DOE Smart Labs Symposium

Smart Benchmarking for Lab Buildings

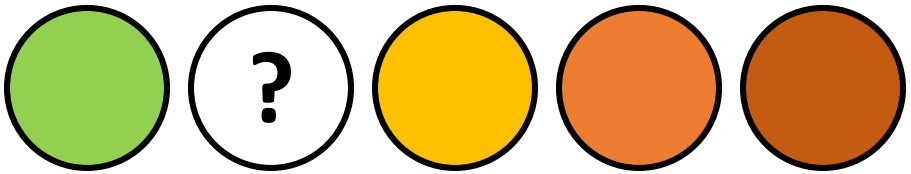
Alison Farmer

Outline

- Defining benchmarking
- Whole building energy benchmarking
  - The Labs21 Benchmarking Tool
  - Latest news and updates
- Future directions
  - The I^2SL Lab Benchmarking Tool and the Smart Labs Accelerator Program
    - Energy scores and the Boston data
    - Best practice benchmarking

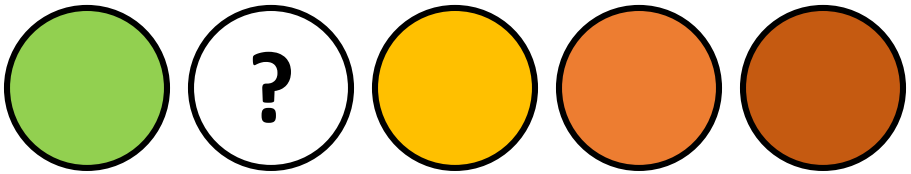
Defining Benchmarking

- Comparing ourselves to others
  - Often energy usage (but not always)
- Doing so constructively
  - Contextualizing
  - Ranking
  - Certifying
  - Prioritizing
  - Motivating
  - Inspiring



Energy Benchmarking

- Whole building energy usage
- Comparing buildings' energy consumption
  - Typically compare EUI (kBtu/sf/yr)
- Important for lab buildings
  - But difficult
  - Complex and varied functional requirements



Energy Benchmarking Demands

- LEED O&M
- AIA 2030 challenge
- ASHRAE energy audits
- Context for disclosed energy data
- Identify opportunities
- Prioritize portfolios
- Conversation starter
- Research and policy

LEED O&M Certification

Option 1. Benchmark against typical buildings

Path 1. National average data available

Demonstrate energy efficiency performance that is 25% better than the median energy performance of similar buildings by benchmarking against the national source energy data provided in the Portfolio Manager tool.

Path 2. National average data not available

If national average source energy data are unavailable for buildings of similar type, benchmark against the building site energy data of at least three similar buildings, normalized for climate, building use, and occupancy. Demonstrate a 25% improvement.

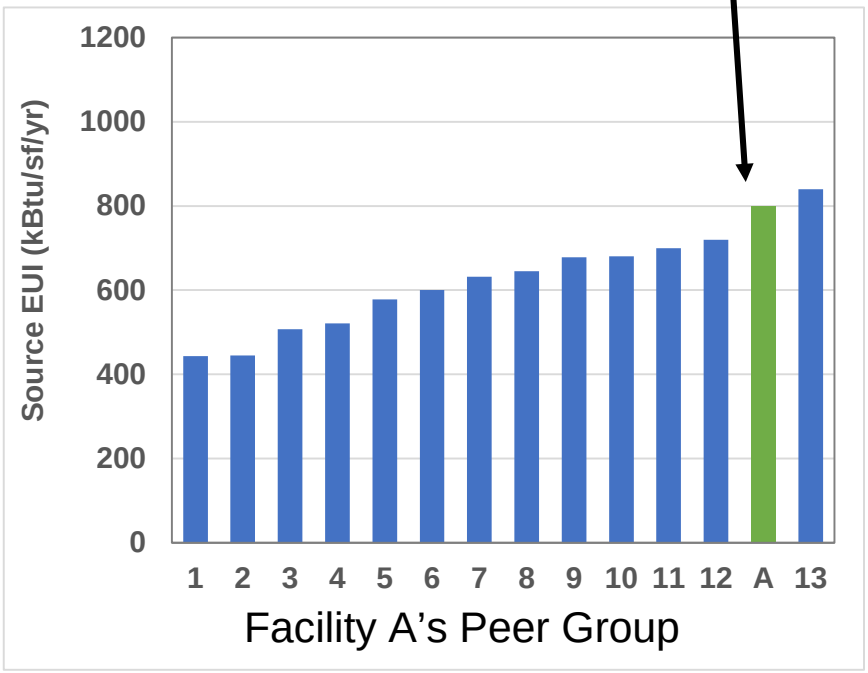
OR

Option 2. Benchmark against historical data

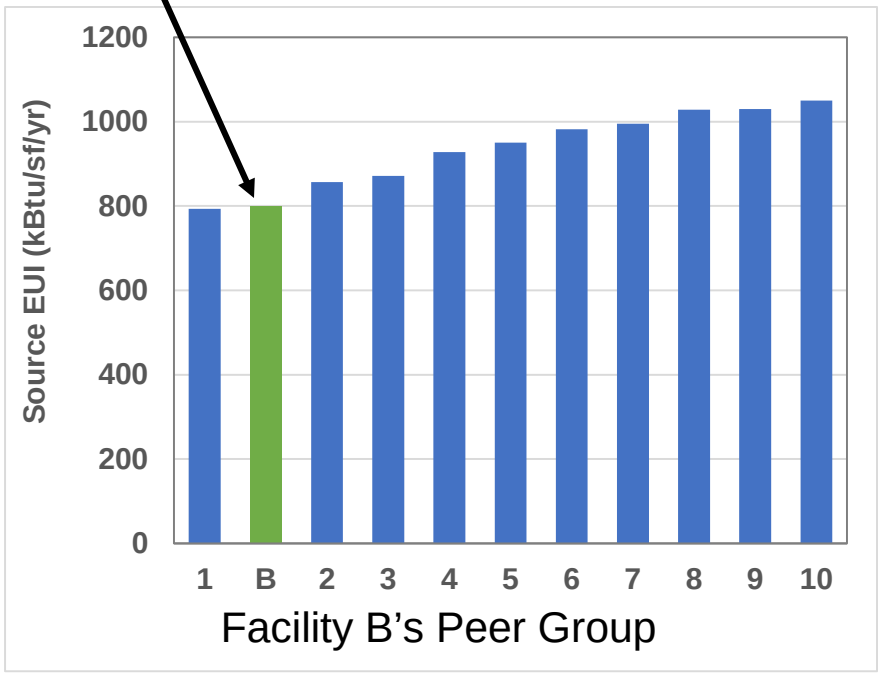
If national average source energy data are unavailable, compare the building's site energy data for the previous 12 months with the data from three contiguous years of the previous five, normalized for climate, building use, and occupancy. Demonstrate a 25% improvement.

Identifying Opportunities

What's going on here?



This seems good



Your facilities

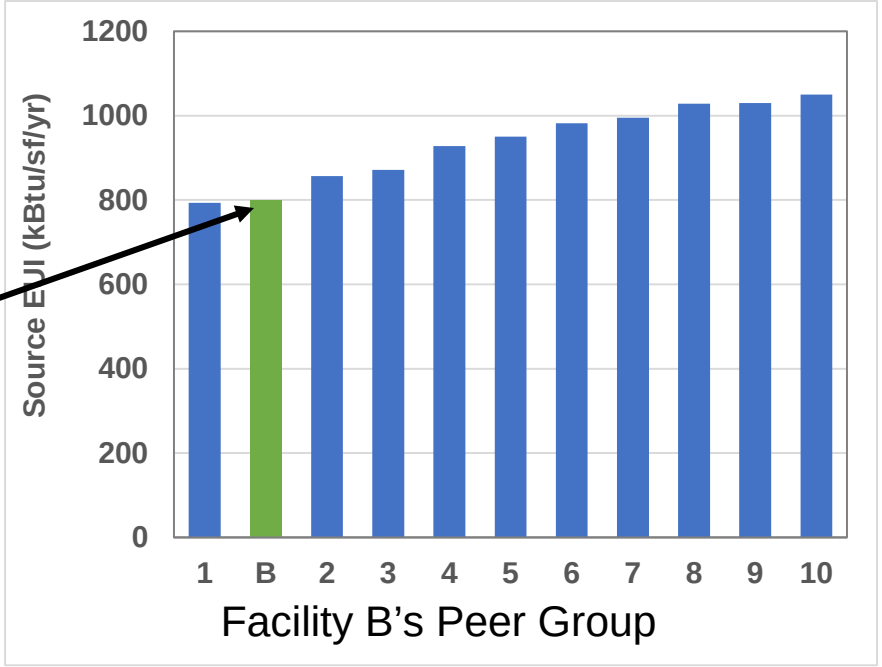
Other similar facilities

Starting Conversations

"What are the main energy drivers in your facility?"

