


Rating Laboratories

Results from the Labs21 Program

Paul Mathew, Dale Sartor
Lawrence Berkeley National Laboratory Otto van Geet
National Renewable Energy Laboratory Sue Reilly

Enermodal Engineering, Inc.

Outline

- Why Laboratories?
- Energy Benchmarking
  - Methods and Metrics
  - Database tool
- Environmental Performance Criteria
  - “LEED for Labs”
- Lessons Learned

Why Laboratories?

- Laboratories are very energy intensive
  - 4 to 6 times as energy intensive as office buildings
- Substantial efficiency opportunities
  - 30%-50% savings over standard practice
- Owner demands to reduce utility costs
  - Typically not speculative – lifecycle incentive

But…

Challenges

- Complex functional requirements
  - Health and safety
  - Research requirements
- What is a lab?
  - Chemical vs. biological vs. physical
  - Research vs. teaching vs. manufacturing
  - % lab area

Benchmarking 101

- Metric Selection
  - Site
  - Building
  - System
  - Component
- Metric Normalization
  - Programmatic parameters (e.g. area)
  - Contextual parameters (e.g. climate)

Labs21 Metrics

- Developed by expert group
- Tradeoff in scope vs. ease of data collection

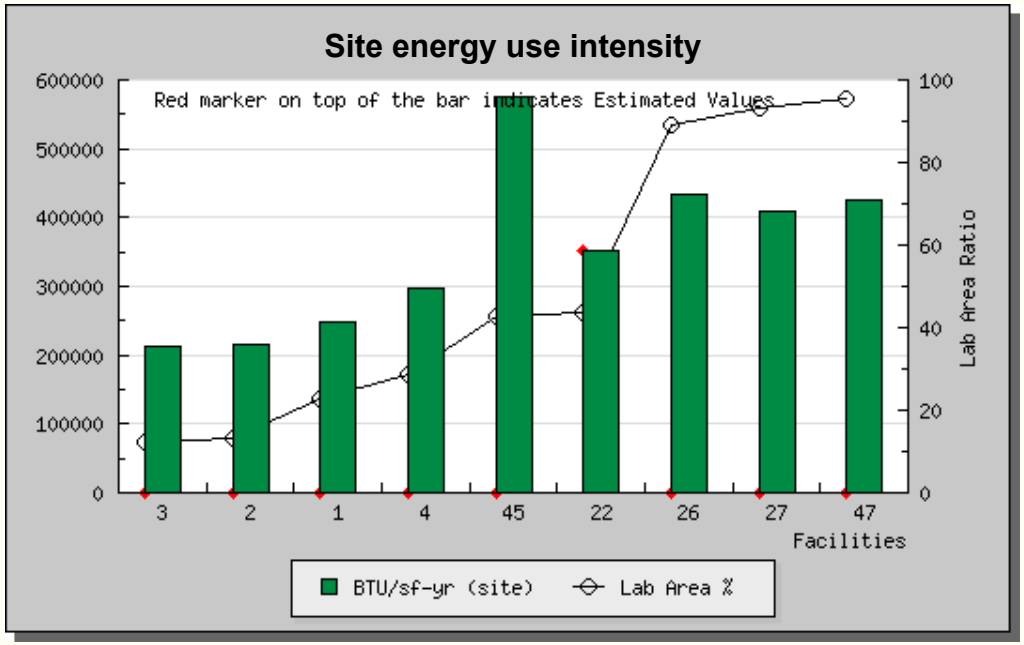
Whole Building	kWh/gsf-yr (elec) Peak W/gsf (elec)	BTU/gsf-yr (site) $/gsf-yr (site)
Ventilation	kWh/gsf-yr Peak W/cfm	Peak supply cfm/sf(lab) Avg cfm/peak cfm
Cooling	kWh/gsf-yr Peak W/gsf	Peak gsf/ton Installed gsf/ton
Heating	BTU/gsf-yr	
Lighting	kWh/gsf-yr Peak W/gsf	Installed W/sf(lab)
Process/Plug	kWh/gsf-yr Peak W/gsf	Peak W/sf(lab)

Normalization

- Some obvious parameters
  - Weather
  - Gross area
  - Lab area
- Some less obvious parameters
  - Ventilation rates
  - Equipment loads
  - Operation schedules

