



Harris Group Inc.
Engineering for Optimum Performance.®

Cellulose Conversion to Fuels and Chemicals in the Pacific Northwest

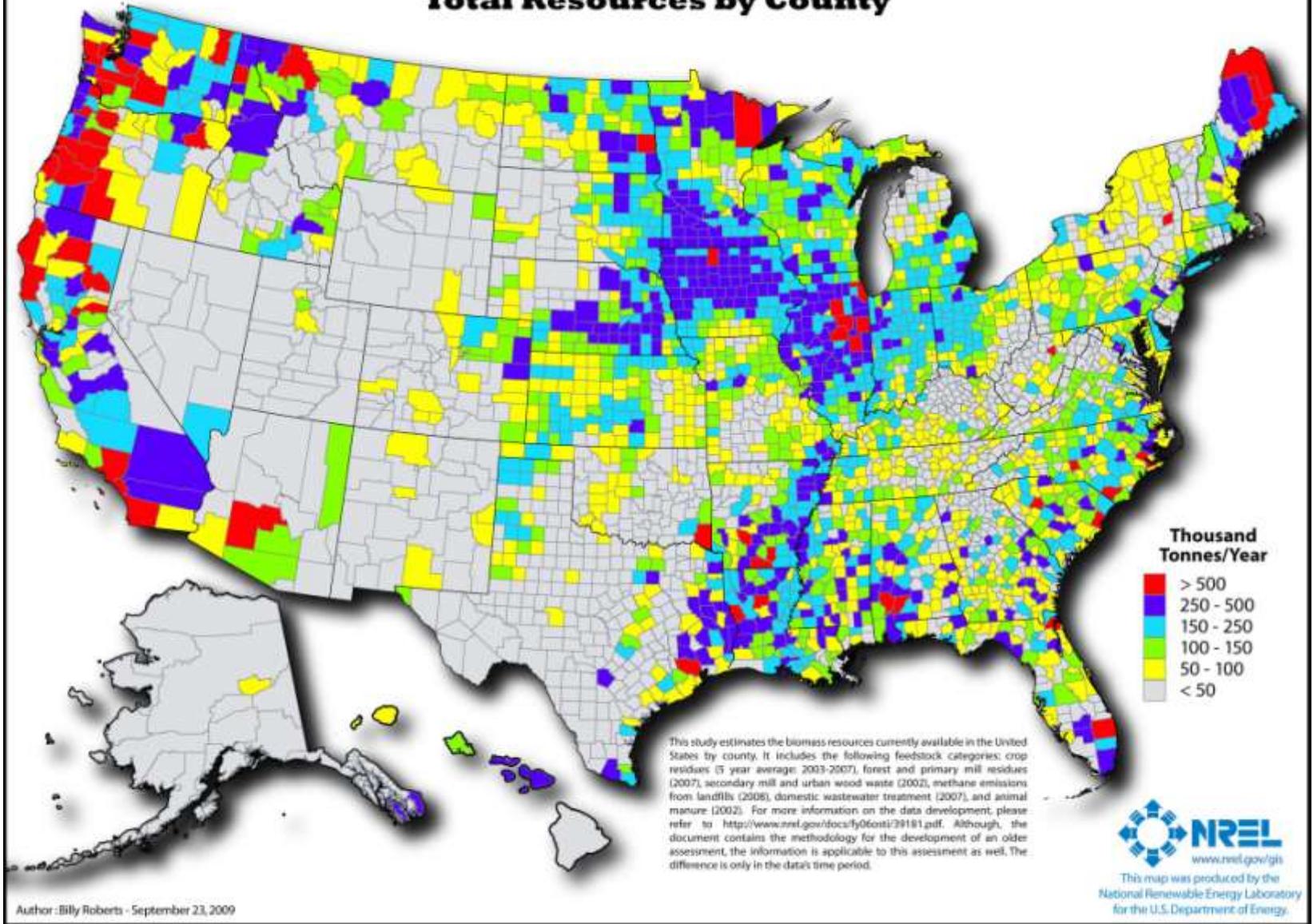
Doug Dudgeon, Ph.D.
Director of Process Development
Harris Group Inc.

