



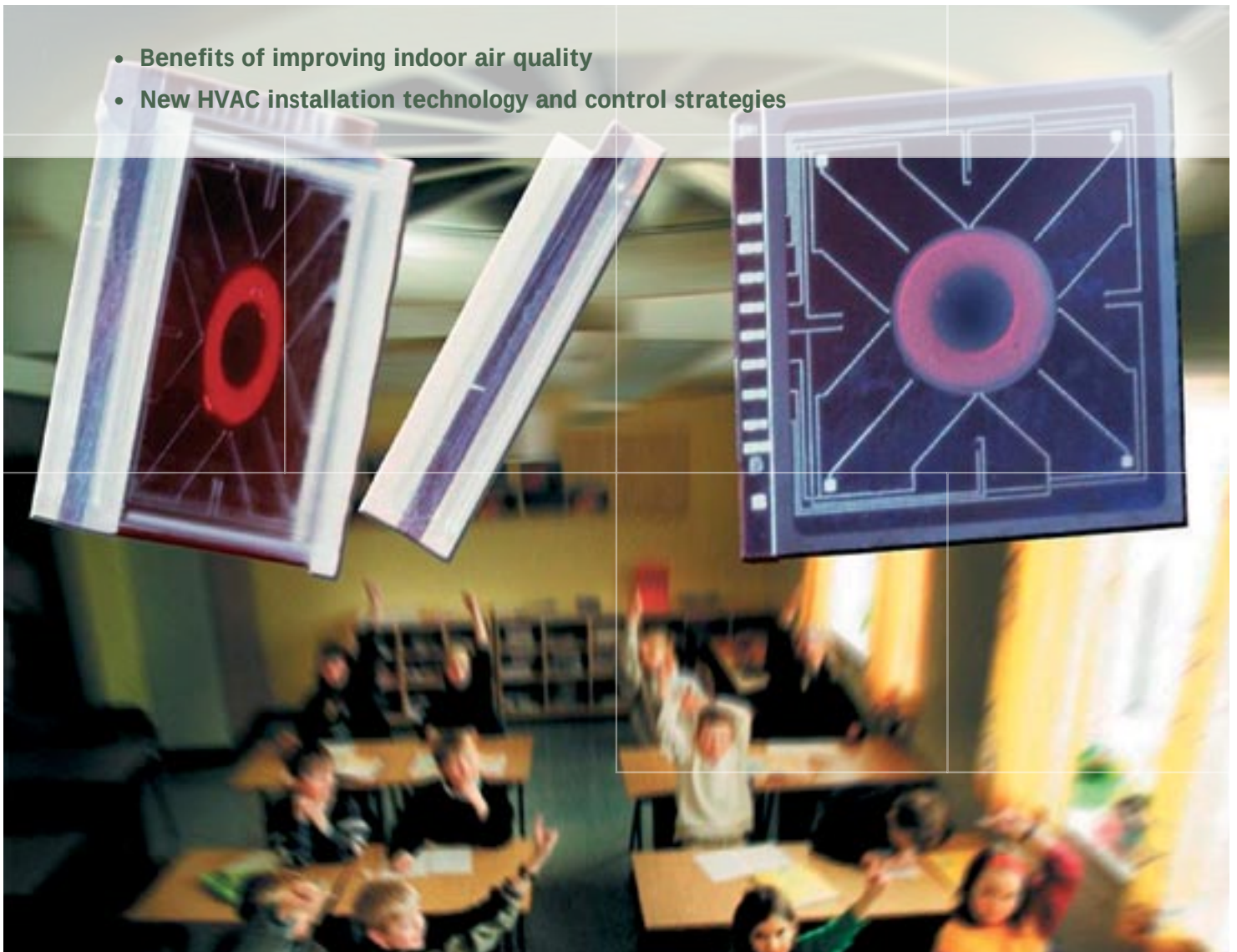
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Multisensors and other new technology for improved indoor environment in buildings

- Benefits of improving indoor air quality
- New HVAC installation technology and control strategies



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Title: Multisensors and other new technology for improved indoor environment in buildings (MONTIE)		
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Abstract: The importance of indoor air quality (IAQ) in buildings is indisputable. Numerous studies have documented that IAQ significantly impacts occupants' comfort, health and productivity and it is estimated that potential savings and productivity gains from providing users with a "good" IAQ are enormous. Key parameters for evaluating IAQ are temperature, CO₂ concentration and relative humidity. The measurement and control of these parameters and understanding of their influence on the perception of IAQ is crucial to meet the requirements for a healthy, comfortable and productive IAQ. However traditional HVAC (Heating, Ventilation and Air-Condition) control strategies are often insufficient. More promising strategies are emerging, but their potential will not become fully utilised until reliable, accurate and inexpensive IAQ sensors become widely available and measurements from these sensors are incorporated into the HVAC control strategies. This project "Multisensors and Other New Technology for improved Indoor Environment in buildings" (MONTIE) has addressed the importance of IAQ and some ways of improving it. A consortium of individual partners with their own competencies and specialised know-how has formed a unique, interdisciplinary Nordic network comprising leading companies, institutes and research institutions within the fields of sensor technology, HVAC and indoor environment. A core activity in the project has been the comprehensive dissemination of knowledge about the importance of IAQ together with state-of-the-art technology on sensors and their application for the objective measurement and demand based control of IAQ. Special focus has been placed on "the user perspective" and how to convert expert academic knowledge into practical applications. Increased knowledge and awareness is imperative in order to increase and initiate new development activities. The goal has been to initiate and boost the number of IAQ development activities and to increase business and commercial export opportunities.		
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Executive summary

