

Energy Conservation at Anheuser-Busch: Brewery WWTP Improvements Create Big Energy Savings

by Thomas Getz, Mark Reif, Robert Cleeton and Michael Aquilino

Anheuser-Busch Inc., a leading producer of beer and related beverages in the United States, operates a brewery in Baldwinsville, NY, northwest of Syracuse. The plant produces more than seven million barrels per year or 2.3 billion 12-ounce servings.

The resulting process wastewater is treated onsite in a state-of-the-art wastewater treatment plant (WWTP) fully owned and operated by Anheuser-Busch (*Figure 1*). This article describes several water treatment processes, the ways by which energy is produced during treatment, the energy conservation measures that have enabled a 60 percent reduction in the electrical power required for treatment and the resulting reduction in carbon emissions.

Brewery Wastewater Treatment

Wastewater treatment professionals have long recognized brewery wastewater for being a challenge to treat by conventional technology due to its high concentrations of biochemical oxygen demand (BOD), low concentrations of nutrients, often high pH and high temperature. However, these same attributes make brewery wastewater very easy to treat with anaerobic technology and, therefore, Anheuser-Busch has invested in the construction and operation of these facilities. The company coined the term Bio-Energy Recovery Systems (BERS) to describe this technology that removes BOD and COD (chemical oxygen demand) while simultaneously producing methane gas which is recovered and beneficially used to produce

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Figure 1. The Anheuser-Busch, Inc. brewery and wastewater treatment plant in Baldwinsville, NY, showing the Bio-Energy Recovery Systems (BERS) facility (center), aeration basins (upper right) and aerobic digesters (far right)



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steam in the brewery powerhouse. Today, Anheuser-Busch is the world's largest user of BERS, which is operating at nine of its 12 US breweries and its brewery in Wuhan, China.

A flow chart of the WWTP (wastewater treatment plant) is shown in **Figure 2**. The following liquid unit processes are employed, in order of flow: influent pumping, static microscreens (1.5 mm gap), primary clarifiers, equalization (including neutralization) upflow anaerobic sludge blanket (UASB) reactors, extended aeration activated sludge, secondary clarifiers and effluent pumping. The brewery has separate sewers for the sanitary waste which is sent to the local POTW (publicly owned treatment works). The biosolids treatment processes are either gravity or dissolved air floatation thickening, followed by aerobic digestion and plate- and-frame filter press dewatering. Biosolids cake is recycled by composting, land application and as an experimental soil supplement, all offsite. Prior to 2004, composting was conducted onsite using biofiltration for odor control.

Environmental Operations Unit Processes

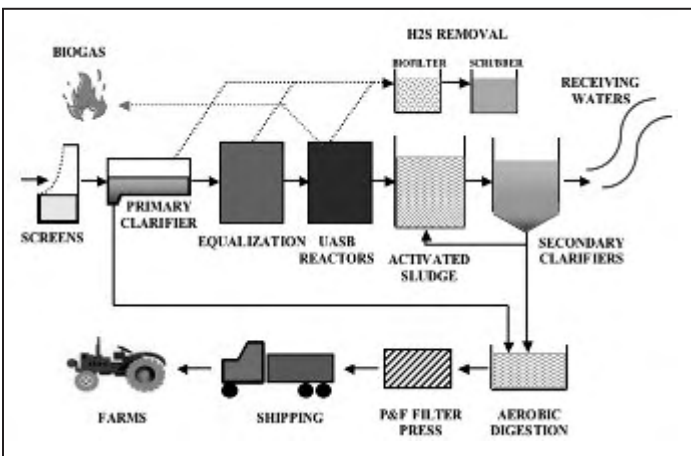


Figure 2. WWTP Unit Process Flow Chart

UASB Startup: 1990 to 1993

From brewery startup until 1991, the sole method of BOD removal was the extended aeration activated sludge and the WTP typically operated two aeration basins and two aerobic digesters simultaneously. Operations were characterized by high oxygen demand that during warm weather sometimes required 3,700 hp (horsepower) of blower capacity plus supplementation with liquid oxygen.

