Science and Technology for the Energy Challenge: National Bioenergy Knowledge Discovery Framework

Presented to the Technical Advisory Committee
Biomass Research and Development Board

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Geographic Information Science and Technology

June 2, 2009
Washington, DC
Initiative Background

- **Project started in FY08**
  - To facilitate information sharing among DOE/OBP funded national laboratories for feedstock research

- **Project expanded in FY09**
  - To address cross platform collaboration in OBP
    - Distribution infrastructure platform

- **Expanding stakeholder community**
  - Other federal agencies
  - State and local governments
  - Private sector

- **Market Challenges**
  - Feedstock Production, Assembly, and Integration
  - Resource Availability and Cost
  - Sustainable Production
  - Feedstock Transport
  - Lack of Biofuels Distribution Infrastructure
  - Availability of Biofuels-Compatible Vehicles
  - Industry and Consumer Acceptance and Awareness

- **Partnerships**
  - National Laboratories
  - Sun Grant Institutes
  - Government agencies
  - Governors Ethanol Coalition
  - Industry
Bioenergy Infrastructure Description

- The physical and socioeconomic components and their interconnections of a bioresource driven supply-chain network that sustains the reliable generation and delivery of energy to the nation.
Guidance for Analysis and Decisions

- What models are available for siting biorefineries?
  - Community models available?

- Which model should I choose and why?
  - Appropriate spatial and temporal scales?

- How do I find data to support the model(s)?
  - Quality assurance for data? Currency?

- How do I validate my results?
  - Model output meaningful? Reasons for difference?

- Has this been done already?
  - Publications exist? Lessons learnt?

- Who else is interested? Who can help?
  - SME database? Services available?
Shared Environment for Collaboration

**Discover**
- Managed knowledge base
- Catalog services
- Data exploration/analytics
- Notification services
- Browse & search function

**Acquire**
- Data acquisition services
- Data modeling
- Data archives
- Geodata services

**Share**
- Data publish and subscribe
- Metadata authoring tools
- Community building tools
- Feedback mechanisms

**Use / Create**
- Visualization tools
- Decision support tools
- Forecasts and models
- Support for interoperability
Conceptual Design of the KDF

Federal Sector

Interactive and Interoperable Visualization

Development of High Performance, Scalable Simulations

Development and Assimilation of Bioenergy Grid and Infrastructure Analysis Models and Tools

Knowledgebase Creation

Dynamic Collection, Integration, Management, and Dissemination of Disparate Data Resources

Private Sector

Private Citizens

State and Local Sector
Benefits to Stakeholder Communities

- Web-enabled and interactive access
- Role-based user levels to allow access to most relevant content
- Ability to selectively share (upload and download) data and information
- Dynamic analysis and exploration

- Easy information access to current status of bioenergy in the US and the world
- Provides easy access to best available and authoritative data, models, and tools
- Incorporate models for environmental, economic and social impact analysis
- Allows communication, collaboration, and synchronization of efforts
- Defining where research or demonstration funds should be targeted
- Analysis, synthesis, and visualization for informed decision making
- Improve public awareness, education, and outreach
Bioenergy Knowledge Discovery Framework

Goal:
- Provide analytical and visualization capabilities for efficient planning, development, and management of the US bioenergy infrastructure.
- Allow analysis, synthesis, and visualization of data that facilitates informed decision making.

Strategy:
- Design and develop a robust geospatial technology framework that
  - Offers guidance and access to comprehensive data, modeling, and visualization resources
  - Standards based

Benefit:
- Provide ready access to status of bioenergy in the US
- Distribute data needed for assessments
- Support emerging bioindustry by providing an integrative perspective
- Support policymaking by visualizing the outcomes of proposed policies
- Defining where research or demonstration funds should be targeted
- Foster education and outreach

Outcome: A national decision support framework for addressing the overall sustainability and security of bioenergy infrastructure
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Success Factors and Challenges

• Integrated access, analysis, and visualization of data for decision support
  – Serve a critical need for the evolving industry
  – Ease of use through Internet and Browser based Interface
  – Ability to share data and analytical results across platforms

• Rapid increase in user community and their priorities must be addressed systematically
  – Diverse and competing programmatic priorities
  – Increasing user access and appropriate selection of technology, security, and role based access strategy
  – Data sharing agreements among partners
Strategic Opportunity

