

DOE Bioenergy Technologies Office (BETO) 2021 Project Peer Review

Cool GTL to Produce Jet Fuel from Biogas

March 25, 2021

WBS: 3.5.1.405

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Gas Technology Institute

Cool GTL for the Production of Jet Fuel from Biogas

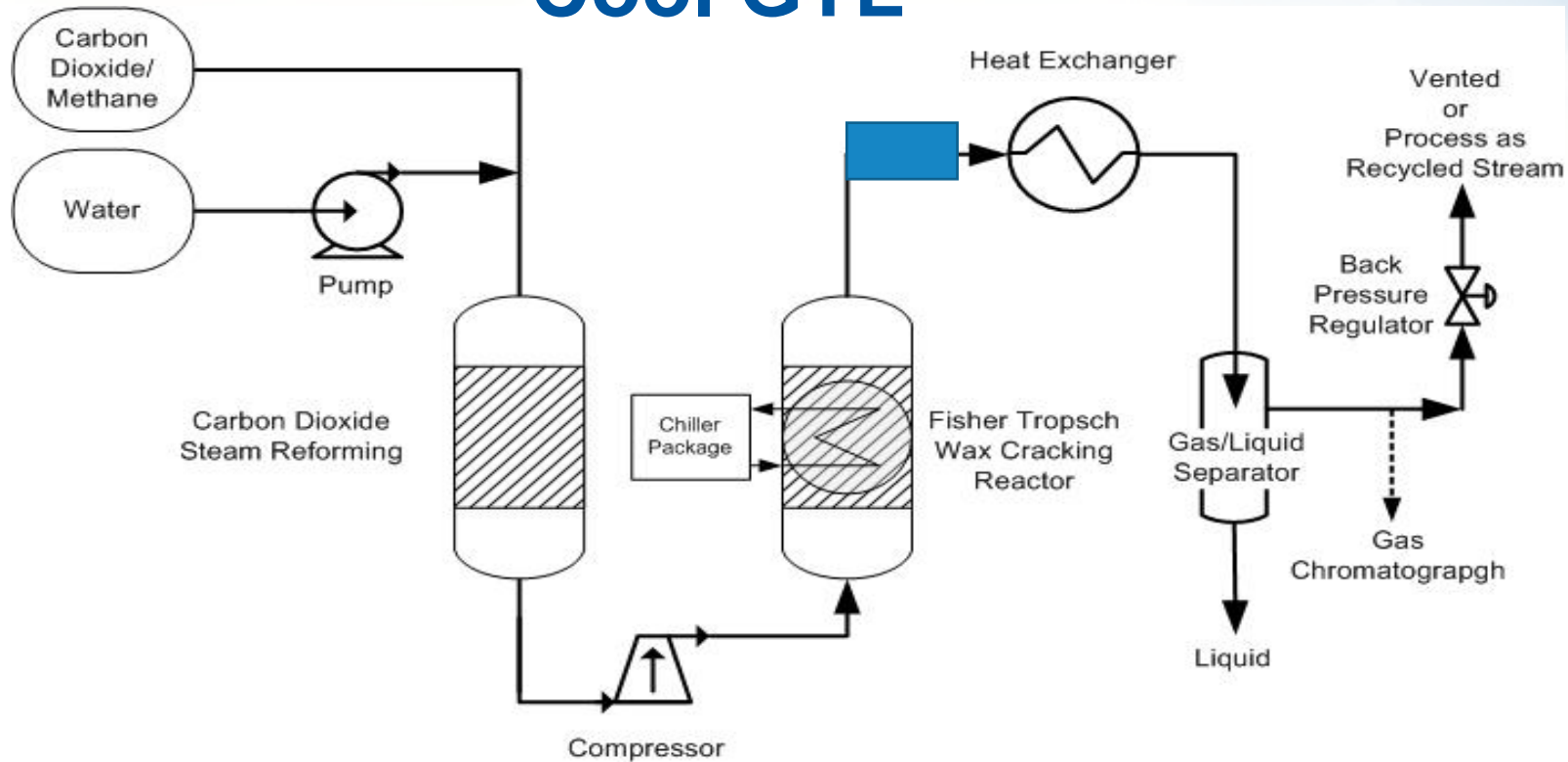
Project Overview

Project Overview

Cool GTL to Produce Jet Fuel from Biogas

- *Goal is to produce 100 gallons of Jet Fuel from Biogas using the Cool GTL Process*
 - *GTI will demonstrate a new simple GTL process which converts biogas, CO₂, and methane directly to jet, gasoline, and diesel*
 - *Show the technology to be significantly lower cost, and more efficient than previous GTL processes- produce jet fuel at < \$3/GGE*
 - *Also complete modeling, engineering, techno-economic and LCA for Cool GTL biogas commercial process- advance from TRL 3 to 5*

