Energy Efficiency Improvement of Abalone Aeration System

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ABSTRACT

The Cultured Abalone LLC is a shore-based aquaculture operation located on the Santa Barbara Channel in Goleta, California. An energy assessment performed by Southern California Edison has identified energy efficiency improvement potential in updating the aeration system. A baseline system of regenerative blowers was used to provide aeration into growing tanks used for abalone and seaweed production. The project scope included replacement of the existing blowers with an efficiency-optimized system sized to provide adequate level of aeration to the tanks. Efficiency gains are achieved by sourcing highly efficient blowers, improving system layout, and enabling precise system tuning via variable-frequency controllers.

OBJECTIVES

- Reduction of energy usage by **313,608 kWh** annually.
- Reduction of peak demand by **35.8 kW.**
- Reduction of peak Improved operational flexibility by varying system output.
- Definition of installation, operation and maintenance strategy.
- Compliance with stakeholder parameters such as noise output limits, system redundancy and corrosion protection.
- Minimized disturbance of ongoing operations during installation and commissioning.
- Utilization of available funding opportunities through grant programs.

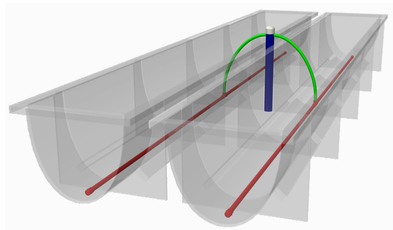
MATERIALS AND METHODS

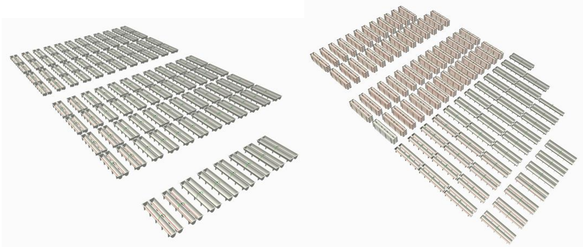
Energy Assessment

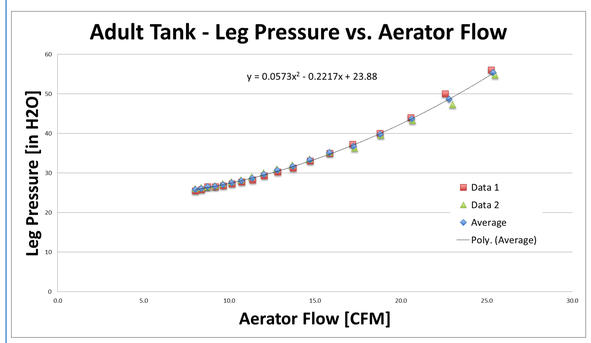
A primary energy assessment was performed by Southern California Edison as part of a Business Energy Efficiency Consultation titled "*Business Efficiency Consultation – High Efficiency Aeration Turbo Blower with Variable Frequency Drive*". The assessment quantifies the existing system, lays out a proposed optimized system and calculates the potential energy efficiency improvements achievable through retrofit.

System Specification

The key parameter for sizing the new system was to establish the acceptable baseline of aeration on a tank basis. This was achieved by measuring operating pressure in the current system and using published fan curves for the existing blowers to calculate the airflow in each tank. To aid in calculating the performance of a new system, the non-linear response of air-flow vs. pressure was also established. This relationship was combined with fan curves of replacement blowers and manifold combinations to optimize the operating point for the new system.



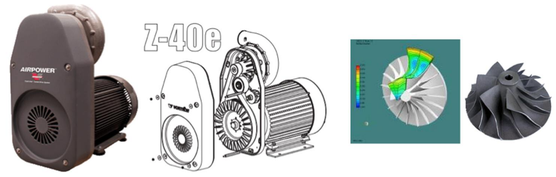




System Design and Hardware Selection

System optimization is a multi-variable problem aimed at creating an aeration layout that utilizes high-efficiency blowers near their optimal operating point while tying the distribution manifold into existing air piping infrastructure within the physical constrains of the existing tank layouts. Having defined the pressure and flow requirements of each tank type, different combinations of tanks and manifolding were matched with possible blower units to evaluate total system efficiency.

