SMELL (Using SMell to choose wELL) – Alternative ways of communicating energy and climate solutions

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Abstract

Increasing the installation of upgraded ventilation system is an important measure to reach Swedish and EU 2030 energy targets. Although improving and upgrading ventilation systems is an important energy-efficiency measure in existing buildings, many property owners hesitate to implement this measure, and tenants are reluctant to have it installed. Seemingly the reduced energy cost is not a large enough incentive and analysing what added values the upgraded ventilation system could provide might offer a better decision ground for the property owners and a communication ground with tenants. The project idea is based on the difficulty of demonstrating and communicating added value, such as improved indoor environment quality, that can be achieved when upgrading ventilation systems in residential buildings. The hypothesis is that measurement and communication of odours linked to types of residential ventilation may help open up for a new way of evaluating indoor air quality and to strengthen arguments for energy-efficient ventilation.

Our pilot study investigated whether property owners can benefit from 1) using odour as part of the communication with residents when considering measures for improved/upgraded ventilation systems, 2) comparing odours associated with different types of ventilation systems in residential building, such as natural ventilation, mechanical ventilation with exhaust air, and mechanical ventilation systems with exhaust and supply air and heat exchange, and 3) participating in a project where an odour based method is developed to stimulate upgrading of ventilation systems. The pilot study was carried out in Sweden, where nine large property owners were interviewed. All of these receive complaints from residents regarding unwanted odours. The complaints are linked to particular types of ventilation systems. The property owners expressed interest in using odour as a parameter when deciding on renovation. However, the lack of standardized monitoring methods and an existing terminology for a comprehensive understanding of the subject is perceived as a potential risk in doing so. Consequently, a standardized monitoring method with clear odour definitions was requested by the interviewed property company representatives. This standardization should 1) differentiate between odours from the building (moisture, mould, chemicals) and odours from living (food, hygiene, medicine, pets); 2) include a delimitation of parameters that may affect odour (temperature, CO^2, presence, moisture).

Introduction

According to the Swedish National Board of Housing, Building and Planning's (Boverket) BETSI (Buildings' Energy performance, Technical Staus and Indoor climate) study, a large part of dwellings in the existing Swedish building stock, apartment buildings as well as single-family houses, are equipped with under-performing ventilation systems with too low air flows and poor energy performance (2010). Inadequate ventilation can cause several problems, with unwanted odours, mould and moisture, with adverse health effects.

An energy efficient solution to overcome problems with odours, mould and moisture is to install a mechanical ventilation system with exhaust and supply air and heat exchange (ESX ventilation)[1] Currently many new Swedish buildings are being developed with ESX ventilation with high performance heat recovery, but in the existing building stock approximately 90 percent of all multi-family buildings lack heat recovery from the ventilation exhaust air.[2] The technical energy saving potential is approximately 5 TWh per annum for existing Swedish apartment buildings.[3]

This study aimed to investigate 1) whether odour can be used as a parameter to achieve significantly improved indoor air quality when upgrading residential building ventilation systems; 2) if odour problems are related to any specific types of ventilation system, 3) if information on odour problems related to specific types of ventilation systems can be used to strengthen the arguments for ESX when renovating, 4) if the interviewed property owners are interested in participating in a project for monitoring and communicating odour problems. The project primarily focussed on residential multifamily buildings from the 1960's and 1970's that make up approximately one third of all multifamily buildings in Sweden. These were the first generation of buildings developed in an industrialised production process, and they generally have a poor energy performance.

The project idea is based on the difficulty of demonstrating and communicating added values, such as improved indoor environment quality, that can be achieved when upgrading ventilation systems in residential buildings. The hypothesis is that measurement and communication of odours linked to types of residential ventilation may help open up for a new way of evaluating indoor air quality and may strengthen the arguments for energy-efficient ventilation. There is no European standard for indoor measuring of odours, but there is an outdoor measuring standard EN13725.

Admittedly, communicating air quality and especially odours is a complicated matter, and it is difficult to be factual in relation to preferences and experiences of odours. The perception of smell consists not only of the sensation of the odour themselves, but the experiences and emotions associated with these sensations. As our olfactory receptors are directly connected to the limbic system, which is thought to be the centre of emotion, by the time we correctly identify a particular scent, it has already activated the limbic system triggering emotional response (2009).

