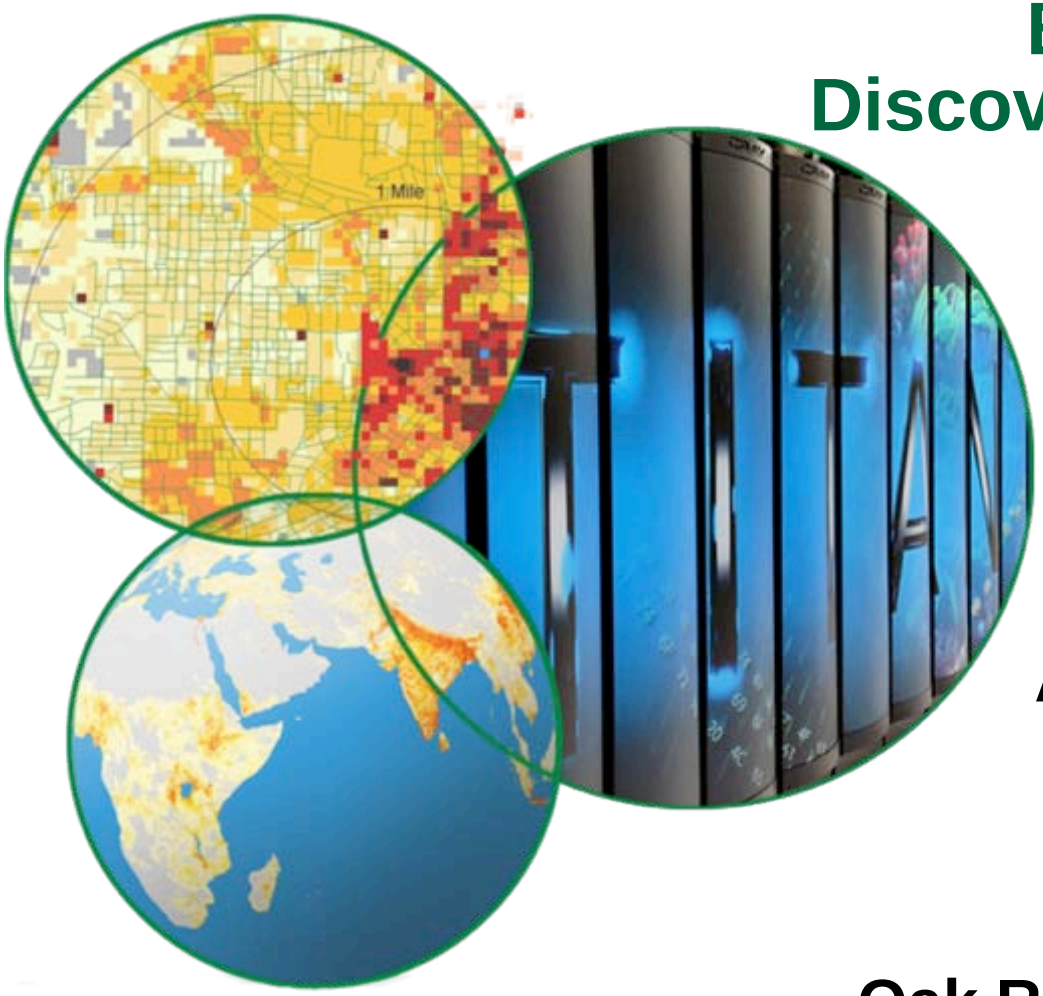
DOE Bioenergy Technologies Office (BETO) 2017 Project Peer Review

Bioenergy Knowledge Discovery Framework (KDF)



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Analysis & Sustainability

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Managed by UT-Battelle
for the Department of Energy

Goal Statement

- **The Bioenergy KDF is designed to connect researchers, industry, and sponsors to share information and build on existing knowledge within the bioenergy research community. While making high-value data and information easily accessible (ex. Billion-Ton 2016, High Octane Fuel Study, Regional Feedstock Partnership, etc.) through an interactive web-based architecture.**

