Kitchen Exhaust Systems for Residential Kitchens in Passive Houses

Guidelines

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Editor

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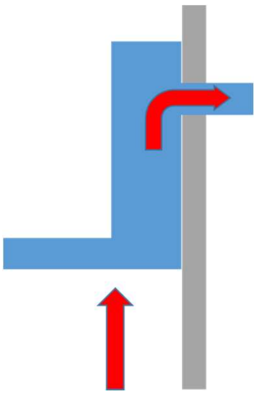
1 Introduction

In view of the higher energy efficiency requirements and comfort requirements of Passive House buildings it has become increasingly important to consider the correct planning aspects of kitchen extractor hoods in the energy balance of the building.
This guide serves as a planning aid for integration of kitchen exhaust systems for energy efficient buildings. In addition, it provides an approach for considering kitchen exhaust systems in the energy balance calculation of the Passive House Planning Package (PHPP).

2 Overview of available kitchen exhaust systems

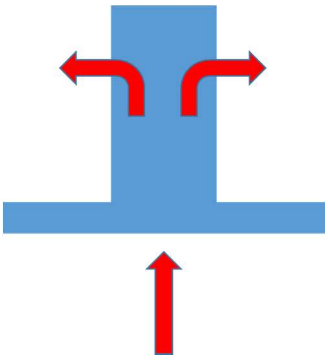
Most kitchen exhaust systems operate as either internal recirculation air hoods or as exhaust air devices. The type of operation for individual systems depends on a variety of criteria, which will be discussed in the following sections.

Exhaust air operation



- The extracted fumes are exhausted externally
- The air volume of the extracted air flow must be supplied back into the room using suitable measures

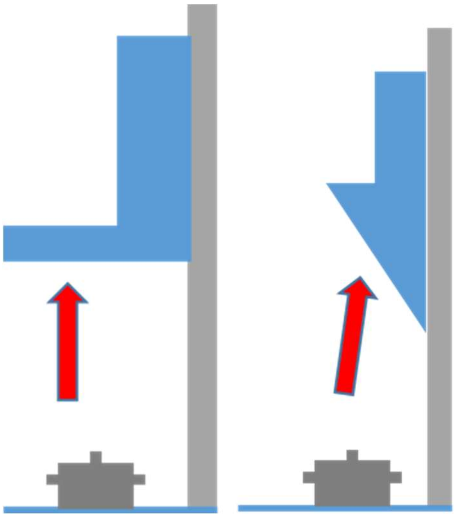
Recirculation operation



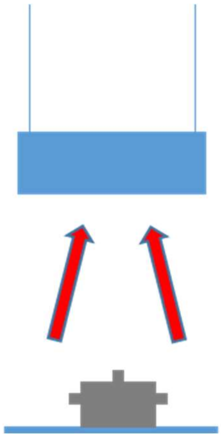
- The extracted fumes are filtered and the extracted air volume is returned into the room
- The moisture in the air is not removed. Therefore, basic air exchange in the kitchen is required

In addition to the two methods of air extraction, there are a variety of construction and configuration types for kitchen exhaust devices. The choice of device is largely determined by the amount of space available and by the specifications of the design.

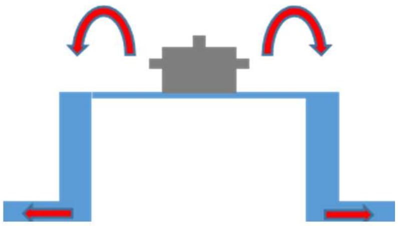
Wall-mounted hood (Rangehood)



