Agile BioFoundry

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

BIOENERGY TECHNOLOGIES OFFICE

ABF Organization, Progress, Plans

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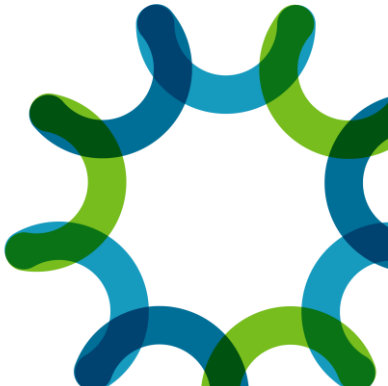
Lead PI, DOE Agile BioFoundry

ABF Industry Listening Day 2023
July 31, 2023



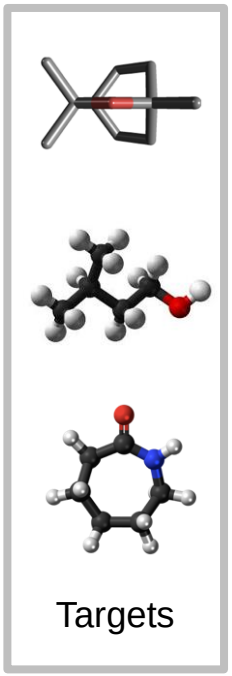
ABF's history (pre-2023)

- **Funding:** from U.S. DOE EERE BETO
  - 2016 pilot project $3M/year
  - 2017-2022 $20M/year

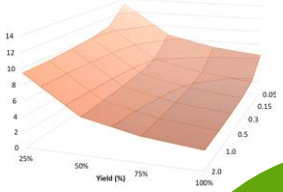
- **Goal:** enable biorefineries to achieve 50% reductions in time to bioprocess scale-up as compared to the current average of around 10 years by establishing a distributed Agile BioFoundry to productionize synthetic biology

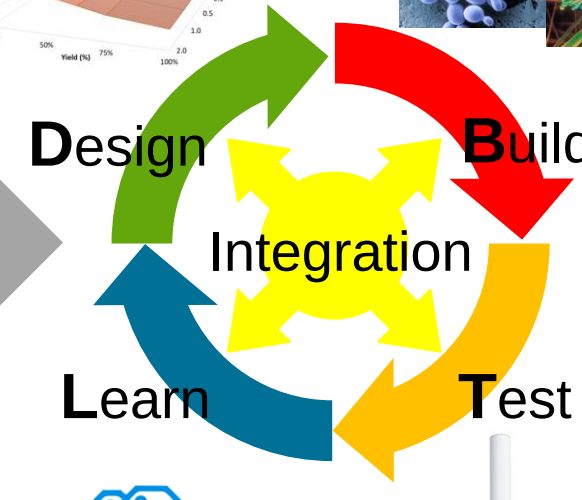
ABF is a consortium of 7 U.S. DOE National Labs

The Agile BioFoundry approach



Putative Targets





Target Metrics Achieved

ABF hosts and tier system

Eleven Hosts Onboarded to Tier 1:

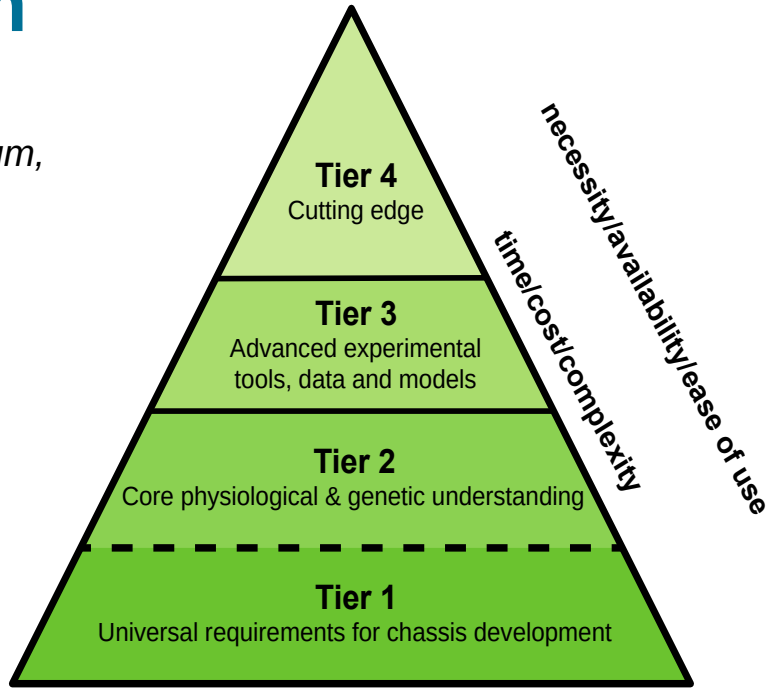
Bacteria - *Clostridium ljungdahlii, Clostridium tyrobutyrium, Cupriavidus necator, Pseudomonas fluorescens, Rhodobacter sphaeroides, Zymomonas mobilis*

Fungi - *Aspergillus pseudoterreus, Lipomyces starkeyi, Pichia kudriavzevii, Yarrowia lipolytica*

Five Hosts Elevated to Tier 2:

Bacteria - *Bacillus licheniformis, Corynebacterium glutamicum, Pseudomonas putida*

Fungi - *Aspergillus niger, Rhodosporidium toruloides*



Tier 1 represents the fundamental tools & information needed for any rational DBTL cycle; these basics must be achieved to be “onboarded”.

Tier 2 criteria consist of the tools and knowledge needed for rapid and robust DBTL cycles.

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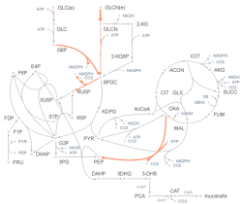
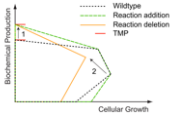
Highlights - DBTL Infrastructure



Bayesian Inference: Metabolic Kinetics



Metabolic Network Modeling

Deep Learning

DiVA

DNAda

DNA Construction

Design

Build

Integration

Learn

Test

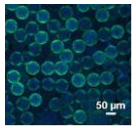
art

EDD

LabKey

Sequence Validation

Automation



Biosensors + Cytometry/ Microfluidics

Scale-up

Transcriptomics, Metabolomics, Proteomics, Lipidomics

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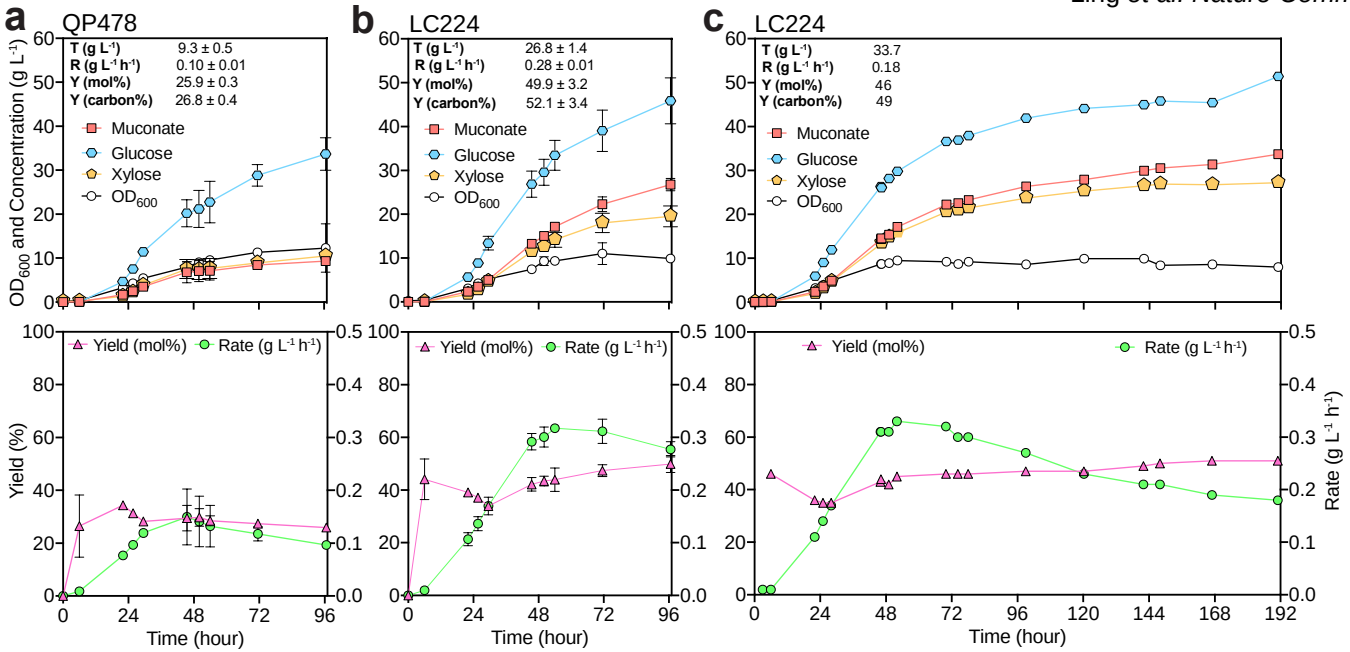
Highlights – Bacterial Demonstrations

- Engineering xylose utilization enables muconate 33.7 g/L titer at 0.18 g/L/hr
- Ongoing work to utilize arabinose to further increase rate

