ANALYSIS AND SUSTAINABILITY

PROGRAM AREA

CONTENTS

INTRODUCTION

The Analysis and Sustainability (A&S) program is one of 14 related technology areas reviewed during the 2019 Bioenergy Technologies Office (BETO) Project Peer Review, which took place March 4–7, 2019, at the Hilton Denver City Center in Denver, Colorado. A total of 26 projects were reviewed in the A&S session by five external experts from industry, academia, and other government agencies.

This review addressed a total U.S. Department of Energy (DOE) investment value of approximately $41,868,415 (fiscal year [FY] 2016–2019 obligations), which represents approximately 4.9% of the BETO portfolio reviewed during the 2019 Project Peer Review. During the Project Peer Review meeting, the principal investigator (PI) for each project was given 30–45 minutes (depending on the funding level) to deliver a presentation and respond to questions from the review panel.

Projects were evaluated and scored for their project approach, technical progress and accomplishments, relevance to BETO goals, and future plans. This section of the report contains the results of the Project Peer Review, including full scoring information for each project, summary comments from each reviewer, and any public response provided by the PI. Overview information on the A&S Program, full scoring results and analysis, the Review Panel Summary Report, and the Technology Area Programmatic Response are also included in this section.

BETO designated Alicia Lindauer as the A&S technology area review lead, with contractor support from Diana Raggio (Allegheny Science & Technology). In this capacity, Ms. Lindauer was responsible for all aspects of review planning and implementation.

ANALYSIS AND SUSTAINABILITY OVERVIEW

BETO is committed to growing a bioenergy industry that enhances energy security, promotes environmental benefits, and creates economic opportunities. To that end, the A&S Program addresses the challenges related to sustainable bioenergy production and use by supporting research, analysis, and tool development to better understand the economic, environmental, and social dimensions of advanced bioenergy and bioproducts. The program works with BETO's research and development (R&D) programs to conduct integrative analyses that facilitate insights across the bioenergy supply chain. These include analyses that integrate economic and environmental dimensions to understand trends, synergies, and tradeoffs. The A&S Program operates through two integrated subprograms: Strategic Analysis and Crosscutting Sustainability.

ANALYSIS AND SUSTAINABILITY SUPPORT OF OFFICE STRATEGIC GOALS

The A&S Program works to develop science-based strategies to understand and enhance the environmental, economic, and social benefits of advanced bioenergy and bioproducts relative to conventional energy systems.

The Crosscutting Sustainability strategic goal is *to understand and promote the positive environmental, economic, and social effects and reduce the potential negative impacts of bioenergy production activities.*

The Strategic Analysis strategic goal is *to provide context and justification for decisions at all levels by establishing the basis of quantitative metrics, tracking progress toward goals, and informing portfolio planning and management.*

ANALYSIS AND SUSTAINABILITY SUPPORT OF OFFICE PERFORMANCE GOALS

The Strategic Analysis subprogram works to identify overall BETO goals and priorities and covers issues that cut across all program areas. System-level analyses inform strategic direction and planning efforts; they also help BETO focus technology development priorities and identify key drivers and hurdles for maximum

national impact. Technology-specific analyses explore sensitivities and identify areas where BETO investment could lead to the greatest impacts as well as outline R&D needed to further develop emerging ideas.

The Crosscutting Sustainability subprogram area supports BETO's strategic goals by providing crosscutting, science-based quantification of the sustainability of advanced bioenergy to support an industry that delivers improved environmental performance and other benefits relative to conventional energy systems. The Crosscutting Sustainability subprogram area interfaces with and impacts all elements of the biomass-to-bioenergy supply chain and each stage of technology development. Considering sustainability early in technology development—rather than after systems are finalized and replicated—enhances the future economic and technical viability of those technologies. The Crosscutting Sustainability subprogram generates scientific knowledge that proactively addresses issues affecting the scale-up potential, public acceptance, and long-term viability of advanced bioenergy systems.

ANALYSIS AND SUSTAINABILITY APPROACH TO OVERCOMING CHALLENGES

BETO has identified the following key barriers and challenges in which improvements are crucial to achieving the goals of the A&S Program:

- Analysis to inform strategic direction
- Analytic tools and capabilities for systems-level analysis
- Data availability across the supply chain
- Identifying new market opportunities for bioenergy and bioproducts
- Quantification of economic, environmental, and other benefits and costs
- Science-based methods for improving sustainability
- Social acceptance and stakeholder involvement
- Consensus, data, and proactive strategies for improving land-use management.

The A&S Program works to overcome these challenges by developing and disseminating knowledge, tools, and mechanisms for more informed decision making and better resource management. Key partners include national laboratories—primarily Argonne National Laboratory (ANL), Idaho National Laboratory (INL), National Renewable Energy Laboratory (NREL), Oak Ridge National Laboratory (ORNL), and Pacific Northwest National Laboratory (PNNL)—academia, nongovernmental organizations, industry, and international organizations. This technology area coordinates internally and externally, working closely with other BETO technology areas, DOE offices, and federal agencies such as the U.S. Department of Agriculture (USDA), U.S. Environmental Protection Agency (EPA), U.S. Department of Defense (DOD), and U.S. Department of Transportation. Robust stakeholder engagement—through workshops, roundtables, and other means—helps advance crosscutting objectives.

The scope of A&S Program projects includes:

- Resource and technical assessments that provide the analytic basis for program planning and assessment of progress
- Advancement of scientific methods and models for measuring and understanding bioenergy sustainability across the full supply chain
- Dissemination of practical tools for analyses, decision making, and technology development that enhance sustainable bioenergy outcomes

- Data compilation to develop and maintain models, tools, and data sets to assist in collecting, compiling, and analyzing data
- Quantification of environmental performance and potential benefits and costs of bioenergy and bioproducts relative to conventional energy systems
- Development of sustainable system design approaches that increase bioenergy and bioproduct production while enhancing economic, social, and environmental outcomes.

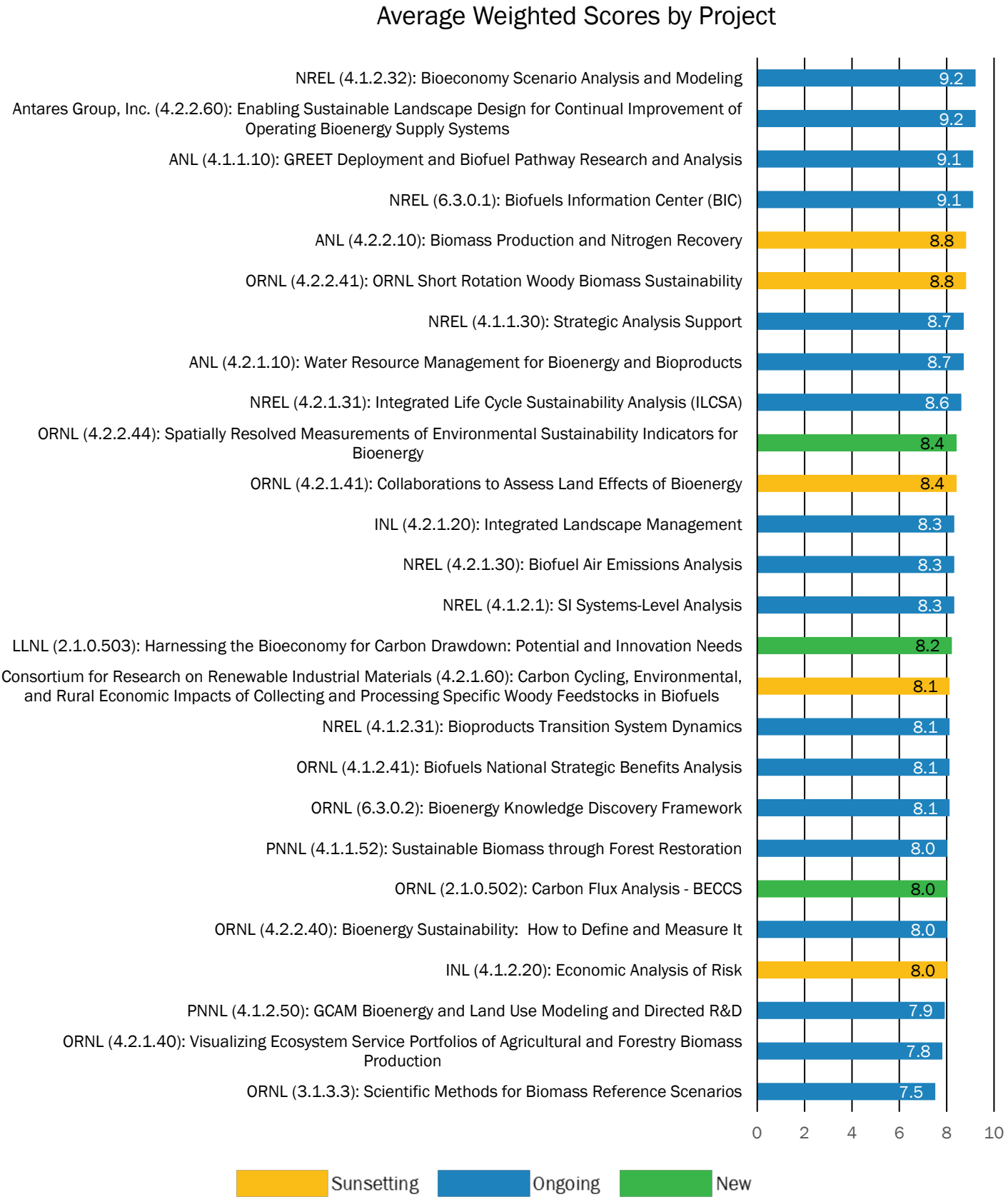
ANALYSIS AND SUSTAINABILITY REVIEW PANEL

The following external experts served as reviewers for the A&S Program during the 2019 Project Peer Review.

Name	Affiliation
Kristin Lewis*	U.S. Department of Transportation – Volpe Center
Christopher Clark	U.S. Environmental Protection Agency
Kevin Fingerman	Humboldt State University
Harry Baumes	Independent Consultant
Bret Strogen	U.S. Secretary of the Army

* Lead reviewer

TECHNOLOGY AREA SCORE RESULTS



ANALYSIS AND SUSTAINABILITY REVIEW PANEL SUMMARY REPORT

Prepared by the Analysis and Sustainability Review Panel

The A&S program is a comprehensive and extremely valuable program within BETO. It is successful at identifying key emerging issues and developing the capacity to address those issues. The portfolio has produced crosscutting and integrative approaches to addressing important bioeconomy-related challenges.

The five-person peer-review panel reviewed a total of 26 projects during three days, covering a broad range of strategic, modeling, analytic, and field-based projects. The peer-review panel was very impressed with the diversity and strength of the program overall and the value of the individual projects. The review panel thanks the PIs for their innovative approaches, valuable contributions, and presentations.

The management of the projects, as well as the portfolio overall, are thoughtful and effective. The review panel observed substantive effort to communicate among project teams and integrate activities. In the following summary, the peer-review panel addresses the impact, innovation, and synergies among projects, addresses the current and future focus of the portfolio, and offers recommendations to continue strengthening the value and reach of the portfolio.

IMPACT

The role of the A&S program portfolio is to provide tools and methodologies to support a variety of bioeconomy-related analyses and then to execute those analyses. The A&S portfolio has significant impact within BETO as well as across the bioeconomy sector. This project portfolio has produced key widely used tools and models that are of high value and utility and enable responsiveness to emerging issues. The analyses exemplify the integration of those tools and models as well as innovative approaches to landscape management, environmental measurements, valuation of ecosystem services, and sustainable biomass production. The strategic mapping of linkages among modeling tools, as well as the use of the map across projects in the portfolio during presentations, helped the panel see the strength of interlinkages among tools and the effort to avoid duplication.

Although most projects scored high in the reviewers' assessments, some projects received particularly high marks and/or very strong positive comments from reviewers:

- The Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) model is a landmark tool. The model is widely used inside BETO and around the world, including in some highly impactful policy applications, such as California's Low-Carbon Fuel Standard Program. The team continues to put forward necessary and valuable improvements. The review panel had some concerns that broadening GREET's scope to include environmental impacts such as water scarcity might be better addressed by leveraging other teams' work (e.g., the Water Analysis Tool for Energy Resources [WATER] model or components thereof) and should be evaluated carefully to ensure that further developments are in the strategic best interest of the GREET model itself, the BETO A&S Program portfolio, and the broader bioeconomy analysis community.

- The Biomass Scenario Model (BSM) is another extremely strong program. The researchers pursued a key goal of identifying specific factors that contribute to the cost effectiveness of subsidies so that they can be better structured and applied. The model is unique in that it addresses feedstock use, alternative conversion technologies, adoption of technology, and end-use fuels. The BSM model has been used in several high-profile analyses, including the modeling of scenarios to expand the use of bio-based jet fuel. A high-profile research award and uptake in academic research and teaching imply methodological rigor as well as potential for future influence. Strategic planning for increased exposure beyond the research sphere is warranted to ensure impact for this modeling platform. The effort to make analysis and the model available to the public is a positive outreach activity.

- The Biofuels Information Center (BIC) is highly effective; has well-defined activities and regular, consistent products; and is a worthwhile use of BETO funds. The value of this program is evidenced by the fact that BIC's website has received more than 800,000 page views.
- Analyses using the Global Change Assessment Model (GCAM) provide a broader economy-wide perspective, and because this model is also widely used, it links BETO analyses to the broader research community.
- Analyses using the U.S. Environmentally Extended Input-Output (USEEIO) model (Work Breakdown Structure [WBS] 4.2.1.31 Integrated Life Cycle Sustainability Analysis) is also especially pertinent to many federal and state decision makers because very few studies to date have examined the life-cycle effects of biofuels beyond greenhouse gases.
- Two field-related studies that stood out for the panel were the Integrated Landscape Management (ILM) project (Antares) and the short-rotation woody crops (SRWC) analyses. The panel found the Antares project to be quite comprehensive as well as practical, generating specific key technological (equipment), modeling, and biomass production advancements. The panel sees value in expanding this approach to multiple locations across the national level using the best practices and tools developed with the current Antares project, with consideration given to potential economic viability. The SRWC analysis stood out as a very comprehensive empirical assessment of the production potential, value proposition, and viability of SRWC.

INNOVATION

Many models and programs within the A&S program portfolio have provided innovative advances in analytic options and methodologies, as evidenced by their broad adoption and use. Many of these innovative tools and models have become long-term investments for BETO, leading to ongoing expansion and improvement over time, which enhances the value of the originally innovative tools.

The new project on Spatially Resolved Measurements of Environmental Sustainability Indicators for Bioenergy using drones to collect water-quality data could eventually yield large rewards because current information relies on grab samples that are few in number and labor intensive (e.g., the U.S. Geological Survey National Water-Quality Assessment Project, the EPA National Aquatic Resource Surveys).

Understanding the potential for the bioeconomy to contribute to carbon drawdown, as well as emissions mitigation, will become more important in the future. The two new complementary projects focused on carbon management (Harnessing the Bioeconomy for Carbon Drawdown: Potential and Innovation Needs and Carbon Flux Analysis - Bioenergy with Carbon Capture and Storage [BECCS]) are moving BETO toward a more comprehensive, systemic approach to assessing opportunities to reduce climate-change impacts and address the value proposition of the bioeconomy. The review panel recommends that BETO identify this emerging need and take steps to begin addressing it, although some reviewers expressed caution regarding the centrality of these topics to the BETO mission.

SYNERGIES

The A&S portfolio is diverse, and evident effort has been made to coordinate it thoughtfully. The panel suggests that deepening those efforts to leverage synergies and avoid duplication is key for this diverse portfolio. Some projects are well connected and take advantage of synergies for both project execution (e.g., overlapping field case studies) and tool complementarity, but it was not always easy for the panel to tell whether this was happening, and to what extent. It also appeared to the review panel that many project teams attempt to incorporate multiple sustainability elements in a cursory manner into their models to show breadth of coverage even when the main contribution of the project was its depth of insight into a particular aspect of sustainability. Although there is good communication among teams, many teams seem to feel the need to generate their own approach and data for the same areas (e.g., sustainability indicators), whereas the panel

would have liked to see groups leverage the approaches of teams that specialized in other particular areas of interest. Researchers who are more proficient in a field can take those roles under a bigger umbrella, rather than having many separate groups researching and coming up with cursory proxies for sustainability elements in which they are not experts. The review panel suggests there might be value in convening researchers in a workshop to develop a larger synthesis project or approach.

The panel also saw a lot of effort to develop and release decision-support tools. Some of these could be very useful, and the panel thought that by integrating these into one or a few models, rather than having many separate models, they might increase their value and be more useful for a broader audience, though the panel recognizes that the integration and maintenance of more comprehensive models can be challenging because of compatibility issues among models and the level of coordination required.

The panel found the Systems-Level Analysis group's model mapping effort helpful as an internal management tool to see how different models link together but found that it does not sufficiently distinguish uniqueness among models as a communications tool. It did not help reviewers to determine where there is duplication, which seems to be a key potential use case for such a tool; rather, because of the selected categories used, the chart suggests there is duplication among models. The reviewers felt it needed more differentiation and/or elimination of defunct models to use it effectively as a communications tool.

The panel discussed the value of field studies. Large umbrella projects such as the Antares Landscape Management project are invaluable because they provide venues for data collection, ground-truthing of models, real-world implementation of strategies, and validation of best practices. For modeling, ground truthing is important until data are sufficiently understood to separate the modeling effort from the field. When evaluating land management approaches, field work is inherently necessary. The panel felt that it might be helpful to expand the number of complementary studies done on the same case study field sites to provide more in-depth analysis for a given location. There is value in expanding the landscape-level projects to more and larger locations nationally when substantive additional insights can be gained by applying such an approach to a different region or context.

The review panel believes these opportunities will help align efforts further to minimize duplication and develop comparable results across multiple case studies and locations.

FOCUS

The A&S program portfolio covers a broad range of topics to continue filling sustainability data gaps across the bioeconomy supply chain, a key role.

In addition to the model mapping, which focused on mapping across the supply chain, the review panel suggests that BETO map how the projects address the domains of sustainability (e.g., environmental, economic, social) and the elements within those domains (e.g., within the environmental domain, air and water quality). In doing so, the BETO A&S management team would be able to identify where there is heavy emphasis within the portfolio and where there is less (e.g., social and economic factors, or specific areas such as biodiversity), enabling BETO to identify gaps and evaluate whether the current emphasis areas are appropriate.

The panel appreciated the case studies presented; however, it was not always made clear how the locations and/or details for the case studies (e.g., the species selected for a biodiversity case study) were selected. To most cost-effectively facilitate the development and deployment of the bioeconomy, the panel thinks it is critical that the case studies executed under the A&S portfolio focus on identifying, prioritizing, and/or overcoming key barriers to developing, growing, or manufacturing more bioproducts in an environmentally sound manner.

The panel suggested that the A&S portfolio should continue to include analyses of induced impacts (e.g., interaction between the bioeconomy and food prices). The proper degree of attribution of effects (e.g., indirect socioeconomic impacts such as food price impacts, land use change) to biofuels generally, and the Renewable Fuel Standard program specifically, remain significant unresolved concerns associated with the net effects of biofuels and bioproducts.

One gap the panel discussed is the need for external coordination and verification and validation of models. For example, GREET is a key successful model that needs to be maintained. Because it is such a flagship model that is so widely accepted and used, errors or issues internal to the tool are likely to be perpetuated in many other models and outside analyses; therefore, the panel felt that there would be value in BETO funding external researchers to execute verification and validation on the model as a quality control and assurance effort. The panel identified the parallel analyses the GREET team has already undertaken with other modelers (e.g., Joint Research Centre) as very valuable for verification and validation as well. External verification and validation would be valuable for many of the public models presented.

TECHNOLOGY DEVELOPMENT PIPELINE

The A&S program portfolio is meant to provide tools and resources to address barriers to technology development and deployment. The tools and resources being developed under the A&S portfolio are in many cases already widely adopted by researchers and industry or have the potential to be widely adopted once made public.

The models that are being developed and publicly released must be maintained and updated on some reasonably regular basis. The review panel felt that there could be opportunities to expand coordination—including potential long-term sharing of resources to support the development and maintenance of models—with other organizations.

RECOMMENDATIONS

The review panel recommends the following three key areas of portfolio enhancement in the near to medium term:

1. Portfolio coordination: The top recommendation of the A&S review panel is to enhance portfolio coordination using the following elements:

    A. Enhance depth of expertise where it resides and leverage that depth for crosscutting analyses (sustainability, life cycle assessment [LCA], carbon management)

    B. Align indicators, model use, and field studies as appropriate

    C. Provide more opportunities for BETO researchers to thoughtfully collaborate

    D. Focus case studies on key barriers to deployment (e.g., monetizing ecosystem services and/or other externalities, concerns related to endangered species)

    E. Create a “project map” to help identify synergies and links among the projects and coverage of sustainability areas and indicators, which would enable the BETO team to more easily identify underrepresented areas in the portfolio

    F. Expand coordination and cost share with other agencies (e.g., USDA) to develop and maintain model resources

    G. Coordinate with international research efforts.

2. Field studies: The review panel recommends continuing to support field studies, which are important as the basis for modeling efforts and are necessary to establish and test land management practices. The review panel felt that there is value in executing multiple complementary studies within the same geographic location.

3. External verification and validation of GREET (in depth) and scope assessment: The review panel suggests that the flagship GREET model undergo a detailed peer review to further enhance its credibility and identify errors or gaps.

Overall, the A&S Program portfolio is extremely successful and could continue to offer valuable insights to BETO program managers and bioeconomy stakeholders through enhancing and expanding upon the program's ongoing efforts.

ANALYSIS AND SUSTAINABILITY PROGRAMMATIC RESPONSE

INTRODUCTION/OVERVIEW

We thank the peer-review panel for their time, active engagement, and constructive review of the A&S Project portfolio. We appreciate the reviewers' recognition that the portfolio is designed to have significant impact and the tools and methodologies developed by A&S are used to inform decision making at strategic and project levels. The peer-review panel recommendations will be used to further enhance the effectiveness of the program's activities and contribution to BETO's goals.

The 2017 peer review panel provided several recommendations for the A&S technology area to act on, and the 2019 peer review panel recognized the progress made on those recommendations. This year's reviewers specifically acknowledged efforts to communicate among projects, integrate activities, expand and improve tools and models over time, and take steps to address emerging needs such as carbon management. We are pleased that we have been able to continue to build an effective portfolio and that our efforts to implement feedback have been fruitful.

Reviewers provided feedback on each project within the A&S portfolio, and in response the PIs are working to address this project-specific feedback to strengthen their future work plans. The reviewers also provided feedback to the overall A&S technology area, which was organized into three general recommendations. BETO technology managers for A&S greatly appreciate these recommendations and are already incorporating these suggestions into priorities for FY 2020 and beyond.

Recommendation 1: Enhance portfolio coordination.

The reviewers called on the A&S Program to enhance the coordination efforts among projects within the portfolio as well as with other agencies and international research efforts. Elements of coordination identified by our reviewers include the alignment of indicators, model use, field studies, and the creation of a project map to better visualize linkages. We greatly appreciate this feedback, and the team will explore ways to better communicate linkages across the projects in the portfolio. It will be useful for the PIs to be able to show how their project relates to the bigger picture and their unique capabilities in addressing research questions as well as how they interface with other modeling and analysis efforts. To support this, A&S will continue to use and improve upon the model mapping tool to identify synergies and gaps in the portfolio.

The A&S Program will continue to focus on creating and promoting platforms for the PIs to interact and discuss their work. The program will continue to hold monthly calls with the PIs to facilitate collaboration and will host biannual modeling workshops to increase coordination of bioenergy modeling efforts. Mechanisms

for interagency coordination will be explored through the Sustainable Bioeconomy and Analysis interagency working groups under the Biomass R&D Board.

Recommendation 2: Increased support of field studies.

The reviewers recommended further support of field studies, recognizing their importance as the basis for model development and validation. The panel applauded the Antares Landscape Management project for providing a valuable resource to other projects in the portfolio to collect data, see strategies implemented in the real world, and validate best practices. The A&S team is excited for Antares to continue working with the national laboratories to increase collaboration on field studies. Also, starting this year, three new projects from the Affordable and Sustainable Energy Crops (ASEC) funding opportunity announcement will join the A&S portfolio. These projects will add to our arsenal of field studies and provide further depth of analysis for other projects to learn from and expand on, and we have plans for the ASEC PIs to hold regular calls to align data collection and enable cross-pollination. The A&S Program will continue to explore opportunities to fund additional field studies in the future.

Recommendation 3: Gather external feedback on GREET.

Reviewers emphasized the need to update publicly available models on a reasonably regular basis. Recognizing the importance and widespread use of the model, the review panel recommended that the GREET model undergo a detailed peer review to further enhance its credibility and identify potential gaps. The A&S team appreciates the panel's recognition of the value of one of our most widely used and trusted models and have begun talks with ANL to identify opportunities for an external review of the model.

CARBON FLUX ANALYSIS – BECCS

Oak Ridge National Laboratory

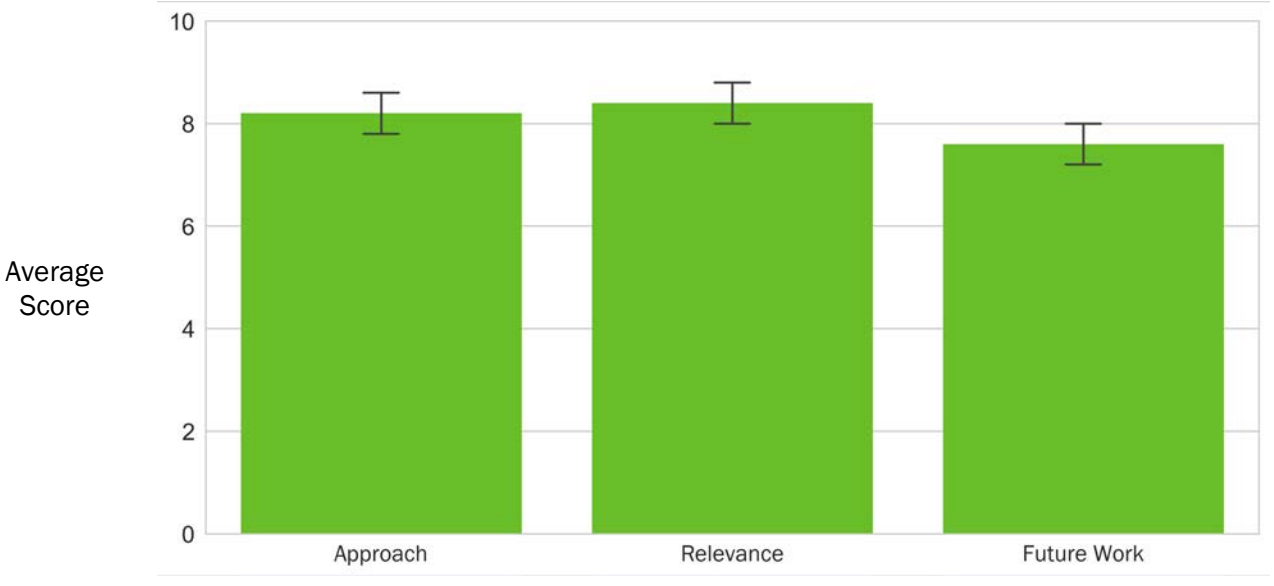
PROJECT DESCRIPTION

WBS:	2.1.0.502
CID:	NL0034938
Principal Investigator:	Dr. Mark Langholtz
Period of Performance:	10/1/2018–9/30/2021
Total DOE Funding:	$667,000
DOE Funding FY16:	$0
DOE Funding FY17:	$0
DOE Funding FY18:	$0
DOE Funding FY19:	$667,000
Project Status:	New

The objective of this project is to assess the potential quantity and economic accessibility of carbon dioxide (CO_2) management of the U.S. bioeconomy through BECCS. BECCS combines bioenergy with geologic carbon capture and storage to produce negative CO_2 emissions. Carbon-negative technologies such as BECCS might be an important component of overall strategies to reduce atmospheric CO_2 concentrations. If demand for carbon mitigation and associated offsets increases, BECCS could become a major strategy to achieve carbon management, which could provide additional revenue streams and value propositions for the emerging bioeconomy. To better understand the national potential for BECCS in the United States, the cost of BECCS as a function of both biomass feedstock and its proximity to geologic formations suitable for BECCS needs to be quantified. The costs of BECCS on a per-ton CO_2 basis are influenced by logistic configurations, feedstock availability, proximity to suitable geologic sequestration basins, and techno-economic assumptions. Thus, it is critical to identify how a nationwide infrastructure for biomass processing, logistics, conversion, and sequestration could provide the capacity to meet increasing demand for carbon offsets. An economic assessment of BECCS requires capabilities in biomass supply and yield analysis (feedstock carbon flux), biomass logistics, and supply-chain modeling. Biomass supply analytics capabilities at ORNL are well suited to these analyses of BECCS. Online interactive visualization of the *2016*

Weighted Project Score: 8.0

Weighting for New Projects: Approach - 25%; Relevance - 25%; Future Work - 50%



I One standard deviation of reviewers' scores

Billion-Ton Report demonstrates both the analysis capabilities at ORNL and the reach and accessibility of online resources that can be leveraged from the Bioenergy Knowledge Discovery Framework (KDF). The Biomass Infrastructure Logistics and Transportation model developed at ORNL with DOE support is applicable to analysis of the spatial allocation of feedstocks and CO_2. The Center for Transportation Analysis at the National Transportation Research Center provides resources for spatial modeling of national infrastructure. External resources relevant to this project include National Energy Technology Laboratory's Carbon Capture and Storage Database and the National Carbon Sequestration Database and Geographic Information System.

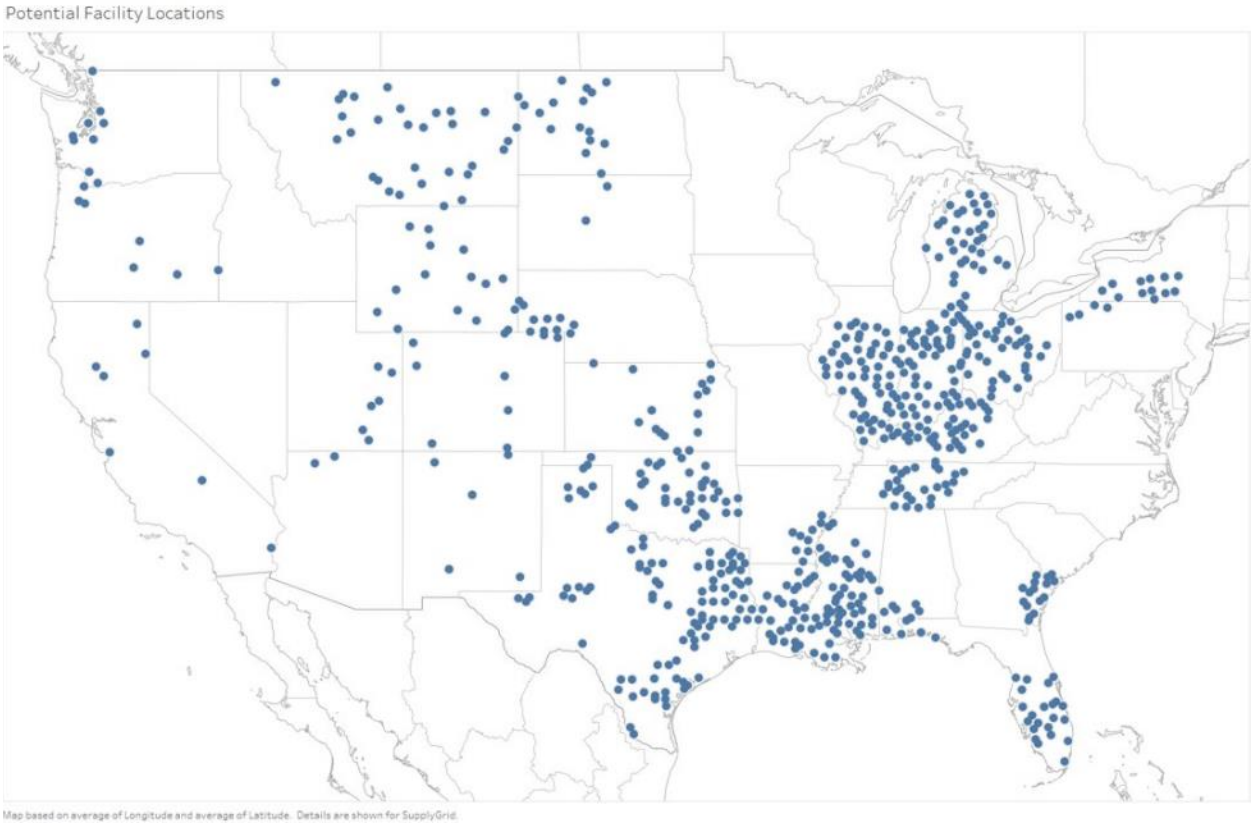


Photo courtesy of Oak Ridge National Laboratory

OVERALL IMPRESSIONS

- This new project is addressing an area not yet fully explored by BETO as a potential ancillary revenue stream for the bioeconomy industry, with the appropriate goal to quantify and estimate costs associated with managing CO_2 through BECCS.

