



NARA

# Northwest Advanced Renewables Alliance

*A new vista for Green Fuels, Chemicals, & Environmentally Preferred Products*

Michael Wolcott

Regents Professor  
Project Co-Director

Ralph Cavalieri

Associate Vice-President for Alternative Energy  
Project Director

Washington State University

Northwest Advanced Renewables Alliance

# The NARA Team

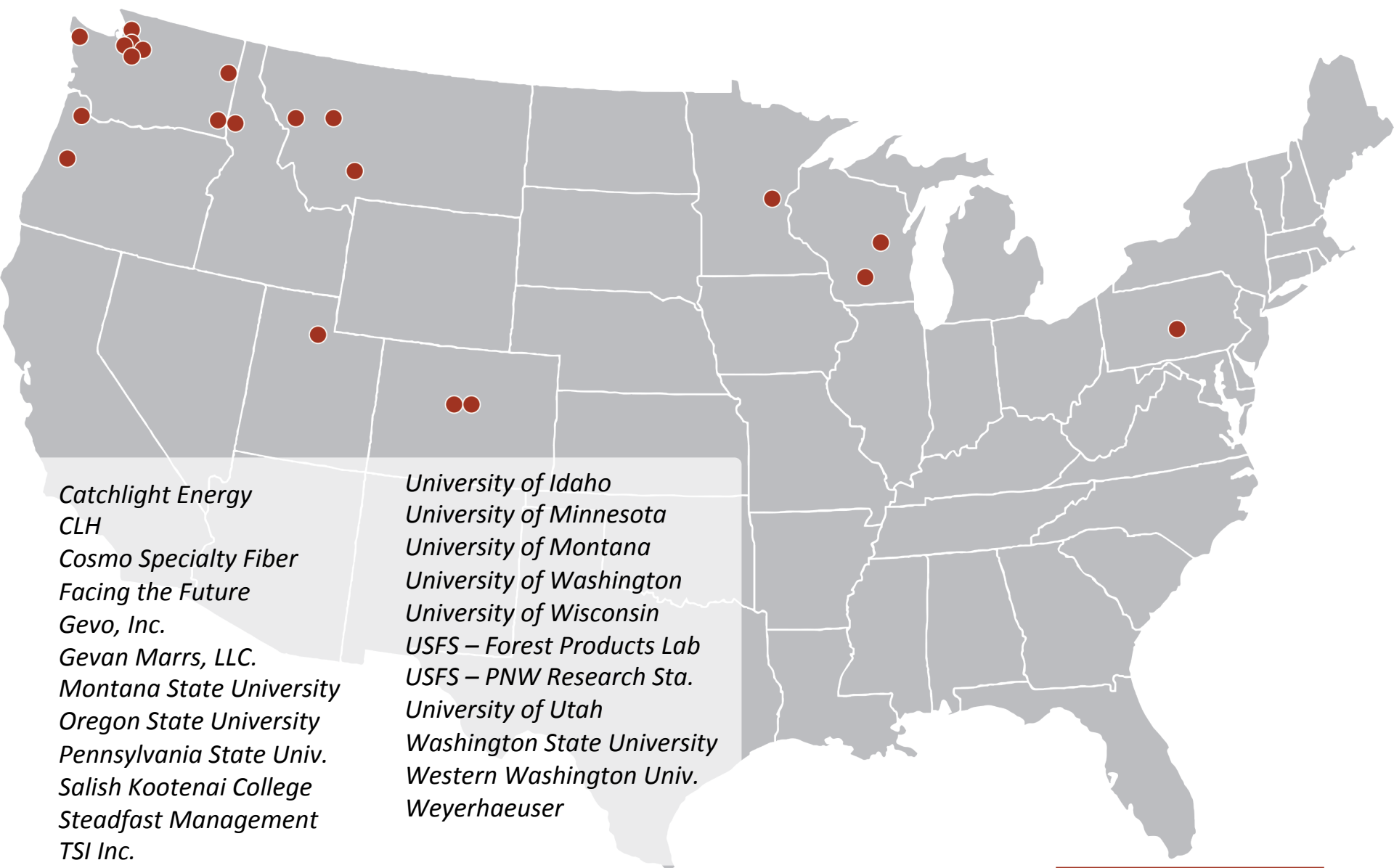
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Catchlight Energy  
CLH  
Cosmo Specialty Fiber  
Facing the Future  
Gevo, Inc.  
Gevan Marrs, LLC.  
Montana State University  
Oregon State University  
Pennsylvania State Univ.  
Salish Kootenai College  
Steadfast Management  
TSI Inc.

University of Idaho  
University of Minnesota  
University of Montana  
University of Washington  
University of Wisconsin  
USFS – Forest Products Lab  
USFS – PNW Research Sta.  
University of Utah  
Washington State University  
Western Washington Univ.  
Weyerhaeuser





FRP

## FOREST RESIDUES PREPARATION

Primary feedstock targets include forest residues from logging and thinning operations. We are also considering mill residues and discarded woody material from construction and demolition, in regions where these materials are under utilized.



T

## TRANSPORTATION

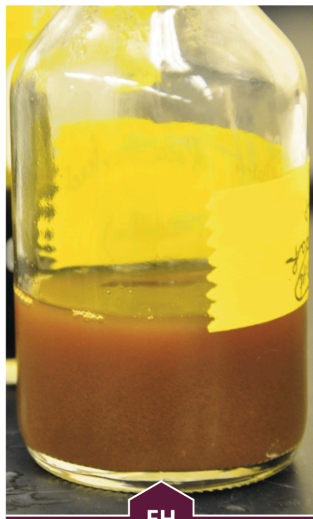
Feedstocks are transported from the collection site to a conversion facility. Chipping can take place at the loading or in a preprocessing facility.



PT

## PRE-TREATMENT

Wood chips are treated to make the sugar polymers (polysaccharides) accessible to degrading enzymes. These processes allow the lignin to be available for separation.



EH

## ENZYMATIC HYDROLYSIS

Specific enzymes are added to hydrolyze (cleave) the polysaccharides and generate simple sugars (monosaccharides).



F

## FERMENTATION

Specialized yeast convert the monosaccharides into isobutanol.



BCP

## BIOJET & CO-PRODUCTS

Aviation fuels can be generated from the platform molecules derived from wood sugars. Lignin can be used to generate co-products such as epoxies, structural materials and bio-based plastics. As an alternative, lignin can be burned to produce renewable energy.

**1000 kg BONE DRY WOODY BIOMASS** + **DIESEL** + **HEAT, WATER, & CHEMICALS** = **~300 kg LIGNIN** AND **~260 LITERS ISOBUTANOL** OR **~190 LITERS BIOJET**

# Completed Year 4 of 5



# Our Biomass Source

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# Industrial Feedstock

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# Biorefinery Approach

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# Isobutanol to Jet Fuel Demonstration

Demonstration unit at South Hampton Resources, Silsbee, TX is fully functional



© 2012 Gevo, Inc.

