DOE Bioenergy Technologies Office (BETO) 2021 Project Peer Review

Agricultural and Woody Biomass to Diesel Fuel with Intermediate

WBS:3.5.1.304 - System Development and Integration (SDI) Technology Area
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WestBiofuels

Project Overview

Project Goals

- Demonstrate the production of a biomass-derived intermediate for upgrading to diesel fuel
- Demonstrate co-processing of the biomass intermediate in conventional refinery equipment
- Facilitate the introduction of renewable carbon into the existing fuels infrastructure

West Biofuels 5 TPD Dual Fluidized Bed Gasification System

NREL Pilot-Scale Davison Circulating Riser Reaction System

Project Overview

Motivation

- Diesel demand is steady while gasoline and ethanol are projected to continue to decrease
- Electrification of heavy-duty diesel equipment has major technical hurdles to overcome
- Potential to leverage refinery infrastructure with reduced carbon intensity precursors
- Biomass conversion can be distributed sending intermediate to centralized refineries
- Alternative uses for forest residues and agricultural biomass are needed in the Western U.S.
- All technical steps are at the TRL level that is ready for technical integration

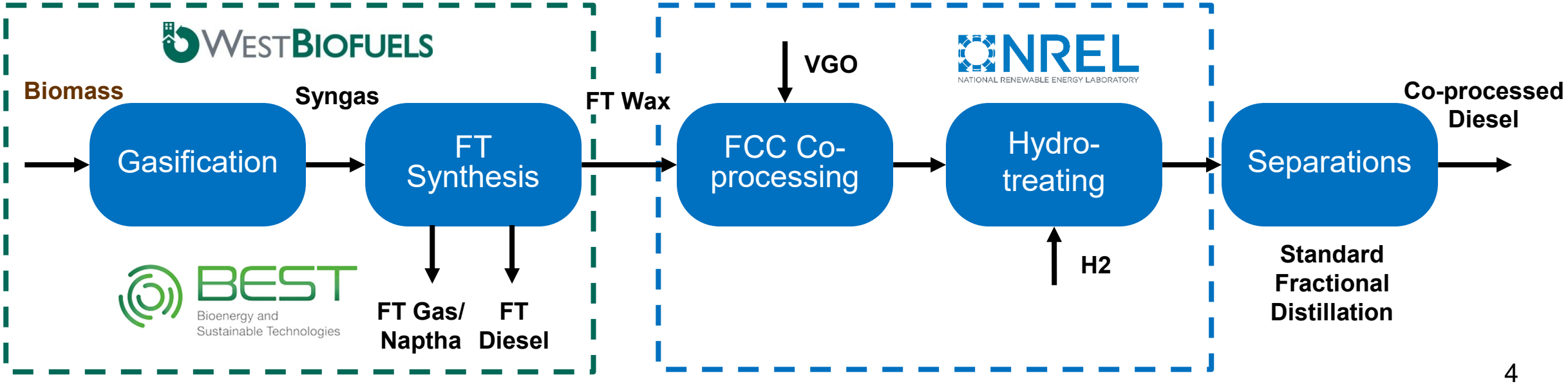
Risks

- Validating the overall efficiency and renewable carbon content of the final product
- Need to integrate multiple challenging process steps, identify opportunities for simplification
- Reasonable costs for producing intermediate at distributed biomass processing facilities

1. Management

Project leverages work being performed at West Biofuels and NREL on the major subsystems:

- West Biofuels has extensive experience with biomass gasification and synthesis and has the facilities to produce and test A) Bio-oil and B) Fischer-Tropsch (FT) products
- NREL has experience with co-processing of bio-liquids with fossil products like VGO and the facilities to produce and test the upgraded diesel product
- BEST Research (AT) to join the team for comparative FT synthesis testing and expertise



1. Management

Project team has extensive experience with biomass conversion and synthesis.

Team members participate in biomass meetings, consortiums, and complementary projects where results are shared and refined.

