Kitchen ventilation solutions in urban dwellings

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Kitchen extract hood design and volumetric flow rates have been discussed for years. The standard airflow rate once recommended for conventional volume hoods is outdated in the context of urban energy-efficient apartments. Can recirculating or downdraft-hoods be acceptable alternatives, and how should the overall ventilation solution then be for the apartment?

Keywords: Kitchen hoods, IAQ, urban apartments, recirculating solutions, downdraft, exposure, Particulate matter, VOC

Urban dwellings and challenges

Increased development of urban areas leaves new challenges for the indoor environment. Area-efficient dwellings with open-plan kitchens and living rooms are becoming the standard in most new Norwegian apartment buildings. At the same time, the design of the kitchen hood is evolving, and new designs such as the integrated downdraft cookers are gaining popularity as they release space above the cooktop.

The existing mandatory airflow rate in Norway of 108 m^3/h once recommended for volume hoods, often results in complaints of insufficient capture, while hoods with high airflow rates have capacity issues due to under-pressure in airtight buildings. Recirculation solutions can be a tempting alternative to ducted exhaust solutions, as the latter demands considerable space for shafts to the rooftop. However, the true performance of these alternative solutions is not well-documented. Existing test standards have their limitations, and the Norwegian building code demands documentation if pre-accepted solutions are not used.

Urban dwellings are generally getting smaller. Minimum exhaust rates for kitchens and bathrooms can result in high air change rates, and thus increase the risk of low humidity in winter. Taking all these aspects into consideration, what recommendations for ventilation rates can be given to achieve healthy and energy-efficient urban dwellings? The Norwegian research project *Health Energy-efficient Urban Home Ventilation* (2020–2024), coordinated by SINTEF, aims to answer this question.

Kitchen design and new products

The layout of urban apartments has changed, and this includes the kitchen. Design of kitchen hoods as well as introducing recirculating solutions reveal potential totally new concepts for kitchen design but need documentation. A team consisting of researchers, housing developers, main manufacturers of kitchen hoods and a ventilation system manufacturer, analysed architectural plans and project drawings to identify typical floor plans and appropriate HVAC solutions.

The analysis showed that separate kitchens as seen in the 1970–80s are now rare. Open-plan kitchen and living rooms are now standard. The kitchen furniture area is predominantly L-shaped (See **Figure 1**), followed by single-sided kitchens. None of the studied projects had kitchen islands or a kitchen hood in the middle of the room; the cooktop was normally placed next to a wall. In smaller apartments, the sofa may be located quite close to the cooktop. Generally, electric cooktops are used in Norway, and induction hobs (cooktops) have become the dominate solution in the marked. The study also revealed a slight variation in mounting height of the kitchen hood, related to variations in the standard set by the manufacturers of kitchen furniture.

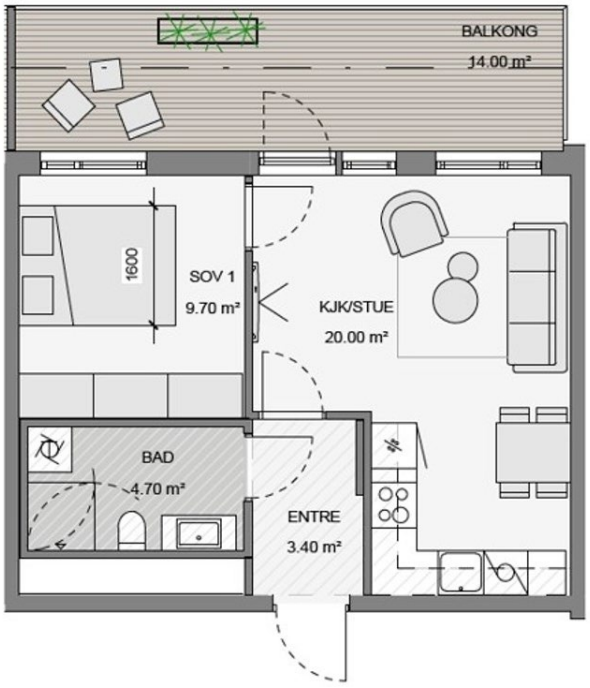

Figure 1. A typical 1-bedroom urban apartment in Oslo, Norway. Courtesy by: Selvaag Bolig.

