

System Development & Integration (SDI) Program Overview

Jim Spaeth, SDI Program Manager



System Development & Integration Agenda



- Team
- Goals and Milestones
- Program Focus and Approach
- History and Past FOAs
- Co-Optima
- Peer Review Panels

Team

System Development & Integration Team



Jim Spaeth



Liz Moore



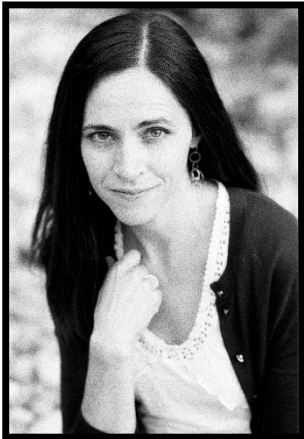
Mark Shmorhun



Josh Messner



Zia Haq



Alicia Lindauer



Brittany Clark



Remy Biron



Marykate O'Brien



Clayton Rohman



Ben Simon



Art Wiselogel



KC Agwu



Alex Jansen

Goals and Milestones

SDI Goals

Strategic Goals:

- To develop and test bioenergy production technologies through verified proof of performance in pre-pilot, pilot, and demonstration scale systems in relevant environments to enable and catalyze commercial deployment.
- Identify **innovative end uses** – Co-Optima



Systems Research and Development to Enable a Robust Bioenergy Process

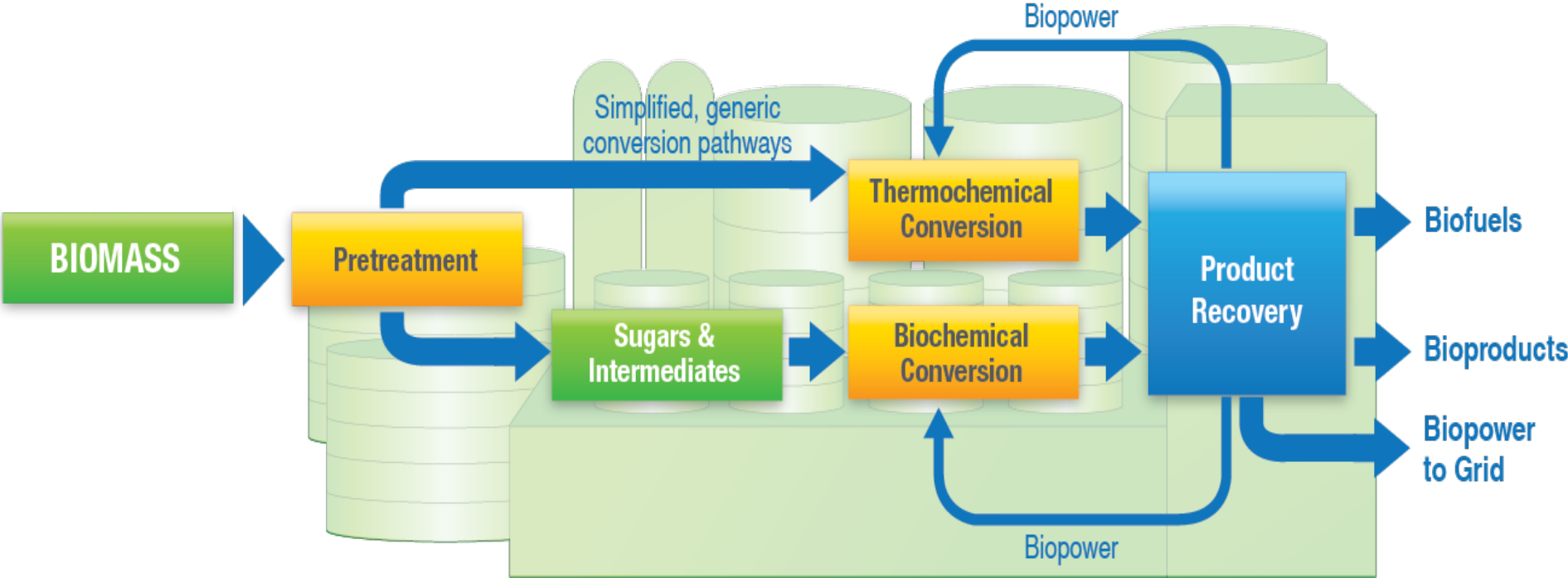
SDI: Major Milestones

By 2022, verify integrated systems research at engineering-scale for hydrocarbon biofuel technologies at mature modeled MFSP of \$3.00/GGE with a minimum 50% reduction in emissions relative to petroleum-derived fuels.