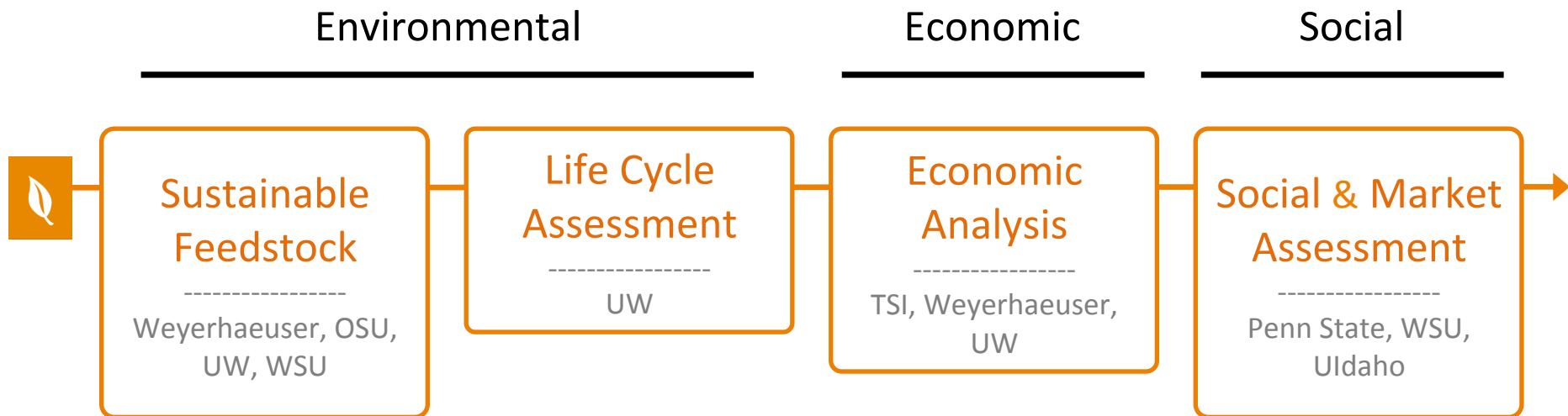


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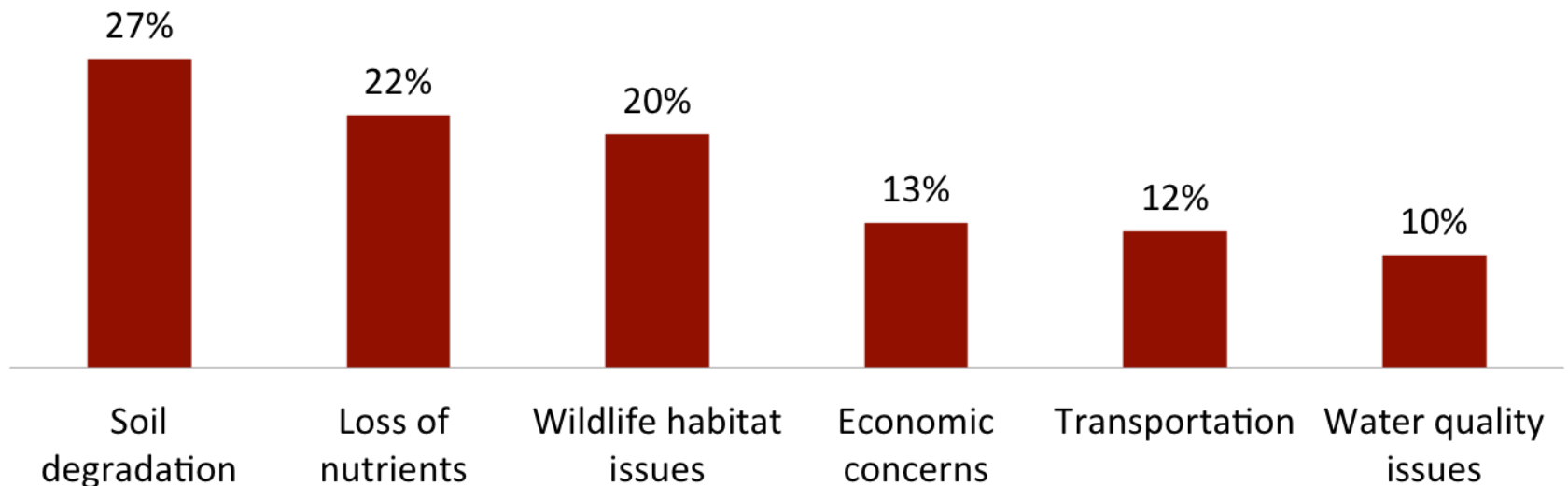
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# Sustainability Assessment



## Stakeholder Concerns



# Research Feeds Education

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# Industry Feeds Education

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31,674	K12 Students
845	Professional Teachers
171	Undergraduate Students
159	Graduate Students
60	Lesson Plans
16	Peer Reviewed Publications

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# EDUCATION STATISTICS

SPEAK FOR THEMSELVES



# Education and Outreach Feeds Research

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# Regional Supply Chain Analyses



## Pacific Northwest (PNW) [Supply Chain Analysis](#)

This site provides supply chain data and analysis generated by NARA research for the region identified as the Pacific Northwest, which includes Montana, Idaho, Washington, and Oregon.



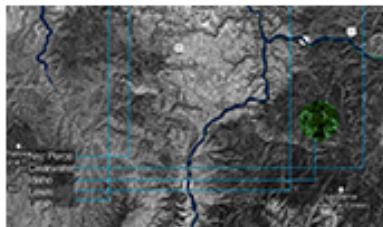
## Mid-Cascades to Pacific (MC2P) [Supply Chain Analysis](#)

This site provides supply chain data and analysis generated by NARA research for the region identified as Mid-Cascades to Pacific, which includes the western sections of Washington and Oregon.



## Western Montana Corridor (WMC) [Supply Chain Analysis](#)

This site provides supply chain data and analysis generated by NARA research for the region identified as the Western Montana Corridor, which includes the western section of Montana, Northern Idaho and northeast Washington.



## Clearwater Basin [Supply Chain Analysis](#)

This site provides supply chain data and analysis generated by NARA research for the region identified as the Clearwater Basin, located in central Idaho.



A photograph of a forest landscape. In the foreground, there is a young evergreen tree growing from a pile of logs and debris. The ground is covered with dry, yellowish-brown vegetation. In the background, a dense forest of tall evergreen trees is visible, with a misty or foggy atmosphere.