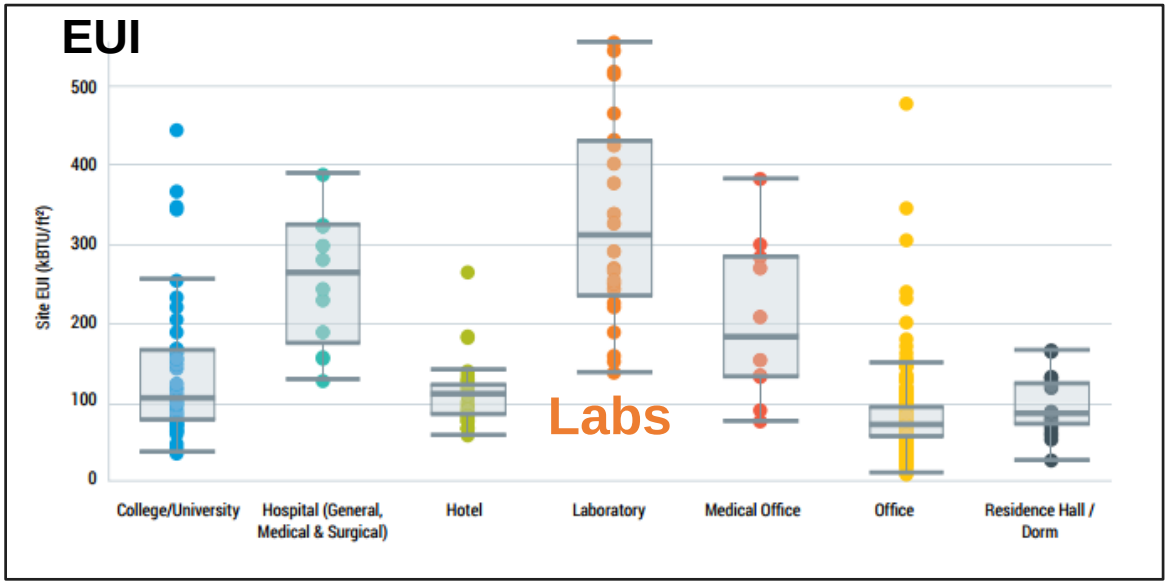
vs.

"Why might your building be **here** relative to its peers?"



Providing Context

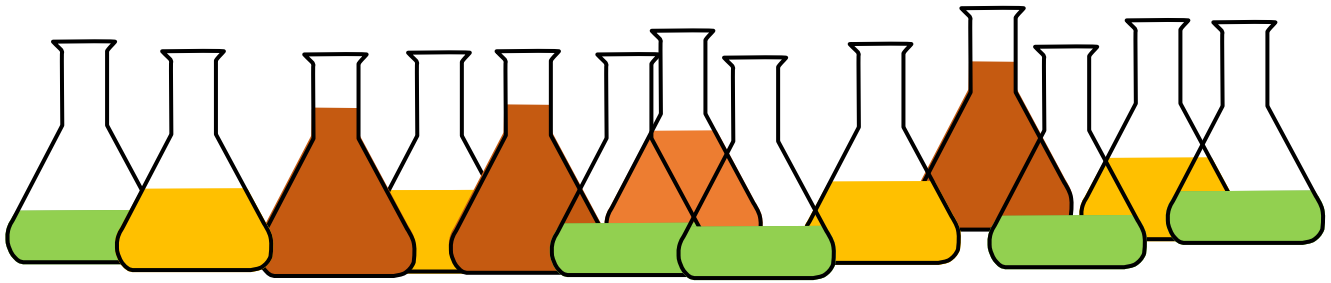
- Energy disclosure ordinances are on the rise
- All labs look like energy hogs
- No energy score to identify high-efficiency labs
- Consequences include audits, penalties, shame



from City of Boston BERDO report August 2015

Lab Benchmarking Datasets

- CBECS
- Portfolio Manager
- Energy disclosure datasets
- Data aggregators
- Private libraries
- The Labs21 Benchmarking Tool



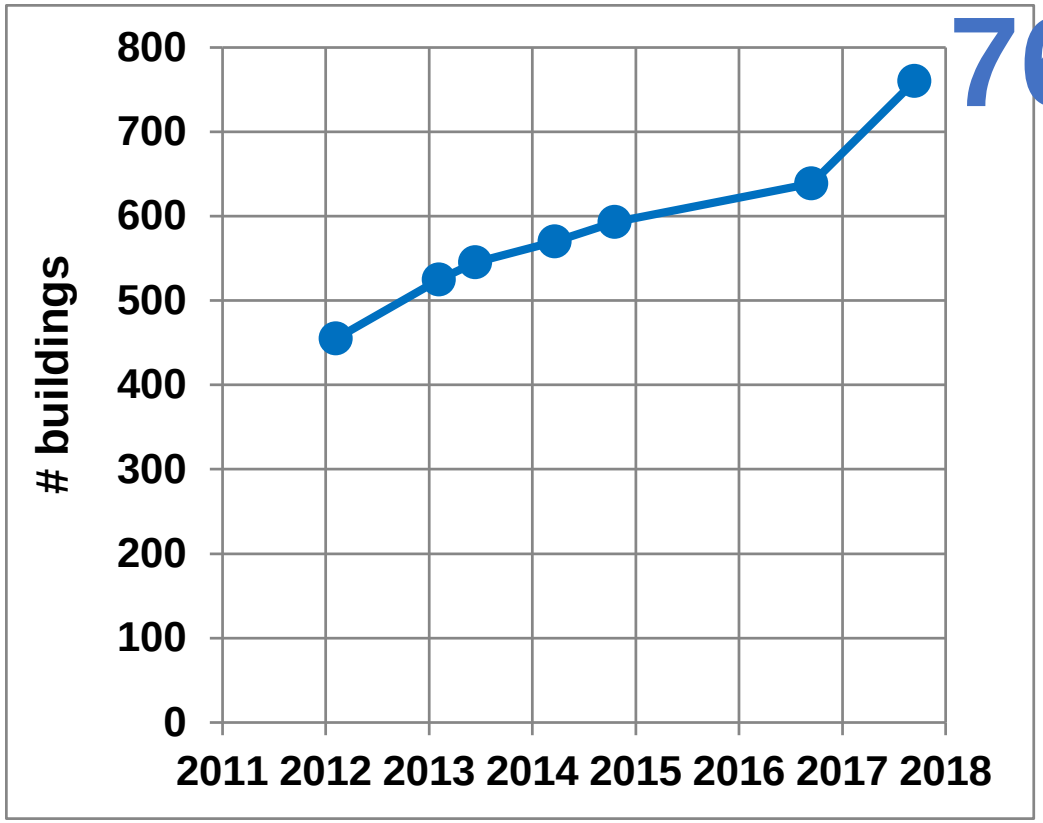
The Labs21 Benchmarking Tool

- Online crowdsourced database:
  - Lab building energy usage
  - Lab-specific functional requirements
- Developed by LBNL for Labs21 program
- Public since August 2002

