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Laboratory autoclaves: A case study

MONITORING, PLUG-LOAD REDUCTION AND SUSTAINABILITY

"Data showed that the research-grade unit used 81 percent less energy and 93 percent less water than a comparable medical-grade model while performing the same tasks with equal effectiveness."

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Research labs are major resource consumers. Estimates vary, but most place lab energy consumption in the range of 3 to 10 times that of similarly sized offices spaces. Although the majority of this variance is accounted for by "regulated loads" (HVAC, fans, hot water, lighting, etc.), so-called "plug loads"—energy consumed by plug-in equipment ranging from computers and ULT freezers to hot plates and coffee pots—still account for roughly 30 percent of total lab energy consumption.

While architects and builders address the optimization of regulated loads, these professionals have no control over what happens once the lab is up and running. For this reason, Moira Hafer of Stanford University, Department of Sustainability and Energy Management, has advised that "Identifying and eliminating plug load waste in labs should be a priority … because the energy use of many types of lab equipment is high, its potential for wasted energy is also high."

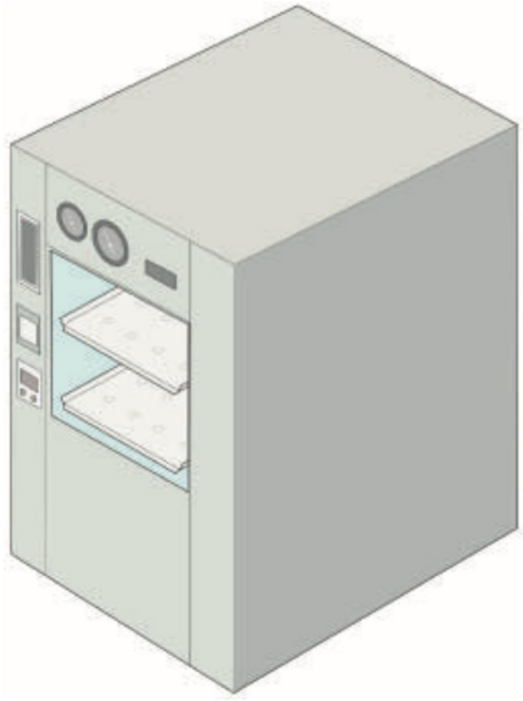
In 2014 Stanford University completed a comprehensive, campus-wide inventory of equipment across 220 of their buildings. They found that 49 percent of the entire campus plug load came from lab equipment alone—with autoclaves a major offender.

Although autoclaves accounted for just 0.15 percent of Stanford's plug-in equipment, they constituted roughly 2.87 percent of campus-wide plug load. Stanford's 167 autoclaves were using as much energy as their 19,205 computer monitors.[1]

Fortunately, facilities can enjoy significant savings (both in cost and resource consumption) by outfitting their research labs with research-grade autoclaves.

VERIFYING POOR PERFORMANCE OF MEDICAL-GRADE AUTOCLAVES IN RESEARCH LABS

Since September 2015, the Office of Sustainability at the University of California, Riverside (UCR) has conducted an ongoing study of autoclave efficiency in their genomics and entomology research labs. Using an automated monitoring system, UCR tracked the amount of water and energy consumed by two of their 37 high-quality medical-grade autoclaves on a day-by-day, cycle-by-cycle basis. Their discoveries were startling.



High-quality, medical-grade autoclave. Image: Priorclave North America

UCR found that their autoclaves were consuming a great deal more water than expected (five to six times as much), amounting to thousands of gallons of water each day—even when no cycles were run.

Medical-grade autoclaves often rely on one gallon-per-minute (gpm) bleeder valves to cool wastewater prior to entering the sanitary sewage system.

Equipment Type	Avg Hrs of Use per Day	Energy Consumption Range (Published)	Energy Consumption Range (kWh/yr)
-80°C Freezer	24	3900 – 13,666 kWh/year	3900 – 11,100
-20°C Freezer	24	1690 – 4876 kWh/year	1690 – 4876
Refrigerator	24	199 - 2686 kWh/year	199 – 2686
Fume Hood	24	30 - 60 kWh/day	10,950 – 21,900
Fluo Microscope	3	0.5 – 1 kWh/day	183 – 365
Centrifuge	3	3.2 – 57 kWh/week	166 – 2964
Water Bath	13.5	2025 – 3850 kWh/year	2205 – 3850
Heating Block	3	243 kWh/year	243
PCR Machine	4	788 kWh/year	788
Incubator	24	13.1 – 167 kWh/week	681 – 8684
Shaker	3	42 kWh/week	2184
Autoclave	3	32 – 630 kWh/week	1664 – 32760
Vacuum Pump	3	0.09 kWh – 7.5 kWh/day	33 – 2730
Tissue Culture Hood	4	60 – 88 kWh/week	3120 – 6862

Average hours of use per day and energy consumption. Image: 2015 Market Assessment of Energy Efficiency Opportunities in Laboratories, Author's Highlights.

