An Energy Efficiency Workshop & Exposition

Palm Springs, California

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and

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Energy Benchmarking in Cleanrooms

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A HOT TOPIC

A Hot Topic

Why Benchmark High-tech Buildings?

PG&E saw that the market was large and growing. In California:

- 9400 GWH in 1997 (all high tech buildings)
- 4.2 million sq. ft. of operating cleanrooms
- Semiconductor and Biotech exhibited high growth

Why Benchmark High-tech Buildings?

Cleanroom owners and operators saw an opportunity to learn about their energy end use, compare their efficiency to others, and find some efficiency improvement opportunities.

Why Benchmark Cleanrooms?

- Identify energy efficiency opportunities
- Discover Operational and Maintenance problems
- Determine best practices to influence retrofit or new construction
- Reduce electrical demand to improve reliability and room for growth

Benchmarking Process

- General plan – informs participants
- Enlist Benchmarking participants
- Site specific plan
- On-site measurement and data collection

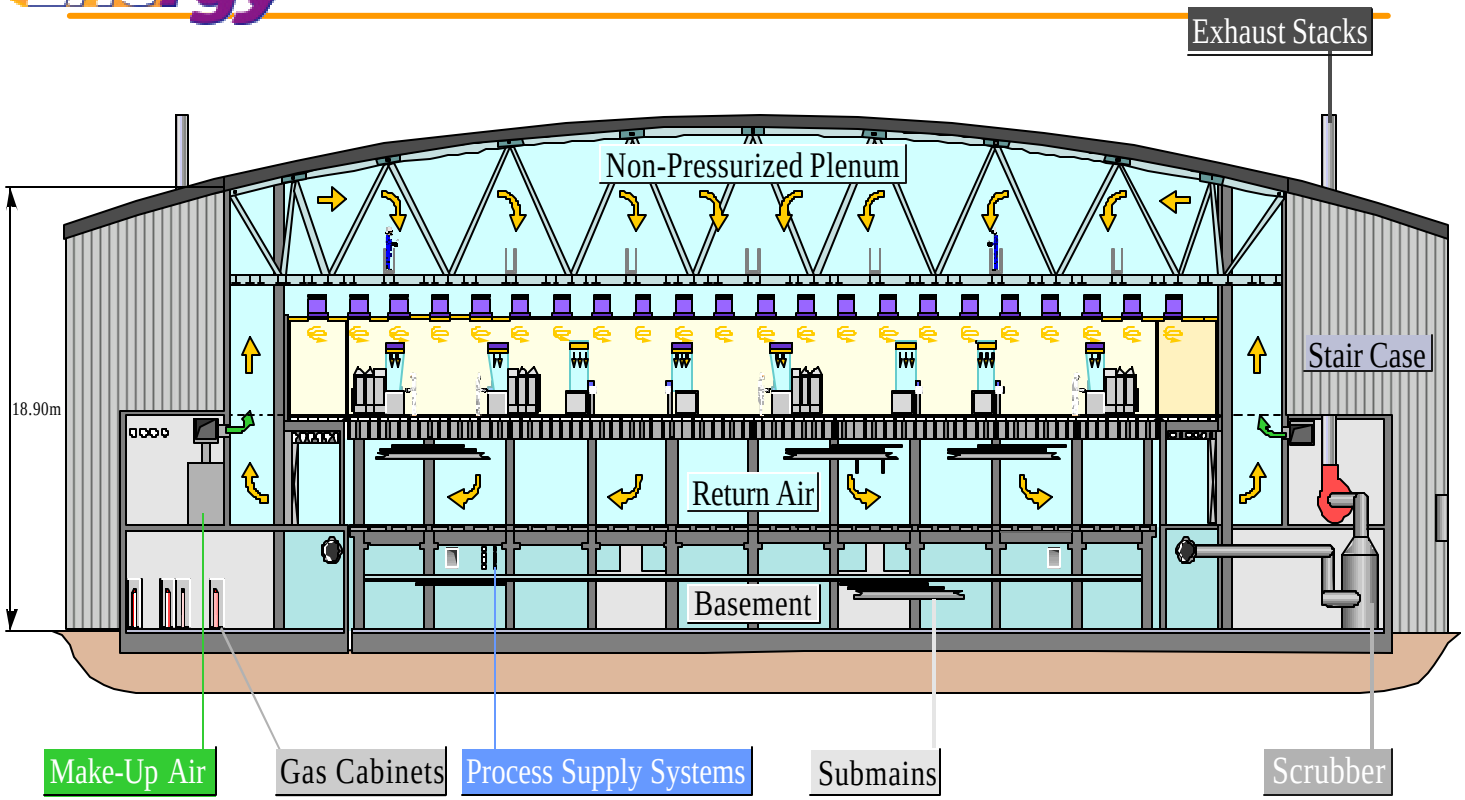
Communicating Results

- Participant review of draft site report
- Final participant report and anonymous version
- Database updated and summarized on LBNL web site along with anonymous reports

What is a cleanroom?

- A space with a controlled environment usually for contamination control
- Cleanliness is achieved by moving large amounts of air through HEPA filters
- Cleanrooms come in varying degrees of cleanliness – called cleanliness class
- Cleanliness class dictates air change rates

Semiconductor Cleanroom

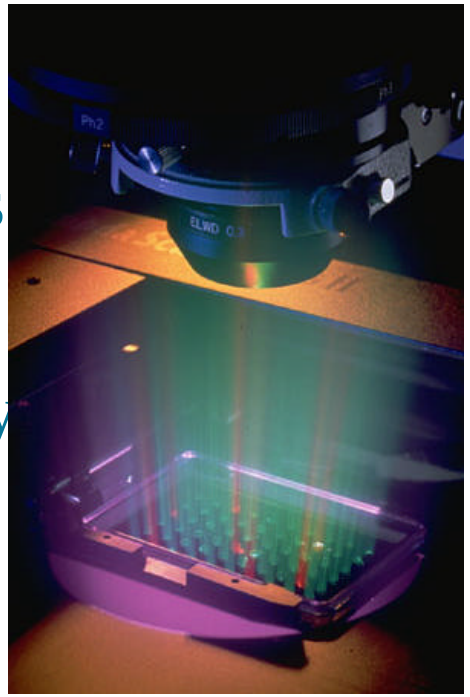


Additional Energy Drivers

- Hazardous materials are often used in processes housed in cleanrooms requiring lots of exhaust
- Processes in cleanrooms often require tight temperature and humidity control

Need for common metrics

- Ability to compare performance regardless of process
- Focus on system efficiency rather than production efficiency



