# DOE Bioenergy Technologies Office (BETO) 2019 Project Peer Review

## WBS 4.1.2.1 Systems-Level Analysis

Analysis & Sustainability

March 4, 2019

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# Goal Statement

Enable the prioritization, rebalancing, and justification for the distribution of projects and funding across BETO's portfolio

## Outcomes

- Systems-level analysis that anticipates emerging issues and informs BETO plans
- Concrete actions to address gaps and improvement opportunities in A&S portfolio
- Cross-portfolio and industry-knowledgeable perspective for updating key modeling assumptions and parameters
- Analysis structures that improve analysis effectiveness and efficiency

## Relevance

- Cross model coherence for accurate, consistent modeling and analysis results
- BETO plans and analysis informed by consensus on industry progress
- Improve A&S program effectiveness
  - Communications
  - Reduce gaps, overlaps, and vulnerabilities

# Quad Chart Overview

## Timeline

- FY17-19
- Previously reviewed in 2015
- Current AOP cycle: FY18-20
- 50% through current cycle

| | Total Costs FY15-16 | FY17 Costs | FY18 Costs | Total Planned Funding FY19 |
|---|---|---|---|---|
| **DOE Funded** | $559 | $243K | $304K | $659K |

## Partners

All BETO National Labs

## FY19 MYP Barriers Addressed

- At-A. Analysis to Inform Strategic Direction
- At-B. Analytical Tools and Capabilities for System-Level Analysis

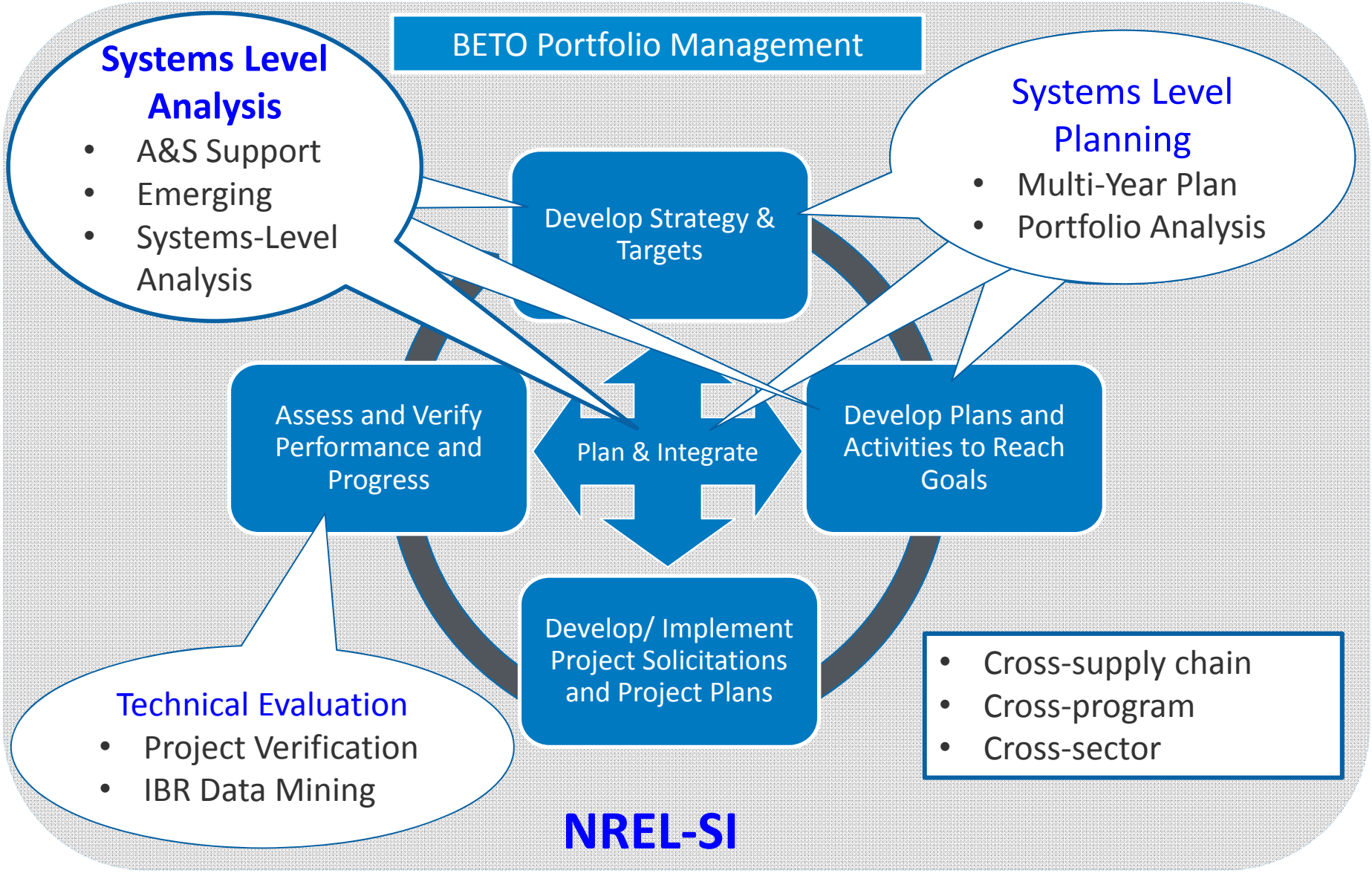
## Objective:

Directly provide BETO strategic systems-level analysis and maintain readily available, established expert resource to respond to high-level ***internal*** analysis requests

## 3-year objective:

Understand factors influencing bioenergy technology R&D progress and factors influencing a growing bioenergy industry and how the BETO portfolio contributes to these developments

# Created in 2004, NREL-Systems Integration (SI) provides independent, strategic systems-level expertise to BETO Portfolio Management



# Management Approach

## Approach

- Inter-disciplinary / wide perspective
  - Analysis expertise in one or more technical areas
  - Systems and strategic orientation
  - Adaptive and collaborative
- Close operating partnership with BETO
  - Bi-weekly with BETO leadership / Weekly with A&S Staff
- On-going prioritization and adaptation of work focus
  - Adapt to current needs while anticipating emerging issues
- Share learnings along the way for actionable insights
- Outreach to rest of BETO, Labs, and outside experts
  - Independent from Labs (including NREL)
- Coordinate and integrate with SI planning and verification

# Management Approach

Diverse activity across three categories of work. Highlighted activities will be discussed.

## Task 1: A&S Program Support

- Support for A&S management to improve effectiveness of A&S portfolio
  - FY17 – 19: **Model Mapping**
  - FY18: **Bioeconomy Modelers' Workshop**

## Task 2: Emerging Analysis

- Analysis capabilities maintained for quick turn-around or emerging analysis topics
  - FY17: Biofuel production projections; **Working Group Analysis**
  - FY18: GPRA Goal analysis; Feedstocks logistics risk standards

## Task 3: Systems-Level Analysis

- Pre-defined topics and milestones for more focused, in-depth analysis
  - FY17: 2016 MYPP scenario analysis; IBR Survey with transition of Industry Report
  - FY19: **Industrial Learning Curve**

# Task 1: A&S Program Support

## Model Mapping

**Purpose:** Enable BETO to more transparently manage and communicate complex model portfolio, identify gaps, duplication, and improvements

### Top Challenges

- Determine data structures
- Design survey instrument
- Refine mapping structures

### Critical Success Factors

- Buy-in and consensus by Lab model owners for definitions
- Contain scope to confirm value
- Assess value in changing environment

### Technical Approach

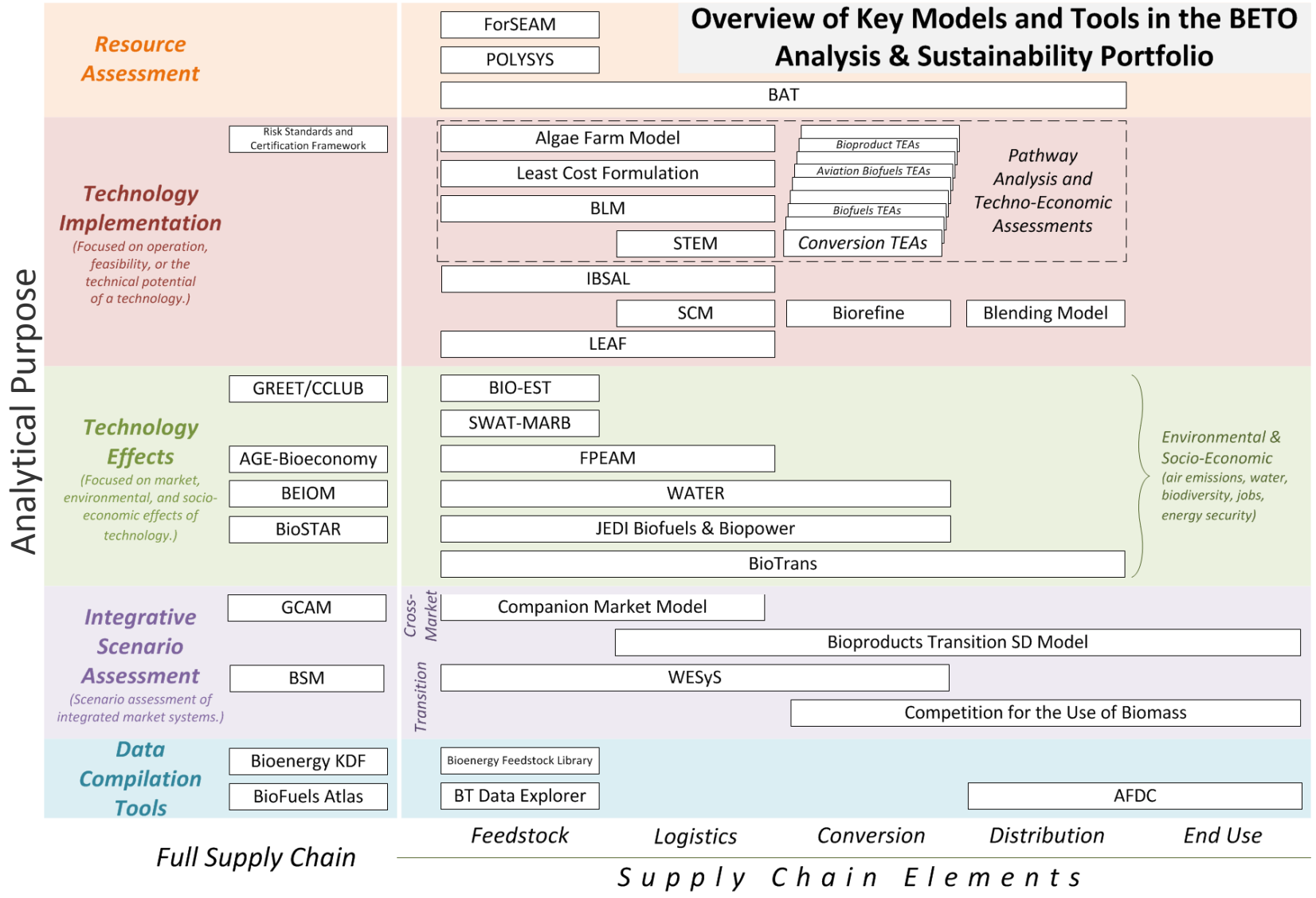
**FY17: Inventory, mapping, gap analysis**