Island or ceiling extractor hood

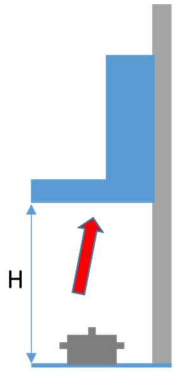


Downdraft Cooktop extractor



3 General planning information

3.1 Positioning of the hood



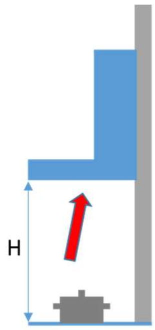
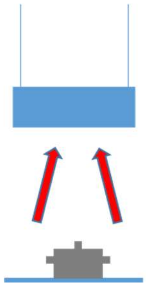
- The lower edge of the hood is usually mounted at a height, H, of about 50 - 60 cm (65 cm in combination with a gas cooktop) from the upper edge of the cooktop. Larger distances should be avoided, because they would increase the required extract air volume flow. Even positioning the extractor hood 20cm higher can increase the required air capture volume flow by 20 % *)
- Wall-mounted hoods should be preferred over island extractor hoods because the fume capture is more steady and effective. With the same capture capacity, the volume flow rate of wall-mounted hoods can be approximately 40% lower than island extractor hoods *)
- The hood should be positioned at an appropriate distance from adjacent kitchen units in accordance with the manufacturer's instructions in order to avoid moisture-related damage to the adjacent furniture.
- Island extractor hoods and wall-mounted hoods should be preferred over downdraft cooktop extractors if possible. First investigations [BewDunst] have shown that the capture of kitchen fumes above the cooktop is more effective.

*) Estimation based on [VDI 2052]

3.2 Dimensioning of air flow rates

Instrumented tests, of a variety of extractor hoods, on the subject of the capture of cooking fumes [BewDunst], confirmed that the type of extractor hood and it's positioning in the room has a much greater influence on the effectiveness of kitchen fume capture than the volume flow. Thus, it was demonstrated that a good level of fume capture can be achieved with a wall-mounted hood, even with much smaller volume flows than those usually planned.
Based on [ERP65/14] the maximum air flow rate of the kitchen exhaust system should be limited to 650 m³/h. Rough calculations (see Table 1) show that the required volume flow for fume capture of kitchen exhaust systems may be much smaller with a good level of fume capture efficiency. Fume capture efficiency, in this case, is influenced particularly by the position of the exhaust hood and by the sensible heat emission of the cooktop.

Table 1: Relative estimate, with regard to the volume flow required for fume capture, depending on the position of the hood for an electric or gas cooktop, based on [VDI 2052]

Position of the hood			
Height H above cooktop [cm]	Wall-mounted 	Ceiling-mounted (island solution) 	Required air flow for fume capture as a percentage of the reference value 1)
80		X	100%
60		X	80%
80	X		65%
60	X		50%

1) Reference value for the necessary volume flow for fume capture = 350 m³/h for gas cooker: 2 cooktops in operation with 2 x 2 kW output, height, H, above cooktop 80 cm, ceiling-mounted (island solution), full capture of the thermal flow, no cross flow

3.3 Information for recirculation operation

Additional hygienic air change rate

No moisture loads are removed with recirculation operation. To prevent moisture-related damage, a basic air change rate of ≥ 0.5/h in the kitchen is recommended which is achieved with a permanent extract air volume flow of 45 m³/h [DIN 1946-6]. This can be achieved by either a centralized or decentralized ventilation system.

Special features of cooktop extractors

With cooktop extractor systems the cooking fumes are extracted downwards and conveyed into the base area of the cabinet. To prevent moisture-related damage, it is recommended that the extracted air is routed out of the cabinet area with ducts. The circulated air outlets (grille) should not be covered or obstructed.

Delayed switch-off time

It is generally recommended that the exhaust system continue operating for 5 – 10 minutes after the cooking has finished, to enable the drying of the hood system (especially if an activated carbon filter is utilised).

Recirculation / activated carbon filter

Recirculation air filters may represent strong flow resistance and lead to increased pressure losses.

In order to ensure proper functioning of the recirculation air system and limit the pressure losses, the air filter must be cleaned and / or replaced at regular intervals.