Cleanroom metrics

- Air Systems – cfm / kW
- Cleanroom air changes – ACh / hr
- Air velocity in cleanroom - ft / sec

Central Plant metrics

Chilled water efficiency – kW / ton

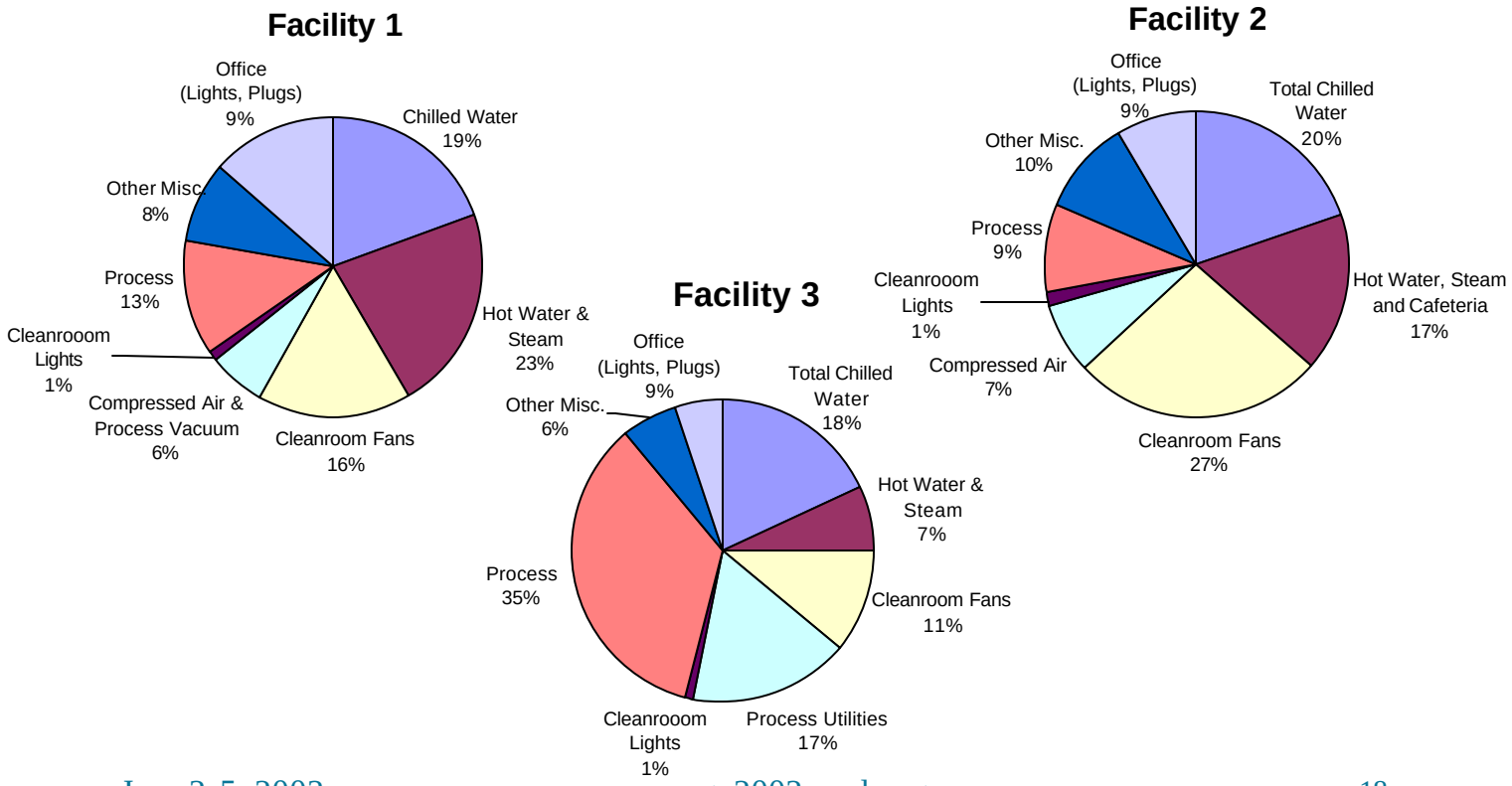
- Chiller
- Cooling tower
- Pumping – Chilled water, Condenser water, hot water

Energy Benchmarks Data Base

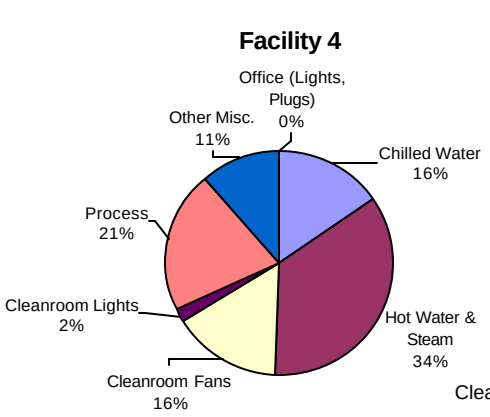
- Anonymous reporting
- System comparison
- Component comparison
- Comparison of overall facility
- No production metrics

