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Energy Efficiency Going Green

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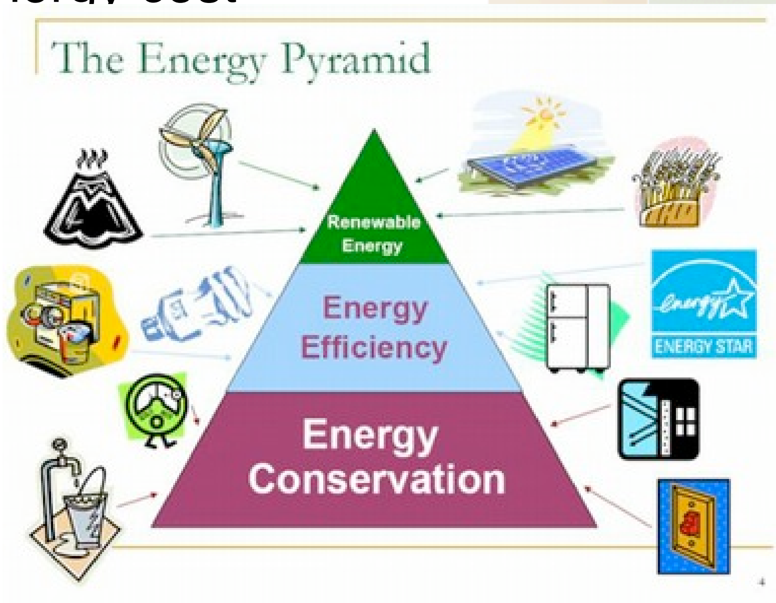
Importance of energy conservation

- Earth's natural resources are limited
- CO_2 emissions are rising contributing to global warming
- Air conditioning running cost of a laboratory is usually 3 times of a similar sized office
- Energy conservation can reduce energy cost
- Increase financial capital

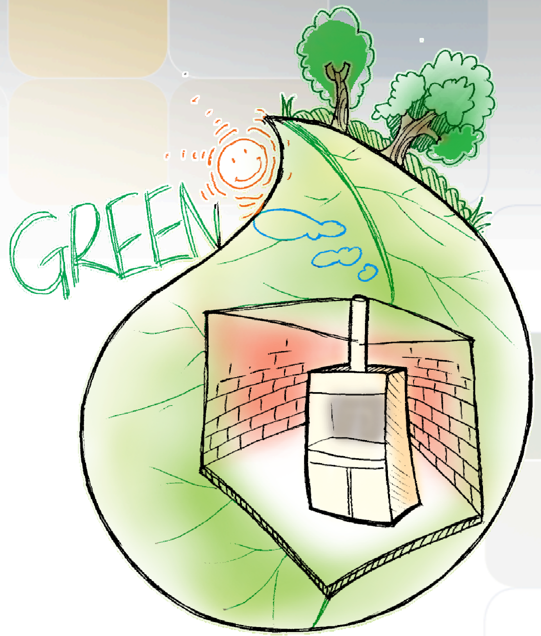


Reducing energy usage in laboratory

- Green laboratory design
- Energy efficient equipment
- Do not over size equipment eg. Heating system
- Maintaining good air ductwork
- Energy efficient designs (fume hoods)
  - Auxiliary air hoods
  - Variable air volume hoods
  - Low velocity fume hoods
- Good laboratory habits

Green laboratory layout

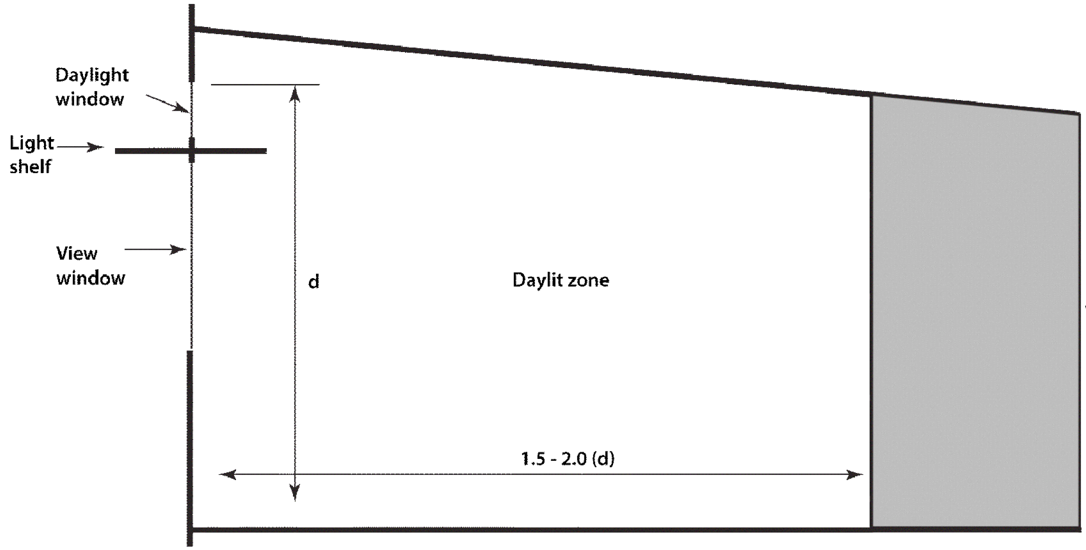
- Daylight in laboratories
- Energy recovery system in ventilation
- Manifold exhaust systems
- On site power generation system
- Improve water efficiency in laboratory



