PG&E's Energy Management Solutions for

LABS AND CLEANROOMS

Pacific Gas and Electric Company offers design assistance and financial incentives, as well as education and training, to support energy efficient cleanrooms and laboratories. Whether you are planning a new facility, retrofitting old inefficient equipment, or implementing demand response capabilities, PG&E's energy management solutions can be customized to meet the unique needs of your project.

For more information on PG&E's ENERGY MANAGEMENT SOLUTIONS, call the Business Customer Center (800) 468-4743 or visit www.pge.com/business

Pacific Gas and Electric Company®

Cleanrooms and laboratories are very energy-intensive facilities that can often consume from five to ten times the amount of energy used in typical office spaces. And some specialty laboratories, such as cleanrooms, can have energy intensities as much as 100 times greater than a commercial building of the same size.

PLUG LOADS - Laboratories have high plug loads due to the use of computers and other specialized equipment. For example, office plug loads are typically from 0.5 to 1.0 watts per square foot, while laboratory plug loads can range from 2 to 20 watts per square foot. Even though most of the laboratory equipment operates intermittently, the resulting plug loads can still have a significant effect on the requirements of mechanical systems. Internal sources of heat gain generated during equipment peak loads can exceed 10 watts per square foot. When this occurs, the supply of cool air required to offset the heat gain can be greater than the rate required for exhaust. Because of these fluctuating loads, installing a variable volume supply and exhaust system is recommended.

VENTILATION - The largest challenge in reducing the energy consumed by laboratories is the large amount of ventilation air required. Because of safety issues and the need to maintain strict pressurization, temperature and humidity requirements, laboratories are typically 100% outside air systems that operate 24 hours per day. While office buildings are commonly designed with ventilation rates equivalent to approximately one air-change-per hour (ACH), laboratories often have ventilation rates ranging from 6-10 ACH, primarily to meet the requirements of the fume hood exhaust.

Cleanrooms have greater air change rates. ISO Class 5 (Class 100) cleanrooms have a recommended 250-700 ACH, however these recommendations were developed many decades ago. Recent benchmarking of cleanroom facilities has shown that most use lower air change rates (between 94-276) while still maintaining adequate cleanliness.

THE FOLLOWING RECOMMENDATIONS ARE PRESENTED TO ASSIST DESIGNERS IN IDENTIFYING MORE EFFICIENT DESIGN APPROACHES.

RIGHT SIZE EQUIPMENT – Engineers may feel more comfortable over-sizing equipment, but oversizing can increase energy consumption, negatively effect life-cycle costs, and may reduce comfort. According to the Department of Energy, studies have shown that single room labs should always be sized for 100% capacity. In large labs with multiple fume hoods, 30-70% of the hoods are either completely closed, or only partially in use during any one period.

LOWER AIR CHANGE RATES FOR CLEANROOMS – According to research conducted by Lawrence Berkeley National Laboratory, an ISO Class 5 facility can maintain required cleanliness at an air change rate of around 200. According to the fan laws (the exponent 3 relationship between fan speed and energy consumption), a 50% reduction in air flow can result in a theoretical potential reduction of fan energy by a factor of 8 (? x ? x ? = 1/8), or 87.5%. Actual savings are somewhat less but still impressive; to be captured they required the use of VFD (Variable Frequency Drives) on the fans.

EXHAUST OPTIMIZATION FOR CLEANROOMS – Even though laboratory exhaust systems can be one of the largest energy users in laboratories, their efficiency is not subject to Title 24 Standards because they are considered to be unregulated process loads. A recent study conducted by International Sematech concluded that manufacturer's suggested exhaust quantities have been overstated and that airflows found in four devices typically used in semi-conductor cleanrooms (wet benches, gas cabinets, ion implanters, and vertical furnaces) could be reduced by an average of 28%. Conditioning air for cleanrooms is very expensive, with an energy cost estimate ranging from $3 to $5 per cfm for exhaust air. This cost includes assumptions for exhaust fans and makeup air.