There are existing projects dedicated to establishing a "language of energy" (see for instance, NATural Language Energy for Promoting CONSUMER Sustainable Behaviour[4]) as part of the decision-making processes. When it comes to indoor air quality, however, the theme is currently not part of the discussion, neither when upgrading or buying residential homes. Furthermore, research on odour problems and how they are linked to different kinds of ventilation systems is limited. Consequently, the access to reference literature in this field is limited. This feasibility study was inspired by the four year research project "Pollution Pods" (PP), launched in 2014, where the air quality of six global cities was mimicked, and smells were used to explain, clarify and increase awareness of air pollution.[5] The PP project successfully illustrated the air pollution problem to the public through odours and in the herein described project, it was explored whether a similar communications approach could be used when evaluating indoor air quality, and if it could strengthen the arguments for energy-efficient ventilation systems.

The problem

There is a large need for renovation of the multi-family buildings from the 1960's and 1970's in Sweden. These buildings generally have a poor energy performance. Hence, renovation presents a major opportunity to increase their energy performance, it is often possible to halve their energy end use, and at the same time upgrade this building stock's ventilation systems to achieve the national building codes' level. In order to reach this there is a need to install high-performance mechanical ventilation systems with exhaust and supply air and heat exchange (ESX). The technical energy saving potential is approximately 5 TWh per annum for Swedish multi-family

[1] ESX = Exhaust and Supply air ventilation system with heat eXchange.
[2] Swedish National Board of Housing, Building and Planning, BETSI, 2010
[3] HEFTIG Casestudies 2016 (in Swedish, Fallstudier till HEFTIG), June 2016, Wahlström Å, Persson A, Glader K, Westerbjörk K, and Göransson A
[4] https://ec.europa.eu/inea/en/horizon-2020/projects/h2020-energy/social-sciences-and-humanities/natconsumers
[5] https://www.climart.info/pollutionpods/

buildings.[6] The choice of ESX ventilation can also be motivated by other benefits such as improved indoor air quality.

A majority of new residential buildings in Sweden are being developed with ESX ventilation with high performance heat recovery so the technology as such is well-known to the property owners. However, many property owners hesitate to implement this measure in existing buildings, and tenants are reluctant to have it installed. Approximately 90 percent of all existing Swedish multi-family buildings have no or only mechanical ventilation with exhaust air without heat recovery.[7]

The main reason that so many property owners hesitate to install ESX when renovating is high investment costs, limited possibility to increase the rent (to cover the ventilation system investment), and difficulties to find space for ventilation ducts. Studies carried out by the Swedish Energy Agency's network on energy efficient residential buildings (BeBo) show that these arguments trump over the large cost-efficient energy-efficiency potential, the major need for improved ventilation, and the ESX ventilation's added value of improved indoor air quality (e.g. more even indoor air temperature).

Methodology

The study started with an external analysis, which included a mapping of existing knowledge material for the area. As previously mentioned, research on odour problems and their links to different kinds of ventilation systems is limited. However, an odour evaluation methodology was developed during the 1980s by Professor Ole Fanger at the Technical University of Denmark. He developed a methodology based on the units *olf* and *decipol*, and this methodology was introduced for the measurement of perceived air quality. The purpose of Fanger's method was to quantify how the strength of indoor air pollutants affects odour and indoor air quality, and how it is perceived by humans[8]. The project did not link odours to actual air quality measures or health issues but was linked to the *perceived* air quality. It was used to establish the necessary distance of odour intense industries from residential housing. The monitoring is done with an instrument, an Olfactory meter, that collects an air sample to trace gases. The odour of the air sample is then analyzed by a panel of people who are carefully selected based on their ability to analyse odours. The panel indicates what types of smell they are sensing, how strong the smells are, and how much the smell must be diluted in order to be perceived as odourless. During the feasibility study, no reports were found regarding use of Fangers´ methodology for indoor air quality. However, there is an EU standard where the method is used for outdoor environment Air quality - Determination of odour concentration with dynamic Olfactometry, EN13725. Examples of use are for spot diagnosis from the paper industry with the aim of establishing odour management plans.