The main objectives of this project have been:

- To increase focus on indoor environment. Special emphasis has been placed indoor air quality (IAQ) and ways of spreading knowledge about its importance
- To establish a strong Nordic knowledge base within a multidisciplinary field combining aspects of indoor environment, sensor and measurements technology and HVAC components, systems and control strategies
- To initiate a Nordic discussion forum to address the current, and future, uses of advanced multi-sensors and other new technology to support the development of improved HVAC components and systems
- To encourage the conversion of expert academic knowledge into practical applications
- To initiate and boost the number of indoor environment development activities

The long term goal is to enable the Nordic region to become the leading centre for research and development within the field and thus increase business and commercial export opportunities for the region as a whole.

Method/implementation

The project has focussed on a comprehensive information and knowledge dissemination plan. More specifically the project has included arranging and holding 6 conference and/or workshop events in four different countries where the importance of IAQ and the advantages gained from using micro-sensors and other new technology have been presented to national, Nordic and international audiences. Speakers have included leading authorities within the different fields and at every event expert oral presentations have been combined with active discussion forums where participants have been encouraged to join in the discussions about concepts, emerging technologies, new developments, existing solutions and potential ways forward. The opportunity for experts within one specialist field to discuss with experts within a different specialist field in order to reach a common goal has judged to be very rewarding.

Easy access to information of common interest for the project partners has been provided by using a simple closed e-Room. In this way information confidential to the project group, or invited guests, i.e. meeting minutes, presentations and other documents could easily be exchanged.

A web-site www.teknologisk.dk/montie has been established and maintained throughout the project. Relevant information has been updated regularly with news about the project's status and coming events. All presentations from past events have been made freely available for download.

Concrete results and conclusions

The aim of the project was to reach out to a wider audience and this has been fully achieved.

The MONTIE project has increased awareness about the importance and significance of IAQ and the series of workshop events have emphasised that it is necessary for several different technical disciplines to cooperate to successfully achieve and maintain an adequate IAQ level. The six workshops, which have been held in four different countries, were attended by several hundreds of participants and the project messages broadcasted to a wide audience. Feed-back from attendees has been very positive. By participation in major existing events information about the project and its ideas has reached many others than the people participating directly. The project's website has registered over 1000 "serious" visitors, i.e. visitors that stay longer than a certain amount of time and visit more than one page of the web-site during the same visit.

A unique interdisciplinary Nordic network has been established and the existing bonds between partners in the core network have been further strengthened. The core network has also established links to new potential collaboration partners and identified areas important for further work efforts. Nordic and international events arranged by the project partners have successfully profiled Nordic knowledge, products and facilities and has given a deeper understanding of marked dynamics and driving forces. The workshop events and follow-up discussions and activities have given increased insight into the complex interaction between a "good" IAQ and the need for its objective measurement and a suitable demand-based control.

The problems that need to be solved before a "good" IAQ can be obtained in any one building are complex and involve a number of different disciplines and expertises. An optimal result cannot be achieved by sub-optimisation and concentrating on one particular part of the problem – useable solutions require cooperation across the borders of traditional engineering disciplines. The strong collaboration and openness in the project team have contributed to breaking down traditional disciplinary barriers and has been an important element in helping achieve the project goals.

Project partners have launched new sensor initiatives and new research activities during the course of the project. New alliances have also been formed during the project and will hopefully bear fruit in due course. One example is contact to an existing EU Framework Programme 6 network seeking partners for a specific Framework Programme 7 proposal.

Recommendations

Feedback from participants in the project group and participants at workshops etc. is very clear: The IAQ-sensor-HVAC field is by no means stationary and there is a need and strong recommendations for further applied research and development work within the field. Continued information dissemination is vital to ensure that expert academic knowledge is converted into practical applications. Information dissemination should be carried out across traditional disciplinary boundaries to further strengthen knowledge about the interaction between IAQ, sensors and HVAC systems. There is a continual need for new products and product development evolving from interactions between the value chain of users, researchers, manufacturers, suppliers consultants and installers. Information dissemination is

important, but future work should be carried out parallel with product development work where the potential of new sensor technology is evaluated by modelling and testing in the laboratory and in buildings in practice. For example, monitoring and control of zones in buildings (local microclimate control) or more widespread use of demand controlled ventilation with inexpensive CO₂ sensors along the theme of “Integration of IAQ sensors into HVAC systems”

Experience from this project has showed that the best results and most value for money were obtained by arranging information dissemination events with the organisers of other relevant, pre-arranged events with an overall theme suitable to the aims of the project. Good examples of this are the satellite workshop arranged at Eurosensors XX in Gothenburg, Sweden and the workshop arranged at Clima 2005 in Lausanne, Switzerland, both of which were very well attended. Organisers of such events are interested in a fruitful cooperation as it is a win-win situation. The organisers of the major event obtain more guest participants, have their event broadcasted to a larger audience and can offer their existing participants extra value for money. The workshop organisers gain access to an event where the organising infrastructure is already in place, a target group that is already participating and “on-site” and there is a good chance of achieving a higher hit rate from inviting people already interested in the subject. This model requires a lot less administrative resources than planning stand-alone events and the resources can then be channelled into other activities – more value for money for the project work.

