BETO FY20 AOP MR Full Application

# Section 1: Project General Information

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| --- | --- |
| **Overview** |  |
| **Project Title:** | Bioeconomy Systems Effects of Carbon Pricing |
| **Control Number:** |  |
| **Applicant (Name and Email Address):** | Laura Vimmerstedt, laura.vimmerstedt@nrel.gov |
| **Organization:** | National Renewable Energy Lab |
| **Topic:** | Analysis and Sustainability |
| **Project Start Date:** | 10/1/2019 |
| **Project End Date:** | 9/30/2022 |

## Partner Laboratories:

|  |  |  |  |
| --- | --- | --- | --- |
| Partner Laboratory | Email | First Name | Last Name |
| PNNL | Marshall.Wise@pnnl.gov | Marshall | Wise |

## Financials

|  |  |  |
| --- | --- | --- |
| Year | Planned Project Base Costs | Planned Project Overtarget Costs |
| Funding Obligated in FY19 (continuing projects only) |  |  |
| FY20 | NREL: $200,000  PNNL: $100,000 |  |
| FY21 | NREL: $200,000  PNNL: $100,000 |  |
| FY22 | NREL: $200,000  PNNL: $100,000 |  |

## Performers

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Subcontractor Name | Start Date | End Date | 2019 Planned Costs | 2020 Planned Costs | 2021 Planned Costs |
|  |  |  |  |  |  |
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# Section 2: Technical Merit, Innovation, and Approach

## Project Overview:

BETO R&D contributes to the development of a more robust U.S. bioeconomy. In parallel, the influence of carbon pricing could grow. Higher carbon prices could incentivize liquid biofuels, but a very high carbon price could have unanticipated consequences, such as driving investments away from pathways presently researched by BETO. An overarching hypothesis is that certain economic, technological, carbon pricing regimes could result in outcomes with more extensive bioeconomic activity, while others could result in carbon capture and land management strategies for carbon value without biofuels, biopower, or bioproduct production. This analytic effort aims to map out carbon price points at which the role in the economy of BETO technology pathways changes by leveraging and building upon existing modeling capabilities at both NREL and PNNL (such as Biomass Scenario Model, the Bioproduct Transition Dynamics Model, the Competition for Uses of Biomass Model, and the Land Use Change model). Carbon pricing interacts with low-carbon fuels, biopower, bioproducts, carbon capture (with or without fuel production or utilization), and land uses, such as land management strategies for carbon value. Related activities may create carbon sinks in land-based biomass, manage industrial waste streams (including biomass or carbon) to sequester carbon, and replace carbon emitting energy pathways with neutral or negative ones. This project will allow BETO to conduct integrated, nimble analysis of the effects of carbon pricing on BETO bioeconomy goals, including the sensitivity of carbon pricing effects to technology performance. The key outcome of this project is the development of an integrated analytic framework that allows considerations of complex dynamics and interlinkages related to carbon pricing and BETO funded technologies. These results can inform decisions about biomass resource use under various carbon pricing scenarios.

*Technical Approach*

This project leverages current work, increasing its chances for success by building from existing models and teams Several NREL system dynamics models, such as the Biomass Scenario Model, the Bioproduct Transition Dynamics Model, the Competition for Uses of Biomass Model, and the Land Use Change model, provide important building blocks because they already assemble many relevant resource, technology, and decision-maker characteristics and interactions, serving as a strong basis for analytic model development. An existing partnership with PNNL complements these NREL assets, providing perspective from the Global Change Assessment Model team.

Scenario analysis will be the primary technical approaches used in this project. We will use system dynamics simulations and integrated assessment {and economic equilibrium} modeling. These approaches enable exploration of wide ranges of potential future conditions of technology, biomass resource, and economic conditions within modeling frameworks that ensure self-consistency and adherence to basic physical and financial limitations. System dynamics approaches generate future conditions based on continuous, dynamic development starting from current conditions, thus ensuring that no impossible or improbable events are required to reach future outcomes.

**The Biomass Scenario Model (BSM)** is a system dynamics model developed under the auspices of the DOE as part of a multi-year project at the National Renewable Energy Laboratory. It is a tool designed to better understand biofuels policy as it impacts the development of the supply chain for biofuels in the United States and the economic agents influencing that development through their decisions. The model is intended to generate and explore plausible scenarios for the evolution of a biofuel transportation fuel industry in the United States, representing multiple pathways leading to the production of fuel ethanol as well as advanced biofuels such as biomass-based hydrocarbons (e.g.–biomass-based gasoline, diesel, jet fuel, and butanol). The BSM, which is implemented using the STELLA (https://www.iseesystems.com) system dynamics simulation platform, integrates representations of resource availability; physical, technological, and economic constraints; behavior; and policy to model dynamic interactions across the supply chain. It simulates the deployment of biofuels given technological development and the reaction of the investment community to those technologies in the context of land availability, the competing oil market, consumer demand for biofuels, and government policies over time. It has a strong emphasis on the behavior and decision making of various agents along the supply chain. A comprehensive overview of the BSM and associated publications is available (<https://openei.org/wiki/Biomass_Scenario_Model>).