By 2030, build and operate 4-5 Demonstration-scale integrated biorefineries with a focus on sustainable aviation fuels capable of >70% improvement in GHG emissions profile vs. Petroleum

SDI Focus and Approach

Challenges Across the Supply/Value Chain

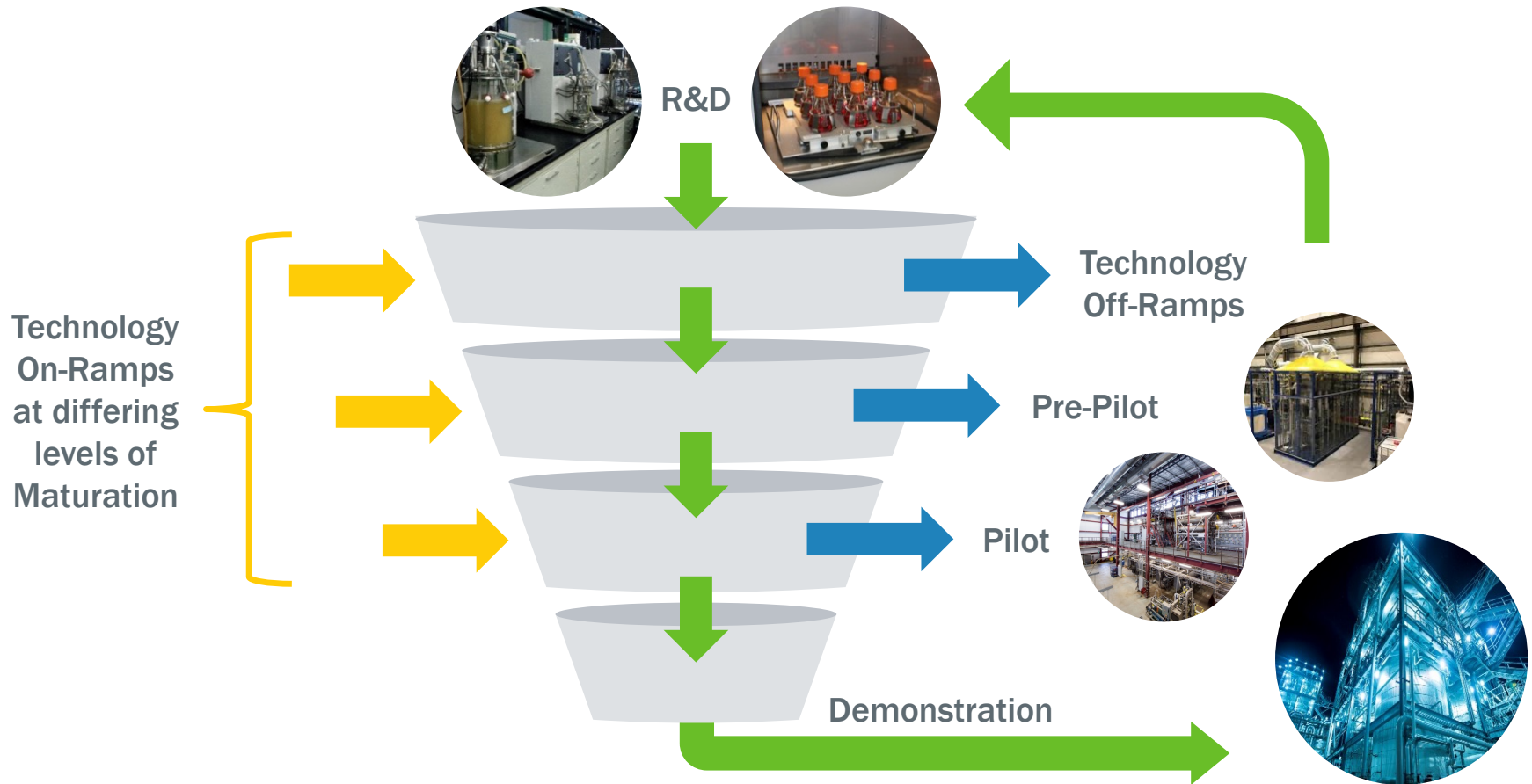


Key Challenges

Feedstock	Pretreatment	Conversion	Product
<ul style="list-style-type: none"> Reliable supply Consistent quality Affordable delivery 	<ul style="list-style-type: none"> Biomass feeding, sizing and moisture Solids handling Material of construction 	<ul style="list-style-type: none"> Products yields Material of construction Catalysts Fermentation organisms 	<ul style="list-style-type: none"> Separations Catalytic upgrading Recycle loops

