2019

DUCTED RANGE HOODS

Recommendations for New and Existing Homes

ISSUE BRIEF

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Tom also served as a technical advisor to national, state, and local agencies and NGOs on various IAQ issues and green building programs for homes, schools, and offices. Since 2010 Tom has served as the principal scientist at Healthy Building Research, where he co-authored a research roadmap for indoor environmental quality in net zero energy buildings and retrofits for California's energy program through 2030. The scope of his consulting work also includes climate change adaptation to extreme heat, resilient buildings and communities, training and communication, and policy and regulation.

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WHAT IS A DUCTED RANGE HOOD?

Ducted range hoods are metal or glass devices installed above cook stoves and ovens. Usually shaped like an inverted funnel or bowl to capture the cooking emissions, they employ a fan and ductwork to remove pollutants directly to the outdoors. Range hoods are also known as kitchen hoods, exhaust hoods, fan hoods, and extractor hoods. Some microwave ovens mounted above stovetops also have an exhaust fan and ducting to move cooking emissions outdoors. However, ductless (or recirculating) range hoods lack a vent to the outside and do not effectively remove cooking emissions, even if the hood has grease, particle, or charcoal filters. *(Note: the following recommendations will only be referring to **ducted (vented)** range hoods that exhaust to the outside of homes, unless specified otherwise.)*

WHY DO HOMES NEED A DUCTED RANGE HOOD?

Cooking produces odor, moisture, and air pollutant emissions in homes, whether done with a gas or an electric appliance.[1] Indoor pollutant levels from cooking can exceed health guidelines for particulate matter, nitrogen dioxide, carbon monoxide, and aldehydes, especially for gas stoves.[2] These pollutants can increase the risk of both short-term and long-term health effects.[3] Residential cooking or space heating with a gas stove has been associated with respiratory problems in children, especially in unventilated kitchens.[4] Cooking can also emit potent mutagens and carcinogens into the air,[5] and the large amounts of moisture emitted by cooking can increase the risk of bio-allergens such as mold, bacteria, and dust mites multiplying in a home.[6]

Using a range hood can help reduce pollutant exposures and health impacts from cooking, by keeping emissions from spreading into and lingering in a home.[7] Opening windows alone is not nearly as effective as a good range hood, especially when wind speeds are low or outdoor pollutant levels are high. Range hoods also help cool a house by removing excess heat and moisture from cooking. They are required for new home construction, major remodels, and additions, and recommended by green and healthy building programs,[8] ventilation industry standards,[9] and state and local building codes.[10]

WHO NEEDS A DUCTED RANGE HOOD?

Everybody who cooks with a stove or oven needs to use a range hood – especially if your household includes children, persons with asthma or other respiratory diseases, the elderly, or persons sensitive to odors. The more burners you use, the longer you cook, and the more the

cooking produces odors, smoke, or moisture, the more you need to use effective kitchen exhaust ventilation. Range hoods are also essential for smaller homes with less volume to dilute the cooking emissions. Anybody planning a new home, remodel, or replacement of any range hood should take advantage of the opportunity to install a better range hood system.

WHEN AND HOW DO I NEED TO OPERATE A DUCTED RANGE HOOD?

- **Use the hood whenever you use the stove or oven, and especially when cooking at high temperatures or producing large quantities of steam, smoke, or odors**. Examples of "high emitting" cooking activities include grilling, frying, stir-frying, broiling, and roasting. Operate the hood fan at the speed that seems to best remove smoke, odors, and steam at the highest noise level your household can tolerate.

- **Use a back burner whenever possible. Also,** use lower cooking temperatures, and cover pots and pans as much as possible.

- **Leave the fan on for at least 10-20 minutes after the cooking ends, or until the cooking surfaces have cooled, whichever comes first**.[11] Continue using the fan if odors or smoke are noticeable when you enter from outdoors or a distant part of the house. (For airtight homes, see *Supplement 3: Caveats and Cautions*.)

- **Minimize movements of the cook and cross drafts near the stove, in order to maximize cooking fume capture and removal.**

- **When using the oven cleaning cycle, evacuate the house and operate the range hood at maximum speed.** Also, clean the hood's grease filters afterwards.

HOW DO I SELECT A "GOOD" DUCTED RANGE HOOD?

The best range hood to meet your needs depends on your building and appliance characteristics, your type of cooking, your household's sensitivity to odor, pollutants, and noise, and your budget. (See *Supplement 2: Criteria for Selecting an Effective Ducted Range Hood*.)

- **Determine the airflow rate you need for your hood type, stove size, building airtightness, and type of cooking.** Airflow rates for typical homes should be 200-350 cubic feet per minute (cfm). Island installations will require higher flows than wall installations.

- **Select a hood with a Capture Efficiency (CE) of 80% or more, based on ratings from Home Ventilating Institute (HVI) or the manufacturer if necessary.** HVI's third-party certification program for CE is expected by 2019.[12] If CE ratings are not available yet, pick a deep, wide hood that has an open bottom and that covers all the burners.[13]

Certified Home Ventilating Products Directory

HVI provides third party, certified test results for airflow (cfm) and noise (sone) for range hoods. Capture Efficiency ratings are being developed. Note: Some manufacturers may report their own test results, often for multiple fan speeds, but the results may not be accurate.

- **Select a range hood that is quiet**. Look for a hood with an HVI noise rating of less than 3 sones at an airflow rate of 200 cfm or more. If you need a larger capacity range hood that does not have a sone rating at 200 cfm, choose one that has a lower sone rating than others at equivalent speeds.

- **Select a multispeed fan that can be used at lower flow rates and sound levels when cooking with low emissions or on small burners.**

- **Make sure the hood and ducting will fit**. Ensure that the hood dimensions from the manufacturer and the duct layout can be accommodated in the available space. Double check that the hood and ductwork are installed properly.

- **Measure the flow rates of the installed hood.** (See *Supplement 4: How to Install Ducted Range Hood Systems*.)

Some cautions:

- **High airflow rates (and even low rates in airtight homes) can depressurize a home, potentially pulling in unwanted pollutants from combustion appliances, outdoor air, soil, or attached garages, basements, or apartments. This may create a need for make-up air.** (See *Supplement 3: Caveats and Cautions*.)

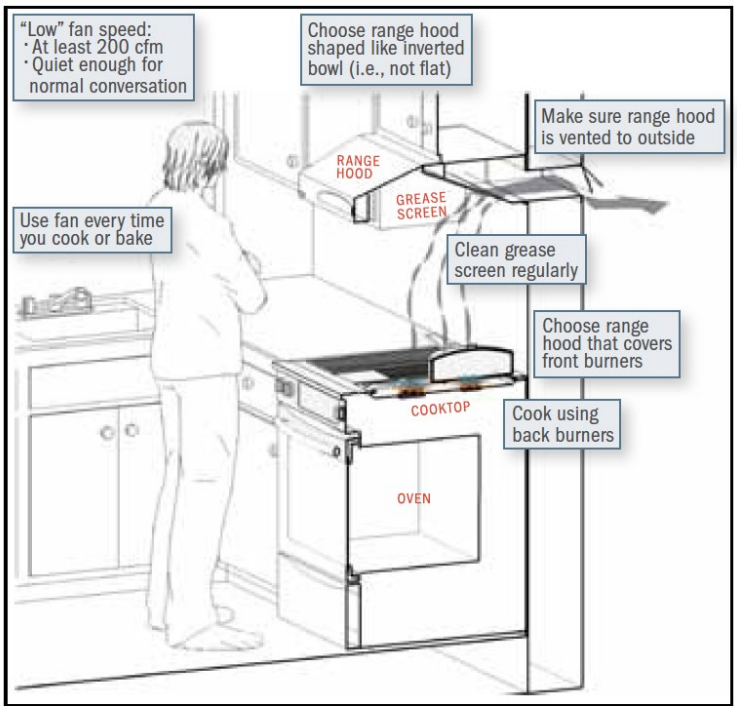
- **Conventional flat "designer" style hoods are not very effective, based on available data.** Also, many existing range hoods with propeller-type fans and small diameter ducts are not very effective and are too noisy.