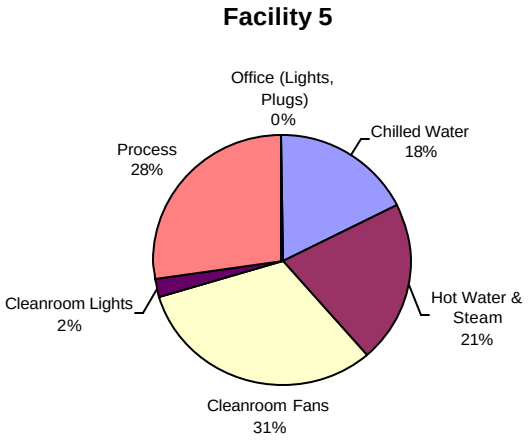
The Results

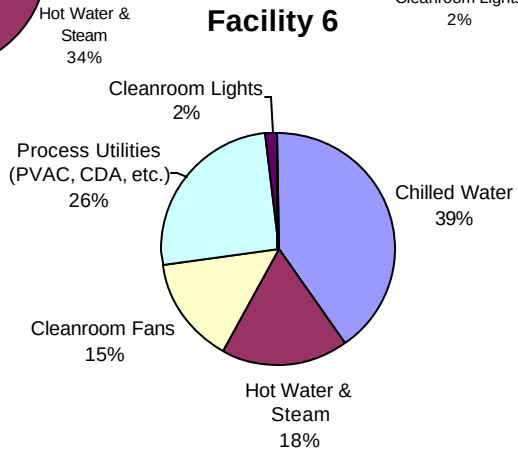
Energy End Use



Energy End Use





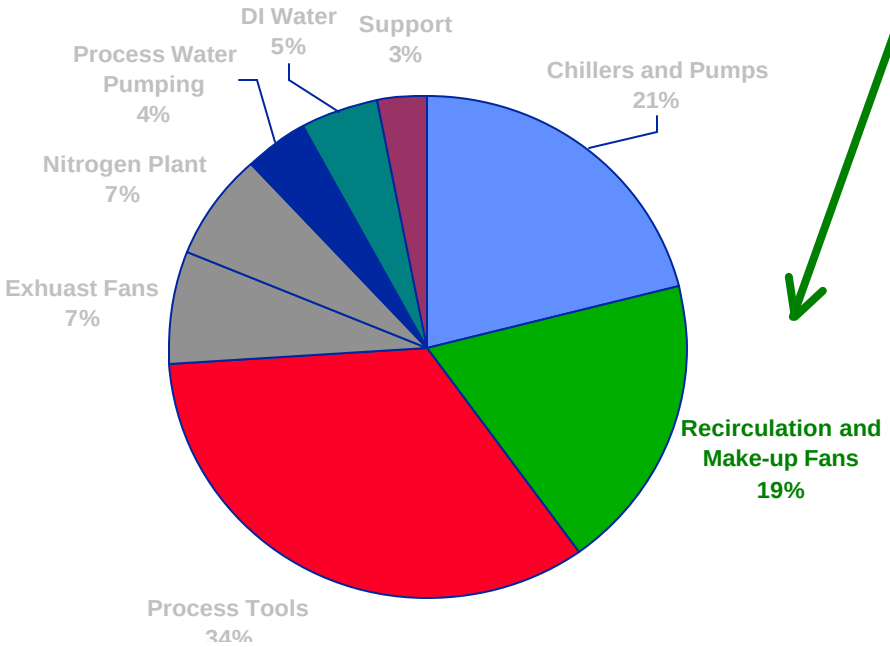


Process load Issues

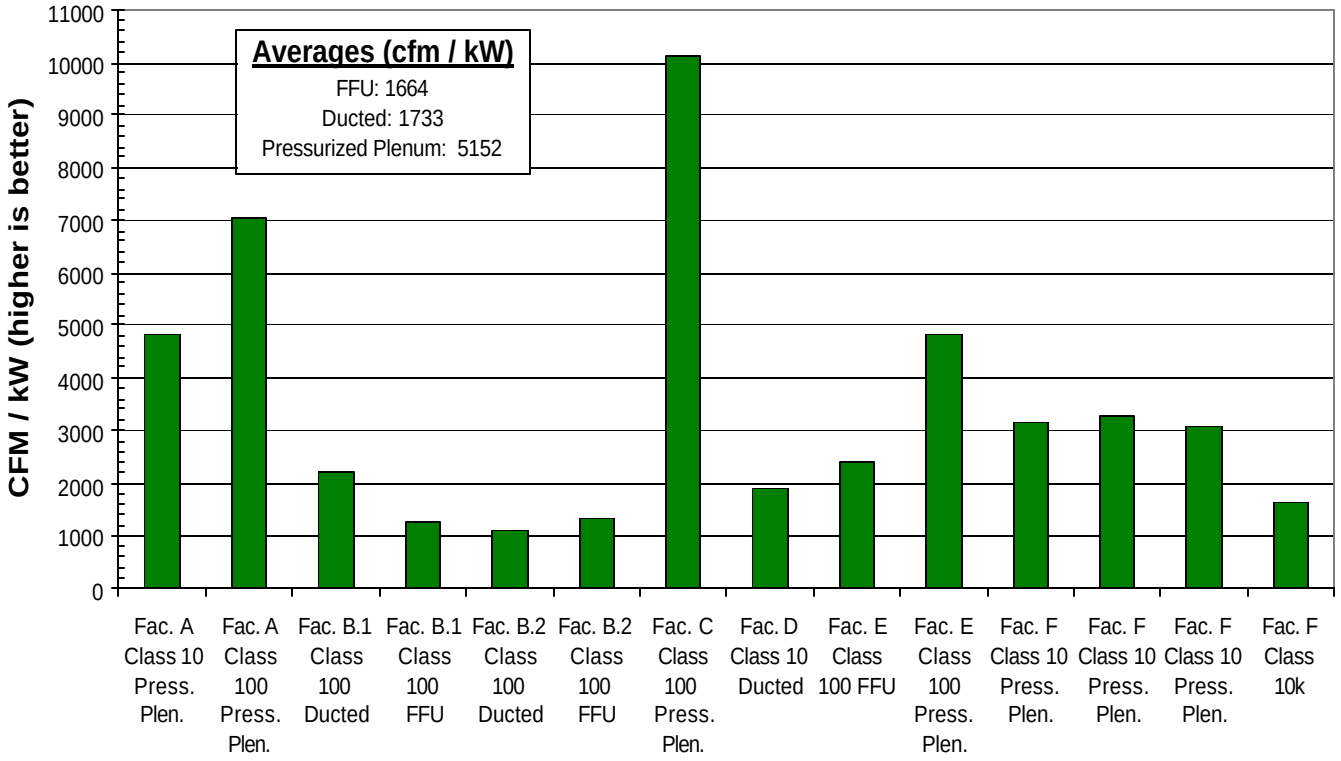
- Total electrical loads vary greatly depending upon the process in the room
- Electrical load is converted to heat which is removed by HVAC and process cooling systems
- Estimating the process heat load is a challenge
- HVAC equipment sized correctly operates more efficiently
- Benchmark data can help determine real design loads for use in future projects

