Cross Sector Opportunities: Integrated Forest Products Biorefineries & Industrial Gasification

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Today's Presentation

- Cross Sector Need for Industrial Gasification
- Integrated Forest Products Biorefinery Concept
- Proposed Demonstration at Cypress Bend
- Forest Products Industry Advantages
  - Locating of Industrial Gasifier Systems
  - Feedstock
  - Industry Infrastructure
  - Benefits

Industrial Gasification: Energy Flexibility for Industrial Applications

- Reduce natural gas consumption through the use of alternative fuels and feedstocks (e.g., syngas)
- Replace natural gas used in industrial boilers and process heaters with
  - Residual oil
  - Coal
  - Coal-oil mixture
  - Coal- or biomass-based gas

The forest products industry is developing solutions that can be applied to other industry sectors.

Source: Adapted from DOE/ITP

Energy Use in Key Industrial Sectors

(All Figures in Trillion BTUs)

Sector	Natural Gas	Residual Fuels	Distillate Fuels	LPG/ NGL	Coal and Coke	Derived Net Electricity	Other	Total Use, Net
Chemicals	1984	50	9	51	284	602	749	3729
Mining	1268	5	262	0	77	355	631	2598
Pet Ref	948	70	4	33	0	123	2300	3478
Forest Products	659	152	21	9	279	327	1825	3272
Steel	456	29	5	0	48	163	971	1672
Glass	194	3	0	1	0	54	2	254
Aluminum	189	0	1	1	1	246	3	441
Metalcasting	136	0	1	2	0	63	31	233
Agriculture	77	0	339	221	0	221	14	1072
TOTALS	5911	309	642	318	689	2154	6526	16749

Taken from “Profile of Total Energy Use for US Industry”, Energetics, Inc. for the US DOE, 12 / 04.
LPG / NGL = Liquefied Petroleum Gas / Natural Gas Liquids
Table does not include energy sources used as raw materials.

Components of the Agenda 2020 IFPB Technology Strategy

Sustainable Forest Productivity

- Apply biotechnology and nanotechnology breakthroughs to sustainable forestry to manage U.S. forest land at a high intensity