Ling *et al. Nature Comm.* 2022



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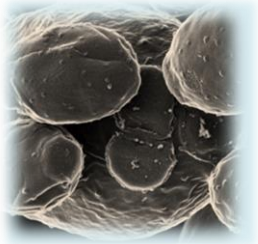
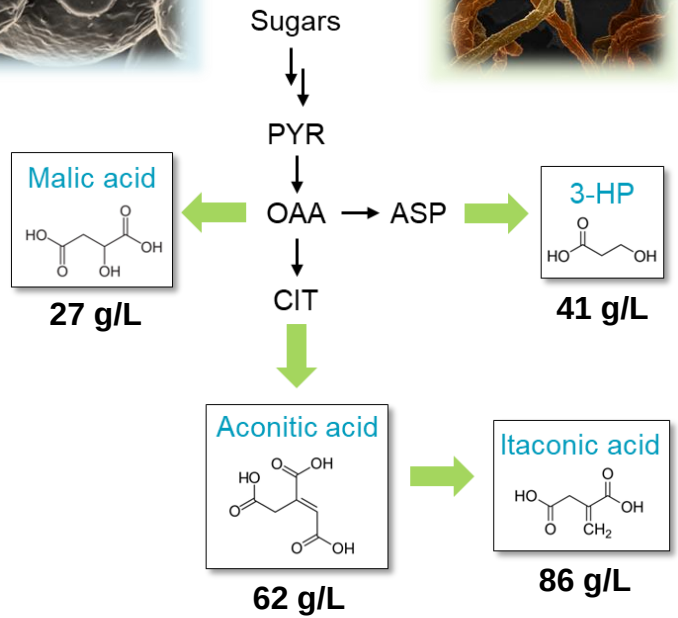
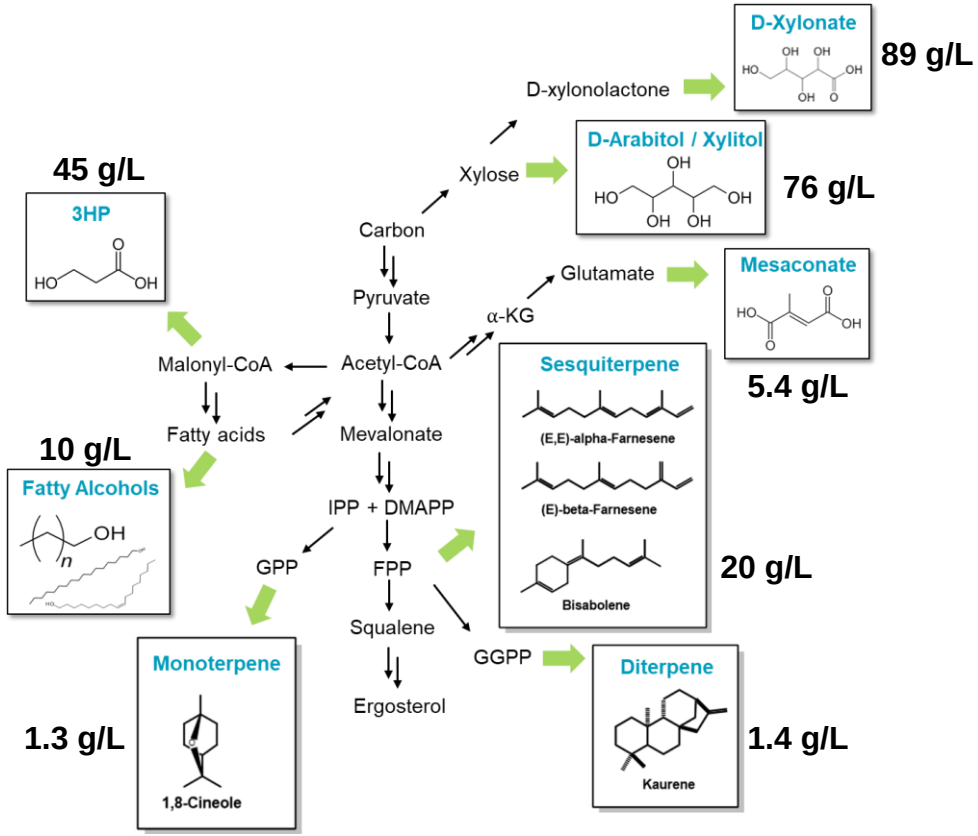
Highlights – Fungal Demonstrations





Highlights – Yeast Demonstrations



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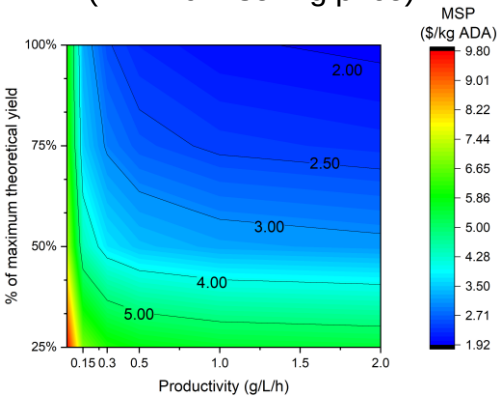
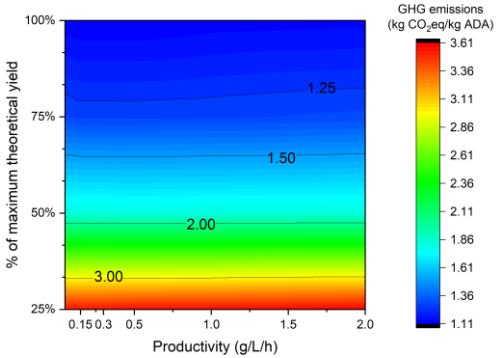
Highlights – Integrated Analysis

Goal: Develop **techno-economic and life cycle analyses (TEA and LCA)** models to quantify the **economic** and **environmental** performance of metabolic pathways of interest to the ABF consortium and provide guidelines for future experimental directions

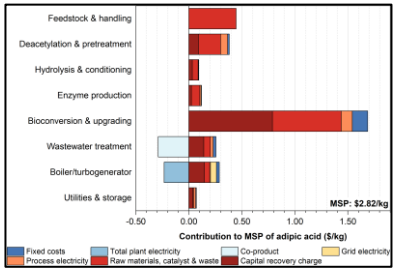
Economic impact
(minimum selling price)

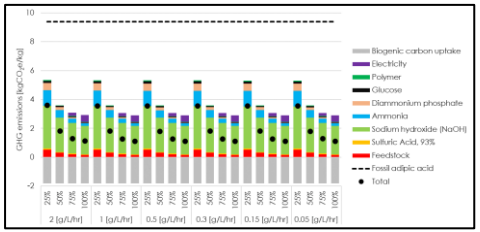


Environmental impact
(greenhouse gas emissions)



Breakdown of impacts





- Incorporate key scientific and technical parameters (titer, rate, yield) around product synthesis/recovery steps into integrated process models
- Provide TEA- and LCA-based guidelines to the experimental teams for process development

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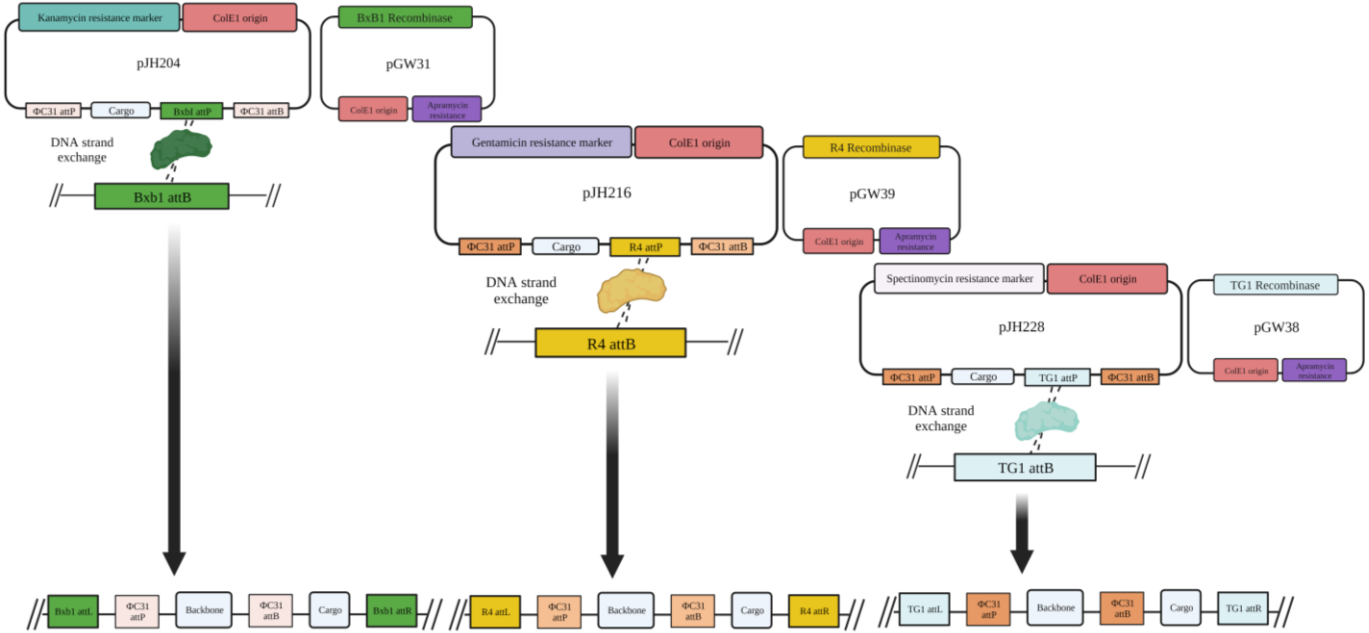
Highlights – Host Onboarding and Development



