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

Presented to the
Technical Advisory Committee
Biomass Research and Development Board

Budhendra Bhaduri
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
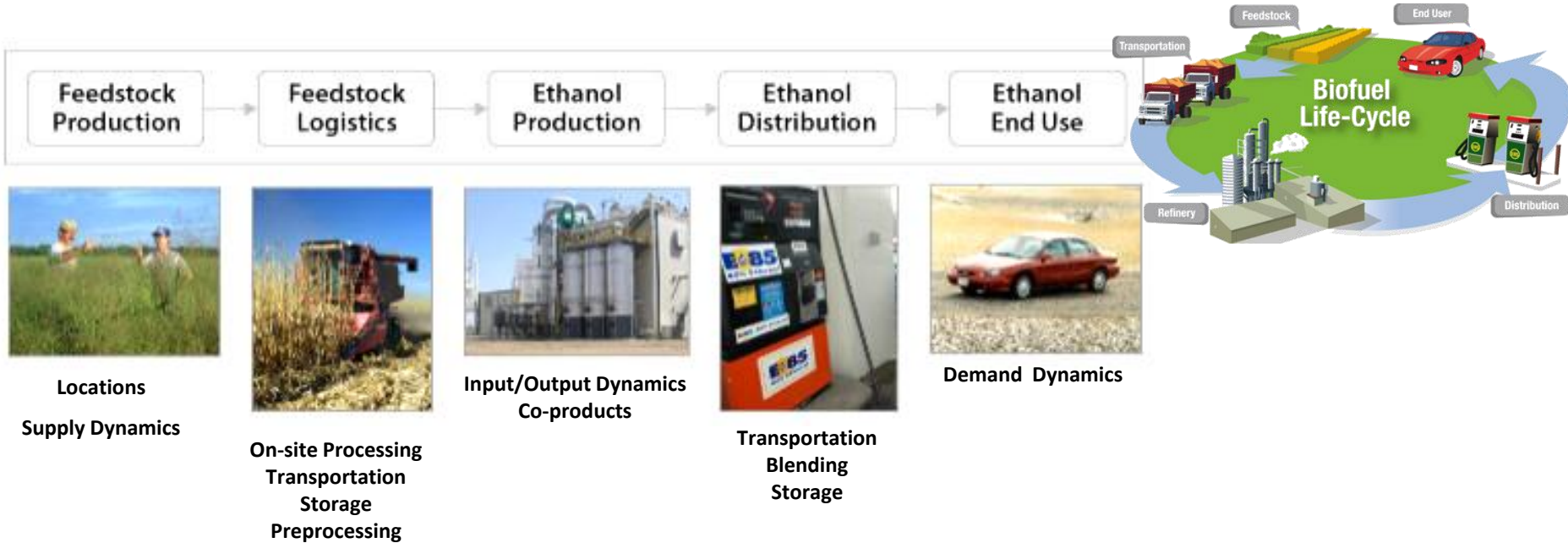 - Industry and Consumer Acceptance and Awareness

- **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**


Feedstock Production	→	Feedstock Logistics	→	Ethanol Production	→	Ethanol Distribution	→	Ethanol End Use

