Supporting Safe, Sustainable Laboratories in the 21st Century

Ralph Stuart, CIH, CCHO
Chemical Hygiene Officer
Cornell University
Three Sustainability Issues for 21st Century Laboratories

1. The Carbon Footprint of Laboratories
2. Developing Green Laboratories
3. Right Sizing through Risk Assessment
1. The Carbon Footprint of Laboratories

• Ventilation is the largest user of energy in labs
  • One fume hood is the equivalent of 3 households
  • Cornell’s 1700 fume hoods represent 15% of Tompkins County’s carbon footprint

• Cold storage of samples is the second largest use of energy
Laboratories constitute 33% of the floor space, but 50% of the energy budget
There are three competing priorities for operating laboratory facilities:

- **Science** needs flexible spaces
- **Safety** requires ongoing risk assessment and management
- **Sustainability** requires careful energy management

This results in a complex system which needs to be carefully managed.
Laboratory Ventilation Management Indicators

**Plan:**
Control banding labs (leading)

**Do:**
Hood housekeeping scores (leading)

**Review:**
Track air quality concerns (lagging)

**Energy Indicator**

**Safety Indicator**
Our Ventilation Control Banding Logic

Step 1: Review chemistry for flammability, toxicity or odor concerns outside of local exhaust.

- Significant chemical sources outside local exhaust systems
  - Maintain normal operating rate of 8/4 ACH

No concerns

Step 2: Consider ventilation effectiveness in the room.

- Development of "dead zones" likely
  - Maintain normal operating rate of 8/4 ACH

No concerns

Step 3: Assess housekeeping practices.

- Specific housekeeping issues found
  - Maintain normal operating rate of 8/4 ACH

No concerns

Reduce operating ventilation rate to 6/3

8/4 ACH

6/3 ACH
[In the aftermath of the earthquake], the University of Tokyo… cut peak power usage by 30–40% by turning off lights and air-conditioning, shutting down extra lifts, and running energy-intensive experiments at night.

Researchers at the university say that their low-energy lives are inconvenient, but largely manageable... "The electricity shortage made us realize that we can indeed save energy easily by 10%, but that 30% cuts will impact productivity in the longer term”, one said.
2. What is a Green Lab?

- A Green Lab goes **beyond compliance** to include environment impacts as well as health and safety in its operational decisions.

- Green Labs also act as community leaders by sharing sustainable practices with their peers.
Green Lab Opportunities We’ve Identified at Cornell

- Chemical Management
- Green Chemistry Opportunities
- Solid Waste Management
- Laboratory Energy Conservation
- Water & Steam Conservation
- Research Impacts
- Innovative Practices
- Community Outreach
The Cornell Green Labs Program

1. A partnership between Cornell Facilities and Cornell EHS to recognizing current Green work in Cornell labs and encourage further such work.

2. The primary strategy is to spread the word about energy conservation and waste reduction opportunities in laboratories.

3. Sharing lab greening opportunities with national peers (UC Davis, Univ of Colorado, Harvard, Duke, etc…).
Students Influencing Students through Specific Activities

- Lower the sash - 50% of fume hoods at Cornell are variable volume and lower sashes will save energy
- Maintain lab refrigerators and freezers - each minus 80 freezer uses roughly the same as an American home
- Identify energy efficient new lab equipment
- Explore less impactful processes
- Engage peers
3. Right Sizing and Risk Assessment

- The Chemical Safety Board and National Academy of Sciences have raised concerns about systematic problems in academic lab safety.

- Industry is similarly concerned.