# **OLYMPIC PENINSULA LIQUIDS DEPOT AND LIGNIN-BASED CO-PRODUCTS STUDY**

Volume I | PRELIMINARY SCOPING

IDX Studio - Spring 2015

**Northwest Advanced Renewables Alliance**



Progress Towards a Defensible Sustainability Analysis

Last Years Comments on Value Chain

*Unacceptable risk with two lignin co-products*

Demonstrating commercialization pathways

*1K IPK (1,000 gallons of biojet)*

Scale-Up for demonstration of integrated technology

What is the NARA Role with < \$40/bbl Crude Oil

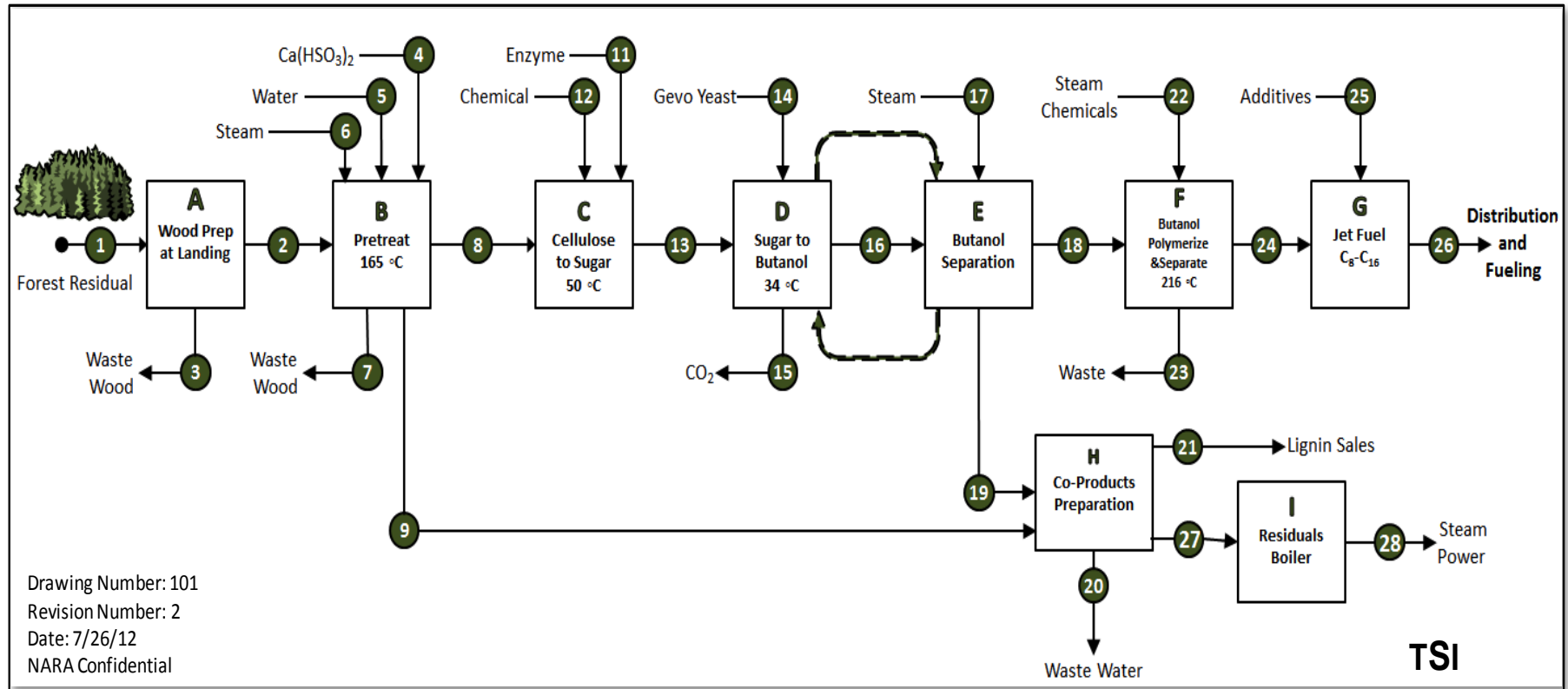
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## CHALLENGES TODAY