- Expanded “SAGE” DNA integration system to enable high efficiency, simultaneous integration of three plasmids (or libraries of plasmids) into the *P. putida* chromosome
- Simultaneous removal of plasmid backbone allows additional rounds of DNA insertion
- This greatly accelerates strain construction and pathway optimization

- **Outcome:** Base SAGE technology has been licensed by a company for use in one organism
- **Outcome:** Highly efficient tools that allow combinatorial pathway assembly in the target host for rapid Build

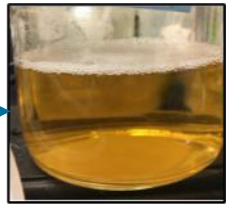
Highlights – Process Integration and Scale-Up

Bioprocess development and strain evaluation

Increase product titers, rates, and yields and testing at different scales

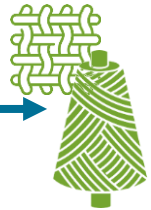
Lignocellulosic hydrolysate production

Deacetylation, mechanical refining, enzymatic hydrolysis



Product delivery to industry and other DOE-BETO funded projects

Test material properties



Test downstream product recovery systems

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Highlights – Industry Engagement & Outreach

Outreach
- Website: Main source of visibility to industry
- Newsletter
- Marketing materials
- Social media: LinkedIn, Twitter, YouTube

Interactions
- IAB Meetings: Quarterly
- Conference attendance
- Annual Industry Day
- Webinar series

Assessment
- Energy I-Corps Approach
- ~25 Interviews annually
- Surveys

ABF's Christopher Johnson describes our metabolic engineering strategies to enable production targets associated with various beachhead molecules.

Deepti Tanjore, co-lead of ABF's Process Integration and Scaling Task, outlines ABF's fermentation capabilities.

SIMB Society for Industrial Microbiology and Biotechnology

Bio IMPACT Ag & Environment Conference

Companies represented in FY22 roster

amyris · Trelys · CALYSTA · Agilent Technologies · GINKGO BIOWORKS THE ORGANISM COMPANY · BioMADE · BASF We create chemistry · novonutrients food and feed from CO_2 · teselagen BIOTECHNOLOGY · SYNTHETIC EVOLUTION · AUTODESK RESEARCH · ThermoFisher SCIENTIFIC

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Highlights – Management

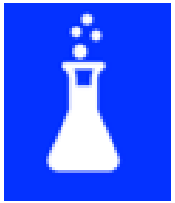
Inaugurated partnership with the National Science Foundation, resulting in **6 co-funded projects** in synthetic biology with BETO/ABF-aligned applications.

Selected **3 funds-out projects** as a new initiative to grow relationships with minority-serving institutions (MSIs). ABF is working to expand access to its capabilities for MSIs and investigators from underrepresented communities.

MSI STEM Research & Development CONSORTIUM

ABF's future – why are we changing course?

- **DOE BETO mission**: strong mission shift to decarbonizing transportation (e.g. sustainable aviation fuels) and industry (e.g. chemical production)



- **Biofoundry performance metrics**: difficult to quantitatively measure impact in reducing time to bioprocess commercialization, and other lessons learned

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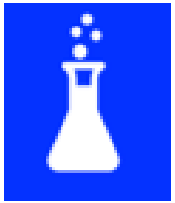
ABF's future direction

- **Vision**: Sustainable biomanufacturing of affordable fuels and chemicals



- **Mission**: Develop biomanufacturing tools, processes, and partnerships that enable sustainable industrial production of renewable fuels and chemicals for the nation

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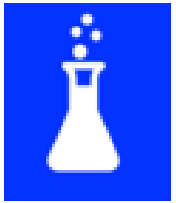
ABF's goals

- **Partnerships**: Actively develop funds-in and BETO-funded projects that result in technology transfer to industry

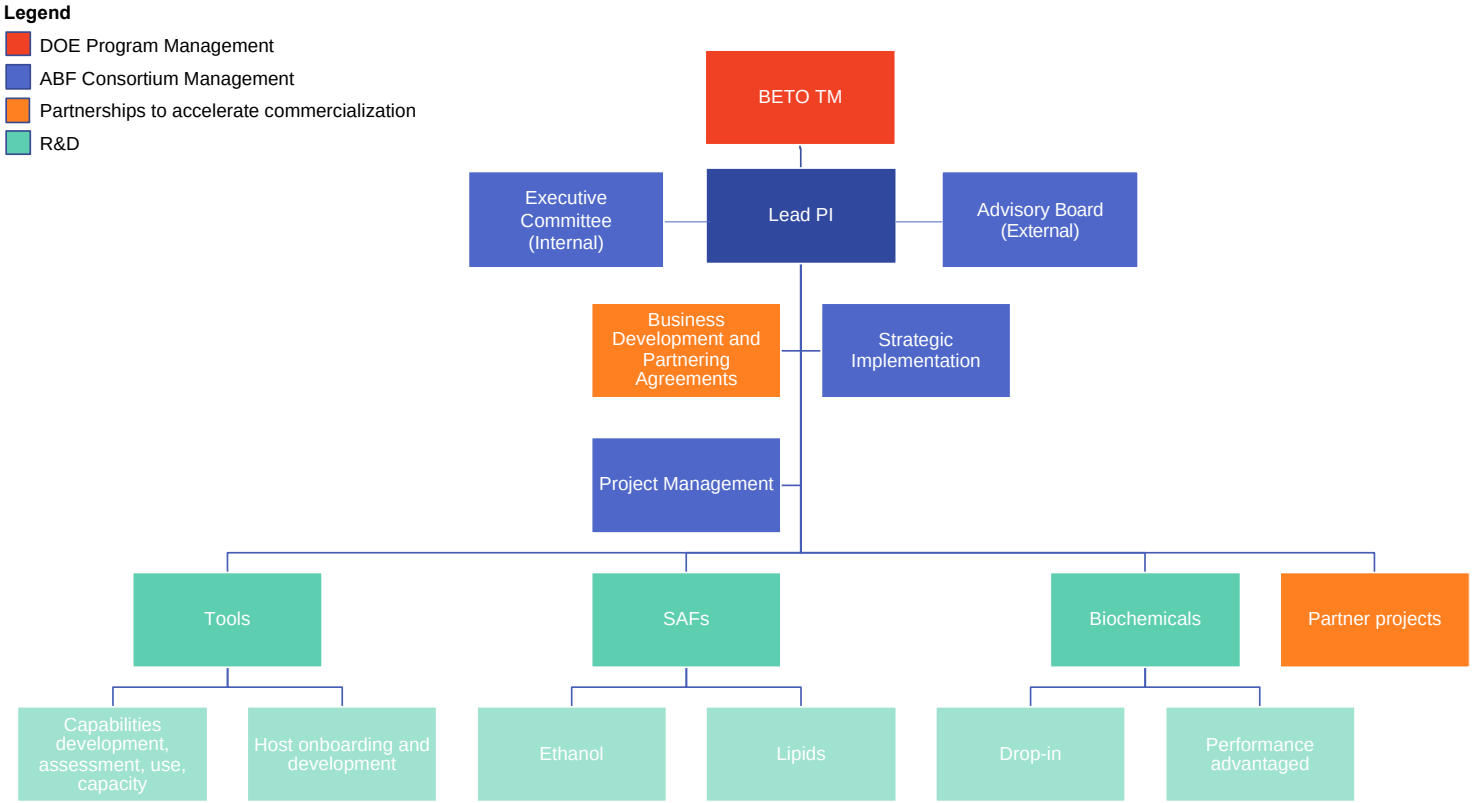
- **Tools**: Develop and demonstrate engineering biology, computational, and bioprocess tools that advance strain performance for the sustainable production of fuels and chemicals

- **SAFs**: Develop innovative pathways, strains, and processes for the production of sustainable aviation fuels

- **Biochemicals**: Develop innovative pathways, strains, and processes for the sustainable production of direct replacement and performance-advantaged chemicals



ABF's organizational structure

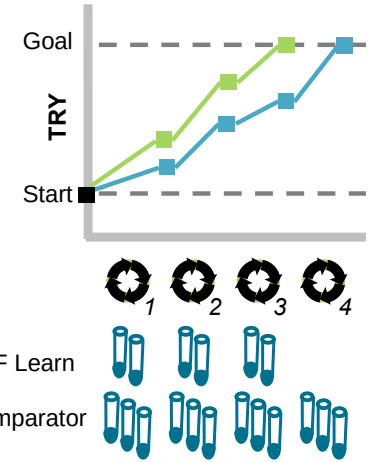


Impact on state of technology/industry if successful

- **A re-imagined DOE Agile BioFoundry**
  - Renewed focus on industry partnerships, sustainable aviation fuels, and renewable biochemicals
  - ≥ 50% of ABF's budget committed to external partnerships

- **Industry-partnered commercialization paths**
  - At least 50% GHG emissions reductions and paths to economic viability for thermophilic ethanol and microbial alkanes to SAF processes
  - At least one biochemical process with at least 70% GHG emissions reductions with a commercial partner and a path to commercialization by 2030
  - At least 2 funds-in projects
  - Enable at least 500 kT CO2e reduction through commercial partnership projects
  - Access to ABF capabilities to advance industry's goals

- **ABF-developed capability benchmarking**
  - ABF capabilities compared to best industry-accessible alternative benchmarks demonstrate operational performance gains of significant impact



ABF's collaborating partners

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Want to learn more about the ABF?

https://agilebiofoundry.org

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Sustainable Aviation Fuel & Biochemical Overview

Gregg Beckham, Di Liu, Kyle Pomraning

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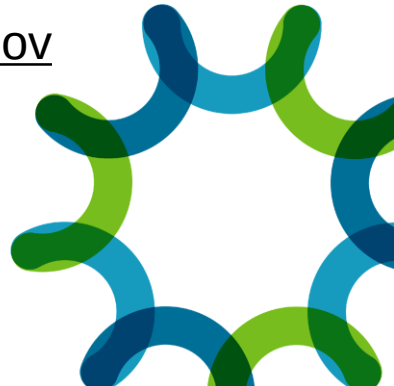
July 31, 2023



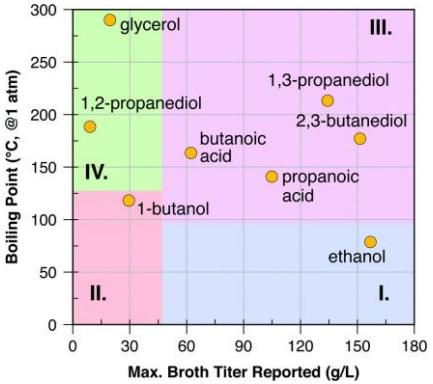
SAF: Why ethanol?

