

# Installing or Replacing a Bathroom Exhaust Fan



This document is designed to help you choose an appropriate bathroom exhaust fan and its system components, considering both your household's need for bathroom and/or whole house ventilation, and the construction of your bathroom. We will provide information on replacing an existing fan and installing a new fan from scratch. This is the second of two documents on bathroom exhaust fans. The first document focused on assessing your existing bathroom exhaust fan and is available on the ROCIS website. The recommendations in this document are provided by Livable Housing, Inc. unless otherwise noted.

## Why do we need a functional bathroom exhaust fan?

- Moisture, moisture, and moisture! Moisture damages building components and leads to mold growth, especially in full baths.
- In both full baths and half-baths, controlling odors may be a concern.
- Exhaust fans can improve indoor air quality by removing contaminants and VOCs, including those found in Personal care and cleaning products.
- Bath fans can be a source of whole house ventilation as outdoor air replaces the exhausted air.

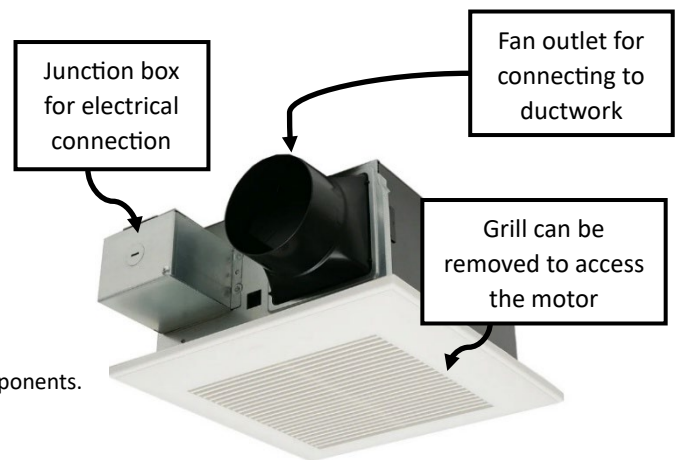
Bathroom exhaust fans manage moisture and odors by moving air outdoors. We prioritize exhaust in full bathrooms because bathing and showering generate so much moisture.

## Four Basic Components of a Bathroom Exhaust System

1. The Fan
2. A method of switching the fan on and off
3. Ductwork
4. A fan outlet with a damper

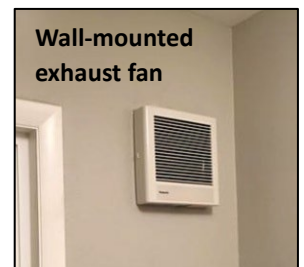
The choice of components and their installation is crucial, and our focus.

The photo to the right highlights a few fan components.



## What is the appropriate location for the new fan?

- For removing moisture, placement of the fan should be close to the source of moisture, for example, directly over the tub/shower.
- If there is an existing ceiling-mounted fan, it will usually be easiest to maintain that location. Otherwise, you will have to patch the existing hole and create a new one. Assess the proximity of an existing fan to the source of moisture. If it's not close, consider relocation.
- If there is an existing wall mounted fan, you may choose to install a new one in that location after assessing its proximity to moisture sources. Most wall mounted fans are noisy, often generating 6 to 10 times the noise level of most ceiling fans.



## What is the appropriate location for the new fan? (cont.)

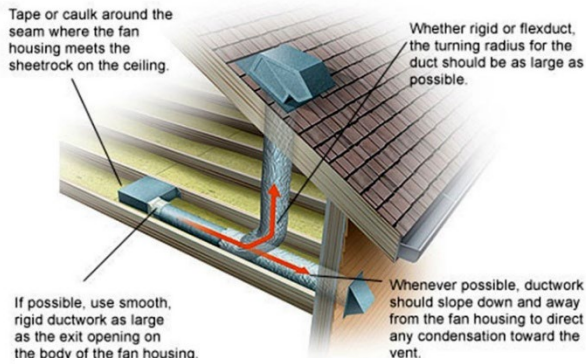


Illustration courtesy of Pacific Northwest National Laboratory (PNNL)

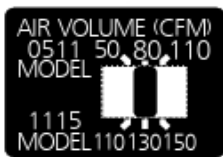
- If you are locating a new exhaust fan in the ceiling of a bathroom, you must also consider the structure of the ceiling. It is likely that the ceiling joists are spaced 16" on-center (OC) (or less likely 24" OC), and it will be easier to install the fan in an opening cut between the joists. Ceiling mounted exhaust fans are universally sized to fit in between standard joist spacing. Note the location of the fan between the joists in the illustration to the left. If you have an existing fan, don't assume it was installed appropriately. Use this guide to analyze its location, orientation, ductwork, and outlet.