Biofuel Life-Cycle

Feedstock · Transportation · End User · Refinery · Distribution

Locations
Supply Dynamics

On-site Processing
Transportation
Storage
Preprocessing

Input/Output Dynamics
Co-products

Transportation
Blending
Storage

Demand Dynamics

Bioenergy (Ethanol) Infrastructure

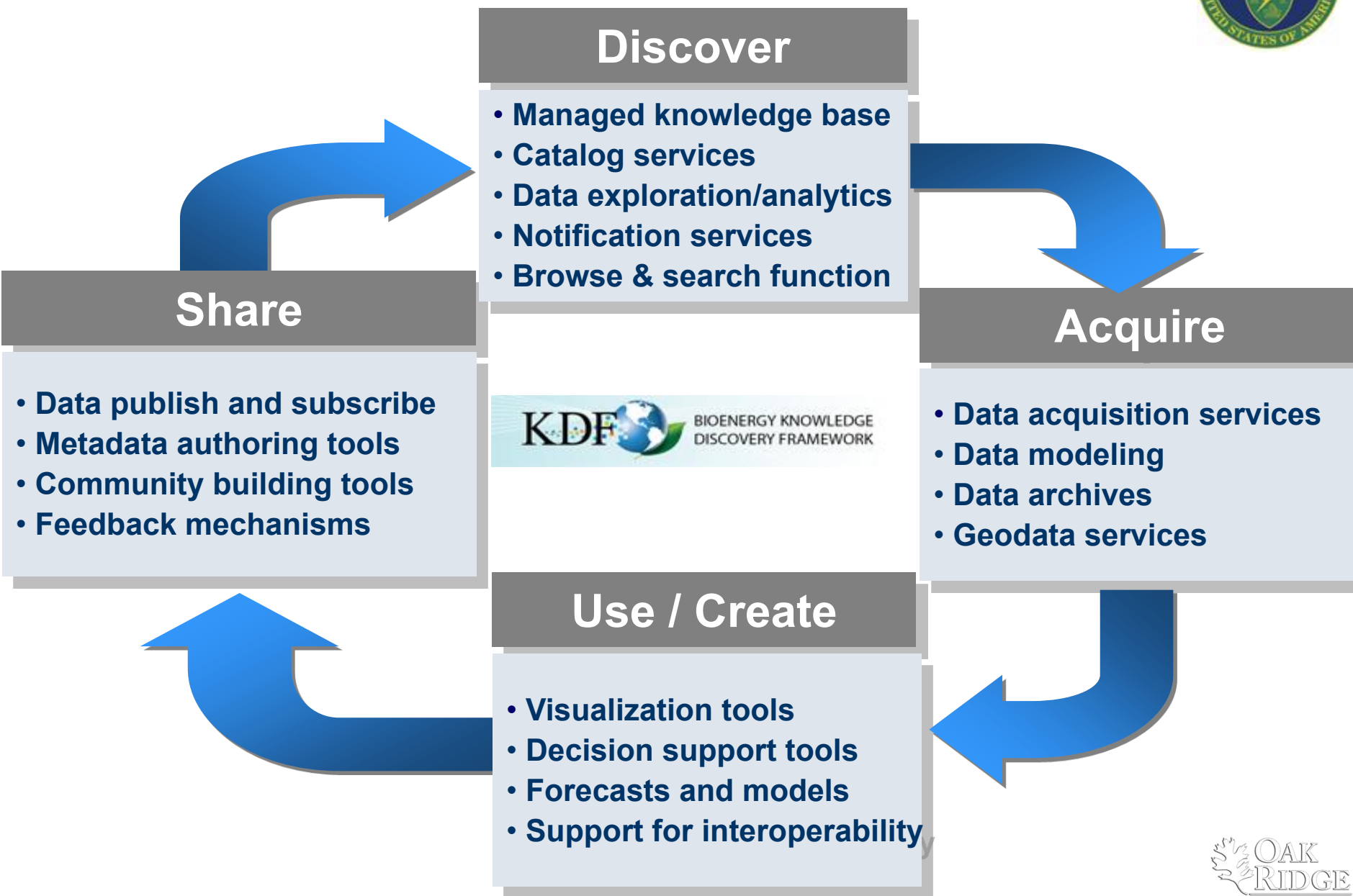**Ethanol Distribution Infrastructure**

OAK RIDGE National Laboratory
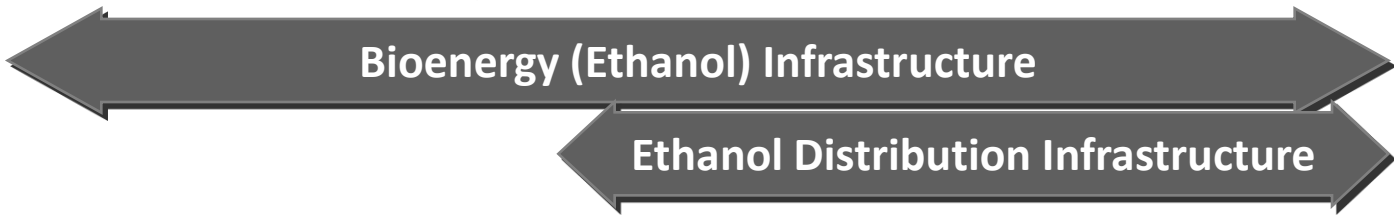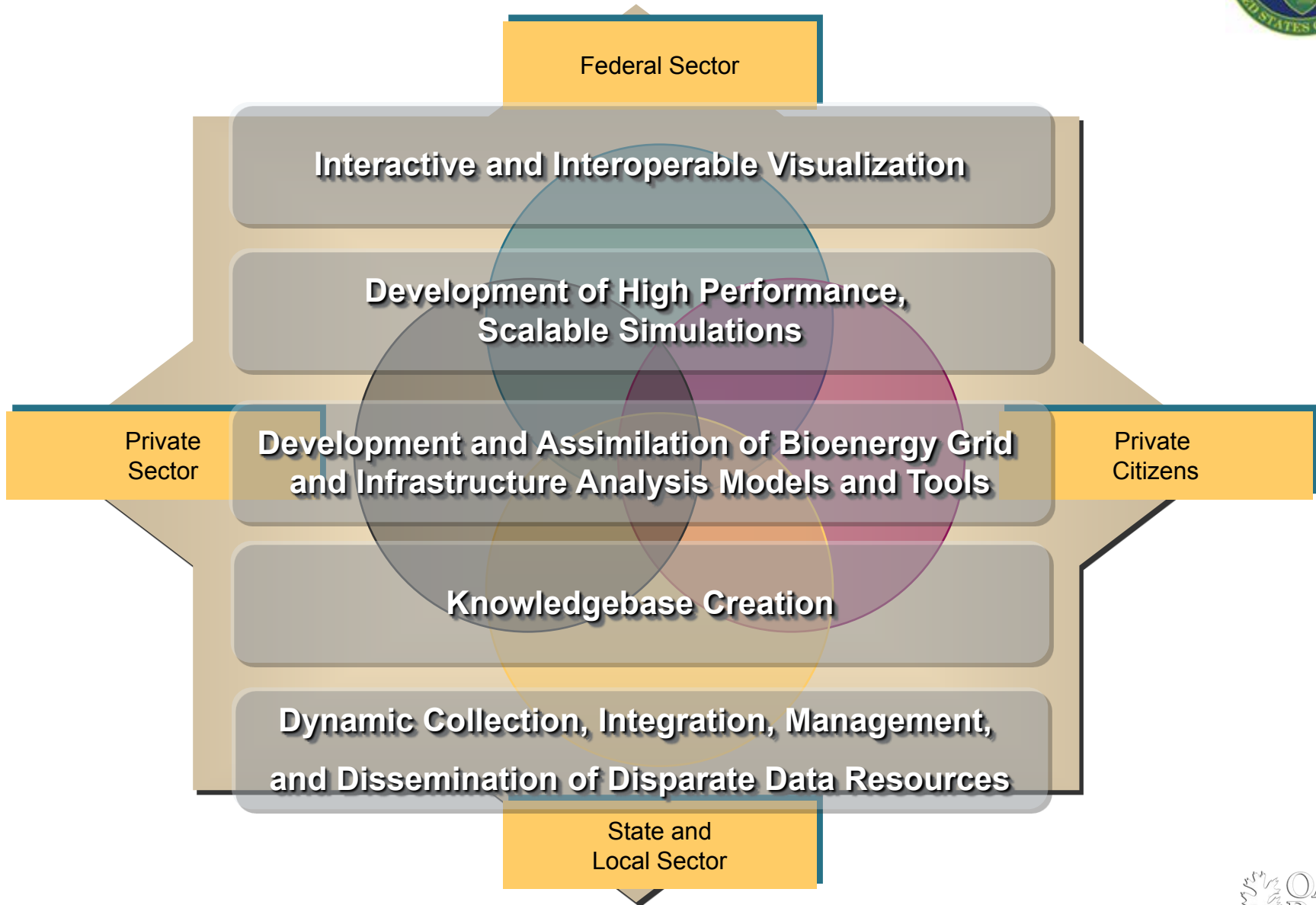
Guidance for Analysis and Decisions

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

- **Which model should I chose 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?
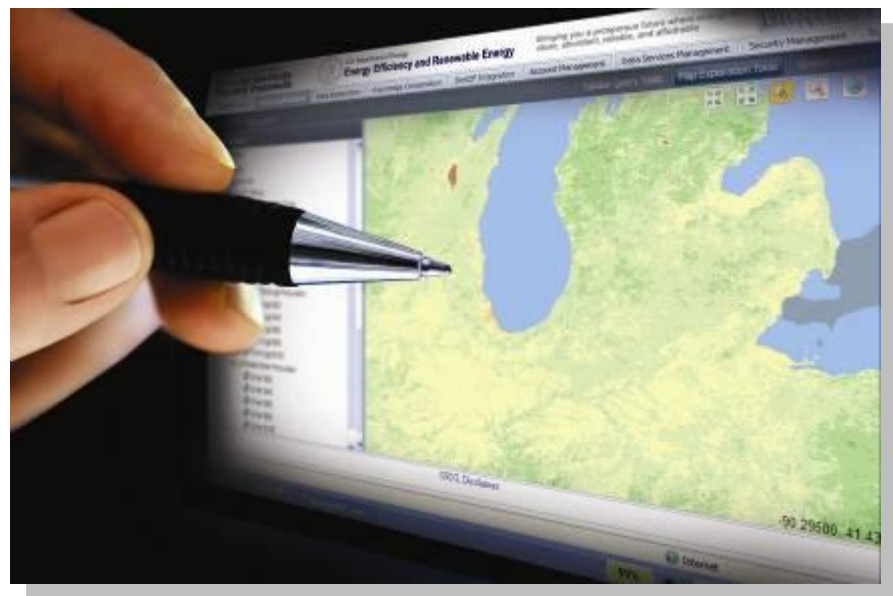
Shared Environment for Collaboration