- This project will be a valuable component of BETO's increasing focus on carbon management, and it will help us understand the potential contribution of BECCS to overall national carbon management. A peer-reviewed publication or report would be a helpful final deliverable as well as the KDF landing page. If this approach is likely to have significant potential for carbon sequestration and carbon management in the economy, other avenues of results dissemination (e.g., stakeholder meetings) should also be considered. It should also be explicit that this project will complement the broader BETO carbon management analyses/programs.

- This project will assess the potential quantity and economic feasibility of CO_2 management in the U.S. bioeconomy through BECCS.

- This research focuses on BECCs, which is a key rising issue/concept in bioeconomy. Supply curve development is an interesting/useful approach—it is based on actual geospatial data on feedstock as well as facility siting. It would be useful to broaden the concept of BECCS for this research by evaluating pathways other than injection as well as considering CO_2 stream sources other than bioethanol.
- As mentioned elsewhere, it would be worth considering a merger or at least direct coordination between this effort with other BECCS project in the BETO portfolio. The two would dovetail nicely, with this project bringing geospatial rigor while the other could contribute its broader scope.

RECIPIENT RESPONSE TO REVIEWER COMMENTS

- Thank you for this feedback.
- We agree that results in accessible literature will be valuable products from this project.
- We agree that coordination with other projects involved in carbon management is valuable.

HARNESSING THE BIOECONOMY FOR CARBON DRAWDOWN: POTENTIAL AND INNOVATION NEEDS

Lawrence Livermore National Laboratory

PROJECT DESCRIPTION

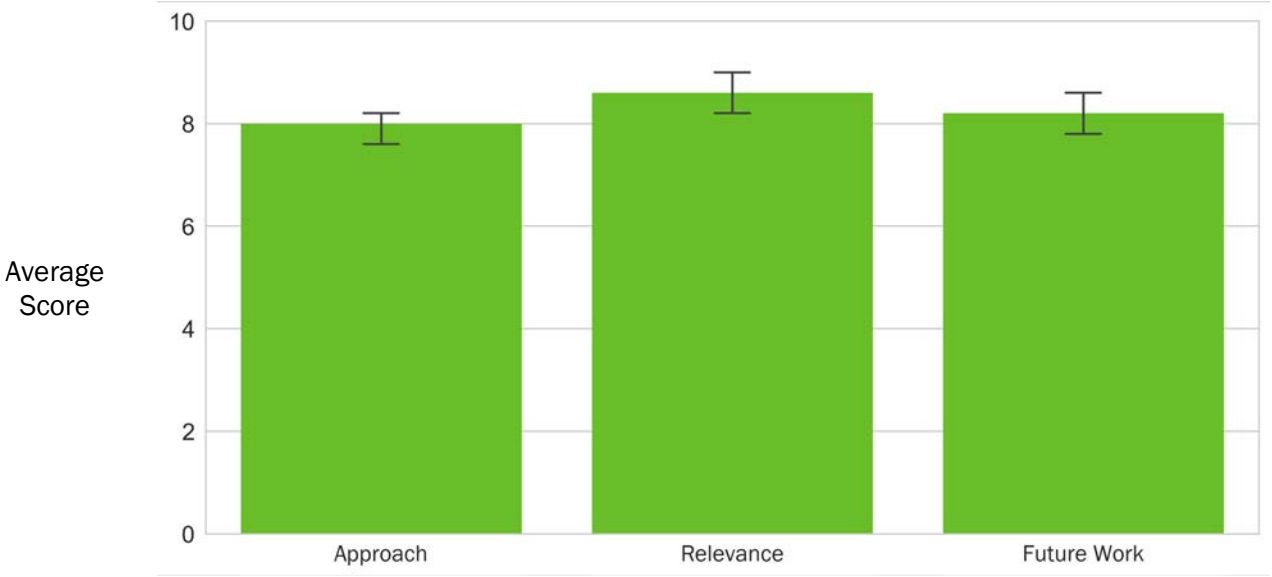
Integrated assessment modeling has identified the importance of establishing robust and large-scale CO_2 removal technologies to reduce atmospheric CO_2 concentrations. CO_2 removal technologies include both physical (so-called "direct air capture") and biological strategies. This project focuses on bioeconomy pathways, a subset of biological CO_2 removal technologies, which are specified combinations of biological feedstocks, conversion processes, and products. The goal of this project is to compare the techno-economic analysis (TEA) potential of multiple, diverse bioeconomy pathways to draw down CO_2 from the atmosphere. Potential pathways include biopower with CO_2 capture and sequestration, biofuels with process CO_2 capture, bioplastics and other chemical products, and biochar applied to augment soil carbon storage.

WBS:	2.1.0.503
CID:	NL0034850
Principal Investigator:	Dr. A.J. Simon
Period of Performance:	10/1/2018–9/30/2019
Total DOE Funding:	$167,915
DOE Funding FY16:	$0
DOE Funding FY17:	$0
DOE Funding FY18:	$167,915
DOE Funding FY19:	$0
Project Status:	New

Each molecule of biogenic CO_2 (from, for example, the use of a biogenic energy carrier) has the same radiative forcing as any other molecule of CO_2, and the avoidance of its emission has the same value as avoiding fossil emissions. The traditional assumption of excluding biogenic CO_2 from emissions accounting is insufficient to capture the value of bioeconomy pathways. This project advances methods for carbon accounting in scenarios

Weighted Project Score: 8.2

Weighting for New Projects: Approach - 25%; Relevance - 25%; Future Work - 50%



I One standard deviation of reviewers' scores

that include negative emissions. To date, we have enumerated myriad bioproduct pathways and qualitatively rated them on both technological and market readiness. We have also developed an LCA framework that leverages existing LCA tools and extends their carbon accounting to the feedstock production, conversion, use, and disposition life-cycle stages of bioeconomy pathways designed for carbon drawdown.

OVERALL IMPRESSIONS

- This meta-analysis of proposed carbon drawdown and management approaches will be an important baseline study for BETO's expanding focus on carbon management in the bioeconomy. It is important that we understand the option space for reducing atmospheric greenhouse gases (GHG), and this study will provide a consistent framework for comparing those options. This initial qualitative analysis should eventually transition to more quantitative approaches (similar to the BECCS study) to help understand the relative importance of these potential technologies/approaches within the bioeconomy for reducing/managing atmospheric CO_2.

- This project pursues important questions surrounding the economics of BECCS systems integrated with agro-industrial systems generating a suite of products and ecosystem services. The researchers have carried out a strong meta-analysis evaluation of technology readiness, market readiness, and other technical factors. This project pursues a strategic direction and is well integrated with BETO goals.

- It would be worth considering a merger or at least direct coordination between this effort with other BECCS project in the BETO portfolio. The two would dovetail nicely, with the other project bringing geospatial rigor while this one would bring expanded scope.

- This project will use TEA to evaluate and rank various bioeconomy pathways to draw down CO_2 from the atmosphere, which is a valuable (albeit unconventional) space for BETO to fund.

- Because atmospheric CO_2 reduction is one of the main (even if only implied) justifications behind favorable bioenergy policies and research programs around the world, this project should help research portfolio managers better understand the GHG significance of a variety of projects (from sequestration to fuels and bioproduct development).

- Carbon drawdown is an important issue. The goal is to compare the technical and economic potential of the bioeconomy pathways to draw down CO_2 from the atmosphere. This is a preliminary analysis project qualitative mete-analysis and quantitative analysis of four to five selected pathways based on CO_2 drawdown. Carbon management informs the R&D community and longer-run decision makers. This is a new project.

RECIPIENT RESPONSE TO REVIEWER COMMENTS

The recipients choose not to respond to the reviewers' overall impressions of their project.

SCIENTIFIC METHODS FOR BIOMASS REFERENCE SCENARIOS

Oak Ridge National Laboratory

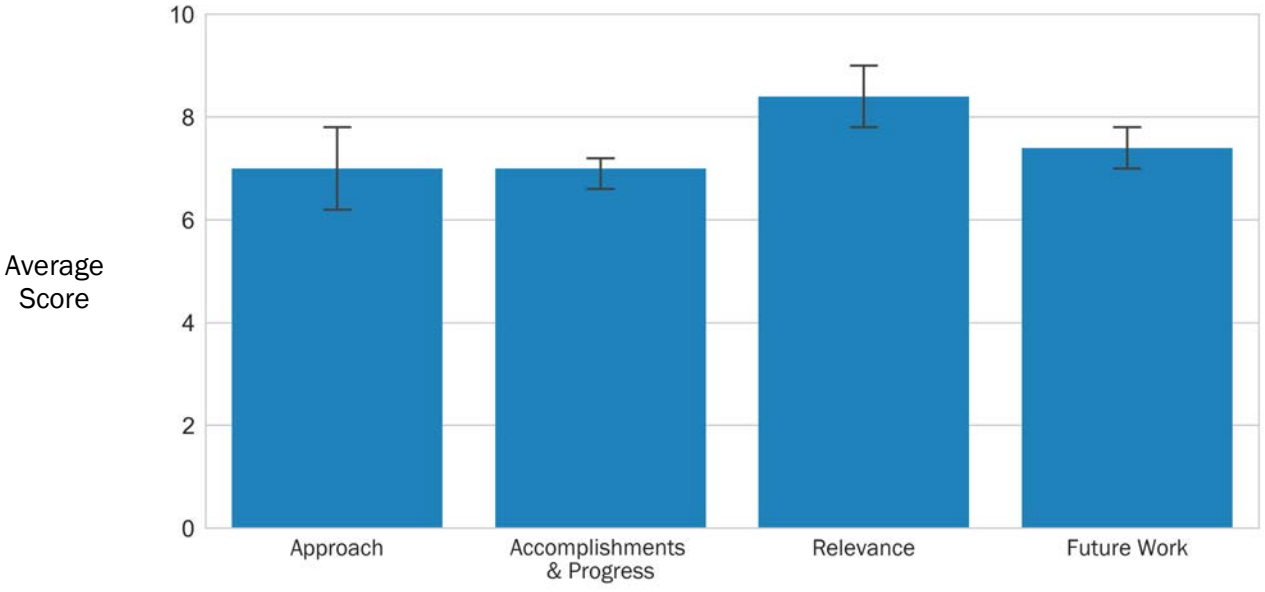
PROJECT DESCRIPTION

WBS:	3.1.3.3
CID:	NL0033318
Principal Investigator:	Mr. Keith Kline
Period of Performance:	10/1/2017–9/30/2020
Total DOE Funding:	$250,000
DOE Funding FY16:	$0
DOE Funding FY17:	$0
DOE Funding FY18:	$250,000
DOE Funding FY19:	$0
Project Status:	Ongoing

The goal of this project is to engage stakeholders in a process to develop and test a protocol for reference scenarios involving bio-based systems. The protocol will provide a set of rules and procedures for selecting reference scenario input parameters and documenting the choices used to characterize the reference scenario. This is important because under the current state of the art, variable and inconsistent assessment results have been attributed to different reference scenario assumptions. The lack of standard procedures constrains fair and comparable analysis, confuses decision makers, and undermines clear communications and trust among stakeholders. The project invited interested experts from diverse backgrounds to develop consensus around what an appropriate reference scenario should contain when assessing the effects of biomass-based products. The project addresses a fundamental issue, relevant to most BETO A&S activities and other DOE Office of Energy Efficiency and Renewable Energy (EERE) projects. A literature review, conducted at the project's start, verified the need for better guidance to support transparent and reasonable reference scenario assumptions.

Weighted Project Score: 7.5

Weighting for Ongoing Projects: Approach - 25%; Accomplishments and Progress - 25%; Relevance - 25%; Future Work - 25%



Project status (40% complete):

- More than 60 participants from civil society, industry, universities, government agencies, private research centers, standards-setting bodies, 11 international organizations, and industrial interests contributed to the literature review as well as drafting and discussions to develop a first draft
- The draft protocol was distributed to more than 100 stakeholders for further review and comment
- An action plan to address comments received was developed and reviewed by the drafting team.

The draft protocol provides key definitions that occupy four pages of single-space text. Definitions include:

- Reference scenario: characterization of conditions that would occur in the absence of the bio-based option (the test case being studied)
- Test scenario: characterization of conditions that occur under the test case that are relevant to the assessment goal.

The team defined the scope as:

- Analyses, evaluations, and comparisons of options to supply energy, chemicals, and other products and coproducts when one option involves biomass as a feedstock. These analyses include but are not limited to LCA, sustainability analyses, and TEA.
- Reviews and evaluations of the suitability of the reference scenario selected for an existing study or comparison.
- All bio-based production systems and materials, including forestry, agriculture, residues, coproducts, and wastes.

The action plan lays out steps for future work:

- Changes recommended by stakeholders will be incorporated into three documents: a literature review and rationale manuscript, an ASTM International standard (initiated December 2018, based on the initial draft protocol), and a paper recommending best practices for reference scenario development and documentation.
- The draft protocol will be tested in partnership with other BETO projects, and these trial applications will both help address specific project needs and provide additional feedback to improve the final protocol.

The expected outcomes of this project are:

- Net effects of an expanding bioeconomy are more clearly and consistently documented
- Best practices for a science-based approach to justify parameters used in reference scenarios will be published
- An international standard will provide guidance to increase the comparability and transparency of input values and assumptions when assessing the relative sustainability of bio-based products
- Two manuscripts will be prepared for peer-reviewed publication
- The application of the protocol generates more consistent quantification of tradeoffs and opportunities to guide decision making.

Figure: What would happen in absence of a bioenergy option? There are many potential answers to such questions. This project provides guidelines for identifying an appropriate reference scenario.

Photo courtesy of Oak Ridge National Laboratory

OVERALL IMPRESSIONS

- This project seeks to develop and test a protocol for reference scenarios involving bio-based systems. The PI has astutely identified the challenge posed by the subjectivity inherent in many LCA studies and seeks to address this through a novel protocol that would enable comparability and transparency across analyses as well as robust meta-analysis. This is a worthwhile agenda, but it poses two key challenges:
    - There might not be a definitive reference case, and if there is, BETO is not positioned to be the final arbiter on what it should look like
    - No civil society involvement means missing a key constituency for this research and a risk in failing to establish consensus.
- This project aims to address a long-term, crosscutting gap in bioenergy research: to establish and articulate reference scenarios.
- Although the team has clearly done an extensive literature review and stakeholder engagement, some audience members had trouble understanding and/or imagining tangible outcomes of this work.
- This is a new project, begun last year (funded under the Advanced Development and Optimization [ADO] platform).
- Better guidance is needed to support more transparent and reasonable reference scenario assumptions. The objective of this is to engage with a broad group of stakeholders in a process to develop and test a protocol for reference scenarios involving bio-based systems. The protocol will provide a defined set of rules and procedures for selecting reference scenario input parameters and documenting the choices used to characterize the reference scenario.
- This project addresses the following barriers: At-E: Quantification of Economic, Environmental, and Other Benefits and Costs; and ADO-C: Codes, Standards, and Approval for Use.
- A reference scenario is an essential starting point from which to measure impacts and inform how synergies can be enhanced and tradeoffs minimized.

- Every study needs a reference scenario, and it is valuable to have a well-defined approach to generating reference scenarios. The challenge will be in creating a scalable approach that fits multiple analysis types as well as dissemination for practical use. Although all can agree that in general it is important to build an appropriate reference scenario, there are valid reasons for people to differ in their assumptions and interpretations when developing a reference scenario that such a protocol cannot address. It will be interesting to see this overall protocol once finalized.

RECIPIENT RESPONSE TO REVIEWER COMMENTS

- Thank you. Two points of clarification: Civil society was invited and has participated in many forms. One of our constructive contributors, for example, works for the Union of Concerned Scientists. Regarding the observation that there "might not be a definitive reference case," we agree. Indeed, the draft protocol noted that there is an infinite number of potential reference scenarios, and the best choice might be to use more than one to frame the results within a reasonable range.

- Thank you. Tangible results include: (1) consensus-based journal publications with definitions of key terms and best practices, (2) an ASTM International standard balloted and published, and (3) clear guidance to improve comparability and transparency of input values and assumptions used in assessments of effects of bio-based products. We are also applying the protocol in two case studies.

- Thank you. We agreed that challenges are many; yet, thus far, we appear to have a "scalable approach." We welcome contributions to help address challenges constructively. The differing perspectives might represent challenges, but they also make the process enlightening and interesting for participants.

GREET DEPLOYMENT AND BIOFUEL PATHWAY RESEARCH AND ANALYSIS

Argonne National Laboratory

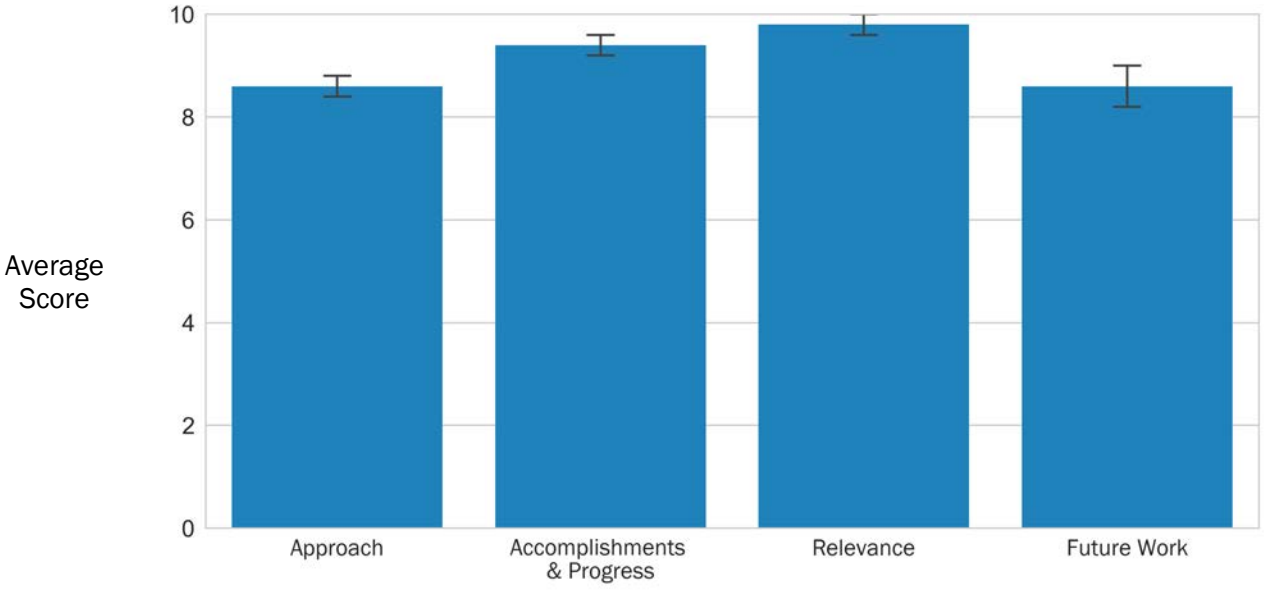
PROJECT DESCRIPTION

With BETO support, ANL has been developing the GREET model to conduct LCA of biofuel bioproduct pathways to holistically quantify energy and environmental effects of production and use of biofuels and bioproducts. The model and its results have been used by BETO and other agencies and organizations to provide information about the system-wide energy and environmental implications of biofuel bioproduct systems to help R&D and other policy decisions. With this project, ANL has been able to develop the GREET model with modeling consistency and transparency and to provide BETO and the bioenergy community with rigorous, reliable, and timely results in responding to key questions regarding biofuel bioproduct energy and environmental sustainability.

WBS:	4.1.1.10
CID:	NL0026651
Principal Investigator:	Dr. Michael Wang
Period of Performance:	10/1/2014–9/30/2020
Total DOE Funding:	$4,327,077
DOE Funding FY16:	$1,462,000
DOE Funding FY17:	$262,000
DOE Funding FY18:	$1,343,077
DOE Funding FY19:	$1,260,000
Project Status:	Ongoing

Weighted Project Score: 9.1

Weighting for Ongoing Projects: Approach - 25%; Accomplishments and Progress - 25%; Relevance - 25%; Future Work - 25%



ANL's key accomplishments since March 2017 include:

- Adding new biofuel and bioproduct pathways and updating baseline pathways—for example, by conducting LCA of jet-fuel pathways for BETO and the International Civil Aviation Organization
- Organization of United Nations assessing water stress from GREET-simulated water consumption results and conducting supply-chain sustainability analysis
- Addressing emerging LCA issues, such as how to assign metrics to coproducts from integrated biorefineries with a large amount of bioproduct output and tracking the carbon flows, carbon sources, and sinks of bioplastics versus fossil plastics
- Quantifying the carbon balances for woody feedstock systems, including land-use change (LUC), soil organic carbon flux, and woody feedstock carbon flows throughout time
- Providing in-depth environmental systems analysis of new conversion technologies, including waste-to-energy pathways, industrial waste CO_2 to bioenergy, and advanced algal systems.

GREET has been an integral part of BETO analysis to address bioenergy sustainability with consistent, complete modeling of the bioenergy supply chain with close interactions with other national laboratories, agencies, and key stakeholders. ANL has published extensively to document data, methods, and results of GREET model development and applications. At present, there are more than 35,000 registered GREET users globally, with key users including governmental agencies, conventional and new energy companies, universities, and research institutions.

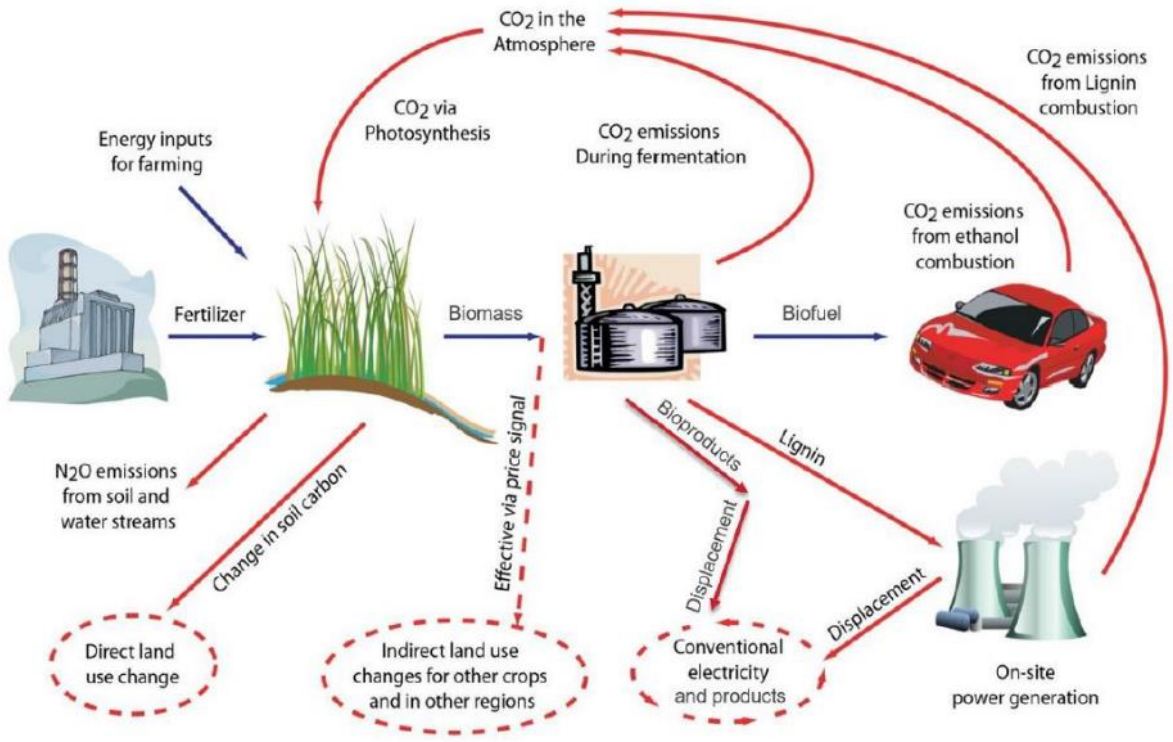


Photo courtesy of Argonne National Laboratory

OVERALL IMPRESSIONS

- GREET is a longstanding (since 1994) DOE-sponsored tool that is respected and used to shed insight on direct and indirect environmental impacts (and tradeoffs) from transportation fuel production and supply systems.

- GREET was a useful resource during my Ph.D. a decade ago, and it is great to see that the tool and team have evolved to help answer emerging questions relevant to the large community of policy-focused and academic research-oriented users.

- GREET is a widely used and trusted model, and the recent advances have made it even more comprehensive. To continue to bolster the already high credibility of the model, the GREET team should continue to work with other teams on parallel LCA or external reviews to continue to enhance verification and validation of the model, and the team should work with other teams from national laboratories when incorporating additional sustainability aspects.

- I have some concern about the scope of GREET and whether Available Remaining Water for the United States is at the same level of quality and validation as GREET's core strengths. I would like to see the GREET team leverage the depth of expertise in other team's modeling water availability and water footprinting (e.g., the WATER modeling group) and maintain the overall quality and trust in GREET by putting equal care into the water scarcity analysis/tool as is used for the core GHG LCA modeling and data quality. GREET could represent an opportunity to integrate several additional tools, resources, and analytic approaches in the long term, and it is important that it be as strong in these additional areas (e.g., water scarcity) as it is on the GHG LCA side. Leveraging strengths from other teams will ensure that the quality remains even across different modules if GREET is expanded further to incorporate other sustainability considerations besides GHG emissions.

- The overall objective to identify and quantify the life-cycle energy and environmental impacts of biofuels with analytic tools is supportive of the EERE BETO mission. The analytic capabilities of the GREET model and the ANL team support the BETO mission to enable sustainable, nationwide production of biofuels that are compatible with today's transportation infrastructure and can reduce GHG emissions relative to petroleum-derived fuels.

- GREET is the giant in the biofuel LCA space. This brings many opportunities and strengths, but there are also some potential liabilities. This is perhaps the A&S portfolio's most impactful effort because it has influenced analysis and policy broadly, and it should be supported and expanded.

- GREET risks becoming an industry unto itself as it continues to grow. Any error or debatable assumption is amplified as other researchers and policies use the tool. BETO should consider funding a critical analysis of GREET to evaluate sensitivities, the impact of key assumptions, etc. Also, is expanding GREET's scope to cover further-flung feedstocks (e.g., waste CO_2, woody feedstock carbon dynamics throughout time) and alternative end products (e.g., bioplastics) limiting development of targeted LCAs in these spaces and weakening GREET's role as it becomes a jack-of-all-trades?

RECIPIENT RESPONSE TO REVIEWER COMMENTS

- The GREET team thanks the reviewers for their encouraging comments and constructive suggestions. We work hard to meet the needs of our stakeholders with rigorous analyses; holistic and peer-reviewed approaches; and up-to-date, high-quality, transparent, and complete data in GREET. The GREET project is focused on BETO's priorities, and we keep a close eye on emerging issues to inform BETO.

- The expansion of GREET's scope responds to the need for more inclusive analysis capabilities to support the development of a prosperous bioeconomy. As R&D progresses, designs incorporate additional feedstock options, carbon sources, and bioproduct outputs to address economic and

sustainability goals. Wastes and forest residues are included as attractive feedstocks because they do not put pressure on agriculture land or product markets, while offering a means to use waste materials in a cost-effective and environmentally beneficial manner. Meanwhile, bioenergy pathways producing multiple value-added coproducts, such as biochemicals and bioplastics, improve market scalability and environmental profiles.

- We would welcome the opportunity to perform a critical analysis of GREET to identify areas where GREET's capabilities should be expanded to meet stakeholder needs moving forward.
- We recognize that LCA is inherently integrative and interdisciplinary. We work closely with collaborators to coordinate and streamline efforts across BETO projects. There appears to be confusion regarding GREET LCA, WATER, and the available water remaining in the United States (AWARE-US). All are part of the ANL biofuel analysis team. GREET LCA tracks water consumption across the life cycles of fuels, vehicles, and products. WATER estimates the water available in a region for new feedstock growth. AWARE-US estimates regional water stress, considering hydrologic factors as well as existing anthropogenic demand. These three efforts use common inputs and shared outputs to address different aspects of bioenergy water sustainability. We will continue to work closely with the other BETO projects and external collaborators to improve and integrate these efforts.
- Moving forward, we will remain focused on quantifying the life-cycle energy and environmental impacts of bioenergy and bioproducts to inform R&D and business decisions related to the developing bioeconomy.

STRATEGIC ANALYSIS SUPPORT

National Renewable Energy Laboratory

PROJECT DESCRIPTION

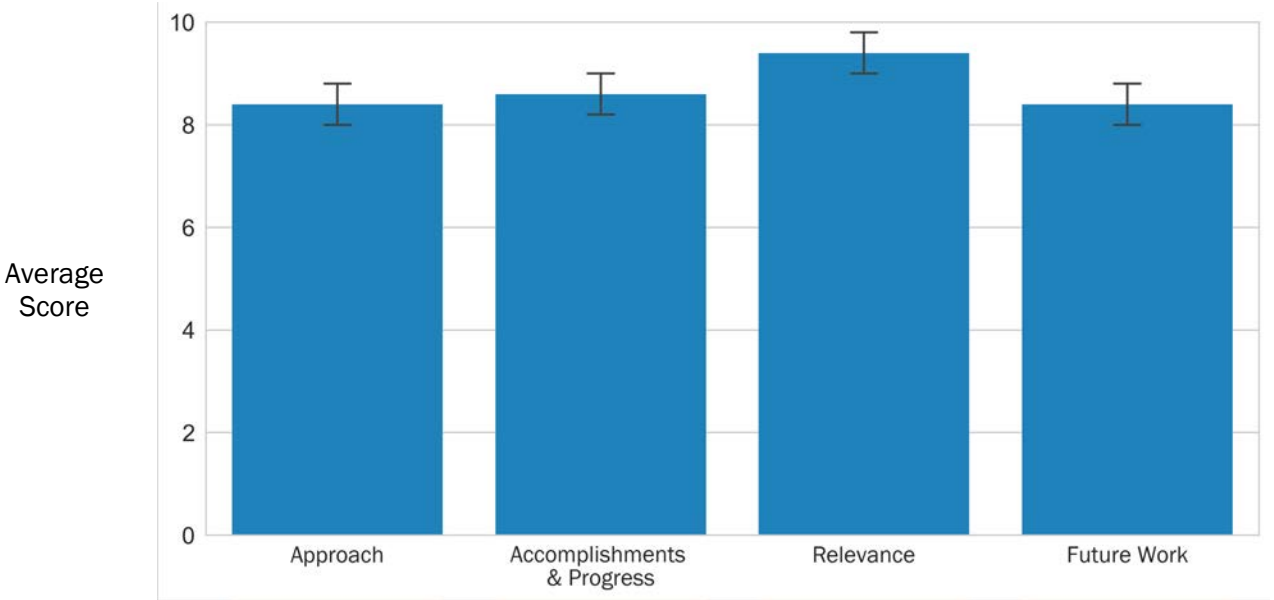
The objective of the NREL strategic support project is to provide sound, unbiased, and consistent analyses to inform the strategic direction of the DOE BETO office. This project addresses key technological questions; provides critical data needed to inform strategy; and highlights barriers, gaps, and data needs in support of the DOE BETO mission to improve the affordability of bio-based fuels and products.