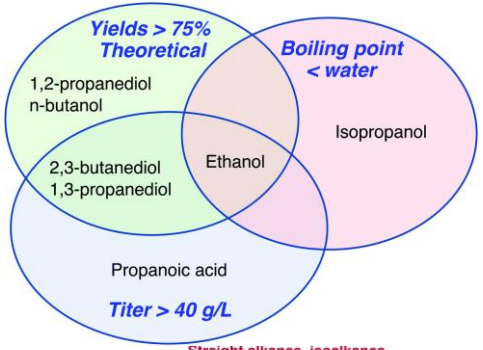
Why anaerobic processes for fuel production?

	Aerobic	Anaerobic
Capital		
Bioreactor vessel	$52 460 771	$5 589 903
Bioreactor air compressor	$1 631 302	$0
Bioreactor agitator	$0	$347 713
Bioreactor cooler	$932 368	$351 837
Seed train equipment	$2 663 748	$3 511 609
Recirculation/transfer pump	$389 057	$103 570
Total	**$58 077 246**	**$9 904 632**
Operating		
Bioreactor system including agitator	$1 916 323	$191 674
Chiller system	$2 909 972	$1 220 396
Total	**$4 826 295**	**$1 412 070**

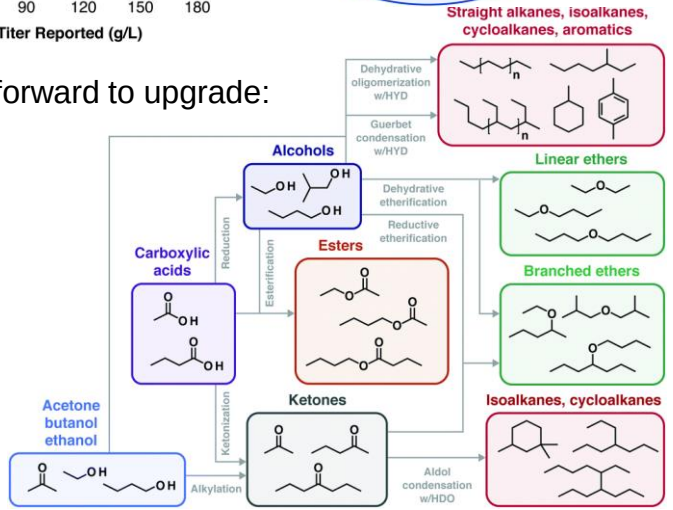
Table information from Biddy *et al. ACS SusChemEng.* 2016
Images from Lynd, Beckham *et al. Energy Env. Sci.* 2022

EtOH is straightforward to separate and accessible at high yields and titers:





And straightforward to upgrade:



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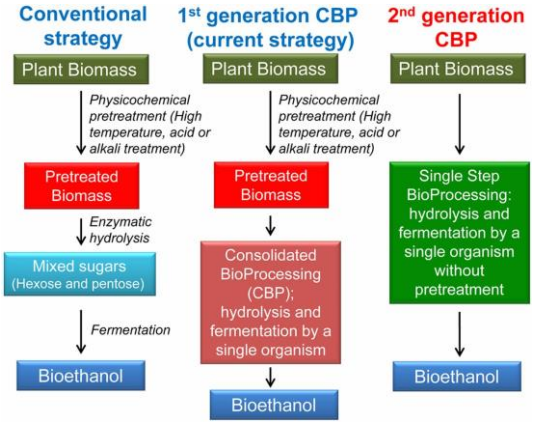
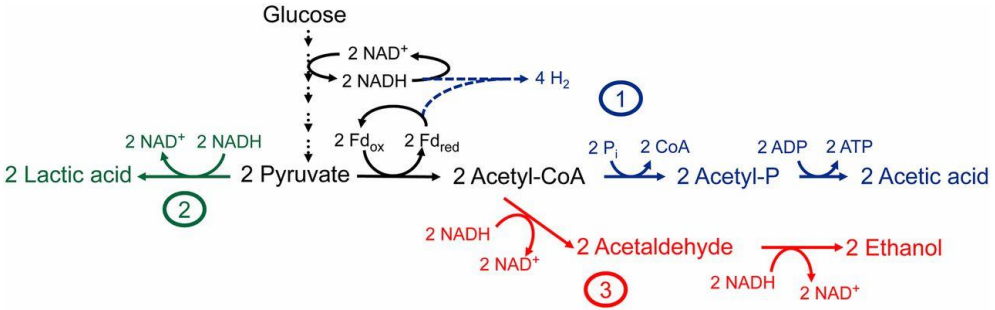
SAF: Consolidated bioprocessing

- CBP is a process intensification strategy for solids fermentation
- High-risk, high-reward effort that could displace pretreatment, enzymatic hydrolysis, and fermentation of sugars
- Avoiding pretreatment could have a major positive impact on both economics and GHG emissions
- Focus on CBP with whole corn stover and lignin-first residues using *Caldicellulosiruptor* strains
- Major cost drivers are solids loadings, EtOH yield and titer, and biomass solubilization
- Project is synergistic, not overlapping with Office of Science-funded efforts – communication plan in place with Center for Bioenergy Innovation efforts, which focus on a different microbe with different challenges

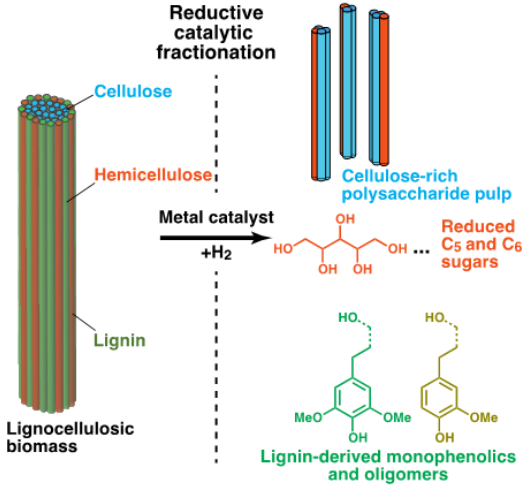


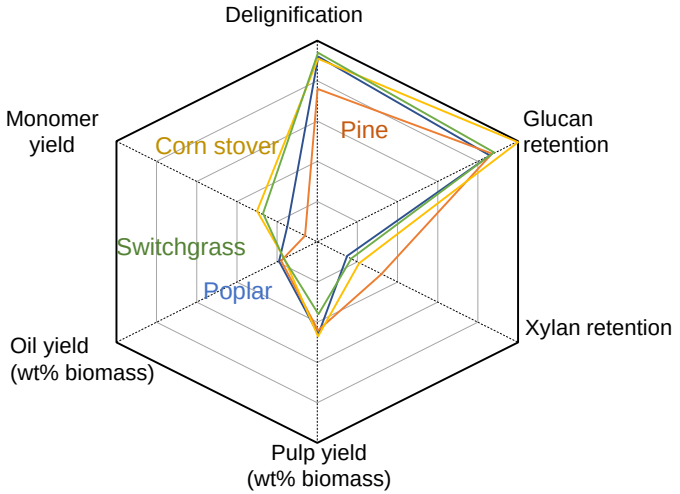


Images from Chung *et al. PNAS* 2014

SAF: Lignin-first residual polysaccharides

- Lignin-first processing can enable woody feedstocks to be used in biochemical conversion processes and lignin to be extracted into a stable oil that can be upgraded in parallel process trains to fuels and / or chemicals
- Offers a lower-risk substrate for consolidated bioprocessing that still avoids separate enzymatic hydrolysis and fermentation steps and can enable feedstocks beyond corn stover as a substrate
- If interested, see AW Bartling *et al. Energy Env. Sci.* 2021 for process model, TEA, and LCA of lignin-first process

