Title
Energy management in cleanrooms: From the lab to the marketplace

Author
Mills, Evan

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Energy Management in Cleanrooms: From The Lab to the Marketplace

Evan Mills
Lawrence Berkeley National Laboratory

Lawrence Berkeley Laboratory is working to improve energy efficiency in high-tech facilities i.e. laboratories, data centers, and cleanrooms. With their high ventilation requirements and correspondingly high process loads, 7x24 operation, and importance to the overall economy, these types of facilities offer important (and often under-exploited) potential for energy savings. In California alone, two large electric power plants could be avoided with the widespread adoption of measures to improve energy efficiency in this arena, saving half a billion dollars per year for facility owners.

To help identify specific promising opportunities, the California Energy Commission sponsored the development of technology research "Roadmaps" for cleanrooms and laboratories (in 2002) and data centers (in 2003). These were developed with industry participation and provided dozens of specific recommendations.

The balance of this article focuses on the case of cleanrooms.

What's Your Cleanroom's Energy IQ?: Benchmarking and Identifying Best Practices

Energy benchmarking can help identify "Best Practices" and establish performance targets for utility incentive programs or in-house energy management goal-setting. LBNL has benchmarked fourteen cleanrooms thus far, with a new series underway. Our results show that indicators of energy efficiency vary widely [Figure 1]. In addition to characterizing the energy use profiles, careful examination often reveals other operational issues such as unintended cooling tower cycling [Figure 2], or chiller part-load efficiency variation (by a factor of two) [Figure 3].

Efficient Air Movement: Evaluating Fan Filter Units (FFUs)

The benchmarking results have also revealed a wide variation in recirculation air systems performance. Examination of the results revealed a tendency for cleanrooms with FFUs to have poorer efficiency (expressed as cfm/kW) than other air-distribution strategies. In addition, huge variations in FFUs performance were observed in test results performed by ITRI in Taiwan [Figure 4]. LBNL is helping to address designer and end-user needs for better information on FFU performance. Currently there is no way to compare one unit's energy performance to another's because they are not tested and rated in a standard fashion. LBNL is working with IEST to develop such a standardized procedure. Standard reporting of performance will also help utilities and others develop incentive programs or other initiatives.

The Potential for Mini Environments

The use of mini cleanroom environments is on the rise. If mini-environments can be used in place of large cleanrooms, energy savings (and quality control) can be improved considerably. However, it is common for mini-environments to be placed inside of standard large cleanrooms. If the cleanliness standards are relaxed in the larger room, then significant energy savings can be attained, but this is not necessarily done today. LBNL is investigating the energy efficiency opportunity, in collaboration with SEMATECH.

From Rules of Thumb to Performance-Based Controls: Demand-Controlled Filtration

Cleanrooms typically maintain a constant airflow, irrespective of the actual level of cleanliness. The concept of demand-controlled filtration allows airflow to be varied based on real-time particle counts. This shift towards a *performance-based* control strategy promises to garner considerable energy savings, with better real-time feedback on cleanroom environmental conditions. LBNL is performing a proof-of-concept demonstration in a small cleanroom, and will subsequently conduct a workshop to discuss the results with practitioners.

Improved Tools for Design and Planning

LBNL has developed a suite of tools to help cleanroom and laboratory designers and planners make better use of energy efficiency, while fostering increased communication and shared goals among owners and design team members. The *Laboratory Design Guide* inventories a wide range of technologies and design strategies, with extensive links to in-depth documentation. The *Cleanroom Programming Guide* gives owners and designers an awareness of efficiency related issues to consider early in the project to avoid inadvertently "locking in" inefficiencies. Lastly, the *Design Intent Tool* provides a convenient method for documenting design objectives and associated performance goals and targets.

Demonstration Projects: From Concept to Application

An essential complement to the LBNL research program is conducting full-scale demonstrations in industrial settings. LBNL and the California Energy Commission are seeking ideas for novel technologies and practices, and industry sites willing to participate in controlled demonstrations. Interested parties can contact William Tschudi at WFTschudi@lbl.gov.

