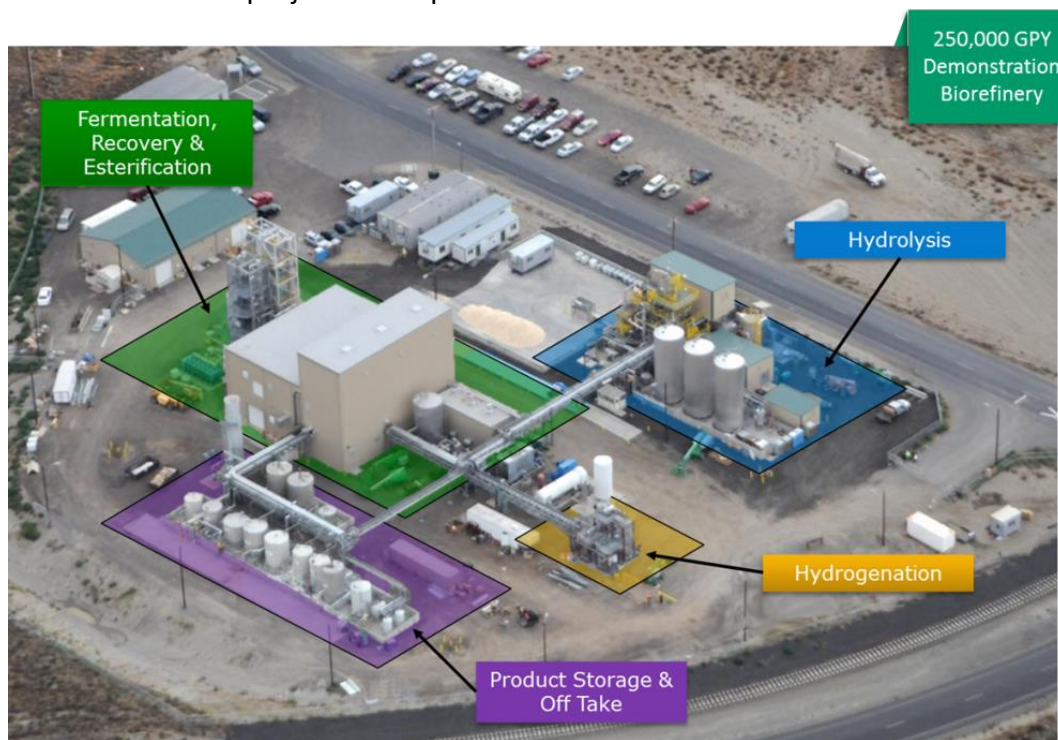


ZeaChem Processing Services Summary

Demonstrate Your Technology at Scale

ZeaChem, at its demonstration scale cellulosic biorefinery in Boardman, Oregon, is now offering third parties a cost effective and accelerated means to prove their technology at scale while avoiding the time, treasure and talent necessary to build, own and operate non-commercial demonstration facilities. ZeaChem successfully produced cellulosic sugars, lignins, acids, esters, and alcohols at its Demonstration Biorefinery and is now wrapping up its technology development activities there. Consequently, ZeaChem is now accepting processing service reservations from third parties interested in using the Demonstration Biorefinery to advance their technologies beyond the pilot scale.

The Demonstration Biorefinery incorporates five primary equipment packages: (1) hydrolysis, (2) fermentation, (3) recovery, (4) esterification and (5) hydrogenolysis. The facility was designed with flexibility in mind; existing units can be easily modified and are ready to accept additional drop-in modules. ZeaChem's engineering and operations teams, with deep domain knowledge, are available to support new demonstration projects as requested.



Demonstration Biorefinery Equipment Description

- (1) The **hydrolysis** unit, an Andritz based system, can process up to 10 tons per day of chipped cellulosic biomass* into separate C5 and C6 sugar streams. The hydrolysis unit can operate using steam explosion, dilute acid/base or auto hydrolysis, in single stage or dual stage configuration. With minor upgrades, the hydrolysis unit can incorporate other pretreatment chemicals and configurations. Enzymatic saccharification is also available at various scales.
- (2) The **fermentation** system has environmentally controlled anaerobic fermenters with clean in place and steam sanitation capability. The fermenters include a seed train that can propagate up from 4 gallons to 40 gallons to 400 gallons to 4,000 gallons and then to three 40,000 gallon

* Instantaneous rate for high density material, actual rates will vary.

production fermenters. With minor modifications the fermenters can be configured for aerobic fermentation.