In the second step of the feasibility study, in-depth interviews were carried out with representatives of nine large property owners in Sweden, two property managers in Norway and representatives of four other organizations. The interviewed Swedish property owners are all members of BeBo, the Swedish Energy Agency's network for energy-efficient multi-family buildings. The BeBo network consists of more than 20 residential property companies. The interviewed Swedish property owner representatives were the technical manager or CEO of the following nine Swedish housing companies: Stockholmshem, Einar Mattsson AB, Örebrobostäder, Eksta Bostads AB, IKANO Bostäder, Gavlegårdarna, Alingsåshem, Kopparstaden and Haningebostäder. In addition to the interviews with Swedish property owners, representatives from the Swedish ventilation industry~~'s~~ trade organisation (Svensk Ventilation) and the Swedish National Tenant Association (Hyresgästföreningen), an energy service company (L&T), and one expert on energy-efficiency in buildings[9]. These additional interviews were carried out to set the Swedish property owners in a broader context. As we wanted to supplement our study with the perspective of working with residents who own their apartments, we performed additional in-depth interviews with two Norwegian property management organisations, tobb[10] and Sørlandets boligbyggelag[11], who have both worked with ambitious upgrading renovation processes together with home-ownerships in Norway.

A questionnaire with questions distributed over seven sub-areas was prepared for all interviews. The questions were based on the purpose of the feasibility study and were also used for framing what direction to choose for a possible future in-depth research project. The seven sub-areas were:

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6 BeBo, Halven the energy use (In Swedish, Halvera mera), Westerbjörk K
[7] Boverket, BETSI, 2010
[8] Fanger 1988
[9] The expert is associated to KTH Royal Institute of Technology, https://www.kth.se/en and works as a freelance expert for BeBo.
[10] www.tobb.no
[11] https://www.sbbl.no

1. Initial Questions / Background
2. Energy and indoor environment
3. Ventilation
4. Decision processes when upgrading / changing ventilation systems
5. Economy
6. Odors as a parameter before making decisions
7. Suggestions for possible in research projects

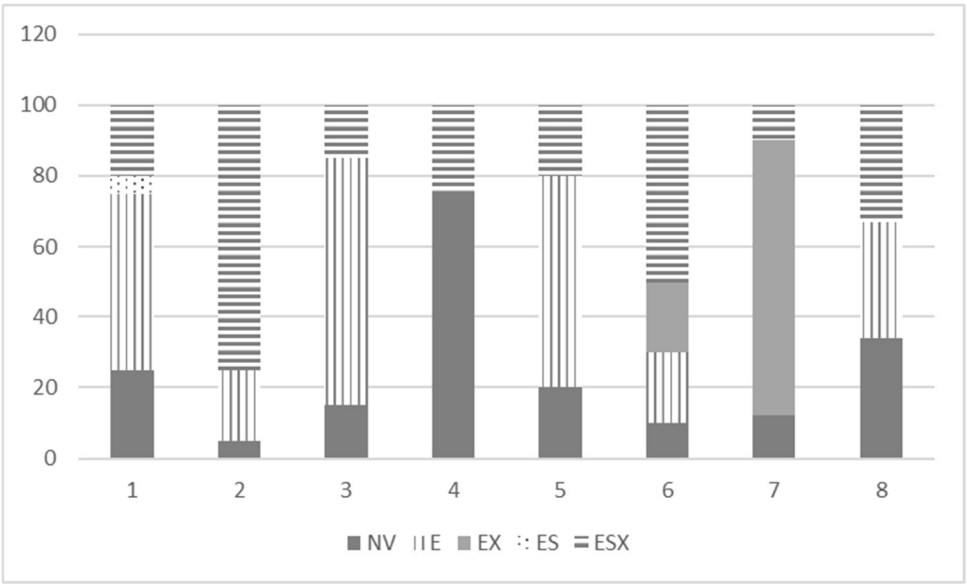
Results

The results section first provides an overview of the distribution between installed type of ventilation systems amongst the interviewed property owners. Thereafter, we present the findings of the study by presenting the different perspectives of the Property owners, the Tenants and the Experts and trade association representatives respectively.