3.4 Information for exhaust air operation

Incoming air flow

Sufficient incoming air flow must be ensured so as to prevent a negative pressure in the kitchen. Incoming air flow can be achieved by means of:

- an open window (manually opened or automatically opened via a window actuator connected to the extractor hood)
- controllable outdoor air intakes
- supply air wall box
- extract-supply air wall box

Incoming air flow from adjacent rooms should be avoided in order to prevent odour transfer (e.g. air from bathroom / toilet).

Required cross sectional area for incoming air flow

The following minimum cross-sectional areas are required for incoming air flow in airtight buildings ($n_{50} < 0.6 h^{-1}$) in order to avoid exceeding a safety-related negative pressure of 50 Pa[1*)] [BewDunst]:

Extract air volume flow	Required diameter of the clear aperture area [2*)]
250 m³/h	140 mm
500 m³/h	200 mm
650 m³/h	220 mm

1*) Safety-related limit value for opening doors. More stringent requirements apply for combined operation with fireplaces, with reference to the maximum negative pressure (see combined operation with fireplaces).

2*) Depending on the design of the incoming air flow damper and additional pressure losses due to the damper baffle and cover, the required cross-section may also be much larger.

The following minimum opening dimensions are required for incoming air flow through tilted windows with the same boundary conditions:

Extract air volume flow	Opening dimensions for a window of size 500 x 600	Opening dimensions for a window of size 800 x 1300
250 m³/h	14 mm	7 mm
500 m³/h	29 mm	15 mm
650 m³/h	35 mm	18 mm

Duct length and pressure losses

The cross-sectional area and the length of the duct influence the pressure losses and thus the effective air flow volume. The stated volume flows will not be achieved with high pressure losses.
The following points must be noted:

- installation of a cross-section with a minimum width of 150 mm (ø150 mm or equivalent rectangular cross-section)
- duct length should be as short as possible with few directional changes
- wall box / outdoor air openings with a large flow cross-section

Exhaust air and intake air vents

When the exhaust air system is not operating the exhaust air and intake air vents should close airtight and should not cause any leakage volume flow. Furthermore, additional insulation will be advantageous at these locations.

Combined operation with fireplaces

Combined operation of exhaust air extractor hoods with room air dependent fireplaces is not recommended. Simultaneous operation can result in an inadmissibly high negative pressure in the room containing the fireplace and may result in the release of flue gases into the room.
Combined operation of an exhaust air extractor hood and a room air independent fireplace can only be recommended if incoming air flow is ensured through an opened window. With airtight buildings, the use of supply air elements leads to negative pressures which are inadmissibly high, even in the case of room air independent fireplaces (limit value 8 Pa based on DIN1946-6 Supplementary Sheets 3 and 4).

4 Recommendations for kitchen exhaust systems in energy efficient buildings

In buildings with a very low heating demand, such as Passive House buildings, the use of an kitchen exhaust air system may increase the heating energy demand of the dwelling significantly. The increased heating energy demand is not only due to the ventilation heat losses incurred during operation of the kitchen exhaust system, but also those losses that are possible at the exhaust air and intake air vents, where significant infiltration losses can occur if installation is not executed airtight.

Recommendations for buildings with an extremely low heating demand (such as Passive House buildings)

- Preference should be given to recirculation hood systems.
- Exhaust air kitchen exhaust systems are possible. The following points must be considered:
  - Solutions should be provided that ensure adequate incoming air flow. The exhaust air outlet and air inlet must be equipped with airtight seals. Non-return valves are usually insufficient.
  - Impairment of comfort cannot be ruled out. Solutions must be sought which allow the introduction of incoming fresh air directly near the cooktop.
  - Systems that limit the operating time and reset the maximum flow rate after a certain time interval (automatic system), should be used.
  - Preference should be given to systems which ensure adequate air capture using moderate exhaust air flows. As investigations relating to the capture of fumes have shown [BewDunst], considerable differences exist between individual products. The air flows required for collecting a defined amount of fumes differ by about 60% in the examined systems.
  - In small apartments the heating demand, and also the heating load, are significantly increased due to the additional ventilation heat losses. Kitchen exhaust systems, which operate by exhausting the fumes externally, should not be used if the average size of the apartment is less than 90 m².