**Bioproduct Transition Dynamics Model (BTD)** is a new system dynamics model representing that examines generalizable aspects of transitions to bioproducts, with applications to bioproducts with the greatest market opportunities. Bioproducts co-produced with biofuels can enable biofuels to reach out-year production cost goals as well as improve the overall sustainability of integrated biorefineries. While BETO has developed a broad understanding of different conversion processes that produce bioproducts and the associated market attributes, the drivers behind investors’ decisions to invest or not invest in bioproduct development, and the possible successful scenarios for advancing the bioproducts and biofuels industries, are not yet well understood. To achieve this understanding, we developed the Bioproduct Transition Dynamics (BTD) model, a transparent, analytic system dynamics model that tracks early-market bioproduct development from initial laboratory research through to commercial-scale production. The BTD represents both the bioproduct development process as well as the decision-making process used by investors when determining whether or not to fund a project. This model includes pre-commercial-scale technology development and early-market transition issues, does not model beyond operation of the first commercial scale plant, and explicitly models the impacts of investor behavior on bioproduct development.

The Bioproducts Transition Dynamics Model includes both quantitative and semi-quantitative factors, including bioproduct techno-economic criteria, demand for bioproducts from both industrial and end consumers, investor optimism and risk tolerance, and expectations around continued government policy support, among others. The BTD can be used to analyze a wide variety of emerging bioproducts that have been developed through economic or policy-driven mechanisms and that satisfy demand for niche, commodity-scale or other market types. This flexibility enables analysts to identify and test technological and market scenarios that lead to a bioproduct’s eventual success (defined as continuous commercial scale production) or failure, and to highlight how financial and scientific support from BETO can enhance a bioproduct’s likelihood of success along with the associated funding needs.

**The Competition for Uses of Biomass (CUB) Model** represents competition for biomass among biofuels, biopower, and bioproducts, using a simplified version of the BSM biofuels system dynamics model. It has been used in analysis of uses of biomass energy feedstocks in the “BSM Biomass Competition” project, and can support analyses of implications of supply shocks on the supply system, analysis of allocation of biomass resources among the different end uses under different incentives, impacts of biomass exports or bioproducts on the biofuel and biopower industries, and geographic regional analysis (contingent on data availability.

**Biofuels Land Use Change (BioLUC) Model.** BioLUC, is a system dynamics (SD) simulation model (NREL 2012, Bush et al 2011) that represents key economic and social drivers of global LUC and their interactions over time, enabling exploration of different scenarios with implications for LUC5 . In particular, BioLUC can explore implications of and assumptions about LUC by analyzing the limits of sustainable biofuels production under varied future conditions regarding inputs, specifically population growth, crop yields, and plant and animal product supply and demand. BioLUC was created using the STELLA Version 9.1.4 software package (ISEE Systems, Lebanon, NH) using a stock-and-flow structure; it focuses on information feedback processes that underwrite the dynamic movement of key quantities over time.

**Global Change Assessment Model** (GCAM) is a long-term, integrated assessment economic equilibrium model that links production and demand of global energy, agriculture, land use, and corresponding emissions (Wise et al., 2014, Wise et al., 2009, Edmonds and Reilly, 1985). GCAM currently models the global energy system with a spatial resolution of 32 regions and agriculture and land use in over 380 regions based on contiguous water basins. GCAM modeling of bioenergy provides comprehensive analyses of the potential role, impacts, and sustainability of bioenergy production and use that considers interactions across all energy and agriculture sectors, both domestic and global. GCAM-USA is a newly developed version which links energy system resolution at the 50-state level inside the global GCAM model. GCAM-USA will be used for this effort. With its broader scope, GCAM can provide quantitative context, feedbacks, and interactions between the U.S. biofuel sector and the rest of the United States and international energy and agriculture systems. The complementary nature of GCAM and BSM is particularly critical for the analysis of bioenergy with a carbon price. A carbon price impacts not only bioenergy but the entire energy system, and the production of bioenergy impacts the agriculture system, both in and out of the U.S. BSM, in contrast, focuses on key aspects of potential evolutionary paths of a biofuel sector in the United States including the cost of pilot facilities, investment risks, technological learning, build times, and other infrastructure details. These factors, also critical to the analysis of bioenergy under a carbon price, would be either impossible or at least impractical to incorporate directly into a large equilibrium model. An informal collaboration was begun in Q3 of FY19 between the Global Change Assessment Model (GCAM) and Biomass Scenario Model (BSM) teams. The purpose of this collaboration is to understand the differences and synergies between the two models and to identify opportunities for performing joint analyses leveraging the relative strengths of the two models. A summary of key comparisons between the models in presented in Table 1.

**Table 1. GCAM and BSM Model Comparison**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Model Characteristic** | **GCAM** | **BSM** |
| General Attributes | Analytical Focus | Global energy, land, and climate | Domestic biofuels industry |
| Geographic Scope | Global | National (conterminous US) |
| Spatial Resolution | Energy and economies represented by 32 regions. Agriculture is disaggregated based on water basins to 384 regions. 50 States in USA | 10 USDA regions |
| Simulation Length (yr) | 110 (1990 – 2100) | 25 (2015 – 2040) |
| Reporting Time Step (yr) | 5 | 1 |
| Calculation Time Step (DT) (yr) | equilibrium at each step | 1/32 |
| Modeling Approach | IAM/partial equilibrium | System dynamics |
| Run time | ~30 min | ~ 2 min |
| Software | C++ | Stella |
| Publicly Available | Yes (GitHub) | Yes (GitHub) |
| Architecture | fixed | modular |
| Energy System | Energy System Represented | All | Light-duty transportation |
| Technology Representation | Specific technologies in energy transformation and demand, generalized elsewhere | Specific DOE conversion processes. |
| Technology Attributes | Explicit Input/output flows of energy, fertilizer, water quantities. Capital and other cost assumptions based on technology data. | Proforma financials, process performance, technological readiness level, industrial learning |
| Market Representation | Global and regional: carbon, water, fossil fuels, renewable fuels, agriculture | Domestic: agriculture, oil, renewable transportation fuels |
| Agricultural System | Conventional Agriculture | 12 major crops: corn, soy | Six major crops: corn, soy, cotton, wheat, small grains, hay |
| Agricultural Scope | Global markets | Domestic commodity markets |
| Soil carbon | Vegetation and soil C | Not represented |
| Initial Agricultural data | FAO, GTAP | USDA |
| Biomass crops | Ag and forest residues, dedicated energy grasses and woody crops. | Ag and forest residues dedicated herbaceous and woody crops, urban residues. Initializations from POLYSYS(ORNL) |
| Supply and Logistics |  | Two systems based on INL’s FSL work. Bale-based and Densified |
| Land Use | Logit function based on profitability. | Logit function based on profitability. |
| Transportation [bio]Fuels | Technologies | Thermochemical, biochemical | ~15 technologies: starch EtOH, cellulosic EtOH, cellulosic hydrocarbon. Based on specific BETO design cases |
| Fuel demand | All modes of transportation | Light-duty vehicles |
| Petroleum prices | Endogenous | Exogenous (AEO) |
| Technological learning | Not represented | Endogenous |
| Boundary | Impact from tail pipe | LDV fuel consumption |

