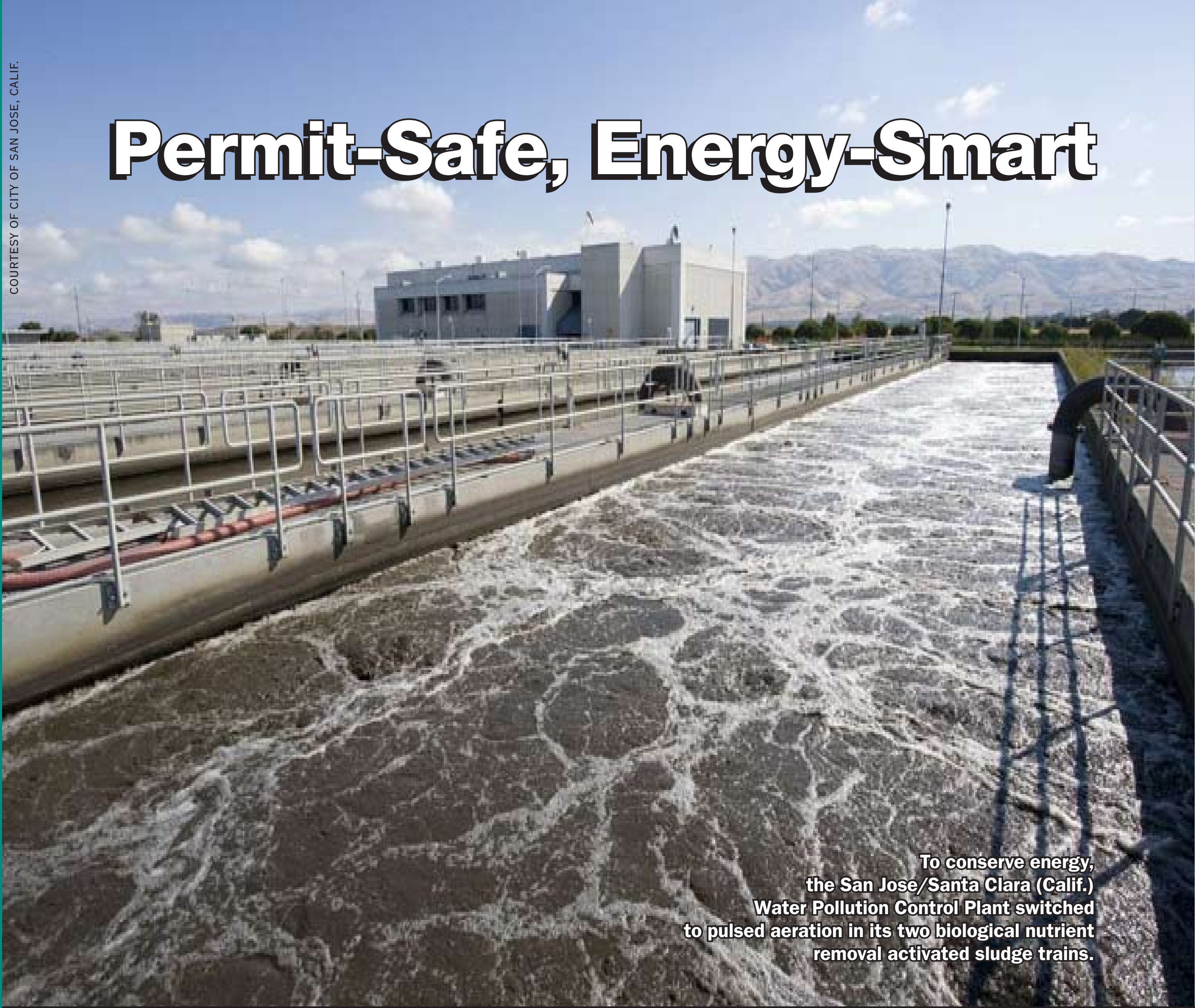
Permit-Safe, Energy-Smart



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To conserve energy, the San Jose/Santa Clara (Calif.) Water Pollution Control Plant switched to pulsed aeration in its two biological nutrient removal activated sludge trains.