- We will focus on ceiling installations of bathroom exhaust fans because they are more common. The same installation principles hold true for wall mounted models. Some exhaust fans can be installed either way. Wall mounted models benefit from much shorter duct runs.

## Criteria for Choosing a New Bathroom Exhaust Fan

### 1. Volume of Air Flow – Cubic Feet per Minute or CFM

- For a typical 5 by 7 foot bathroom with a shower, tub, or tub/shower combination, we recommend a fan rated in the range of 80 to 100 CFM. A fan with that rating is sufficient **IF** it is installed and correctly ducted to the outside. The type, length, diameter, and number of fittings in the ductwork can drastically affect the fan's performance. Bathrooms that are significantly larger, or generate unusually high moisture levels, may require fans with higher CFM ratings.



Pick-A-Flow<sup>®</sup> switch

- Some bathroom exhaust fans allow the installer to select CFM performance from a switch in the fan assembly. The Panasonic Whisper Green Select fans have that feature. The image to the left shows their switch which allows options of 50/80/110 or 110/130/150 CFM settings, depending on the model.

### 2. Noise Level (Sones)

- Exhaust fan noise may discourage occupants from using fans that must be manually switched on to operate.
- Sones is the standard unit of measure for fan noise. Unlike decibels, which measure the intensity of a sound, sones measure the subjective loudness as perceived by the human ear. The sone scale is linear, so a 2-sone fan is perceived to be twice as loud as a 1-sone fan.
- The Home Ventilation Institute (HVI) recommends bathroom exhaust fans with noise levels of 1 sone or less. The HVI product directory lists sone levels.

For reference, 4.0 sones is the sound of standard television operation; 3.0 sones is typical office noise; 1.0 sones is the sound of a refrigerator; and 0.5 sones is the sound of rustling leaves.

### 3. Home Ventilation Institute Certified

- All bathroom exhaust fans with a “Home Ventilation Institute” (HVI) certification have been tested to confirm their rated performance levels. The HVI-Certified Products Directory is updated monthly and offers consumers a means to compare products using a variety of criteria. Look for the HVI logo on the packaging. [www.hvi.org](http://www.hvi.org)



### 4. ENERGY STAR® Certified

- Use about 50% less energy than standard models.
- Provide better efficiency and comfort with less noise.
- Feature high performance motors and improved blade design, providing better performance and longer life.

We recommend ENERGY STAR® Certified products for the reasons above, and because they are readily available and easy to identify because of the logo. The ENERGY STAR® website has a [Product Finder page](#) for Certified Ventilating Fans. Look for the ENERGY STAR® logo on the packaging.



### 5. Installation Requirements

- Consider downloading the installation instructions for each fan that you are considering. This information can help you to determine if the manufacturer’s requirements are suitable for your situation.
- Installation instructions may affect your equipment choice. For example, the maximum length and the minimum diameter requirements for ductwork may vary by the fan model.
- Some fans are designed to replace an existing fan and use the existing ductwork. Examples include the Broan EZ Fit and Panasonic WhisperFit fans.



### 6. Lighting Option

- Do you need to include a light in the fan assembly? Is the existing lighting in your bathroom adequate?

Integrated Light/Fan Combo

### Switching Options for a Bathroom Exhaust Fan

The switching option(s) selected can make the difference in having an exhaust fan that is used effectively or never turned on. The following options can be used independently or in combination.

#### 1. Adding a separate switch for the fan

- Allows the option to separate the switching of the bathroom light and the fan and run the fan as long as you prefer. But you must turn it off manually.