- Compile inventory of 115 models
- Down-select and collect data on 40+ models
- Lab surveys & interviews
- Analyze data and organize maps
- Prepare and present results

**FY18: Explore use of results to extend usefulness**

# Model Mapping Accomplishments

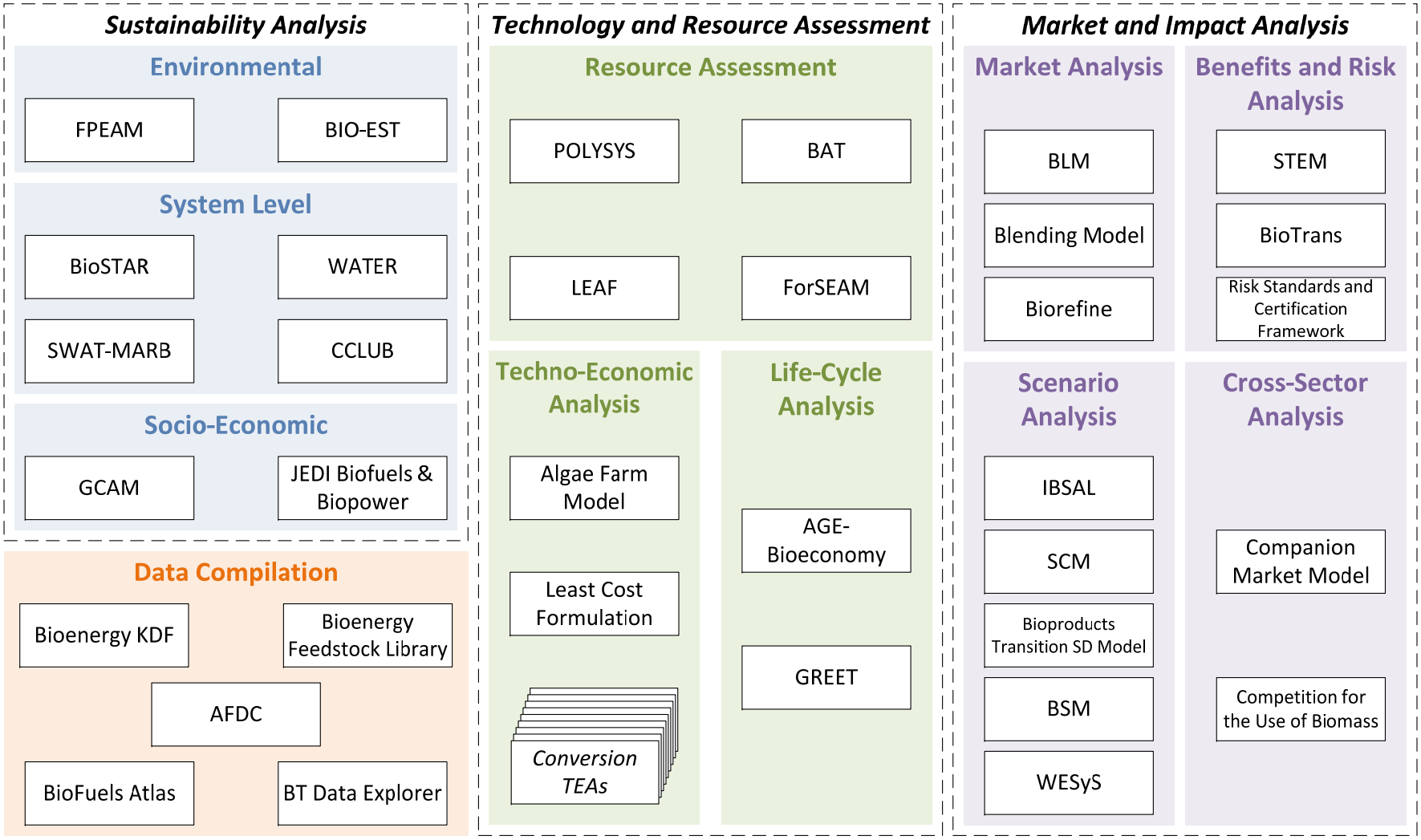
Model maps give a snapshot how each model fits into broader BETO modeling eco-system. This FY17 map shows how models array across analytic purposes and supply chain elements.



# Model Mapping Accomplishments

Multiple maps illustrate the varying perspectives and dimensions necessary to fully understand analytic purposes and assess gaps and overlaps

**BETO 2016 MYPP Work Breakdown Structure (WBS) Map**



# Model Mapping Accomplishments

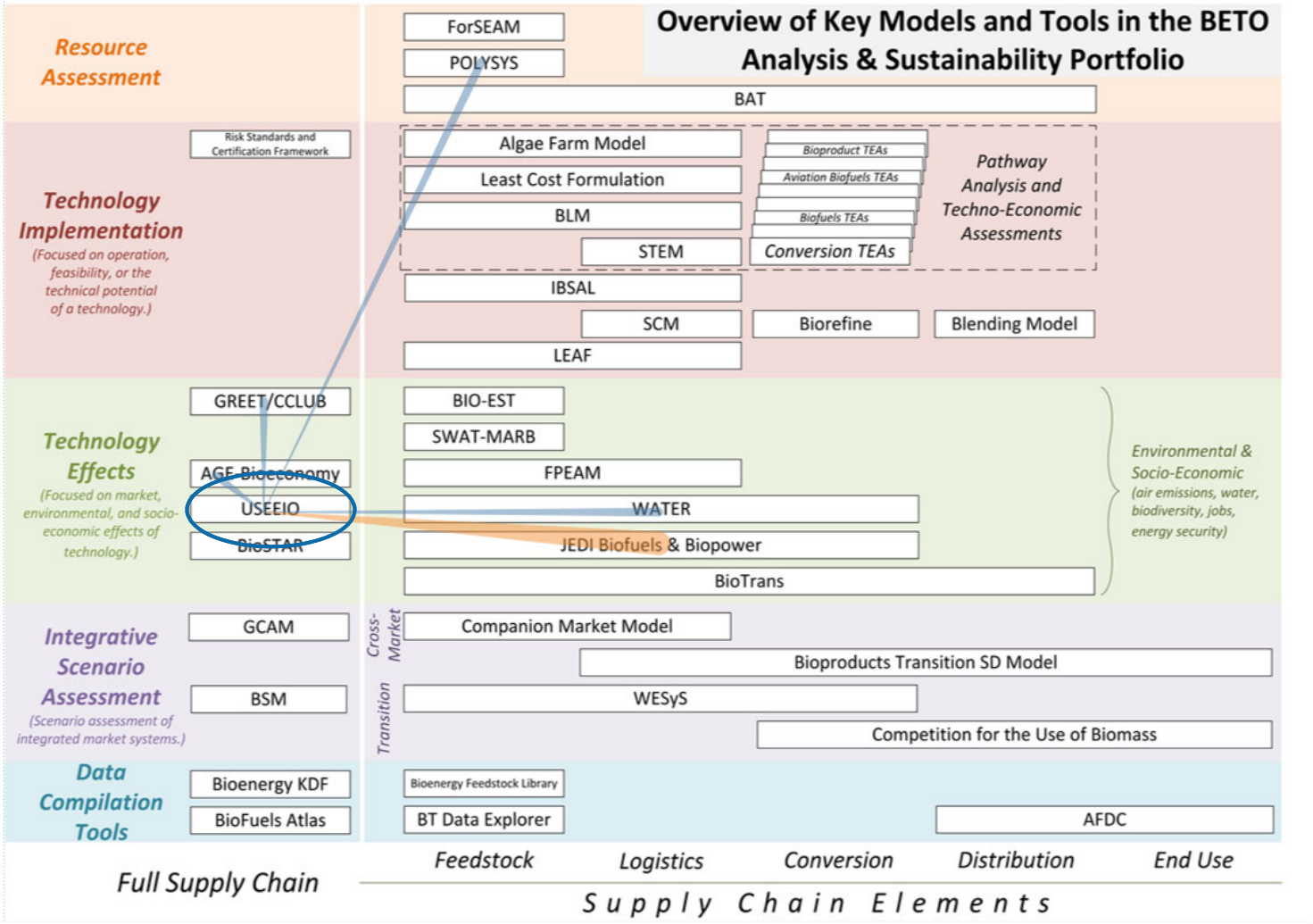
**FY17 Analysis Findings:**

- Primary analytical purpose of each model is unique
  - Potential risks of overlap / duplication in secondary and tertiary analytical purposes
- No single map captures the differences in analytical purposes across relevant dimensions
- *Gap*: Integrated Scenario Assessment - Scenario Optimization
- Manual data linkages pose opportunities to improve portfolio efficiencies
- Most models focused on BETO as primary audience
  - Opportunity to emphasize alternate / additional audiences