Crosscutting Modeling & Analysis

Technology Strategy On-Ramps to Scaling



Elements of Scale-up Approach

- Opportunities for pre-pilot, pilot, and demonstration scale projects
- Use of all potential feedstock resources
- Bioproduct enable biofuels development
- Leveraging first-generation biorefinery infrastructure, supply chains, and resources
- Leveraging existing industrial infrastructure including petrochemical, pulp & paper, past advanced biofuels, and other
- Use of predictive models and high-performance computing as tools
- Expanding the use and capabilities in our existing national laboratory pilot facilities

National Lab PDUs to Enable Scaling



Advanced Biofuels PDU
LBNL



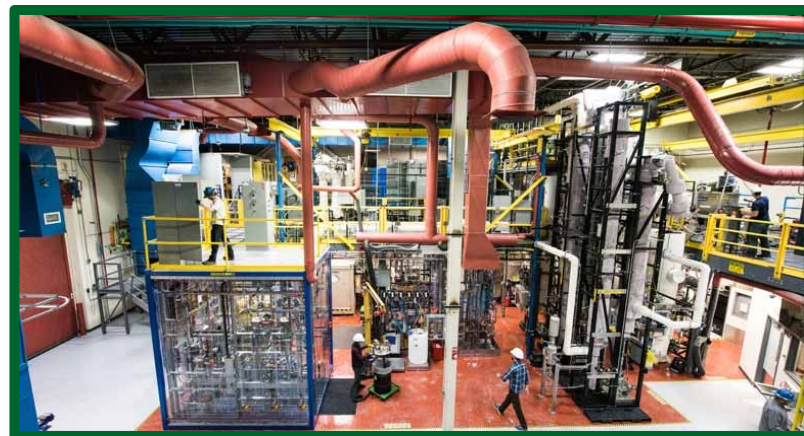
Biomass Feedstock PDU
INL



Integrated Biorefinery PDU
NREL

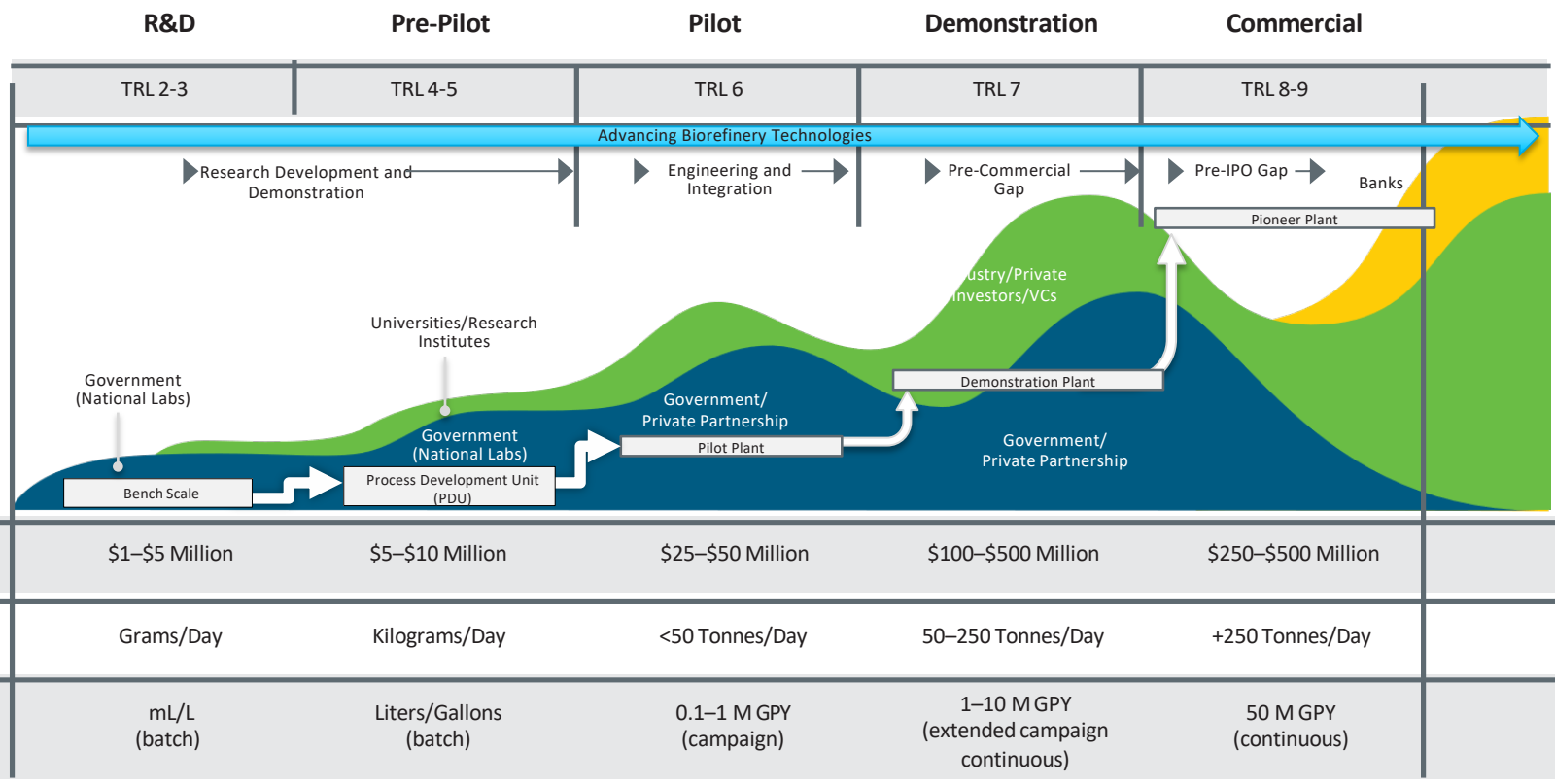


Hydrothermal
Liquefaction
(HTL) PDU
PNNL



Thermochemical PDU - NREL

BETO Strategy from R&D through Pioneer Refinery to Commercialization



● Government ● Project Recipients and Partners ● Banks

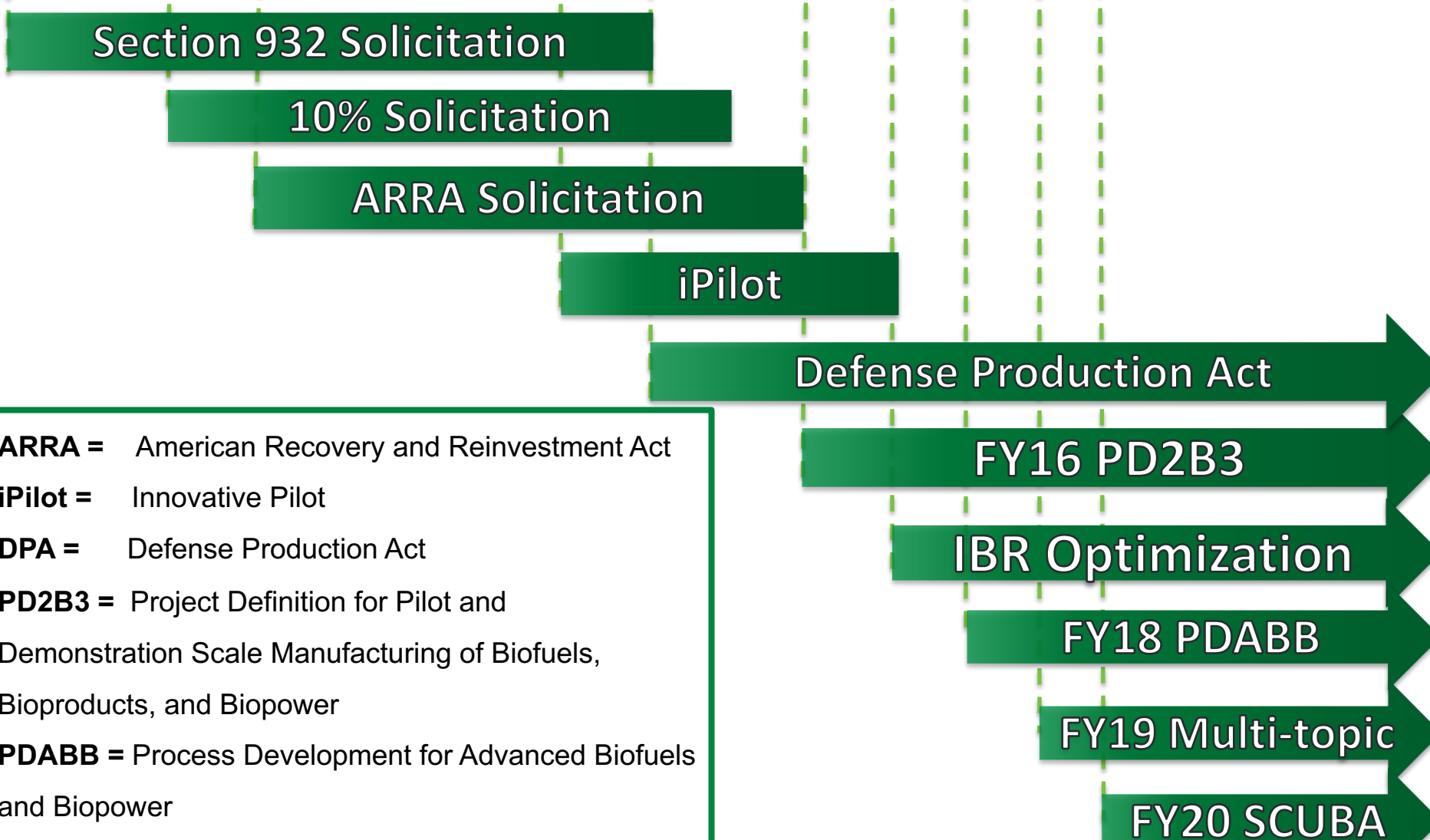
History and Past FOAs

Evolution of the Program



SDI Program FOA History

2006 2008 2010 2012 2014 2016 2018 2020 2021 2022



ARRA = American Recovery and Reinvestment Act
iPilot = Innovative Pilot
DPA = Defense Production Act
PD2B3 = Project Definition for Pilot and Demonstration Scale Manufacturing of Biofuels, Bioproducts, and Biopower
