High-Performance Buildings for High-Tech Industries

High-Performance High-Tech Buildings/Laboratories, Cleanrooms, and Data Centers Project

OVERVIEW

Lawrence Berkeley National Laboratory
Applications Team

http://hightech.lbl.gov

Public Interest Energy Research (PIER)
California Energy Commission
California Institute for Energy & Environment (CIEE)

August 16, 2004

Wide breadth of activities

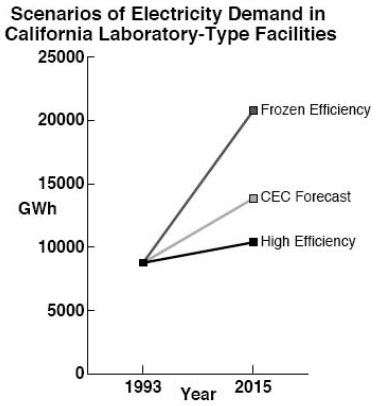
Project Team

- LBNL
  - Bill Tschudi
  - Dale Sartor
  - Evan Mills
  - Tim Xu
  - Geoffrey Bell
  - Steve Greenberg
  - David Faulkner
- Consultant Researchers
  - Ecos Consulting: Chris Calwell, My Ton
  - EPRI-PEAC: Arshad Mansoor
  - Rumsey Engineers: Peter Rumsey
  - EYP Mission Critical Facilities: Jay Madden

California savings potential: The opportunity for PIER

California Savings Potential	Electricity		Natural Gas
	Megawatts	GWh/year	TBTUs/year
Cleanroom & Laboratory Benchmarking	100	470	1.25
Fan Filter Unit Test Procedure	90	426	
Efficient Mini-environments	40	188	0.5
High-performance Fume Hoods	215	936	7
Data Center Benchmarking & Best Practices	188	1643	
Efficient UPS Systems for Data Centers	19	164	
Efficient Cooling of IT Equipment in Data Centers	19	164	
Improved Power Supplies for IT Equipment	38	440	
	709	4431	8.75

Source: LBNL Applications Team: estimates for PIER.

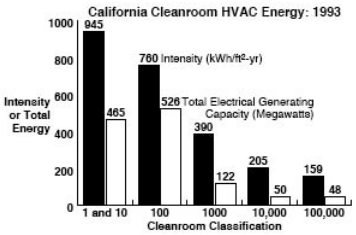


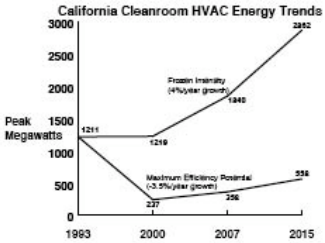
Why high-tech sector?

- Many industries and sectors involved
  - Electronics, pharmaceuticals, biotech, communications, research, education, …
- CA industries of the future: large and growing numbers of relevant facilities, (e.g., biotech and nanotechnology)
  - Retention of industries in California by managing costs
- Technology solutions may have broader applicability ("race-car" analogy)

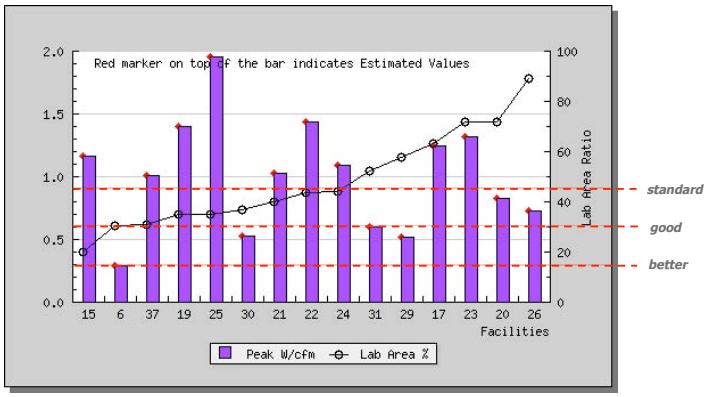
Why high-tech energy?

