DuPont Danisco Cellulosic Ethanol (DDCE) LLC Evaluates Business Opportunities with Sustainability Assessments

Oak Ridge National Laboratory
Center for BioEnergy Sustainability Forum
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Presentation Overview

- Introduction to DDCE
- Integrating Life Cycle Assessment (LCA) into process development and commercialization
- LCA results and comparisons
- A Vision for Biofuels Sustainability
- Q&A

Introduction to DDCE

DuPont Danisco Cellulosic Ethanol

- Joint venture between DuPont and Danisco, which brings $140 million investment, Legacy IP, and multimillions of prior R&D
- Cost effective biochemical solution for sustainably converting cellulosic feedstocks such as corn residues & switchgrass to ethanol
- Planning for our own commercial biorefinery and licensing technology to customers

Cellulosic ethanol allows us to *accelerate* America's transition into the bio-economy by expanding opportunities for other advanced biofuels and bio-based products.

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Demonstration-Scale Biorefinery

- Vonore, TN – processing started up December 2009
- Nominal capacity 250kgal/yr
- Corncob & stover
- Demonstrate Integrated Unit Operation and Basic Data Package

DDCE's Integrated Conversion Process

Milling

- High bulk density
- Minimize dirt, rocks

Pretreatment

- Minimal capital
- Facilitate enzymes
- Minimize inhibitors
- Mild process

Saccharification

- High sugar yield
- High sugar titers
- Low enzyme loading
- Minimize inhibitors

Fermentation

- C5/C6 utilization
- High Ethanol yield
- High ethanol titer

Separation

- Recover product
- Recover lignin
- Recycle water

Integrating Life Cycle Assessment into Process Development and Business Decisions

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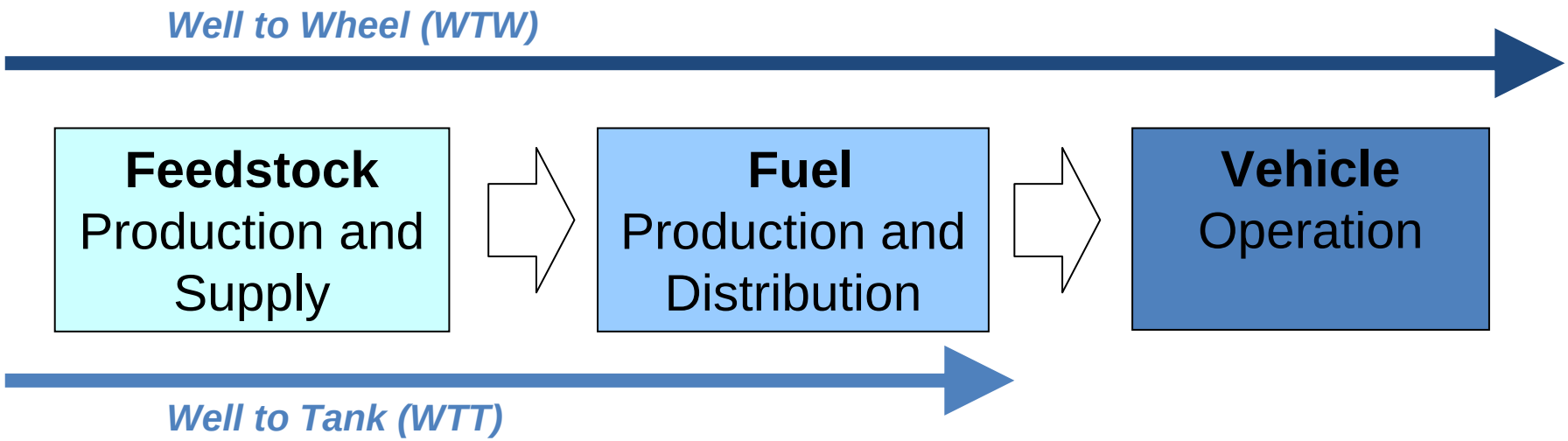
Biofuel Value Chain



Biofuel Sustainability in the Value Chain

Sustainable Agriculture
- Land Use
- Soil Health, Erosion
- Water Use & Quality
- Agrochemicals Footprint
- Field Emissions
- Biodiversity
- …….

Sustainable Biorefinery
- Feedstock Yield
- Energy Efficiency
- Energy Source
- Water Use & Discharge
- Air Emissions
- Waste
- …….

Sustainable Transportation
- Drive train efficiency
- Fuel performance
- Tailpipe emissions
- ……..

Well to Wheel (WTW)

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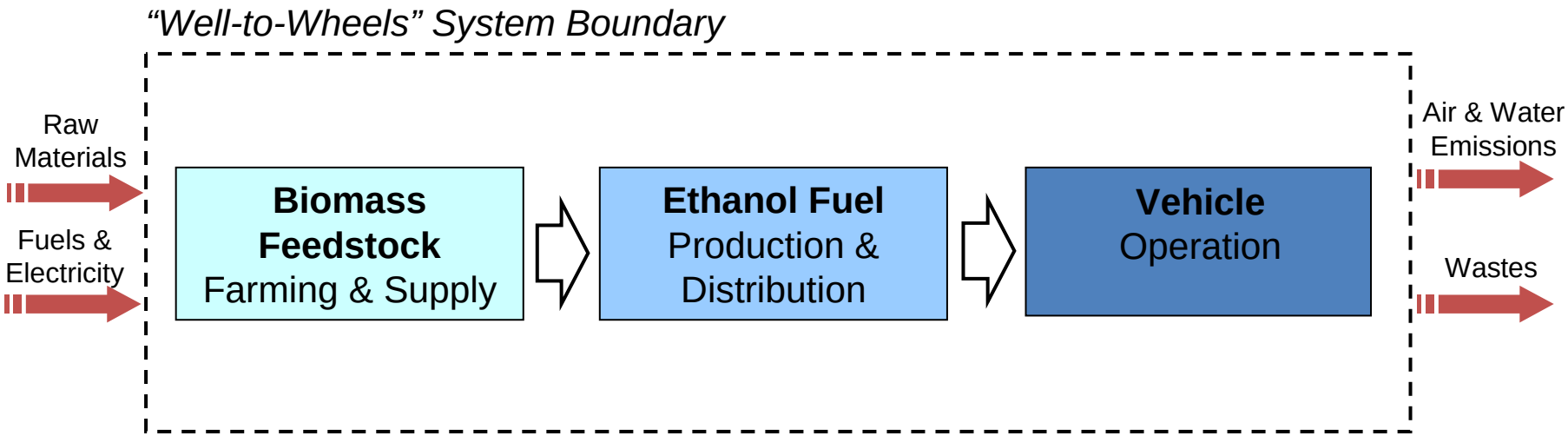
The DDCE Sustainability Vision

- Deliver comprehensive cellulosic ethanol solutions with competitive social, economic, and environmental benefits
- Integrate sustainability into all business practices and decisions, including:
  - process design
  - site selection
  - feedstock supply
  - co-product management
- Assess environmental well-to-wheel impacts early and often, to understand consequences of business and technology choices
- Engage stakeholders in a dialogue on sustainability.

The Biofuel Well-to-Wheel LCA System



LCA ISO standards 14040 series: only standardized method to evaluate the environmental footprint of the whole supply chain.

LCA should be complemented with assessments of local or regional environmental issues and evaluations of socio-economic impacts, including safety.