Engineering Solutions for a Better World™



Biomass Resources of the United States

Total Resources by County

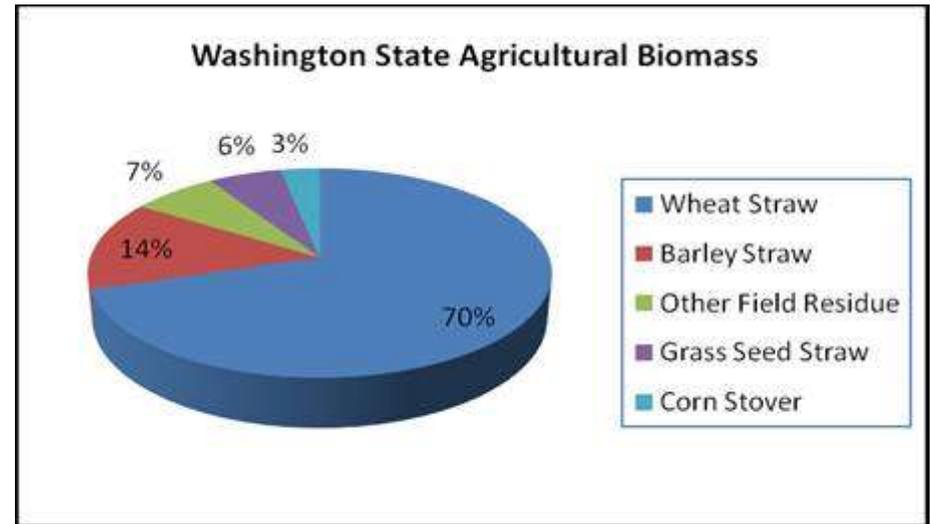
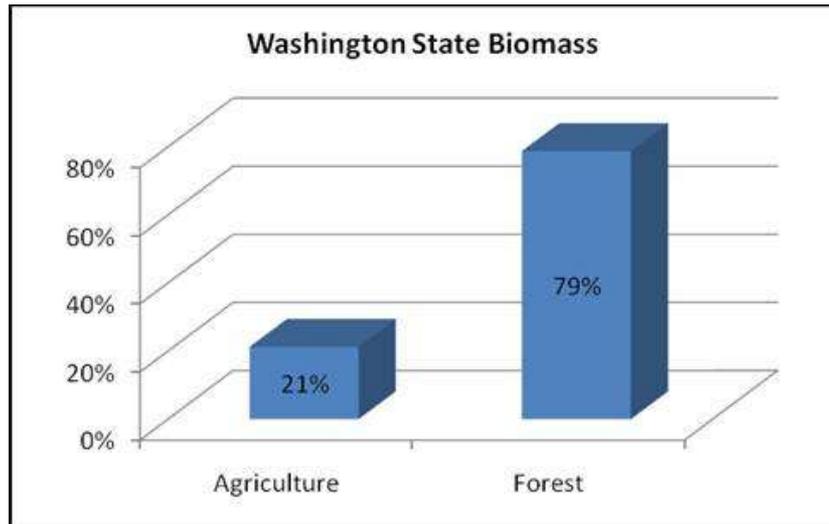