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Sponsors of the research described here include the California Energy Commission (Public Interest Energy Research), the California Institute for Energy Efficiency, the U.S. Department of Energy, the U.S. Environmental Protection Agency (via Labs21), Pacific Gas and Electric Company, and San Diego Gas and Electric Company. For More information, see http://ateam.lbl.gov

Figure 1. Cleanroom benchmarking results (recirculation air, CFM/kW)

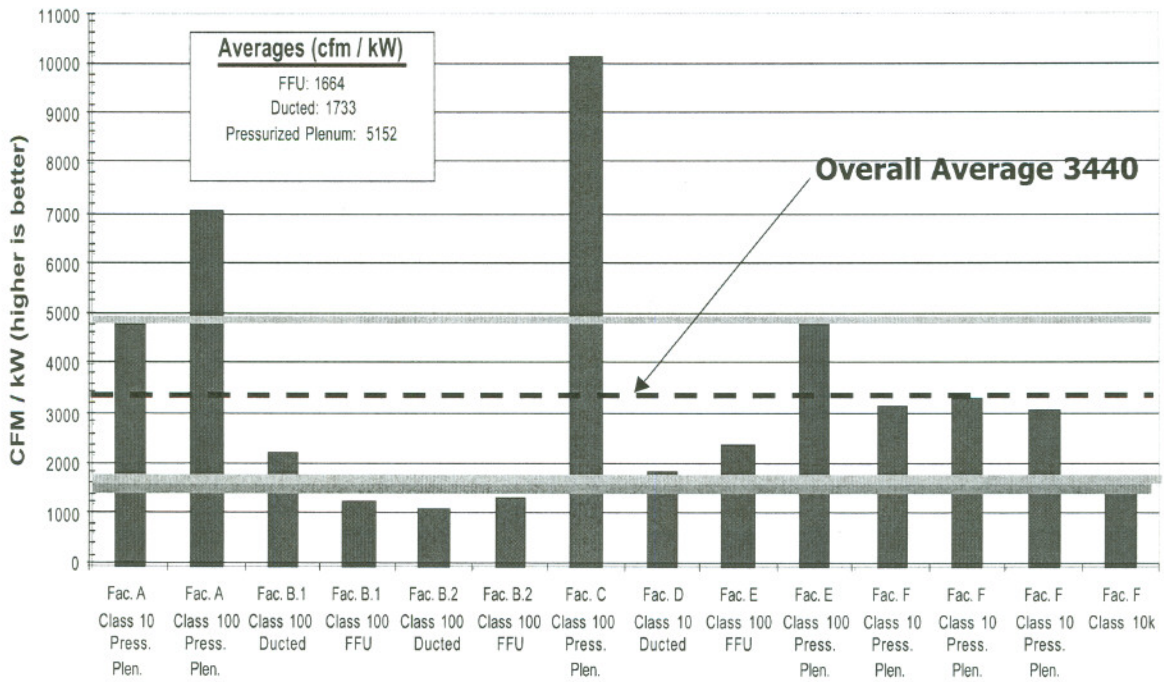

Figure 2. Unintended cooling tower cycling.

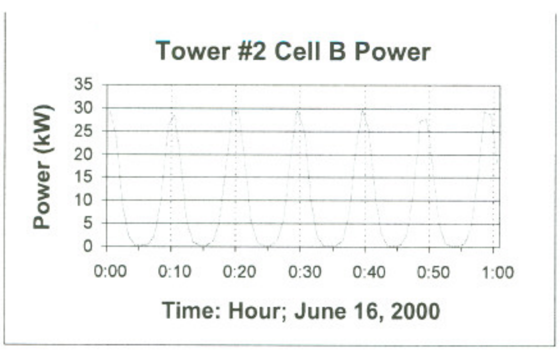

Figure 3. Chiller efficiency variation.

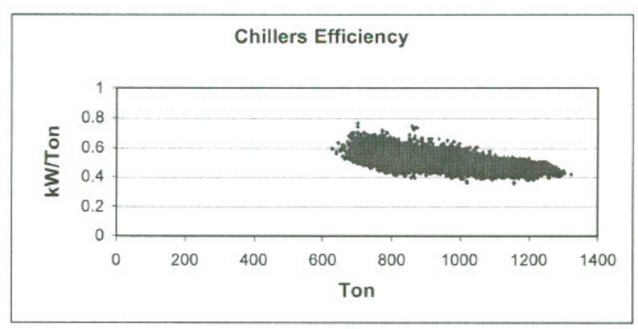

Figure 4. Fan filter unit efficiency variation.