# FY18 Model Mapping Accomplishments

**Direct Linkages**

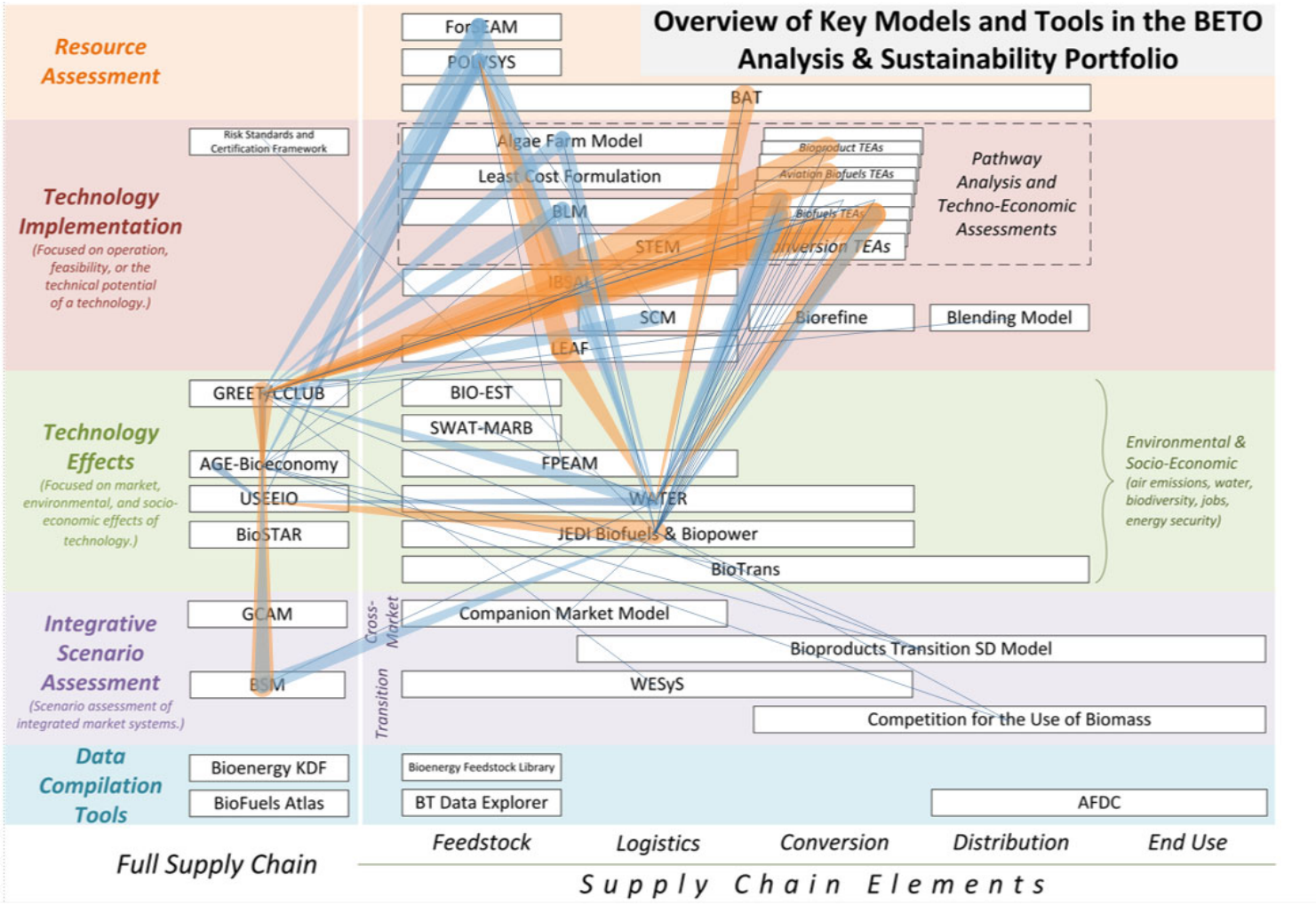
- 5 key primary data flows from other models
- No flows out



# FY18 Model Mapping Accomplishments

**Indirect Linkages:**

- Direct linkages map to many indirect relationships
- Shows interdependencies and potential vulnerabilities



# Model Mapping

**BETO Portfolio Impact**

- Concrete improvements to address gaps, overlaps, and vulnerabilities
- Communicates breadth and depth of portfolio
  - Shows how models fit in the bigger picture
- Provide framework for scoping new efforts
  - Identify potential data sources and validation points
  - Ensure that new efforts complement not compete

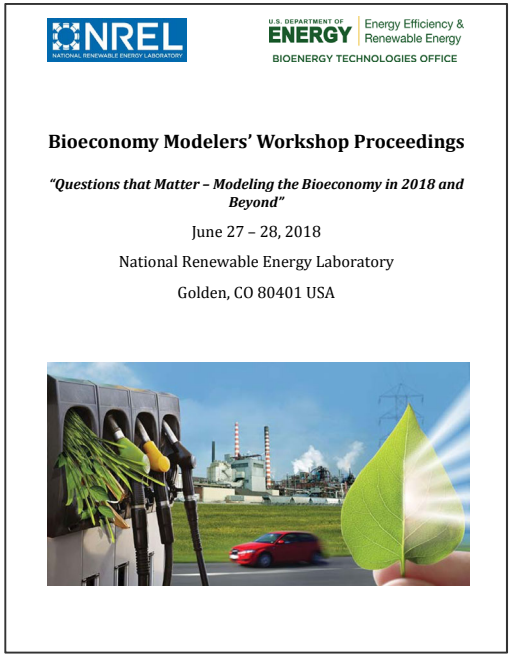
# Task 1: A&S Support Accomplishments

## Sixth Bi-annual Modelers Workshop

**Purpose:** Improve BETO's understanding of the current state of bioeconomy modeling and emerging questions, issues, and methods. Improve collaboration across bioeconomy modeling community> Generate ideas for future action

**Technical Approach:**

- Open Space Technology$^{tm}$ facilitation engaged participants in designing agenda
- Attracted 41 attendees from across bioeconomy modeling community
  - International
  - Federal & State Government
  - NGO
  - Academic
  - National Laboratories
- Proceedings captured key questions and session take-aways


NREL
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy
BIOENERGY TECHNOLOGIES OFFICE

**Bioeconomy Modelers' Workshop Proceedings**

*"Questions that Matter – Modeling the Bioeconomy in 2018 and Beyond"*

June 27 – 28, 2018

National Renewable Energy Laboratory

Golden, CO 80401 USA

## Key outcomes

- Inventory of emerging questions and hot topics
- Recommendations:
  - Model comparisons
  - Improve access to model mapping data

# Task 2: Emerging Analysis

## Working Group Analysis

**Purpose:** Engage staff to understand supply-chain effects of program-level plans while reviewing model parameters

### Challenges

- Efforts cross sectors and disciplines
- BETO staff with deep technology expertise may not see cross-supply chain implications
- Newer staff unfamiliar with cross-supply-chain tools for analysis, their possible uses, and limitations

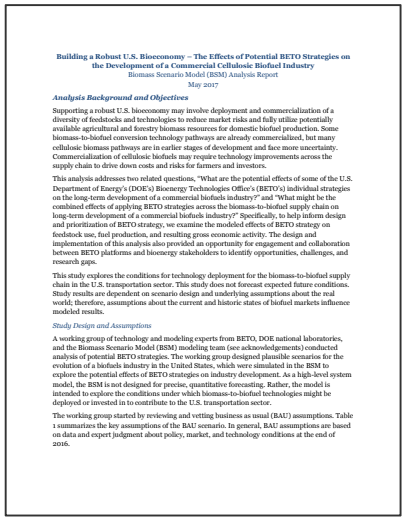
### Critical Success Factors

- Selecting topics of direct relevance
- Improve credibility of results through understanding model
- Update model parameters based on subject matter expertise

### Technical Approach

- Convene 5 internal working groups of BETO and Lab staff on relevant questions
- Deploy scenario analysis to understand cross-system implications
  - While validating assumptions and updating model parameters

# Emerging Analysis Accomplishments



**Building a Robust U.S. Bioeconomy – The Effects of Potential BETO Strategies on the Development of a Commercial Cellulosic Biofuel Industry**

Biomass Scenario Model (BSM) Analysis Report

May 2017

***Analysis Background and Objectives***

Supporting a robust U.S. bioeconomy may involve deployment and commercialization of a diversity of feedstocks and technologies to reduce market risks and fully utilize potentially available agricultural and forestry biomass resources for domestic biofuel production. Some biomass-to-biofuel conversion technology pathways are already commercialized, but many cellulosic biomass pathways are in earlier stages of development and face more uncertainty. Commercialization of cellulosic biofuels may require technology improvements across the supply chain to drive down costs and risks for farmers and investors.

This analysis addresses two related questions, "What are the potential effects of some of the U.S. Department of Energy's (DOE's) Bioenergy Technologies Office's (BETO's) individual strategies on the long-term development of a commercial biofuels industry?" and "What might be the combined effects of applying BETO strategies across the biomass-to-biofuel supply chain on long-term development of a commercial biofuels industry?" Specifically, to help inform design and prioritization of BETO strategy, we examine the modeled effects of BETO strategy on feedstock use, fuel production, and resulting gross economic activity. The design and implementation of this analysis also provided an opportunity for engagement and collaboration between BETO platforms and bioenergy stakeholders to identify opportunities, challenges, and research gaps.

