Sapphire Energy, Inc.

DOE Bioenergy Technologies Office (BETO) 2015 Project Peer Review

Sapphire Energy - Integrated Algal Biorefinery

EE0002884

March 24 2015

Original project goals (2009)

Project objectives

Demonstrate the technical and economic feasibility of an algae-to-drop-in green fuels process that will form the basis for the development of a series of commercial scale biorefineries.

- Deploy the algae to green fuels process at the pre-commercial scale
- Integrate the key process for the entire production chain from feedstock to transportation fuel.
- Continue to reduce the capital and operating costs through an ongoing development effort.

Sapphire background information

Corporate HQ
San Diego, CA

-Full Suite of Strain Development

-Established in 2007

Field Testing
Las Cruces, NM

-22-acre facility with > 70 active ponds

-Operating since 2008

Commercial Facility
Columbus, NM

-96 Acres of Algae Production Ponds

-Operating Since 2012

Sapphire

Quad Chart Overview

Timeline

Project start - Jan 2010
Project end -April 2015
Percent complete -100% against revised

Budget

	Total Costs FY 10 – FY 12	FY 13 Costs	FY 14 Costs	Total Planned Funding (FY 15-Project End Date
DOE Funded	31.1m	2.8m	1.7m	.3m
Project Cost Share (Comp.)*	46.7m	3.5m	1.7m	.3m

*If there are multiple cost-share partners, separate rows should be used.

