Alfa Laval in brief

Alfa Laval is a leading global provider of specialized products and engineered solutions.

Our equipment, systems and services are dedicated to helping customers to optimize the performance of their processes. Time and time again.

We help our customers to heat, cool, separate and transport products such as oil, water, chemicals, beverages, foodstuffs, starch and pharmaceuticals.

Our worldwide organization works closely with customers in almost 100 countries to help them stay ahead.

How to contact Alfa Laval

Up-to-date Alfa Laval contact details for all countries are always available on our website at www.alfalaval.com

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Tap into a sea of solutions

Alfa Laval's algae-processing solutions

The farming of algae, or algaculture, has the potential to address several of the world's most demanding challenges, from rising oil prices and conflicts between the demand for biofuel and food, to the needs of a rapidly growing worldwide population. Biofuels, one of the most promising areas, can replace fossil fuels and help reduce the introduction of new carbon dioxide (CO_2).

Alfa Laval offers solutions that can help advance these efforts.

Facing the big challenges

While large-scale commercialization of algae is still to be realized as a source of biofuels, algaculture is already producing food for humans and animals as well as fertilizers, dyes and colorants for a wide range of industries. A number of entrepreneurs, such as Aurora Algae, based in Hayward, California, are currently producing Omega-3 EPA oil for the pharmaceutical and neutraceutical markets.

A number of other "green" benefits are significant. At some coal-fired power stations in Australia, for example, greenhouse gases are captured and recycled as feedstocks in an enclosed algae-based growth system.

The source of 'green' opportunities

In general, algae refer to plant-like organisms that exist worldwide in the sea, freshwater and wastewater. The unicellar forms of algae, known as microalgae, have an extraordinary potential for cultivation as energy crops. In fact, algae can produce up to 300 times more oil per acre than conventional crops, such as rapeseed, palms or soybeans, and have a short harvesting cycle – one to ten days.

However, the commercialization of algae presents a number of challenges, from processing capacity limitations to costs. To address this problem, Alfa Laval is joining the growing number of players to help them exploit the opportunities in algaculture with its separation, heat exchange and other leading technology solutions.

High concentrations of Omega-3 fatty acids are being used in pharmaceutical and health supplement products, as well as many other foods and beverages.

Algae: a platform for change

To meet the food and energy challenges of the future, radical new solutions will be required. Algae, as a renewable and sustainable resource, are ideal for addressing the following:

- **Biofuels**. Due to their growth rate and yields, algae can theoretically produce 10 to 100 times more oil than other "energy" crops. They can be grown under conditions unsuitable for conventional crop production, reducing the burden on agricultural land.
- **Food**. Algae are important foods in many nations, especially in Asia. They are a popular source of Omega-3 fatty acids for vegetarians who cannot get long-chain EPA and DHA from other vegetarian sources.
- **Pharmaceuticals and biochemicals**. Algae are a promising source of other sustainable high value end products in areas such as pharmaceuticals, nutraceuticals, biochemicals, fertilizer, plastics and cosmetics.
- **Fish and animal feed**. The production of low-cost fish and animal feed from algae can provide a natural food source for fish and farm animals.
- **Pollution control**. Algae can have a positive impact on the environment. For example, the CO_2 that a carbon-fuel burning plant produces can feed into open or closed algae systems, capturing the CO_2 and accelerating algae growth. Also, untreated sewage can supply additional nutrients, thus turning two pollutants into valuable commodities.
- **'Green' jobs**. A thriving algaculture industry would also create employment in an emerging green area, as well as increased demand in industry-related products and services.

Cases: pilot tests show real promise

Alfa Laval is playing an important role in algae pilot plants at facilities around the world. Here are two examples:

• **The Utah State University Research Foundation's Energy Dynamics Lab – Solar BioInnovations Facility, North Logan, Utah**, utilizes a Clara 80 centrifuge during harvesting to separate the algae cells from the liquid growth media. This produces a thick algae slurry which is solar-dried so that the oils can be extracted.

About the Solar BioInnovations Facility: The facility has been in operation since January 2010 to develop and demonstrate low cost, large-scale, commercially viable technologies to produce fuel from algae. Currently, funding comes from the U.S. Department of Energy grants and the state funded Utah Science Technology and Research (USTAR) initiative.

• **Aurora Algae** has adopted Alfa Laval's solid-ejecting centrifuges for its demonstration plant in Karratha, Western Australia, to perform multiple stages of algae dewatering downstream of Aurora's proprietary primary harvesting step.

"Alfa Laval centrifuges ideally fit Aurora's stringent process requirements in terms of biomass recovery efficiency and solid concentration. This type of centrifuge is able to perform in conditions of high solid load and high solid concentration while maintaining a satisfactory hydraulic rate," says Guido Radaelli, VP Engineering.

About Aurora: Founded in 2006 by three University of California-Berkeley graduates with a vision for developing highly productive algae strains that could be used to generate much needed sustainable products, Aurora Algae is a producer of high-performance algae-based products for use in the pharmaceutical, nutrition, aquaculture, animal feed and fuels market.