Energy Intensive systems

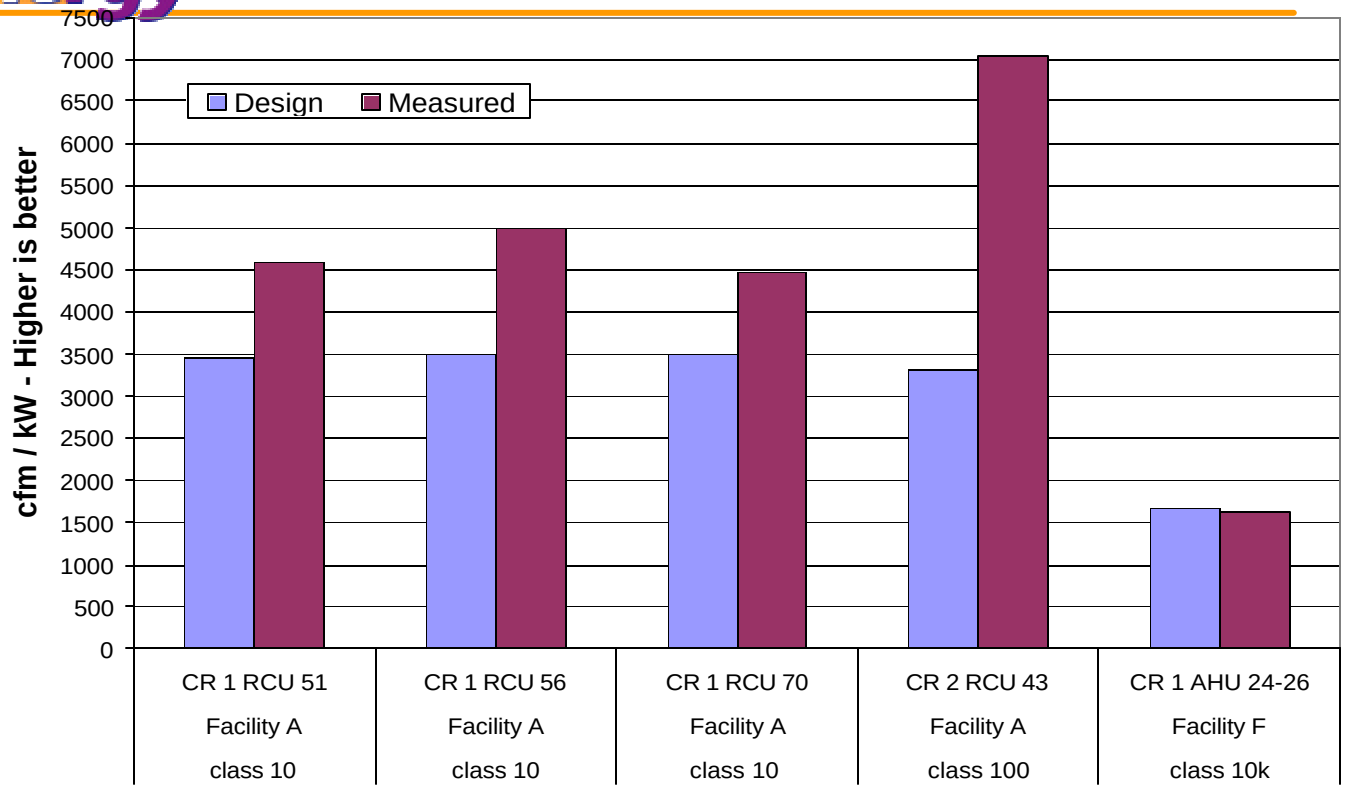
Recirculation in cleanrooms



Recirculation Efficiencies



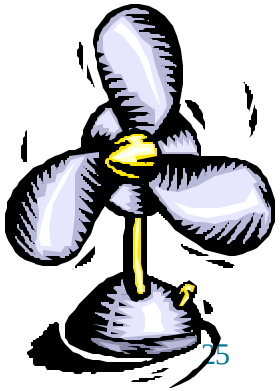
Recirculation Systems Design vs. Measured



A Typical Recirculation Air Handler

Recirculation System Findings

- Energy use for recirculation systems varied by as much as a factor of 10
- Plenum systems (low pressure drop) were generally more efficient
- Ducted systems (high pressure drop) were less efficient
- Fan-filter units were relatively inefficient (but are improving)



A Ducted System

Observations

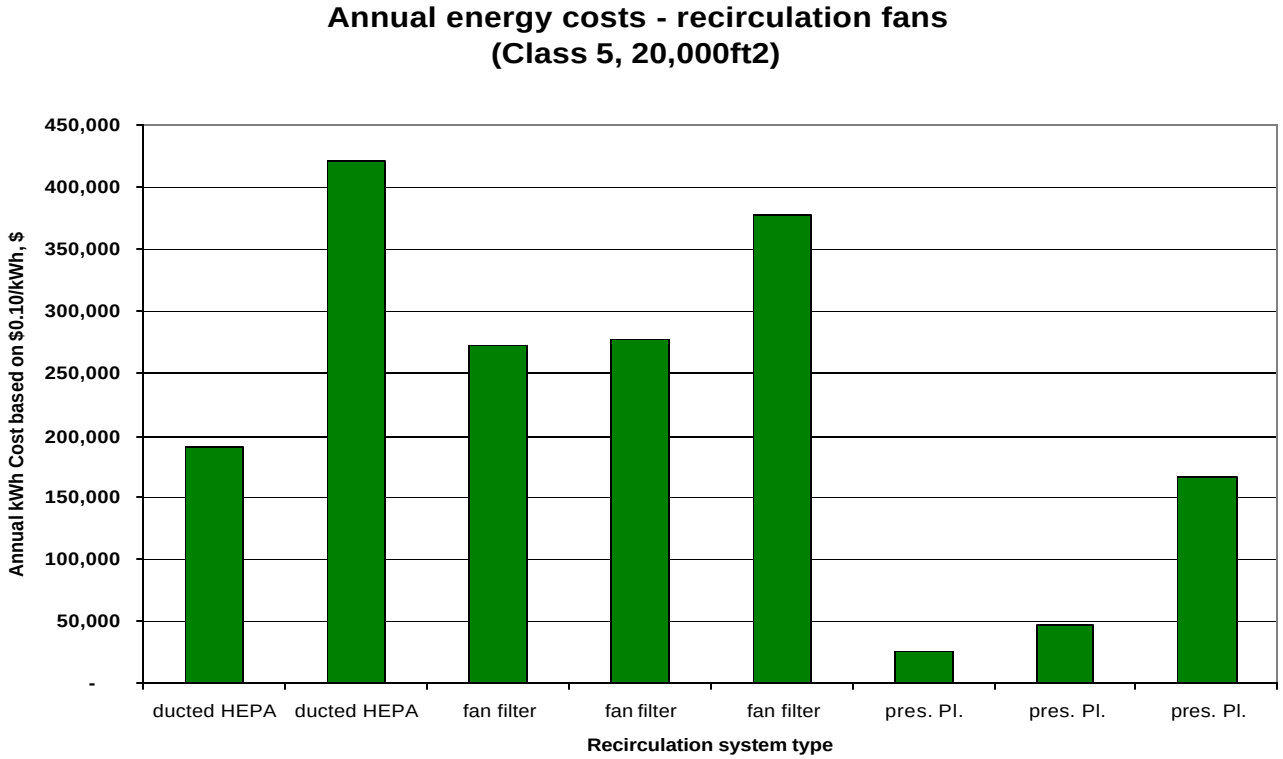
- Large variations exist
- Designers, Owners, and Facility staff do not know what is possible to attain
- Or how they are operating
- There is generally a lack of monitoring instrumentation