- **Some over-the-range microwaves can effectively remove indoor pollutants, but only at very high (and noisy) fan speeds and flow rates.**

- **Large "power" burners produce much more heat and pollutant emissions than typical gas burners, and may need a wider range hood and higher airflow rates.**

WHAT ELSE CAN I DO?

Regardless of whether you have an effective ducted range hood, there are some easy ways to further reduce indoor pollution exposures from cooking and to improve pollutant removal by the hood, such as reducing cooking emissions and funneling the plume into the hood. (See *Supplement 1: Easy Ways to Reduce Exposures to Cooking Pollutants*.)



Tips for Effective Range Hoods:

- ✓ *A quiet, ducted (vented) range hood should be installed in new and existing homes, and used whenever you cook.*
- ✓ *Low emission cooking practices and hood side extensions can also help reduce exposure to cooking pollution, odors, and moisture.*

Image: Stratton, 2015.

MORE INFORMATION

For more information, see *Range Hood Resources, Tools & Presentations* at the end of this document and updates at the ROCIS website: http://rocis.org/range-hood-resources-tools-presentations

Supplement 1: Easy Ways to Reduce Exposures to Cooking Pollutants

In addition to operating a ducted range hood, using a kitchen exhaust fan, removing children and sensitive persons from the kitchen and adjoining areas, or opening windows, you can take some simple actions to further reduce exposure to indoor pollution from cooking. These steps are relatively easy and are summarized below.

REDUCE COOKING EMISSIONS

- **Remove the indoor emission source:** Consider moving cooking activities that produce a lot of smoke or odors outdoors if you have an outdoor grill or a solar cooker.[14]

- **Trap the emission source:** Whenever possible, cover pots and pans with a lid, or partially cover if necessary, to help trap much of the moisture and fumes from cooking. This will also enable you to turn down the heat (and save energy) and perhaps direct cooking fumes towards the back of the range hood.

Using induction electric stoves and covering pots and pans can help reduce cooking emissions.
Image: Jacobs et al., AIVC 2016.

- **Reduce the cooking temperature and burning:** Avoid grilling, charring, burning, and frying at high temperatures and over prolonged periods, especially when cooking meat. Using lower cooking temperatures and marinating meat reduces the formation of potent carcinogens (heterocyclic amines) in the fumes and the food.[15] An induction stove is another option for reducing burner temperatures and particle emissions (it also reduces

energy use and greenhouse gas emissions). Also consider using a microwave oven for cooking and pre-cooking food.

- **Keep it clean:** Clean stovetop burners and oven interiors periodically, especially after major spills. Dirty burners and ovens tend to emit more pollutants.

- **Contain the emissions:** Temporarily close doors to living areas and open windows in those areas to assist with keeping the emissions contained in the kitchen.[16]

- **Stay safe:** When using the oven cleaning cycle, ALWAYS evacuate the house and run the range hood at its maximum speed. To reduce fume buildup indoors, clean the grease filters first, ventilate the house with outdoor air thoroughly before re-entering, and clean the grease filters again if they look dirty.

FUNNEL THE PLUME TO THE HOOD: IMPROVE POLLUTANT CAPTURE EFFICIENCY

- **Use the back burner:** This helps keep pollutants from escaping the hood and is very important for cooking activities that produce a lot of emissions, or that are operating for long periods.[17]

- **Clean the hood's grease mesh filters:** To prevent cooking fumes from backing up and spilling outside the hood, clean the grease filters about four times a year to maximize airflow through the ducting. These metal mesh filters are usually dishwasher safe.

- **Reduce crosscurrents and fume drift:** Do not open nearby windows if it is windy, and do not operate a ceiling fan in the same room if cooking is producing a lot of smoke or odors. Minimize cook movements near the stove.

- **Use fireproof side shields (vertical extensions):** Make side shields yourself from lightweight metal panels, cookie sheets, or acrylic plastic. Side shields help contain the fume spillover from the hood cavity, especially for high emission activities.[18] They also help improve pollutant removal for hoods installed on islands or peninsulas, where rear shields help funnel the cooking plume. The shields can be hung on magnetic hooks on the overhead cabinets next to the hood and stored on the side of a refrigerator, in cabinets, or in other convenient areas. Rectangular shield shapes are preferred, but triangular shapes also help.[19]

Supplement 2: Criteria for Selecting an Effective Ducted Range Hood

LOW NOISE

Noise is the main reason hoods are not used. Select the quietest range hood at a comparable airflow rating that you can afford. Noise ratings (in "sone" units) are published by the Home Ventilating Institute (HVI) but may not be available for all fan speeds.[20] One sone roughly equals the sound of a refrigerator running.[21] Normal conversations produce about 4 sones, and light traffic produces about 8 sones. Some manufacturers also publish sone ratings, but they may not be consistent with HVI test methods and ratings.

Choose a range hood with an HVI noise rating of 3 sones or less at 200 cubic feet per minute (cfm) or more. These are fairly quiet and recommended for home applications. The low fan setting should be 100 cfm or lower with a sone level of 2 or lower.[22] Unfortunately, field studies indicate that all the hoods with high Capture Efficiency (CE) were also noisier at higher fan speeds, including the microwave exhaust systems.[23] Listening to noise levels of range hoods in showrooms may not be a realistic test, but it is a good start.

For context, ASHRAE Standard 62.2-2016 recommends no more than 3 sones at 100 cfm for occupant-controlled residential range hoods, and no more than 1 sone for continuously operating, whole-house exhaust ventilation.[24] Furthermore, multispeed exhaust fans (demand controlled) must have at least one speed that operates at less than 3 sones.

If you are very sensitive to noise, consider an in-duct fan mounted in the attic, or an external fan on the roof or in the attic, basement, or crawlspace, along with noise-dampening bushings and brackets.

GOOD POLLUTANT REMOVAL (CAPTURE EFFICIENCY, CE)

The hood's overhang above stove burners, its height from the stovetop, and its internal volume are important factors in achieving good CE. Select a range hood deep and wide enough to cover all the burner areas, and one with a large internal volume (height) and an open bottom area.

Lab and field studies of several residential range hoods by Lawrence Berkeley National Laboratory (LBNL) have assessed the factors that affect CE. Study results showed that most hoods do not effectively remove pollutants, and that many are too noisy. The researchers also found that the range hoods with more internal volume and better coverage of the cooking surface had better CEs. Flat, "designer" style hoods and over-the-stove microwave oven exhaust systems have much lower CEs than range hoods, based on available data.[25] Range hoods with different air flow patterns and configurations are also being tested and developed, so rely on third-party CE ratings for the most relevant performance criterion.

Deep hoods with large internal volumes, and full coverage of cooking surface, are more effective at capturing cooking emissions. Left: Ducted (vented) range hood. Right: Wall installation. Images: B. Singer, LBNL.

A standard test method for CE was approved by the American Society of Testing and Materials,[26] and CE ratings for range hoods are expected from HVI by 2019.[27] In any case, hoods with designs similar to those shown to have high CEs (at least 80%) in research studies should be very effective.

In summary, the hood should have a CE of 80%, or higher if possible. Avoid the low profile, "designer" type hoods, and pick a range hood that is at least 7 inches in vertical height to help contain cooking fumes. Also select a hood that is roomier inside, with recessed grease filters and blower entries well inside the hood.

