Laboratories for the 21st Century – An Overview
Why Focus on Laboratories?

- Laboratories are energy intensive.
  - On a square foot basis, labs often consume ten times as much energy as a typical office building.
- Most existing labs can reduce energy use by 30% or more with existing technology.
- Reducing laboratory energy use will significantly reduce greenhouse gas emissions.
- Energy cost savings possible from U.S. labs may be as much as $2.4 billion annually.
- Labs are typically not speculative buildings—informed owners are more likely to invest with lifecycle costs in mind.
Whole Building Design Approach for Laboratories

- Optimize overall laboratory performance through integrated design and engineering with a life-cycle cost perspective.
- Avoid the traditional approach of optimizing components based on narrowly defined functions.
- Consider benefits of sustainability.
Sustainability – Beyond Energy

- Water conservation and recovery
- Building materials reduction, reuse, and recycling
- Health and safety risk management
- Innovations in chemical management
- Building for flexibility in design
Laboratories for the 21st Century – Labs21 Basics

- Adopt aggressive low-energy design and operation targets.
- Assess opportunities from a “whole buildings” approach.
- Use life-cycle cost decision-making.
- Commission equipment and controls.
- Employ a broad range of sustainable energy and water efficiency strategies.
- Measure energy and water consumption and track emission reductions.
Laboratories for the 21st Century – Labs21 Basics...

- Evaluate on-site power generation, combined heat and power technologies, and renewable power purchases.
- Specify “green” construction materials.
- Promote energy and water efficiency operation and training efforts.
- Explore sustainable design opportunities beyond the building site.
  - For example, campus-wide utility or mass transit projects.
What is the Labs21 Program?

- A joint EPA/DOE program to improve the environmental performance of U.S. laboratories.

- The goal of the program is to encourage the design, construction, and operation of sustainable, high-performance, facilities that will:
  - Minimize overall environmental impacts.
  - Protect occupant safety.
  - Optimize whole building efficiency on a life-cycle basis.
Labs21 Program Components

- Pilot Partnership Program
  - Draws together lab owners and operators committed to implementing high performance lab design.
- Training Program
  - Includes annual technical conference, training workshops, and other peer review opportunities.
- Best Practices and Tool Kit
  - An Internet-accessible compendium of case studies and other information on lab design and operation, building on the Design Guide for Energy Efficient Research Laboratories developed by Lawrence Berkeley National Laboratory, and more...
Partnership Program

- **Private-Sector Partners**
  - Bristol-Myers Squibb
  - Carnegie Mellon University
  - Duke University
  - Harvard University
  - Raytheon Company
  - University of California-Merced
  - University of Hawaii
  - University of North Carolina-Asheville
  - Wyeth-Ayerst Pharmaceuticals
  - New York City School Construction Authority

- **Federal partners:**
  - Lawrence Berkeley National Laboratory
  - National Renewable Energy Laboratory
  - National Oceanic & Atmospheric Administration
  - Sandia National Laboratories
  - U.S. Environmental Protection Agency
Labs21 Training Program

- Workshop Course Topics

  Architecture of High-Performance Laboratories
  Engineering and Energy-Efficient Lab Design
  Air Supply and Distribution Systems
  Laboratory Exhaust Systems
  Commissioning and Direct Digital Controls
  Lighting and Daylighting
  Sustainability and Green-Design Techniques
  Case Studies
  Resources and Tools
Labs21 Best Practices
Environmental Performance Criteria (EPC)
Based on US Green Building Council’s LEED™ Rating System

- Sustainable Sites
  Safety and Risk Management
- Water Efficiency
  Laboratory Equipment Water Use
  Process Water Efficiency
- Energy and Atmosphere
  Minimum Energy Performance
  Minimum Ventilation Requirements
  Optimize Energy Efficiency
  Renewable Energy
  Energy Supply Efficiency
  Improved Laboratory Equipment Efficiency
  Right-Sizing Laboratory Equipment Load
- Materials and Resources
  Hazardous Materials Handling
  Chemical Resource Management
- Indoor Environmental Quality
  Laboratory Ventilation
  Exterior Door Notification System
  Controllability of Systems
  Indoor Environmental Safety
- Innovation and Design Process
Labs21 Tool Kit

The Labs21 program has developed a Tool Kit of resources to support the design, construction, and operation of high-performance laboratories. The tools include design guides, case studies, a performance rating system, a video, and other products that are planned or under development.