One experience worth noting is that in retrospect it proved difficult to make established “national” events “Nordic”, i.e. an event in Norway was predominately visited by Norwegians, and an event in Sweden attracted mainly Swedes etc. By combining workshops targeting a Nordic audience with an international event held in the Nordic region (and there are many to choose from) increases the chances of wider participation – and spreads the Nordic message to the international arena.

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INTRODUCTION

In the industrialised world people spend about 90% of their time indoors - at home, at work, participating in sport and other leisure activities, travelling etc. Human productivity is regularly proclaimed to be an important resource but even though the importance of indoor environment on humans is indisputable as many as 40% of office workers are not satisfied with their local indoor environment conditions and exhibit symptoms of poor indoor environment and Sick Building Syndrome (SBS). Throughout Europe the occurrence of asthma and allergies is at record levels, especially among children, and the incidence rates are steadily increasing.

Over the years the Nordic countries have adopted slightly different building construction concepts and associated building HVAC (heating, ventilation and air-condition) practices and control methods. However, a clear trend is that, almost completely independent of geographical location, traditional building HVAC control strategies are often insufficient to provide a satisfactory, demand controlled indoor environment. In addition the systems often operate at unacceptably high energy-squandering levels and it is not uncommon to find HVAC systems operating in heating and cooling mode at the same time, or spaces being uncontrollably heated or cooled with windows and doors wide open.

New, promising control strategies are emerging, providing a greater understanding of how complex building automation systems interact with their environment. Recent increases in the price of imported energy have resulted in increased focus on the energy performance of new buildings and their indoor environment. Reliable, accurate and inexpensive sensors to measure key indoor environment parameters are becoming available and it is important to find ways of utilising information from these sensors in the HVAC control strategies to provide better technical solutions and improved indoor environment conditions.

AIM AND SCOPE OF THE PROJECT

The aim of the this project “**M**ultisensors and **O**ther **N**ew **T**echnology for improved **I**ndoor **E**nvironment in buildings” (MONTIE) has addressed the importance of IAQ and some ways of improving it. A project has been to spread knowledge to a wide audience about state-of-the-art technology on sensors and their application for the objective measurement and demand based control of indoor air quality. During the project a number of conference and workshop events have been organised and held. An additional aim of the project has been to use these events actively as a forum to initiate discussions about the future needs for development work and information dissemination.



In the Nordic countries there is considerable academic and practical expertise within all the disciplines related to the indoor environment field. However, this knowledge is widely dispersed with e.g. university research groups concentrating their efforts on the academic/scientific aspects of indoor environment whilst not specifically considering practical implementations such as sensor design/development, HVAC control strategies etc., whilst manufacturers and other technology providers are in the opposite situation. To achieve the goals of the project it has been necessary to break down the traditional barriers between the different disciplines and a unique interdisciplinary network comprising Nordic companies and research institutions within the fields of sensor technology, HVAC and indoor climate has been successfully created. This is a unique achievement.

The MONTIE project was preceded by a feasibility study, **M**ulti-**S**ensor for **I**ndoor **E**nvironment **C**ontrol (MUSIC), also carried out for the Nordic Innovation Center. Most of the current project group participated in MUSIC.

STATE OF THE ART REVIEWS

Indoor environment

Numerous studies have documented that the indoor environment in buildings significantly impacts occupants' comfort, health and productivity. For office workers in the United States, studies estimate potential annual savings and productivity gains of 10 - 30 billion USD from reduced Sick Building Syndrome symptoms (SBS) and 20 - 160 billion USD from direct improvements in worker performance that are unrelated to health (Fisk 2000). Additional savings may be gained from reduced respiratory disease and reduced allergies and asthma. In addition, (Milton et al. 2000) indicated that lower levels of outdoor air supply in office buildings were associated with increased sick leave. Thus, the economic consequences to society of effects on health and productivity due to inadequate indoor environments are considerable.

Appropriate measurement and control of significant indoor environment factors are crucial for building technical installations to meet the requirements to a healthy, comfortable and productive indoor environment. The aspects of the indoor environment that are influenced by the ventilation and climatic systems and their control comprise the thermal environment, the air quality and to some extent the acoustic environment.

Several models allow for the prediction of thermal sensation and comfort (Fanger 1973; Gagge et al. 1986), and experimental studies have been carried out that successfully controlled the thermal indoor environment based on the integrated measurement and estimation of these parameters (Goto et al. 2000; Kakegawa et al. 2000).

Recent research has documented that the air temperature and humidity not only have a strong impact on human heat loss, but also on the perceived air quality (Fang et al. 1998; Toftum et al. 1998). In addition, elevated temperatures may exacerbate SBS symptom intensity (Mendell 1999). Thus appropriate measurement and control of the parameters that determine the thermal environment are important not only for thermal comfort, but also for other aspects of the indoor environment.