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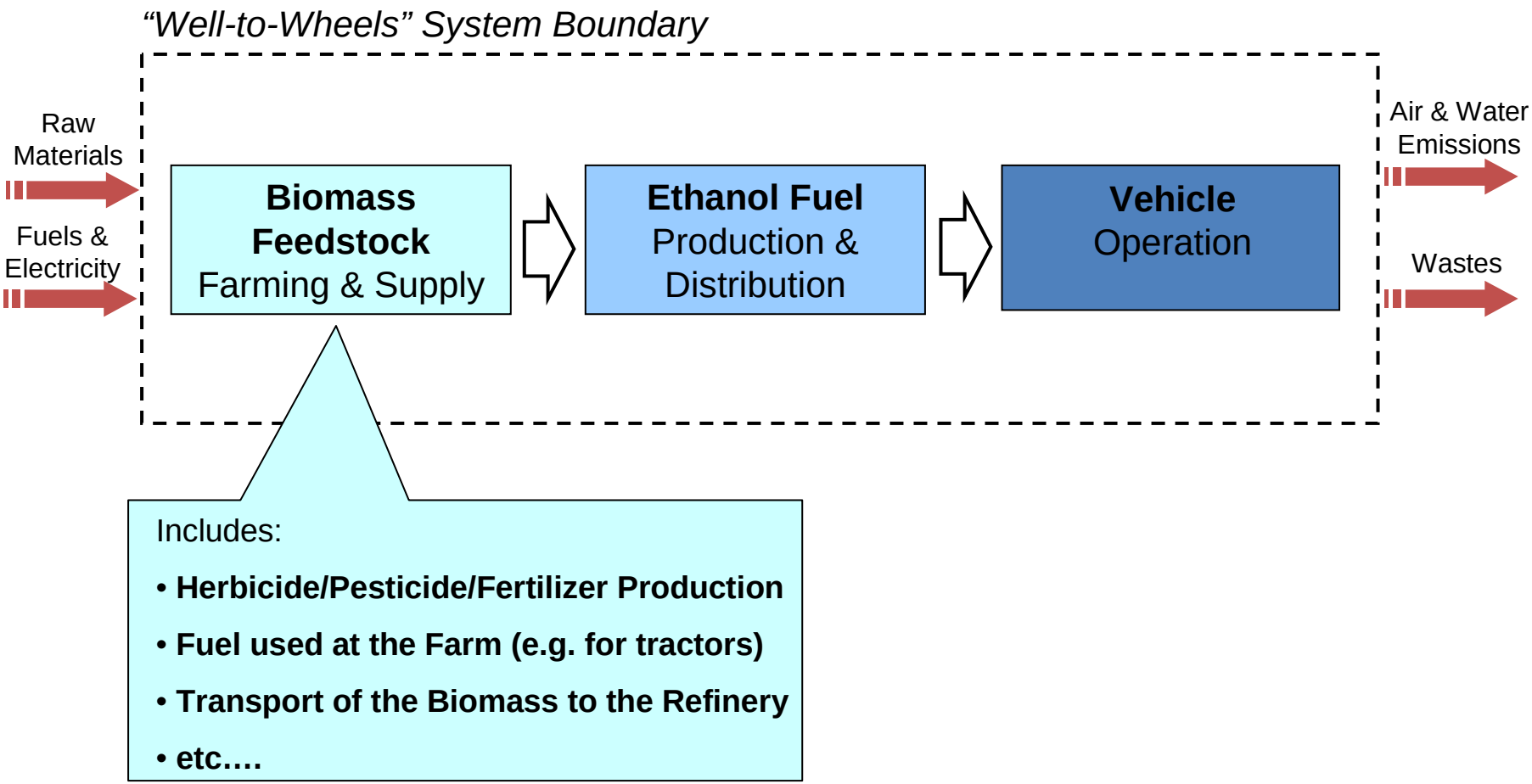
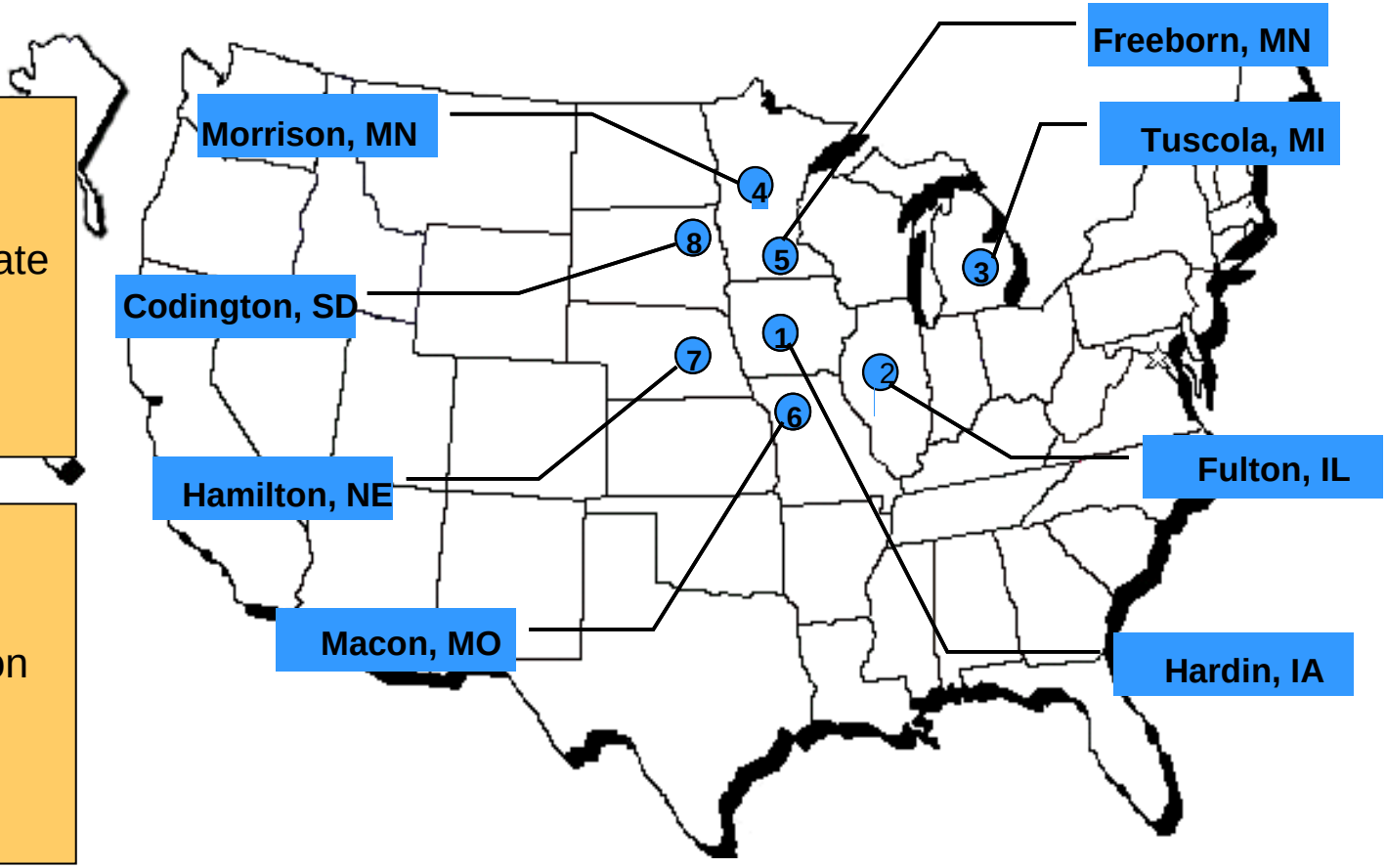
LCA in Biofuels Applications



Corn Farming LCA with MSU: Locations across Corn Belt

Variables:
- Location
- Stover Removal Rate
- Farming Practice (Tillage and Winter Cover Crop)

Outputs:
- GHG
- Soil Organic Carbon
- Eutrophication
- Air Acidification
- Fossil Energy Use



see Kim, Dale, and Jenkins (2009):
"Life cycle assessment of corn grain and corn stover in the United States", In J LCA, on-line @http://www.springerlink.com/content/c2205l5747622673/fulltext.pdf

