ENVIRONMENTAL SCIENCES AND STEWARDSHIP

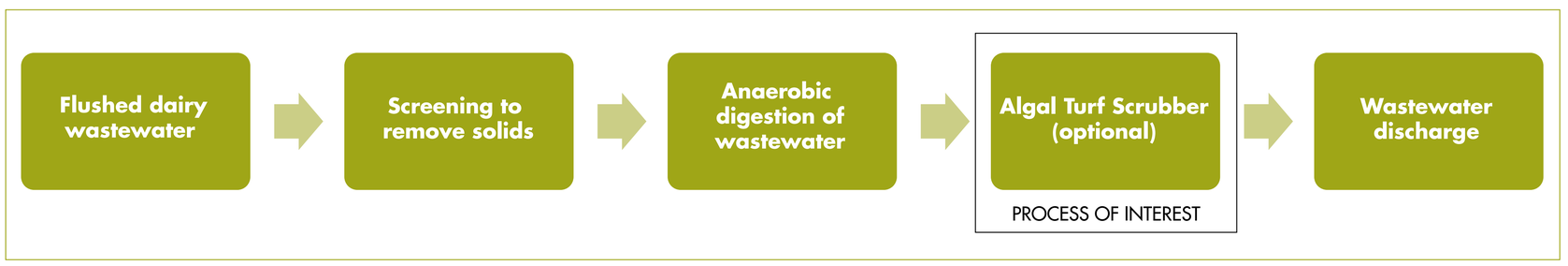
Wastewater + Algae = Energy

There are 1.8 million dairy cows in California. Using algae, we can treat dairy waste, produce energy and reduce greenhouse gas emissions.

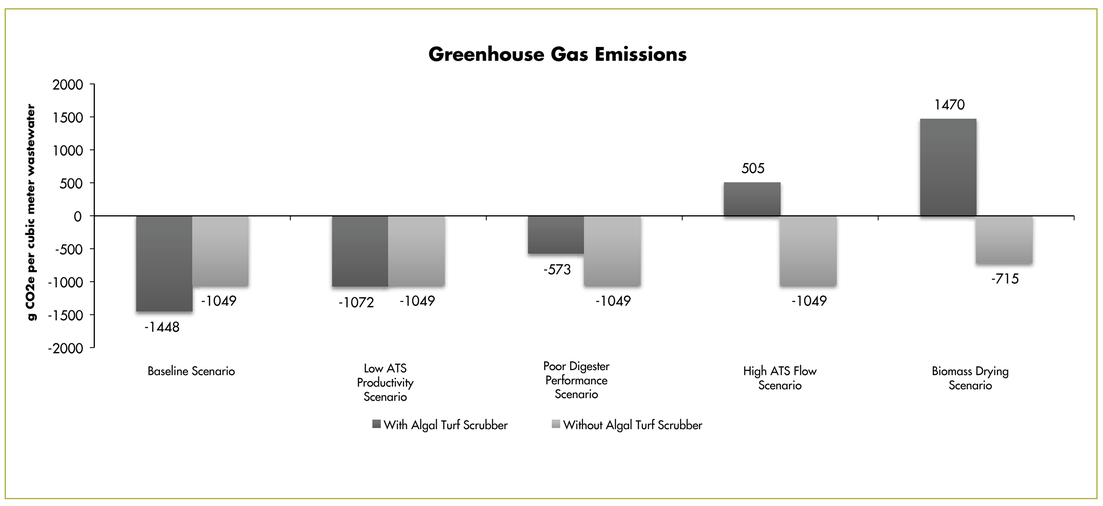
WE DEVELOPED AN ENGINEERING MODEL of a dairy wastewater treatment process that incorporates algae technology in the form of an algal turf scrubber (ATS). The treatment process includes solids screening, anaerobic digestion, and an algal turf scrubber as shown in Figure 1. The goal of the research was to determine the environmental and cost impacts of using an ATS in this application. Our model incorporates impacts of the treatment system from the construction and operation phases of the life cycle.

The algal turf scrubber (ATS) is an inclined flow-way over which wastewater passes. Algae attach to the surface of the flow-way and absorb pollutants from the water. The ATS removes approximately 90% of the nitrogen and phosphorous and 75% of COD pollutants from the wastewater. Every few days, the algae can be harvested by scraping the surface of the flow-way and the biomass can be anaerobically digested to produce methane gas. Methane can be combusted to produce electricity or sold as a natural gas replacement. The digestion of the algae also produces bio-solids which can be spread on agricultural fields as a fertilizer substitute.

We designed and modeled a hypothetical treatment facility and found that decisions about water pumping had a significant impact on greenhouse gas (GHG) emissions. Drying the algae sludge after anaerobic digestion also increased GHG emissions significantly and made the ATS a net emitter of greenhouse gases. However, with conservative pumping requirements and no sludge drying, use of the algae system resulted in a small net reduction in GHG emissions.



Left is a schematic of the wastewater treatment process. The process was modeled with and without the algal turf scrubber (ATS) in order to understand the impact of ATS on the treatment process. Without the ATS, the treatment process is comparable to existing practice by some dairies in the US.



The treatment of a single cubic meter of wastewater (about 2,200 pounds) results in either net greenhouse gas emissions (positive values) or displaced emissions (negative values). The scenarios were developed by changing individual aspects of the baseline scenario. High water flow rates on the ATS and the drying of algae bio-solids results in high GHG emissions. In low-flow scenarios with good digester performance, use of the ATS reduces GHG emissions.

In California	With Algal Turf Scrubber	Without Algal Turf Scrubber	Difference	**If the ATS system is employed, then . . .**
Net energy consumption (PJ/yr)	-29.7	-22.8	-7.0	***Produce energy equivalent to 58 million gallons of gasoline per year***
GHG emissions ($MMTCO_2e$/yr)	-1.350	-0.978	-0.372	***Reduce CO2 emissions by 372 thousand metric tons per year***
Total cost ($million/yr)	1,139	225	913	***Cost equivalent to 6 Starbucks coffees per Californian per year***

Employing the ATS treatment process at all California dairies would result in net energy production as indicated by he negative values in the table. Doing so would also reduce greenhouse gas emissions. The baseline scenario was used for these calculations. The column at the far right converts the "Difference" values into meaningful quantities. NOTE: Numbers may not add due to rounding.

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