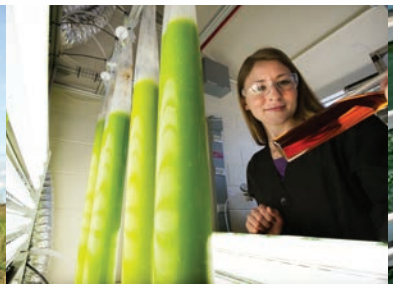
U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY






2019 PROJECT PEER REVIEW

U.S. DEPARTMENT OF ENERGY
BIOENERGY TECHNOLOGIES OFFICE

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INTRODUCTORY LETTER

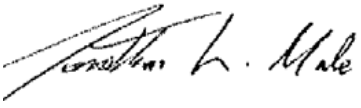
Dear Colleagues,

In the spring and summer of 2019, the U.S. Department of Energy's (DOE's) Office of Energy Efficiency and Renewable Energy's (EERE's) Bioenergy Technologies Office (BETO) continued its long-standing commitment to transparency by implementing the ninth biennial external review since 2005 of its research, development, and demonstration portfolio. Conducted in accordance with EERE peer review guidelines, the review was designed to provide an external assessment of the projects in BETO's portfolio and collect external stakeholder recommendations on BETO's overall scope, focus, and strategic direction. Results from the peer review process are used to inform programmatic decision-making; enhance active project management; and modify, expand, or discontinue existing projects.

This review process is critical to the success of our mission: to develop technologies that convert domestic biomass and waste resources into fuels, products, and power; to enable economic growth and innovation in affordable energy and chemicals production; and to support the growth of the domestic bioeconomy. The peer review process enables external stakeholders to provide feedback on the responsible use of taxpayer funding and develop recommendations for the most efficient and effective ways to accelerate the development of an advanced bioeconomy.

The 2019 Peer Review comprised three levels of review: (1) individual projects were scored on the basis of technical approach, relevance, progress, and future direction; (2) each technology area portfolio was evaluated for overall potential impact, innovation, synergies, focus, appropriate level in technology development pipeline, and recommendations; and (3) the structure and overall strategic direction of BETO was reviewed by an external steering committee. This report contains the results of each level of review and the inputs of approximately 400 participants in the peer review process, including principal investigators, reviewers, steering committee members, and BETO's staff and contractors.

BETO thanks all the reviewers and members of the steering committee who participated in this review, as well as the nearly 600 attendees of the Project Peer Review in March 2019. BETO appreciates the valuable insights and contributions provided throughout the peer review process. Achieving the objectives of BETO depends on the effective management of all projects in BETO's existing portfolio and on the appropriate focus and structure of future initiatives. BETO values the input of all stakeholders in the bioenergy sector and looks forward to working with them in the years ahead to continue progress on the path toward building a successful bioenergy industry and a sustainable bioeconomy.



Jonathan L. Male
Director, Bioenergy Technologies Office
Office of Energy Efficiency and Renewable Energy
U.S. Department of Energy

EXECUTIVE SUMMARY

BETO manages a diverse portfolio of technologies covering the full spectrum of bioenergy production, from the feedstock source to end use, as illustrated in Figure 1. BETO systematically prioritizes research and development (R&D) into technology opportunities across a range of emerging scientific breakthroughs and technology-readiness levels. This approach supports a diverse R&D portfolio while developing the most promising and widely applicable technologies, testing technologies as integrated processes, and verifying integrated processes at the engineering scale. These technologies will use a broad variety of currently underused domestic biomass and waste resources to produce increasing volumes of biofuels, bioproducts, and biopower.

Figure 1. Biomass-to-bioenergy supply chain.

The biennial peer review process enables external stakeholders to provide feedback on the responsible use of taxpayer funding and develop recommendations for the most efficient and effective ways to accelerate the development of a bioenergy industry. BETO completed these reviews in 2019. This report includes the results of both the Project Peer Review meeting held in March 2019 and the Program Management Review meeting held in July 2019.

ACRONYMS AND ABBREVIATIONS

A&S	Analysis and Sustainability
AAS	Advanced Algal Systems
ABBA	Advanced Biofuels and Bioproducts with AVAP
ABPDU	Advanced Biofuels and Bioproducts Process Development Unit
ACED	Atmospheric CO_2 Enrichment and Delivery
ACN	acrylonitrile
ACSC	Advanced Catalyst Synthesis and Characterization
AD	anerobic digestion
ADC	(TRI) Advanced Development Center
ADO	Advanced Development and Optimization
AGNPS	Agricultural Non-Point Source Pollution Model
ANL	Argonne National Laboratory
AOP	annual operating plan
ARS	Agricultural Research Service
ASEC	Affordable and Sustainable Energy Crops
AST	Allegheny Science & Technology
ATEC	Algae Technology Educational Consortium
ATJ	alcohol-to-jet
ATM	Assessment of Likely Technology Maturation
ATP3	Algae Test Bed Public-Private Partnership
ATS	algal turf scrubber
AVAP	American Value-Added Pulping
AWARE-US	Available Water Remaining for the United States
AzCATI	Arizona Center for Algae Technology and Innovation
BAT	Biomass Assessment Tool
BDO	butanediol
BECCS	bioenergy with carbon capture and sequestration
BETO	Bioenergy Technologies Office
BFI	biofuel intermediate
BFL	Bioenergy Feedstock Library
BFNUF	Biomass Feedstock National User Facility
BIC	Biofuels Information Center
Bio-BDO	bio-based 1,4-butanediol
BioSep	Bioprocessing Separations Consortium
BioSTAR	Bioenergy Sustainability Tradeoffs Assessment Resource
BIP	Biofuels Infrastructure Partnership
BMP	best management practice
BODIPY	boron-dipyrromethene
BR&D	Biomass Research and Development Board
BSCR	biomass supply chain risk
BSI	boosted spark-ignition
BSM	Biomass Scenario Model
BTD	Bioproduct Transition Dynamics
BTS	biomass-to-syngas
Cal Poly	California Polytechnic State University
CAP	combined algal processing
CapEx	capital expenditure
Cas	CRISPR-associated
CCPC	Consortium for Computational Physics and Chemistry
CFD	computational fluid dynamics
CFP	catalytic fast pyrolysis