Discover

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

Share

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

KDF BIOENERGY KNOWLEDGE DISCOVERY FRAMEWORK

Acquire

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

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

Private Sector

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

Private Citizens

Knowledgebase Creation

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

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

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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.**


Biofuel Life-Cycle

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

Federal Sector

Interactive and Interoperable Visualization

Development of High Performance, Scalable Simulations

Private Sector

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

Private Citizens

Knowledgebase Creation

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

State and Local Sector

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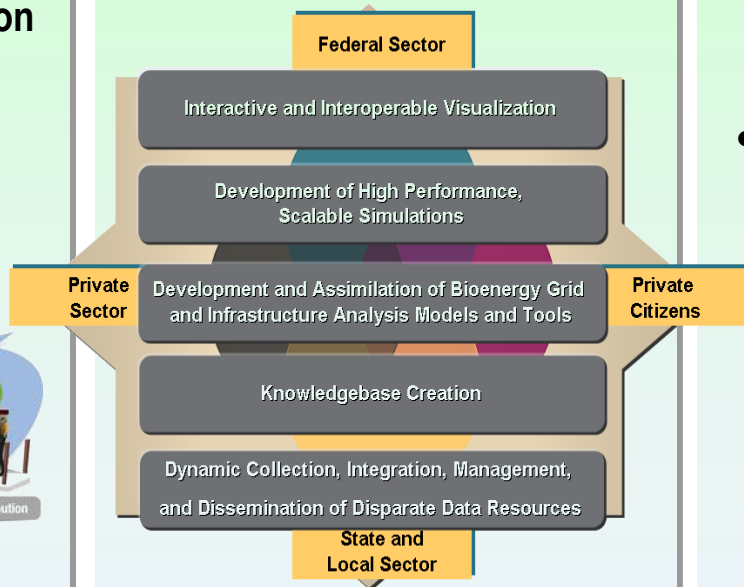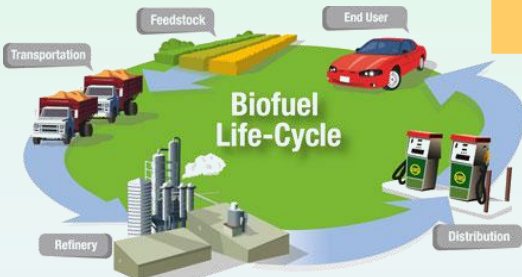
Outcome: A national decision support framework for addressing the overall sustainability and security of bioenergy infrastructure

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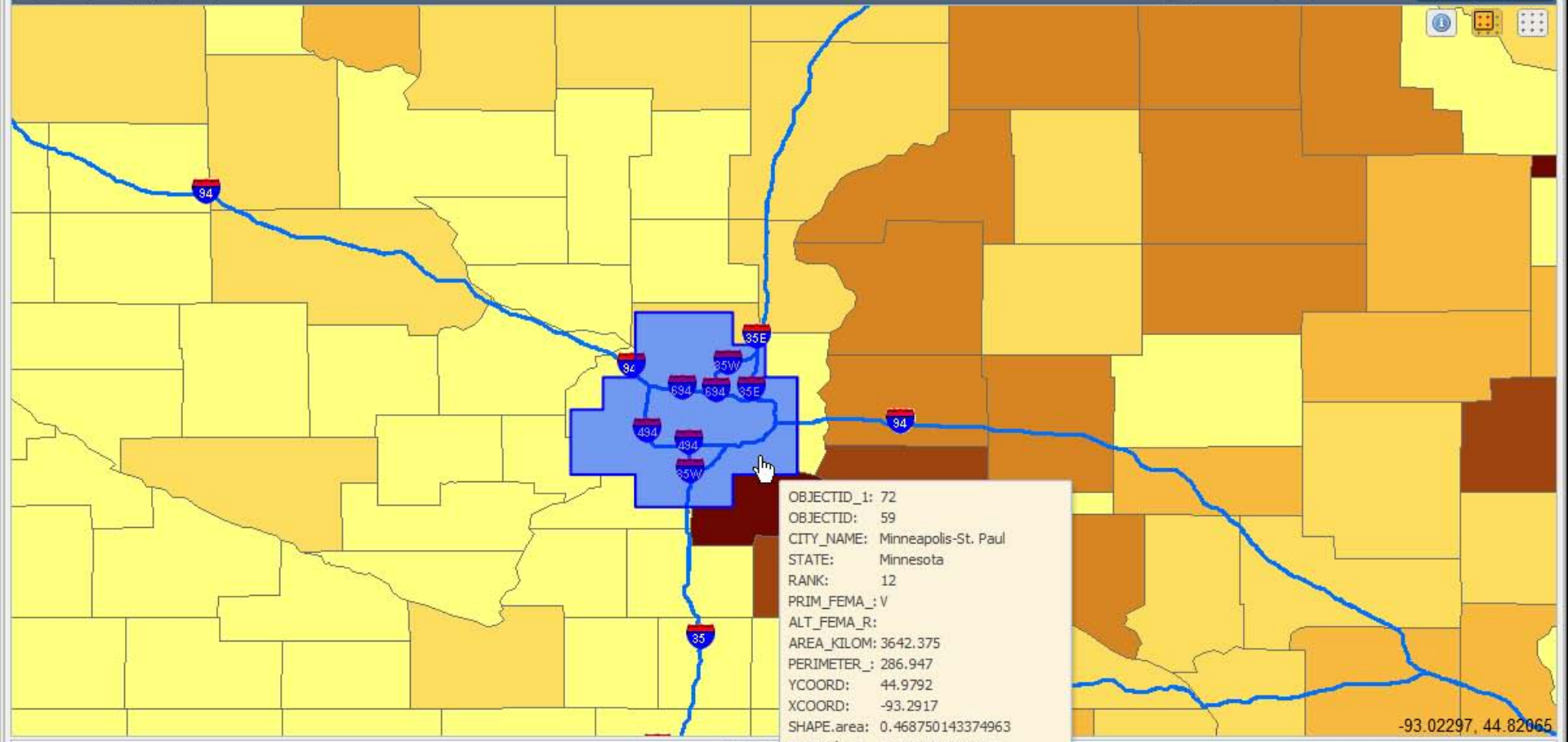
Bioenergy KDF

KDF — BIOENERGY KNOWLEDGE DISCOVERY FRAMEWORK

U.S. Department of Energy
Energy Efficiency and **Renewable Energy**
Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable