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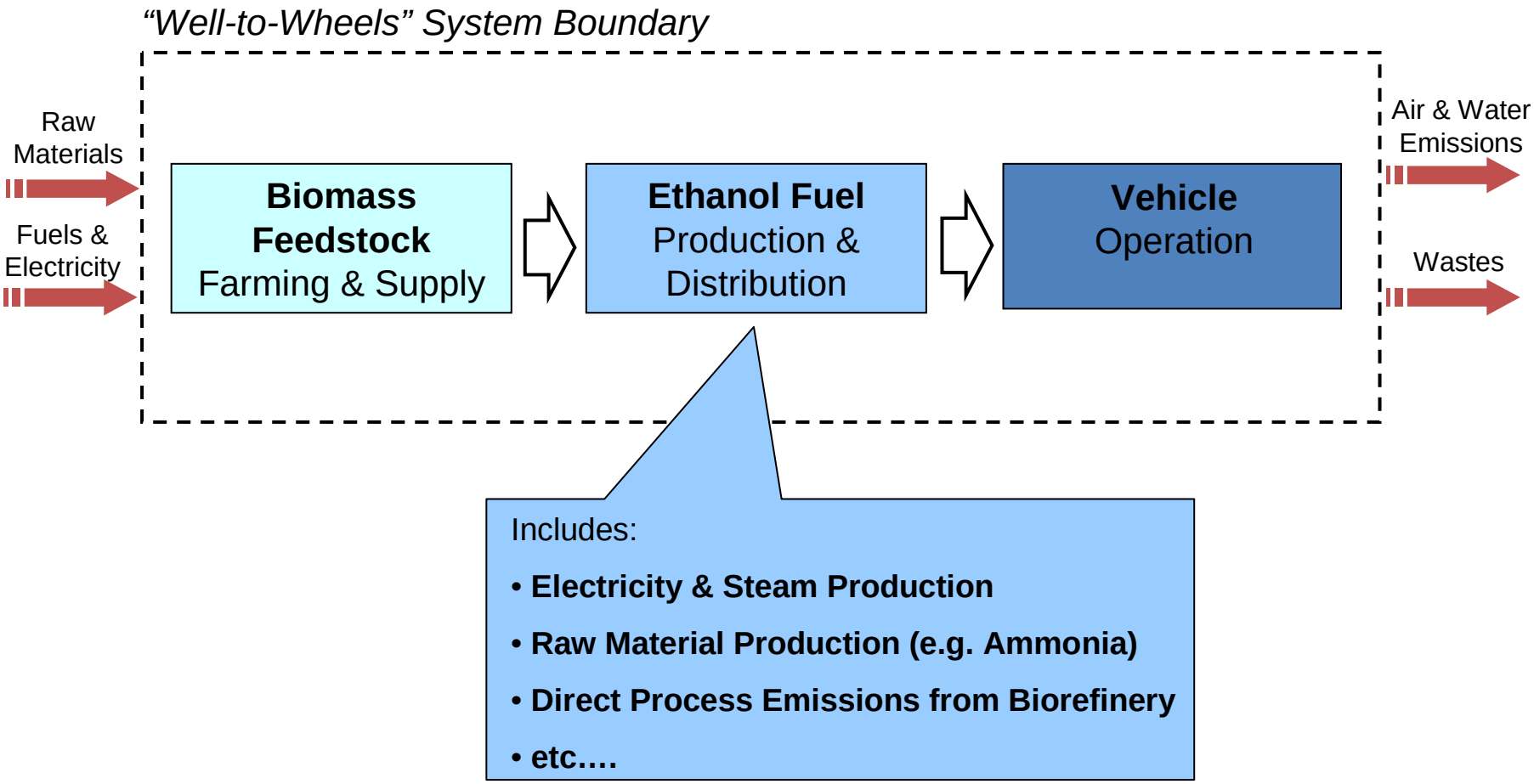
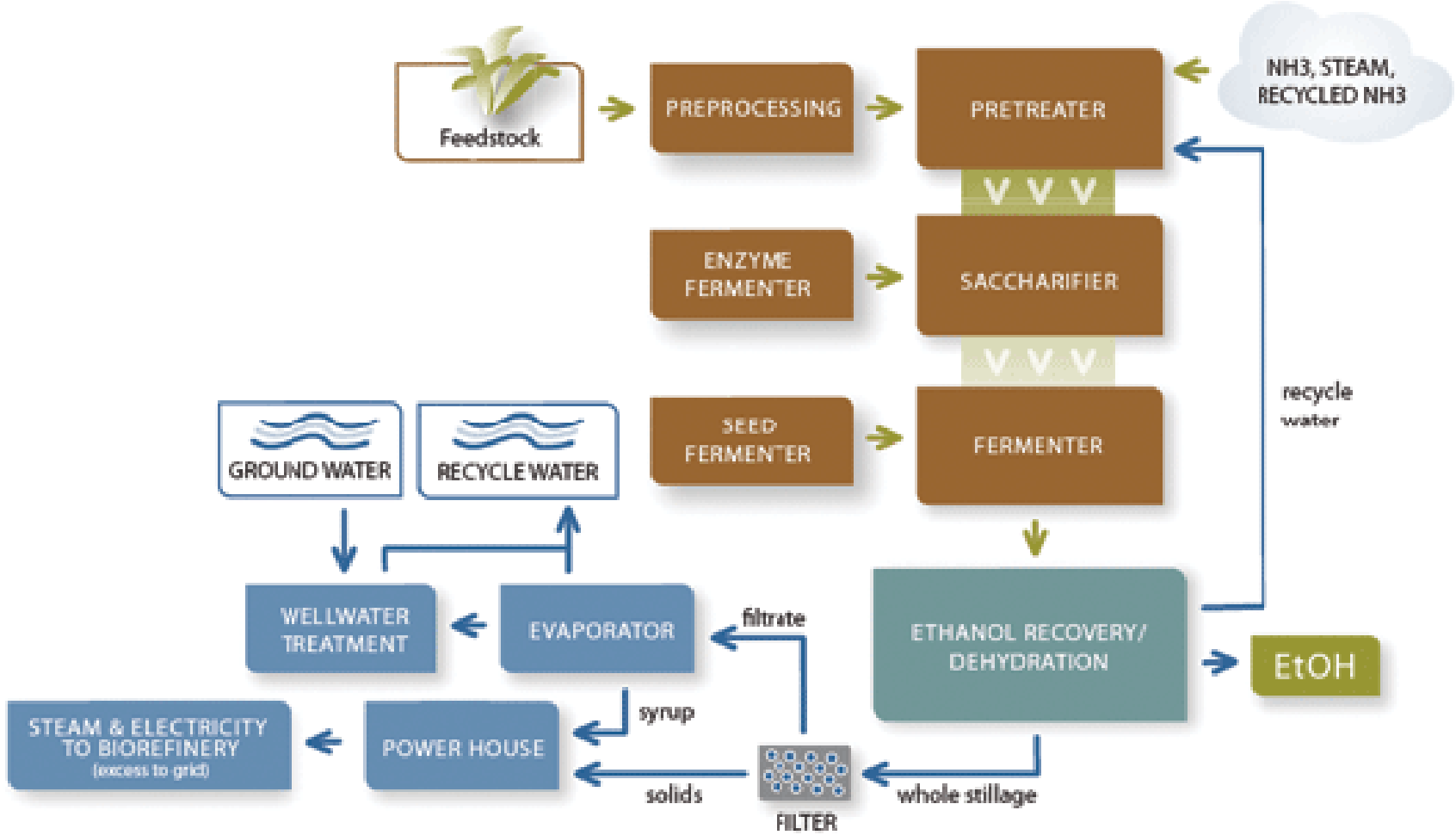
LCA in Biofuels Applications



