High-Performance Science Buildings at the University of California, Irvine

Wendell C. Brase
Vice Chancellor, Administrative & Business Services
University of California, Irvine
Chair, Climate Solutions Steering Group
University of California

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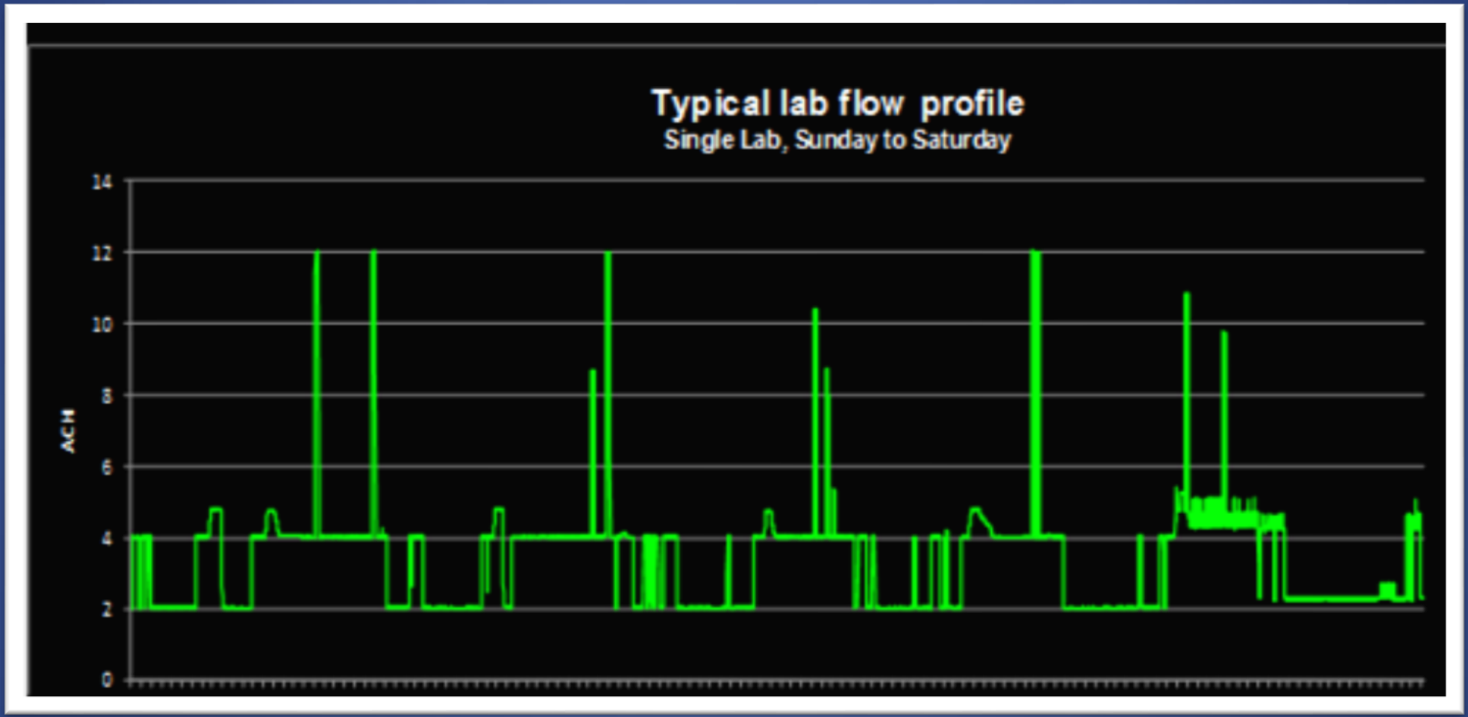
LABORATORY RETROFITS

Key Features of “Smart Labs” Retrofit

- Digital controls and variable-air volume
- Real-time, demand-based ventilation
- Lighting efficiency upgrades
- Reduced exhaust fan energy