Cool GTL



- Converts CO₂-rich methane, ethane and propane to high-quality gasoline, diesel and jet fuel
- Works well for any gas containing CO₂ or CO
- Uses unique CO₂/steam reforming catalyst to directly make 2:1 H₂/CO synthesis gas
- Uses unique combined Fischer-Tropsch and wax-cracking reactor
- Simple and compact with unique catalysts in each stage

Unique Cool GTLSM Technology

Novel Features

- Unique bi-reforming catalyst
- Unique wax cracking-FT catalyst
- Unique electric reformer design



Two patents issued
and several others
pending

Beneficial Results

- Modular, low-cost GTL
- Small footprint
- Great economics
- Distributed plant locations

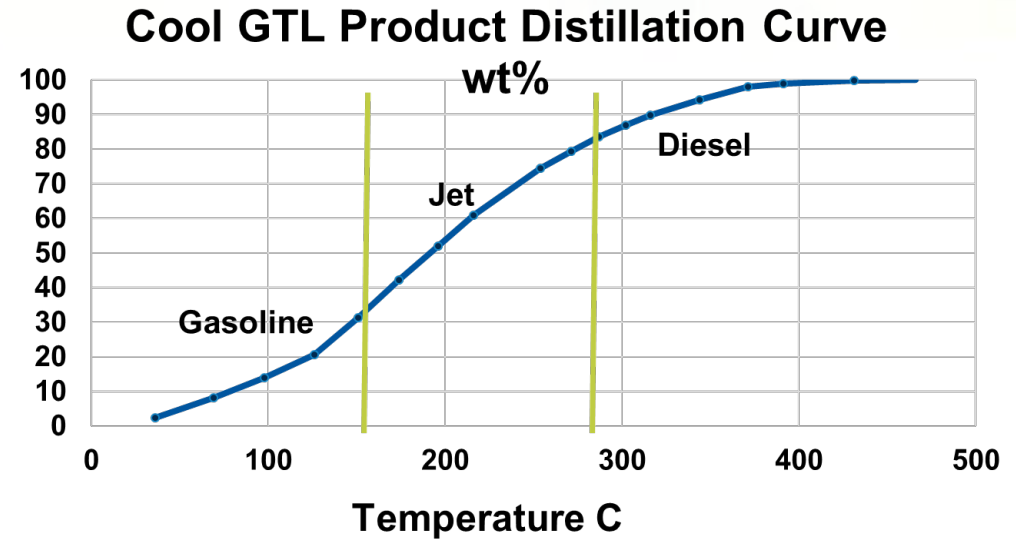
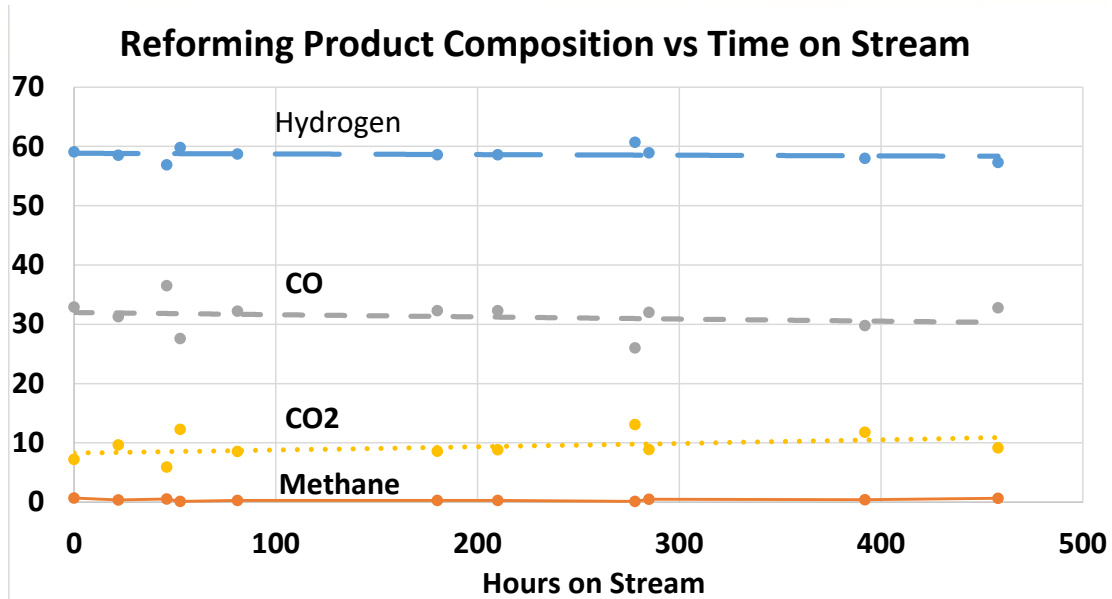
Current GTL