Green laboratory layout

Daylight in laboratories

- Studies shown that daylighting helps increase productivity and enhance performance
- Introduce daylighting into laboratories to lower lighting cost
- Daylighting come from 3 sources: External reflection, internal reflection, direct illumination

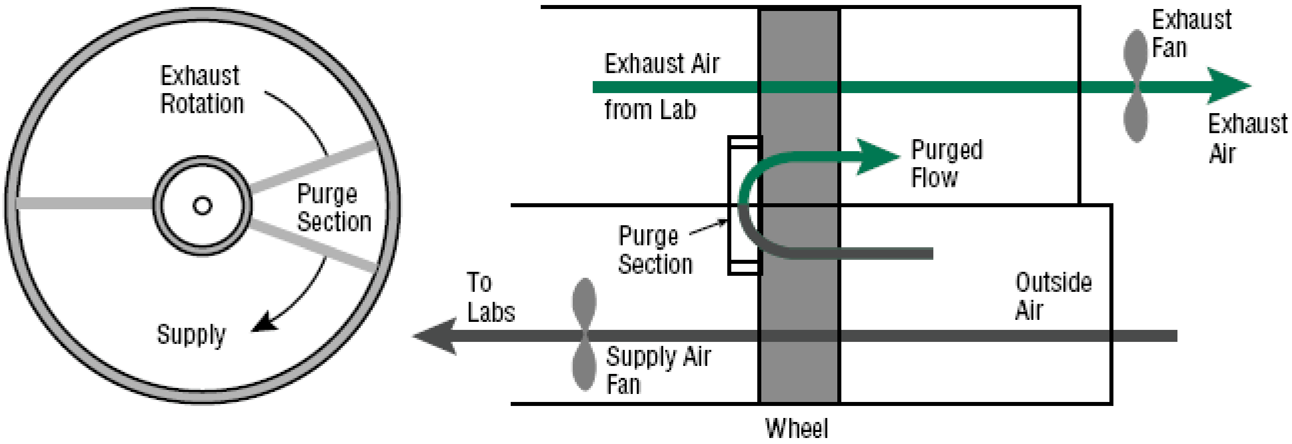


Side lighting with lighting relief to increase area illuminated

Green laboratory layout

Energy recovery system in ventilation

- Air to air exchange using enthalpy wheels



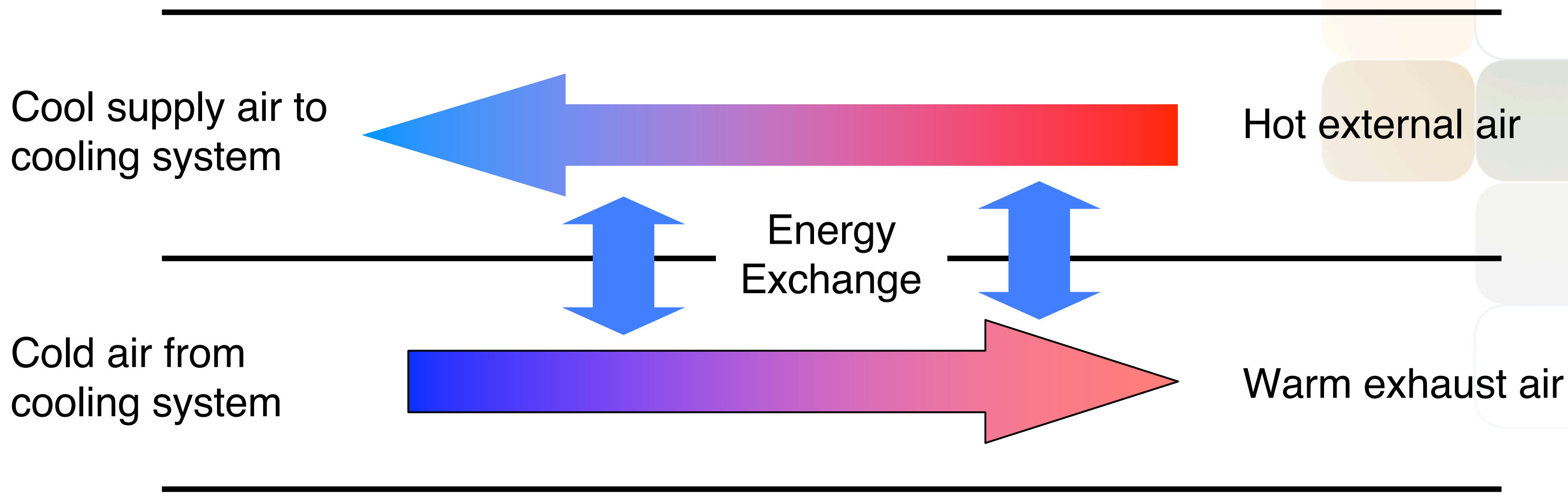
Front Cross Section with Upstream Exhaust