WBS:	4.1.1.30
CID:	NL0027592
Principal Investigator:	Dr. Mary Biddy
Period of Performance:	10/1/2015–9/30/2021
Total DOE Funding:	$2,532,325
DOE Funding FY16:	$650,000
DOE Funding FY17:	$500,000
DOE Funding FY18:	$932,325
DOE Funding FY19:	$450,000
Project Status:	Ongoing

This task employs various quantitative (TEA) and qualitative (gap analysis) approaches to allow for direct comparisons of biomass conversion technologies across a wide slate of processing platforms and products. Further, this project develops and uses novel analyses beyond traditional biorefinery-focused TEA LCA to identify both technical (e.g., in sustainable design) and nontechnical (e.g., in value proposition) barriers as well as to outline mitigation strategies and R&D needs for emerging technologies. Additionally, the project is tasked with evaluating drivers that support the growing bioeconomy, which is achieved by the development and public release of tools to advance the understanding and facilitate comparisons of socioeconomic impacts along the supply chain.

Weighted Project Score: 8.7

Weighting for Ongoing Projects: Approach - 25%; Accomplishments and Progress - 25%; Relevance - 25%; Future Work - 25%



I One standard deviation of reviewers' scores

Critical to the success of this project is the development of defensible methodologies, analyses, and tools that are publicly available to support stakeholders and bioeconomy growth. To develop such high-quality analyses, the biggest challenge to this project—as with most analysis-focused projects—is the availability and reliability of the underlying data. Therefore, the project team works extensively with key stakeholders (e.g., policymakers, bioenergy technology developers, and investors) in developing and reviewing the results of these analyses to overcome this challenge. Any remaining uncertainties associated with the analysis efforts are clearly defined and quantified.

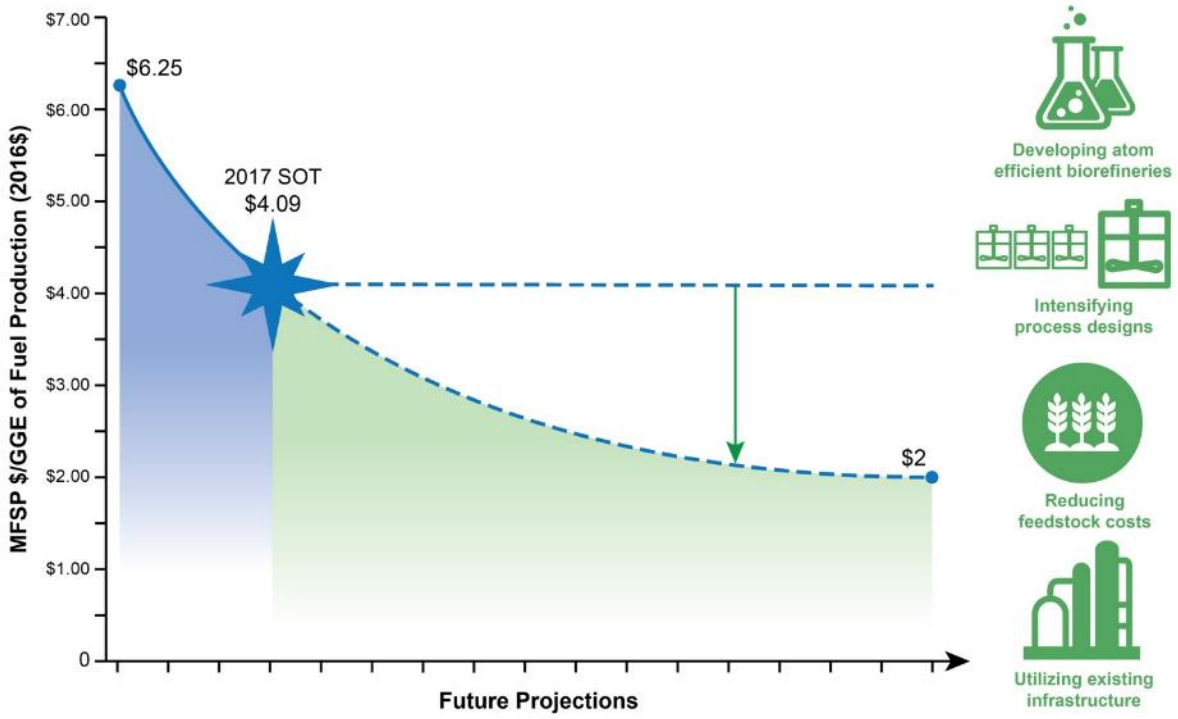


Photo courtesy of National Renewable Energy Laboratory

OVERALL IMPRESSIONS

- This multifaceted program, started in 2010, has played an important role in shaping BETO's strategic shifts (e.g., ethanol to drop-ins and bioproducts), and the team continues to stay relevant by developing tools to address technical and financial barriers to the deployment and adoption of bioenergy and bioproducts.

- The strategic analysis support team provides a key function for the A&S portfolio by integrating data from many BETO studies into publicly accessible databases and by executing strategic analyses that the project teams should focus on more deeply, such as the analysis to identify key cost drivers for biofuels. This is a broad suite of analyses that effectively contribute to the strategic integration and communication of the BETO portfolio. The intentions to develop a common approach of transparent/rigorous models with consistent assumptions, detailed vetting by stakeholders, and communications are great. Following are a few specific comments on individual pieces of this portfolio:

    - It's not clear from the summary of the TEA database whether the authors include a sensitivity/range of TEA parameters (or some sort of guidance for stochastic TEA) in the database itself for a given element or if there is a function for crowdsourcing data (e.g., enabling outside researchers to submit data for review/inclusion).

  - It would be helpful to know if the cost-reduction levers from the aviation fuel $2.50/gal analysis are the same or different from the $2/gasoline gallon equivalent (GGE) gap analysis.
  - The strategic goal to identify job creation and the economic benefit of the bioeconomy seems to have significant opportunities to connect with the integrated LCA project and should clearly indicate if results are an input to the latter.
  - The use of the EPA's GREENSCOPE tool requires a lot of data for a variety of different sustainability performance indicators and perhaps should be a joint effort among multiple teams to leverage the depth of knowledge on the different performance criteria.

- This project develops tools and performs analyses to address key questions and provide key data needs in support of the strategic direction of the DOE BETO. The objective of the NREL strategic support project is to provide sound, unbiased, and consistent analyses to inform the strategic direction of the DOE BETO office.
- This project addresses the following barriers: At-A: Analysis to Inform Strategic Direction; At-D: Identifying New Market Opportunities for Bioenergy and Bioproducts; and At-E: Quantification of Economic, Environmental, and Other Benefits and Costs.
- The Jobs and Economic Development Impact (JEDI) model and the TEA database seem strong, but GREENSCOPE seems to be biting off too much to do it rigorously.
- This it generally true, but especially for the emerging technologies, that this project group rightly identifies as warranting detailed evaluation. It is not clear how to achieve this detailed level of evaluation on emerging technologies for which there might not be much data. Does this project have necessary buy-in across the BETO portfolio? Its efficacy depends on other research teams feeding data into this analysis. It is not this team’s fault, but too many such projects could risk engagement fatigue across research teams.

RECIPIENT RESPONSE TO REVIEWER COMMENTS

- We thank the reviewers for their helpful insights and feedback. Our team works to be highly integrated within the A&S platform portfolio and the overall BETO portfolio. For example, the job analysis work is highly integrated with the A&S-supported integrated LCA project as well as with the Co-Optimization of Fuels and Engine analysis efforts, among others. For the TEA and the GREENSCOPE tasks, our team works closely with researchers within the other BETO-supported platforms and with external collaborators to ensure we use the best information available as well as the most appropriate methodologies for our analyses. As we continue to apply the GREENSCOPE methodologies to emerging technologies, we will work closely with the researchers and analysts developing these ideas to ensure we have the most up-to-date and best information. We will continue to perform sensitivity analysis and uncertainty evaluations to understand the impact that assumptions have on the underlying output of these studies. The goal for all our analyses is to develop defensible studies and tools in support of the strategic direction of the DOE BETO.
- We have been using the JEDI outputs to inform the integrated LCA project with respect to job growth opportunities and economic impacts along the entire supply chain. Because most biofuel pathways have not been commercialized and are not represented in the USEEIO model, the method to disaggregate the industrial sectors in the JEDI model for these pathways is also used to inform the disaggregation of the USEEIO model for the integrated LCA.

SUSTAINABLE BIOMASS THROUGH FOREST RESTORATION

Pacific Northwest National Laboratory

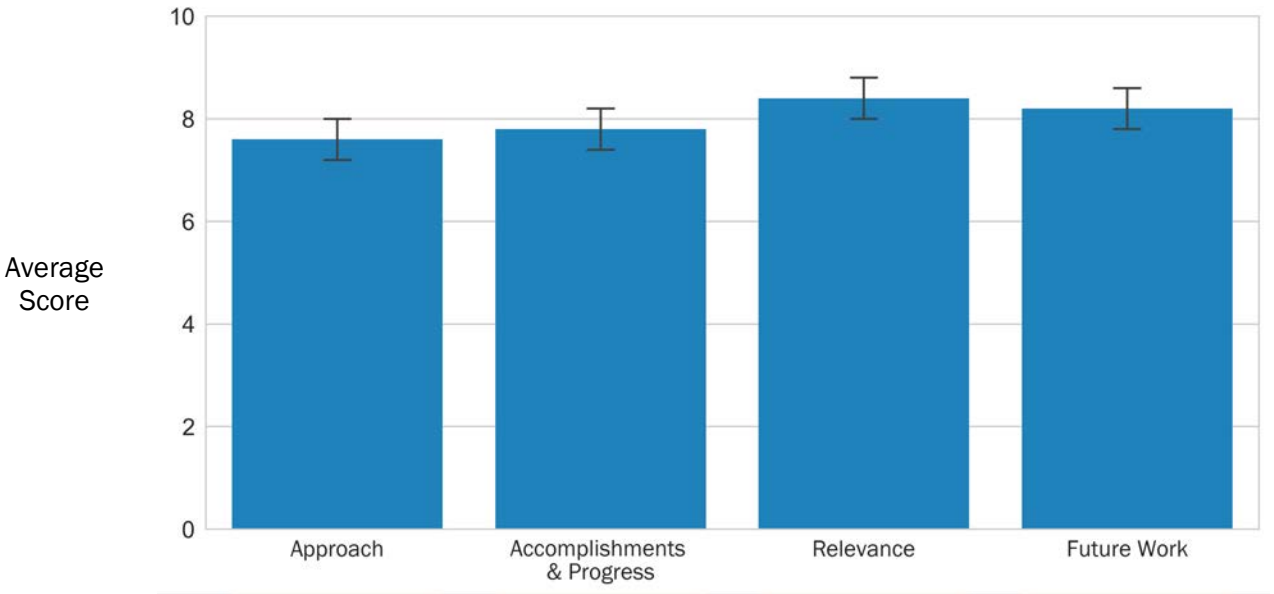
PROJECT DESCRIPTION

WBS:	4.1.1.52
CID:	NL0032233
Principal Investigator:	Dr. Mark Wigmosta
Period of Performance:	10/1/2016–9/30/2019
Total DOE Funding:	$681,887
DOE Funding FY16:	$0
DOE Funding FY17:	$220,000
DOE Funding FY18:	$261,887
DOE Funding FY19:	$200,000
Project Status:	Ongoing

Forest restoration has the potential to reduce high fuel loads and fire risk; provide a significant source of bioenergy; and provide increased ecosystem services, such as improved flow regimes for aquatic habitat. However, additional planning and decision-support tools are needed to ensure economic and environmental sustainability. A multiagency collaboration between DOE and the U.S. Forest Service (USFS) is using high-resolution, 30-m by 30-m topographic, soils, and vegetation data along with detailed road network data to develop accurate estimates of sustainable forest biomass along with distributed hydrologic, ecological, and wildfire risk modeling. Location-specific restoration scenarios are developed based on measured departure in ecological patterns of vegetation structure composition and modeled potential for spread of large wildfires. The Distributed Hydrology Soil Vegetation Model (DHSVM) is used to assess the impacts of the fine-scale forest restoration scenarios on hydrologic conditions, including snowpack and the timing, temperature, and volume of streamflow. DHSVM spatiotemporal outputs are used in a network modeling approach to articulate causal pathways between alternative restoration strategies on ecosystem services that provide input to the Ecosystem Management Decision Support (EMDS) software. EMDS provides multi-objective logic and decision support to select the locations and type intensity of restoration to achieve desired outcomes based on user-defined criteria and our sustainability indicators. EMDS is the USFS

Weighted Project Score: 8.0

Weighting for Ongoing Projects: Approach - 25%; Accomplishments and Progress - 25%; Relevance - 25%; Future Work - 25%



I One standard deviation of reviewers' scores

corporate software solution for decision support and has been used by the USFS and bureaus of the U.S. Department of the Interior since 2006 to evaluate wildfire potential across all administrative units in the continental United States and to establish priorities for allocating fuel-treatment budgets.

These data and models are integrated in a multi-objective analysis framework to assess the extent of forest-thinning activities that restore landscape function to reduce high fuel loads while increasing biomass yield and streamflow in a publicly and ecologically acceptable manner. We are initially focused on high fire risk areas in the Pacific Northwest at the subbasin to regional scale using data, models, and analysis techniques that can be applied nationally. Initial results confirm the need for high-resolution data to properly represent hydrologic and ecological process as well as detailed road network data to estimate delivered costs of biomass for energy. We demonstrated the potential of forest restoration to provide sustainable biomass for energy considering cost, wildfire mitigation, and improved streamflow. Particularly in areas where snowpack supplies late season flows (typical of the western United States), forest restoration can help increase flow during critical salmon-rearing periods while reducing flows in the spring and winter during incubation and emergence.

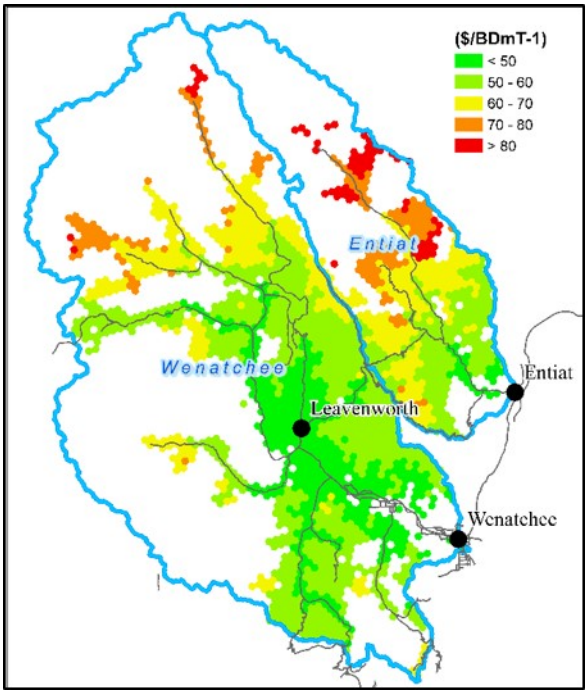


Photo courtesy of Pacific Northwest National Laboratory

OVERALL IMPRESSIONS

- This is a valuable, albeit niche, project characterizing potential win-wins for improved forest management and increased availability of bioenergy feedstock.
- This project addresses a very timely and important goal in developing and demonstrating an analysis framework to prioritize how and where to target forest restoration (timber harvest and thinning) and fuels reduction to have the greatest benefit for bioenergy, reduce severe wildfire risk, increase water yield, and improve ecosystem services. This is aligned with BETO goals. My concern is with the scope of the analysis the team is attempting in one study. Touching on restoration ecology, fire modeling, economics, hydrology, and other analytic frameworks is a risky proposition for a project of this size.
- This project is extremely relevant—forestry biomass has been identified in each of the *Billion-Ton* reports as a major source of biomass. Developing and providing decision-support tools demonstrating that harvesting forest materials can be done sustainably and lead to environmental benefit is essential.

Regarding reducing forest fire risk, additional planning and decision-support tools are needed to assess ecosystem services.

- This project addresses key BETO goals for Analysis and Sustainability.
- This project assesses the potential for synergistic achievement of forest thinning and fire management with bioenergy production while protecting biodiversity. The data from this analysis will provide valuable information to stakeholders about the potential to balance tradeoffs and achieve environmental goals in this system. The team indicated that this forest management is an ongoing process that would allow for repeated harvests throughout time (sustainable production) but did not clearly indicate whether the intention is to move toward controlled burns on the managed lands, which would reduce bioenergy feedstock availability.

RECIPIENT RESPONSE TO REVIEWER COMMENTS

- Forest restoration is being used to reduce wildfire risk and has been identified as a potentially significant source of bioenergy (0.2–0.6 billion tons in five western states per DOE). As noted, this project is characterizing potential win-wins for improved forest management and increased availability of bioenergy feedstock—specifically, by developing and demonstrating an analysis framework to prioritize how and where to target forest restoration (timber harvest and thinning) to have the greatest benefit for bioenergy, reduce severe wildfire risk, increase water yield, and improve ecosystem services. Beyond forest restoration, the framework can be used to evaluate economic and environmental tradeoffs associated with other forest-derived biomass, estimated in the *2016 Billion-Ton Report* at 103 million and 97 million tons per year of biomass potentially available in 2017 and 2040, respectively.
- Given the broad scope of this project, each task has a designated lead based on expertise. We are primarily using existing models that have been exercised (independently) in the study domain. This work builds on a previous USFS-PNNL collaboration (funded by the State of Washington) to develop a tool to estimate the impact of forest restoration on streamflow but without consideration of biomass yield or decision support. We chose an existing USFS decision-support system to speed technology transfer.
- Future enhancements include simulating the impacts of forest regrowth on biomass yield and the impacts of restoration on smoke and GHG emissions. This will allow consideration of repeated harvests throughout time to estimate sustainable production rates of biomass, continued reduction of wildfire intensity, and improved streamflow and salmon habitat. We can also identify the reduction in smoke emissions with restoration compared to natural wildfires and the reduction in emissions through the collection of forest residue for energy rather than disposal through prescribed burning.

SYSTEMS INTEGRATION SYSTEMS-LEVEL ANALYSIS

National Renewable Energy Laboratory

PROJECT DESCRIPTION

Systems Integration Systems-Level analysis maintains a readily available, established, expert analysis resource for BETO to respond to high-level internal analysis requests. This enables BETO's prioritization, rebalancing, and justification for the distribution of projects and funding across the BETO portfolio. It also enables cross-model coherence for accurate, consistent modeling and analysis results, improves A&S program effectiveness, and supports BETO planning.

WBS:	4.1.2.1
CID:	NL0022704
Principal Investigator:	Ms. Amy Schwab
Period of Performance:	10/1/2017–9/30/2020
Total DOE Funding:	$2,427,120
DOE Funding FY16:	$0
DOE Funding FY17:	$1,300,000
DOE Funding FY18:	$627,120
DOE Funding FY19:	$500,000
Project Status:	Ongoing

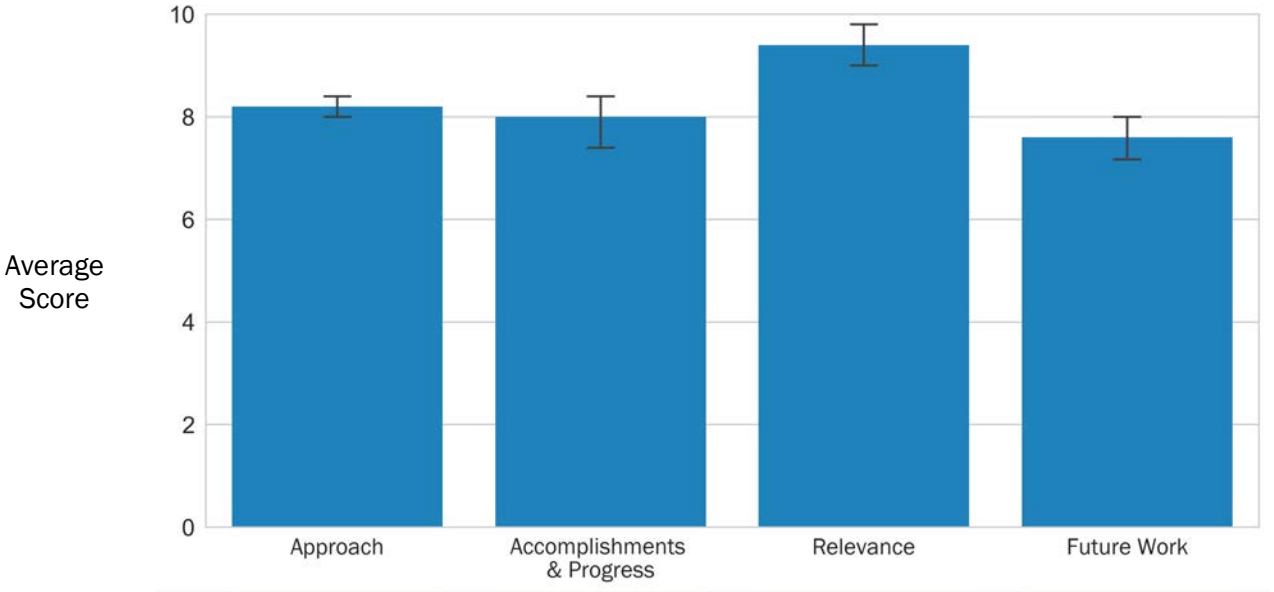
Using an interdisciplinary approach in close partnership with BETO, this work encompasses three categories: (1) A&S Program support, (2) emerging analysis, and (3) systems-level analysis.

The A&S program support task supports A&S management to improve the A&S portfolio effectiveness by developing frameworks to manage BETO's model portfolio. This helps monitor and communicate the depth and breadth of this complex, multidimensional portfolio while identifying concrete improvements.

The emerging analysis task focuses on maintaining capabilities for quick turnaround or emerging analysis topics. Anticipating trends, issues, and topics, and bringing together experts across the BETO laboratory

Weighted Project Score: 8.3

Weighting for Ongoing Projects: Approach - 25%; Accomplishments and Progress - 25%; Relevance - 25%; Future Work - 25%



community, this task provides analysis capabilities in BETO's planning processes while providing a conduit for updating modeling assumptions from the latest technology and industry developments.

The systems-level analysis task provides focused, in-depth analysis on key internal topics. Future work on industrial learning curves is aimed at understanding factors influencing a growing bioenergy industry, factors influencing bioenergy technology R&D progress, and how BETO can leverage these factors.

OVERALL IMPRESSIONS

- This is a critical program for BETO to essentially view a dashboard and understand the interconnections across its modeling efforts, enabling project managers to quickly identify expertise, gaps, and steps forward to address emerging modeling questions.
- This work is crosscutting across all laboratories and BETO headquarters. BETO has developed and maintains a huge complement of models, supporting data, and modeling expertise that enable BETO to provide analytic and quantitative analyses across current issues, identify gaps and weakness to improve analytic capacity, and refine decision support.
- The model mapping carried out in this project is an important agenda with potential to create actionable information for BETO portfolio managers. Is it providing useful information that can be used to shape the program? If not, it warrants evaluation and reshaping.
- The maps generated through this analysis appear to imply there is a lot of overlap in the BETO model portfolio—probably more than there really is. Perhaps it would be worth indicating graphically the currently supported models so that it does not seem like there is so much potential/probable overlap?
- This project encompasses several different efforts to inform the strategic direction of the A&S portfolio. The model map provides useful insight into the interconnections among models and where models reside in terms of their analytic approach and aspects of the supply chain, and it would be made even more useful as a communications tool by further differentiation, perhaps over several versions of the map (e.g., eliminate defunct/no-longer-funded models or color-code models based on specific elements). The proposed effort to enhance and harmonize industrial learning approaches across BETO projects would be a valuable step toward overall harmonization of assumptions and metrics in the portfolio as long as there is buy-in from the modeling/research teams.

RECIPIENT RESPONSE TO REVIEWER COMMENTS

- We appreciate recognition of the value of this model mapping effort.
- The ability of this effort to provide actionable information is evidenced by portfolio actions that BETO has taken based on our initial analysis. As noted in the presentation, the maps presented, which were selected by BETO as the single snapshot depicting the overall portfolio in FY 2017, do not fully capture the multiple dimensions that characterize the models that our effort captured. We plan to work with BETO in the future to ensure that visualizations are effective for the map.
- As mentioned, we presented only two of the variations of maps that were produced and provided as part of this project.

ECONOMIC ANALYSIS OF RISK

Idaho National Laboratory

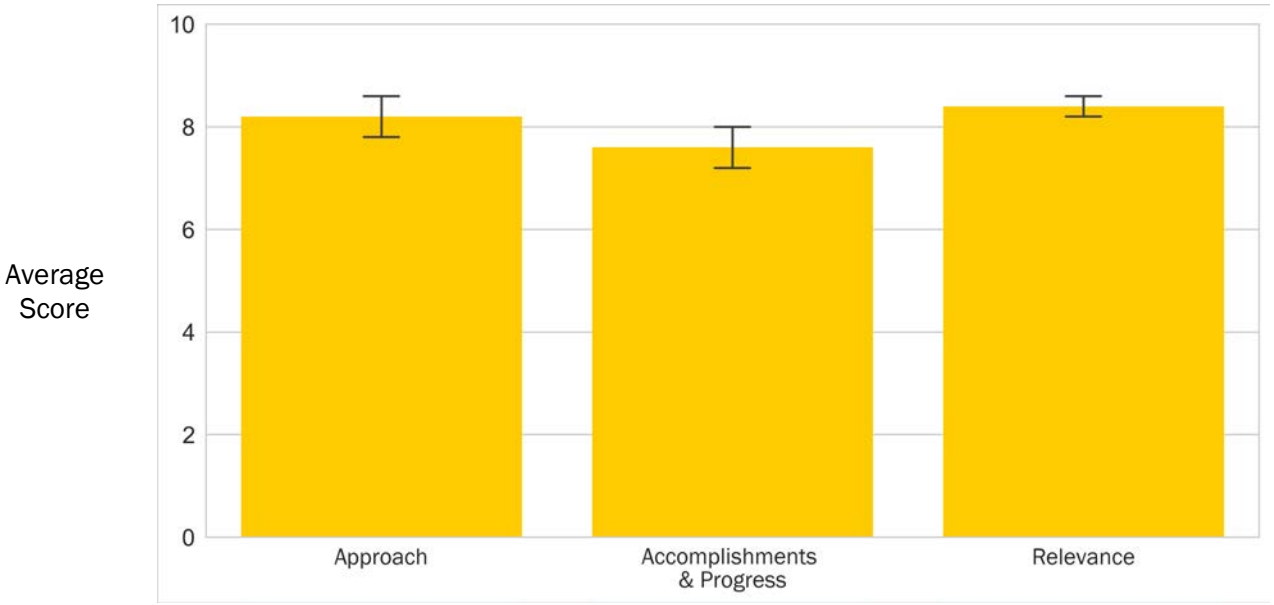
PROJECT DESCRIPTION

WBS:	4.1.2.20
CID:	NL0026663
Principal Investigator:	Dr. Jason Hanson
Period of Performance:	10/1/2015–9/30/2021
Total DOE Funding:	$1,118,177
DOE Funding FY16:	$250,000
DOE Funding FY17:	$570,047
DOE Funding FY18:	$298,130
DOE Funding FY19:	$0
Project Status:	Sunsetting

Advancing the cellulosic industry hinges on the ability to quantify risk, and feedstock risk is one of the greatest impediments today. This point repeats itself in stakeholder engagement and literature findings as a key impediment to industry growth. A clear and present need is to identify and reduce risk exposure along the feedstock supply chain; however, today, inconsistent methods for analyzing risks in the feedstock supply chain lead to an investment barrier in the form of high financing costs. Because the industry is in its infancy, the lack of historical data increases perceived investor risks, which amplifies the need for a quantitative, simulation-based approach. Tackling one aspect of risk, the goal of this project is to design and develop a tool for quantifying cost risk, on an economic basis, in the feedstock supply chain. Project researchers developed the Stochastic Techno-Economic Model (STEM), which simulates possible cost outcomes from which risk can be quantified and then compared across supply chain design alternatives. STEM enables consistent, systematic modeling on an economic basis. Applying the model, researchers have quantified uncertainty in alternative supply chain design configurations, by each unit operation, then translated modeled uncertainty to a logistics distribution of costs to assess risk. The STEM contributes to systems-level risk analysis by generating potential outcomes against which researchers, project developers, financial analysts, or other interested agents can establish mitigation strategies.

Weighted Project Score: 8.0

Weighting for Sunsetting Projects: Approach - 25%; Accomplishments and Progress - 50%; Relevance - 25%



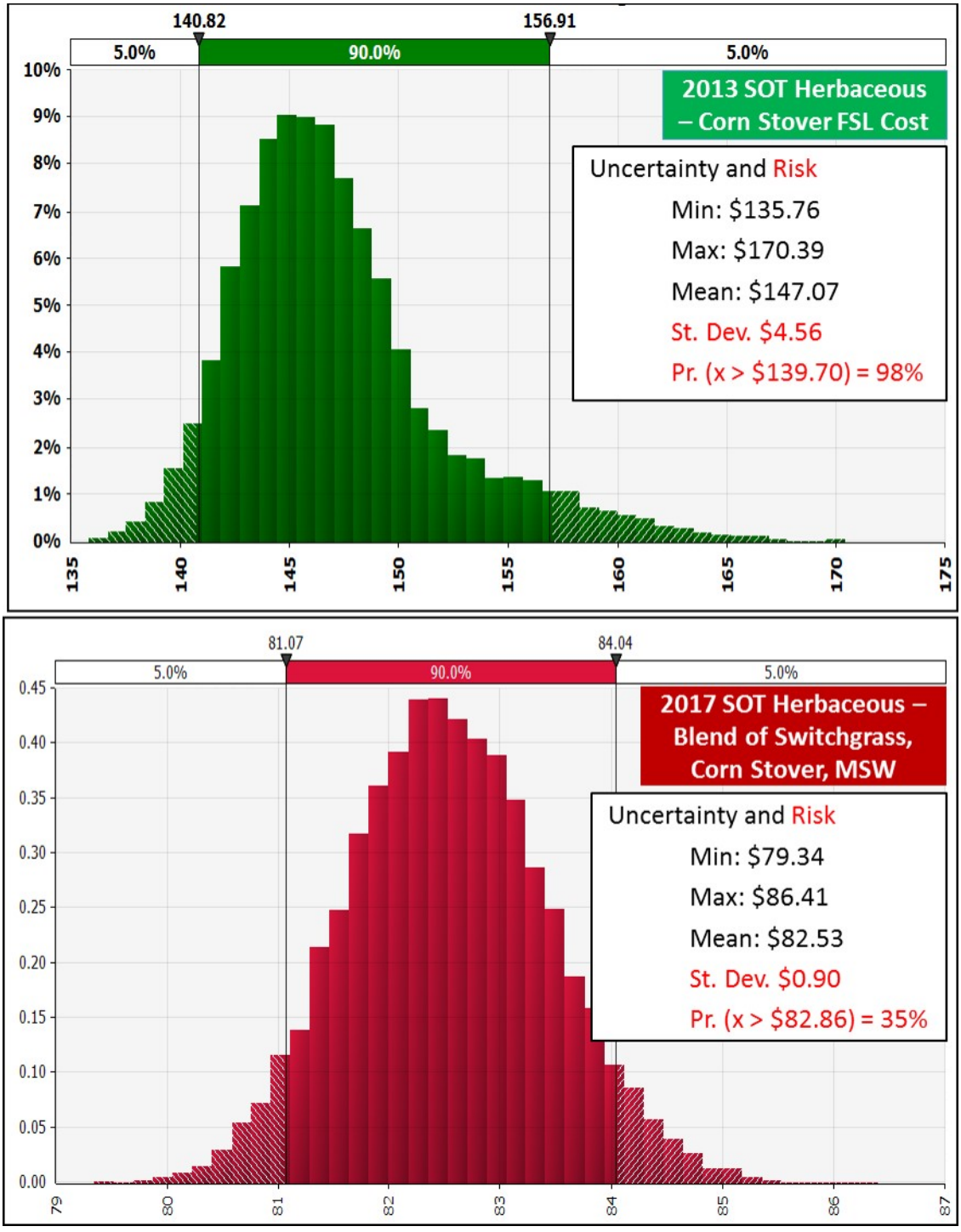


Photo courtesy of Idaho National Laboratory

OVERALL IMPRESSIONS

- Overall, this is a (policy and investment) relevant project with useful, publicly available products to improve understanding of cost variability and risks.

