Evaluation report 2005

Evaluation of the Healthy Building Key Action – Stage 2 2001–2004

formas

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Preface

Formas shall promote outstanding research for sustainable development in the areas of environment, agricultural and forestry sciences and spatial planning. The research supported shall meet high demands for scientific quality and, where applicable, be relevant for the sectors of society concerned. The council shall also provide an impetus in initiating research that promotes economic growth in the sectors affected. Part of Formas responsibility is to initiate and organize scientific evaluations of the research financed by the council.

Lisa Sennerby Forsse
Secretary General
Formas

Besides open calls for research applications, Formas also funds coherent research programs in important areas. The building sector is of great importance to the Swedish economy and for the wellbeing of the Swedish population. Therefore, Formas has continued the Healthy Building Key Action Research Program, originally started by the former Swedish Council for Building Research in November 1997. The program has been aiming at providing the knowledge base for buildings to be designed in such a way that they do not give rise to, or aggravate, diseases or complaints. The first 3-year stage of the program for 1998–2000 was evaluated in April 2000.

The second and final 4-year stage of the research program (2001–2004) has been supported by Formas grants of 38.7 million SEK. Approximately the same amount has been provided by other sources. Stage 2 has now been evaluated, including an assessment of the goal achievements and the societal relevance of both stages.

As a basis for the evaluation, the basic data, a compilation of individual research reports (Status of Research August 2004. Formas Working Paper 1:2004), a summary report of the major results of the key action (Research Results Achieved During The Second Four-Year Period 2001–2004. Formas Working Paper 2:2004), and the internationally peer-reviewed scientific

articles hitherto published within the program were sent to the evaluation panel during the autumn of 2004. The panel chair submitted the evaluation report in February 2005.

On behalf of Formas and the Building Sector I am very grateful to the international expert panel chaired by professor Erik Dybing for their skilful and efficient work in evaluating the key action program The Healthy Building – Stage 2. Their findings and recommendations to Formas and the Building Sector are highly appreciated.

Lisa Sennerby Forsse
Secretary General
Formas

Content

Summary

'The Healthy Building' Research Key Action has significantly increased our knowledge about the causes and mechanisms of indoor environmental problems. It was found that the overall scientific productivity of many of the projects within the Key Action has been good. However, for some of the projects that have been well funded, the research productivity has not been acceptable. The scientific quality of the Key Action has in general been good, but variable. Some of the projects have failed to publish their results and several have not been completed. The societal relevance of many of the projects is apparent, especially in the field of exposure and health effects of microbial and chemical agents. The best results have been achieved from large projects with good collaboration between scientific disciplines and institutions. There were, however, several projects funded in the Key Action that were too scattered and small in size to make significant contributions to the overall goals of the programme. The dissemination activities from the various projects within the Key Action have been quite uneven. In the best cases, the future users of the information were included already in the planning and execution of the project. There are also other good examples of dissemination activities, but from some of the projects the dissemination activities are totally missing. The Key Action has obviously not solved many problems related to buildings, thus there is an obvious need for more research and dissemination of research results in this area.

Sammanfattning

Forskningsprogrammet 'Det sunda huset' har på ett betydande sätt ökat vår förståelse av de orsaker och mekanismer som leder till problem i inomhusmiljön. Utvärderingsgruppen bedömer att många av projekten i programmet har visat god vetenskaplig produktion. Men några projekt har haft en oacceptabelt låg produktion, trots att de har fått god finansiering. Den vetenskapliga kvaliteten har generellt varit god, men varierar tämligen mycket mellan projekten. Några projekt har inte publicerat resultat, och många var oavslutade vid tiden för utvärderingen. Flertalet projekt är uppenbart samhällsrelevanta, särskilt när det gäller exponering och effekt av mikrobiologiska och kemiska ämnen. De mest värdefulla resultaten kommer från stora projekt med omfattande forskningssamarbete. Flera av projekten var för små och ämnesmässigt spridda för att på ett avgörande sätt kunna bidra till att nå programmets övergripande mål. Spridningen av resultat från de olika projekten skiljer sig avsevärt. I de fall man lyckats bäst i detta avseende hade man involverat framtida användare av resultaten redan under arbetets planering och genomförande. Flera andra projekt visar också goda exempel på hur resultat kan spridas, medan vissa överhuvudtaget inte redovisat någon aktivitet. Många byggnadsrelaterade problem har undersökts inom programmet, och resultaten bidrar till att hitta lösningar på dessa. Trots det finns det fortfarande många problem som inte hanterats eller lösts inom programmet. Därför är det uppenbart att det behövs såväl ytterligare forskning som systematisk spridning av forskningsresultat inom området.