Benchmarking Methods…1

- Simple data filtering - provides crude normalization
  - May be adequate for coarse screening, opportunity assessment, goal setting



Facilities located in cool-humid climate zone; standard occupancy hours (<= 14 hrs/day)

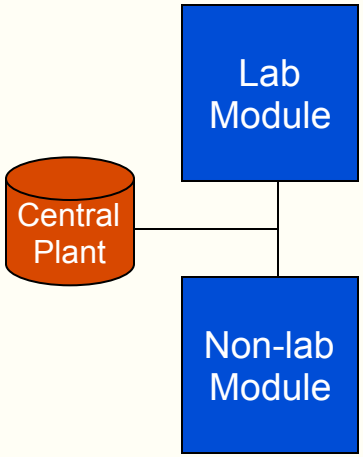
Benchmarking Methods…2

- Regression analysis
  - Equation relates normalizing parameters and metric
  - Used in EnergyStar
  - Works well if:
    - There is an adequate representative dataset
    - Dataset includes range of possible efficiencies.

- Lack of adequate dataset for laboratories
  - CBECS data limited by lab area, normalizing parameters
  - Labs21 database collects normalizing parameters, but has limited data

Benchmarking Methods…3

- Simulation-model based benchmarking
  - Model is used to calculate a benchmark (e.g. “ideal” case)
  - Model accounts for normalizing parameters
  - Benchmark is compared to actual energy use



Simulation model

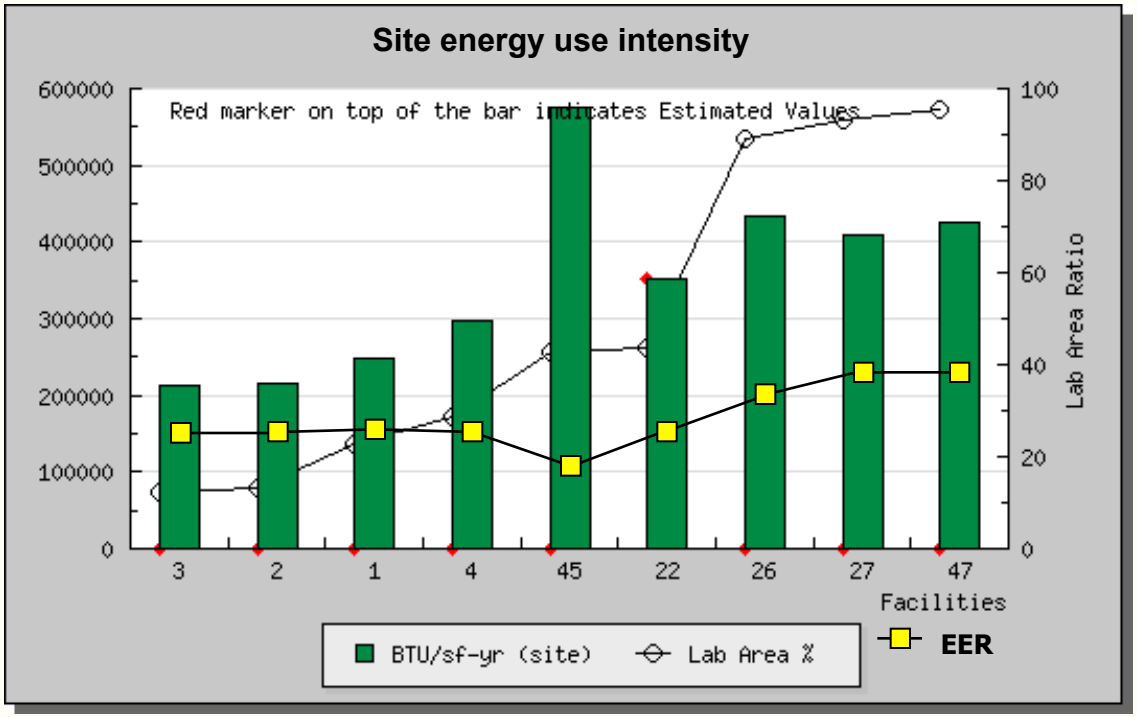
$$\text{Energy Effectiveness Ratio (EER)} = \frac{\text{Benchmark energy use (e)}}{\text{Actual energy use (E)}}$$

$$e = (A_l * ei_l) + (A_{nl} * ei_{nl})$$

A_l: Actual laboratory area
A_{nl}: Actual non-laboratory area
ei_l: benchmark energy use intensity for lab module
ei_{nl}: benchmark energy use intensity for non-lab module

