Cooking habits and usage of kitchen hoods in Norwegian homes

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Abstract. Sustainable urban development results in more space and energy-efficient apartments. Open plan solutions are becoming more common, and the market is exploring new configurations and ventilation solutions for the kitchen in direction of the design and minimize space for ductwork. Cooking is an important aspect of human life and is considered one of the major sources of particle emissions. The cooking method, the type of cuisine, and the type of kitchen hood are some of the factors that will influence this. In Norway, the minimum requirement for general kitchen exhaust is 36 m^3/h, with a minimum additional forced ventilation by the kitchen hood of 108 m^3/h. However, these requirements might not be sufficient to mitigate the exposure from cooking. Electricity is the main heating source, traditionally with hot plate, today mainly induction or ceramic cooktop. In this work, we aim to investigate representative Norwegian cooking habits, typical meals and set up a procedure for cooking in the laboratory to perform intensive exposure studies. A survey has been performed to identify the type and usage of kitchen hoods in different living situations as well as typical Norwegian meals. A total of 336 people responded to the survey, of which 111 provided answers to a few additional questions. More than 60% of the respondents belonged in the age groups 30 – 60 years old and 92% owned their dwelling. Wall-mounted kitchen hoods were found in the majority of the homes, and almost 4% had downdraft. Only 12% of the homes had recirculating hoods. 76% of the respondents used the kitchen hood during cooking. The Norwegians mainly cook or fry their food, while deep-frying is not common. For the question related to what meal is most often cooked, the categories of food that were most mentioned were pasta dishes, taco, meat, fish, boiled potatoes, and chicken. Based on this we developed the cooking procedure for three different test meals suitable for exposure studies.

Keywords. kitchen hoods, cooking emissions, cooking activities
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1. Introduction

Modern apartments in urban areas are built more energy and space-efficient, often resulting in open-plan kitchen solutions. We spend the majority of our time indoors and cooking activities can generate harmful air pollutants [1,2]. The open plan solution increases the risk of exposure if pollutants are not properly removed. The cooking method, the type of cuisine, and the type of kitchen hood are some of the factors that will influence the level of pollutants [3,4]. A kitchen hood can minimize the level of exposure to pollutants if they have a reasonable capture efficiency and are used during a cooking event [5].

As seen in Table 1, the requirements for kitchen extract airflow rates vary between countries. In Norway, the minimum requirement for the basic kitchen ventilation rate is 36 m^3/h, with a minimum additional forced ventilation by the kitchen hood of 108 m^3/h. However, these requirements might not be sufficient to mitigate the exposure from cooking.

The requirements are similarly low in other Scandinavian countries and are based on tests of volume range hoods done in the 1980s. At the same time, design and configuration for kitchen hood have progressed in the last decade, and the available maximum extract airflow for the offered products is often 400 -700 m^3/h, sometimes even higher. This results in a problem for makeup air, both in terms of under pressure in an airtight building, to be handled by the balanced ventilation system, as well as an

increased air change rate. Recirculating solutions are introduced as a measure, but with insufficient documentation on resulting exposure of cooking emissions and odor in the room, as well as not removing the moisture.

Tab. 1 – Kitchen ventilation requirements.

Country	Min. requirement (m^3/h)	Additional forced (m^3/h)
Sweden	36	140
Denmark		72
Finland	29	90
Norway	36	108
The Netherlands		72
UK		108

Cooking habits, kitchen configurations, usage of kitchen hoods among other things might vary geographically [6]. A major survey of everyday eating habits was conducted in the four Nordic countries in 1997 and 2012 [7]. The results indicate that meat and fish were the main ingredients in hot dinners in Norway, particularly minced meat. Almost a decade has passed since the survey, and thus it might be interesting to see whether there are any changes in Norwegian food habits.

This study is part of a larger research project, where one of the aims is to determine what principles and ventilation rates can be recommended for kitchens to avoid contamination risk, high energy use, and power load peaks, as well as maintain moisture control (hood configurations, the flow rate of range-hoods, types of cooking, installation position (wall/island). The purpose of the study reported in this paper is to identify typical cooking habits and usage of kitchen hoods in Norwegian homes, intending to set up a procedure for cooking in a laboratory kitchen.