My Recommendation

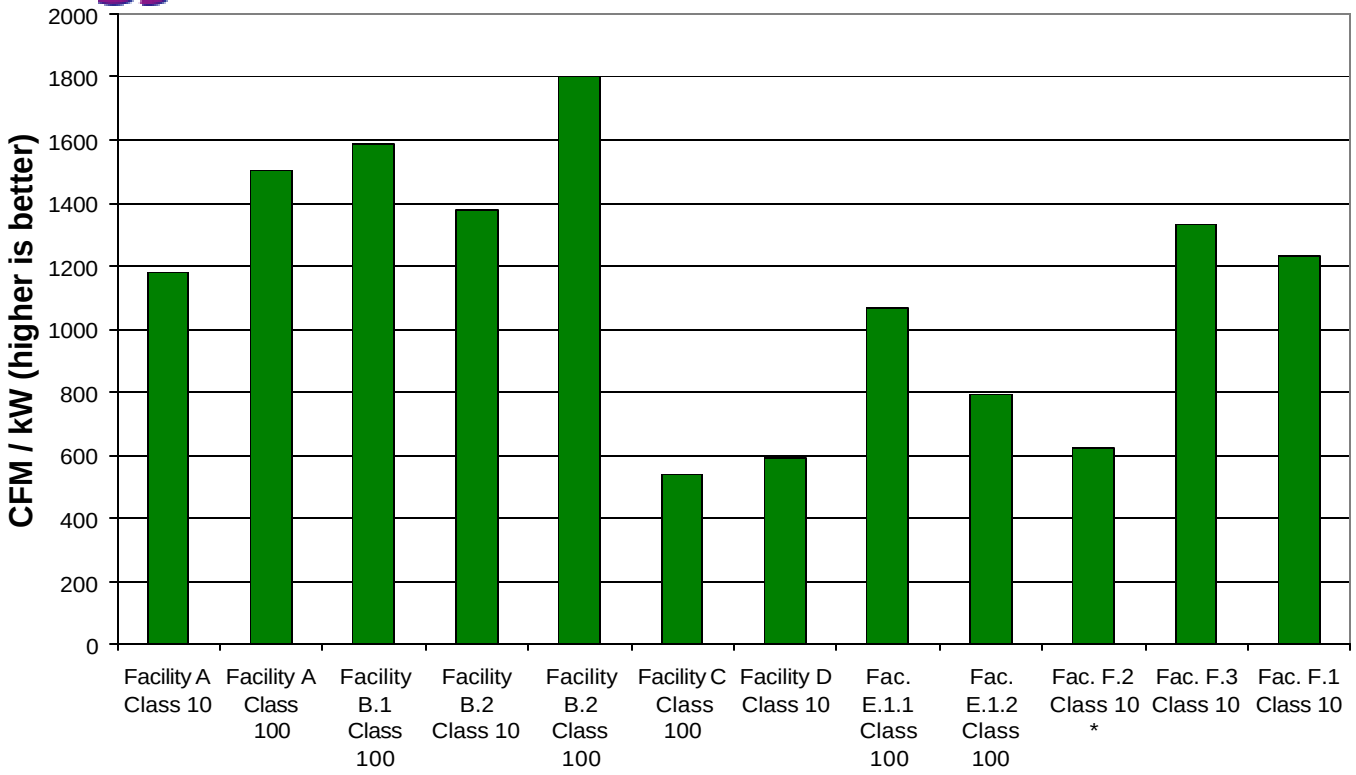
Designers (and constructors) will provide what their customers ask for.

If you want efficient systems, ask for them.

What is the cost impact?



Make-up Air Comparison

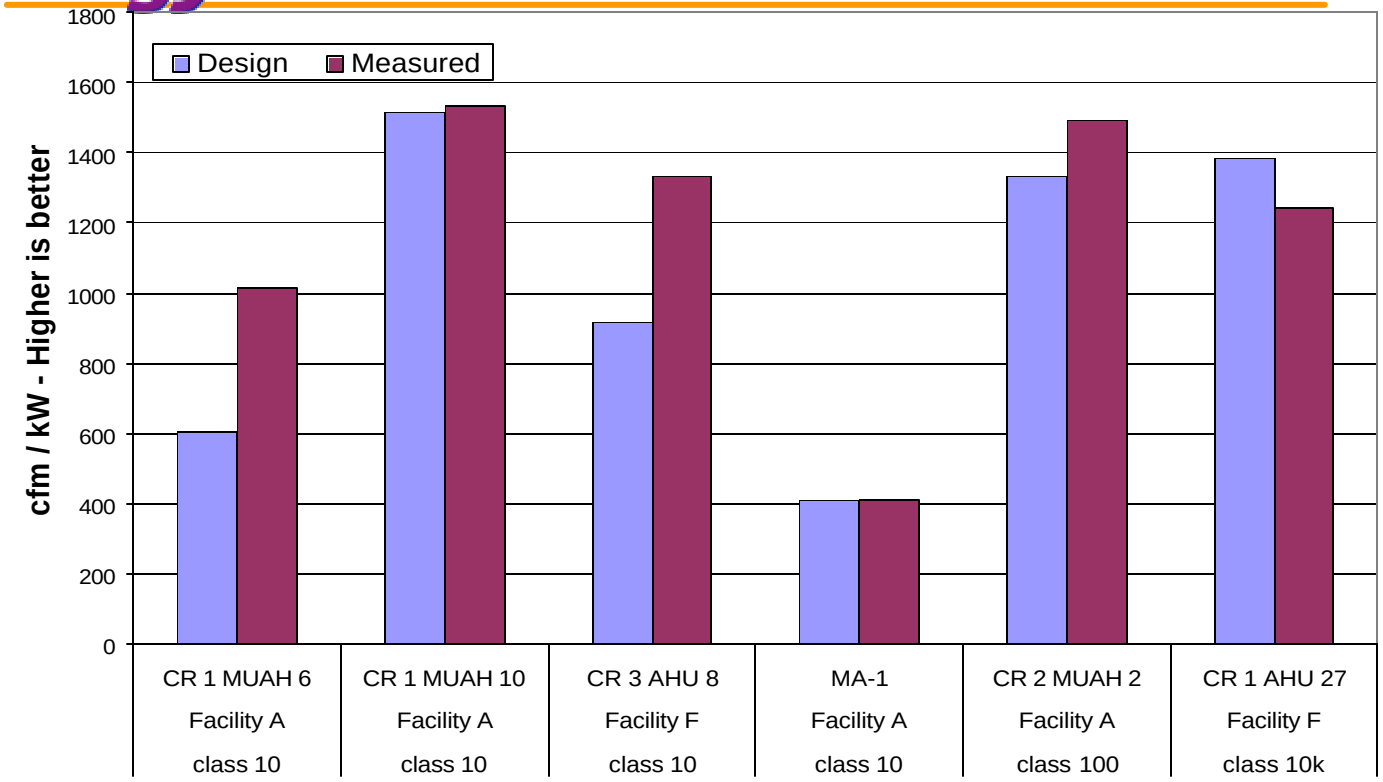


Why is make-up air system efficiency lower?