For some types of mental work (e.g. complex or creative mental work) optimum thermal comfort and productivity may coincide, whereas for other types of mental work slight warm or cold discomfort may increase arousal and thus productivity (Fisk 2000). Given that the optimum temperature differs between tasks and also varies among individuals, delegation of individual control of temperature may be a practical means to decrease thermal discomfort, reduce SBS and increase productivity.

Indoor air is a complex mixture of numerous compounds in very small concentrations. The concentration of the pollutants depends on indoor sources, ventilation and cleanliness of the outdoor air. CO₂ is often used as an indicator of the pollution generated by humans. At the low concentrations typically occurring indoors, CO₂ is harmless and not perceived by occupants, but it is a good indicator of other human bioeffluents being perceived as a nuisance. In rooms with a high occupancy, which may change in a short time, CO₂ monitoring is a well-established practice for controlling the supply of outdoor air. Demand

controlled ventilation is based on the actual need of ventilation, and, compared with a constant airflow system, saves energy without degrading the indoor air quality. However, to fully utilize the advantages of demand controlled ventilation in commercial buildings, there is a need for reliable, stable and inexpensive air quality sensors.

Volatile organic compounds (VOC) may originate from building materials, furniture, occupant activities or intake air and are a likely cause of health effects and comfort problems in non-industrial indoor environments (Andersson et al. 1997). A large number of individual VOCs in low concentrations have been detected in indoor environments, but the knowledge concerning the health effects of individual VOCs is often sparse or inconclusive (WHO 1989). Identification of compounds has been restricted to a rather narrow "chemical window" and currently it is speculated, which "stealth chemicals" that have not yet been identified may cause symptoms among occupants of many buildings.

The total VOC (TVOC) has been suggested as a measure of the concentration of indoor air pollution. However, the TVOC concept has been questioned for a number of reasons including the fact that simple addition of the quantities of individual VOCs may not be relevant from a health point of view (Andersson et al. 1997). Although the performance of artificial noses to assess perceived indoor air quality has been studied in non-industrial environments, reliable sensors and algorithms for processing measurement data are not available yet (Posselt et al. 1999).

Indoor exposure to ultrafine particles ($< 1 \mu\text{m}$) and the subsequent health effects is currently an area of special concern, since ultrafine particles may deposit deep in the lung (alveoli). Numerous epidemiological studies have reported significant associations between outdoor airborne particle concentrations and excess morbidity and mortality. At present, only limited information is available on indoor exposure to particulate matter and the resulting effects on comfort, health and productivity.

A multitude of physical and chemical factors affect human perception of, and response to, the indoor environment. The leading parameters are the air temperature, the air velocity and the air humidity. The potential of demand-controlled ventilation to improve the indoor environment and reduce energy consumption in common office buildings depends on the development of reliable and inexpensive air quality sensors. A future aim is to identify the compounds in the air that cause complaints, symptoms and reduced productivity. With such knowledge, improved air quality sensors that enable the evaluation of perceived air quality, individual VOCs, mixed gases and airborne particles can be developed for the creation of healthy, comfortable and productive indoor environments.

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Individual sensors

The physical parameters necessary to measure in conjunction with indoor environment are temperature, relative humidity and CO₂ concentration. In addition it would be useful to be able to measure local pressure variations and if possible to measure draught (local undesired air flow)

Commercially available CO₂ sensors are mostly based on the infrared absorption band at a wavelength of approximately 4.3 μm . A typical sensor includes a blackbody radiator heated to approximately 700°C, chopper, tuned filter, and pyroelectric detector. Various schemes for differential operation to minimise the effect of common mode errors are being used. A relatively long optical path, 100-300 mm, is required due to the weak absorption at small CO₂ concentrations. Using multiple reflections to fold the optical path, the sensor design can be made somewhat more compact. The demands on mechanical precision to align the optical elements and secure high reflectivity of surfaces are high. The IR source is subject to ageing with the consequence that the devices require repeated re-calibrations. Power consumption is also inherently high due to the need for high temperature operation. No micro-system implementation of a complete CO₂ sensor based on IR absorption has been reported to date. Typical accuracy of state-of-the-art CO₂ sensors is ± 50 -100 ppm within the measurement range of 0-2000 ppm, response time 1-2 minutes, and power consumption 2-5W.

Capacitive or resistive humidity sensing elements are available from a large number of suppliers at a price range of € 5-20. Typical accuracy is $\pm 3\%$ within the range 10 to 90% RH. In most cases, polymers or ceramics having relatively strong water adsorption are being used as sensing material. The phenomena involved are not truly irreversible, and subject to ageing and other undesired properties. Consequently, the accuracy and long-term characteristics of state-of-the-art humidity sensors are far from ideal. It is believed that measurement of a physical property within the gas itself (average molecular mass) will not suffer from these limitations. Pressure and temperature sensor elements with adequate performance are available from many suppliers. However the integration of temperature and pressure elements into one micro-system with extremely low power consumption represents a significant engineering challenge. Most sensors on the market provide analogue output signals, 0-10 V and/or 4-20 mA. Strong efforts to launch e.g. LON Works (system interface and communication protocol launched by Echelon, Inc.) as a basis for network solutions have not resulted in widespread acceptance. However, the issue of a related standard (ISO164845) may promote this solution. Very few industrial references can be found on wireless solutions.