Explore the Tool Kit by selecting one of the following items:

**For an overview:**
- Introduction to Low Energy Design
- Labs21 Video

**Core information resources:**
- Best Design Practices: New Construction
- Labs21 Scenarios: New Science
- Energy Benchmarking

**Design practice tools:**
- Environmental Performance Indices
- Design Intent Tools: New Release 1.1

Recapping...

**Benefits of the Labs21 Approach**

- Reduce operating costs.
- Improve environmental quality.
- Expand capacity.
- Increase health, safety, and worker productivity.
- Improve maintenance and reliability.
- Enhance community relations.
- Maintain recruitment and retention of scientists.
Sustainable Design Process using the Labs21 Toolkit
Tools and Process

- Sustainable design process
  - Seamlessly integrates sustainability into the decision-making process
  - Team-based approach

- The Labs21 toolkit is an interlinked set of tools that can effectively support a sustainable design process

- The toolkit does not prescribe a fixed process

- Tools are interlinked but can be used independently if desired.
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Explore the Tool Kit by selecting one of the following items:

For an overview:
- Introduction to Low Energy Design
- Labs21 Video

Core information resources:
- A Design Guide for Energy Efficient Research Labs
- New Release 3.0
- Lab Designing Guide New Edition
- Labs21 Scoring Tool New Rating System
- Energy Benchmarking

Design process tools:
- Environmental Performance Index
- Design Score Tool New Release 1.1
- Labs21 Design Score Tool New Edition

last updated: March 10, 2014
The Toolkit

- **Overview resources**
  - Intro to Low-Energy Design
  - Labs21 Video

- **Core information resources**
  - A Design Guide for Energy-Efficient Research Labs, Ver. 4.0
  - Best Practice Guides *(New Guide)*
  - Case Studies *(New Studies)*
  - Energy Benchmarking

- **Design process tools**
  - Design Intent Tool, Version 1.1
  - Environmental Performance Criteria

*Two Sources: Toolkit CD, Labs21 website*
Overview resources

Intro to Low-Energy Design

Laboratories for the 21st Century:
An Introduction to Low-Energy Design

As a building type, the laboratory demands our attention. When the cathedral was in the 14th century, the main station was in the 9th century, and the office building was in the 20th century, the laboratory is in the 21st century. That is, it is the building type that embodies, in both program and technology, the spirit and culture of our age and attracts some of the greatest minds (both and economic resources of our society.

Unfortunately, a laboratory is also a prodigious consumer of natural resources. For example, laboratories typically consume five to ten times more energy per square foot than do office buildings. And some specialty laboratories, such as cleanrooms and labs with large process systems, can consume as much as 10 times the energy of a similarly sized institutional or commercial structure.

The challenge for architects, engineers, and other building professionals is to design and construct the next generation of laboratories with energy efficiency, renewable energy sources, and sustainable construction practices in mind. And to do so while maintaining - and even advancing - the contemporary standards of comfort, health, and safety.

If successful, the benefits will be significant. Assuming that half of all American laboratories can reduce energy use by 30%, the U.S. Environmental Protection Agency (EPA) estimates that the nation could reduce its annual energy consumption by 300 trillion Btus. This is equivalent to the energy consumed by 150 million households. An improvement of this magnitude would save $1 billion annually and decrease carbon dioxide emissions by 90 million tons - equal to the environmental impact of removing 9 million cars from U.S. highways.

With these benefits in mind, this publication describes some energy-efficient strategies for designing and equipping the laboratories of the 21st century. It introduces the basic issues associated with energy consumption in the laboratory and summarizes key opportunities to improve energy performance at each phase of the design and acquisition process. Both standard and advanced new technologies and practices are included.
Overview resources

Labs21 Video

“Labs embody the spirit, culture, and economy of our age...what the cathedral was to the 14th century and the office building was to the 20th century, the laboratory is to the 21st century.”