- The publicly available stochastic TEA STEM will be extremely valuable to industry and researchers to be able to generate comparable supply-chain TEA risk. It will improve transparency for supply-chain participants and identify key areas of risk and opportunity for improvement of supply-chain performance. It was good to know that the team leveraged expertise of experts on deterministic models to help understand different possibilities and uncertainty in data around economics and performance, but it would have been helpful to get more information on the model itself, the sensitivities tested, and the software platform. The histograms of cost for different case studies and the explanation of uncertainty and associated risk provide an easily understandable output with an intuitive interpretation and enable comparisons among feedstocks/blends. It is great to see that the plan includes assessing the integrated land management approach.

- The goal of this research is to design and develop a tool for quantifying cost risk (economic basis) in the feedstock supply chain. The team developed STEM to simulate possible cost outcomes from which risk can be quantified and then compared across alternative supply-chain designs, providing a framework for consistent and systematic analyses. Model development built on past work, including state-of-technology (SOT) reports. Several analyses were conducted, including landscape design alternatives (stover and switchgrass) and herbaceous feedstocks (stover versus a blend). The project contributed to overcoming barriers identified by BETO: to reduce risk, to provide improved understanding of the cost of risk, and to reduce feedstock cost through risk reduction. Barriers addressed include At-B: Analytical Tools and Capabilities for System-Level Analysis; Ft-A: Feedstock Availability and Cost; and At-E: Quantification of Economic, Environmental, and Other Benefits and Costs.

- The STEM simulates possible cost outcomes from which cost risk can be quantified. This is an important goal. Its use of Monte Carlo simulation to characterize probability distributions around point estimates is an appropriate approach to the issue. It is not clear how the probability distributions are being derived given that the input parameters are being drawn from other projects that did not characterize uncertainty. It is also not clear how this model is integrated with others in the BETO portfolio. What is its pathway to impact?

RECIPIENT RESPONSE TO REVIEWER COMMENTS

- Thank you for your comments.

- The STEM will be hosted on INL servers on the Biomass Feedstock Library page. It will be accompanied by documentation on how the model is built and how the parameters used in the uncertainty model are attained. The reports included there also contain examples of how the STEM has been applied in various applications of alternative feedstock supply chains.

- In terms of impact, two separate analyses where STEM has been used are under review in journal publications. These papers, along with reports generated during the project and hosted on the online site, provide other researchers a way to use the STEM.

BIOPRODUCTS TRANSITION SYSTEM DYNAMICS

National Renewable Energy Laboratory

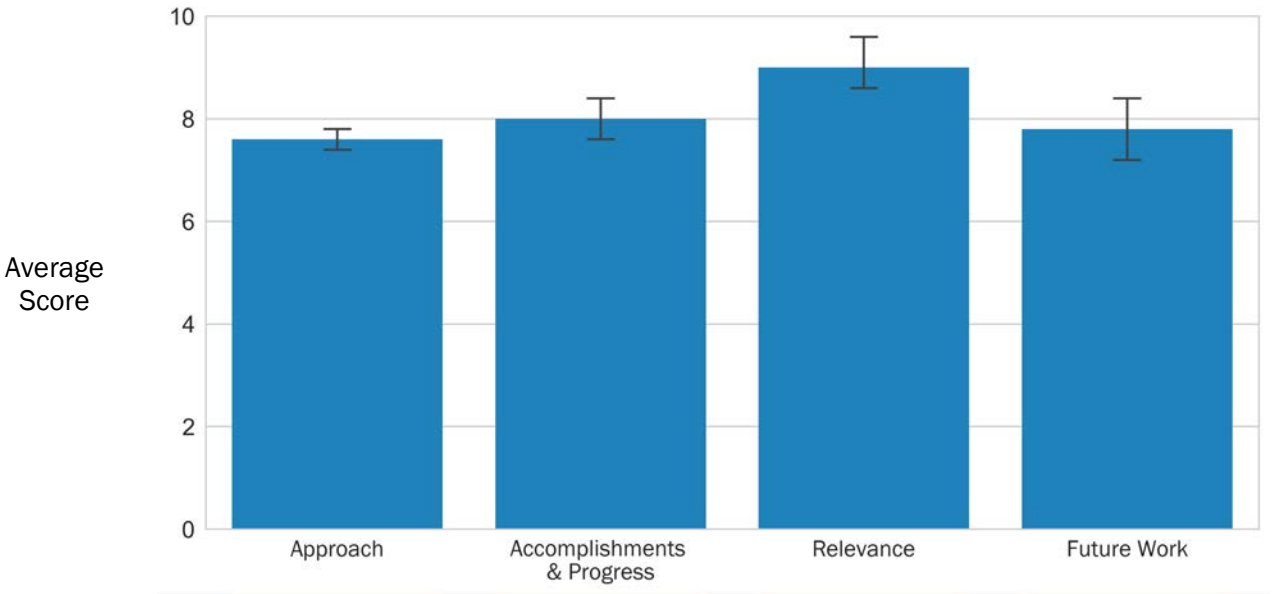
PROJECT DESCRIPTION

WBS:	4.1.2.31
CID:	NL0032347
Principal Investigator:	Dr. Mary Biddy
Period of Performance:	10/1/2016–9/30/2020
Total DOE Funding:	$700,000
DOE Funding FY16:	$51,000
DOE Funding FY17:	$200,000
DOE Funding FY18:	$249,000
DOE Funding FY19:	$200,000
Project Status:	Ongoing

Bioproducts are chemicals derived from a biomass feedstock. They can be produced on their own or as coproducts of a biorefinery that also produces biofuels. Bioproducts have historically been difficult to scale up and bring to market, despite a broad understanding developed within BETO of the various conversion processes that can be used to produce bioproducts. Expanding the bioproduct industry by bringing more bioproducts to market would have a variety of positive impacts. Growth in the bioproduct industry would support the biofuel industry by enabling biorefinery coproducts that yield additional revenue streams, allowing biofuel selling prices to be reduced and expanding the biofuel market. A larger bioproduct industry also has the potential to reduce carbon and other emissions associated with the U.S. chemical sector and contribute to increased price stability in some areas of the chemical market by shifting portions of the chemical sector away from reliance on fossil feedstocks. The key barrier to realizing these positive impacts is a lack of knowledge around the factors that prevent or enable bioproducts to reach the commercial market. To date, there has been essentially no research done on how successful bioproducts (commercially produced bioproducts that have captured market share) become successful, why failed bioproducts fail, and the similarities and differences between successful and failed bioproducts.

Weighted Project Score: 8.1

Weighting for Ongoing Projects: Approach - 25%; Accomplishments and Progress - 25%; Relevance - 25%; Future Work - 25%



The current project addresses this knowledge gap with a decision-support tool that can be used by investors, technology developers, and government agencies to bring more bioproducts to market, thereby simultaneously growing the bioproduct and biofuel industries. Development of the decision-support tool was based on research on the technology development process and success rates in analogous industries, data gathered during previous BETO-funded projects, and a series of interviews with subject matter experts within BETO, the bioproduct industry, and the investment community. This information formed a knowledge base around how bioproducts are developed from applied research to commercial-scale assembly, which was used to build the Bioproduct Transition Dynamics (BTD) model, a system dynamics model that tracks bioproduct development projects from applied research through the "valley of death" of piloting and demonstration to commercial-scale production. The end-of-project goal is to release the BTD, along with supporting documentation, as a transparent open-source model that will inform decisions around bioproduct development and investments and enable more bioproducts to reach the market.

The BTD takes as inputs techno-economic data on specific bioproducts, behavioral parameters for developers and investors, expectations around government support, and exogenous market factors. Model outputs include bioproduct technological progress throughout time, a cash flow statement for the development project, and market share estimates. Following initial model development, a sensitivity analysis was performed on a subset of model inputs to determine, first, if the BTD could be used to answer analysis questions of interest to BETO, and second, which of the inputs considered were most influential on bioproduct success. Results indicate that the BTD can be used to identify scenarios that enable bioproduct development and that "soft" or semiquantitative factors play a large role in determining if a bioproduct will reach the market. A workshop was also held for subject-matter experts and prospective BTD users in July 2018. The workshop covered BTD model logic, input data and assumptions, as well as the sensitivity analysis results and a discussion of potential use cases. Workshop feedback was used to identify additional model development tasks and was incorporated into a draft technical report completed in September 2018. BTD model development, validation, and application will continue through September 2020.

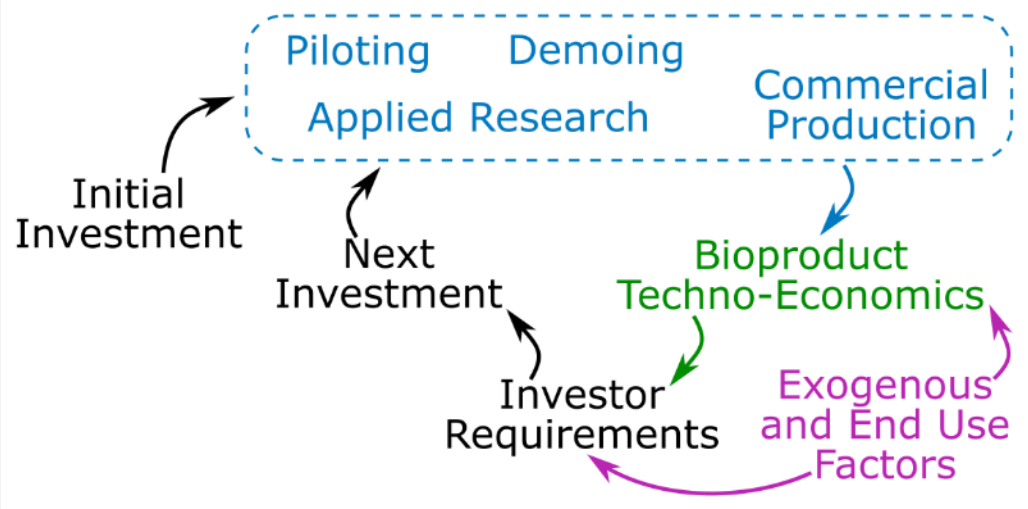


Photo courtesy of National Renewable Energy Laboratory

OVERALL IMPRESSIONS

- This project, which started in 2016, addresses issues critical to ensuring the success of bioproducts because product transition challenges have not been addressed as much as bioenergy products.
- My layperson interpretation is that the team is trying to forecast (and potentially mitigate) adverse impacts of market flooding (e.g., glycerin from biodiesel industry) and new, higher-value, unique products (e.g., dried distillers grains as feed, bioadvantaged products).

- This project addresses interesting and timely questions related to bringing bioproducts from demonstration through to market maturity. Addressing the valley-of-death challenges faced by bioproducts will shed light on a key but understudied barrier to an integrated and sustainable bioeconomy.
- The project represents needed work. The project fills a research, information, and data gap in identifying factors impacting the development of the bioproduct industry, and it develops a decision-support model, the BTD.
- This project will leverage the extensive expertise in system dynamics of the bioeconomy developed for the BSM to develop a similar approach to analyzing early-stage bioproducts to assess market penetration potential. This is a valuable initial start to this assessment process that has been used to identify the factors with the greatest influence on bioproduct success. It can be used as a starting point to develop the model to more fully address coproducts and the integration of bioproducts into the overall bioeconomy production scenarios.
- At some point, this analysis/model will need to address coproducts with the bioproducts because most bio-based production processes produce multiple products, potentially including fuels. It might not make sense, therefore, to model bioproducts in isolation. Perhaps this should eventually become an early technology readiness level module of the BSM.
- One of the outcomes of the BTD workshop is listed as a new focus of model scope on pilots and demos. This does not seem to match the focus here on overcoming the valley of death, which is about bridging the gap between pilot/demonstration and true commercial scale. The principal driver analysis seems most relevant to a commercial endeavor than a pilot or demonstration, and indeed, this is the rationale for the project's relevance.

RECIPIENT RESPONSE TO REVIEWER COMMENTS

- We thank the reviewers for their feedback, and we will work to incorporate these suggestions into our future modeling and analysis efforts.

BIOECONOMY SCENARIO ANALYSIS AND MODELING

National Renewable Energy Laboratory

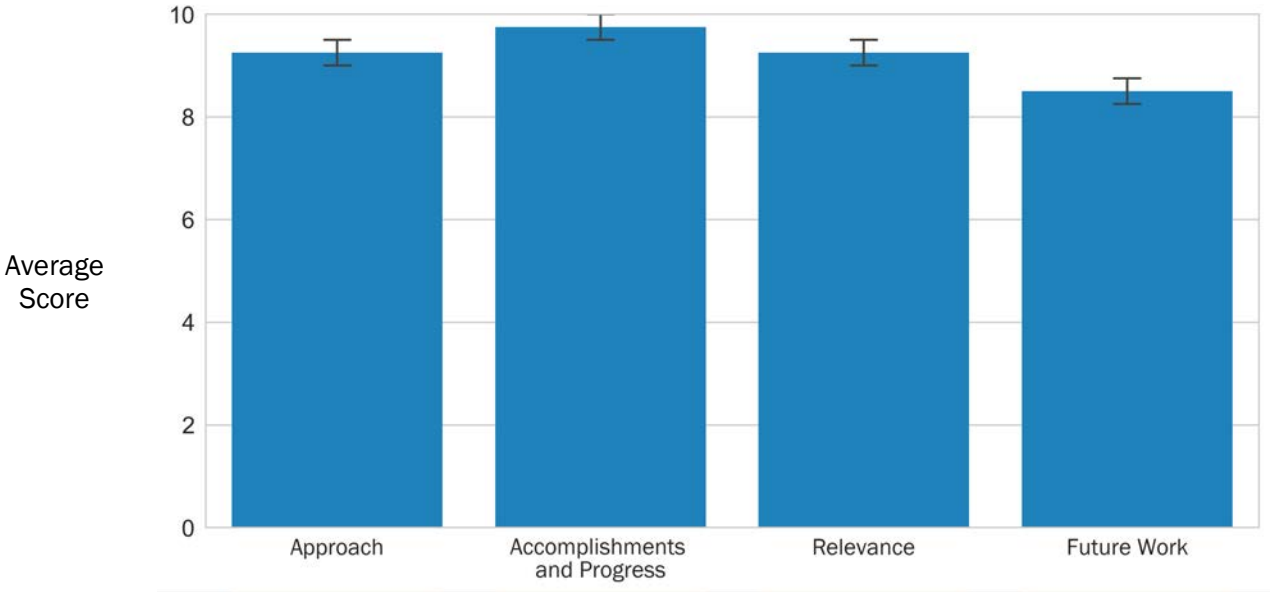
PROJECT DESCRIPTION

WBS:	4.1.2.32
CID:	NL0033742
Principal Investigator:	Ms. Emily Newes
Period of Performance:	10/1/2017–9/30/2020
Total DOE Funding:	$1,200,000
DOE Funding FY16:	$0
DOE Funding FY17:	$0
DOE Funding FY18:	$750,000
DOE Funding FY19:	$450,000
Project Status:	Ongoing

The Bioeconomy Scenario Analysis project uses systems thinking and analysis to assess current and/or prospective techno-economics, R&D, deployment strategies, policy, and market conditions and their impact on the potential development trajectories of the bioenergy industry throughout time. Results from this project include the identification of opportunities and constraints to industrial development; quantification of multiple metrics (energy, economic, environmental); and informing researchers, decision makers, and industry of the steps needed for a sustainable, nationwide biofuel industry. Analyses from this project enable the creation of a bioenergy industry by (1) inciting policymakers to explore scenarios for nationwide biofuel production and identifying policy actions consistent with pathways for growth; (2) improving the industry's understanding of industry growth potential under different technology and investment conditions and better targeting their development efforts; and (3) providing universities and other interested stakeholders with tools and analyses that can be adapted to meet research and teaching objectives, connecting students with careers that build the industry. One modeling tool used in this project, the BSM, is a publicly available, unique, validated, state-of-the-art, award-winning, fourth-generation model of the domestic biofuel supply chain that explicitly focuses on how and under what conditions biofuel technologies might be deployed to contribute to the U.S. transportation energy sector. We use models such as the BSM to examine the

Weighted Project Score: 9.2

Weighting for Ongoing Projects: Approach - 25%; Accomplishments and Progress - 25%; Relevance - 25%; Future Work - 25%



I One standard deviation of reviewers' scores

implications of policies and incentives as well as their potential side effects. The BSM uses a system dynamics simulation to model interactions and transitions across the supply chain; it tracks the deployment of biofuels given industrial learning and the reaction of the investment community in the context of land availability, projected oil markets, consumer demand for biofuels, and government policies throughout time. Under expected market conditions, analyses using the BSM suggest that the biofuel industry might require significant external actions in the early years to thrive. Interventions that accelerate the industrial learning process (e.g., operation of precommercial and commercial facilities) have been identified as having strong influence in starting the growth of a commercial biofuel industry. Policies that are coordinated across the whole supply chain in BSM foster the growth of the biofuel industry, and production of tens of billions of gallons of biofuels might occur under sufficiently favorable conditions.

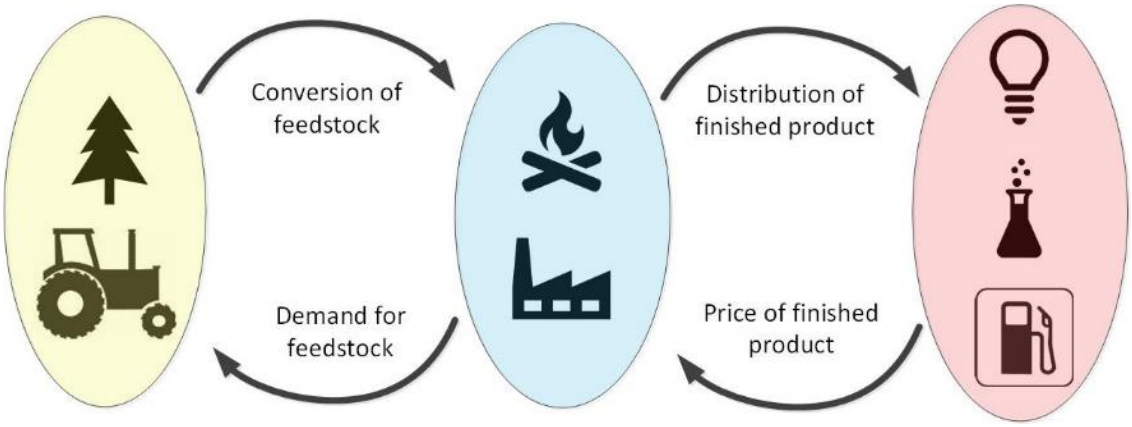


Photo courtesy of National Renewable Energy Laboratory

OVERALL IMPRESSIONS

- Overall, this is a very appropriate project for BETO to continue to fund.
- Insights from their system-of-systems scenario modeling are understandable and useful to policymakers.
- The BSM allows scenario exploration to support decision making, highlighting interactions across systems and evolving markets. The project informs BETO, other stakeholders, and policy decision makers of the implications of policy choices and market developments to enable prioritization and evaluation of various actions and enable researchers to design and analyze the impacts of additional biomass-to-bioenergy scenarios
- The BSM enables the study/assessment of transition dynamics to a bioeconomy (using a complement of tools); generates plausible scenarios for prospective policies, incentives, investments, R&D impacts, and strategies; and enables and facilitates focused discussion among stakeholders
- The project addresses barriers At-A: Analysis to Inform Strategic Direction, At-B: Analytical Tools and Capabilities for System-Level Analysis, and At-D: Identifying New Market Opportunities for Bioenergy and Bioproducts.
- The BSM is a promising newer development in the BETO model portfolio. The researchers have pursued a key goal of identifying specific factors that contribute to cost effectiveness of subsidies so that the subsidies can be better structured and applied. A high-profile research award and uptake in academic research as well as teaching imply methodological rigor as well as potential for future influence. Strategic planning for increased impact beyond research sphere is warranted.

RECIPIENT RESPONSE TO REVIEWER COMMENTS

- We thank the reviewers for their thoughtful and supportive feedback. We will strive to address their comments in future scenario analysis topics.

BIOFUELS NATIONAL STRATEGIC BENEFITS ANALYSIS

Oak Ridge National Laboratory

PROJECT DESCRIPTION

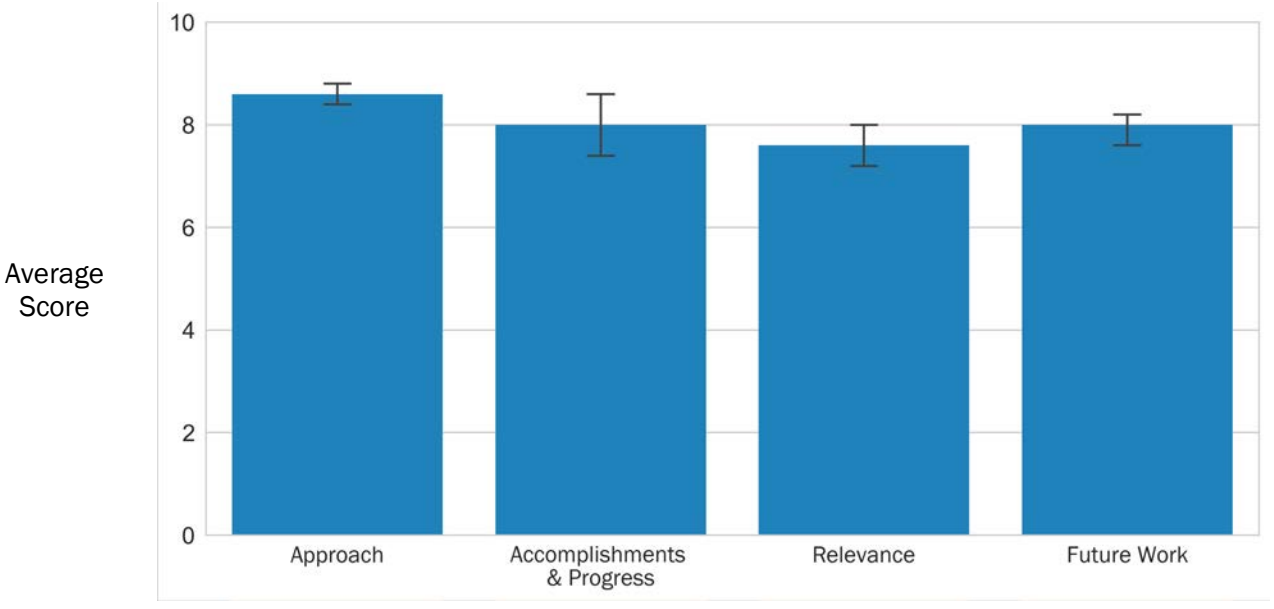
This project helps DOE assess, quantify, and explain the economic and energy security benefits of biofuels and bioproducts. It identifies system configurations and conditions that advance economic welfare and improve resilience along the biofuel products supply chain. To meet its objectives, the project approach is twofold. First, BioTrans—a mathematical programming model that optimizes long-run investment and operation decisions along the U.S. biofuel/bioproduct supply chain—is used to simulate scenarios of interest regarding market conditions, policy changes, and supply-chain configurations. Second, empirical analysis of historical data is conducted to analyze the dynamics of the gasoline-ethanol price relationship.

WBS:	4.1.2.41
CID:	NL0024441
Principal Investigator:	Mr. Paul Leiby
Period of Performance:	10/1/2015–9/30/2020
Total DOE Funding:	$1,041,138
DOE Funding FY16:	$200,000
DOE Funding FY17:	$300,000
DOE Funding FY18:	$341,138
DOE Funding FY19:	$200,000
Project Status:	Ongoing

During the last merit review cycle (FY 2016–FY 2018), this project generated insights regarding the impact of changing market conditions (reduced oil prices and expanded domestic oil and gas production), policy changes (revised renewable fuels standard [RFS] requirements), and alternative supply-chain configurations on the introduction of advanced biofuels and the energy security role of biofuels. BioTrans was used to explore the role of biofuels in mitigating the cost of oil and biomass supply shocks. Empirical analysis of historical ethanol and gasoline price time series focused on the estimation of the effect of biofuel blending on fuel price

Weighted Project Score: 8.1

Weighting for Ongoing Projects: Approach - 25%; Accomplishments and Progress - 25%; Relevance - 25%; Future Work - 25%



volatility. Estimates of the economic value of those volatility reductions were also generated using two different approaches: modern portfolio theory and real option valuation.

The additional work proposed for FY 2019–FY 2021 will extend past the analysis of economic resilience and energy security benefits that focused on biofuels to include new issues and supply-chain configurations that are increasingly viewed as essential to improving the value proposition of advanced biofuels. First, the development of bioproducts as a complement to biofuel production is essential to strengthening the economics of advanced biorefineries. The aspects of the value proposition of multiproduct biorefineries explored in this project will include economic sustainability profitability for farmers and biorefiners, value for consumers, and economic and energy security benefits for the nation. Second, the planned work will explore potential impacts that an octane performance standard, in addition to or in place of the RFS, could have on the biofuel industry.

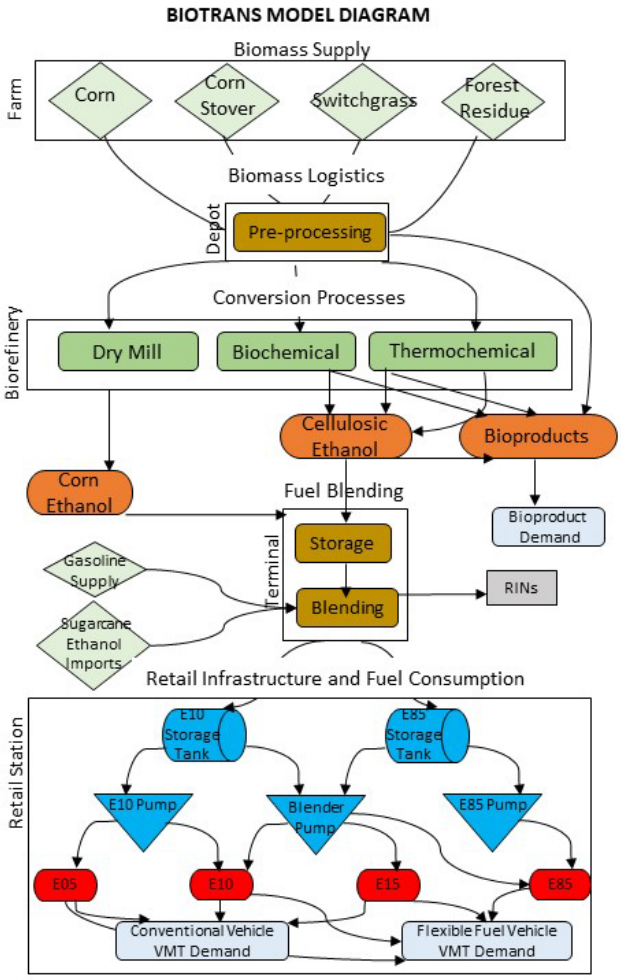


Photo courtesy of Oak Ridge National Laboratory

OVERALL IMPRESSIONS

- This project, initially funded by ORNL almost a decade ago, has evolved to improve the economic equilibrium market model BioTrans (which captures farm-to-pump supply-chain connections and petroleum-biofuel interactions). The justification for this project is strong, and results are interesting so far; future work could be strengthened with some minor changes to assumptions (and/or articulation of default assumptions).

- The market price and economic analysis model (BioTrans), strength long-range analysis, 30-year model horizon (year-by-year or comparative statics) solves for optimal investment patterns. The focus themes for the model are the issues of transition to alternative fuels.
- This project helps assess, quantify, and explain the economic and energy security benefits of biofuels and bioproducts. The project identifies system configurations and conditions that advance economic welfare and improve resilience along the biofuel products supply chain.
- This project addresses barriers At-B: Analytical Tools and Capabilities for System-Level Analysis; BioTrans Model; and At-E: Quantification of Economic, Environmental, and Other Benefits or Costs. The project also addresses energy security benefits and the value of fuel price volatility reduction.
- Energy security and economic sustainability considerations are critical, and much of the A&S portfolio focuses on the environmental considerations/arguments surrounding biofuels. There is clearly some dead-weight loss associated with fuel volatility, and quantifying this effect is useful. If increased biofuel blend levels carry increased cost but reduced volatility risk, this quantification could be a key element of the value proposition.
- Although this approach is very interesting, it seems somewhat academic or theoretical, and it is unclear how supply-chain participants would use the modeling approach or results when defining a project or supply chain. The team should think carefully about and communicate how to enable this information to be used to help with deployment and supply-chain development.

RECIPIENT RESPONSE TO REVIEWER COMMENTS

- Thank you all for the positive comments and for the critiques and suggestions. We are grateful that you took the time to listen to us and review our work with such care.
- Our communication of research findings has typically been through periodic BETO briefings, conference presentations, and peer-reviewed journal publications. The non-BETO outlets mostly reach other researchers and explain why this work is in a technical format. We acknowledge that, to maximize their impact, our results need to be (1) further translated into actionable insights and (2) communicated to supply-chain participants.
    - Translating the results into actionable insights: In the supply shock scenario analysis, it would help to further unpack national aggregate shock costs to show the impacts on different market participants in different regions. We want to convey the effect of different supply-chain configurations (investments) on mean revenue, revenue variability, and resilience to different types of shocks. Flexibility levers (e.g., advanced logistics, biorefinery feedstock flexibility, bioproducts) are one option to enhance resilience. For bioproducts, one planned industry-relevant contribution is to develop general classifications regarding process flexibility and substitutability with petroleum-based alternatives and identify strengths and vulnerabilities associated with the introduction of bioproducts with different levels of those two attributes. The analysis framework can then be applied to any specific bioproduct pathway.
    - Communicating our results in outlets that reach supply-chain participants more easily: We will work to summarize and present our insights in outlets more likely to reach supply-chain participants: articles in trade journals (e.g., *Biomass Magazine*) and/or presentations at more industry-focused conferences. Another potential avenue for increased engagement with industry stakeholders is through further development and publicizing of our current web interactive tool with a focus on key questions that would be of interest for supply-chain participants and making it accessible in the KDF.

GCAM BIOENERGY AND LAND-USE MODELING AND DIRECTED R&D

Pacific Northwest National Laboratory

PROJECT DESCRIPTION

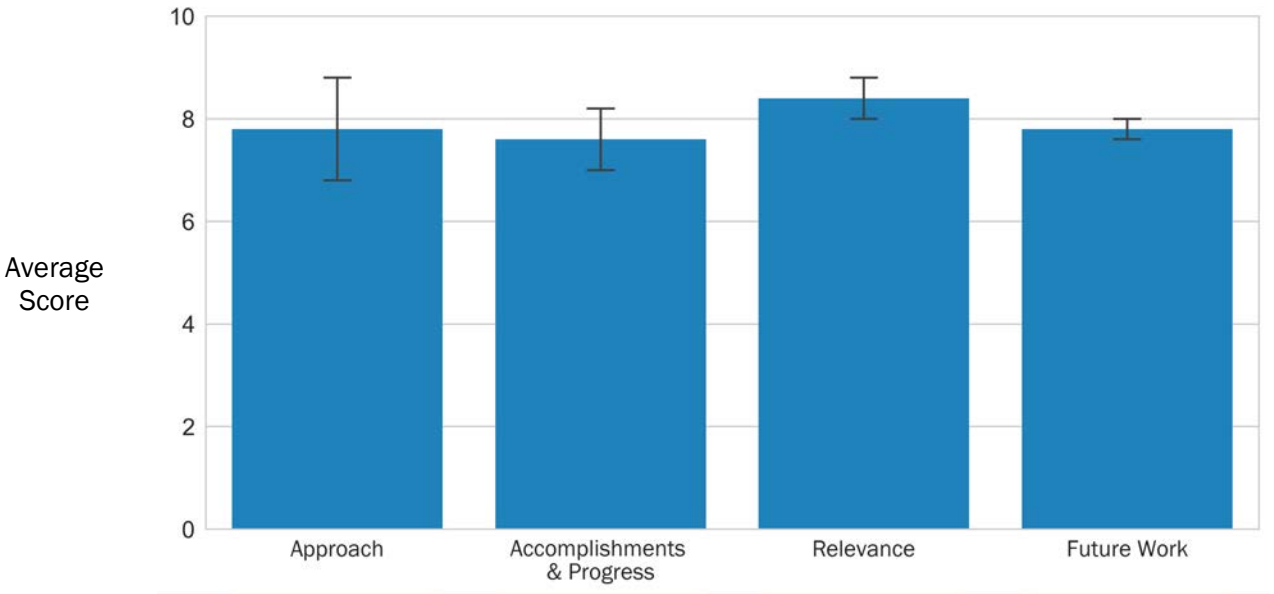
WBS:	4.1.2.50
CID:	NL0022708
Principal Investigator:	Mr. Marshall Wise
Period of Performance:	10/1/2016–9/30/2019
Total DOE Funding:	$450,000
DOE Funding FY16:	$150,000
DOE Funding FY17:	$150,000
DOE Funding FY18:	$150,000
DOE Funding FY19:	$0
Project Status:	Ongoing

This project serves the BETO A&S platform by providing quantitative analyses and published studies of the potential and impact of bioenergy in the integrated context of global energy and agriculture. Much of the analysis involves developing and using the PNNL GCAM, an established modeling program widely used by DOE, the EPA, academics, and the energy industry. The BETO project leverages the developments of the larger GCAM program to focus on improving modeling capabilities, data, and analysis in key areas related to bioenergy production and use. GCAM has been used by PNNL in international analysis efforts, such as the Intergovernmental Panel on Climate Change (IPCC) and the Stanford Energy Modeling Forum, and it is available and widely used as an open community model. GCAM analysis is complementary to BETO TEA/LCA by providing long-term, multisectoral economic context for bioenergy technologies and systems.

