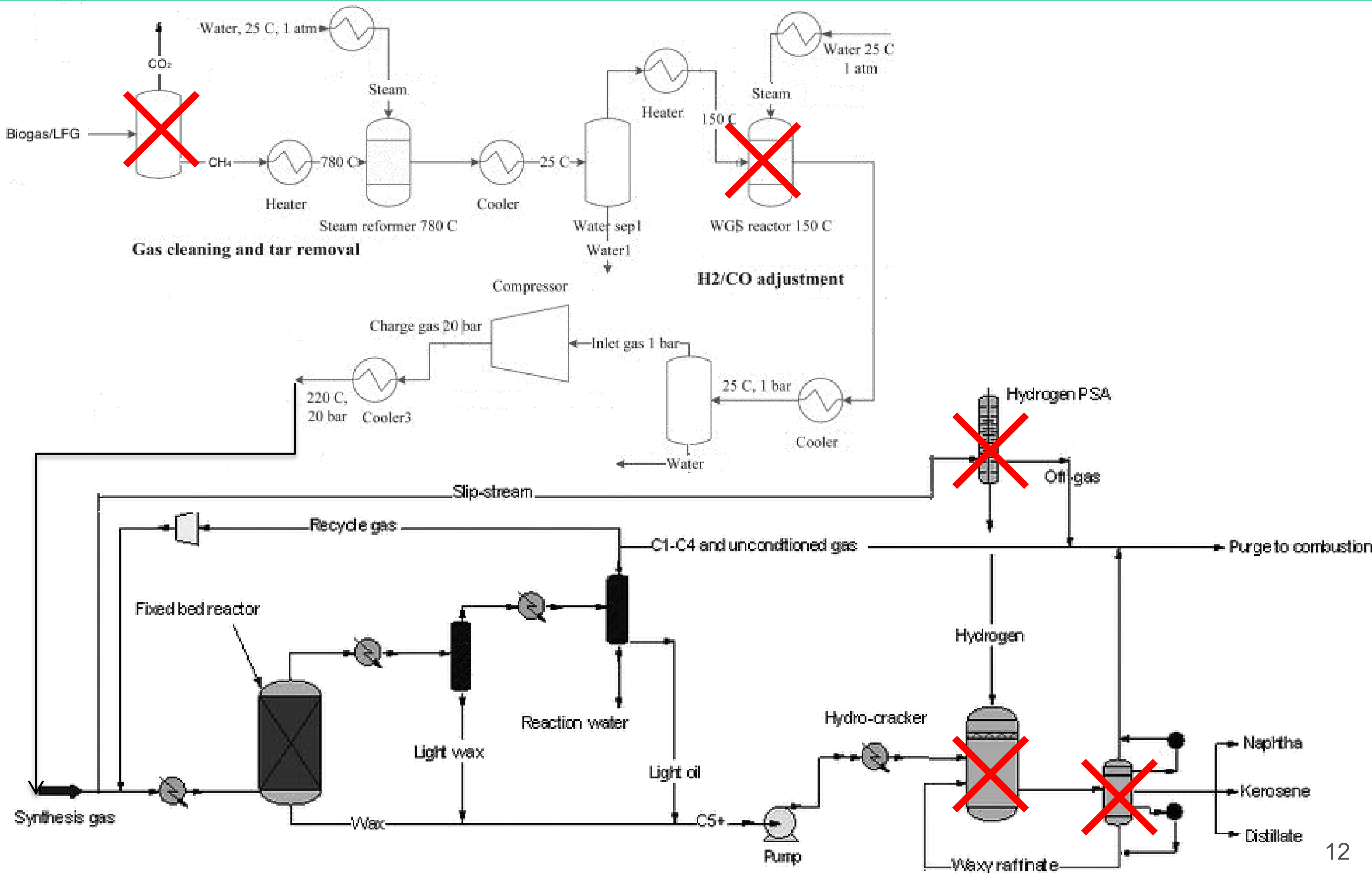
| Fuel Analysis, ASTM Standard | Spec (No. 2 Diesel) | Commercial Diesel | TRIFTS LFG | TRIFTS LFG (Dist 55C) |
|---|---|---|---|---|
| Specific Gravity, ASTM D4052 (g/cc) | | 0.8215 | 0.7386 | 0.7489 |
| Cetane Index, ASTM D976 | ≥ 40 | 57.6 | 84.5 | 72.7 |
| Cetane Index, ASTM D4737 | ≥ 40 | 59.7 | 92.3 | 83.4 |
| Flash Point, ASTM D93 (°C) | ≥ 52 | 87 | 49 | 57 |
| Cloud Point, ASTM D2500 (°C) | | -6 | -6 | -3 |
| Pour Point, ASTM D97 (°C) | | -9 | -9 | -6 |
| Distillation, ASTM D86 (°C) | | | | |
| IBP: 0.5wt% | | 203 | 143 | 142 |
| 10% | | 220 | 164 | 154 |
| 50% | | 269 | 234 | 216 |
| 90% | 282-338 | 329 | 327 | 314 |
| FBP: 99.5% | | 378 | 388 | 378 |
| Net Heat Comb., ASTM D3338 (MJ/kg) | | 43.164 | 44.520 | 44.355 |