This study explores the conditions for technology deployment for the biomass-to-biofuel supply chain in the U.S. transportation sector. This study does not forecast expected future conditions. Study results are dependent on scenario design and underlying assumptions about the real world; therefore, assumptions about the current and historic states of biofuel markets influence modeled results.

*Study Design and Assumptions*

A working group of technology and modeling experts from BETO, DOE national laboratories, and the Biomass Scenario Model (BSM) modeling team (see acknowledgements) conducted analysis of potential BETO strategies. The working group designed plausible scenarios for the evolution of a biofuels industry in the United States, which were simulated in the BSM to explore the potential effects of BETO strategies on industry development. As a high-level system model, the BSM is not designed for precise, quantitative forecasting. Rather, the model is intended to explore the conditions under which biomass-to-biofuel technologies might be deployed or invested in to contribute to the U.S. transportation sector.

The working group started by reviewing and vetting business as usual (BAU) assumptions. Table 1 summarizes the key assumptions of the BAU scenario. In general, BAU assumptions are based on data and expert judgment about policy, market, and technology conditions at the end of 2016.

## Working Group Analysis

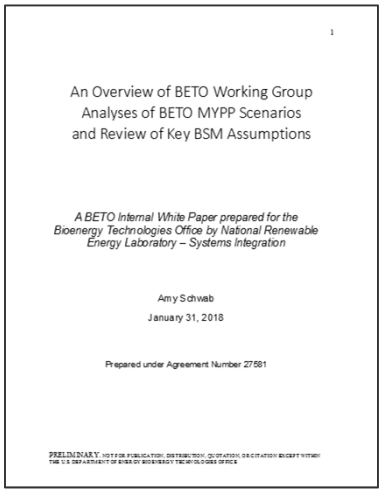
First three focused on 2016 MYPP Scenarios

1. ***Demonstration and Market Transformation***
   - Biorefinery investments impacts
   - Update technology pathway maturity assumptions and learning curve parameters
2. ***Conversion***
   - Co-processing pyrolysis oil in petroleum refineries
3. ***Feedstock Supply and Logistics***
   - Transition to advanced feedstock logistics systems
   - With changes to biorefinery scale

## Internal Report on Combined Effects

*Building a Robust U.S. Bioeconomy – The Effects of Potential BETO Strategies on the Development of a Commercial Cellulosic Biofuel Industry,* May 2017

# Emerging Analysis Accomplishments


An Overview of BETO Working Group Analyses of BETO MYPP Scenarios and Review of Key BSM Assumptions

*A BETO Internal White Paper prepared for the Bioenergy Technologies Office by National Renewable Energy Laboratory – Systems Integration*

Amy Schwab

January 31, 2018

Prepared under Agreement Number 27581

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## Working Group Analysis

In FY17 two groups selected topics:

4. ***Feedstock Supply & Logistics***
   - Impact on biofuel production of demand collapse in wood pellet markets
5. ***Conversion***
   - Bioproduct impact on development of biofuel production
   - Develop cross-technology shared-learning assumptions

## Internal Report

*An Overview of BETO Working Group Analyses of BETO MYPP Scenarios and Review of Key BSM Assumptions; A BETO Internal White Paper prepared for the Bioenergy Technologies Office by National Renewable Energy Laboratory – Systems Integration,* January 2018

# Emerging Analysis

## Working Group Analysis

**BETO Portfolio Impact**

- Identify improvements to related models
- Point to potential new areas for analyses across and within supply chain elements
- Assess potential impacts
  - Combined internal actions: BETO multi-year plan targets
  - BETO bioproducts strategies
  - External events - market disruptions

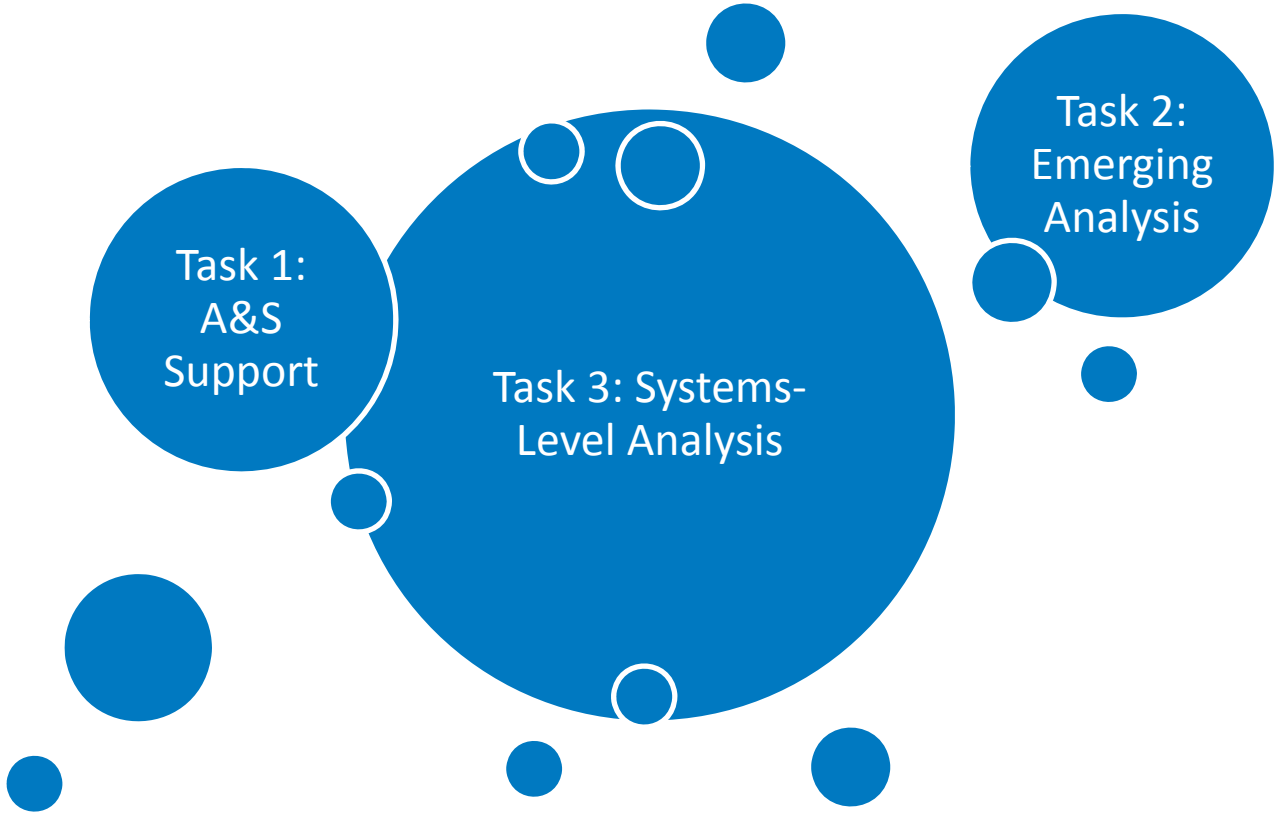
# Relevance

- Enable the prioritization, rebalancing, and justification for the distribution of projects and funding across BETO's portfolio
- Improve cross-model coherence for accurate, consistent modeling and analysis results
- Improve A&S program effectiveness
  - Communicate breadth and depth of portfolio and help modelers see how they fit in the bigger picture
  - Identify gaps, overlaps, and vulnerabilities with actions for improvement
  - Enable new analysis and modeling efforts to develop scope and work plans more effectively and efficiently

# Relevance

- Improve BETO planning with analysis across complex supply chain
- Translate industry knowledge into updated model parameters
  - Validate modeling approaches
  - Identify improvements to related models / potential new analysis areas
  - Assess potential impacts Of BETO strategies and plans and of external disruptions
- Improve BETO's understanding of emerging questions, issues, and methods in bioeconomy modeling
  - Improve collaboration across modeling community

# Future Work


Task 1: A&S Support
Task 3: Systems-Level Analysis
Task 2: Emerging Analysis

# Task 1 & 2

## Task 1: A&S program support

- FY19 Model Mapping
  - Improve accessibility
  - Expand analysis capabilities
  - Establish processes for regular updates
- FY20: Bioeconomy Modelers' Workshop

## Task 2: Emerging Analysis

- Short turn-around time analysis requests by BETO
- Determined throughout the FY

# Task 3: Systems-Level Analysis

## Industrial Learning Curves

### Goal:

Build analytic bridge between $n^{th}$ plant MFSP targets and first-of-a-kind plant biofuel costs to understand factors driving cost reductions over time

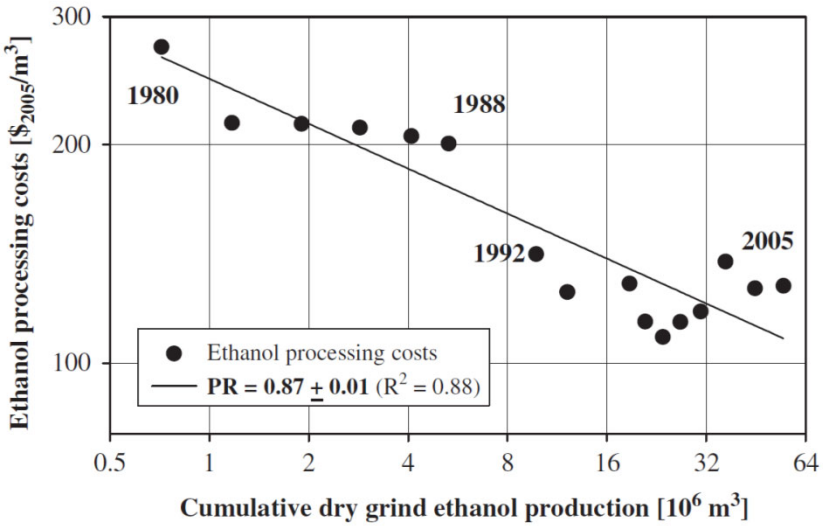



**Fig. Experience curve on ethanol production costs**
Source: Hettinga et al. 2009, Energy Policy, doi:10.1016/j.enpol.2008.08.002