- Retrofitted systems with less than optimal configurations
- High face velocity air handlers (due to space constraints or just inattentive design)
- Older less efficient equipment (motors, fans)
- Resistance due to heating and cooling coils, filters, etc.
- Duct sizing and layout

A Typical Make-up Air Handler

Make-up Air
Design vs. Measured

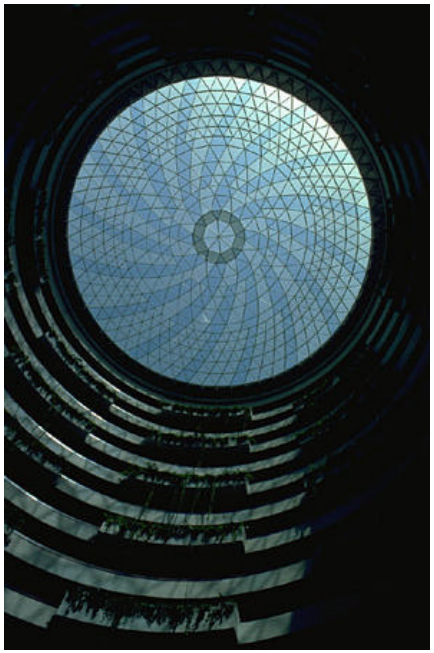


Why are Design Efficiencies less than Measured Efficiencies?

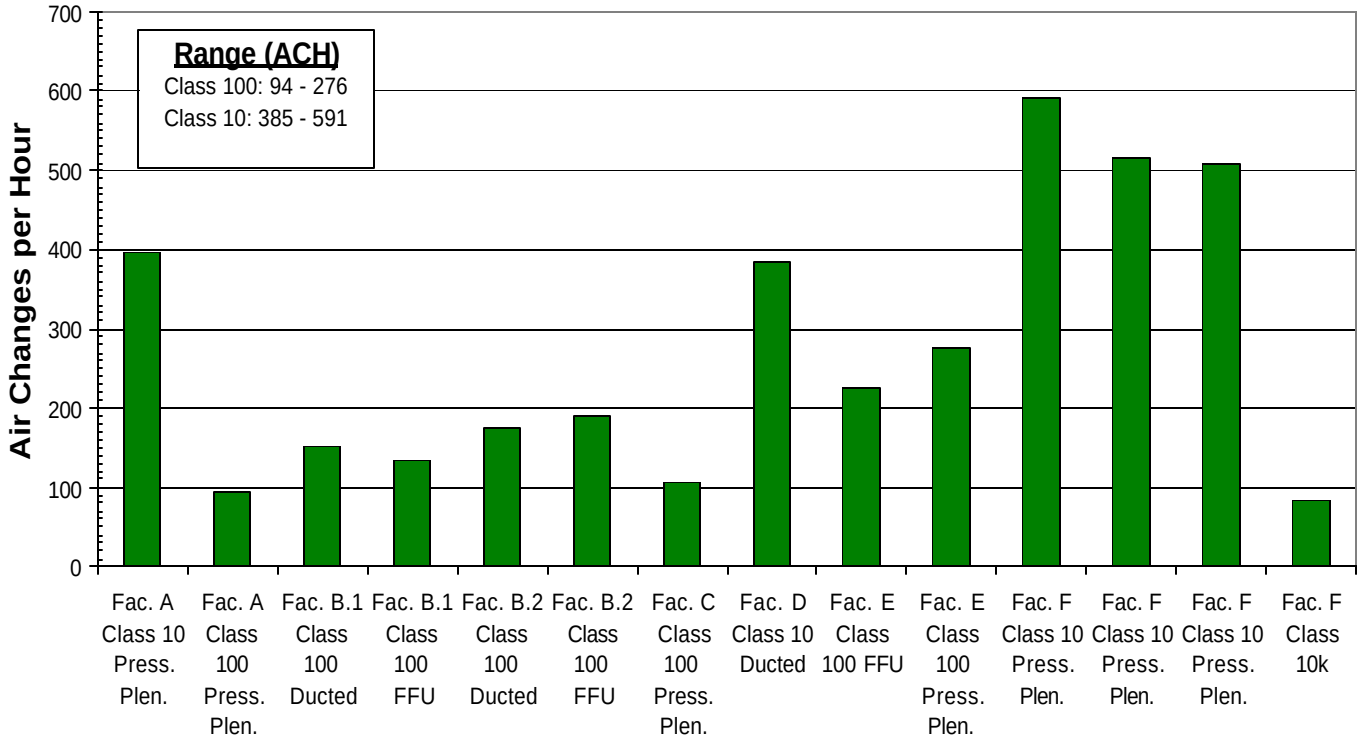
Design efficiency is generally understated because larger power consumption (kW) is generally assumed.