For purposes of this article, 1990 (or pre-UASB) is considered the baseline year. **Figure 3** shows a progressive reduction in both total electrical power and power per unit BOD loading over the succeed-

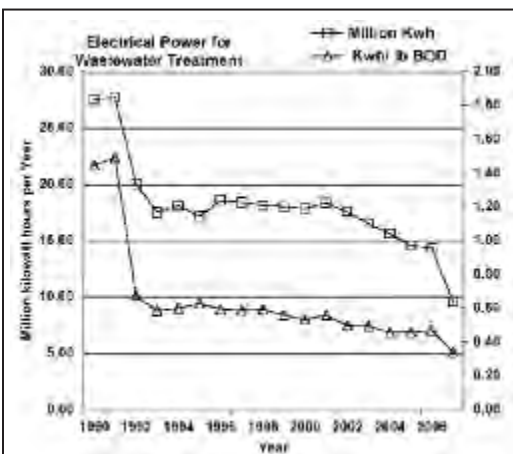


Figure 3. The 17-year trend in million kilowatt hours per year and kilowatt hours per pound of BOD (biochemical oxygen demand)

ing 17 years. The 17-year history is summarized by reporting the changes that occurred between 1990 to 1993, and 2005 to 2007, which represent particular milestones.

The electrical power reduction from 27 million kWh/yr (kilowatt hours per year) during 1990, to 18 million kWh/yr during 1993, was due to the startup of the UASB anaerobic unit process during 1991 and 1992. The UASB process works by using colonies of anaerobic bacteria to convert soluble degradable chemical oxygen demand (SCOD) into methane gas. The process requires a high concentration of SCOD, pH control above 6.4 standard units and warm wastewater temperatures. More than 90 percent of the BOD is removed, along with the SCOD. The UASB startup added electrical loads for additional pumping, biogas compression and odor control, but the BOD removal achieved enabled Anheuser-Busch to remove one aeration basin from service. This shut down 12 submersible jet mixing pumps plus reduced the aerobic oxygen demand load on the other basin. Other benefits were the elimination of load swings and rapid increases in oxygen demand, which, in turn, avoided extra blowers and pure oxygen supplementation.

The UASB process generates biogas containing 75 percent methane at a yield of 5.9 cubic feet of methane/lb (per pound) of COD removed corresponding to an energy yield of 5,900 BTU (British thermal units)/lb of COD removed. (The methane purity is higher for high rate anaerobic processes treating ethyl alcohol and other soluble COD than for anaerobic digestion of volatile solids.) This biogas is recovered, filtered, compressed, dried and transmitted to the brewery powerhouse. A final benefit of UASB treatment was increasing the BOD capacity of the overall wastewater treatment process from 45,000 lb/day of BOD without anaerobic treatment to in excess of 150,000 lb/day with anaerobic treatment.

Electricity Reductions: 1993 to 2005

The electrical power reduction between 1993 and 2006 was due to several incremental improvements itemized here. These added up to a considerable power savings but the power savings of each separate strategy was not calculated.

The in-vessel compost process utilized a biofilter to provide odor control on 64,000 cfm (cubic feet per meter) of ventilation air, which was moved by eight centrifugal fans with 50 hp motors operating against a back pressure of 24-inch water column. Experimentation led to replacement of the biofilter filtration media with an improved media comprised of ground wood, which resulted in improved odor treatment and reduced the back pressure to four-inch water column at the same airflow. The belts and sheaves for the motors and fans were resized to turn the fans slower with substantial electrical power savings.

The activated sludge aeration blowers are positive displacement rotary lobe type and the original motors were fixed speed 4160-volt AC with no method of turndown. Anheuser-Busch installed 4160-volt variable frequency drives on two of the fixed speed motors to enable adjusting motor speed to match a desired target for dissolved oxygen (DO).