Value Prior to Pulping –

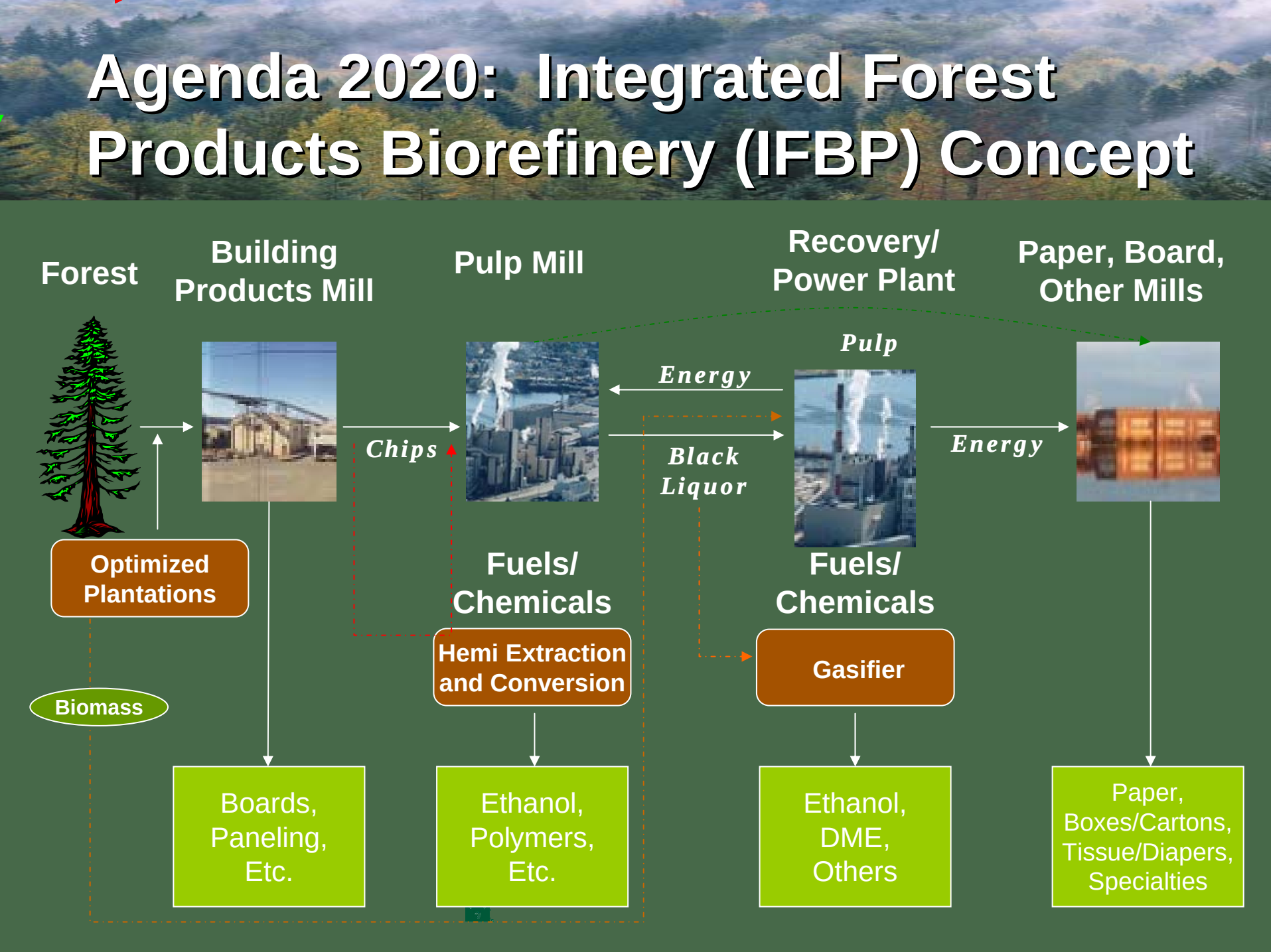
Fermentation/Biochemical Pathway

- Separate and extract selected components of wood prior to pulping, and process these streams to