Multi-sensors

Existing technology for measuring indoor environment parameters is based on a wide range of traditionally constructed sensors measuring individual physical parameters usually connected by cables or wires. Often traditional installation control strategies are based on temperature control alone, whereas there are a number of arguments pointing to the fact that control strategies should be adapted to human presence in a more intelligent way. A multi-sensor (or sensors) incorporated into the control system, as part of an ambient intelligence network will be able to address this problem by providing key information about a range of useful indoor environment parameters. The few multi-sensors that are currently available are

based on traditional technology. Similarly, there is some experience available of individual wireless sensors.

Thus there is considerable scope for a wireless multi-sensor that is inexpensive, easy to install, flexible, user-friendly, maintenance-free, and reliable with long battery life. By using e.g. MEMS technology (Micro Electro Mechanical Systems) it is possible to perform several environment parameter measurements with small and compact multi-sensors with low power consumption and wireless communication to the surrounding control systems.

Such multi-sensors based on MEMS technology will contribute to considerably improved indoor environment measurement and control possibilities with an intelligent interaction with the building's control systems and with the immediate surroundings.

The feasibility of MEMS was studied by three of the MONTIE partners in a European project called "MASCOT" (Micro Acoustic Sensor Systems for CO₂ Tracking) partly financed by the European Commission under Framework Program 5, in which implementation of an acoustic CO₂ sensor was demonstrated. While the technology platform has thus been established and low-cost production in high volume proven feasible, important performance improvements are still required. The present MASCOT demonstrator does not fully meet the performance required for use in IAQ solutions (the signal resolution needs to be improved by a factor of 5-10). Furthermore, the sensor was designed without attention to power consumption. To achieve the low-power operating characteristics required for implementing wireless installations of the sensor, major modifications of both activating and detecting elements will be necessary.

Low-cost multi micro-sensors offer a number of new possibilities:

- Low cost would enable the installation of more sensors, possibly several sensors even in one room, which would reduce current difficulties in the selection sensor location.
- Diagnostics of system function and performance is an important field of application for micro-sensors. Measurements from micro-sensors would give added value information about air quality in and around the expensive filters often used in buildings.
- The quality of supply air could be controlled (e.g. shutting down ventilation during high outdoor pollution), if low-cost particle/gas sensors were available.
- Commissioning of buildings would be easier with high amount of sensors in the building. The ready availability of wireless sensors would allow commissioning firms to easily install temporary sensors during the commissioning process and subsequently easily uninstall them when the job is done and move them to the next location
- Important and reliable information about the IAQ and energy performance of buildings would be gained by combining sensor networks with real-time building simulation. This information could be used as basis for IAQ and energy supply agreements and productivity / energy saving investments.

For multi-sensors to be successfully adapted the following comments have been collected during workshops

- Resolution of a CO₂ sensor should be in the order of 20 ppm.
- Multi-sensors should be able to compensate for humidity.
- Response time should be of the order 2 - 3 seconds, but depends on specific application
- Long-term drift should be comparable with existing sensors i.e. 20-30 ppm is acceptable
- Sensitivity aspects need to be addressed in future research.
- Calibration issues need to be addressed future research – how to ensure that gas sensors are still measuring correctly and have not been “poisoned” during operation by other gases
- In addition to typical IAQ parameters – temperature, CO₂ and relative humidity, the issue of monitoring other gases (NO_x, ozone etc), nanoparticles and micro-organisms (pollen etc) is relevant to investigate, along with reliability problems with state-of-the-art catalytic sensors.
- Power consumption of the sensor element is the critical issue in making wireless sensors; low power transmitters will become available soon.

HVAC components and installations

The increasing focus on energy consumption in buildings and the on the possibility for pre-fabricated modular and standardised solutions places increasing requirements on better control systems, integrated installations and integrated sensor solutions to ensure the quality of IAQ.

There is a growing need for easy-to-install and self-configuring HVAC/IAQ system components and affordable multi-purpose sensors. The future will see integrated solutions rather than singular systems and modularisation and standardisation of components and systems. The growing complexity of installations will require effective control strategies, and better, full-range concepts such as combined commissioning, operation and service products. And there will be the need for indicators to identify suitable IAQ markers and levels.

A large amount of work is being carried out on demand controlled ventilation and a number of specific demand controlled ventilation solutions have been addressed during the project and its workshops:

- Experience from France has shown considerable potential savings in large meeting rooms, and up to 20 - 30 % savings in offices. Occupancy sensors are widely used in France, experience shows that good savings are achieved also this way.
- A demand controlled ventilation solution based on calculating the maximum profitable investment due to a) Reduced energy use only and b) Reduced energy use, installation cost and reduction of technical area, has demonstrated a promising concept for persuading building owners that they can invest savings on installations costs in improved indoor environment technology.
- Personalised ventilation, a method of supplying individual persons with clean air directly to their breathing zone shows promising results, allowing individual control and preferred airflow direction, temperature and velocity. Individuals exhibit large

- differences in their preference to preferred temperature, air movement sensation, clothing insulation level, activity level and air quality perception
- As a natural extension of personalised ventilation systems personalised heating and ventilation systems can easily be imagined, where the individual is provided with pre-chosen thermal conditions and fresh air.