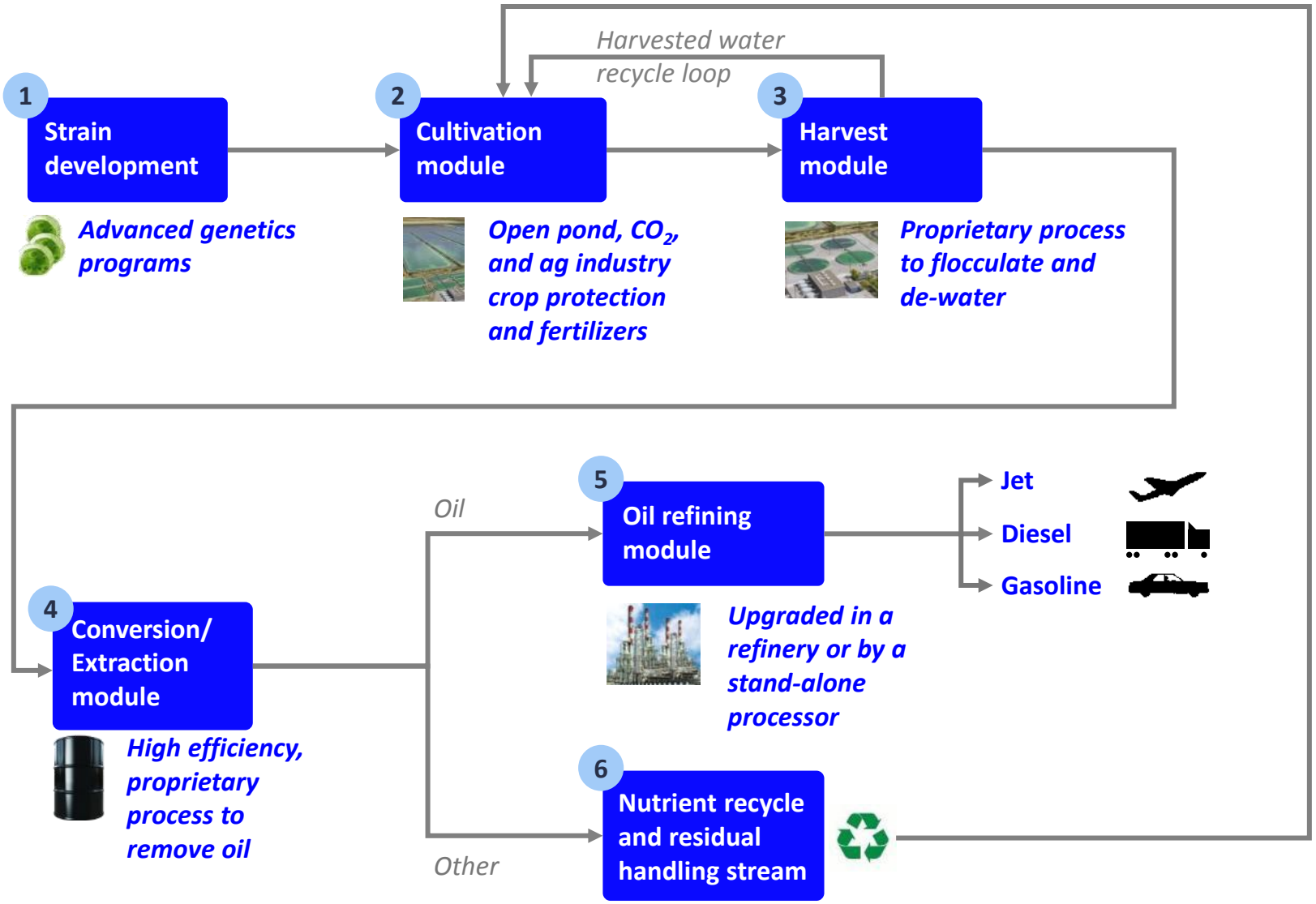
Barriers

- ✓ Debris, foreign materials and weather impacts on productivity
- ✓ Open pond invasion and contamination impacts on productivity
- ✓ Low cost harvest for dilute cultures
- ✓ CO2 utilization efficiency
- ✓ Oil yield on biomass
- ✓ Opex/capex especially in low crude price environments

Partners

- ✓ Harris Group
- ✓ Brown and Caldwell
- ✓ AMEC/Geomatrix
- ✓ Linde (CO2 and conversion)
- ✓ Tesoro (offtake agreement)
- ✓ Phillips 66 (upgrading and part 79 registration for on road diesel fuel)
- ✓ DOE co-processing grant

Overview of the integrated end-to-end process



General Overview

Overall Status and Progress of the Project

IABR To Date

Constructed Facilities

- Columbus 100 acre facility fully constructed and operable
    - On time and on budget
- Las Cruces Extraction Expansion (PDU) completed October 1, 2012

Overall Process

- Stable, reliable and suitable strains (including new strains and strain transitions) for year round production at Columbus
- Primary unit operations de-risked and at scale suitable for process demonstration
- Produced over 2,000 gallons of crude oil
- Upgraded bio crude oil to produce on specification ASTM975 ULSD and applied for US EPA Part 79 Fuel Certification

General Overview

Continuously cultivated algae for 29 months in Columbus, New Mexico

- Site of cultivation and harvest
- 520+ tonnes of algae biomass produced
- 1760+ tonnes of CO_2 consumed

Produced Green Crude for 24 months in Las Cruces, New Mexico

- Site of conversion and extraction and finished product storage
- 2000+ gallons of Green Crude produced since 2012
- Joint development refining program with Phillips 66

General Overview

Highlights in 2014

Successes:

- ✓ Over 240 tonnes of biomass produced
- ✓ Highest ever quarterly biomass productivity of nearly 18 g/m2/d
- ✓ Overall 2014 annual productivity ~2X the 2013 performance.
- ✓ 3rd Quarter DAF efficiency of nearly 90% achieved
- ✓ Continued successful integrated pest management (continuous cultivation of 107 for over 22 months)
- ✓ Produced over 1000 gallons of Green Crude
- ✓ Continued to make steady progress on variable cost reduction

Challenges:

- ✓ Debris, foreign materials and weather impacts
- ✓ Pond invasion and contamination
- ✓ Limited conversion and extraction capacity
- ✓ Remote location/lack of infrastructure.