Operators found that by improving the planning of solids dewatering it was possible to operate only one aerobic digester at a time. The aerobic digester and aeration basins were originally constructed on a common header, which required all air supplied to be developed at the same pressure and distributed by throttling valves. Anheuser-Busch installed an isolation valve on the main air header that enabled the processes to be isolated. This enabled air to

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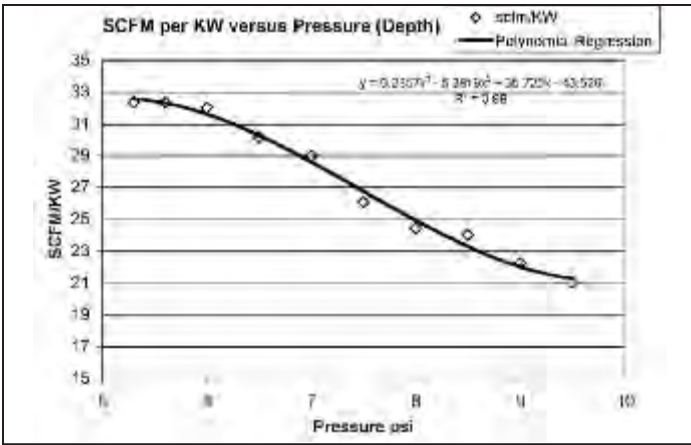
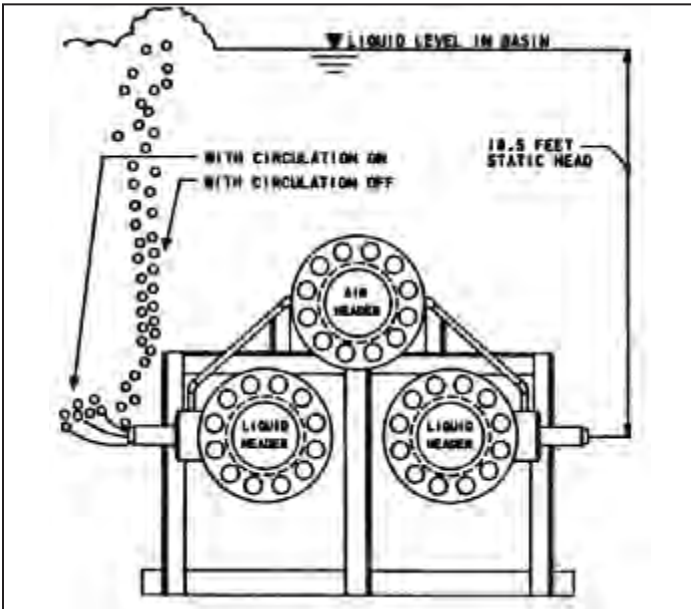


Figure 4. Air Efficiency versus Depth for the Aerobic Digester

the aeration basin – liquid depth 20 feet – to be supplied at nine psi (pounds per square inch) while the digester, with a variable and lower liquid level – generally 11 to 18 feet – could be supplied at five to seven psi. *Figure 4* shows the relationship between depth and

Figure 5. Comparison of Jet Aerators and Fine Bubble Diffusers



Jet aerators use submersible pumps (12) to pump wastewater through pipe laterals in one direction while blowing compressed air through the same laterals in the opposite direction. The results were an air/wastewater mixture.



The more efficient fine bubble diffuser system consists of 6,044 round membrane diffusers covering the entirety of the aeration basin floor. Blower air is pushed up through each membrane creating millions of tiny air bubbles.

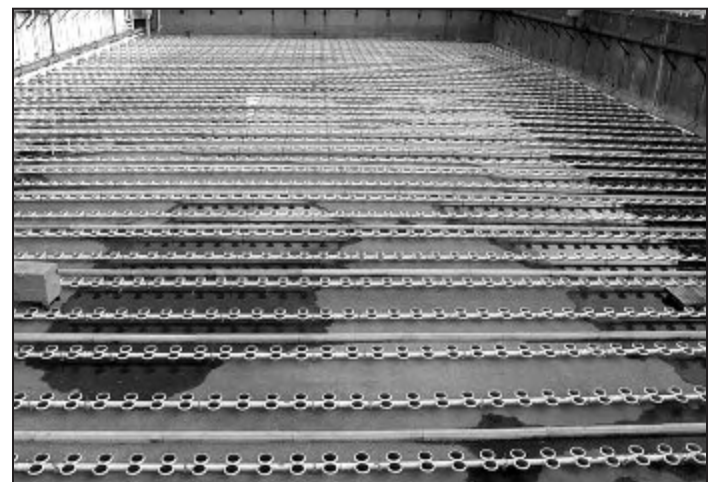
power required to aerate the aerobic digester at various depths.