### Relevance:

- Provide production cost and timeline trajectories for industrial development between TEA $n^{th}$-plant biofuel cost projections and first of a kind biorefinery performance
- Address the critical question, "*How many plants / how much cumulative capacity may be required to reach mature industry ($n^{th}$ plant) cost levels?*"
- Experience from industrial development of similar/analogous industries may help identify factors around which R&D can be focused

### Challenges:

- Determining "analogous" industries
- Accessing robust, accessible, and reproducible time series industry data

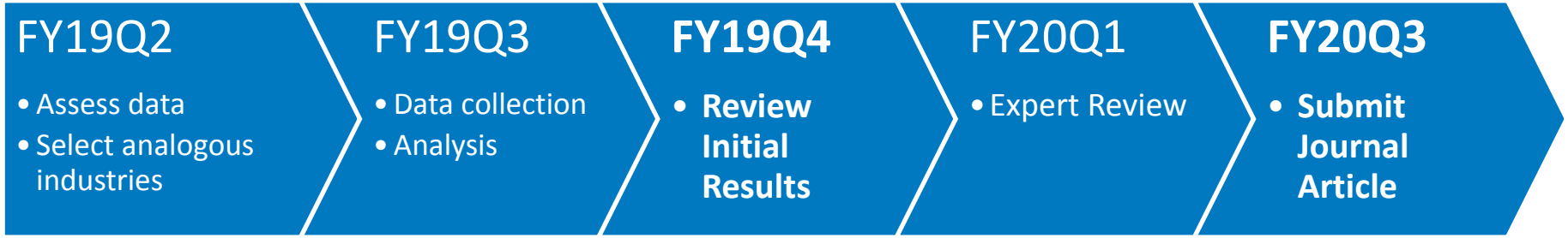
# Task 3: Systems-Level Analysis

## Industrial Learning Curves

### Technical Approach

- Develop new/update prior work on industry learning across similar industries
  - Review prior research (External, BETO internal, methods)
  - Update/extend bioenergy-related data, e.g., starch and sugar ethanol
  - Develop data on "analogous" industries
    - E.g., food-related, Municipal Solid Wastes, tar-sands
- Analyze data for new insights / industry differences

### Timeline




- Guided by external expert input with structured stakeholder validation

# Summary

**Approach**

- Deep collaboration with DOE BETO to anticipate and prepare for emerging systems-level questions and provide internal systems-level analysis and A&S program support

**Accomplishments**

- Map and analyze BETO model to identify improvements, more effectively communicate the breadth and depth of the portfolio, and help modelers see how they fit into the broader eco-system of models.
- Analysis of combined BETO planning scenarios and updated model assumptions and parameters
- Bi-annual modelers workshop

**Relevance**

- Enable the prioritization, rebalancing, and justification for the distribution of projects and funding across BETO's portfolio
- Support concrete improvements in BETO A&S portfolio while demonstrating application to scoping new modeling efforts
- Improved planning from analysis of 2016 MYPP scenarios

**Future Work**

- Quantify trajectory between first of a kind plant and projected $n^{th}$ plant costs and identify factors influencing industry development
- Provide accessibility and update capabilities for model mapping information
- As-needed analysis for BETO

# Thank You

**www.nrel.gov**

amy.schwab@nrel.gov

**NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.**

# Additional Slides

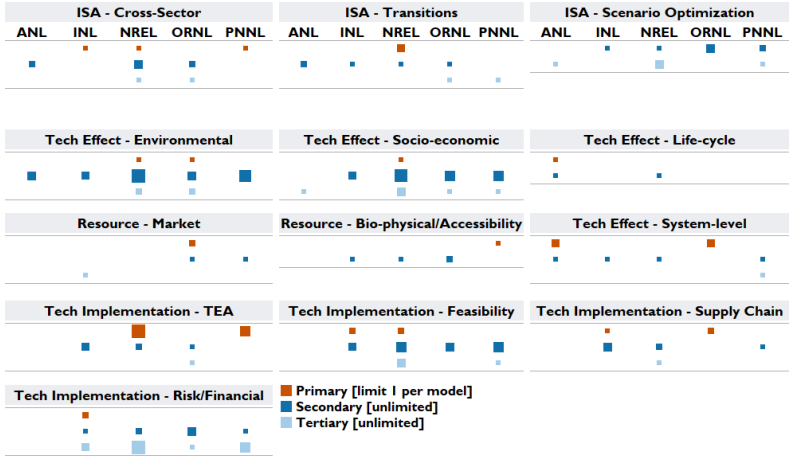
4.1.2.1 Systems Level Analysis

# Model Mapping Results

***BETO A&S-focused results*** identified specific A&S program portfolio improvements

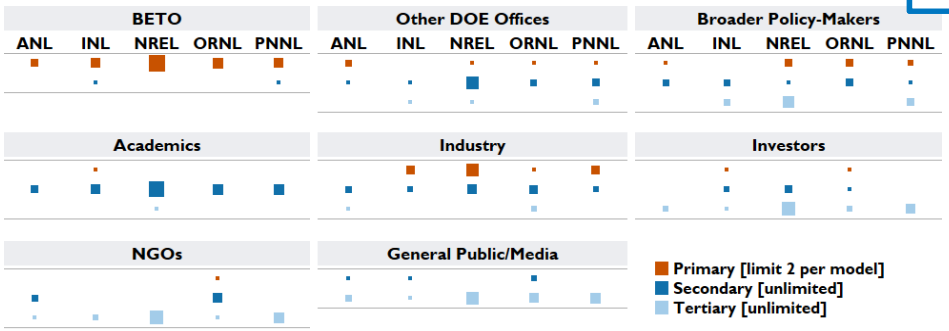
***Lab-focused results*** (e.g., linkages) were communicated broadly for use by model owners/PIs for future planning

Models' Analytical Purpose. Identified gap: no primary focus on Integrated Scenario Assessment (ISA)-Scenario Optimization




Square size is intended to qualitatively show the relative number of models and not the precise number (0-10).
The frequency of models claiming a primary purpose is comparatively lower due to limiting to 1 per model

Overview of Audience Focus: Most models primarily focused on BETO as audience with opportunity to emphasize alternate / additional audiences.




Square size is intended to qualitatively show the relative number of models and not the precise number (0-20). The frequency of a model claiming a primary purpose is comparatively lower due to limiting to 2 per model. ISA = Integrated Scenario Assessment

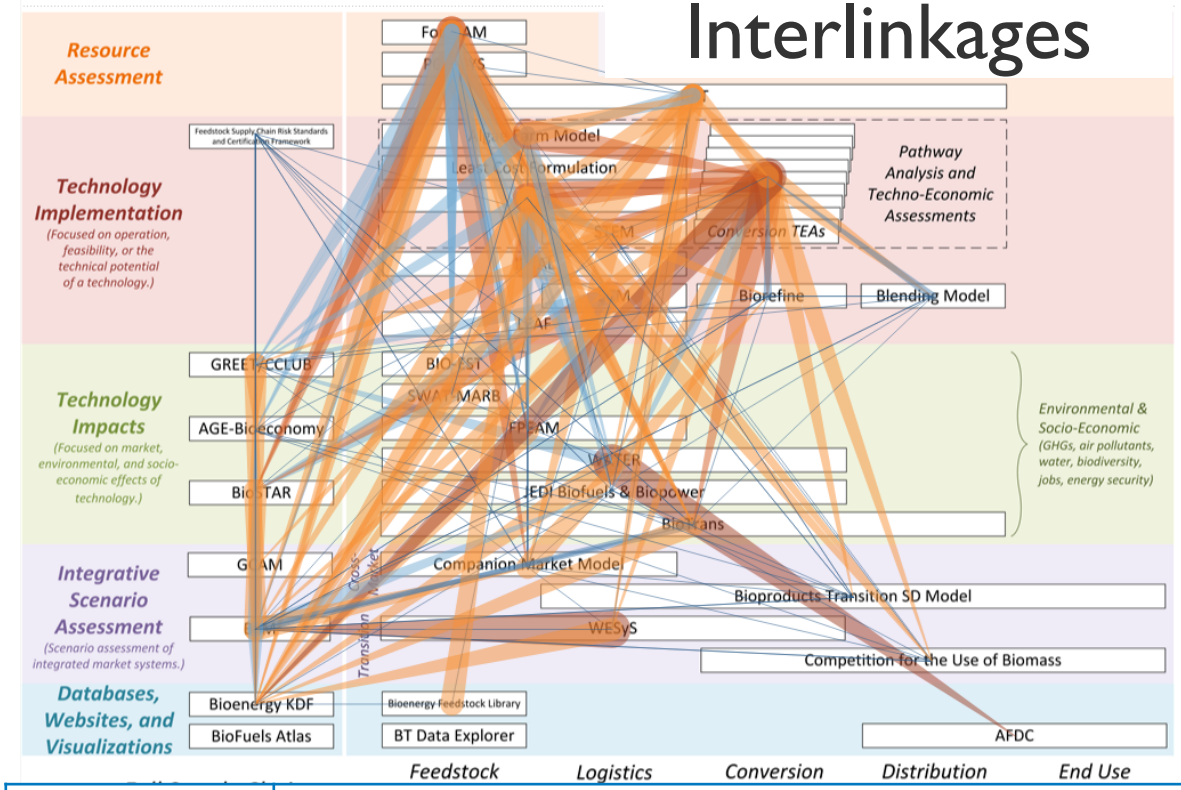
Other dimensions analyzed:

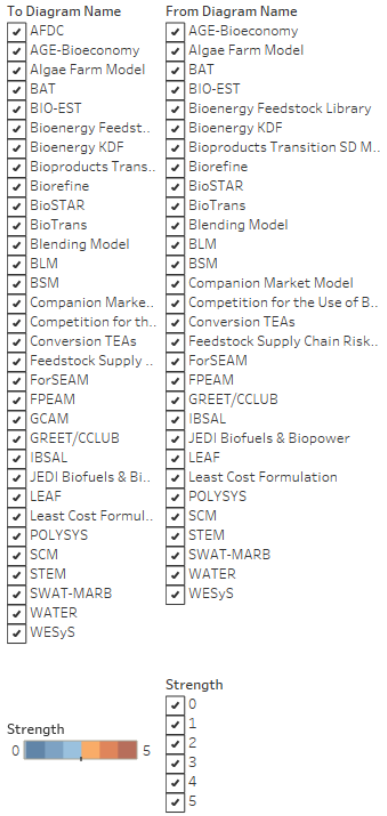
- Level of validation
- Maturity Level

# Model Mapping Results

Linkage maps identify opportunities to improve efficiency of data exchanges to help BETO identify effects of changing priorities on downstream data users.