Biomass

| BioKDF Home | Knowledge Compendium | Data Exploration | Map Exploration | SGI Data Management | BioKDF Integration | Account Management | Data Services Management | Security Management | System Ma |

Display Legend | Display Data   Tabular Query Tools | Map Exploration Tools | Spatial Query Tools

DataDisplay

NAME	STATE NAME	STATE FIPS	CNTY FIPS	FIPS	fcode	commcode	production	producti 1	price
Washburn	Wisconsin	55	129	55129	55129	LOGO	8163.2	ton-dry	60
Sawyer	Wisconsin	55	113	55113	55113	LOGO	31321.8	ton-dry	60
Barron	Wisconsin	55	005	55005	55005	LOGO	4259	ton-dry	60
Rusk	Wisconsin	55	107	55107	55107	LOGO	28092.4	ton-dry	60
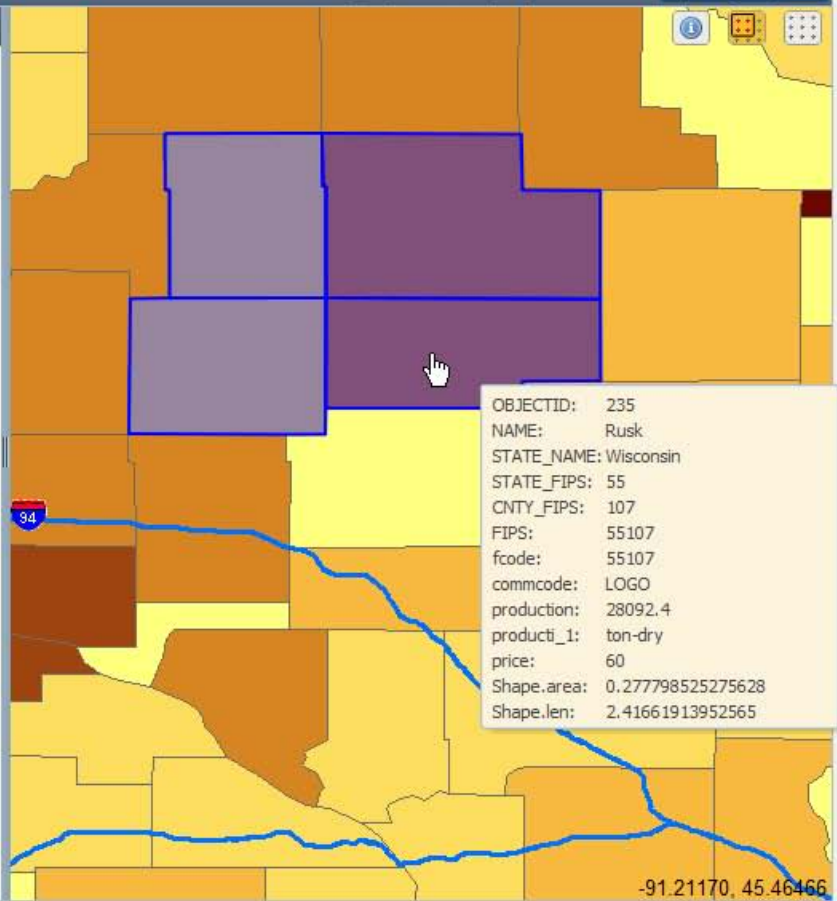
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STATE_NAME: Wisconsin
STATE_FIPS: 55
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commcode: LOGO
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Bioenergy KDF   ×

KDF BIOENERGY KNOWLEDGE DISCOVERY FRAMEWORK

U.S. Department of Energy
Energy Efficiency and Renewable Energy
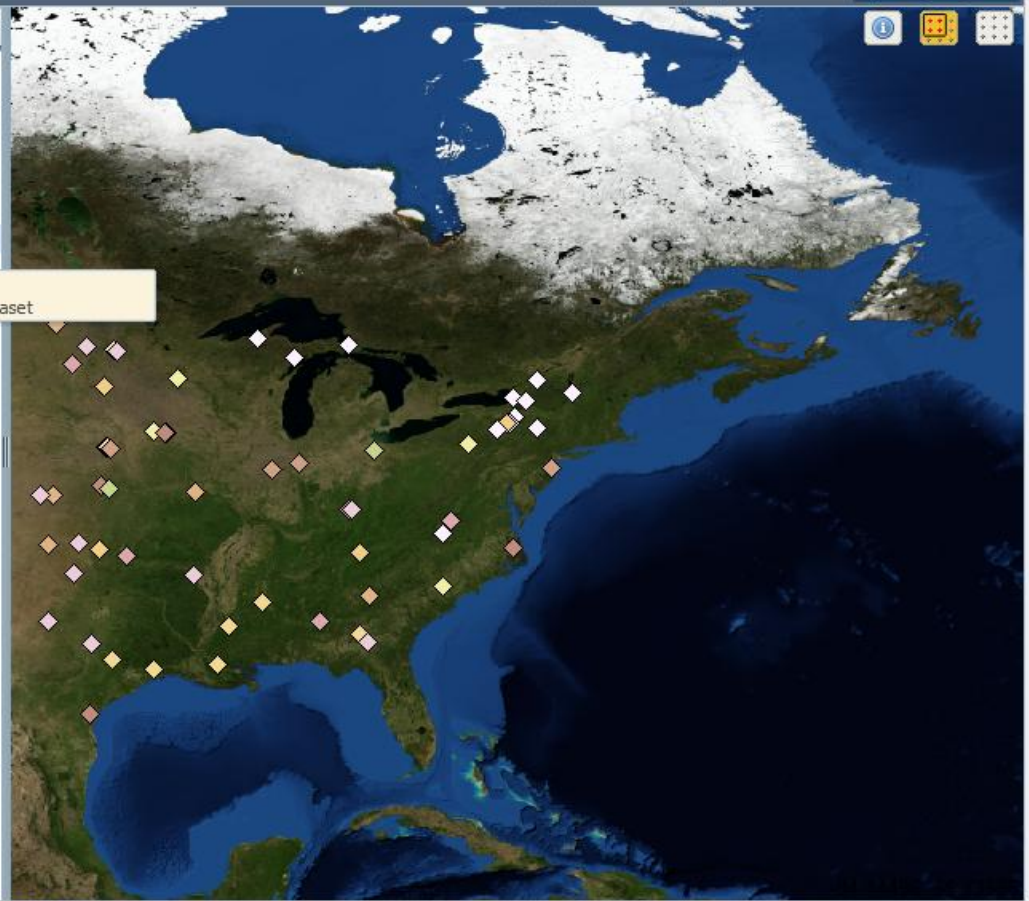Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable

Biomass

| BioKDF Home | Knowledge Compendium | Data Exploration | **Map Exploration** | SGI Data Management | BioKDF Integration | Account Management | Data Services Management | Security Management | System Ma |