labs21benchmarking.lbl.gov

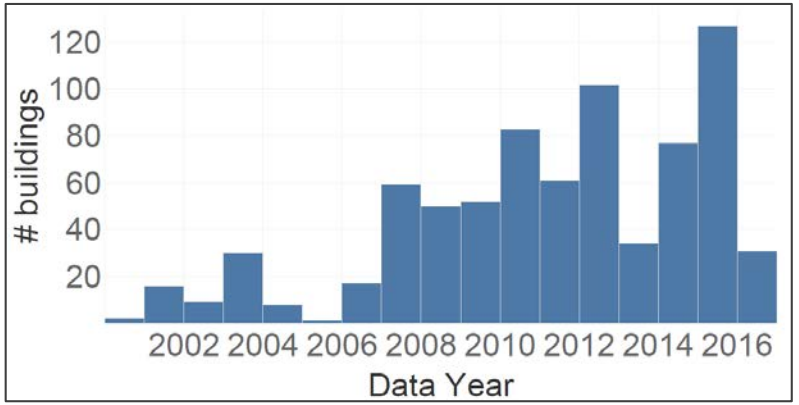
Labs21 Benchmarking Tool: Dataset

- Typically ~40 new buildings per year
- Big uptick recently



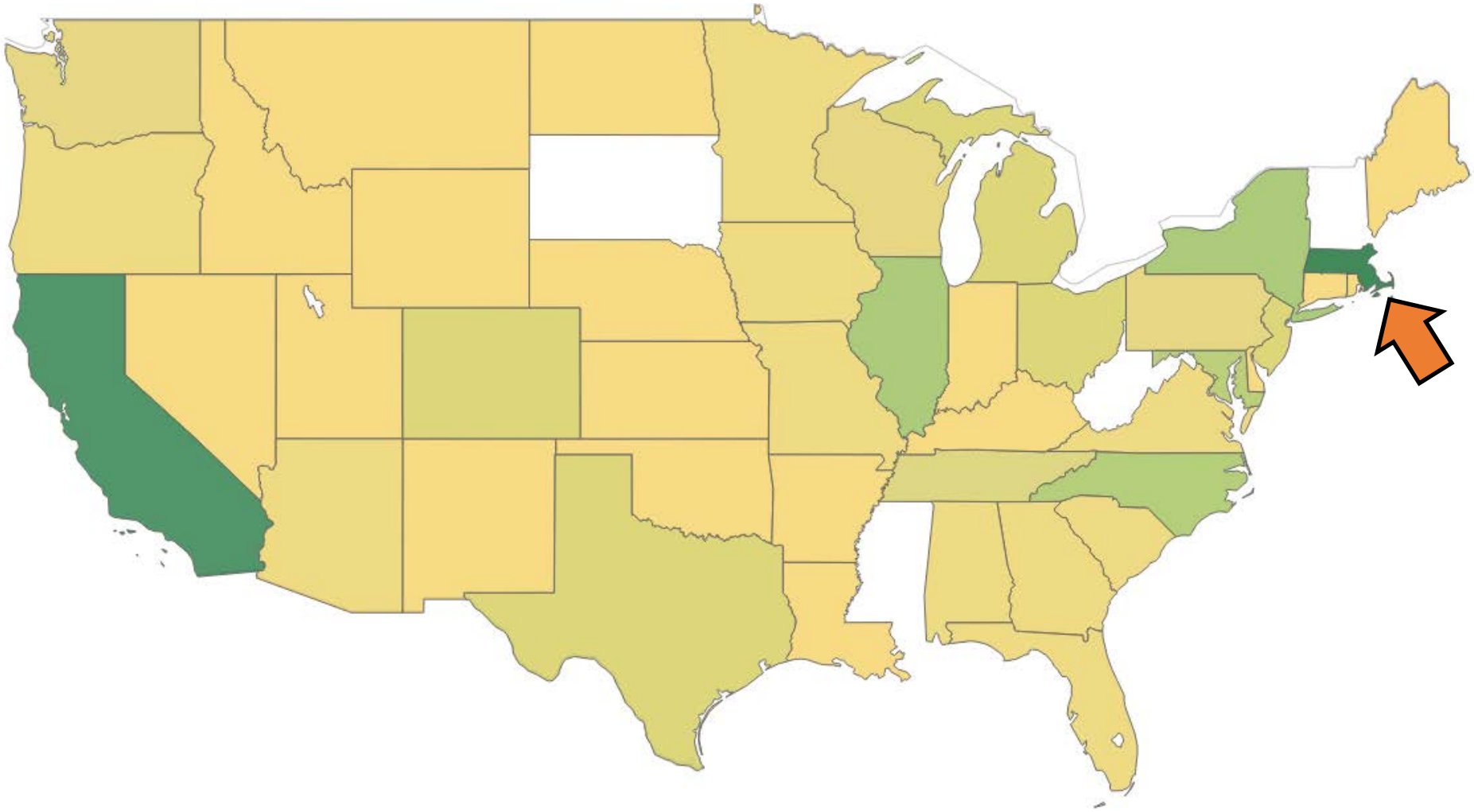
760!