(Note: Regarding energy efficiency standards, many range hoods are Energy Star rated by the federal government for environmental performance. However, most range hoods simply do not use very much energy compared to other residential appliances, and Energy Star for range hoods does not currently consider CE.)

AIRFLOW RATE

The airflow rate needed to capture and remove cooking emissions effectively depends on not only the CE, but also the type of cooking, the walls and cupboards adjoining the hood, building characteristics, local climate, and the design of the hood and ducting. For frequent high emitting cooking activities your hood should have a rated airflow rate of at least 300-400 cfm. A multispeed feature is also recommended to allow lower fan speeds (and less noise) during light cooking or when the fan is used as part of the house ventilation system.

Other guidelines for hood flow rates have been proposed, but they are not based on measured CE. For example, the HVI recommends 100-250 cfm airflow rate for a 30-inch wide range hood that is wall-mounted over a 30-inch wide stove, with the higher flow rate being more effective. Even higher flow rates are recommended for wider range hoods, and for island and peninsula installations (not wall-backed). For new, airtight homes with kitchen exhaust fans that run on demand (presumably for a 30-inch stove width), ASHRAE and other groups recommend a minimum of 100 cfm.

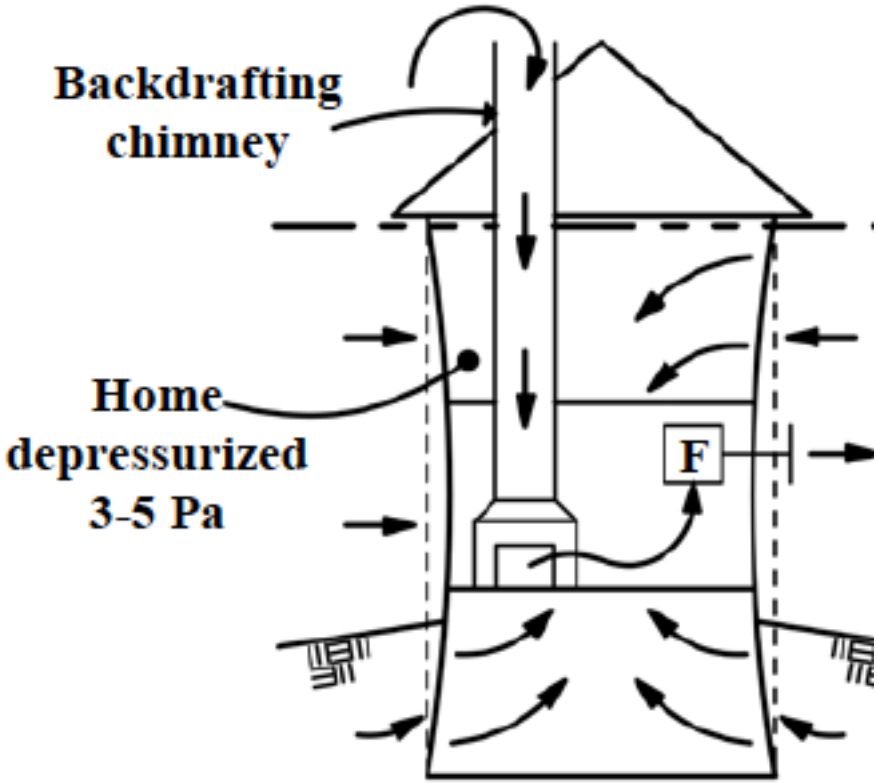
No microwave range hoods (over-the-range microwaves) currently comply with ASHRAE Standard 62.2-2016 requirements for airflow or noise. In addition, few microwave range hoods currently have sound or airflow ratings certified by HVI. Consequently, microwave range hoods would not yet be a good choice for households sensitive to noise, odors, or air pollution or for those who cook frequently or for long periods.

Kitchen exhaust fans and range hoods can also be designed to run continuously to meet requirements for whole house ventilation. ASHRAE Standard 62.2-2016 recommends that such fans achieve 300 cfm or 5 kitchen air changes per hour (5 complete turnovers of the room's air volume per hour). Thus, the appropriate hood flow rate would be calculated based on the kitchen volume. Homes that have natural draft combustion appliances such as furnaces, water heaters, and fireplaces should not use exhaust fans for whole house ventilation.

Supplement 3: Caveats and Cautions

PREVENT EXCESS DEPRESSURIZATION

Hoods with higher maximum airflow rates (over 300-400 cfm) can often cause imbalances in airflows in and out of the home. Professional style gas stoves with large burners and downdraft exhaust systems typically require high airflow rates. When insufficient air is brought into the home to balance exhaust flows from exhaust fans and other appliances, depressurization (negative air pressure, or suction) of the home occurs. This can cause combustion equipment to backdraft carbon monoxide and other combustion pollutants into the home. It can also pull unwanted pollutants from adjoining spaces and the outdoors. If naturally vented combustion appliances are present, a combustion appliance safety test is recommended in such situations; t this test is required in most home weatherization programs.[28]



Exhaust airflows can create excessive vacuum pressure (suction) in a home, unless the exhaust flow is balanced by make-up air. Certain airflow rates of exhaust fans (F) can combine with house airtightness to depressurize a house enough to backdraft chimneys and flues from combustion appliances and to pull in soil gases. This can lead to indoor pollution hazards and moisture condensation problems. Image: Jellen et al. 2012a.

Make-up air devices are available to prevent depressurization problems; some can be integrated with central air or ventilation systems. The International Mechanical Code used in some regions requires make-up air if the fan has a rating of 400 cubic feet per minute (cfm) or more when natural draft combustion appliances are present. It also requires make-up air for hood flows of 300 cfm or more in alterations of some types of older homes, exhaust flow calculations for multiple appliances, and a backdraft and spillage test in newer homes.[29] However, both natural draft and induced draft appliances can easily backdraft, so the more efficient direct-vent (sealed combustion) appliances are recommended to minimize such problems.[30]