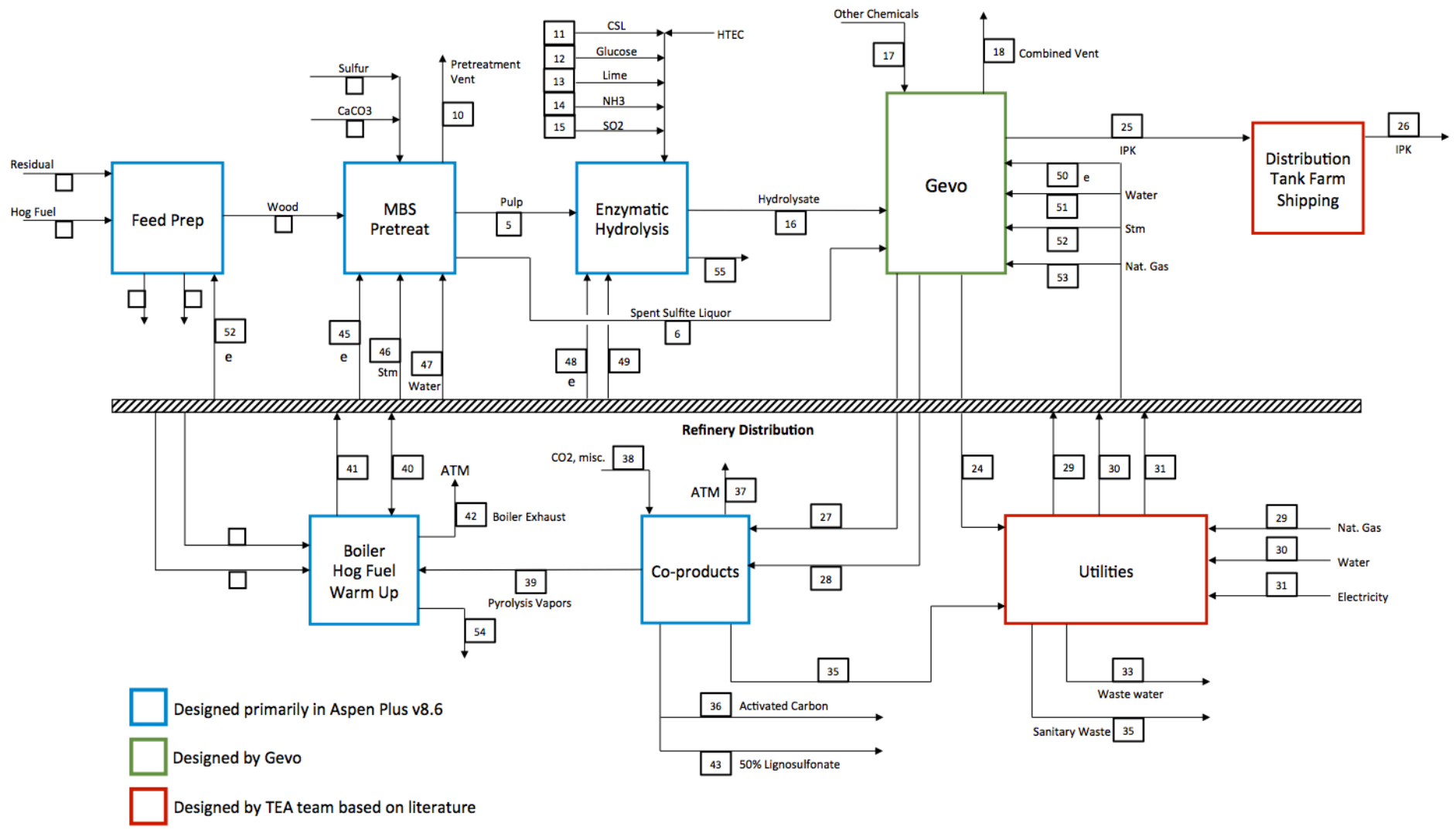
# NARA Process - Simplified

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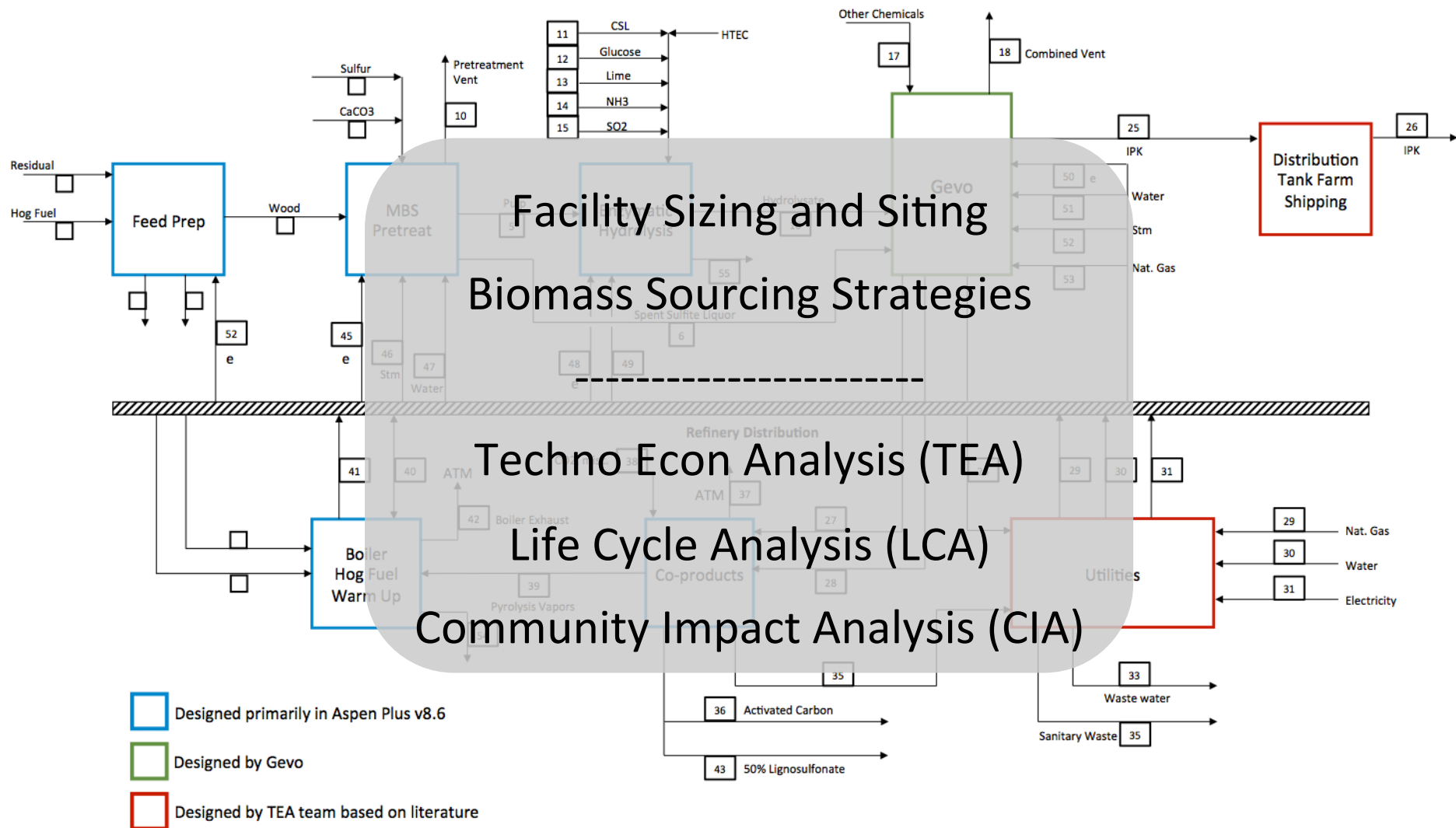


# NARA ASPEN Process Model

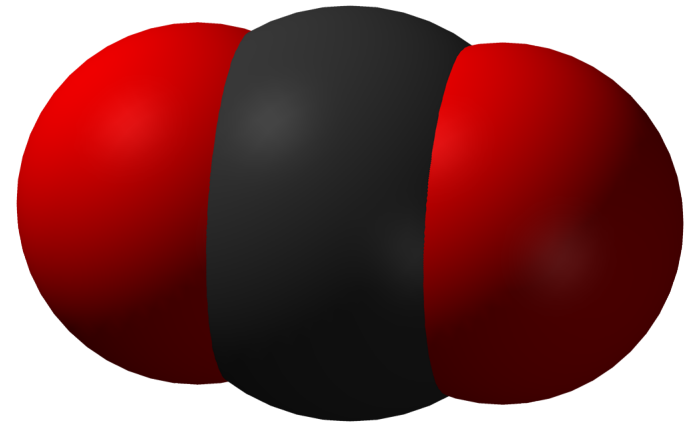
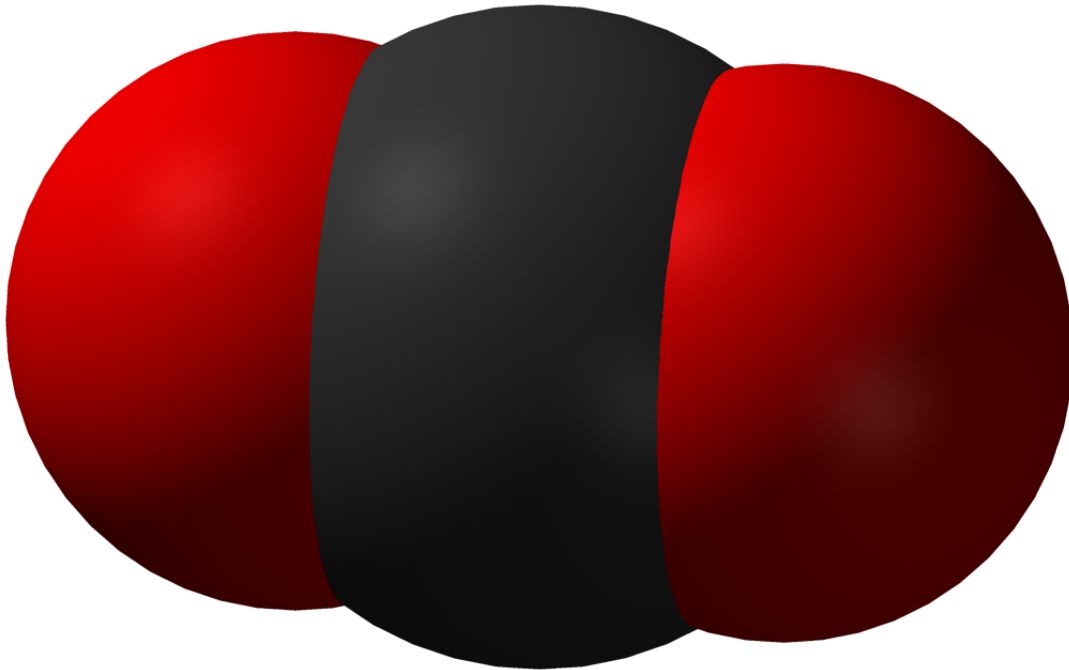