## Interlinkages




| Link Strength | Description |
|---|---|
| 0 | No connections in FY17, but there are aspirations for a connection in the near future. |
| 1 | No data connection, but there has been a QA/QC exchange. |
| 2 | Manual data connection with HIGH levels of data processing. |
| 3 | Manual data connection with LOW levels of data processing |
| 4 | Manual data connection, without data processing |
| 5 | Automated data connection. |

# Interlinkages Strength 0

| Link Strength | Description |
|---|---|
| 0 | No connections in FY17, but there are aspirations for a connection in the near future. |
| 1 | No data connection, but there has been a QA/QC exchange. |
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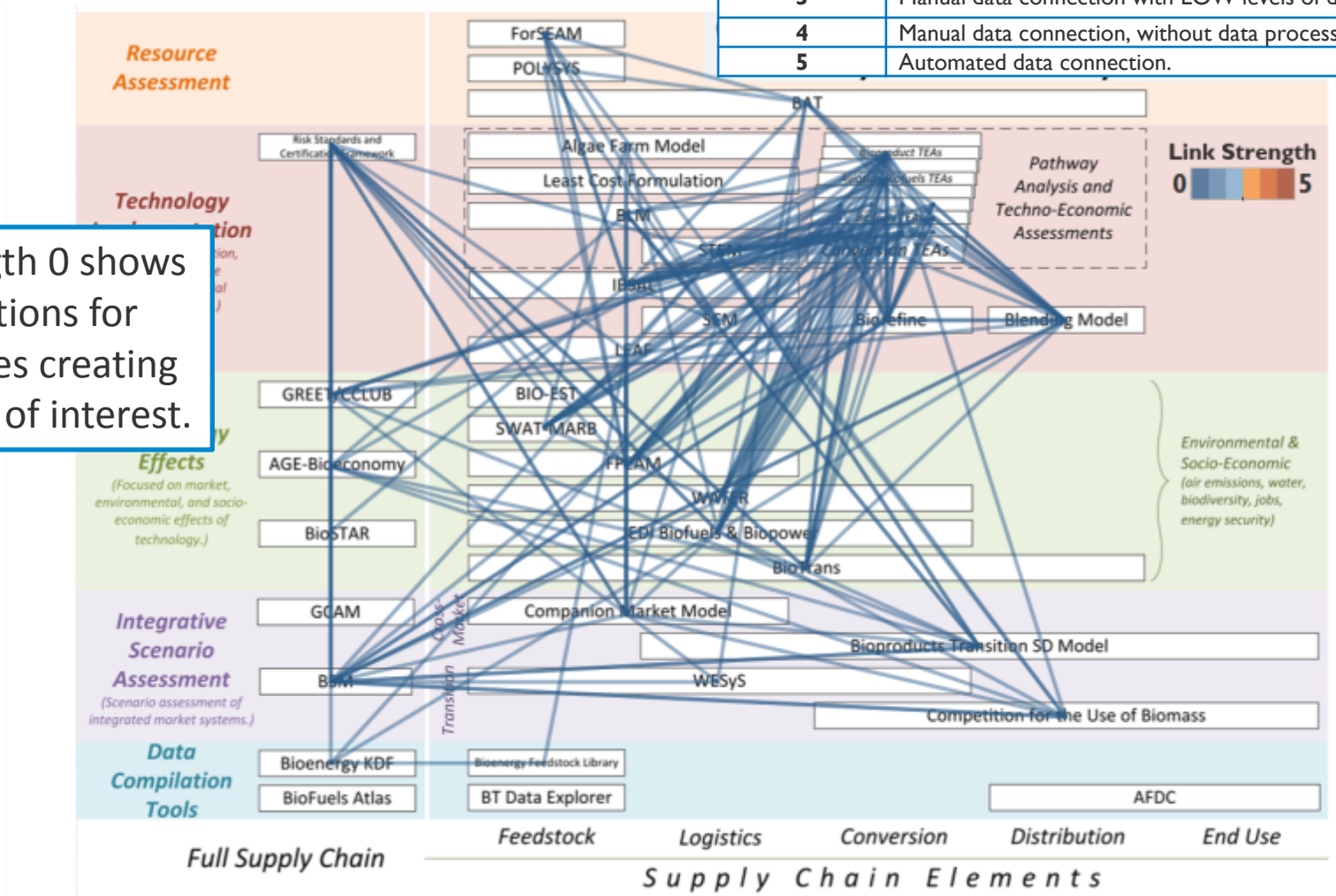
| 4 | Manual data connection, without data processing |
| 5 | Automated data connection. |

Strength 0 shows aspirations for linkages creating a web of interest.



# Interlinkages Strength 1

| Link Strength | Description |
|---|---|
| 0 | No connections in FY17, but there are aspirations for a connection in the near future. |
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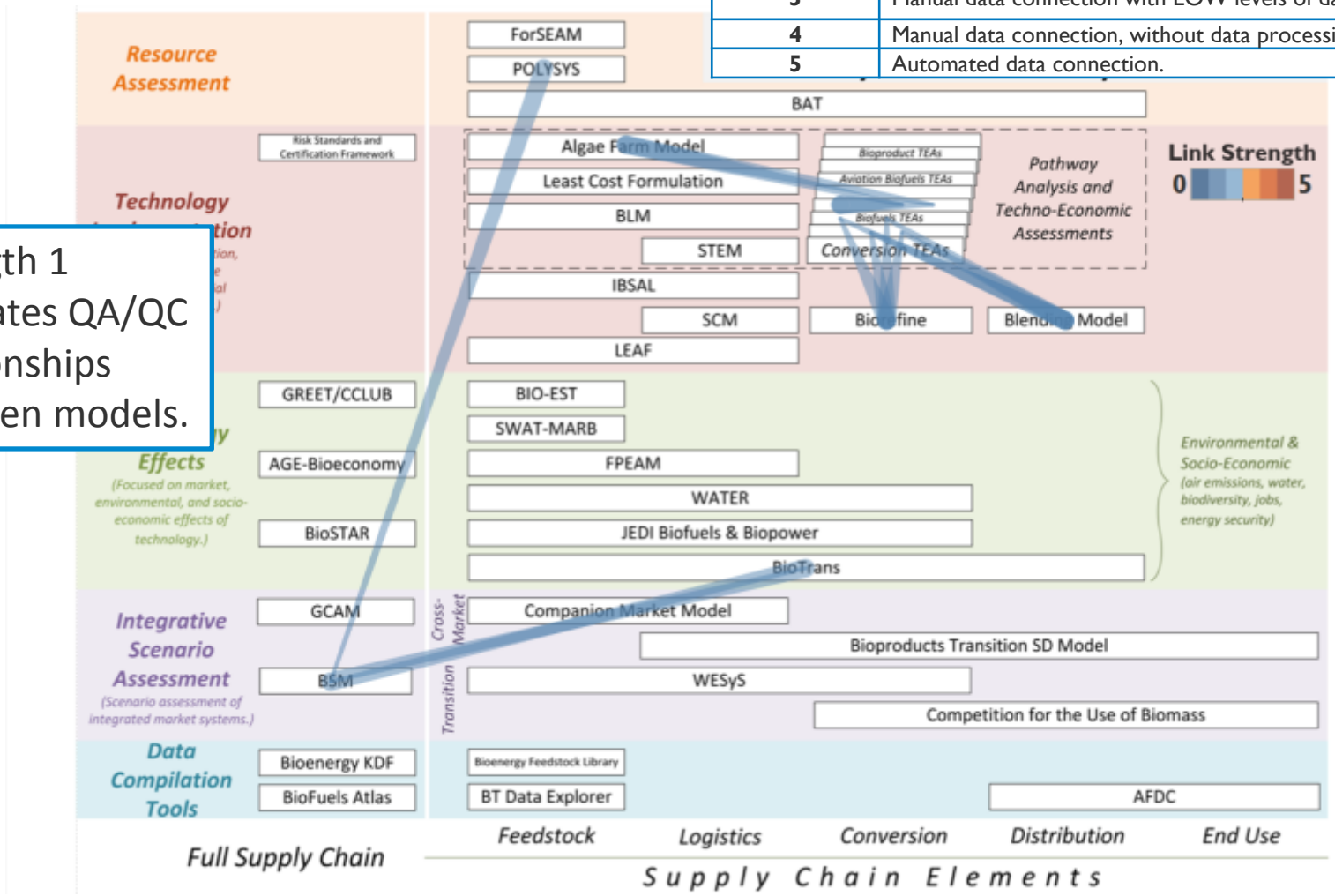
| 4 | Manual data connection, without data processing |
| 5 | Automated data connection. |

