

**U.S. Department of Energy (DOE)  
Bioenergy Technologies Office (BETO)  
2017 Project Peer Review  
1.2.1.5 Resource Mobilization  
March 6, 2017  
Feedstocks**

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# Goal Statement

**Investigate the dynamics and growth of current and emerging feedstock markets via business-to-business market information and econometric analysis to identify pathways for domestic resource mobilization.**

- Identify and evaluate **non-biofuel feedstock** markets and determine their potential role in mobilizing domestic biomass resources
- Determine the impact of **competing** uses, policy and market demands on domestic feedstock supply and price projections
- Evaluate the risks and benefits of **commoditization and trade** on domestic feedstock resources and mobilization rates
- Provide feedstock **market intelligence** to related BETO efforts (e.g., BT16, BSM) to strengthen scenario developments / model runs

# Quad Chart Overview

## Timeline

- Project start date: 10/01/14
- Project end date: 09/30/17
- On-going
- Percent complete: 77%

## Budget

	FY 15 Costs	FY 16 Costs	Total Planned Funding (FY 17- Project End Date)
DOE Funded (x1000)	\$349	\$215	\$255

## Barriers

- Barriers addressed
  - Ft-A. Terrestrial Feedstock Availability and Cost
  - Ft-I. Overall Integration and Scale-Up
  - Mt-A. Optimization of Supply Chain Interfaces and Cross-System Integration
  - At-C. Data Availability across the Supply Chain

## Partners

- Collaborators
  - Oak Ridge National Laboratory (ORNL)
  - National Renewable Energy Laboratory (NREL)
  - Michigan Biotechnology Institute
  - IEA Bioenergy Task 40 members

# 1 – Project Overview

## HISTORY

- FY14: global logistics model connection (collaboration with Utrecht University)
- FY15: *International Feedstock AOP* (adapted following 2015 Peer-Review)
- FY16-17: **Domestic feedstock market and mobilization focus**

## CONTEXT

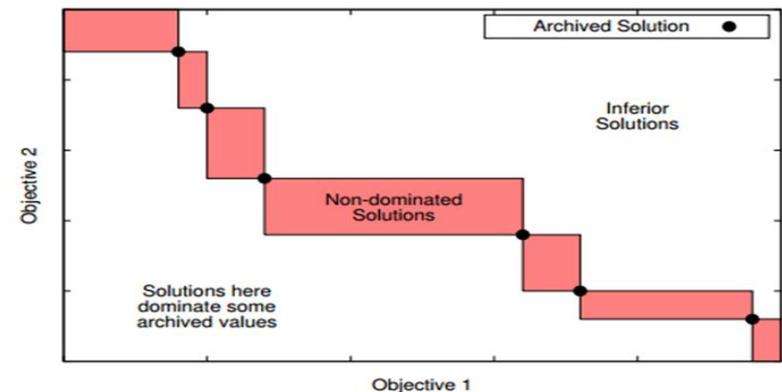
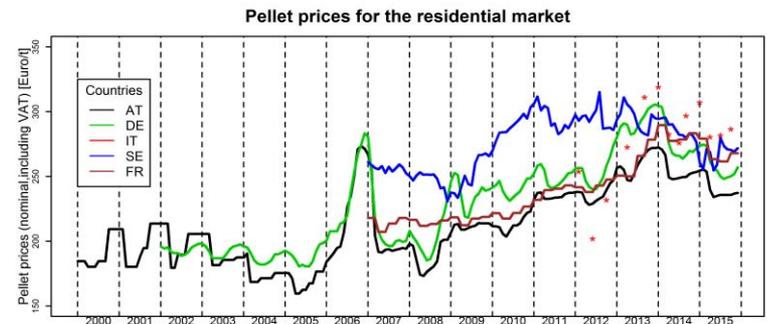
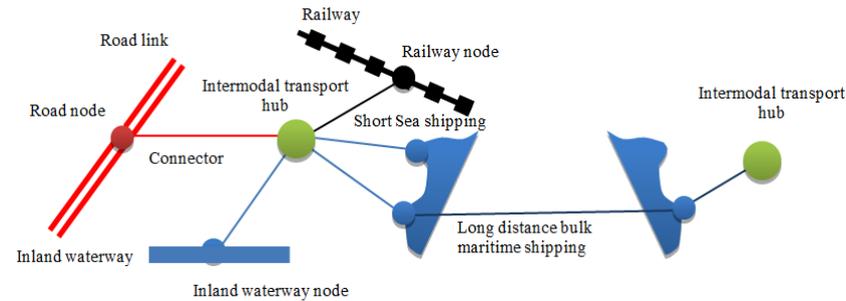
- **Chicken-and-egg**: Conversion industry financing requires secure supply
- In-field resources need to be **made available to the market** (merchandisable)
- Processing is required to achieve **feedstock fungibility**
- Leveraging alternative markets to **build out** processing and logistics industry