The company also installed solid state power meters on the electrical distribution system to enable the operators to monitor the power of various operations on a real-time basis via the facility SCADA (supervisory control and data acquisition) system.

During 2004, an economic analysis of the available biosolids recycling alternatives led to the decision to discontinue onsite compost operations in favor of offsite composting and land application to area farms. Additional power and fuel savings were realized as the eight biofilter fans and 60 compost aeration fans were shut down along with three electrically-powered compost blending machines. The annual use of 670,000,000 BTU of natural gas to heat the portion of the facility used for mixing and maintenance was also eliminated.

At the time of construction of the UASB system, the process supplier recommended a minimum operating temperature of 85° F (Fahrenheit). The design included steam boilers fired on natural gas or biogas to heat the wastewater as needed to meet this condition. Anheuser-Busch invested in pilot scale anaerobic reactors and bench scale anaerobic activity bioassay equipment and experimentally

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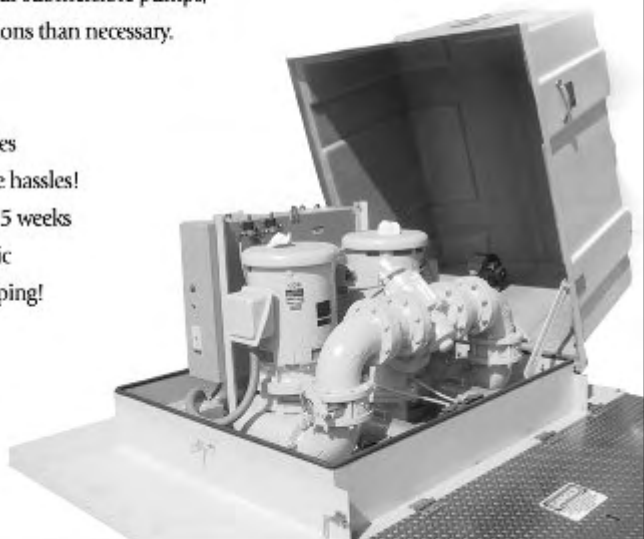
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determined a mathematical relationship between wastewater temperature and anaerobic microbiological activity. Essentially, microbial activity does decrease as temperature decreases but this can be offset by maintaining more anaerobic biomass in the reactors. Knowledge of this relationship has enabled operation of the process at 70° F and the complete elimination of natural gas for heating the wastewater without any reduction in UASB efficiency. This development was very fortuitous from an energy standpoint because the brewery has implemented several energy conservation measures that have reduced the February average temperature of the WTP influent from 81°F during 1992, to 76°F during 2007. The UASB process has acclimated to the lower temperatures and heating of the wastewater was shown to be unnecessary.

As mentioned, brewery wastewater is known to professionals in the field as being deficient in essential nutrients, particularly nitrogen. During the early 2000s, full-scale experimentation with the addition of nitrogen in the form of urea led to an increase in the anaerobic efficiency from 95 to 97 percent removal of SCOD. This in turn reduced BOD loading even further with a concomitant reduction in the oxygen demand of the activated sludge process.

Equipment and Process Changes: 2005 to 2007

The preceding has explained how the electrical power for WTP operation was reduced from 18 million kWh/yr during 1990 to 14 million kWh/yr during 2005. During 2007, three additional power conservation improvements were placed in service. These were fine bubble aeration, variable frequency drives on the 200 hp biogas compressors and high efficiency lighting. Collectively these resulted in electrical power being reduced to 9.275 million kWh/yr in 2007.

The extended aeration activated sludge process used jet aerators to mix and supply oxygen. This required the operation of 12 submersible mixing pumps at 35 hp each in addition to the aeration power. Anheuser-Busch conducted six months of pilot testing of fine pore diffusers from six different manufacturers and selected an EDPM (ethylene propylene diene monomer) membrane as best suited based on efficiency, resistance to fouling and method of construction. These were installed late in 2006 and fully operational throughout 2007 for an annual savings of 2,700,000 kWh/yr. The change from jet aerators to fine bubble diffusers is illustrated in *Figure 5*.