2. Methods

A survey consisting of 15 questions with multiple answers was used. To gain as many answers as possible, the survey was shared on social media platforms such as Facebook and LinkedIn. The questions asked are given below:

- Do you rent or own your home?
- What type of housing do you live in?
- What age group are you in?
- How often do you cook in a week?
- How many do you cook for?
- What type of kitchen hood do you have?
- Do you have a recycling kitchen hood or with exhaust?
- How often do you wash the grease filter?
- If you have a recirculating fan, how often do you change the charcoal filter?
- How often do you use the kitchen hood when you cook?
- What setting do you usually have the kitchen hood on when it is in use?
- If you choose not to use a kitchen hood, what is the reason for it?
- Do you use the kitchen hood when you use the oven?
- What meal do you make most often?
- How long after cooking do you leave the kitchen hood on?

The responses were analyzed to determine the following parameters: (1) type of kitchen hood, (2) usage of kitchen hood and (3) typical Norwegian meals.

3. Results and discussion

3.1 Respondents

A total of 336 respondents answered the survey, of which 92% owned the dwelling. As shown in fig. 1, there is an even distribution of the various age groups, except the youngest age group. Almost 70% of the respondents live in houses, while 27% live in apartments. According to Statistics Norway, apartment blocks account for 25% of residential building types in Norway in 2021, while detached houses represent 49% and attached houses 12% [8]. The respondents are thus regarded representative of Norwegian households.

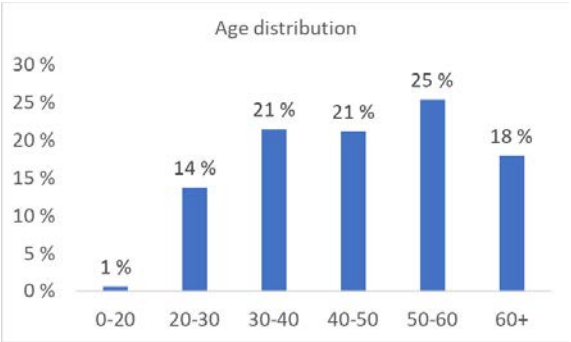


Fig. 1 – Age distribution of the respondents.

3.2 Types of kitchen hoods

Regardless of dwelling type, the majority of the kitchen hoods are wall-mounted. 13% of the homes have kitchen island with hood mounted on the roof, while close to 4% reported they have downdraft kitchen hoods. The majority of the kitchen hoods are ducted hoods (82%) where the air is exhausted outdoors, while 12 % are recirculating hoods.

Generally, kitchen hoods with an exhaust to open-air are the pre-accepted solution and regarded as a more safe and efficient solution for reducing cooking emissions than recirculating alternatives [9]. Fig. 2 shows the distribution of the different types of kitchen hoods and their ventilation solutions. Other kitchen hood types such as slimline and roof-mounted hoods are also reported by the respondents.

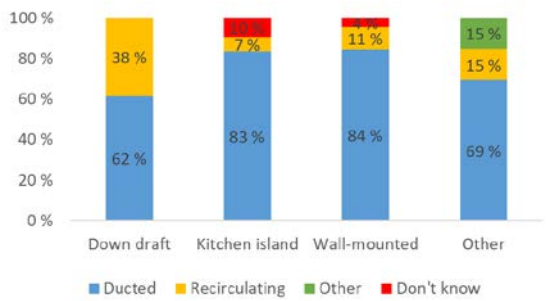


Fig. 2- Different types of kitchen hoods and the ventilation solution.

For those with recirculating hoods (N=40), more than 60% of the respondents reported that they rarely or never changed the charcoal filter, while 22.5% changed once a year. Charcoal filters are often used to removed gases and odors and might have less effect on particulate matter. A Dutch study on recirculating hoods showed that adding a carbon filter removed about 60% of the NO_2 concentrations and resulted in a reduction of about 30% for $PM_{2.5}$ [10]. However, the filter efficiency dropped substantially after only a few weeks of cooking, reducing the removal of NO_2 to 20%. Nevertheless, it is important to change it as the filter may lose its efficiency after a while. More documentation is needed for exposure risk by using recirculating solutions over time.

On the other hand, as shown in fig. 3, the grease filter was washed at least once a year by the majority of the respondents, where 32% washed it either once every 3 months or once a year. Only 16% washed it once a month. A few of the participants also responded that their kitchen hood had a notification function for when it was time to wash or change the charcoal filter and/or the grease filter.