Dynamic Air Change Rates



Sequence

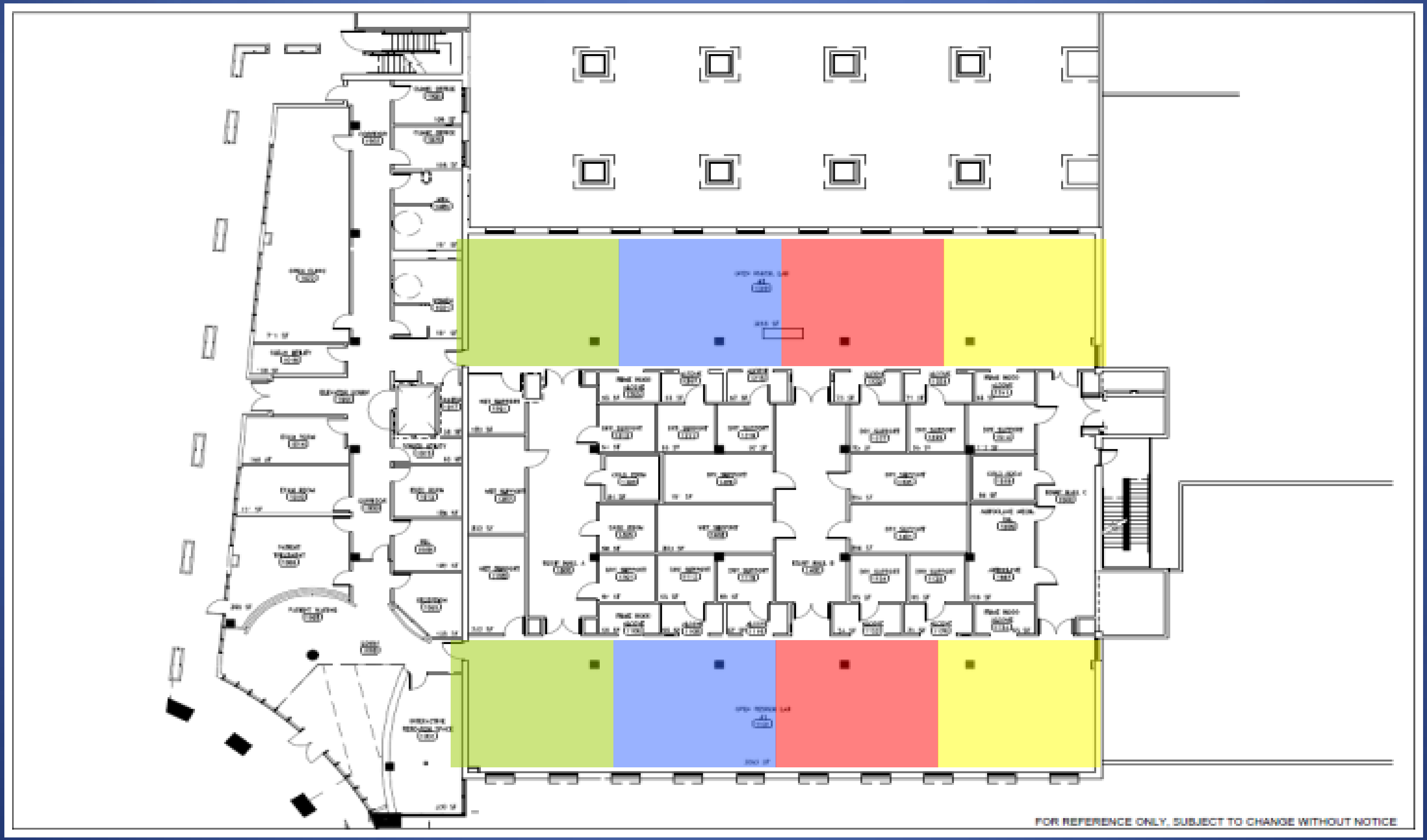
Auto on to 50%

Manual on to 100%

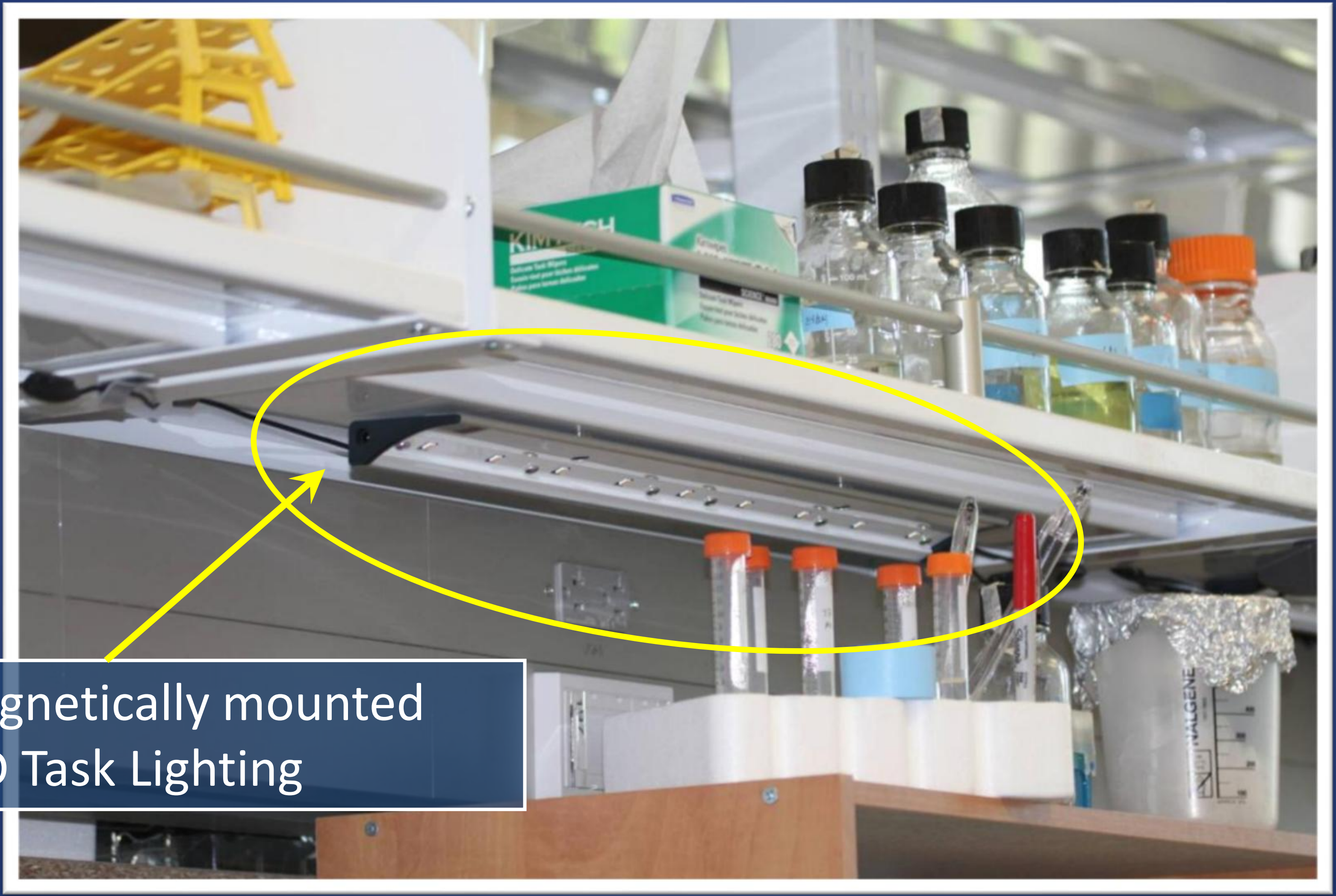
Auto off

Lighting

Lighting is controlled per lab bay -- not per lab -- to maximize savings.