Don Prowler
Core information resources

Design Guide for Energy-Efficient Laboratories

- A searchable, detailed reference on high-performance, low-energy lab design and operation

- 4-level hierarchy – from general to specific
  - Level 1: Major topics
    - E.g. Exhaust Systems
  - Level 2: Sub topics
    - E.g. VAV fumehoods
  - Level 3: Components
    - E.g. VAV fumehood face velocity control
  - Level 4: Background/Supporting information
    - E.g. Fume Hood Face Velocity Response Time

Filter power calculation

\[ \text{hp} = \left( \frac{\text{CFM} \times \text{TP}}{33856} \right) \]

Where:

- \( \text{hp} \) = Air horsepower required to overcome filter system resistance
- \( \text{CFM} \) = Quantity of air being filtered expressed in cubic feet per minute.
- \( \text{TP} \) = Total pressure of filter system (in. w.g.)

Total pressure is the sum of static pressure and velocity pressure. Since the filter media velocity is low, the velocity pressure can be ignored. For this reason, the equation can be written as:

\[ \text{hp} = \left( \frac{\text{CFM}}{33856} \right) \]
Core information resources

Design Guide for Labs - Contents

- Chapter 1: Introduction
- Chapter 2: Architectural Programming
- Chapter 3: Right Sizing
- Chapter 4: Direct Digital Control Systems
- Chapter 5: Supply Systems
- Chapter 6: Exhaust Systems
- Chapter 7: Distribution Systems
- Chapter 8: Filtration Systems
- Chapter 9: Lighting Systems
- Chapter 10: Commissioning
Core information resources

Best Practice Guides

- Describes how to implement a strategy, with implementation examples

- Completed guides:
  - Daylighting in Laboratories
  - Energy Recovery
  - On-Site Combined Heat and Power

- Several in development
  - Labs21 seeking contributing authors
Core information resources

Case Studies

- Sandia National Laboratories PETL
- National Institutes of Health Building 50
- Fred Hutchinson Cancer Research Center
- Georgia Public Health Laboratory
- U.S. EPA National Vehicle and Fuel Emissions Lab
- Pharmacia Building Q
- Nidus Center
- Bren Hall

All case studies have whole-building and system level energy use data
Core information resources

Energy Benchmarking Tool

- National database of lab energy use data
  - Web-based input and analysis
  - About 40 facilities

- Why benchmark during design?
  - See where you stand
  - Set targets
    - Building level (e.g. Site BTU/sf)
    - System level (e.g. W/cfm)
# Benchmarking Metrics

The table below outlines the core information resources focusing on energy consumption and demand metrics for various systems.

<table>
<thead>
<tr>
<th>System</th>
<th>Energy Consumption</th>
<th>Energy Demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ventilation</td>
<td>kWh/sf-yr</td>
<td>Peak W/ft³/min Peak cfm/sf (lab) Avg cfm/peak cfm</td>
</tr>
<tr>
<td>Cooling</td>
<td>kWh/sf-yr</td>
<td>Peak W/ft² Peak sf/ton</td>
</tr>
<tr>
<td>Lighting</td>
<td>kWh/sf-yr</td>
<td>Peak W/ft²</td>
</tr>
<tr>
<td>Process/Plug</td>
<td>kWh/sf-yr</td>
<td>Peak W/ft²</td>
</tr>
<tr>
<td>Heating</td>
<td>BTU/sf-yr</td>
<td>Peak W/ft²</td>
</tr>
<tr>
<td>Aggregate</td>
<td>kWh/sf-yr (total elec) BTU/sf-yr (site) BTU/sf-yr (source) Utility $/sf-yr</td>
<td>Peak W/ft² Effectiveness (Ideal/Actual)</td>
</tr>
</tbody>
</table>
### Core information resources