PDABB = Process Development for Advanced Biofuels and Biopower
SCUBA: Scale-up of Bench Applications

Brief BETO Large Project History



Commercial Scale
6 projects selected – 3 built
\$25M - \$100M federal each
60% minimum cost share
770 dry tons per day

Demonstration Scale
9 projects selected
\$25M - \$50M federal each
50% minimum cost share
50 dry tons per day

Pilot & Demonstration Scale
11 Pilot projects selected
\$15M - \$25M federal each
20% minimum cost share
1 dry ton per day

4 Demo projects selected
\$40-\$50M federal each
50% minimum Cost Share
50 dry tons per day

Pilot Scale
4 projects selected – none built
\$5M - \$10M federal each
50% minimum cost share
1 dry ton per day

Pilot & Demonstration Scale
4 Pilot projects selected for phase 1
\$1M - \$3M federal each
1 dry ton per day design effort

2 Demo projects selected for phase 1
\$4M - \$5M federal each
50 dry tons per day design effort

Down Select for \$20M - \$40M

Pilot Scale
10 Pilot projects selected
\$1M - \$3M federal each
20% minimum cost share
1 dry ton per day

Brief BETO Large Project History

2006:
932 Pioneer
Scale

2007:
10% Demo
Scale

2009:
ARRA

2013:
I-pilot

2016:
PD2B3

2018:
PDABB

- Over 15 years of large project experience
- 6 FOAs
- Over \$700,000,000 federal (mostly ARRA)
- Over 35 larger scale projects
- 3 scales (pilot, demonstration, and pioneer)



POET-DSM Project Liberty (Pioneer scale)