Quad Chart Overview

Geographic Information Science and Technology

Timeline

- FY 2015
- FY 2017
- 75%

Budget

	FY 15 Costs	FY 16 Costs	Total Planned Funding (FY 17-Project End Date)
DOE Funded	$200K	$250K	$1,000K
Project Cost Share (Comp.)*	0	0	0

Barriers

- At-C Data Availability Across Supply Chain
- At-A Comparable, Transparent, and Reproducible Analysis
- St-B Consistent and Science-Based Message on Bioenergy Sustainability

Partners

- Partners
  - Code Journeymen (Sub)
- Other interactions/collaborations
  - NREL, INL, PNNL, ANL, ORNL
- Non-technical project management partners
  - BCS

1 - Project Overview

- **Provide access to bioenergy knowledge, data, and tools via a single access point**
- **Build on an open-source, customizable, and scalable infrastructure**
- **Bring bioenergy researchers and stakeholders together**
- **Bring private content to the public**
  - Biomass Scenario Model
- **Optimize access to high priority data, models, and information**
  - Ex. Billion-Ton 2016, High Octane Fuel Study, Biomass Scenario Model

2 – Approach (Technical)

- **Building from and customizing existing open source software to create a Government owned web-based collaboration framework for knowledge management and data visualization**
- **Using well established software development paradigms to collect user requirements and implement them in a easy to use functional application**
- **Challenges**
  - User engagement and acceptance of web-based data storage and distribution
  - Identify domain tools and data needed to extend the current state of bioenergy research

2 – Approach (Management)

- **Team Structure**
  - KDF System Development – ORNL
  - Content Management/Graphics – BCS
  - Media – BCS
- **Weekly Meetings**
  - KDF Development Team and BCS Graphics, Media, and Content Teams have weekly teleconference to track progress, discuss direction, and strategize for new capabilities
- **Quarterly Updates**
  - BETO Check-Ins: Quarterly conversations with BETO about project status, recent updates and deliverables
  - Reports: KDF Development Team summarizes progress, issues, challenges overcome, and upcoming focus in Quarterly Report
- **Collaboration**
  - Work with other labs to facilitate new capabilities

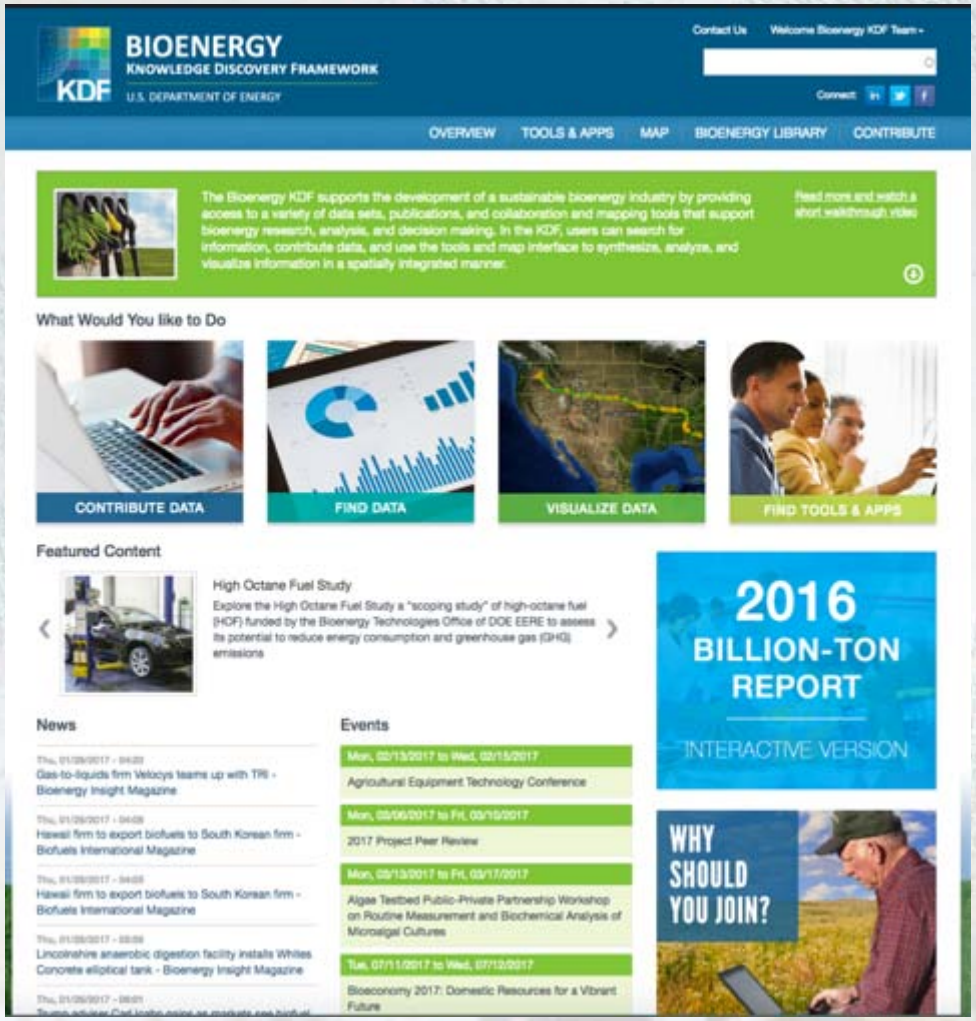
2 – Approach (Management)