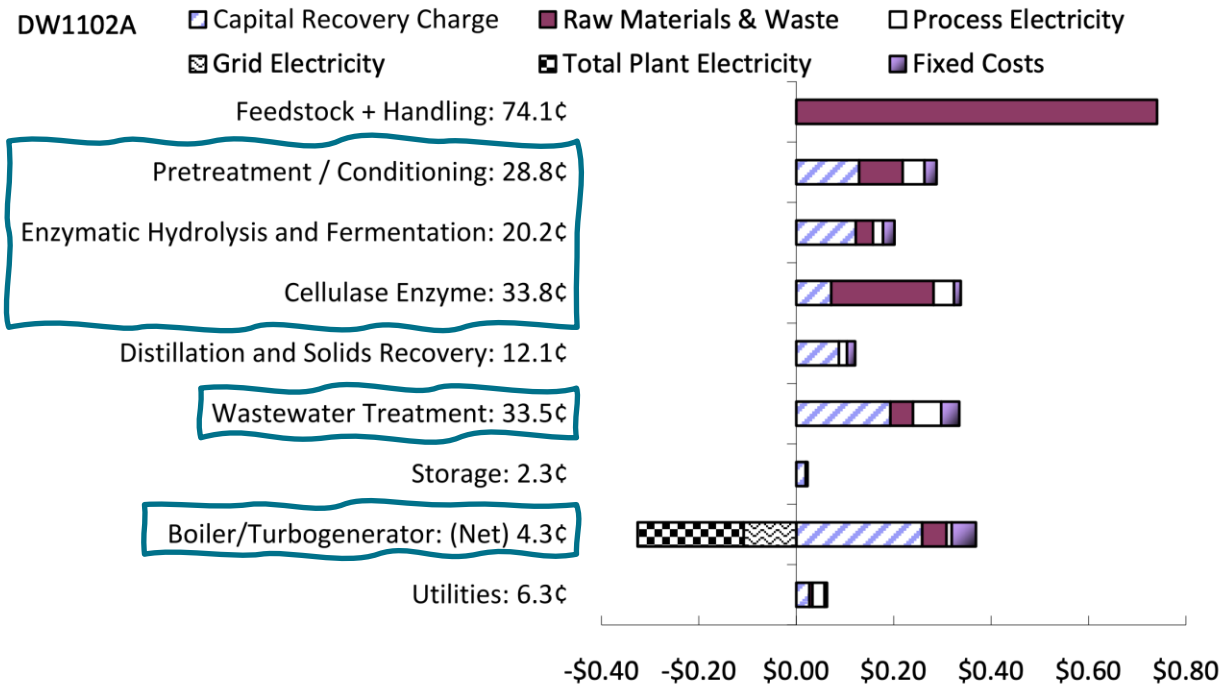




Abu-Omar, Barta, Beckham, Luterbacher, Ralph, Rinaldi, Román-Leshkov, Samec, Sels, Wang, *Energy Env. Sci.* 2021

Jang, Morais *et al. Green Chem.* 2023

SAF: Consolidated bioprocessing potential impacts



- Removal of pretreatment, enzymatic hydrolysis, and cellulase enzymes for CBP of whole biomass
- Removal of cellulase enzymes and enzymatic hydrolysis for CBP on lignin-first residuals
- Could remove the boiler / turbo-generator in both cases – this is almost always the most expensive estimated unit operation in the biorefinery
- Fewer pH swings would reduce burden on wastewater treatment – major area of uncertainty in process modeling

Image from Humbird *et al.* NREL Design Report 2011

SAF: Ethanol milestones

Overall goal: Deliver an **anaerobic thermophilic** strain and an associated **conversion process** to convert lignocellulose directly at near industrially-relevant **solids loadings**, **solubilization extent**, and **ethanol titers** that would meet at least **50% greenhouse gas (GHG) emissions reductions** relative to fossil-based jet fuel, with a path towards economically viable ethanol production at higher solids loadings for out-years

FY23 and select FY24 milestones:

FY23 Q3: All accessible *Caldicellulosiruptor* strains (and other relevant microbes) procured from publicly-available culture collections

FY23 Q4: Build foundation for transformation system in *Caldicellulosiruptor* strains by performing methylome analysis. Begin to build *E. coli* strains that methylate the same patterns to enable transformation.

FY24 Q1: Biomass solubilization trials conducted in temperature and pH-controlled conditions on whole corn stover and lignin-extracted biomass substrates (with Lignin-First Biorefinery Development project)

FY24 Q4: Down-selection to a single CBP strain (>70% biomass solubilization and >80% carbon closure known on fermentation products)

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SAF: Why Alkanes

8 technology platforms ASTM certified to produce SAF for use in commercial aviation

• Fischer-Tropsch (FT)	Syngas
• Alcohol to Jet (AtJ)	Alcohol
• Synthesized Iso-Paraffins (SIP)	Farnesene
• Hydrotreated Esters and Fatty Acids (HEFA)	Fats, oils
• Catalytic Hydrothermolysis (CHJ)	Fatty acid esters, fatty acids
• Hydroprocessed Hydrocarbons, Esters and Fatty Acid (HC-HEFA)	Alkenes, fatty acid esters, fatty acids
• Co-processing	Fats, oils

Alkanes fuels can leverage our previous work on terpenes and lipids

SAF: Why lipids

8 technology platforms ASTM certified to produce SAF for use in commercial aviation

• Fischer-Tropsch (FT)	Syngas
• Alcohol to Jet (AtJ)	Alcohol
• Synthesized Iso-Paraffins (SIP)	Farnesene*
• **Hydrotreated Esters and Fatty Acids (HEFA)**	**Fats, oils**
• Catalytic Hydrothermolysis (CHJ)	Fatty acid esters, fatty acids
• Hydroprocessed Hydrocarbons, Esters and Fatty Acid (HC-HEFA)	Alkenes*, fatty acid esters, fatty acids
• Co-processing	Fats, oils

HEFA-based biofuel is the major commercially available product and powers over 95% of SAF flights so will likely be our focus area

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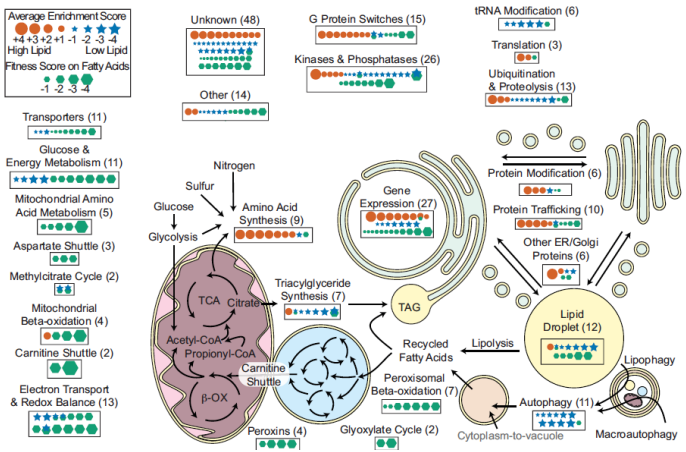
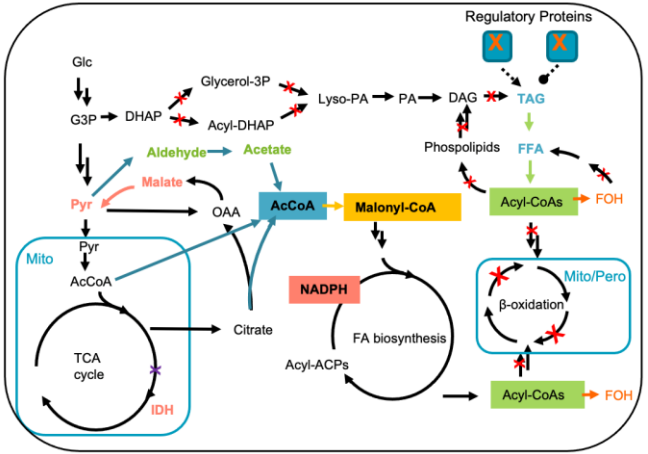
SAF: Next steps on microbial alkanes

ABF's onboarded high lipid producing hosts: *R. toruloides*, *Y. lipolytica*, *L. starkeyi*





Prior ABF efforts on elucidating lipid metabolism and fatty alcohol production in *R. toruloides*

- **Strain engineering**: Identify biosynthetic routes to SAF targets and engineering strategies. Baseline production and optimize titers, rates and yields.
- **Process development**: Conduct bioreactor cultivations and optimize conditions. Examine specific scenarios for standalone microbial SAF technology or co-integrated technology. Collaborate with Separations Consortium for product recovery
- **Tool development**: Establish tools needed to enable efficient engineering
- **TEA/LCA**: Leverage existing and develop as needed process models for lipid/alkane-based SAF pathways

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Coradetti et al, *Elife*, 2018
Liu et al, in preparation

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SAF: Alkane/lipids milestones

Overall goal: Develop route of economic **microbial production of an alkane-rich biomolecule** as a feedstock for an ASTM certified jet fuel. Examine stand-alone scenarios and scenarios that integrate the microbial production routes with current industrial SAF processes. Target **lipid titers that would meet at least 50% GHG emissions reductions** and at **costs approaching parity with fossil-based jet fuel**.

FY23 and select FY24 milestones (including Tools-related milestone):

FY23 Q4: Automated transformation through omics sample prep initiated for first organism. Key
performance metrics identified for assessments made in FY24 and FY25, including how this approach enables the demonstration projects to succeed.

FY23Q4 (GNG): Down select to one target molecule and one host organism for the production of alkanes for SAF.