General Overview

Highlights in 2014

- Technology development in support of next phase IABR continued in 2014
  - Strain improvement
  - Cultivation and crop protection improvements
  - New pond prototypes developed
  - Basis for next generation conversion and extraction unit developed
  - Process Integration

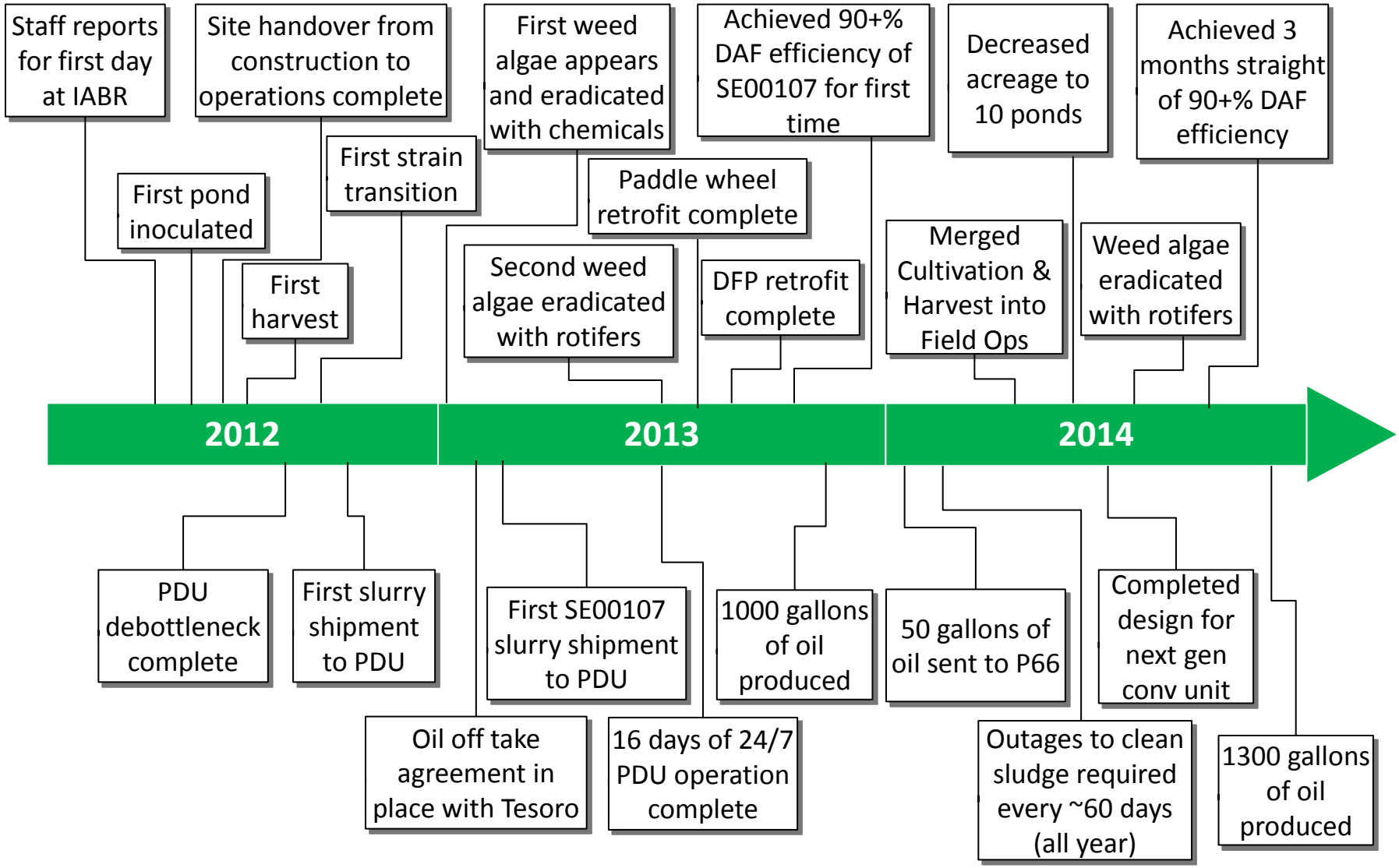
- Advanced all key process performance metrics