Greening wastewater treatment plant operations

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The San Jose/Santa Clara (Calif.) Water Pollution Control Plant is an advanced wastewater treatment facility with a rated capacity of 167 mgd (630,000 m^3/d). During the past several years the plant has been quite active and successful in identifying and implementing energy-saving projects without compromising its effluent quality.

The projects have produced significant sustained savings in operating costs. In addition to energy savings, financial incentives in the form of rebates from its electric and natural-gas utility, Pacific Gas & Electric Co. (PG&E; San Francisco), helped drive these projects. In many cases, the rebates covered the entire expenses of the projects, making the final implementation cost zero.

For example, in 2008, the plant completed several energy-efficiency measures under the California Wastewater Process Optimization Program (CalPOP). PG&E tested and verified these measures and issued a post-savings verification report that confirmed a total savings of up to $1.3 million per year. PG&E already reimbursed the City of San Jose $279,969 for the costs incurred in implementing these measures, and additional rebate for this project is expected.

Furthermore, the resulting energy savings translate to a plant carbon footprint reduction of at least 10,357 ton (9400 Mg) of carbon dioxide annually — the equivalent of taking 1441 vehicles off the roads.

Process Snapshot

Influent entering the San Jose/Santa Clara Water Pollution Control Plant receives full tertiary treatment, complete with biological nutrient removal (BNR).

First, the influent passes through screening and grit-removal facilities. Then, pumps move the wastewater on to primary settling. After settling, the flow splits into two parallel BNR plants (BNR1 and BNR2), followed by filtration. The BNR plants consist of multiple treatment trains with multiple aerators and clarifiers. Air is supplied to BNR1 by engine-driven blowers that utilize a mixture of digester, landfill, and natural gas. Hot water is a byproduct of operating the engine-driven blowers, and this hot water is used for digester heating. Air is supplied to the BNR2 by blowers driven by electricity.

The filter effluent is disinfected with chlorine prior to dechlorination and discharge to San Francisco Bay.

The solids wasted from the BNR processes are thickened in dissolved-air flotation (DAF) tanks. These thickened solids are then fed to the plant's 16 mesophilic digesters, where they are blended with the solids from the primary clarifiers.

Digested solids are stored in sludge-stabilization lagoons, and the dredged material from these lagoons is dried in 20 solar drying beds. The dried solids are then hauled to a nearby landfill and used as landfill cover.

The figure below shows a schematic of the plant. The blue illustrations indicate optimized processes and equipment.