Side Cross Section with Purge Section

Green laboratory layout

Energy recovery system in ventilation

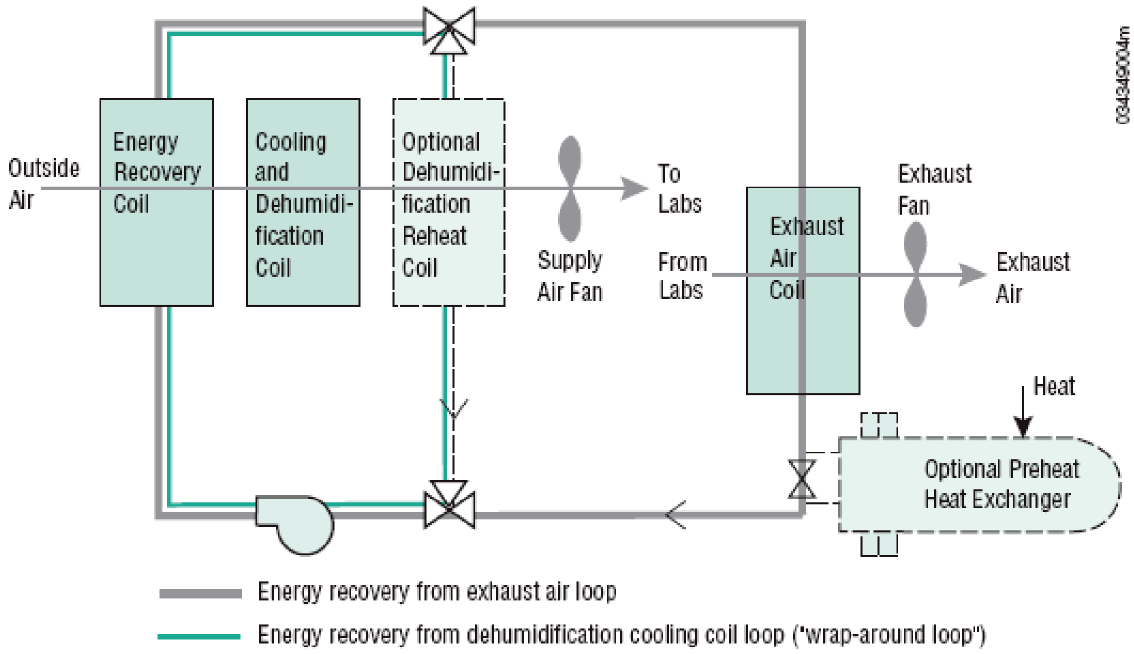
- Hot external air is preconditioned by relatively cool waste air