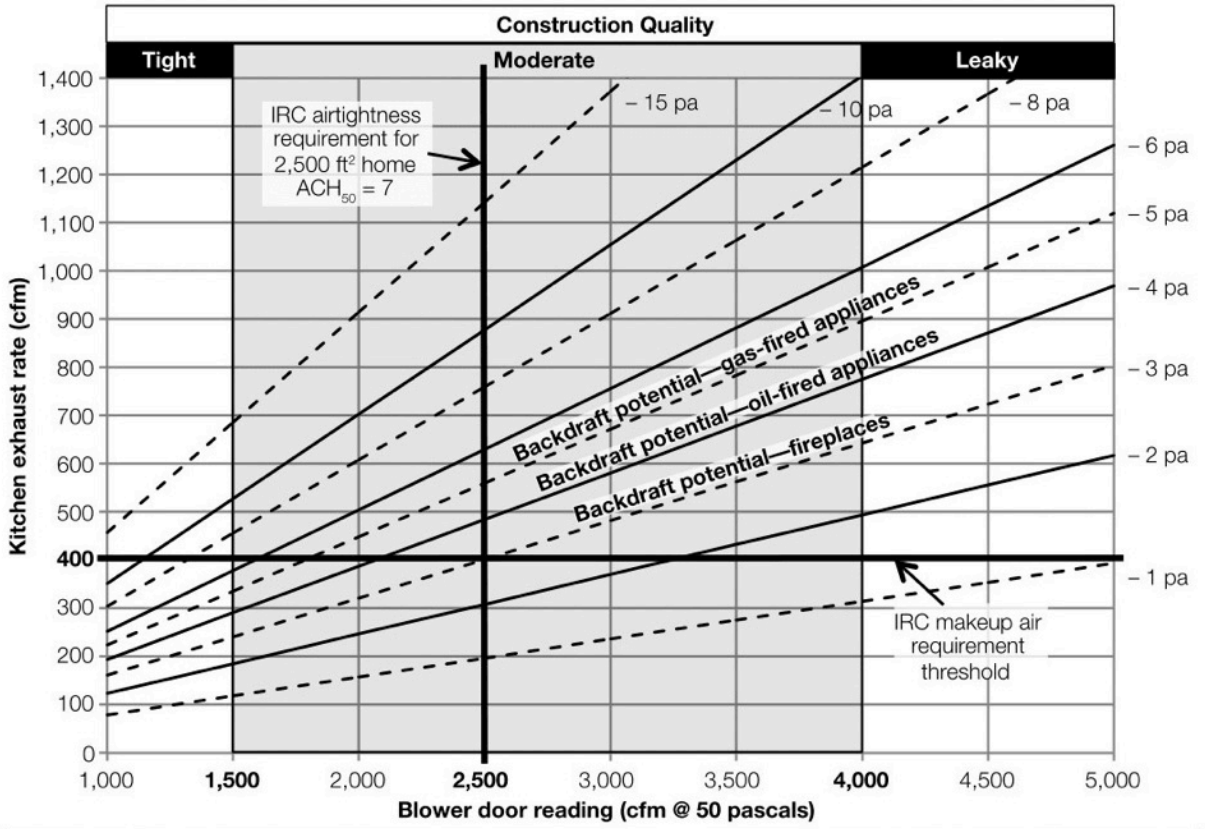
Downdraft stovetop exhaust systems are an example of fans with very high flow rates. They often produce flows of over 500 cfm in order to effectively overcome the hot, buoyant plume generated by cooking. Commercial style stoves and ovens also require very high flow rates, in order to remove the large amount of heat produced. High flow hood systems that are used frequently can also substantially increase building energy use for meeting cooling, heating, or dehumidification needs.

For airtight homes and homes with high flow exhaust hoods, test the pressure difference between indoors and outdoors when the range hood is on. The graph below (Exhibit 1) illustrates how much house depressurization could be anticipated from various sizes of kitchen exhaust fans at different levels of home airtightness. The hood airflow rate of 400 cfm is also highlighted; the International Residential Code (IRC) requires make-up air above that airflow rate. A tight home is defined there as one with a blower test rating of 1,500 cfm or less at 50 Pascals pressure (CFM_{50}).

For example, the diagonal lines in Exhibit 1 indicates that a fireplace in a tight home (1,500 CFM_{50} or less) would potentially start backdrafting at a hood flow rate of 250 cfm or less, whereas a gas-fired appliance (natural draft) would potentially start backdrafting at a hood flow rate of 350 cfm or less, even though they are both below the IRC makeup air threshold of 400 cfm. Local weather conditions can also affect house pressures. Note that many homes have blower door ratings of less than 1,000 CFM_{50} and would backdraft at much lower airflow rates for the hood.

Exhibit 1

Induced House Pressures Under Various Exhaust Rates and House Tightness



ACH = air changes per hour. cfm= cubic feet per minute. ft² = square feet. IRC = International Residential Code. pa = pascals.
Source: Jellen, Wolfgang, and Turns (2012a)

Consult building officials and building performance experts to determine what local depressurization limits are and how to best meet them. These limits range from -2 to -50 Pascals, depending on the type of combustion appliance, airtightness, and regional climate.[31]

In order to provide reliable operation, gravimetric or barometric dampers are not allowed for use in make-up air systems, according to ASHRAE 62.2-2016. Rather, an automatic (interlocked) motorized damper or a fan-powered system is required.[32] In addition, make-up air systems should have an air filter to help keep outdoor air pollution, allergens, and dust from entering the home. Test the installed makeup air system to verify safe depressurization levels and proper damper operation and air flow, as shown by Guertin.[33]

Make-up air systems can also cause thermal comfort problems (cold drafts) and humidity problems. In order to avoid cold drafts from make-up air, some designers recommend supplying 70% of the make-up under the stove and 30% to a common area, in order to create negative pressure near the stove and minimize draft problems.[34] A designer of very airtight

homes (near Passive House criteria) in California has successfully used ducted range hoods with make-up air with little impact on energy use or comfort.[35]

Research continues on how to best integrate kitchen and whole house ventilation. European researchers have recently recommended that low energy, airtight homes use either 1) a motorless range hood, with a high quality grease filter, that can be connected to a common exhaust system using a balanced ventilation system for the house, or 2) a ducted exhaust vent used with a supply ventilation system at specific design pressures[36]; further studies are underway. A small field study found that heat or energy recovery ventilators did not effectively remove particle emissions from cooking in low energy single-family homes, even when using the boost function.[37] Also, range hoods with automatic sensors are under development.[38] These are evolving areas of healthy building design, so proceed with caution.

PREVENT CARBON MONOXIDE (CO) POISONING

- Never heat the house with a gas stove or oven. This can be fatal or cause permanent damage to your health. It can also increase the risk of pneumonia in young children.[39]

- Have a technician check the gas pressure and burner adjustments, especially in propane stoves or if the flame is mostly yellow, erratic, or causing sooting on pots and pans.[40] Gas stoves and ovens often produce excessive amounts of CO, but regular testing and maintenance can greatly reduce this hazard.[41]

- Do not cover the bottom of natural gas or propane ovens with aluminum foil. Doing so blocks the combustion airflow through the appliance and can increase CO emissions.

- If you are cooking on several burners or over extended periods and do not have a working range hood, open some windows to create a cross draft to remove the indoor pollutants, or use a kitchen exhaust fan.

- Install a CO alarm if you have a gas stove or oven or other natural draft (non-direct vent) gas appliances in the home. This is required in many jurisdictions.

Supplement 4: How to Install Ducted Range Hood Systems

- **Plan for room above the stove (32 inches or less), the width and height of the hood, and the routing of the exhaust duct run when designing kitchen cabinet layout.** Route the ducting through the roof or outer wall, not into the attic space, in order to avoid moisture problems. For cold climates, route the ducting downward and outwards to prevent continuous convection and condensation.

- **Locate the hood on a wall between cabinets to improve pollutant removal.** In comparison, island and peninsula installations have lower effectiveness, and corner installations have even higher effectiveness.[42] If gaps exist between the range hood and adjoining cabinets or walls, consider adding horizontal spacers to help funnel airflow towards the hood.

- **If the system is not installed immediately upon arrival, then cover and seal all openings in range hoods, ductwork, and adaptor joints until installation.** This will avoid build-up of dust, debris, and other contaminants in the system.

- **Use 8-inch round smooth metal ducts (NOT FLEX DUCT**). Smooth ductwork has less air resistance and is less likely to collect dirt and grease than flex duct, which has ribbing. In many installations, rectangular ducts may be needed; they come in various configurations.

- **Minimize bends in the duct layout and avoid 90 degree to reduce improve air flow.** Two 45-degree fittings are less restrictive than one 90-degree fitting.

- **Mechanically fasten all duct joints**. Draw bands, external clamps, or rivets are preferable to sheet metal screws. Seal all duct and adaptor joints from exhaust fan to roof cap with metal tape (NOT DUCT TAPE) or mastic.

- **Avoid reductions in the cross-section area at the vent cap and duct transitions or adaptors.**

- **Use an 8-inch diameter roof cap for sloping roofs – it has screen mesh built into it and it has equivalent surface area for the roof vent.** Where deep snow is usually expected, a wall vent well above record snow depths may be a more practical approach.