- **Community Engagement**
  - Interacting with the KDF team to develop novel capabilities and ensure access to data
  - Establishment of stakeholder engagement plan and focus groups to guide technical development tasks and priorities
- **Data Access**
  - Easy access to critical bioenergy data and information
  - Most relevant data is quickly accessible
- **Challenges**
  - Information becoming stale or out of date
  - Incomplete or inaccurate metadata
  - Consistent cycle of new information to help pull users back to the KDF

3 – Technical Accomplishments

Geographic Information Science and Technology

- **Updated KDF Architecture**
  - Cloud-like Infrastructure
  - Automated Failover
  - Latest Versions of Software
  - Removed unused capabilities
  - Enhanced Usability
  - Results
    - 0 Unplanned Outages since release
    - Live deployments of updates
- **Released Nov. 2015**



3 – Technical Accomplishments

- High Octane Fuel Study
  - Updated framework for showcasing research
  - Quickly linking Fact Sheet Information with Documents in the KDF
  - New Documents automatically added via tags

High Octane Fuel Study

In vehicles designed for its use, high octane fuel blends have the potential to increase vehicle efficiency through improved knock suppression. When the high-octane blend is made with 25–40% ethanol by volume, efficiency improvements of 5–10% are sufficient to offset the reduced vehicle range often associated with the decreased volumetric energy density of the fuel (such as with flexible-fuel vehicles (FFVs) fueled with E85). The prospects for a high-octane, mid-level ethanol blend are attractive because it could be used legally in the 18 million FFVs currently on the road. Thus the current FFV fleet could provide an immediate market for the new fuel so that it is widely available as high-efficiency vehicles designed to use it are entering the market.

Project Details

The Bioenergy Technologies Office of DOE EERE has sponsored a "scoping study" to assess the potential of high-octane fuel (HOF) to assess its potential to reduce energy consumption and greenhouse gas (GHG) emissions, and to understand barriers to its successful market introduction. The goal was to provide information about the benefits of bringing this new fuel to the market, barriers to its adoption, and strategies for market introduction.

The current project, which began in late FY 2013 and culminates in early FY 2016, uses the combined expertise of Argonne National Laboratory, the National Renewable Energy Laboratory, and the Oak Ridge National Laboratory. It builds upon ongoing work at these national labs funded by DOE.

Task Descriptions

The HOF project consists of the following integrated tasks:

Efficiency Gains of HOF in Dedicated Vehicles: Quantify the fuel economy benefits of HOF at the vehicle level. Significant efficiency improvements are possible through a combination of improved engine thermal efficiency and improved system efficiency from downspeeding and downsizing.

Description of Properties for Engine Knock Resistance: Develop a description of fuel knocking resistance that considers octane numbers and heat of vaporization; include the development of methods of measuring the heat of vaporization of ethanol–gasoline blends.