Based on these findings and discussions with the four kitchen hood manufacturers, two different setups were chosen for testing:

- Standard wall-mounted kitchen hood fitted between wall-mounted cupboards
- Downdraft in the centre of an induction hob (cooktop) fitted in a countertop along the wall.

These two setups (**Figure 2**) are being tested for both ducted exhaust and recirculation configurations. The manufacturers selected products with known good performance from their product range, to be tested in the laboratory (**Figure 3**).

Typical Nordic cooking habits

The manufacturers of kitchen hoods strongly wanted realistic testing conditions for cooking meals. Nordic meals and cooking habits can be slightly different than ones found in the literature [1]. Two surveys were performed to find representative Norwegian cooking habits. Based on the responses and nutrition facts, procedures were developed for cooking three typical nutritious meals for two persons. These involved

Figure 2. Ducted standard setup (left) and downdraft recirculating solution (right).

frying of minced meat with taco spices, fried salmon with a vegetable and rice mix, and a vegetarian pasta Bolognese alternative [2]. Teflon-coated frying pan was used as it is the most common choice.

New methods and advanced studies

Based on the analysis of kitchen layouts in modern dwellings, and existing test standards, a test environment and test methods were developed to study both capture efficiency and exposure to persons in the room. The test room which emulates a typical open-plan living room and kitchen, as shown in **Figure 3**, is larger than the standard test room in EN 61591:2019 which more reflects older kitchens. Two different kitchen configurations were built: standard wall-mounted kitchen hood based on the standard setup, and a downdraft solution. The flexible setup of the test facilities allowed for recirculating and extraction solutions for both kitchen configurations. In addition, the height of the cupboards was adjustable. Diffuse supply air to the room is chosen, as balanced ventilation with supply air in bedrooms and living room is the standard solution in Norwegian dwellings.

As preparation for more advanced measurements, the first round of tests was performed for the three meals using the standard kitchen extraction configuration at different air flow rates and heights. Each experiment has a procedure of 13–16 minutes of cooking, followed by 45 minutes of continued logging of airborne particle concentrations.

Based on the results [3], frying salmon was selected to be explored further using more advanced instruments to perform real-time measurements of volatile organic compound (VOC) and particle (≤1 µm) concentrations.

The advanced experiments were done for two main setups – a standard wall-mounted hood and a downdraft kitchen hood. For each setup, both extraction and recirculation solutions were tested. Recirculation solutions were tested with retailed charcoal filters (activated carbon). The following airflow rates were tested for both setups: 108, 180, 250, 350 m³/h. In addition, the test room is ventilated with a basic ventilation rate of 36 m³/h. As there is no international standard for testing with real cooking, a new method was developed based on the international standard IEC 61591:2019 [4] and NORDTEST NT VVS 047 [5].

Indicative results can change the kitchen design and recommendations

The results of the VOC measurements are still being processed, but the preliminary results of the particle measurements can provide some indications:

- The Norwegian requirement of 108 m³/h is clearly insufficient in terms of reducing exposure to particles. Higher minimum rates will be recommended.
- The majority of the particles in the size range of ≤ 1 µm were difficult for the charcoal filter to