EUI vs. EER

- EER improves “apples to apples” comparison

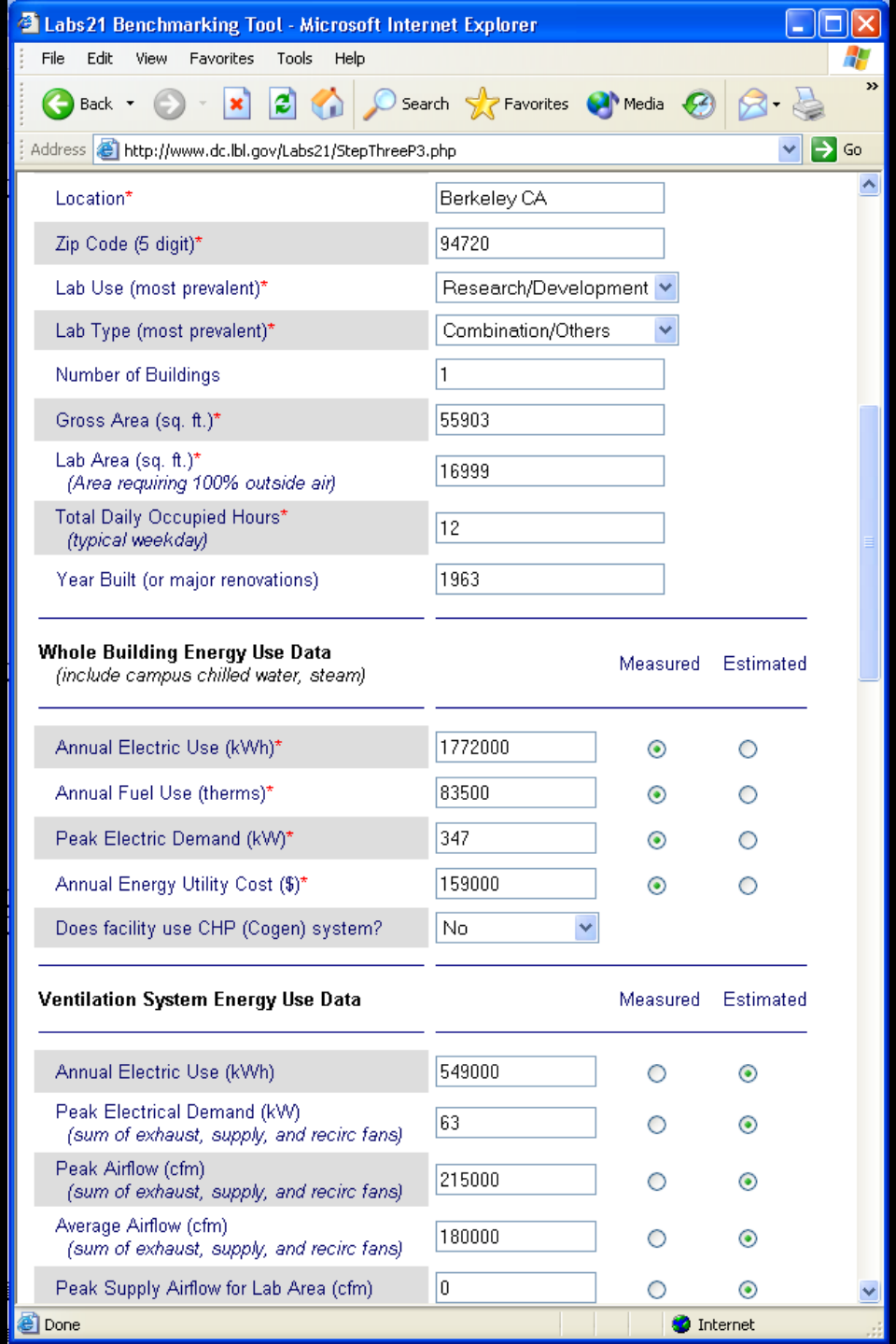


Facilities located in cool-humid climate zone; standard occupancy hours (<= 14 hrs/day)