- Highly energy intensive (5-100x typical bldgs.)
  - Labs, cleanrooms, data centers
- Continuous operation
- Industry inaction on energy
- Underserved markets
- Ripe for improvement
  - 40-50% energy savings potential
  - Industries are engaged and concerned about: cost, availability, reliability, and power quality





Wide range of efficiencies:
For example: laboratory ventilation

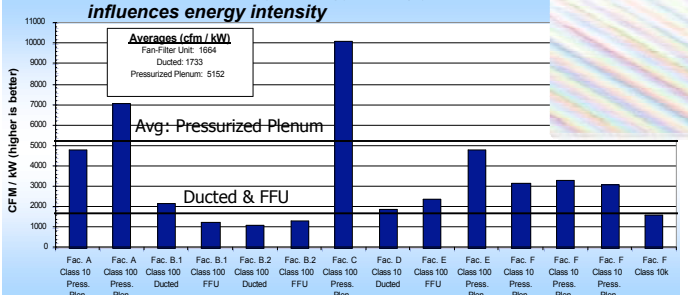


Standard, good, better benchmarks as defined in
"How-low Can You go: Low-Pressure Drop Laboratory Design" by Dale Sartor and John Weale

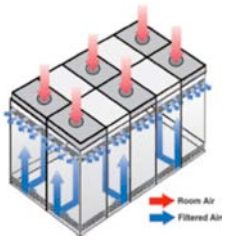
Wide range of efficiencies:
For example: cleanroom recirculation systems

Air-change rates vary for given cleanliness level

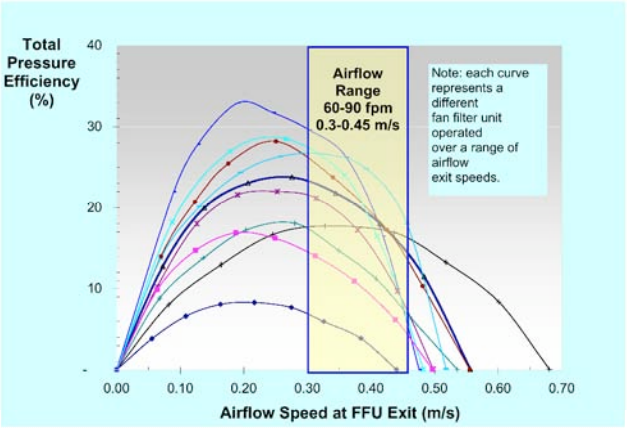
Choice of air delivery strategy strongly influences energy intensity



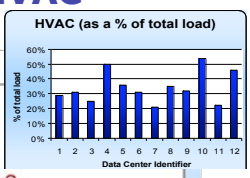
Wide range of efficiencies:
For example: fan-filter units



- Efficiencies vary by a factor-of-four
- Need for test standards



Wide range of efficiencies:
For example: data center HVAC



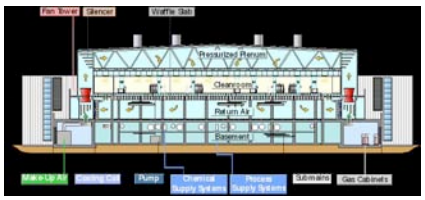
Cleanrooms: The Opportunity

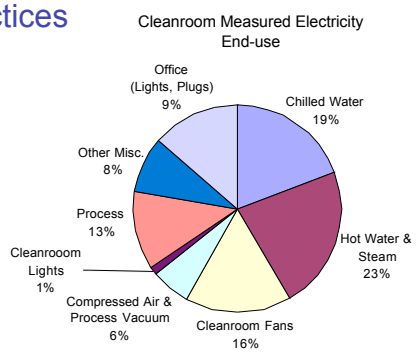
- Up to 100x more energy-intensive than typical buildings (Class-1 cleanroom can be up to 600 ac-h)

- Promising Measures
  - Govern ventilation by performance rather than rules of thumb
  - Improved processes
  - More efficient HVAC
  - Low-pressure-drop design

Current PIER cleanroom activities

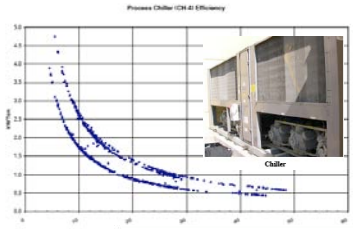
- Benchmarking and Best Practices
- Fan-filter unit test procedure
- Demand-controlled filtration
- Minienvironments





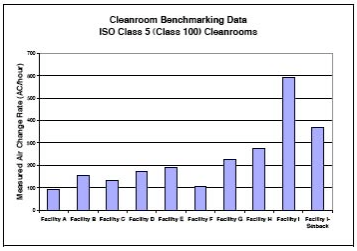
Major accomplishments: Cleanrooms

- Benchmarking & Best Practices
  - 2 case-study reports (Rockwell Scientific and Abgenix); +1 in draft (J&J); Agilent and Jazz Semiconductor also interested
  - Benchmarking results being reviewed for best practices



