How to determine if Green Fume Hoods are right for your laboratory

Ken Crooks, Director, GFH Filtration Technology, Erlab, Rowley, MA
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Key Words:

- Chemical Fume Hood
- Zero Net Energy
- Chemistry Laboratory
- Sustainability
- Laboratory Renovation
- Filtered Fume Hood

Abstract
There are many considerations that must be analyzed when adding or replacing a chemical fume hood in your lab. One of the initial decisions is whether to consider using a Green Fume Hood (a filtered, recirculating fume hood) or to just stay with a conventional ducted fume hood. Many people unknowingly and incorrectly limit the applications for Green Fume Hoods (GFH) to just those historically considered most appropriate for 'ductless' fume hoods. GFH Filtration Technology contains the most advanced molecular filtration, reliable breakthrough detection and network communications; thereby allowing it to safely replace many ducted hood applications. Investing the time to honestly consider using a Green Fume Hood can deliver a lifetime of safety and savings when compared to the ducted alternatives.

Introduction
The GFH Selection Chart can be divided into (4) major steps, these steps are specifically ordered so that you can quickly determine if a GFH is an option for your particular chemical fume hood application. Once the application is pre-qualified, the in-depth chemical review process will be performed to assure that the users will be safe at all times.

Step 1: Confirm that there will be monetary savings by using GFH.

Step 2: Review the chemicals being used to make sure all will be captured and retained by GFH filtration.

Step 3: Perform the in-depth chemical review process and calculate filter life time.

Step 4: Final review and confirmation of both safety and savings.

15 Minutes will give you a lifetime of safety!

To properly use the GFH selection chart, follow these instructions working from the "Start Here" arrow at the top left of the chart, all the way to the final selection box of GFH or Ducted fume hoods at the bottom of the chart, whichever is ultimately most appropriate for your needs. Keep in mind that the best arrangement for your project may well be a combination of both filtered and ducted fume hoods; these are not mutually exclusive solutions.

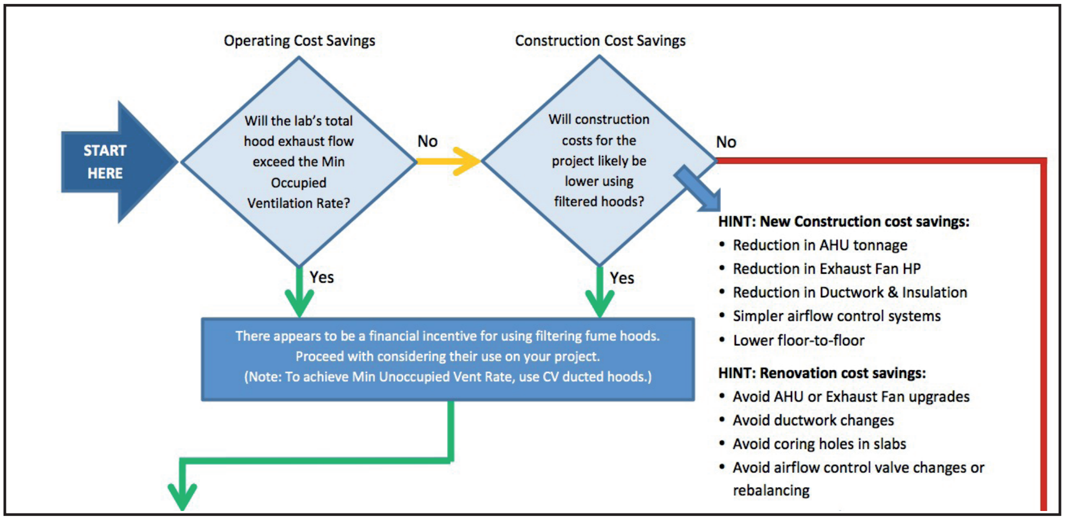


Figure 1: Step 1 - Determine monetary savings

1) Will there be cost savings by using GFH? In almost all cases there will be both operational and construction cost savings, whether this is a renovation project or new construction (Figure 1).

a. Operational cost savings:

i. The largest operating cost of a laboratory is the HVAC systems that provide the correct environmental conditions. The control system must balance the airflow needs of the lab and provide enough conditioned air to satisfy the greater demand of (3) main categories:

1. To satisfy minimum ventilation (fresh air) rates as required by building codes and guidelines.
2. To satisfy the comfort requirements of the occupants via cooling and/or heating air.
3. To provide make-up air to replenish all air exhausted by the ducted fume hoods.