Author: Billy Roberts - September 23, 2009



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Washington State Biomass



The Luck of Bellingham



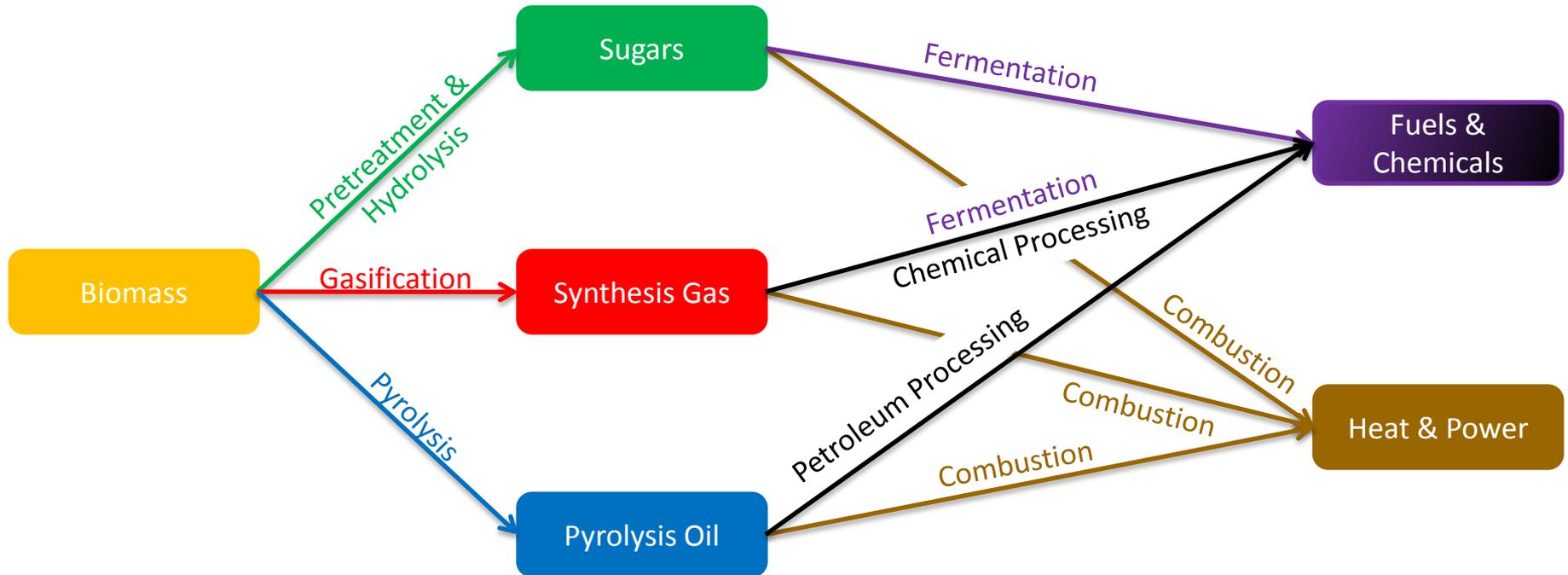
Photo: Center for Pacific Northwest Studies, Western Washington University

Sulfite pulp mill
produces ethanol for
World War II and 55
years more

Hard-drinking U.S. synthetic rubber and smokeless powder plants, which in 1944 downed about 90% of the domestic sugar, grain and molasses alcohol supply, have been searching feverishly for more & more industrial alcohol spigots. Almost equally fervent has been the Pacific Northwest's hunt for new industries with postwar promise. Last week, in one happy stroke, the Government got its spigot and the Northwest its new industry.

The timely provider of both was sprawling Puget Sound Pulp & Timber Co., owner of the U.S.'s largest unbleached sulphite pulp mill at Bellingham, Wash., and first U.S. pulp mill in this war to manufacture alcohol from wood-pulp wastes.