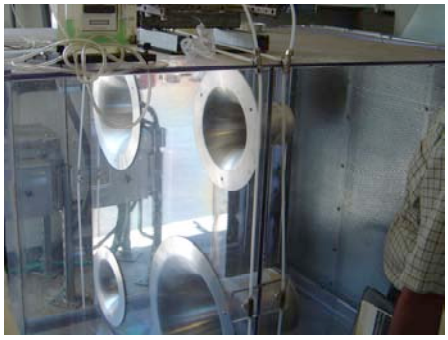
Chiller COP ranged from 0.5 to 5 kW/ton over range of 5 to 50 tons

Air-change rates [700 max]: Subject (facility 1) to far right: standard operation and setback (40% reduction without compromising process)



Major accomplishments: Cleanrooms

- Fan Filter Test Procedure
  - Draft Test Standard reviewed by industry - ready for trial use
  - LBNL leading IEST effort to establish industry standard
  - LBNL worked with PG&E to find test facility



PG&E fan test apparatus showing calibrated flow nozzles. This test facility can perform tests using the Fan-Filter Test Procedure.

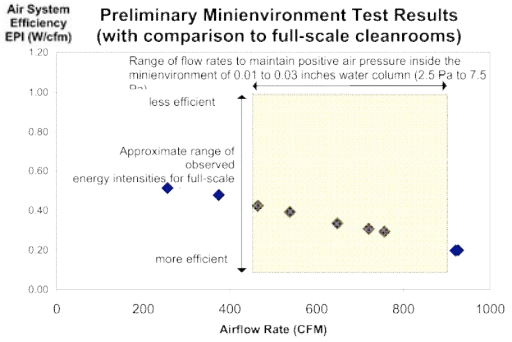
Major accomplishments: Cleanrooms

- Demand-controlled Filtration
  - Completed pilot study in LBNL cleanroom. Preliminary estimate: payback times 1 to 4 years
  - Industry partner ready to participate in demonstration project

Shown are two particle-measuring systems (0.1-2.0 microns). Sampling done in a 300-sq.ft. Class-100 cleanroom at LBNL.

Major accomplishments: Minienvironments

- Baseline measurements at ASYST Tech.
- Workshop with International SEMATECH

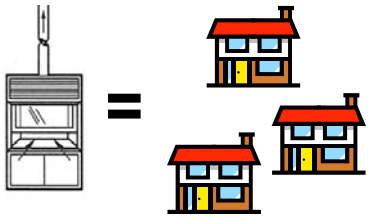


Minienvironment: LBNL case-study research site at ASYST Technologies, Inc.

Labs: The Opportunity

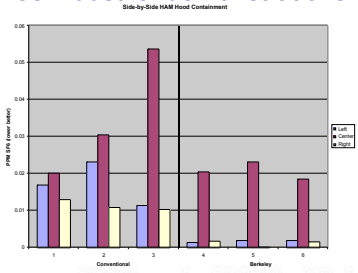
- Labs are up to 10x as energy-intensive as typical buildings; fume hoods use >3x as much energy as typical home
- Promising Measures
  - Low-pressure-drop design
  - Ventilation and hood flows governed by performance rather than rules of thumb

Berkeley Hood installed at UCSF



Current PIER lab activities

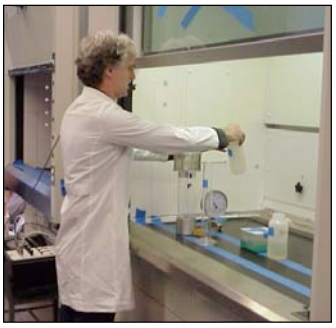
- Benchmarking and Best Practices
- High-Performance Fume Hood
  - Overcoming barriers (CAL/OSHA)
  - Side-by-side testing
  - Three industrial demonstrations