The DDCE Biorefinery



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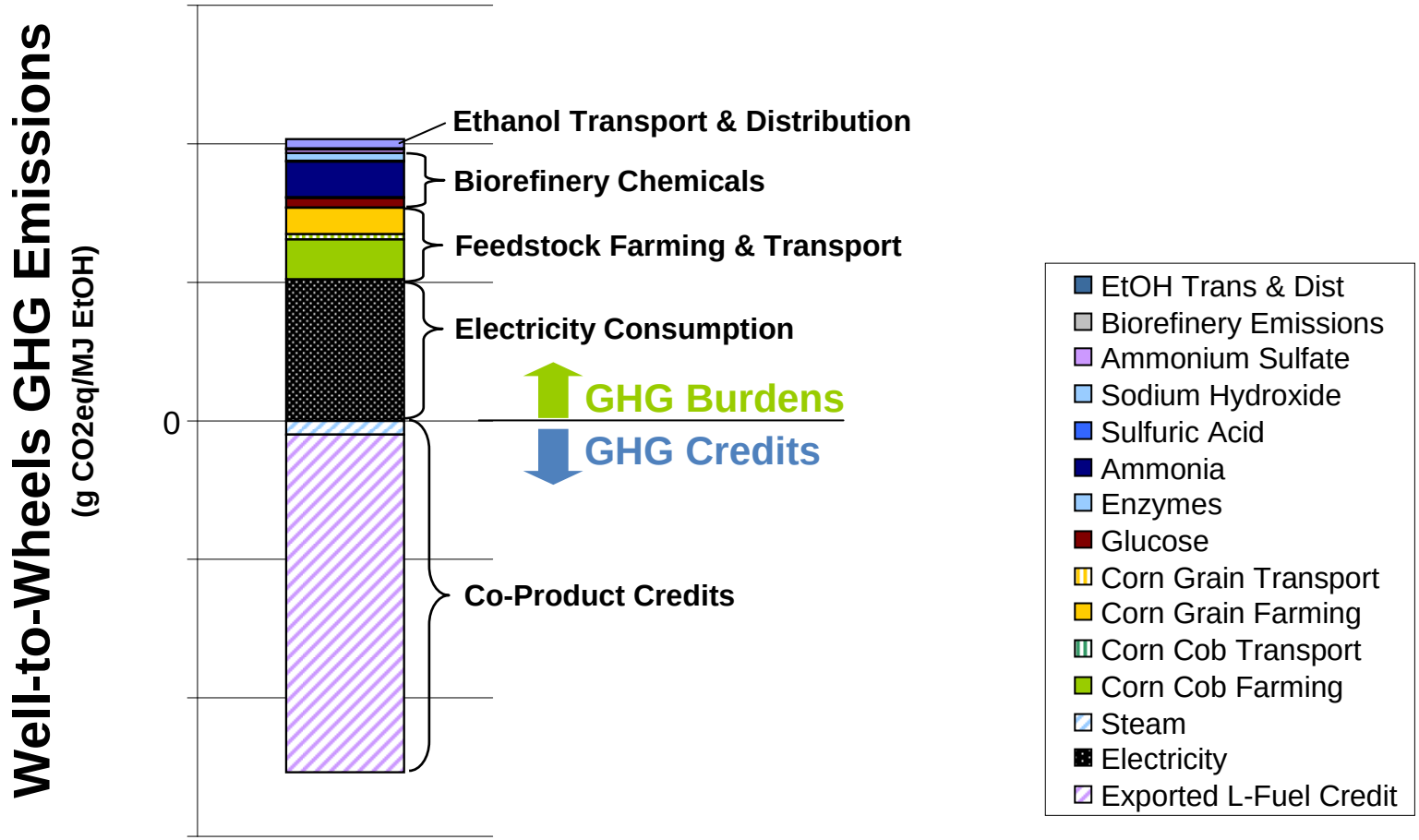
LCA Results:

What does the DDCE GHG Footprint look like?



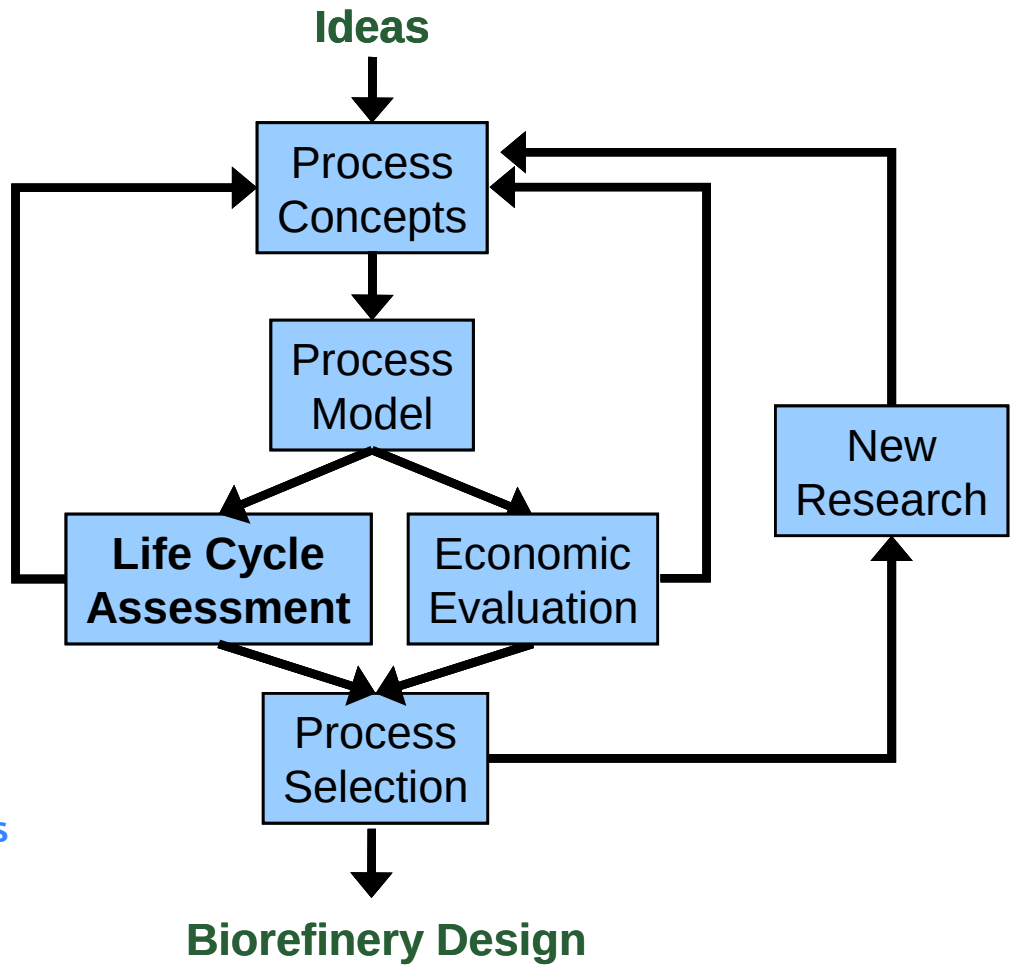
Incorporation of LCA in Process Development

LCA Results:

- Validate compliance with government mandates
- Compare DDCE versus benchmarks

LCA Sensitivities:

- Shows impact of R&D progress on overall sustainability
- Provide insight for key business decisions