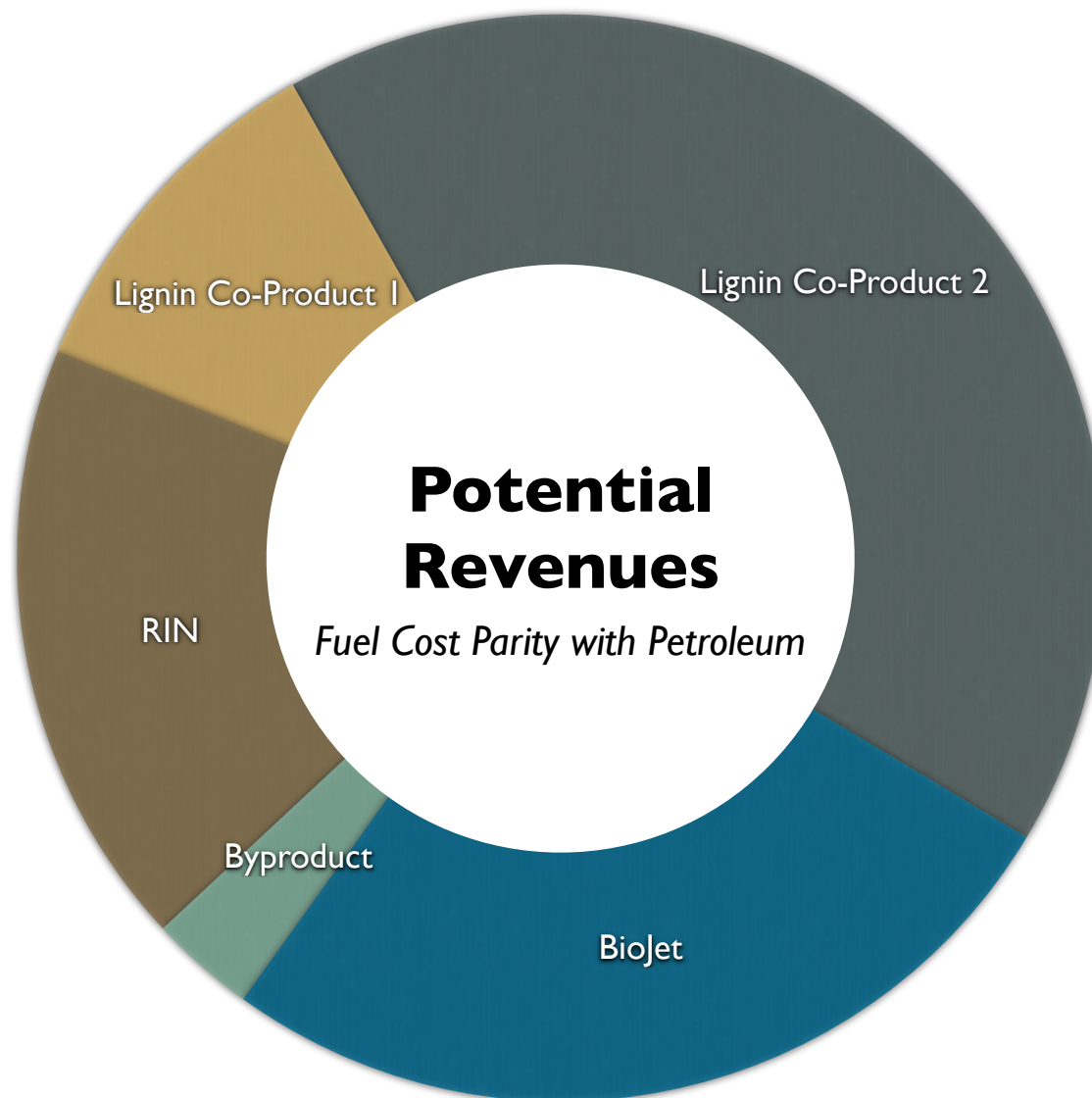
# ... underpins our Sustainability Analyses

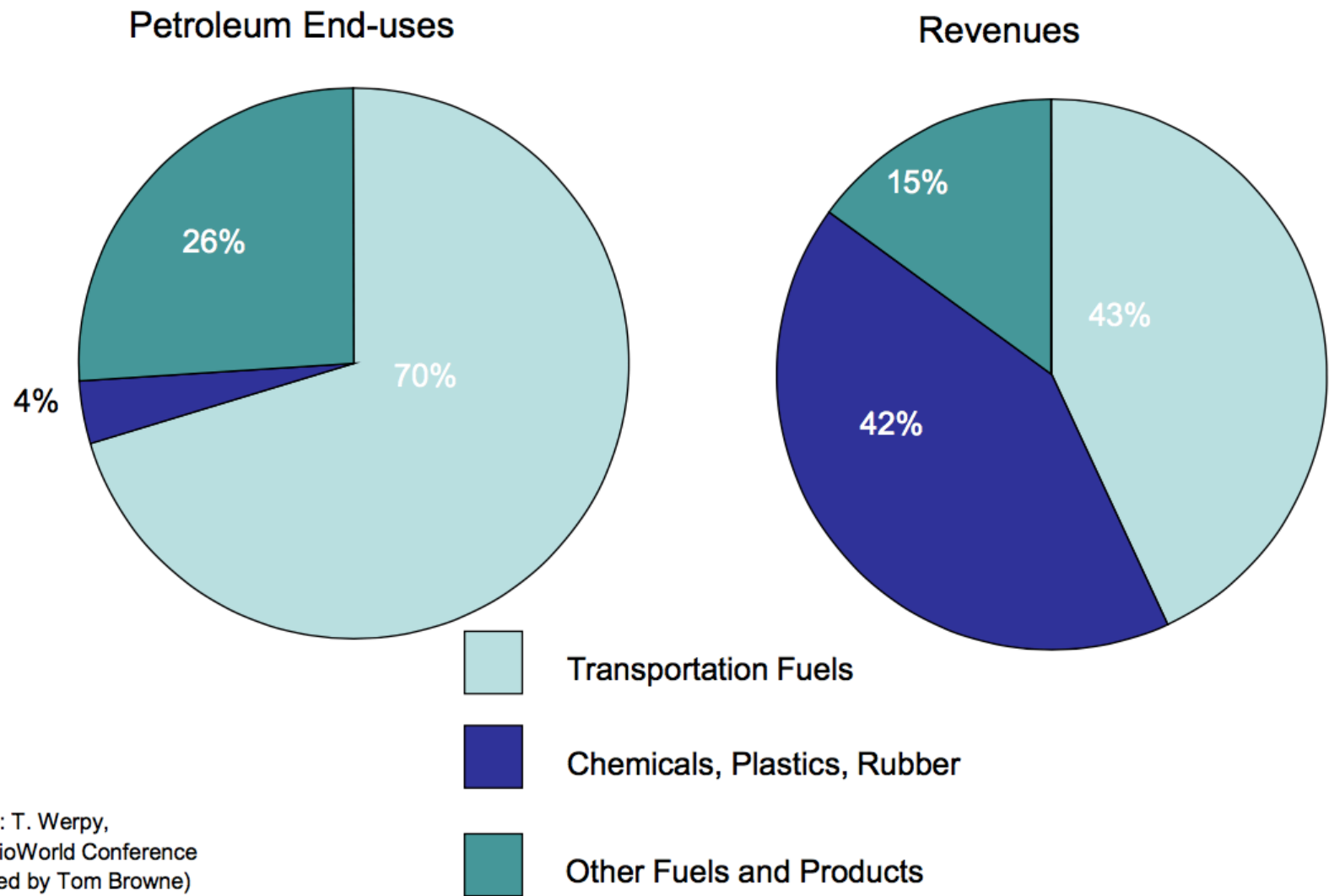


**> 60%  
Reduction**









Source: T. Werpy,  
2009 BioWorld Conference  
(Modified by Tom Browne)



