Bio Architecture Lab, EcoShift make waves with seaweed-based biofuels

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Measuring the greenhouse gas (GHG) intensity of biofuels has become increasingly important in recent years. Studies have shown a significant amount of variation in biofuels made from different feedstocks. In some cases, biofuels are only marginally better than fossil fuel counterparts. In other cases, there are significant improvements in GHG performance.

EcoShift Consulting (www.ecoshift.com) recently conducted a GHG intensity analysis of a seaweed-based ethanol product that performs significantly better than gasoline as well as ethanol made from other feedstocks. The ethanol is being developed by Bio Architecture Lab, Inc. (BAL), a firm that partnered with ARPA-e—the premier energy research institute in the U.S.—on a grant to develop a process for producing ethanol from seaweed. Research by BAL scientists was recently featured on the cover of Science for their breakthrough technological advances that can convert alginate into fermentable sugars. As BAL prepares to bring this seaweed-based ethanol into production, they worked with Santa Cruz-based EcoShift to model and optimize the GHGs associated with their process to ensure that it is among the lowest carbon intensity transportation fuels commercially available.

BAL—the Berkeley, California-based ethanol firm (www.ba-lab.com) —is utilizing macroalgal feedstocks because they are low-cost at commercial scale, and do not present the land use and food conflicts associated with other less-sustainable biofuel solutions. BAL's ocean-based farming of seaweed also avoids the significant GHGs associated with land-based farming, which can comprise up to 40% of the carbon intensity of other biofuels.

EcoShift modeled the carbon intensity—the GHG emissions emitted per unit of energy—of BAL's processing pathway to demonstrate that it qualifies as an advanced biofuel under the EPA's Renewable Fuel Standard. The EPA has defined benchmark carbon intensity values for gasoline and diesel fuel carbon intensity. To qualify as a renewable fuel, ethanol must demonstrate a 20% or greater GHG emissions savings over those fossil fuels values. Advanced biofuel status requires that the life cycle GHG emissions are a 50% or greater improvement over the carbon intensity of gasoline. Advanced biofuel status is valuable to producers who then sell these biofuels to blend with fossil fuel transportation fuels.

A carbon intensity estimate is also required for California's Low Carbon Fuel Standards (LCFS), which requires that California's GHG emissions from transportation fuels be reduced by 10% by 2020. This means that ethanol with lower carbon intensities is more valuable to transportation fuel producers. Similar emissions standards are being pursued by eleven other U.S. states as well as Canada.

To meet the aims of the EPA's Renewable Fuel Standard and California's Low Carbon Fuel Standard, EcoShift performed a life cycle analysis (LCA) of GHG emissions, often referred to as a well-to-pump (fossil fuels) or field-to-pump (biofuels) analysis. EcoShift, which specializes in LCA and industry-specific sustainability, completed its "sea-to-pump" carbon intensity analysis in April 2013.

To quantify BAL's full "sea-to-pump" emissions profile, EcoShift mapped out the system boundary, which includes all of the materials and energy inputs used in production. From there the team developed an inventory of all material and energy inputs, identifying sources of emissions, emission factors, heating values, process yields, and aqua-farm to refinery to pump transportation distances. From these inventory data, the carbon intensity of BAL's seaweed to ethanol process calculated using Argonne National Labs' Greenhouse gases, Regulated Emissions, and Energy use in Transportation (GREET) model.

The LCA results allowed EcoShift to help evaluate several scenarios and identify potential opportunities for carbon intensity reductions across their fuel's life cycle to ensure they qualify as an advanced biofuel. This is one of the benefits of conducting LCAs early in the design phase. There are opportunities to choose from various energy and processing technologies that will be used to manufacture seaweed-based ethanol. For example, does it make sense to install cogeneration for electricity and steam, when the region has a low carbon intensity for grid-electricity? Or, how might swapping natural gas for bio-methane in production impact the overall carbon intensity of the fuel? Investing in the lowest carbon energy sources requires large capital investments, and an LCA of GHGs can help determine if the capital investments are rewarded with value derived from the lower carbon sources.

The shift to lower carbon transportation fuels is already underway. Many biofuels companies are conducting LCAs to meet one or more emerging incentives or regulations on the carbon intensity of biofuels. But many of these LCAs are conducted on existing plants, where investments in lowering carbon intensities might come at a great cost. To hasten a transition to lower carbon biofuels, it is critical to make informed choices during the plant design phase, where means to improve the carbon intensity of biofuels can be illuminated using LCA prior to breaking ground on new plants and refineries.

The LCA performed by EcoShift for BAL's seaweed biorefinery included feedstocks of various compositions (M. pyrifera and S. latissima), and various process configurations (alternative unit operations applied in biorefinery, and biorefinery configurations with and without electrical co-generation). The analysis identified several process configurations which will result in net GHG emissions of less than 49,000 g CO_2 equivalents per MM BTU of fuel ethanol produced (in other words, greater than a 50% reduction in GHGs versus petroleum). This means that the ethanol produced will qualify as an advanced biofuel under the EPA RFS standard. Seaweed is a particularly interesting feedstock for production of next-generation fuels, since production of seaweed does not consume arable cropland or fresh water, and does not require the use of polluting fertilizers. In fact, this technology can displace fossil fuel-based fertilizers as well as one bi-product is potash.

The results of the LCA performed by EcoShift indicate that the overall "sea-to-pump" GHG emissions from production and processing of seaweed will be quite an environmentally favorable prospect.

BAL's ethanol production process could set a new standard for sustainability and how biofuel feedstocks should be grown. The collaboration with EcoShift has helped them ensure that GHG emissions from their production process are the lowest possible.