Much of the data for this project has already been generated through other projects that have used these models. Key data already curated through these projects includes the land base of the United States and other regions of the world, biomass resource production costs and yields, detailed biomass-to-biofuel and biomass-to-bioproducts conversion pathway characteristics, general distribution logistics data, and end-use data such as vehicle stocks, alternative vehicle adoption, and bioproduct markets.

We will implement this effort to estimate bioeconomy effects of carbon pricing conscious of both data limitations and emerging data sources. In some cases, sufficient key data exist to input into a financial cash-flow model to assess investment prospects, but other key data may need to be framed as financial and technical scenarios, likely including carbon prices and technological maturity. Scenario results for net present value of investments can be compared to identify different economic behavior regimes. Data will include retrofit costs for existing biorefineries, and carbon capture, cleanup, transport, carbon dioxide injection, and storage costs for new biorefineries; capital- and performance-based incentives; biomass resource data; biopower production cost data; land management data; carbon management data. Geographic scope will encompass interactions across international, U.S., and state levels.

Specific scenarios will explore carbon prices, energy prices, fuel demands, and vehicle stocks, for which time series trajectories can be generated by GCAM and can exported into NREL system dynamics models. Scenarios will also explore how technology costs and learning dynamics from NREL system dynamics models can provide additional detail and explore dynamic system behaviors not available from GCAM alone.

The project will help answer key questions such as:

* How do carbon prices direct the behavior across the U.S. (bio) economy, and how might this differ with different carbon market structures?
* How do carbon prices across the energy system (i.e., outside the bio-economy) affect bioenergy competitiveness and deployment, considering competition with hydrocarbon fuels and carbon-free electricity generation, with the associated new opportunities for electricity demand?
* What effects might carbon prices have on the U.S. biofuels deployment?
* What are the effects of carbon pricing scenarios on the needs of enabling technologies for biofuels for additional incentives, R&D, or both?
* How can biofuels R&D maximize the potential co-benefits of carbon markets related to use of resources (biomass, land, water, etc.) for different applications within the bioeconomy (biopower, biofuels, biochemicals)?

Targets for each FY are as follows:

* In FY 20, the project will complete an analytic plan, prepare data and tools, and conduct exploratory analysis that targets at least one of the key questions. Development of the analytic plan will entail first defining technology scope, data sources, and analytic tools for the scenario analysis, and then parameterizing a set of scenarios. We will conduct an exploratory analysis to answer one of the key question, which will also serve as proof-of-concept for further work. With key learnings from the exploratory analysis, we can identify gaps, set priorities to fill them, and implement selected gap-filling actions. All the learnings and key results for FY20 will be documented and reported in the end of year milestone report for BETO. “Presentation on analytic status and initial findings.”
* During FY21, the project will extend analysis to additional key questions. A go/no-go deliverable at 18 months will address whether the project has demonstrated the feasibility of using systems modeling approaches to reveal effects of carbon pricing on technologies relevant to the bioeconomy. Analysis that supports the go/no-go will also be delivered as a draft publication, and by the end of FY21 could be submitted for publication, contingent on DOE approval.
* During FY22, the project will conclude analysis and develop final reporting deliverables, including the End-of-Project deliverable “Presentation on effects of carbon pricing on BETO bioeconomy goals” and a draft conference poster, draft conference paper, or draft peer-reviewed journal article delivered to DOE.

The key outcomes of this project are:

1. Analytic findings, delivered to BETO in draft publishable form with integrated results data in an interactive, distributable form.
2. An analysis suite that targets carbon pricing effects, consisting of an analytic model, data management system, and connections of personnel and data between BETO projects.

The key innovations of this project are:

1. Development of an integrated analytic framework that allows considerations of complex dynamics and interlinkages related to carbon pricing and BETO technologies.
2. Assessment of carbon pricing opportunities and risks for BETO technologies within this framework.

Project Context

Analysis of bioeconomy opportunities has often been conducted with carbon prices at modest or negligible levels, and carbon emissions effects as a metric that is secondary to biomass utilization for fuels, products, and power. However, carbon markets could develop that might price carbon emissions mitigation at levels that could rival the value stream from bioeconomic activities. Such pricing differentiates strongly among bioeconomic activities based on their carbon mitigation potential.