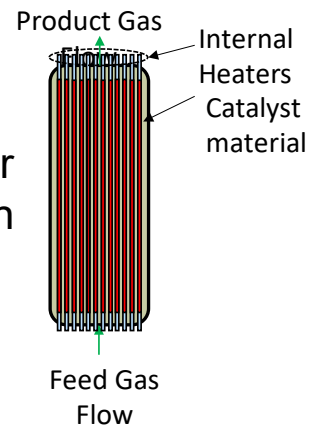
Cool GTLSM



Cool GTLSM – High Quality Products



Electric reformer
One reactor with
internal heating
elements

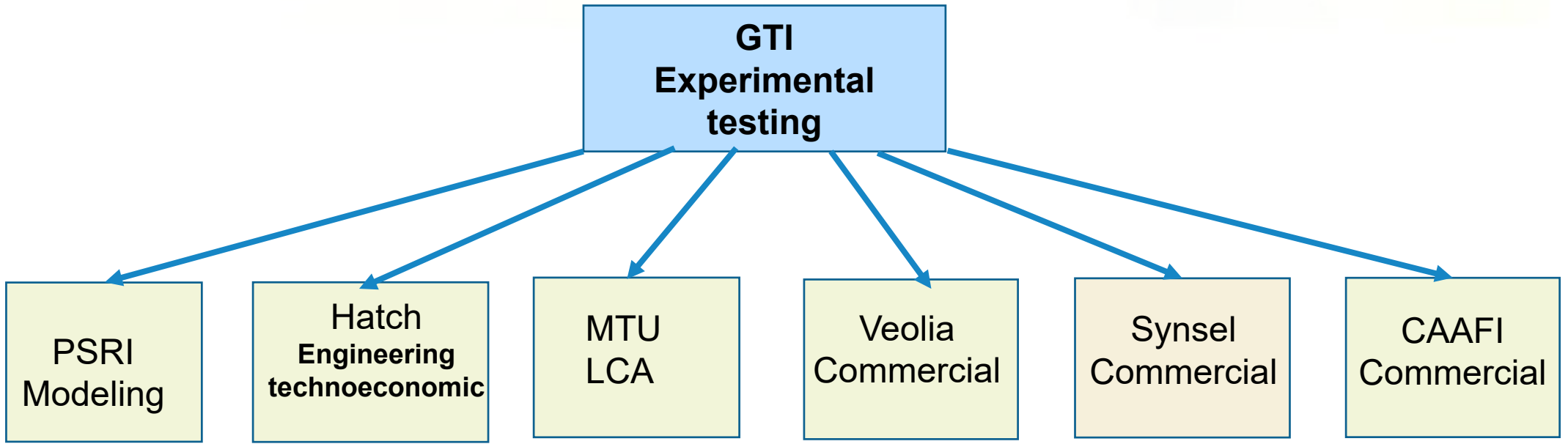


Cool GTL for the Production of Jet Fuel from Biogas

Management

Project Management

Cool GTL to Produce Jet Fuel from Biogas



Additional Contractors

- 1 INL-Forest Concepts- IH2 Feed Preparation
- 2 Intertek/SGS – Jet Product Workup

Project Management –Risk Mitigation

Cool GTL to Produce Jet Fuel from Biogas

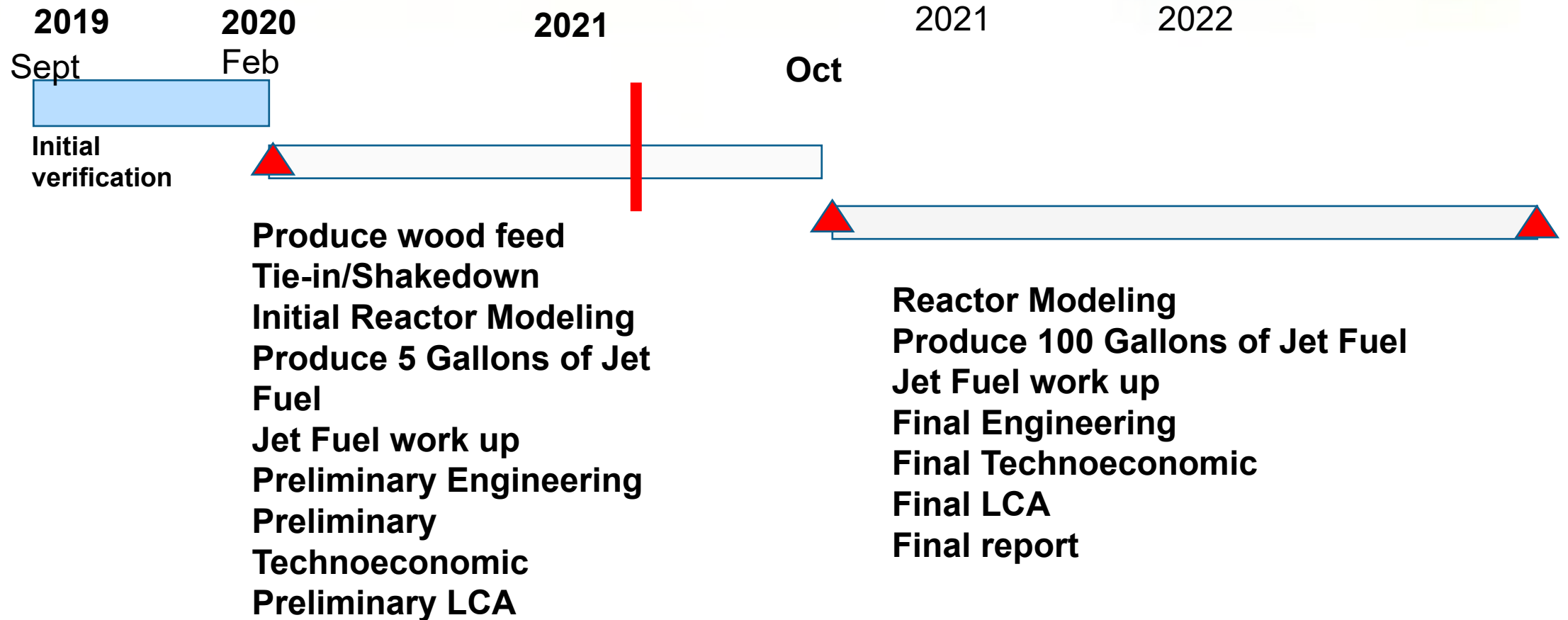
- Monthly Team Meetings
- Additional meetings as needed with engineering, modeling and LCA team.
- 3 phase approach with important milestones and intermediate reports