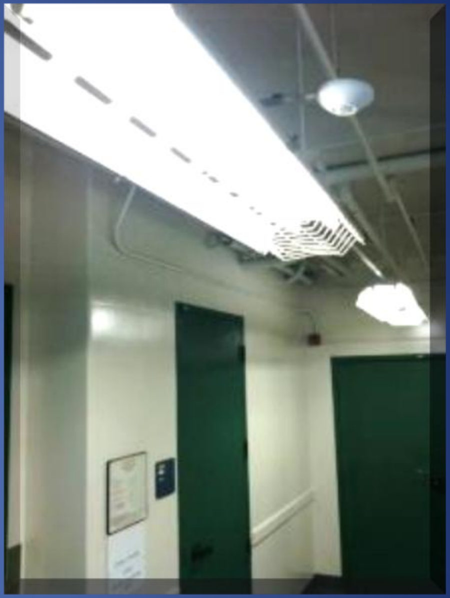
LED Task Lighting

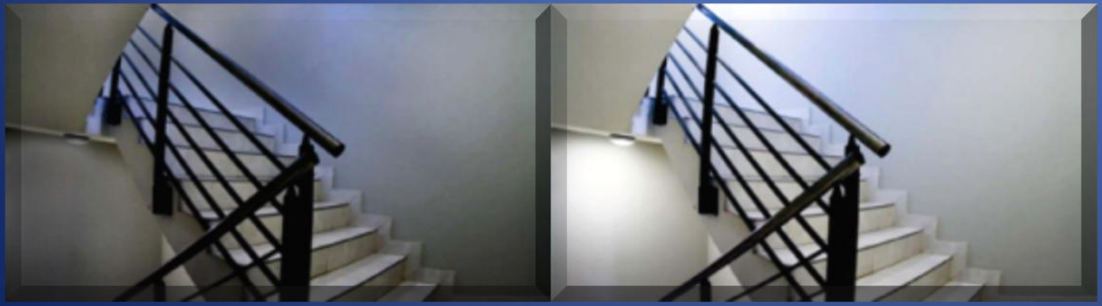


Magnetically mounted LED Task Lighting

Bi-Level Lighting in Stairwells and Corridors

Corridor and stairwell lighting is often on all year, 24 hours a day and represents a good opportunity for occupancy sensing.





Reducing Exhaust for Energy Consumption

- Power ~ $(\text{airspeed})^{2\text{-}3}$
- Every building different…no one-size-fits-all solution
- Measures that may apply singularly or in coordination:
  - Reduce fan speed and close bypass damper
  - Extend stack heights
  - Run all manifold fans in-parallel
  - Wind-responsive controls
  - Contaminant sensors in exhaust airstream