SPECIFY VARIABLE AIR VOLUME (VAV) FUME HOOD CONTROLS – Fume hoods use a large amount of fan energy, and because they exhaust a large amount of conditioned air, they also have a large impact on heating and cooling energy. VAV controls make fume hood exhaust systems more efficient by reducing fan energy. Use systems that include an occupancy sensor to realize even more savings.

USE SEPARATE HVAC UNITS FOR LABS AND SUPPORT SPACES – Many laboratory facilities commonly include non-laboratory spaces, such as conference rooms and offices. These support spaces do not have HVAC requirements as demanding as the laboratories. To save heating and cooling energy, office and administrative spaces should be separated from laboratories so that recirculation systems can be specified in these spaces.

EXHAUST HEAT RECOVERY AND PROCESS ENERGY RECOVERY – Energy can be recovered from exhaust air streams using systems such as heat wheels, heat pipes, and fixed-plate heat exchangers. These systems can be utilized to transfer heat in situations where two different mediums should not be allowed to come into contact. Recovered heat can be used to pre-heat outside air, or for other uses. In

facilities that use significant amounts of hot water, waste heat can be captured and reused. For example: air handling units can use wastewater to pre-heat the air. Preheating boiler makeup water with a heat recovery system from the boiler exhaust stacks can significantly decrease boiler energy use. In facilities with reheat coils, waste heat from air compressors or return water from chiller condensers can be used.

DESIGN HIGH-EFFICIENCY LIGHTING SYSTEMS – It is common for laboratory procedures to require high light levels at the work area. The ambient lighting level can be lowered by using task lighting to meet these needs. Illumination levels of 30 footcandles provides plenty of ambient light.

CONTROL FANS AND PUMPS USING VARIABLE-SPEED DRIVES – VSD controls allow the fans and pumps to slow down when the load decreases. Reducing fan speed by one-half reduces the energy use by up to seven-eighths.

UTILIZE OCCUPANCY SENSORS – Occupancy sensors allow lights to automatically switch off or dim in spaces that are unoccupied.

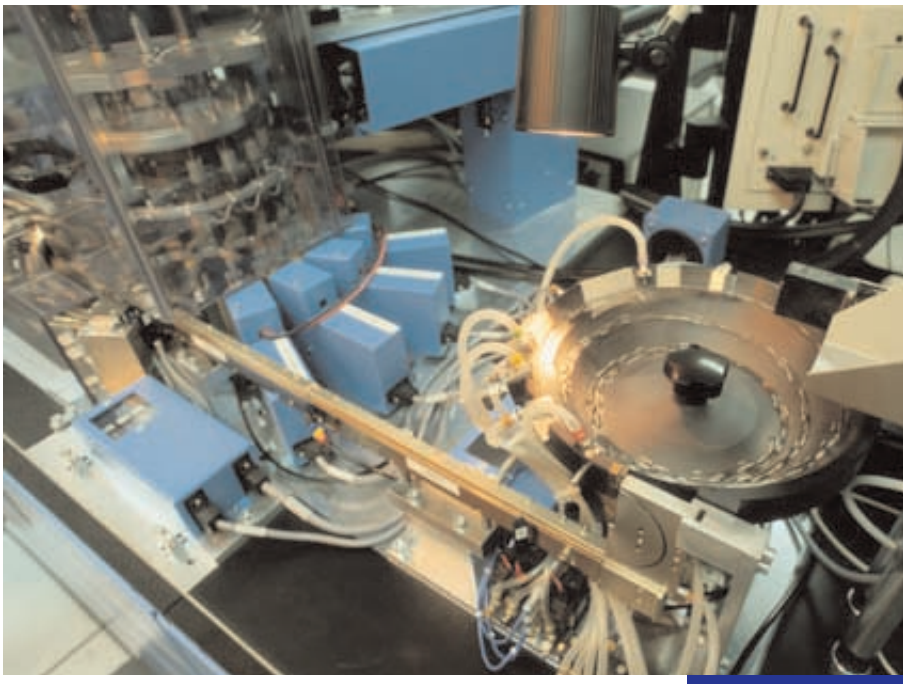
MOTOR EFFICIENCY – In cleanroom facilities, motors use most of the electricity. Variable speed drives (VSDs) ensure efficient motor operation at varied output. Recommending premium-efficiency motors and minimizing the load before sizing the motor should be a standard part of laboratory specifications.