Display Legend   Display Data   Tabular Query Tools   Map Exploration Tools   Spatial Query Tools

DataDisplay

ID	CROP	LAT	LONG	LOCATION	PMC NO	PI	ORGAN
62	Wheat	36.12126	-97.06757	Stillwater, OK	GFO-07-135-56	Gregory, Mark	Oklahoma State U
65	Switchgrass	35.74247	-95.63951	Bixby, OK	GFO-07-135-01	Farris, Rodney	Oklahoma State

OBJECTID: 62
ID: 62
CROP: Wheat
LAT: 36.12126
LONG: -97.06757
LOCATION: Stillwater, OK
PMC_NO: GFO-07-135-56
PI: Gregory, Mark
ORGAN: Oklahoma State University
Link: Composition Link

-97.06311, 36.12656

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	Wheat sample	Glucan Mean	Xylan Mean	Galactan Mean	Arabinan Mean	Mannan Mean	Klason_Lignin	Acid_soluble_lignin	Ash	Acetic_Acid	C6_Sugars
1	G-6d	0.3466	0.1893	0.0099	0.0279	0.0080	0.2071	0.0115	0.0841	0.0451	0.3645
2	G-2d	0.3351	0.1824	0.0095	0.0265	0.0069	0.2051	0.0125	0.0900	0.0394	0.3515
3	G-5g	0.3457	0.1932	0.0094	0.0272	0.0053	0.1821	0.0118	0.0752	0.0363	0.3604
4	G-2c	0.3363	0.1822	0.0091	0.0261	0.0059	0.2051	0.0143	0.0734	0.0410	0.3513
5	G-5a	0.3233	0.1860	0.0119	0.0273	0.0074	0.2361	0.0126	0.0887	0.0352	0.3426
6	G-5e	0.3325	0.1850	0.0105	0.0267	0.0041	0.2141	0.0128	0.0874	0.0402	0.3471
7	G-2b	0.3316	0.1815	0.0047	0.0251	0.0050	0.2275	0.0172	0.0786	0.0344	0.3414
8	G-2a	0.3338	0.1843	0.0108	0.0278	0.0061	0.2059	0.0102	0.0759	0.0410	0.3508
9	G-5h	0.3413	0.1844	0.0107	0.0244	0.0050	0.1999	0.0100	0.0663	0.0390	0.3570
10	G-2e	0.3324	0.1861	0.0141	0.0269	0.0057	0.2194	0.0101	0.0869	0.0354	0.3523
11	GGB-b	0.3578	0.1928	0.0120	0.0277	0.0064	0.1869	0.0113	0.0868	0.0425	0.3762
12	G-6b	0.3569	0.2004	0.0130	0.0293	0.0058	0.2071	0.0157	0.0729	0.0496	0.3757
13	G-2h	0.3339	0.1766	0.0155	0.0246	0.0052	0.2178	0.0102	0.0874	0.0326	0.3546
14	GGB-e	0.3346	0.1835	0.0119	0.0260	0.0048	0.1885	0.0127	0.0972	0.0305	0.3514
15	G-7c	0.3336	0.1850	0.0079	0.0288	0.0047	0.1942	0.0119	0.0997	0.0354	0.3463
16	G-6f	0.3298	0.1900	0.0092	0.0274	0.0057	0.1950	0.0144	0.0976	0.0324	0.3446
17	G-6e	0.3352	0.1921	0.0092	0.0269	0.0047	0.1911	0.0149	0.0932	0.0394	0.3491
18	GGB-c	0.3611	0.1950	0.0096	0.0278	0.0059	0.1937	0.0161	0.0668	0.0424	0.3766
19	GGB-h	0.3524	0.1958	0.0106	0.0307	0.0061	0.1761	0.0155	0.0888	0.0410	0.3691
20	GGB-f	0.3629	0.1990	0.0107	0.0306	0.0057	0.1864	0.0170	0.1213	0.0401	0.3794
21	GGB-a	0.3305	0.1852	0.0113	0.0290	0.0055	0.1816	0.0183	0.0647	0.0358	0.3473
	Maximum	0.3629	0.2004	0.0155	0.0307	0.0080	0.2361	0.0183	0.1213	0.0496	0.3794
	Minimum	0.3233	0.1766	0.0047	0.0244	0.0041	0.1761	0.0100	0.0647	0.0305	0.3414
	Average	0.3403	0.1881	0.0105	0.0274	0.0057	0.2010	0.0134	0.0849	0.0385	0.3566
	Std Dev	0.0116	0.0062	0.0022	0.0017	0.0009	0.0158	0.0026	0.0134	0.0046	0.0121

Sheet tabs: Combined / Glucan / Xylan / Galactan / Arabinan / Mannan / Others / 1-14 / 15-21 / Sheet2