Myriant (Demo scale)



ClearFuels (Pilot scale)

SDI Recent FOAs

FY19 Multi Topic FOA

Topic 3: Efficient Wood Heaters

- Novel and innovative wood heater technology

Topic 4: Systems Research Of Adv Hydrocarbon Biofuel Techs

- Verify **innovative technologies at engineering-scale** to enable cost-competitive integrated biofuel technology pathways

Topic 5: Optimization Of Bio-derived Jet Fuel Blends

- Identify **novel bio-based drop-in jet fuel molecules**

FY20 Multi Topic FOA

Topic 1: Scale-Up of Bench Applications (SCUBA)

- Develop **specialized engineering-scale equipment** that will reduce technology uncertainty and risk prior to fully integrating

2021 SDI Peer Review

- The SDI portion of the Peer Review will be held from
 - **March 22 – 26, 2021**
- 48 projects in the SDI portfolio to be reviewed
 - Projects range from early stage TRL modeling work through demo-scale Integrated Biorefineries
- Projects from the SCUBA FOA Topic Area
 - **will not be reviewed** this year

SDI Peer Review Panel

Name	Role and Affiliation	Previous Peer Review Experience
Daniel Lane (lead)	Principal at Saille Consulting	2019
Mark Penshorn	Senior Project Manager at bb7	2017
Ignasi Palou-Rivera	Technology Platform Director - RAPID Manufacturing Institute at AIChE	New this year
Paul Bryan	Independent Consultant	2020 (AMO)
Vicky Putsche	Independent Consultant	New this year