RESULTS

The MONTIE project has increased awareness about the importance of IAQ and demonstrated the necessity for its objective measurement and demand-based control. Six workshops presenting “user perspectives” to different communities have been held in four countries, attracting several hundreds of participants and reaching out to many others. The project’s website has registered over 1000 “serious” visitors.

A unique interdisciplinary Nordic network has been established and strengthened. National, Nordic and international events arranged by the network have profiled Nordic knowledge and products and given a deeper understanding of market dynamics and driving forces. The project has given increased insight into the complex interaction between a “good” IAQ and its measurement and control. Project partners have been present and actively participated in events and exhibitions where their companies/organisations have never before been exposed. This has contributed to giving extra insight into the technical requirements for IAQ sensors and their applications and has been educational about learning several important lessons about the structure and players in the IAQ market.

Project partners have launched several new sensor initiatives and new research activities during the course of the project. New alliances have also been formed during the project and will hopefully bear fruit in due course. A group consisting of several MONTIE partners and new contacts from one of the workshops has submitted a common project proposal to a EU programme and are currently awaiting results of evaluation.

Quoting Danfoss: “For Danfoss the MONTIE project has definitely contributed to keeping focus on the issues of combining HVAC and IAQ. As an indirect result a focussed IAQ sensor development project is to be launched in 2007 aiming at overcoming identified issues. The project is fully financed by Danfoss”.

Quoting FiSIAQ: “The MONTIE project has succeeded in showing possible ways of combining good indoor environment with high energy efficiency. Although the technologies are still at demonstration stage, the potential has become clearly visible.”

Quoting DTU: “For DTU, participation has been an eye opener for future research and development. Direct spin off from the project has been the submission of several research grant applications, both to the EU and to national funding sources”.

At the seminars that were organized as part of the project, constructive dialogue between research communities and companies has pointed out several other application fields where

new sensor technology coupled with advanced control of HVAC systems has a great future potential (e.g. bioterrorism or chemical attack on buildings)

The main results of the project build on information dissemination via the following events. Further detailed information about the events and the expert presentations can be found in the CD-ROM appendix. The MONTIE logo shown below has been used at all events, along with NICE's logo.



Workshop at Clima 2005, Lausanne, Switzerland

The “Clima” congresses organised by REHVA, the Federation of European Heating and Air-Conditioning Associations, are major international forums for disseminating knowledge about indoor environment, especially IAQ, but also sensors, HVAC installations etc. The congresses include key-note and invited presentations, poster sessions and workshops on scientific trends and practical developments within the HVAC technology area. A well-attended MONTIE workshop was held at the latest Clima conference, Clima 2005 in Lausanne, Switzerland in October 2005 presenting MONTIE ideas and ambitions to a wide audience, including participants from outside the Nordic and European area.

The MONTIE workshop programme included summaries of state-of-the-art (Nordic) technology on sensors, applications of these sensors for the measurement and demand based control of IAQ and a discussion forum (more than 40 participants) where future needs for development and dissemination were discussed. The findings from the workshop were published in the Clima 2005 report, available at www.rehva.com

Conference in Taastrup, Denmark

A two-day “MONTIE” conference on the “Technological advances for controlling indoor environment” was held at the Danish Technological Institute in November 2005. The conference focus was on "State-of-the-art" technology with key-note presentations on user-driven issues and invited presentations on technology-driven issues.

The conference programme included IAQ, sensors and measurements, wireless communication and other new technology, intelligent HVAC installations and installation technology, including the use of sensors and coupling with Facility Management issues and security aspects, new business opportunities and challenges and innovative solutions. More information is available at www.teknologisk.dk/montie

”Thematic overview” presentation at MSW, Västerås, Sweden

The Micro Structure Workshop (MSW) is a forum for those interested in MEMS (Micro Electro-Mechanical Systems) and MST (Micro Systems Technology). The workshop is aimed at acting as a catalyst and a place to meet for industry, suppliers, financiers and researchers. The workshop held in May 2006 included key-note presentations and invited presentations on a wide range of topics, supported by a poster session and an exhibition. MSW traditionally enjoys very strong industrial participation. A MONTIE “thematic overview” introduced a well-attended session on “industrialisation” aspects and aimed at presenting the current status for the MONTIE initiative, and to inspire innovative thoughts for possible new applications for (MEMS) sensors. Several MONTIE partners participated actively in the workshop. More information is available at www.minst.nu/msw2006

Workshop at Eurosensors, Gothenburg, Sweden

Eurosensors is a major conference event – and reputedly the only one in Europe covering the entire field of sensors, actuators and microsystems. The conferences are aimed at scientists and engineers from academy, national research institutes and industry. Although the title conjures up a European perspective the conference has grown during the years to include a large number of participants from outside Europe. The conference has key-note presentations and invited presentations on a wide range of topics and a comprehensive poster session.