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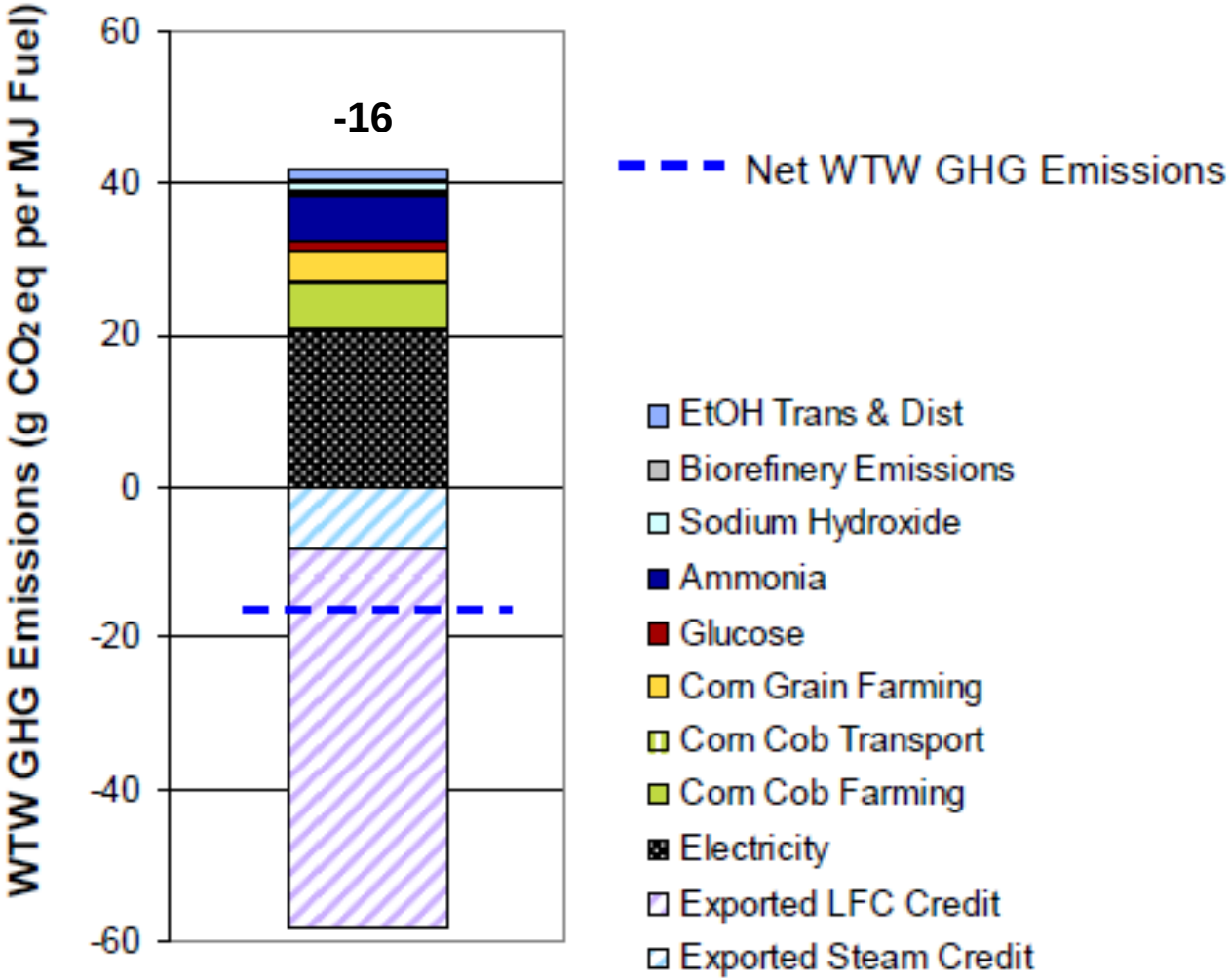
LCA Results and Comparison to Gasoline

Key Assumptions for the DDCE 2010 Case

- **Functional Unit and system boundary**
  - 1 MJ of ethanol is functionally equivalent to 1 MJ of gasoline.
  - Well-to-Wheel system boundary
  - Fulton County, IL - a typical corn belt location
- **Major inputs**
  - All inputs contributing more than 1% of the total mass of inputs are included.
  - Cob feedstock, collected with 50 mile radius of Fulton County
  - Local grid electricity
  - No fuel import to biorefinery, but syrup co-product used in steam boiler
- **Co-product uses**
  - System is expanded to include displacement credits for co-products.
  - Excess steam displaces steam generated by natural gas at a co-located facility.
  - Lignin filter cake displaces coal used at a co-located facility.
- **The carbon in the biomass is considered carbon neutral.**
  - The same amount of CO_2 sequestered in the biomass is eventually emitted upon combustion, resulting in net zero CO_2 emissions from the DDCE feedstock.
- **Indirect effects not included**