As such, if the make-up air demand for the fume hoods (item 3 above) is so great that it exceeds the other two categories for at least some periods of time, then there is the potential for reducing the volume of air being delivered to the lab. That reduction in air volume is where operational cost savings will be generated. Heating, cooling, filtering, dehumidifying and delivering make-up air to the lab is very expensive (see Figure 2 below). In North America, the typical cubic foot per minute (CFM) of fresh air costs between $5.00 and $8.50 per year in energy costs and a standard ducted fume hood can consume between 600 and 1,250 CFM of air, depending upon sash position. This high operational cost provides ample savings to offset the cost of replacement filters over time.

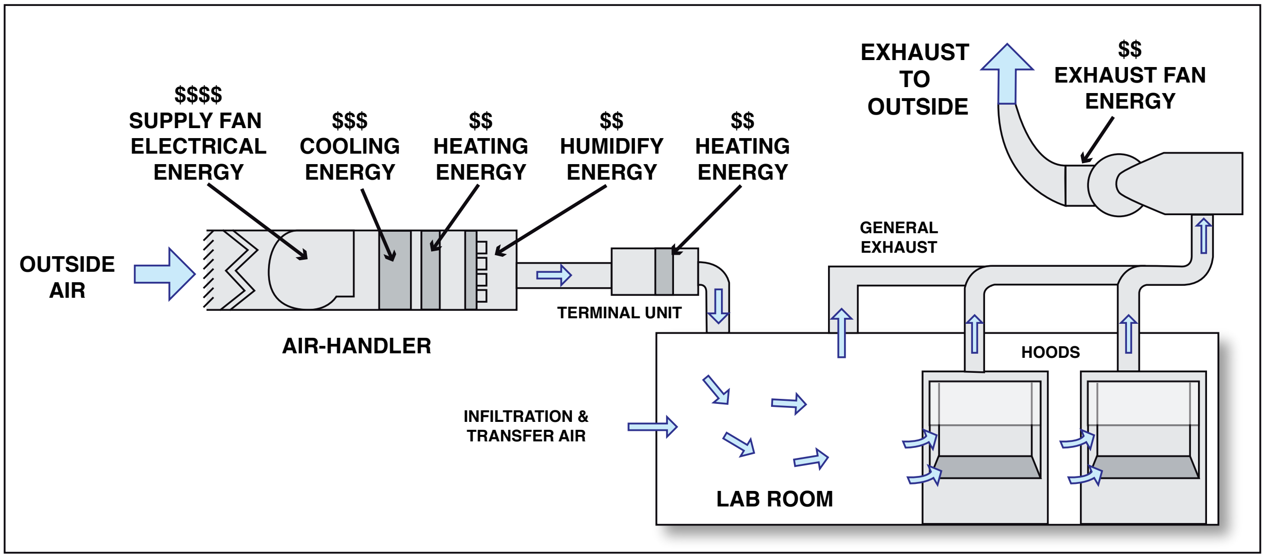


Figure 2: Intensive energy use for ducted fume hoods (US DOE, 2014)

ii. However, if the laboratory is fairly large and the number of fume hoods is relatively low (aka “low hood density”) then likely the minimum ventilation rate (item 1 of 3 above) is consistently greater than the make-up air demand for the hoods. In these cases, using ducted fume hoods may well be the best option as they assist with achieving the minimum ventilation rates. The next step of reviewing construction cost savings must first be considered before making a final decision to use ducted hoods. In many cases, the reduction in Heating Ventilation and Air Conditioning (HVAC) systems will provide significant first cost savings, making the GFH a lower first cost option. In most cases, there is a reduction of both operational costs and construction costs.

b. Will there be construction cost savings by using GFH?

i. A ducted chemical fume hood will not function on its own. Ducted hoods require many complex and expensive HVAC systems to be installed in the building so that air is properly extracted from the hood and tempered make-up air is delivered into the laboratory. Those systems include:

1. Hood exhaust ductwork
2. Hood exhaust air valve and associated hood controls
3. Hood exhaust fan(s)
4. Make-up Air Handler Unit (AHU) to temper and supply fresh outside air for the lab
5. Supply air ductwork and insulation
6. Supply air control valve(s)
7. Penthouse or mechanical room space for all of the HVAC systems
8. There are the costs associated with longer construction schedules and delayed occupancy that must be considered when using ducted hoods.

ii. GFH are unitary pieces of equipment that do not require connections to complex HVAC systems. Many of the HVAC items listed above are eliminated and those remaining are downsized. Also, the construction schedule can be shortened due to the simplicity of installing GFH.

iii. Independent architects and engineers have determined that the HVAC systems required to allow a ducted hood to function properly cost between $20,000 and $25,000 USD for each hood (see Figure 3).