Existing efforts funded by BETO/EERE have supported the development and use of all of the models proposed for use in this project. The Bioeconomy Scenario Analysis project (WBS 4.1.2.32) has ongoing work that relates to this effort as it explores opportunities for biofuels deployment under various scenarios and maintains the BSM. The GCAM Bioenergy and Land Use Modeling project (WBS 4.1.2.50) is a continuing project with a current focus on analyzing the potential and impact of biopower generation in the United States. Ongoing technoeconomic analyses of pathways that have significant carbon mitigation potential is under way. Results of these analyses will likely become useable within the scope and capacity of this project during this proposed 3-year scope.

**Current TRL of the proposed technology (1-9): N/A**

**Estimated TRL the technology will reach at project end (2-9): N/A**

**\*If project is another modality besides TRL 1-9 please put N/A above and indicate that here:** Modality 5 (Strategic, Market and Techno-Economic Analysis)

# Section 3. Project Impacts and Outcomes

## Project Impact:

This analytic effort aims to map out carbon price points at which the role in the economy of BETO technology pathways changes. It will provide BETO with insights on the effectiveness of carbon utilization and management with an integrated analysis capacity. Stakeholders will gain an improved understanding of risks and opportunities to that carbon prices pose to their long-range planning for carbon risk. This project will serve stakeholders such as biomass, agricultural, energy, chemical products, electricity and technology industries and industry groups; agricultural and forest landowners; biomass technology and system researchers and developers, including universities; civil society; state, regional, and national governments, especially their planners, and including international agencies and U.S. government agencies such as DOE, EPA, and USDA.

This project links directly to several objectives that are outlined in the Biomass Research and Development Framework.

As stated in the BR&D framework report, 4.9.2, “There are significant gaps in the nationwide, macroeconomic analysis of the entire bioeconomy.” It also highlights major analytic activities that include, “Feedstock and product markets—understanding supply and product allocations and technology and policy impacts at various levels of sector growth” as well as “Benefits and negative impacts—addressing sustainability, environmental, social, technical, and economic factors.” This project aims to fill in the gaps on carbon pricing’s impact on the bioeconomy, such as impacts on costs, biomass supply and resource distribution, biofuel/bioproduct allocations, and technology deployment strategies. The BPTD and BSM provide frameworks for detailed analysis of supply and product allocations for bioproducts and biofuels in response to technology and policy impacts, and the focus on carbon pricing will elaborate an important policy impact. The CUB integrates across biofuel, biopower, and bioproducts to provide a more comprehensive context for such analysis. GCAM and BioLUC offer strong capability for assessment of benefits and negative impacts, specifically emissions and land use effects.

The BR&D framework, 4.9.3.4 states a goal to “Link U.S. domestic economic and trade models to global models.” This project will support that goal by linking several powerful existing modeling capabilities at both PNNL and NREL. This project will establish strong conceptual and analytic linkages between several U.S. domestic biofuels, biopower, and bioproducts models (BPTD, BSM, CUB) and two global models that include the United States as one of many global regions (GCAM, BioLUC).

# Section 4. Project Workplan

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| --- | --- |
| Task 1: Analytic Planning | |
| Performer: | NREL and PNNL |
| Description of Task: | Define and parameterize a set of scenarios that will serve as the basis for model runs and interactions. Scenario development will include identifying analytical scope and collecting necessary data. Additionally, we will refine the analytic plan to answer selected key questions for the go / no-go decision point, , technology scope, data sources, and analytic tools. Phase I plan will be a proof-of-concept, implemented expediently. Phase II will identify gaps, set priorities to fill them, and implement selected gap-filling actions. |
| Duration of Task: | 4 months: 10/1/2019 – 2/1/2020 |
| Planned Costs FY20: | NREL: $50,000  PNNL: $25,000 |

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| --- | --- |
| Task 2: Data and Tool Preparation | |
| Performer: | NREL and PNNL |
| Description of Task: | Perform QA/QC and testing on relevant model connections/interactions and parameter translations. Prepare tools and data to implement Phase I (and post FY20, Phase II) of the project plan. |
| Duration of Task: | 5 months: 2/1/2020 – 7/1/2020 |
| Planned Costs FY20: | NREL: $75,000  PNNL: $30,000 |

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| --- | --- |
| Task 3: Exploratory Analysis | |
| Performer: | NREL and PNNL |
| Description of Task: | Perform exploratory analysis using scenarios developed in Task 1. Based on results and outcomes, Scenarios may be modified and/or further developed. |
| Duration of Task: | 3 months: 7/1/2020 – 10/1/2020 |
| Planned Costs FY20: | NREL: $75,000  PNNL: $45,000 |

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| --- | --- |
| Task 4: Revision, Refinement, and Reporting | |
| Performer: | NREL and PNNL |
| Description of Task: | Conduct revised analysis and develop reporting to support the go / no-go decision point. Deliver resulting analysis as a draft conference poster, draft conference paper, or draft peer-reviewed journal article to DOE. We also plan to develop an interactive results explorer for analytical results from this project. The exact platform is yet-to-be determined, but will likely be web-hosted using open source tools. |
| Duration of Task: | 6 months: 10/1/2020 – 4/1/2021 |
| Planned Costs FY21: | NREL: $100,000  PNNL: $50,000$0 |

