



Algal Biofuels Guide: Renewable Energy from Algae, Macroalgae (Seaweed), Cyanobacteria, Feedstocks, Cultivation, Harvesting, Extraction, Conversion, Distribution and Utilization

U.S. Government, U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy

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Algal biomass is a fast-growing, renewable resource and a promising feedstock for advanced biofuels. Algal biofuels are generating considerable interest around the world. In the United States, they represent promising pathways for helping to meet the biofuel production targets set by the Energy Independence and Security Act of 2007. Algae are a diverse group of primarily aquatic organisms that are capable of using photosynthesis to generate biomass. Some algal strains are able to double their mass several times per day. In some cases, more than half of that mass consists of lipids or tricylglycerides. These bio-oils can be used to produce drop-in replacements for diesel, gasoline, and aviation fuels. Some algae accumulate carbohydrates (including starch), which can also be used to form intermediates for processing into biofuels. Proteins from the residual biomass could provide supplemental feed for livestock and aquaculture operations.

Advantages of Algal Feedstocks * A History of Domestic Algal Biofuels Development * Early Work to 1996 * Research from 1996 to Present * Algae-to-Biofuels: Opportunity and Challenges Today * Technology and Analysis Challenges * Regulations and Standards * Public-Private Partnerships * References * Algal Biology * Strain Isolation, Screening and Selection * Isolation and Characterization of Naturally Occurring Algae * Role of Culture Collections as National Algae Data Resource Centers * Selecting Algal Model Systems for Study * Algal Physiology and Biochemistry * Photosynthesis and Light Utilization * Carbon Partitioning and Metabolism * Algal Carbohydrates * Lipid Synthesis and Regulation. * Biohydrogen * Algal Biotechnology * The Genetic Toolbox * Enabling Technologies: "Omics" Approaches and Bioinformatics * Applications of Biotechnology to Algal Bioenergy * Considerations of Genetic Modifications * References * Algal Cultivation * Cultivation Pathways * Microalgae and Cyanobacteria * Macroalgae * Scale-Up Challenges * Stability of Large-Scale Cultures * System Productivity * Nutrient Sources, Sustainability, and Management * Water Management, Conservation, and Recycling * Downstream Processing: Harvesting and Dewatering * Approaches for Microalgae * Harvesting * Drying * Approaches for Macroalgae * Harvesting * Preprocessing * Systems Engineering * References * Preliminary Look at Energy Balance * Extraction of Products from Algae * Current Practices for Lipid Extraction * Mechanical Disruption (i.e., Cell Rupture) * Organic Co-solvent Mixtures * Accelerated Solvent Extraction * Selective Extraction * Subcritical Water Extraction * Supercritical Fluid Extraction * Heterotrophic Production * Challenges * References * Algal Biofuel Conversion Technologies * Direct Production of Biofuels from Algae * Alcohols Alkanes * Hydrogen * Processing of Whole Algae * Pyrolysis * Gasification * Liquefaction * Supercritical Processing * Anaerobic Digestion of Whole Algae * Conversion of Algal Extracts * Chemical Transesterification * Biochemical (Enzymatic) Conversion. * Catalytic Cracking * Conversion to Renewable Diesel, Gasoline, and Jet Fuel * Processing of Algal Remnants after Extraction * References * Co-products * Commercial Products from Microalgae and Cyanobacteria * Commercial Products from Macroalgae * Potential Options for the Recovery of Co-products * References * Distribution and Utilization * Distribution * Utilization * Algal Blendstocks to Replace Middle-Distillate Petroleum

Products * Algal Blendstocks for Alcohol and Gasoline-Range Petroleum Products * References * Resources and Siting * Resource Requirements for Different Cultivation Approaches * Photoautotrophic Microalgae Approach * Heterotrophic Microalgae Approach * Photoautotrophic Macroalgae Approach * Resources Overview * Climate * Water * Carbon Dioxide * Land * Integration with Water Treatment Facilities * Wastewater Treatment and Recycling Applications * Algae Production Techniques for Wastewater Treatment Plants

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