Green laboratory layout

Energy recovery system in ventilation

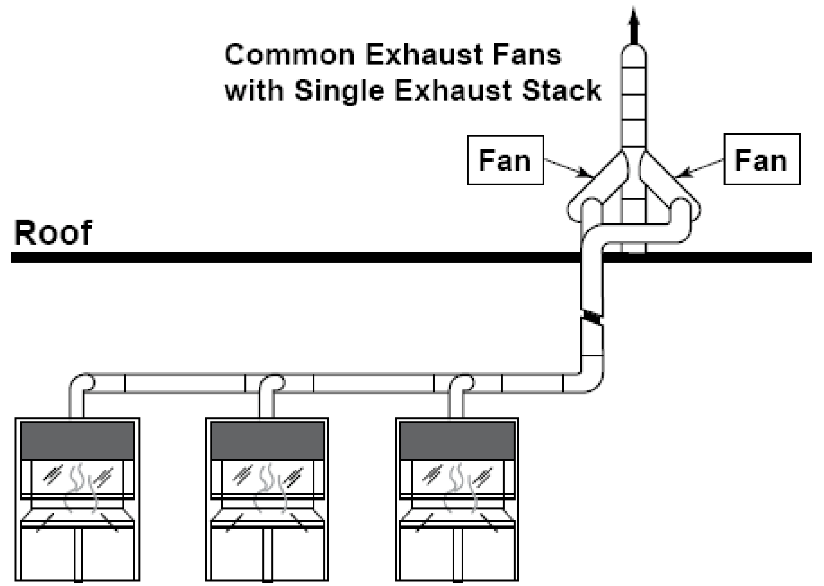
- Run - around loops



Green laboratory layout

Manifold exhaust system

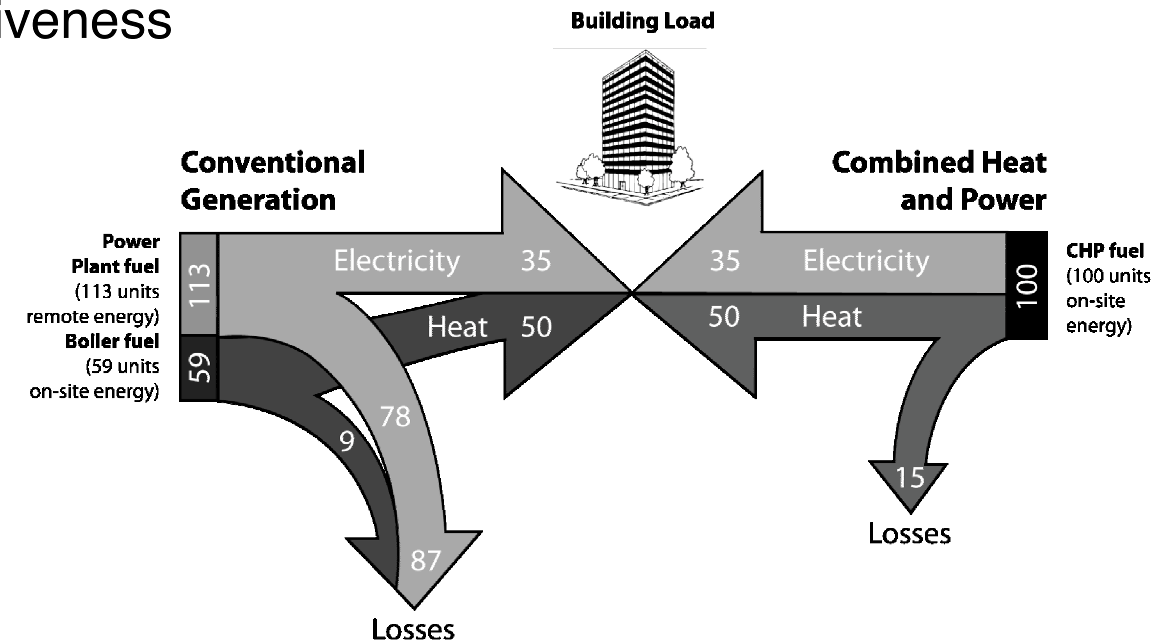
- Reduces fan power due to lower pressure drop in larger ductwork
- Reduces initial cost due to easier installation and less ductwork required
- Common exhaust fan will require a backup fan system, which will provide redundancy and therefore enhance user safety
- Less conditioned air exhausted



Green laboratory layout

On site power generation

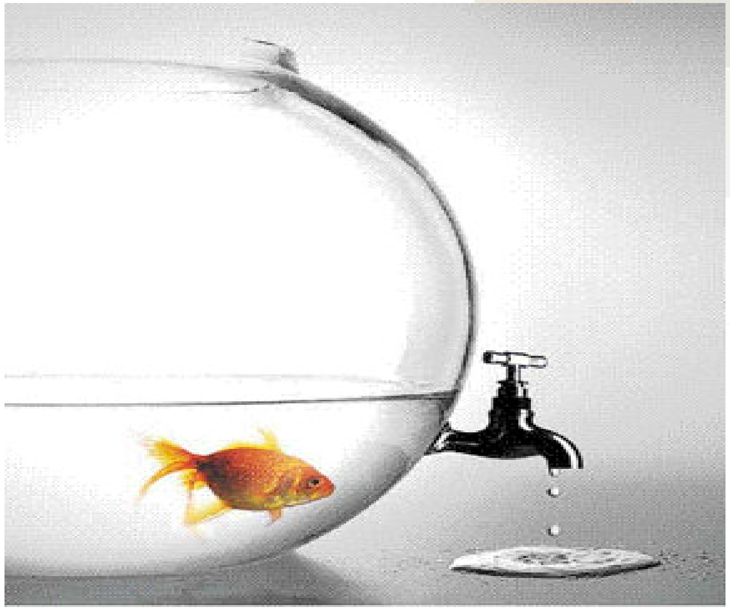
- Provide laboratories with reliable power source
- Avoid transmission and distribution cost of electricity
- Allow both electricity and heat be produced together
- Detailed life cycle study must be done to ensure cost effectiveness



Green laboratory layout

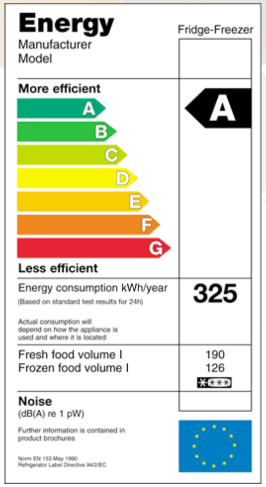
Improve water efficiency in laboratory

- Laboratories uses more water per square foot then normal buildings
- Use equipment that circulates cooling water
- Do studies to find optimal concentration ratio for laboratory cooling towers
- Use alternative water sources
  - Rainwater harvesting
  - Condensate recovery



Use energy efficient equipment

- Change lighting to energy savings bulbs
  - Use electronic ballast to improve efficiency
- Use energy efficient refrigerators
  - Energy Star rating ~ up to 40% less energy usage
  - EU Energy Labeling
- Air conditioning system with zonal control
  - Able to separate different rooms into zones
  - Reduce operating cost



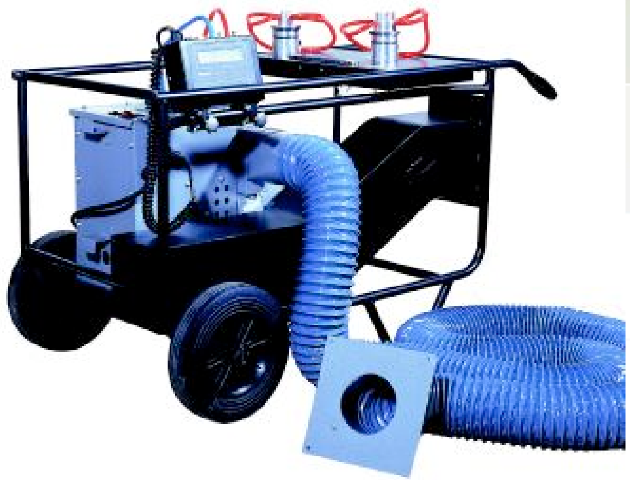
Sizing of equipment

- Engineer may have tendency to oversize central cooling and heating system
  - Provide significant margin of error builds in flexibility and reliability
  - Reduce chances of litigation and improve comfort
- Over sizing increase energy consumption
- Right sizing is the better strategy