Most of the data is pretty recent



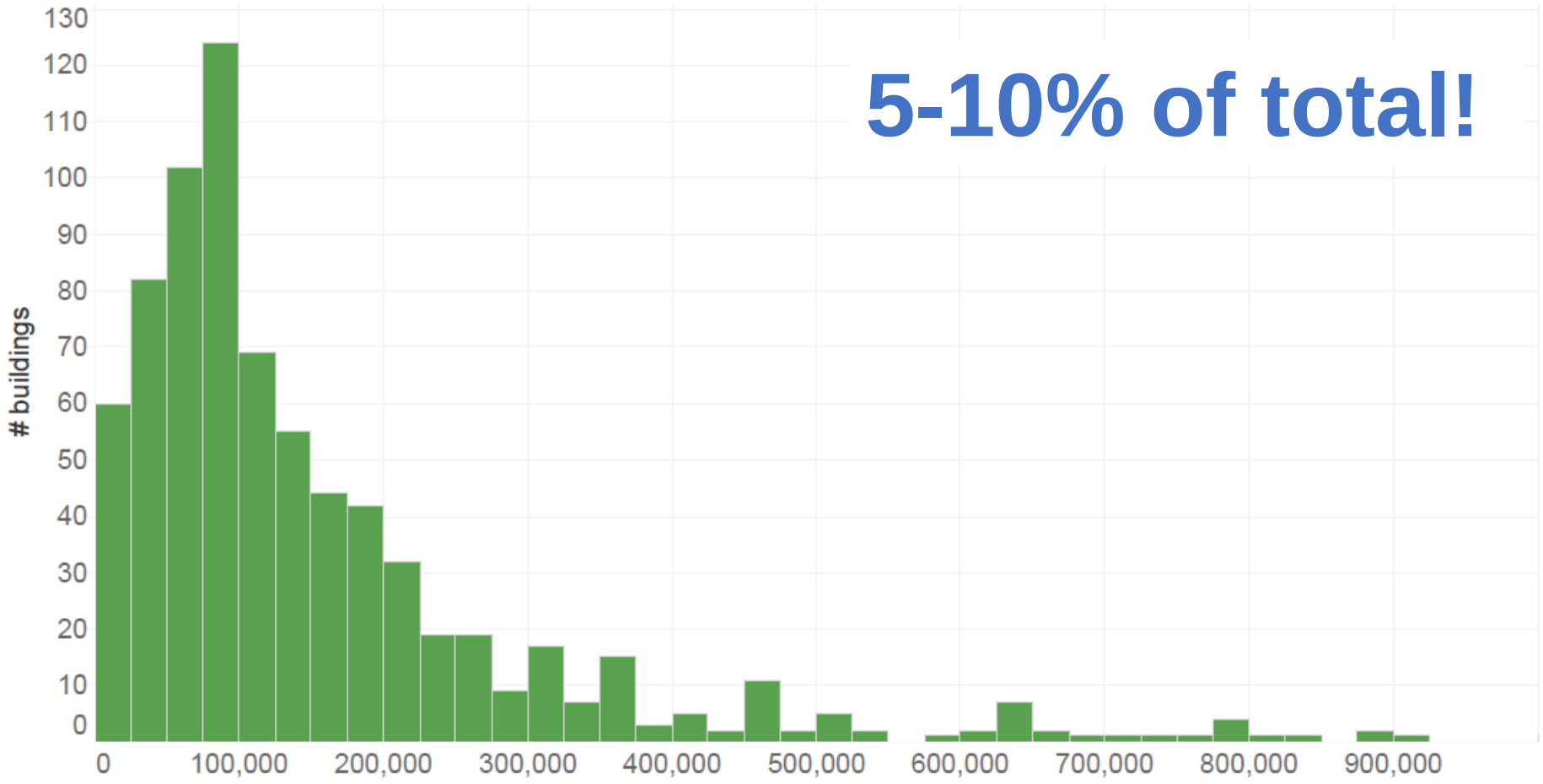
Labs21 Benchmarking Tool: Dataset

- Distribution of buildings across country



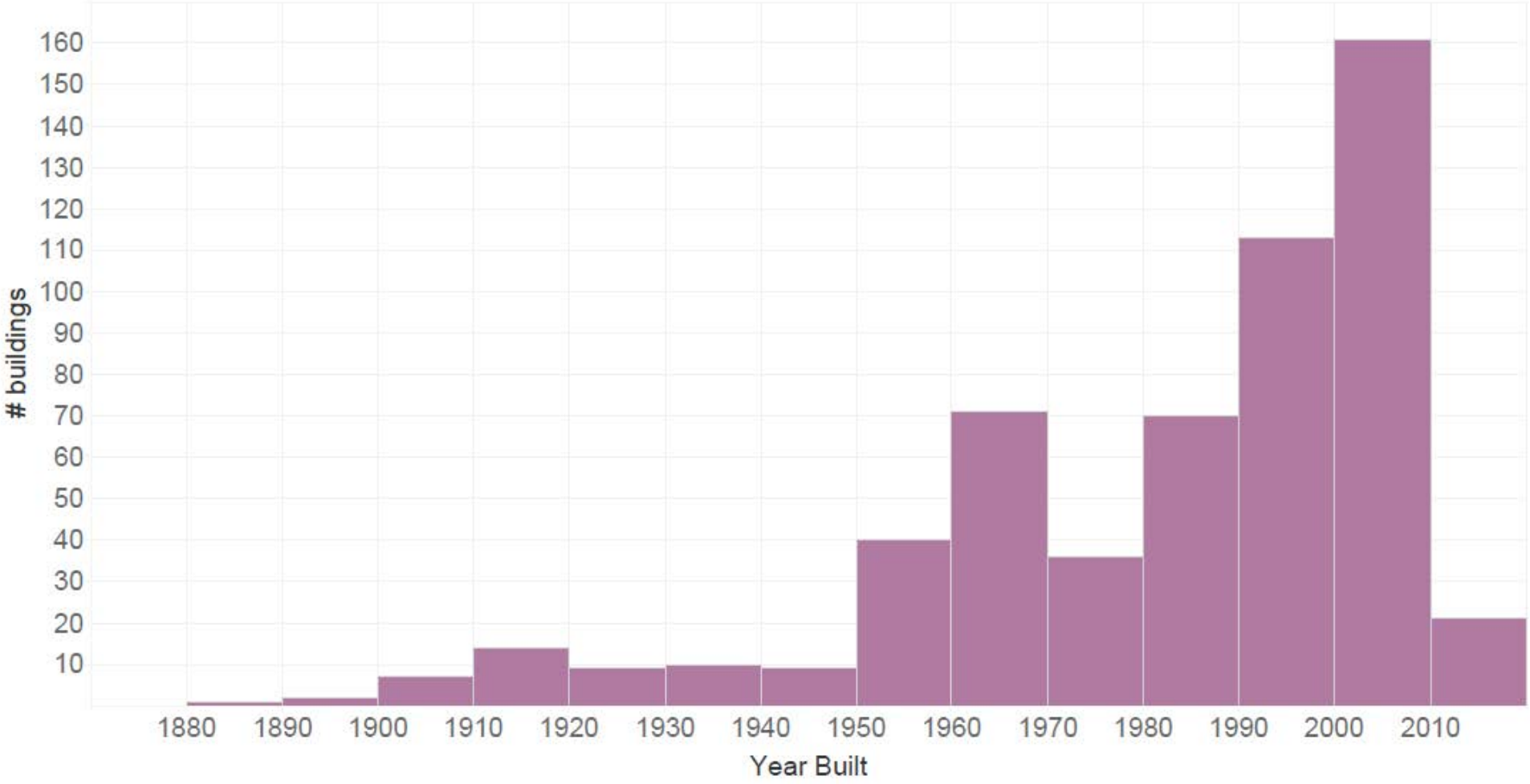
Labs21 Benchmarking Tool: Dataset

- 140 million sf of buildings
- 64 million sf of lab space

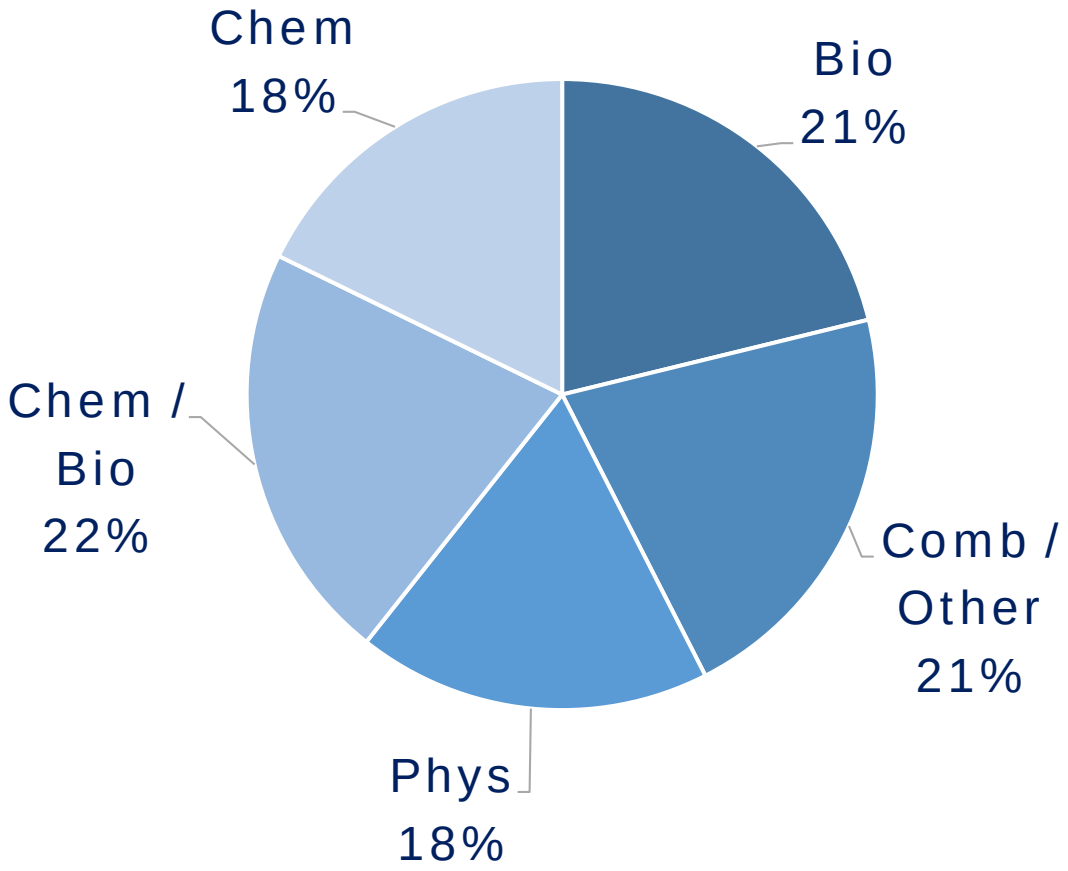


Labs21 Benchmarking Tool: Dataset

- Buildings from all eras



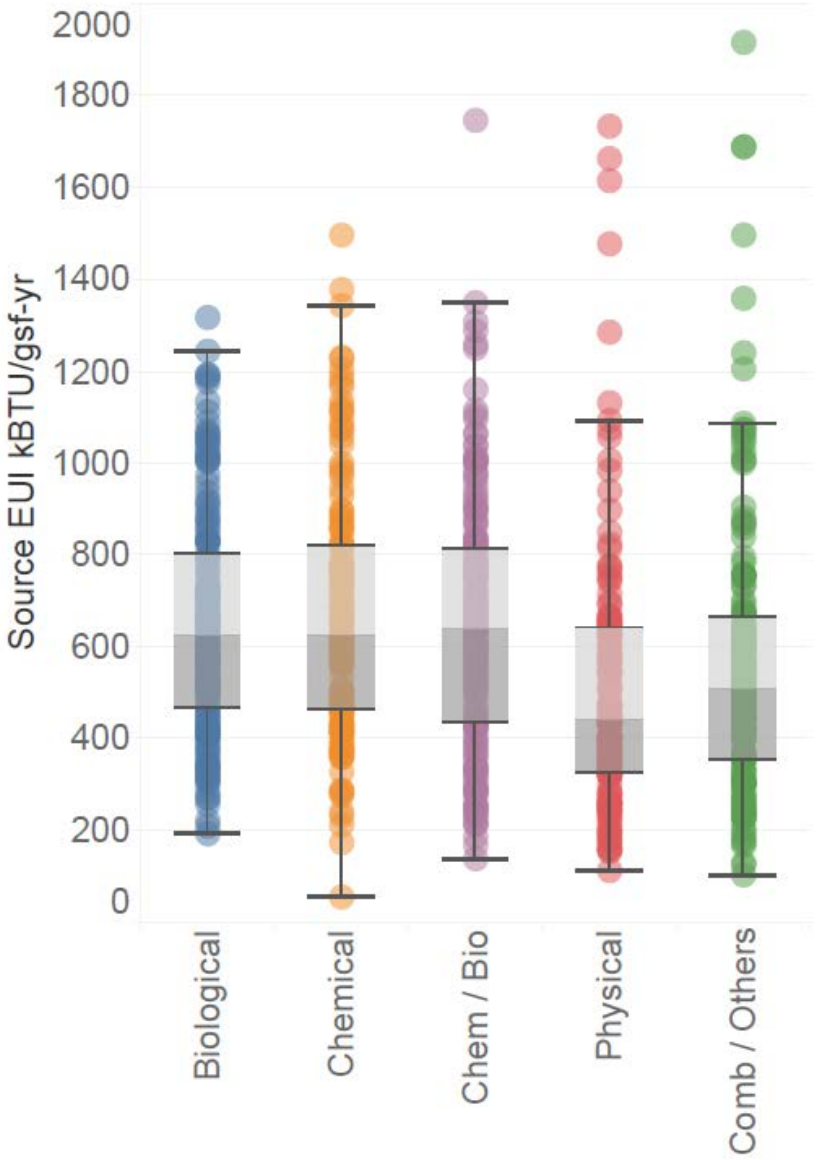
Labs21 Benchmarking Tool: Dataset



Lab Type

Most (75%) are from R&D and academic sectors

Labs21 Benchmarking Tool: Dataset



- Large spread of energy intensity
- Average source EUI: 580 kBtu/sf/yr
- Average site EUI: 270 kBtu/sf/yr
- Median lab area: 41%

Contributing to the Labs21 Dataset

Welcome to the Labs21 Benchmarking Tool!

Use this tool to compare the energy use of your lab buildings with that of similar facilities in the US. The tool's database contains owner-submitted data from an ever-growing number of lab facilities.

Buildings in database: 760

Last database update: August 2017

Enter Data

Enter your data into the database.
Your facilities appear in output reports.
Username and password required.

View Data

View data already in the database.
Output reports show database facilities only.
No login required.

Viewing the Labs21 Dataset

Welcome to the Labs21 Benchmarking Tool!

Use this tool to compare the energy use of your lab buildings with that of similar facilities in the US. The tool's database contains owner-submitted data from an ever-growing number of lab facilities.

Buildings in database: 760

Last database update: August 2017

Enter Data

Enter your data into the database.
Your facilities appear in output reports.
Username and password required.

View Data

View data already in the database.
Output reports show database facilities only.
No login required.

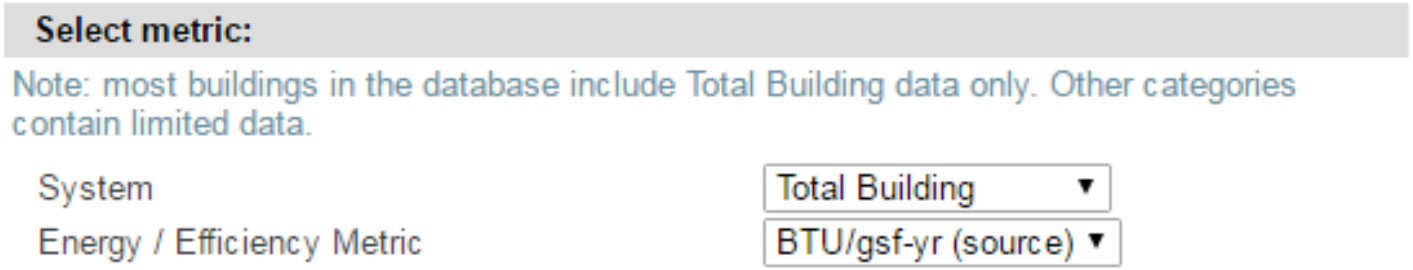
Benchmarking with the Labs21 Tool

Can be done via “Enter Data” and “View Data” pathways.

