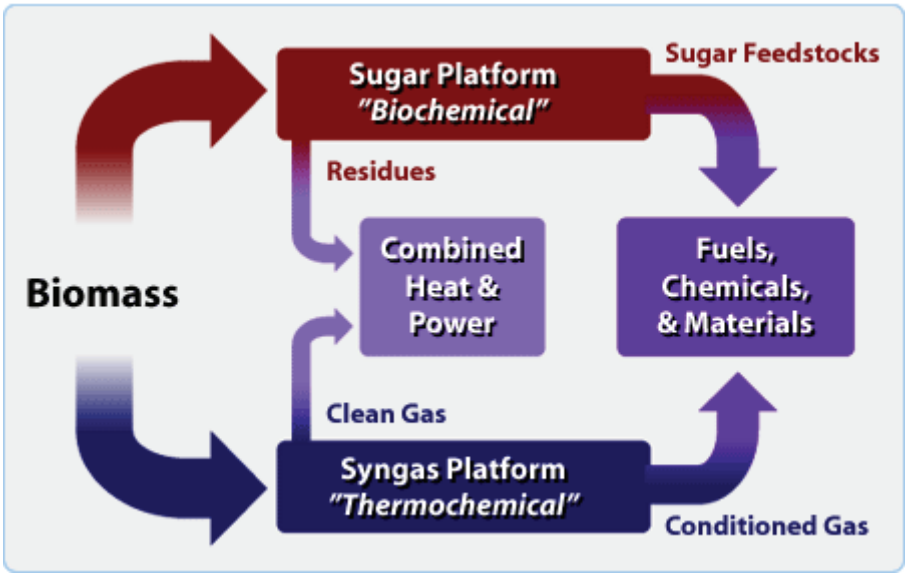
4. BIOREFINERIES

BRIEF OVERVIEW

As a petroleum refinery uses petroleum as the major input and processes it into many different products, a biorefinery uses lignocellulosic biomass as the major input and processes it into many different products. Currently, wet-mill corn processing and pulp and paper mills can be categorized as biorefineries since they produce multiple products from biomass. Research is currently being conducted to foster new industries to convert biomass into a wide range of products, including ones that would otherwise be made from petrochemicals. The idea is for biorefineries to produce both high-volume liquid fuels and high-value chemicals or products in order to address national energy needs while enhancing operation economics.

Two of the most promising emerging biorefinery platforms are the sugar platform and the thermochemical platform (also known as the syngas platform). Sugar platform biorefineries would break biomass down into different types of component sugars for fermentation or other biological processing into various fuels and chemicals. Thermochemical biorefineries would convert biomass to synthesis gas (hydrogen and carbon monoxide) or pyrolysis oil, the various components of which could be directly used as fuel.

The diagram below illustrates the biorefinery concept.



Source:
National Renewable Energy Laboratory, Biomass Program, June 2006,
http://www.nrel.gov/biomass/biorefinery.html

The Department of Energy Biomass Program is currently focusing efforts on two biorefinery platforms – sugar and thermochemical – but other platforms also have potential for expanding the use of biomass energy.

Table 4.1
Biorefinery Platforms

Platform	Description
Sugar Platform	Developing technology to break cellulose and hemicellulose down into their component sugars. Those sugars can then be processed to fuel ethanol or other building block chemicals. Lignin can either be burned to provide process heat and electricity or can itself be converted to fuels and chemicals.
Thermochemical Platform	Converting solid biomass to a gaseous or liquid fuel by heating it with limited oxygen prior to combustion can greatly increase the overall efficiency, and also make it possible to instead convert the biomass to valuable chemicals or materials. Developing thermochemical technologies will allow a more efficient means of tapping the enormous energy potential of lignocellulosic biomass.
Biogas Platform	Decomposing biomass with natural consortia of microorganisms in closed tanks known as anaerobic digesters produces methane (natural gas) and carbon dioxide. This methane-rich biogas can be used as fuel or as a base chemical for biobased products.
Carbon-Rich Chains Platform	Natural plant oils such as soybean, corn, palm, and canola oils are in wide use today for food and chemical applications. Transesterification of vegetable oil or animal fat produces fatty acid methyl ester, commonly known as biodiesel. The glycerin byproduct of biodiesel, and the fatty acids from which it is made, could all be platform chemicals for biorefineries.
Plant Products Platform	Selective breeding and genetic engineering can develop plant strains that produce greater amounts of desirable feedstocks or chemicals or even compounds that the plant does not naturally produce — getting the biorefining done in the biological plant rather than the industrial plant.

Source:
U. S. Department of Energy, Energy Efficiency and Renewable Energy, Biomass Program, June 2006, http://www1.eere.energy.gov/biomass/index.html

Note: This is not an exhaustive list of platforms.

In April 2002 the U.S. Department of Energy solicited projects for "Biomass Research and Development for the Production of Fuels, Power, Chemicals and Other Economical and Sustainable Products." The following six projects, which will be completed in three to four years, were selected to assist in the development of sugar platform research.

Table 4.2
U.S. Department of Energy Sugar Platform Biorefinery Projects

Project name	Partner	Project cost	Project Description
A Second Generation Dry Mill Biorefinery	Broin and Associates	$5.4 million	Separate bran, germ, and endosperm from corn kernels prior to making ethanol from the remaining starch. Investigate making high-value products, as well as ethanol and animal feed from the separated fractions.
A New Biorefinery Platform Intermediate	Cargill, Inc.	$6 million	Develop fermentative organisms and processes to ferment carbohydrates to 3-hydroxypropionic acid (3-HP) and then make a slate of products from the 3-HP.
Making Industrial Biorefining Happen	Cargill-Dow LLC	$26 million	Develop and build a pilot-scale biorefinery that produces sugars and chemicals such as lactic acid and ethanol from grain.
Integrated Corn-Based Biorefinery	E.I. du Pont de Nemours & Co., Inc.	$18.2 million	Development of a biorefinery concept that converts both starch (such as corn) and lignocellulose (such as corn stover) to fermentable sugars for production of value added chemicals (like 1,3 propanediol) and fuel ethanol.
Advanced Biorefining of Distillers' Grain and Corn Stover Blends: Pre-Commercialization of a Biomass-Derived Process Technology	High Plains Corporation (now Abengoa S.A.)	$17.7 million	Develop a process for pretreating a blend of distillers' grain (animal feed co-product from corn ethanol production) and stover to allow ethanol production from both, while leaving a high-protein animal feed. A large-scale pilot facility will be built for integration with High Plains' ethanol plant in York, Nebraska.
Separation of Corn Fiber and Conversion to Fuels and Chemicals Phase II: Pilot-Scale Operation	National Corn Growers Association	$2.4 million	Under a previous DOE-funded project, a process was developed for separation of hemicellulose, protein, and oil from corn fiber. This project will pilot-scale test and validate this process for commercial use.

Source:
U. S. Department of Energy, Energy Efficiency and Renewable Energy, Biomass Program, June 2006, http://www1.eere.energy.gov/biomass/sugar_biorefineries.html