Ductwork

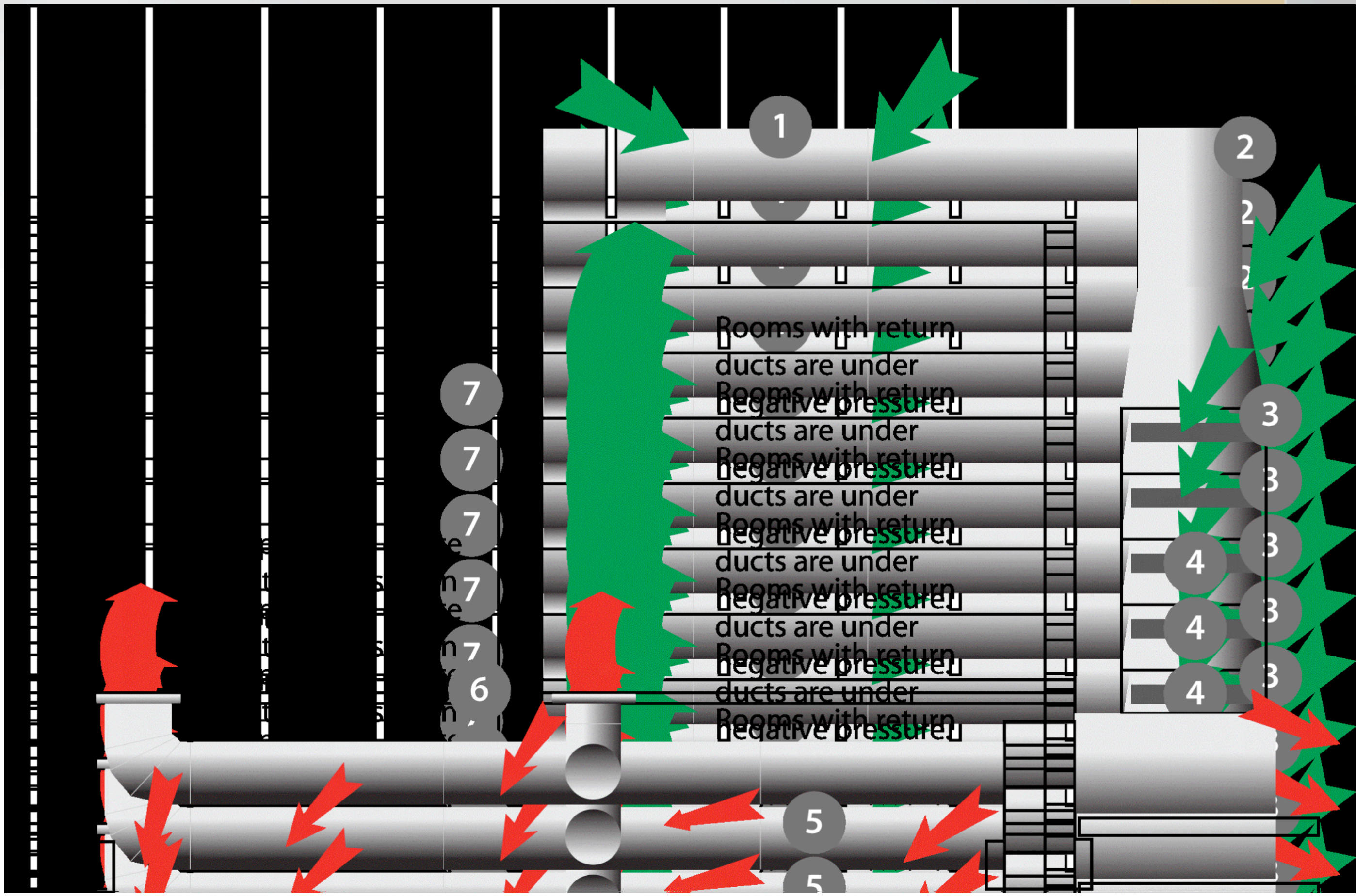
- Ensure no leakage
- Insulate the ductwork where possible to reduce energy exchange with surrounding air
- Regularly do maintenance checks to ensure ductwork is performing optimally