- Continued overall progress
  - Benefits of lab to pilot to field feedback mechanisms
  - Informed program to improve lab to field transition

- Maintained rigorous stage-gate project and company decision making

History

Timeline of events at the IABR since start of operations



Downstream (refining)

Sapphire's algae bio-crude quality supports many upgrading options within existing refining infrastructure

Oil upgrading

Sapphire's algae bio-crude is not a finished transportation fuel

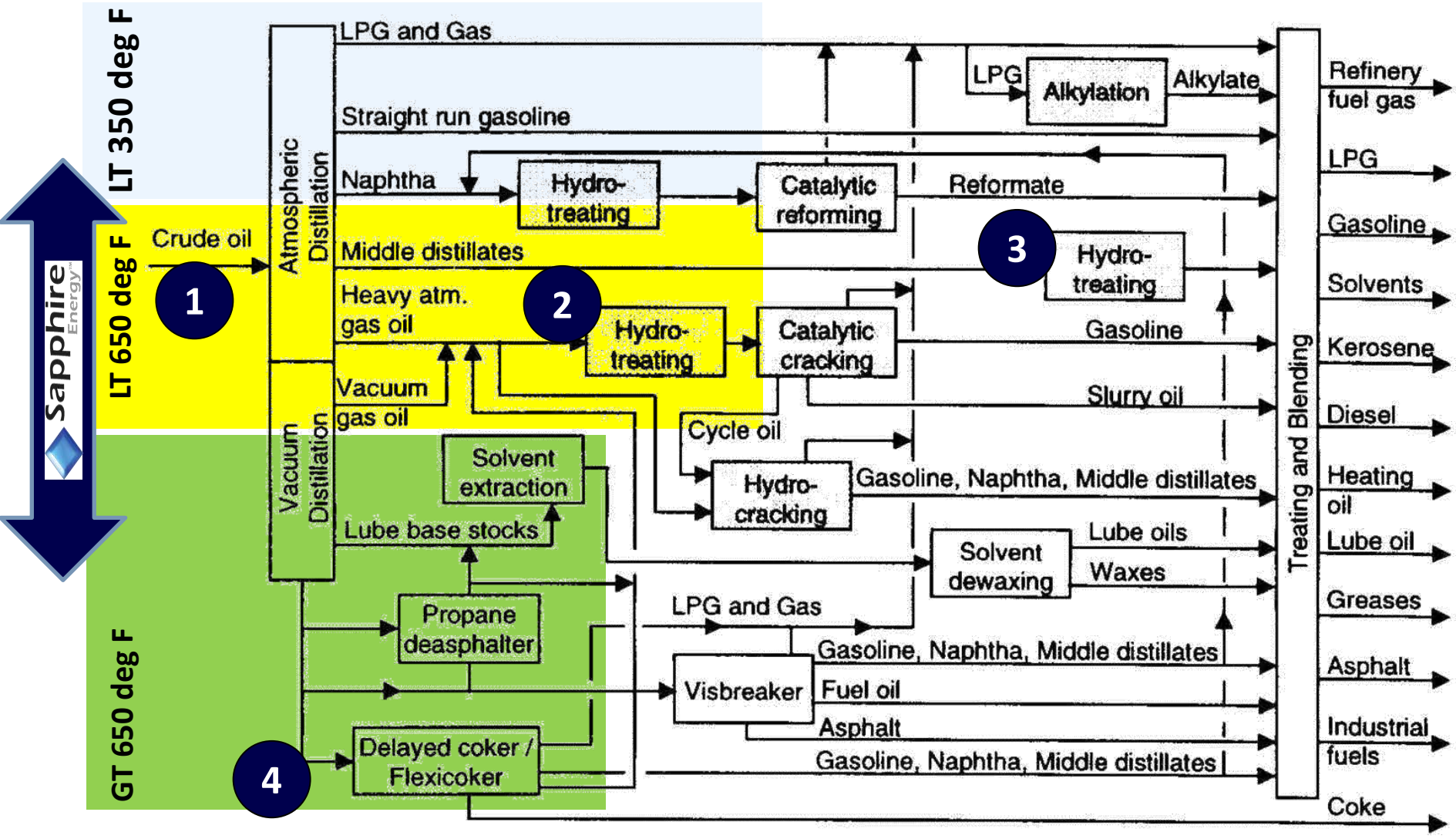
- Fungible with petroleum derived crude oils and intermediate feed stocks (*e.g.*, gasoil)
- Transported through existing petroleum infrastructure