Liquid-Pumping Optimization

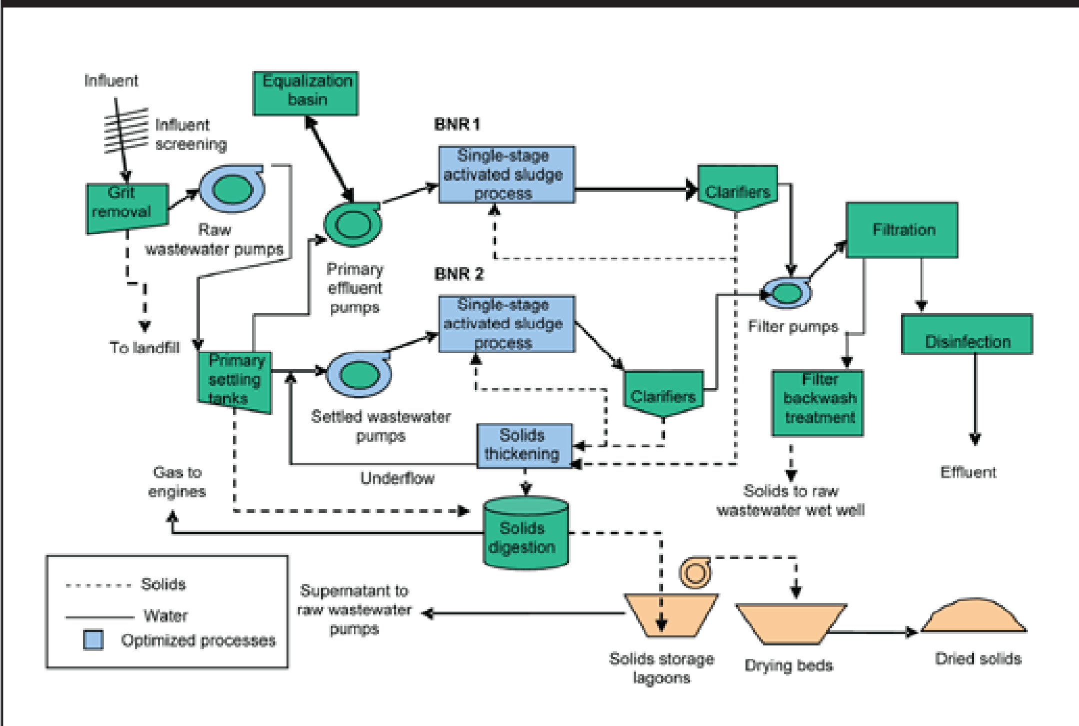
The first project was aimed at reducing energy consumption by optimizing the operation of pump stations. The plant used a proprietary optimization algorithm to select the proper pump operating schedule.

The software used field data, such as pump-station flows, discharge pressures, wet-well levels, and the power usage for the pumps. The data were collected using a specially designed pump-testing routine.

With the data in hand, the software selected the best combination of which pumps to operate and what speed to set the variable-speed motors to for each flow rate. By utilizing two optimization algorithms in tandem (genetic and gradient-reduction algorithms), rather than one, it is guaranteed that the selected pump and speed combination for each flow regime consumes less energy than any other combination.

Staff programmed the distributed-control system (DCS) for the selected sequences and speeds for each flow range. In addition, discharge pressures and wet-well levels were optimized by reassessing minimum safety requirements. Table 1 (p. 62) lists information about each optimized pump station.

San Jose/Santa Clara Wastewater Treatment Plant



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Plant staff optimized the operating schedule for the pump station that immediately follows screening and grit removal at the San Jose/ Santa Clara (Calif.) Water Pollution Control Plant. In addition to reducing energy use, the changes enabled each pump to operate closer to its best efficiency point.

Optimizing the pump stations led to energy reductions of more than 20% (see Table 2, below). These changes also enabled each pump to operate closer to its best efficiency point; as a result, pump life is expected to increase significantly.

During this project, the plant compared field data to the pump manufacturers' data. Comparison of manufacturers' pump performance curves and experimental curves showed that some of the pumps had lost 5% to 7% of their efficiency, probably due to age. This reinforced the idea that curves generated with field data — not manufacturer's pump curves — should be used to develop optimized operating sequences.

The plant plans to refurbish the underperforming pumps when the reduction of available pumps during the time required for repair does not jeopardize pump-station reliability. For example, in the near future, a recently built raw-wastewater pump station will enable retrofitting one of the underperforming raw-wastewater pumps.

BNR Process Improvements

The next project tackled switching the aeration strategy of the anoxic compartments and mixed liquor channel (MLC) of the plant's two activated sludge BNR trains from continuous to pulsed aeration. Before the change, solids were maintained in suspension in the anaerobic–anoxic compartments and MLCs by continuous air flow.

The plant used a patent-pending method to replace continuous aeration with pulsed aeration. Implementing this change required significant modifications to the aeration system. The plant installed new valves, actuators, pneumatic lines, electrical infrastructure, and special DCS programming. These changes had to be implemented within 6 months due to deadlines associated with the CalPOP program.