# Pilot/Demonstration Scale Up

**35 SCFM LFG Feed → 111 Gal/Day Diesel**

Example of skid mounted unit

# Key Challenges and Approach

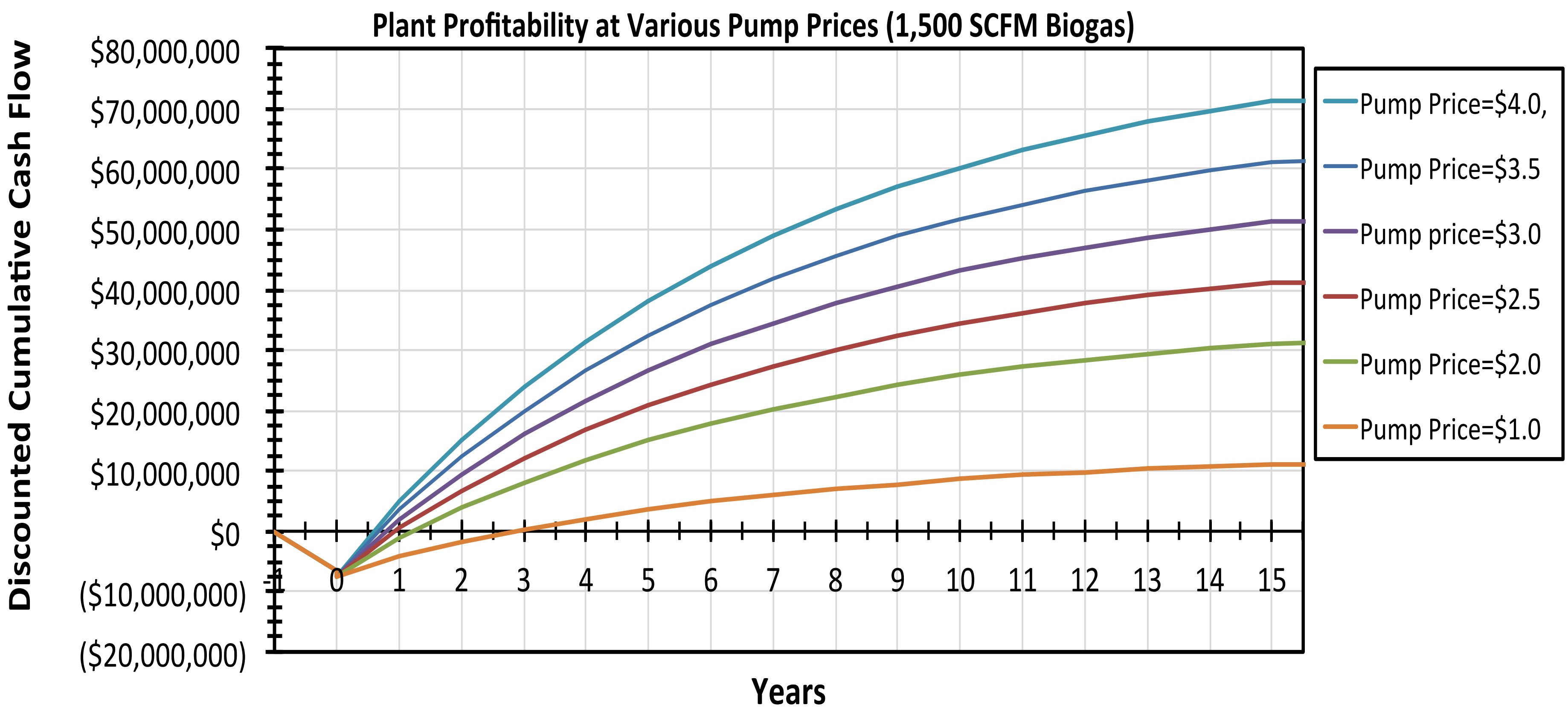


# Key Challenges and Approach

- Reformer energy requirement met by FTS fuel gas
- Efficient heat integration
- Utility requirements provided by process itself
- Overall self sufficient process
- Minimize any outside fossil fuel derived energy inputs

| Energy Requirements and Generation from 1500 scfm LFG Plant | | |
|---|---|---|
| | BTU/hr Required | BTU/hr Produced |
| Reformer requires | 14,472,000 | |
| Fuel Gas Energy Content | | 22,488,465 |
| Boiler | 1,820,786 | |
| LFG cooler | 160,414 | |
| Reformer HX | | 7,319,143 |
| Syngas cooler | 1,807,500 | |
| FTS cooler | 3,451,114 | |
| FT reactor | | 9,761,143 |
| Compressor 1 | 399,112 | |
| Air Compressor | 258,223 | |
| Compressor 2 | 1,287,300 | |
| Compressor 3 | 1,068,006 | |
| TOTALS | | |
| Equip/RXN Required | 24,724,456 | |
| Energy Produced | | 39,568,751 |
| Net Energy Produced | | 14,844,295 |