Effects of HOF on Legacy FFVs: Determine the effects of high-octane gasoline blends, such as blends of gasoline with 25–40% ethanol (E25–E40) on legacy FFVs. Demonstrating a performance benefit in legacy FFVs would help in marketing ethanol blends for the legacy FFV fleet, which could bolster development of the infrastructure for fueling future vehicles specifically designed for this fuel.

Analysis of Energy and GHG Emissions and Modeling of Refinery Impacts: Conduct petroleum refinery simulations for various ethanol blending levels and HOF market shares. Evaluate the "well-to-wheels" energy and GHG effects of HOF use, accounting for vehicle efficiency gains, refinery operation changes, and the blending effects of ethanol.

Market Analysis: Identify and assess the economic, logistical, behavioral, and regulatory barriers to introducing HOF to the market and ways to address these barriers during a transition period. Stakeholders were engaged to help identify barriers and ways to overcome them and to estimate their potential impact on dedicated HOF vehicle sales and ethanol use.

Infrastructure Assessment: Work with stakeholders to assess the compatibility of mid-level ethanol blends with the existing storage and fueling infrastructure.

Evaluation of Cost Reduction Potential of HOF Blendstocks: Evaluate the potential to use natural gasoline as a low-cost blendstock for HOF.

Pertinent Findings and Outcomes

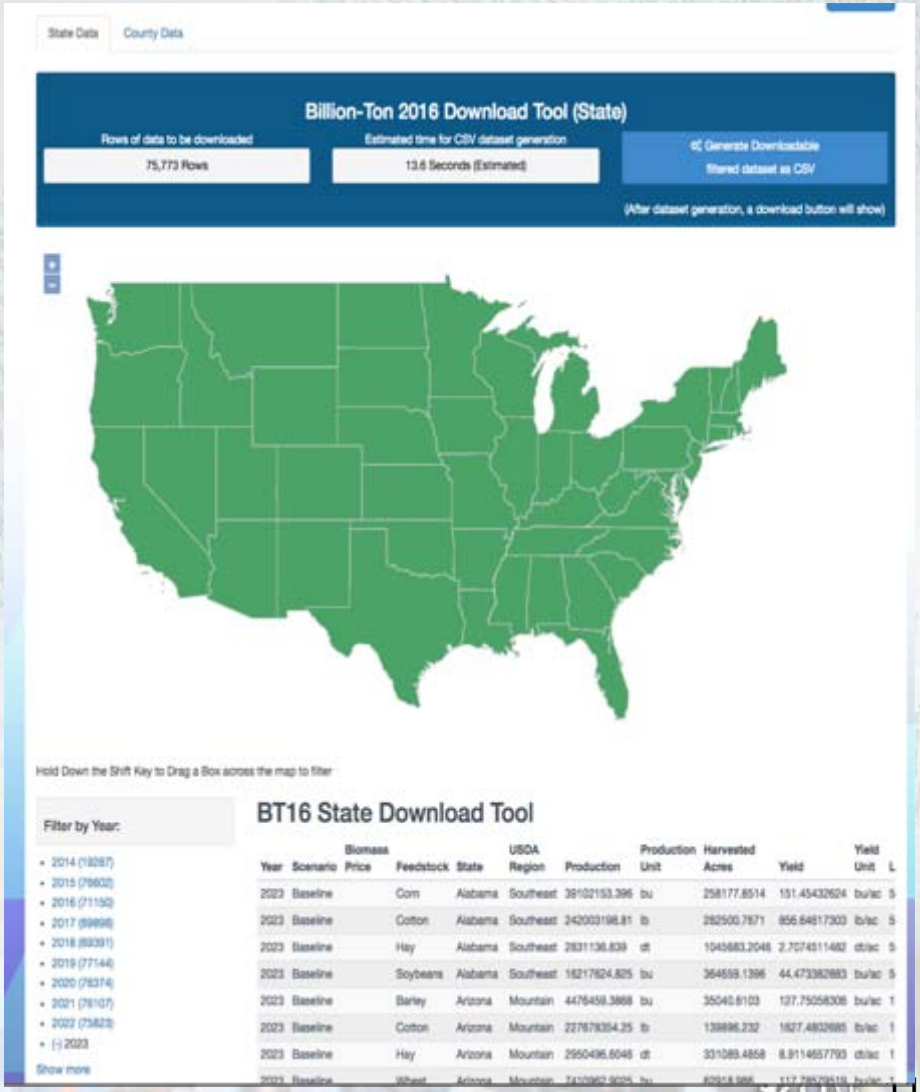
- E25 and E40 would achieve volumetric fuel economy parity with today's E10 with a 5 and 10% improvement in vehicle efficiency, respectively (i.e., fuel economy would be the same using HOF as today's vehicle using E10, and so every gallon of ethanol used in HOF would displace a full gallon of gasoline.)
- Fuel efficiency gains of up to 10% over E10 were demonstrated in vehicles with turbocharged, direct-injected engines. Operating engines in more efficient but more knock-prone conditions—through downspeeding, downsizing, and increasing the compression ratio—improves efficiency with HOF. The exact fuel economy benefit will vary depending on ultimate engine/vehicle design and driving conditions.
- Measurements of heat of vaporization of ethanol blended with a range of gasoline blendstocks, including natural gasoline, show that there is little difference between the hydrocarbon components and that the major factors affecting ethanol blend heat of vaporization are ethanol content and temperature. Research is ongoing under other DOE programs to understand how octane number and heat of vaporization interact for fuel knock resistance.
- Most legacy FFVs offer a performance benefit (i.e., improved acceleration) using HOF with no engine modifications required. This finding is a potential marketing pathway for introducing high octane mid-level blends, because they are legal to use in today's FFV fleet. For "normal driving," fuel economy using HOF was proportional to the energy density of the fuel.
- The efficiency gain of HOF overwhelmingly overtakes the potential increase in refinery GHG emissions for HOF production, resulting in net GHG reductions by HOF.
- Modeling further suggests that even under very aggressive market penetration assumptions, the availability of ethanol feedstocks does not limit the growth of the market. Fuel