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Bioenergy KDF

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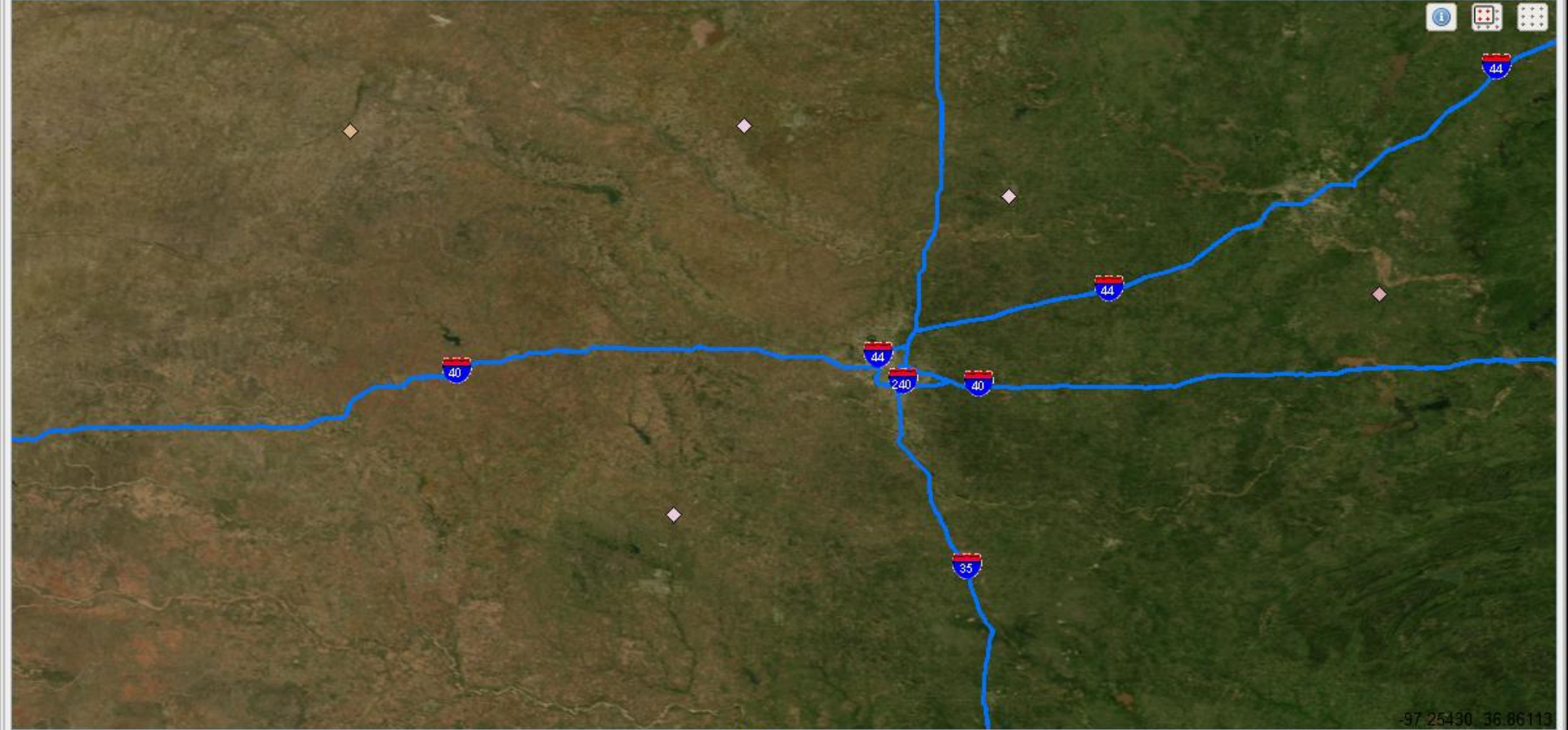
U.S. Department of Energy
Energy Efficiency and Renewable Energy
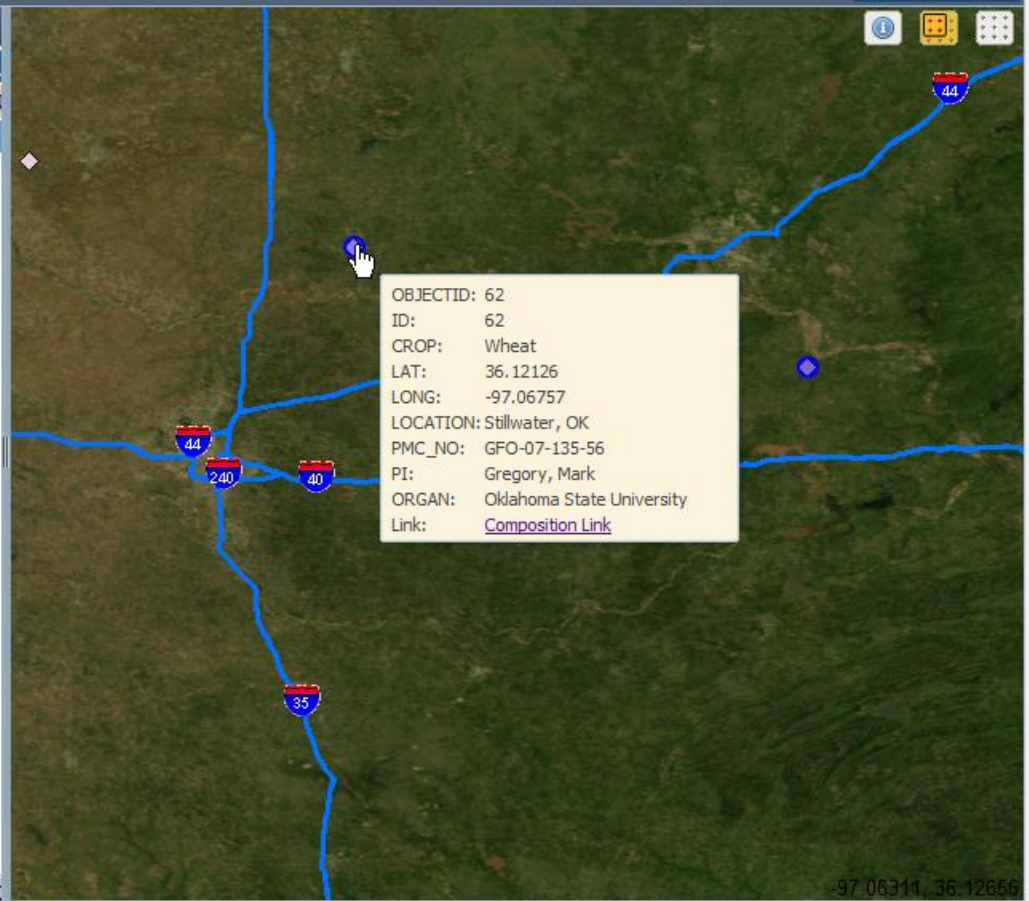Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable

Biomass

| BioKDF Home | Map Exploration | Data Exploration | Knowledge Compendium | BioKDF Integration | SGI Data Management | Account Management | Data Services Management | Security Management | System Man |

SGI Data

Organization	PMC Number	Principle Investigato	Experiment ID	Contact Person	Email Address	Institution Address	Institution City	In
⊟ **Organization: Auburn University**								
Auburn University	NA	David Bransby	NA	David Bransby	bransdi@auburn.ec	224 Funchess Hall	Auburn	
Auburn University	NA	David Bransby	NA	Don Viands	bransdi@auburn.ec	224 Funchess Hall	Auburn	
⊟ **Organization: Clemson University & USDA ARS**								
Clemson University	NA	James Frederick & .	NA	James Frederick	jfrdrck@clemson.ec	Pee Dee Research	Florence	
⊟ **Organization: Cornell University**								
Cornell University	NA	Don Viands	NA	John Fike	-9999	155 Roberts Hall Cc	Ithaca	
⊟ **Organization: Institution**								
Institution	NA	PI	NA	NA	NA	NA	Corvallis	
Institution	NA	PI	NA	NA	NA	NA	Hallock	
⊟ **Organization: Iowa State University**								
Iowa State Univers	NA	Doug Karlen	NA	NA	Doug.Karlen@ars.t	314 National Soil Til	Ames	
Iowa State Univers	NA	Ken Moore	NA	Ken Moore	kjmoore@iastate.ec	1571 Agron Ames I	Ames	
⊟ **Organization: Kansas State University**								
Kansas State Unive	NA	Keith Harmony	NA	Keith Harmoney	kharmone@ksu.edu	NA	Hays	
Kansas State Unive	NA	Scott Staggenborg	NA	Scott Staggenborg	staggen@k-state.e	NA	Manhattan	
⊟ **Organization: Louisiana State University**								
Louisiana State Uni	NA	Kenneth Gravois	NA	Kenneth Gravois	kgravois@agcenter	NA	St. Gabriel	
⊟ **Organization: Mississippi State University**								
Mississippi State Ur	NA	Brian Baldwin	NA	Brian Baldwin	bbaldwin@pss.mss	Dept. of Plant & Soi	Starkville	
Mississippi State Ur	NA	Jimmy Ray Parish	NA	Jimmy Ray Parish	-9999	Dept. of Plant & Soi	Raymond	
Mississippi State Ur	NA	Bisoondat Macoon	NA	Bisoondat Macoon	bmacoon@ra.mssti	1320 Seven Spring	Starkville	
⊟ **Organization: Montana State University**								
Montana State Univ	NA	Chengci Chen	NA	Chengci Chen	cchen@montana.ec	Central Agricultural	Moccasin	
⊟ **Organization: NA**								
NA	NA	Turn	NA	Turn	NA	NA	Molokai	
NA	NA	NA	NA	NA	NA	NA	Boardman	