Since the BETO GCAM activities started in 2010, we have developed modeling capabilities and published analyses about lignocellulosic bioenergy crops globally, bioenergy technologies for liquid fuels and power, and bioenergy with CO_2 capture and storage. In recent years, we have focused on integrated economic analysis of bioenergy in the energy demand and transformation sectors. In FY 2017, we published a paper exploring the

Weighted Project Score: 7.9

Weighting for Ongoing Projects: Approach - 25%; Accomplishments and Progress - 25%; Relevance - 25%; Future Work - 25%



potential scale and the impacts on energy, land, and emissions of large-scale production and use of biofuels for global aviation to 2050. In FY 2018, we designed and performed an analysis of the competition and potential synergies of electric vehicles (EVs) and bioenergy. Currently in FY 2019, we are studying the economic potential and impact of biopower using GCAM-USA, which models the energy systems in each of the 50 states while maintaining integration with the global model.

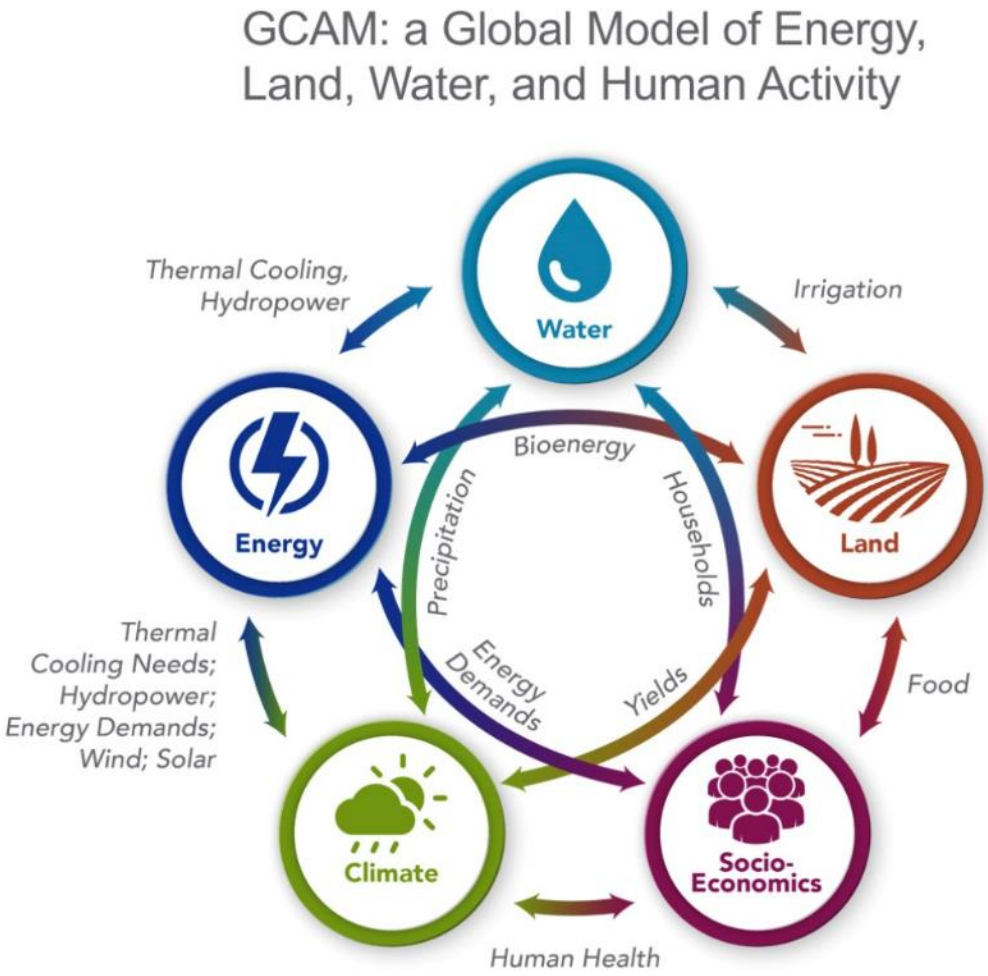


Photo courtesy of Pacific Northwest National Laboratory

OVERALL IMPRESSIONS

- This established, high-impact program quantitatively tackles specific scenario-related questions associated with bioenergy demand and production in the context of broader agricultural and energy economic systems.
- I had difficulty with this project review. I thought the approach was vague and the accomplishments weak.
- This is important work expanding the GCAM scope and application to include key emerging applications, such as bio-jet and bioelectricity for transport.
- The researchers' evaluation of biopower as a biofuel is relevant, for example, in the California Low-Carbon Fuel Standard policy context. This project fills a key gap in the BETO portfolio by explicitly

studying biofuels in the context of an EV future. Missing these dynamics would ignore a key trend influencing this space, so this is a strong development.

- The fact that GCAM is being used by analysis outside of the project team is a strong sign of its relevance.

- The use of the well-accepted GCAM for broader economy-wide modeling of bioeconomy effects is helpful to better understand the broader impacts of the BETO portfolio.

RECIPIENT RESPONSE TO REVIEWER COMMENTS

- Thank you to the reviewers for sharing your time and expertise on this effort. As in past peer reviews, your focused questions and comments have been invaluable in helping us plan for future analyses and improve the ways we communicate the results of our project to a broader audience outside BETO.

- Each year, we work closely with BETO to plan project tasks and milestones that are relevant to BETO's current analysis needs and for which GCAM can provide new quantitative insights that are complementary in scope to other BETO analyses. The fact that GCAM is developed as part of a larger, multiclient program provides many opportunities for leveraging model developments, but it also creates challenges for clearly delineating work performed specifically for BETO. We believe that we have been successful in designing and performing relevant bioenergy analyses for BETO and the larger stakeholder community during the past several years.

- A specific concern raised by the review panel is the level of regional resolution in the GCAM modeling. We have achieved much more spatial resolution in our economic modeling of land use within the main GCAM model during the last decade, from 11 world regions to more than 300 with our current water basins. It will always be a conceptual and computational challenge to model economics at a very fine resolution within a global model. Our current strategy for analysis where more resolution is needed is to downscale using geographic information system tools, such as Xanthos for water.

- Because GCAM models many aspects of bioenergy production and demand, the range of possible analyses is broad. This project has had an eclectic mix of analysis topics and papers throughout the years, and this might make it more difficult to discern a long-term plan. Our experience is that being opportunistic to address evolving areas of interest is a fruitful strategy; however, based on reviewer comments, we will also more clearly define a longer-term path for specific analyses and capability improvement.

WATER RESOURCE MANAGEMENT FOR BIOENERGY AND BIOPRODUCTS

Argonne National Laboratory

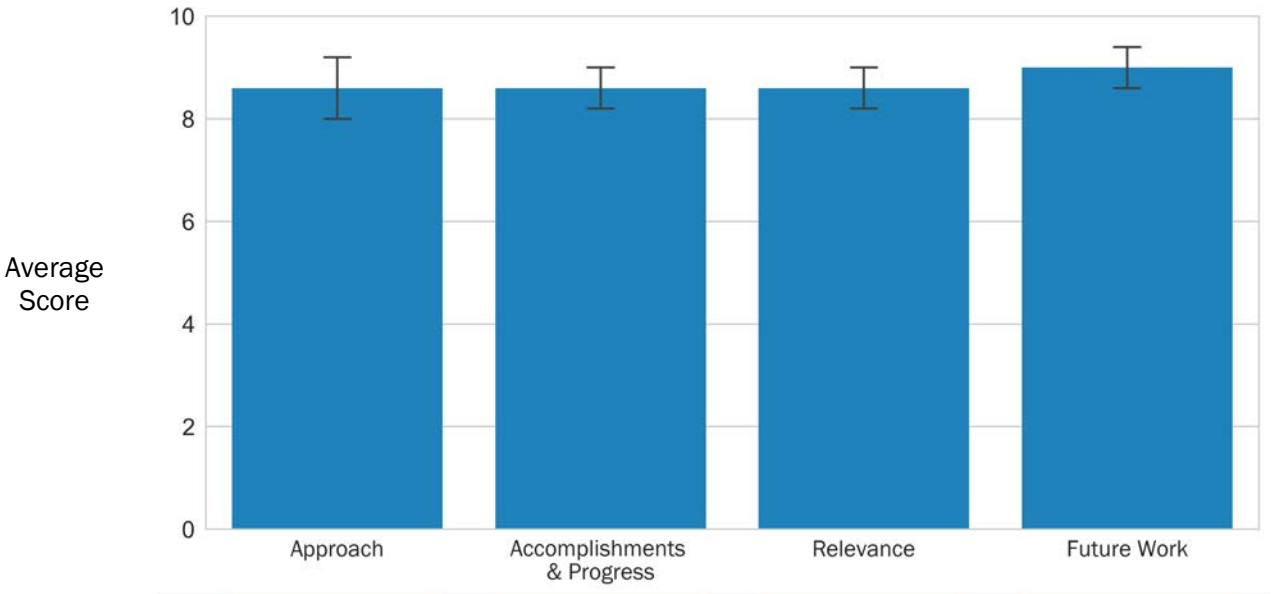
PROJECT DESCRIPTION

WBS:	4.2.1.10
CID:	NL0022889
Principal Investigator:	Dr. May Wu
Period of Performance:	10/1/2014–9/30/2020
Total DOE Funding:	$2,348,512
DOE Funding FY16:	$725,000
DOE Funding FY17:	$714,310
DOE Funding FY18:	$509,202
DOE Funding FY19:	$400,000
Project Status:	Ongoing

This project (1) develops an analytic framework and hydrologic models that characterize geospatial water resource needs in the production of bioenergy and bioproducts under landscape design and management and pathway technologies and (2) applies the models and analysis in the United States to understand how growing and processing feedstock affects water use intensity, regional water availability, and water quality at watershed and regional scales. The work aims to (1) evaluate management practices in bioenergy landscapes that protect water resources and increase water-use efficiency and (2) identify scenarios that can improve the water sustainability of advanced bioenergy systems. The output of the project includes geospatial analyses of national- and regional-scale, county- and watershed-level resolution water footprints and the water availability index of biofuels; a spatial-explicit model, WATER; an energy-water inventory; and a suite of multiscale Soil and Water Assessment Tool (SWAT) hydrologic models that feed into BETO feedstock sustainability analysis, feedstock landscape TEA, and supply-chain sustainability assessment.

Weighted Project Score: 8.7

Weighting for Ongoing Projects: Approach - 25%; Accomplishments and Progress - 25%; Relevance - 25%; Future Work - 25%



OVERALL IMPRESSIONS

- The assessment of a variety of water resource impacts is critical to informing discussions of the sustainability of various agricultural and industrial practices—especially bioenergy.
- This project is well integrated with other BETO-funded projects and other experts throughout the U.S. Geological Survey
- This project assesses bioenergy feedstocks from the water resource perspective to improve understanding of water quality and quantity; develops an analytic framework/hydrologic models that characterize geospatial water resource needs in the production of bioenergy and bioproducts under landscape design and management and pathway technologies; and applies the models for analysis of the United States to understand how growing and processing feedstock affects water use intensity, regional water availability, and water quality at watershed and regional scales. The goal is to evaluate management practices in bioenergy landscapes that protect water resources and increase water-use efficiency and identify alternative landscape design (LD) that can improve the water sustainability of advanced bioenergy systems.
- This project addresses barriers At-B: Analytical Tools and Capabilities for System-Level Analysis; At-E: Quantification of Economic, Environmental, and Other Benefits and Costs; and At-H: Consensus, Data, and Proactive Strategies for Improving Land-Use Management.
- This work should be feeding into multicriteria analyses elsewhere in the BETO research space. If not, we are missing (1) an opportunity and (2) necessary detail on the water criterion in other efforts. This applies to the multicriteria assessment sustainability analyses in BETO and to the GREET model. Is this work embedded in GREET?
- This speaks to my concern with some of the larger system-level analyses in the portfolio. Can the team be doing a sufficiently rigorous job on each criterion?
- It is important to understand the freshwater demand and implications for water quality of the bioenergy sector, and the WATER model is very comprehensive. Water resource mapping of soil moisture, streamflow, etc., and evidence for water quality/quantity benefits of various management strategies could be very valuable as siting decision criteria for growing/selecting feedstocks and/or for landscape management decisions. It was not clear how the analysis accounts for existing and planned uses of the water that are not in the bioenergy sector, nor if there are interactions among water demand types (i.e., if a shift to growing bioenergy crops reduces water demand from some other crop).

RECIPIENT RESPONSE TO REVIEWER COMMENTS

- The project team expresses its deep appreciation to the reviewers for their time, encouragement, and valuable input. We also thank the reviewers for recognizing our accomplishments and providing future directions. Looking forward, we will increase the level of interaction with other water/sustainability tools and models and provide water analysis results that contribute to multifactor tradeoff analysis. We will continue to work with other federal agencies, research institutes, and private sectors to address water use, water resource availability and resulted stress, and water quality with geospatial resolution. Finally, we will stay focused and continue our contributions to BETO as well as to the development of the bioeconomy.
- Water consumption data for corn and soybean irrigation generated from WATER were fed to GREET.
- Thanks for the comments. This water analysis considers existing land use by agricultural sector and forestry sector—the largest water consumption players in non-bioenergy sectors. We have analyzed and will continue to examine the interactions and effects of shifting land use and shifting crop types among these sectors and bioenergy on various freshwater resources across geographic regions.

INTEGRATED LANDSCAPE MANAGEMENT

Idaho National Laboratory

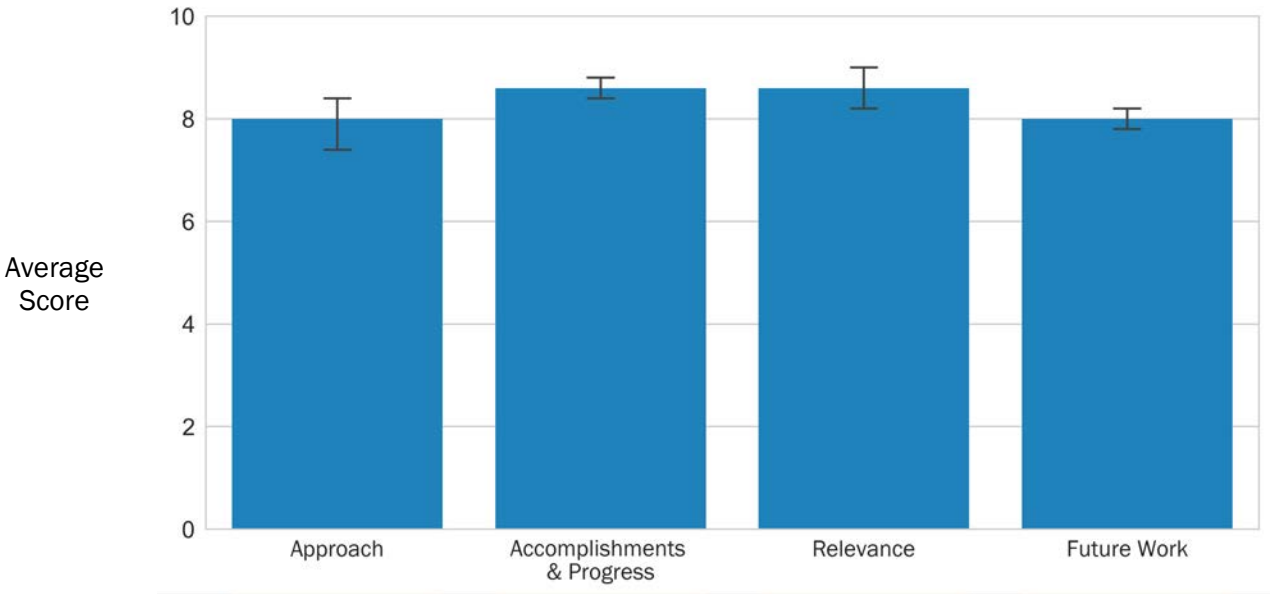
PROJECT DESCRIPTION

WBS:	4.2.1.20
CID:	NL0015077
Principal Investigator:	Mr. Mike Griffel
Period of Performance:	10/1/2015–9/30/2020
Total DOE Funding:	$1,751,051
DOE Funding FY16:	$450,000
DOE Funding FY17:	$550,000
DOE Funding FY18:	$451,051
DOE Funding FY19:	$300,000
Project Status:	Ongoing

The ILM project represents a path forward to augment biomass feedstock supply chains with herbaceous biomass supplies at reduced access costs while improving sustainability outcomes relative to soil erosion and water quality. The intended outcome of ILM analysis is to support the BETO renewable fuel cost target of $2.50/GGE by reducing biomass access costs. ILM is a strategy to integrate biomass production practices via sustainable crop residue collection practices and dedicated energy crop production in subfield areas where soil health is not suitable to meet traditional crop yield goals, resulting in economic and environmental waste. In FY 2017, ILM analysis using the Landscape Environmental Assessment Framework (LEAF) showed that significant volumes of biomass are available at state levels for agriculturally diverse states, such as Iowa and Kansas. In Iowa, LEAF modeling coupled with economic analysis during a four-year period indicated almost 60 million metric dry tons of stover from *Zea mays* (corn) could be accessed as a biomass resource with an additional 40 and 113 million metric dry tons of *Panicum virgatum* (switchgrass) and *Miscanthus* × *giganteus* (miscanthus), respectively. During the same four-year period, Kansas producers could potentially generate an additional 1.6 million metric dry tons of stover and 126 and 118 million metric dry tons of switchgrass and miscanthus, respectively. Analysis with additional modeling tools, including the Agricultural Non-Point Source (AGNPS) Pollution Model, developed by the USDA

Weighted Project Score: 8.3

Weighting for Ongoing Projects: Approach - 25%; Accomplishments and Progress - 25%; Relevance - 25%; Future Work - 25%



Agricultural Research Service (ARS), has shown that ILM could significantly reduce sediment and nutrient loading of agricultural watersheds by shifting crop inputs away from vulnerable and unsuitable soil types at subfield levels. AGNPS modeling of the impacts of incorporating perennial energy crop production within the Beaver Creek Watershed in Iowa indicate sediment loading could be reduced by more than 4,000 tons during a four-year period. In FY 2018, a TEA evaluating the impact of ILM designs on economic and sustainability outcomes of agricultural production fields showed biomass access costs could be reduced by 20% while improving economic outcomes at the field level across three Midwest watersheds. To support the TEA, the ILM design portfolio was expanded to include scenarios with efficient subfield geometries; prairie contour strips targeting vulnerable, high-slope areas; and the integration of biomass sorghum production at a whole-field level in lieu of fallow management. An updated soil-erosion modeling software, the Revised Universal Soil Loss Equation 2 (RUSLE2), raster-developed by USDA-ARS, was used to better incorporate the impacts of field topographic features and ILM changes within USDA-defined soil zones. The analysis also shows that soil erosion was reduced in two of the three watersheds, with additional reductions possible by further reducing crop residue recovery rates. Continuing in FY 2019, ILM analysis is focused on developing improved spatial subfield yield variability modeling capabilities and incorporating additional agricultural producer field efficiency metrics in the analysis to better account for the impacts of ILM on field equipment operational efficiency.

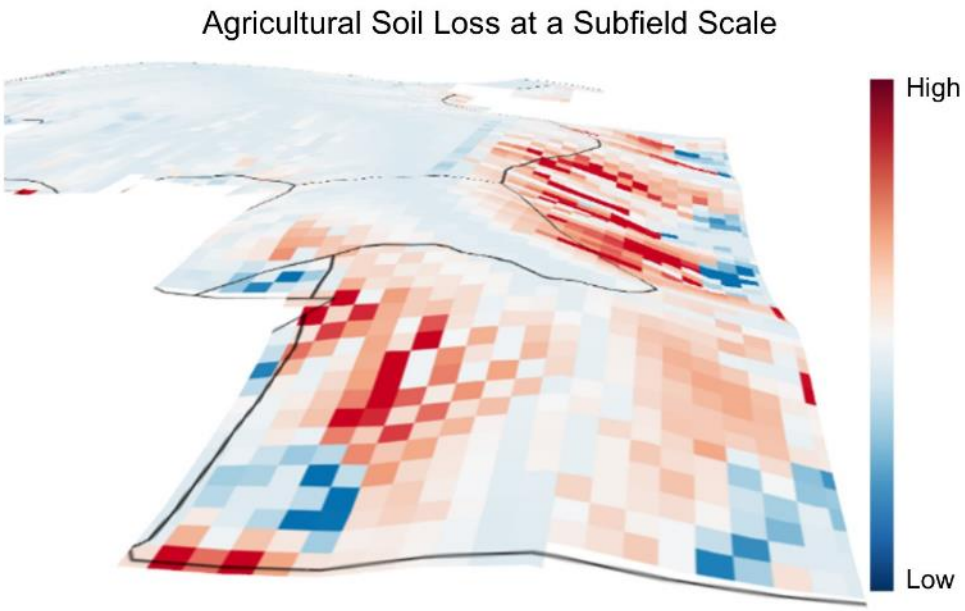


Photo courtesy of Idaho National Laboratory

OVERALL IMPRESSIONS

- This team has a clearly articulated goal and approach to demonstrate through modeling that ILM can reduce biomass feedstock costs at the field level. Results so far indicate that opportunities should exist for farmers to plant bioenergy crops at the marginal fringes of their properties, improving environmental quality and generating revenue.

- The goal of the project is to demonstrate (by modeling) how ILM can reduce feedstock production costs, while maintaining economic and sustainable outcomes, and the project directly supports BETO's fuel cost target (2030) of $2.50/GGE. Project researchers have provided history indicating that the project is based on earlier work (Sustainable Feedstock Production–Logistics Interface) and leverages (and aims to

improve) LEAF. Farmers, ranchers, landowners, and land managers are potential major suppliers of biomass materials (energy conversion), and the land is the source of those biomass materials.

- This project is pursuing an interesting research question, and its integration of TEA and watershed-scale agricultural analysis is an interesting/relevant approach. Portfolio managers would be well served to ensure that this study is integrated with the Antares analysis as it would offer a useful data source and validation pathway.

- The ILM approach could be an extremely valuable tool for enhancing feedstock production and sustainability outcomes; it requires field validation to ensure that the modeling is an accurate representation of field performance. The team's approach to identifying subfield locations that could be targeted for economic and environmentally beneficial bioenergy feedstock production could be extremely valuable for identifying areas for potential production that will add value for farmers. The team has updated the revised universal soil loss equation (RUSLE), which is a valuable advance beyond the ILM modeling and is successfully used within the project The analysis suggests that applying ILM can reduce feedstock production costs by more than 20%—this would be a significant accomplishment that would greatly enhance the economic viability of more feedstocks (and thereby fuel pathways) going forward if validated through field measurements. Some estimate of statistical significance on the results would be valuable to determine if the differences presented matter regarding environmental performance. Given the potential utility of this modeling approach in real farming conditions, it would be very valuable to do field verification and validation and to implement the proposed subfield management approach in a few instances.

RECIPIENT RESPONSE TO REVIEWER COMMENTS

- The researchers agree that field validation is important. Efforts to collaborate with projects with available field data will continue.

BIOFUEL AIR EMISSIONS ANALYSIS

National Renewable Energy Laboratory

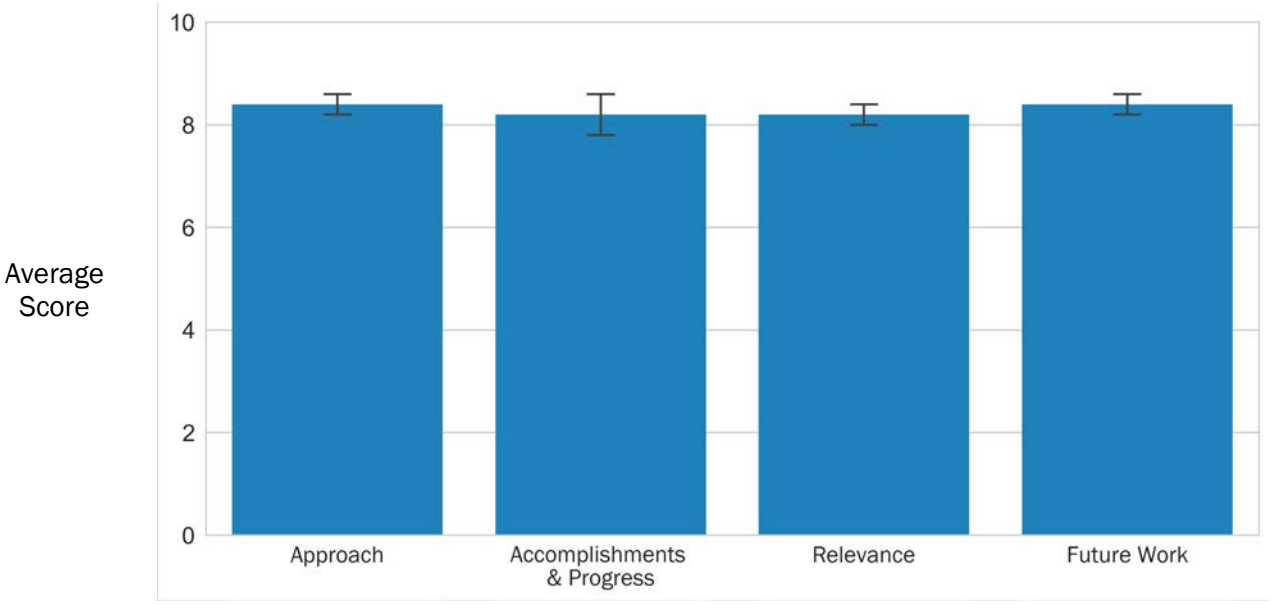
PROJECT DESCRIPTION

WBS:	4.2.1.30
CID:	NL0022588
Principal Investigator:	Dr. Danny Inman
Period of Performance:	10/1/2015–9/30/2021
Total DOE Funding:	$2,172,000
DOE Funding FY16:	$558,000
DOE Funding FY17:	$650,000
DOE Funding FY18:	$614,000
DOE Funding FY19:	$350,000
Project Status:	Ongoing

NREL's Biofuel Air Emissions Analysis project is unique and innovative in terms of the tools, approaches, and analyses provided. NREL is the only national laboratory that is actively working at the intersection of federal air-quality regulations, air emissions across the supply chain, and process design. Meeting federal air-quality standards is prerequisite to being issued a construction permit. Negotiating the permitting process for a new biorefinery can be onerous and cost investors significant time and money. In a report looking at large-scale projects, 98% of projects incur cost overruns and delays over the project's life. As of 2015, the average delay is 20 months, and the average cost overrun is 80% of the project's capital. Although there are numerous reasons for delayed biorefinery construction, air permitting is fraught with pitfalls because the air permitting process relies on precedence, which the biorefining industry presently lacks. For example, the Tesoro Refining and Marketing Company LLC currently has a bio-oil feed project (in Martinez, California) that has been delayed for 10 months (as of June 5, 2018) because of problems obtaining air permits for the facility. This project is focused on providing much-needed data and analyses that address biorefinery air permitting. This project develops models and quantitative analyses and measures progress toward meeting air-quality regulatory requirements. Biofuels are not necessarily cleaner than fossil fuels in terms of air emissions; however, it is important to emphasize that air emissions from biofuels depend in a large

Weighted Project Score: 8.3

Weighting for Ongoing Projects: Approach - 25%; Accomplishments and Progress - 25%; Relevance - 25%; Future Work - 25%



part on how biomass is produced and converted to biofuels. An accurate air-quality impact assessment requires understanding not only the type and magnitude of air pollutant emissions, but also where and when pollutants are released into the environment, aligning with the latest understanding of how biomass will be produced, collected, and then converted to fuels. Since the initiation of this project, we have been building BETO's capability to meet stakeholders' stated needs to accurately assess potential air-quality impacts by addressing a number of research gaps, including (1) a scarcity of spatially, temporally, and chemically resolved air pollutant emission inventories for the biofuel supply chain(s); (2) a lack of understanding about the types and quantities of air pollutants emitted from advanced biofuel conversion process designs and whether these advanced design cases can meet federal air regulations; and (3) a dearth of quantitative emission estimates on criteria air pollutant emissions from different advanced biomass logistics systems envisioned for biomass feedstocks to supply a large-scale bioenergy industry. In addition to filling research gaps, this project aims to disseminate and communicate our results to the relevant stakeholders at BETO, the national laboratories, and regulatory agencies. To begin to overcome these challenges, we have developed a framework that is designed to assess the air pollutant emissions for several BETO-prioritized advanced biofuel design cases across the biofuel supply chain. One key component of this framework is the Feedstock Production Emissions to Air Model (FPEAM), which allows for estimation of spatially explicit air pollutant emissions from biomass feedstock production, harvest, and transportation.

Photo courtesy of National Renewable Energy Laboratory

OVERALL IMPRESSIONS

- Overall, this is a well-focused, well-teamed, high value-added project that could help reduce time and financial burdens (and uncertainty) associated with permitting commercial biorefineries.

- This project fills a void in providing a better understanding of emissions data along the supply chain and providing/developing data/emission estimates required for permitting, thereby overcoming a bottleneck in building biorefineries.
- The project addresses barriers At-A: Analysis to Inform Strategic Direction; At-B: Analytical Tools and Capabilities for System-Level Analysis; At-C: Data Availability Across the Supply Chain; ADO-C: Codes, Standards, and Approval for Use; and ADO-G: Co-Processing with Petroleum Refineries.
- This is an interesting project carried out by a well-qualified team. This effort is well connected to other models in the national laboratory space, and the team is working to make the "handshake" more robust. This will be important for other analyses to be able to leverage this work.
- The goal of this project is to provide crucial data, tools, and analyses to the biofuel and air regulatory community to enable the biofuel industry to develop sustainably. Its focus and rigor on criteria emissions accounting from farm to plant fills what would otherwise be a key gap in the BETO portfolio.
- The model aims to ensure that biorefineries will be able to comply with regulations, which is very useful to know at this point in their development. What is not clear is how this modeling will aid in permitting, as the team aims to do. The project is modeling air impacts on a notional basis, whereas a permit would need to be applied to a real facility. Is there a precedent for facilities being permitted on the strength of a model like this?
- If the team is successful in developing the assessment approach and gaining acceptance for a precedent for air pollution permitting for bioenergy facilitating, this project outcome will be very valuable for reducing investor and project risk during commercial facility development. It is not clear if there is an established path for setting precedents using modeling. The proposed release of the FPEAM as a public model and integration with existing spatiotemporal models of air quality will be very useful to industry and researchers.

RECIPIENT RESPONSE TO REVIEWER COMMENTS

- We thank the reviewers for their helpful and supportive feedback. We will work to incorporate these suggestions in our project plans as we move forward.