produce commercially attractive chemical and liquid fuel products

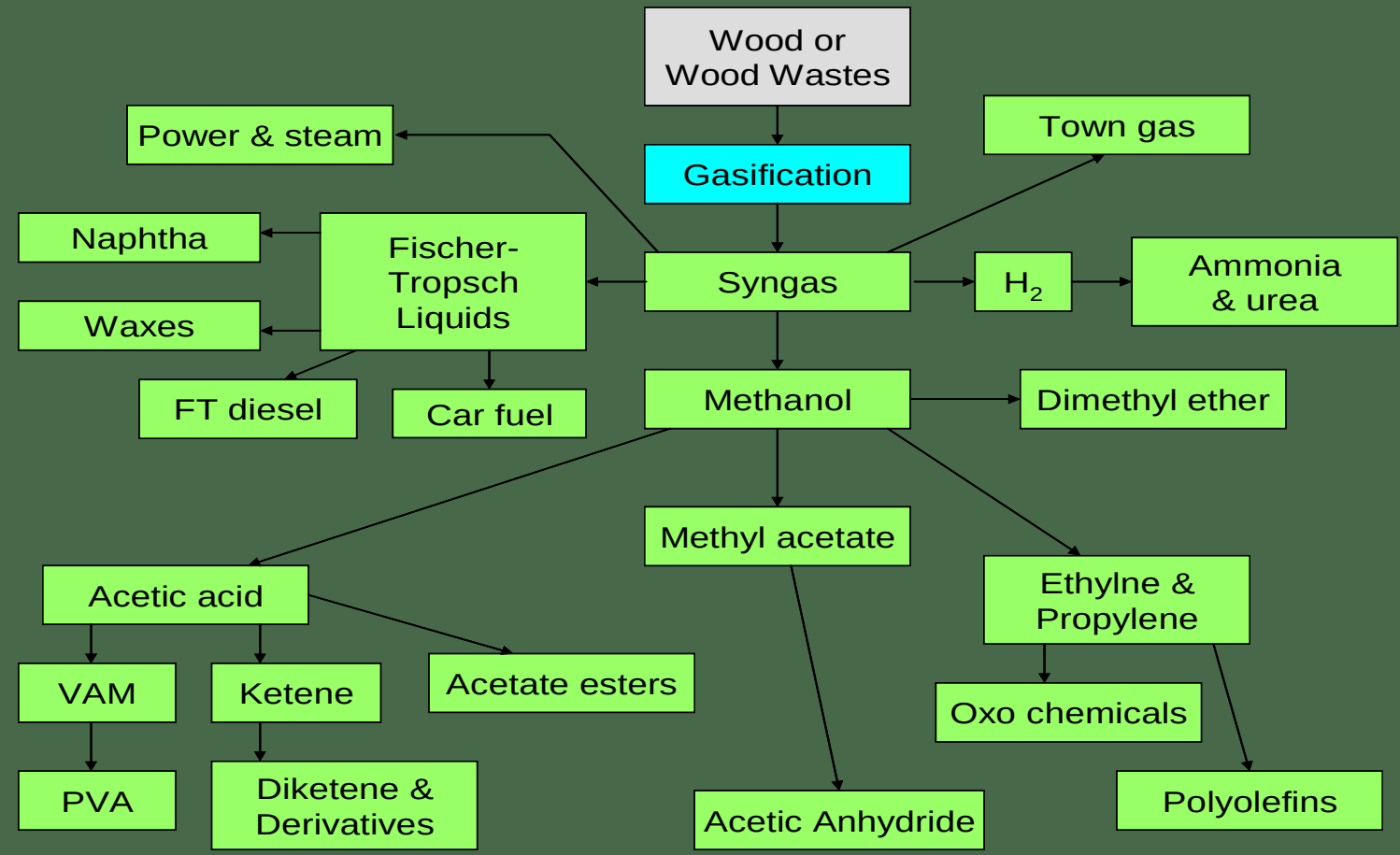
New Value Streams from residuals and spent pulping liquors – **Thermochemical Pathway**