ChemCatBio	Chemical Catalysis for Bioenergy Consortium
CO_2	carbon dioxide
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
CRADA	cooperative research-and-development agreement
CRISPR	Clustered Regularly Interspaced Short Palindromic Repeats
CTT	cubical triaxial tester
DBTL	Design-Build-Test-Learn
DEM	discrete element method
DFA	directed funding award
DFO	directed funding opportunity
DHSVM	Distributed Hydrology Soil Vegetation Model
DIC	dissolved inorganic carbon
DISCOVR	Development of Integrated Screening, Cultivar Optimization, and Verification Research
DMR	deacetylation and mechanical refining
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOM	dissolved organic matter
EERE	Office of Energy Efficiency and Renewable Energy
EISA	Energy Independence and Security Act of 2007
EMDS	Ecosystem Management Decision Support
EOS	engineering of catalyst scale-up
EPA	U.S. Environmental Protection Agency
EV	electric vehicle
FCC	fluid catalytic cracking
FCIC	Feedstock-Conversion Interface Consortium
FCTO	Fuel Cell Technologies Office
FEM	finite element method
FOA	funding opportunity announcement
FOG	fats, oils, grease
FPEAM	Feedstock Production Emissions to Air Model
FSL	Feedstock Supply and Logistics
FY	Fiscal Year
GAI	Global Algae Innovations, Inc.
GARDN	Green Aviation Research and Development Network
GBEP	Global Bioenergy Partnership
GCAM	Global Change Assessment Model
GDP	gross domestic produce
GGE	gallons gasoline equivalent
GHG	greenhouse gas
GMO	genetically modified organism
GREET	Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation
H_2	hydrogen
HiSCI	High-throughput Screening of Cell-to-cell Interactions
HPF	high-performance fuel
HTL	hydrothermal liquefaction
HTP	hydrothermal processing
HVO	heavy fuel oil
HYPOWERS	Hydrothermal Processing of WastewatER Solids
IAB	industry advisory board
IBR	integrated biorefinery
IDL	indirect liquefaction
IEA	International Energy Agency

ILM	Integrated Landscape Management
ILUC	indirect land-use change
INL	Idaho National Laboratory
IP	intellectual property
IPCC	Intergovernmental Panel on Climate Change
JEDI	Jobs and Economic Development Impact
JudO	Jet fUels blenD Optimizer
KDF	Knowledge Discovery Framework
LAP	laboratory analytical procedures
LBNL	Lawrence Berkeley National Laboratory
LCA	life cycle assessment
LEAF	Landscape Environmental Assessment Framework
LEAPS	Laboratory Environmental Algae Pond Simulator
LLNL	Lawrence Livermore National Laboratory
LUC	land-use change
MAGIC	Marine Algae Industrialization Consortium
MBE	MicroBio Engineering Inc
MBSP	minimum biomass selling price
MCCI	mixing-controlled compression ignition
MFSP	minimum fuel selling price
MIBR	multi-stream integrated biorefinery
MMSI	multi-mode spark ignition
MOOC	Massive Open Online Courses
MSW	municipal solid waste
MW	megawatt
MYP	Multi-Year Plan
NAABB	National Alliance for Advanced Biofuels and Bioproducts
NEPA	National Environmental Policy Act
NIR	near-infrared
NREL	National Renewable Energy Laboratory
OEM	original equipment manufacturer
OpEx	operating expenditures
ORNL	Oak Ridge National Laboratory
OSU	The Ohio State University
P5CS	*Pyrroline-5-carboxylate synthase*
PABP	performance-advantaged bioproducts
PACE	Producing Algae for Coproducts and Energy
PBR	photobioreactor
PCR	polymerase chain reaction
PDU	Process Development Unit
PI	principal investigator
PNNL	Pacific Northwest National Laboratory
R&D	research and development
RACER	Rewiring Algal Carbon Energetics
RAFT	Regional Algal Feedstock Testbed
RCFP	reactive catalytic fast pyrolysis
RFS	renewable fuels standard
RRB	Red Rock Biofuels
RUSLE2	Revised Universal Soil Loss Equation 2
SAF	sustainable aviation fuel
SCP	single-cell protein
SI	spark-ignition
SNF	sucrose nonfermenting

SNL	Sandia National Laboratories
SNRK	sucrose nonfermenting-related kinase
SOFAST	Streamlined Optimization of Filamentous *Arthrospira/Spirulina* Traits
SOPO	statement of project objectives
SOT	state of technology
SRWC	short-rotation woody crop
STEM	Stochastic Techno-Economic Model
SWAT	Soil and Water Assessment Tool
TABB	Targeted Algal Biofuels and Bioproducts
TCPDU	Thermal and Catalytic Process Development Unit
TEA	techno-economic analysis
TEG	thermoelectric generator
TERA	Toxic Substance Control Act Environmenmental Release Application
TRI	ThermoChem Recovery International, Inc.
TRL	technology readiness level
TSF	three-stone fire
UAV	unmanned aerial vehicle
USDA	U.S. Department of Agriculture
USEEIO	U.S. Environmentally Extended Input-Output
USFS	U.S. Forest Service
USV	unmanned service vehicle
VFA	volatile fatty acids
WATER	Water Analysis Tool for Energy Resources
WBS	Work Breakdown Structure
WDL	White Dog Labs Inc.