5 Approaches for energy-relevant consideration of recirculation air systems and exhaust air systems in a residential building kitchen

5.1 Recommendations and boundary conditions

Recirculation kitchen exhaust systems should be favoured.
For energy-relevant consideration of exhaust air systems in residential buildings, the following two influences must be taken into account:

- ventilation heat losses during the operation time (0.5 h/d)
- infiltration losses outside of the operation time through the exhaust air vents (23.5 h/d)

Due to the current lack of validated energy data for kitchen exhaust systems, the energy-relevant influences can only be roughly estimated. A distinction is made between the following extraction systems:

Recirculation Kitchen Exhaust Systems:

U1 Standard version:

- Additional heat loss 0 kWh/a,
  Electricity demand ca. 25 kWh/a.

U2 Efficient version:

- At least 3 fan levels, automatic reset of the boost level
- Recommended: fan with EC motor
- Additional heat loss 0 kWh/a,
- Electricity demand ca. 11.5 kWh/a.

Exhaust Air Kitchen Exhaust Systems:

A1 Standard version

- Maximum volume flow > 600 m³/h (target: maximum volume flow < 650 m³/h, volume flows > 900 m³/h should be avoided at all costs)
- Exhaust air vent is less airtight
- Assumed: average air flow rate of the extractor hood system 450 m³/h, usage duration 0.5 h per day.
- Estimated additional heat loss per extractor hood 500 kWh/a [1)], electricity demand ca. 25 kWh/a.

1) Heat losses refer to cool-temperate climates.

A2 Efficient version

- Maximum volume flow < 600 m³/h
- At least 3 fan levels, automatic reset of the boost level
- Recommended: fan with EC motor
- Airtight exhaust air vents
- Assumed: average air flow rate of the extractor hood system 250 m³/h, usage duration 0.5 h per day.
- Estimated: additional heat loss per extractor hood 185 kWh/a [1)], electricity demand ca. 11.5 kWh/a.

5.2 Approach for energy-relevant consideration in the PHPP

Recirculation Kitchen Exhaust Systems

Recirculation kitchen exhaust systems can be taken into account in the PHPP with an input for the electricity demand for an operating time of 0.5 h/d.
Enter the following electricity demand values in the Electricity worksheet under "other" according to Figure 1:

- U1 Standard version: 25 kWh/a (standard demand)
- U2 Efficient version: 11.5 kWh/a (standard demand)

Figure 1: Enter of electricity demand in worksheet Electricity

Column no.	1	2	3			4	5	
Application	Used ? (1/0)	Within the thermal envelope? (1/0)	Norm demand			Utilisation factor	Frequency	
Dishwashing	0	1	1,10	kWh/Use		* 1,00	* 65	/(P*a)
2-Kaltwasseranschluss								
Clothes washing	1	1	1,10	kWh/Use		* 1,00	* 57	/(P*a)
2-Kaltwasseranschluss								
Clothes drying with:	1	1	3,50	kWh/Use	Residual dampness 0,60	0,88	* 57	/(P*a)
1-Wäscheleine								
Energy consumed by evaporation	1	1	3,13	kWh/Use		* 0,60	* 57	/(P*a)
Refrigerating	0	1	0,78	kWh/d		* 1,00	* 365	d/a
Freezing	0	1	0,88	kWh/d		* 1,00	* 365	d/a
or combination	1	1	1,00	kWh/d		* 1,00	* 365	d/a
Cooking with:	1	1	0,25	kWh/Use		* 1,00	* 500	/(P*a)
1-Strom					Average lamp efficiency [lm/W]			
Lighting	1	1	14	W	50	* 1,00	* 2,90	kh/(P*ε
Consumer electronics	1	1	80	W		* 1,00	* 0,55	kh/(P*ε
Small appliances, etc.	1	1	50	kWh		* 1,00	* 1,00	/(P*a)
Total aux. electricity								
Other:								
Recirculation Hood	1	1	25	kWh/a				
				kWh/a				
				kWh/a				
Total								
Specific demand								

If there are several extraction systems, multiply the electricity demand value by the corresponding number of extraction systems.