#### 2. Wiring the circuit so that the fan runs when the light switch is turned on

- Some fans and some fan switches enable this approach. This reduces the number of switches, and it increases the likelihood that the fan will be operated whenever someone enters the room. The wiring is more complicated and may require an electrician.

## Options for Switching on the Bathroom Exhaust Fan (cont.)

### 3. Installing a motion sensor to switch the fan

- Some fans have the option of an integral motion detector switch, which automatically starts the fan when someone enters the room. The photo shows a motion detector's green light flashing.
- This eliminates the need to have the light and fan switched together because the fan turns itself on when it sees motion.
- There are also motion detector switches that can be installed in place of the wall switch at the entry to the bathroom.



### 4. Using a humidistat as the switch

- Humidistats sense the level of humidity, and can turn the fan on and off based on the humidity level, which can effectively control moisture. A delay timer is unnecessary with a humidistat switch.
- Humidistats are available as an optional fan component accessory or as a sensor in a wall switch.
- We recommend having the humidistat installed on the fan. We have seen mixed results with the humidistats built into the wall switch, probably because the switch cannot sample the air in the room as effectively as a humidistat mounted on the fan.
- If you use personal care or cleaning products with strong odors, a humidistat will not sense them.

### 5. Adding a timer (delay function) to extend fan usage

- We can achieve better moisture removal by extending the time that the fan runs after someone takes a shower or bath. This is often referred to as a “delay” function, as it delays turning off the fan for a preset amount of time. Research has shown that 20 minutes of run time with a minimum 80 CFM fan is required to remove the excess moisture after a typical shower.
- The delay function is a standard feature in some fans. It is adjusted with a dial on the fan housing under the grill, showing optional time intervals for delay. An example is pictured on the right.
- A delay function can also be added with a wall switch that contains a timer.



### 6. Whole House Ventilation Option

- Some bathroom exhaust fans can provide a continuous level of exhaust, and provide a level of whole house ventilation.
- Fans with this feature have a separate background ventilation setting that runs the fan constantly at a reduced level of CFMs. The fan provides a boost in CFMs when the bathroom is in use.
- For fans with this built-in feature, the CFM boost can be initiated by any of the switching methods mentioned, and a delay function is available.
- Wall switches can provide a background ventilation option and the delay function. The AirCycler switch pictured costs \$75. Note the closeup of the background ventilation and delay function adjustment dials. For whole house ventilation the switch runs the fan at full speed intermittently.



## Additional Thoughts on Exhaust Ventilation

- Ventilation using an exhaust fan does not control the source of the makeup air. For every cubic foot (CF) of air exhausted from the house, another CF must enter the home from some source to replace it. The air replacing the exhausted air is called makeup air.
- Makeup air typically enters through leaks in the building envelope. These leaks bring in air from the outdoors, or perhaps from an attic or crawlspace.
- Outdoor air, or air from attics and crawlspaces, may contain contaminants or moisture. Imagine that there are pests such as mice nesting in the attic or crawl space and the result on the air quality in that space. There might also be excessive moisture or sources of chemical contaminants.
- Exhaust fans may also bring contaminants from other parts of the house, including those from cooking or from combustion appliances. Would you want the particulate and contaminants from a large holiday meal spread throughout the house or exhausted near the kitchen.
- A bathroom exhaust fan is very good for removing contaminants and moisture from bathrooms. Using one for constant whole house ventilation can be worthwhile and improve indoor air quality by adding contaminant free fresh air, but it is more complicated. For this reason we believe that if you are considering using a bathroom fan for whole house ventilation, it may warrant a review of the dynamics of your house by a credentialed professional, e.g., a Building Performance Institute certified Building Analyst ([www.bpi.org](http://www.bpi.org)). That qualified professional should be able to analyze the risks and benefits of using a bathroom exhaust fan for whole house ventilation.

## Examples of Bathroom Exhaust Fans with Built-In Switching and Delay Options

The following examples are not meant to be endorsements of specific fans. These are products from national brands that have features that can encourage fan usage and offer functions such as the delay timer that we discussed previously.

Each of the fans are ENERGY STAR and HVI Certified. They all have a variety of switching options, including switching the bathroom lights and the fan together while maintaining other features such as the delay and the background ventilation functions. All are national brands and readily available online.

