BR&DB
BIOMASS RESEARCH & DEVELOPMENT BOARD

Building a Billion Ton Bioeconomy Analysis

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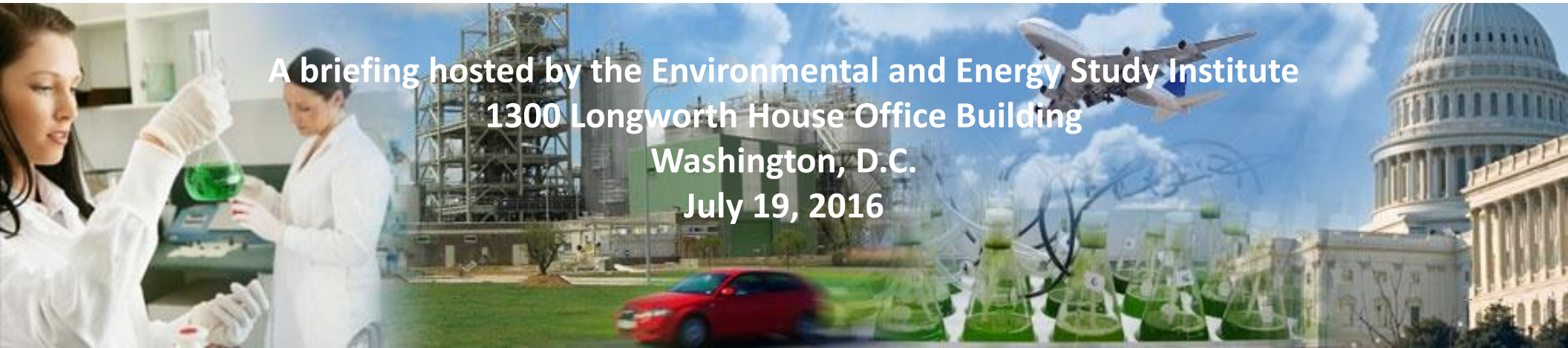

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A BILLION DRY TONS OF SUSTAINABLE BIOMASS

HAS THE POTENTIAL TO PRODUCE

1.1 MILLION Direct Jobs
and keeps about
$250 BILLION
in the U.S.
(direct contribution and inflation adjusted)

85 BILLION* kWh of electricity to power **6 MILLION** households. Plus **1050 TRILLION BTUs** of thermal energy.

50 BILLION gallons of biofuels displacing almost **25%** of all transportation fuels.

50 BILLION POUNDS of biobased chemicals and bio-products, replacing a significant portion of the chemical market.

400 MILLION TONS of CO_2e reductions every year.

STEPS TO BUILDING THE BIOECONOMY

1. Accelerate research & technology development
2. Develop production, conversion and distribution infrastructure
3. Deploy technology
4. Create markets and delivery systems

Projections based on:

- 2016 Billion Ton Study Report (Forthcoming)
- EIA 2015 AEO
- 2015 USDA Long-Term Forecast
- Various data sources

* Includes 27 billion kWh and 90 TBtu from livestock anaerobic digestion

Overview

The analysis was conducted under the U.S. Department of Energy and U.S. Department of Agriculture Biomass Research and Development Board by the Interagency Working Group (IWG).

Zia Haq (DOE) and Harry Baumes (USDA) – IWG co-chairs

1. The Biomass R&D Board and the Bioeconomy Vision
2. The Billion-Ton Bioeconomy Analysis and the Billion-Ton Report
3. Methodology and Analysis Tools
4. Biomass Availability and Product Distribution
5. Sensitivity Analyses and High Level Findings
6. Summary

The Biomass R&D Board and the Bioeconomy Vision

The Biomass R&D Board

- Created through the enactment of the Biomass Research and Development Act of 2000
- The Board facilitates coordination among federal government agencies that affect the research, development, and deployment of biofuels and bioproducts

For the Bioeconomy Analysis, the **"Bioeconomy"** is a global industrial transition of sustainably utilizing renewable aquatic and terrestrial biomass resources in energy, intermediate, and final products for economic, environmental, social, and national security benefits.

From 2014 Report: Why Biobased? Opportunities in the Emerging Bioeconomy: Why BioPreferred, *biopreferred.gov/files/WhyBiobased.pdf*

The Billion-Ton Bioeconomy Analysis and the Billion-Ton Report

Billion-Ton Reports

- 2005
- 2011
- 2016

Resource Assessments – biophysical, economic, and sustainable availability of biomass resources under given assumptions and modeling capabilities

How much biomass?