Labs21 Tool

- National database of lab energy use data
  - Web-based input and analysis
  - About 50 facilities - Building and system level data
- Data Input
  - Users input data
    - All data reviewed before being accepted
  - Data remains anonymous to other users
- Analysis
  - Benchmarking using metrics with data filtering
  - Model-based normalization currently not integrated with tool


Labs21 Benchmarking Tool - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites Media
Address http://www.dc.lbl.gov/Labs21/StepTwo.php
Go
LABS FOR THE 21ST CENTURY
benchmarking
step one of four - login
step two of four - enter facility name and year of data
step three of four - enter data for the facility
step four of four - review / edit entered data
Welcome LBNL
Organization - Lawrence Berkeley National Laboratory
Please select the following
Facility name
Please choose one
Year for which data is being entered
Please choose one
Enter Facility Data...
Data currently in database:
Facility Name
Year
Bldg2-AdvancedMaterialLab 2001
Bldg62 2001
Bldg66-SurfaceScience-CatalysisLab 2001
Building84 2001
Benchmarking Analysis
(For current facilty data)
Internet


Labs21 Benchmarking Tool - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites Media
Address http://www.dc.lbl.gov/Labs21/StepThreeP3.php
Go
Location* Berkeley CA
Zip Code (5 digit)* 94720
Lab Use (most prevalent)* Research/Development
Lab Type (most prevalent)* Combination/Others
Number of Buildings 1
Gross Area (sq. ft.)* 55903
Lab Area (sq. ft.)* (Area requiring 100% outside air) 16999
Total Daily Occupied Hours* (typical weekday) 12
Year Built (or major renovations) 1963
Whole Building Energy Use Data (include campus chilled water, steam)
Measured Estimated
Annual Electric Use (kWh)* 1772000
Annual Fuel Use (therms)* 83500
Peak Electric Demand (kW)* 347
Annual Energy Utility Cost ($)* 159000
Does facility use CHP (Cogen) system? No
Ventilation System Energy Use Data
Measured Estimated
Annual Electric Use (kWh) 549000
Peak Electrical Demand (kW) (sum of exhaust, supply, and recirc fans) 63
Peak Airflow (cfm) (sum of exhaust, supply, and recirc fans) 215000
Average Airflow (cfm) (sum of exhaust, supply, and recirc fans) 180000
Peak Supply Airflow for Lab Area (cfm) 0
Done
Internet

Labs21 Benchmarking Tool - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Search Favorites Media

Address http://www.dc.lbl.gov/Labs21/CompareData.php Go

LABS FOR THE 21ST CENTURY

benchmarking

Choose Metrics and Filtering Criteria

More Information

User LBNL

Organization Lawrence Berkeley National Laboratory

Select metric:

System: Total Building

Energy / Efficiency Metric: Peak W/gsf (elec)

Specify data filtering criteria:

1. Lab Area / Gross Area ratio

is greater than or equal to 0.00 and is less than or equal to 1.00

2. Occupancy

- ○ Standard (≤14 hours)
- ○ High (>14 hours)
- ◉ Both (all data)

3. Climate [Climate Code, Climate Type, Representative City]

(Click here to see map of climate zones)

- ☑ 1A, **Very Hot - Humid** (Miami, FL)
- ☑ 2A, **Hot - Humid** (Houston, TX)
- ☑ 2B, **Hot - Dry** (Phoenix, AZ)
- ☑ 3A, **Warm - Humid** (Memphis, TN)
- ☑ 3B, **Warm - Dry** (El Paso, TX)
- ☑ 3C, **Warm - Marine** (San Francisco, CA)
- ☑ 4A, **Mixed - Humid** (Baltimore, MD)
- ☑ 4B, **Mixed - Dry** (Albuquerque, NM)
- ☑ 4C, **Mixed - Marine** (Salem, OR)
- ☑ 5A, **Cool - Humid** (Chicago, IL)
- ☑ 5B, **Cool - Dry** (Bosie, ID)
- ☑ 6A, **Cold - Humid** (Burlington, VT)
- ☑ 6B, **Cold - Dry** (Helena, MT)
- ☑ 7, **Very Cold** (Duluth, MN)
- ☑ 8, **Subarctic** (Fairbanks, AK)