- Convert forest residues and spent pulping liquors into liquid fuels, power, and chemicals

Agenda 2020: Integrated Forest Products Biorefinery (IFBP) Concept



Options for IFPB Fuels and Chemical Production



Source: Eastman

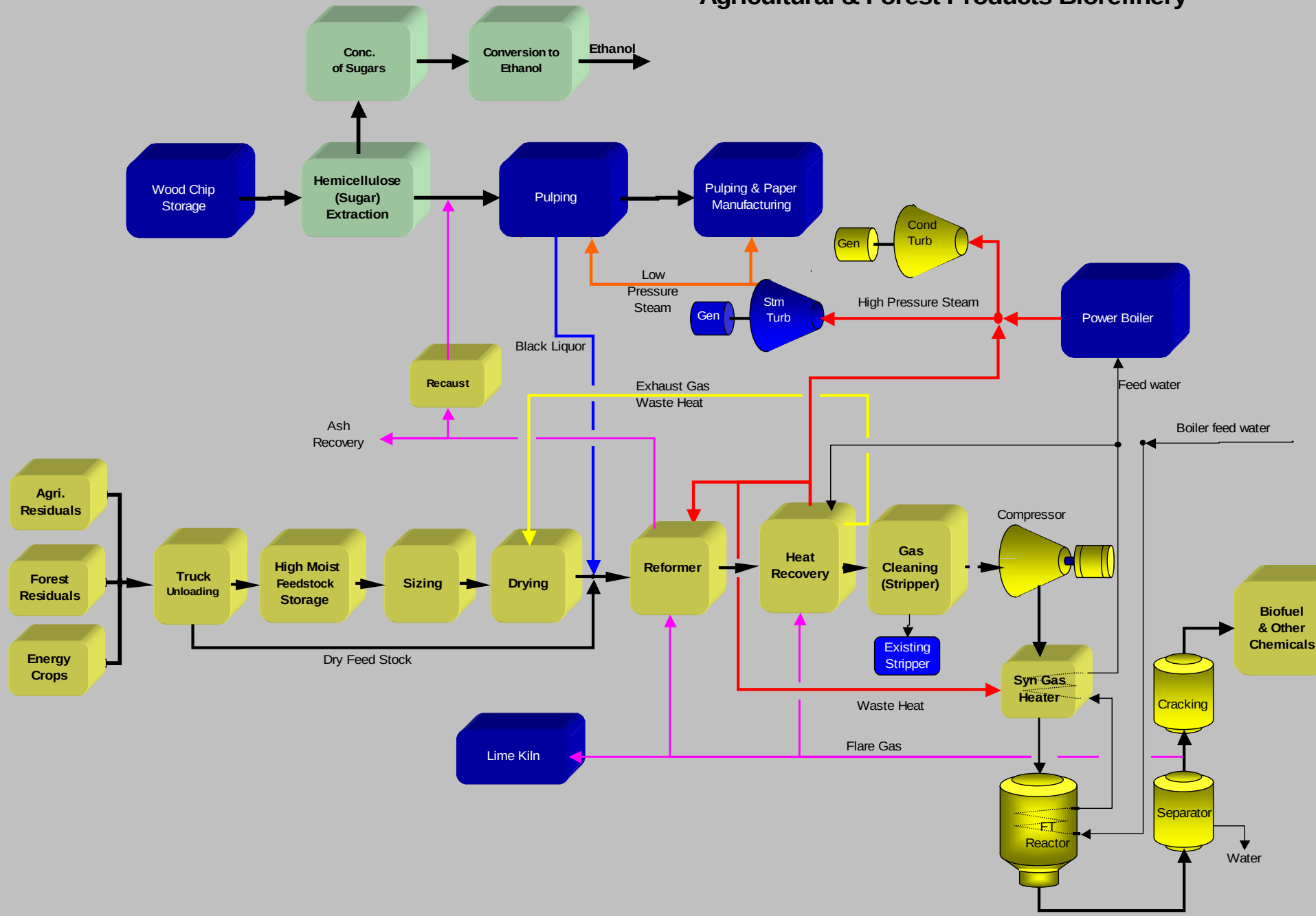
Southeast Arkansas Biorefinery at Cypress Bend Mill