The biogas is compressed with positive displacement rotary vane compressors powered by 200 hp motors and the original design had no turndown. Changes in output were accomplished by recirculation back through the compressor which kept the compressor running at full power regardless of biogas load. Variable frequency drives were installed which matched motor speed to biogas flow and saved power, allowed the compressors to run cooler, saved cooling water during the summer operations, reduced noise and conserved 30,000 kWh/yr of power.

The final conservation change was to replace mercury vapor light fixtures with instant-on high efficiency fluorescent fixtures controlled by motion sensors so that the lights were left off except when the space was occupied. The resulting savings equaled 50,000 kWh/yr.

Substantial Energy Savings

The net effect of all conservation efforts made at the WWTP over the 17-year period is best summarized in *Table 1*, which shows a 60 percent reduction in the power required for treatment. Also, when all forms of energy consumed by wastewater treatment (calculated on 2007 data) are converted to BTUs, it can be seen that the energy produced from biogas is more than five-fold greater than the sum of

Table 1. Power Utilization Compared from 1990 to 2007

Parameter	kWh 2007	kWh 1990
Pumping	1,245,116	1,000,000
Anaerobic Pumping	1,265,976	0
Biogas Compression	549,077	0
Odor Control	2,296	220,911
Sludge Thickening	51.8	39.0
Compost	0	159,400
Sludge Dewatering	145,639	80,000
Aeration/Digestion	4,232,870	21,975,000
Miscellaneous	2,143,611	3,024,000
Total	9,687,527	27,499,911

Table 2. Net Power Production by Wastewater Treatment Plant

Consumption	Units	Value	Million BTU
Electricity	kWh	9,687,527	31,623
Natural Gas	Ft ³	5,926,805	6,371
Propane	gal	7,816	712
Diesel Fuel	gal	567	78
Total BTUs	***	***	38,784
Generation of Biogas	Ft ³	273,260,000	210,410
Net Production	***	***	171,626
Ratio Generated/Consumed	***	***	5.4

The WWTP is a net energy producer with energy from biogas five-fold greater than all other forms of energy consumed (2007 data).

all forms of energy consumed by wastewater treatment equipment including: electrical power, natural gas, propane and diesel fuel, as shown on *Table 2*.

Another important consideration is the quantity of carbon dioxide, the main greenhouse gas, not released as a result of energy conservation measures. *Figure 6* shows the reduction in carbon dioxide because of both the electrical conservation efforts and the

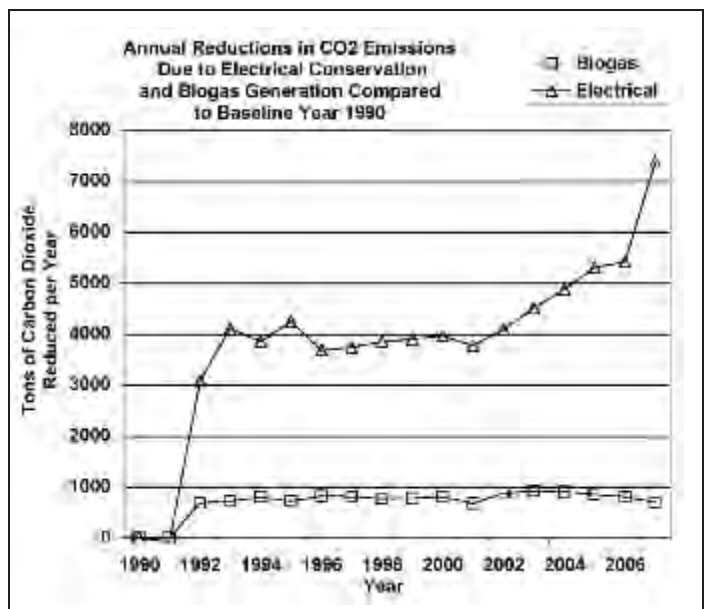


Figure 6. Annual carbon dioxide reductions through electrical conservation and biogas generation compared to baseline year 1990

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generation of carbon-neutral biogas. The carbon reductions were calculated using the values of 819.684 lb of CO₂ per megawatt hour and 0.11lb of CO₂ per cubic foot of biologically produced methane.

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