There are many upgrading options

- In traditional petroleum refineries to make a co-processed bio fuel
- In stand alone biofuel upgrading facilities to make a 100% bio-derived product

No exotic process conditions or equipment required to upgrade Sapphire's algae bio-crude

Sapphire has tested of many options for refinery co-processing of Green Crude oil



Status of process design progress for Phase 2 (next gen) of IABR demonstration.

Design developed for large scale demo of next generation pond and harvest systems

- Extensive use of CFD tools to model novel pond designs, motive systems and primary harvest approaches
- Novel pond designs (lower capex and opex) field pilots in Las Cruces
- Novel harvest primary dewatering step pilot has been field trials in Las Cruces

Design developed for large scale demo of next generation conversion/extraction process

- Bench scale testing has been completed, validating process conditions, vessel configuration and solvent selection
- Testing of novel heat exchanger application performed to insure reliable heat integration
- Detailed high viscosity material handling/pump designs and vendors quotes have been obtained
- Reactor design has been agreed upon vendor quote obtained
- Cost estimate has been received and evaluated by Linde and Sapphire project teams and management

Status

Using information learned during operation and design of phase 2 requirements

- Required capital investment requirements for deployment of next generation unit operations exceed budgets deemed necessary to demonstrate commercial scale feasibility
- Additional R&D required to improve performance and reduce capital and operating costs
- Balance of original schedule period does not provide sufficient opportunity to complete the balance of R&D to deliver the full scope of the IABR
- Underlying investment and economic conditions dictate adjustments to Sapphire's business direction

IABR status

The IABR has helped define algae to fuel

- **2009 State of technology has been entirely revised**
- **Commercial strains are now:**
  - Viable for large scale outdoor use in host natural environments
  - Strain improvement progression will be via traditional crop selection, advancement and improved mechanisms
- **Crop protection:**
  - Pioneered large scale commodity based chemical, biological, and agricultural methods
  - Consistent with large scale agricultural practices and protocols
- **Harvesting and Handling:**
  - Pioneered effective primary de-watering methods using a wet slurry eliminating the need to dry algae to a powder while significantly increasing availability of recoverable oil
- **Conversion and Extraction:**
  - Determined that no 2009 vendor extractions solutions were viable
  - Established technical viability of Sapphire's proprietary processes for commercial application
- **GHG Footprint:**
  - Data from IABR was analyzed by researchers at UVA who concluded fuels produced via this process had a 30+% reduction in GHG vs. petroleum derived fuels

IABR status

The IABR has helped define algae to fuel

- **Refining and Products:**
  - Established critical need to recycle all available original process inputs
  - IABR provided biocrude oil required for upgrading into finished transportation fuels and application for US EPA Part 79 certification

- **Scale:**
  - Helped define and differentiate the scale requirements for meaningful algae to fuel projects and integration with existing industry business and infrastructure platforms

- **Technoeconomics:**
  - Reset of techno-economic metrics needed for true commercialization of an integrated algae to oil process