Table 1. Optimized Pump Stations

Pump station	Average flow (mgd)	Total number of pumps*	VFD-equipped motors	Power use (kWh)
Post screening	113	7	3	282
Post primary settling	109	4	4	384
Post clarification	108	5	5	570

VFD = variable-frequency drive.
*Not all pumps are used simultaneously.

Table 2. Energy Use Before and After Pump-Station Optimization

Pump station	Before optimization (kW/million gal)	After optimization (kW/million gal)	Change (kW/million gal)
Post screening	59.58	46.25	–13.33
Post primary settling	84.51	64.62	–19.89
Post clarification	126.51	104.88	–21.63

Table 3. Energy Savings Achieved by Switch to Pulsed Aeration

	Annual energy use before optimization	Annual energy use after optimization	Net annual energy savings
BNR No. 1	3.1 × 1011 Btu	1.9 × 1011 Btu	1.2 × 1011 Btu
BNR No. 2*	6.2 × 106 kWh	1.4 × 106 kWh	4.8 × 106 kWh

BNR = biological nutrient removal.
*Energy used only for mixed liquor channel aeration.

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For several years, staff members at the San Jose/Santa Clara (Calif.) Water Pollution Control Plant have been successfully finding ways to reduce the plant's energy use without compromising effluent quality.

To meet the unusually stringent time requirements, the staff performed the conceptual and detailed designs in-house and prepared all other pertinent documentations, including the bid packages. Staff also specified control valves, flow meters, actuators, and auxiliary control elements, such as air piping for actuators and input–output units for the DCS.

During implementation of the pulse-aeration methodology, staff discovered that providing pulsed aeration for multiple tanks at the same time could lead to oscillation of the blower output. A special programming routine has been developed to avoid this control-system oscillation. The routine sequences the tanks, rather than providing air to all the tanks at the same time to resuspend solids.

Energy savings achieved by the implementation of pulsed aeration is provided in Table 3 (p. 62). Additionally, by maintaining better anoxic conditions in the anoxic compartment (created by intermittent air supply), nitrate removal improved while the effluent total suspended solids and ammonia levels remained the same.

DAF Process Optimization

The final project in this first round of changes was to reduce the amount of energy used by the pressurization pumps in the DAF system. Again, proprietary algorithms provided the means to optimize the control systems.

Prior to optimization, each DAF tank was operating at a constant pressurized flow, which was significantly higher than required. The algorithm allowed automatic adjustment of the pressurized flow based on the number of DAF tanks in service and the incoming solids load to maintain the same air-to-solids ratio (A/S). The new algorithm also allows almost equal solids loading throughout the day for each DAF unit. Plant staff found the minimum A/S by trial and error.

The criterion utilized was the equality of water and solids concentrations before and after A/S reduction. The current A/S stands at 0.005 and is one of the lowest ever reported in the literature. This reduction of A/S has yielded an energy saving of more than 1.5 million kWh/yr.

Continuing Projects

The three projects mentioned above were only the beginning for the San Jose/Santa Clara Water Pollution Control Plant. Now, additional energy savings projects are under way.

One proposed project, titled "Ammonia Load Equalization and Ammonia Based Airflow Control," would equalize ammonia loads and airflow control. This would potentially present nearly 1.2×10^{10} Btu of savings for the gas-operated engine blowers and 1.5 million kWh savings for the electric blowers. The combined total would amount to $198,017 per year. The cost of implementation is less than $90,000. The return on investment on this project is less than 6 months.

Another proposed project would involve upgrading the plant's fine-bubble diffusers (FBDs). FBDs have been in use at the plant since 1992, but research indicates that certain other types of FBDs would be more suitable. As a result, the plant is moving toward retrofitting 60% to 70% of its aeration tanks with FBDs of appropriate length and pore size. The implementation cost would be about $600,000, with a return on investment of about 18 months.

Also, a group of process engineers is working closely with staff from various sections of the plant to identify additional energy-saving projects. This effort has truly paid off, and several other projects with significant potential for energy savings have been suggested.

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