Broken duct beneath insulation



A portable ductwork leakage tester

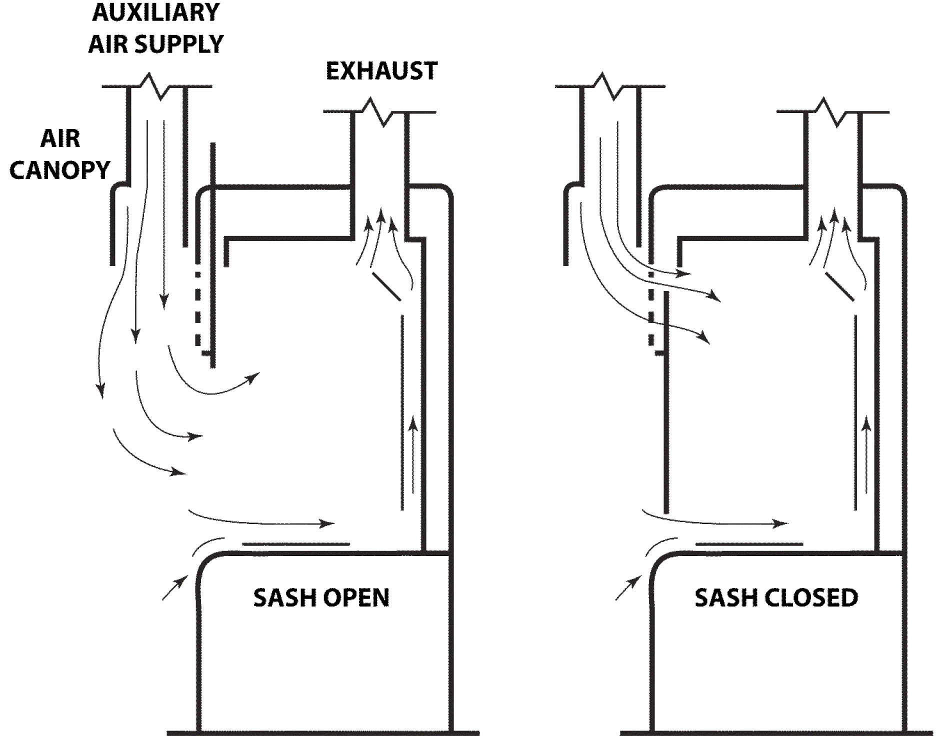
Ductwork



1. Leaky joints in return ducts
2. Leaky return plenum and furnace cabinet
3. Unsealed filter access
4. Furnace (or air handler) located in garage or other unconditioned space
5. Leaky joints and seams in supply ducts
6. Gaps around register boots
7. Closed doors block air flow through house

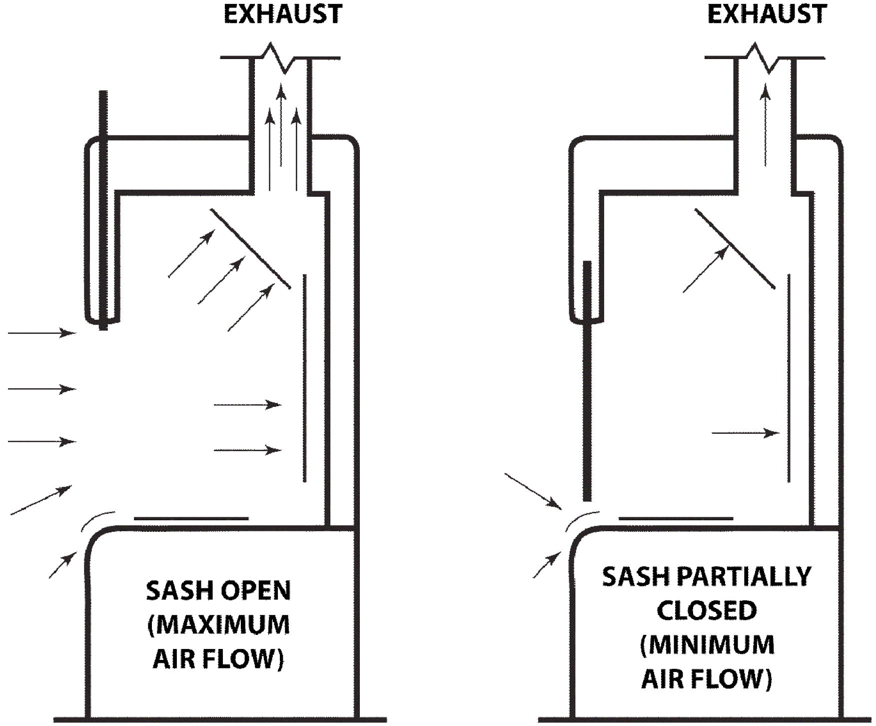
Energy efficient designs - Fume hood

- **Auxiliary air fume hoods**
  - Takes in air from atmosphere not from room
  - Reduce load on air conditioning / heating
  - Reduce running cost of air conditioning / heating



Energy efficient designs - Fume hood

- **Variable air volume hoods**
  - In built damper that restricts air flow based on sash opening
  - Reduce air flow when not in use
  - Reduce running cost of air conditioning / heating



Energy efficient designs - Fume hood

- **High performance low velocity fume hood**
  - Lower air flow into hood
  - Less air to be heated / cooled
  - Smaller air conditioner / heating system needed
  - Lower installation cost

High performance fume hood

- *Depending on climate and system design, estimated energy costs for fume hoods range from approximately US$3.40-$7.40/cfm (US$130-$260/m^3-min), based on face velocities of 0.5m/s (100fpm) at full sash open position
- Frontier Acela operates safely at 60fpm (0.3m/s) at 18” (457mm) or full open sash position while maintaining excellent ASHRAE and EN containment
- Energy savings of **up to US$5,735** annually