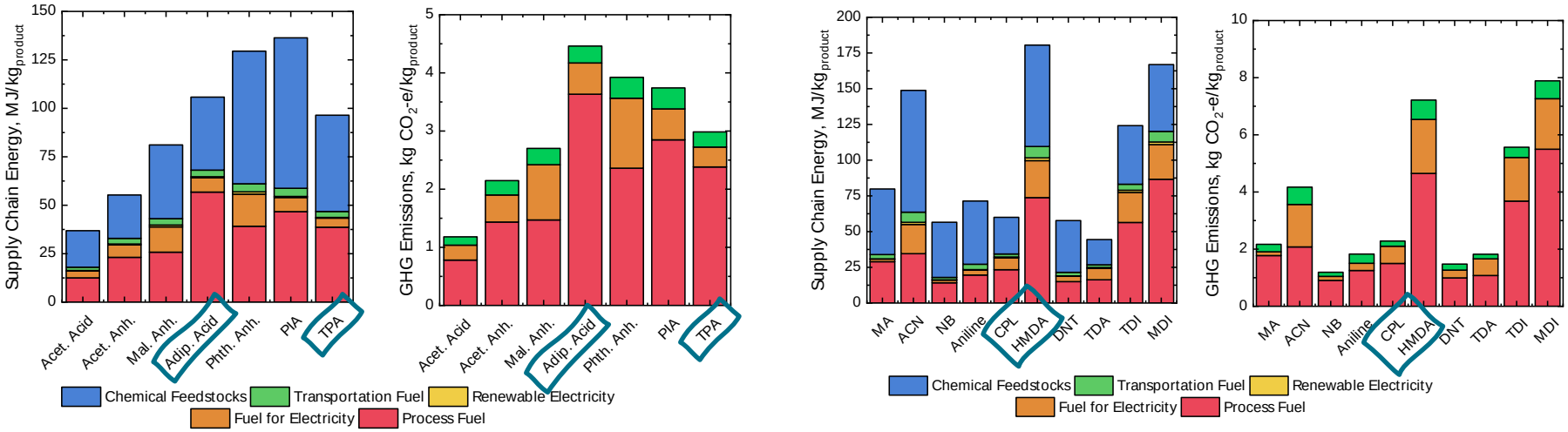
FY24 Q4: Baseline TRY established for alkane sustainable aviation fuel (oils,

Biochemicals: Why muconate?

- Muconate enables access to **adipic acid**, **terephthalic acid** (TPA), **caprolactam** (CPL), **1,6-hexamethyldiamine** (HMDA), **functional replacements** for e.g., maleic anhydride, and **performance-advantaged bioproducts**
- Have existing option to license IP in place for muconic acid-producing strains from ABF, soon-to-start industrially-funded projects on muconate conversion to drop-in replacement for textile applications

CHO chemicals

CHN and CHNO chemicals



Data and images from Nicholson, Rorrer *et al. ACS SusChemEng.* 2023

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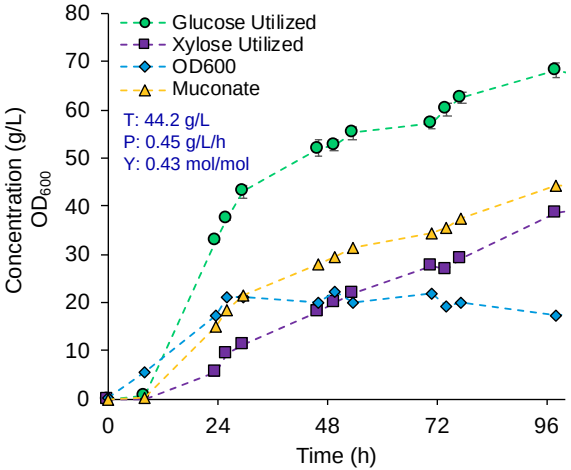
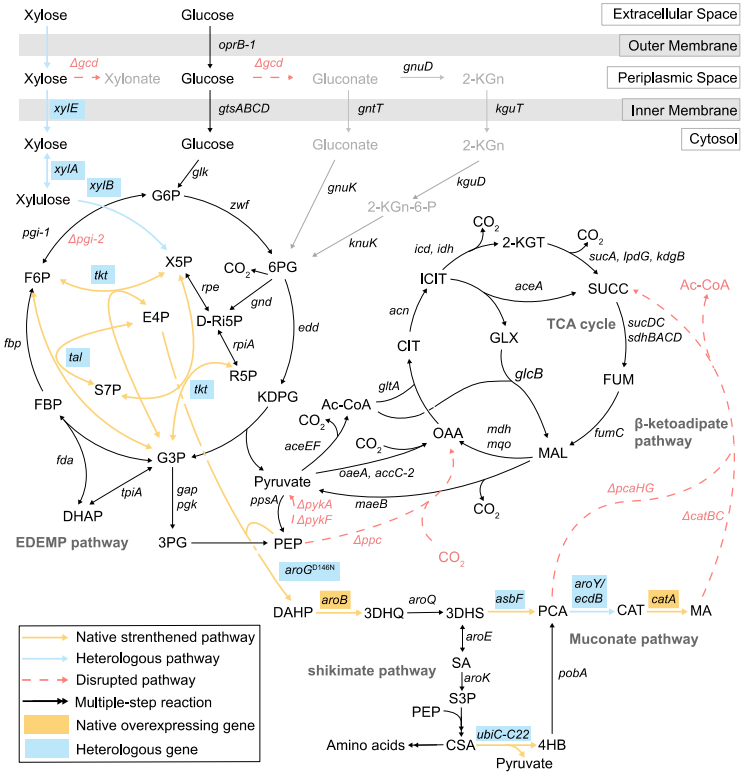
Biochemicals: Next steps on muconate

Pseudomonas putida KT2440





Major areas of focus:

- Titer improvements for improved separations yield
- Further rate improvements including protocatechuate decarboxylation
- Arabinose utilization
- Excellent testbed strain and product for new tool development for non-intuitive strain improvements (e.g., RB-TnSeq, CRISPRi, ART, etc.)
- Incorporation with *in situ* product recovery in Separations Consortium
- Use of muconic acid as a substrate for catalytic conversion or direct use in polymers and formulated products with industry partners

Ling *et al. Nature Comm.* 2022
Mokwatlo *et al.* in preparation

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Biochemicals: Muconate

Overall goal: Transfer strains and processes to industry to produce direct replacement and performance-advantaged chemicals at **industrially relevant titers, rates, and yields** and at **70% reduction in GHG emissions relative to fossil-based adipic acid production**

FY23 and select FY24 milestones (including Tools-related milestone):

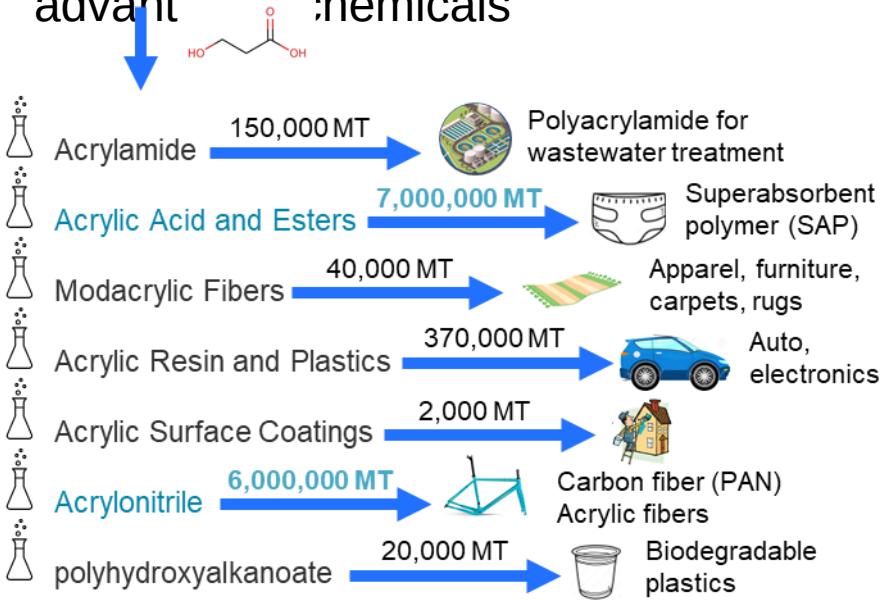
FY23 Q3: Arabinose utilization engineered into muconic acid-producing strains of *P. putida*. Demonstrated 10% improvement of strain growth in a bioreactor cultivation on mixed sugars

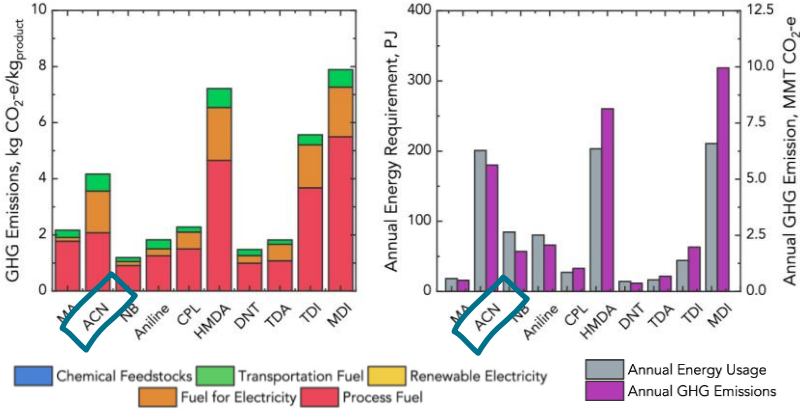
FY23 Q4 (Tools): RB-TnSeq library in a muconic acid production strain of *P. putida*. Use RB-TnSeq library to assay muconate production in a bioreactor. Work in FY24 will focus on reverse engineering of potentially beneficial mutations into the clean background production strain

FY23 Q4 Conduct a media screening trial with ART to understand if we can improve muconate strain performance through media development

Biochemicals: why 3-HP?