Make-up Air System Considerations

- Optimize exhaust and pressurization
- Minimize resistance of make-up air path
- Close coupling large equipment
- Reduce air handler face velocity
- Select efficient fans and motors
- Use VFD controls



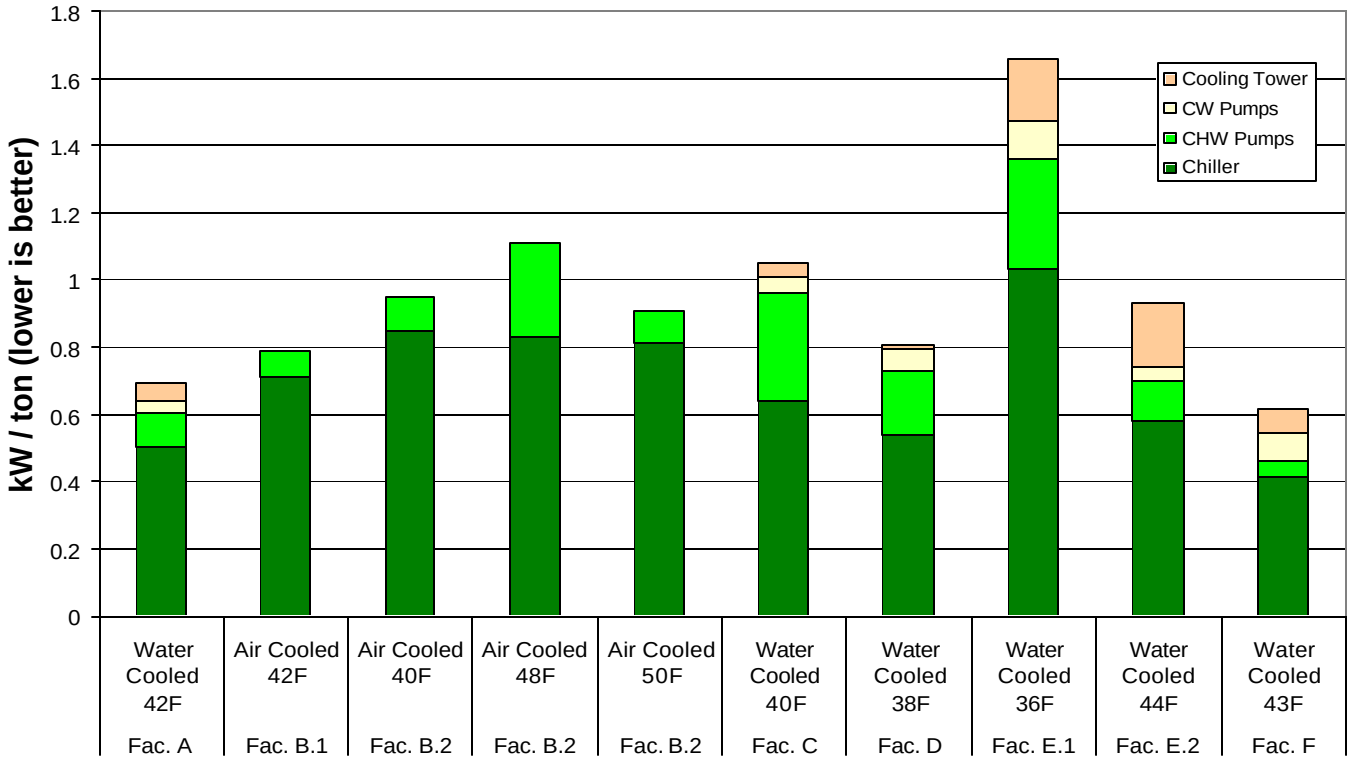
Air-Change Rate Comparison



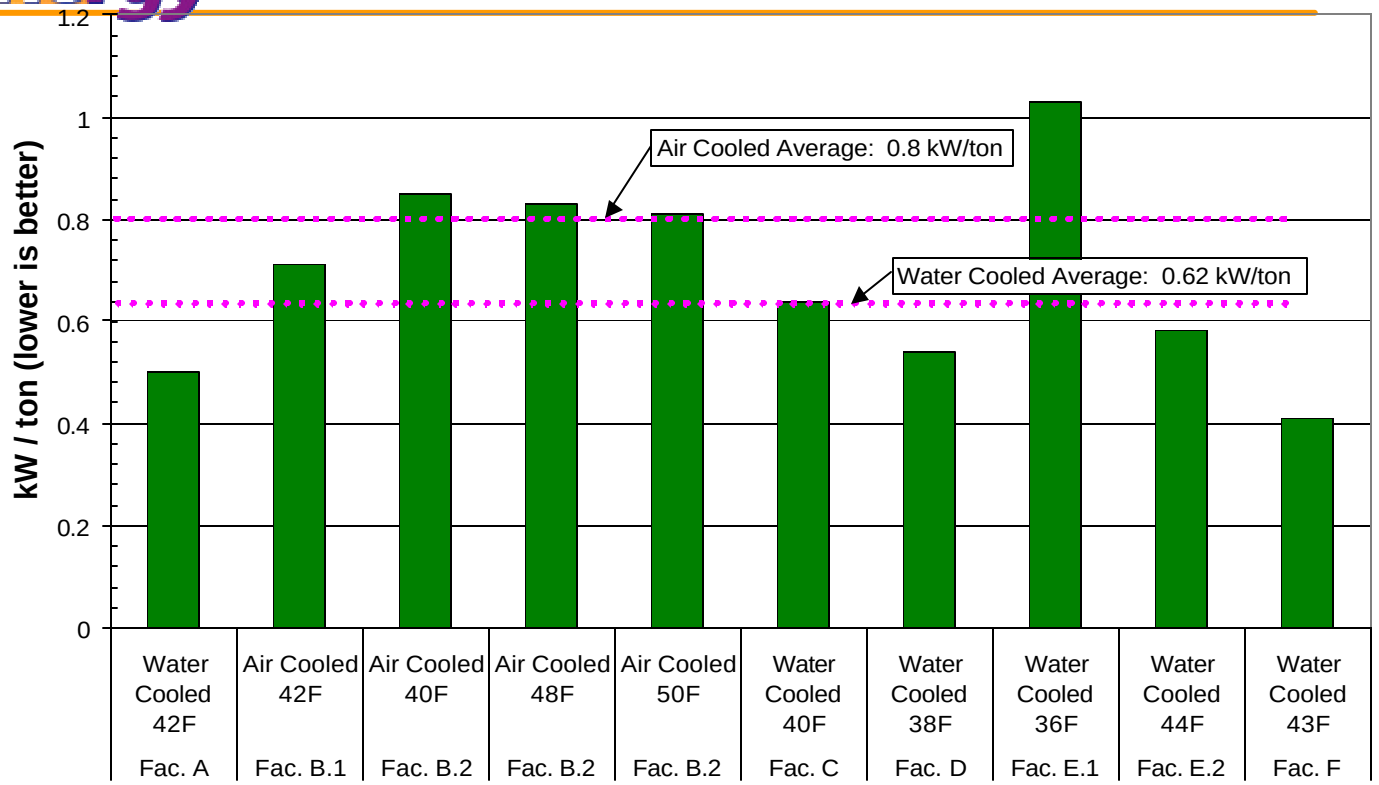
Air Change Rate and Velocity Observations