Benchmarking by data filtering:

1. Select metric for comparison
2. Select a peer group of buildings for comparison
3. Compare energy use intensity with peer group

1. Select Metric



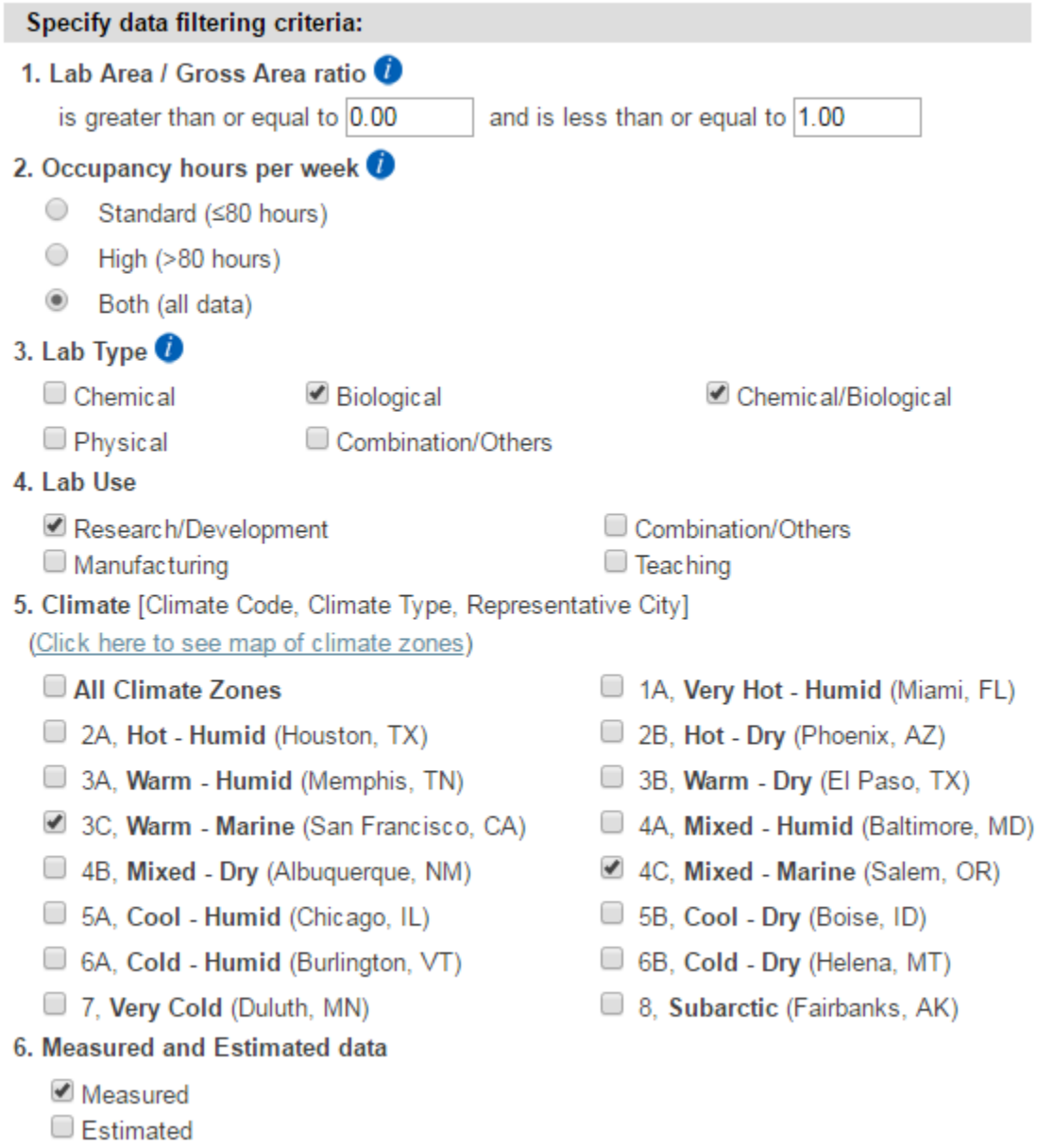
Tips:

- Total Building has the most data
- Source energy is the best metric
- Read the instructions and tooltips

2. Select Peer Group

Tips:

- Iterative process
- Expand selection if selected peer group is too small
  - Climate zone
  - Lab type
- Use measured data



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 hours per week

- ○ Standard (≤80 hours)
- ○ High (>80 hours)
- ◉ Both (all data)

3. Lab Type

- ☐ Chemical
- ☑ Biological
- ☑ Chemical/Biological
- ☐ Physical
- ☐ Combination/Others

4. Lab Use

- ☑ Research/Development
- ☐ Combination/Others
- ☐ Manufacturing
- ☐ Teaching

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

(Click here to see map of climate zones)

- ☐ **All 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** (Boise, ID)
- ☐ 6A, **Cold - Humid** (Burlington, VT)
- ☐ 6B, **Cold - Dry** (Helena, MT)
- ☐ 7, **Very Cold** (Duluth, MN)
- ☐ 8, **Subarctic** (Fairbanks, AK)

6. Measured and Estimated data

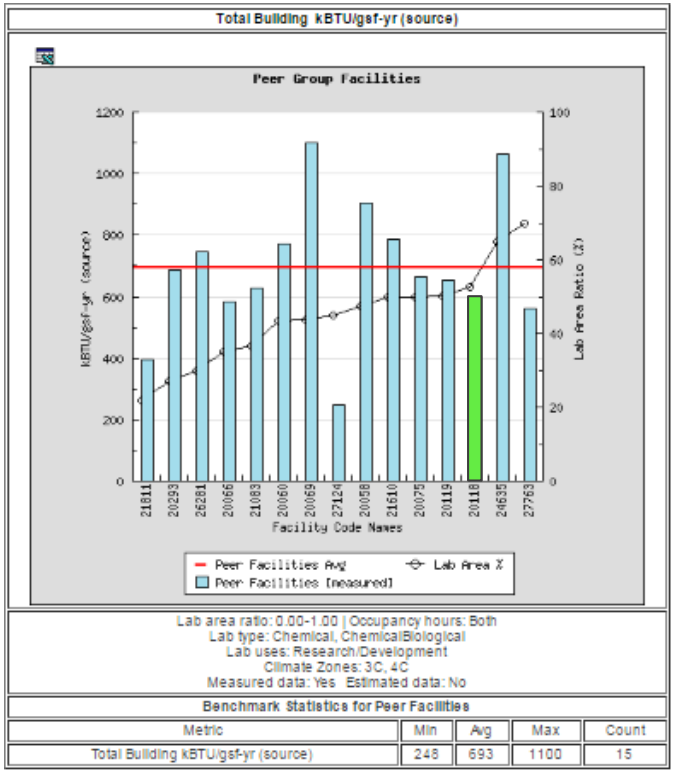
- ☑ Measured
- ☐ Estimated

3. Compare Energy Usage

- Chart shows EUIs of peer group facilities
- Red line is average EUI
- Facilities sorted in order of increasing % lab area
- Your facilities will also appear (if applicable)

Tips:

- Create your own plots using outputs



Lab area ratio: 0.00-1.00 | Occupancy hours: Both
Lab type: Chemical, ChemicalBiological
Lab uses: Research/Development
Climate Zones: 3C, 4C
Measured data: Yes Estimated data: No

Benchmark Statistics for Peer Facilities

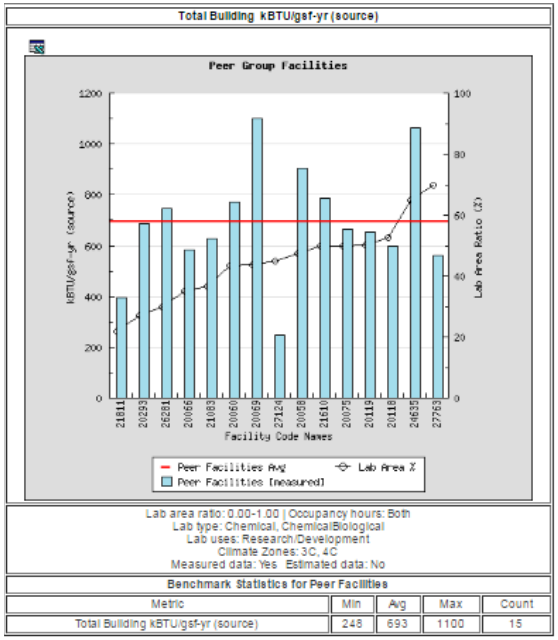
Metric	Min	Avg	Max	Count
Total Building kBTU/gsf-yr (source)	248	693	1100	15

Click titles of columns below to sort
Data for your facilities are highlighted | Estimated data are indicated in *Italics*

Facility	Lab Type	Year	kBTU/gsf-yr (source)	Lab Area Ratio	Occupancy hours per week	Climate
21811	Chemical	2009	395.26	22%	80	3C
20293	Chemical/Biological	2008	685.51	27%	168	3C
26281	Chemical/Biological	2007	747.57	30%	50	3C
20066	Chemical/Biological	2003	581.98	35%	72	3C
21083	Chemical/Biological	2010	629.08	37%	72	4C
20060	Chemical/Biological	2004	771.49	43%	72	3C
20069	Chemical	2003	1099.76	44%	72	3C
27124	Chemical/Biological	2012	248.05	45%	60	4C
20058	Chemical/Biological	2003	903.47	47%	72	3C
21610	Chemical/Biological	2009	786.8	50%	45	3C
20075	Chemical/Biological	2004	664.92	50%	66	4C
20119	Chemical	2014	654.07	50%	60	4C
20118	Chemical	2014	599.49	53%	60	4C
24635	Chemical/Biological	2011	1064.53	65%	80	3C
27763	Chemical/Biological	2012	560.2	70%	60	3C