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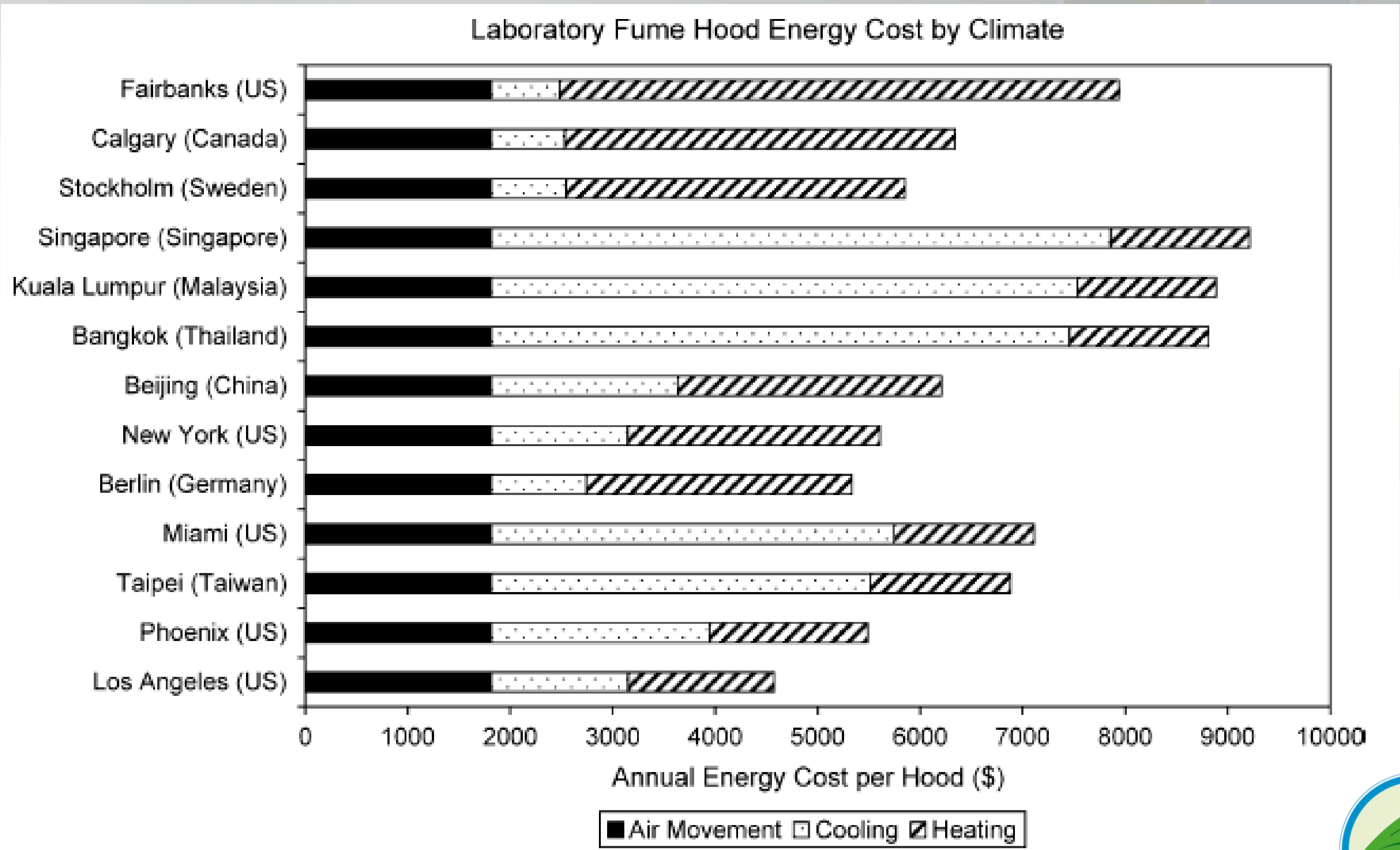
* Energy use and savings potential for laboratory fume hoods, Evan Mills, Dale Sartor; Energy, 2003

Laboratory fume hood energy cost



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* Energy use and savings potential for laboratory fume hoods,
  Evan Mills, Dale Sartor; Energy, 2003

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Comparison of different designs

	Conventional Fume Hood	Variable Air Volume (VAV) Fume Hood	High Performance Low Flow Fume Hood
Working Principle	0.5m/s (100fpm) @ full open sash position	0.5m/s (100fpm) @ all sash positions with help of sophisticated control system	0.3m/s (60fpm) @ 457mm(18") sash opening using advanced aerodynamic designs
Initial cost	Low	High	Medium
Running Cost	Very High	Low	Low
Ease of installation, commissioning and maintenance	Easy	Difficult	Easy

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Reduction in exhaust volume

Fume Hood Width	Exhaust Volume		% Reduction in Exhaust Volume
	Frontier Acela 0.3m/s(60fpm) @457mm/18”	Conventional Fume Hood 0.5m/s(100fpm) @full sash open	
1.2m(4’)	492cmh/290cfm	1296cmh/763cfm	**62%**
1.5m(5’)	642cmh/378cfm	1400cmh/824cfm	**54%**
1.8m(6’)	793cmh/467cfm	1543cmh/908cfm	**49%**
2.4m(8’)	1094cmh/644cfm	2372cmh/1396cfm	**54%**