These costs are in addition to the cost of the hood itself. Each lab project will be unique in many ways and these costs will differ slightly from project to project. Nonetheless, there are significant HVAC system costs associated with every ducted fume hood that cannot be avoided regardless of the type of ducted hood being used (i.e. from the simple Constant Volume hood to the complex High Performance hood). All ducted hoods require these HVAC systems to make them work properly.

Comparison First Cost NC Ducted vs. Filtered	CV	VAV	VAV HP/LF	Filtered
Fume Hood, 6Ft, Vertical Sash [1,2]	$10,000	$10,000	$12,000	$25,000
Building Infrastructure: M-E-P, Lab Services & Data [0,3]	$20,000	$25,000	$25,000	$2,000
Total First Costs	**$30,000**	**$35,000**	**$37,000**	**$27,000**

Energy Costs/Year				
Exhaust Fans[4]	$1,367	$911	$711	$293
Make-up Air ($5/cfm) [5]	$6,000	$4,000	$3,120	$0
Maintenance Costs/Year	$1,200	$1,500	$1,500	$1,800
Total Operating & Maintenance/Year	**$8,567**	**$6,411**	**$5,331**	**$2,093**

Figure 3: Cost comparison – Ducted vs. Filtered Fume Hoods (Ellenzweig, 2010)

iv. These cost savings apply to both new construction projects and renovation projects. Commonly, major renovation projects are replacing the HVAC systems due to their being undersized for the new programming and/or due to their age and decrepit condition. Use of GFH can avoid replacing undersized HVAC systems provided they are still functional and in acceptable condition. If replacement HVAC systems are still needed, use of GFH can allow engineers to downsize them, thereby reducing the project costs. In addition to all the systems above, there are additional costs and challenges that must be considered during a renovation project:

1. Ductwork size: adding ducted fume hoods during a renovation will require larger ductwork. The age of the building will generally indicate if there is room available for larger ductwork. Buildings constructed during the 70's and 80's or earlier, typically do not have the floor-to-floor height to allow increases in ductwork size.
2. Reusing existing HVAC systems, even if in proper operating condition, may not be possible simply because of the higher air flow rates required to support additional ducted fume hoods.
3. Existing supply and exhaust airflow control valves will likely be undersized and require replacement with larger valves. Same for the supply air ductwork and the main exhaust air trunk from the lab.
4. Ducted hoods will require additional or larger capacity hood exhaust fans which in turn may require more roof top area and structural support.

v. Adding a chemistry lab to a building not originally designed to support wet chemistry presents many additional challenges:

1. Boring (coring) holes for new ducts to pass through each concrete floor slab is troublesome and costly. Each slab (floor) must be X-rayed to assure no pipes, electrical or other services are in the way. The process of cutting large holes in concrete slabs is very noisy and disruptive to all building occupants. The cooling and dust suppression water makes it a very messy process.
2. Alternatively, the decision to avoid coring holes in the concrete slabs is to place ductwork on the outside of the building. This is very unsightly and the least desirable option (see "ugly duct-ling" photo at right!).
3. Any roof structure and strength must be sufficient to support exhaust fan(s). Engineers will review the existing structure and recommend the extra support necessary.
4. Depending upon the type of building, there is likely a lack of proper air handling equipment to temper the amount of make-up air necessary for ducted hoods.