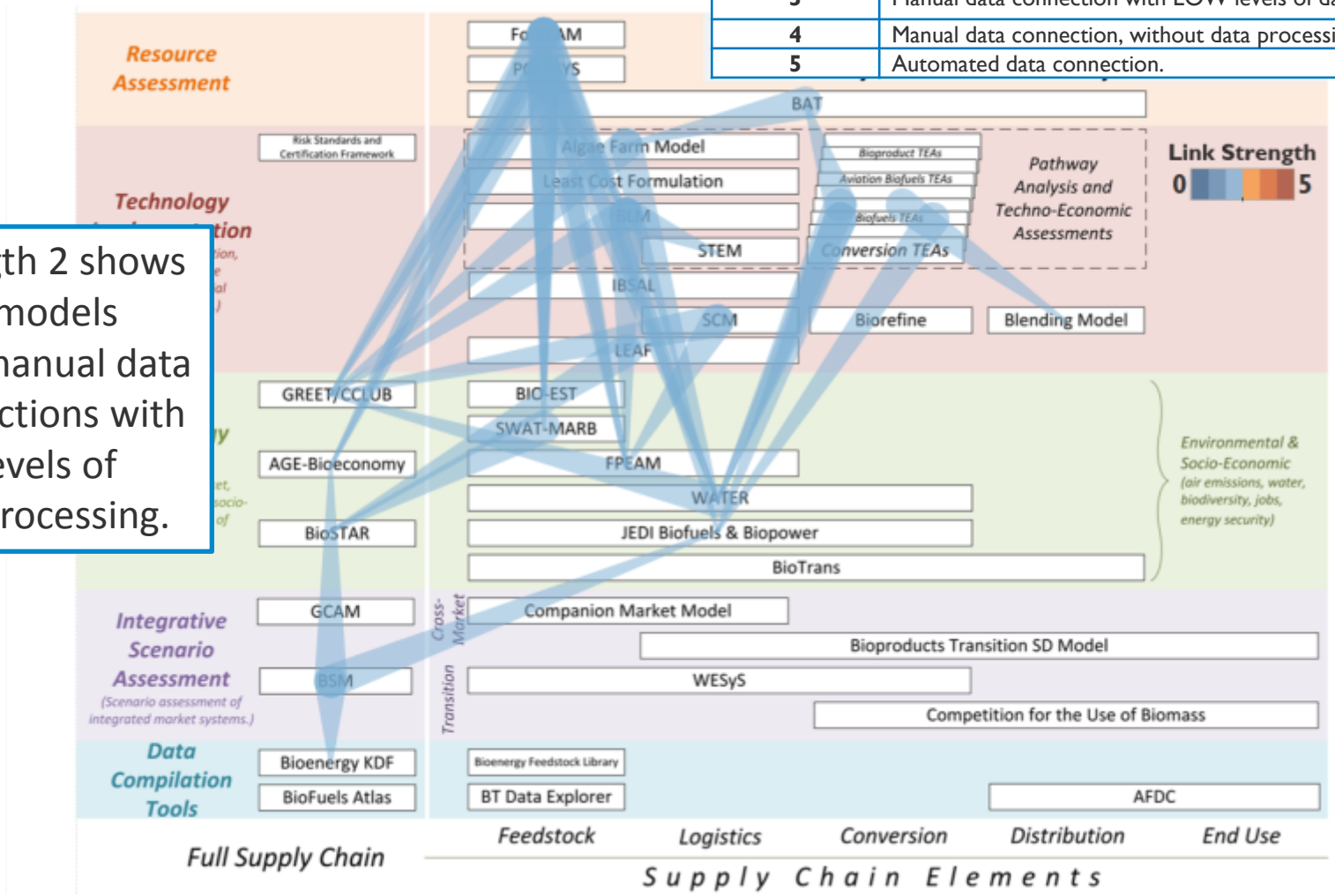
Strength 1 illustrates QA/QC relationships between models.



# Interlinkages Strength 2

| Link Strength | Description |
|---|---|
| 0 | No connections in FY17, but there are aspirations for a connection in the near future. |
| 1 | No data connection, but there has been a QA/QC exchange. |
| 2 | Manual data connection with HIGH levels of data processing. |
| 3 | Manual data connection with LOW levels of data processing |
| 4 | Manual data connection, without data processing |
| 5 | Automated data connection. |

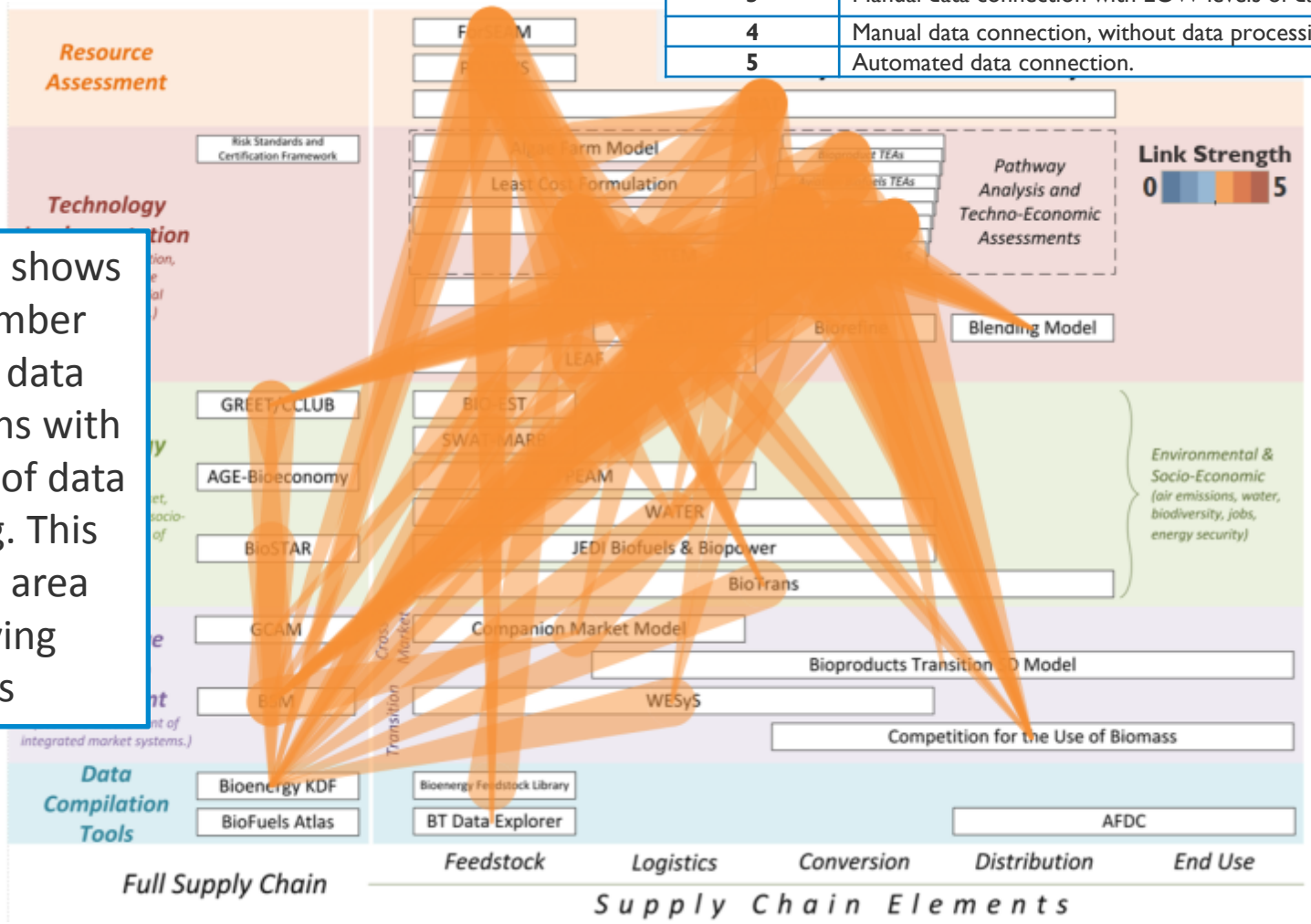
Strength 2 shows more models with manual data connections with high levels of data processing.



# Interlinkages Strength 3

| Link Strength | Description |
|---|---|
| 0 | No connections in FY17, but there are aspirations for a connection in the near future. |
| 1 | No data connection, but there has been a QA/QC exchange. |
| 2 | Manual data connection with HIGH levels of data processing. |
| 3 | Manual data connection with LOW levels of data processing |
| 4 | Manual data connection, without data processing |
| 5 | Automated data connection. |