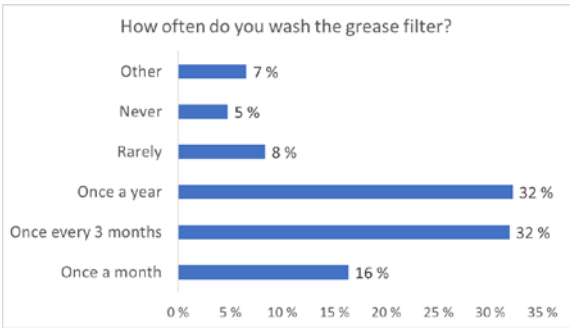


Fig. 3 - How often the grease filter is cleaned.

3.3 Usage of kitchen hoods

In terms of cooking habits, 74% of the respondents replied that they cook daily, while 16% cook five times a week. Also, the majority responded that they cook for 2 people (40%) or 3-5 people (46%). This is also reflected in the usage of the respective kitchen hood, the majority of the respondents reported daily use (76%) while cooking (see fig 4). The numbers reported in our study are much higher than the studies done in the US, where generally less than 40% reported the usage of the kitchen hood during cooking events [3,11].

When asked why the kitchen hood was not used, besides noise and having forgotten to turn the hood on, many respondents also mentioned that they did not see the necessity of turning on the kitchen hood when they only boiled food or cooked food that does not smell or generate fume. A survey done in the US indicated that noise is one of the causes of why the majority of people are not using the kitchen hood [12].

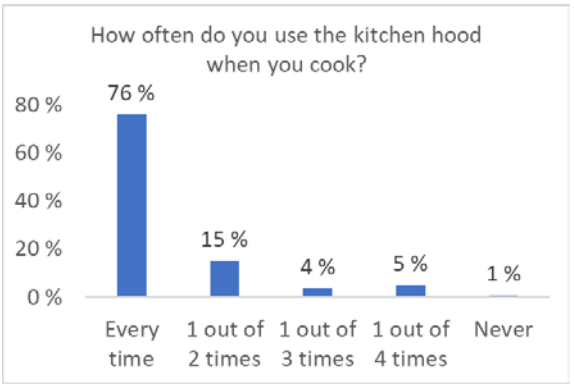


Fig. 4 – Overview of how often the kitchen hood is used.

How long time the kitchen hood is used as well as the flow rate will influence the exposure to cooking emissions. Regarding the operation setting chosen when the kitchen hood is used, as seen in fig. 5, the majority of the respondents replied the medium or max setting. The flow rates were not assessed in this survey, although one respondent did add that the kitchen hood had a capacity of 500 m^3/h.

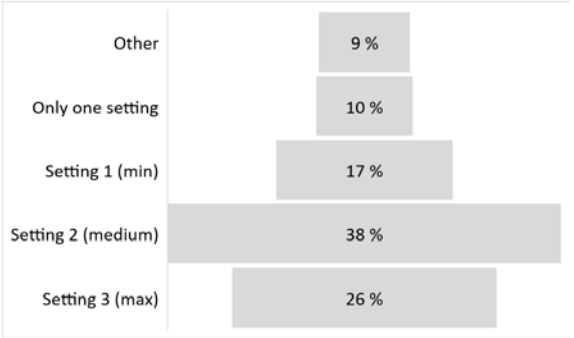


Fig. 5 – Operation setting when using the kitchen hood.

For newer apartments that often have balanced mechanical ventilation, the kitchen hood only has one setting, which is on and off. Some of the respondents that responded "Other" stated that they vary the operation setting depending on what is being cooked. This is also reflected in the question related to the usage of the kitchen hood when the oven is used, as close to 80% of the respondents replied "No" to this question. Some also commented that the oven was not placed nearby the cooktop.

Other habits such as leaving the kitchen hood on after cooking was finished were also questioned. It

can be seen from fig. 6 that more than half of the respondents (N=224) turn it off immediately after they finish cooking. For those who replied other, some had timers that can turn the hood off automatically after a certain amount of time, while the majority responded that they do leave the kitchen hood on for at least 5 – 10 minutes longer, depending on what they have cooked, and the amount of fume generated during cooking. One study in the US assessed the effect of running the kitchen fan continuously after cooking for various flow rates on pollutants but did not find significant reductions. They found that the flow rate and physical characteristics of the kitchen hood were more important factors affecting the exposure during cooking [13].