## OBJECTIVES

- Identify **leverage points** of non-biofuel feedstock industries (e.g., animal feed or biopower) to grow the mobilized resource base
- Identify **risks and opportunities** for increasing feedstock mobilization through **commoditization and trade**

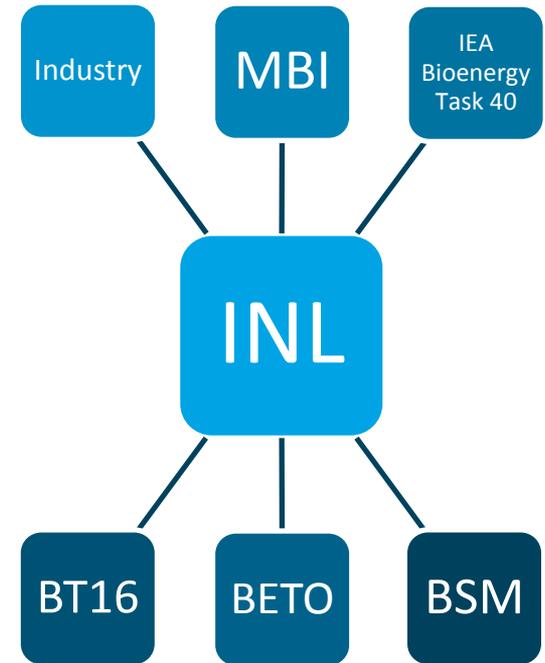
# 2 – Approach (Technical)

- **Collect** B2B market information
- **Improve and expand** INL feedstock market analysis modeling capabilities
- **Link and align** data and modeling experiences from collaborators
  - BSM (NREL), BT16 (ORNL)
  - Commodity trade theory (SEI)
  - EU policy projections (TUV)
- **Simulate** domestic and international **feedstock markets** (quantities and prices)
- Provide white papers / **business intelligence reports** to BETO and related efforts