| Additional Electric Power Generation | 0.86 | MW |

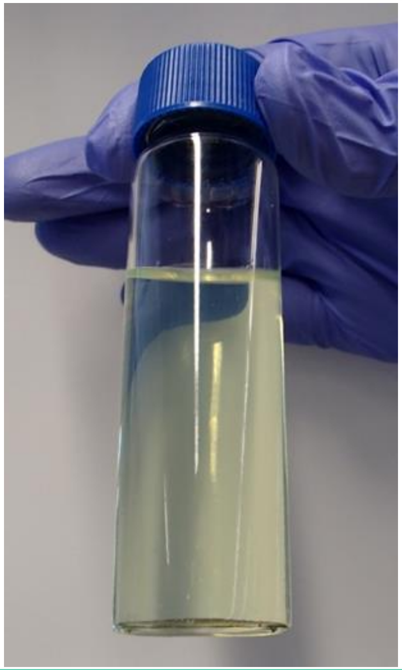
# **Financials** (1,500 SCFM Biogas)
## 118 bpd (5k gal/day) Diesel Facility




- At current pump price of 2.47 NPV = $40.6MM
- Initial Construction Capital $7MM
- RIN = $4.47/gal diesel (D3 ~ $2.63/RIN)
- Breakeven No RIN credit at 435 SCFM biogas production rate

# Unique Aspect Summary

- **Utilize 100% of  Biogas Feedstock ($CO_2$ Utilization)**
- **Significant Reduction of Unit Operations**
- **Compatible with Current Infrastructure**
- **High Quality Value Add Product (Drop-In Diesel)**
- **Self Sufficient Process**
- **Vastly Improved Economics and Profitablitliy**

# Management Team

**Devin Walker**
CEO

**Dr. John Kuhn**
President

**Dr. Babu Joseph**
VP

**Timothy Roberge**
CFO

**Dr. Ali Gardezi**
CTO

- 40+ Years in Biofuel Industry
- Recognized Industry Leaders
- Proven Track Record in Technology Scale Up
- Partnered with USCleantech and Renovare Fuels as part of US and Global Business Strategy

# Questions

# Sustainable Solutions for The Waste To Energy Sector