Reformatting the Output

- Copy the output table into Excel



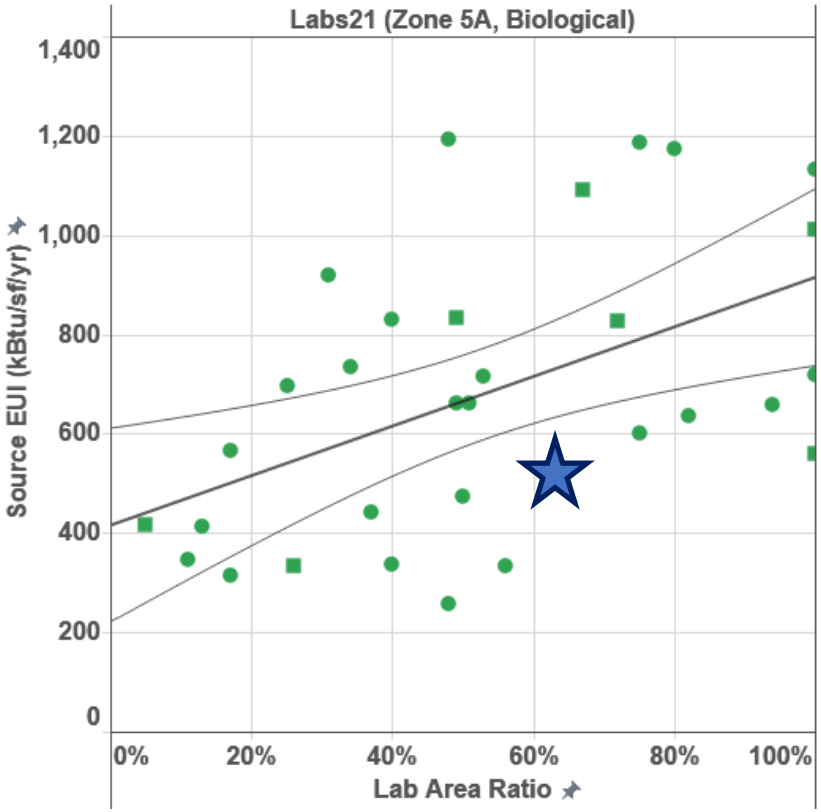
Lab area ratio: 0.00-1.00 | Occupancy hours: Both
Lab type: Chemical, ChemicalBiological
Lab uses: Research/Development
Climate Zones: 3C, 4C
Measured data: Yes Estimated data: No

Benchmark Statistics for Peer Facilities

Metric	Min	Avg	Max	Count
Total Building kBTU/gsf-yr (source)	248	693	1100	15

Click titles of columns below to sort
Data for your facilities are highlighted | Estimated data are indicated in *italics*

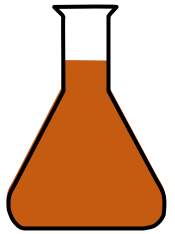
Facility	Lab Type	Year	kBTU/gsf-yr (source)	Lab Area Ratio	Occupancy hours per week	Climate
21811	Chemical	2009	395.26	22%	80	3C
20293	ChemicalBiological	2008	685.51	27%	168	3C
26281	ChemicalBiological	2007	747.57	30%	50	3C
20066	ChemicalBiological	2003	581.98	35%	72	3C
21083	ChemicalBiological	2010	629.08	37%	72	4C
20060	ChemicalBiological	2004	771.49	43%	72	3C
20069	Chemical	2003	1099.76	44%	72	3C
27124	ChemicalBiological	2012	248.05	45%	60	4C
20058	ChemicalBiological	2003	903.47	47%	72	3C
21610	ChemicalBiological	2009	786.8	50%	45	3C
20075	ChemicalBiological	2004	664.92	50%	66	4C
20119	Chemical	2014	654.07	50%	60	4C
20118	Chemical	2014	599.49	53%	60	4C
24635	ChemicalBiological	2011	1064.53	65%	80	3C
27763	ChemicalBiological	2012	560.2	70%	60	3C



Labs21 Benchmarking Tool: Summary

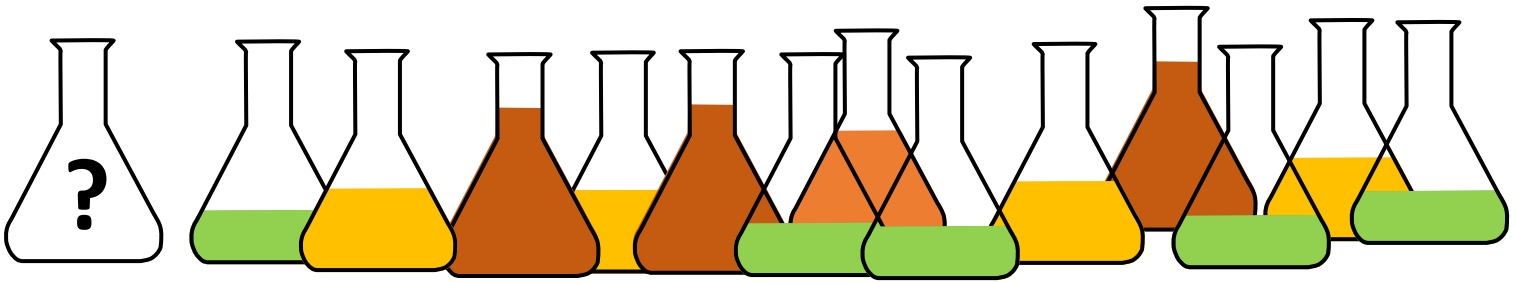
- Rich dataset
- Unsurpassed in size and function
- Simple to use
- Enormously useful

- But not perfect…



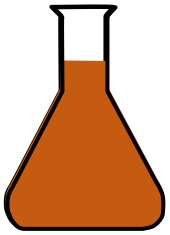
The I²SL Lab Benchmarking Working Group

- Volunteers from I²SL community
- Formed in 2014
- Mostly focused on Labs21 Benchmarking Tool
  - Preservation
  - Understanding usage and needs
  - Maintenance
  - Upgrades



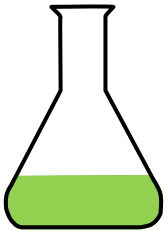
Working Group Achievements

- Identified areas for improvement:
  - Industry confusion about use and use cases
  - Infrequent database updates
  - Clunky interface
  - Data quality



Working Group Achievements

- Made improvements!
  - Industry confusion about use and use cases – 2014 survey; 2017 FAQs; 2015-17 conferences
  - Infrequent database updates – worked with LBNL staff; provided data reviews
  - Clunky interface – 2016 website facelift; “select all” buttons
  - Data quality – new 2016 regression analysis; live data checks
- Identified future opportunities



Before

Introduction

The purpose of this benchmarking database tool is to allow laboratory owners to compare the performance of their laboratory facilities to similar facilities and thereby help identify potential energy cost savings opportunities. The tool will allow benchmarking with energy use metrics (e.g. BTU/sf/yr) as well as system efficiency metrics (e.g. W/cfm).

To benchmark a facility, you will need to input facility characteristics (e.g. lab type, gross area) and energy use data (e.g. annual electricity use). Although measured data is preferred, estimated data may also be provided. The data you provide will remain anonymous to other users of the database.

Note: You will be prompted for a username and password in order to enter data and benchmark your lab. You may input data over multiple sessions. If you only wish to view the data, without inputing data for your lab, login is not required.

- Acquire a username and password, or edit your existing profile
- Bulk data input spreadsheet (to input 5 or more facilities)
- Guidance on how to use this tool for LEED-EB

Frequently Asked Questions

Benchmark Your Lab (login req'd)

View Data (as guest user)

After

BENCHMARKING

Welcome to the Labs21 Benchmarking Tool!

Use this tool to compare the energy use of your lab buildings with that of similar facilities in the US. The tool's database contains owner-submitted data from an ever-growing number of lab facilities.