Currently installed ventilation system

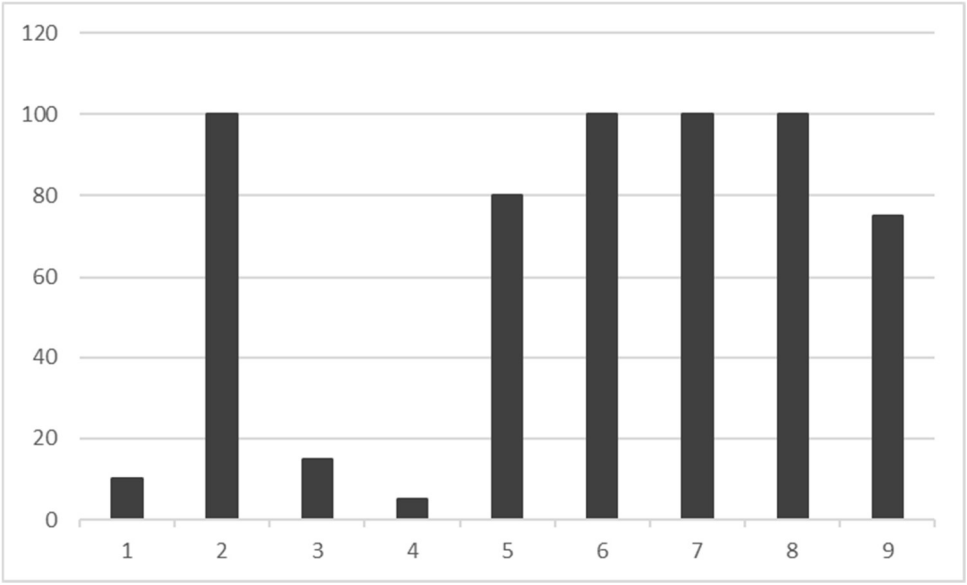
The distribution between installed type of ventilation systems varies between the interviewed property owners. Exhaust air ventilation dominates, ESX ventilation is installed in a relatively high degree (dominates in two of the nine property owners' building stock), and natural ventilation constitutes a minor part. One of the property owners has a large share of mechanical ventilation system with exhaust air with heat recovery installed (see Diagram 1). N = Natural Ventilation, E = Exhaust air vention, EX = Exhaust air ventilation with heat exchange, ES = Exhaust and supply air ventilation, and ESX = Exhaust and supply air ventilation with heat exchange.

Diagram 1: Distribution between different types of currently installed ventilation systems for eight the interviewed Swedish property owners (statistics from one of the property owners missing).
(N = Natural Ventilation, E = Exhaust air ventilation, EX = Exhaust air ventilation with heat exchange, ES = Exhaust and supply air ventilation, and ESX = Exhaust and supply air ventilation with heat exchange



When upgrading or renovating existing buildings, ESX systems are installed by the property owners where technically possible and economically viable. Three of the nine interviewed Swedish property owners responded that they always install ESX when renovating, one installs ESX in 80 per cent of the renovation cases, and one installs ESX in most of their renovation cases. Two of the interviewed property owners have only to a small degree changed the ventilation systems, and one of the property owners always chose EX when renovating.

Diagram 2: The interviewed property owners' share of ESX after renovating.



Property owners

All of the interviewed property owners work in a structured way with energy and environmental issues and have ambitious goals on reducing their energy end use. However, when it comes to indoor air quality, their specific targets are simply to comply with legislation, although all of them say that indoor air quality is a priority in their daily work. They regularly use a satisfied customer index (NKI) to monitor how their tenants experience their indoor air quality. A majority indicates that there is a major renovation need in their building stock, and for the next five years they are planning for renovation in approximately 12,000 apartments. All of the interviewed property owners mentioned that they receive complaints from their tenants regarding odour problems. The most common complaints relate to cigarette smoke and odours from cooking between apartments and between apartments and the stairwell. The property owners' understanding is that there is a connection between type of ventilation system (natural ventilation, exhaust air, ESX ventilation) and the magnitude of the experienced problems with odour. Their perception is that most odour problems occur in buildings with natural ventilation and exhaust air ventilation. According to the interviewed property owners most problems are reported with natural ventilation and exhaust air ventilation systems, but also ESX with rotating heat exchangers are reported to cause odour problems. When upgrading or renovating existing properties, the property owners install ESX ventilation systems when technically possible and economically viable. They describe negotiations with the tenant association to increase the rent as fundamental in the renovation decision-making process.