UCR found that the bleeder valves in their units had drifted notably (upwards of 2 gpm). This is a frequent issue with medical-grade sterilizers, especially when installed in research settings.

Ideally, water usage should vary with the type of cycle, and throughout the day. But even with the sterilizers properly calibrated, the UCR data showed no correlation between the number of cycles run each day and water consumption. During one 39-day period in which no cycles were run, they found that their autoclaves consumed nearly 16,000 gallons of water.

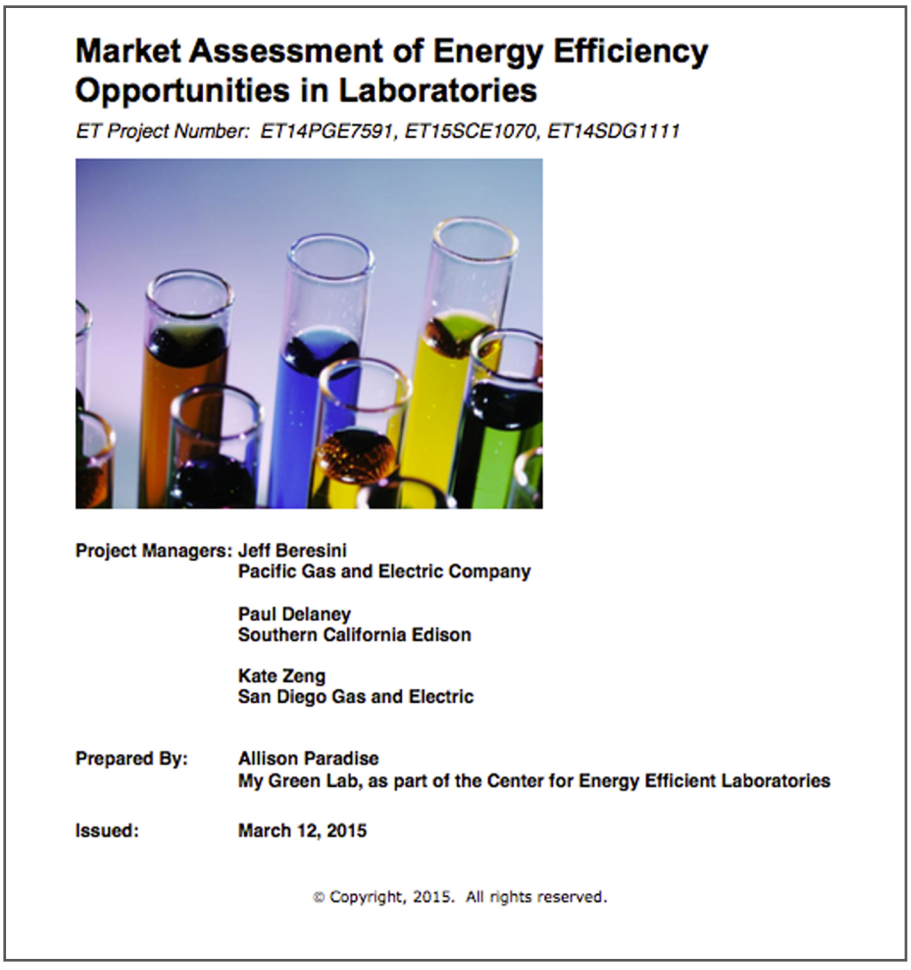
Similarly, energy usage should vary with the type of cycle, as well as throughout the day. However, UCR data showed no correlation between the number of cycles run and energy consumption. One possible cause: medical-grade autoclaves run 24 hours per day even though actual use of the autoclaves is sporadic. In fact, the 2015 Market Assessment of Energy Efficiency Opportunities in Laboratories shows that the average autoclave in the State of California is used just three hours per day.[2]

Each autoclave tracked in the UCR study was using almost 700 gallons of water and 84 kWh of electricity per day (even after re-calibration). Across the campus's 37 sterilizers, this added up annually to 1,134MWh of electricity and 8.8 million gallons of water (more than half of which was consumed while the machines sat idle).