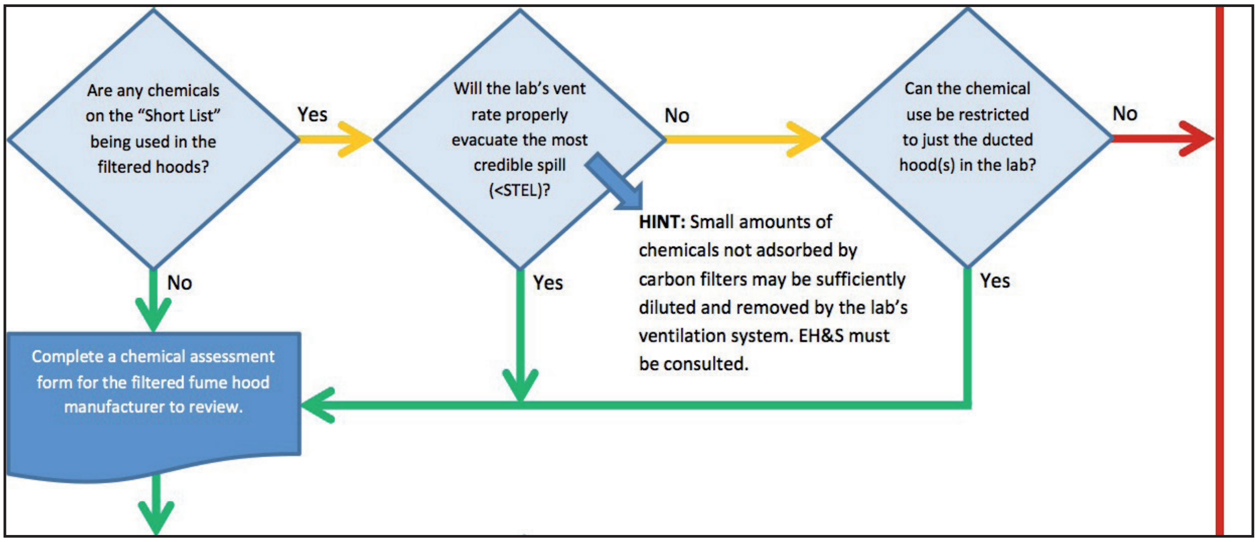


Figure 4: Step 2 - Chemical review

2) Once you have determined that there are operational and/or construction cost savings by using GFH, the next step is to make sure that the chemicals to be used by the researchers, scientists and students will be captured and retained by the GFH filtration technology (see Figure 4).

a. Review the "short list" of chemicals not captured well by any carbon-based filtration technology. These chemicals are those with very low molecular weights and low boiling points (gaseous at standard temperatures and pressures). They include: Hydrogen, all (6) Noble Gases, Methane, Ethane, Ethylene Oxide, Carbon Monoxide, Carbon Dioxide, Nitrogen Monoxide, Propylene, Propyne, Propane, Acetylene, etc. Fortunately, these chemicals are not commonly used in chemistry labs. If they are used, typically they are in small quantities.

b. If your researchers are using some of the chemicals on the "short list" then the next step is to determine if the quantities being used are great enough so that their release into the lab environment would raise the concentration level in the lab air to a point where action must be taken.
   i. For example, propane is sometimes used as a source for heat and, prior to igniting the flame, some of this gas will be released into the air. That small amount of a release will not raise the lab air concentration anywhere close to the action levels determined by the American Conference of Industrial Hygienists (ACGIH), OSHA and other safety organizations. Propane levels can rise to 2,500 ppm concentration (the ACGIH TLV-TWA) or 1,000ppm (the NIOSH REL and the OSHA PEL) before action must be taken to avoid risks to human health. Obviously, your Environmental Health and Safety (EH&S) department must be consulted when making this determination.
   ii. If the concentration would rise to a hazardous level, or a level high enough to cause other concerns, there is the option of moving this chemical handling to a ducted hood within the lab. Quite commonly, the first hood in the lab is a ducted hood so as to help achieve the minimum ventilation rate required by codes (item 1.a.i above). This single ducted hood could be the location for handling any chemicals on the short list, thereby allowing the remaining hoods to be GFH.