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| --- | --- |
| Task 5: Extension to Additional Topics | |
| Performer: | NREL and PNNL |
| Description of Task: | Contingent on a “go” decision, further refine and extend analysis to additional topics. |
| Duration of Task: | 12 months: 4/1/2021 – 4/1/2022 |
| Planned Costs FY21: | NREL: $100,000  PNNL: $50,000 |
| Planned Costs FY22: | NREL: $100,000  PNNL: $50,000 |

|  |  |
| --- | --- |
| Task 6: Final Reporting | |
| Performer: | NREL and PNNL |
| Description of Task: | Contingent on a “go” decision, develop final project reporting on the additional topics. Submit results as a draft conference poster, draft conference paper, or draft peer-reviewed journal article to DOE. |
| Duration of Task: | 6 months 4/1/2022 – 9/30/2022 |
| Planned Costs FY22: | NREL: $100,000  PNNL: $50,000 |

## Project Milestones:

|  |  |  |
| --- | --- | --- |
| Type | Description and Criteria | End Date |
| Quarterly | Quarterly Status Memo that describes progress on analytic planning. | 12/31/2019 |
| Quarterly | Quarterly Status Memo that describes progress on analytic planning and preparation of data and tools. | 3/31/2020 |
| Quarterly | Quarterly Status Memo that describes progress on analytic planning and preparation of data and tools. | 6/30/2020 |
| Annual SMART | Briefing to BETO managers on analytic planning, critical data, and status of tool development. This briefing will seek BETO’s feedback and opinions on modeling options and project directions. Results of the briefing will be incorporated into a memo on NREL results, including collaboration, data, modeling, and analysis plan and initial findings regarding key questions. | 9/30/2020 |
| Quarterly | Memo on PNNL results: initial findings regarding key questions. | 9/30/2020 |
| Annual SMART | Integrated presentation to BETO Project Manager on collaboration, data, modeling, and analysis plan and initial findings regarding key questions. | 12/30/2020 |
| Quarterly | Memo on NREL results: collaboration, data, modeling, and analysis plan and status of findings regarding key questions. | 9/30/2021 |
| Quarterly | Memo on PNNL results: status findings regarding key questions. | 9/30/2021 |
| Annual SMART | Integrated presentation to BETO Project Manager on collaboration, data, modeling, and analysis plan and status of findings regarding key questions. | 12/30/2021 |
| Quarterly | Memo on NREL results: final findings regarding key questions. | 6/30/2022 |
| Quarterly | Memo on PNNL results: final findings regarding key questions. | 6/30/2022 |
| End of Project / Annual SMART | Presentation on effects of carbon pricing on BETO bioeconomy goals, model release, and draft publishable journal article. | 9/30/2022 |

## Project Go/No Go Decision Point:

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| --- | --- | --- | --- |
| Decision | Description | Criteria | Date |
| Continue, revise, or cancel the project | Go/No-Go: Has the project demonstrated the feasibility of using systems modeling approaches to reveal effects of carbon pricing on technologies relevant to the bioeconomy using a system dynamics model with rich representation of interlinkages across the bioeconomy and carbon markets? | Feasible analytic plan  Available data sources  Exploratory analysis relevant to at least one key question | 3/31/2021 |

## Risks

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Risk Description | Response Plan | Severity | Probability | Classification |
| Project is unable to answer key questions. | Go / No-Go Decision point provides opportunity to assess this risk. | High | Low | Scope |
| Answers to key questions are not of interest to BETO. | Go / No-Go Decision point provides opportunity to assess this risk. | Moderate | Low | Scope |
| Analysis proves more complex than expected | Quarterly Status Memos will help manage complexity | Moderate | Moderate | Cost, Schedule |

# Section 5: References and Relevant CVs

## References

Edmonds J, Reilly JM. 1985. *Global energy: assessing the future*. Oxford University Press.

Wise, Marshall, Katherine Calvin, Page Kyle, Patrick Luckow, James Edmonds. 2014. Economic and Physical Modeling of Land Use in GCAM 3.0 and an Application to Agricultural Productivity, Land, and Terrestrial Carbon. *Climate Change Economics*. Volume 5, Issue 2. pp. 1450003-1-1450003-22. DOI 10.1142/S2010007814500031.

Wise M., K. Calvin, A. Thomson, L. Clarke, B. Bond-Lamberty, R. Sands, S. Smith, A. Janetos, and J. Edmonds, 2009, “Implications of limiting CO2 concentrations for land use and energy,” ***Science*** 324:1183-1186.

## Relevant CVs:

**Laura Joan Vimmerstedt**

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**Education**

M.S., **Environmental Studies**, University of Wisconsin, Madison, WI, 1993

B.A., **Chemistry**, Oberlin College, Oberlin, OH, 1989

**Professional Experience**

National Renewable Energy Laboratory, Golden, CO, *Energy Analyst*, Sep. 1994 - Present

* Analyzed the biomass to biofuels system using the Biomass Scenario Model, with a focus on industrial learning, conversion technology adoption, deployment investment, sensitivity analysis, and alternative jet fuel.
* Developed scenario analysis and modeling tools to explore scenarios for transportation sector adoption of alternative technologies.

**Relevant Publications**

Clinton, B., C. Johnson, K. Moriarty, E. Newes, and **L.Vimmerstedt**. 2017. Preliminary Assessment of Spatial Competition in the Market for E85: Presentation Supplement. Golden, CO: National Renewable Energy Laboratory. NREL/TP-6A20-66943.

**Vimmerstedt, L.** and E. Newes. 2016. Dynamics of Aviation Biofuel Investment, Incentives, and Market Growth: An Exploration Using the Biomass Scenario Model. Golden, CO: National Renewable Energy Laboratory. NREL/PO-6A20-67276.