Manifold Exhaust Fans

Natural Sciences 1 Prior Condition

Natural Sciences 1 4-Foot Extension

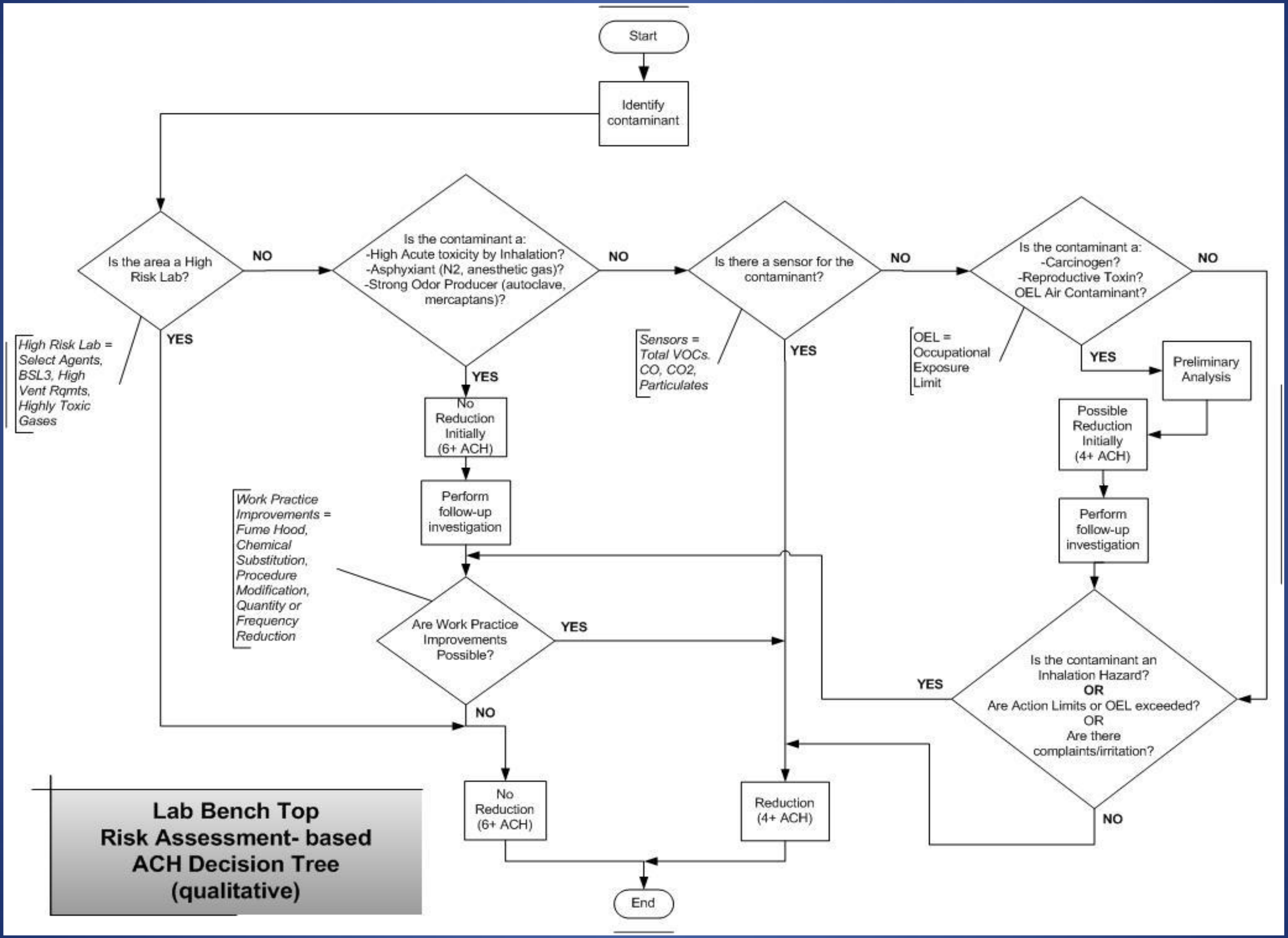
Natural Sciences 2 Prior Condition

Natural Sciences 2 4-Foot Extension

Croul Hall Prior Condition

Croul Hall 8-Foot Extension

85-90% of Labs Appropriate for Airchange Reduction



Results

Laboratory Building		BEFORE Smart Lab Retrofit			AFTER Smart Lab Retrofit		
Name	Type[1]	Estimated Average ACH	VAV or CV	More efficient than code?	kWh Savings	Therm Savings	Total Savings
Croul Hall	P	6.6	VAV	~ 20%	40%	40%	40%
McGaugh Hall	B	9.4	CV	No	57%	66%	59%
Reines Hall	P	11.3	CV	No	67%	77%	69%
Natural Sciences 2	P,B	9.1	VAV	~20%	48%	62%	50%
Biological Sciences 3	B	9.0	VAV	~30%	45%	81%	53%
Calit2	E	6.0	VAV	~20%	46%	78%	58%
Gillespie Neurosciences	M	6.8	CV	~20%	58%	81%	70%