GHG Footprint of the DDCE 2010 Case



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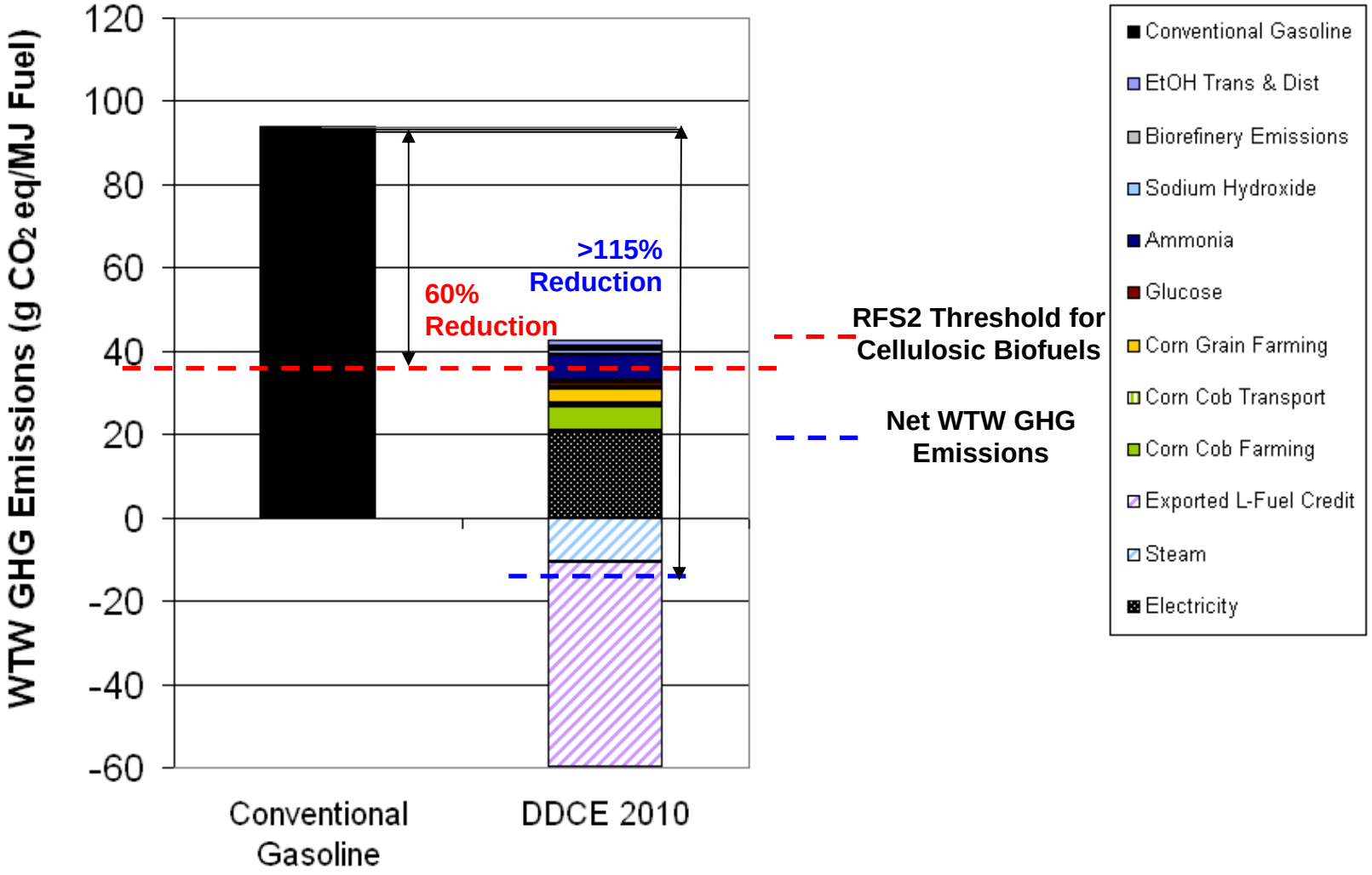
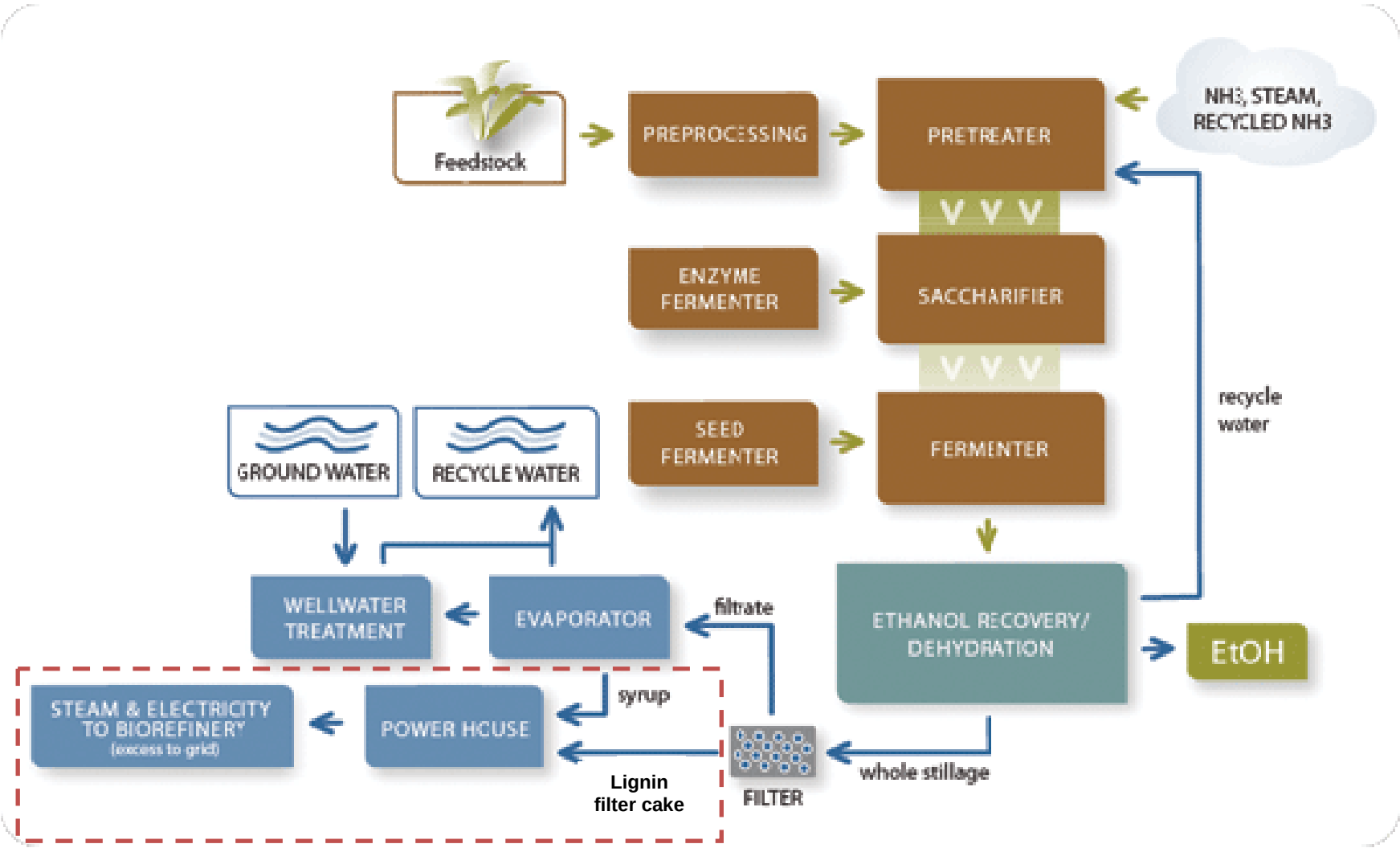
LCA Results: Comparison vs. the Renewable Fuel Standard



LCA Sensitivity Analyses: Energy Management Scenarios

The DDCE Biorefinery



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Energy Management Sensitivities: Key Assumptions and Definitions

▶ Biomass Co-Products Produced:

- "Lignin-Rich Filter Cake" (LFC)
- "Syrup"

These co-products can be used as fuels.

▶ Scenarios Evaluated:

- Co-Location of the DDCE Biorefinery with a steam user
- LFC utilization on-site or at a Coal-Fired Powerplant
- Cogeneration of Heat and Power at the DDCE Biorefinery

Energy Management Sensitivities: Co-Location Decisions

- **Business-critical questions:**
  - "How does co-location affect the DDCE footprint?"
  - "Does it matter who we co-locate with?"

- **Scenarios evaluated:**

Case #	On-Site Boiler/Cogen	Syrup Sent To	LFC Sent To	Exported Steam Displaces
1	Boiler	Boiler	Off-Site Powerplant	No Export
2	Boiler	Boiler	Off-Site Powerplant	Natural Gas
3	Boiler	Boiler	Off-Site Powerplant	Coal

Energy Management Sensitivities:

Co-Location Decisions

Case #	On-Site Boiler/Cogen	Syrup Sent To	LFC Sent To	Exported Steam Displaces
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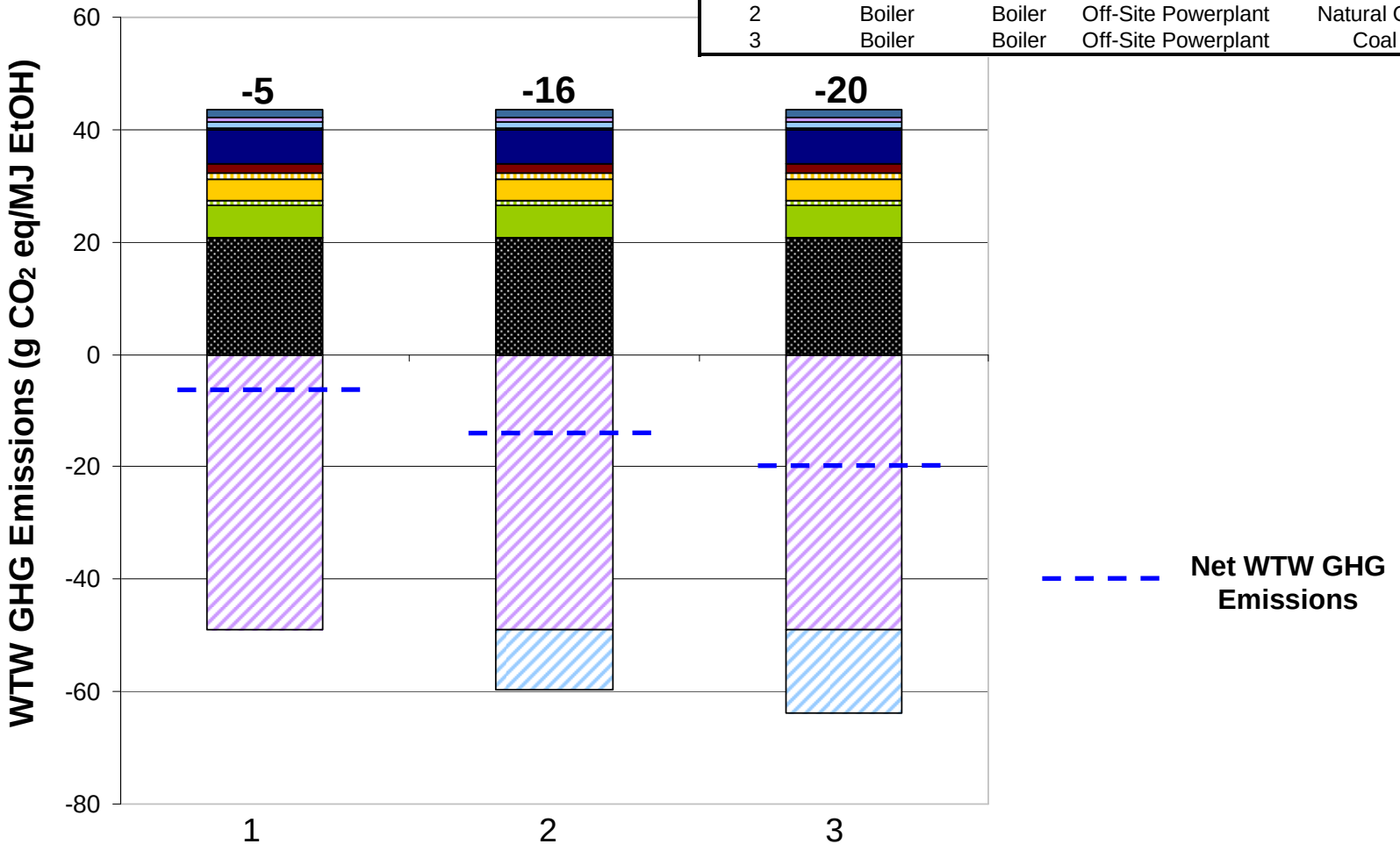