September 2006 saw the 20th anniversary of Eurosensors and a MONTIE workshop was arranged with the organisers. The topic was “Future sensorics for indoor environment measurement and control applications” and presentations focused on “the user perspective” to targeted the “sensor research community” representatives present at the conference/workshop and to invoke discussions. The workshop was a Discussion forum with about 40 participants. More information is available at www.mc2.chalmers.se/conferences/EUROSENSORS2006/

Workshop at VVS-Dagene, Norway

VVS-Dagene is the major HVAC exhibition in Norway with strong representation from HVAC suppliers, manufacturers, contractors and consultants. A number of seminars are held parallel to the exhibition and VVS-Dagene in October 2006 included a MONTIE workshop. The workshop presentations focused on presenting “the sensor user perspective” to discuss with the “HVAC user community” present at the workshop. More information is available at www.vvs-dagene.no

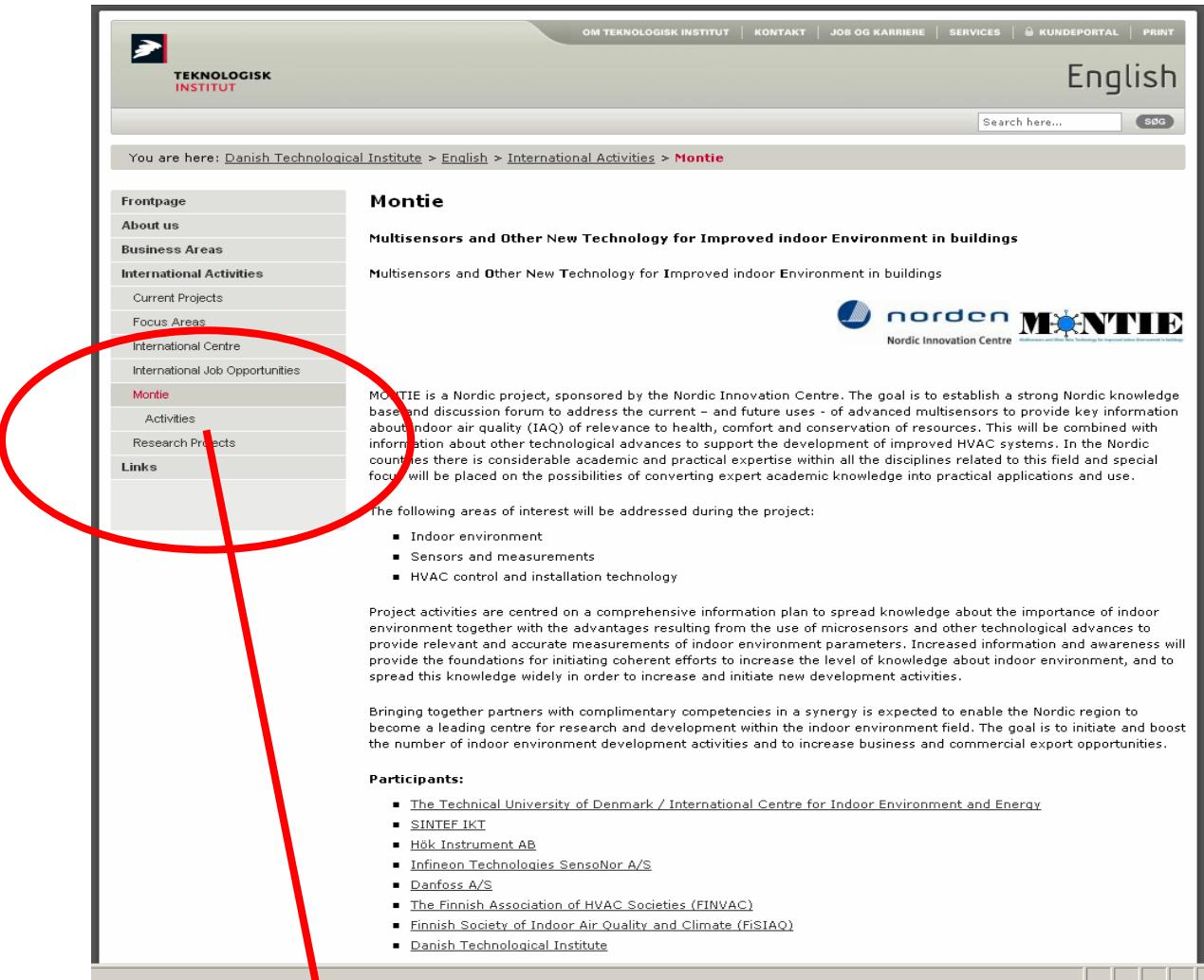
Workshop in Helsinki, Finland

A MONTIE workshop was held in Espoo in November 2006. The event was organised in cooperation with the Finnish Society for Indoor Air Quality and Climate, FiSIAQ and was aimed directly at a smaller targeted group of interested parties within the sensor, HVAC and indoor environment area.

A MONTIE workshop was held in Espoo in November 2006. The event was organised in cooperation with the Finnish Society for Indoor Air Quality and Climate, FiSIAQ and the Finnish Association of HVAC Societies (FINVAC/SuLVI). The workshop was successfully aimed directly at a smaller targeted group of interested parties within the sensor, HVAC and indoor environment area. Especially the theme of integration of sensors in HVAC equipment arose during discussions.