## 2 – Approach (Management)

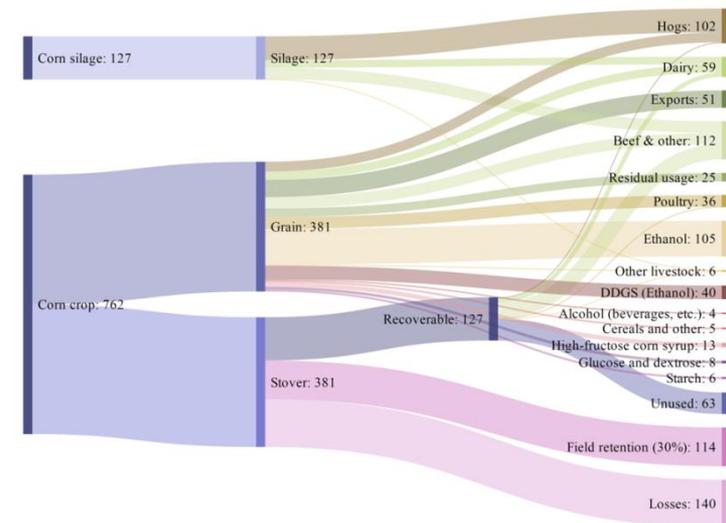
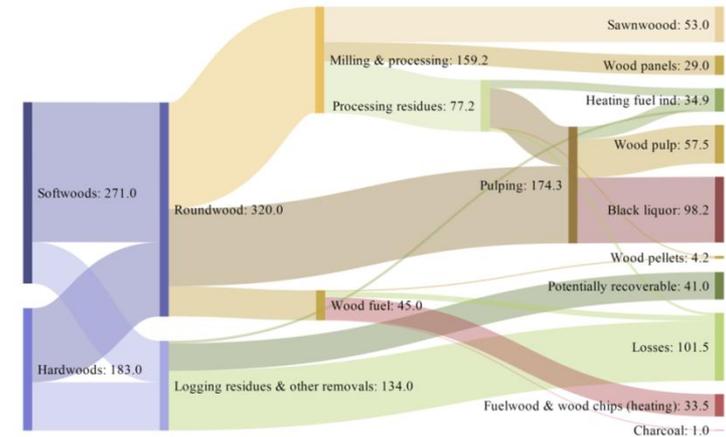
- Bi-Weekly conference calls with BETO, four written reports (milestones) per year
- Annual results vetted by peer-review (academia) and disseminated at industry conferences
- Data collection and alignment through collaboration and industry outreach, engagement in platform working groups
- Leveraging of existing collaborations to create synergies across the platform and reduce costs
- Potential challenges:
  - Scope limitation to most relevant feedstock markets
  - Keeping up to date on policies and markets which change continuously



# 3 – Technical Accomplishments/Progress/Results

## Review of Domestic Feedstock Markets / Use

- Quantification of current domestic production and use of corn stover and wood
- Data collection and compilation from EIA, USDA, USFS, MBI, and others
- Currently underutilized fractions per year:
  - Corn stover: ~ 63 million tons
  - Forestry material: > 41 million tons
- Promising alternative feedstock markets
  - Combustion (heat and power)
    - Wood pellets, mainly export
    - Growth potential (additional resources)
  - Animal feed (domestic, herbaceous)
    - Herbaceous biomass, co-feed (e.g., AFEX)
    - Level market (but large)
  - Absorbents
    - Any pellet, small market, level



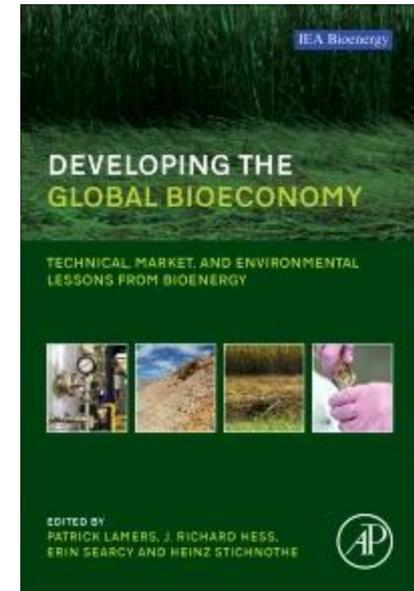
# 3 – Technical Accomplishments/Progress/Results

## Compilation of Mobilization Knowledge at INL and collaborators

- Outlining technical, logistics and market lessons from bioenergy
- Logistical integration, market transition, impact of commoditization
- Commoditization criteria
  - Intermediate good: stable/storable, flowable, dense, tradeable
  - Standard quality: fungible → transparency & confidence
  - Market: competitive, liquid (as a result often international)

Commodity-Criteria	Wood pellets	Herbaceous pellets
Intermediate (B2B)	√	√
Standard quality	√	-
Competitive markets	(√)	-
Liquid markets	√	-
International markets	√	-
Futures contract	√	-