Principal Process Routes



Process Challenges

Biochemical

- Pretreatment
- Enzymes
- Fermentation Yield

Thermochemical

- Gasification Reliability
- Gas Conditioning
- Catalyst Selectivity

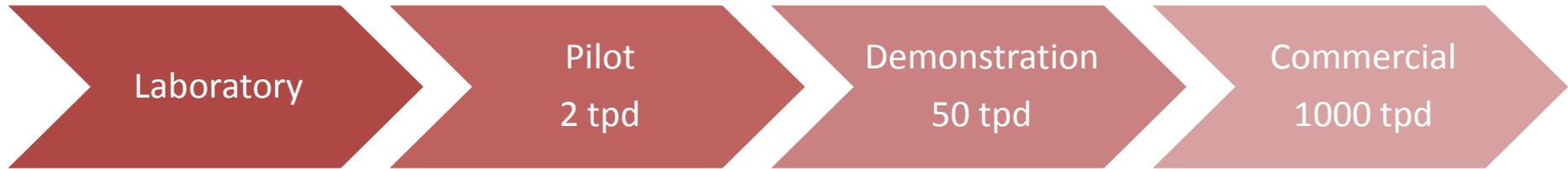
Algae

- Bioreactor design
- Dewatering
- Oil Recovery

- + Water Utilization
- + Energy Integration



Deployment Pathway

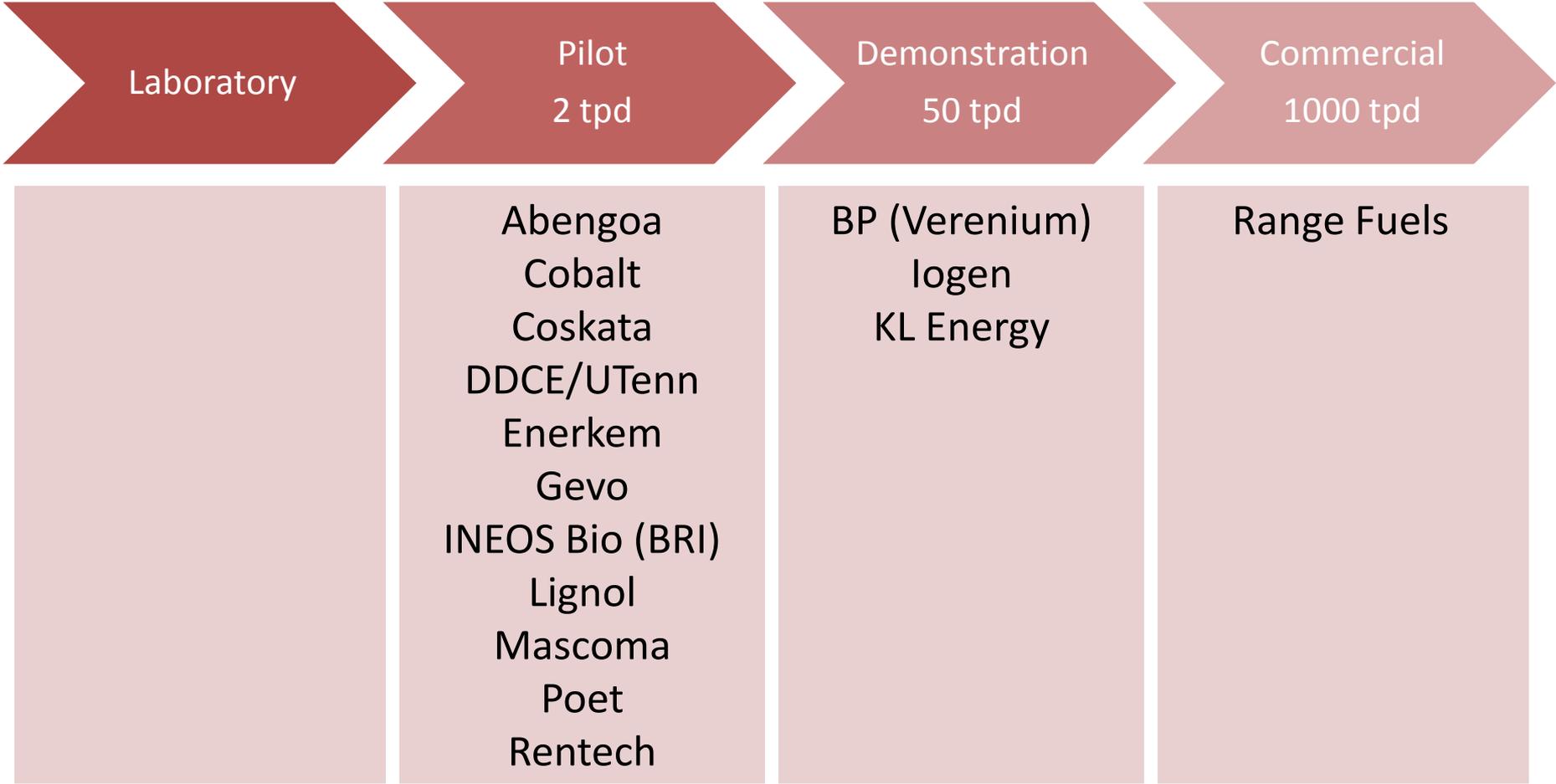


Show me the data

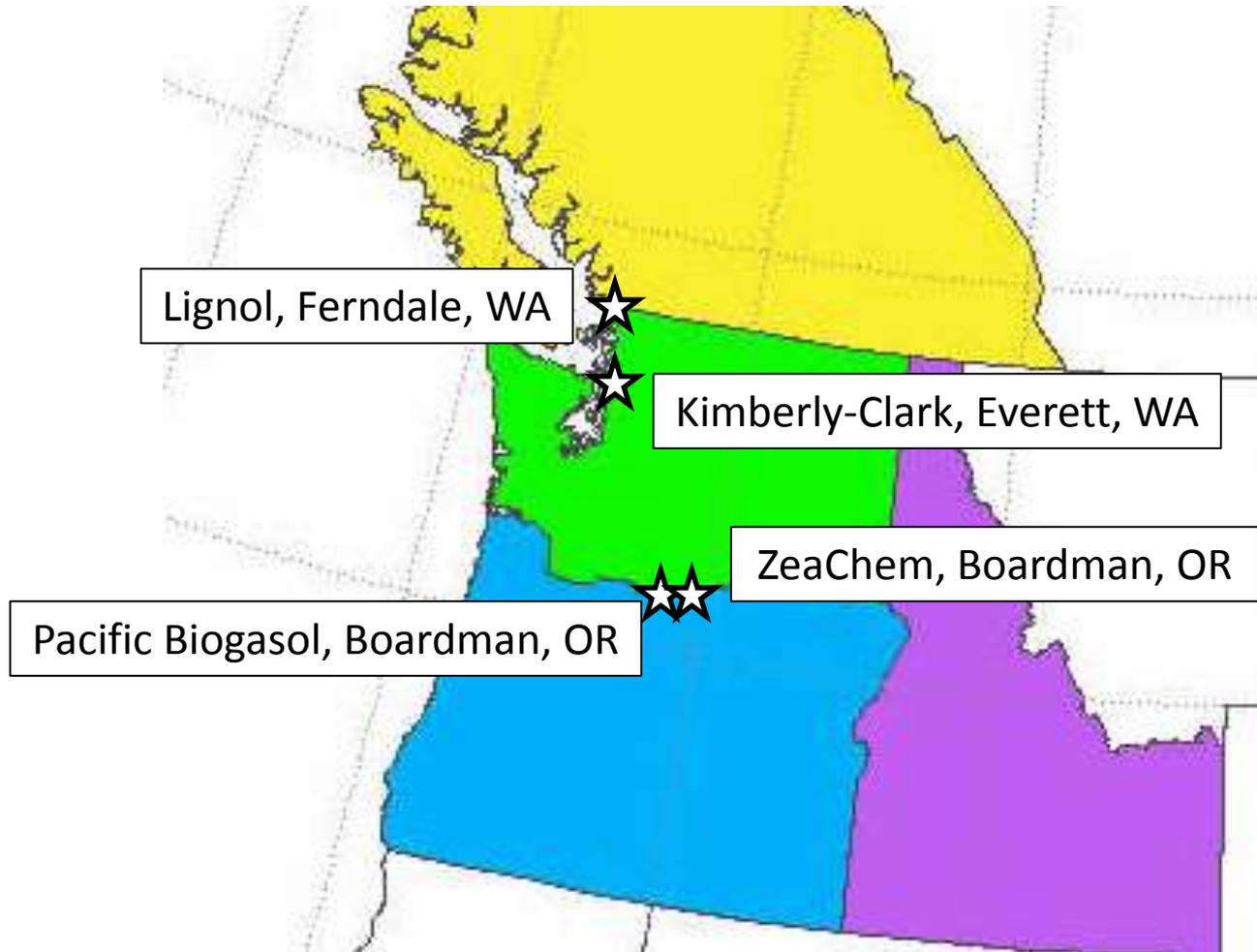
Engineering design runs
on data and owner decisions



Operating Facilities in North America



Projects in the Pacific Northwest



Lignol Demonstration Plant

Ferndale, Washington

Feedstock: Hardwood chips, 100 bdtpd

Products: 1.8 million gpy ethanol, 5500 tpy lignin, 550 tpy furfural

Process:

- Organosolv pretreatment (Alcell)
- Enzymatic hydrolysis & fermentation



Lignol Pilot Plant, Burnaby, BC (from lignol.ca)

Status: \$30 million grant from USDOE; project on hold pending cost share



Ethanol at Kimberly-Clark Everett

Everett, Washington

Feedstock: Pulp mill sludge,
spent sulfite liquor

Products: 6-8 million gpy
ethanol

Process: Biochemical

Status: \$5 million in
Recovery Act bonds
through Snohomish
County; seeking project
partners