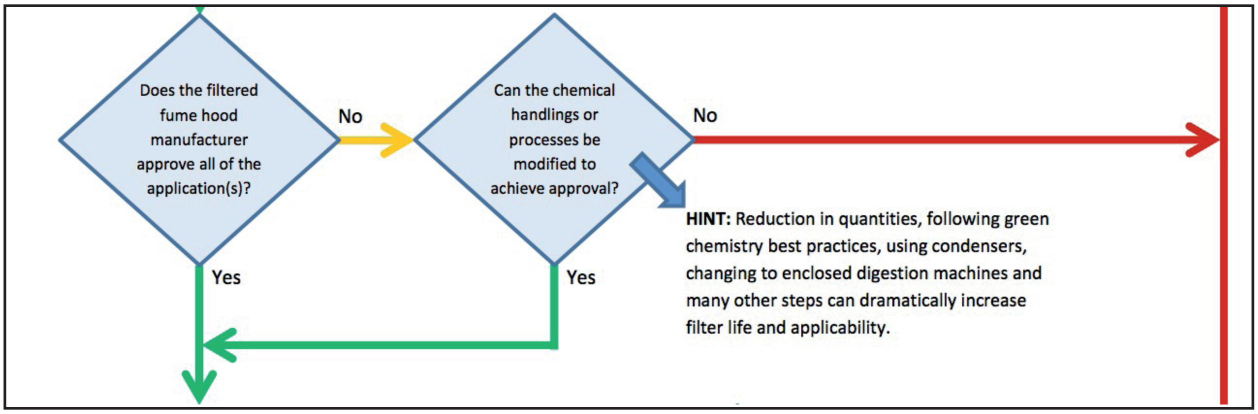


Figure 5: Step 3 - Application Approval or Changes

3) The next step is to perform the in-depth chemical analysis (see Figure 5).

a. Complete the Lifecycle Payback Questionnaire (LPQ) form. We ask you to list each chemical handling (manipulation) to be performed inside the hood. The chemical name, container type, concentration, temperature, quantity, frequency and duration are all needed to properly assess the volume of vapors generated from each chemical handling. Anything less than this full review will not accurately calculate the filter life.
b. Each chemical handling must be a separate entry. There are extensive drop-down menus to guide the user and streamline data entry. If the item you are looking for is not listed, simply type in your value or chemical name.
c. Submit the LPQ form to the manufacturer and their research lab will complete the review.
d. The review will assess (4) important categories:
   i. Is a fume hood the proper containment device for the chemicals and powders listed on the LPQ? This category rarely fails review. The process of selecting a fume hood as the proper containment device has most likely already been thoroughly reviewed by the architects and engineers. For a simple addition of one hood, though, where architects and engineers may not be involved it is important to make this determination.
   ii. Are all of the chemicals and powders listed captured and retained by the filtration technology? The fil-

tration manufacturer will review all chemicals being used and compare it to their own testing and "long list" of chemicals retained by the filter media. If the addition of HEPA filters are necessary to capture particles and/or protect the carbon filters, they will be detailed in this section.

iii. Are the chemicals detectable by the GFH technology when they eventually breakthrough the filtration media? As the chemical filters are used they will approach stated capacity. Saturation occurs near the end of life for the chemical filters. Prior to saturation, small amounts of breakthrough will occur and it is vital that the GFH technologies detect the presence of chemicals in the air after the primary filters and before the secondary (safety) filters.

iv. Lastly, filter life is conservatively calculated based upon the total volume of vapors generated and the various chemical retention capa,cities of the filtration media.

e. If all (4) categories are approved, it is time to move forward to the final verification step. If one or more categories are not approved, then depending upon the category, you may be able to modify the chemical handling to accommodate GFH:

i. Green Chemistry is a movement to use and consume lower quantities of chemicals and to always consider using less volatile chemicals without impacting the quality of research or instruction. Green Chemistry can drastically reduce the volume of vapors and allow a filtering fume hood to provide acceptable filter life. If you haven't already investigated Green Chemistry please do!

ii. Acid Digestion processes have advanced by using low-volume, self-contained systems that generate far fewer vapors (i.e. HotBlocks by Environmental Express, etc.). Using equipment such as this, if possible, can drastically reduce the volume of vapors and allow a filtering fume hood to provide acceptable filter life. If you haven't already investigated self-contained acid digestion equipment please do!

iii. Can open containers be covered except during the dispensing of the chemical? Can open trays of solvents (for cleaning/rinsing) be covered when not being used?

iv. Consider using condensers to reduce chemical evaporation during many applications (Reflux, Distillation, Bromination, Recrystalization, etc.).

v. If any of these changes can be made, resubmit the Lifecycle Payback Questionnaire with the modifications. If not, then a ducted fume hood is best for your application.