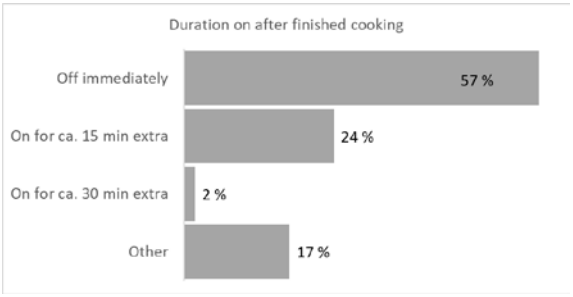


Fig. 6 – Duration of leaving the kitchen hood on after finishing cooking.

3.4 Typical Norwegian meals

With regards to the meal that is often cooked, we received a variety of answers. Since the majority of the respondents cook every day, several dishes are listed. Fig. 7 shows the meals that are most frequently mentioned. Fish, meat, and pasta dishes are the three mentioned the most often, followed by chicken and taco. Potato or rice was also mentioned as they are often boiled along with different types of proteins.

Fig. 7 - Illustration of the most common mentioned meals by the respondents.

Based on the results from the survey and test meals used in other studies, three different meals were chosen to be tested further in the kitchen lab. The chosen meals were taco (meal 1), vegetarian pasta Bolognese (meal 2), and fried salmon (meal 3). The vegetarian meal was added due to the increasing number of people choosing to eat a plant-based diet. According to a recent survey on "Trends in the Norwegian diet by the Norwegian Directorate of Health, more than 10% are substituting meat or other animal-derived foods for plant-based alternatives regularly [14]. Fish also ranked high as one of the most mentioned meals. We chose salmon filet, as it is very commonly used and a fatty fish, to address the issue of odor in open plan kitchen solutions. Fig. 8 shows the ingredients used in the different meals.

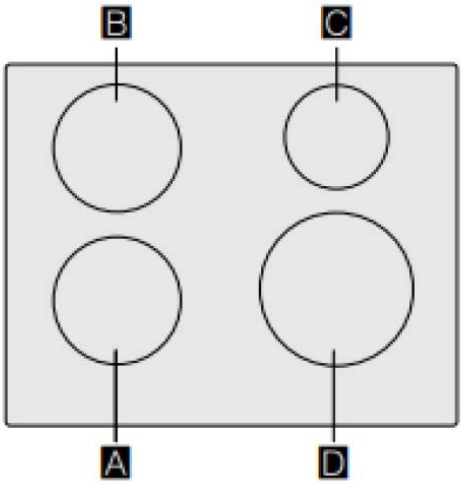
Fig. 8 - Ingredients for the three test meals.

3.5 Cooking procedures

In this section, we present the procedure for cooking typical Norwegian meals arising from the survey. These meals will be cooked in our laboratory kitchen to assess exposure from cooking emissions. To ensure the repeatability of the cooking procedure, the meals are simplified in such a way that, there is minimal possibility of variations in the content of the meals to perform exposure experiments. It was also decided to prepare a meal for two adults, considering that the kitchen lab is representative of a typical apartment with an open kitchen and living room. One portion size is assumed to be between 1400 kcal – 1600 kcal per meal.

An overview of the induction cooktop used in the study is shown in fig. 9. We chose to only use the front hot plates as previous studies have shown that the capture efficiency is lower compared to the backplate, resulting in higher exposure [5,15]. Two Teflon frying pans are used, with a diameter of 24 cm for fish at plate A, and 28 cm are used on plate D for minced meat, soya mince, and vegetable frying. A 36-liter aluminum pot was used for boiling pasta.

Table 2 – Table 4 show the detailed cooking procedure for each of the three test meals. All ingredients are prepared and measured in advance before the start of the cooking. Apart from ensuring the choice of the meals which represents the typical Norwegian meals, we also incorporated different ways of cooking (frying, boiling) the meals. Both meal 1 and meal 2 involved frying and boiling of ingredients, while meal 3 involves only frying. The cooking duration is 16 minutes for meal 1 and 13 minutes for meal 2 and meal 3.