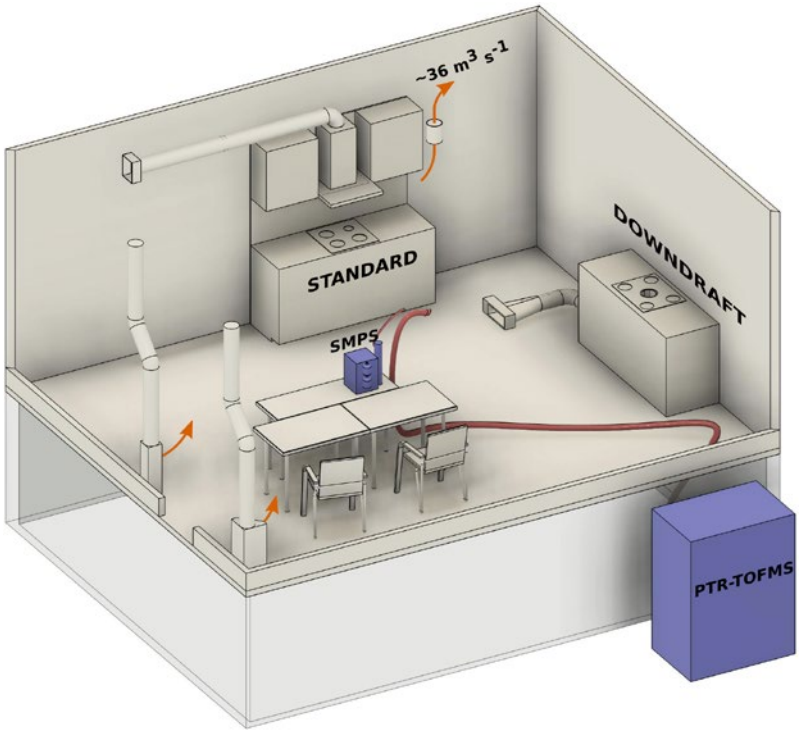

Figure 3. Testroom setup with advanced real-time measurements.

retain (**Figure 4**). The tested charcoal filers are not suitable as particle filters; recirculation solutions need further development.

- Recirculation solutions as today will then not perform as well as ducted solutions and cannot be an adequate solution.
- The capture efficiency of downdraft ducted solutions is better than expected, and downdraft solutions will have to be considered as a real alternative to standard wall-mounted solution. There are of course several considerations to be discussed, like type of downdraft and height of used frying pan/boiler.

More results to come

In the next phase of the project, we will further assess the recirculation solutions, particularly the filter efficiency. A dedicated test chamber will be set up to investigate the effect of different types of filters (plasma versus charcoal) and the age of the filter on the concentration of volatile organic compounds.

Besides recommendations for kitchen ventilation rates and exposure assessment of cooking, the ventilation and resulting healthy indoor environment will be assessed in a holistic approach. These include extraction rates for the bathroom, moisture generation and removal [6], energy use and peak load. Recommendations for optimal future ventilation of urban dwellings will take into account also the fact of different needs for different size and use of apartments. Recommendations should be suitable for balanced ventilation systems for one apartment as well as several in a centralized system.

Read more: https://www.sintef.no/projectweb/healthy-energy-efficient-urban-home-ventilation/ ■

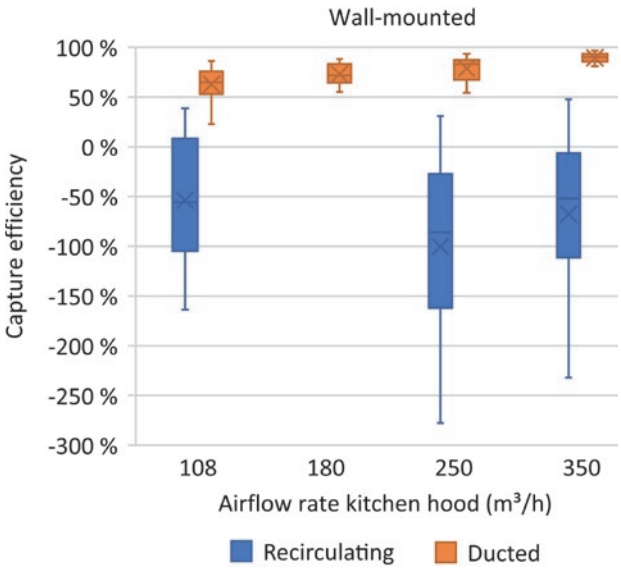

Figure 4. Capture efficiency of particles 0.3–2.5 µm, measured in the room's return air terminal, for wall-mounted kitchen setup with ducted and recirculation solution, preliminary results.

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