- **For exhaust vents on exterior walls, keep birds and rodents out by inserting a corrosion-proof, cleanable screen (e.g., copper or stainless steel mesh) in the vent opening.**

- **Insulate any ductwork above the ceiling insulation, at insulation levels that meet current building energy standards in your area, to avoid condensation inside the ducting in cold weather.** For ducting that exits through an exterior wall, insulate the outside of the duct and completely air-seal the gaps between the duct and the walls.

- **For an in-duct or in-line fan, mount it at least 4 feet away from the range hood**. Use a vibration-dampening bracket and a fan made of metal (not plastic).

- **Locate exhaust vent terminations at least 3 feet from any operable or inoperable openings in building, and at least 10 feet from air intakes unless the exhaust is at least 3 feet above the intake.**[43]

- **Inspect and test the entire fan, duct, and control system before closing up the wall or install attic insulation.** It is difficult to reach and fix equipment in the attic. Make sure the backdraft damper in the hood fully opens upwards or outwards, and that the knockout panel has been removed.

- **Finally, test the airflow rate of the installed hood and the damper operation and depressurization of the makeup air system.** Many installed hoods and makeup air systems do not perform nearly as well as rated or designed.[44] Building performance contractors and energy auditors can test using devices such as flow hoods or blower doors and pressure gauges.

- **If you can't test the flow, feel the airflows at the hood and at the roof or wall vent at all fan speeds, before the vent cap is put on.** Make sure the airflow is noticeable, stronger at higher fan speeds, and moving away from the house. (See *Supplement 3: Caveats and Cautions*.)

ENDNOTES (Go to Reference section for full citation.)

[1] (Fortmann et al. 2001; Fluckiger et al. 2000; Dennekamp et al. 2001; Parrott et al. 2003;Svedahl et al. 2009; Arbex et al. 2007; Zhang et al. 2010; Jørgensen et al. 2013)

[2] (Fortmann et al. 2001; Logue et al. 2011; Singer et al. 2017; Borsboom et al., 2018; O'Leary et al., 2018)

[3] (Coker et al. 2015; Belanger et al. 2006)

[4] (Dekker et al. 2001; Coker et al. 2015; Kile et al. 2014)

[5] (Felton 1995; Knize 2006; Sjaastad et al. 2010; NCI, 2017; Poudel et al. 2017; Sohn 2017)

[6] (US EPA 2015)

[7] (Fluckiger et al. 2000; Fortmann et al., 2001; Kile et al. 2014; Jacobs et al., 2016; Jacobs & Borsboom, 2017; Singer et al. 2017; Pacitto et al. 2018)

[8] (US EPA 2015; Build It Green 2017; USGBC 2017)

[9] (ASHRAE 2016)

[10] (Stratton & Singer 2014)

[11] (Sjaastad & Svendsen 2010; AIVC 2019)

[12] (Windmeyer, 2019)

[13] (Singer et al. 2012; Borsboom et al., 2016)

[14] (Wikipedia, 2019)

[15] (Felton 1995)

[16] (Poon et al. 2016)

[17] (Delp & Singer 2012; Rim et al. 2012)

[18] (Kuehn et al. 1989; Fluckiger et al. 2000; Fortmann et al. 2001; Jacobs et al. 2016)

[19] (Fisher et al. 2015)

[20] (HVI 2018)

[21] (Grainger 2017)

[22] (MSHI 2018)

[23] (Delp and Singer 2012)

[24] (Karg 2016)

[25] (Singer et al. 2012)

[26] (ASTM 2017)

[27] (Windmeyer 2018)

[28] (BPI 2012; US EPA 2014)

[29] (IMC 2018)

[30] (Minnesota 2015; Bohac & Cheple 2002)

[31] (Nelson 2010; BPI 2012; Jellen et al. 2012a)

[32] (Karg 2016)

[33] (Guertin 2017)

[34] (Lstiburek 2014)

[35] (Barry 2017)

[36] (Jacobs & Borsboom 2017)

[37] (Militello-Hourigan and Miller 2018)

[38] (DOE 2019; Walker, 2019)

[39] (Coker et al. 2015)

[40] (Appliance411 2018)

[41] (Birkby 2008)

[42] (Sjaastad & Svendsen 2010)

[43] (IMC 2018)

[44] (Singer et al. 2010; Delp & Singer 2012)

Range Hood References

AIVC (Air Infiltration and Ventilation Centre), 2019. New Perspectives on Kitchen Ventilation. Webinar, May 23. *https://www.aivc.org/event/23-may-2019-webinar-new-perspectives-kitchen-ventilation*.

ASTM (American Society of Testing and Materials), March/April 2017. Proposed Standard Will Test Range Hood Ventilation. *https://www.astm.org/standardization-news/?q=update/proposed-standard-will-test-range-hood-ventilation.* See also: ASTM, 2017. ASTM E3087 – 17, Standard Test Method for Measuring Capture Efficiency of Domes.c Range Hoods. *http://www.astm.org/Standards/E3087.htm*.

Appliance411, 2018. FAQ: What Should My Gas Range's Flames Look Like? *http://www.appliance411.com/faq/gas_range_flames.shtml*.

Arbex, M.A., Martins, L.C., Pereira, L.a.A., Negrini, F., Cardoso, A.A., Melchert, W.R., Arbex, R.F. Saldiva, P.H., Zanobetti, N.A., and Braga, A.L F., 2007. Indoor NO2 Air Pollution and Lung Function of Professional Cooks. Brazilian Journal of Medical and Biological Research 40(4): 527–534. *http://dx.doi.org/10.1590/S0100-879X2007000400011*.

ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers), 2016. ANSI/ASHRAE Standard 62.2-2016. Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings, Atlanta, GA. *https://www.ashrae.org/resources--publications/bookstore/standards-62-1--62-2*. Addenda updates are at *https://www.ashrae.org/standards-research--technology/standards-addenda*.

Barry, B., 2017. One Sky Homes, San Jose, CA. Personal communication. March 6.. See also: Mother Nature News, n.d. Hyperventilation about kitchen ventilation. *https://www.mnn.com/your-home/remodeling-design/blogs/hyperventilation-about-kitchen-ventilation*.

Belanger, K., Gent, J.F., Triche, E.W., Bracken, M.B., Leaderer, B.P., 2006. Association of Indoor Nitrogen Dioxide Exposure with Respiratory Symptoms in Children with Asthma. Am J Respir Crit Care Med 173, 297–303. *https://doi.org/10.1164/rccm.200408-1123OC*.

Birkby, G.M., 2008. Carbon Monoxide Surveillance, Education and Response: Findings from Baltimore City. 2008 National Healthy Homes Conference, Baltimore, MD, September 15–17. *https://www.hud.gov/sites/documents/DOC_12396.pdf*.

Bohac, D., and Cheple, M., 2002. Ventilation and Depressurization Information for Houses Undergoing Remodeling. Minneapolis, MN: Final Report for the Minnesota Department of Commerce State Energy Office. *https://www.mncee.org/getattachment/Resources/Resource-*

Center/Technical-Reports/Ventilation-and-Depressurization-Information-for-H/Ventilation-and-Depressurization-Information-for-Houses-Underoing-Remodeling.pdf.aspx.

Borsboom, W., De Gids, W., Logue, J., Sherman, S., and Wargocki, P., 2016. Technical Note AIVC 68: Residential Ventilation and Health. AIVC (Air infiltration and Ventilation Centre). *http://www.aivc.org/about-us/what-is-aivc*

Borsboom, W., de Gids, W., Walker, I., and Jacobs, P., 2018. Assessment of range hoods based on exposure. AIVC 2018 Conference. *http://www.aivc.org/resource/assessment-range-hoods-based-exposure*.