		9*	b*
A / B	Ø 18	1.800 W	3.100 W
C	Ø 14,5	1.400 W	2.200 W
D	Ø 21	2.200 W	3.700 W

* IEC 60335-2-6

Fig. 9 - Induction cooktop used in the study. 9* indicates the effect when the cooktop is used on setting 9, and b* for when the boost-mode is used.

Tab. 2 – Cooking procedure for test meal 1, taco.

Step	Description	Time mm:ss
1	Turn on burner D on setting 8, add 15 ml rapeseed oil	00:00
2	Add minced meat, fry	01:00
3	Flip the piece of meat	02:00
4	Chop the meat into pieces, fry without movement	02:30
5	Stir and chop up meat	04:00
6	Add spice mix, mix for 1 min	05:00
7	Add 1.5 dl of water, switch to setting 5, mix every 2 min for 10 minutes	06:00
8	Turn off, transfer to a serving plate, and move to dining area	16:00
9	Remove the pan from the room	17:00

Tab. 3 – Cooking procedure for test meal 2, vegetarian pasta Bolognese.

Step	Description	Time mm: ss
1	Turn on burner A, fill the pot with 2L of water and 10 g salt, turn on boost setting	00:00
2	Turn on burner D, setting 7, add rapeseed oil to the pan	01:00
3	Add soya mince, mix for a few seconds every minute for 7 minutes?	02:00
4	Add pasta to the pot, reduce to setting 8, boil for 7 min (without lid)	05:00
5	Add tomato sauce to the soya mince, mix well for 1 minute	09:00
6	Turn off burner A, drain pasta and add to pan	12:00
7	Turn off the cooktop, add pasta to a plate and transfer to dining area	13:00
8	Remove the pan from the room and leave the room.	14:00

Tab. 4 – Cooking procedure for test meal 3, fried salmon with wok vegetables and whole grain rice.

Step	Description	Time mm:ss
1	Season salmon filets with salt and pepper	
2	Turn on burner A to setting 9, add 15 ml rapeseed oil	00:00
3	Turn down to setting 7, add salmon filet skin side down	01:00
4	Press the salmon down with spatula for 5 seconds to get crispy skin, then let it fry for 5 mins	01:30
5	Change locations of the two salmon filets in the pan	03:00
6	Flip the salmon, fry for 30 seconds	06:00
7	Turn off burner A, remove the salmon from the pan, put it on a plate	06:30
8	Turn on burner D, setting 8, add oil	07:00
9	Add defrosted wok mix in the pan, stir every minute for 5 minutes	08:00
10	Turn off cooktop, transfer wok to the plate with salmon. Move the plate to the dining area	13:00
11	Remove the pan from the room and leave the room.	14:00

Different extract airflow rates will be assessed in addition to the Norwegian minimum requirement for basic kitchen ventilation rate (hood off, 36 m^3/h) and the minimum additional forced ventilation by the kitchen hood of 108 m^3/h. The developed cooking procedures and responses from the survey will provide the basis for further studies, these include: (1) comparing traditional wall-mounted ducted kitchen hoods with downdraft ducted solutions. (2) Ducted versus recirculation solutions, (3) Effect of filter for recirculating solutions, (4) different airflow rates and its relation to the type of kitchen hood.

4. Conclusions

A survey was conducted to identify the type and use of kitchen hoods as well as representative Norwegian cooking habits and typical meals. Based on the results, cooking procedures to be used in our lab kitchen are developed.

The ducted kitchen hood is still the main solution used, while recirculation is an emerging solution, especially the downdraft. A medium operation setting is a dominating choice, and cleaning of the grease filter is mainly done 1-4 times a year. Norwegian homes use electricity for cooking, mainly frying or boiling of a dinner meal. Frying different type of meat and fish is common, alongside boiling potato, rice, or pasta, and vegetarian alternatives are becoming popular.

Based on the results, procedures for three test meals were developed: taco-meal with minced meat, vegetarian pasta Bolognese and fried salmon with wok. The meals are regarded suitable for two persons and to have a reasonable nutritional content, as well as being simple enough for repeatability in cooking procedure and to be used in exposure studies.

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The datasets generated and analysed during the current study are not publicly available because they are in Norwegian and are part of an initial study but will be available by personal request.