U.S. DEPARTMENT OF
ENERGY

Office of
ENERGY EFFICIENCY &
RENEWABLE ENERGY

2021 PROJECT PEER REVIEW

U.S. DEPARTMENT OF ENERGY
BIOENERGY TECHNOLOGIES OFFICE

Co-Optimization of Fuels and Engines (Co-Optima)



Co-Optima Overview

Co-Optimized
Solution



Engine R&D

Fuel R&D

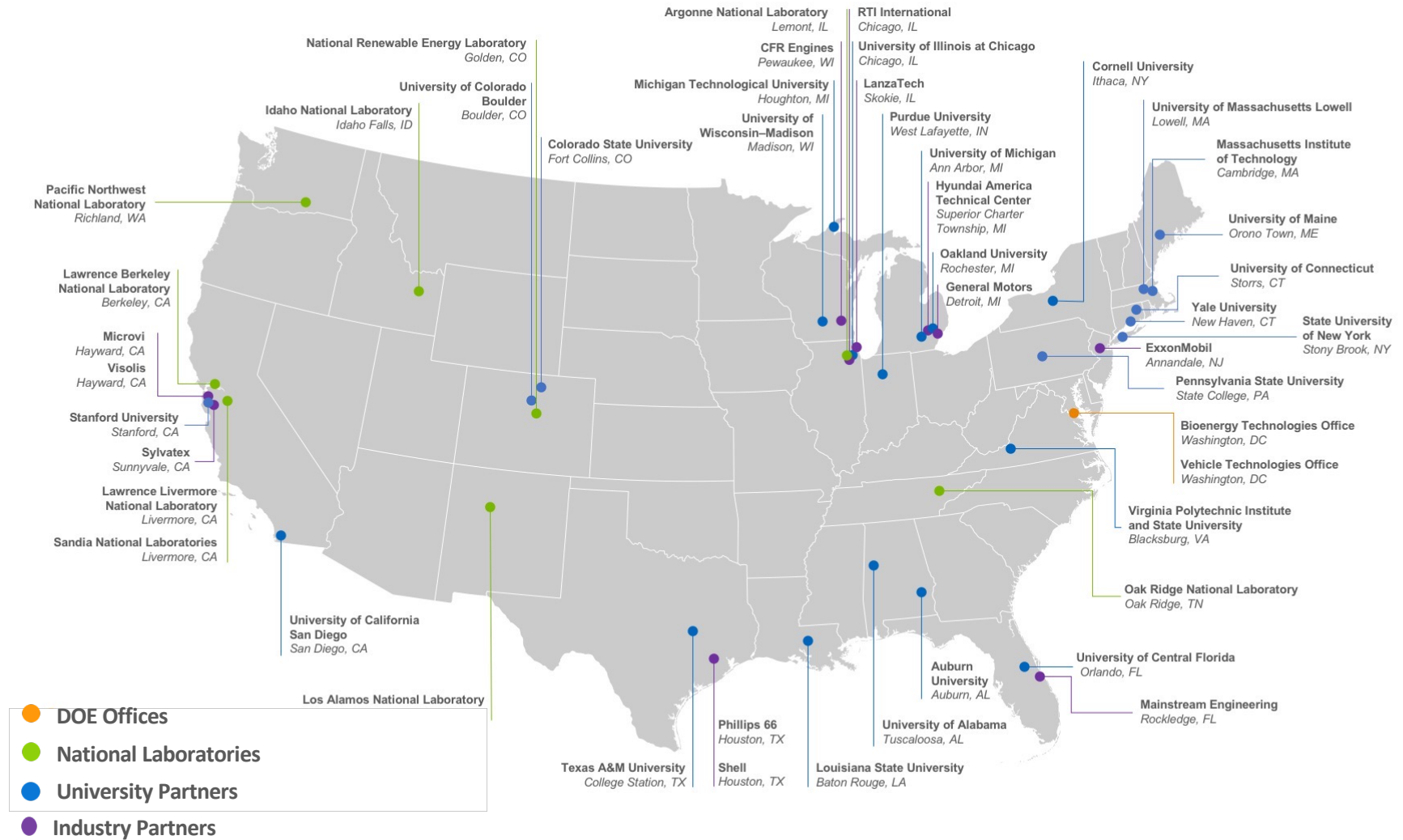


*Co-Optima: Better fuels
and better vehicles
sooner*



Objective: Advance the underlying science needed to develop fuel and engine technologies that will work in tandem to achieve significant efficiency and emissions benefits