Bioenergy KDF strategically positions DOE to be a key player

Biomass R&D Board Actions
The Board will establish an interagency working group led by DOT to study and make recommendations to the Board by October 2008 on the following issues:

- Feasibility of pipeline use for biofuels transport, including facilitation of the necessary interagency collaboration on standards development.
- Liquid fuel flows over infrastructure, including pipelines, rail, barge and truck transportation to identify short and long-term infrastructure bottlenecks that will inhibit biofuels development.
- Integration of Geographic Information System (GIS) based tools housed at agencies such as DOT, USDA, EPA, and DOE in order to begin to link transportation infrastructure, demand, feedstock location, as well as water and other resources.
Future Work

- **Based on stakeholder input, continue integration of data, models, and tools**
  - Identify, collect, and integrate prioritized list of databases and models
  - Create and maintain a benchmark LULC data model and database; and a national multi-modal transportation dataset for biofuels
  - Develop data analysis, synthesis, and visualization functions (tools)

- **Continue developing the architectural design**
  - Implement access, security, and reliability protocols
  - Develop and implement data update and maintenance strategies and tools

- **Design, develop specific Knowledge Discovery (KD) tools**
  - Textual analysis and visualization of dynamic information sources and compiled knowledge bases

- **Outreach**
  - Identify and support user/stakeholder communities
  - Coordinate with other agency efforts
  - Raise awareness through demonstrations, publications, and presentations
The National Bioenergy Knowledge Discovery Framework

Budhendra Bhaduri
Daniel Getman
Oak Ridge National Laboratory

DOE Biomass Program
Feedstock Platform Review
April 8-10, 2009
Overview

Timeline
- Project Start Date: FY08
- Project End Date: Continuing
- Percent Complete: 15%

Budget
- Funding received in FY08
  - $400K
- Funding for FY09
  - $925K

Stage
- Preliminary Investigation

Barriers
- Feedstock Production, Assembly, and Integration
  - Resource Availability and Cost
  - Sustainable Production
  - Feedstock Transport

Partners
- INL, ANL, PNNL, NREL
- Sun Grant Initiative
- USDA, DOT
- Governors Ethanol Coalition
Goal: Develop Capabilities for Bioenergy Infrastructure Modeling and Analysis

- **User requirement analysis**
  - Assessing the needs for data and analysis functionalities of DOE and other agencies

- **Design a scalable system architecture**
  - Design a secure, reliable system for wide adoptability and usage

- **Efficient biomass resource assessment**
  - Evaluate data resources
  - Develop GIS based analytical approaches for resource assessment and sustainable production

- **Optimizing geospatial data and models**
  - Develop data categorization and organization
  - Optimal transport of biomass and biofuel

- **Development of KDF interface**
  - Develop user friendly and interactive interface for data integration, analysis, synthesis, and visualization

- **Develop comprehensive data and modeling resources**
  - Gather information across the bioenergy community

- **Develop knowledgebase of previous R&D**
  - Strategies for resource allocation
FY09 Tasks

- **User requirement analysis**
  - Assessing the needs for data and analysis functionalities of DOE, USDA, DOT, and EPA

- **Design a scalable system architecture**
  - Document the evolving design of a secure, reliable, system for wide adoptability and usage

- **Evaluate LULC data resources for suitability of biomass assessment**
  - Assess availability and extents of global, continental, and regional databases
  - Analyze and evaluate data attributes (spatial and temporal resolutions, currency, and categorization)

- **Optimizing geospatial data and models**
  - Develop data categorization and organization for feedstock and other platforms
  - Collect and integrate biomass and distribution infrastructure data
  - Integration of features and attribute enrichment for biomass and biofuel distribution infrastructure for capacity assessment and routing analysis

- **Development of KDF interface**
  - Develop user friendly and interactive interface for data integration, analysis, synthesis, and visualization
  - Collect and integrate biomass supply curves and SGI field trial data
  - Implement security and reliability controls
  - Test, demonstrate, and solicit feedback on evolving functionalities for spiral development

- **Develop comprehensive data and modeling resources**
  - Develop and implement an interface to ingest information across the various national laboratories
  - Implement a simple key word and platform based query functionality

- **Develop knowledgebase of previous R&D**
  - Develop a data model for previous research outcome database
  - Develop and implement an interface to ingest information across the various national laboratories
  - Implement a simple key word based query functionality
LULC Data: Comparison of Cropland Areas