### Panasonic WhisperGreen Select™ 50-80-110 CFM FV-0511VKS3 - \$195



Multi-Speed & Time Delay Module



Motion Sensor Modul



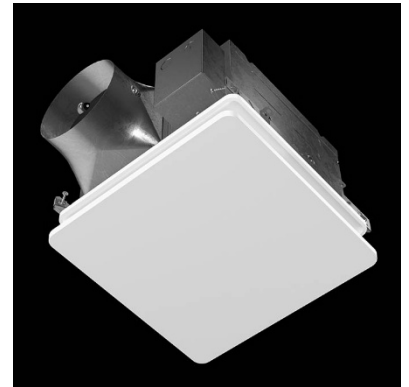
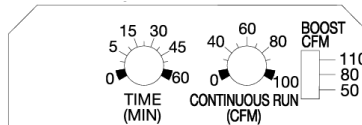
Condensation Sensor Module



- Fan speed can be adjusted to 50, 80 or 110 CFM
- Has optional humidistat and motion sensing modules.
- Built-in Delay function
- Built-in background ventilation setting
- Modulating DC ECM motor that adjusts to maintain CFM setting

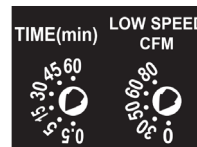
### Broan Evolve® 50-80-110 CFM Fan PTE511RK - \$225

- Fan speed can be adjusted to 50, 80 or 110 CFM
- Has optional humidistat and motion sensing modules.
- Built-in Delay function
- Built-in background ventilation setting



### Delta Breez Signature 80-110 CFM Fan SIG80-110D - \$160

- Fan speed can be adjusted to 80 or 110 CFM
- Built-in Delay function
- Built-in background ventilation setting
- Available with motion sensor and humidistat for \$220
- DC motor



## Installing a New Fan

Hopefully, you have decided which bathroom exhaust fan to install and have reviewed the installation instructions. Ideally, you've also decided on a switching method to turn the fan on and off. Here are recommendations for either installing the fan yourself, or hiring and supervising the installation by a contractor. Some of our recommendations go beyond the manufacturer's instructions, but they are based on researched and well understood building science principles. If you are replacing an existing fan, and/or cannot access the ductwork, compromises may be necessary.

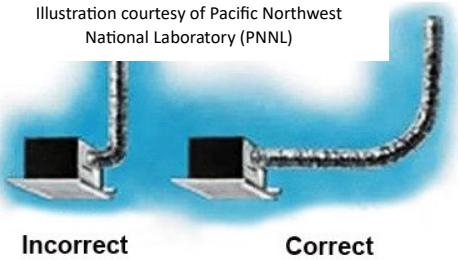
- **Fan location, orientation and anticipating the path of the ductwork**

- If the fan is to be installed in the bathroom ceiling, the orientation of the fan's outlet can have a significant effect on the path of the duct. Note the photos to the right and the negative impact of the fan orientation on the duct runs, adding elbows and duct length.
- For efficient air flow, the path of the ductwork should be as short as possible, leading directly to the exterior with a minimum number of elbows. In the photos provided, a shorter and more direct run would have been possible if the fan had been rotated 90 to 180 degrees.

Not Recommended



Illustration courtesy of Pacific Northwest National Laboratory (PNNL)



- When installing a new fan from scratch, determine the duct path, and the location of the outlet to the exterior, before settling on fan location and orientation.
- If you are replacing an existing fan, try to determine the path of the existing ductwork, the type of duct material used, and the location and condition of the outlet.

- As shown in the illustration above, when the duct exits the fan, it should be straight for 2 to 3 feet before the first elbow for the best air flow. The orientation of the fan can facilitate that. This is based on well researched building science, supported by several manufacturers' recommendations.

- **Duct fittings and materials**

- Elbows that sharply change direction will restrict air flow more than elbows with gradual bends. Use gradual rather than 90-degree turns if possible.
- The preferred version in the illustration uses two 45-degree elbows with straight pipe in between, reducing resistance to air flow.
- Smooth rigid duct is preferred over flex duct. Compared to smooth metal duct, the ridges in flex duct create resistance to air flow that reduces volume of air the fan can exhaust.

