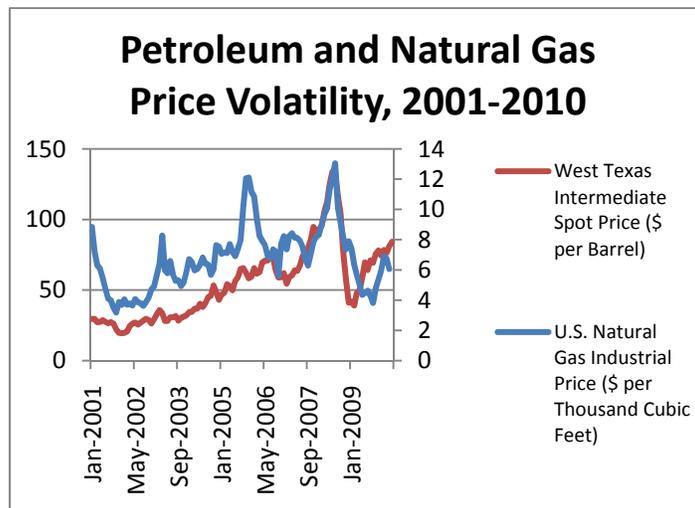


## The Potential for Biobased Products Made from Algae

Thousands of items throughout the world are made from plastics or chemical ingredients, including highly beneficial ones from pipes that deliver water to containers that keep food fresh and personal care products that enhance health. Many consumer items are made more widely available, more efficiently and at lower cost through use of plastics and chemical ingredients. But plastics and chemicals are made primarily from fossil resources – petroleum and natural gas. Volatile pricing for fossil fuels, political instability in petroleum producing regions, and the environmental impacts of fossil fuels are some of the key reasons that producers of chemicals and plastics are searching for alternative, renewable resources.



Oils produced by algae hold the potential for replacing fossil resources in many products. In fact, according to recent research, much of the petroleum and coal we drill for and use today was originally produced thousands of years ago by a species of green algae.<sup>1</sup>

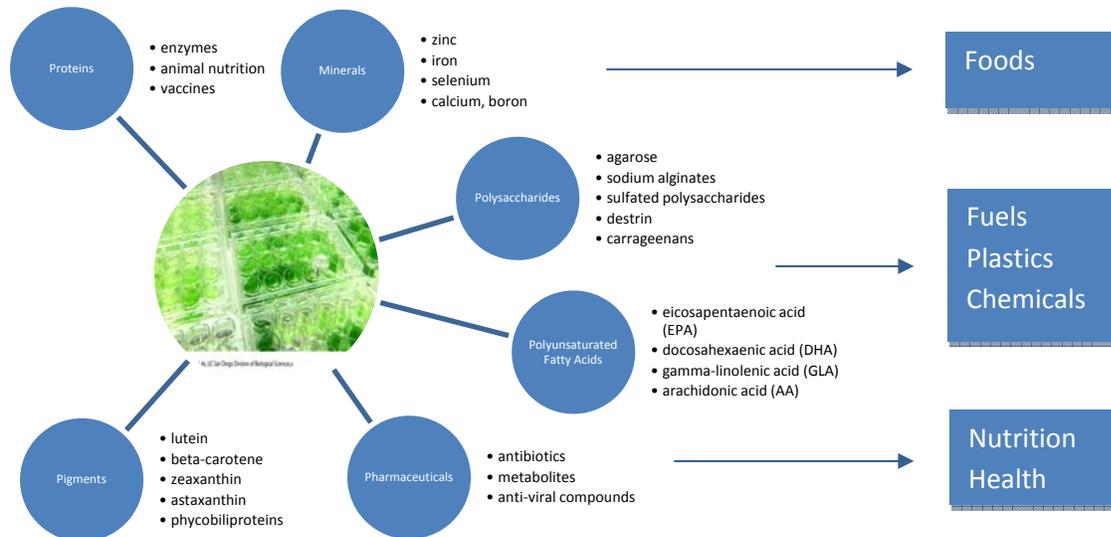
### Algal Oils Displace Fossil Fuels

Oils produced by different algae strains range in composition. Most are like vegetable oils, though some are chemically similar to the hydrocarbons in petroleum. In general, high hydrocarbon concentrations exist only in non-growing or decaying algae cultures. Algae also produce proteins, isoprenoids and polysaccharides. Some strains of algae ferment sugars to produce alcohols, under the right growing conditions.

Growing conditions (such as light and temperature), nutrient levels (nitrogen, salt and silicon), and growth stage all have an effect on what types of oils algae produce. Biotechnology is used to understand and characterize the balance of oils, proteins and sugars that various algae strains produce in different conditions. With this knowledge, metabolic engineering techniques can be used to optimize targeted algae strains for production of proteins, fatty acids, and sugars that can be used as building blocks for chemicals, plastics and biofuels.

Algae-derived starches, oils and proteins can be used in food, animal feed or nutrition supplements. Fatty acids can be used in diesel biofuels or as building blocks in chemical mixtures. Algal sugars can be

<sup>1</sup> Weiss, T.L., et al, "Phylogenetic Placement, Genome Size, and GC Content of the Liquid-Hydrocarbon-Producing Green Microalga *Botryococcus Braunii* Strain Berkeley (Showa) (Chlorophyta)," *Journal of Phycology*, 46(3), 534-540.



converted into chemical products that can be used for many purposes. For example, algae can be used to make ethanol, which in turn can be converted into polyethylene.

## Environmental Benefits

Bio-based feedstocks offer key environmental and economic advantages over crude oil and natural gas as the building blocks for some consumer products. First, algae can be grown in many countries around the world as a substitute for fossil fuels. Algae can be produced wherever there is plenty of sunshine and nutrient-rich water. Arable land and high-volume freshwater are not required. Algae do not require acreage better suited for food and feed production.

Second, bio-based feedstocks that replace fossil fuels in the production of plastics, for example, can actually reduce atmospheric concentrations of greenhouse gases by fixing atmospheric carbon. Both algae and cellulosic plants absorb carbon dioxide as they grow. The carbon that they remove from the atmosphere through photosynthesis is fixed in the product – potentially hundreds of everyday items as varied as grocery bags, plastic pipes, and shampoo bottles – until they are recycled or composted. The oil and natural gas formerly used can remain deep below ground.