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Example - 4ft fume hood

Location: New York City, New York, United States | New York City, New York, United States

ASSUMPTIONS	Hood 1	Hood 2	
Energy Prices [1]			
Electricity	0.1814	0.1814	$/kWh
Electricity Demand	120	120	$/kW-yr
Fuel	6.5	6.5	$/million BTU
Operation [2]	12	12	hr/day
Hood Opening (Horizontal)	60	60	inches
Hood Opening (Vertical)	28	18	inches
Face Velocity	**100**	**60**	ft/min
Fan Power (supply/exhaust) [3]	1.80	1.80	W/CFM
Cooling Plant Efficiency	1.00	1.00	kW/ton
Heating System Efficiency	70	70	percent
HVAC Supply Air Setpoints			
Heating	55	55	°F
Cooling	55	55	°F
Reheat Energy [4]			
Delivery Air Temp.	65	65	°F
Energy Type	Electricity	Electricity	

ANALYSIS	Hood 1	Hood 2	Difference
Flow Rate	1,167	450	717 CFM
Cooling & Air-handling			
Chiller Energy [5]	9,450	3,645	5,805 kWh/year
Fan Energy	9,198	3,548	5,650 kWh/year
Total	18,648	7,193	11,455 kWh/year
Total Power	6.3	2.4	3.9 kW/hood
of which Fan	2.1	0.8	1.3 kW/hood
of which Chiller	4.2	1.6	2.6 kW/hood
Heating			
Supply Load [5]	89	34	55 million BTU
Reheat Load	55	21	34 million BTU
Total Load	145	55	90 million BTU
Energy (fuel)	0	0	0 million BTU
Energy (electric)	16,170	6,237	9,933 kWh
Average Reheat Power	1.8	0.7	1.1 kW
Total Per-Hood Costs	**7,293**	**2,813**	**4,480 $/year**
Cost Per CFM	6.25	6.25	0.00 $

By reducing face velocity, potential savings per year in New York's climate is $4,480
This does not include reduced installation cost for smaller sized blower and air conditioning system due to lower air flow

* Concept and methodology by Evan Mills and Dale Sartor; Web programming and GUI by Christopher Bolduc

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Increase in capacity

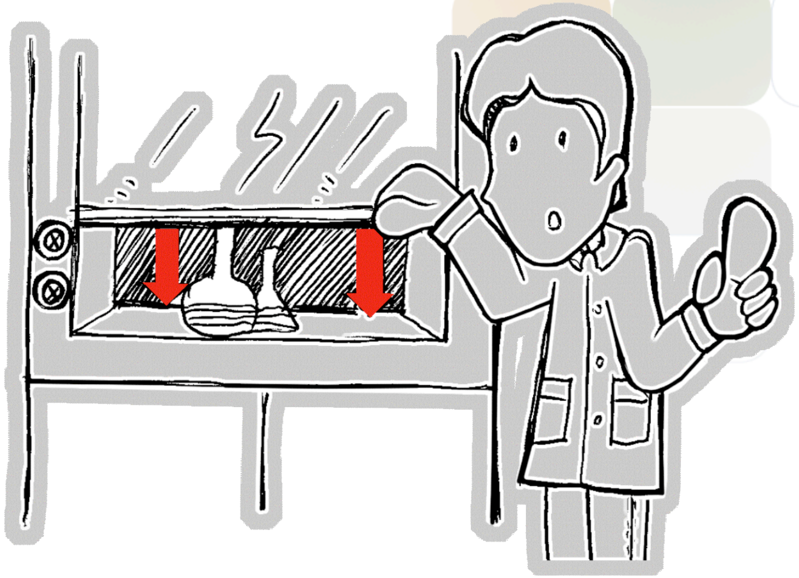
- Usually labs are “starved” for air
  - Due to expansion or other reasons
- In some instances, low airflows cause inadequate exhaust and increased potential for hood spillage.
- Increasing airflow is very costly
- Replace conventional fume hoods with high performance low flow fume hood
- Able to substantially reduce air flow of each fume hood
- Allow more air flow to be allocated for additional fume hoods
- Reduce overall expansion cost

Sample calculation

- Capacity for a 50-hood lab building
- The building uses a 330 ft^2 laboratory planning module and has one 6-ft. benchtop chemical hood per module. Assuming average utility rates and Midwestern U.S. weather patterns. The base case is a 6-ft bench hood with 1200 cfm of exhaust, operating continuously year-round.
- Base Case: Older-style Conventional hoods, minimal controls (1200 cfm)
- 1200 cfm X 50 hoods = 60,000 cfm
- New high performance low flow fume hood (720cfm)
- 60,000 cfm ÷ 720 cfm/hood = 83 hoods
- Possible increase in number of fume hoods = 33 more fume hoods
- More than 65% increase in capacity based on current air flow utility.

Good laboratory habits

- Switch off equipment when not in use
- Close sash of fume hoods when not in use
- Regular maintenance checks



Looking ahead....

- Energy conservation is important
  - Financial gains
  - Everyone's responsibility
- Make use of technology to improve energy efficiency
- Maintain ductwork
- Use energy efficient equipment
  - High performance low velocity fume hood >> Esco Frontier Acela
- Practice good habits