Culturing capacity. The algae raceways and ponds at the Solar BioInnovations Facility have a total capacity of more than 200,000 liters of algae.

"Alfa Laval provided an ideal product platform to seamlessly move from pilot to demonstration scale, proving to be an ideal partner for first-of-a-kind applications."

Some key processing challenges

Significant challenges confront the algae cultivation, including:

Costs. Since the most common method for growing algae is by fermentation, costs are relatively fixed. Tanks and other equipment are required as well as sugar or yeast, a high value feedstock, are necessary.

But many are finding ways to address this challenge. For example, Aurora is using renewable resources like sunlight and seawater and CO_2, a renewable feedstock, to cut down on their fermentation costs. Alfa Laval's separators are also proving to be a cost-effective way to extract algae cells from the liquid growth medium.

Large-scale production. A major challenge is producing enough feedstock to test and improve technologies that allow for large-scale production along the entire production stream. To increase dewatering capacity in the fermentation stage, for example, production facilities would require an equivalent boost in separation capacity.

Economic competition. In the end, the success of algae-based products, such as biofuels, depend on the cost per unit. To compete with fossil fuels, the production of biofuels would have to be so efficient that the cost per gallon is economically competitive. While technical challenges, such as harvesting with centrifuges and other technologies, are being addressed, the upfront costs present obstacles.

Many experts view algae as a viable alternative to fossil fuels as oil prices rise and technical and engineering solutions launch the green wave of the future.

Algae facts

- A large group of diverse organisms, ranging from unicellular to multicellular forms, such as kelps that grow to 65 meters in length.
- Usually photosynthetic and acquatic plant-like organisms
- Simple reproductive structures (no roots, stems, leaves, vascular tissue)
- Distributed world wide in sea, freshwater and wastewater

Algae-processing solutions

Alfa Laval has a number of solutions available for algae farming, particularly in the fermentation stage of the process. These include:

High-speed separators
A number of Alfa Laval separators are used in the harvesting stage to separate the algae cells from the liquid growth media. These include both intermittent and continuous discharging separators.

Decanters
Alfa Laval decanters are suitable for dewatering the algae biomass slurry after it has been processed in a separator, resulting in a concentrated product.

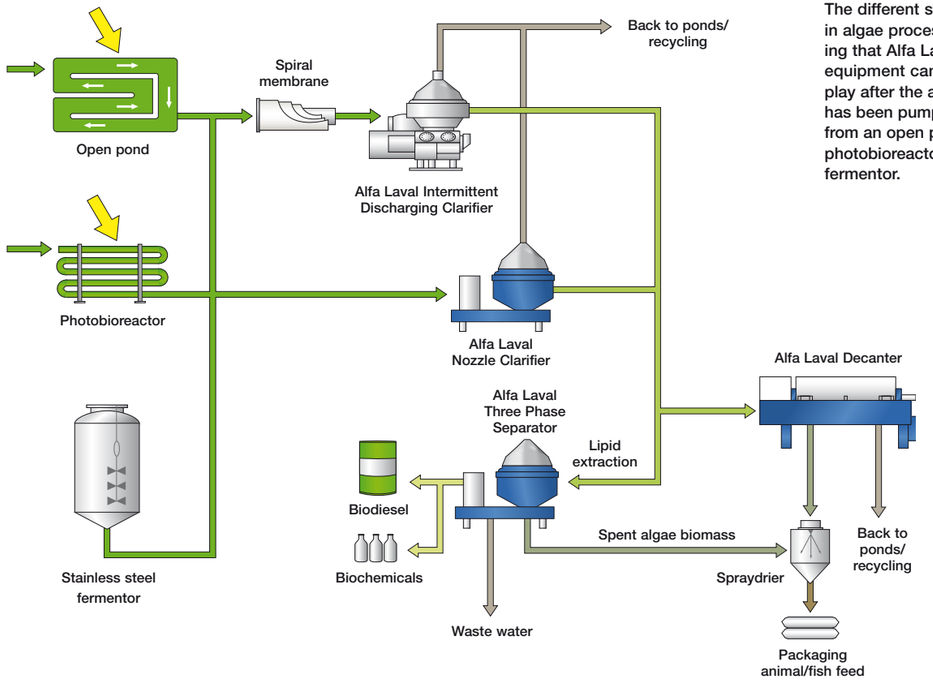
Membranes
Alfa Laval membranes can be employed to enhance the separation performance, for examplein the pre-concentration step.

High-speed separator system

Decanter

Membrane

How it all comes together



The different stages in algae processing that Alfa Laval equipment can play after the algae has been pumped from an open pond, photobioreactor or fermentor.

The selection of Alfa Laval's separators, decanters or membranes depend on capacity required, as well as the product's viscosity, solids content, pH value in the fermentation broth and limpidity.