- Ag Census 2002
- National Land Cover Database-2001
- Global Land Cover -2000
- GlobCover-2006
- MODIS Land Cover-MOD12Q1-2001
- MODIS Land Cover-MCD12Q1-2001

Area - 000'Km2

- Kansas
- Iowa
- Texas
- North Dakota
- Illinois
- Minnesota
- Nebraska
- South Dakota
- Montana
- Missouri
Bioenergy: Misaligned Data and Modeling Approaches

IBSAL INPUT

- Temperature
- Snow
- Humidity
- Evaporation
- Precipitation

Weather

- Weekly Harvest Progress

Harvest

- Tonnage
- Temperature
- Distance
- Storage Capacity
- Moisture

Transport

- Landuse
- Farm Size
- Location
- Temperature
- Yield
- Winding factor

Farm

- Equipment Specifications
- Cost of Equipment Used

Equipment

Bioenergy Models

Feedstock Production

Feedstock Logistics

Biofuel Production

Biofuel Distribution

Biofuel Enduse

Feedstock Harvesting and Preprocessing

Feedstock Transportation

Conversion to Ethanol

Distribution from Biorefineries to Blending Facilities

Ethanol Blending with Gasoline

Distribution to Retail Outlets

Retail Outlet Location

Enduse of E10 and E85

POLYSYS
ORIBAS
GREET
IBSAL

IBSAL
IGEM
MARKAL
EPA NonCO2

ORIBAS
IBSAL
APAMISAM
FASIM-DH

MPLP Ethanol
ORIBAS
GREET
APAMISAM

MPLP Ethanol
INSLA
APAMISAM
Biorefinery Siting

GREET
APAMISAM
Hydrogen Station Locator

IGEM

GREET
HYDRA
VOLPE
MOVES
SGM
Functional Design of the KDF

- **Supercomputing Analysis**
  - (custom code and very customized data processing software)

- **Collaborative and Individual Research and Analysis**
  - (complex application specific interfaces)

- **Server Side Processing**
  - (custom code and very customized data processing software)

- **Geospatial Data Visualization Framework**
  - Designed to integrate research and analysis efforts
  - Traditional geospatial data visualization framework

- **DOE Bioenergy Data Management**

- **Other Related Data Management**

- **Research and Analysis Component**
  - Easily integrates with mapping component
  - Easily adapts to many application connections

- **Mapping Component**
  - Map Exploration (GES)
  - Baseline Data
  - Predefined Views
  - Tabular and Spatial Queries
  - Many Disparate Data

- **Variety of Data Providers**

- **Variety of Data Consumers**
Goal: Develop Capabilities for Biofuel Infrastructure Modeling and Analysis

- Multimodal freight analysis from state to regional scales
  - Assessing capacity, congestion, delay

- Multimodal routing analysis from local to national scales
  - Assessing distance, time, and risk of transport; contingency analysis

- Socioeconomic characterization through high resolution data modeling and simulation
  - Assessing feasibility of deployment and potential demand
FY09 Tasks: Infrastructure Platform

- Development and Integration of Features and Attribute Enrichment for Biofuel Distribution Infrastructure for Routing Analysis
  - Collection of infrastructure data on biofuels production locations, transportation networks, transfer and storage locations, as well as blending facilities
  - Leverage DOE investments in Transportation Routing Analysis GIS (TRAGIS) modeling platform

- Capacity Analysis for Ethanol Transport
  - Develop capacity assessment model for transportation scenarios

- Integration of National Infrastructure Databases for Analysis and Visualization
  - Identify and integrate transportation and socioeconomic data
Future Work

- **Data integration at sub-county level**
  - Extend high resolution data modeling and integration to other representative states and counties.
  - Develop infrastructure data analysis and visualization tools based on stakeholder input.

- **Continue Developing the National Multi-modal Biofuels Transportation Network**
  - Create and maintain a benchmark multi-modal transportation dataset for biofuels
  - Integration of import/export traffic of biofuels through U.S. ports.
  - Expansion of the database and model to accommodate cellulosic sources and transportation analyses.

- **Expand the capacity analysis to other U.S. regions.**
  - Create available capacity database for the national network
  - Integrate capacity analysis with routing analysis model