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SUMMARY
At present, indoor air quality is assessed exclusively by human panels. As this method is time consuming and cost intensive, little attention is paid to indoor air quality in the planning and operation of buildings. In recent years multi-gas sensor systems have been developed in order to mimic the human sense of smell. These systems comprise an array of gas sensors, with sensors of different sensitivity and selectivity, and a data processing unit. Up to now the sensors are not sensitive enough to mimic the perception of a human being. To further the development of these systems, the European research project SysPAQ (Innovative Sensor **Sys**tem for Measuring **P**erceived **A**ir **Q**uality and Brand Specific Odours) was started in September 2006. It will end in September 2009.

KEYWORDS
Sensor systems, perceived air quality, perceived intensity

INTRODUCTION
An innovative sensor system to measure perceived indoor air quality and odour intensity is in high demand for European society, as humans spend about 90% of their time indoors, either at work, at home or when commuting between work and home. Recent data show that improved indoor air quality results in fewer complaints, increased comfort, fewer health problems and higher productivity. Consequently, the quality of life is improved.

Up to now, indoor air quality has been quantified by applying three different measurement methods separately. The three methods are based on the human perception of indoor air quality, chemical measurements and sensors for specific odours. Regarding the measurement of perceived air quality, human assessments are still superior to chemical measurements because of the unmatched sensitivity to many odorous indoor air pollutants. One of the reasons is that in most cases the chemical measurements or signals from chemical sensors designed to detect special odours could not be correlated with the assessments made by humans. Obviously they do not measure the relevant indoor air pollutants that trigger human

sensory response. The SysPAQ project builds upon current knowledge of the perceptual effects of indoor air pollutants and on the experience gained in using chemical measurements and sensors for specific odours. The aim of the project is to enhance the present state of the art of sensor systems, perceptual methods and software tools for modelling human response, in order to integrate them into a single innovative sensor system for measuring indoor air quality as it is perceived by humans. This would consequently create a bridge between the previous work in this area, and progress is achieved by integrating measurements, sensors and modelling using a holistic approach.

PROJECT OBJECTIVES

The main goal of this project is to develop an innovative sensor system to measure indoor air quality as it is perceived by humans based on perception modelling, combining measurements of sensors and assessments of perceived air quality by sensory panels. The innovative sensor system can be used as an indicator, monitor and control device for the indoor air quality in buildings and vehicles. Furthermore, the system will be able to detect brand-specific odours, and it will serve as a novel interior odour design tool for the vehicle industry. The main objectives of the project are:

1. To define a method for measuring the perceived air quality and perceived odour intensity in buildings and vehicles. This method will be applied by all of the labs involved which are using sensory panels.
2. To find an advanced perception model for indoor air assessment. The model will be the major input to the software design for the innovative sensor system, and it will provide new insight into the human reaction towards odours.
3. To develop an innovative sensor system for measuring perceived air quality and brand-specific odours.
4. To calibrate and test the innovative sensor system for measuring perceived air quality and brand-specific odours. The final version of the system is intended for the following applications :
    - Monitoring the ambient air within buildings and vehicles.
    - Monitoring the quality of the inlet air into buildings to ensure the health and comfort of occupants.
    - Labelling emissions from building and vehicles materials.
    - Controlling the production process of building and vehicles materials.

Along with human activities, emissions from building materials, furnishings and equipment are the main contributors to air pollution indoors. Two suggested methods for reducing indoor air pollution are using low-polluting materials and increasing outdoor air supply rates. The new EU Energy Directive requires substantial reduction of energy use, which may lead to reduction of ventilation rates and increased indoor air pollution, enhancing the need for low-emission materials. In addition to measurements of indoor air quality as perceived by humans, the system developed in the project can be used to control the emission rates from building materials as early as the production stage. At present, manufacturers generally reduce the emissions from building materials by monitoring the emission rates of a few compounds, but these are not necessarily the most relevant odour active compounds for perceived air quality. The pollution mixture affects the perceived air quality indoors. This has not been taken into account so far. The proposed system can be used by the producers of building materials, furnishings and equipment to ensure that the emissions from their products will not negatively

affect the perceived air quality indoors. In many countries, labelling systems for building materials exist, so the end-users can select materials that fulfil certain criteria for emissions. The suggested system for measuring perceived air quality can also be used to assess whether a material can obtain a label.

The selection of interior materials is a very important factor for the vehicle and transportation industry (trains, cars, boats, airplanes, etc.). The goal of the selection process is to create a high standard of perceived air quality in vehicles combined with a brand-specific odour impression. To meet this goal, a system for measuring perceived air quality seems indispensable.

The interdisciplinary structure of the project consortium will make innovative research possible, and it will provide new insights into the human perception of air quality and brand-specific odours. The project management will ensure a strong interaction between new perception models, hardware development and software design for the innovative sensor system.