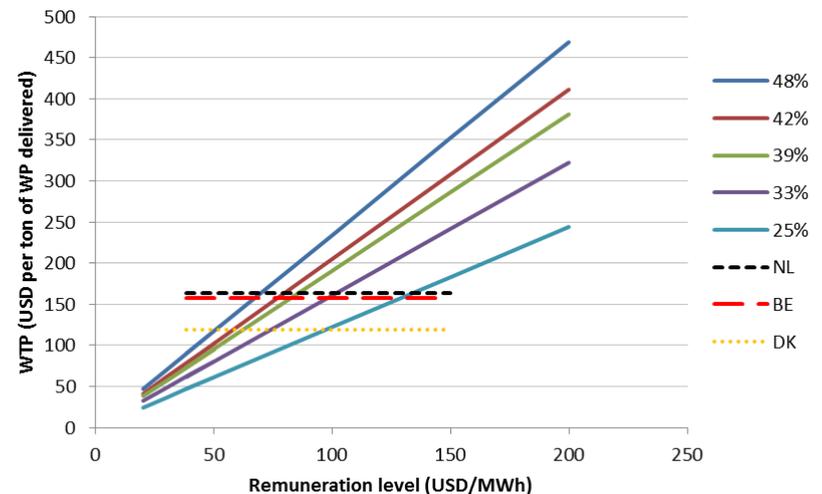
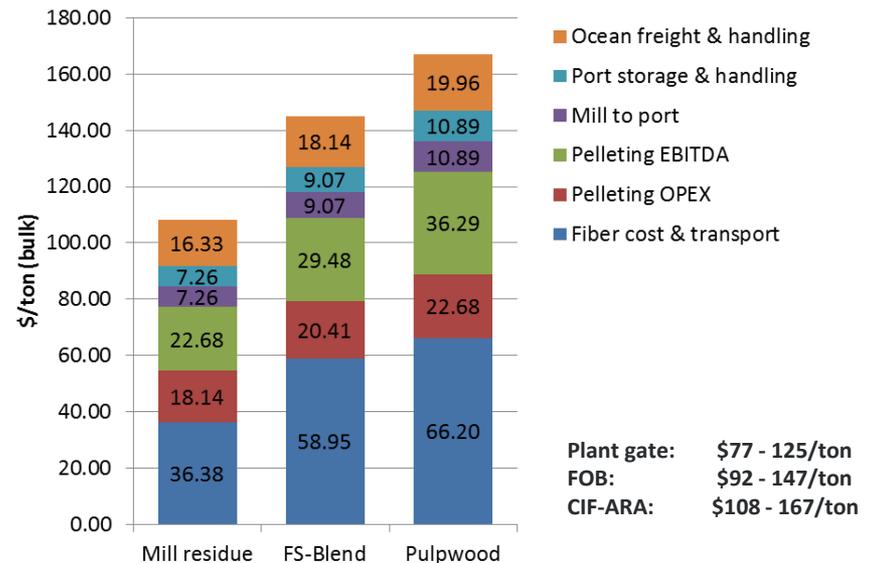
- Lessons from fossil fuel commodity markets
  - Oil: supply disruptions changed market structure and pricing (indexing to spot price)
  - Vertical integration as a risk management tool
  - Rigid fuel quality standards perceived as obstacles to market liquidity
  - Coal: steam vs. metallurgical / biofuel vs. combustion



# 3 – Technical Accomplishments/Progress/Results

## Feedstock Value: Willingness-To-Pay (WTP)

- Identification of demand markets
  - Combustion in Europe (until 2027)
  - Combustion in Asia (growing slowly)
- WTP influenced by
  - Policy schemes/remuneration level
  - Plant efficiencies
- Ex post price analysis
  - U.S. wood pellet production, transport and transloading costs
  - International shipping costs
- WTP of export markets (plant level, 2015)
  - In U.S. harbors (FOB): \$90-\$145 per ton
  - At destination harbors (CIF-ARA): \$120-\$175 per ton