Kimberly-Clark Everett Mill



Pacific Biogasol West Coast Biorefinery

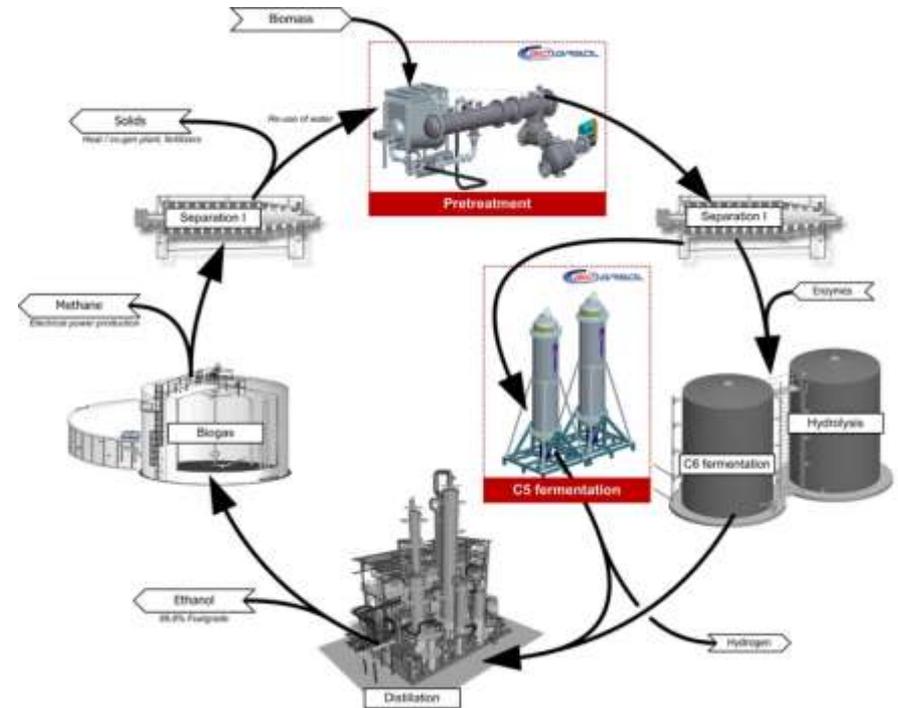
Boardman, Oregon

Feedstock: Wheat straw, corn stover, and poplar residues, 120 bdtpd

Products: 2.7 million gpy ethanol

Process:

- Enzymatic hydrolysis & fermentation
- Integrated with adjacent corn ethanol plant



BioGasol Process Technology (from biogasol.com)

Status: \$24 million grant from USDOE; technical development proceeding; seeking cost share



ZeaChem Pilot Plant

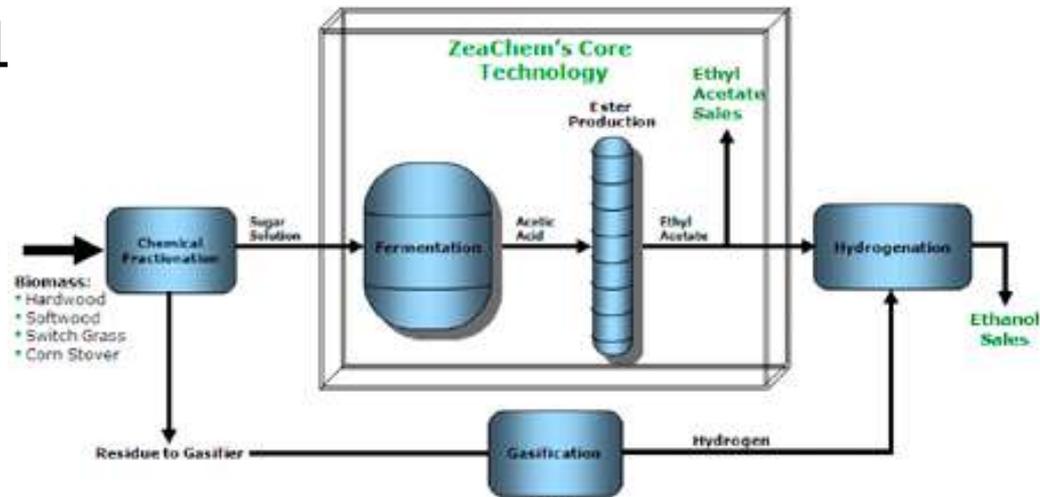
Boardman, Oregon

Feedstock: Hybrid poplar, 1
bdtpd

Products: Ethyl acetate,
ethanol

Process:

- Chemical fractionation
- Fermentation to acetic acid
- Esterification
- Hydrogenolysis



(from zeachem.com)

Status: \$25 million grant
from USDOE; project in
front-end engineering
design



Summary

- Plenty of feedstock available
- Multiple projects in development in the region
- Principal focus on fuels
- Funding remains a significant issue

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Wheat Straw to Ethanol Demonstration Plant
Abengoa Bioenergy, Salamanca, Spain



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