**Vimmerstedt, L.,** S. Peterson, and B. Bush. 2016 Dynamic Modeling of Learning in Emerging Energy Industries: The Example of Advanced Biofuels in the United States. Golden, CO: National Renewable Energy Laboratory. NREL/CP-6A20-66897. Proceedings of the 33rd International Conference of the System Dynamics Society 2015, 19-23 July 2015, Cambridge, Massachusetts pp. 3248-3272.

**Vimmerstedt, L.**, E. Warner, and D. Stright. 2016. [Effects of Deployment Investment on the Growth of the Biofuels Industry: 2016 Update](http://www.nrel.gov/docs/fy16osti/65903.pdf)*.* Golden, CO: National Renewable Energy Laboratory. NREL/TP-6A20-65903.

**Vimmerstedt, L.**, B. Bush, D. Hsu, D. Inman, and S. Peterson. 2015. "[Maturation of Biomass-to-Biofuels Conversion Technology Pathways for Rapid Expansion of Biofuels Production: A System Dynamics Perspective](http://www.nrel.gov/docs/fy15osti/60444.pdf)." *Biofuels, Bioproducts and Biorefining* 9, no. 2 (March/April 2015): 158-176. NREL/JA-6A20-60444.

**Vimmerstedt, L.**, B. Bush, and S. Peterson. 2012. "[Ethanol Distribution, Dispensing, and Use: Analysis of a Portion of the Biomass-to-Biofuels Supply Chain Using System Dynamics](http://nrel-primo.hosted.exlibrisgroup.com/primo_library/libweb/action/search.do?fn=search&ct=search&initialSearch=true&mode=Basic&tab=default_tab&indx=1&dum=true&srt=date&vid=Pubs&frbg=&vl%28freeText0%29=Ethanol+Distribution%2C+Dispensing%2C+and+Use%3A+Analysis+of+a+Portion+of+the+Biomass-to-Biofuels+Supply+Chain+Using+System+Dynamics&scp.scps=scope%3A%28PUBS%29%2Cscope%3A%28NREL_INTERNAL%29)." *PLoS One* 7, no.5 (May 2012). NRE/JA-6A2-47590. [doi:10.1371/journal.pone.0035082](http://dx.doi.org/10.1371/journal.pone.0035082)

**Emily Klawon Newes**

emily.newes@nrel.gov 303-275-3802

**Education**

M.S., **Mineral Economics**, Colorado School of Mines, Golden, CO, 2009

B.A., **Mathematical Economics**, Colgate University, Hamilton, NY, 2000

**Professional Experience**

National Renewable Energy Laboratory, Golden, CO, *Energy Analyst*, Sep. 2009 - Present

* Developed the Stochastic Energy Deployment System model and employed system dynamic modeling techniques to study the potential impacts on energy systems of market changes and policy decisions, using stochasticity to arrive at more robust results.
* Analyzed possible outcomes of policy decisions related to biofuels using the Biomass Scenario Model and revised the model to more accurately reflect the current biofuels atmosphere.
* Created databases with energy-related information in order to better analyze possible inconsistencies.

Platts, A McGraw-Hill Company, Westminster, CO*, Primary Research Manager*, Sept. 2003 - Aug. 2009

* Implemented data quality checks resulting in a 20% increase in efficiency.
* Managed projects tracking natural gas pipelines, power solicitations, state renewable legislation, power projects, environmental controls, and mergers & acquisitions in North America.
* Researched coal data to determine power plant purchases, transportation routing and rate estimation.

**Relevant Publications**

**Newes, E.,** S. Peterson, and J. Han. **“**Potential Avenues for Significant Biofuels Penetration in the U.S. Aviation Market.” Golden, CO: National Renewable Energy Laboratory, 2017.

Johnson, C., **E. Newes**, A. Brooker, R. McCormick, S. Peterson, P. Leiby, R. Uria Martinez, G. Oladosu, and M. Brown. “High-Octane Mid-Level Ethanol Blend Market Assessment.” Golden, CO: National Renewable Energy Laboratory, December 2015.

**Newes, E.**, B. Bush, C. Peck, and S. Peterson. “Potential Leverage Points for Development of the Cellulosic Ethanol Industry Supply Chain.” *Biofuels* 6, no. 1–2 (March 4, 2015): 21–29.

Davidson, C., **E. Newes**, A. Schwab, and L. Vimmerstedt. “An Overview of Aviation Fuel Markets for Biofuels Stakeholders.” Golden, CO: National Renewable Energy Laboratory, 2014.

Ruth, M., T. Mai, **E. Newes**, A. Aden, E. Warner, C. Uriarte, D. Inman, T. Simpkins, and A. Argo. “Projected Biomass Utilization for Fuels and Power in a Mature Market.” Transportation Energy Futures. Golden, CO: Prepared for the U.S. Department of Energy by National Renewable Energy Laboratory, 2013.

Lin, Y., **E. Newes**, B. Bush, S. Peterson, and D. Stright. “Biomass Scenario Model v2.0 Documentation: Data and References.” Golden, CO: National Renewable Energy Laboratory, May 2013.

Peterson, S., **E. Newes**, D. Inman, L. Vimmerstedt, D. Hsu, C. Peck, D. Stright, and B. Bush. “An Overview of the Biomass Scenario Model,” 79. Cambridge, MA, 2013.

**Newes, E.**, B. Bush, D. Inman, Y. Lin, T. Mai, A. Martinez, D. Mulcahy, et al. “Biomass Resource Allocation among Competing End Uses.” Golden, CO: National Renewable Energy Laboratory, May 2012.

**Newes, E.**, D. Inman, and B. Bush. “Understanding the Developing Cellulosic Biofuels Industry through Dynamic Modeling.” In *Economic Effects of Biofuel Production*. InTech Open Access Publisher, 2011.