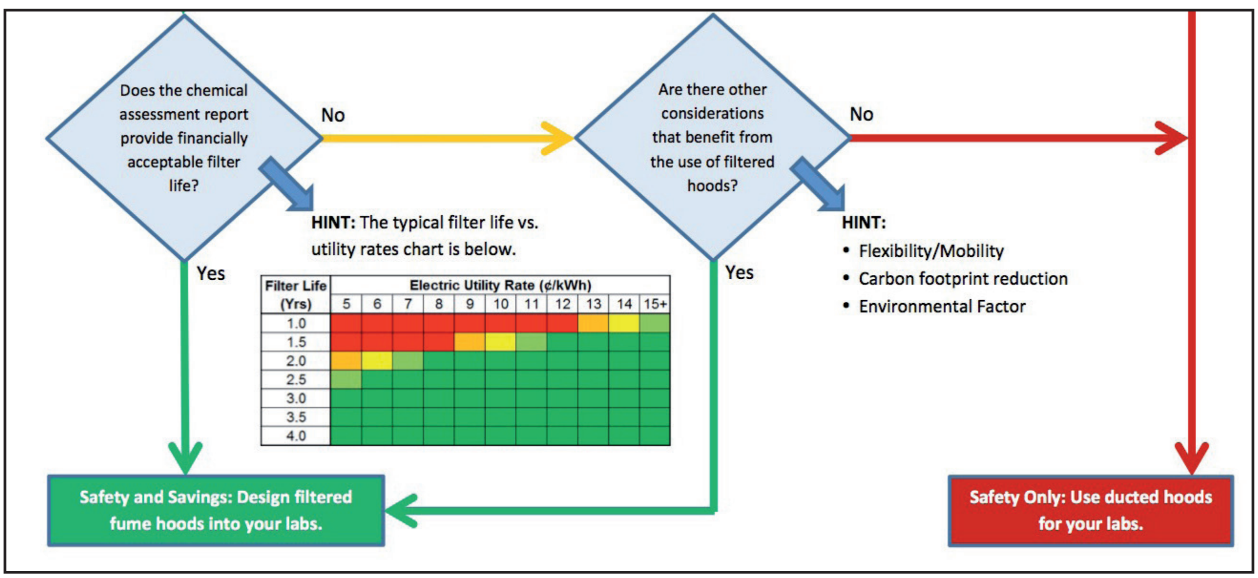


Figure 6: Step 4 - Confirmation of Safety and Savings

4) The last step is confirming all previous assumptions are correct (see Figure 6):

a. The application is fully approved.
b. The filter life is long enough to provide the operational savings calculated in step 1.
c. Are there other goals being achieved by using GFH that are not associated with costs:
    i. Reduction in carbon footprint.
    ii. Increased mobility allowing the hood to be brought to the need (demonstrations in theaters, ADA compliant hood, etc.).
    iii. Avoidance of exhausting chemicals outdoors (“up the stack”) in difficult locations such as a congested campus, city location, etc.

Congratulations!

Your willingness to consider newer technology has delivered a better result for you, your company and the environment.

Safety and Savings are provided by using a fume hood equipped with GFH Filtration Technology.

REFERENCES

DOE. 2014. “A Guide to Navigating Building and Fire Codes for Laboratories”. Better Buildings Alliance – Laboratories Project Team. http://i2sl.org/elibrary/documents/bba_building_and_fire_codes.pdf.

Ellenzweig Architects in collaboration with BR+A Consulting Engineers, R.W. Sullivan Engineering, and Vanderweil Engineers.

APPENDIX

Figure 3 foot notes:

Cost comparison data prepared by Ellenzweig Architects in collaboration with BR+A Consulting Engineers, R.W. Sullivan Engineering and Vanderweil engineers.