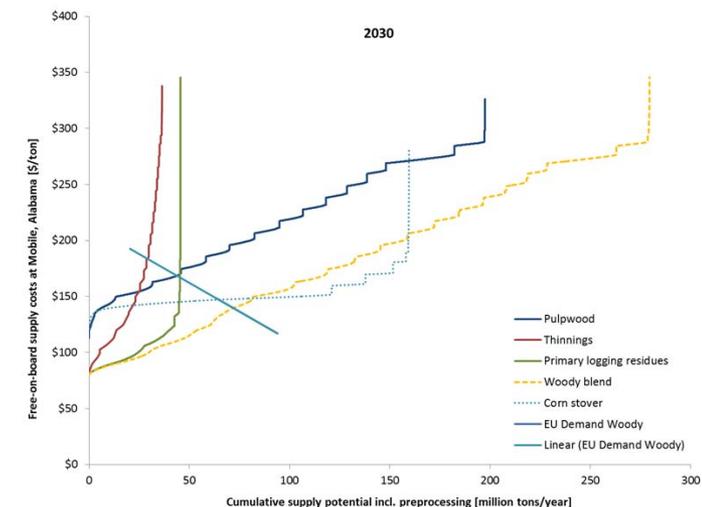
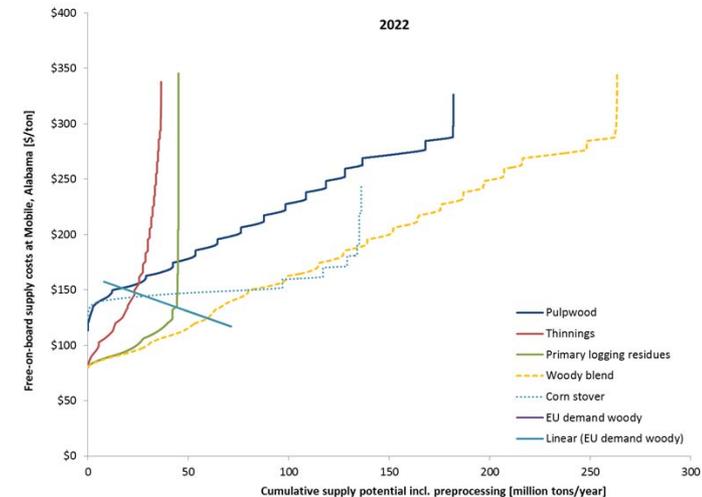


# 3 – Technical Accomplishments/Progress/Results

## Feedstock Supply Curves at U.S. Export Locations

- Feedstock blends (based on BT2)
  - Woody: Pulpwood, thinnings, logging residues
  - Herbaceous: Corn stover
- Least-Cost Formulation Spatial Analysis
  - Export location: Mobile, AL
  - Inland depot infrastructure (pelletizing)
  - Optimization of transport costs
  - Compute total biomass available
- Theoretical EU demand curve (based on historic demand-price points) creates equilibria

	2022	2030
Woody blend	60 Mtons	72 Mtons
	\$124/ton	\$140/ton
Herbaceous blend	28 Mtons	64 Mtons
	\$145/ton	\$148/ton