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**Education**

Ph.D. Colorado State University: Soil Science, 2006

M.S. University of Tennessee: Soil Science, 2000

B.S. University of Tennessee: Plant and Soil Science, 1997

**Professional Experience**

* *Research Scientist,* National Renewable Energy Laboratory, 2/08 - Present
* *Research Associate*, Dept. Soil & Crop Sciences, CSU- 8/07- 2/08
* *Consulting Soil Scientist*, Asheville, NC- 2/07 – 8/07
* *Research Associate*, Dept. Soil & Crop Sciences, CSU- 10/04- 2/07
* *Graduate Research Assistant:* Dept. Soil & Crop Sciences- CSU: 8/02- 10/04
* *Soil Scientist:* USDA/NRCS Coop. Soil Survey, Roane Co. TN- 1/01-2/02
* *Temporary Research Associate*, Dept. Biosystems Eng., Univ. TN- 8/00- 1/01
* *Graduate Research Assistant:* Dept. Plant & Soil Science, Univ. TN- 8/98- 8/00

**Areas of Expertise**

* Life-cycle modeling of renewable fuels
* Feedstock production and handling
* Biofuel sustainability
* Statistical analysis of temporal and spatial datasets
* System Dynamics

**Computer Competency**

* R, statistical programming language: advanced intermediate user
* Splus, Statistical analysis software: intermediate user
* Stella, system dynamic modeling: advanced user
* PowerSim, system dynamic modeling: novice/intermediate user
* SimaPro, lifecycle assessment software: advanced user
* LaTex, word processing programing language: intermediate user
* Tableau, data visualization software: advanced user

**Current NREL Projects**

* Sustainability Analysis – Platform lead
* Biofuels Air Emissions Analysis: Task lead
* Waste to Energy Systems Analysis: Task lead
* Biomass Scenario Model

**Relevant Publications**

**Inman. D.**, E. Warner, D. Stright, J. Macknick, and C. Peck. 2016. Estimating biofuel feedstock water footprints using system dynamics. J. Soil and Water Conservation. 71(4)343-355. doi: 10.2489/jswc.71.4.343.

Bush, B., **D. Inman**, E. Newes, C. Peck, S. Peterson, D. Stright, and L. Vimmerstedt. 2016. Using system dynamics to model industry’s developmental response to energy policy. *In:* Handbook of Applied System Science. Z. P. Neal, Ed. Routledge, New York.

Jacobson, R.A., R.F., Keefe, A.M.S. Smith, S, Metlen, D. A. Saul, S.M. Newman, T.J. Laninga, and **D. Inman**. 2015. Multi-spatial analysis of forest residue utilization for bioenergy. Biofuels, Bioproducts, and Biorefining. doi: 10.1002/bbb.1659.

**Inman, D.**, R. Elmore, and B. Bush. 2015. A case study to examine the imputation of missing data to improve clustering analysis of building electrical demand. Building Services Engineering Research and Technology. doi: 10.1177/0143624415573215.

Vimmerstedt, L.J., B.W. Bush, D.D. Hsu, **D. Inman**, and S.O. Peterson. 2014. Maturation of biomass-to-biofuels conversion technology pathways for rapid expansion of biofuels production: a system dynamics perspective. Biofuels, Bioproducts, and Biorefining. doi: 10.1002/bbb.1515.

Dunn, J.B., M Johnson, Z Wang, M Wang, K Cafferty, J Jacobson, E Searcy, M Biddy, A Dutta, **D Inman**, E Tan, S Jones, L Snowden-Swan. 2014. Supply Chain Sustainability Analysis of Three Biofuel Pathways. Biochemical Conversion of Corn Stover to Ethanol Indirect Gasification of Southern Pine to Ethanol Pyrolysis of Hybrid Poplar to Hydrocarbon Fuels. ANL Technical Report ANL/ESD-14/15. OSTI 1149252. Argonne National Laboratory.

**Inman, D.**, L. Vimmerstedt, B. Bush, and S.O. Peterson. 2014. Biomass Scenario Model scenario library: definitions, construction, and description. NREL Technical Report NREL/TP-6A20-60386.

Ruth, M., T. Mai, E. Newes, A. Aden, E. Warner, C. Uriarte, **D. Inman**, T. Simpkins, A. Argo. 2013. Transportation Energy Futures Series. Projected Biomass Utilization for Fuels and Power in a Mature Market. Technical ReportDOE/GO-102013-3707. OSTI 1219930.

Warner, E., Y. Zhang, **D. Inman**, and G. Heath. 2013. Challenges in the estimation of greenhouse gas emissions from biofuel-induced global land-use change. Biofuels, Bioprod. Bioref. DOI: 10.1002/bbb

Argo, A. M., Tan, E. C., **Inman, D**., Langholtz, M. H., Eaton, L. M., Jacobson, J. J., Wright, C. T., Muth, D. J., Wu, M. M., Chiu, Y.-W. and Graham, R. L. 2013. Investigation of biochemical biorefinery sizing and environmental sustainability impacts for conventional bale system and advanced uniform biomass logistics designs. Biofuels, Bioprod. Bioref.. doi: 10.1002/bbb.1391

Warner, E., **D. Inman**. 2013. Insight: how will biofuels change land use? Environmental research web. March 20, 2013. url: <http://environmentalresearchweb.org/cws/article/news/52780>

Warner, E., **D. Inman**, B. Kunstman, B. Bush, L. Vimmerstedt, S. Peterson, J. Macknick, and Y. Zhang. 2013. Modeling Biofuel Expansion Effects on Land Use Change Dynamics. Environmental Research Letters (8)015003 (10pp). doi: 10.1088/1748-9326/8/1/015003.