Internet

Labs21 Benchmarking Tool - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Search Favorites Media

Address http://www.dc.lbl.gov/Labs21/Graphing.php Go

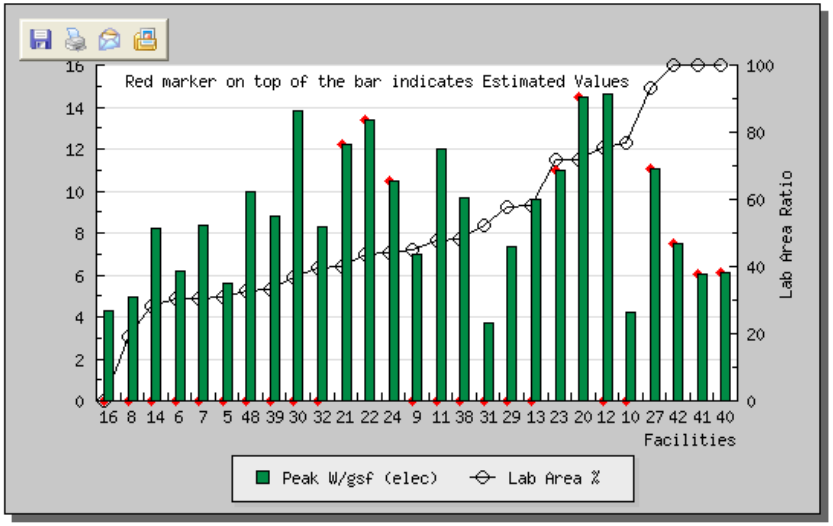
Benchmarking Results

How to read these results

User	**LBNL**
Organization	**Lawrence Berkeley National Laboratory**

Data and ID numbers for your facilities are highlighted in the table below

Total Building Peak W/gsf (elec)