BPI (Building Performance Institute), 2012. Combustion appliance safety testing. *http://www.bpi.org/sites/default/files/Technical Standards for the Building Analyst Professional.pdf*.

Build It Green, 2017. GreenPoint Rated 2017, Builder's Handbook 7.0. *https://builditgreen.org/images/gpr-collateral/download/Executive_Summary_of_Updates_GPR_V7.pdf*.

Coker, E.S., Smit, E., Harding, A.K., Molitor, J., and Kile, M.L., 2015. A Cross Sectional Analysis of Behaviors Related to Operating Gas Stoves and Pneumonia in U.S. Children under the Age of 5. BMC Public Health 15(1): 77. *https://doi.org/10.1186/s12889-015-1425-y*.

Dekker, C., Dales, R., Bartlett, S., Brunekreef, B., and Zwanenburg, H., n.d. Childhood Asthma and the Indoor Environment, 2001. CHEST 100(4): 922–926. *https://doi.org/10.1378/chest.100.4.922*.

Delp, W.W., and Singer, B.C., 2012a. "Performance Assessment of U.S. Residential Cooking Exhaust Hoods." Environmental Science & Technology 46(11): 6167–6173. *https://doi.org/10.1021/es3001079*.

Dennekamp, M., Howarth, S., Dick, C., Cherrie, J., Donaldson, K., and Seaton, A., 2001. Ultrafine Particles and Nitrogen Oxides Generated by Gas and Electric Cooking. Occupational and Environmental Medicine 58(8): 511–516. *https://doi.org/10.1136/oem.58.8.511*.

DOE (U.S. Department of Energy), 2017 and 2019. Development of the Industry's First Smart Range Hood. Peer review presentations. *https://www.energy.gov/eere/buildings/downloads/development-industry-s-first-smart-range-hood*.

Felton, J., 1995. Food Mutagens: The Cooking Makes the Difference. Science and Technology Review, Lawrence Livermore National Laboratory, Livermore, CA, June-July. Three part series. *https://str.llnl.gov/content/pages/past-issues-pdfs/1995.09.pdf*.

Fisher, D., Swierczyna, R., and Karas, A., 2015. Commercial Kitchen Ventilation Exhaust Hoods: Capture and Containment. ASHRAE J, November: 26–37. *https://fishnick.com/publications/ventilation/026-039_Ashrae_Fisher_web.pdf*.

Fisher-Nickel, Inc., 2011. Side Shields Really Work (video). Ventilation Lab, Food Service Technology Center, San Ramon, CA.

Fluckiger, B., Seifert, M., Koller, T., and Monn, C., 2000. Air Quality Measurement in a Model Kitchen Using Gas and Electric Stoves. Proceedings of Healthy Buildings 2000, Espoo, Finland, August 6–10, paper 363. *https://www.aivc.org/resource/air-quality-measurement-model-kitchen-using-gas-and-electric-stoves*.

Fortmann, R., Kariher, P., and Clayton, R., 2001. Indoor Air Quality: Residential Cooking Exposures. Final Report, California Air Resources Board, Sacramento, CA, Contract # 97-330. *https://www.arb.ca.gov/research/single-project.php?row_id=60171*.

Grainger, 2017. How to Choose the Right Exhaust Fan. (Based on AMCA Publication 302). W.W. Grainger, Inc., Miami, FL. *https://www.grainger.com/content/supplylink-how-to-choose-the-right-exhaust-fan*.

Guertin, M., 2017. Makeup Air for the Range Hood. Design, installation, and commissioning tips. Fine Homebuilding. *https://www.finehomebuilding.com/2017/05/12/make-air-range-hood*

HVI (Home Ventilating Institute), 2018. Publication 911: Certified Home Ventilating Products Directory, Kitchen range hood category. Morehead City, NC, January 5 edition. *https://www.hvi.org/proddirectory/index.cfm*.

IMC (International Mechanical Code), 2018. Chapter 5 Exhaust Systems. ICC PublicACCESS. Accessed January 10, 2018. *https://codes.iccsafe.org/public/document/yc7355qxk7/chapter-5-exhaust-systems*.

Jacobs, P., Boorsboom. W. and Kemp, R., 2016. PM2.5 in Dutch dwelling due to cooking. AIVC 2016 Conference, Alexandria, Egypt. Accessed January 19, 2018. *https://www.tno.nl/media/8957/pm2-5_in_dutch_dwelling_due_to_cooking_-_aivc_alexandria_2016_19-august.pdf*.

Jacobs, P., and Borsboom, W., 2017. REHVA European HVAC Journal, June 2017: 21–26. Cooking exhaust systems for low energy dwellings. *http://www.rehva.eu/publications-and-resources/rehva-journal/2017/062017.html.*

Jellen, A.C., Wolfgang, B.M, and Turns, M.A., 2012a. Kitchen Ventilation Systems: Part 1. Evaluating the 2009 IRC Requirement for Makeup Air. The Pennsylvania Housing Research Center, Builder Brief, BB0312, March 2012. *http://www.phrc.psu.edu/assets/docs/Publications/BB0312.pdf*.

Jørgensen, R., Bramming, B., Strandberg, A., Sjaastad, K., Johansen A., and Svendsen, K., 2013. Simulated Restaurant Cook Exposure to Emissions of PAHs, Mutagenic Aldehydes, and Particles from Frying Bacon. Journal of Occupational and Environmental Hygiene 10(3): 122–131. *https://doi.org/10.1080/15459624.2012.755864*.

Karg, R., 2016. ASHRAE 62.2: What's New in in 2016? 2016 RESNET Conference, Scottsdale, AZ, February 29–March 2. *http://conference2016.resnet.us/data/energymeetings/presentations/ASHRAE%20622%20Whats%20New%20in%202016.pdf*.

Kile, M.L, Coker, E.S., Smit, E., Sudakin, D., Molitor, J., and Harding, A.K., 2014. A Cross-Sectional Study of the Association between Ventilation of Gas Stoves and Chronic Respiratory Illness in U.S. Children Enrolled in NHANESIII. Environmental Health 13: 71. *https://doi.org/10.1186/1476-069X-13-71*.

Kim, Y.-S., Walker, I.S., and Delp, W.W., 2018. Development of a Standard Capture Efficiency Test Method for Residential Kitchen Ventilation. Science and Technology for the Built Environment, January, 1–12. *https://doi.org/10.1080/23744731.2017.1416171*.

Knize, M.G., 2006. 11 : Assessing Human Exposure to Heterocyclic Aromatic Amines. In Acrylamide and Other Hazardous Compounds in Heat-Treated Foods, 231–246. Woodhead Publishing. *https://doi.org/10.1533/9781845692018.2.231*.

Kuehn, T.H., Ramsey, J., Han, H., Perkovich, M., and Youssef, S., 1989. A Study of Kitchen Range Hood Exhausts. ASHRAE Transactions 95(1): 744. *https://www.aivc.org/sites/default/files/airbase_3381.pdf*.

Logue, J.M., Klepeis, N.E., Lobscheid, A.B., and Singer, B.C., 2013. Pollutant Exposures from Natural Gas Cooking Burners: A Simulation-Based Assessment for Southern California. Environmental Health Perspectives 122: 43–50. *https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3888569/*.

Logue, J.M., McKone, T.E., Sherman, M.H., and Singer, B.C., 2011. Hazard Assessment of Chemical Air Contaminants Measured in Residences. Indoor Air 21(2): 92–109. *https://doi.org/10.1111/j.1600-0668.2010.00683.x*.

Logue, J.M., and Singer, B.C., 2014. Energy Impacts of Effective Range Hood Use for All U.S. Residential Cooking. HVAC&R Research 20(2): 264–275. *https://doi.org/10.1080/10789669.2013.869104*.