Miner, G.L, N. C. Hansen, **D. Inman**, L.A. Sherrod, and G.A. Peterson. 2013. Constraints and Capabilities of No-Till Dryland Agroecosystems as Bioenergy Production Systems. Agron. J. doi: 10.2134/agronj2012.02

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Education

M.S., Industrial Engineering and Operations Research, Virginia Tech. 1990.

B.S., Industrial Engineering and Operations Research, Virginia Tech. 1988.

Professional Experience

2002- Senior Systems Engineer, Joint Global Change Research Institute, Pacific Northwest National Laboratory, College Park, MD.

1998-2002 Project Manager (previous position: Senior Associate), ICF Consulting, Fairfax, VA.

**1990-1998 Senior Research Scientist** (previous position: Scientist, Research Scientist),Pacific Northwest National Laboratory, Washington, DC, Office.

Selected Publications

Bauer, Nico, Steven K. Rose, Shinichiro Fujimori, Detlef P. van Vuuren, John Weyant, **Marshall Wise**, Yiyun Cui, Vassilis Daioglou, Matthew J. Gidden, Etsushi Kato, Alban Kitous, Florian Leblanc, Ronald Sands, Fuminori Sano, Jessica Strefler, Junichi Tsutsui, Ruben Bibas, Oliver Fricko, Tomoko Hasegawa, David Klein, Atsushi Kurosawa, Silvana Mima, and Matteo Muratori (2018). “Global energy sector emission reductions and bioenergy use: overview of the bioenergy demand phase of the EMF-33 model comparison.”, *Climatic Change*. July 2018. https://link.springer.com/article/10.1007/s10584-018-2226-y

**Wise, M.**, M. Muratori, P. Kyle (2017). “Biojet Fuels and Emissions Mitigation in Aviation: an Integrated Assessment Modeling Analysis.” *Transportation Research Part D: Transport and Environment, 52*, pp 244-253. May 2017. <http://dx.doi.org/10.1016/j.trd.2017.03.006>

Calvin, K., **M. Wise**, P. Luckow, P. Kyle, L. Clarke and J. Edmonds (2016). "Implications of uncertain future fossil energy resources on bioenergy use and terrestrial carbon emissions." *Climatic Change* 136(1): 57-68.

Muratori, M., K. Calvin, **M. Wise**, P. Kyle and J. Edmonds (2016). "Global economic consequences of deploying bioenergy with carbon capture and storage (BECCS)." *Environmental Research Letters* 11(9): 095004.

**Wise, Marshall**, Elke L. Hodson, Bryan K. Mignone, Leon Clarke, Stephanie Waldhoff, Patrick Luckow. (2015). "An approach to computing marginal land use change carbon intensities for bioenergy in policy applications.” *Energy Economics. Vol. 50*. pp 337-247. July 2015. [doi:10.1016/j.eneco.2015.05.009](http://dx.doi.org/10.1016/j.eneco.2015.05.009)

**Wise, M.A.**, J.J. Dooley, P. Luckow, K. Calvin, and P. Kyle. 2014. Agriculture, land use, energy and carbon emission impacts of global biofuel mandates to mid-century. *Applied Energy*. Volume 114, February 2014. pp. 763-773. doi: 10.1016/j.apenergy.2013.08.042.

**Wise, M.**, McJeon, H. C., Clarke, L., Calvin, K. & Kyle, P. 2014. Assessing the interactions among U.S. climate policy, biomass energy, and agricultural trade. *The Energy Journal*, Vol 35. pp. 165-180. http://dx.doi.org/10.5547/01956574.35.SI1.9.

Calvin, K., **M. Wise**, D. Klein, D. McCollum, M. Tavoni, B. van der Zwaan, D. van Vuuren. 2014. A multi-model analysis of the regional and sectoral roles of bioenergy in near-term and long-term carbon mitigation. *Climate Change Economics*. Vol. 4, Issue 4.

Calvin, K.V., **M.A. Wise**, P. Kyle, P.L. Patel, L.E. Clarke, and J.A. Edmonds. 2014. Trade-offs of different land and bioenergy policies on the path to achieving climate targets. *Climatic Change.* 123: 691-704.

Calvin, K., **M. Wise**, et al. Implications of uncertain future energy resources on bioenergy use and terrestrial carbon emissions. Climatic Change, doi:10.1007/s10584-013-0923-0 (In press).

Edmonds, J.A., P.W. Luckow, K.V. Calvin, **M.A. Wise**, J.J. Dooley, P. Kyle, S.H. Kim, P.L. Patel, and L.E. Clarke. 2013. Can radiative forcing be limited to 2.6 Wm-2 without negative emissions from bioenergy and CO2 capture and storage? *Climatic Change* 118: 29-43.

Luckow, P. **MA Wise**, JJ Dooley, SH Kim. 2010 “Large-scale utilization of biomass energy and carbon dioxide capture and storage in the transport and electricity sectors under stringent CO2 concentration limit scenarios.” *International Journal Of Greenhouse Gas Control*. Volume 4, Issue 5, September 2010, Pages 865-877.

**Wise M.**, K. Calvin, A. Thomson, L. Clarke, B. Bond-Lamberty, R. Sands, S. Smith, A. Janetos, and J. Edmonds, 2009, “Implications of limiting CO2 concentrations for land use and energy,” *Science* 324:1183-1186.