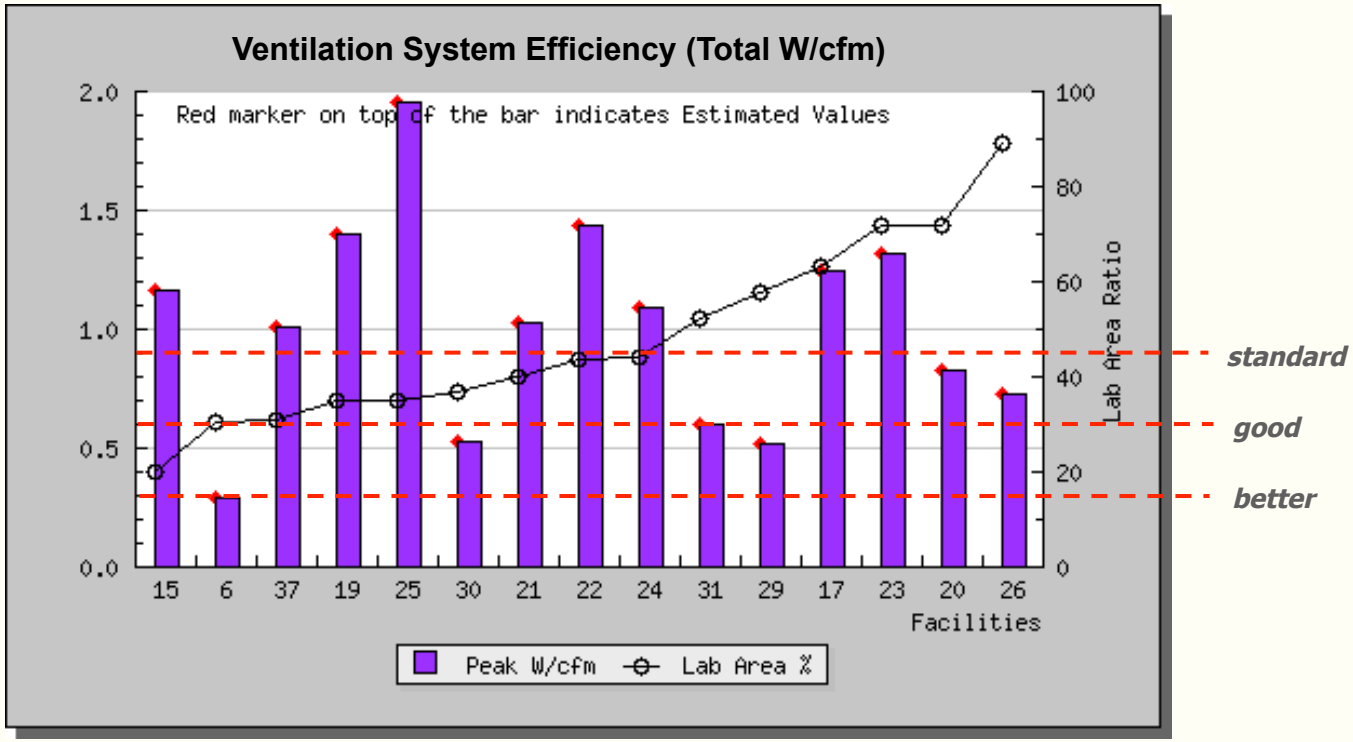


Facility	Peak Electric Demand(W)	Gross Area (sq.ft.)	Peak W/gsf (elec)	Lab Area Ratio	Occupancy Hours	Climate
16	2492000	578000	4.31	0	12	5A
8	270000	54962	4.91	0.19	12	3C
14	2556000	311617	8.2	0.28	24	6A
6	347000	55903	6.21	0.3	12	3C
7	369000	44152	8.36	0.31	12	3C
5	478000	85761	5.57	0.31	12	3C
48	412000	41233	9.99	0.33	12	4A

Internet

System Efficiency Metrics

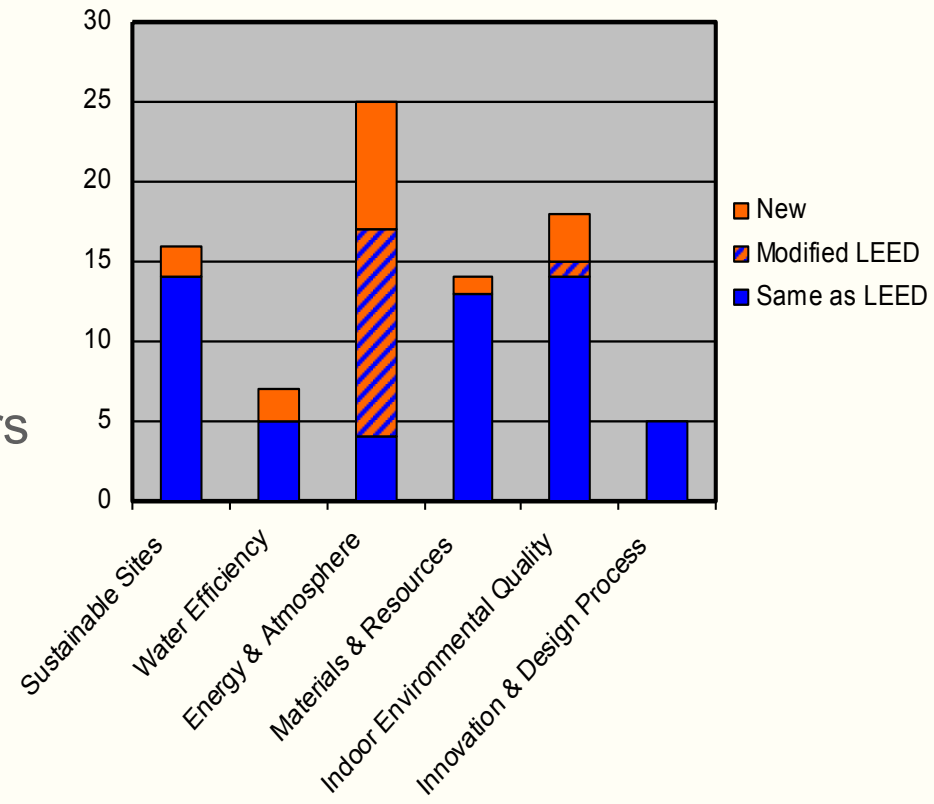
- System metrics especially useful in labs



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

Rating Sustainability

- Labs21 Environmental Performance Criteria
  - Point-based rating system
  - Leverages LEED 2.1
    - Adds new credits and prerequisites
    - Modifies existing credits and prerequisites
  - Over 40 industry volunteers
  - Version 2 released 2002



