Biofuels-2015: Path to commercial algal biofuels through combination of process cost reductions and identification of novel co-products- Philip T Pienkos - The National Renewable Energy Laboratory (NREL)

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Although algal biomass is considered to be a potentially high value feedstock for biofuel production, the path to commercialization is challenged by high production costs. For more than five years from around 2005, algae-based biofuel companies, including the likes of Algenol, Sapphire Energy and Solazyme, raised hundreds of millions of dollars in private sector investment on the promise that chemically engineering algae could scale up to produce tens of millions of gallons of fuel in a matter of years, at prices competitive with fossil fuels. Fuel conversion from algae is broadly based on the feedstock's high concentrations of lipids: fatty, oil-containing acid molecules that can be extracted to create biofuels. Nearly 15 years later, the green tech world has fallen out of love with algal biofuel. Despite the large sums spent on developing the conversion process, the industry's ambitious production goals – not to mention cost-competitiveness with fossil fuels – remain a distant dream. In terms of cost, major oil price declines in 2008 and 2014 certainly didn't help biofuel competitiveness, but technical issues have also proven a major sticking point. Intractable problems have been encountered in terms of the energy balance of lipid extraction, maintaining suitable growing conditions in open ponds, and the immense volumes of water, CO_2 and fertiliser required to allow the algae to photosynthesise fast enough at large scales. "Simulations of microalgal biofuel production show that to approach the 10% of EU transport fuels expected to be supplied by biofuels, ponds three times the area of Belgium would be needed," wrote Swansea University marine biologist Professor Kevin Flynn in 2017. "And for the algae in these ponds to produce biofuel, it would require fertiliser equivalent to 50% of the current total annual EU crop plant needs. As a result, most of the companies touting algal biofuel in 2005-2012 have been driven out of business or shifted their business models to algal production of higher-value products such as dietary supplements, food additives, animal feed and cosmetics. But while the prospect of algal biofuel lies dormant and the venture capital funding of 2005 has long since moved on, the technology's long-term potential remains and advances in recent years are keeping the algal ball rolling. The road ahead might be long, but these recent ideas and discoveries could all represent significant steps. This improvements in any other unit operations will also be needed. Algae are organisms that grow in aquatic environments and use light and carbon dioxide (CO2) to create biomass. There are two classifications of algae: macroalgae and microalgae. Macroalgae, which are measured in inches, are the large, multi-cellular algae often seen growing in ponds. These larger algae can grow in a variety of ways. The largest multicellular algae are called seaweed; an example is the giant kelp plant, which can be more than 100 feet long. Microalgae, on the other hand, are measured in micrometers and are tiny, unicellular algae that normally grow in suspension within a body of water. Microalgae have long been recognized as potentially good sources for biofuel production because of their relatively high oil content and rapid biomass production. Microalgae grow very quickly compared to terrestrial crops; the practice of algal mass culture can be performed on non-arable lands using non-potable saline water and waste water. Thus, use of microalgae as an alternative biodiesel biofuel feedstock is gaining increasing interest from researchers, entrepreneurs, and the general public. Current Potential for Use as a Biofuel is algal biomass contains three main components: carbohydrates, proteins, and lipids/natural oils. The biomass from algae can also be burned similar to wood or anaerobically digested to produce methane biogas to generate heat and electricity. Algal biomass can also be treated by pyrolysis to generate crude bio-oil. Microalgae grow quickly and contain high oil content compared with terrestrial crops, which take a season to grow and only contain a maximum of about 5 percent dry weight of oil, (Chisti, 2007). They commonly double in size every 24 hours. During the peak growth phase, some microalgae can double every three and one-half hours (Chisti, 2007). Oil content of microalgae is usually between 20 percent and 50 percent while some strains can reach as high as 80 percent (Metting, 1996; Spolaore et al., 2006). This is why microalgae are the focus in the algae-to-biofuel arena.This presentation will highlight research activities at NREL that are aimed at development of production strains with improved biofuel production characteristics, identification of large volume co-products, and development of novel technologies for biomass conversion to reduce costs and energy inputs. These activities will be placed into a framework of techno-economic analysis to help establish a scenario for an integrated algal biofuel production process that could compete with petroleum-based fuels.

Biography:

Philip T Pienkos earned his BS in Honors Biology at the University of Illinois and his PhD in Molecular Biology at the University of Wisconsin. He has nearly 30 years of biotechnology experience in the pharmaceutical, chemical and energy sectors. He is a co-founder of two companies: Celgene, an established biotech/pharma company, and Molecular Logix, a case study for technology-rich/funding-poor biotech startup. He joined NREL in 2007 as a section supervisor and now holds the title of Principal Group Manager for the Bioprocess R&D Group in the National Bioenergy Center. In addition to his line management responsibilities, he is also the Algal Biofuels Platform Lead for the National Bioenergy Center at NREL. He is part of a team of algae experts from NREL and Sandia National Laboratories who worked with the Department of Energy to organize National Algal Biofuels Technology Roadmap Workshop held in December, 2008 and was a contributor to the National Algal Biofuels Technology Roadmap document, published in May, 2010. He is a founding member of the Algae Biomass Organization and has served as a member of the board of directors for that organization from 2008 to 2013. He is currently on the board of directors of the Algae Foundation. He was named in Biofuels Digest’s list of the top 100 people in biofuels for four running years.

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