INTEGRATED LIFE-CYCLE SUSTAINABILITY ANALYSIS

National Renewable Energy Laboratory

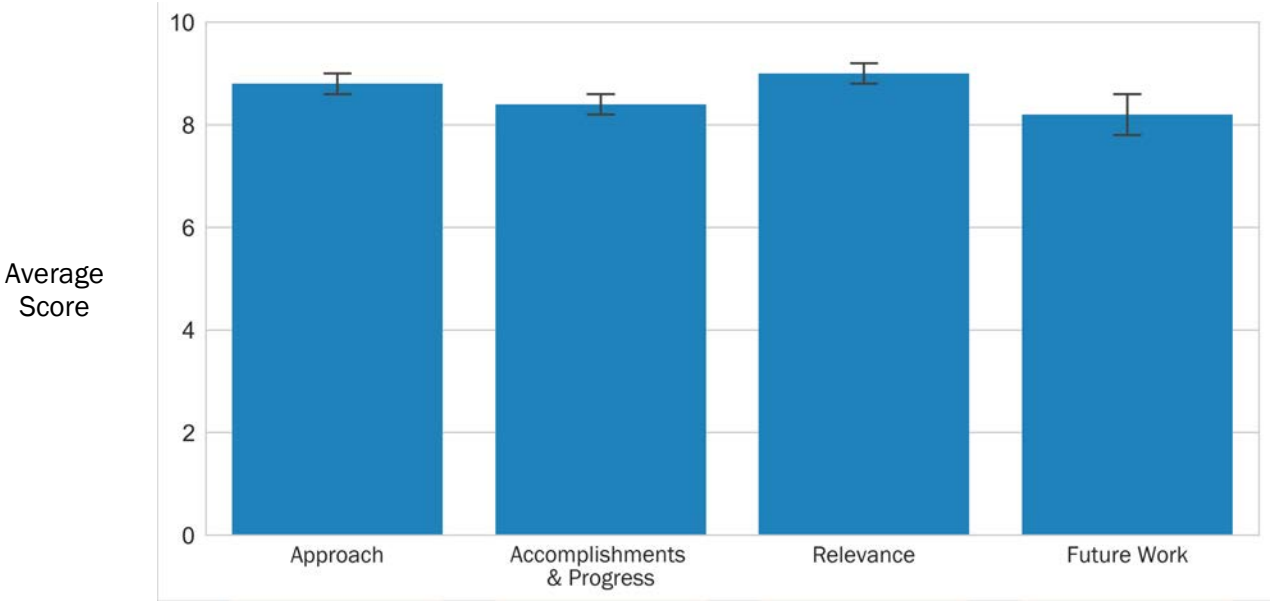
PROJECT DESCRIPTION

WBS:	4.2.1.31
CID:	NL0027593
Principal Investigator:	Dr. Patrick Lamers
Period of Performance:	10/1/2015–9/30/2019
Total DOE Funding:	$1,325,968
DOE Funding FY16:	$200,000
DOE Funding FY17:	$300,000
DOE Funding FY18:	$475,968
DOE Funding FY19:	$350,000
Project Status:	Ongoing

The main objective of this project is to provide BETO with a coherent methodology and modeling framework based on LCA and economic input-output analysis, tested and vetted with stakeholders, to better understand the net effects of an expanding U.S. bioeconomy at specific levels. This directly supports a 2019 milestone of BETO's *Multi-Year Plan* (MYP) and simultaneously addresses a gap previously identified by the DOE BETO peer review. To achieve this, NREL collaborates with developers of the national-level USEEIO model at the EPA and partners with other federal agencies (e.g., USDA), interagency initiatives (e.g., Biomass Research and Development Board), and DOE national laboratories to create an open-source model that aligns well with similar efforts, including the Federal LCA Commons and the Sustainable Acquisition Program at DOD. During the review period, following the collection of feedback on the suggested modeling approach from a selected group of practitioners and developers of LCA and input-output models, NREL built a prototype by disaggregating the economic activities associated with and attributed to a selected product of the bioeconomy: corn ethanol. As an important part of the present U.S. bioeconomy and providing a large amount of public, validated economic industry information as well as peer-reviewed literature to compare to, corn ethanol was deemed a suitable test case. Validating the framework through a test case is important because disaggregation is a critical step in creating a representative and accurate framework. By the end of FY

Weighted Project Score: 8.6

Weighting for Ongoing Projects: Approach - 25%; Accomplishments and Progress - 25%; Relevance - 25%; Future Work - 25%



2018, the team was able to generate several scenarios for corn ethanol on national and selected regional levels, providing results across multiple environmental and economic impact categories (reaching a "go" decision by DOE BETO).

A second objective of the project is to inform BETO's strategic decision making by engaging in, evaluating, and synthesizing selected global, multilateral activities that develop, compare, or apply metrics, methods, and tools to quantify sustainability effects of bioeconomy products, specifically the International Energy Agency's Technology Collaboration Programme on Bioenergy (IEA Bioenergy) and the Global Bioenergy Partnership (GBEP). This helps to identify gaps, barriers, and critical areas for future BETO bioenergy and sustainability assessments, identify opportunities and challenges to a sustainable U.S. bioeconomy, and contribute to and disseminate BETO information to and from major global bioenergy and sustainability efforts. Across the review period, this project contributed to, among others, a comparison of biofuel life-cycle emissions calculated by LCA tools with regulatory relevance. It found large initial discrepancies among the tools, which could be reduced via a harmonization of default values and allocation methods, indicating a continuous need for global alignment across LCA tools and underlying default values.

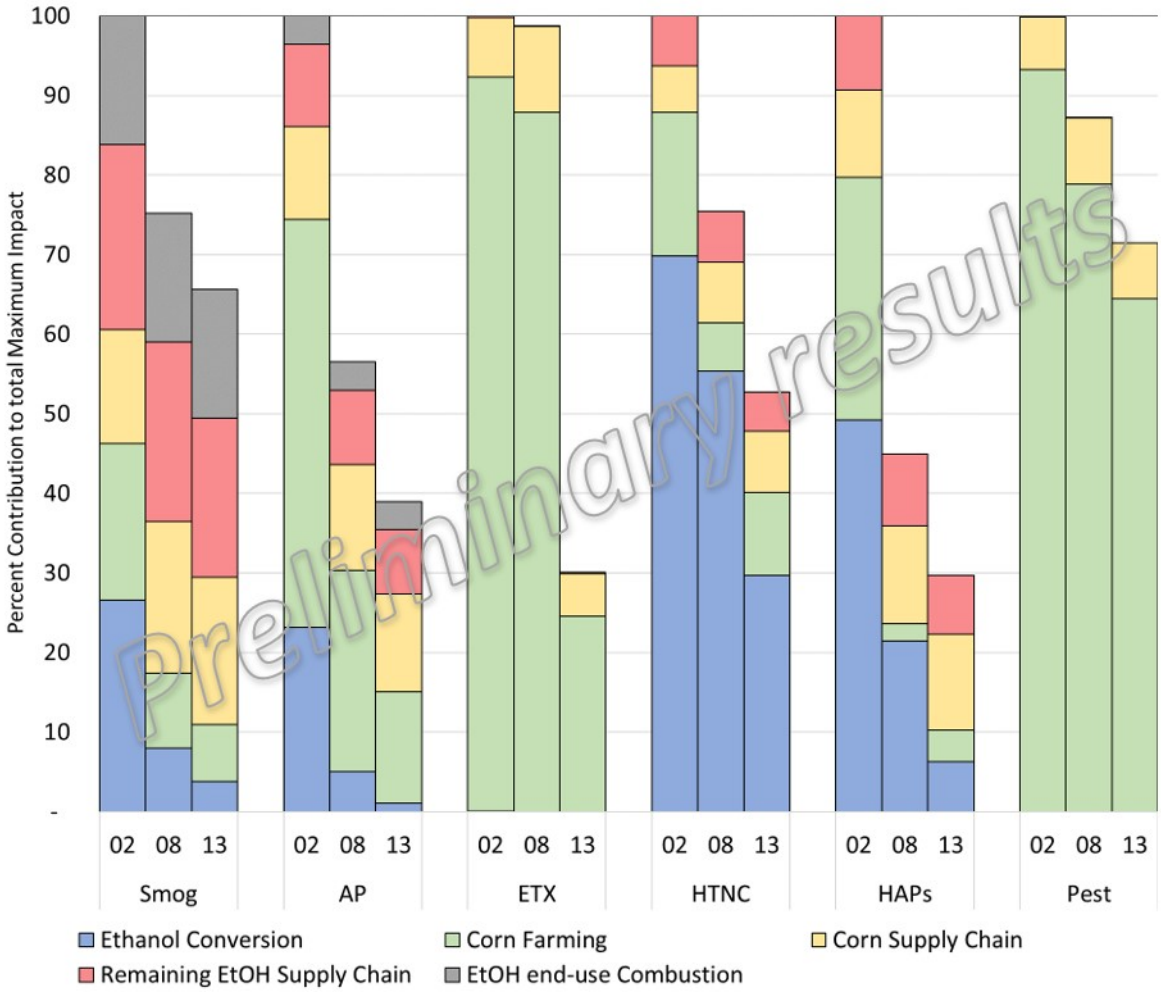


Photo courtesy of National Renewable Energy Laboratory

OVERALL IMPRESSIONS

- Overall, this is a unique project among the BETO projects we have reviewed, and it offers value in improving harmonization and capturing indirect impacts related to the sustainability of bioenergy.
- There is concern that there is so much scope it is hard to address individual parameters rigorously. Dr. Lamers answered this concern directly, stating that this is to some extent an irreducible problem. Other models offer a great deal of rigor on a bottom-up basis. This project is taking a top-down approach, and its results can be usefully compared to those other models.
- This economy-level LCA approach will be very valuable for understanding the impacts of a scaled-up bioeconomy. The ability to assess improvement throughout time and broad regional differences in environmental performance can be valuable to help identify gaps and opportunities for improvement. Regarding the multilateral LCA metrics, tools, and analysis comparisons, this seems more appropriate for (or at least to be done in close collaboration with) the GREET team, which has done a lot of this work on understanding distinctions among GHG LCA tools already. Regarding the conclusion that there is a need for additional global harmonization of data and tools, there are actually good reasons for some of the differences in assumptions and methodology because there are geographic differences as well as valid debate about the best approach for some of these elements (e.g., allocation method). Further, those methods/approaches are sometimes codified by regulations (and are different for regulations in different places). Therefore, it might not be a realistic conclusion or goal to harmonize all metrics and methodologies.
- This project addresses this BETO A&S gap and related MYP A&S milestone, and it provides sufficient background detail to provide BETO with a credible, coherent methodology and modeling framework based on LCA and economic input-output analysis to quantify the net effects of an expanding U.S. bioeconomy at the national and regional levels.
- This project's goal is to inform BETO's strategic decision making by engaging in, evaluating, and synthesizing selected global, multilateral activities that develop, compare, or apply metrics, methods, and tools to quantify sustainability effects of bioeconomy products.
- This project addresses barriers At-A: Analysis to Inform Strategic Direction; At-B: Analytical Tools and Capabilities for System-Level Analysis; and At-E: Quantification of Economic, Environmental, and Other Benefits and Costs.

RECIPIENT RESPONSE TO REVIEWER COMMENTS

- We thank the reviewers for their constructive feedback, and we appreciate the recognition of the value of this project. The main goal of this effort is to provide BETO with an economy-wide integrated framework that applies a consistent and coherent methodology across multiple environmental and economic metrics. By default, this encompasses a broad scope, but it also purposefully creates a distinction to present BETO-supported, supply-chain-specific, bottom-up models such as GREET that cover fewer metrics. The benefit of the integrated framework is the capability to put product-level effects into an economy-wide context (in relative and absolute terms). Further, we calibrate the integrated model with data generated by and for bottom-up assessments. As such, we automatically review those results and ensure alignment of data and assumptions. A secondary component of the project is to provide scientific support to BETO across multilateral activities that assess the sustainability of bioeconomy products, including, among others, IEA Bioenergy (Task 45) and the GBEP. Rather than harmonizing sustainability metrics, models, and tools, the main intent is to assess respective methods and approaches to improve their transparency so that differences in results and values and their underlying reasons are clearly communicated and can be understood by the various stakeholders interested in these values.

VISUALIZING ECOSYSTEM SERVICE PORTFOLIOS OF AGRICULTURAL AND FORESTRY BIOMASS PRODUCTION

Oak Ridge National Laboratory

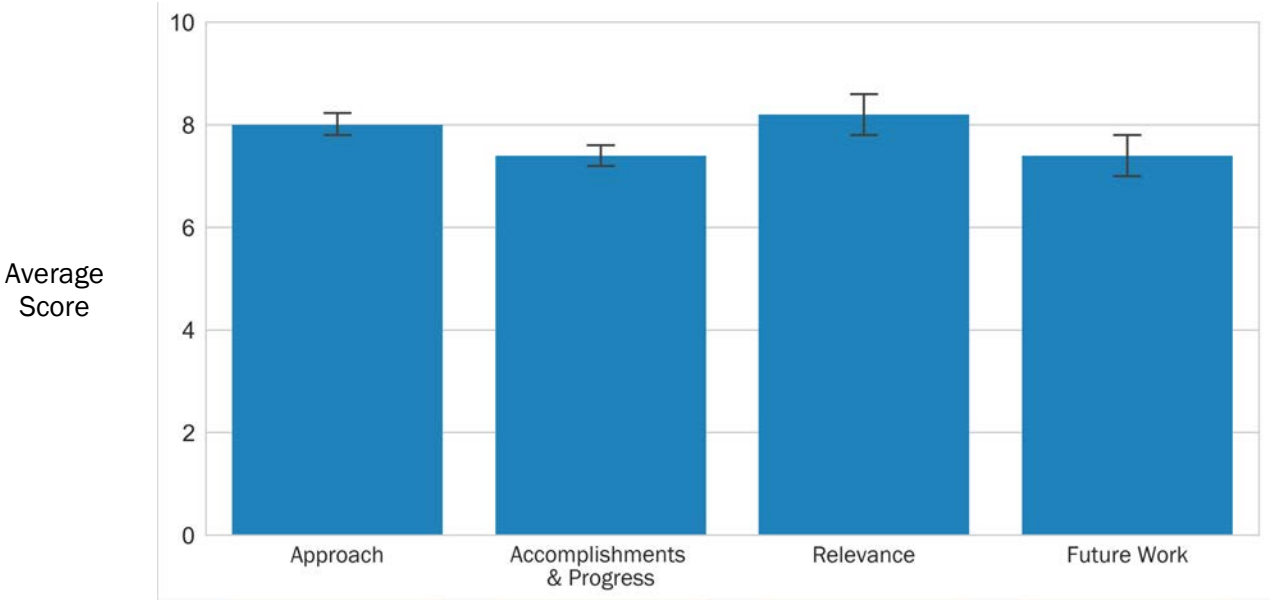
PROJECT DESCRIPTION

WBS:	4.2.1.40
CID:	NL0022890
Principal Investigator:	Dr. Yetta Jager
Period of Performance:	10/1/2015–9/30/2020
Total DOE Funding:	$1,456,556
DOE Funding FY16:	$350,000
DOE Funding FY17:	$400,000
DOE Funding FY18:	$406,556
DOE Funding FY19:	$300,000
Project Status:	Ongoing

Society needs renewable energy and clean water and ecosystem goods and services derived from biodiversity. The goal of this project is to discover how we can manage the production of advanced feedstocks to generate added value through ancillary (non-energy) ecosystem services. Our research develops and uses bioeconomic models to quantify and communicate the costs and benefits of alternative biomass production scenarios. To date, this project has demonstrated the benefits of growing perennial feedstocks in two tributary basins of the Mississippi River and highlighted potential water quality improvements downstream. In addition, we have developed new tools for quantifying, visualizing, and mapping ecosystem services. In our first task, we developed the concept of a total supply curve to visualize stacking values for different ecosystem services associated with growing biofuels. We demonstrated that the value of improved water quality (avoided water treatment cost) exceeded feedstock production cost for at least 40 metric tons of biomass supply in the Arkansas-White-Red river basin. Spatial analysis was used to map where these benefits are experienced.

Weighted Project Score: 7.8

Weighting for Ongoing Projects: Approach - 25%; Accomplishments and Progress - 25%; Relevance - 25%; Future Work - 25%



These valuation and visualization methods will be used to quantify and visualize ecosystem service portfolios for each of two case studies: one in an agricultural and one in a forestry system. Each requires models to link management decisions related to biomass production to biodiversity outcomes (ecosystem services providing units) and associated values.

For the agricultural system, we are developing ecological models to support the Antares Landscape Design project.

- At the fuel-shed scale, we are implementing the BioEstimate (BioEST) model to understand the effects of biofuel production on a range of native taxa. We reviewed differences in pesticide use in corn and switchgrass. Future research will model where perennials can be grown in Iowa fuel sheds to provide the greatest value to native biodiversity (amphibians, reptiles, insects, mammals, birds).

- At the field scale, we developed an agent-based, tractor-pheasant-hunter model that will identify optimal spatiotemporal harvest strategies to maximize production of high-quality feedstock and recovery of pheasants. Scenarios will compare tractor paths, temporal tradeoffs between nesting success and decomposition of biomass, and spatial strategies for providing refuge.

For forestry, in the forested Pacific Northwest, we are collaborating with PNNL (Wigmosta) and the USFS to develop a decision tool to identify spatial opportunities for selective forest treatments to reduce wildfire and restore listed salmonids. We have developed models of incubation and juvenile rearing survival to evaluate forest-thinning scenarios. Preliminary results show benefits for spring Chinook salmon. A "Wildfire and Wildlife Symposium" is proposed at a joint American Fisheries Society and Wildlife Society meeting in Reno, Nevada. In the future, changes to portfolios of ecosystem services will be valued under alternative spatial-treatment scenarios.

OVERALL IMPRESSIONS

- This is generally a worthwhile project for ecosystem management, and I'm glad this work is being done. I believe there are clear novel contributions this group can make to inform some next steps on scaling up bioenergy development (e.g., informing resilience and risk calculus), but this message could be clearer to those less familiar with ecosystem services work.

- This project should illuminate paths leading toward the coproduction of biomass, clean water, and utility derived from biodiversity. The goal of this project is to discover how we can manage the production of advanced feedstocks to generate added value through ancillary (non-energy) ecosystem services.

- The project addresses barriers At-E: Quantification of Economic, Environmental, and Other Benefits and Costs; and At-F: Science-Based Methods for Improving Sustainability.

- This project offers an interesting ecological economic modeling for ecosystem services via biomass feedstock production using an ecosystem service valuation approach. In particular, it focuses on biodiversity impacts as indicated by two case-study species. It is important to push on biodiversity impacts, but is there a way to do a more generalized analysis that does not hinge on a highly detailed approach to a couple of key species?

- Not everyone should make a decision-support tool. BETO could consider supporting a large one, but these will not get used if there are a dozen of them and each one is niche.

- This project will provide useful information on how to achieve multiple environmental goals with bioenergy/biomass production. Monetizing these results in the real world, however, will depend on policies such as state payment programs to reduce nutrient loading in rivers/bays or some program that provides revenue to farmers to reward maintenance of recreational opportunities. One recommendation is that these case studies should address key barriers to deployment, and it was not clear if pheasant

conservation is of the same level of importance for local/regional conservation efforts as salmonids are in the West, so selecting and clarifying the importance of these different case-study elements for actual deployment would be helpful.

RECIPIENT RESPONSE TO REVIEWER COMMENTS

The recipients choose not to respond to the reviewers' overall impressions of their project.

COLLABORATIONS TO ASSESS LAND EFFECTS OF BIOENERGY

Oak Ridge National Laboratory

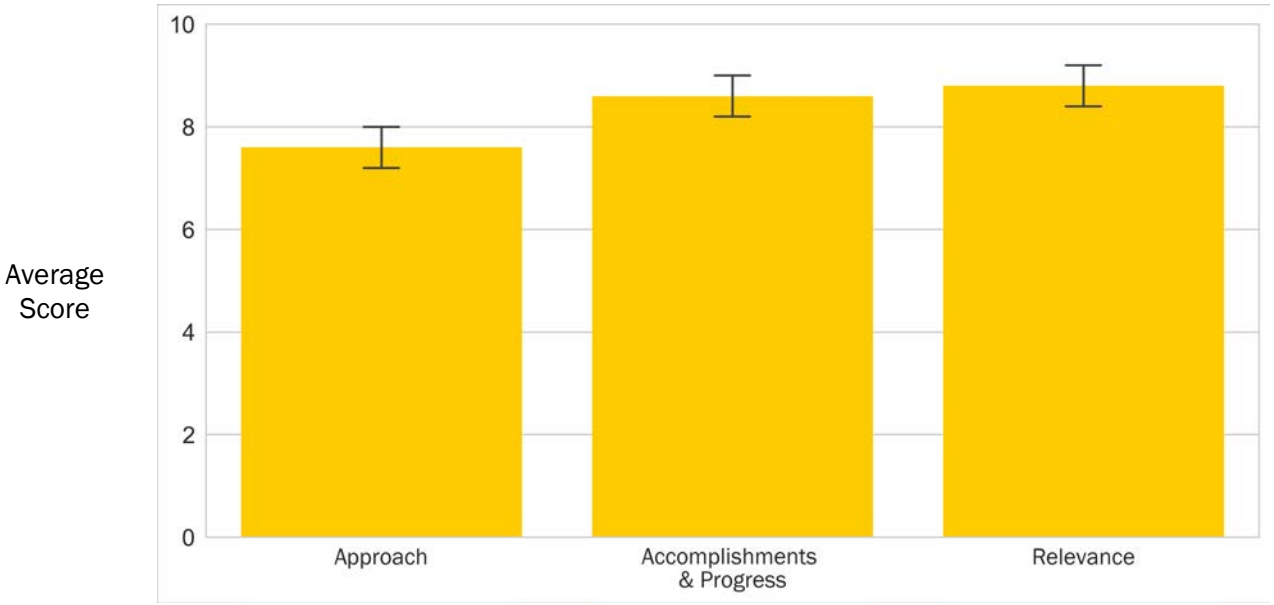
PROJECT DESCRIPTION

WBS:	4.2.1.41
CID:	NL0026709
Principal Investigator:	Mr. Keith Kline
Period of Performance:	10/1/2016–9/30/2019
Total DOE Funding:	$1,257,373
DOE Funding FY16:	$250,000
DOE Funding FY17:	$350,000
DOE Funding FY18:	$382,373
DOE Funding FY19:	$275,000
Project Status:	Sunsetting

This project aims to (1) develop science-based approaches to support more consistent and accurate assessments of bioenergy effects on land and (2) facilitate public access to BETO sustainability research and relevant data on sustainability standards and indicators. As a stretch goal, the project strives to shift the LUC debate toward the opportunities and benefits attainable by integrating bioenergy and improved land management, or beneficial LUC. The project's approach supports BETO to clarify, quantify, and communicate the costs and benefits of an expanding U.S. bioeconomy by focusing on consistent definitions for land cover, disturbance, and management practices; explicit baseline data; evidence-based testing of hypotheses; and analytics to identify relationships among observed changes and potential driving factors. We (1) conduct research and develop publications in collaboration with other international researchers; (2) contribute strategically to relevant reports and tools being developed by third parties; and (3) established a sustainability portal on the KDF website to facilitate access to information on standards, indicators, and LUC research. Assessing a feedstock's effects on land and indirect land-use change (ILUC) is challenging. Model estimates and assumed LUC relationships continue to have a significant bearing on most indicators of sustainability. A review of 50 regulatory and voluntary sustainability frameworks applicable to the bioeconomy found LUC/ILUC to represent the greatest sustainability risk. Project outcomes include the

Weighted Project Score: 8.4

Weighting for Sunsetting Projects: Approach - 25%; Accomplishments and Progress - 50%; Relevance - 25%



following: During the past two years, the project's research and outreach efforts have generated more than 20 publications, 50 presentations, and significant contributions to dozens of reports by partners, such as the IEA's *Technology Roadmap: Delivering Sustainable Bioenergy*, the GBEP's *Technical Report: Attribution of Impacts to Bioenergy Production and Use for the Implementation of the GBEP Sustainability Indicators for Bioenergy (GSI)*, the climate calculator tools, and others. The project has begun to shift the debate toward identifying opportunities for beneficial LUC as reflected in work that collaborators will continue through IEA Bioenergy, the Food and Agriculture Organization, and other entities. By documenting and testing alternative conceptual frameworks for understanding LUC, and by promoting science-based methods, we expect the project impacts to increase throughout time as better data become available. Publications and methods will reduce uncertainties about costs and benefits associated with an expanding U.S. bio-based economy on land. New KDF web pages on sustainability, standards, and indicators will facilitate access to an expanding body of research aimed at quantifying these effects (see: https://bioenergykdf.net/content/sustainability-and-standards-home).

Fig.: Over the past two years, the project contributed to 21 journal articles and 24 other reports ranging from IEA Bioenergy publications to a book chapter on the challenges to measuring LUC.

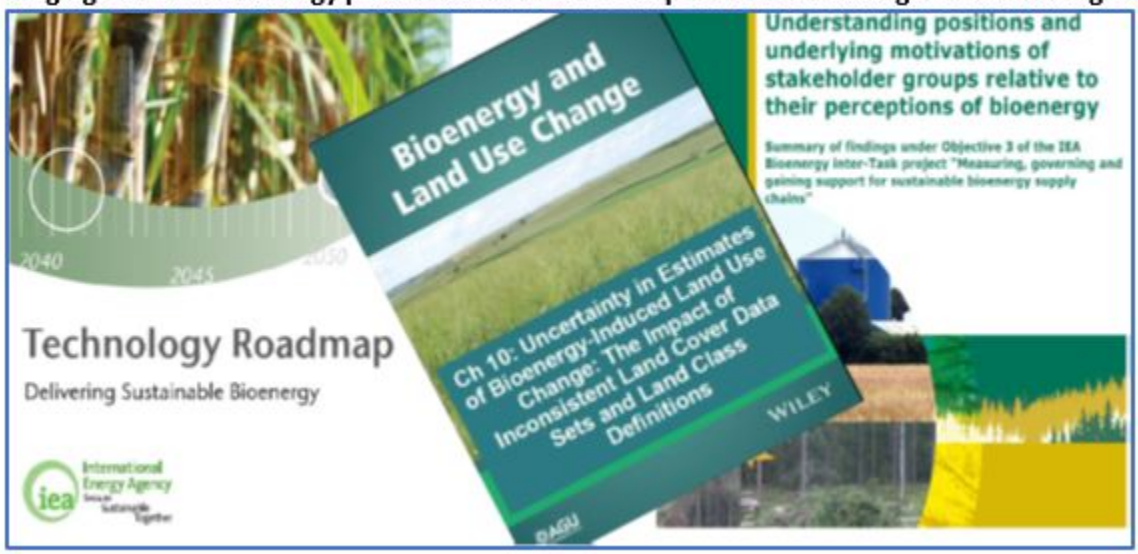


Photo courtesy of Oak Ridge National Laboratory

OVERALL IMPRESSIONS

- This group has demonstrated clear value to the BETO portfolio by being one of the few groups to actively engage with international efforts and by pushing modelers to question, defend, and incorporate real-life evidence as much as possible when approximating very complex sustainability concerns (in this case, LUC).

- This project addresses the important topic of cost-benefit assessments of bioenergy impacts on land. The team presents a valuable analysis of drivers of LUC and food prices and potential cherry-picking or narrowness in previous analyses. Understanding how and/or whether bioenergy production is impacting food prices (and other indirect effects) will be critical to the public perception and success of bioenergy products. It would be helpful to acknowledge diverse points of view and valid points of contention in the analyses that remain to be resolved.

- This is a sunsetting project.

- The project aims to develop science-based approaches to support more consistent and accurate assessments of bioenergy effects on land, facilitate public access to BETO sustainability research and relevant data on sustainability standards and indicators, and inform the ILUC and LUC debate.

- This project aims to facilitate collaboration and evidence-based analysis around LUC, which is an estimable goal. It has yielded many publications, though it is not clear whether they are all uniquely the product of this project. It has also yielded a great deal of international collaboration and interaction, which creates value for BETO and EERE. The project PI is clearly well networked and influential globally. The primary thrust of this work appears to be facilitating BETO's participation in IEA Bioenergy and GBEP conversations. If this is the intent, then it has been successful in this regard.

RECIPIENT RESPONSE TO REVIEWER COMMENTS

- Thank you for acknowledging the value of our efforts to address the challenging LUC debate through science-based approaches, statistical analysis of evidence, and the provision of documentation to improve model input values and assumptions. By engaging various perspectives in this process, we aim to improve overall understanding and broaden the "ownership" of final products and results of analysis. Regarding a question on outreach and public access to project results, we note that more than 50 presentations were made by team members during the past two years, and the KDF team reports that the project's new website for sustainability indicators received more than 2,200 visits in the first three months since release.

- We should clarify that we fully agree with a reviewer regarding the need to acknowledge diverse points of view. Diverse perspectives and points of contention, such as the issues associated with shifts in U.S. feed supplies and uses, are addressed in an approach. Such perspectives are explicitly acknowledged and examined in past papers, with several being highlighted in the 2017 paper in *Global Change Biology Bioenergy* on "Biofuels and Food Security: Priorities for Action." Also, diverse perspectives were sought and are being represented among coauthors in several final reports and papers in preparation (see 13 papers listed in the peer-review presentation).

CARBON CYCLING, ENVIRONMENTAL & RURAL ECONOMIC IMPACTS OF COLLECTING & PROCESSING SPECIFIC WOODY FEEDSTOCKS IN BIOFUELS

Consortium for Research on Renewable Industrial Materials

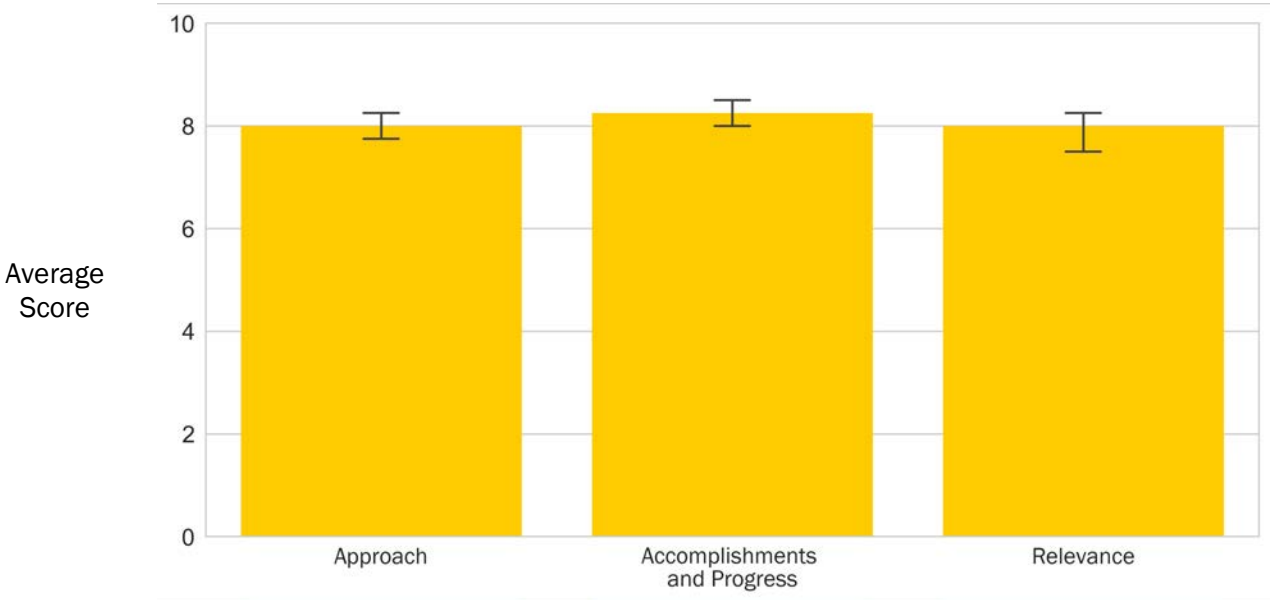
PROJECT DESCRIPTION

The goal of this project is to understand the carbon flows for woody biomass allocated for bioenergy products relative to no bioenergy, including the role of wood products, and an evaluation of the implications for different forest management systems.