0. The figures listed above do not include potential savings due to reduced chiller capacity resulting in a lower chilled water load.
1. Cost comparison is based on new construction and includes estimated costs per single 6 ft. fume hood with a vertical sash configuration and utility connections including compressed air, lab vacuum, natural gas, electrical power and data. (Exception – combo sash of HP hood).
2. National Grid and other local and national utility companies provide a first time equipment cost rebate of up to 70% of the difference in cost between a conventional constant volume bypass hood and a filtering green fume hood. (Energy rebate savings are not included in the figures listed above).
3. Estimated building infrastructure cost (M-E-P Data) per fume hood based on new building construction with approximately 100 fume hoods.
4. Estimated electrical energy costs per year per fume hood.
    1. Assumption: Fans will operate 24 hrs/day, 365 days/year, 8,760 hours/year at $0.12kWh
    2. Fan HP required 1HP/ 2 in. SP
    3. Equivalent electrical load per NEC Article 430/full load current at 460 volts/3 phase/2.1 amps = 1.3 kWh
5. Estimated mechanical energy cost per year per fume hood:
    1. 6’ CV bypass (1,200 CFM x $5.00/CFM/year=$6,000)
    2. 6’ VAV (800 CFM x $5.00/CFM/year=$4,000)
    3. 6” VAV HP hood (624CFM x $5.00/CFM/year=$3,120)
6. The cost savings illustrated do not take into account possible additional cost savings associated with a reduced floor to floor height related to possible reduced HVAC ductwork.

ERLAB GREENFUMEHOOD "SHORT LIST"

Not retained (or not retained long enough) by any filtration technology*:	
Chemicals which are naturally gaseous under normal temperature and pressure conditions with a very low boiling point (<25°C)	Hydrogen
	Noble Gases: Helium, Neon, Argon, Krypton, Xenon and Radon
	Methane
	Ethane
	Ethylene Oxide
	Carbon Monoxide
	Carbon Dioxide
	Nitrogen Monoxide
	Propylene
	Propyne, Propane and Propene
	Acetylene

**Non-exhaustive list*

Not recommended:	
Organophosphoric Compounds	Because of their very high toxicity (can be used as Chemical weapons)
Mercury	Well retained but remains extremely toxic (TLV = 0.05 ppm) and difficult to detect
Hydrogen Cyanide	Immediately lethal
Perchloric Acid, Acid Digestion or Radioisotopes	These are demanding applications with specific hood construction criteria that is not appropriate for filtered fume hoods
Experiments that generate smoke and highly exothermic reactions. Carbon-based filtration does not capture fine smoke particles. HEPA filters can be optionally added to the GreenFumeHood.	

Erlab's state of the art Research & Development Laboratory relying exclusively on filtration

North America
+1 800-964-4434 | captairsales@erlab.com

China
+86 (0) 512 5781 4085 | sales.china@erlab.com.cn

France
+33 (0) 2 32 09 55 80 | ventes@erlab.net

Germany
0800 330 47 31 | verkauf@erlab.net

Italy
+39 (0) 2 89 00 771 | vendite@erlab.net

Malaysia
+60 (0) 7 3 555 724 | erlab@tm.net.my

Spain
+34 93 673 24 74 | ventas@erlab.net

United Kingdom
+44 (0) 1722 341 940 | salesuk@erlab.net

www.erlab.com

Erlab above

About Erlab

We provide safety, we protect your health

Erlab invented the ductless fume hood in 1968. With more than 45 years of experience in the field of chemical filtration and protection of laboratory personnel; we know we know the formula for safety. With Erlab, you will never have to wonder or worry if our products are safe. We build each one of the following 7 ingredients into our products, and without all of them, your health and safety will be compromised.

1 Erlab R&D Laboratory

The engineers and chemists in our state-of-the-art R&D laboratory understand molecular filtration and continuously work to ensure our products are safe, constantly innovating to improve our products, and developing new products to ensure greater protection in the laboratory.

2 Strict Safety Standards

We hold ourselves to the highest standard and adhere to the strict AFNOR NF X 15-211: 2009 filtration safety standard as recognized by ANSI Z9.5-2012.

3 A Published Chemical Listing

It all begins here. Without this listing, we are not compliant with AFNOR NFX 15-211. Our in-house laboratory tests and independent testing verifies the retention capacity of over 700 chemicals for our filters.

4 Independent Testing

Erlab filters have been independently tested multiple times at various concentrations guaranteeing that our safety solutions all adhere to the strict performance criteria of the AFNOR NF X 15-211:2009 standard assuring that the emissions concentration at the filter exhaust will always be lower than 1% of the TLV.

5 Application Questionnaire

Our laboratory specialists will recommend the appropriate filtration fume hood, type of filter, and personalized advice.

6 Certificate of Validation for the chemicals used in the hood

A certified PhD chemist issues a Certificate of Validation with a list of the chemicals approved for use in the hood.