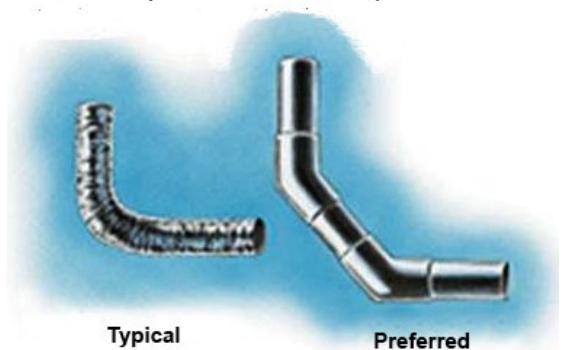


Illustration courtesy of Pacific Northwest National Laboratory (PNNL)

## • Duct design and types of ductwork materials

- Fan manufacturers have specific requirements for ductwork, including a minimum diameter. Connecting your fan to a smaller duct than specified will reduce the airflow.
- Round ductwork is by far the most likely option for bathroom exhaust fans.
- Increasing the diameter of the ductwork can be helpful in long duct runs because it significantly reduces resistance to air flow. Adapters are readily available to increase the outlet size at the fan.
- The outlet to the exterior should be at least the same diameter as the ductwork.

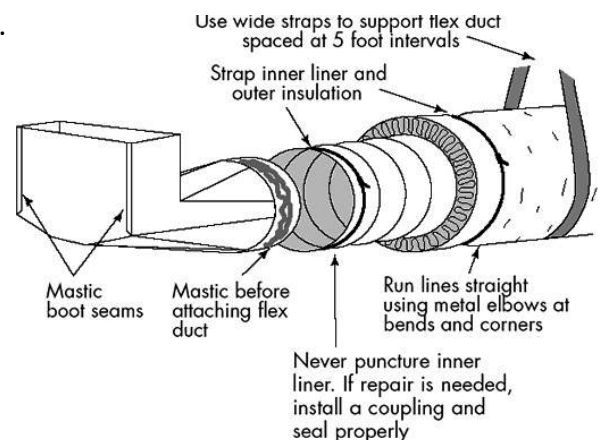


○ Here are typical ductwork types:

1. Flexible vinyl
2. Snaplock sheet metal
3. Aluminum foil
4. Semi-rigid aluminum

○ #s 1 & 3 are easier to install, but they create significantly more resistance to air flow because of the ribs supporting the flexible duct material. They are also more prone to being crushed, kinked and are more vulnerable to damage in general. We do not recommend using them.

- # 2 is the best for airflow and the least likely to be damaged in operation. # 2 could be galvanized metal or aluminum. But smooth metal duct, often referred to as Snap-Lock, requires more skill to install and may require hiring a skilled contractor.
- #4 is smoother on the inside compared to 1 & 3, and has some flexibility. It can be useful in short lengths for gradual changes in direction, but is more expensive than #2 with smooth metal elbows.
- Flex Duct, pictured to the right, is a type of flexible duct. The inner liner on insulated flex duct is similar to #1.
- Flex duct is typically insulated, which is important for ducts located in attics, crawl spaces and any other unconditioned spaces.
- Any type of flexible duct is easily pinched and compressed. Following the installation instructions is very important, which means no sharp bends, no kinks, connections to metal boots must be well sealed, and it must be level and stretched tight for the best performance.
- Most manufacturers will recommend against using flexible duct to make turns because it kinks so easily. Metal elbows are much more reliable for changing direction.



- Check out the gallery of mistakes with flexible duct below. Remember, sharp bends and kinks reduce air flow, sags are gathering points for condensation, ducts in attics should be insulated, and duct runs should be as short as possible.