Co-Optima Partners



Research spans on-road from light-duty to heavy-duty



Light-Duty

- **Near-term** opportunity for improved efficiency at higher load (boosted spark ignition)
- **Longer-term** opportunity for improved efficiency across the drive-cycle (multi-mode spark ignition / advanced compression ignition)



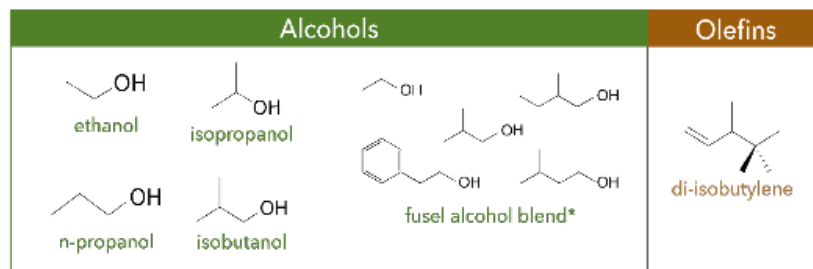
Medium/Heavy-Duty

- **Near-term** opportunity to improve engine emissions (mixing controlled compression ignition)
- **Longer-term** opportunity for improved efficiency and emissions and efficiency (advanced compression ignition)

Key Accomplishments

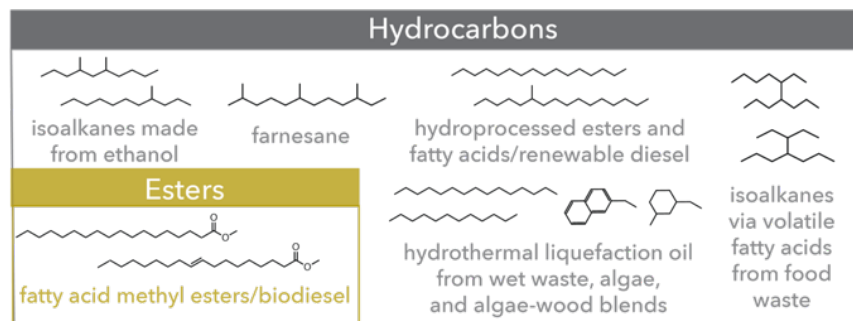
- **Value of biofuels** in improving light-duty vehicle engine **efficiency**
- And reducing **emissions** in light-, medium-, and heavy-duty vehicles.
- Improved understanding of how blendstock chemical **structure** affects **fuel properties**.
- Identified **ten boosted SI blendstocks** for improving light-duty engine efficiency, including 6 with minimal barriers.
- Identified **eleven MCCI blendstocks** that provide target fuel properties and reduce GHG and criteria emissions, including 6 with minimal barriers to adoption.
- Completed integrated **modeling** to quantify the potential **impact** of co-optimized fuels and engines.

Light-Duty Boosted SI Blendstocks with the Highest Efficiency Benefits and Minimal Market Barriers



*Fusel alcohol blend: 57% isobutanol, 15% phenyl ethanol, 12% 3-methyl-1-butanol, 10% ethanol, 6% 2-methyl-1-butanol

Medium-/Heavy-Duty MCCI Blendstocks with the Highest Potential to Reduce Emission and Minimal Market Barriers

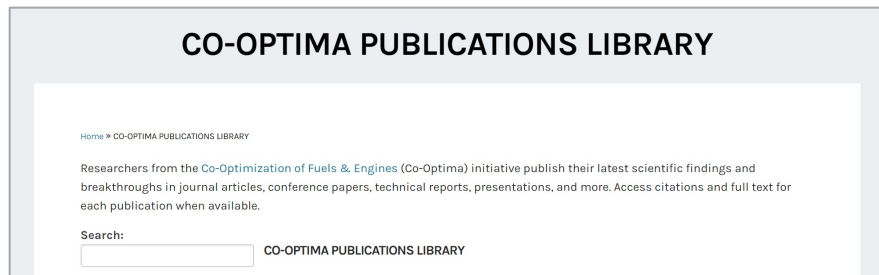


SI = Spark Ignition; MCCI = Mixing Controlled Compression Ignition

More Information

Searchable Co-Optima Publications Library

<https://www.energy.gov/eere/bioenergy/co-optima-publications-library-0>



Co-Optima Year in Review

<https://www.energy.gov/eere/bioenergy/co-optima-publications-library-0>



Co-Optima Capstone Webinar Series kicks off March 25, 2021

<https://www.energy.gov/eere/bioenergy/co-optima-capstone-webinars>

2021 Co-Optima Peer Review

- The Co-Optima portion of the Peer Review will be held
 - **March 15 - 16, 2021**
- 4 National Laboratory Consortium Project Presentations
- 6 University Project Presentations