Sprague Hall	M	7.2	VAV	~20%	71%	83%	75%
Hewitt Hall	M	8.7	VAV	~20%	58%	77%	62%
Engineering Hall	E	8.0	VAV	~30%	59%	78%	69%
Averages		**8.2**	**VAV**	**~20%**	**57%**	**72%**	**61%**

Type: P = Physical Sciences, B = Biological Sciences, E = Engineering, M = Medical Sciences

Secondary Benefits of Smart Labs Retrofits (besides >50% energy savings)

1. Safety/air quality longitudinal data
2. Data to do real time commissioning and diagnostics
3. Lower wear and failure rates for fan motors and bearings
4. No need for periodic recommissioning

NEW CONSTRUCTION

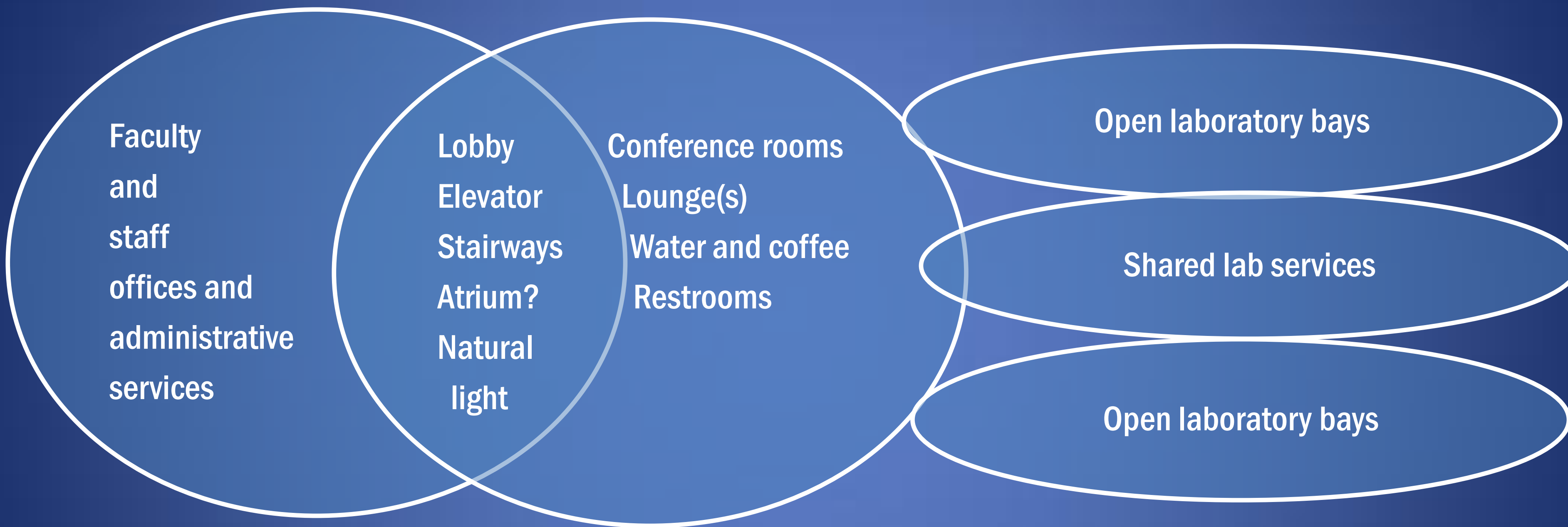
Tools We Have Used

- Labs21 "Tool Kit"
- Cost and energy performance goals
- Design concepts and principles based on life-cycle cost

Important caveat:

We don't have all the answers!