BIOECONOMY VISION

Bioeconomy – expanded economy/market sector of various products under estimated feedstocks levels and given scenarios

What can we do with it?

Assume that demands for food, feed, industrial uses, and exports continue to be met.

The Billion-Ton Bioeconomy Analysis and the Billion-Ton Report

The Billion-Ton report has a lot of variables to account for!

Feedstock Types

- Agricultural residues
- Forest resources
- Energy crops
- Waste resources
- Algae

Biophysical Availability

- Productivity and growth scenarios
- Forest resource demand scenarios
- Land allocation and water consumption constraints

Economic Availability

- Roadside and farmgate cost supply curves
- Logistics and transportation cost impacts

The Billion-Ton Bioeconomy analysis constrains these variables:

Using specific assumptions based on BT16 to establish a range of possible products and economic and environmental impacts.

This is a demonstrative analysis – not predictive or a roadmap.

Methodology and Analysis Tools

The Bioeconomy Analyses are based on:

- RFS actual production volumes
- 2016 Billion Ton Report
- EIA Annual Energy Outlook 2015
- EIA Monthly Energy Review 2015
- EIA Electric Power Annual 2015
- 2015 Livestock Anaerobic Digestion Database (AgSTAR)
- EIA U.S. Refinery Production Report
- Economic Impact Analysis of the U.S. Biobased Products Industry, Congressional Report, 2015
- IEA Bioenergy Task 42
- Landfill Methane Outreach Project (LMOP)
- United Nations Food and Agricultural Organization
- Other

Supporting Models and Tools Include:

- A dynamic Excel® spreadsheet to complete calculations and maintain the data
- **Air emissions, Greenhouse gas emissions, and Energy consumption (AGE)** developed by Argonne National Laboratory based on the GREET model
- **Policy Analysis Framework (POLYSYS)** utilized by Oak Ridge National Laboratory to generate biomass supply curves
- **Biomass Logistics Model** Feedstock logistics and pre-processing costs were provided by Idaho National Laboratory's model (INL, 2014).
- **ForSEAM** Comprehensive economic characterization of the US forest sector and is calibrated to the US Forest Service Resource Planning Act 2010 assessment [US Forest Service, 2012].

Biofpr Biofuels, Bioproducts & Biorefining

SCI

Manuscript submitted to Biofuels, Bioproducts, and Biorefining and is currently undergoing peer review

Biomass Availability and Product Distribution

An expanded analysis considers scenarios impacted by:

Feedstock Availability

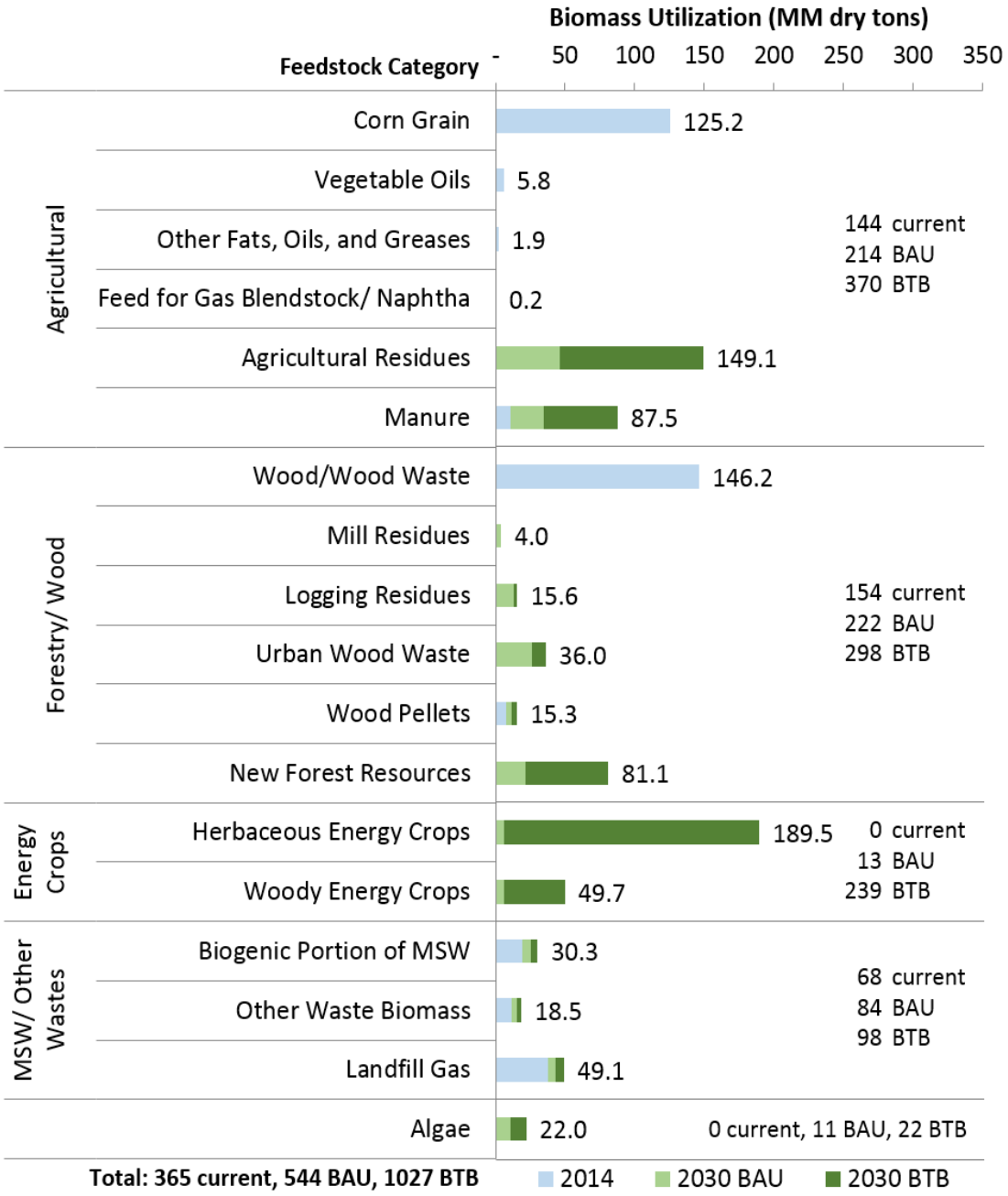
- **Current (2014)**
- **Projected (2030)**
  1. **Business-as-Usual Availability**
     Primary feedstocks from BT16 baseline yield, $40/dry ton (w/out transportation or logistics costs)
  2. **Billion-Ton Availability**
     Primary feedstocks from BT16 baseline yield, $60/dry ton (w/out transportation or logistics costs)

Product Distribution

- Chemicals
- Fuels
- Wood Pellets
- Heat & Power

Sensitivity analyses are used to explore a range of, “What ifs?”