Organization	Name	Position	Role
West Biofuels	Dr. Matthew Summers	COO	Project Manager, PI
	Michael Long	Research Manager	Management, Engineering
	An Nguyen	Engineer	Engineering, Operations
	Brandon Bruning	Plant Manager	Operations
NREL	Dr. Robert Baldwin	Principal Scientist	Principal Investigator
	Dr. Josh Schaidle	Staff Engineer	Engineering
	Dr. Kimberly Magrini	Senior Chemist	Testing and Evaluation
	Dr. Reinhard Seiser	Staff Scientist	Testing and Evaluation
UCSD	Dr. Robert Cattolica	Professor	Research Support
BEST Research*	Dr. Gerald Weber	Unit Head	Principal Investigator
	Dr. Markus Luisser	Area Manager	Management
	Matthias Binder	Staff Engineer	Engineering & Testing

*Proposed team member

1. Management

Task	Lead	Supporting Organization
Task 1: Verification	West Biofuels	BEST*, NREL, UCSD
Task 2: Reaction System Design and Configuration	West Biofuels	BEST*, NREL
Task 3: Intermediate FT Production Studies	West Biofuels & BEST*	NREL
Task 4: Co-Processing Studies	NREL	West Biofuels
Task 5: Hydrotreating Studies	NREL	West Biofuels
Task 6: Continuous FT Production	West Biofuels	BEST*, NREL
Task 7: Continuous Co-Processing	NREL	West Biofuels
Task 8: Technoeconomic Analysis and Life Cycle Assessment	NREL	West Biofuels, BEST*
Task 9: Evaluation of Project Benefits	West Biofuels	NREL
Task 10: Technology/ Knowledge Transfer Activities	West Biofuels	NREL, BEST*
Task 11: Production Readiness Plan	NREL	West Biofuels

2. Approach

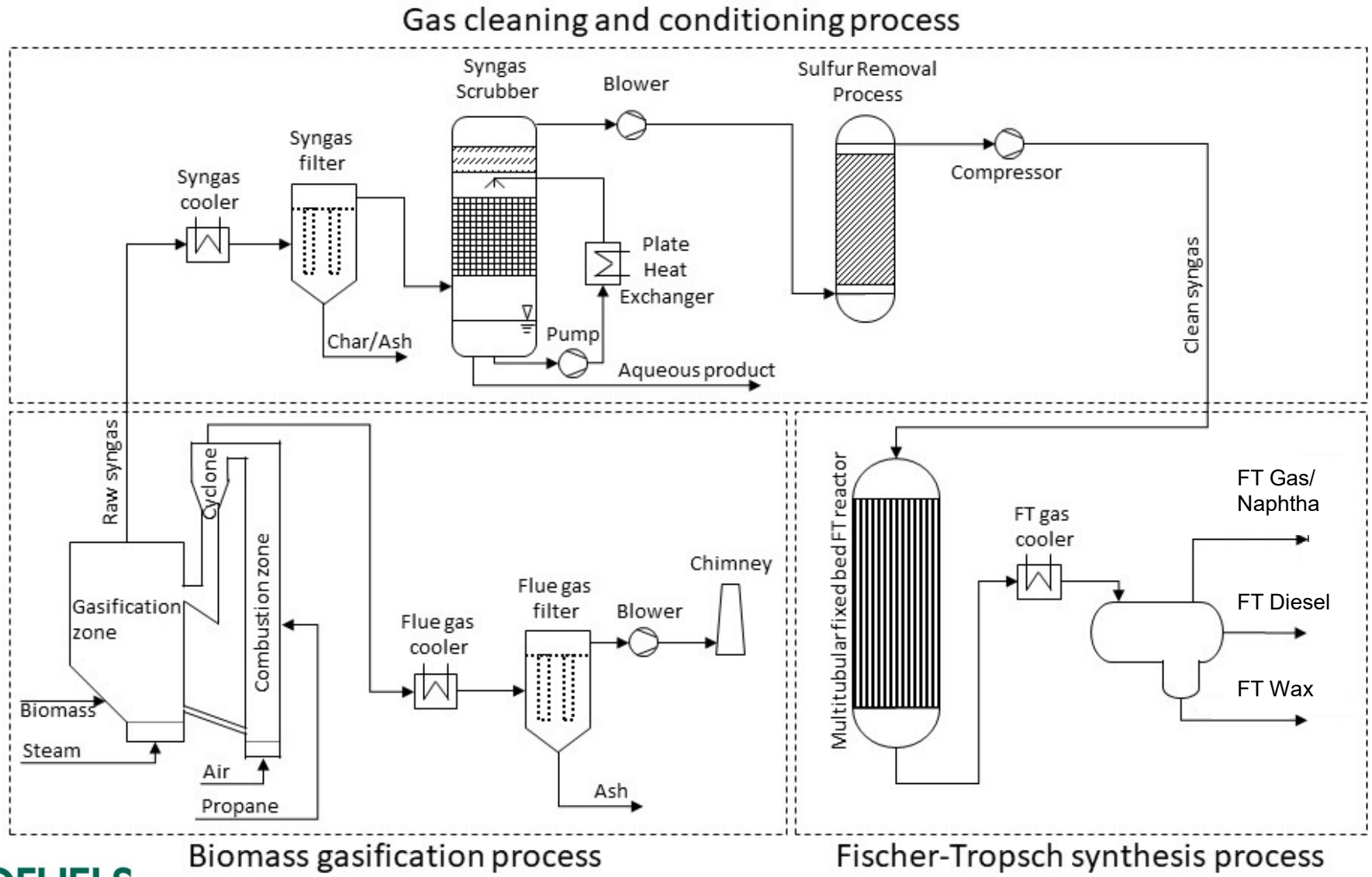
Original approach - Use catalytic fast pyrolysis (CFP) bio-oil as intermediate but encountered:

- Reactor problems: Difficulty with catalyst retention, phase separation, and control in fluid bed
- Yield problems: Bio-oil yields too low in lab (7-10%) and pilot system (1-4%) vs. target (30%)
- Market problems: Bio-oil does not yield fractions easily upgraded to diesel at refineries

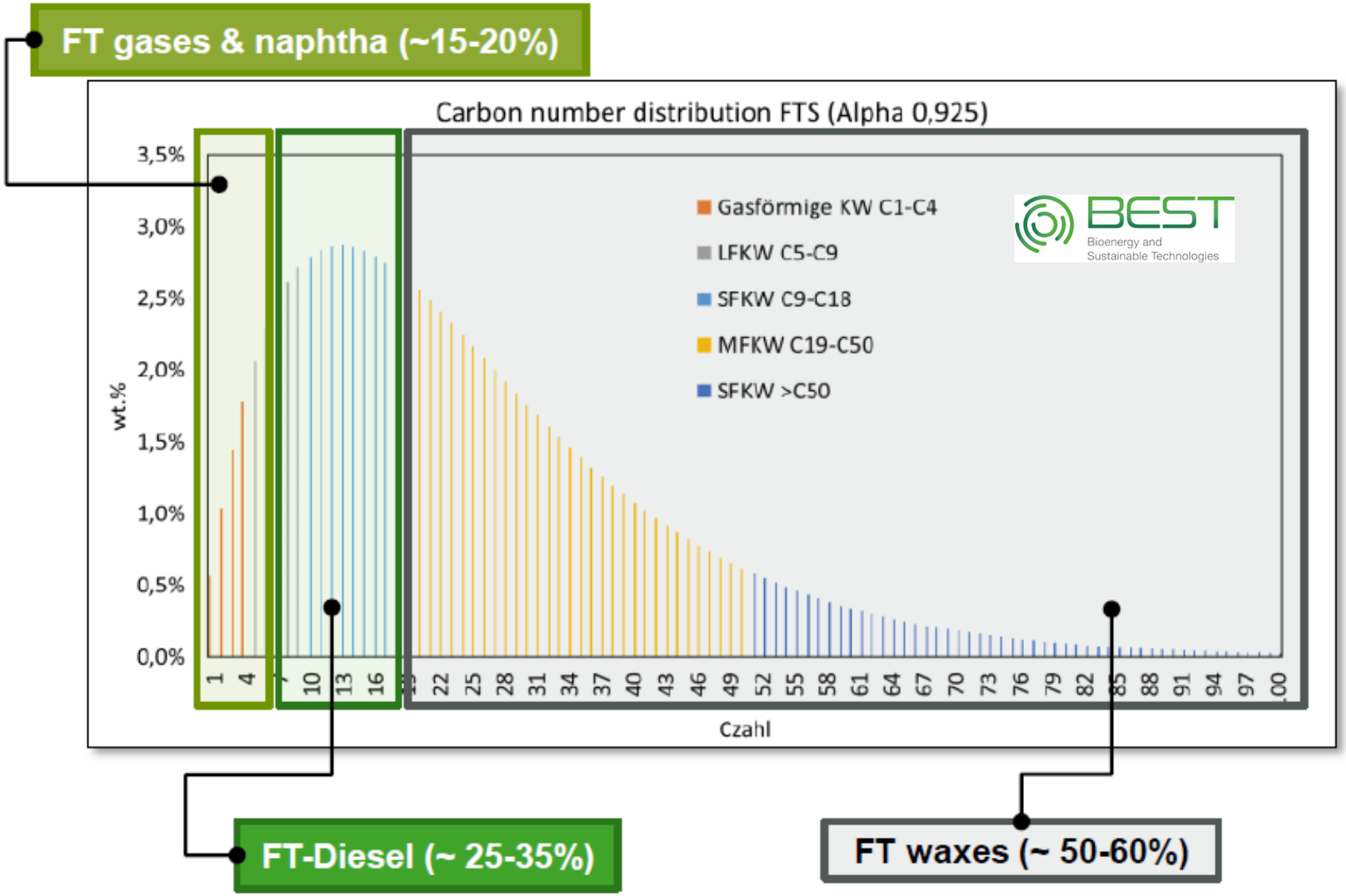
New proposed approach - Use gasification/Fischer-Tropsch synthesis to produce FT diesel and FT wax as intermediate to address the issues with CFP bio-oil:

- Reactor issues: Fluidized bed reactor used in proven gasification mode with ex-situ catalyst
- Yield issues: Diesel production from FT pathway projected to be 7 times the CFP oil pathway
- Product issues: FT products have higher purity, higher molecular weight and low oxygen content yielding more renewable content and less contaminants in refinery upgrading steps
- Market issues: Refineries have history of acceptance of FT products including waxes