Cool GTL for the Production of Jet Fuel from Biogas

Approach

Approach

Simplified Biogas to Jet Fuel Timeline

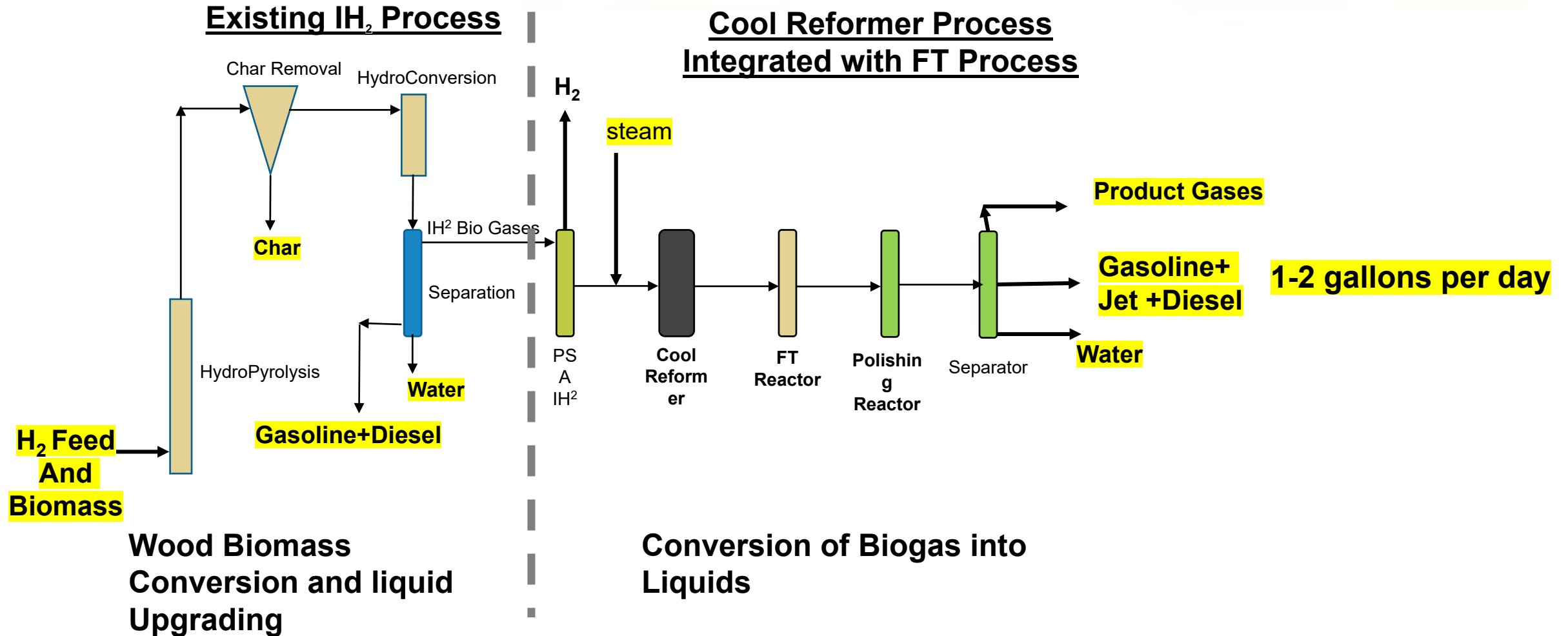


We are currently in Budget Period 2

Second Budget Period Key Tasks

- Integrate/Tie in Cool GTL Pilot plant with IH² Unit
- Shakedown integrated system
- Preliminary Engineering, modeling and LCA
- Make 5 Gallons Jet fuel
- Analyze the Jet fuel – pass specifications