Setup for side-by-side fume hood testing at LBNL

Major accomplishments: Labs

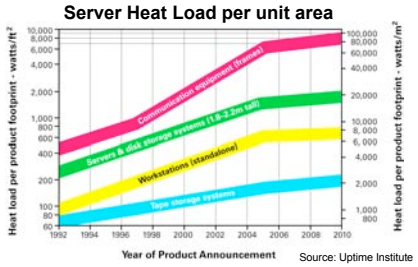
- Benchmarking & Best Practices
  - Data collected from major pharmaceutical company in S. Cal.
  - Synergistic activity: Labs21 collecting benchmarks nationally
- High-Performance Fume Hoods
  - Tacit Cal/OSHA approval of dynamic test
  - ANSI interpretation and letter of support
  - Successful initial static tests (ASHRAE 110) and dynamic (human-as-mannequin)
  - Partnering with CA fume hood manufacturer for demonstration hoods
  - Simplified web-based calculator

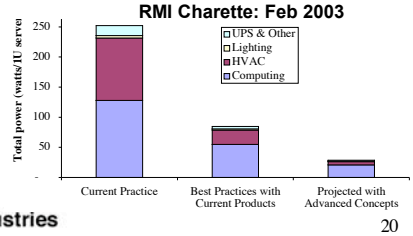


LBNL's Geoffrey Bell performing dynamic side-by-side tests comparing 6-foot Berkeley Hood with a standard hood.

Data Centers: The Opportunity

- Design loads are often significantly higher than actual
- Observed energy intensities vary by a factor of 10 (8-80 W/ft^2)
- Power conversion losses are one-third of server load
- Promising Measures
  - Opportunities range from UPS, to power supply, cabinet design/layout, to facility HVAC choice and sizing, to lighting & envelope improvements



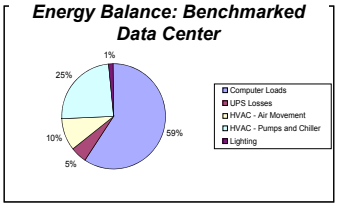


Current PIER data center & IT equipment activities

- Benchmarking and Best Practices identification
  - Research-directed benchmarking
  - Self-benchmarking protocol
- Investigate uninterruptible power supplies (UPS)
- Track HVAC-IT developments (e.g. innovative rack design)
- Investigate power supplies in IT equipment

Major accomplishments: Data Centers

- Benchmarking & Best Practices
  - Benchmarking sites identified (Equinix, Earthlink, Cisco, 365 Main)
  - Two sites in progress
  - Results being reviewed to determine best practices
  - Work began on "self-benchmarking" protocol

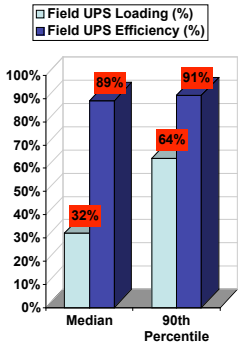


Preliminary benchmarking findings: An example

- Standby Generation Losses
  - Several Sources
    - Heaters
    - Battery chargers
    - Transfer switches
    - Fuel management systems
  - One study (Emcor - telecommunications): $3M/year (80%) heater savings in 2500 generators over 75 kW
  - Heaters alone (many operation hours) use more electricity than produced by the generator (few operating hours)
  - May be possible to eliminate heaters, batteries, and chargers

Major accomplishments: UPS

- Data collection protocols completed
- Completed review of efficiency versus load for current-generation static and inertial UPS, based upon manufacturers' data
- Technical review of efficiency versus load (based on specification) for current generation static and inertial UPS topology completed
- Developed simplified calculatior at rack level for comparing AC powering versus DC powering architecture and for evaluating cost savings due to higher efficiency UPS
- Completed testing of UPS to show impact of "high efficiency" option on static UPS

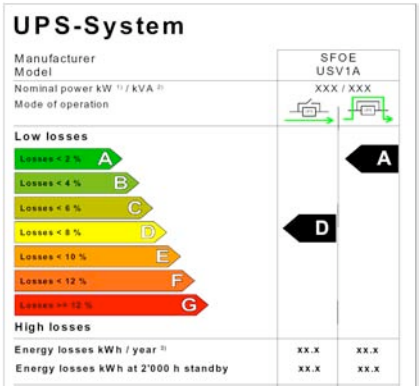


Sample of 12 field measurements, including ten from LBNL roadmap activity, using new Protocol developed under PIER project.