2. Proposed Approach – FT Intermediate

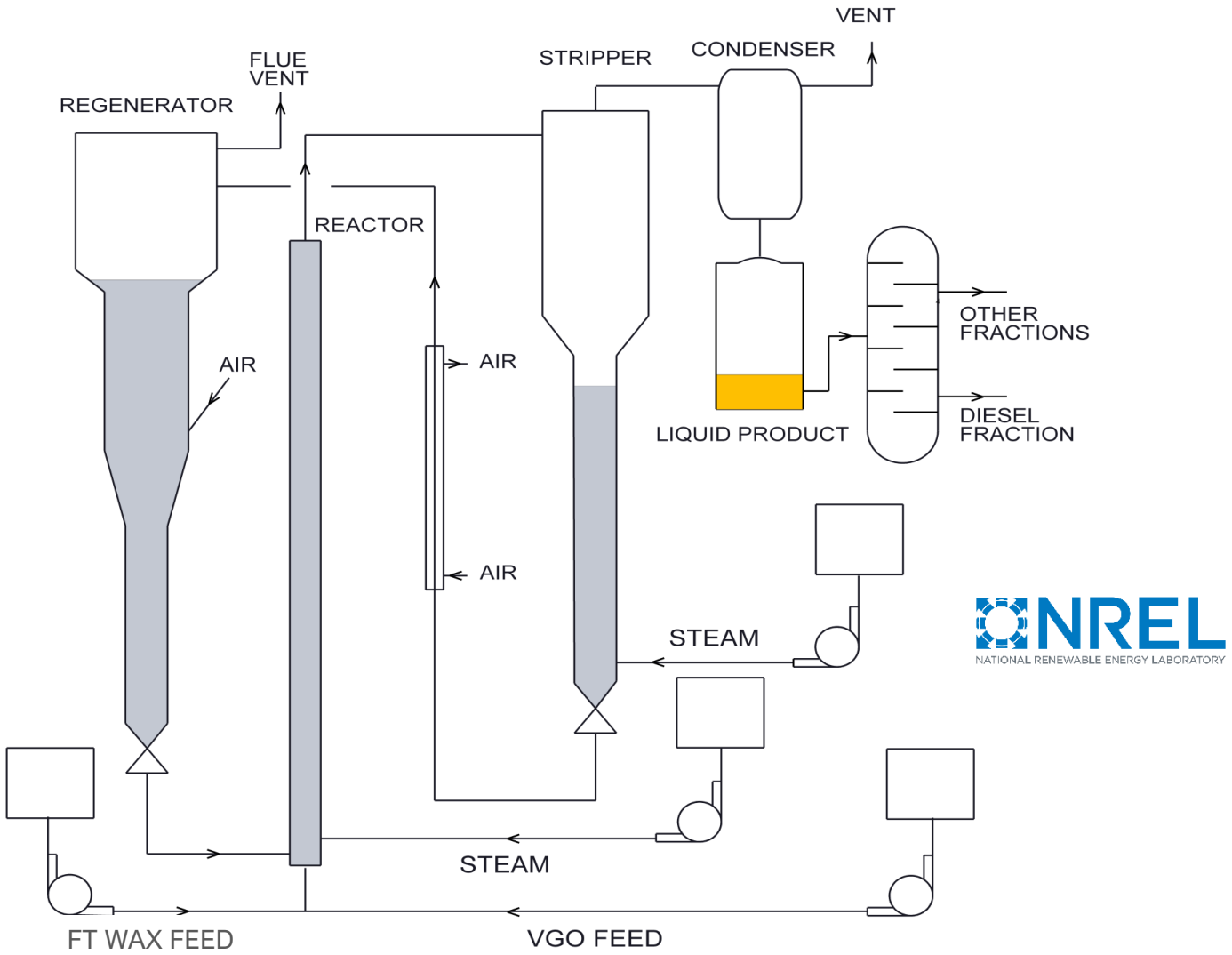


2. Proposed Approach – FT Intermediate



SOURCE: BEST RESEARCH AND VIENNA UNIVERSITY OF TECHNOLOGY

2. Approach – Co-processing to Diesel



FCC co-processing process

2. Approach - Challenges

Name	Description	Mitigation Plan	Probability	Severity
Lower than expected yields of intermediate products	Inhibition of catalyst reactor performance	Change reactor conditions and/or catalyst; modify syngas composition or gas cleaning	Medium	Medium
Difficulty co-feeding intermediate wax product	Plugging occurs during co-feeding	Use dual feed, independently heated feed system; adjust blend levels	High	High
Biogenic carbon efficiency low for preferred pathways	Excessive carbon loss to CO/CO_2 and coke	Change synthesis or co-processing catalysts and/or reaction conditions; Change blend ratio	Medium	Medium
Diesel fuel products do not meet specifications required for blendstock	High oxygen or physicochemical properties out of range	Trace issue through process; adjust FT synthesis, co-processing, and/or hydrotreating conditions/catalysts	Medium	High