The majority of the property owners mentioned that they have internal discussions between colleagues on odour problems and how to solve them. Currently, tenants have limited possibilities to influence the property owners' choice of ventilation solution when renovating. Two of the interviewed property owners mentioned that tenants can comment on the choice of ventilation system during the consultation that takes place before the renovation is carried out. Several property owners experience difficulties when communicating odour issues. Following are quotes from the actual interviews in order to illustrate our findings. Specifically, the property owners experience from discussing odours with tenants have alerted them that this may open up for time-consuming discussions:

"Smell is a complex and difficult issue, and it can be a time-consuming process to investigate"

"There is a risk that discussions/consultations will take too much time. In such cases, routines must be simple and rational"

Also, opening a discussion without being able to foresee the possible turns of the discussions is perceived as risky amongst the property owners:

"The risk is that the discussion will be subjective, people may claim that the smell problem is bigger than it is and there is a risk that you don´t agree"

This perceived risk seems to be related to the lack of appropriate terminology with actual standards for odours in buildings:

"What´s normal? Who is right and who is wrong?"

One of the property owners elaborates on how personal the smell of ones´ home may be:

"People are perhaps content with the smell of their home. If monitoring shows that the smell of their home is a problem and they don't agree, it will be difficult to justify a rent increase caused by a new ventilation system"

However, despite of the perceived risks involved in raising "the smell issue" with tenants, six of the nine property owners mentioned that an established standard for measuring odour could contribute positively to tenant dialogues on ventilation, and that it can strengthen the arguments for upgrading to ESX ventilation.

However, there is a lack of not only a terminology to communicate this but also more general lack of knowledge on air quality issues:

"There is a lack of knowledge, which often leads to choosing the cheapest solution"

The interviewed property owners expressed the need for a scientific monitoring method, and emphasise that clear definitions are important. The monitoring method should include a clear definition on odours stemming from the building; (moisture, mould, emissions from materials etc) and odours that can be derived from the household and tenants (cooking, cigarette smoking, etc.). There is also a need for a delimitation for other parameters that can affect odour emissions, for example, temperature, CO_2, occupancy numbers and moisture. It is also crucial that a common language for communicating odours in an objective and understandable way to the tenants can be developed. Provided that monitoring can be carried out in a standardized manner, they believe that the results can contribute positively to the tenant dialogues on ventilation, and that it can strengthen the arguments for energy-efficient solutions such as ESX. That would mean that more tenants would benefit from the added values of ESX ventilation, such as a more even indoor air temperature distribution, and reduced power and energy cost.

The Norwegian property management organisations did not express the same concern with raising the issue of smells per se. This may be because of their different role with regards to the residents as advisors or consultants rather than landlords. They both said that using odours as part of the communication may enrichen the decision-making process and contribute to air quality becoming a factor that is considered in processes that involve choice of ventilation and heating systems and measures addressing the building envelope:

"An odour standard, and clear definitions of air quality factors might actually help us in explaining and motivating residents to go for the higher quality solutions" (Housing organization representative A).

"Making odour more visible and tangible might open up for new arguments and discussions with residents" (Housing organization representative B)

Tenants

The interviewed representative from the national tenant association is well acquainted with the added values to the tenants that can be achieved by upgrading the ventilation system. The representative said that the tenant association is open for a solution where property owners can raise the rent in conjunction with upgrading the ventilation system, for example by assessing the indoor air quality within the utility value system. The score could be based on the system's delivered performance based on parameters such as odour distribution, degree of down draught from windows, indoor air temperature, filtered supply air, noise level etc. However, an established praxis showing what problems that can be solved is necessary.

Experts and trade association representatives

The interviewed expert on energy efficiency in buildings stated that buildings with mechanical ventilation systems with only exhaust air and heat recovery (EX) cause a larger degree of smell migration between

apartments in a multi-family building. According to the expert this has been shown in a number of studies. The expert said that that such systems require that the building has an under pressure for the ventilation system to work properly, and that the ducts are tight to avoid odour migration.[12] Odour problems in ESX ventilation systems with rotating heat exchangers can be mitigated by a careful adjustment to get the air flow balanced between the supply and exhaust air. This view was shared by the interviewed property owners, and they said that a balanced mechanical ventilation system (ESX) with flat heat exchangers is preferred to minimize the risk of odour migration.