3 – Technical Accomplishments

- **Billion-Ton 2016 (Released July 2016)**
  - Interactive Report to Accompany the Printed Version
  - Close Collaboration with Researchers
  - Level of Effort
    - 3 developers for 3 months
  - Accessing 80 Million Records of Data in Seconds
  - Embedding of Tableau Visualizations
    - Taking advantage of existing capabilities
  - Updated Map and Download Tools
    - backported for BTU for consistency

3 – Technical Accomplishments

- **Billion-Ton 2016 Download Tools**
  - Quickly Filter to Desired Dataset
  - Combine Multiple Scenarios, Feedstocks, Prices, and Years
  - Filter by USDA Region
  - Download of Millions of Records
    - BTU Capability Limited to 300K
  - Downloads Include Citations and Metadata
  - Visualize Coverage of Selection



3 – Technical Accomplishments

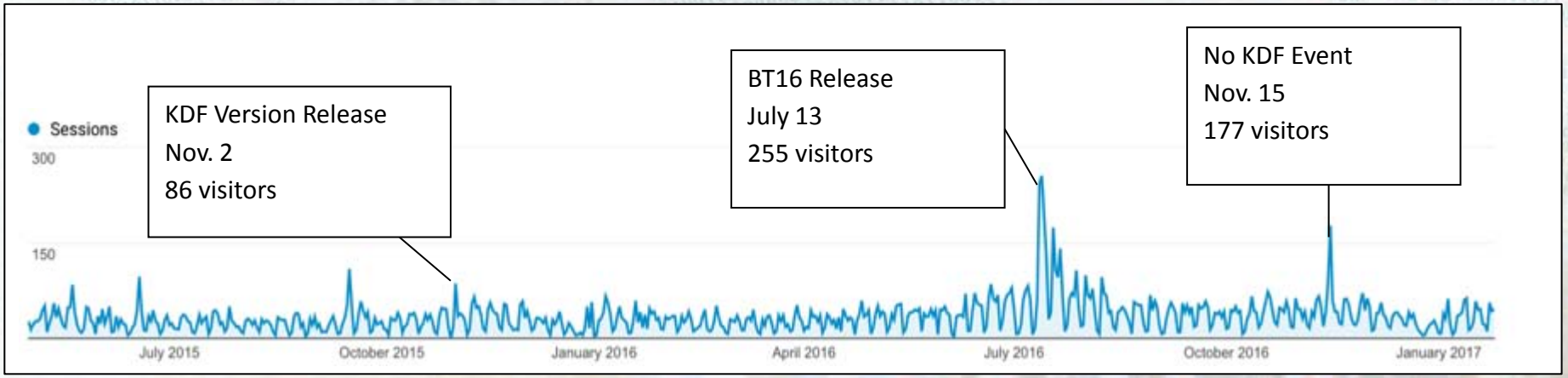
- **Billion-Ton 2016 Vol. 2 (Initial Release)**
  - Released Jan. 2017
  - Level of Effort:
    - 2 Developers, 48 Hours
  - Download Volume Chapters
  - Download Volume Data
  - Visualizations to be Completed in FY16