1) Heat losses refer to cool-temperate climates.

Exhaust Air Kitchen Exhaust Systems

Exhaust air kitchen exhaust systems can be taken into account in the PHPP as follows:

- Two additional ventilation units are created in the Components worksheet (see Table 2)
- In the Additional Vent worksheet, these two ventilation units are taken into account with the volume flows V'_{SUP} and time slices, given in Table 2

Table 2: Data for taking into account exhaust air kitchen exhaust systems (EEH) in residential buildings

Version	Description	PHPP "Components"		PHPP "Additional Vent"	
	Ventilation unit	Effective HR [%]	Electric efficiency [Wh/m³]	Volume flow V'_{SUP} [m³/h]	Operation time [h/d]
A1 Standard	1 EEH on	0	0.30	450	0.5
	1 EEH off [1)]	0	-	10	23.5
A2 Efficient	2 EEH on	0	0.25	250	0.5
	2 EEH off [1)]	0	-	2	23.5

1) This "ventilation unit" considers the additional heat losses due to infiltration because of exhaust air vents that are not airtight. If the building certification airtightness test is carried out with fully installed and functional air vents, infiltration losses can be disregarded.

The input steps are explained in detail in the following section:

Figure 2: Input of ventilation units in worksheet components

Ventilation units with heat recovery				
	Recommended specifications to start planning: Frost protection: Yes; Humidity recovery: Yes	75 %		0,45
ID	Description	Effective heat recovery efficiency	Humidity recovery efficiency	Electric efficiency
	User defined area	%	%	Wh/m³
01ud	Elysee standard WG	85%	72%	0,35
02ud	Elysee groß WG	85%	72%	0,35
03ud	Elysee Eingang	85%	72%	0,35
04ud				
05ud	EEH on	0%	0%	0,30
06ud	EEH off	0%	0%	0,00
07ud				

Figure 3: Selection of ventilation units

Venti-lation unit no.	Quan-tity [-]	Description of ventilation units	Selection of type of ventilation	Design vol. flow per unit m³/h	Application range for volume flow rate from m³/h	to m³/h	Electrical efficiency Wh/m³	Pressu ODA-SUP Δp_{Duct} Pa
			Change sorting type					
1	168	Aldes Elysee 03A	01ud-Elysee standard WG	60	N/A	N/A	0,35	
2	24	Aldes Elysee 03A	02ud-Elysee groß WG	70	N/A	N/A	0,35	
3	12	Aldes Elysee 03A	03ud-Elysee Eingang	100	N/A	N/A	0,35	
4	192	EEH on	05ud-EEH on	450	N/A	N/A	0,30	
5	192	EEH off	06ud-EEH off	10	N/A	N/A	0,00	
6								
7								

Figure 4: Assignment of ventilation units and input of air volume

Room no.	Amount a	Room name	Allocation to ventilation unit (No.)	Area A m²	Clear height h m	Room vol. A x h m³	Volume flow per room V_{SUP} m³/h	V_{ETA} m³/h	V_{TRANS} m³/h	Air chng. rt. per room n 1/h	Utilisation times h/d h	d/week d	Duration of holidays d	Reduction factor 1	Operation red. 1
1	12	WG Typ 1	2	75	2,50	187	80	60		0,43	24	7		100%	100%
2	6	WG Typ 2	2	62	2,50	156	60	60		0,39	24	7		100%	100%
3	12	WG Typ 3	1	48	2,50	120	60	60		0,50	24	7		100%	100%
4	6	WG Typ 4	2	60	2,50	150	60	60		0,40	24	7		100%	100%
5	156	WG standard	1	42	2,50	105	60	60		0,57	24	7		100%	100%
6	6	Eingang1	3	112	2,50	281	100	100		0,36	24	7		100%	100%
7	6	Eingang2	3	79	2,50	196	100	100		0,51	24	7		100%	100%
8															
9	192	EEH on	4	50	2,50	125	450	450		3,60	0,5	7		100%	100%
10	192	EEH off	5	50	2,50	125	10	10		0,08	23,5	7		100%	100%
11															

Summer operation

The air exchange caused by exhaust air kitchen exhaust systems should also be taken into account in the worksheet “SummVent”.