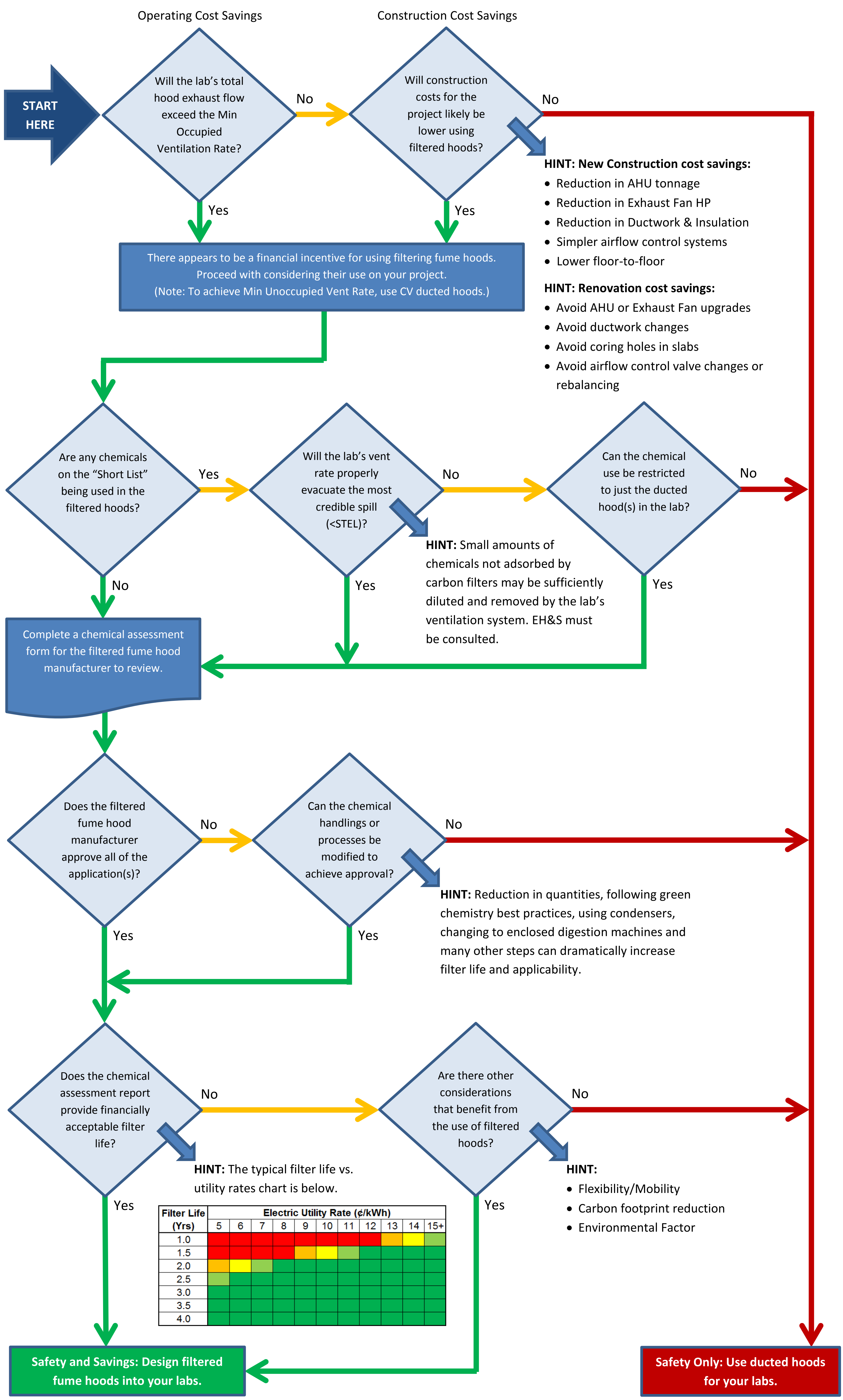
7 Our Safety Program

We back up our products 100%. This program includes your specialized chemical evaluation, validation of your hood upon installation, and your filtration safety specialist that ensures your hood is operating to its full potential.

erlab

Experts in air filtration for the protection of laboratory personnel since 1968

GreenFumeHood Selection Chart



Filter Life (Yrs)	Electric Utility Rate (¢/kWh)										
	5	6	7	8	9	10	11	12	13	14	15+
1.0											
1.5											
2.0											
2.5											
3.0											
3.5											
4.0											

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