3 – Technical Accomplishments

- **Content Curation and Cleanup**
  - Now Occurs Annually
  - Ensure content is up-to-date and accurate
  - Reach out to PI if needed
  - Results of this effort released July 2015 and November 2016
- **Identified and corrected inaccurate metadata and non-functioning for 150 map layers and 104 documents, publications, and web links**
- **Fixing this data will help researchers find the information they seek and ensure the KDF has the best available data**
- **Removal of Legislative Library**

3 – Technical Accomplishments

- Site Analytics Review
  - KDF has a steady user base
  - Spikes in Visitors after major releases/updates with new capabilities
  - Users stay longer on the site with a purpose (ex. Exploring a new feature)
  - 39% (-5%) found the KDF from a search, 27% (-5%) went directly to home page, 32% (+8%) were referred from another site (Direct users tended to stay longer vs Referred Users in 2015)



4 – Relevance

- The fundamental objective of the KDF is to provide researchers with access to the tools, data, and information needed to help further research
- Brings together data from across the supply chain
- Helps prevent duplication of existing research
- Allows for transparent, comparable, and reproducible analysis
- Provides a mechanism for disseminating a consistent science-based message
- Technology developed and lessons learned from the KDF can be extended to other research domains within the Department of Energy

4 – Relevance

- **User Growth**
  - 1,214 users
  - Growth of 273 users since last peer review
  - Total Number reduced by removing inactive accounts
- **Community Engagement**
  - Average 100 page views/day

5 – Future Work

- **Software updates and enhancements**
  - Released regularly
  - As capabilities become production ready
- **Integration with other data repositories**
  - NREL Data API, Data.gov, DataONE, etc.
- **Biomass Resources Library data integration**
- **Facilitate release of Billion-Ton 2016 Vol 2. data and visualizations**
- **Updated/Enhanced Legislative Library to be managed on the KDF**
- **Increase Community Engagement Activities**

Summary

- **Approach**
  - Design and develop a robust, collaborative informatics framework
- **Technical Accomplishments**
  - Billion-Ton 2016
  - System Upgrades
  - Content Curation
- **Relevance**
  - Providing access to most up-to-date Bioenergy Data
- **Success Factors**
  - Most relevant publication/data are accessible
  - KDF is stable, dynamic and updated
  - Active user communities
- **Future Work**
  - Incorporate new models
  - Access to shared data/information
  - Increase Community Engagement
  - Enhanced Legislative Library

Additional Slides

Responses to Previous Reviewers' Comments

- User-Base Seems Small
  - The actual "user base" is much larger than that. We require that users who want to contribute have an account; however, if you want to view, map, query, and download data, you do not need a user account.
- The project team's clean-up of outdated and erroneous metadata inside the KDF is very a important activity (now and on-going).
  - This has been completed and has resulted in easier discovery of relevant content

Publications, Patents, Presentations, Awards, and Commercialization

- **"Bioenergy KDF: Enabling Spatiotemporal Data Synthesis and Research Collaboration"**
  - Second place for best paper at the ACM SIGSPATIAL Conference, November 4–7, 2014 in Dallas, Texas.
- **The underlying architecture developed for the Bioenergy KDF is supporting a similar capability for DOE SFWD and for Energy-Water Nexus KDF**