Lstiburek, J., 2014. Zeroing In: Net Zero Houses. ASHRAE J, October. *https://www.nist.gov/system/files/documents/2017/05/09/044-053_BuildingSciences_Lstiburek.pdf*.

Militello-Hourigan, R., and Miller, S.L., 2018. The impacts of cooking and an assessment of indoor air quality in Colorado passive and tightly constructed homes. Building and Environment 144: 573-582. *https://doi.org/10.1016/j.buildenv.2018.08.044*.

Minnesota, 2015. Minnesota Mechanical and Fuel Gas Codes. The 2015 Minnesota Administrative Rules, Part 1346.0501, Section 501 General, Department of Labor and Industry. *https://www.revisor.mn.gov/rules/?id=1346.0501*.

MSHI (Minnesota Sustainable Housing Initiative), 2018. Range Hoods. *http://www.mnshi.umn.edu/kb/scale/rangehoods.html*.

NCI (National Cancer Institute), 2017. Chemicals in Meat Cooked at High Temperatures and Cancer Risk. *https://www.cancer.gov/about-cancer/causes-prevention/risk/diet/cooked-meats-fact-sheet*.

Nelson, B., 2010. Successful Implementation of Air Tightness Requirements for Residential Buildings. Best2 Conference, National Institute of Building Standards, Portland, OR, Session WB6-5. *https://www.brikbase.org/sites/default/files/best2_nelson.pdf*. Presentation: *https://cdn.ymaws.com/www.nibs.org/resource/resmgr/BEST/BEST2_WB6-5.pdf*.

O'Leary, C., Jones, B., and Hall, I., 2018. Estimated distributions of PM2.5 concentrations in the kitchens of the English housing stock for infiltration and mechanical ventilation scenarios. AIVC 2018 Conference. *http://www.aivc.org/resource/estimated-distributions-pm25-concentrations-kitchens-english-housing-stock-infiltration-and?volume=37602*.

O'Leary, C., Kluizenaar, Y., Jacobs, P., Borsboom, W., Hall, I., Jones, B., 2019. Investigating measurements of fine particle ($PM_{2.5}$) emissions from the cooking of meals and mitigating exposure using a cooker hood. Indoor Air 29: 423– 438. *https://doi.org/10.1111/ina.12542*.

Pacitto, A., Stabile, L., Moreno, T., Kumar, P., Wierzbicka, A., Morawska, L., and Buonanno, G., 2018. The Influence of Lifestyle on Airborne Particle Surface Area Doses Received by Different Western Populations. Environmental Pollution 232(January): 113–122. *https://doi.org/10.1016/j.envpol.2017.09.023*.

Parrott, K., Emmel, J., and Beamish, J., 2003. Use of kitchen ventilation: Impact on indoor air quality. The Forum for Family and Consumer Issues 8(1). *https://www.theforumjournal.org/2003/01/04/use-of-kitchen-ventilation-impact-on-indoor-air-quality/*.

Paulin, L.M., Williams, D.L., Peng, R., Diette, G.B., McCormack, M.C., Breysse, P., Hansel, N.N., 2018. 24-h Nitrogen Dioxide Concentration Is Associated with Cooking Behaviors and an

Increase in Rescue Medication Use in Children with Asthma. Environmental Research 159: 118–123. https://www.ncbi.nlm.nih.gov/pubmed/28797886.

Poon, C., Wallace, L., and Lai, A.C.K., 2016. Experimental Study of Exposure to Cooking Emitted Particles under Single Zone and Two-Zone Environments. Building and Environment 104(August): 122–130. https://doi.org/10.1016/j.buildenv.2016.04.026.

Poudel, B.K., Choi, J., Park, J.H., Doh, K.O., and Byeon, J.H., 2017. In Vitro Exposure of Simulated Meat-Cooking Fumes to Assess Adverse Biological Effects. Scientific Reports 7: 10841. https://doi.org/10.1038/s41598-017-11502-8.

Rashkin, S., 2016. Improving Air Quality in the Kitchen. Professional Builder, November. https://probuilder.s3.amazonaws.com/s3fs-public/pdf/26_PB1116.pdf.

Rim, D., Wallace, L., Nabinger, S. and Persily, A., 2012. Reduction of Exposure to Ultrafine Particles by Kitchen Exhaust Hoods: The Effects of Exhaust Flow Rates, Particle Size, and Burner Position. Science of The Total Environment 432(August): 350–356. https://doi.org/10.1016/j.scitotenv.2012.06.015.

Rosenbaum, M., 2012. An Induction Cooktop for Our Kitchen. Guest Blog, Green Building Advisor. http://www.greenbuildingadvisor.com/blogs/dept/guest-blogs/induction-cooktop-our-kitchen.

Seltenrich, N., 2014. Take Care in the Kitchen: Avoiding Cooking-Related Pollutants. , Environmental Health Perspectives 122(6): A154–A159. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4050506/.

Singer, B.C., Delp, W.W., and Apte, M.G., 2010. Experimental Evaluation of Installed Cooking Exhaust Fan Performance. Berkeley: Lawrence Berkeley National Laboratory. LBNL Report LBNL-4183E. https://indoor.lbl.gov/publications/experimental-evaluation-installed.

Singer, B. C., Delp, W.W., Price, P.N., and Apte, M.G., 2012. Performance of Installed Cooking Exhaust Devices. Indoor Air 22(3): 224–234. https://doi.org/10.1111/j.1600-0668.2011.00756.x.

Singer, B.C., Pass, R.Z., Delp, W.W., Lorenzetti, D.M., and Maddalena, R.L., 2017. Pollutant Concentrations and Emission Rates from Natural Gas Cooking Burners without and with Range Hood Exhaust in Nine California Homes. Building and Environment 122(September): 215–229. https://doi.org/10.1016/j.buildenv.2017.06.021.

Sjaastad, A.K., Jørgensen, R.B., and Svendsen, K., 2010. Exposure to Polycyclic Aromatic Hydrocarbons (PAHs), Mutagenic Aldehydes and Particulate Matter during Pan Frying of Beefsteak. Occupational and Environmental Medicine, January. https://doi.org/10.1136/oem.2009.046144.

Sjaastad, A.K., & Svendsen, K., 2010. Different Types and Settings of Kitchen Canopy Hoods and Particulate Exposure Conditions during Pan-Frying of Beefsteak. Indoor and Built Environment 19(2): 267–274. *https://doi.org/10.1177/1420326X09347426.*

Sohn, E. 2017. Evidence Is Mounting For a Link Between Grilled Meat and Cancer, But You Can Lower the Risk. ScienceAlert. June 6. *http://www.sciencealert.com/evidence-grows-linking-grilled-meat-and-cancer-but-you-can-lower-the-risk*.

Sonne, J., Withers, C., and Vieira, R., 2015. Investigation of the Effectiveness and Failure Rates of Whole-house Mechanical Ventilation Systems in Florida. Florida Solar Energy Center, Cocoa, FL., Final Report: FSEC-CR-2002-15, June 1. http://www.fsec.ucf.edu/en/publications/pdf/FSEC-CR-2002-15.pdf.

Stratton, C., 2015. Kitchen Ventilation. Home Energy Magazine, March–April. *http://homeenergy.org/show/article/nav/ventilation/id/2027*.

Stratton, J.C., and Singer, B. 2014. Addressing Kitchen Contaminants for Healthy, Low-Energy Homes. LBNL- 6547E. *https://indoor.lbl.gov/sites/all/files/lbnl-6547e.pdf*.