- Leadership: Potlatch Corporation
- Location: Bleached kraft board mill in McGehee, Arkansas
- Driver: Potentially reduce natural gas usage by 1,600,000 MMBTU per year and purchased electricity by up to 80,000 MWH
- First-of-a-kind Commercial Scale Biorefinery
- “Open” project to help advance deployment of biorefinery technologies in the forest products industry

Objective: Implement a Fully Integrated Agricultural & Forest Products Bio-refinery That Would:

- Use untapped waste products from farming and the forest to produce bio-fuels and other chemicals
- Use the waste heat from the refinery to meet the energy needs of existing manufacturing operations
- Include both the Thermochemical (gasification) and Bioconversion (fermentation) Pathways to maximize conversion of the untapped waste streams

Fully Integrated
Agricultural & Forest Products Biorefinery



Potlatch Phased Approach to Biorefinery Demonstration

- Phase 1 would incorporate a thermo-chemical pathway that would convert agricultural and forest biomass to biofuel
- Phase 2 would employ black liquor (lignin) gasification
- Phase 3 would use hemicellulose extraction prior to pulping to produce ethanol.

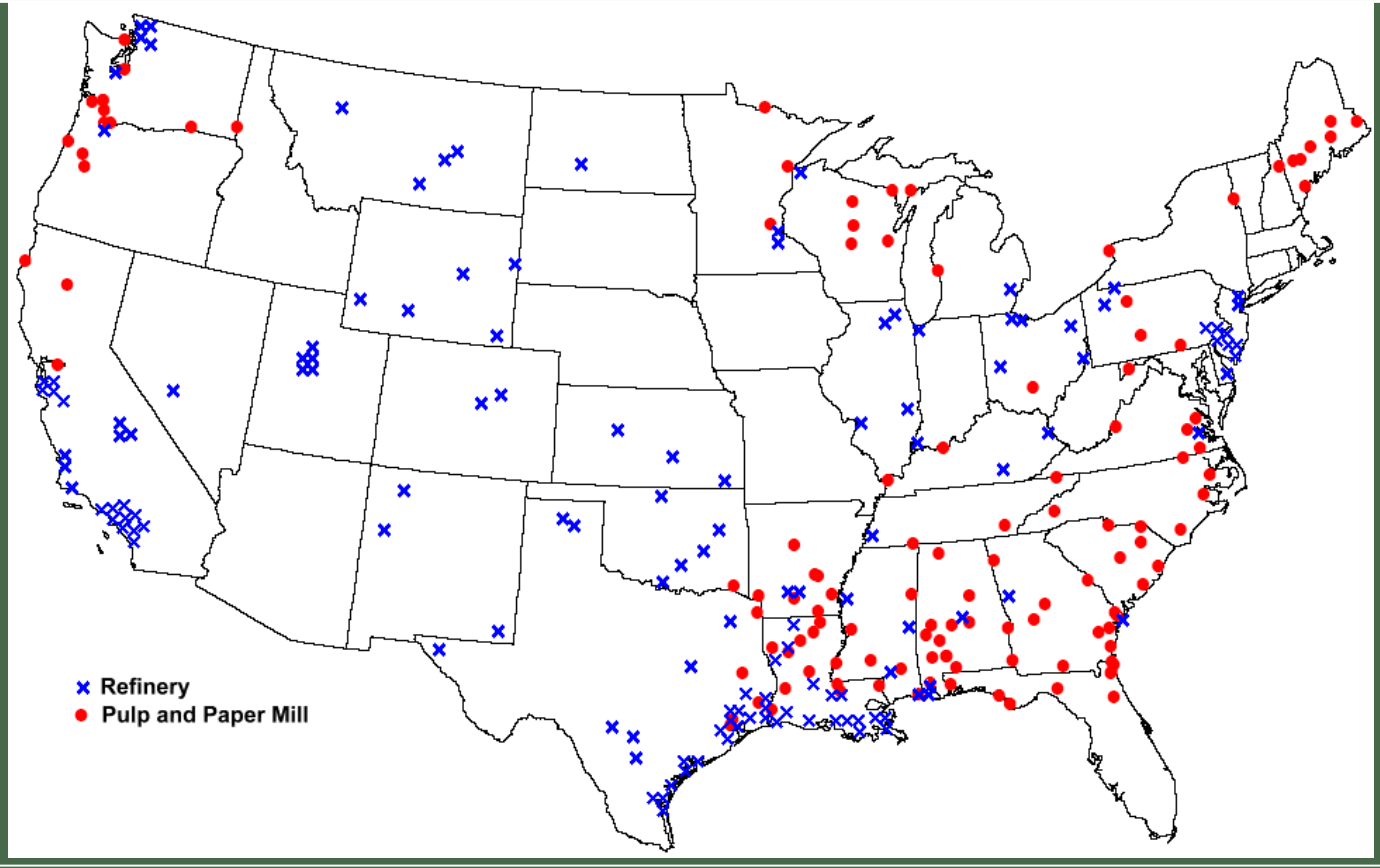
IFPB: Forest Products Industry Advantages – Options for Locating Industrial Gasifier Systems

- Industrial Owned – Forest Products Industry
  - Biomass (agricultural and forest residues) gasification
  - Black Liquor gasification
  - Co-location by chemical supplier possible
  - Proximity to major US refining installations

- **Industrial Park** Centered on P&P Mill
  - Utility Type BLGCC may be easily adapted
  - Industry is already a major power cogenerator
  - Overall size may depend on ability to balance mill energy needs

In some parts of the United States there is good overlap between P&P mills and petroleum refineries.

Location of U.S. Refineries and Pulp and Paper Mills



Sources: Paper mills: Lockwood-Post, 2001; Refineries: National Petrochemical and Refiners Association, *NPRA United States Refining and Storage Capacity Report,* July 2004 (NPRA data based on DOE EIA's 2003 Petroleum Supply Annual and covers 149 refineries)

IFPB: Forest Products Industry Advantages

- Forest-based materials as feedstock
  - Forest-based materials represent 30% of resources needed to support emerging bio-industries.
  - Ethanol production from wood-based hemicellulose uses significantly less fossil fuel than production from other biomass resources.
  - Managed forests have positive ecological impacts that are not mirrored in other biomass feedstocks.

- Industry has infrastructure and expertise
  - Industry owns and manages operations for feedstock harvesting, transportation and storage, manufacturing and conversion, and waste handling and recovery.
  - Raw material already is being supplied to mills.
  - Industry has experience in chemical processing and handling in compliance with related standards and regulations.
  - Location of facilities in rural areas can realize important synergies between agricultural and forest-based feedstocks.