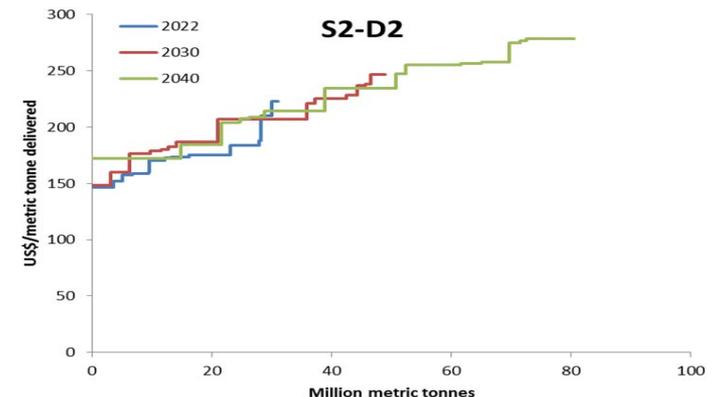
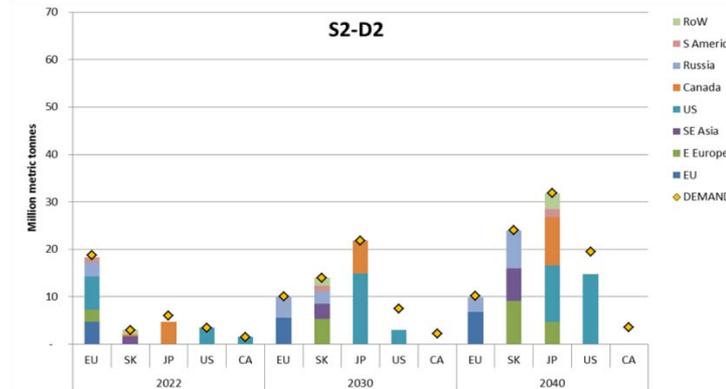
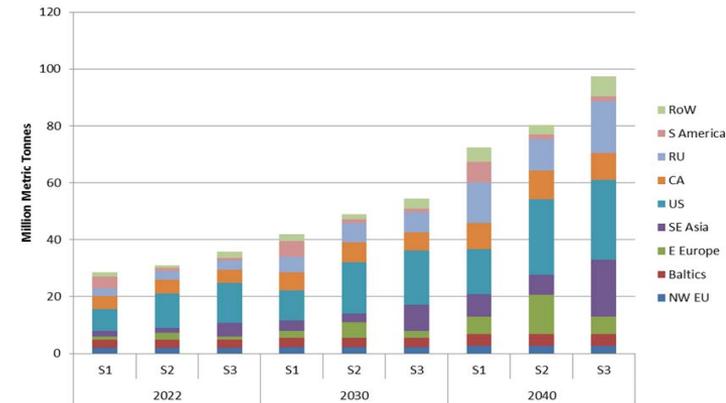


# 3 – Technical Accomplishments/Progress/Results

## Domestic Prices in Competitive Feedstock Markets

- Commodity market: independent buyers and sellers
  - U.S. domestic plus global feedstock supply (expected wood pellet processing capacity)
  - Domestic and global demand
  - Represents spot market
- Non-cooperative, bi-level Stackelberg model
  - Any demand can be satisfied by any supply
  - Supply defined by costs, demand by WTP
  - Demand competition: cost minimization
  - Supplier flexibility (sell to any/multiple buyers): profit maximization
- Country-level results: supply cost (delivered)

	2022	2030	2040
Domestic	\$133	\$135	\$156
Export	\$138-\$159	\$140-\$188	\$162-213



## 4 – Relevance

- Industry confirms that **markets** will be the primary driver to **enable a future** U.S. billion-ton **bioeconomy** (DOE workshop 2015)
- Lack of biorefinery demand requires **non-biofuel markets to mobilize** biomass resources (which makes them accessible to biorefineries)
- A secured **feedstock supply** beyond individual farmer contracts or farmer cooperatives is essential to access financing for processing and conversion facilities (USIPA conference 2016)
- **Processing** of feedstock is a requirement to achieve product **fungibility** across multiple markets
- Understanding the value, size and quality requirements in these markets is critical to determine domestic **mobilization pathways**
- **Commoditization** of feedstock intermediates could grow the domestic resource base and provide finance sector acceptance (due to wider product fungibility)

## 5 – Future Work

- **MYPP milestone:** Determine the impact of **competing** uses, policy and market **demands** on domestic feedstock supply and price projections
- Analyze how a feedstock **supply push** (e.g., the anticipated overcapacity in U.S. wood pellet production) could facilitate the establishment of a U.S. bioeconomy and in what timeframe
- Evaluate the relevance of **aggregating and cascading non-biofuel feedstock markets** within this context
- Model the related feedstock **infrastructure build-out** and its potential industry dynamics (e.g., spill-over effects)
- Identify **underutilized domestic resources and market voids** due to structural sector trends (e.g., forest sector decline) creating regional opportunities to increase domestic biomass mobilization