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INTRODUCTION

BETO research strategy is captured in two documents: the *Strategic Plan for a Thriving and Sustainable Bioeconomy* (Strategic Plan) and the BETO *Multi-Year Plan* (MYP). The Strategic Plan was released in 2016. The MYP was last published in 2016; it was recently updated and will be released again soon. Both documents can be found on the BETO website and are referenced throughout this report. The following section summarizes the Strategic Plan and MYP and introduces the vision, mission, goals, and structure of BETO. This is followed by an overview of the peer review process and format of this report.

STRATEGIC PLAN OVERVIEW

In 2016, BETO published the Strategic Plan reflecting the transformation and the advancements made in the bioenergy industry since the 1990s. This plan expanded BETO's mission beyond the cellulosic ethanol market to include renewable drop-in fuels (including diesel and jet fuels), bio-based chemicals, and bioproducts. The new strategy also emphasized the need to address environmental concerns associated with increased agricultural demand, including water and soil quality. The Strategic Plan was intended as an operational guide for managing and coordinating activities among technology areas. The Strategic Plan is BETO's blueprint to tackling the challenges and opportunities associated with building a sustainable U.S. bioeconomy. Although the BETO vision is set for 2040, it is important that processes are in place to verify progress, understand competing technologies, and periodically revisit the strategy.

BETO's Strategic Plan encompasses programmatic-level guidance and sets the foundation as the driver for the MYPs, annual operating plans (AOPs), and technology road maps. The MYP identifies R&D pathways and performance goals for the next 5 years and outlines how BETO plans to meet its mission and vision. AOPs are prepared and reviewed annually prior to each fiscal year for all programs within DOE's EERE. National laboratory AOPs and the project management plans from competitive funding opportunity announcements (FOAs) describe implementation plans to achieve strategic and performance goals.

The main components of BETO's Strategic Plan include key opportunity areas, a strategic goal for each key opportunity area, and strategies for accomplishing each strategic goal. These components are intended as crosscutting programmatic-level guidance and should be used to determine how to adapt and align BETO activities and project portfolios to best meet its objectives and carry out its mission in a continually changing environment.

Figure 2 summarizes BETO's Strategic Plan. Key opportunities reflect the best paths available to support BETO's mission, and each opportunity is aligned with a strategic goal that will be achieved by implementing a range of strategies. Progress on these activities will be measured against success indicators or milestones.

BETO conducts early-stage R&D and experimental development activities through an integrated supply chain approach addressing supply (feedstocks), conversion, distribution, and end use. Several activities underscore the R&D conducted by BETO—such as sustainability and strategic analysis—that enable the development and dissemination of knowledge and tools related to the economic, environmental, and social dimensions of advanced bioenergy.

Although cellulosic biofuel production is the primary focus, BETO supports the production of chemical intermediates that are traditionally petroleum-derived but can be coproduced from biomass. These intermediates are converted into high-value bioproducts, including bioplastics, bio-based chemicals, lubricants, solvents, cosmetics, and food ingredients, such as algal oil—all of which have places in future commercial markets. These also seek to maximize the value of fuels and coproducts produced within an integrated biorefinery based on this successful model in petroleum refineries.

BETO's Strategic Plan is aligned with the goals of the Biomass Research and Development (BR&D) Board's Bioeconomy Initiative. In March 2019, the BR&D Board released *The Bioeconomy Initiative: Implementation*

Framework, which lays out the key technical challenges that the BR&D Board member agencies will work to address to unlock the full potential of the U.S. bioeconomy.