Functional Schematic

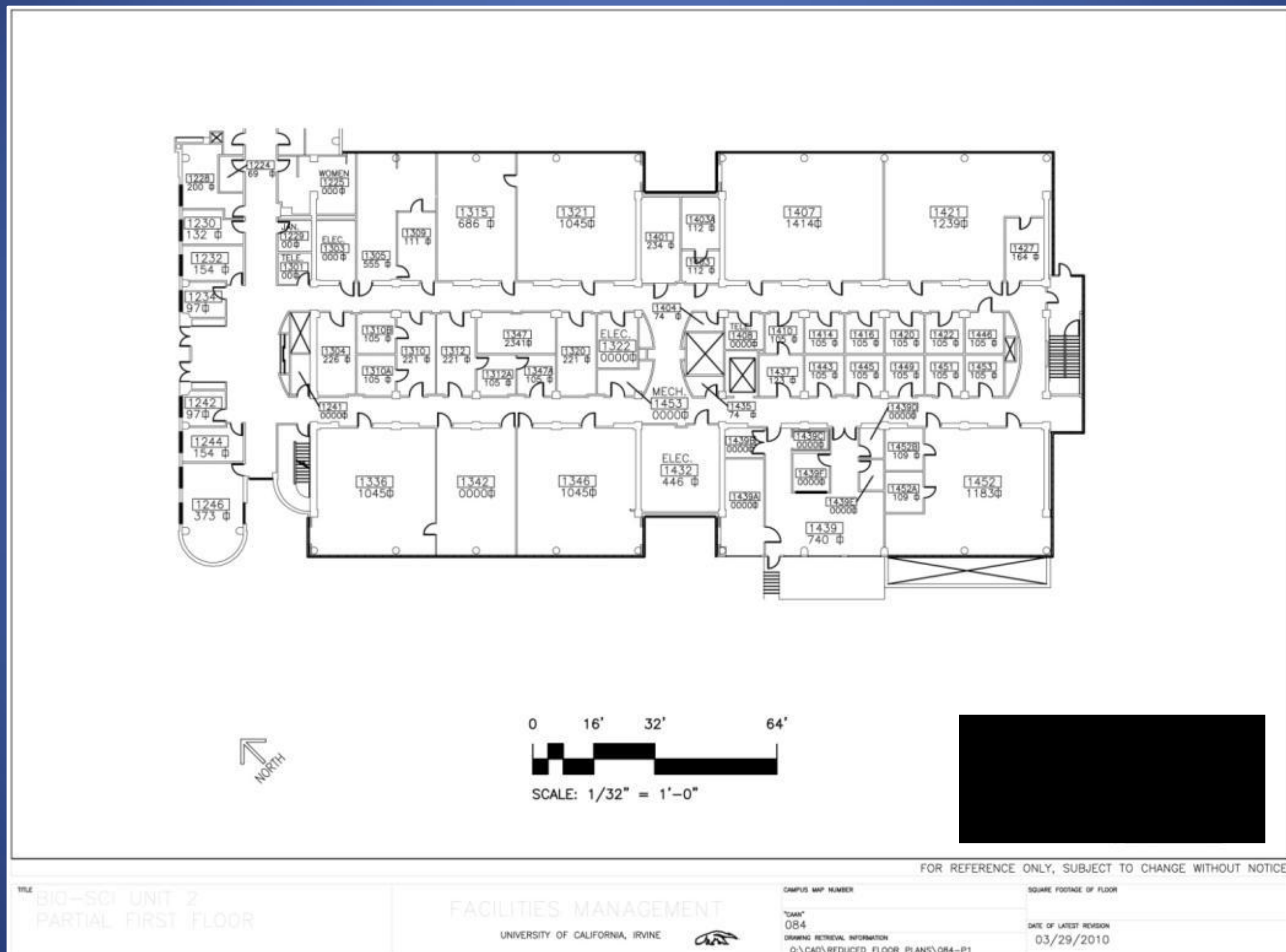


Looks Like One Building…

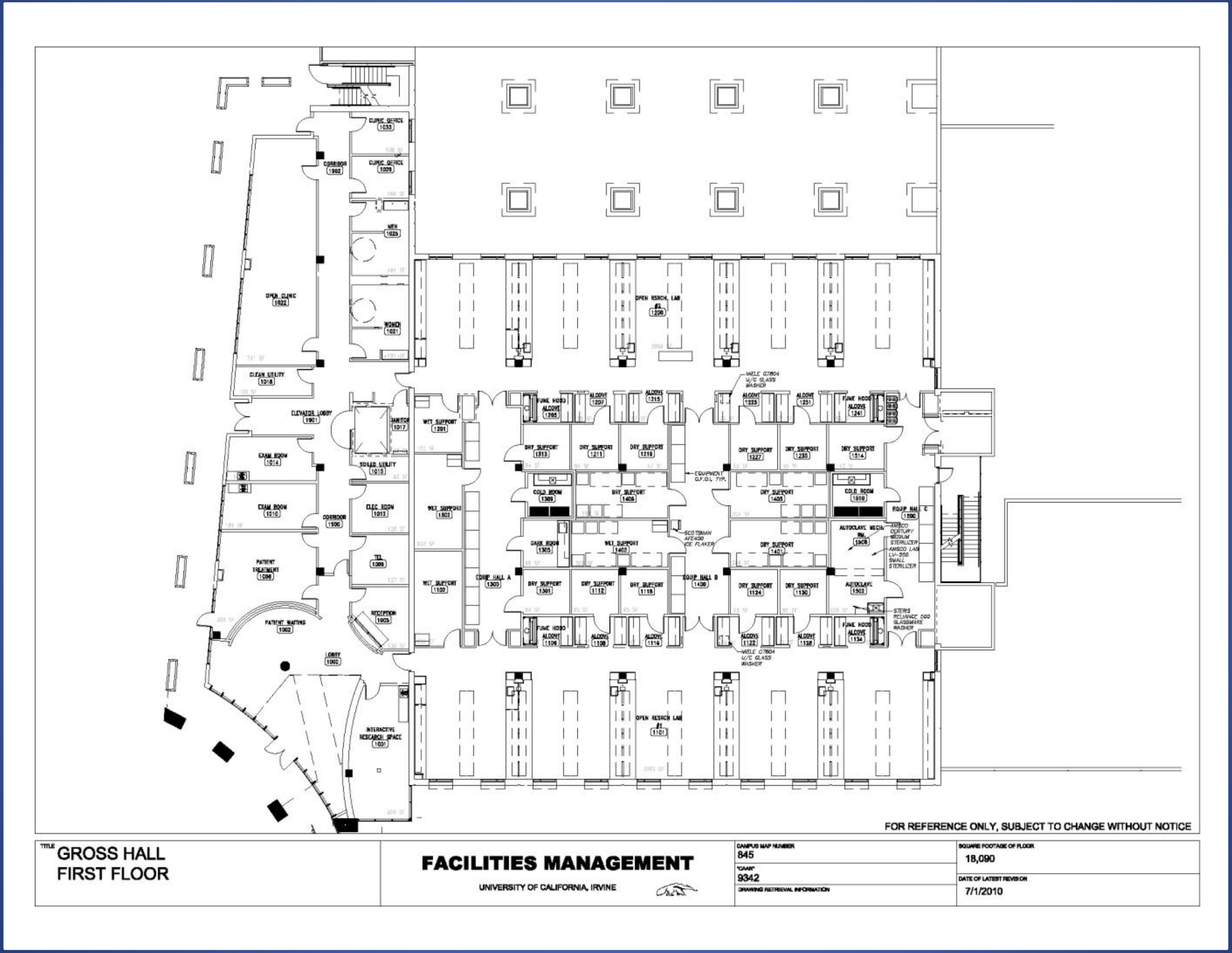
Non-Laboratory Spaces in a Less Expensive Structure (separate but attached)

- Lower-cost HVAC (heating/ventilation/air-conditioning) system
- Recirculating HVAC
- Less expensive structural system, with lower floor stiffness and loading
- Fewer code requirements than lab block
- Less expensive exterior cladding
- Operable windows