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Energy Management Sensitivities: Lignin-Rich Filter Cake (LFC) Utilization

▶ Business-critical question:

- "Export LFC to a power plant or use at the biorefinery?"

▶ Scenarios evaluated:

Case #	On-Site Boiler/Cogen	Syrup Sent To	LFC Sent To	Exported Steam Displaces
4	Boiler	Boiler	Off-Site Powerplant	Natural Gas
5	Boiler	Boiler	Boiler	Natural Gas
6	Boiler	Boiler	Off-Site Powerplant	Coal
7	Boiler	Boiler	Boiler	Coal

Energy Management Sensitivities:

Lignin Filter Cake Utilization

Case #	On-Site Boiler/Cogen	Syrup Sent To	LFC Sent To	Exported Steam Displaces
4	Boiler	Boiler	Off-Site Powerplant	Natural Gas
5	Boiler	Boiler	Boiler	Natural Gas
6	Boiler	Boiler	Off-Site Powerplant	Coal
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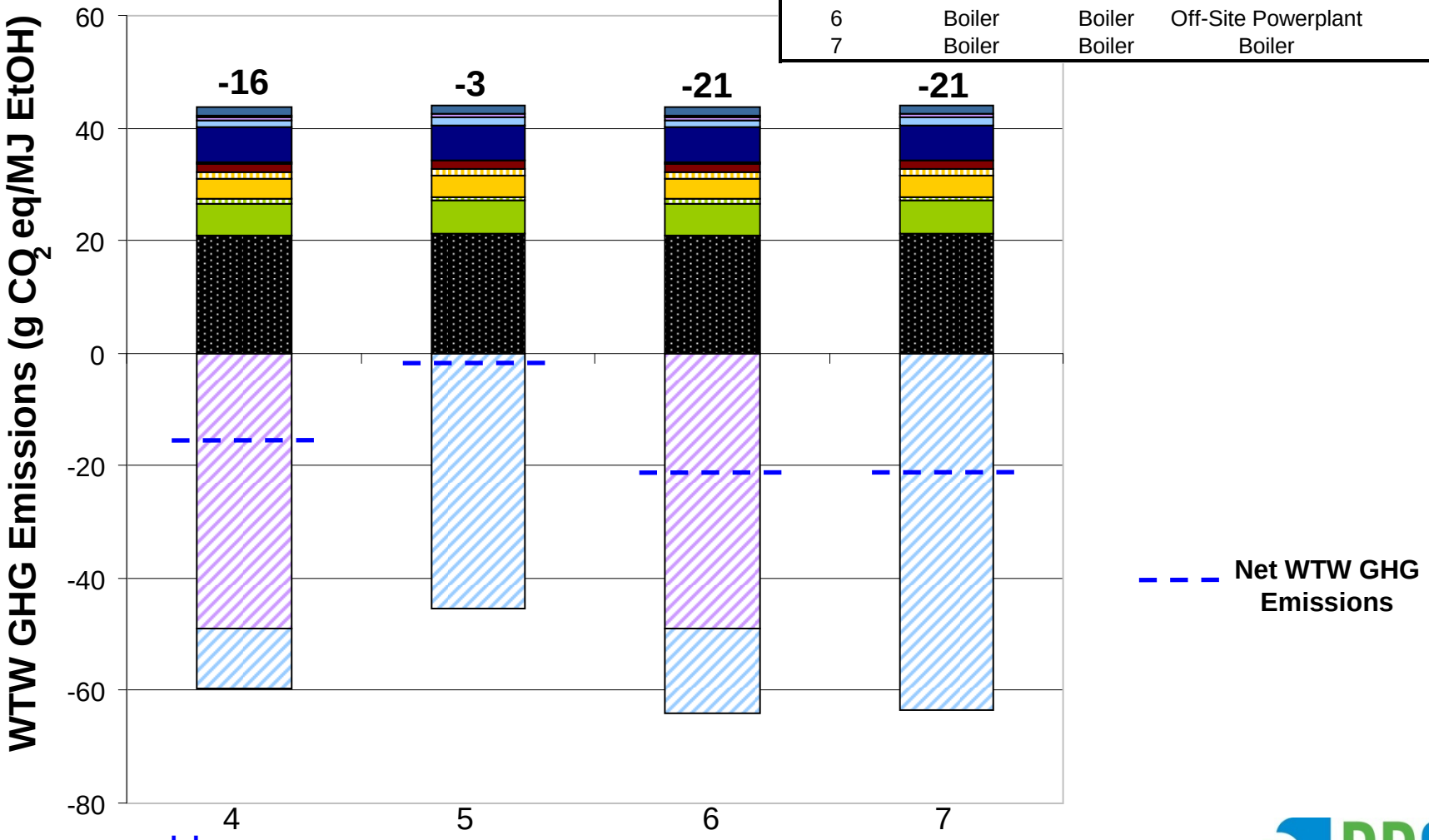

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Energy Management Sensitivities: Boiler vs. Cogeneration

▶ Business-critical question:

- "How does the energy efficiency of cogeneration improve the DDCE footprint?"