LOW PRESSURE DROP SYSTEMS – According to the U.S. Department of Energy, a low pressure drop system offers the greatest potential for energy savings in a laboratory's ventilation system, with a savings potential in the range of 30-65%. Fan energy can account for 20-40% of a cleanrooms total energy use. Conventional air handler systems for office buildings are based upon a face velocity of 500 feet per minute (fpm) at the coil face. A lower face velocity design utilizes a larger air handler with smaller fans that allows the same flow to be maintained at a lower velocity. This design reduces the pressure drop of the AHU and thereby reduces its energy consumption. For example, a 25% reduction in face velocity results in a 44% reduction in energy use. Another important design feature of a low pressure system is the use of larger, more direct duct work.

VENTILATION SETBACK – In non-critical lab areas and cleanrooms, consider setting back the ventilation rates slightly late at night if the space is unoccupied. It is not recommended that fume hood areas be set back.

ENERGY RECOVERY – According to the Department of Energy, because energy recovery systems reduce peak heating and cooling requirements, heating and cooling systems can be downsized.

WATERSIDE FREE COOLING – In facilities with requirements for process and/or cooling



loops of 50º, - 70ºF chilled water, free cooling is an effective energy efficiency option. Free cooling uses the cooling tower to indirectly produce chilled water under low temperature conditions, and can produce non-compressor backup cooling for part of the year. This measure is best-suited to locations with wetbulb temperatures below 55ºF for at least 3,000 hours annually. An LBNL benchmarking study found that cooling towers were operating at an efficiency of 0.07kW/ton while the chillers were averaging 0.5 to 0.7 kW/ton at part load. By using the cooling tower for free cooling and bypassing the chillers completely, approximately 90% of energy can be saved.

VARIABLE SPEED DRIVE CHILLERS – According to one study, some designers don't believe VSD chillers are needed due to the constant loads present in many cleanroom facilities. VSD

chillers save energy whenever loads are under 90 or 95 percent. For example, a 1,000-ton chiller with a constant load at 70 percent capacity would save $20,000 to $30,000 annually, with a pay back of about one year, by using a VSD. These estimates are based on chiller manufacturer data and assume a rate of $0.05/kWh.

INCORPORATE DAYLIGHTING – Studies have shown that daylighting not only saves energy, but has the potential to increase productivity. In most labs, ventilation requirements use much more energy than lighting, and in some laboratories daylighting may not be compatible with the processes. However, with proper design, daylighting could provide a significant amount of lighting and if automatic daylighting controls are used the average lighting power density will be significantly reduced during part of the day.

COMMISSIONING – The commissioning of a building is a process for verifying that the performance of a building and its various systems meet the intention of the designer and owner. According to the Department of Energy, studies show that on average the operating costs of a commissioned building range from eight to twenty percent below that of a noncommissioned building. In other words, a one-time investment in commissioning may result in reduced operating costs that will last the life of the building. In most cases, the cost of commissioning is less than the cost of NOT commissioning.

COGENERATION – Some laboratories have large process heat load requirements, an excellent opportunity for cogeneration. Heat is a by-product of electric generation and this heat could be used for an on-site process application, such as heating water. Cogeneration systems could also be designed to offer a secondary benefit of redundancy of electricity sources.

RENEWABLE ENERGY – Currently there are several sources of incentives and rebates available to partially off-set the initial costs of installing renewable energy. The California Energy Commission offers cash incentives to consumers who install qualifying renewable energy systems of up to 30kW. Pacific Gas and Electric Company offers incentives through the Self-Generation Incentive Program for photovoltaic systems between 30kW and 1.5MW. Building-integrated photovoltaic (BIPV) materials serve the dual purpose of producing electricity and serving as construction materials. They can replace traditional building components, including curtain walls, skylights, atrium roofs, awnings, roof tiles and shingles, and windows. Although costs of BIPV materials can vary greatly, in some cases, the incremental cost increase of installing BIPV may be as little as two to five percent over the total construction cost. BIPV materials are unbreakable and do not require roof penetrations or racks to install. Solar modules now come in a variety of styles, colors and sizes, making it easy to integrate into a building design. There are modules made of thin film that can be rolled out between the roof seams. There are also solar modules that resemble traditional roof shingles. Solar modules are often used in covered parking.