Process Flow Diagram for the IH² and Cool GTL Process Larger Pilot Plant for Budget Period 2 DOE Tests



Key Milestones Budget Period 2



In Progress



- Integrate Cool GTL with IH²
- Shakedown of the Cool GTL System with the IH² system
- Short term testing of the Cool GTL system.
 - Make 5 Gallons of Jet Fuel
 - Cool reformer makes 2.1-2.4 H₂/CO synthesis gas
 - Cool FT operates at >60% Conversion per pass
 - Catalyst deactivation < 5C./200hours
- Modeling of the Fischer Tropsch Reactor
- Initial Engineering design package
 - 2 commercial designs 800bbl/d for IH₂ and 100bbl/d for digester
- **DECISION POINT** DOE verification – Initial analysis jet fuel at 3.5 /GGE

Key Technical Challenges Budget Period 2

- Integrated system working stably
- Produce high quality jet fuel which makes freeze point
- Reach \$3.5/GGE in initial techno-economic pass verification

Cool GTL to Produce Jet Fuel from Biogas

Impacts

Cool GTL Applications & Markets

- Biogas to GTL → Direct utilization of CO₂ methane, ethane, propane
- Increase liquid production from biomass conversion with IH₂ and Gasifiers
- CO₂ from DAC plus Hydrogen conversion to liquid fuels
- Flare gas mitigation → any CO₂ containing natural gas, offshore, Africa
- High CO₂ content natural gas → utilize some shut-in natural gas

Cool GTL is a versatile process with multiple applications

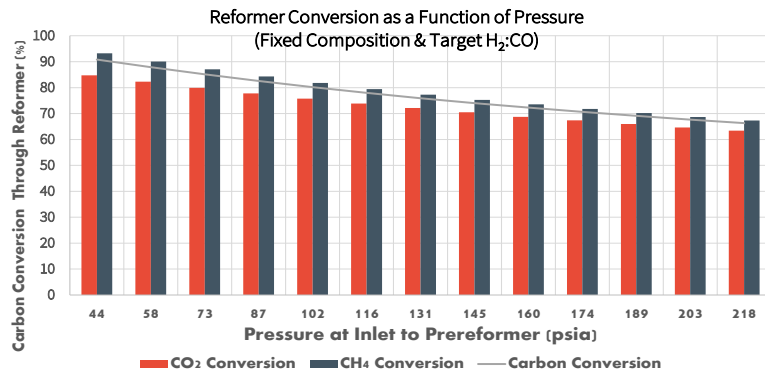
Cool GTL for the Production of Jet Fuel from Biogas

Progress and Outcomes

Cool GTL to Produce Jet Fuel from Biogas Progress – Engineering - HATCH

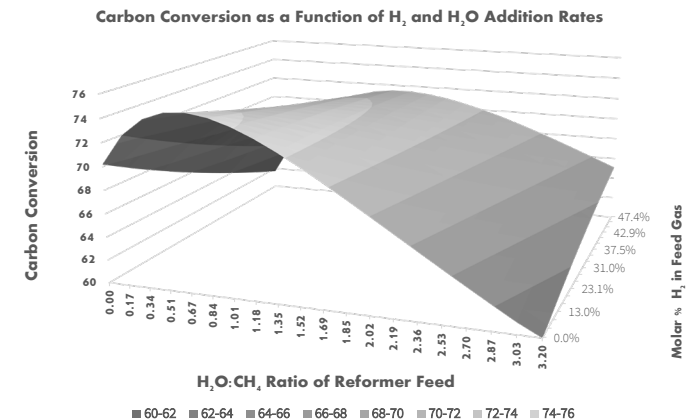
- Initial Process design and modeling complete
 - 800bl/d case IH₂ feed
 - 100bbbl/d digester feed

Bi-Reformer Optimization – IH²



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Bi- Reformer Optimization – Biogas Case