IFPB: Forest Products Industry Advantages (cont)

- If fully developed and commercialized, IFPB technologies have potential for significant national benefits:
  - Diversified, more secure national energy supply
  - Geographically distributed supply source
  - Reduced environmental impacts
  - Improved energy efficiencies

- Quantified Potential Benefits
  - $8.8 billion/year new revenues throughout industry
  - 175.72 MM bbl/year in energy savings
  - 153.7 MM tons/year positive impact on carbon balance
  - 166,700 new jobs in primarily rural communities

IFPB: Forest Products Industry Advantages (cont)

- Carbon benefits include:
  - Displace use of natural gas and fossil fuel use in industrial applications (including power generated using fossil fuels)
  - “Green” liquid transportation fuels produced as co-product, displacing use of petroleum fuels
  - Use of energy crops can lead to changes in land management, increasing the net average carbon stored per acre

Questions?

Potential biorefinery products could target a variety of fuel and commodity chemical markets.[1]

Biorefinery Product	Target Product Market	Comment
FT Liquids - Naphtha	Motor Gasoline	Blending component for gasoline that may require further refinery upgrading
FT Liquids - Distillate	Distillate Fuel	High cetane, sulfur free refinery blendstock
FT Liquids - Waxes	Waxes	Potential high-value co-product, but wax production in the US is declining
Ethanol	Ethanol or MTBE (oxygenate / octane enhancer)	U.S. MTBE production sharply declining due to phase-outs
Methanol	Methanol	Global markets are growing but U.S. fuel-related use is declining because of MTBE phase-outs. North American production capacity has decline considerably due to international competition.
DME	Diesel or LPG	Currently used mainly as a propellant
Mixed Alcohols	Ethanol or MTBE, existing alcohol markets	Could be used as fuel additive or as chemical
Synthetic Natural Gas	Natural Gas	Blend directly in NG pipeline
Hydrogen	Hydrogen	Market is growing, mainly for use in refineries (captive market)
Ammonia	Ammonia	Among the largest commodity chemicals

1. A wide range of chemicals can be produced from syngas, but their volumes are typically smaller than the fuels and chemicals listed here.

Source: Kickoff Meeting for DOE funded study, A Cost-Benefit Analysis of Gasification for Fuels/Chemicals Production at Kraft Pulp Mills. 24 January 2005 .

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Target Product Market	Approximate US Market Size for Target Product		Annual Average Price Range, 2001-2004 (2004 US$/MMBtu except where noted)	Approximate US Market Size for Target Product (2004 US$)
	Physical Units	Quads/year		
Motor Gasoline	9 million bbl/day	17	$7.1-10.7 (refiner price)[2]	$121-181 B/yr (refiners)
Distillate Fuel (transportation only)	2.6 million bbl/day	5.5	$5.6-8.6 (refiner price)[2]	$31-47 B/yr (refiners)
Waxes	< 20,000 bbl/day	NA	$60-120 / bbl, varies with oil price and wax type	~$0.5 B/yr
MTBE	282,000 bbl/day (2001)	0.40	$6.4-16.9 (1996-01)	$4 B/yr
Ethanol	222,000 bbl/day (2004)	0.28 (2004)	$14-20	$3.8-5.4 B/yr
LPG	2 million bbl/day	2.75 (2003)	$5.1-8.3 (refiner price)[2]	$14-23 B/yr (refiners)
Natural Gas	15,700 Billion SCF	15.7	$4.0-6.2 (industrial price)	$63-97 B/yr
Methanol	185,000 bbl/day (2001)	NA	$0.30-0.85 / gallon	$1-2 B/yr
Hydrogen	10 million tonnes (85% captive, 15% merchant)	1.3	$10-50	~$2 B/yr (merchant mkt)
Ammonia	21 Million tons (2001)	NA	$94-325 / ton f.o.b. Gulf Coast (1996-01)	~ $4 B
Mixed Alcohols	3.7 billion pounds	NA	$0.45-0.55/lb	$1.7-2 B

1. In addition to the products shown here, a wide range of chemicals can be produced, but their volumes are typically smaller than the fuels and chemicals listed here.
2. Corresponding price at which refineries purchase crude oil: $24-$36/bbl ($4.3-$6.5/MMBtu).

Sources: EIA AEO 2005; Kline Group (2004); The Innovation Group, NCI estimates.