● **Insulating Ductwork and Sealing Connections**

- The connections between sections of ductwork should be airtight for better air flow and to minimize the risk of moisture problems from condensation.
- The best ways to seal duct connections is with either a tape that is specifically designed for that purpose or a duct sealing mastic, which is a fiber reinforced paste designed specifically for sealing seams in ductwork.
- Remember to seal the ductwork seams and connections before insulating the ducts, while you have good access.
- Exhaust ductwork in unconditioned spaces such as attics and crawl spaces should be insulated to reduce the potential for condensation. In winter, the warm moist air being exhausted from the living space can condense when it contacts cold ductwork, and water can accumulate inside the ducts. In summer, when the air conditioning keeps the air inside the home colder, that air cools the exhaust ductwork in spaces like attics. The attic air is warm and humid and can condense on the outside of the colder ducts. Insulating the ducts helps to avoid condensation year-round. Readily available fiberglass duct wraps work well.



## • Duct Outlets

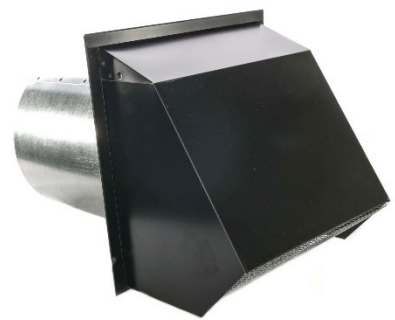
- There are many options for outlet locations, including roofs, soffits and walls.
- If the bathroom is directly under the attic, utilizing a roof outlet may be tempting to minimize the length of the ductwork. Installing roof outlets requires a penetration through the roof, and someone skilled with roofing installations.
- Wall outlets are a little easier to install but also require experience to install properly.
- We discourage soffit outlets as they can increase the potential for ice dams. Also, the exhausted air can be sucked back into the attic through nearby soffit vents.
- All exhaust vents should have a damper that closes securely to prevent pest entry and air flow from the outdoors. Some wall vents have a screen that provides added protection against pests. All must have a leak-free construction of a long-lasting material, and must be sealed properly to prevent water penetration and air leaks around the assembly. Prices range from \$20 to over \$100. The least expensive options are often louvered plastic or thin gauge metal, neither of which have long life spans.
- Here are a few examples of vents to consider:



Broan Roof Cap



Inovate Premium Wall Vent



Famco Hooded Wall Vent

## Fan Installation

All the major bathroom fan manufacturers have good instructions for installation of their products, and they also provide supporting installation videos on their websites. We recommend spending time with both the instructions (all downloadable as PDFs) and watching any videos that they make available. Here is a screen grab from the [Panasonic website](#) as an example:



WhisperGreen Select Wiring Animation



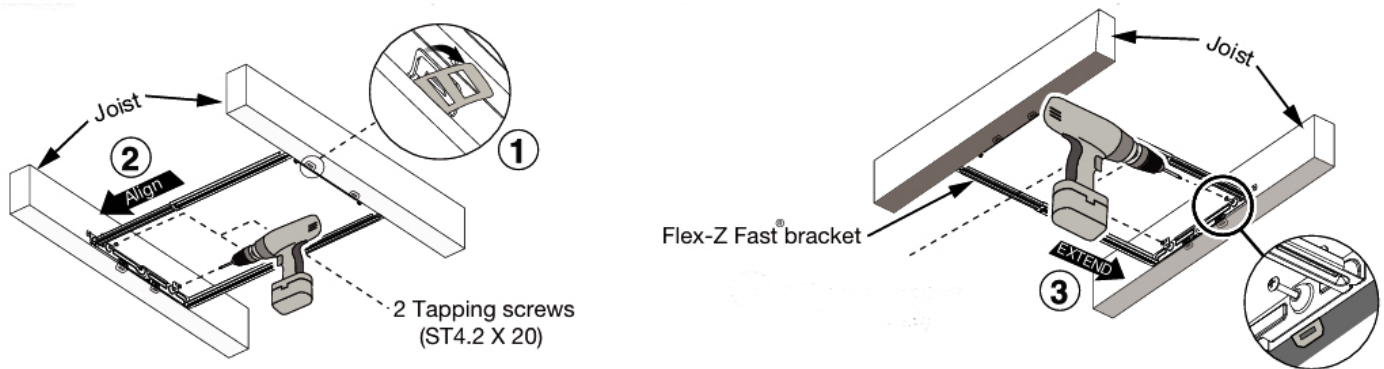
WhisperGreen Select Modules Video



WhisperGreen Select Installation Video

**Here are our recommendations regarding installation:**

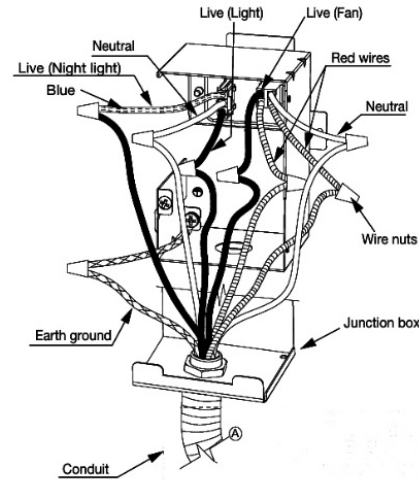
- If your home was built before 1978 there is the possibility of creating a lead-based paint (LBP) hazard by disturbing painted surfaces. The EPA has regulations for contractors working on pre-1978 housing under its “Renovation, Repair and Painting Program.” The EPA also provides information for DIYers. We have provided references to EPA information about both using a contractor and doing the work yourself in the Resources section.
- Electrical connections require professional expertise and potentially a licensed contractor. We recommend hiring a qualified contractor if you lack substantial experience with electrical work.
- Use the cutout template provided with the fan to create an opening in the ceiling for a new fan. The template will also let you know if an existing opening will work for a new fan. If the ceiling is drywall (a single layer of gypsum board), it should be relatively easy to create a new opening or enlarge an existing opening. There is also the possibility of plaster board with multiple layers of plaster. This will be marginally more difficult because the layers of plaster will make cuts more difficult. If the construction is older, and the ceiling is a combination of plaster over wood lath (thin wood strips with gaps between them), the task will be much more difficult for the inexperienced.
- Be aware that dirt, insulation and other debris may be on top of the finished ceiling - plan accordingly. To minimize debris falling into the bathroom, it may be possible to access the location from the attic and clear the area for the fan installation. For any modifications to the ceiling or walls as part of the fan installation, we recommend the use of personal protection (especially eye protection), drop cloths, and sealing the entrance of the bathroom to contain debris.
- Typically, the installation kits include an adjustable bracket to accommodate differences in spacing between the ceiling joists. An illustration of the installation of such a bracket is included below.



- After the opening is created or modified, the bracket is installed, the fan is secured in the bracket, and the ductwork is connected to the fan, but not necessarily in that order. Follow the instructions.
- The wiring is connected to both the fan and the switching mechanism. For fans with added features, such as built in lighting, night lights, delay switches, humidistats and options for continuous background ventilation, the wiring can be complex. Knowing the level of difficulty in advance is helpful. Research the installation instruction as part of your product selection process.

## Fan Installation (cont.)

- A relatively complex example of a wiring diagram is shown on the right.
- After the fan is installed on its bracket, the wiring is connected, the ductwork is connected, and you've tested to see if it works (confirming that air exits from the outlet & it passes the TP test, see 1<sup>st</sup> session doc.), it's time to seal the fan to the ceiling finish.



- Sealing the fan housing to the ceiling finish can be a significant energy saver, especially if the fan is in the attic. Air leaks in the ceiling below the attic create unnecessary heat loss and heat gain depending on the season, and those leaks also enable contaminants to move from the attic to the living space.
- The gap between the fan housing and the ceiling finish can be filled with a flexible caulk if the gap is 3/8" or less. Larger gaps may require spray foam.
- If you've moved insulation out of the way to install the fan, now is the time to move it back. If the fan is in the attic, and there is no insulation, it may be time to have insulation installed.
- All that's left now is to install the grill and enjoy your new bathroom exhaust fan!