WBS:	4.2.1.60
CID:	EE0002992
Principal Investigator:	Dr. Steve Kelley
Period of Performance:	8/31/2010–3/31/2019
Total DOE Funding:	$1,430,535
Project Status:	Sunsetting

Weighted Project Score: 8.1

Weighting for Sunsetting Projects: Approach - 25%; Accomplishments and Progress - 50%; Relevance - 25%



OVERALL IMPRESSIONS

- This Consortium for Research on Renewable Industrial Materials program has been evaluating connections between what type of biomass is grown, how it is harvested, and what it is used for—with a focus on biomass residues and durable wood products from three regions (Pacific Northwest, Southeast, Northeast).
- Analytic findings on the fate of carbon under different regions and harvesting scenarios help inform researchers and policymakers and select findings have been incorporated into GREET (the gold-standard LCA model for biofuels).
- This is a sunsetting project.
- The objective of this project is to assess the potential quantity and economic accessibility of CO_2 management of the U.S. bioeconomy through BECCS. The project provides foundational work for FY 2019 projects (1) Bioeconomy Carbon Flux Assessment and (2) Harnessing the Bioeconomy for Carbon Drawdown: Potential and Innovation Needs.
- The project addresses barriers At-A: Analysis to Inform Strategic Direction, At-C: Data Availability Across the Supply Chain, and At-D: Identifying New Market Opportunities for Bioenergy and Bioproducts.
- This project provides valuable insight into the life-cycle GHG emissions associated with various woody material production pathways and fates. I was glad to see a direct connection with the GREET team highlighted to ensure that the new data generated are incorporated into that model.

RECIPIENT RESPONSE TO REVIEWER COMMENTS

- The statement of work does not include an economic evaluation of alternative woody biomass feedstocks.
- Working with the GREET team is very valuable.

BIOMASS PRODUCTION AND NITROGEN RECOVERY

Argonne National Laboratory

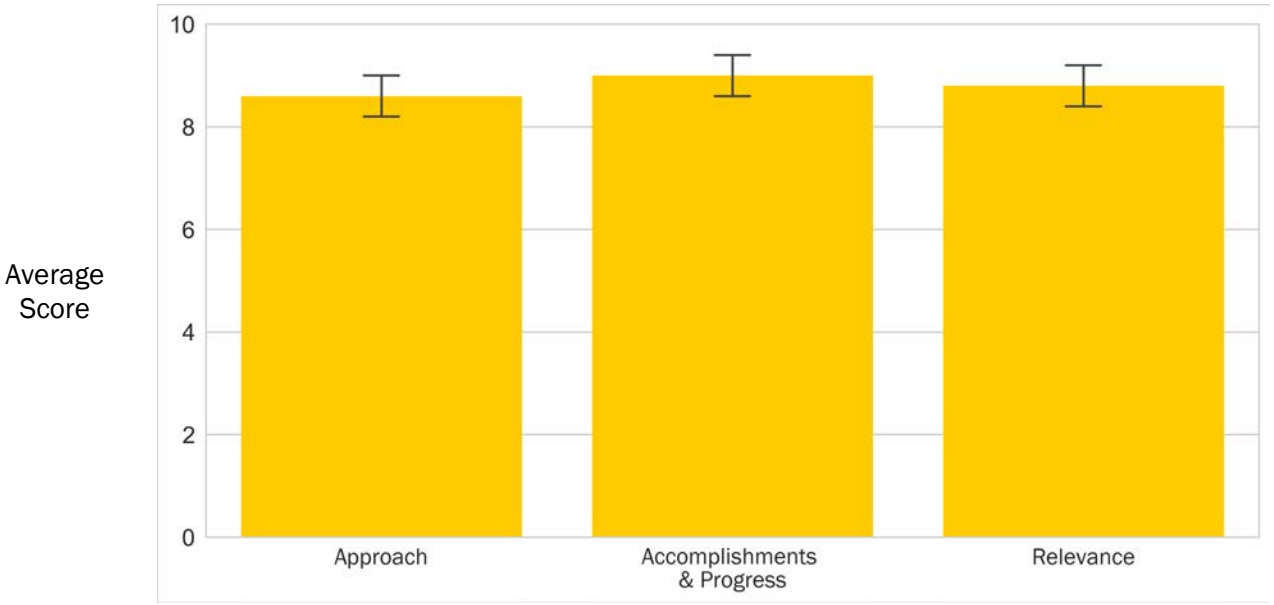
PROJECT DESCRIPTION

WBS:	4.2.2.10
CID:	NL0022598
Principal Investigator:	Dr. Cristina Negri
Period of Performance:	10/1/2016–9/30/2019
Total DOE Funding:	$2,350,000
DOE Funding FY16:	$600,000
DOE Funding FY17:	$630,000
DOE Funding FY18:	$600,000
DOE Funding FY19:	$520,000
Project Status:	Sunsetting

This project aims to bolster the cost-competitiveness of bioenergy through the valuation of ecosystem services produced by bioenergy crops on marginal land in an integrated landscape design. It does so by (1) generating primary data from field experimentation to quantify the ecosystem services produced by bioenergy crops grown in marginal land; (2) modeling at a small-watershed scale two water-quality-enhancing landscape designs, integrating bioenergy with grain crops and conservation; and (3) expanding this approach across a range of Midwestern settings through a TEA conducted in collaboration with INL. A multiyear primary field data-collection effort shows clearly favorable results, in particular for soil water nitrate and GHG reduction, in the bioenergy plots compared with the commodity crops. The results, therefore, provide a rationale for working with other stakeholders and Natural Resources Conservation Science to include bioenergy buffers as a conservation practice. Modeling analyses include the development of a method to assess marginal land, the analysis of the effectiveness of saturated bioenergy buffers in improving the hydrogeochemistry of nutrients and erosion sedimentation, and LCA of emissions. Valuation of ecosystem services has demonstrated that the replacement of commodity crops in marginal farmland with perennial bioenergy crops can provide an advantageous value proposition for producers, given the pricing for the lignocellulosic material and the calculated value of ecosystem services, such as water quality improvement.

Weighted Project Score: 8.8

Weighting for Sunsetting Projects: Approach - 25%; Accomplishments and Progress - 50%; Relevance - 25%



Outcomes from the project are anticipated to be a modeling framework to guide the transformation of the agricultural landscape to a future state of integrated bioenergy and commodity crops, with improved crop yields and ecosystem services, a better economic outlook for rural communities, and reduced water-quality issues realized at the local to national (e.g., Gulf of Mexico) scales.

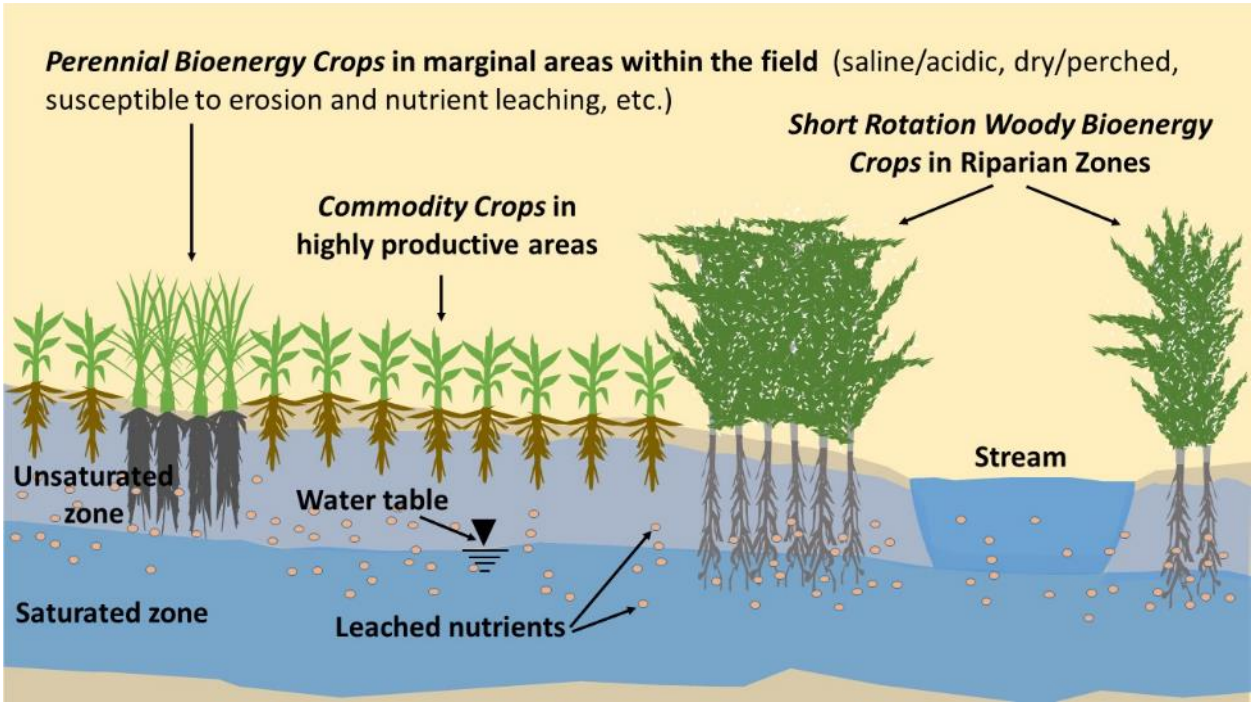


Photo courtesy of Argonne National Laboratory

OVERALL IMPRESSIONS

- This project, which has existed in some form for almost a decade, valuably integrates modeling and fieldwork to understand and improve ecosystem services (and overall sustainability) through incorporating energy crops, with unique insights for potential development of ecosystem service markets.
- This is a sunsetting project.
- This project aims to bolster the cost competitiveness of bioenergy through the valuation of ecosystem services produced by bioenergy crops on marginal land in an integrated landscape design and to investigate the integration of bioenergy buffers into the agricultural landscape and evaluate the associated economic factors and associated ecosystem services.
- This project addresses barriers At-E: Quantification of Economic, Environmental, and Other Benefits and Costs; At-F: Science-Based Methods for Improving Sustainability; and At-H: Consensus, Data, and Proactive Strategies for Improving Land-Use Management.
- This project offers an interesting and well-designed approach to designing a bioenergy-integrated landscape to produce environmental services. The analysis hinges on a strong integration of modeling and field testing, scaling up from farm to watershed. It also takes an interesting approach to integrating yield with ecosystem services to evaluate the economics of these integrated systems alongside conventional cultivation as well as alternate conservation alternatives. I encourage the researchers to

integrate with other, similar BETO-funded efforts to leverage, rather than overlap, efforts across the portfolio.

- My concerns are:
    - This group is taking on both breadth and depth in its research. This is not inherently problematic as long as it does not sacrifice rigor anywhere or duplicate efforts elsewhere in the pursuit of comprehensiveness.
    - The TEA hinges on ecosystem services valuation. This is valid, but it does not offer real financial benefit unless a market emerges for the services being created.
- This project executes an extremely valuable field implementation of the team's approach to identifying subfield marginal lands that can be leveraged to produce bioenergy feedstocks while reducing nutrient runoff and enhancing field economics. The team has undertaken several field analyses of biodiversity effects of the subfield management approach, including analyses of soil biota and canopy insect diversity. The combination of modeling/analysis to identify the field locations and field experimentation is demonstrating the value of this ILM approach and is an exemplary project for this type of work.

RECIPIENT RESPONSE TO REVIEWER COMMENTS

- We thank the reviewers for the summaries of the project, which was initiated in FY 2011.
- We are engaged with other researchers as appropriate, given the various approaches, goals, settings, etc., of different project teams. To address the two concerns: (1) Each task and activity of this unique field study is carefully thought out and necessary for this system-level investigation. We are addressing critical questions at the interface between production and ecosystem services, with a focus on the marginal areas of the agricultural landscape. We maintain a detailed approach to both the collection of fundamental field data and the calculation/modeling of ecosystem services benefits and economic value. (2) Examples of water quality trading systems offer a good set of insights (e.g., Chesapeake Bay, Ohio River), and in the next funding cycle we intend to further the understanding of the value of trading through public-private partnership.

BIOENERGY SUSTAINABILITY: HOW TO DEFINE AND MEASURE IT

Oak Ridge National Laboratory

PROJECT DESCRIPTION

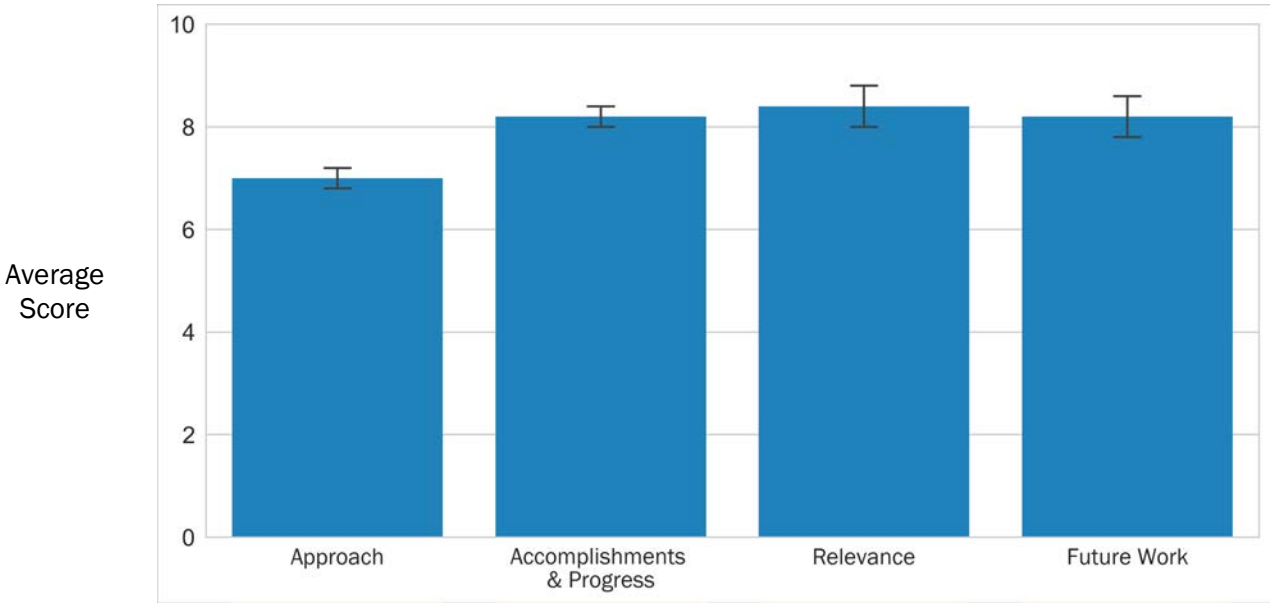
WBS:	4.2.2.40
CID:	NL0022601
Principal Investigator:	Dr. Esther Parish
Period of Performance:	10/1/2015–9/30/2021
Total DOE Funding:	$3,061,907
DOE Funding FY16:	$750,000
DOE Funding FY17:	$800,000
DOE Funding FY18:	$861,907
DOE Funding FY19:	$650,000
Project Status:	Ongoing

The objective of this project is to propel the U.S. bioenergy industry toward implementation of cellulosic biomass systems that maximize benefits (e.g., rural jobs, water quality, biodiversity) while minimizing negative impacts. Although there is strong consensus regarding the need for sustainability, there is little agreement about the methods or metrics that can measure it. The first phase of our project, "Bioenergy Sustainability: How to Define & Measure It," worked to characterize environmental and socioeconomic costs and benefits of cellulosic bioenergy production in the context of stakeholder priorities. We applied indicators of progress toward bioenergy sustainability in three different landscapes: east Tennessee switchgrass-to-ethanol production, southeastern U.S. bioenergy wood pellet production, and Iowa ethanol production from corn stover and switchgrass. A checklist of 35 environmental and socioeconomic indicators and these three case studies were used to develop an overall approach for assessing sustainability:

- Work with stakeholders to establish a set of goals based on the bioenergy project context and scope
- Select and prioritize a set of sustainability indicators that can inform decision making relative to those goals

Weighted Project Score: 8.0

Weighting for Ongoing Projects: Approach-25%; Accomplishments and Progress-25%; Relevance-25%; Future Work-25%



I One standard deviation of reviewers' scores

- Establish baseline and target values for each indicator to assess future sustainability outcomes relative to a reference case of no bioenergy production
- Characterize indicator trends using empirical measurements, surveys, and/or computer models
- Analyze potential tradeoffs between environmental and socioeconomic indicators under a set of defined alternative future scenarios
- Use results to identify good practices.

We designed the Bioenergy Sustainability Tradeoffs Assessment Resource (BioSTAR) to allow stakeholders to view the results of our sustainability case studies and/or conduct a sustainability assessment for their own bioenergy project. Since March 2017, we have published 19 papers about sustainability theory, our case study results, and successful engagement with Iowa stakeholders. The new three-year phase of our project was funded in October 2018 and focuses on the quantification, aggregation, prioritization, and visualization of sustainability indicators for improved understanding of the potential tradeoffs and synergies between environmental and socioeconomic priorities. We are developing the underlying sustainability theory needed to assess these tradeoffs and synergies at the fuel-shed scale (i.e., the scale of the entire landscape supplying cellulosic biomass to a biorefinery). We are leveraging research by other DOE laboratories, the USDA, EPA, U.S. Geological Survey, and universities to develop a starting set of national-scale spatiotemporal sustainability indicator data sets that can be used to characterize baseline conditions and cellulosic feedstock sustainability trends anywhere in the continental United States. These new data sets and methods will be incorporated into our web-based BioSTAR tool so that DOE, industry, and other researchers can holistically quantify costs and benefits and analyze tradeoffs of U.S. biomass production options, integrating environmental and socioeconomic indicators of sustainability tailored to local conditions and stakeholder priorities.

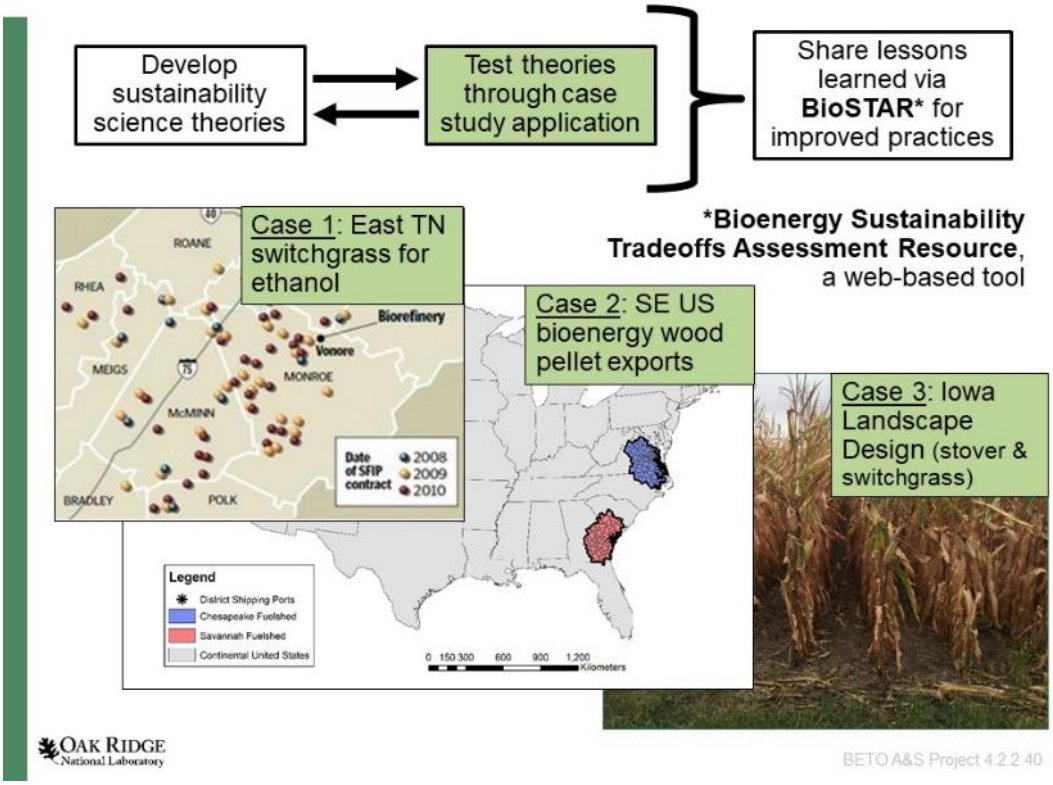


Photo courtesy of Oak Ridge National Laboratory

OVERALL IMPRESSIONS

- This ambitious program is working to compile and simplify the presentation of complex sustainability metrics over various scales, regions, and metrics.

- The abstract provides ample detail about the history and genesis of work, the relevance of the research contributing to a better understanding of sustainability issue/theory, and metrics. The primary objective is a bit altruistic in a sense that the goal to propel the U.S. bioenergy industry toward implementation of cellulosic biomass systems that maximize benefits (e.g., rural jobs, water quality, biodiversity) while minimizing negative impacts could be the goal for any project in this space. It would be nice to have more definitive goals identified in the presentation. A desired outcome is to provide science-based data and web-based analytic tools (e.g., BioSTAR) to holistically analyze tradeoffs of U.S. biomass production options by integrating environmental and socioeconomic indicators of sustainability tailored to local conditions and stakeholder priorities.

- This is clearly an important and timely issue, and it is relevant to many national and international discussion in the bioenergy space. It is not clear that the model described can be generalized. Can it be applied to new cases other than the case studies under consideration? Thirty-five indicators are very comprehensive. It would be hard to rigorously assess them in a single case study—let alone build a generalized model capable of doing so for all possible cases.

- This is a valuable effort in terms of better understanding how target sustainability performance criteria can inform feedstock selection and potentially landscape-level design, and it will be even more valuable when available publicly. It might be challenging to implement at a national level because of the site-specificity and target-setting requirements outlined. If some fundamental overall tradeoffs were evaluated for different feedstocks, that could help with upfront screening even absent detailed site data and target setting. Knowing there are many existing sustainability certification schemes and approaches for varying audiences, the team should think carefully about and communicate whether and/or how BioSTAR differs from existing certification/sustainability schemes (including the one being developed under the EE0007088 project) in terms of audience/utility and any complementarities.

RECIPIENT RESPONSE TO REVIEWER COMMENTS

- Thank you for the thoughtful comments acknowledging the ambitious objectives set forth by this project. Specific project goals are summarized as milestones. A key clarification is that the BioSTAR tool is being developed in parallel with three case studies. Each case study is useful and addresses specific BETO strategic goals while providing the team with examples for testing BioSTAR's usefulness. BioSTAR is a visualization tool designed to illustrate tradeoffs among a set of user-defined indicators. BioSTAR incorporates some aspects of a calculator to facilitate estimation of indicator values, but the tool focuses on making it easier to understand and compare options without losing the details behind each source of indicator data. BioSTAR output could be used to illustrate the degree to which desired metrics are met or not, including defined certification requirements, but BioSTAR was not designed for certification purposes. Users determine indicators and targets, making the BioSTAR platform adaptable to any existing standard or certification. An evaluation of individual indicators is done using other models outside of BioSTAR. The starting checklist of indicators presented in BioSTAR is based on earlier project publications. The team reviewed indicators from various sustainability certification schemes (and other sources) and then worked with U.S. bioenergy stakeholders for several years to deliberately narrow the focus to a set of essential, practical measurements that could be repeated across multiple bioenergy projects. But we agree that most studies will not measure all 35 indicators, and we have developed and published an indicator selection framework that allows users to choose from any set of indicators as they determine the most important indicators for their situation. In summary, this project has: (1) developed a sustainability assessment approach based on a decade of research; (2) tested the approach through case studies of bioenergy production in three different U.S. landscapes; and (3)

prepared a prototype web-based visualization tool (BioSTAR) designed to help researchers and educators visualize indicator baselines, targets, trends, and tradeoffs among targets for particular cases of cellulosic bioenergy production.

SHORT-ROTATION WOODY BIOMASS SUSTAINABILITY

Oak Ridge National Laboratory

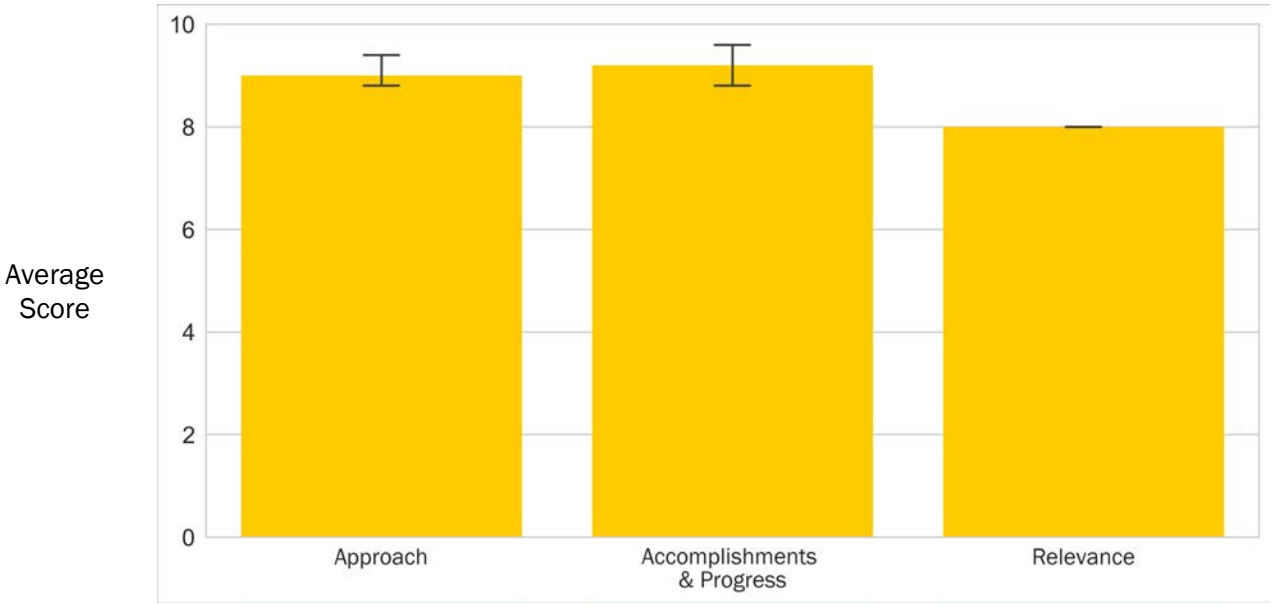
PROJECT DESCRIPTION

WBS:	4.2.2.41
CID:	NL0025180
Principal Investigator:	Dr. Natalie Griffiths
Period of Performance:	10/1/2014–9/30/2018
Total DOE Funding:	$1,489,884
DOE Funding FY16:	$345,000
DOE Funding FY17:	$345,000
DOE Funding FY18:	$799,884
DOE Funding FY19:	$0
Project Status:	Sunsetting

The southeastern United States is projected to be an important region to produce loblolly pine as an SRWC for bioenergy. SRWC production differs from traditional forestry (i.e., pulpwood and sawtimber) because more frequent rotations can increase ground disturbance, and greater weed control and fertilization might impair water quality; however, the environmental effects of growing loblolly pine in a short-rotation system have not been evaluated at a watershed scale. Further, current forestry best management practices (BMPs), developed for traditional forestry, have not been tested for SRWC production. In this study, we used a combined watershed-scale experiment and a watershed-modeling approach to examine the environmental sustainability (i.e., effects on water quality, water quantity, soil quality, and productivity) of SRWC production in the southeastern United States. The watershed experiment used a before-after, control-impact approach. Baseline conditions in three adjacent watersheds in South Carolina were monitored for two years, and then 50% of two (treatment) watersheds were harvested, planted with loblolly pine seedlings, and managed for SRWC production (i.e., multiple herbicide and fertilizer applications to achieve high yields). Environmental responses were measured for six years after loblolly pine were planted; approximately halfway through the approximate 10-year rotation.

Weighted Project Score: 8.8

Weighting for Sunsetting Projects: Approach - 25%; Accomplishments and Progress - 50%; Relevance - 25%



The intensive silviculture plan resulted in rapid tree growth. After the sixth growing season, carbon sequestration by the loblolly pine was 6–14 years ahead of standard timber plantations, and water use (i.e., evapotranspiration) was similar to a 10- to 20-year-old loblolly pine stand. Watershed modeling results suggest that during multiple rotations, SRWC production will result in slightly more reduced evapotranspiration and slightly more increased streamflow than conventional forestry; however, structural differences in the watershed models sometimes resulted in inconsistent results. Ecosystem nitrogen dynamics changed during six years of tree growth. During the first two growing seasons, nitrate leaching rates were high, and there was a corresponding increase in groundwater nitrate concentrations (to less than 2 mg N/L). Despite the elevated groundwater nitrate, stream-water nitrate concentrations remained low and unchanged through the sixth growing season. Groundwater modeling suggests that elevated nitrate in groundwater should have reached the stream after six years. Therefore, biotic processes (e.g., denitrification) might have removed this nitrate. Denitrification measurements that were initiated in the last two years of our project found that this microbial process was likely important in removing elevated nitrate, especially in the organic-rich, riparian-zone streamside management zones separating the pine plantations from the streams. Overall, the minimal effect of SRWC production for bioenergy on stream water quality suggests that current forestry BMPs are effective at protecting surface waters in the coastal plain landscape even with high levels of fertilization and herbicide application associated with SRWC production.

Photos courtesy of Oak Ridge National Laboratory

OVERALL IMPRESSIONS

- This project focuses on the nutrient, carbon, and water fluxes in a short-rotation woody biomass plot and sheds valuable insights on nutrient-loading policies and denitrification dynamics in the subsurface.
- This combined field and modeling analysis to assess the environmental performance of intensive SRWC production in the Southeast is well implemented and provides a significant advancement of our understanding of the viability and sustainability of this production system. The replication at the watershed level is (probably necessarily) low; nevertheless, the teams have amassed a valuable set of data on SRWC performance. Although this approach used current state-of-the-art cultivation practices, these practices leverage chemical inputs rather heavily. Given that sustainability is a fundamental goal of these bioenergy production systems, it would have been nice to see a treatment with a more environmentally friendly management regime (i.e., reduced chemical inputs) to assess performance and sustainability differences.
- This is a sunsetting project.
- Current forestry BMPs, developed for traditional forestry, have not been tested for SRWC production. This study uses a combined watershed-scale experiment and a watershed-modeling approach to examine the environmental sustainability (i.e., effects on water quality, water quantity, soil quality, and productivity) of SRWC production in the southeastern United States.
- This project determines whether current forestry BMPs are adequate to protect water and soil resources.
- This project addresses barriers At-C: Data Availability Across the Bioenergy Supply Chain and At-E: Quantification of Economic, Environmental, and Other Benefits and Costs.
- The high temporal and spatial resolution as well as the sophisticated field techniques applied to the field-monitoring element of this research is yielding a valuable data set. This field testing is well integrated with the agronomic modeling, making the overall research project very coherent. The field trials carried out in this research are yielding strong and promising results as to the efficacy of the BMPs evaluated through this research.

RECIPIENT RESPONSE TO REVIEWER COMMENTS

- Thank you for all these comments. We agree that watershed-scale experiments are very difficult to replicate. Our original study design included two treatment watersheds, each with a different management regime; however, it was decided to focus on one management treatment in two watersheds based on the inherent variability among watersheds and because adding multiple experimental treatments would make interpreting the results more difficult. We pushed the system in terms of the amount of fertilizer applied at the watershed scale because we wanted to measure potential maximum responses. We also wanted to see if standard BMPs would work at high fertilizer application rates. Although we did not include different management scenarios at the watershed scale, we did use different levels of herbicide and fertilizers at the plot scale to examine the effects on the ecosystem nitrogen budget.