PG&E'S ENERGY MANAGEMENT SOLUTIONS can help you control your operating expenses through building energy efficiency and demand response capabilities into your new and existing facilities, and your long-range planning. Services include energy analyses of existing facilities, design assistance for planned projects, equipment rebates, project incentives, and education and training.

PG&E'S Energy Management Solutions

PG&E OFFERS A WIDE RANGE OF SOLUTIONS TO HELP YOU MANAGE THE ENERGY AT YOUR FACILITY. CONTACT PG&E TO FIND OUT HOW YOU CAN TAKE ADVANTAGE OF THESE SERVICES.

Energy Analyses

An energy analysis – also referred to as an "energy audit" – is the first step towards a comprehensive energy management plan and can help you identify a no cost, low cost and investment grade action plan. PG&E offers an on-site Integrated Energy Audit that identifies opportunities in demand response and self-generation as well as energy efficiency.

Energy Efficiency Rebates for Your Business

Rebates are the quickest and simplest way for you to get cash back for your eligible energy efficient purchases. PG&E offers rebates for hundreds of energy-efficient technologies in multiple categories: Appliances and General Improvements, Boilers and Water Heating, Food Service, Heating Ventilation and Air Conditioning (HVAC), Lighting, and Refrigeration. To find out if a product qualifies under the rebate program, go to www.pge.com/biz/rebates/rebates_assistance or contact the Business Customer Center at 1 (800) 468-4743 to request an application and one or more technology catalogs.

Customized Energy Efficiency/Demand Response Incentive Application

For more customized energy efficiency projects or projects with a demand response component, PG&E offers design assistance, calculation support, and standardized incentive rates through the Customized Energy Efficiency/Demand Response Incentive.

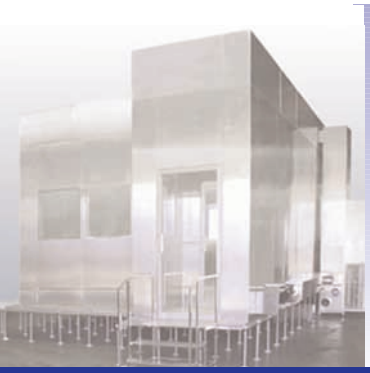
Total incentive payments are based on actual reductions in energy usage. Customers and their consultants may sponsor projects under this approach. Be sure to contact PG&E early in the design process, before you start your project, so that you can schedule optional technical support and the required pre-inspection of your existing equipment.

New Construction Design Assistance and Cash Incentives

PG&E's new construction program provides owners and design teams with cash incentives, technical design assistance, and education to support the design and construction of energy efficient new facilities and process systems. Incentives are based on exceeding Title 24 requirements by at least 10% for standard building systems, and on exceeding industry standard practice baselines for process systems. Through both the simple Systems Approach and the more integrated Whole Building Approach, owners and design teams may be eligible for cash incentives.

Energy Management Education and Training

You can learn about the latest and best energy-efficiency practices, technologies, tools and more through the hundreds of free classes offered by PG&E every year. To search by market sector, technology, class location (including web-based classes) or target audience, use the Pacific Energy Center's class search tool at www.pge.com/education_training/classes/energy_efficiency



Additional Resources on Energy Efficiency for Labs and Cleanrooms

• **Labs21** is a voluntary program sponsored by the U.S. Environmental Protection Agency and the U.S. Department of Energy. The goal of the program is to improve the energy efficiency of labs in the U.S. Labs21 has developed a "tool kit" to provide design guides, case studies, energy benchmarking information, and other tools for optimizing energy efficiency in labs. **www.labs21century.gov**

• **Energy Design Resources** (EDR) is a collection of energy design tools and resources funded by the rate payers of California and administered by the major utilities in California. EDR resources for laboratories include design guides and case studies to assist in the design of energy efficient labs. **www.energydesignresources.com/category/hospitals-labs**

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