Major accomplishments
Data Centers: UPS Labeling

- Reviewing international labeling effort for quality & efficiency matrix
- Promising applications in California/US context

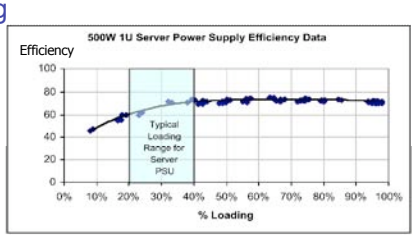
Possible UPS Efficiency Labeling Criteria



Major accomplishments: Power Supplies

- Developed loading guidelines and test protocol: AC/DC power supplies for 1U, 2U, and pedestal servers
- Created Excel calculator for evaluating impact of improving power conversion process efficiency at rack
- Coordination with Server System Infrastructure (SSI) members to adopt loading guidelines and recommend higher efficiency levels
- Evaluate "real life" server PS loading level and processor usage activity

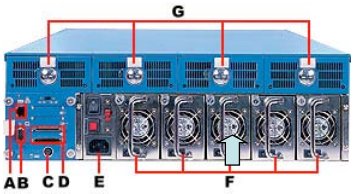
Server Efficiency v. Loading



Opportunity

Power supply system redundancy can be accomplished without using "redundant power supplies".

Redundant Power Supply
(300W + 300W)
At 50% Design Load each
supply is loaded 25%



1200 W 4+1 (N+!)
Redundant Power Supply
System
At 50% design load each
supply is loaded 40%

PIER demonstration projects

- LBNL to "broker" demonstrations
  - Fume hood demonstrations are currently funded in the PIER project
- Current project tasks are logical for follow-on [in addition to current project] e.g.:
  - Demand-controlled filtration
  - Fan-filter test procedure
  - Minienvironment
  - UPS systems

Major accomplishments: Demonstrations

- Potential demonstration partner sites
  - Lam Research, Sun Microsystems, Hewlett Packard, National Food Lab, ChevronTexaco, Johnson & Johnson, Network Appliance, Jazz Semiconductor, Equinix
  - Minimal activity pending PIER direction
- Potential technology partners
  - Asyst Technologies, Lygan, Nextek, Nisvara, Triton Technology
- PG&E interested in co-funding data center demonstrations

PIER tech transfer activities

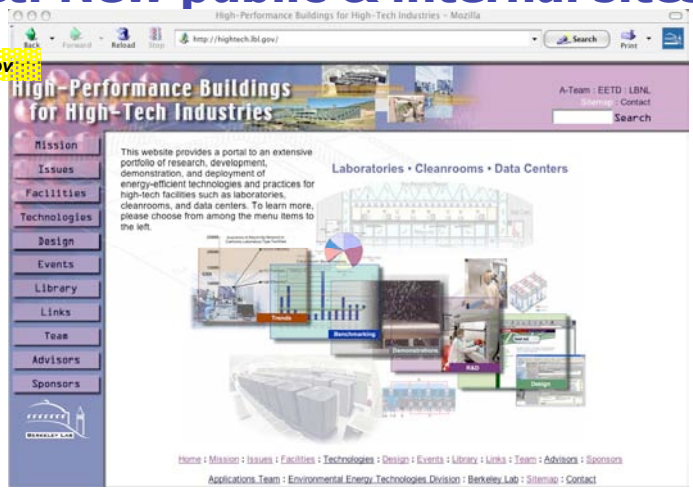
- Effort: Significant and broad-based
- Audiences: Manufacturers, designers, end users, utilities, policymakers, educators/students, *and* PACs
- Methods: Publications (all channels), presentations, workshops, training sessions, design guidelines
- Working with:
  - Industry associations and trade press
  - Professional societies (committee work, etc.)
  - Facility managers trying to communicate benefits to management

Major accomplishments

- Technology Transfer and Outreach
  - ~40 presentations, training sessions, workshops delivered or scheduled
  - Design aids for fume hoods, servers, and power supplies
  - Publicity
  - Internet Sites
  - Training Events

Internet: New public & internal sites

http://hightech.lbl.gov



Collaborations

- Labs 21 – leadership, training, conference, design assistance
- Cornell University – demand-controlled filtration
- GA Tech/SUNY – data center "air management" (NYSERDA)
- ITRI (Taiwan) – fan-filter test procedure, cleanroom benchmarking
- Sematech - fan-filter units, mini-environments, energy benchmarks
- Silicon Valley Mfr's Association
- Critical Facilities Roundtable
- NEEA – workshop in September
- ASHRAE – labs, cleanrooms, data center TC's
- Utilities (PG&E, SCE, SDG&E) - training, program development, etc.
- IEST - key standards-setter for contamination-control industry
- UC-UCOP & Individual Campuses - Labs21, LEED for Labs
- 7x24 Exchange
- Uptime Institute
- SSI