Feedstock Availability Comparisons



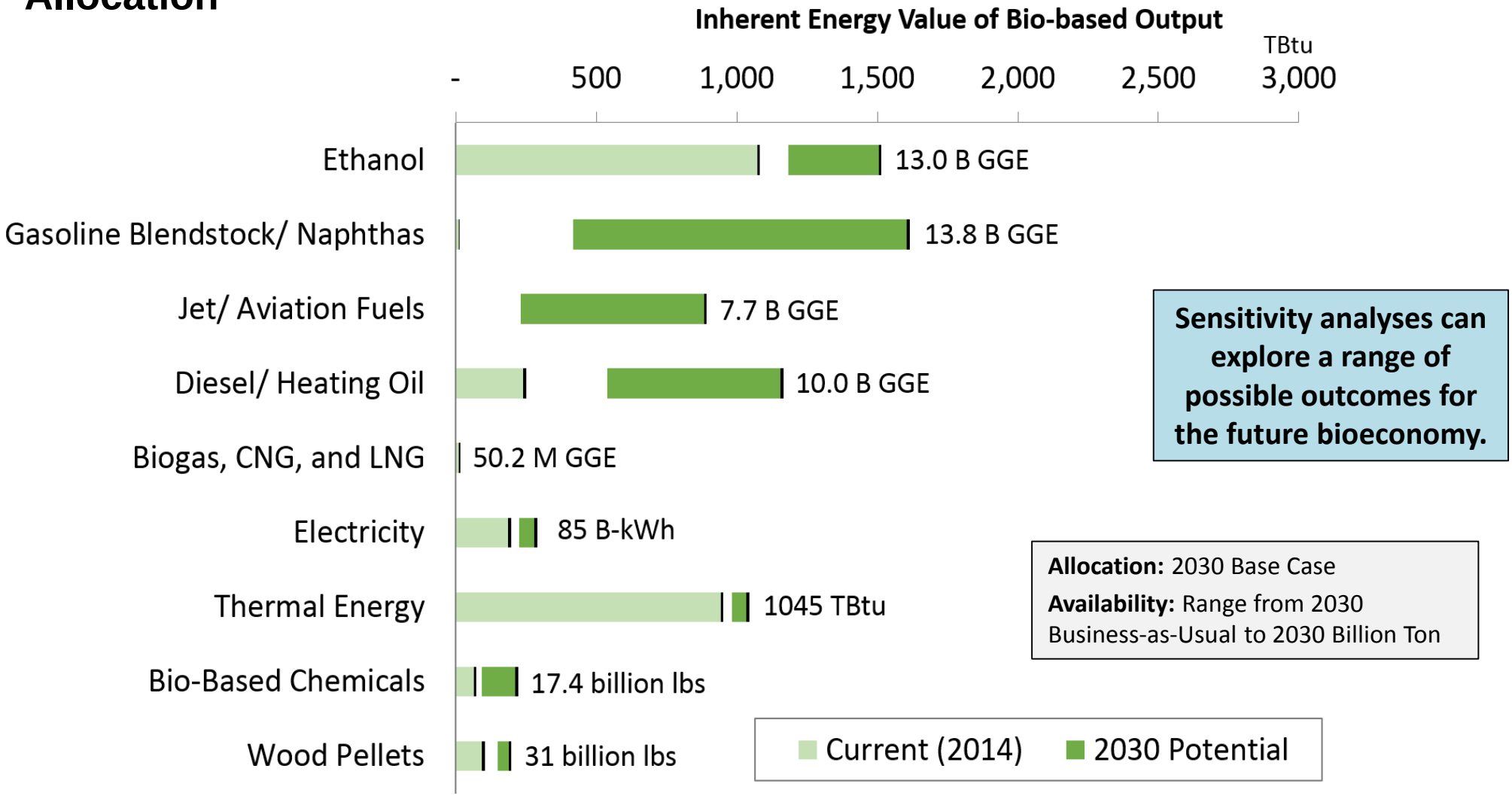
Feedstock Availability

- Current (2014)
  - **365 MM dry tons utilized**
- 2030 Business-as-Usual
  - **544 MM dry tons utilized**
  - Primary feedstocks from BT16, $40/dry ton (w/out transportation or logistics costs)
- 2030 Billion Ton potential
  - **1027 MM dry tons utilized**
  - Primary feedstocks from BT16, $60/dry ton (w/out transportation or logistics costs)

Stacked bars represent additional biomass availability for each scenario

Presenting the Bioeconomy as a Range of Possibility

Potential Product Outputs for the 2030 Base Case Product Allocation



Sensitivity analyses can explore a range of possible outcomes for the future bioeconomy.

Allocation: 2030 Base Case
Availability: Range from 2030 Business-as-Usual to 2030 Billion Ton

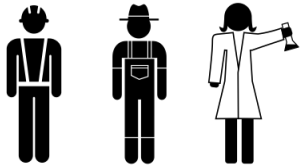
Note: 2030 Potential ranges from the "Business-as-Usual" availability to the "Billion Ton" potential.

Sensitivity Analyses and High Level Findings

Sensitivity Analyses

Revenue

Direct Employment



Avoided GHG emissions

Land allocation

Blue water consumption

High Level Findings

The bioeconomy presents significant opportunities for biomass to make positive economic and environmental contributions to the United States

Success is contingent upon developing feedstock supplies, lowering production costs, and enhancing the value of bioeconomy products

Aviation fuels and bio-based chemicals present unique commercialization opportunities

Summary

- This is a demonstrative analysis – not a prediction or a roadmap
- Biomass resources and bio-based energy, fuels, and products will play an important role in the transition to a sustainable low-carbon economy
- We are working to complete the BioFPR peer review process for the Billion-Ton Bioeconomy Analysis manuscript
- We will continue to support Biomass R&D Board and Interagency Working Group efforts to expand the bioeconomy

Contributors

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THANK YOU