All told, each autoclave was using, on average, $3,300 in energy and water annually. This finding is consistent with the maximum efficiency one might expect from medical-grade autoclaves like these in research settings.

COMPARING RESEARCH- AND MEDICAL-GRADE AUTOCLAVES

Medical-grade steam sterilizers are optimized for round-the-clock use in hospitals, and thus need constant cooling. In a research setting—which is very



Market Assessment of Energy Efficiency Opportunities in Laboratories

ET Project Number: ET14PGE7591, ET15SCE1070, ET14SDG1111

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My Green Lab, as part of the Center for Energy Efficient Laboratories

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UNIVERSITY OF CALIFORNIA, RIVERSIDE

UCRIVERSIDE

Autoclave Cost Analysis

Cost of New Autoclave

- Medical-Grade Unit: ~$52,000 + $3,000 maintenance/year
- Research-Grade Unit: ~$40,000 + $1,200 meter + maintenance (based on use)

Projected Costs of Operation per Research-Grade Autoclave

- Energy savings: 25,000 kWh per year saved, or a minimum of **$2,500/year** @ $0.1/kWh
- Water savings: **220,000 gal/year**

SAVINGS	1 years	15 years	20 years	25 years
Energy - $	$2,500	$37,500	$50,000	$ 62,500
Carbon - M Ton CO2	17.6	264	352	440
Water –M gallons	0.22 M	3.3 M	4.4 M	5.5 M

Autoclave cost findings. Image: University of California Riverside, Office of Sustainability

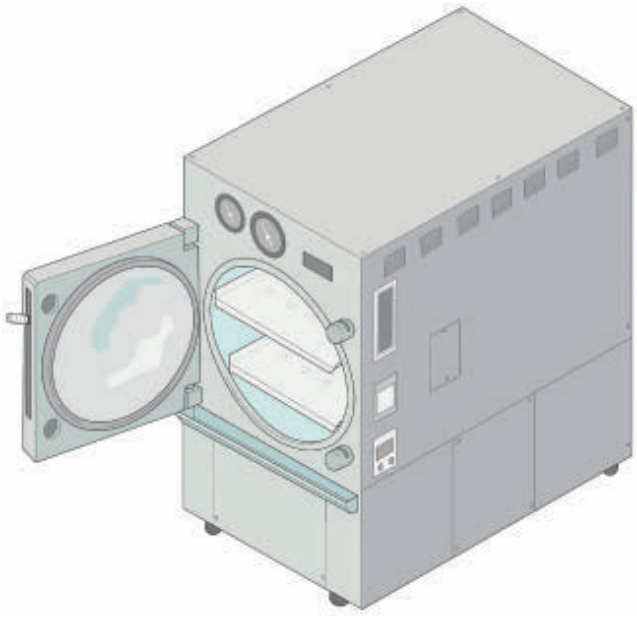
low-usage by comparison—more than half of their water consumption is to keep the unit cool while it sits idle. Unlike medical-grade units intended for high throughput, 24-hour operation, research-grade autoclaves are designed for up to 5 cycles per day, or 1,000 cycles per year, only generating steam on-demand. They heat and cool quickly, using water only when a cycle is running. The result is a sterilizer that uses substantially less water and electricity.

As part of their study, UCR installed a research-grade sterilizer in April 2016, and tracked this autoclave's performance against their existing medical-grade sterilizers.

In the first 26 weeks of their comparison, data showed that the research-grade unit used 81 percent less energy and 93 percent less water than a comparable medical-grade model while performing the same tasks with equal effectiveness. The UCR data indicates that over the course of the sterilizer's lifetime, the utility savings alone could pay for the device.

SUSTAINABILITY AND LIFECYCLE COSTING

Based on this study, UCR estimated a 25,000 kWh plug-load and 220,000 gallons savings per autoclave per year. As of September 2016, the entire University of California has instituted a policy of replacing "all single-pass cooling systems and constant flow sterilizers and autoclaves in laboratories" on all of its campuses. UCR has already outfitted their new Environmental Health and Safety building exclusively with research-grade autoclaves.



Research-grade autoclave. Image: Priorclave North America

This is a perfect example of the place where technology, sustainability and lifecycle costing mesh: Right-sizing the autoclave for the task and facility creates tremendous plug-load and water consumption savings, while reducing operation and maintenance costs.

REFERENCES

1. Hafer, M. "Inventorying Plug Load Equipment and Assessing Plug Load Reduction Solutions on a University Campus," October 2015.

2. http://www.etcc-ca.com/reports/market-assessment-energy-efficiency-opportunities-laboratories

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