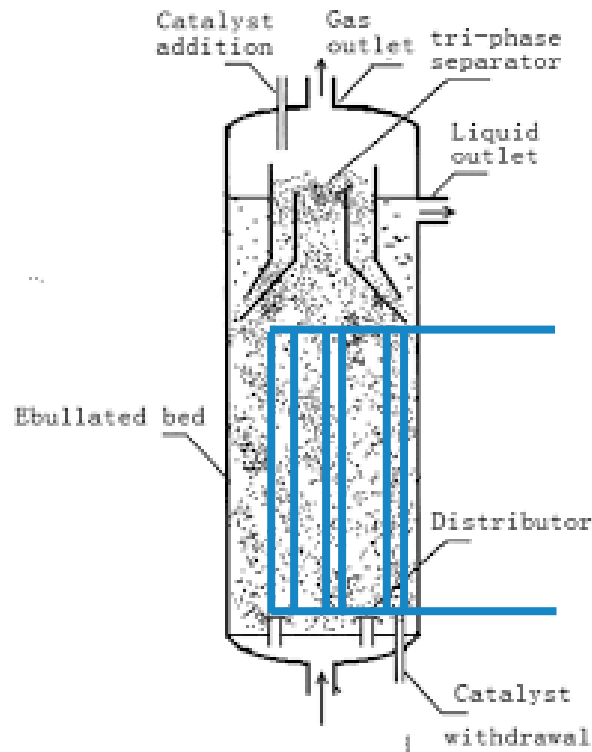


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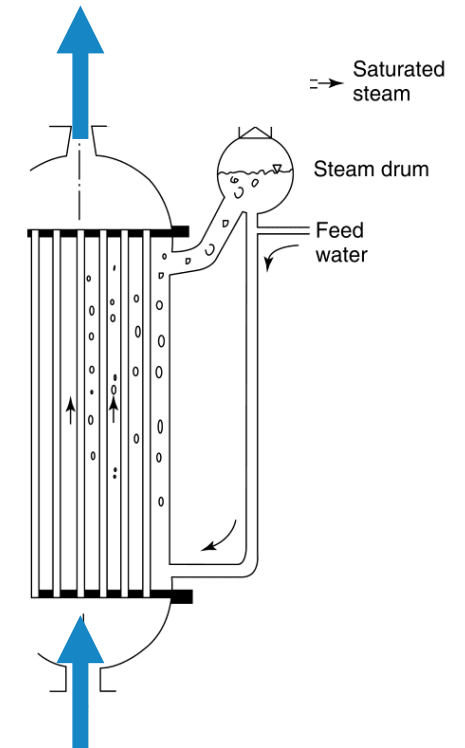
- Capital cost and technoeconomic in progress

Cool GTL to Produce Jet Fuel from Biogas Progress – Fischer Tropsch Reactor Modeling - PSRI

- Two reactor designs to be evaluated
 - Ebulliated bed reactor
 - Tubular Reactor



Ebulliated Bed



Tubular Reactor

Cool GTL Pilot Plant – Connected to IH2



Cool GTL Pilot Plant – Control Room and Product Recovery



Cool GTL Sulfur Guard Bed and Panoramic view



Cool GTL – Large Pilot Plant work

- Integration complete
- Shakedown In Progress
- 5 Gallon Jet Fuel from Biogas to be produced April

Cool GTL – Life Cycle Analysis

- In Progress

Cool GTL for the Production of Jet Fuel to Biogas

Summary

- Unique new GTL technology for Biogas Conversion
- Project in Budget Period 2
- Engineering, LCA, Modeling, Pilot Plant Shakedown Progressing

Quad Chart Overview

Cool GTL for the Production of Jet Fuel from Biogas

Timeline

- Project start date **Sept 2019**
- Project end date March 2023

	FY20 Costed	Total Award
DOE Funding	\$538,208	\$2,986,005
Project Cost Share	\$258,000	\$853,563

Project Partners*

- Hatch, MTU, PSRI
- Veolia, Synsel, CAAFI.

Project Goal

Make 100 gallons of Jet fuel from Biogas using Cool GTL technology

End of Project Milestones

- 100 gallons of jet fuel while achieving catalyst deactivation <5C/500hr
- Jet fuel specifications are passed.
- The model predicts pilot plant results well +/- 10C at 60% CO conversion
- Complete engineering design package for 800bbl/day and 100bbl/day
- Jet Fuel produced at <\$3/GGE
- Biogenic fuel reduces greenhouse gas emissions by > 65%
- DOE verification passed

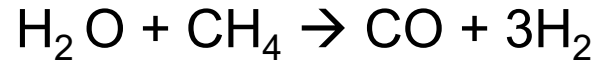
Funding Mechanism

DOE DE-EE-0001926 – Topic area 1 ,
FOA issued in 2018

Additional Slides

Cool GTLSM Reactions

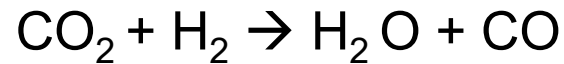
Cool Reforming Reactor



CO and H₂ formation (800°C)

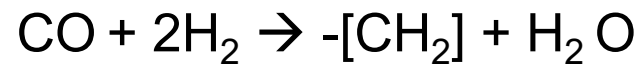


CO and H₂ formation (800°C)



Water-gas shift to equilibrium

Fischer-Tropsch (F-T) Reactor



Hydro/oligomerization (200°C)