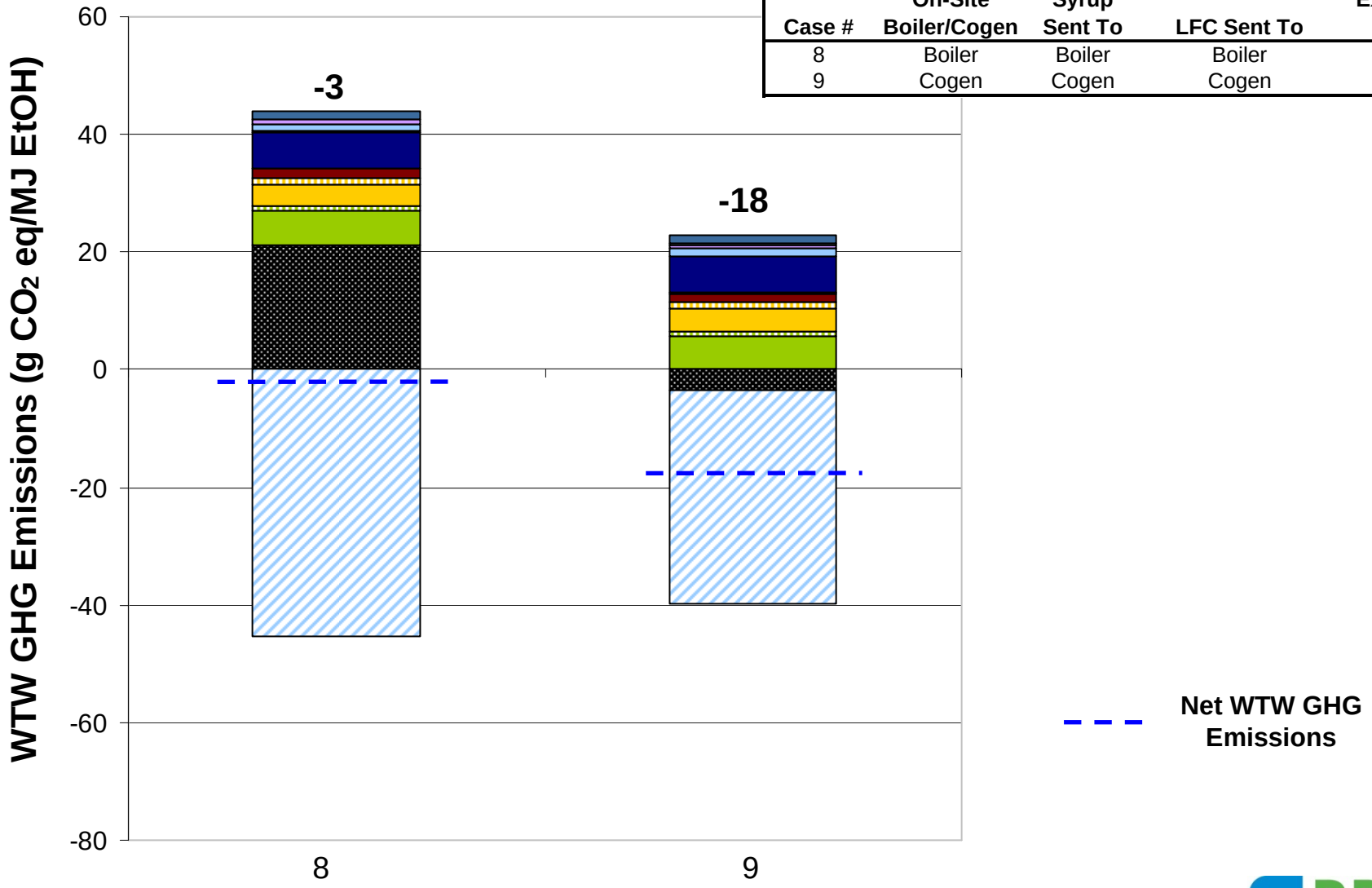
▶ Scenarios evaluated:

Case #	On-Site Boiler/Cogen	Syrup Sent To	LFC Sent To	Exported Steam Displaces
8	Boiler	Boiler	Boiler	Natural Gas
9	Cogen	Cogen	Cogen	Natural Gas

Energy Management Sensitivities:

Boiler vs. Cogeneration

Case #	On-Site Boiler/Cogen	Syrup Sent To	LFC Sent To	Exported Steam Displaces
8	Boiler	Boiler	Boiler	Natural Gas
9	Cogen	Cogen	Cogen	Natural Gas



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Summary

- LCA is implemented early, highlighting environmental consequences of business and technology choices.
- The cellulosic biorefinery delivers multiple benefits beyond a low carbon biofuel.
- Sensitivities show that co-product utilization can be critical to well-to-wheel greenhouse gas emissions.

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A Vision towards Biofuels Sustainability

Emerging Sustainability Standards: Beyond Greenhouse Gas Emissions

Water

Biodiversity / Conservation

GHG

COUNCIL ON SUSTAINABLE BIOMASS PRODUCTION

Social…

Soil

Roundtable on Sustainable Biofuels (EPFL École polytechnique fédérale de Lausanne)

Legality

Management

Continuous Improvement

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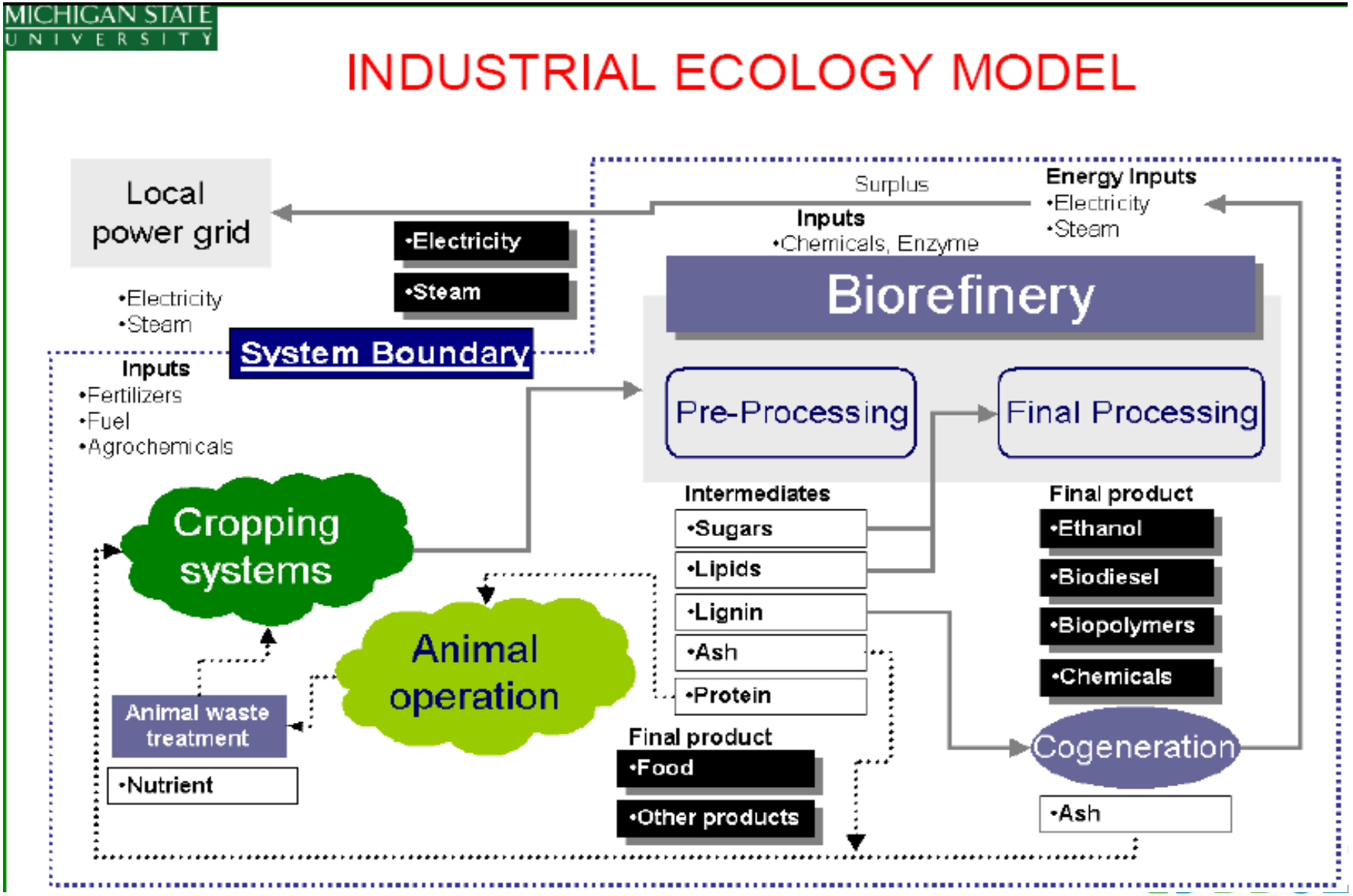
Integration of Production Systems



Questions?

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