A series of Vortron blowers were down-selected for testing due to their superior efficiency near the expected operating point of the system. Vortron specializes in high-efficiency blowers by focusing on advances in turbo machinery design, computational fluid dynamics utilization and extensive performance testing. These centrifugal blowers are capable of operating near 80% adiabatic efficiency.

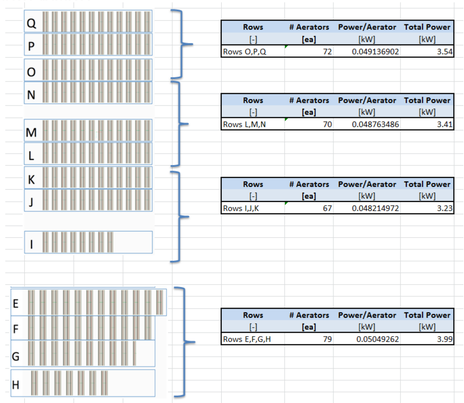


Calculating system performance of the Vortron units required specification of the operating point (pressure and flow). This defined the blower efficiency and the required electrical power can be calculated by the following equation:

$$HP = CFM \times 528 \times \left[\left(\frac{P+407}{407}\right)^{.286} - 1\right]\frac{1}{n_c} \times .000425$$

Where P is the blower discharge pressure in in-H_2O

The final system utilizes 4 Vortron Z40 blowers in the configuration shown below:

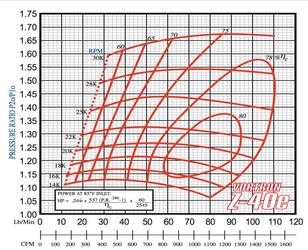


Rows	# Aerators	Power/Aerator	Total Power
[-]	[ea]	[kW]	[kW]
Rows O,P,Q	72	0.04913690	3.54

Rows	# Aerators	Power/Aerator	Total Power
[-]	[ea]	[kW]	[kW]
Rows L,M,N	70	0.048763486	3.41

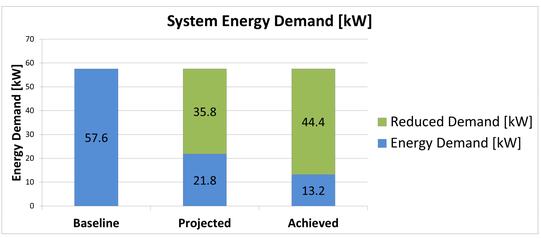
Rows	# Aerators	Power/Aerator	Total Power
[-]	[ea]	[kW]	[kW]
Rows I,J,K	67	0.048214972	3.23

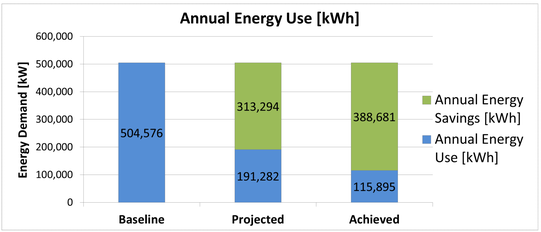
Rows	# Aerators	Power/Aerator	Total Power
[-]	[ea]	[kW]	[kW]
Rows E,F,G,H	79	0.05049262	3.99

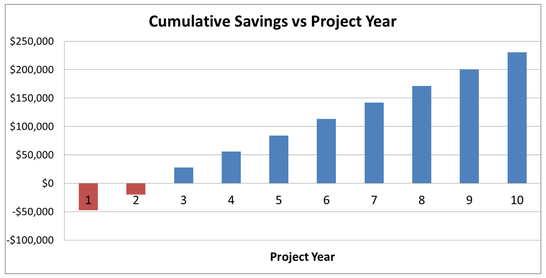


RESULTS

The system was successfully installed and commissioned without major interruption of aquaculture operations. Grant funding was secured from SC Edison as well as the US Department of Agriculture REAP program which substantially lowered the required capital expense of the installation. Testing of the installed system has shown a projected reduction in annual energy usage of **388,681kWh** with a reduction in peak demand of **44.4 kW**, exceeding the efficiency improvement objectives.







REFERENCES

Anderson, Robert B. "Don't Blow This One Off" Clean Tech Magazine (March 2002).

Corlett, Gary. *"Business Efficiency Consultation – High Efficiency Aeration Turbo Blower with Variable Frequency Drive" July 2014*

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