## Choosing and Working with a Contractor

Here are our recommendations regarding contractor installed fans:

- Contractor selection:
  - Obtain pricing from at least 3 qualified contractors.
  - Energy Auditors of local energy efficiency programs may have recommendations for contractors to install a bathroom exhaust fan.
  - Qualified contractors will have at least 5 years of experience installing bathroom fans (ideally more), and confidently provide you with several references. They will have insurance, and their Better Business Bureau ratings will be good [www.bbb.org](http://www.bbb.org).
  - Electrical, HVAC, Remodeling, Renovation and General are all types of contractors that might do this work.
  - Give each of the bidders the same clear instructions about what you want done, ideally in an email or another format that can be documented. If you can, be specific about either the fan that you want installed, or the specifications that detail the features that you desire. HVI certification, ENERGY STAR® certification, CFM ratings, included light fixture or not, delay function, type of switching, type and diameter of ductwork, insulation of ductwork and location and type of outlet are examples of features you might specify.
  - Let the bidders know that your priorities are: Good Indoor Air Quality, Energy Efficiency, and Durability.
  - You can purchase the fan yourself, which may diminish the contractor's need for a deposit. It's unlikely that having the contractor purchase the fan will save you any money or affect the fan's warranty.
  - State your preferences for the type of ductwork and outlet if you have any.
  - Let the bidders know that you have done research and that your preferences are based on informed choices, and that you are familiar with the installation instructions for the fan that you selected.

## Choosing and Working with a Contractor (cont.)

- Don't be discouraged if contractors push back on your preferences, saying things like the following.
  - I've been doing this for years and I've never done it that way.
  - That will never work the way you want it to, trust me I know.
  - No one does it that way.
  - Smile and thank them for the information.
- You may have to talk to numerous contractors to find three that you would want to hire.
- Carefully compare proposals for level of detail and completeness.
- Demonstrate healthy skepticism for the very charming handy-person, working out of an unmarked vehicle, regardless of the rock bottom price.
- Contractor and firm are RRP certified by the EPA and trained in lead-safe work practices (see Resources section)
- Contractor supervision:
  - Insist on a signed contract.
  - Require the winning bidder to provide proof of insurance before signing a contract.
  - Humans perform better when they know that their work will be supervised. Let the bidders know during the bidding process that you will want to look at their installation at different stages. As an example, if you have access to inspect work in the attic, tell them when the fan and the ductwork are installed you will want to inspect before they are obscured by insulation. At a minimum, insist on having the contractor provide time-stamped photos of their work.
  - Don't hesitate to ask questions about the installation before, during and after.

### Summary:

1. What type of fan should you install? Wall or ceiling? How many CFM?
2. How should it be ducted to the exterior?
3. How will you switch it?
4. Should you include a delay feature so that the fan runs for 20 or so minutes after a shower?
5. Is this a DIY project or do you need a contractor?

## Resources:

- Building America Solution Center - Bathroom Exhaust Fans  
<https://basc.pnnl.gov/resource-guides/bathroom-exhaust-fans#edit-group-scope>
- Regarding Lead Based Paint:
  - If your home was built before 1978, any project can create dangerous lead dust. The EPA instituted the Renovation, Repair and Painting (RRP) rule to protect people, particularly children, from lead poisoning by requiring specific work practices when renovating or repairing buildings built before 1978.
  - The EPA recommends homeowners hire a lead-safe certified contractor who is certified and trained in lead-safe work practices. the RRP rule requires that contractors performing RRP projects in pre-1978 homes, child care facilities, and preschools be lead-safe certified.
  - Generally speaking, the RRP rule does not apply to homeowners doing RRP projects in their own home, but it's still a good idea to understand the regulation and read the EPA's recommendations for homeowners. For more information, see the EPA's recommendations for homeowners here: <https://www.epa.gov/lead/lead-safe-renovations-divers#:~:text=Any%20renovation%2C%20repair%2C%20or%20painting,protect%20you%20and%20your%20family>
- Registration for Webinar 1 – Assessing Your Bathroom Exhaust Fan  
<https://attendee.gotowebinar.com/register/1884266513341189467>



- Registration for Webinar 2 – Installing or Replacing a Bathroom Exhaust Fan  
<https://attendee.gotowebinar.com/register/1523134118221418589>



- ROCIS Webpage for Bathroom Exhaust Ventilation Content – Registration and Handouts  
<https://rocis.org/bathroom-exhaust-fans/>



To find Building Performance Institute (BPI) Certified Professionals:



[Locator Tool | Building Performance Institute, Inc.](#)

[locate.bpi.org](http://locate.bpi.org)