- Again, wide variation
- All processes had acceptable yields (so why do some work with less airflow?)
- Some air flows exceed recommended ranges (IEST provides recommendations based upon historical adequacy – not science based)
- Air velocity reduction and ceiling filter coverage represent opportunities

Chilled Water Systems Comparison



Chiller Comparison



Chilled Water System Observations

- Wide variation in overall efficiency
- Surprise! Measured chiller efficiency is different than name plate
- Pumping energy can be significant-and excessive
- Chiller performance dominates
- Water Cooled chillers are more efficient

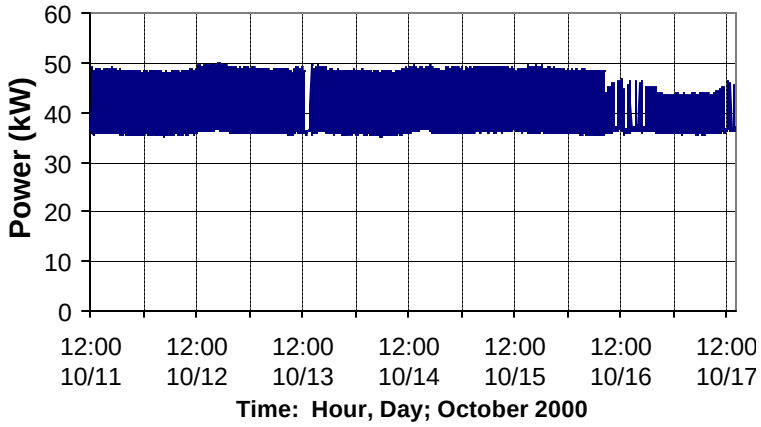
My conclusion:

Existing efficiency information for chilled water plants is under-utilized.

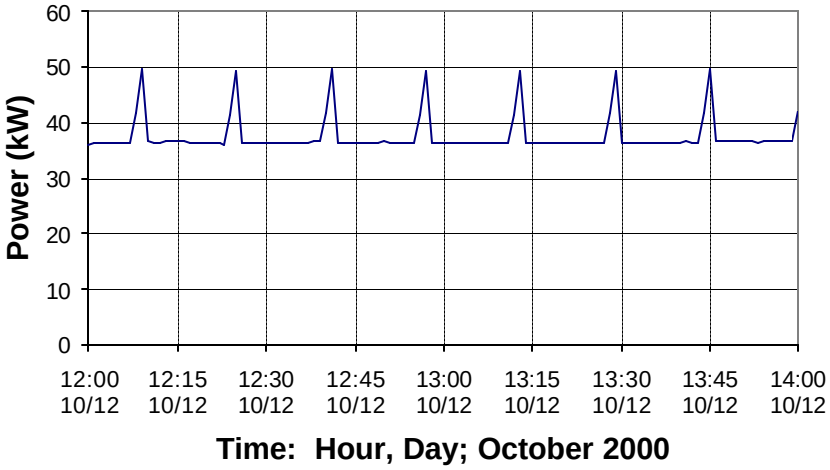
Non-energy benefits of Benchmarking

- Maintenance problems are discovered
- Operational inefficiencies are revealed
- Reliability can be improved
- Safety issues can be discovered

Chilled Water Pump Power



Chilled Water Pump Power



Benchmarking Can Help Establish Efficiency Goals

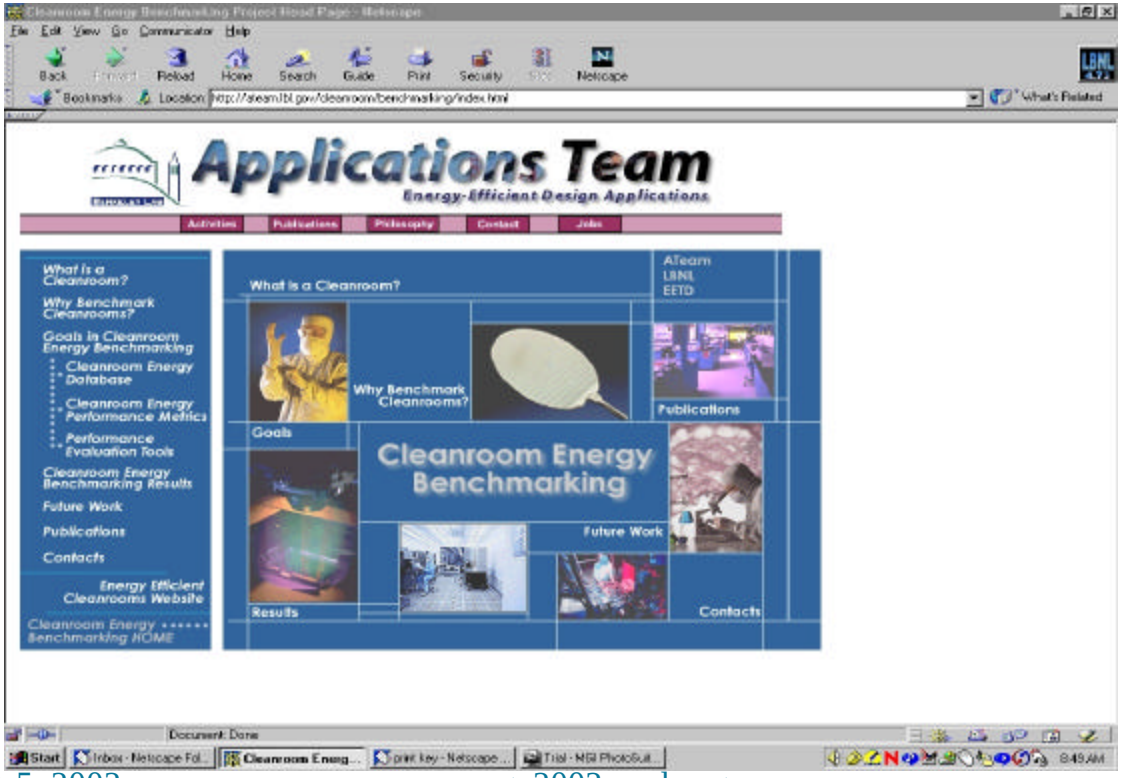
- Energy Budget
  - **Total facility**
  - **End use**
- Efficiency Targets for key systems/components
  - **Cfm/KW**
  - **KW/ton**
  - **Pressure drop**

Benchmarking Identified New Efficiency Concepts

For Cleanrooms:

- Match cleanliness to contamination problem
- Investigate reduction in air change rates
- Optimize chilled water pumping
- Optimize flow resistance

Cleanroom Benchmarking Website



Thank You