Old Paradigm

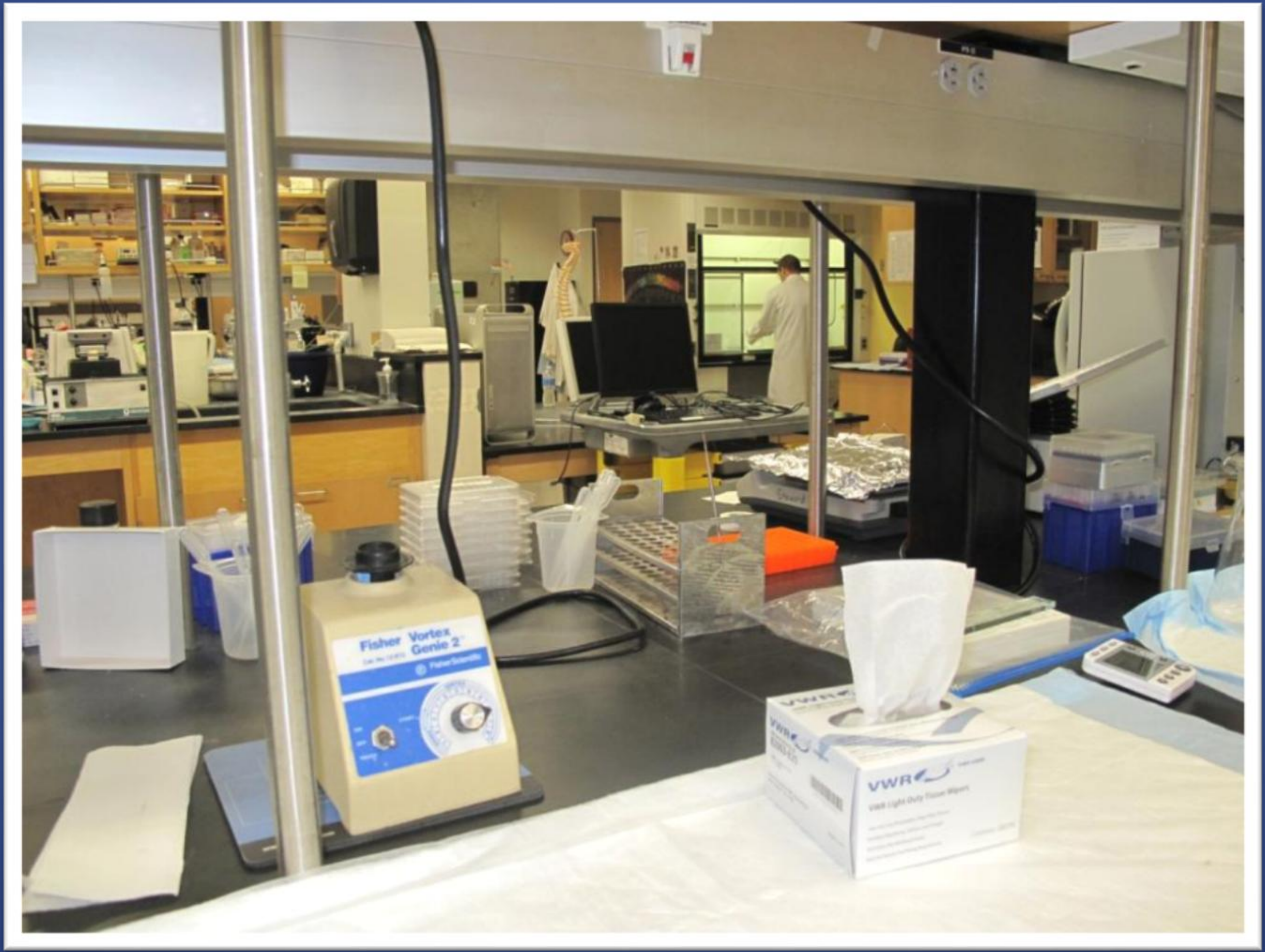


New Paradigm



Two Research Groups Share This Open Lab

Open Laboratory



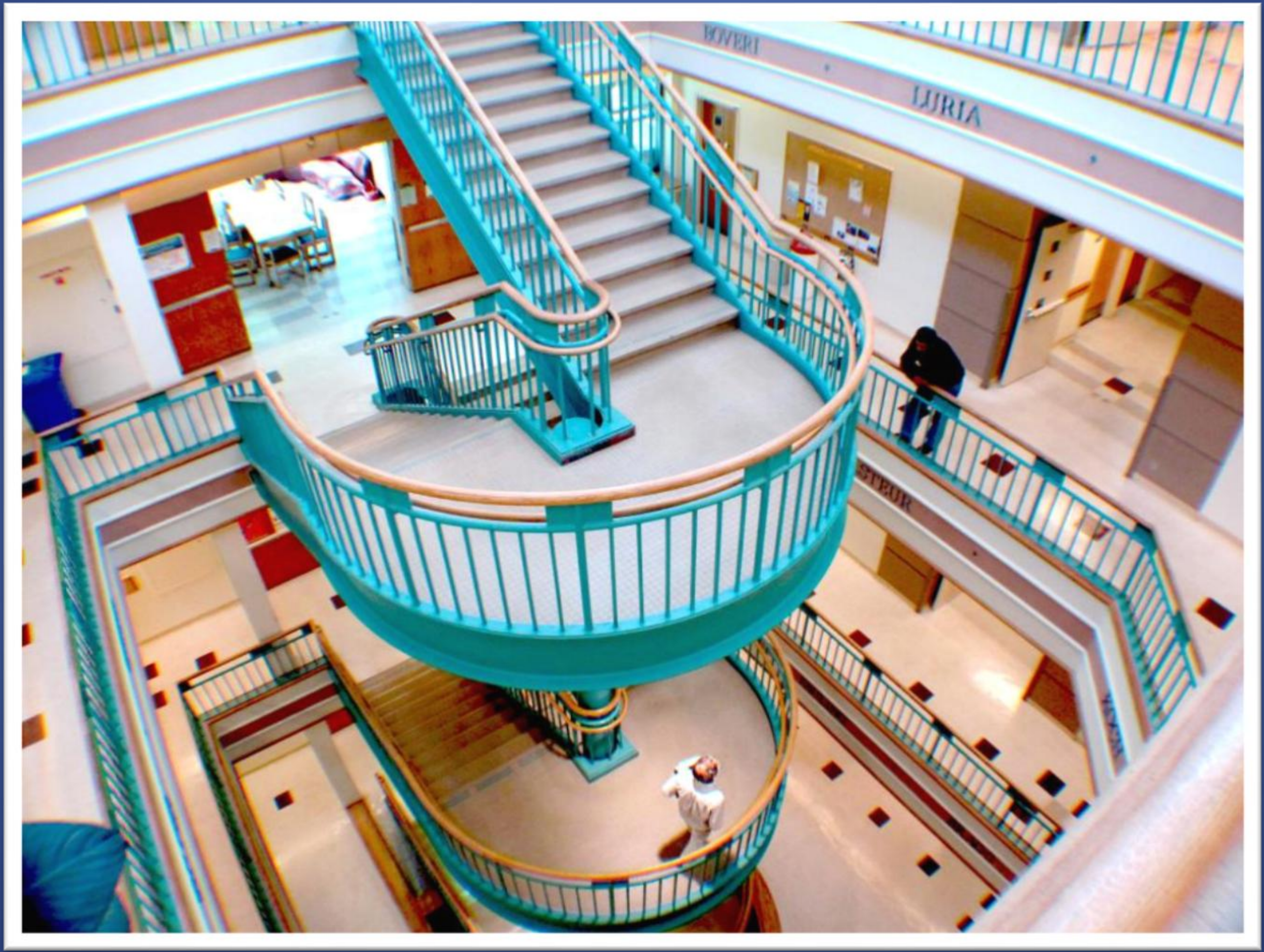
Typical Shared Equipment Corridor

How Can a Laboratory Building be Designed to Enhance Chance Interactions?