According to the Swedish ventilation equipment manufacturers' trade association (Swedish ventilation), an overall trend is that the industry is steadily expanding and has done so since the latest financial crisis. In 2018, more than SEK 18 billion (approximately 2 billion Euros) were invested in ventilation equipment in Sweden. However, installation of ESX has slowed down in Sweden compared to other Nordic countries, due to different legislation requirements and installers' lack of knowledge. The probability of ESX being installed during renovation is low; partly because it has a higher investment cost and partly because of knowledge gaps.

According to the interviewed trade association representative, tenants generally have limited access to the ventilation decision process. The interviewed trade representative was in favour of a research project that raises the issues of odour and indoor air quality, and said it would be timely and of large interest to the trade organisation's members whose drivers are increased knowledge and possibilities to sell "packages of solutions", i.e. improved indoor air quality, and improved energy efficiency simultaneously avoiding disturbing odours.

Discussions and conclusions

Our conclusions are that a larger share of the cost-efficient potential for reduced energy end-use in connection with renovation that can be realised by visualizing odour problems and highlighting solutions to solve these problems. Problems with migration of odours could be reduced by installing energy-efficient mechanical ventilation systems with high performance heat recovery, ESX, but it is also a necessity to ensure that ventilation ducts are air tight and well insulated. Other points specified by property owners and energy experts are that heating and ventilation systems must be properly installed and that the air flows must be in balance (with a slight indoor under pressure when using ESX). ESX ventilation also leads to added values such as a more even indoor air temperature distribution and reduced power and energy costs. To be able to evaluate the benefits and costs, there is a need to develop a standardized monitoring method based on clear definitions. Requirements expressed at the interviews were that the monitoring method should distinguish between odours from the building (e.g. moisture, mould, chemicals) and odours from the household and tenants' activities (food preparing, hygiene, medicines, pets), and it should include clear delimitations of parameters that can affect odours (e.g. temperature, CO_2, presence, moisture).

There is also a need to develop a comprehensive and objective terminology to communicate odour issues. This is a complicated matter and it is difficult to be factual in relation to preferences and experiences of odours. An odour that by some is perceived as "safe and homey", can by others be directly identified as unwanted, e.g. the odour of mould or of emissions from materials. For property owners, the odour issue sometimes can be perceived as negative, since it is normally discussed only when there is a problem. Obviously, the odour of mould is not only a matter of preference as it is also health-related, which adds to the necessity of finding a means to communicate odours in a non-threatening way. Today, silence (absence of complaints) can be perceived as that there are no problems or that a previous problem has been solved. For some people discussions on odours reminds them of poorly implemented energy efficiency measures in the 1970s, when a lot of property owners put on additional insulation to their buildings without ensuring that a proper ventilation system was installed, which led to moisture and mould damaged buildings. Knowledge needs to be disseminated to eliminate such myths being cemented.

Experiences from the research in the project "Pollution Pods"[13] (PP) and those of the aforementioned EU-project NATCONSUMERS[14] are available and may be used to develop a novel terminology as a basis for communication. Relevant in this context is also the growing and relatively new research field of eco-

[12] To create the desired under pressure in an apartment with ESX mechanical ventilation one normally needs an air flow balance (a ratio between supply air flow/exhaust air flow) of 0.9-0.95. In apartments with a high air tightness the air-flow balance should not be less than 0.85. The under pressure in an apartment should not exceed 10 Pa (if the apartment under pressure exceeds 25 Pa the apartment outer door will be difficult to open).

[13] https://www.climart.info/pollutionpods/

[14] https://ec.europa.eu/inea/en/horizon-2020/projects/h2020-energy/social-sciences-and-humanities/natconsumers

visualizations (Löfström & Svanæs, 2017), where different means of visualizing indoor air quality data may be interesting to develop with the intent of creating awareness, flexibility and spur debate. As an example, air quality sensors could be installed as a standard in residential housing, and the data could then be made available in a comprehensive way for the residents by means of eco-visualization. Other conclusions from this feasibility study are that new services and business opportunities can be created for ventilation companies that provide energy efficient solutions, insulation companies, installers and energy service companies. Nine of the fifteen interviewed persons were interested to participate in a research project to develop a monitoring method for odour problems that corresponds to their requirements and investigate how odour problems can be communicated. Based on the findings and the stated interest by the participants to partake in further studies, we intend to carry our further studies on how odours are linked to indoor air quality and whether these odours can strengthen arguments for energy-efficient ventilation. However, we have not yet found a relevant call where we could apply for funding.

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