3-HP is a building block for drop-in and performance advant :hemicals



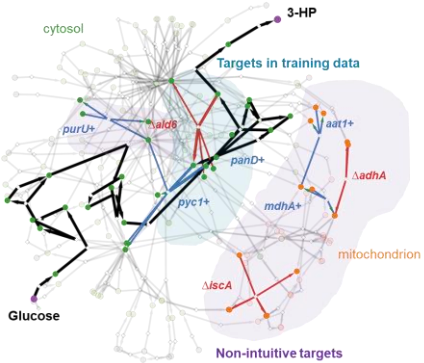


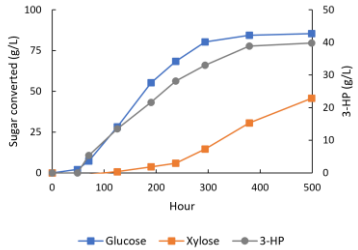
Nicholson, Rorrer *et al. ACS SusChemEng.* 2023

- Acrylic acid and acrylonitrile represent large (>1MM tons/yr) commodity chemical markets with the ability to reduce GHG emissions by >70% versus existing petrochemical routes.
- The ABF has developed diverse pathways to 3-HP that access alternative feedstocks, fermentation, and separations routes with options to license IP.

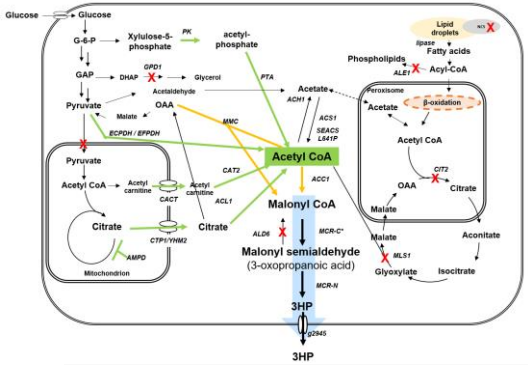
Biochemicals: next steps for 3-HP

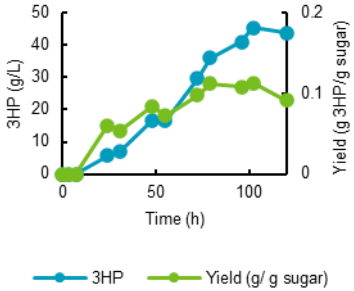
3-HP via aspartate beachhead in *Aspergillus* sp.





3-HP via acetyl-CoA beachhead in *Rhodosporidium*





DBTL based engineering to improve TRY

- Elimination of competing pathways to increase yield and stacking of modifications
- Balancing of metabolic precursors and redox
- Media and fed-batch or continuous process optimization to improve rate and titer

TEA/LCA

- Evaluate feedstocks and separations for specific downstream products informed by industrial input and Separations

Pomraning K et al., *Front Bioeng Biotechnol*, 2021
Daj Z et al., *Biotechnol Biofuels*, 2023
Liu D et al., *Metab Eng*, 2023

Biochemicals: 3-HP

Overall goal: Transfer strains and processes to industry to produce direct replacement and performance-advantaged chemicals at **industrially relevant titers, rates, and yields** and at **70% reduction in GHG emissions relative to fossil-based incumbents (acrylic acid, acrylonitrile)**

FY23 and select FY24 milestones

FY23 Q4: 3-HP production to >40 g/L on relevant feedstocks to demonstrate bioprocess maturity.

FY23 Q4: (GNG): Down select to one 3-HP process to pursue in FY24 and beyond that exhibits sufficient commercial interest to pursue.

FY24 Q3: Leverage existing process modeling frameworks to conduct TEA and LCA based on current experimental data. Quantify CO2e reduction compared to fossil incumbent.

FY24 Q4: Media optimized for a 3-HP producing strain with the ART tool resulting in 10% gains in one or more TRY parameters.

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Emerging Tools / Capabilities

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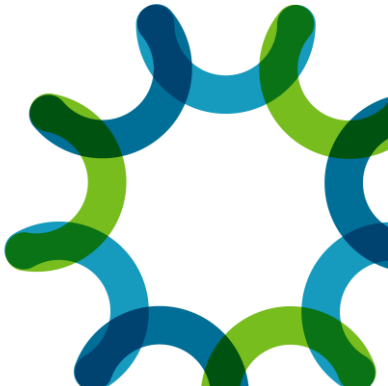
Lead PI, DOE Agile BioFoundry

ABF Industry Listening Day 2023
July 31, 2023



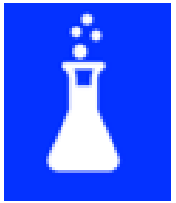
ABF's goals

- **Partnerships**: Actively develop funds-in and BETO-funded projects that result in technology transfer to industry

- **Tools**: Develop and demonstrate engineering biology, computational, and bioprocess tools that advance strain performance for the sustainable production of fuels and chemicals

- **SAFs**: Develop innovative pathways, strains, and processes for the production of sustainable aviation fuels

- **Biochemicals**: Develop innovative pathways, strains, and processes for the sustainable production of direct replacement and performance-advantaged chemicals



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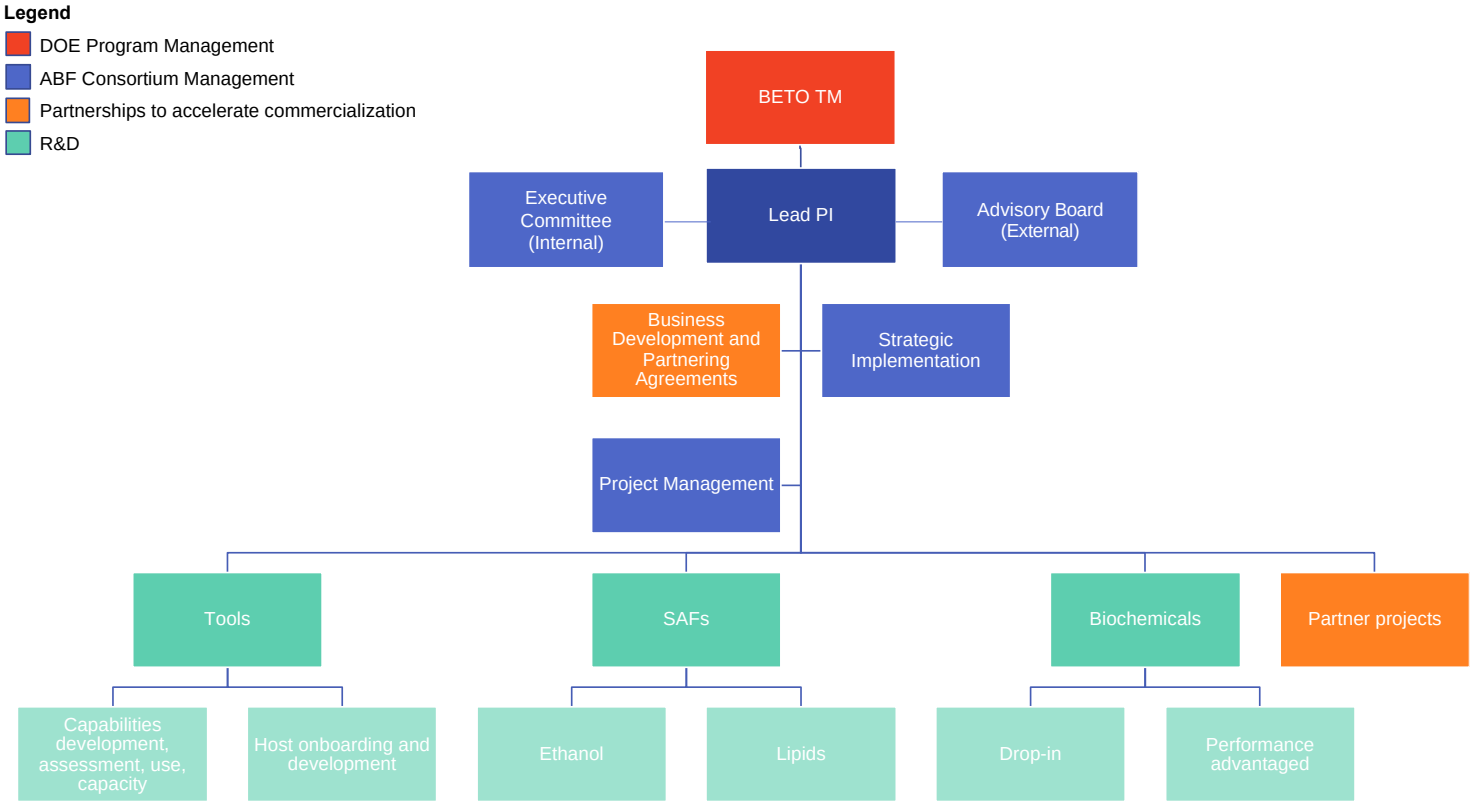
ABF's organizational structure



Tools – FY25 deliverables

- **Capabilities development, assessment, and application**
  - All capabilities and activities must clearly connect with strategic goals
  - Advance SAF, biochemical, and industry projects by developing and using benchmarked technologies that out-perform state of the art
  - Track technology usage in industry projects and number of times technologies transferred to industry
  - Demonstrate process for sunsetting technologies where benchmarking fails to show value
  - Demonstrate at least 6 new technologies across Design (including TEA/LCA), Build, Test (including scale-up), and Learn between FY23 and FY25
  - Demonstrate operational performance gains of significant impact for at least 2 ABF technologies benchmarked to state of the art
  - Measure ABF capability capacities and advertise capabilities and their technical advantages