References

[1] Q. Zhang, R.H. Gangupomu, D. Ramirez, Y. Zhu, Measurement of Ultrafine Particles and Other Air Pollutants Emitted by Cooking Activities, Int. J. Environ. Res. Public. Health. 7 (2010) 1744–1759. https://doi.org/10.3390/ijerph7041744.

[2] Y. Zhao, L. Liu, P. Tao, B. Zhang, C. Huan, X. Zhang, M. Wang, Review of Effluents and Health Effects of Cooking and the Performance of Kitchen Ventilation, Aerosol Air Qual. Res. 19 (2019) 1937–1959. https://doi.org/10.4209/aaqr.2019.04.0198.

[3] H. Zhao, W.R. Chan, W.W. Delp, H. Tang, I.S. Walker, B.C. Singer, Factors Impacting Range Hood Use in California Houses and Low-Income Apartments, Int. J. Environ. Res. Public. Health. 17 (2020). https://doi.org/10.3390/ijerph17238870.

[4] O. Han, A. Li, R. Kosonen, Hood performance and capture efficiency of kitchens: A review, Build. Environ. 161 (2019) 106221. https://doi.org/10.1016/j.buildenv.2019.106221.

[5] D. Rim, L. Wallace, S. Nabinger, A. Persily, Reduction of exposure to ultrafine particles by kitchen exhaust hoods: The effects of exhaust flow rates, particle size, and burner position, Sci. Total Environ. 432 (2012) 350–356. https://doi.org/10.1016/j.scitotenv.2012.06.015.

[6] M. Amouei Torkmahalleh, S. Gorjinezhad, H.S. Unluevcek, P.K. Hopke, Review of factors impacting emission/concentration of cooking generated particulate matter, Sci. Total Environ. 586 (2017) 1046–1056. https://doi.org/10.1016/j.scitotenv.2017.02.088.

[7] S. Bowen, Everyday Eating in Denmark, Finland, Norway, and Sweden: A Comparative Study of Meal Patterns 1997–2012, Contemp. Sociol. 50 (2021) 49–52. https://doi.org/10.1177/0094306120976390m.

[8] Statistics Norway, Dwellings, SSB. (n.d.). https://www.ssb.no/en/bygg-bolig-og-eiendom/bolig-og-boforhold/statistikk/boliger (accessed December 7, 2021).

[9] R.E. Militello-Hourigan, S.L. Miller, The impacts of cooking and an assessment of indoor air quality in Colorado passive and tightly constructed homes, Build. Environ. 144 (2018) 573–582. https://doi.org/10.1016/j.buildenv.2018.08.044.

[10] Jacobs, Piet, Cornelissen, Henricus J.M., Efficiency of recirculation hoods with regard to PM2.5 and NO2, in: Lublin, Poland, 2017: p. 7.

[11] W.R. Chan, Y.-S. Kim, B.D. Less, B.C. Singer, I.S. Walker, Ventilation and Indoor Air Quality in New California Homes with Gas Appliances and Mechanical Ventilation, Lawrence Berkeley National Lab. (LBNL), Berkeley, CA (United States), 2019. https://doi.org/10.2172/1509678.

[12] N.A. Mullen, Participant Assisted Data Collection Methods in the California Healthy Homes Indoor Air Quality Study of 2011-13, (2013).

https://escholarship.org/uc/item/4sd2k5nh (accessed December 7, 2021).
[13] N.A. Dobbin, L. Sun, L. Wallace, R. Kulka, H. You, T. Shin, D. Aubin, M. St-Jean, B.C. Singer, The benefit of kitchen exhaust fan use after cooking - An experimental assessment, Build. Environ. 135 (2018) 286–296. https://doi.org/10.1016/j.buildenv.2018.02.039.
[14] Norwegian Directorate of Health, Trends in the Norwegian Diet 2021, Helsedirektoratet. (2021). https://www.helsedirektoratet.no/rapporter/utviklingen-i-norsk-kosthold (accessed December 7, 2021).
[15] M.M. Lunden, W.W. Delp, B.C. Singer, Capture efficiency of cooking-related fine and ultrafine particles by residential exhaust hoods, Indoor Air. 25 (2015) 45–58. https://doi.org/10.1111/ina.12118.