

**Award Category**

Load Management

**System Features**

Chiller refurbished with seven-stage steam turbine drive

Variable speed drive installed on chiller compressor

Programmable logic controller

Three-megawatt electrical generator installed in Central Utilities Plant

**Annual Energy Savings**

Over 30 million kWh

569,575 therms

32% efficiency improvement over chiller's baseline energy usage

\$1.3 million

**Annual CO<sub>2</sub> Emissions Avoided**

12.9 million kg

**Cost**

\$5.5 million

**Completion Date**

June 2004

# University of California, San Diego Chiller Upgrade & Turbine Addition

UC San Diego has a robust set of demand response strategies to reduce utility-provided power purchases during peak times. The campus increased its load management capabilities by refurbishing its largest chiller and applying the steam savings to run a new three-megawatt steam turbine electrical generator.

UC San Diego's energy bills are \$1.3 million lighter since the campus upgraded its oldest and largest steam-powered chiller and installed a steam turbine electrical generator. Combining these two projects has enabled the university to produce an additional 30 million kilowatt-hours of electricity without a net increase in natural gas consumption at the campus's cogeneration plant.

Installed in 2001, the 27-megawatt cogeneration plant produces 90 percent of UCSD's peak electrical demand and 75 percent of its steam demand. A portion of this steam is used to power the 4500-ton chiller. The university first began to consider ways to increase the efficiency of this process when it observed a disconnect between the equipment's seasonal use and the campus's demand for steam and electricity.



View of the steam turbine electrical generator (silver, foreground). Photo: John Dillio.

The chiller is run from May through the end of October to support UCSD's summer cooling load. The size of the chiller necessitates this seasonal usage because its operating efficiency drops under partial loading conditions. Spring and fall are typically mild in San Diego, which reduces the campus's demand for chilled and hot water. An influx of students

and increased activity on campus over this same time period increases the electrical load. UCSD's Facilities Management Department found that while the cogeneration plant was producing plenty of steam during these months, the campus Central Utility Plant was unable to use it. Instead, the university was importing expensive utility-provided electricity to cover its load and backing down the gas turbine generators to reduce its steam production.

**The energy savings achieved by this project reduce the campus's CO<sub>2</sub> emissions by 12,900 metric tons, which is equivalent to removing nearly 2,800 cars from the road.**

While installing a steam turbine electrical generator to capture the excess steam could effectively solve this problem, the cogeneration plant was fairly new, and Facilities Management could not allocate funds to purchase and install additional equipment. Observing the performance of another steam-powered chiller on campus provided the department with a creative way to justify installing an expensive generator.

Facilities staff looked at the operation of a 3000-ton chiller that was recently installed to serve newly constructed buildings. Metering data showed that it used less than nine pounds of steam to produce one ton of cooling, while the old chiller required thirteen pounds to produce the same amount of cooling. Through this comparison, the department saw an opportunity to increase the efficiency of the old chiller and apply the steam savings to running a new electrical generator.

Combining these two projects was the key to justifying the expensive generator installation. Increasing the efficiency of the old chiller's steam usage would allow the university to produce electricity without a net increase in natural gas usage. Generating millions of

# BEST PRACTICES

## Additional Awards

2005 Award for Special Achievement in Energy: San Diego Excellence in Energy Award (SANDEE), San Diego Region

## Contacts

Energy and Utilities Manager:  
John Dillriott,  
jdillriott@ucsd.edu  
858.822.2807

## Team

UCSD Facilities Management

UCSD Facilities Design and Construction

Engineering Consultant: Carter & Burgess

## More Information

[mysolar.cat.com/cda/files/154908/7/dscpuucsd.pdf](http://mysolar.cat.com/cda/files/154908/7/dscpuucsd.pdf)

kilowatt-hours without any additional energy purchases would considerably improve the project's payback. Additionally, the new generator would enhance UCSD's demand response capabilities. During simultaneous peak electricity loading and high chilled water demand, the campus could fire up conventional boilers to create additional steam for cooling, and also run the steam turbine generator to cover the electrical load. Having this robust load management strategy in place would allow the campus to avoid peak utility pricing and participate in third-party demand response programs.

Before implementing upgrades to the chiller, the campus collected one year's worth of baseline data for chilled water production, steam usage, average steam rate, and average hourly load. This data would be used to compare the performance of the chiller before and after the retrofit.

	Baseline	Post-retrofit
Chilled water production (tons)	10,851,500	10,993,000
Steam usage (lbs)	140,750,000	96,949,000
Average steam rate (lbs/ton-hour)	12.97	8.82
Average hourly load (tons)	3,400	3,093

*Baseline and post-retrofit data.*

The 1972 vintage chiller was originally equipped with a six-stage steam turbine drive and pneumatic controller with a constant speed drive. The campus upgraded to a seven-stage turbine drive, which can extract more useful cooling out of the steam. The campus also incorporated a programmable logic controller (PLC) and a variable speed drive (VSD). Whereas the original pneumatic controls use pressurized air to control the operation of the chiller, the digital PLC control uses a computer to interface with chiller equipment. This

control system is more accurate and reliable, which translates into large energy savings. The VSD saves additional energy by enhancing chiller performance during partial loading. Variable speed control allows the compressor to operate at its optimal efficiency point throughout the range of daily load conditions.

The upgrades produced a 32 percent increase in the operating efficiency of the chiller. It now uses 8.82 pounds of steam per ton-hour of cooling, freeing up four pounds of steam to power the electrical generator.



*The CO<sub>2</sub> emissions avoided through this project are equivalent to removing nearly 2,800 cars from the road. Photo: ©2006 Hans E. Hyttinen.*

UCSD installed the three-megawatt generator in the Central Utilities Plant without any disruption to utilities services to the campus. The project has increased UCSD's on-site energy generation capacity by 11 percent. The campus now produces an additional 30 million kilowatt-hours of electricity without any natural gas purchases above pre-installation levels. The university will recoup its investment for the chiller upgrade and generator installation projects in just over four years.

## LESSONS LEARNED

UCSD's Energy Manager, John Dillriott, recommends looking for ways to combine projects to yield a faster payback, and suggests taking note of lessons learned in previous projects to apply them to current energy issues.

*Best Practices* is written and produced by the Green Building Research Center, at the University of California, Berkeley.

The Best Practices Competition showcases successful projects on UC and CSU campuses to assist campuses in achieving energy efficiency and sustainability goals. Funding for *Best Practices* is provided by the UC/CSU/IOU Energy Efficiency Partnership.



A Sempra Energy utility™

A Sempra Energy utility™