- Open laboratory bays
- Shared services
- Concentrate offices and other non-lab functions into attached structure
- Cluster “magnets” strategically near circulation flows and intersections

Sprague Hall Atrium
(Cancer Research)

Sinsheimer Labs Atrium



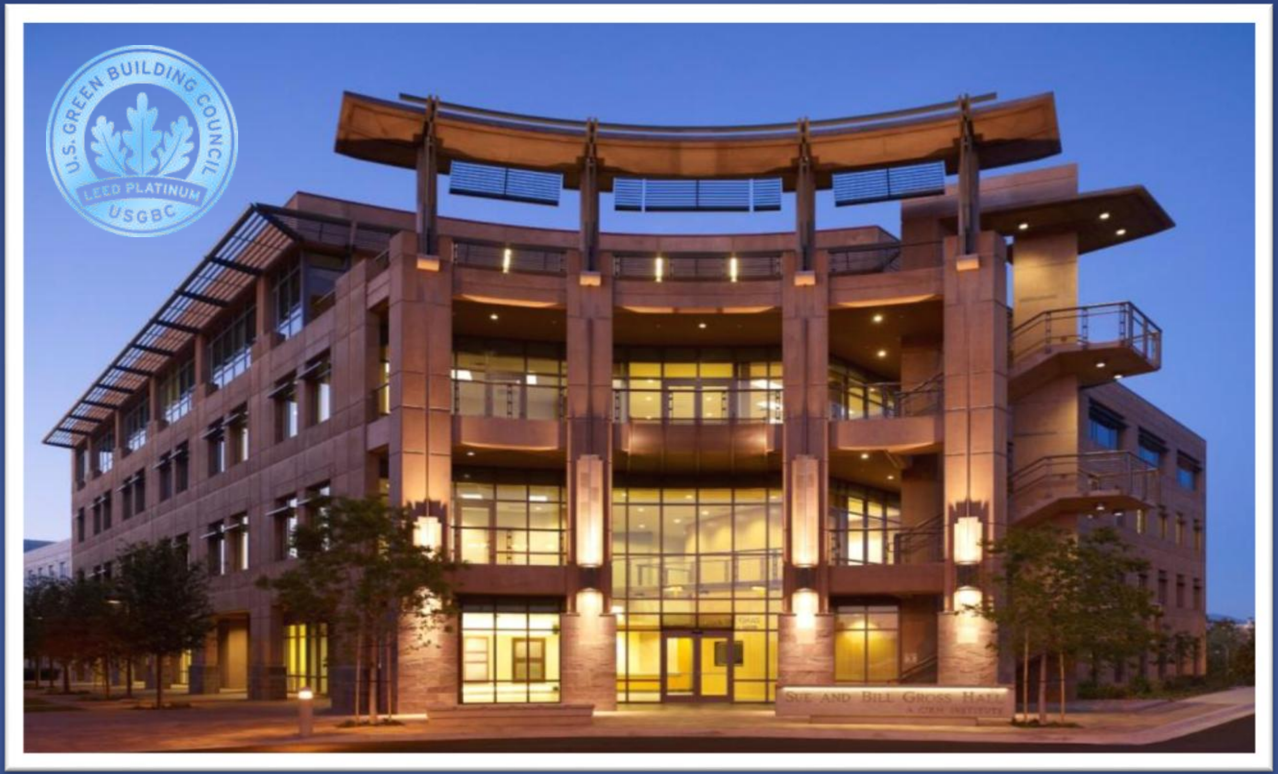
Sinsheimer Laboratories (Biology)
UC Santa Cruz

50 Percent Movable Casework

"Smart Lab" Energy Design Parameters

Parameters/Features	Recent Best Practice	"Smart Lab"
Base occupied lab air-changes/hr. (ACH)	6 ACH	4 ACH w/contaminant sensing
Unoccupied air-change setback	No setback	2 ACH w/contaminant sensing + reduced thermal inputs while building "coasts" during setback
Air-handler/filtration airspeeds	400 ft/min. max	350 ft/min. max
Total system (supply + exhaust) pressure-drop	~ 6 in.w.g.	< 5 in.w.g.
Duct noise attenuators	Few	None
Low-flow/high-performance fume hoods	No	Yes, where hood density warrants
Exhaust stack discharge velocity	~3,000 FPM	>1,500 FPM only if/when necessary
Lab illumination power-density	~0.9 watt/SF	< 0.6 watt/SF w/LED task lighting as needed
Fixtures near windows on daylight sensors	No	Yes
Outperform CA Title 24	20-25%	> 50%

Sue & Bill Gross Stem Cell Laboratory



- Applies “smart lab” energy design parameters
- Awarded LEED Platinum by U.S. Green Building Council
- Outperforms California’s energy code by 50.4%

Life-Cycle Costs and Benefits

50 years, all figures 2010 dollars

Feature	Capital costs	50-year operational costs
Exemplary energy-efficiency including “smart lab” features	+$1.0 million	– $5.6 million in energy expense – $.2 million in equipment deterioration + $.75 million in HVAC maintenance -$1.9 million avoided 5yr re-commissioning
Segregation of labs and offices	– $2.5 million	Energy savings included above
Open lab bays and 50% movable casework	–$1.5 million	– $3 million in lab retrofits
TOTALS	–$3 million	– $10 million

Cost-Control Strategies to *Enable* Life-Cycle Features

- Set firm, specific energy and other life-cycle goals
- Segregate laboratory and non-lab functions into separate structures
- Efficient ratio for exterior “skin”
- Generic, modular approach to lab design
- Fume hoods
- Conventional structural and cladding systems
- Avoid custom-fabricated, exotic, specialized materials and finishes
- Open lab bays with shared, interior “wet zone”
- Use cross-corridors for shared equipment as well as circulation
- Establish these goals and criteria ***early***!