- **Host onboarding and development**
  - Following assessment for strategic opportunities, extend diversity (process, phylogeny, metabolic) of hosts, and demonstrate how this extended diversity enhances process performance (TRY, TEA) and industrial engagement (industry licensing/uptake)
  - As needed, select and onboard approximately 5 additional hosts for internal and external projects for use in industrial processes related to SAF and renewable chemical production
  - All work beyond onboarding will be internal project and industry-driven

Tools - development and benchmarking

- **Identify and prioritize capability gaps / opportunities**

- **Develop new capabilities**
  - Machine learning tools to predict the temperature and pH optima of enzymes
  - Protein structural modeling to change substrate specificity and improve thermostability
  - New automation onboarding (Vantage and anaerobic Tecan)
  - Automation of transformation through omics sample prep (includes high-throughput electroporation/conjugation)
  - Genome-scale screening (e.g., RB-TnSeq) and genome-modification tools (e.g., SAGE, CRISPR)
  - Isotopomer/genome fluxomics/metabolic flux analysis models, and multi-labeled substrate methods
  - Expanded targeted metabolomics coverage of key pathway molecules, substrates, and products
  - High-throughput high-quality proteomics methods (e.g., plate-based SPCE, DIA-MS)
  - High-throughput RNA-seq and data analysis pipeline
  - Data visualization tools
  - Integration of machine learning and mechanistic models, and machine learning to improve flux model predictions

- **Sunset capability development**
- **Capability benchmarking**
- **Monitor capability capacities, usage, and transfer to industry**
- **Maintain and continuously develop capabilities**

Tools Goal: Develop and demonstrate engineering biology, computational, and bioprocess tools that advance strain performance for the sustainable production of fuels and chemicals

Tools – host onboarding and development

- **Strategically assess the prospective onboarding of additional hosts**
  - Focus on expanding the metabolic, phylogenetic, and bioprocess diversity available within the ABF
  - Anticipate future needs including use in sustainable aviation fuels and biochemicals goal activities
- **Use market pull to direct host development beyond onboarding**
  - ABF core-industry partnerships, funds-in projects
  - Sustainable aviation fuels and biochemicals goal activities
- **Demonstrate how extended host diversity enhances process performance and industry engagement**
- **Update the host Tier system as needed**

Tools Goal: Develop and demonstrate engineering biology, computational, and bioprocess tools that advance strain performance for the sustainable production of fuels and chemicals

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Tools

- **FY23 milestones**
  - Go/No-Go: Colony identities post FACS match distribution profile expectations
  - New automation (Vantage, anaerobic Tecan) onboarded
  - Pilot benchmarking experiment initiated
  - Machine learning method for enzyme temperature and pH optima predictions developed
  - Genome-scale screening tool (e.g. RB-TnSeq) successfully constructed in a production strain, and actionable outcomes for strain improvement reported
- **FY24 milestones**
  - Automated transformation through omics sample prep demonstrated for 2 organisms
  - Two additional benchmarking experiments completed
  - Additional genome-scale screening tool (e.g. over-expression library) successfully constructed in a production strain, and actionable outcomes for strain improvement reported
- **FY25 milestones**
  - At least 6 new technologies across Design (including TEA/LCA), Build, Test (including scale-up), and Learn demonstrated between FY23 and FY25
  - Operational performance gains of significant impact demonstrated for at least 2 ABF benchmarked technologies
  - Report delivered demonstrating assessments of ABF tools against benchmarks, the ABF capacity for using each tool, frequencies of ABF capabilities usage in internal and partner projects, and tool transfers to industry
  - Report delivered demonstrating transfer of host onboarding and development efforts to industrial partners

Tools Goal: Develop and demonstrate engineering biology, computational, and bioprocess tools that advance strain performance for the sustainable production of fuels and chemicals

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Want to learn more about the ABF?

https://agilebiofoundry.org

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Partnering with ABF

Angela Tarver, Robin Johnston
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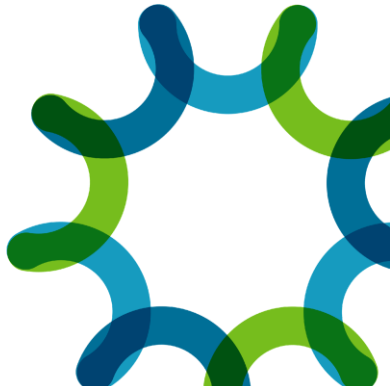
ABF Industry Listening Day
July 31, 2023



Partnering with ABF

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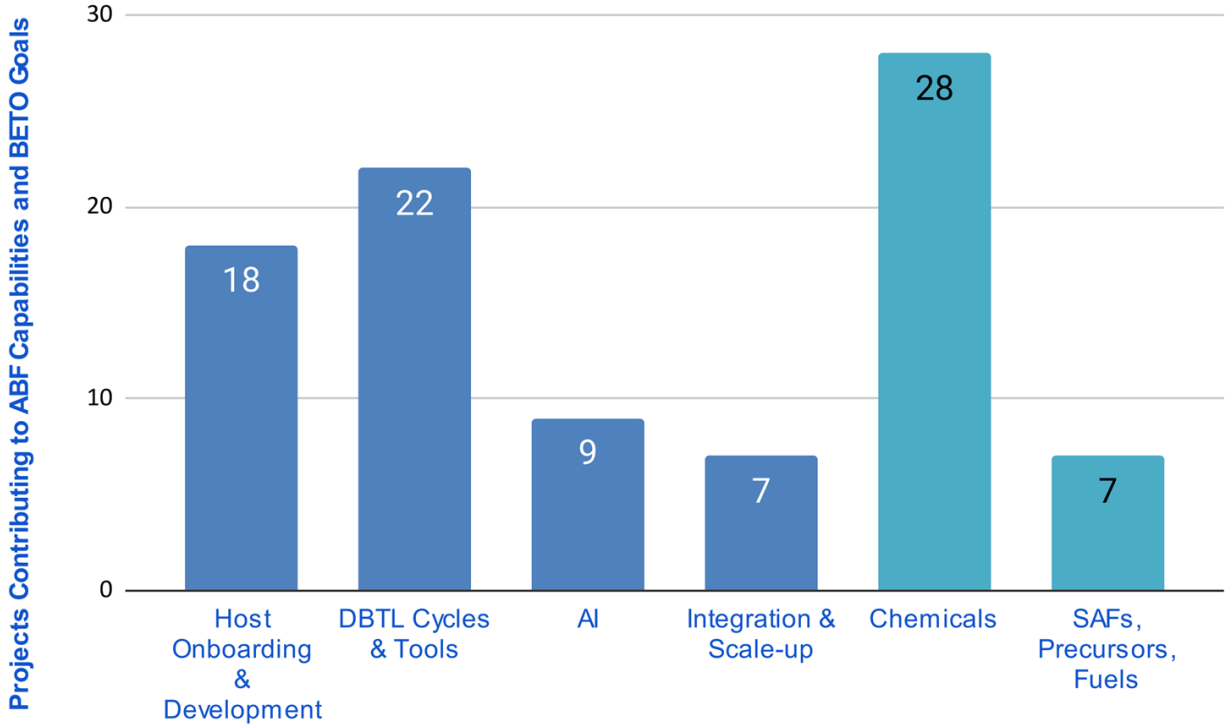
Partnering with ABF

Partner projects expanding knowledge and tools of the ABF.

Partner projects with a target chemical or fuel.



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Partnering with ABF

Current and upcoming partnering mechanisms

- ABF funding opportunity
- National Science Foundation
- Minority Serving Institutions
  - BioMADE
  - Annual Operating Plan (AOP) Activities
  - Collaborator funded projects

Partnering with ABF

ABF Funding Opportunity - Industry

- FY23: $3 million DOE
- Requires 20% cost share and CRADA
- Process:
    - Feasibility review
    - Coordination calls
    - Proposal submission
    - External review

Partnering with ABF

National Science Foundation ABF Joint FO - Academia

- FY23: $1 million DOE, $4 million NSF
- Requires CRADA
- Process
    - Feasibility review
    - Coordination calls
    - Proposal submission
    - NSF handles external review

Partnering with ABF

Minority Serving Institutions

- MSRDC: MSI STEM Research & Development Consortium
- Underrepresented Investigators
- FY22: $1 million DOE

BioMADE

- MRL-focused

Mechanism when federal funding is used

Non-negotiable Cooperative Research and Development Agreement (CRADA)

- Joint statement of work (SOW)
- Each party can take title to its subject inventions; joint inventions jointly owned
- With regard to a DOE-Lab subject invention, participant (non-DOE Lab party) can choose:
  - Six-month no-cost option to an **exclusive** license in a negotiated **field of use**; or,
  - Eighteen-month no-cost option to a **non-exclusive** license in **all** fields of use
  - Participant has 45 days after receiving the disclosure to decide.

- Why non-negotiable? Reduces execution time by ~ 10 months; also applies when many Labs are participating.

Otherwise…

CRADA

- Joint statement of work
- Negotiable
- Start with the same terms as the non-negotiable CRADA
- The Labs have little wiggle room when it comes to most legal terms, e.g. product liability, warranties
- No general indemnity

Strategic Partnership Program (SPP) agreements

- Only the Lab(s) conduct work
- US-owned company, sponsor can take title to Lab IP; otherwise, lesser rights can sometimes be negotiated with DOE approval
- Sponsor provides general indemnification to the Lab(s)