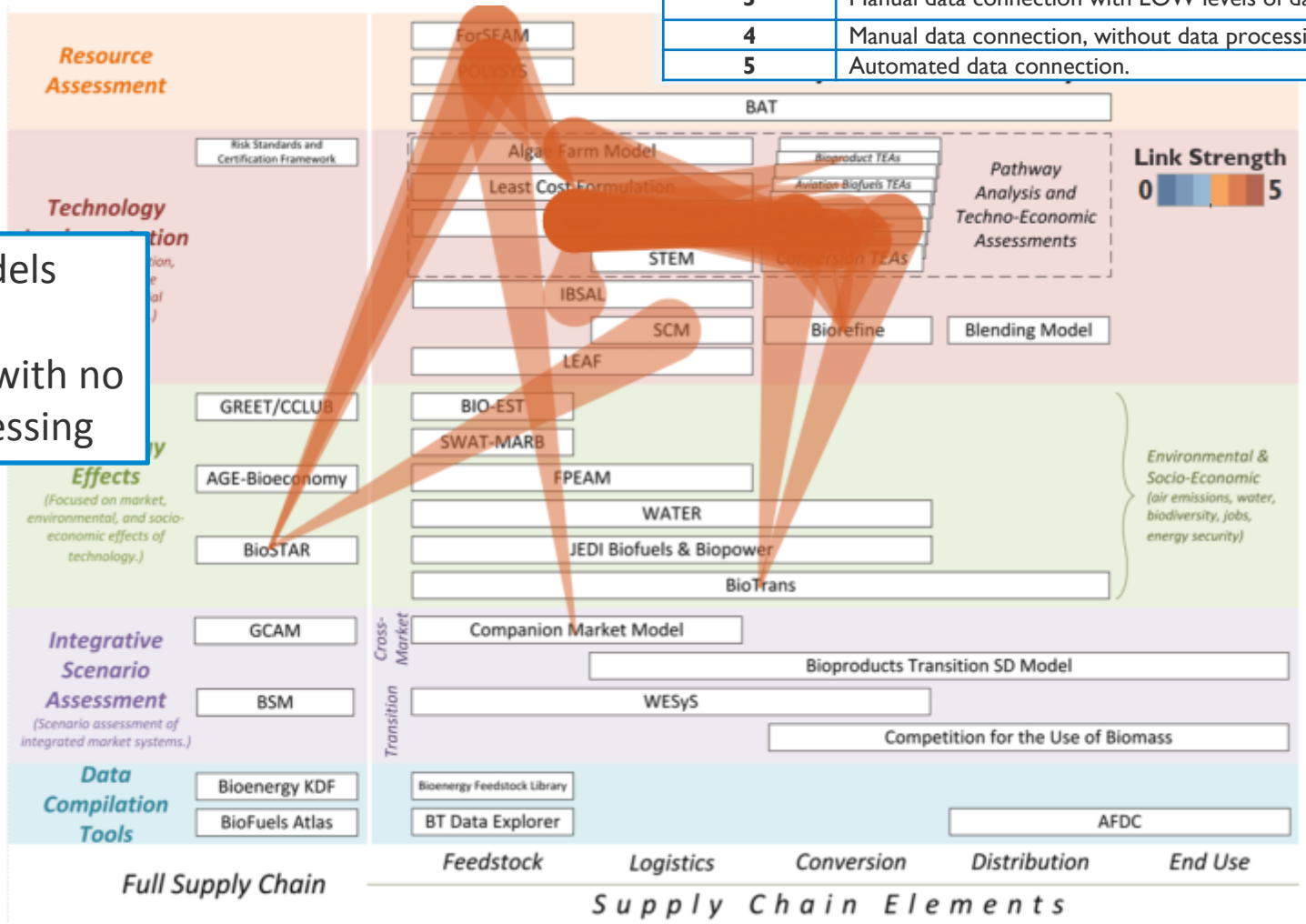
Strength 3 shows a large number of manual data connections with low levels of data processing. This may be an area for improving efficiencies



# Interlinkages Strength 4

| Link Strength | Description |
|---|---|
| 0 | No connections in FY17, but there are aspirations for a connection in the near future. |
| 1 | No data connection, but there has been a QA/QC exchange. |
| 2 | Manual data connection with HIGH levels of data processing. |
| 3 | Manual data connection with LOW levels of data processing |
| 4 | Manual data connection, without data processing |
| 5 | Automated data connection. |

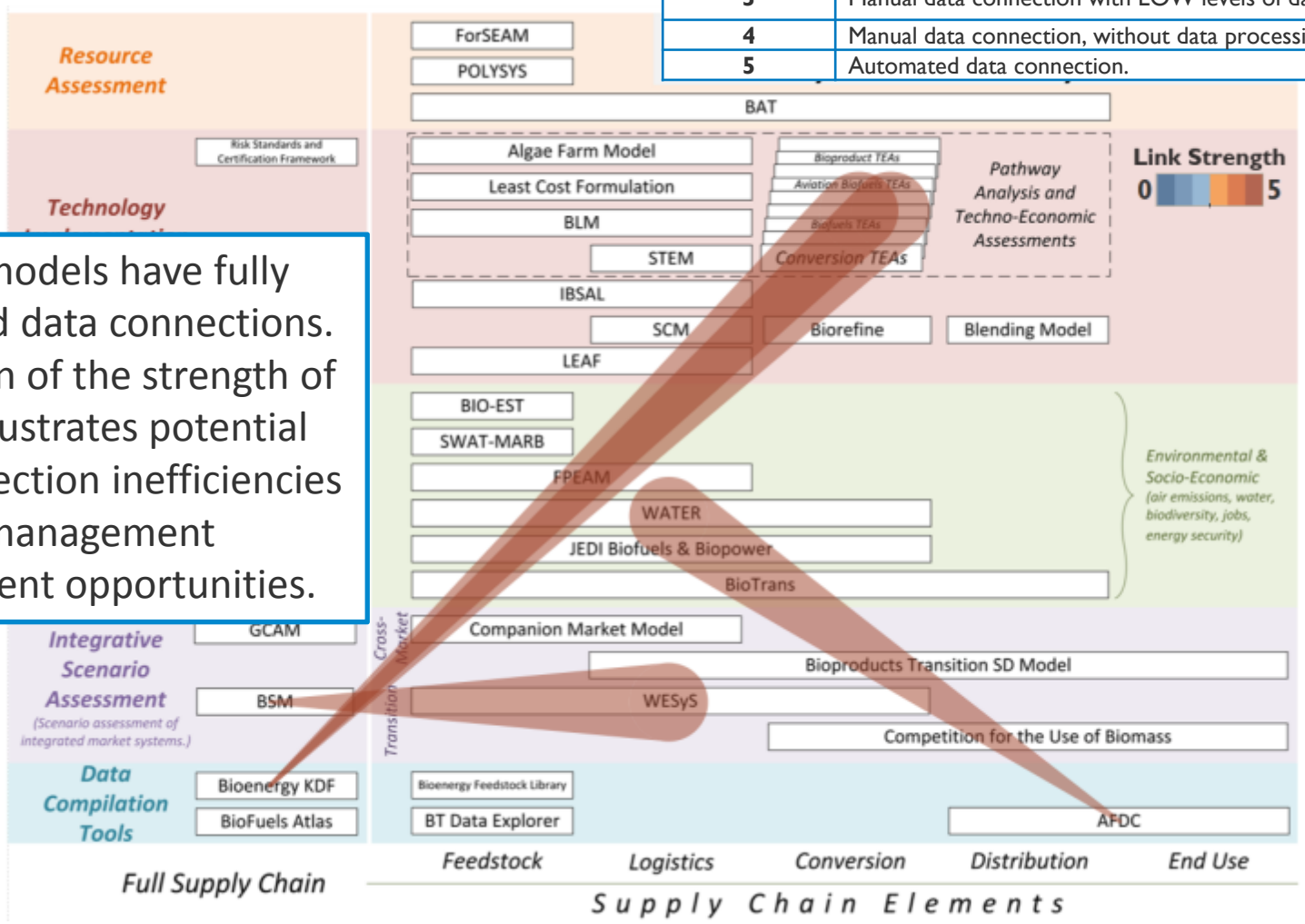
A few models pass data manually with no data processing



# Interlinkages Strength 5

| Link Strength | Description |
|---|---|
| 0 | No connections in FY17, but there are aspirations for a connection in the near future. |
| 1 | No data connection, but there has been a QA/QC exchange. |
| 2 | Manual data connection with HIGH levels of data processing. |
| 3 | Manual data connection with LOW levels of data processing |
| 4 | Manual data connection, without data processing |
| 5 | Automated data connection. |

Very few models have fully automated data connections. Exploration of the strength of linkages illustrates potential data connection inefficiencies and data management improvement opportunities.



# Acronyms

A&S: Analysis & Sustainability
BETO: (DOE) Bioenergy Technologies Office
FSL: Feedstock Supply & Logistics Program
MYPP: Multi-Year Plan (DOE BETO)
R&D: Research & Development

# Modeling Workshop – Emerging Questions #1

- What are broad benefits of the bioeconomy?
- How to show benefits to relevant stakeholders?
- How to make best use of biomass resources?
- How to strategically build out the bioeconomy?
- How do biofuels best compete in a changing landscape?
- How do biofuel markets and pathways interact in a larger transportation system?
- How do we estimate the impacts of using bioenergy (environmental and economics)?
  - How to we attribute the impacts?
  - How do we capture variances over time?
- How do we measure the impacts of government policies aimed at bioenergy and bioproducts?

# Modeling Workshop – Emerging Questions #2

- What feedstock supply chains are sustainable and reliable?
- How to reduce production cost?
- How to best utilize existing infrastructure?
- What is the best use of C contained in waste streams?
- Future tipping point for waste utilization (what is the tipping point for using waste C for products vs. electricity)?
- How to treat waste sources in LCA?
- How do we make our work more transparent and more relevant?

# Modeling Workshop – Hot Topics #1

- Integrated Transportation Models
- With limited time and money, how to prioritize modeling efforts
- Climate Change, Land Use, Biofuels / What are the potential impacts of landscape design optimization
- Current understanding of land use change and what need to be done in next few years / agroecological systems modeling for biofuels production
- Community modeling
- Why do we need or want bioenergy
- Moral and political aspects of bioeconomy
- Scales of modeling and different roles in informing policy
- What strategies (or situations/audiences/clients) make model results relevant
- How can we integrate with fossil industry with agriculture? Competition, Collaboration
- Social: modeling, measurement, verification for biofuel policy
- Model mapping: Next Steps?

# Modeling Workshop – Hot Topics #2

- What are our assumptions about “expanding” the bioeconomy? (How do we model demand and diffusion)
- Methods for bounding and dealing with uncertainty
- Can we develop a global bio-economy model? Should we?
- Biofuels and Electrification. Are there synergies?
- How do we decide the best applications for biomass/bioenergy?
- Role of bioeconomy in mitigating economic inequality (esp. rural)
- State and local policies vs. federal activities – modeling, benefits, costs
- “Simple” models for integrated thinking
- Modeling the impacts of a farm crisis on the bioeconomy
- How best to model an integrated supply chain to explore barriers/drivers for deployment?
- How do we address the social impact (Daley’s Delta)
- Credibility and maximum impact
- Visualizing the impact of decisions