# Summary

- U.S. biorefineries will **compete for feedstock with existing markets**
- Currently they would need to pay a premium **unless additional** domestic resources are mobilized
- But the emerging biorefining industry does not yet create sufficient **demand pull** to increase domestic biomass mobilization
- **Non-biofuel feedstock markets** need to be leveraged to increase resource mobilization, reduce supply prices and business risk
- **Dynamics in feedstock markets** need to be understood to determine (new) mobilization pathways
- **Feedstock market intelligence** generated in this project serves as strategic input to other BETO efforts (e.g., BT16, BSM)
- Results are vetted by **peer-review** and **disseminated** through active participation at industry conferences (e.g., USIPA)

# Questions

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# Responses to Previous Reviewers' Comments

- Project goals were clearly defined and important to the growing bioeconomy [...] however not sure if BETO needs to lead this effort.
  - *BETO's programmatic goal to facilitate a domestic bioeconomy is directly linked to this effort via the quantification of potential resource mobilization hurdles as well as opportunities for expanding the domestic resource base.*
  - *Collaboration with USDA and USITC was pursued but eventually phased-out due to a lack of interest and commitment by the other agencies.*
- Work is relative to BETO as trade factors and policies will impact feedstock supply [...] but [...] policy is fluid and I'm not sure how this work can be used to direct policy given our policies are set by the Executive powers and other nations.
  - *The dynamic policy context of renewable energy will remain over the course of the project. Hence, the team closely follows global policy developments via respective literature and news.*
- How will these results be disseminated to policy makers?
  - *Dissemination beyond publications, particularly to address policy makers and other stakeholders, has been done and will be continued in the form of national and international workshops and conference presentations. BETO is briefed bi-weekly and receives four written reports (milestones) per year.*

# Publications (1)

- Lamers, P., E. Searcy, J. R. Hess and H. Stichnothe (2016). *Developing the Global Bioeconomy*. Cambridge, MA, USA, Elsevier Academic Press, 197pp.
  - Chapter 1 - Bioeconomy Strategies. Hess, J. R., P. Lamers, H. Stichnothe, M. Beermann and G. Jungmeier: 1-9.
  - Chapter 5 - Biomass Supply and Trade Opportunities of Preprocessed Biomass for Power Generation. *Developing the Global Bioeconomy*. Batidzirai, B., M. Junginger, M. Klemm, F. Schipfer and D. Thrän: 91-114.
  - Chapter 6 - Commodity-Scale Biomass Trade and Integration with Other Supply Chains. Searcy, E., P. Lamers, M. Deutmeyer, T. Ranta, B. Hektor, J. Heinimö, E. Trømborg and M. Wild: 115-137.
  - Chapter 7 - Commoditization of Biomass Markets. Olsson, O., P. Lamers, F. Schipfer and M. Wild: 139-163.
  - Chapter 8 - Transition Strategies: Resource Mobilization Through Merchandisable Feedstock Intermediates. Lamers, P., E. Searcy and J. R. Hess: 165-185.
  - Conclusions. Lamers, P., E. Searcy, J. R. Hess and H. Stichnothe: 187-192.
- Three chapters in: Thiffault, E., M. Junginger, T. Smith and G. Berndes (2016). *Mobilisation of Forest Bioenergy in the Boreal and Temperate Biomes: Challenges, Opportunities and Case Studies*. Cambridge, MA, USA, Elsevier Academic Press, 239pp.
  - Chapter 4 - Environmental Sustainability Aspects of Forest Biomass Mobilisation. Egnell, G., D. Paré, E. Thiffault and P. Lamers: 50-67.
  - Chapter 8 - Challenges and Opportunities for International Trade in Forest Biomass. Lamers, P., T. Mai-Moulin and M. Junginger: 127-164.
  - Chapter 10 - Challenges and Opportunities for the Mobilisation of Forest Bioenergy in the Boreal and Temperate Biomes. Thiffault, E., G. Berndes and P. Lamers: 190-213.