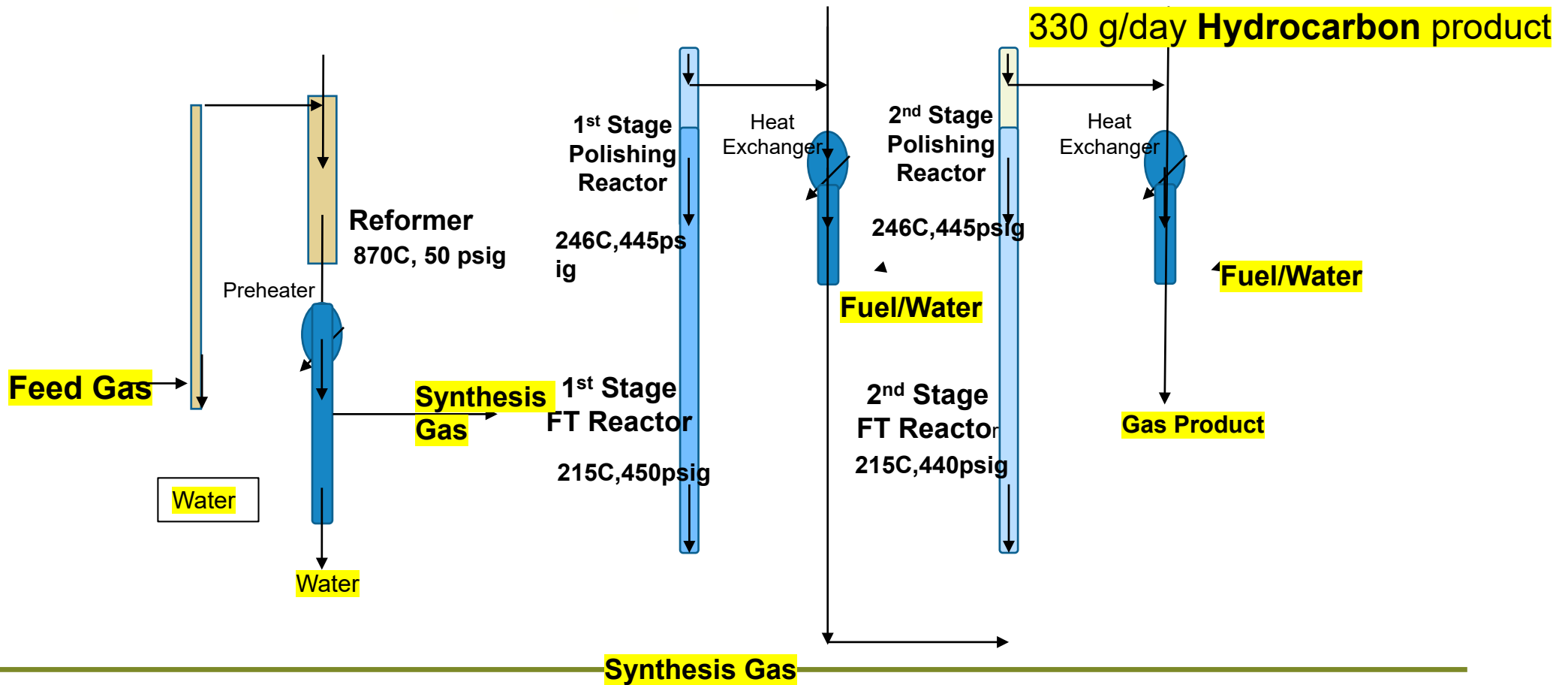


Isomerization (200°C)