Svedahl, S., Svendsen, K., Qvenild, T., Sjaastad, A.K., and Hilt, B., 2009. Short Term Exposure to Cooking Fumes and Pulmonary Function. Journal of Occupational Medicine and Toxicology (London, England) 4: 9. *https://doi.org/10.1186/1745-6673-4-9*.

Thiébaud, H.P., M.G. Knize, P.A. Kuzmicky, D.P. Hsieh, and J.S. Felton. 1995. Airborne Mutagens Produced by Frying Beef, Pork and a Soy-Based Food. Food and Chemical Toxicology 33(10): 821–828. *https://doi.org/10.1016/0278-6915(95)00057-9*.

Turns, M., 2013. Reducing Appliance Backdrafting Risks with HVAC-Integrated Makeup Air Systems. Cityscape: A Journal of Policy Development and Research 15(1): 311–316. *https://www.huduser.gov/portal/periodicals/cityscpe/vol15num1/Cityscape_March2013_reducing_app.pdf*.

US EPA (U.S. Environmental Protection Agency), 2014. Energy, Weatherization and Indoor Air Quality. Overviews and Factsheets. Office of Air and Radiation. September 15. *https://www.epa.gov/indoor-air-quality-iaq/energy-weatherization-and-indoor-air-quality*.

———, 2015. Moisture Control Guidance for Building Design, Construction and Maintenance. Policies and Guidance. June 9. *https://www.epa.gov/indoor-air-quality-iaq/moisture-control-guidance-building-design-construction-and-maintenance-0*.

USGBC (U.S. Green Building Council), 2017. LEED BD+C, V4. Ventilation. *https://www.usgbc.org/credits/homes-high-rise/v4-draft/eqp1?view=language*.

Walker, I., 2019. Healthy Efficient Homes. Presented at DOE Building Technology Office Peer Review, May. LBNL. https://www.energy.gov/eere/buildings/downloads/healthy-efficient-homes-research-standards

Wikipedia, 2019. Solar Cooker. *https://en.wikipedia.org/wiki/Solar_cooker*.
Windmeyer, B., 2019. Chief Technology Officer, Home Ventilation Institute, Morehead City, NC. Personal communication, February 1.

Zhang, Q., Gangupomu, R.H., Ramirez, D., and Zhu, Y., 2010. Measurement of Ultrafine Particles and Other Air Pollutants Emitted by Cooking Activities. International Journal of Environmental Research and Public Health 7(4): 1744–1759. *https://doi.org/10.3390/ijerph7041744*.

Range Hood Resources, Tools & Presentations

GENERAL INFORMATION AND TOOLS

Range Hood Buying Guide. Getting Started. (Summary of key features of range hoods). Consumer Reports. May 2017. https://www.consumerreports.org/cro/range-hoods/buying-guide.

Installation guides and training videos for kitchen ventilation. Building America Solutions Center, Pacific Northwest National Labs, U.S. Department of Energy, 2017. https://basc.pnnl.gov/building-components/browse/180327.

- Kitchen Exhaust Guide describes how to install efficient kitchen exhaust systems.
- Air Sealing Bathroom and Kitchen Exhaust Fans Guide describes how to air seal bathroom and kitchen exhaust fans.

First Deal with the Manure and Then Don't Suck. BSI-070. Recommendations for designing residential range hoods and ventilation systems. Lstiburek, J. 2014. Building Science Corporation, Westford, MA. https://buildingscience.com/documents/insights/bsi-070-first-deal-with-the-manure.

Home, Home on the Range Hood. Brook, D., 1997. Home Energy, November–December. http://www.homeenergy.org/show/article/nav/kitchen/id/1342.

Kitchen Ventilation Systems – Part 2. Builders Brief 0412. Jellen, A., Turns, Brian Wolfgang, B. 2012b. Pennsylvanian Housing Research Center. University Park, PA. http://www.phrc.psu.edu/assets/docs/Publications/BB0412.pdf.

How to Provide Makeup Air for Range Hoods: If your kitchen has a powerful exhaust fan, it may be making your indoor air worse. Holladay, M., June 8, 2015. Green Building Advisor. http://www.greenbuildingadvisor.com/articles/dept/green-building-blog/how-provide-makeup-air-range-hoods.

Makeup Air for the Range Hood. Design, installation, and commissioning tips. Guertin, M., May 12, 2017. Fine Homebuilding. https://www.finehomebuilding.com/2017/05/12/make-air-range-hood.

Range Hood Make-Up Air Specifier. Broan, 2018. Interactive tool for meeting building codes in several states make-up air for domestic range hoods in dwelling units. http://tools.broan.com/muatemplate.aspx.

REHVA Residential heat recovery ventilation – European guidebook under preparation. Kurnitsky, J., REHVA Journal 54(6), December 2017. https://www.rehva.eu/knowledge-base/rehva-journal/detail/06-2017.

Healthy Indoor Air Quality Guides and Checklist Tool for energy upgrades and retrofits, Single- and Multi-Family. EPA and DOE. See local exhaust ventilation topics. https://www.epa.gov/indoor-air-quality-iaq/energy-savings-plus-health-indoor-air-quality-guidelines-multifamily-building and related links.

Cooking Up Indoor Pollution. News article on LBNL modeling study of health risks from gas stove and on electric stove emissions. Nicole, W., 2014. Environmental Health Perspectives, 122: A27. https://ehp.niehs.nih.gov/122-a27/.

Fact Sheet: Residential Cooking Exposure Study Finds Unhealthful Levels. Highlights and recommendations from extensive test home study of gas and electric stove cooking. CARB (California Air Resources Board), 2001. https://www.arb.ca.gov/research/indoor/cookingstudy.pdf.

Videos on residential kitchen ventilation and indoor air quality:

- Lawrence Berkeley National Laboratory, 2013: https://www.youtube.com/watch?v=aFep5DDMhpI.
- University of Colorado, 2017: https://www.youtube.com/watch?v=qkC-JsyA1FM.

RESEARCH AND STANDARDS

New Perspectives on Kitchen Ventilation. Webinar, AIVC (Air Infiltration and Ventilation Centre), May 23, 2019. http://www.inive.org.

Technical Note AIVC 68: Residential Ventilation and Health. Borsboom, W., De Gids, W., Logue, J. Sherman, S., and Wargocki, P., 2016. AIVC (Air infiltration and Ventilation Centre). http://www.aivc.org/about-us/what-is-aivc.

Cooking and Range Hoods. Research summary, seminar, reports, etc. from California Air Resource Board, 2016. https://www.arb.ca.gov/research/indoor/cooking/cooking_range_hoods.htm.

Development of the Industry's First Smart Range Hood. Research project to develop very quiet, highly effective range hood with automatic controls using a pollutant sensor. U.S.

Department of Energy, 2017 and 2019. https://www.energy.gov/eere/buildings/downloads/development-industry-s-first-smart-range-hood.

California Building Standards update. Jeff Miller presentation, Residential Indoor Air Quality Workshop. 2019 Building Energy Efficiency Standards Pre-Rulemaking Workshop, CEC (California Energy Commission), June 16, 2017. See also: CEC, 2019. 2019 Building Energy Efficiency Standards for Residential and Nonresidential Buildings. Requirements for Kitchen Ventilation, Sec. 150, Subchapter 7. https://www.energy.ca.gov/2018publications/CEC-400-2018-020/CEC-400-2018-020-CMF.pdf.

PRESENTATIONS

North American Passive House Network 2018 Conference
October 17-21, 2018, Pittsburgh, PA

- **"Beyond Dilution: Reducing Exposure to Particle Pollution in High Performance Homes" - Linda Wigington (ROCIS)** [PDF here]

- **"Healthy Kitchen Ventilation: Best Practices in Low-E Homes" - Tom Phillips (ROCIS)** [PDF here]