## Publications (2)

- Olsson, O., L. Bruce, B. Hektor, A. Roos, R. Guisson, P. Lamers, D. Hartley, J. Ponitka, J. Hildebrandt and D. Thrän (2016). *Cascading of woody biomass: definitions, policy implications and impacts on international bioenergy markets*. Technical Report, IEA Bioenergy Task 40.
- Schipfer, F., L. Kranzl, O. Olsson, and P. Lamers (2017). The European wood pellet market for small-scale heating - Data availability, price developments and drivers for trade. *Energy Policy* (submitted).
- Schipfer, F., L. Kranzl, O. Olsson, P. Lamers and M. Wild (2016). *The European wood pellet market for small-scale heating - Data availability, price developments and drivers for trade*. Technical Report, IEA Bioenergy Task 40.
- Wild, M., M. Deutmeyer, D. Bradley, B. Hektor, J. R. Hess, L. Nikolaisen, W. Stelte, J. Tumuluru, P. Lamers, S. Proskurina, E. Vakkilainen and J. Heinimö (2016). *Possible effects of torrefaction on biomass trade*. Technical Report, IEA Bioenergy Task 40.
- Ren, L., Cafferty, K., Roni, M., Jacobson, J., Xie, G., Wright, C. (2015). Analyzing and Comparing Biomass Feedstock Supply Systems in China: Corn Stover and Sweet Sorghum Case Studies. *Energies*, 8(6), 5577-5597.
- Roni, M., Cafferty, K., Hess, R., Jacobson, J., Kenney, K., Searcy, E., Tumuluru, J. (2016). *Supply Chains for Bioenergy and Biorefining: Lignocellulosic Crop Supply Chains*. Woodhead Publishing Series in Energy.
- Hoefnagels, R., Searcy E., Cafferty, K., Cornelissen, T., Junginger, M., Jacobson, J., Faaij, A., (2014). Lignocellulosic feedstock supply systems with intermodal and overseas transportation, *Biofuels, Bioproducts, Biorefining*, 8(6), 794-818.

# Presentations, Outreach

- Olsson, O., P. Lamers and R. Guisson (2016). Cascading of woody biomass - impacts on forest markets and trade. U.S. International Pellet Association - Exporting Pellets Annual Conference. Miami, Florida, USA, 6-8 November.
- Talmadge, M., Batan, L., Lamers, P., Hartley, D., Bidy, M., Tao, L., Tan, E. (2016). Optimizing Biorefinery Design and Operations via Linear Programming Models. Symposium on Thermal and Catalytic Sciences for Biofuels and Biobased Products, Chapel Hill, North Carolina, USA, 1-4 November.
- Lamers, P., (2016). Developing the Global Bioeconomy - Technical, Market, and Environmental Lessons from Bioenergy. International Wood Refining Week, Stockholm, Sweden, 24 May.
- Thompson, D., Searcy, E., Lamers, P., Kenney, K., Hess, J. R. (2015). Feedstock supply system designs for mobilizing a billion tons of biomass. AIChE Conference, Salt Lake City, USA, 10 November.
- Lamers, P. (2015). Biomass Trade and Supply in a Global Bio-based Economy. IEA Bioenergy & DIA-CORE Workshop, Sassari, Sardinia, Italy, 5 May.

# Abbreviations

AFEX	Ammonia Fiber Expansion
AOP	Annual Operating Plan
B2B	Business-To-Business
BETO	(U.S. Department of Energy's) Bioenergy Technologies Office
BT2	Billion Ton Update
BT16	Billion Ton Update 2016 Volume 1
BSM	Biomass Scenario Model
CIF-ARA	Cost, Insurance, Freight – Amsterdam, Rotterdam, Antwerp (harbors)
DOE	U.S. Department of Energy
FAS	Free Alongside Ship
FOB	Free On Board
IEA	International Energy Agency
LCF	Least Cost Formulation
MBI	Michigan Biotechnology Institute
MYPP	Multi-Year Program Plan (of U.S. DOE BETO)
NREL	National Renewable Energy Laboratory
ORNL	Oak Ridge National Laboratory
SEI	Stockholm Environment Institute
TUV	Technical University of Vienna
UU	Utrecht University
WTP	Willingness-To-Pay