Buildings in database: 760

Last database update: August 2017

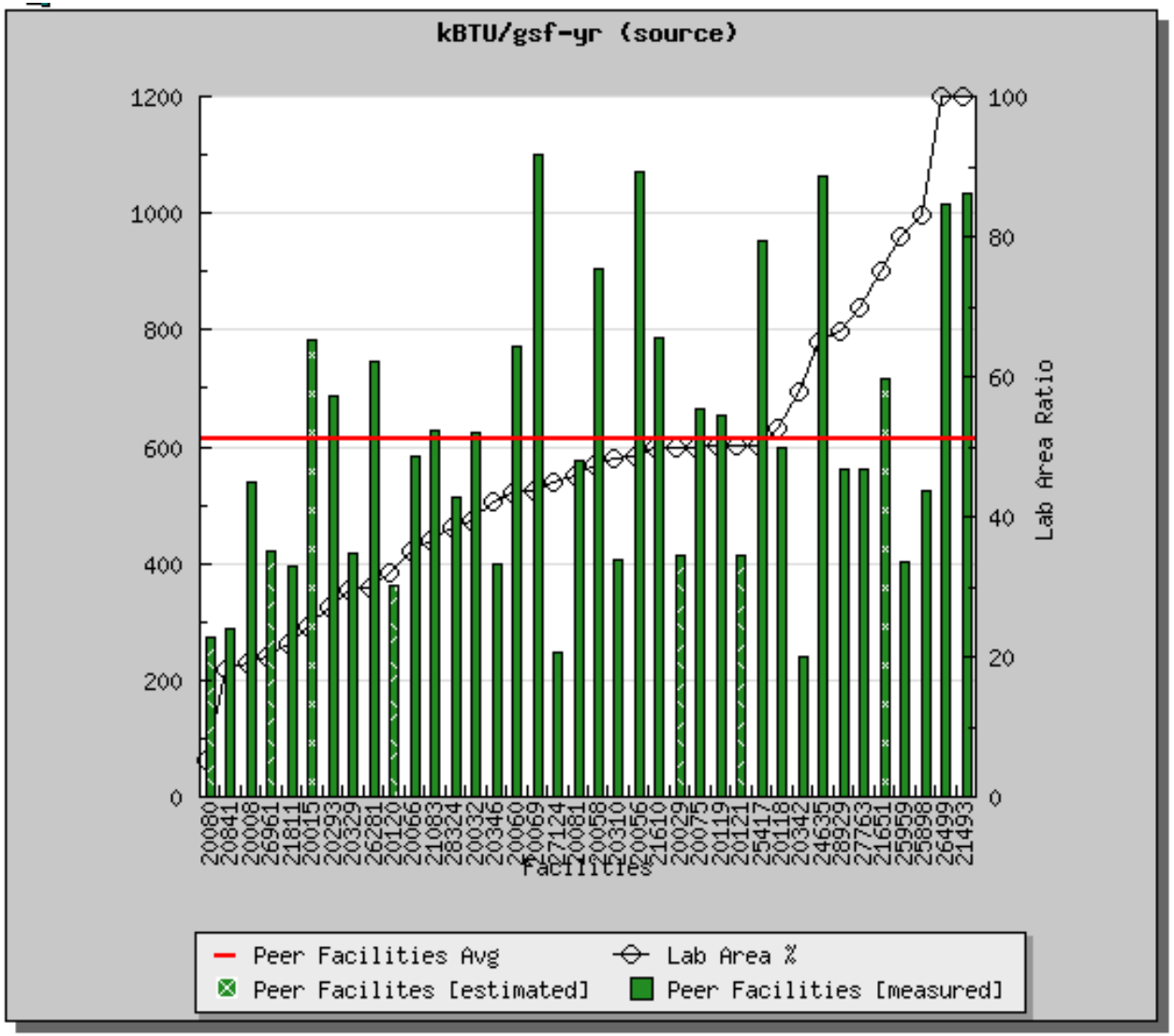
Enter Data

Enter your data into the database.
Your facilities appear in output reports.
Username and password required.

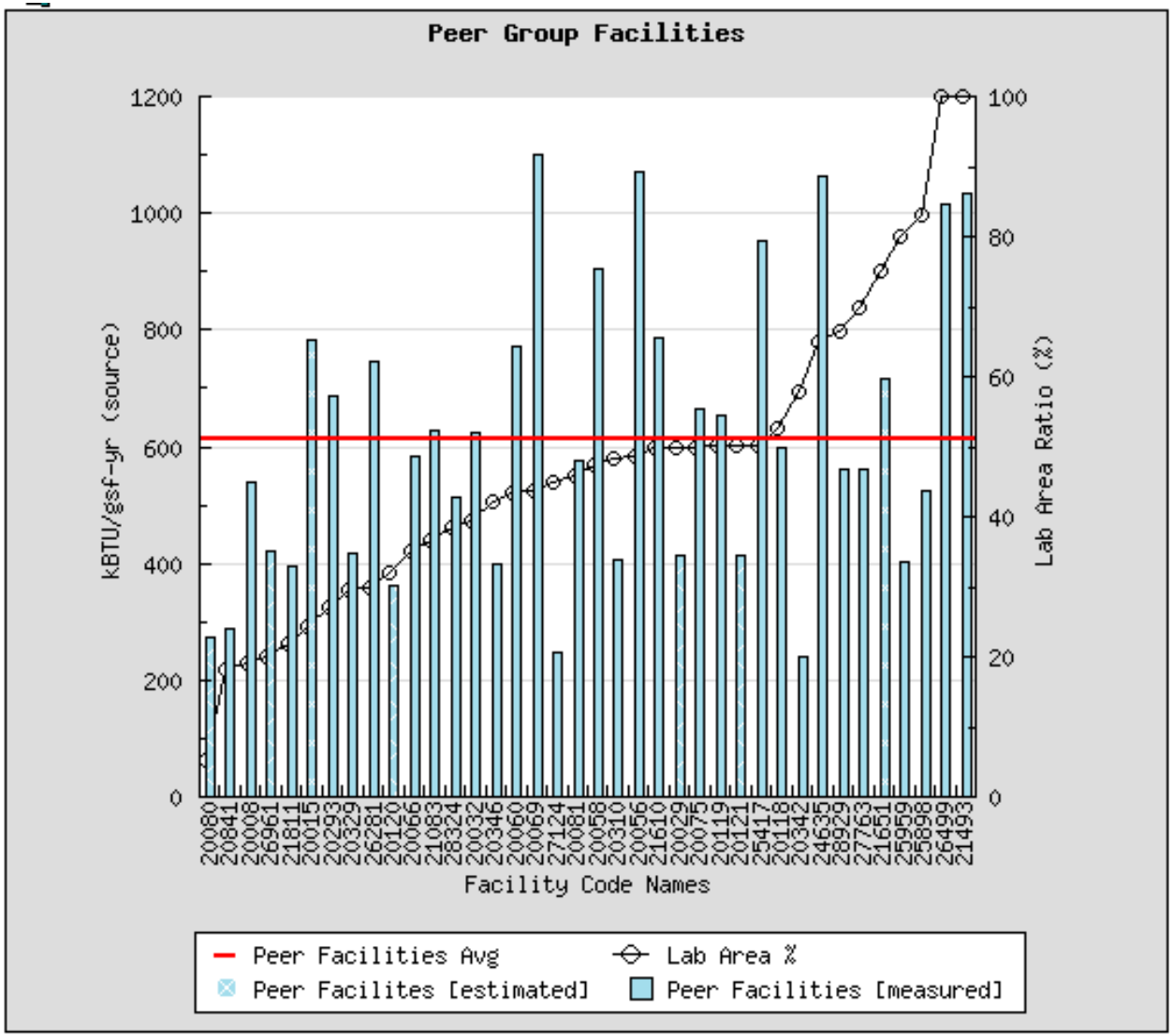
View Data

View data already in the database.
Output reports show database facilities only.
No login required.

Output Plot: Before



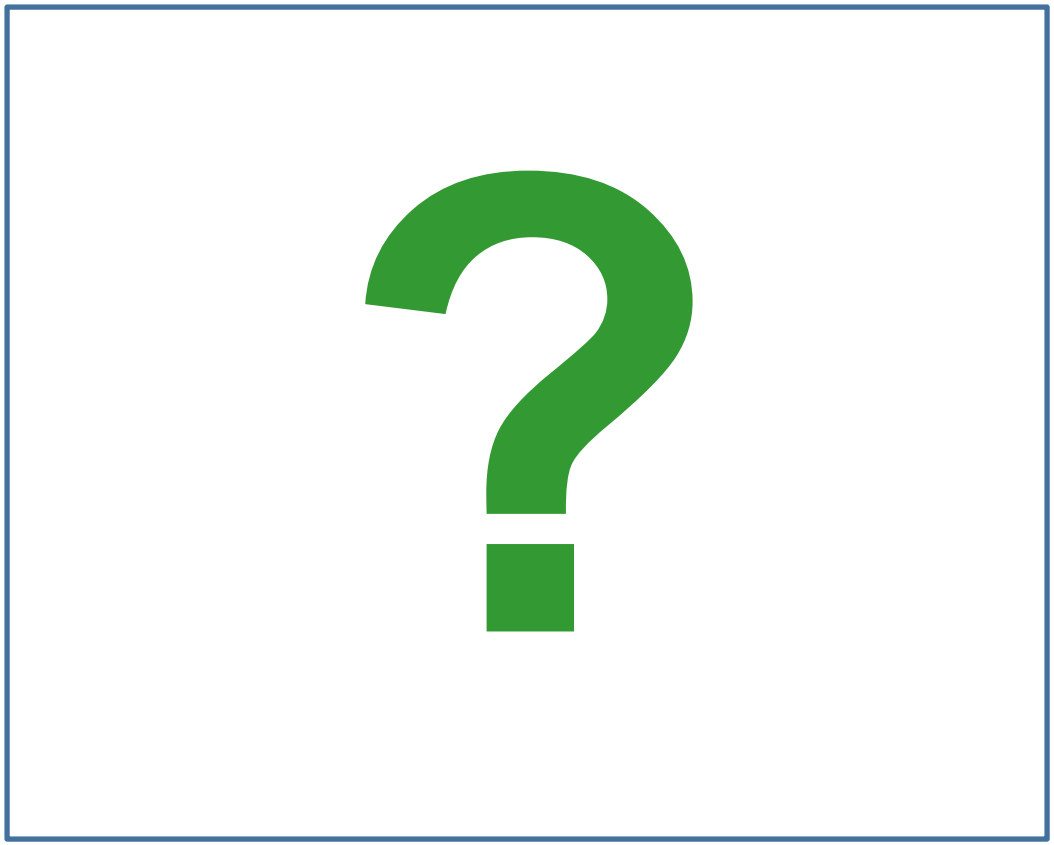
Output Plot: After



There is more work to be done…

What's Next?