Initial verification – Passed – Feb 2020

– Cool Reformer and FT Process Small Pilot Plant in 554

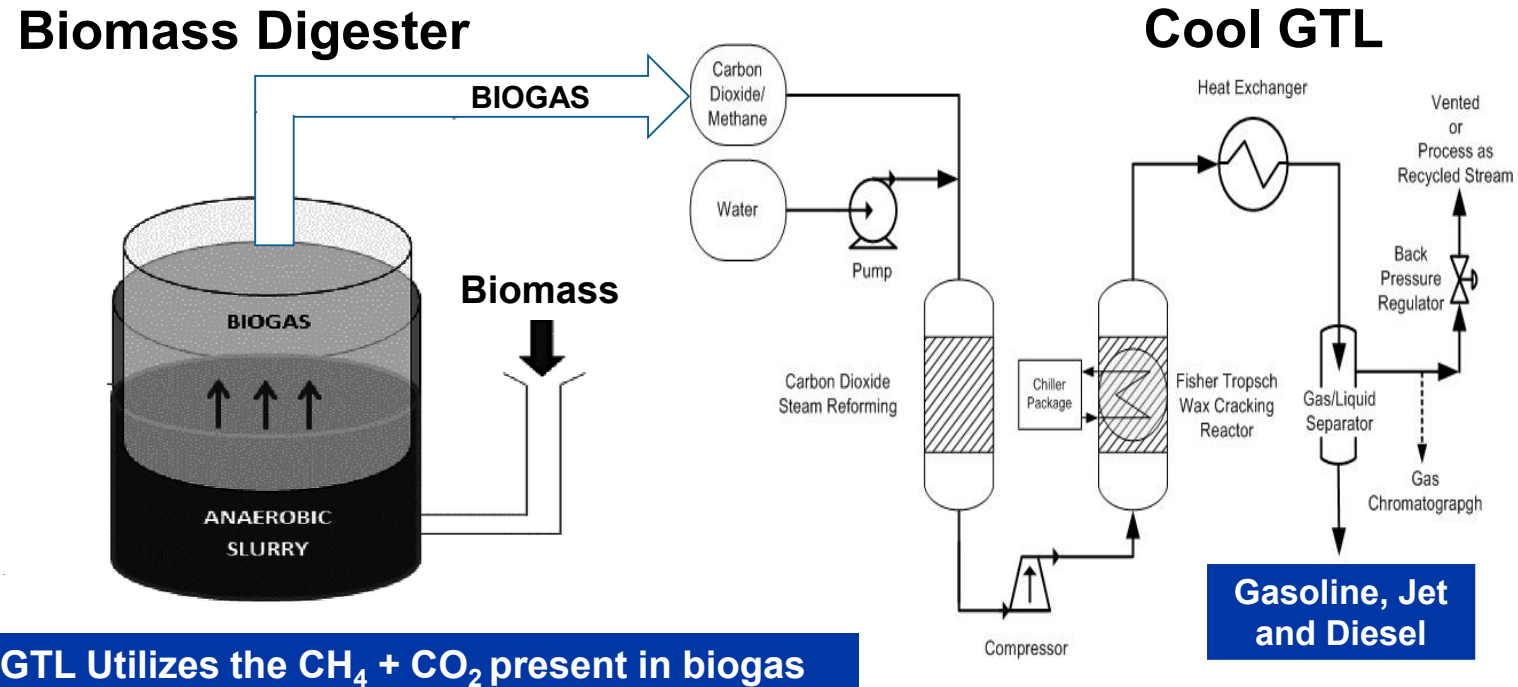
Cool Reformer Process



Cool GTL to Produce Jet Fuel from Biogas

Veolia sells digestors

Cool GTL for Biogas Conversion



US Digestors Map

Over 2200 Digestors in the United States

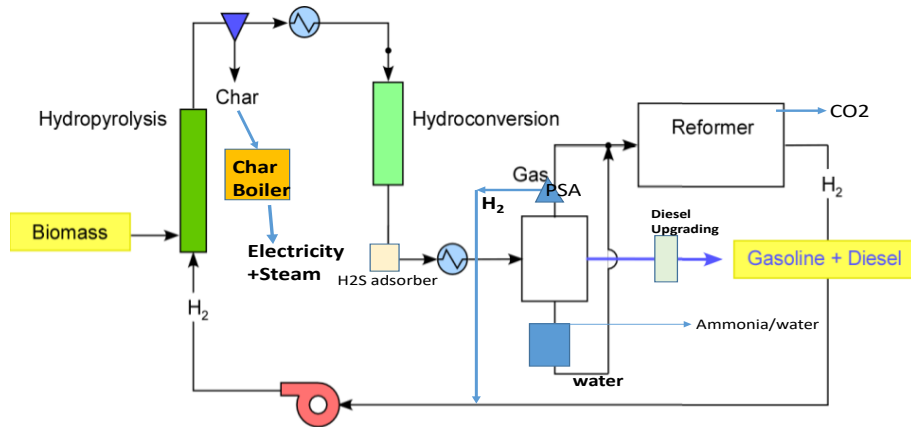


IH²[®] Cool GTL Application

Synsel interested in Waste wood/MSW conversion

Case 1

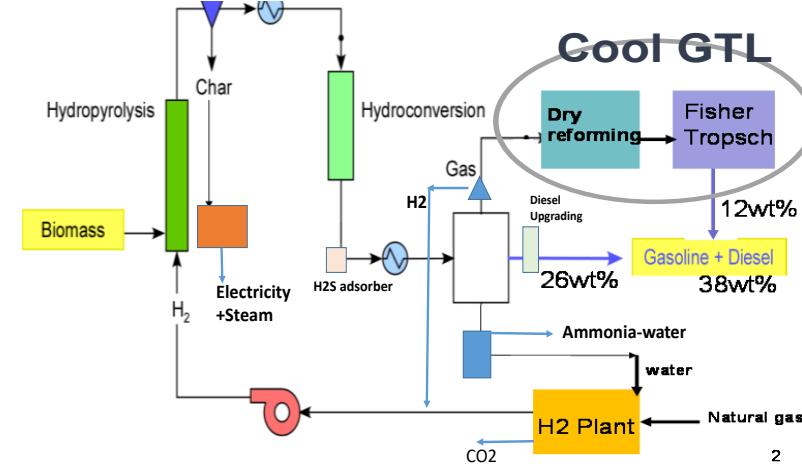
BASE IH2 PROCESS
(showing more details)



86 GPT Liquid Yield from wood

Case 2

IH2 plus CO2/H2O Reforming of IH2 Light Gas to Increase biogenic Liquid
Yields to 38% - LCA- Case 2



126 GPT Liquid Yield from wood

- Use natural gas to make H₂, use Biogenic gas to make more biogenic liquid
- LCA says IH²+Cool GTL still above 60% GHG reduction