# Good for Environment – Not so for Profit

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# Final Form for Deployment

- Biomass Sourcing Model
- Biorefinery Siting Methodology
- ASPEN Process Model for IBR
- Life Cycle Assessment Model (LCA)
- Community Impact Assessment (CIA)
- Techno Economic Analysis (TEA)
- Environmental Assessment Systems

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## SUSTAINABILITY ANALYSIS STATUS

READY TO SHARPEN THE PENCIL





# 1K IPK

## WOOD TO WING



## WHY

Demonstrate Integrated  
Technologies

Supply Chain to Deliver  
Technologies

Needs of Aviation Partners

Learn, Educate, Connect

11K  
WOOD TO WING



# 1K-IPK – Feedstock Supply Chain

## Feedstock Suppliers

Weyerhaeuser Corp (OR)  
Confederated Salish and  
Kootenai Tribes (MT)  
Muckleshoot Tribe (WA)

## Processing Partners

Lane Forest Products (OR)  
Kevin Jump (MT)  
Bill Bass (WA)





Conf. Salish and Kootenai  
Kevin Jump





Weyerhaeuser Corp  
Lane Forest Products

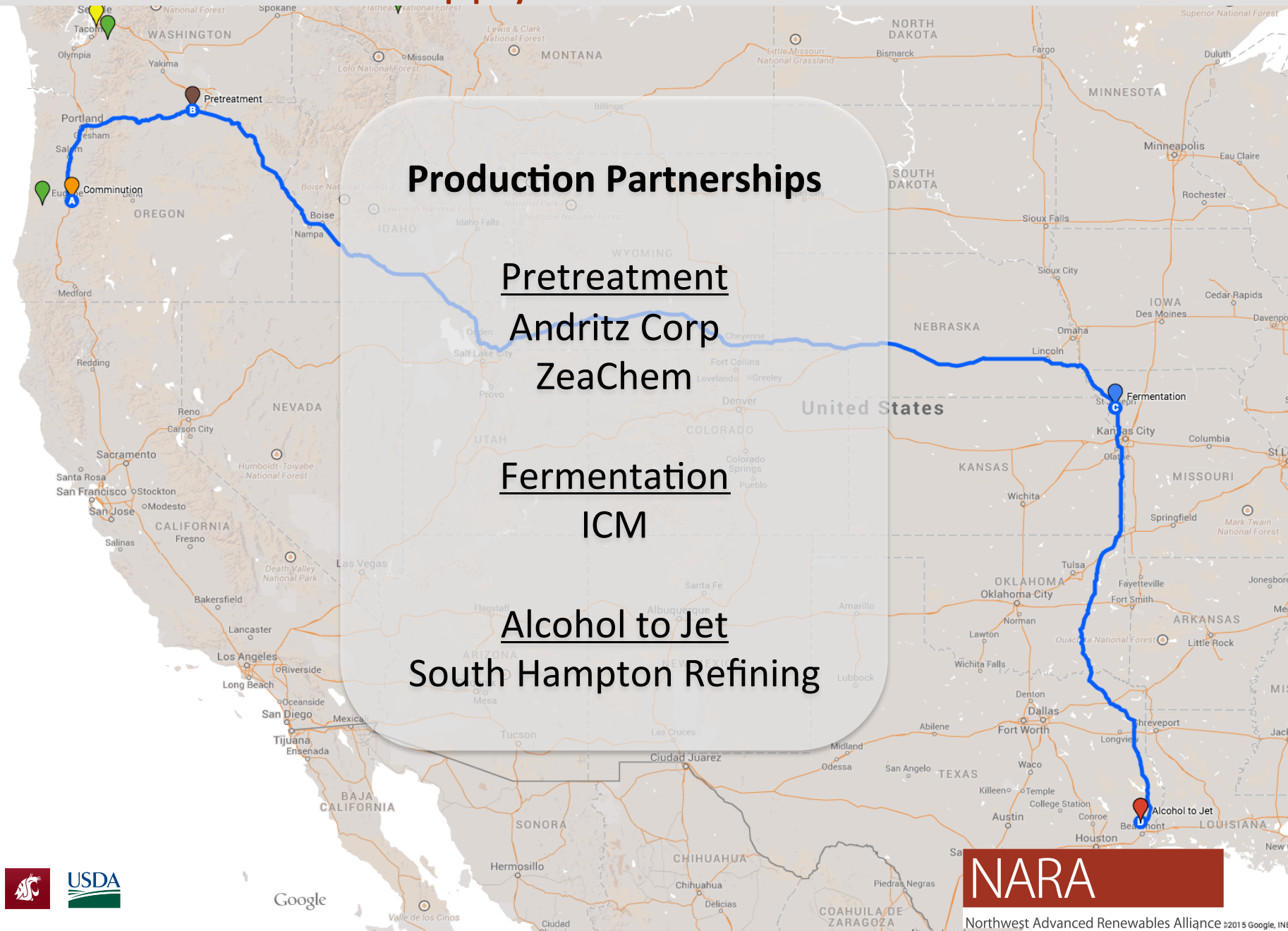




Weyerhaeuser Corp  
Lane Forest Products



# 1K-IPK – Conversion Supply Chain



Google

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# 1K-IPK – Fuel Distribution and Demonstration