WEBSITE

Presentations from all the workshop events are available, along with other useful project information, from the project web-site www.teknologisk.dk/montie and from the Nordic Innovation Centre at www.nordicinnovation.net



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Montie

Multisensors and Other New Technology for Improved indoor Environment in buildings

Multisensors and Other New Technology for Improved indoor Environment in buildings

norden **MONTIE**
Nordic Innovation Centre

MONTIE is a Nordic project, sponsored by the Nordic Innovation Centre. The goal is to establish a strong Nordic knowledge base and discussion forum to address the current – and future uses – of advanced multisensors to provide key information about indoor air quality (IAQ) of relevance to health, comfort and conservation of resources. This will be combined with information about other technological advances to support the development of improved HVAC systems. In the Nordic countries there is considerable academic and practical expertise within all the disciplines related to this field and special focus will be placed on the possibilities of converting expert academic knowledge into practical applications and use.

The following areas of interest will be addressed during the project:

- Indoor environment
- Sensors and measurements
- HVAC control and installation technology

Project activities are centred on a comprehensive information plan to spread knowledge about the importance of indoor environment together with the advantages resulting from the use of microsenors and other technological advances to provide relevant and accurate measurements of indoor environment parameters. Increased information and awareness will provide the foundations for initiating coherent efforts to increase the level of knowledge about indoor environment, and to spread this knowledge widely in order to increase and initiate new development activities.

Bringing together partners with complimentary competencies in a synergy is expected to enable the Nordic region to become a leading centre for research and development within the indoor environment field. The goal is to initiate and boost the number of indoor environment development activities and to increase business and commercial export opportunities.

Participants:

- [The Technical University of Denmark / International Centre for Indoor Environment and Energy](#)
- [SINTEF IKT](#)
- [Hök Instrument AB](#)
- [Infineon Technologies SensoNor A/S](#)
- [Danfoss A/S](#)
- [The Finnish Association of HVAC Societies \(FINVAC\)](#)
- [Finnish Society of Indoor Air Quality and Climate \(FISIAQ\)](#)
- [Danish Technological Institute](#)

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MONTIE Workshop at Clima 2005, Lausanne, Switzerland, 12 October 2005

This international conference took place on October 9-12, 2005. The conference dealt with scientific trends and practical developments in heating, air-conditioning, refrigeration, plumbing and ventilation technologies, also discussing the importance of and the implications of these trends for architecture and politics.

The conference featured plenary and short presentations, poster sessions and workshops. A workshop presenting MONTIE ideas and ambitions was arranged with the organisers, with the goal of initiating discussions about the future needs for development work and information dissemination. More than 40 people attended the workshop.

Download the programme for the workshop here:
[Clima 2005 Final Programme \(43 KB\)](#)

Download the workshop presentations here:
[Sateri and Drvrsdale Introduction.pdf \(134 KB\)](#)
[Toftum.pdf \(211 KB\)](#)
[Hök, Giersen and Østbe.pdf \(460 KB\)](#)
[Gravesen and Jensen.pdf \(459 KB\)](#)

Rehva Workshops at Clima 2005
Lausanne, Switzerland
10 – 12 October 2005

REHVA REPORT

RECOMMENDATIONS

The IAQ-sensor-HVAC field is by no means stationary and feedback from participants in the project group and participants at workshops etc. is very clear: Dynamic developments are taking place within the IAQ-sensor-HVAC area and further applied research and development work will continue within the field. Continued information dissemination is vital to ensure that expert academic knowledge is converted into practical applications. Information dissemination should be carried out across traditional disciplinary boundaries to further strengthen knowledge about the interaction between IAQ, sensors and HVAC systems.

Development work on multi-sensors will continue. It is obvious that there is worldwide interest and future market for this work. Inexpensive sensors will enable better indoor environmental conditions and more efficient use of energy. Better indoor environment conditions will improve the comfort and productivity in buildings.

There is a continual need for new products and product development evolving from interactions between the value chain of users, researchers, manufacturers, suppliers consultants and installers. Information dissemination is important, but future work should be carried out parallel with product development work where the potential of new sensor technology is evaluated by modelling and testing in the laboratory and in buildings in practice. For example, monitoring and control of zones in buildings (local microclimate control) or more widespread use of demand controlled ventilation with inexpensive CO₂ sensors along the theme of “Integration of IAQ sensors into HVAC systems”

Legislation will also drive developments, e.g. demands in the EU Energy Performance in Buildings Directive will have consequences for energy and IAQ aspects in Nordic buildings. There are strong recommendations for addressing the possibilities of integrating (inexpensive) sensors in HVAC components and installations to provide better monitoring and control solutions in new buildings – but also as retrofit solutions in existing buildings. Expertise is still fragmented and widely distributed and there basis for greater cooperation between the different players in the field.



norden

Nordic Innovation Centre

Nordic Innovation Centre

The Nordic Innovation Centre initiates and finances activities that enhance innovation collaboration and develop and maintain a smoothly functioning market in the Nordic region.

The Centre works primarily with small and medium-sized companies (SMEs) in the Nordic countries. Other important partners are those most closely involved with innovation and market surveillance, such as industrial organisations and interest groups, research institutions and public authorities.

The Nordic Innovation Centre is an institution under the Nordic Council of Ministers. Its secretariat is in Oslo.

For more information:

www.nordicinnovation.net