Introduction

Background for Evaluation

The Swedish Council for Building Research started in November 1997 The Healthy Building Research Key Action Research Programme in order to provide the knowledge base for buildings to be designed in such a way that they do not give rise to, or aggravate, diseases or complaints. The first 3-year stage of the programme for 1998-2000 was evaluated in April 2000. The second and final 4-year stage of the research programme (2001-2004) is the focus of the present evaluation, although the goal achievements and the societal relevance of both stages should be considered jointly. The second stage of the programme has been governed under the auspices of the Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning (Formas).

The goal of the Key Action has been:

- to halve the number of unexplained environmental problems, and
- to halve the risk of incorrect actions in design, construction and management which can result in indoor environment-related health problems.

The aim of the special Key Action The Healthy Building is to contribute to buildings being designed and managed so that they do not give rise to, or aggravate, illnesses and complaints.

The Key Action has comprised the following problems:

- ill-health which may be building-related
- technical requirements, user demands and the consequences of alternative solutions
- the user, the premises and the indoor climate
- indoor environment in a sociological, humanistic and legal perspective

Research within the Key Action shall be based on scientific foundations and be conducted so as to have high scientific quality, in harmony with international research. The research shall have identified the obstacles to, and the possibilities for, increased use of existing and future knowledge, and should be instrumental in explaining and disseminating existing knowledge.

In addition to projects covering technical and medical aspects, the Key Action has also sought projects to elucidate sociological, legal, behavioural scientific and humanistic problems related to the consequences which can be identified in future applications of the research results.

Particular value when funding research projects within the Key Action has been attached to those that have been characterised by:

- a clear focus on the goals
- interdisciplinary research
- originality
- a sound theoretical and methodological basis
- systematic and judicious planning
- applicability of the expected results
- clear presentation of the planned research with a time schedule.

Aim of Evaluation

The aim of the evaluation is to examine the scientific quality, the goal achievements and the societal relevance of the research and development activities within the Key Action The Healthy Building. In their evaluation, the panel should address the following topics:

Scientific quality

- Publication performance
- Scientific competence

Societal relevance, also from an international point of view

- Importance, direction and balance
- Implementation

Dissemination

Measures taken after the previous evaluation of Stage 1 of the Key Action

Overall conclusions

The enhancement of the level of knowledge aimed for in formulating the goals of the Key Action will be considered achieved if research is judged to have made essential contributions to an

understanding of how the indoor environmental problems known today arise. In addition to the overall evaluation of the Key Action, the research projects should also be evaluated individually with regard to scientific content and relevance.

The materials used for the present evaluation have been:

- Lists of projects in Stage 1 and Stage 2 of the Key Action The Healthy Building.
- The Healthy Building – A Key Action Initiated by the Swedish Council for Building Research (Initial programme for Stage 1). Formas G4:1998.
- Status of Research November 25, 1999. (Compilation of project reports in Stage 1). Formas G6:2000.
- Review of the "Healthy Building Research Key Action", Stage 1. Appendix 3 to Status of Research, November 1999. Formas G6:2000.
- The Healthy Building, Stage 1 – Research Results Achieved during the First Three-Years Period 1998-2000. Report by the Nordic Expert Group. Formas G4:2002.
- The Healthy Building Stage 2 – Targeted building research for a better health and environment. (Programme for Stage 2). Formas G8:2000.
- The Healthy Building. Stage 2 – Status of Research, August 2004. Working Paper 1:2004.
- The Healthy Building. Stage 2 – Research Results Achieved During the Second Four-Year Period 2001-2004. Working Paper 2:2004.
- Anderson, J. and Rantama, M. National Research Programs: Are We Using Money the Right Way? Workshop 27. Helsinki: Proceedings of the Healthy Building 2000.
- Abel, E., Andersson, J., Dawidowicz, N., Christophersen, E., Hanssen, S O, Lindén, A.-L., Lindvall, T. and Pasanen, A. L. The Swedish key action "The Healthy Building – Research results achieved during the first three-years period 1998-2000. Proceedings of Indoor Air 2002, pp. 996-1001, 2002.
- Wieslander, G. and Rylander, R. (editors). Workshop on humid buildings. Indoor and Built Environment, 12(4), 209-264, 2003.
- Presentations at the research seminar of "The Healthy Building", 26 August 2004.
- Submitted reprints of articles published in scientific journals.

Evaluation Group

For the present evaluation, Formas has established the following evaluation panel:

Professor Erik Dybing, Norwegian Institute of Public Health (NIPH), Oslo. Director of its Division of Environmental Medicine. Research experience in cellular toxicology, xenobiotic metabolism/reactive metabolites, genotoxicity, mechanisms of organ damage and risk assessment. Chair/member of numerous national and international expert committees on toxicology, risk assessment, environmental health and reserach. President of EUROTOX (European Societies of Toxicology) 1993-96. President of IUTOX (International Union of Toxicology) 2001-2004.

Professor Bent A Borresen, Research and Development department of Norways largest consulting engineering company, Norconsult. Specialising in ventilation, energy use and fire safety. Part time professor at AHO - The Oslo School of Architecture and Design

Senior researcher Kirsten Gram-Hanssen, Danish Building Research Institute, Hørsholm, Denmark. Main research fields: social science studies on housing issues. Focus on how different groups use and interpret the built environment, and on households' energy consumption and everyday life.

Ms. Helena Säteri is the Head of the Building Division at the Ministry of Environment in Finland. She is responsible for the legislation concerning construction in Finland. Ms. Säteri has a M.Sc. (Mech.)-degree from the Technical University of Helsinki. She has worked as the Secretary General of the Nordic Committee on Building Regulations. In 1986-1995 she was in charge of the Nordic Indoor Climate Group.

Dr Ann Thuvander, associate professor in toxicology and head of the Unit of Environmental Medicine, National Board of Health and Welfare. The unit has the overall responsibility for environmental health in Sweden, which includes legislative work and guidance for supervision of the indoor environment.

Evaluation of Stage 1

At the time of the mid-term review in April 2000, a total of 29 individual projects had started or were in the starting phase. Already at that time, it was stated that the overriding goals of the Key Action were very ambitious, and as formulated rather unrealistic. It was seen as very doubtful that the knowledge generated by the research in the programme would cut in half the number of indoor environment-related health problems that are at present unexplained. However, the possibility of reaching the second goal seemed possibly more readily attainable. Over all, the evaluations concluded that it was apparent that the research programme in many instances would contribute significantly to the overall goals of the programme. Evaluating the individual projects, it was found that many of the projects were descriptive studies associating indoor environment factors with various health outcomes, whereas there were few projects evaluating preventive measures. Thus, one of the recommendations was to intensify intervention-type studies. Also, better co-operation between disciplines was sought and improved competence in behavioural research was seen as necessary.

Overall Scientific Quality

Publication Performance

There are quite remarkable large differences in the scientific productivity between the various individual projects. Some of them have shown excellent publication performance, whereas others must be judged as poor. In fact, only 14 of the total 37 projects were given the rating excellent, very good or good with respect to scientific productivity as judged by the publications at the time of reporting. It is understandable that some of the projects have had limited productivity when they still are in an investigatory phase, and several of these have indicated good publication plans with scientific reporting in international journals and conference proceedings with peer review. On the other hand, it is seen as not acceptable that some projects have received considerable funding without resulting in scientific publications. Some researchers seem to have taken on too many projects so that they have not been able to complete the projects within the allotted time.