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## Fuel Certification

Alter Jet - ASTM D7566

Blending

Conv Jet – ASTM D1655

Distribution to Wing

Commercial Demonstration

Flight

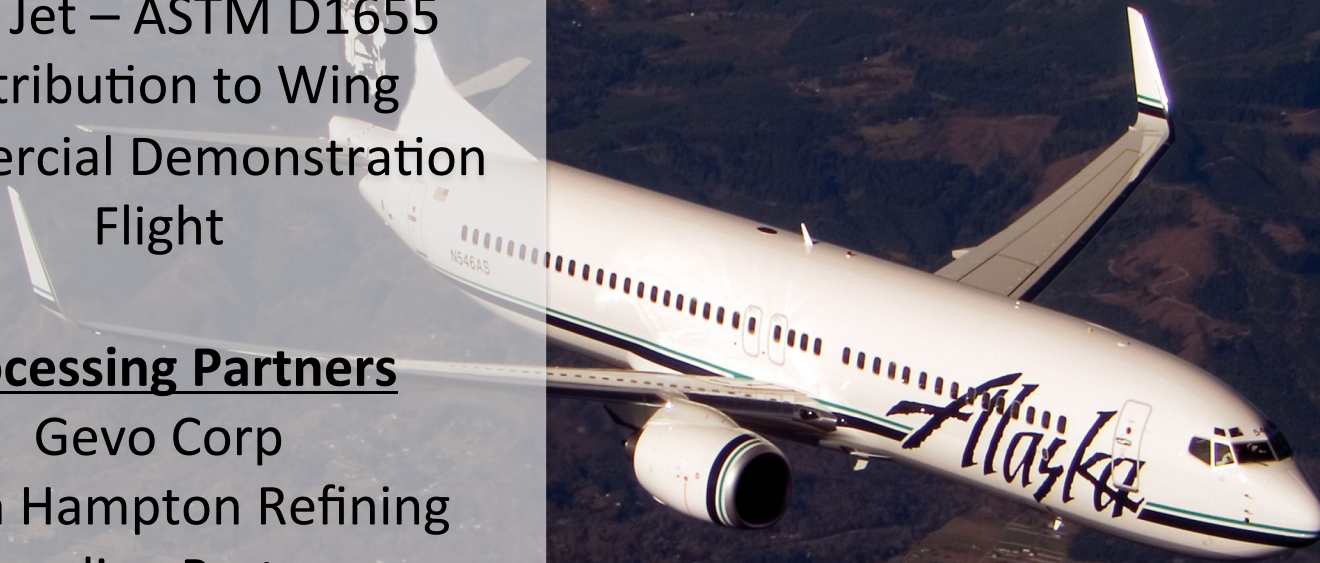
## Processing Partners

Gevo Corp

South Hampton Refining

Blending Partner

Alaska Airlines





## Alaska Airlines Imagine TOMORROW

Now Twelve Challenges: May 20-22, 2016

### Challenge Topics:

**The Food, Energy, and Water Challenge**

**The Aerospace Challenge**

**The Built Environment Challenge**

**The NARA Biofuels Challenge**

### Challenge Approach:

**Technology**

**Design**

**Behavior**

Interested in Judging? Email [imagine@wsu.edu](mailto:imagine@wsu.edu)



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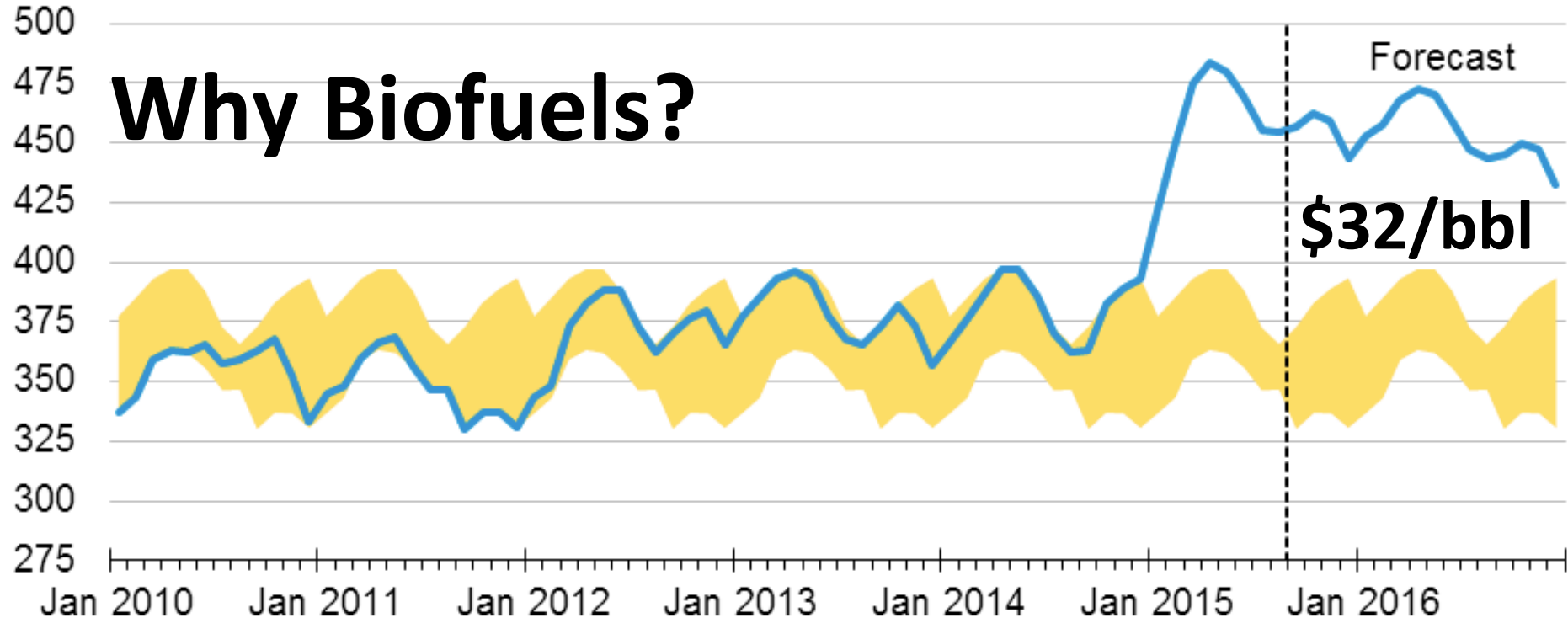
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# With Crude Oil Stocks High and Prices Low....