2. Approach – Go/No Go Decision Points

Tasks	Description	Verification Process	Mo #	Qtr #
Task 1:Initial Verification	Project Team presents qualifications, facilities, and readiness of the project	BETO Verification Team determines if the project passes the initial verification based on the criteria outlined	3	1
Tasks 2 – 5: Reaction system and initial studies	Project Team demonstrates process for FT production and co-processing to maximize diesel fuel production that approaches project targets	BETO Verification Team determines if the project has met project targets to proceed with continuous production runs	24	8
Tasks 6 – 11: Continuous production, assessments and plan development	Project Team demonstrates the continuous production of fuel meeting the project targets and the results of the assessments and production plans	BETO Verification Team determines if the project has met project targets from continuous production runs and other objectives	33	11

3. Impacts

Outcomes will contribute to innovation and technology advancement including:

1) Comparing the performance of three approaches to biogenic intermediate production:
   a. Catalytic fast pyrolysis
   b. Fixed-bed low-temperature FT synthesis, Co-based catalyst
   c. Slurry-bed low-temperature FT synthesis, Co-based catalyst
2) Developing a quantitative assessment of the fate of biogenic carbon in FCC co-processing
   a. Biogenic carbon in fuel-range products
   b. Biogenic caron in coke-on-catalyst
   c. Biogenic carbon in light gases and carbon oxides
3) Developing process conditions in commercial FCC to maximize diesel fuel range materials
   a. Temperature
   b. Reactor space time
4) Providing an industrial end-use for new biogenic feedstocks coming to the market soon and facilitating an understanding of the carbon intensity of fuels from co-processing
5) Developing an understanding of the chemistry and mechanisms for co-processing of fossil and biogenic materials in the FCC

4. Progress and Outcomes

The project team has had the following progress:

- Project is in Budget Period #1 - Initial Verification
- Completed a comprehensive technical data review of proposed approach:
  - Developed mass/energy balances and process block-flow
  - Developed technical/financial data supporting process and commercialization
  - Compared the new process with project performance data of CFP approach
- Currently undergoing a review of proposed approach
- Verification review is ready to be scheduled with third-party engineer
- The project technical tasks can begin after the verification is complete

Summary

- Novel process converts forest and agricultural biomass into FT diesel and FT wax intermediate to be processed in a conventional refinery to additional diesel fuel
- Biomass-derived intermediate can be co-processed using standard refinery equipment to introduce renewable carbon into the existing fuels infrastructure
- First project to investigate FCC co-processing of FT product with VGO providing data on a novel pathway for diesel fuel with significant biogenic content
- Full commercialization of this technology will:
  - Utilize infrastructure at refineries to produce drop-in renewable diesel fuel
  - Reduce climate emissions, wildfire and open burning
  - Increase fire mitigation, jobs, energy security and flexibility
- The project will be undergoing initial verification so the technical tasks can begin

Agricultural and Woody Biomass to Diesel Fuel with Intermediate

Timeline

- Project start date: April 2020
- Project end date: March 2023

	BP 1	Active Project
DOE Funding	$69,811	$2,200,000
Project Cost Share	$17,500	$550,000

Project Lead:

WestBiofuels

Project Partners:

NREL
National Renewable Energy Laboratory

BEST*
Bioenergy and Sustainable Technologies

University of California San Diego

Project Goal

Demonstrate the production of a biomass-derived intermediate for co-processing in conventional refinery equipment to facilitate the introduction of renewable carbon into the existing fuels infrastructure

End of Project Milestone

A full process pilot demonstration to generate intermediate product to produce at least 100 gallons of drop-in diesel fuel in the total intermediate and co-processing products

Funding Mechanism

DE-FOA-0001926: Process Development for Advanced Biofuels and Biopower

Topic Area 2: Drop-in Renewable Diesel Fuel Blendstocks

Year: 2018

Questions and Discussion

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