SGI Data Editor

Field	Value
Organization:	Iowa State University
PMC Number:	NA
Principle Investigator:	Doug Karlen
Experiment ID:	NA
Contact Person:	NA
Email Address:	Doug.Karlen@ars.usda.gov
Institution Address:	314 National Soil Tilth Laboratory
Institution City:	Ames
Institution State:	IA
Institution Zip Code:	50011
Institution Phone Number:	(515) 294-3336
Latitude:	42.027222
Longitude:	-93.631667
Region:	North Central
Cultivar:	NA
Species/Feedstock Region:	Corn Stover
Samples:	NA
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Status:	Received
Upload Data Source:	SpreadSheet
Comments:	None
Modified:	4/2/2009 12:08:02 PM

[Reset Form] [Delete Record] [Update Database] [Create New]

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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

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.

BR&Di
BIOMASS RESEARCH & DEVELOPMENT INITIATIVE

National Biofuels Action Plan

DRAFT
June 2008

Bioenergy KDF strategically positions DOE to be a key player

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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

Additional Slides

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

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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
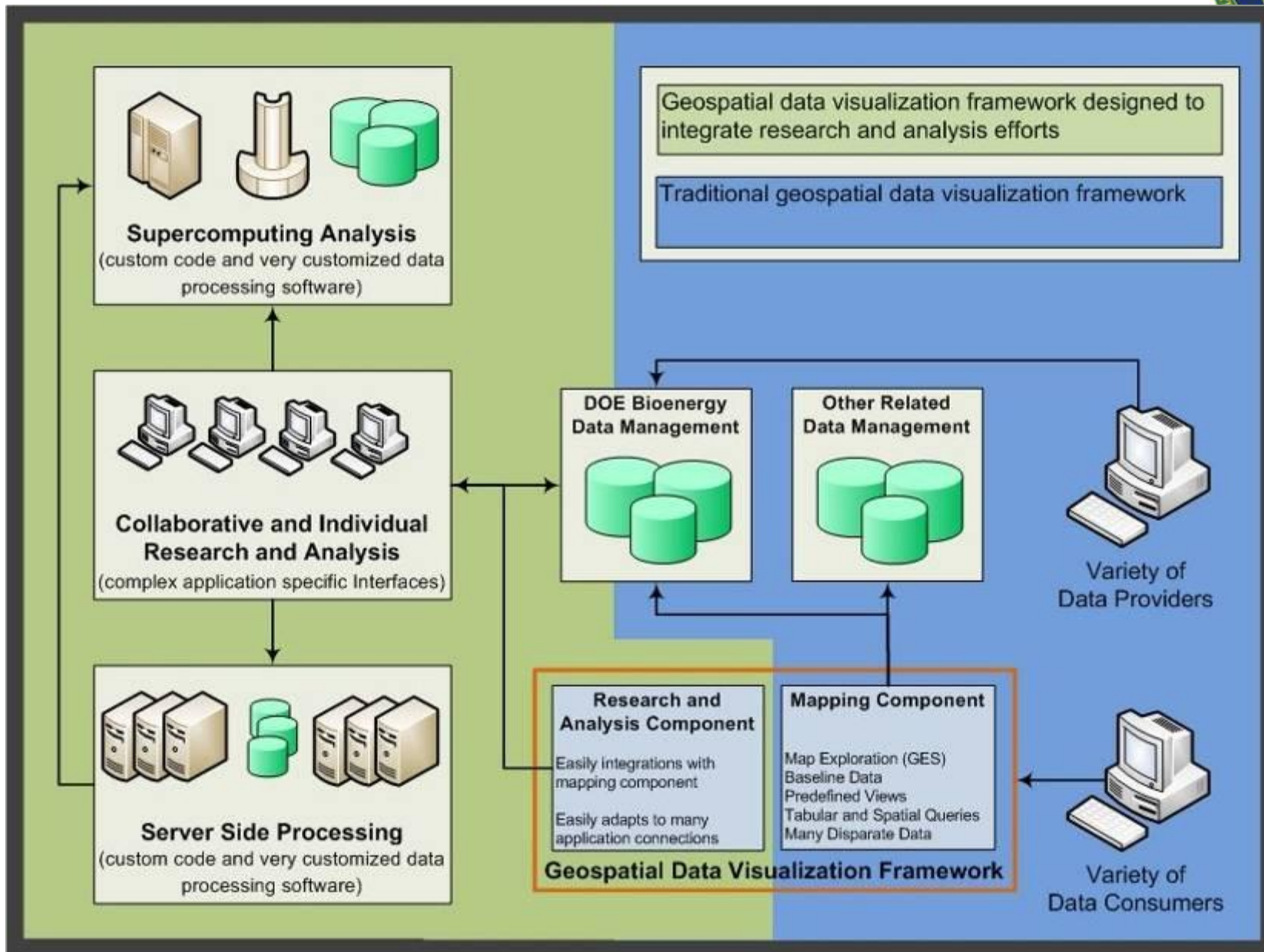 - Implement a simple key word based query functionality