Co-Optima Peer Reviewer Panel

Name	Affiliation
Cory Phillips*	Phillips 66
Karl Albrecht	Archer-Daniels-Midland Company
Aron Butler	U.S. EPA Office of Transportation and Air Quality
Bhupendra Khandelwal	University of Alabama
Nikita Pavlenko	The International Council on Clean Transportation
Reuben Sarkar	American Center for Mobility
Luca Zullo	Synergy BurCell Technologies and VerdeNero LLC

*Lead Reviewer

Thank You!

We look forward to seeing you at the SDI and Co-Optima sessions!



Jim Spaeth

Program Manager

System Development & Integration

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Recent FOAs – FY19 Multi Topic FOA

TOPIC 3: EFFICIENT WOOD HEATERS

- Novel and innovative wood heater technology
 - to significantly reduce emissions and improve efficiency
 - through improved design (combustion optimization),
 - sensors and advanced control,
 - thermoelectric power generation and catalyst technologies.
- With performance targets by the end of the project of
 - A. 50-80% reduction in emissions
 - B. 5-15% improvement in efficiencyfor residential wood heaters relative to their current baseline residential wood heater design.

Recent FOAs – FY19 Multi Topic FOA

TOPIC 4: SYSTEMS RESEARCH OF ADVANCED HYDROCARBON BIOFUEL TECHNOLOGIES

- Verify **innovative technologies at engineering-scale** to enable cost-competitive integrated biofuel technology pathways.
- Focus on integrated systems research projects that combine technology components and unit operations.
- Performance targets by the end of the project:
 - A. A Minimum Fuel Selling Price of < \$3/gge
 - B. A cumulative time on stream of > 500 hours
 - C. A continuous time on stream of > 100 hours
 - D. A production of > 100 gallons

Recent FOAs – FY19 Multi Topic FOA

TOPIC 5: OPTIMIZATION OF BIO-DERIVED JET FUEL BLENDS

- Identify **novel bio-based drop-in jet fuel molecules**
 - that maximize engine performance and fuel efficiency,
 - and provide pathways to reduce the cost of fuel production.
- With performance targets by the end of the project of:
 - A. Produce > 2 gallons of neat renewable jet fuel blendstock and carry out ASTM tests for fuel suitability and operability purposes
 - B. Produce a bio-derived fuel blend with zero or minimal (<8%) aromatics content that does not compromise seal swell of engine O-rings
 - C. A neat synthesized jet fuel that exhibits > 4% net increase in combine specific and volumetric energy content without impacting drop-in fuel requirement
 - D. A Minimum Fuel Selling Price of <\$3/gge and maximum reduction in greenhouse gas emissions.

Recent FOAs – FY20 Multi Topic FOA

TOPIC 1: Scale-Up of Bench Applications (SCUBA)

- Develop specialized engineering-scale equipment that will reduce technology uncertainty and risk prior to fully integrated engineering or pilot-scale facility.
 - One or multiple unit operations.
 - Go from laboratory or bench-scale process to the next logical process scale.
 - Further development of these technologies prior to integration into an integrated biorefinery
 - Will increase the likelihood to achieve \$2.50/GGE by 2030.

Pre-Selection Strategies for Large Projects



Strategies Include:

- Subject Matter Experts during MRC
 - Independent Engineers
 - Project Risk Analysis (Independent Project Analysis, LLC)
- Oral presentations
- Written Q&A
- Special purpose reviews
 - NEPA, IP, LCA, cost share, feedstock logistics
- **Block Flow Diagram and Supplemental Data**

More information to make an informed decision, but can be expensive and time consuming

Post-Selection Strategies



Strategies Include:

- Cost Share verification (liquid versus bonded)
- Contingency requirements (outside of project cost)
- Completion of prior scale work (if needed, limited to 10% TPC)
- Design phase budget period
- Annual Comprehensive Project Reviews
- Monthly reporting
- Project Management Plans
- Risk Mitigation Plan
- Verification of data
- DOE Order 413.3 Critical Decision Go / No Goes
- Independent Engineer (Onsite invoice accuracy reviews)
- Down-selects