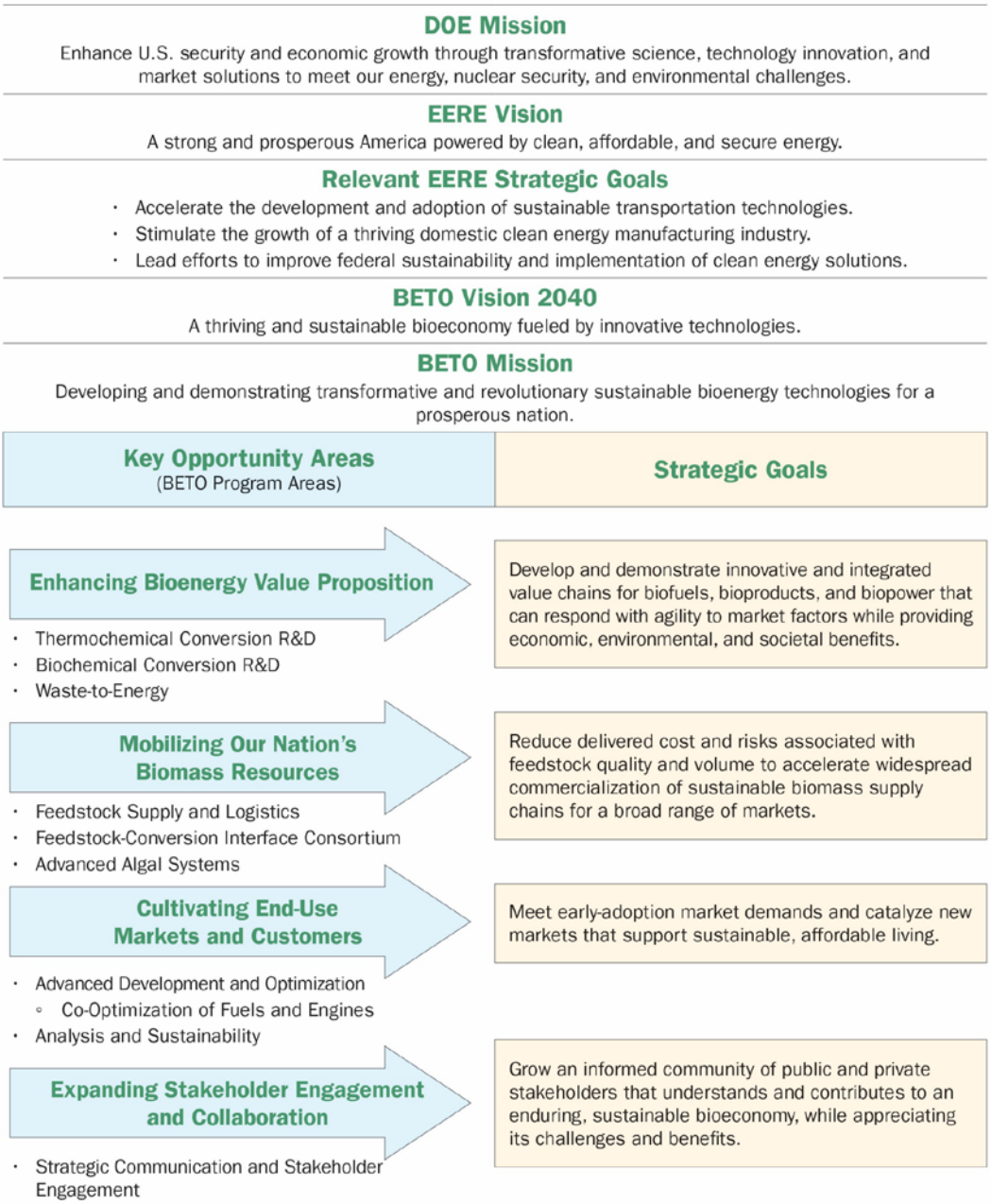

Figure 2. BETO Strategic Plan summary and program areas crosswalk.

MULTI-YEAR PLAN OVERVIEW

The MYP, which is updated periodically, sets forth the goals and structure of BETO and identifies the R&D, process development, and crosscutting goals and activities that BETO will focus on through the year 2030. The

MYP describes how these activities will contribute to U.S. energy supplies, create domestic jobs to support the growth of the domestic bioeconomy, secure the nation's global leadership in bioenergy and clean energy technologies, and enhance U.S. energy security. The MYP is intended as an operational guide to help BETO manage and coordinate its activities as well as a resource to communicate its mission, goals, plans, and priorities to stakeholders and the public.

BETO manages a diverse portfolio of technologies covering the full spectrum of bioenergy production, from the feedstock source to end use. The MYP identifies technical, process, and scale-up challenges, barriers, and uncertainties to be addressed for each program area as well as those that cross the entire supply chain. BETO R&D activities focus on high-impact technologies that are applicable across multiple technology pathways and products.

Figure 3 shows how BETO's program areas align with supply chain elements, with major emphases on feedstock supply, the conversion of biomass- and waste-derived feedstocks, and how crosscutting programs support all areas. Key components of the portfolio include:

- R&D of feedstock supply systems that can reliably deliver industrially relevant quantities of quality feedstocks
- R&D of high-productivity advanced algal systems
- R&D of conversion technologies able to efficiently process diverse and variable feedstocks into biofuels (e.g., gasoline, diesel, jet, and marine fuels), bioproducts, and biopower
- Development of integrated processes, tested and verified at the engineering scale, to reduce technology uncertainties and enable industry deployment
- Codevelopment of high-performance fuels with advanced engine designs
- Crosscutting sustainability and strategic analysis of economic, social, and environmental effects to inform decisions, identify emerging opportunities, and assess technology progress.