- (3) The **recovery** system includes a solvent extraction and distillation based unit that can recover glacial organic acids from fermenter broths of less than 5%. The recovery system also includes: micro-, ultra-, and nano-filtration, reverse osmosis, centrifugal separation, and distillation capabilities.
- (4) The **esterification** unit is a catalytic reactor capable of converting glacial organic acids into esters in the presence of alcohols. With modification it can also be run as a 2 stage distillation column.
- (5) The **hydrogenolysis** unit is a vapor phase catalytic reactor capable of converting esters into alcohols. With modification it can be configured as a trickle bed catalytic reactor.

Processing Services

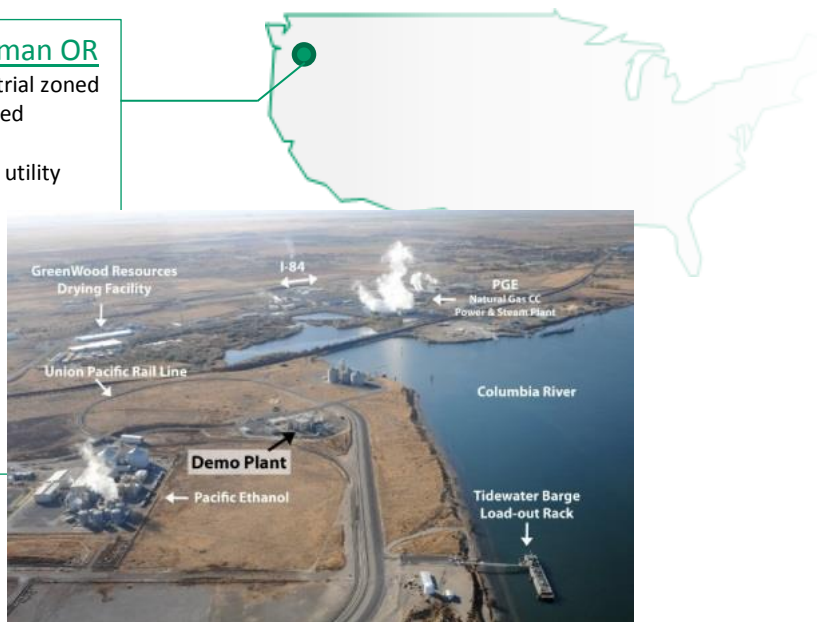
Similar to other private technology facilities, ZeaChem plans to contract out its Demonstration Biorefinery to help other interested biorefiners prove their technologies. ZeaChem's Demonstration Biorefinery offers a multitude of baseline processing services including: diverse cellulosic feedstock processing, C5 and C6 sugar production using a range of hydrolysis conditions, pelletized lignin production, controlled pilot and large semi-work scale fermentation, and intermediate product thermochemical processing. With the addition of third party technology modules, ZeaChem's Demonstration Biorefinery can be readily reconfigured to incorporate specialized bioreactions, dehydration, oligomerization capabilities, and more.

ZeaChem Demonstration Biorefinery – Boardman OR

ZeaChem's Demonstration Biorefinery was built in the industrial zoned Port of Morrow in Boardman, OR. Port of Morrow is a qualified enterprise zone and an eligible NMTC credit census tract.

The facility is sited adjacent to significant transportation and utility infrastructure including:

- Union Pacific Rail Line
- Columbia River and a Tidewater Barge load out rack
- Interstate access
- PGE Power & Steam Plant
- Greenwood Resources Tree Farm
- Agricultural residue feedstock providers
- Waste Water Treatment Plant
- Pacific Ethanol



ZeaChem works with clients to understand their objectives and then define a scope, schedule and budget to achieve those goals. ZeaChem is willing to consider plant modifications/upgrades, unit bolt-ons and provides necessary integration engineering of third party modules as well as feedstock procurement services.

Inquiries

Interested parties should contact Zac Mitchell, ZeaChem's Commercial Development Manager, at (303) 838-2218 or zmitchell@zeachem.com.