LULC Data: Comparison of Cropland Areas
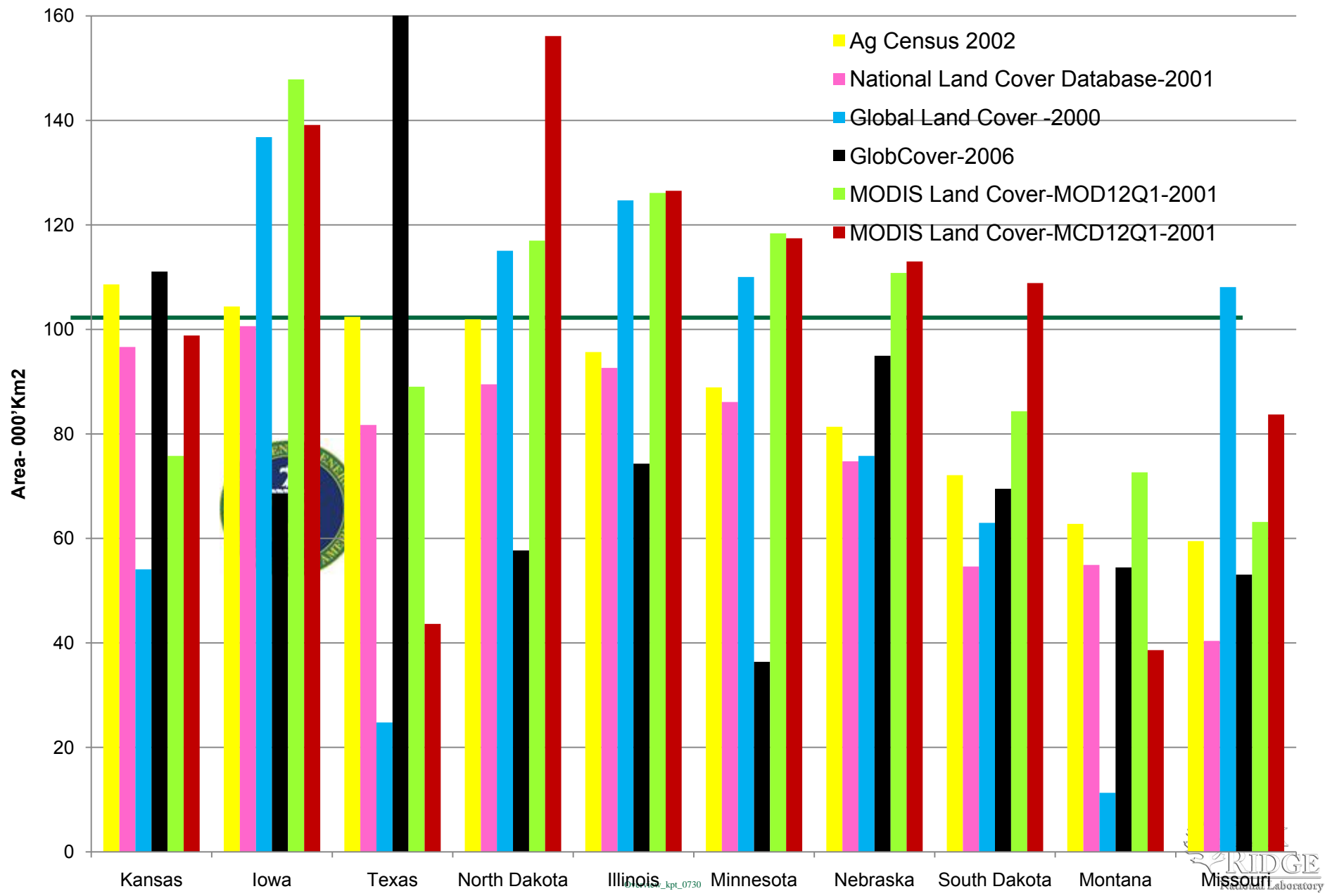
Bioenergy: Misaligned Data and Modeling Approaches
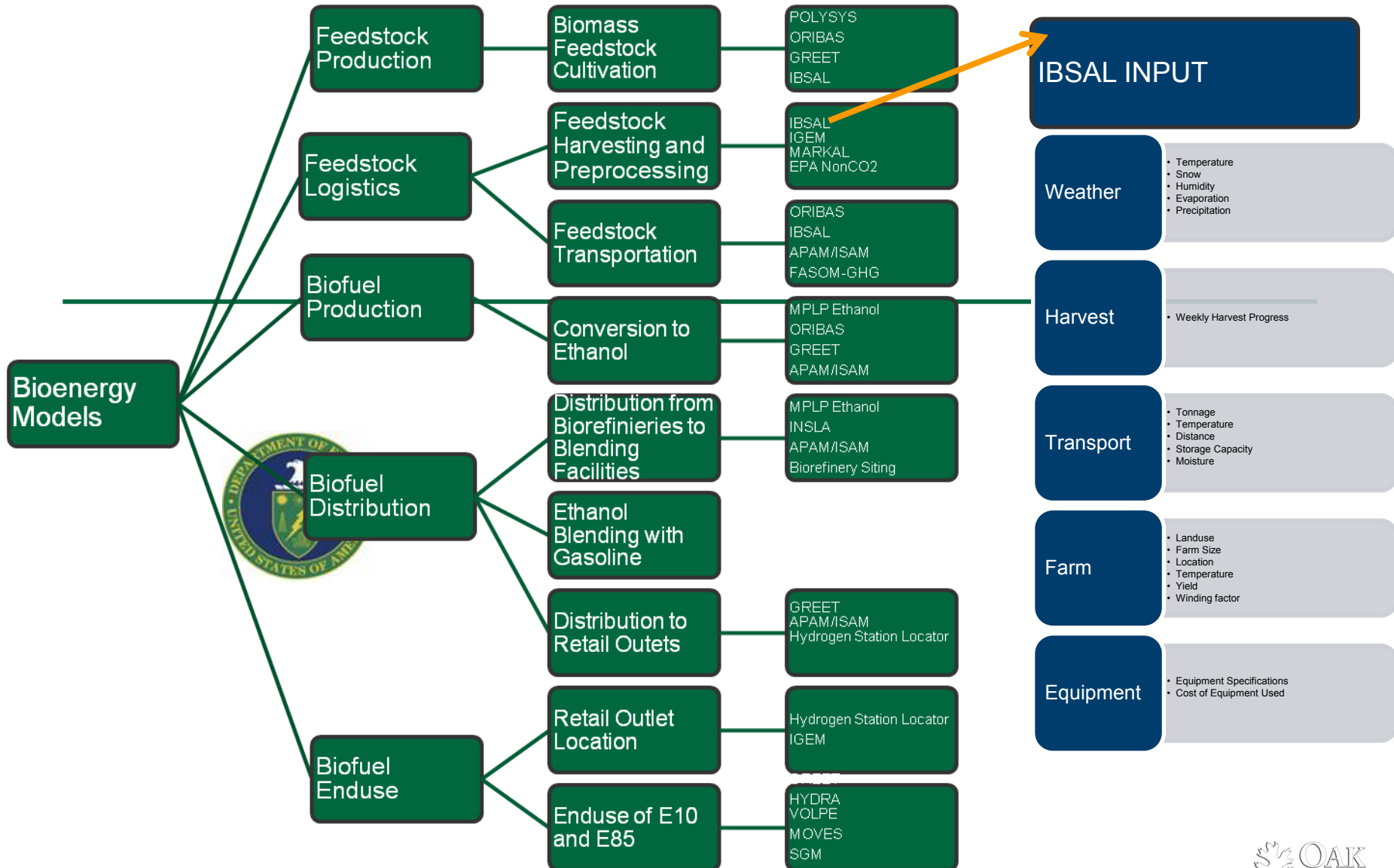
Goal: Develop Capabilities for Biofuel Infrastructure Modeling and Analysis

- **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**

- **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

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