Further information

- Product information and manufacturers' instructions relating to maintenance and care.
- Bundesverband des Schornsteinfegerhandwerks Zentralinnungsverband ZIV (federal trade association of flue gas inspectors, central association of guilds)
  www.schornsteinfeger.de
- Federal Building Regulations
  http://www.bauordnungen.de/html/deutschland.html
- AMK Arbeitsgemeinschaft die Moderne Küche e.V. (working group on modern kitchens)
  www.amk.de

List of references

[BewDunst]	Endbericht der „Studie zur technischen, energetischen und wirtschaftlichen Bewertung von Abluft- und Umluft-Dunstabzugshauben in Wohnküchen in energieeffizienten Gebäuden“. Passivhaus Institut, Institut für Technische Gebäudeausrüstung Dresden, Institut für Holztechnologie Dresden. Dezember 2018. [Final report of the “study on the technical, energy-relevant and economic evaluation of exhaust air and recirculation air extractor hoods in combined kitchen/living areas in energy efficient buildings”. Passivhaus Institut, Institut für Technische Gebäudeausrüstung Dresden, Institut für Holztechnologie Dresden. December 2018.]
[PHPP]	Passivhaus Projektierungs-Paket. Berechnung von Energiebilanzen und Planungstool für energieeffiziente Gebäude. Passivhaus Institut, Darmstadt 1998–2016. Aktuelle Version (Deutsch): PHPP 9.7 (2016). [Passive House Planning Package. Energy balance and planning tool for efficient buildings. Passivhaus Institut, Darmstadt 1998-2016. Latest version (English): PHPP 9.6 (2016).]
[VDI 2052]	Verein Deutscher Ingenieure: VDI 2052, Raumlufttechnische Anlagen für Küchen. Beuth Verlag Berlin, April 2006. [Association of German Engineers VDI 2052, Air conditioning – Kitchens. Beuth Verlag Berlin, April 2006]
[ERP65/14]	https://eur-lex.europa.eu/legal-content/DE/TXT/PDF/?uri=CELEX:32014R1254
[ERP66/14]	https://www.eup-network.de/fileadmin/user_upload/OEkodes_Haushaltsbackoefen_VO_66_2014.pdf

Impressum

Authors: Dipl.-Ing. Kristin Bräunlich Dipl. Phys. Oliver Kah Dipl.-Ing. Julia Sophie Weiser M.Sc. Eng. Arch. Maria Chiara Failla Unter Mitarbeit von: Dr.-Ing. Alfred Bruns (Naber GmbH) Prof. Dr.-Ing Thomas Hartmann (ITG GmbH) Dipl.-Ing. Christine Knaus (ITG GmbH)	These guidelines reflect the main contents of the research project „Studie zur technischen, energetischen und wirtschaftlichen Bewertung von Abluft- und Umluft-Dunstabzugshauben in Wohnküchen in energieeffizienten Gebäuden“, which was funded by the Forschungsinitiative Zukunft Bau (*Future Construction Research Initiative*) of the Bundesinstitut für Bau, Stadt- und Raumforschung. (File number: SWD-10.08.18.7-17.27) The authors are responsible for the content of this guide.
Editor: Passivhaus Institut Rheinstraße 44/46 D-64283 Darmstadt Tel: 06151-82699-0 E-Mail: mail@passiv.de www.passiv.de Darmstadt, April 2019	