SPATIALLY RESOLVED MEASUREMENTS OF ENVIRONMENTAL SUSTAINABILITY INDICATORS FOR BIOENERGY

Oak Ridge National Laboratory

PROJECT DESCRIPTION

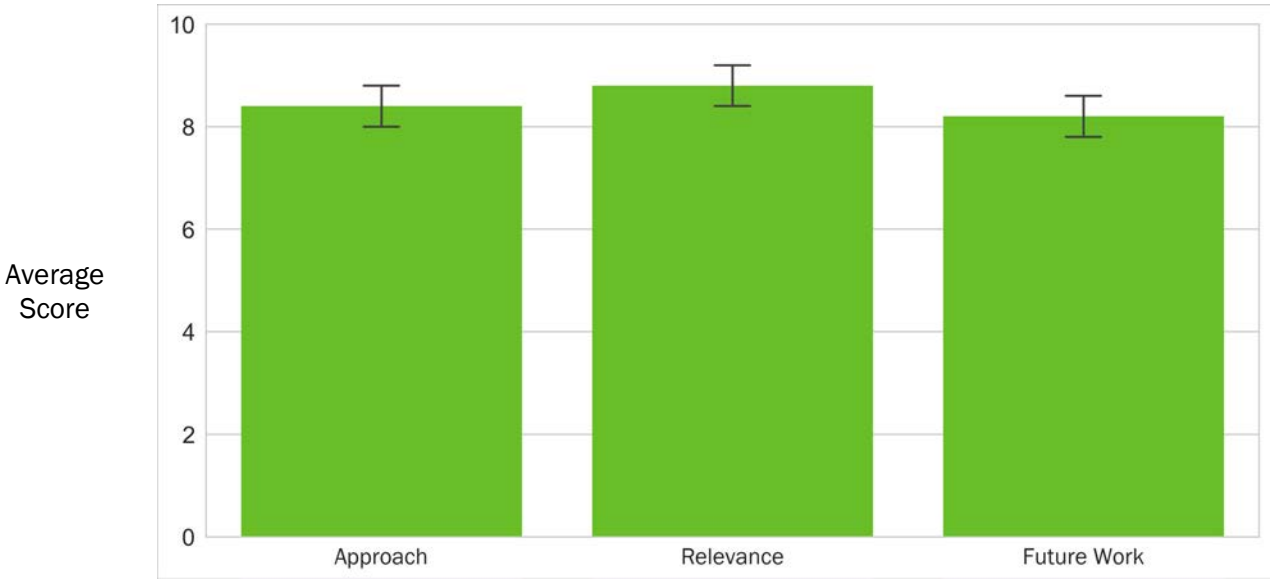
WBS:	4.2.2.44
CID:	NL0035013
Principal Investigator:	Dr. Natalie Griffiths
Period of Performance:	10/1/2018–9/30/2021
Total DOE Funding:	$350,000
DOE Funding FY16:	$0
DOE Funding FY17:	$0
DOE Funding FY18:	$0
DOE Funding FY19:	$350,000
Project Status:	New

A suite of environmental indicators has been identified to evaluate the environmental sustainability of bioenergy production systems (i.e., water quality and quantity, soil quality, GHG, biodiversity, air quality, productivity). Measurement of many of these environmental indicators requires manual sampling in the field. Often, these measurements can be time and labor intensive to collect and thus limited in spatial and temporal resolution. Environmental sensors have improved understanding of temporal variability of some indicators, but spatial variability is still understudied. Coupling environmental sensors with unmanned vehicles provides the ability to measure environmental indicators at high spatial resolution. The goal of this project is to quantify spatially resolved environmental sustainability indicators in a bioenergy feedstock production landscape using state-of-the-art and commercial, off-the-shelf water-quality sensors coupled with unmanned surface vehicles (USVs).

This new project, which began in FY 2019, will focus on developing a USV-water-quality platform for measuring nitrate concentrations at a high spatial resolution. The USV-water-quality platform will be tested in nearby lotic and lentic water bodies to assess measurement accuracy compared to traditional measurements

Weighted Project Score: 8.4

Weighting for New Projects: Approach - 25%; Relevance - 25%; Future Work - 50%



(i.e., grab sampling). After development and testing of the USV-water-quality platform, the system will be used to assess spatial patterns in stream water nitrate concentrations in the BETO-sponsored Antares Landscape Design project. Bioenergy feedstock production coupled with conservation practices have the potential to improve water-quality conditions in the agricultural Midwest, where nitrate pollution is a significant concern. The USV-water-quality platform will be used to assess the efficacy of saturated buffers, a conservation practice implemented within the Antares Landscape Design project, at reducing nitrate inputs. The USV-water-quality system will also be used to examine spatial patterning in water quality that might arise because of variation in bioenergy feedstock plantings, conservation practices, and hydrologic inputs (e.g., tile drains) within the two Antares focus watersheds. Overall, this project will evaluate the ability of sensors coupled with USVs to advance understanding of a key environmental sustainability indicator by providing valuable, spatially resolved water-quality data within a bioenergy production landscape.

Photo courtesy of Oak Ridge National Laboratory

OVERALL IMPRESSIONS

- This project is a novel effort to leverage new technology to improve the potential frequency, cost effectiveness, labor efficiency, and spatial resolution of farm runoff water-quality data.
- I would have liked more discussion on the current and near-term competing alternatives to provide the water sampling service provided by this USV system.
- This project will advance field measurements for water quality by deploying and testing the use of inexpensive, automated vessels for sampling water quality at high spatial and temporal resolution with

low cost. If successful, these sensors would enhance the ability of researchers to cost-effectively acquire much-needed data to evaluate benefits/impacts of various land management strategies on nutrient runoff and water quality. In addition to cost and performance assessments indicated in the project plan, I strongly suggest some evaluation of reliability, durability, and maintenance of performance throughout time because the long-term performance will significantly affect the overall cost to run these sensors.

- This is a new FY 2019 project.
- The goal of this project is to quantify spatially resolved environmental sustainability indicators (water quality and quantity, soil quality, GHG, biodiversity, air quality, productivity) in a bioenergy feedstock production landscape using state-of-the-art and commercial, off-the-shelf water-quality sensors coupled with USVs. Coupling environmental sensors with USVs provides the ability to measure environmental indicators at high spatial resolution.
- This project addresses barriers At-C: Data Availability Across the Supply Chain; and At-E: Quantification of Economic, Environmental, and Other Benefits and Costs.
- This is an interesting, novel research/engineering project. I'm glad to see it in the BETO portfolio because it stands to serve other BETO projects well if the technology being developed aids in broader field data-collection campaigns.

RECIPIENT RESPONSE TO REVIEWER COMMENTS

- Thank you for these comments. Similar approaches (coupling USVs and/or unmanned aerial vehicles [UAVs] with water-quality measurement systems) have been described in the literature; however, we are not aware of any studies that have used USVs to measure nitrate concentrations in freshwater, and we are also not aware of any studies that have USVs to measure water quality when addressing scientific questions related to bioenergy sustainability. These are the objectives of our study. Most studies on USV/UAV-water-quality sensor systems that we reviewed in the literature focus on describing the technology and associated measurements, but few have used this technology to address specific research questions. USVs have been used to measure temperature, conductivity, turbidity, salinity, and chlorophyll in rivers, and UAVs have been equipped with water-quality (temperature, conductivity, dissolved oxygen, pH) sensors or sampling devices to collect water for later analysis in the laboratory. Most USVs that have been used for water-quality measurements are larger systems for deployment in larger water bodies (i.e., lakes, rivers). The USV system we selected was designed for bathymetric mapping and is one of the few USV systems we found that was small enough to navigate smaller bodies of water but large enough to hold nitrate sensor payloads.
- Thank you for these excellent comments and suggestions. We will incorporate an assessment of reliability, durability, and maintenance in our cost-benefit analysis (FY 2019 Q4 milestone).

ENABLING SUSTAINABLE LANDSCAPE DESIGN FOR CONTINUAL IMPROVEMENT OF OPERATING BIOENERGY SUPPLY SYSTEMS

Antares Group, Inc.

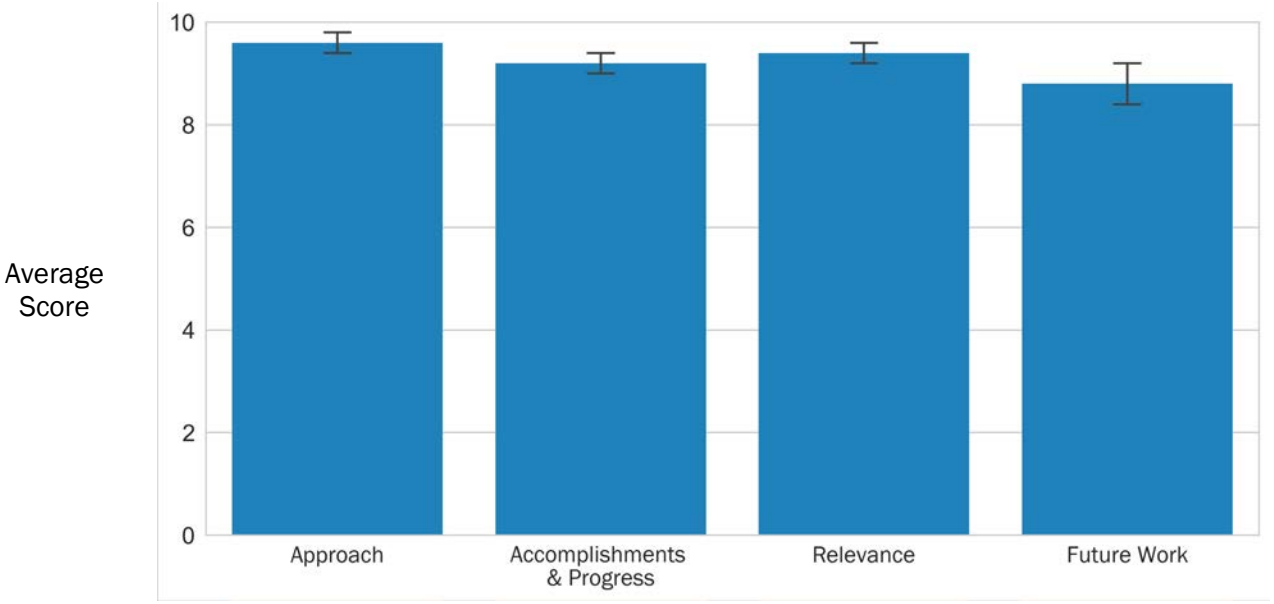
PROJECT DESCRIPTION

WBS:	4.2.2.60
CID:	EE0007088
Principal Investigator:	Mr. Kevin Comer
Period of Performance:	4/1/2016–3/31/2021
Total DOE Funding:	$4,974,990
Project Status:	Ongoing

When fully developed, documented, and demonstrated in three commercially relevant bioenergy supply sheds, the landscape-design activities, associated enabling tools and practices, and the field-level sustainability and logistics system results will advance the state of the art of sustainable bioenergy landscape design processes that will support current and future cellulosic biorefineries and the emerging bioenergy and bioproduct industries. Through outreach and information resources developed by the project team, the template created by this project can be adapted and implemented elsewhere and will offer a path to shared benefits for a broad range of federal, state, local, and industrial stakeholders. This project will use new and emerging subfield analytic software that will enable management decisions via precision agronomics. This will allow for the identification of optimum areas to incorporate perennial energy crops and conservation practices into corn- and soybean-producing fields in a manner that is both economically and environmentally beneficial. The foundation of the project's multistage stakeholder outreach plan is to leverage existing federal, state, and local conservation programs, coupled with a transformative approach of integrating herbaceous energy crops into the bioenergy supply mix to supplement agricultural residues. The project team will fully monitor harvested acres of agricultural residues and warm-season grass energy crops. The project team will seek to implement a modified conservation grasslands approach on a pilot program basis to allow for the establishment and harvest of up to 2,000 acres of warm-

Weighted Project Score: 9.2

Weighting for Ongoing Projects: Approach - 25%; Accomplishments and Progress - 25%; Relevance - 25%; Future Work - 25%



I One standard deviation of reviewers' scores

season grass energy crops that allow landowners to retain their conservation program benefits while harvesting and selling their grass crop. Additional conservation practices will be implemented and monitored, including the establishment of up to 15,000 acres of cover crops. A multiyear comprehensive field research, testing, and monitoring program will be conducted on targeted fields within the project's activities.

The best and most immediately relevant opportunities to develop and demonstrate innovative and impactful landscape design practices for bioenergy systems exist within the feedstock supply sheds of operating bioenergy projects. This project will be conducted in the biomass feedstock supply sheds serving POET-DSM's Project LIBERTY biorefinery in Emmetsburg, Iowa, and formerly DuPont Cellulosic's biorefinery in Nevada, Iowa (the plant recently sold to Verbio for renewable natural gas production from herbaceous biomass feedstocks). These are areas where LUC is already underway but is still early in its evolution in supporting the supply chains of groundbreaking cellulosic biorefineries. The project will build from information available from these operating bioenergy systems and collect additional data necessary for addressing barriers and stakeholders' objectives. The project's activities are also coordinated with the Iowa Department of Agriculture and Land Stewardship and are aligned with their aggressive efforts through the Iowa Nutrient Reduction Strategy to reduce nutrient runoff that contributes to Gulf hypoxia and other negative impacts to water quality. The project team is also implementing precision agriculture strategies to improve profitability and sustainability of biomass harvest operations and decision-making processes.

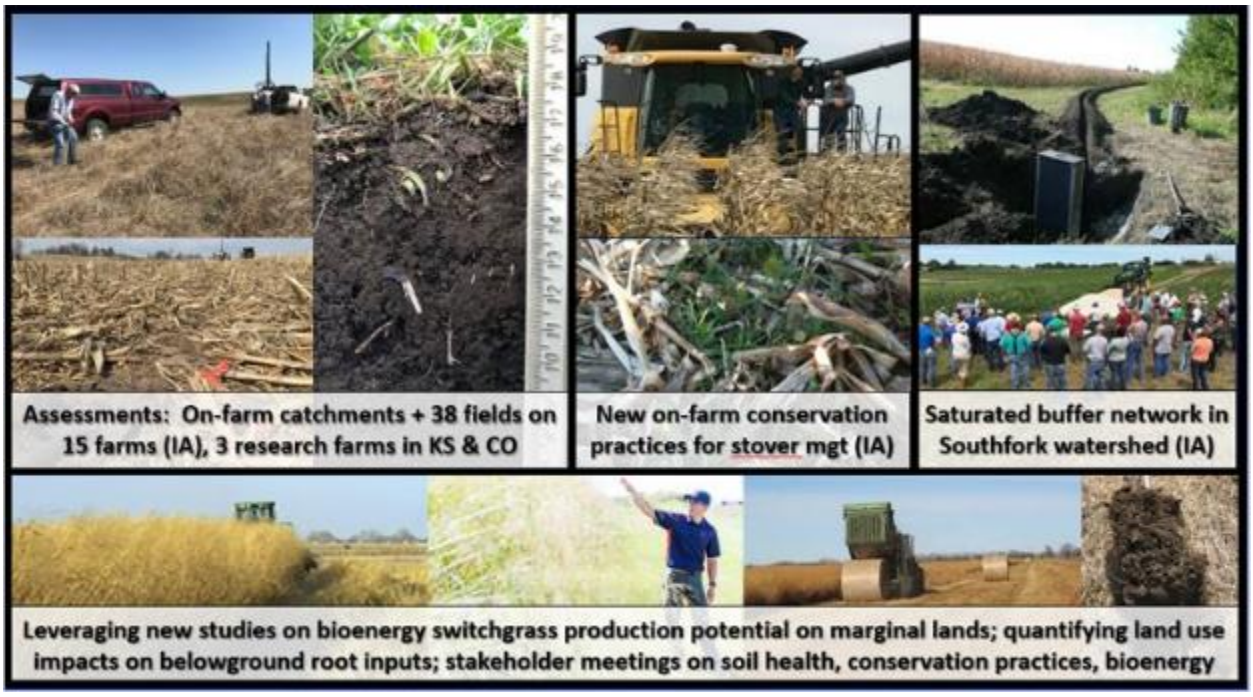


Photo courtesy of Antares Group, Inc.

OVERALL IMPRESSIONS

- This is an incredibly valuable project to develop new tools and approaches for landscape design to improve profit, biomass supply, and sustainability, with the ability to develop, test, and validate models on large real plots of agricultural land.

- As one of the largest programs (in terms of financial resources, partners, and acreage), this project has been appropriately evolving as a key partner to many other BETO-funded programs.

- This is a valuable project. The project provides a valuable resource to other projects in the portfolio to collect data and lends itself to landscape design (three bioenergy supply sheds), testing and developing equipment, and access to expertise and lessons learned.
- This project advances the state of the art for sustainable bioenergy landscape design processes, and it will develop and demonstrate new tools and approaches for planning and implementing sustainable landscape design strategies aimed at simultaneously improving farm profitability, environmental sustainability, and future sustainable biomass supply production, thereby improving the viability of future herbaceous biomass supply systems and projects.
- This project addresses barriers At-B: Analytical Tools and Capabilities for System-Level Analysis; At-C: Data Availability Across the Supply Chain; At-E: Quantification of Economic, Environmental, and Other Benefits and Costs; At-F: Science-Based Methods for Improving Sustainability; and At-G: Social Acceptance and Stakeholder Involvement.
- This project exhibits a strong and well-designed integrated use of empirical field assessment of corn stover and perennial grass cultivation, including use on buffer strips integrated with common and well-supported modeling frameworks (such as the SWAT model). Its focus on concrete case studies in service of broader questions is commendable. I do see some redundancies between this project and others in the BETO portfolio, but this should be an opportunity to better integrate this project's methods, frameworks, and case-study sites across the portfolio to take advantage of potential synergies.
- This is a significant and comprehensive field effort to experimentally test approaches to leveraging marginal lands for economically and environmentally beneficial feedstocks for the bioeconomy, including the development of novel field equipment that will advance the viability of residue harvesting. Although representing a large investment, this project is providing significant real-world value and is well integrated with national laboratory projects to enable data collection, validation of modeling, and field testing of landscape management approaches. My only recommendation on any of the project components is that the team should carefully assess whether there is true value in developing a new sustainability certification scheme as outlined in the presentation given how many existing voluntary certification schemes there are, and if the team determines it is somehow uniquely valuable, the uniqueness should be clearly explained as part of the description of the approach.

RECIPIENT RESPONSE TO REVIEWER COMMENTS

The recipients choose not to respond to the reviewers' overall impressions of their project.

BIOFUELS INFORMATION CENTER

National Renewable Energy Laboratory

PROJECT DESCRIPTION

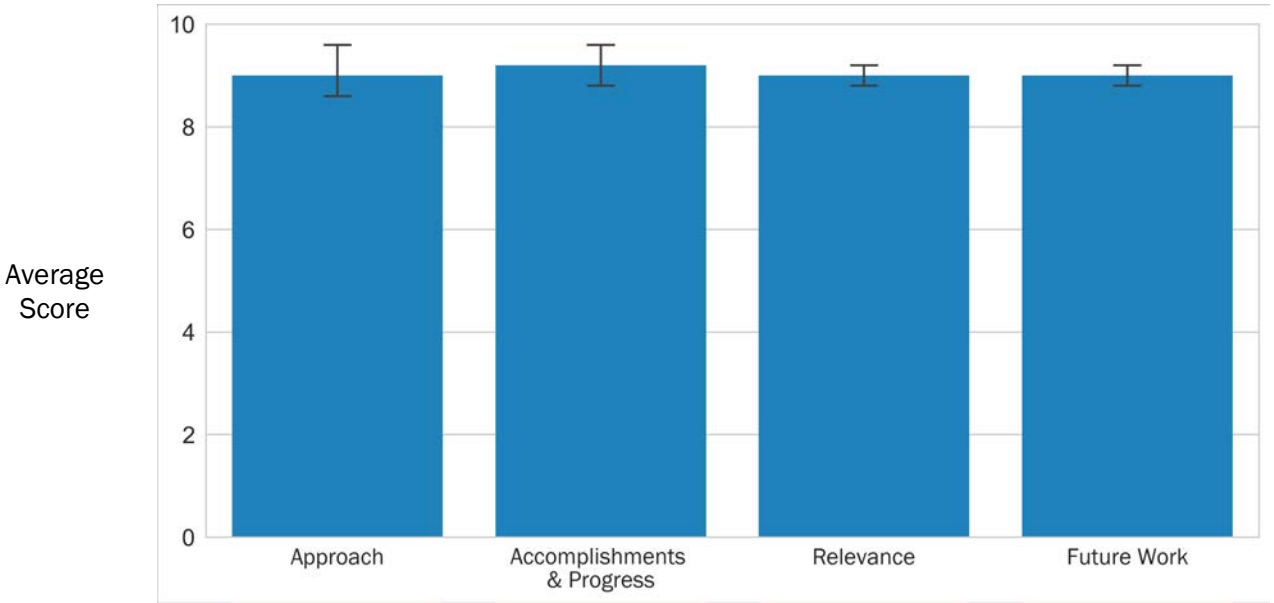
WBS:	6.3.0.1
CID:	NL0016477
Principal Investigator:	Ms. Kristi Moriarty
Period of Performance:	10/1/2015–9/30/2020
Total DOE Funding:	$1,420,000
DOE Funding FY16:	$110,000
DOE Funding FY17:	$500,000
DOE Funding FY18:	$410,000
DOE Funding FY19:	$400,000
Project Status:	Ongoing

The purpose of the BIC task is to provide relevant data, information, reports, and web-based tools to all bioenergy stakeholders. The BIC task began in FY 2008 to meet the requirement under Title II, Sec. 229 of the Energy Independence and Security Act of 2007 (EISA) that requires DOE to develop a "Biofuels and Biorefinery Information Center."

The BIC task supports biofuel pages on EERE's most visited website, the Alternative Fuels Data Center (https://afdc.energy.gov/), as well as the Bioenergy Atlas tools (https://nrel.gov/gis/biomass). This task results in more than 800,000 web page views (an instance of an Internet user visiting a web page) per year. In FY 2017, the task expanded to include the USDA's Biofuels Infrastructure Partnership (BIP) and the annual *Bioenergy Industry Status Report*. The USDA BIP expanded infrastructure for E15 (gasoline blend with 15% ethanol) and/or E85 (gasoline blend with 51% to 83% ethanol) to approximately 1,400 stations, and NREL collects and analyzes all infrastructure and sales data collected by the USDA. Stations are privately held, and previously it was difficult to ascertain infrastructure and sales data. This unique data set allows insight into infrastructure data (number of pumps and tanks, costs to install new equipment) and sales data (price and volume for E10 [gasoline blend with 10% ethanol], E15, E85, and diesel by month). The *Bioenergy Industry Status Report* provides key bioenergy metrics in one place. Topics covered include biofuels (ethanol, both starch and

Weighted Project Score: 9.1

Weighting for Ongoing Projects: Approach-25%; Accomplishments and Progress-25%; Relevance-25%; Future Work-25%



cellulosic; biobutanol; biodiesel; and renewable hydrocarbons), renewable natural gas, biopower, and bioproducts. Reports were published in 2013, 2015, and 2016, and the 2017 report is under review.

The task also supports the PI's time to engage stakeholders on infrastructure and deployment of biofuels. This includes leading, membership, and participation in the following roles: member board of advisors at the Fuels Institute, voting member for multiple UL standards committees, cochair of the infrastructure team at Agriculture Auto Ethanol, member of Society of Automotive Engineers Fuel Grade Assurance Protocol Committee, and member of Coordination Research Council's Ultra-Low Sulfur Diesel Corrosion Committee. The PI routinely responds to industry inquiries to assist in deployment of biofuels.

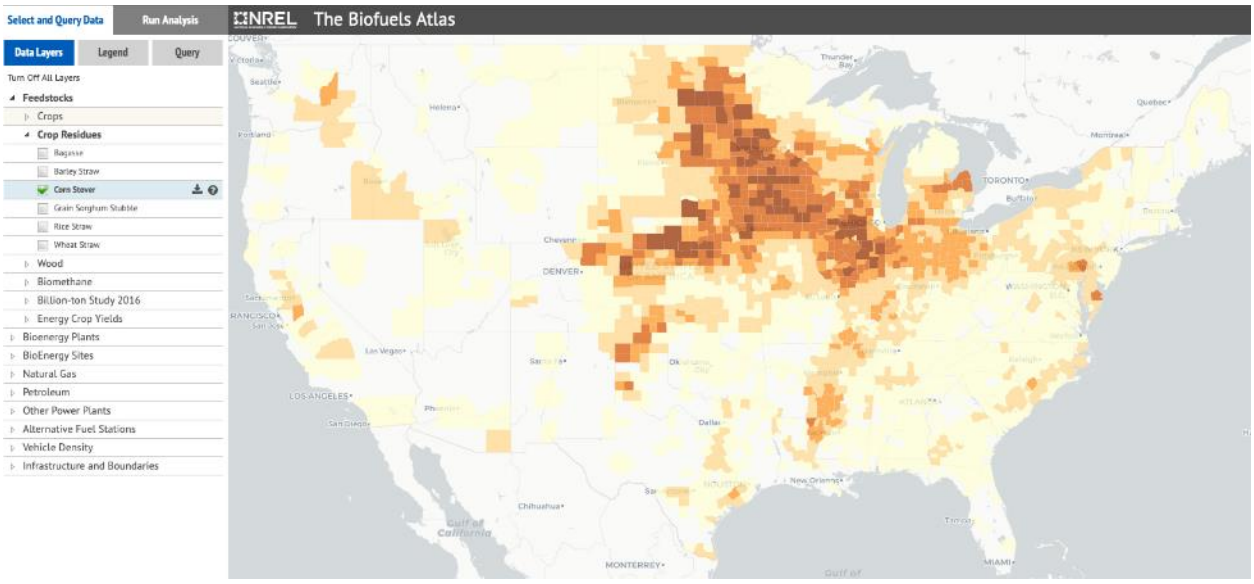


Photo courtesy of National Renewable Energy Laboratory

OVERALL IMPRESSIONS

- This program was created in response to EISA 2007 Sec. 229, but it has turned into an invaluable resource to characterize the myriad barriers to domestic biofuel deployment.
- The purpose of the BIC task is to provide relevant data, information, reports, and web-based tools to all bioenergy stakeholders. The establishment of the BIC was mandated under Title II, Sec. 229 of EISA.
- This project addresses barriers At-B: Analytical Tools and Capabilities for System-Level Analysis; At-C: Data Availability Across the Supply Chain; At-G: Social Acceptance and Stakeholder Involvement; and ADO-C: Codes, Standards, and Approval for Use.
- The BIC is practical, serves a clear demand that would otherwise be unfulfilled, and is a good use of DOE money.
- Aggregating data and making them accessible is an important goal because they reach key, nontechnical players in the bioenergy system. A strength of this project is its interaction with end-market commercial actors. This key piece of the story is missed by BETO otherwise.
- The BIC is an extremely valuable resource that is leveraged extensively by the stakeholder community to help make informed market decisions and understand costs. This program is highly valuable and a very efficient use of BETO resources, and it should be continued with further redundancy (i.e., additional deeply engaged personnel) to ensure continuity and performance.

RECIPIENT RESPONSE TO REVIEWER COMMENTS

- I thank the reviewers for their helpful and supportive feedback.

BIOENERGY KNOWLEDGE DISCOVERY FRAMEWORK

Oak Ridge National Laboratory

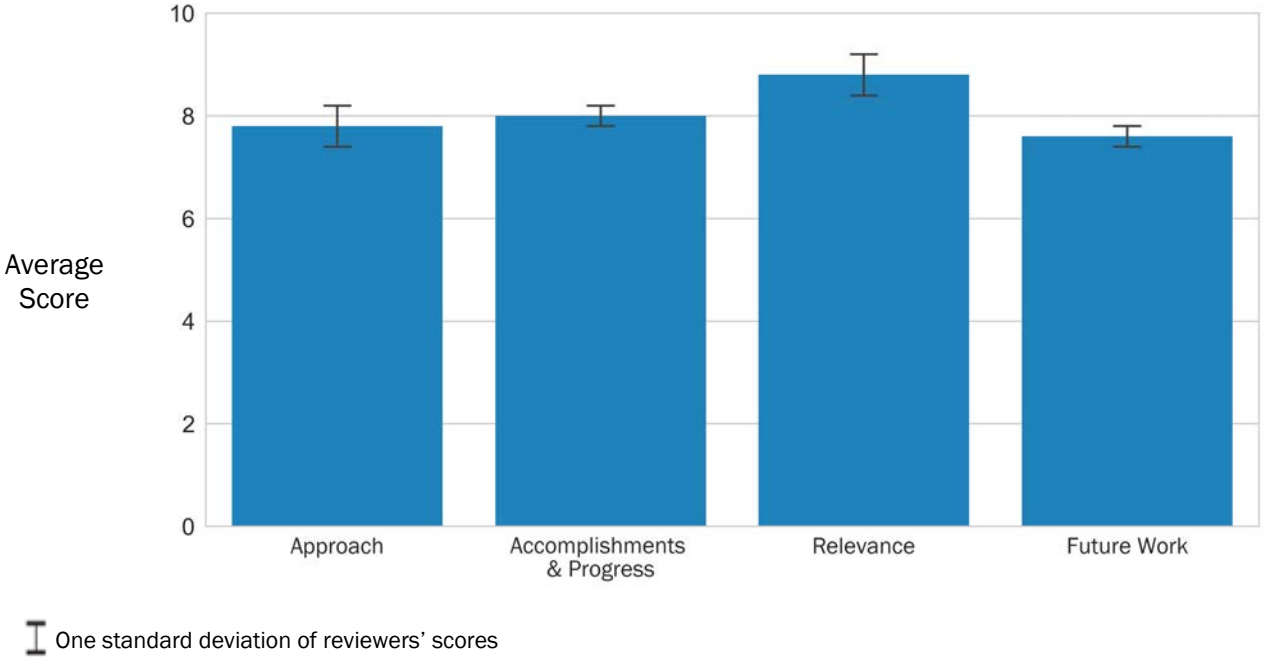
PROJECT DESCRIPTION

Many issues in the biofuel supply chain, from production to delivery, need to be addressed to foster a viable biofuel industry. Infrastructure issues related to generation, distribution, and delivery of biofuels include finding the optimal locations to site a biorefinery to minimize cost with adequate availability of feedstock resources nearby. The Bioenergy KDF is a collaborative platform for knowledge collection, curation, and discovery to support DOE's effort to develop a sustainable biofuel industry. The Bioenergy KDF facilitates expanded research opportunities by providing a means to synthesize vast amounts of information from across the bioenergy supply chain. The Bioenergy KDF enables data harmonization from different sources and serves as a source of authoritative and benchmark data sets and key topics.

WBS:	6.3.0.2
CID:	NL0022893
Principal Investigator:	Mr. Aaron Myers
Period of Performance:	10/1/2007–9/30/2022
Total DOE Funding:	$917,000
DOE Funding FY16:	$250,000
DOE Funding FY17:	$300,000
DOE Funding FY18:	$187,000
DOE Funding FY19:	$180,000
Project Status:	Ongoing

Weighted Project Score: 8.1

Weighting for Ongoing Projects: Approach - 25%; Accomplishments and Progress - 25%; Relevance - 25%; Future Work - 25%



OVERALL IMPRESSIONS

- This KDF project, which has been ongoing for more than a decade, continues to provide clear value to the public and researchers through making data and visualization/analysis tools available to the public.
- To me, this is more of a resource and communications program than "analysis," but it is worth funding, nonetheless.
- This project provides access to knowledge, data, and tools at one site. The Bioenergy KDF is a collaborative platform for knowledge collection, curation, and discovery to support DOE's effort to develop a sustainable biofuel industry.
- This project bringing formerly unavailable data or opaque tools to sunlight is an important goal. For example, the BSM is a key element of EERE/BETO strategic positioning and impact. Keep an eye on what is being used and focus where the demand exists.
- I believe a geospatial data repository would be very useful for a variety of reasons. It would enable ongoing hosting of data sets that are otherwise hard to find and would offer both increased traffic to the KDF site as well as a mechanism for discovery of research via links on the KDF site. The challenge will be the cost of the storage and computing power required.
- The KDF is a useful resource for finding BETO work quickly and easily, and significant improvements have been made recently to facilitate finding related work via landing pages. Continuing to enhance the KDF to enable long-term retention of data sets and generate DOI numbers will help maintain relevance. The KDF is a great way to crowdsource appropriate data relevant to bioenergy.

RECIPIENT RESPONSE TO REVIEWER COMMENTS

- Thank you for the feedback. We think the reviewers presented interesting ideas and viewpoints, and we will look to address these moving forward.