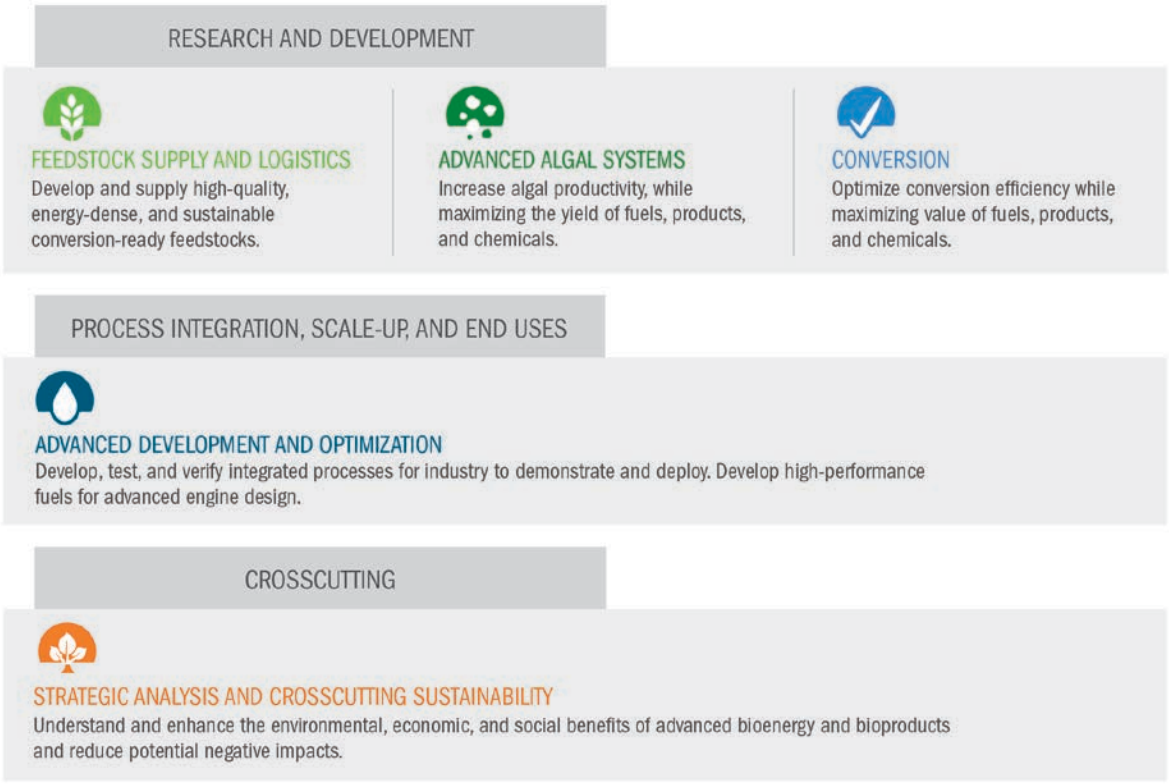

Figure 3. BETO program area alignment with biomass-to-bioenergy supply chain.

Note: Conversion includes Biochemical Conversion, Catalytic Upgrading, Performance-Advantaged Bioproducts and Separations, Waste-to-Energy, Lignin Utilization, Agile BioFoundry, and Carbon Dioxide Utilization. Advanced Development and Optimization includes Process Integration and Scale-up, Analysis and Modeling, and Co-Optimization of Fuels & Engines.

BETO 2019 PEER REVIEW OVERVIEW

The Project Peer Review meeting took place on March 4–7, 2019, in Denver, Colorado. During the event, 447 projects in BETO's research portfolio were presented in 14 simultaneous review sessions and two poster sessions. Projects were systematically reviewed by 57 external subject matter experts from industry, academia, and federal agencies. The 14 review sessions included presentations of projects grouped within the following technology areas, some of which are subcategories of the primary program areas, as indicated:

FEEDSTOCK SUPPLY AND LOGISTICS

FEEDSTOCK-CONVERSION INTERFACE CONSORTIUM

ADVANCED ALGAL SYSTEMS

CONVERSION RESEARCH AND DEVELOPMENT

Agile BioFoundry Consortium
Biochemical Conversion
Carbon Dioxide Utilization
Catalytic Upgrading
Lignin Utilization
Performance-Advantaged Bioproducts and Separations
Waste-to-Energy

ANALYSIS AND SUSTAINABILITY

ADVANCED DEVELOPMENT AND OPTIMIZATION

Analysis and Modeling
Process Integration and Scale-Up

CO-OPTIMIZATION OF FUELS & ENGINES

The Program Management Review meeting took place on July 17, 2019, in Golden, Colorado, and provided an office-level assessment of strategic planning and programmatic initiatives. The 246 presentations reviewed, representing 447 projects, represent approximately 94% of BETO's portfolio and a total DOE investment during the period covered by this peer review (FY 2016–FY 2019) is nearly $860 million. Each review panel developed overall recommendations regarding the focus, management, and impact of the projects in each technology area. In addition, an external steering committee developed overall recommendations for BETO based on the summary reports from each review panel. Results of the 2019 Peer Review have been, and will be, used to help inform programmatic decision-making, modify or discontinue existing projects, guide future funding opportunities, and support other budget and strategic planning objectives.

The peer review brought together reviewers, BETO staff, principal investigators (PIs), and other stakeholders along the entire bioenergy supply chain. Converging stakeholders in this way creates synergy across technology areas and enables the cross-fertilization of ideas and expertise while providing a more comprehensive review process. Figures 4 and 5 depict the number of presentations reviewed by technology area session and the associated funding allocation.