EPC: Extending LEED

- Emphasis on lab energy use, health & safety

Sustainable sites	CFD or wind tunnel modeling of air effluents Containment controls for liquid effluents
Water efficiency	Eliminate “once-through” cooling Process water efficiency
Energy and atmosphere	Optimize ventilation requirements Energy efficiency for lab systems Co-generation Laboratory plug-in equipment Right-sizing HVAC
Materials and resources	Tracking and managing hazardous materials
Indoor environmental quality	Meet ANSI-Z9.5 ventilation requirements CFD modeling of indoor airflow Fume hood commissioning per ASHRAE-110 Self-identifying and failsafe alarm systems

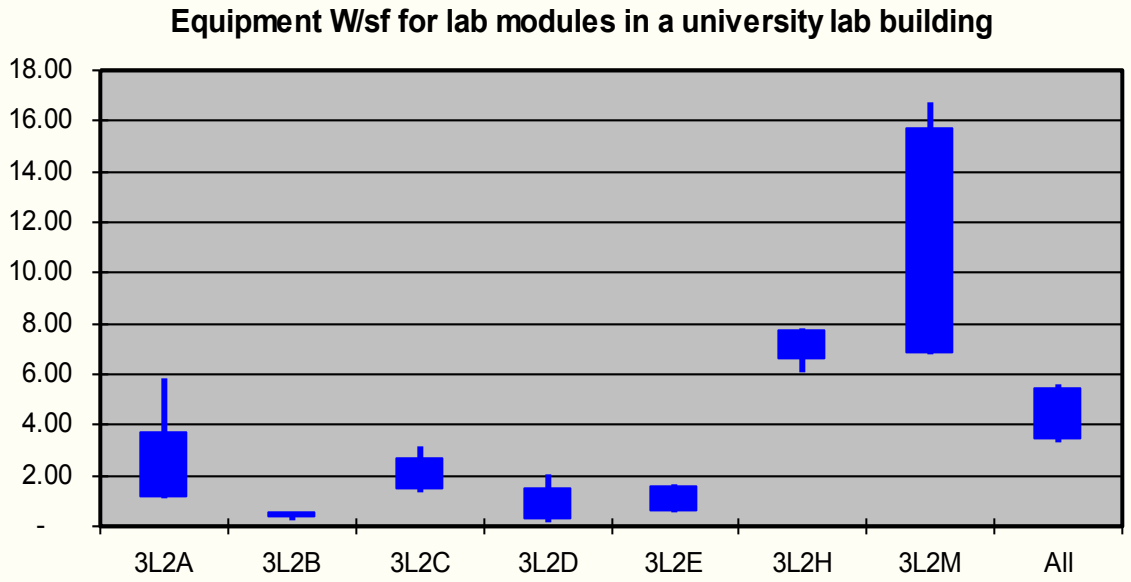
Energy Efficiency Credit

- "Points" for % reductions below ASHRAE 90.1 base

- Current Limitations (LEED/ASHRAE 90.1):
  - Fumehoods excluded from % reduction
  - Fan power limitations unrealistic for labs
  - Strategies not rewarded
    - High performance fumehoods
    - Minimizing reheat
    - Occupancy controls (?)
    - Low pressure drop design (?)
    - Cascading air supply (?)

Energy Efficiency Credit

- Labs21 modeling guidelines
  - "Supplement" to ASHRAE 90.1
  - Properly account for lab energy efficiency strategies
    - e.g. reheat due to plug load schedule diversity



Toward LEED for Labs

- EPC and LEED
  - Labs21 does not provide certification
  - EPC used for self-certification in many projects
    - Effective in lab design charrettes
  - Many EPC credits used for LEED innovation points

- USGBC developing LEED Application Guide for Laboratories (LEED-AGL)
  - Uses EPC as starting point
  - Draft expected Nov 04; Final expected mid-2005

Lessons Learned

- Significant efficiency opportunities in labs
- Need to adapt benchmarking and rating systems
  - Allow for diversity of functional requirements
    - Simulation-based benchmarking preferred
  - Consider energy use of core systems
  - System level metrics important
  - Ensure that rating approach accounts for all major efficiency strategies

- Don't ignore "niche" buildings – they can add up!


www.labs21century.gov

PAMathew@lbl.gov