RESULTS

The first set of calibration data was generated in May 2008. For the calibration and validation of the first sensor system, sets of data consisting of measurements of perceived air quality by a sensory panel and measurements with the sensor system are collected. The data is collected in the form of measurements of polluted air. The pollutions are generated by emissions from a series of building materials. The concentration of air pollutants is varied within a realistic range to ensure and test if the sensor system works appropriately. The variation in concentration is achieved in small-scale test chambers in a laboratory setting by varying the material loading at a fixed ventilation rate and by selecting high and low-emitting individual materials.

A paid, untrained sensory panel comprising 36 panellists *(Knudsen 2008)* performed the sensory evaluations. The panellists evaluate different intensity methods (Yaglou Scale, Borg Scale, perceived intensity with a comparison scale), acceptability and some descriptor profiling. For more about this investigation see (Knudsen/Wargocki, in the HB09 proceedings).

Table 1. Descriptor list used by panellists

• Irritating	• Dry
• Pleasant	• Stuffy
• Fresh	• Humid
• Cool	• Warm
• Odours	•

A first result of several multivariate analysing methods applied to the data is shown in Figure 1. This figure shows the results of a Partial Least Square (PLS) – classifier. The values for perceived intensity (in pi) can be read on the abscissa. The perceived intensity predicted out of the sensor signals by the statistical method can be read on the ordinate. There are remarkable variances between the measured and the calculated results only in a few cases. This mathematical model leads to usable results.

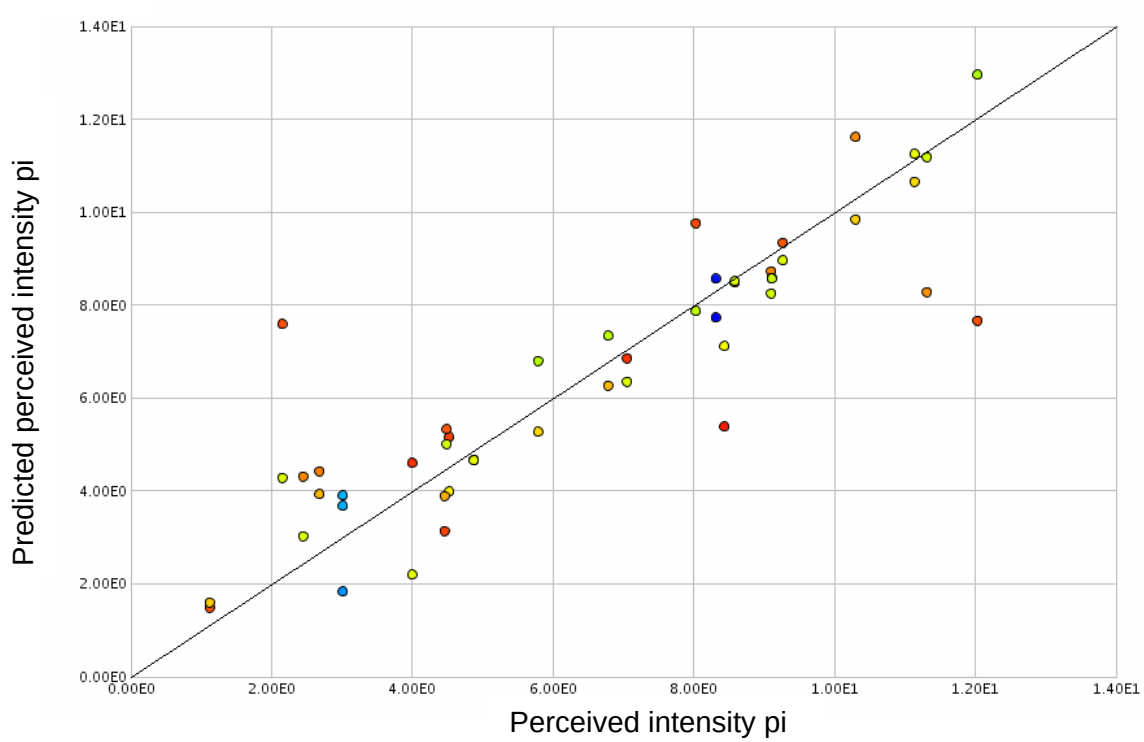

Figure 1: Results of calibration data for sensor system predicted PI and panel data using PLS-classifier method

DISCUSSION and CONCLUSIONS

The project SysPAQ is drawing to a close. The main measurement campaign for collecting the calibration and validation data for sensor system will start at the end of April. Some arising difficulties with the sensitivity of the sensor regarding humidity must be solved. As seen in Figure 1, the sensor system is able to predict the perceived intensity relatively well. It is still necessary to make some efforts to find the best mathematical model for the different questions.

ACKNOWLEDGEMENT

SysPAQ is partly sponsored by the European Community in the Nest programme (NEST-28936) under the management of Ms. P. Lopez and Ms. A. Cabornero-Marco. The co-ordination is done by the Technische Universität Berlin. Other participants are: Danish Building Research Institute, Aalborg University; Technical University of Denmark; Karolinska Institute; Centre Scientifique et Technique du Bâtiment; Forschungszentrum Karlsruhe; Federal Institute for Materials Research and Testing; REGIENOV; Alpha MOS; Halton Oy.

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