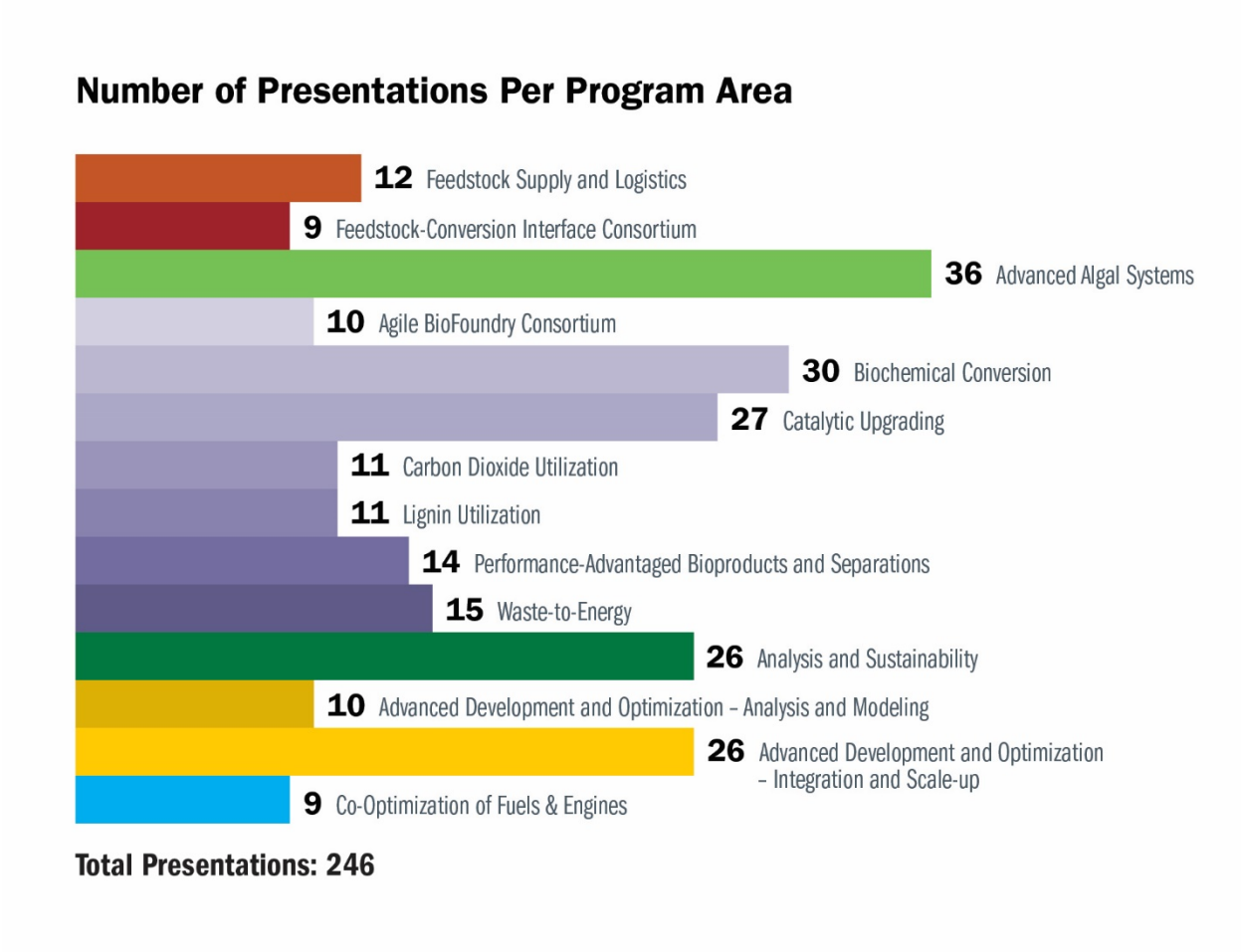

Figure 4. Number of presentations by technology area session.