- CSB recommendation to ACS
  - Develop good practice guidance that identifies and describes methodologies to assess and control hazards.
The Interplay of Protective Measures

1. Replacing the hazard
2. Engineering controls
   - Fume hood
   - Specialized transfer equipment
3. Housekeeping
4. Personal Protective Equipment
5. Emergency Planning and Response
Building a More Robust Lab Hazard Assessment tool

- SDSs and Wikipedia provide chemical safety information on specific chemicals, not lab processes
- An **intelligent** platform is necessary to support risk assessment for research processes that involve multiple chemicals and change over time.
- This platform would include:
  - Wider range of chemicals
  - Curated information
  - Logic connecting the data
  - Documentation of the judgments made
  - Sharing of best practices
Sources of Hazard Assessment Data and Logic

- Globally Harmonized System for Classification and Labeling of Chemicals

- Prudent Practices in the Laboratory from the National Research Council

- The RAMP paradigm from Hill and Finster (2010)
Key Information Management pieces

• An **ontology** is a *shared vocabulary* that describes the knowledge of a particular domain (e.g. chemical educators vs. chemical researchers).

• **Curation** is the human-based process of collecting, organizing and displaying information relevant to a particular topic (e.g. preparing topics for a chemistry curriculum).
The iRAMP Information Model So Far

### iRAMP: A Chemical Hazard Assessment Platform
Managing laboratory chemical risk information for multiple audiences
Leah McEwen, Chemistry Librarian; and Ralph Stuart, Chemical Hygiene Officer, Cornell University

### Stakeholders
- Bench chemists and lab workers plan and execute lab-scale processes with hazardous chemicals.
- Peer chemists oversee and lead bench chemists by peer review and planning projects.
- Chemical information professionals are both librarians and data management experts who provide access to chemical information and best practices for maintaining it.
- Chemical Health and Safety (CH&S) professionals identify and mitigate chemical hazards for a chemical or process-specific basis.
- Environmental Health and Safety (EHS) professionals guide and promote safe and sustainable chemical practices, including consideration of scalability and transferability oversight processes.

### Information Channels
- Raw Information: experimental process information and raw data.
- Published Literature: peer reviewed articles, methods, and data.
- Curated Chemical Information: chemical literature managed to support assessment of data quality and maintains accessibility.
- Chemical Health and Safety Assessments: information organized to support chemical risk management.
- EHS Oversight Process: information designed to support management of chemical hazards.

### The Iterative RAMP Information Vision

#### The Challenge: Lab science is a complex system which highly values emerging knowledge. To provide effective safety support while protecting emergence, safety information must be translatable, scalable, and sustainable. This entails using ontology and curation tools currently being developed in the field of cheminformatics.

#### Information Steps
- **Chemical Process Description**
- **Process Description from Bench Chemist**

#### Risk Assessment Process
- **Risk Assessment Process**
- **Relevant data are collected from SDS, box, and reactivity databases.**
- **A Chemical Safety Level is proposed from evolving criteria in the ontology.**

#### Curation of Chemical Safety ontologies
- CH&S Community
- CSL Suggested by the Chemical Safety Ontology

#### Risk Assessment Tools

#### RAMP Paradigm
1. Be aware of potential concerns
2. Recognize the hazards
3. Evaluate the risks
4. Manage the hazards
5. Prepare for emergencies
6. Protect the environment

#### Laboratory Risk Assessment Methods Described by ACS 2013
- **Laboratory Hazard Analysis**
  - Identifies best practices for a process
- **Lab Hazard Analysis**
  - Identifies emergency scenarios and PPE needs

#### Tools to be Developed
- **Chemical safety ontology**
- **Process description plan**
- **Process description template**
- **Risk management plan**
- **Data warehouse structure**
- **Data warehouse location**
- **Lessons learned data entry**
- **Curation interfaces for primary and secondary reviewers**
- **CH&S suggestion wizard**

### For More Information
- Globally Harmonized System of Classification and Labeling of Chemicals (GHS) [PDF version](https://doi.org/10.1021/acs.orl.5b00117)
- ACS Committee on Chemical Safety, Identifying and Evaluating Hazards in Research Laboratories, 2013
- National Research Council, Prudent Practices in the Laboratory: Handling and Management of Chemical Hazards, 2011
- The Ontology and curation definitions based on Wikipedia entries.