**Labs21 Benchmarking Tool – Data Input**

#### Energy Use

<table>
<thead>
<tr>
<th>Description</th>
<th>Measured</th>
<th>Estimated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Energy Utility Cost ($)</td>
<td>231000</td>
<td></td>
</tr>
<tr>
<td>Annual Heating Energy (kWh/m²)</td>
<td>124000</td>
<td></td>
</tr>
<tr>
<td>Does facility use CHP (Cogen system)?</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Annual Electric Use (kWh)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ventilation</td>
<td>101000</td>
<td></td>
</tr>
<tr>
<td>Cooling Plant (including campus chld. water, if and)</td>
<td>196000</td>
<td></td>
</tr>
<tr>
<td>Lighting</td>
<td>460000</td>
<td></td>
</tr>
<tr>
<td>Precess/plag</td>
<td>115000</td>
<td></td>
</tr>
</tbody>
</table>

#### Peak Demand (kW)

<table>
<thead>
<tr>
<th>Description</th>
<th>Measured</th>
<th>Estimated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>476</td>
<td></td>
</tr>
<tr>
<td>Ventilation</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Cooling Plant (including campus chld. water, if and)</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Lighting</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Precess/plag</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

### General Information

#### Date / Facility Information

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>User</td>
<td>LSINL</td>
</tr>
<tr>
<td>Organization</td>
<td>Lawrence Berkeley National Laboratory</td>
</tr>
<tr>
<td>Facility chosen</td>
<td>LBNL Advanced Materials Lab</td>
</tr>
<tr>
<td>Year chosen</td>
<td>2001</td>
</tr>
</tbody>
</table>

#### General Facility

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shoot Address*</td>
<td>One Cyclotron Road</td>
</tr>
<tr>
<td>Location*</td>
<td>Berkeley, CA</td>
</tr>
<tr>
<td>Zip Code (5 digits)*</td>
<td>94720</td>
</tr>
<tr>
<td>Lab Use*</td>
<td>Research/Development</td>
</tr>
<tr>
<td>Lab Type*</td>
<td>Combination/Others</td>
</tr>
<tr>
<td>Lab Category*</td>
<td>Combination/Others</td>
</tr>
<tr>
<td>Number of Buildings*</td>
<td>1</td>
</tr>
<tr>
<td>Gross Area (sq. ft.)*</td>
<td>65761</td>
</tr>
</tbody>
</table>
Core information resources

Labs21 Benchmarking Tool – Analysis

Choose Metrics and Filtering Criteria

1. Lab Area / Gross Area ratio
   - Greater than or equal to 0.80
   - Less than or equal to 0.95

2. Occupancy
   - Standard (≤14 hours)
   - High (>14 hours)
   - Even (all data)

3. Climate (Climate Code, Climate Type, Representative City)
   (see the map of climatic distribution)

   - 1A. Very Hot-Humid (Miami, FL)
   - 2B. Hot-Dry (Phoenix, AZ)
   - 3B. Warm-Dry (El Paso, TX)
   - 4A. Mixed-Humid (Baltimore, MD)
   - 4D. Mixed-Marine (Salem, OR)
   - 6A. Cold-Humid (Burlington, VT)
   - 6D. Cold-Dry (Helena, MT)
   - 8. Subarctic (Fairbanks, AK)

Reset Values

Continue...
Design process tools

**Process Manual**
- Purpose: Design process guidance
- Action items for each stage of design process
  - Links to appropriate tools and resources
- Checklist of sustainable design strategies
  - Portal to core information resources
  - Useful for design charrettes
- Access at Labs21 web site or Tool Kit CD
Design process tools

Design Intent Tool

- **Purpose:** Documentation of Design Intent
  - Structured approach to recording sustainable design strategies, metrics
  - Database tool – MS Access
  - Automated report generation

- **Benefits**
  - Allows owners and users to verify that design intent is being met.
  - Gives commissioning agents, facility operators, and future renovators an understanding of how the building systems are intended to operate.
Design process tools

Environmental Performance Criteria (EPC)

- A rating system for evaluating laboratory design
  - Builds on the LEED™ rating system
  - Adds credits and prerequisites pertaining to labs
    • Health & safety issues
    • Fume hood energy use
    • Plug loads

- Represents Labs21 perspective on sustainability criteria
  - Public domain document
  - Labs21 does not provide certification process
  - Useful for design charrettes
End of Session