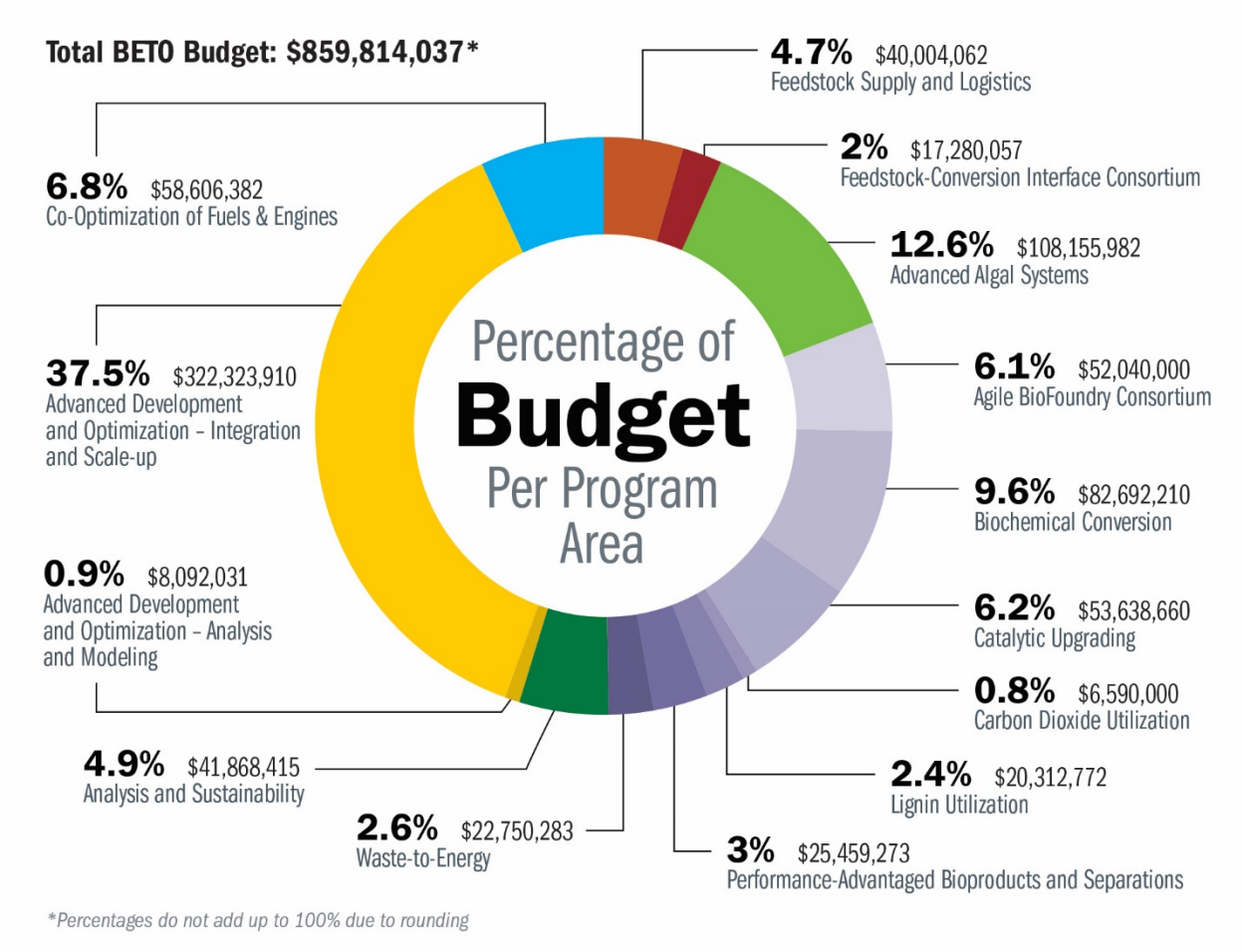

Figure 5. BETO presentation portfolio: total budget by technology area session.

Roles and Responsibilities

The BETO 2019 Peer Review was conducted by an internal planning committee, an external steering committee, 14 external review panels, and a selection of poster reviewers. Upon initiation of the review process, an internal BETO planning committee was designated with the responsibility for coordinating all aspects of the review process, from initiation through completion. This committee included a lead and support person for each of the 14 technology areas as well as a chair and overall coordination support. Support contractors from Allegheny Science & Technology (AST), BCS Incorporated, Redhorse Corporation, and The Building People, LLC provided planning support for each session and for the peer review overall. AST developed a reviewer evaluation system.

At the beginning of the process, the BETO planning committee identified and recruited an external steering committee to represent perspectives of academia, industry, the financial community, and nongovernmental organizations. The steering committee provided independent and impartial guidance on planning activities and the selection of external reviewers; participated in the review process; and developed crosscutting recommendations on BETO's overall focus, scope, and strategic direction.

Review panels for each technology area consisted of four to six external experts who were selected based on technical expertise and high-level qualifications in their designated technology area. Individual candidates

were proposed by the BETO technology area teams and submitted to the external steering committee for input. Efforts were made to ensure balance within each review panel by including a mix of reviewers from industry, academia, and federal agencies, with a range of expertise in the many subfocus areas within each technology area. Review panel members were required to sign legal agreements stipulating an absence of a conflict of interest with the projects they reviewed. Final decisions on reviewer selection were made by the internal planning committee and BETO's director. Each review panel was guided by a lead reviewer who in most cases had previous experience participating in a BETO Project Peer Review.

Table 1 and Table 2 list the members and affiliations of the peer review steering committee and the lead reviewers, respectively. Members of each technology area review panel are listed within each technology area session summary.

Table 1. Steering Committee Members

Name	Affiliation
Bill Crump*	Leidos
Suzanne Lantz	DuPont
Kelsey McNeely	ExxonMobil
John Sheehan	Colorado State University
Stephen Costa	U.S. Department of Transportation - Volpe

* Chairman

Table 2. Lead Reviewers

Name	Affiliation
Alissa Park*	Columbia University
Brandon Emme	ICM, Inc.
Charles Abbas	iBiocat
Emma Master	University of Toronto
Glenn Farris	AGCO
Joe Bozzell	University of Tennessee
Kristin Lewis	Volpe DOT
Larry Bauer**	LBJ Chemical Consulting
Luca Zullo	VerdeNero, LLC.
Raghubir Gupta	Susteon Inc
Toby Ahrens	Larta Institute

* Report drafted by reviewer Jason Ren (Princeton University)

** Report drafted by reviewer Jesse Bond (Syracuse University)

PROJECT CATEGORIES AND EVALUATION CRITERIA

Each project in the BETO portfolio was categorized based on its start and/or end date. To capture projects that have been active since the 2017 Project Peer Review, the three project categories included sunsetting (projects that ended prior to March 2019), ongoing (projects with end dates after February 2019 and start dates prior to October 2018), and new (projects with start dates after September 2018). Project scoring involved weighting the evaluation criteria based on a project's category. Table 3 lists the assignment of weighting for each project category and evaluation criteria.

Table 3. Project Evaluation Criteria Weighting

	Sunsetting Projects (Ended Prior to March 1, 2019)	Ongoing Projects	New Projects (Started After October 1, 2018)	Directed Funding Award (Lab Projects with Industry Partners)
Approach	25%	25%	25%	50%
Accomplishments/ Progress	50%	25%	0%	25%
Relevance	25%	25%	25%	0%
Future Work	0%	25%	50%	25%

Review panel members were asked to evaluate each project on specific criteria including approach, accomplishments/progress, relevance, and future work. These evaluation criteria served as the standard template for the scores and comments provided to each project:

- **Overview:** Projects were evaluated on the degree to which the project performers communicated the project's history, the context in which the project fits into the portfolio, and its high-level objectives.
- **Approach:** Projects were evaluated on the degree to which:
    - The project performers implemented technically sound research, development, and deployment approaches and demonstrated the results needed to meet their targets.
    - The project performers identified a project management plan that includes well-defined milestones and adequate methods for addressing potential risks.
    - The project performers clearly described critical success factors that will define technical and commercial viability and explained and understand the challenges they must overcome to achieve success.
- **Technical progress and accomplishments:** Project were evaluated on the degree to which:
    - The project performers made progress toward reaching their objectives based on their project management plan. The project performers described their most important accomplishments in achieving milestones, reaching technical targets, and overcoming technical barriers.
    - The project performers clearly described the progress since the period of the last review.
- **Relevance:** Projects were evaluated on the degree to which:
    - The project performers described how the project contributes to meeting program/technology area goals and BETO objectives as cited in the MYP.
    - The project performers considered applications of their expected outputs.
    - The project performers presented the relevancy of the project and how successful completion of the project will advance the state of technology and impact the viability of commercial bioenergy applications.
- **Future work:** Projects were evaluated on the degree to which:

- The project performers outlined adequate plans for future work, including key milestones and go-no-go decision points.
- The project performers communicated key planned milestones and addressed how they plan to deal with upcoming decision points and any remaining issues.

FORMAT OF THE REPORT

Information in this report has been compiled as follows and is based on the following sources:

1. **BETO overview:** This section provides an overview of BETO's mission, vision, and goals as well as descriptions of BETO's approach to achieving technical goals and the challenges in doing so.
2. **Peer review report introduction:** This section contains overview information on the peer review process, roles and responsibilities, and project evaluation criteria.
3. **Technology area summaries:** This section contains 14 chapters that represent the comprehensive evaluation for each technology area reviewed. All technology area reports in this section were prepared independently by the review panel and the lead reviewer. Each chapter includes:
    A. **Introduction:** An overview of the technology area's project portfolio, including total funding obligated for FY 2016–FY2019 and percentage of total BETO project portfolio.
    B. **Program overview:** Background information about the BETO program that operates the given technology area, including the program scope, R&D activities, and important definitions. This component also includes context regarding the program approach for overcoming challenges as well as for supporting BETO strategic and performance goals.
    C. **Review panel members:** A list of names and affiliations for each individual who provided project evaluations and contributed to the Review Panel Summary Report.
    D. **Technology area score results:** This chart depicts the average weighted score for each project in each technology area.
    E. **Review panel summary report:** This summary of project evaluations provides insight regarding the technology area's overall impact, level of innovation, leverage of synergies, appropriate focus, feasibility for commercialization, and top recommendations. This chapter was drafted by the lead reviewer for each technology area in consultation with the full review panel. Consensus among the reviewers was not required, and reviewers were asked to include differences of opinion and dissenting views within the report.
    F. **Technology area programmatic response:** Represents the program's official response to the recommendations provided in the Review Panel Summary Report.
    G. **Project evaluations:** The project reports constitute two- to three-page reports that summarize the results of each project evaluated during the review process, including the following elements:
        i. **Project name and the work breakdown structure (WBS) number:** The full project name is listed as the heading with the identifying code below in parentheses. Project evaluations for each technology area are ordered by WBS# from lowest to highest.
        ii. **Weighted project score:** Each project's average weighted score is stated numerically. A bar chart depicts the average scores for each evaluation criteria and whiskers illustrating the range of scores given to the project by the individuals within the review panel. The

average value for each evaluation criteria across all projects within the technology area is also indicated.

iii. **Summary table:** Reference information about a project, which includes the recipient organization, PI name, project dates, project type, and funding values.

iv. **Recipient:** Indicates the organization tasked with leading the project (might include multiple organizations in situations where the project has more than one recipient).

v. **PI:** The PI is the individual affiliated with the recipient organization and assigned to lead the project.

vi. **Project category:** Sunsetting, ongoing, or new, depending on start/end date.

vii. **Project type:** There are many types of projects within the BETO portfolio, but this review focused primarily on two types of projects—AOPs, which are core R&D projects performed by DOE national laboratories; and projects awarded through a FOA, which are indicated in this table by listing the FOA name, number, and fiscal year.

viii. **Funding:** The project budget allocated. Values for AOPs are available on a fiscal year basis, whereas competitively awarded project funding is available only as a total value.

ix. **Project descriptions:** Compiled from the abstracts submitted by the PI for each project.

x. **Overall impressions:** Verbatim comments made by the review panel, edited only for grammar and clarity. Each bulleted response represents the opinion of one reviewer. Reviewers were not asked to develop consensus remarks, and in most cases the reviewers did not discuss their overall comments on each project with one another. In a limited number of cases, reviewer remarks deemed inappropriate or irrelevant were excluded from the final report.

xi. **PI response to reviewer comments:** The response to the reviewer comments provided by the PI. In some cases, PIs chose to respond to each bullet point of the comments made by the reviewers; in other cases, PIs provided only a summary response. Responding to reviewer comments was optional, and in some cases PIs chose not to respond.

4. **Programmatic evaluation:** The overall summary feedback and final recommendations of the external steering committee following the conclusion of the Program Management Review. This report was based on the participation of the steering committee in each component of the peer review process as well as closed-door, facilitated review sessions following the Project Peer Review and the Program Management Review meetings. Components of this report include identification of overall strengths and weaknesses, comments on the portfolio impact, assessment of BETO's strategic plan, and input regarding technologies and market trends that could affect BETO's ability to achieve its goals.

5. **BETO programmatic response:** The official, comprehensive response from BETO leadership on the feedback and recommendations provided by the steering committee evaluation.