## U.S. Commercial Crude Oil Stocks

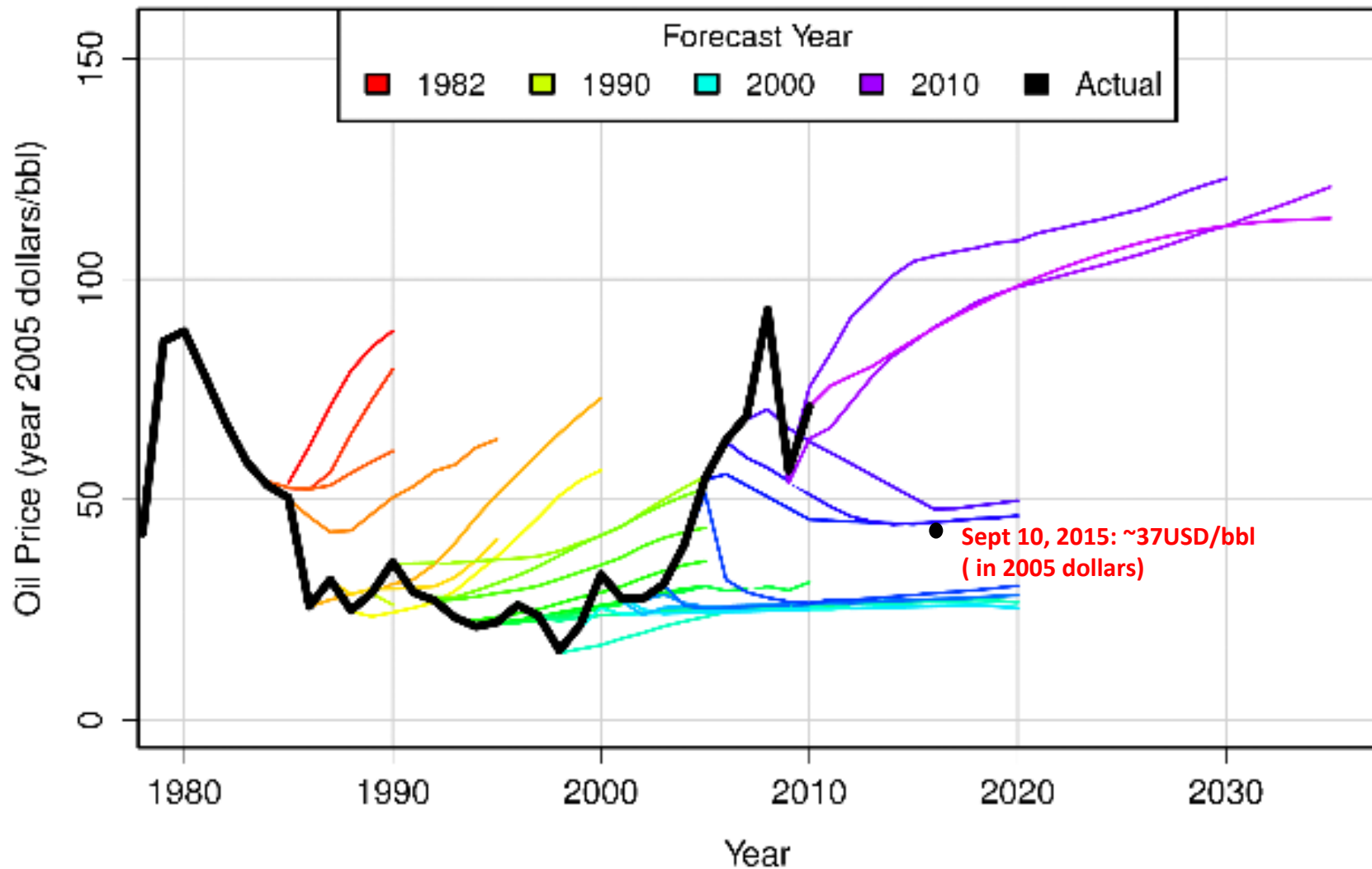
million barrels



Note: Colored band around storage levels represents the range between the minimum and maximum from Jan. 2010 - Dec. 2014.

Source: Short-Term Energy Outlook, September 2015.

# Difficult to Predict Oil Market



Source: Lynnette Dray (U. Cambridge), augmented with current oil price by Robert Malina (MIT)  
Analysis of EIA Annual Energy Outlook Forecasts

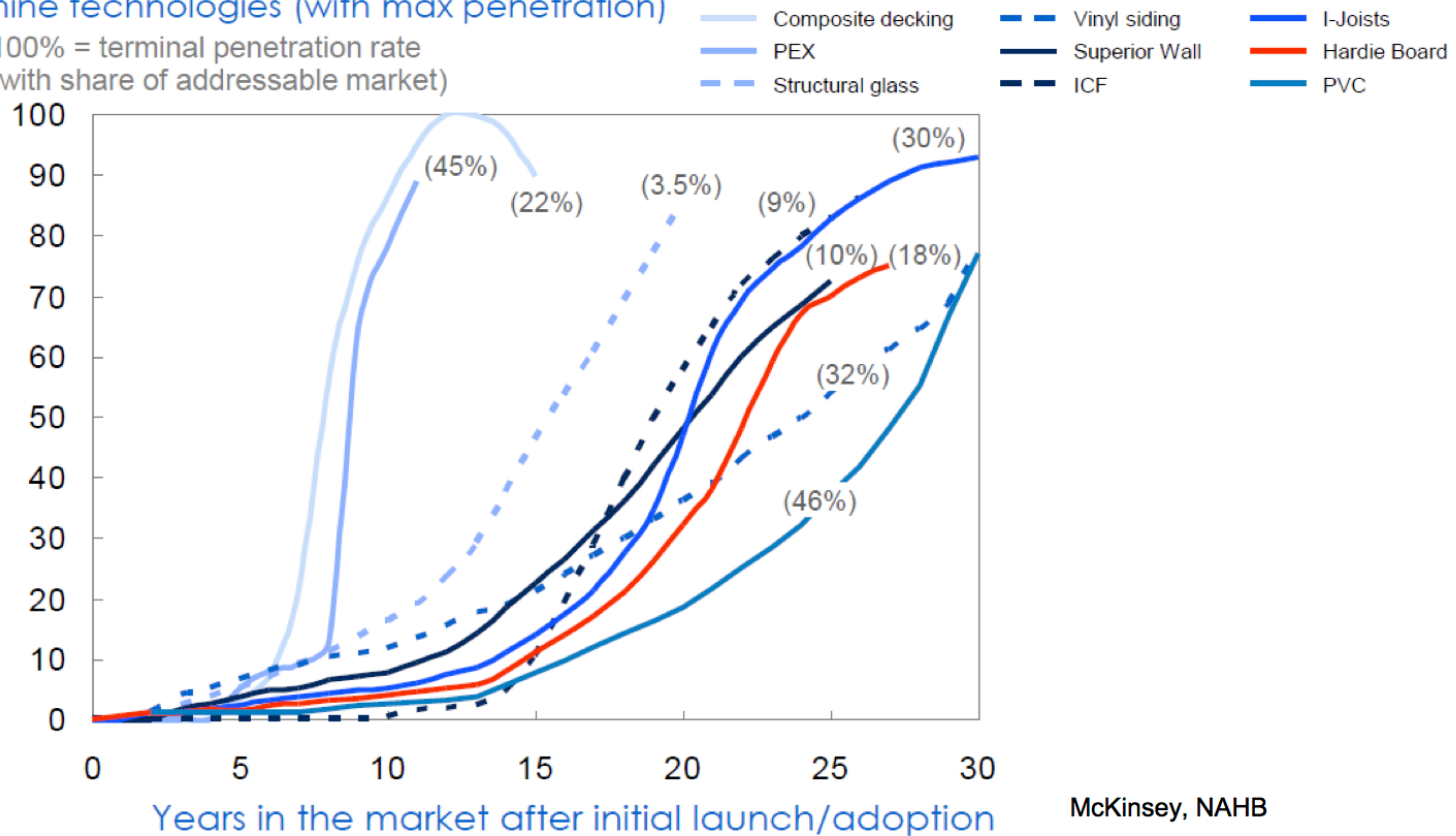


# Product Substitution takes Time

**With a few exceptions, it takes 10 or more years to make significant market penetration with a new product or substitution**

Normalized adoption curves for  
nine technologies (with max penetration)

100% = terminal penetration rate  
(with share of addressable market)



McKinsey, NAHB

20

Timwood



Ian de la Rouche. 2014. Northwest Biofuels and  
Co-Products Conference. Seattle, WA.

# Our Nations First Energy Crisis....

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June 15, 1979  
Library of Congress

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Solar Cells – Invented in 1941

LED – Invented in 1962

Lithium Ion Battery – Conceived in 1980

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**COMMERCIAL ENERGY  
DEVELOPMENTS  
SINCE THE 1<sup>ST</sup> ENERGY CRISIS**

# Moving from Invention to Commercial Reality

- Forest Residue Collection and Preparation
- Envisioning Integrated Facilities and Siting
- SPORL / MBS Pretreatment
- Alcohol to Jet
- Demonstrating Feasibility with Supply Chain Implementation Partners
- Educating Citizens, Industry, Policy Makers

## Advancing Supply Chain Development

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# THE ROLE OF NARA



Invention is important.

Improvement is crucial....

A crisis doesn't go away by ignoring it.

It is solved by working on it.

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## A REVOLUTION COMES IN LAYERS

JOHN YEMMA | CSMONITOR.COM | AUGUST 30, 2015

# THANK YOU

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