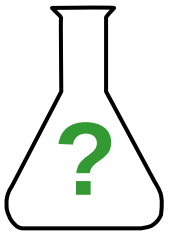
- New I^2SL lab benchmarking tool!



  - Support from DOE Smart Labs Accelerator Program
  - Continued collaboration with LBNL

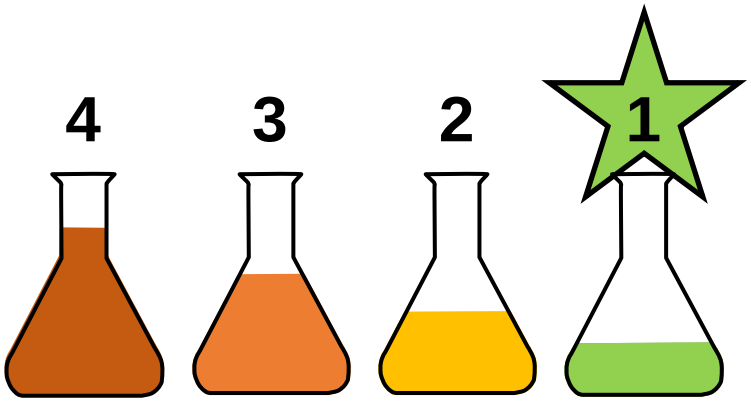
The New I²SL Benchmarking Tool

- An **excellent opportunity** for improvement!
  - New modern, more usable website and graphing
    - Improved data quality checks
  - Expanded data fields
    - e.g. water usage
  - Modernized lab building classifications
    - Maintain back-compatibility
  - Special case study buildings
  - Automatic connection to Portfolio Manager
  - Energy scores for lab buildings
  - Data submission drives
    - e.g. submeter data; underrepresented regions
  - Benchmarking operational practices



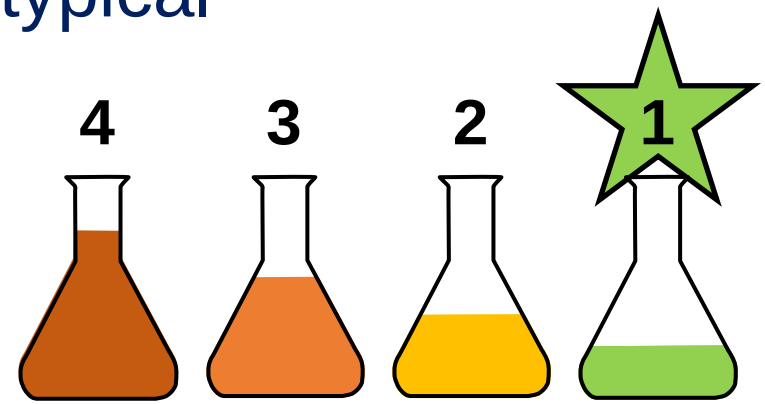
Lab Energy Scores

- Comparison is inevitable: can we make it fair(er)?
- Regression analysis like Energy Star?
  - Historically too much scatter in Labs21 data



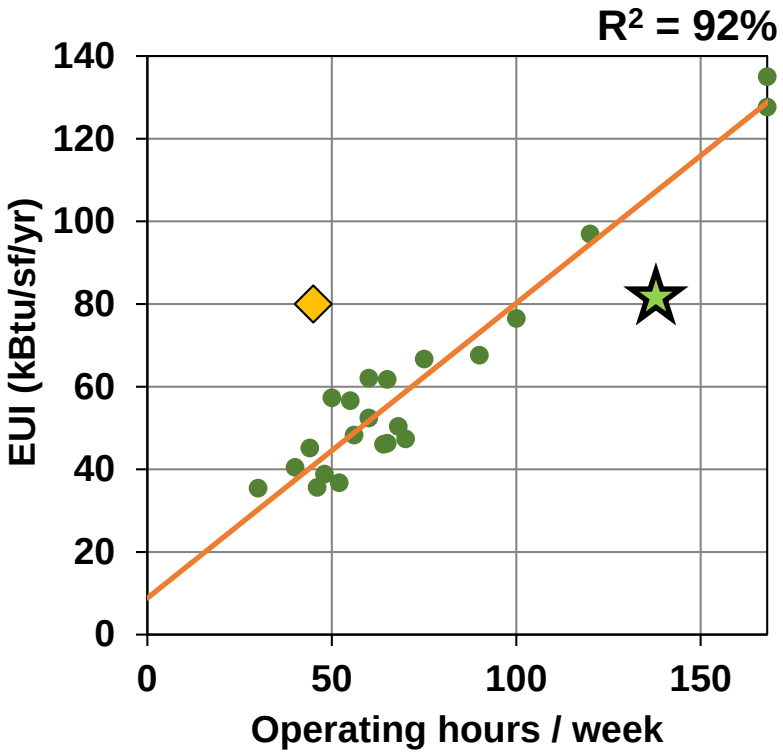
Regression Analysis: Approach

1. Identify functional requirements impacting energy use
2. Collect large dataset of buildings
3. Correlate energy use with requirements
4. Develop formula for energy use of “typical” building
5. Rank buildings against “typical”



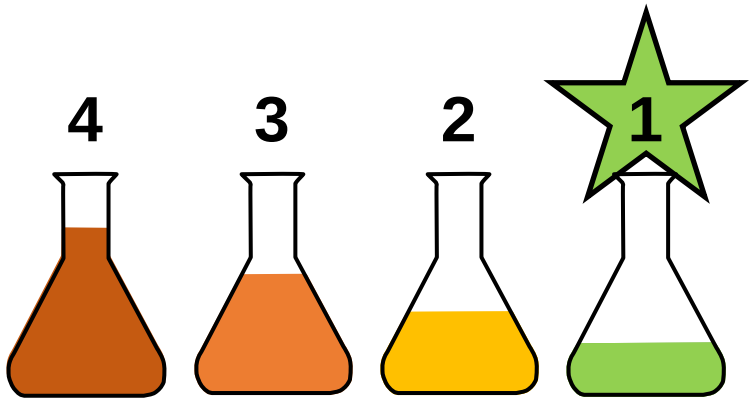
A Simple (Fake) Example

1. Operating hours should affect EUI
2. Collect sample of office buildings
3. Correlate EUI with operating hours
4. Score other buildings against best fit line
5. Diamond gets low score; star gets high score



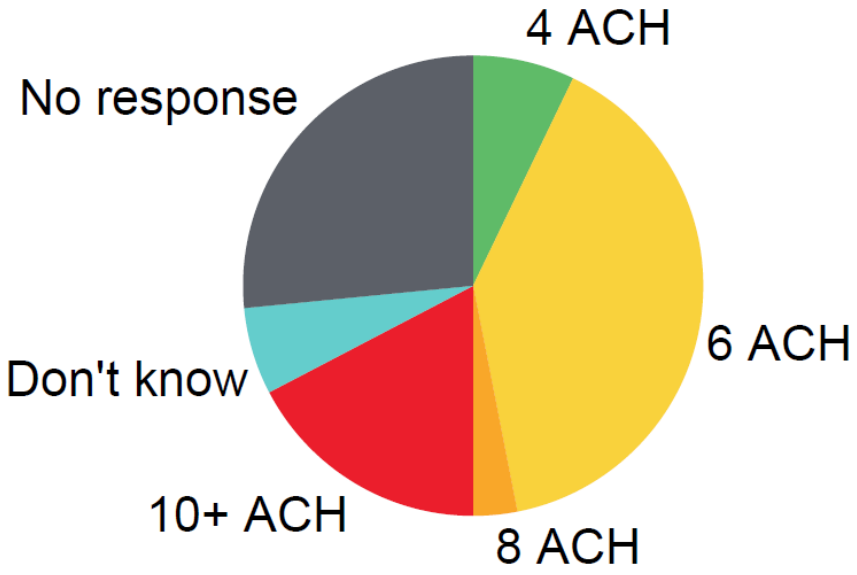
Lab Energy Scores

- **Boston** has been leading the way!
- Boston Green Ribbon Commission Higher Ed Working Group: draft energy score for lab buildings
  - Uses multilinear regression (like Energy Star)
  - High-quality dataset with less scatter than Labs21
  - Functional reqs: lab type, % lab area, #FHs / lab area, occ hours/wk
- Include in new I^2SL tool?



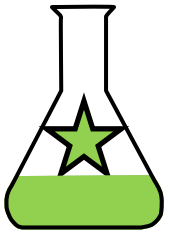
Benchmarking Operations

- Beyond energy benchmarking
- Compare **operational practices and policies**



- Useful for facilities:
  - Behind or ahead of the curve?
  - Demonstrate that projects have been achieved elsewhere
    - No need to reinvent from scratch
  - Best when combined with case studies
- Useful for community:
  - Take industry's pulse
  - Identify trends

Summary

- Industry demands benchmarking for lab buildings
- The Labs21 tool is a unique, valuable, simple, and free lab benchmarking resource
- Successful collaboration between I^{2}SL and LBNL has enhanced our resources
  - More improvements coming soon
  - Let us know what you need!

- **Working Group Meeting:** Wed 1pm