It is also obvious that the scientific output has been better from the larger projects where researchers with complementary competence have collaborated; one such example, which stands out, is the multi-centre study "Dampness in buildings and health (DBH)". With the many complex research questions which are related to the indoor field, and the need to apply advanced methodologies to answer such questions, it is not unexpected that investigations carried out by single individuals may have problems in showing good productivity.

There appears to be differences in scientific productivity between the various disciplines, this may be related to differences in culture and tradition between them. Health-related research has a long tradition in publishing their accomplishments in peer-reviewed international journals, whereas technical research more often publish their results primarily in scientific conference proceedings. Within the Healthy Building Key Action the health-related projects seem to be more scientifically established than the other projects, although also technical research in this area has been ongoing for quite some years. On the other hand, social scientific research is under establishment.

Scientific Quality and Competence

The scientific quality of the individual projects is also quite variable. Some of these have been judged to be very good, whereas other projects have been evaluated to have only limited or an acceptable quality. Of the total 37 projects within the Key Action, 12 of them were rated to have a very good or a good scientific quality. Due to the fact that many projects are ongoing at the time of reporting and have not produced any scientific papers yet, it has not been possible to evaluate their scientific quality. Thus, it is possible that the scientific quality of these projects also will be high. On the other hand, if there are no scientific publications being produced at all for projects with an obvious scientific content, this cannot be judged as acceptable.

An obvious finding by evaluating the Key Action and its outcomes is that there is much less overall research on indoor air health problems than that, which occurs, related to ambient air, both in Sweden and elsewhere. This may be related to scientific traditions in that ambient air research has a much longer history than research on indoor air problems. There may also be cultural differences between the research groups involved in outdoor air health investigations and those researchers studying indoor air problems. Another reason for the relatively low participation in "Healthy Building"-type research is that it must involve wider interdisciplinary competence in order to be effective, and such interdisciplinary collaboration is difficult to undertake. This is in fact shown by the projects involved in the Key Action, rather few of them have been truly interdisciplinary. The various technical projects within the technical sector are in part characterised by a certain conservatism and lack of novel ideas in order to develop new competence.

Many of the research projects have been important for developing and expanding scientific competence within the themes covered by the Key Action. It is of interest to note that several projects in the area of social scientific research appear to be quite successful. However, the Key Action could have profited from having a stronger focus on producing doctoral theses thus generating more competent younger scientists within the indoor research field.

Societal Relevance of the Key Action

This part of the evaluation considers the societal relevance of the Key Action by evaluating the relevance of the projects with regard to the contribution they make to the main goals of the key action. The report is divided into chapters quite similar to the structure of the report produced by the Nordic Group of Experts (The Healthy Building, Working Paper 2:2004).

General Remarks

The importance of the indoor climate problems in Sweden has been stated in the Environmental Health Report (2001) and repeated in the summary provided by the Nordic Group of Experts (2004). The stated main problems are damp dwellings and moulds, inadequate ventilation, noise, environmental tobacco smoke, radon and allergic complaints due to house dust mites and other causes. The same concerns are relevant to other Nordic countries as well. The goal of the Key Action was to halve the number of unexplained (indoor) environmental problems, and to halve the risk for incorrect actions that can result in indoor environment related health problems.

In order to be able to meet the first goal, the focus should be on the most common problems and their analysis and remedial methods. Analysis tools and procedures are extremely important in finding the problem buildings and diagnosing the causes so that correct remedial actions can be taken. To be effective, these tools should be available and usable by the experts on the field, including health and safety inspectors and consultants. In order to be able to plan sufficient, but not too extensive, remedial actions, the same tools should be used to study the health impacts of the problems and the effectiveness of the remedial measures. At the same time, the remedial measures for the problems should be developed and/or tested in practise. Both the analysis tools and remedial measures should then be disseminated into practise.

To meet the second goal, the most common or harmful incorrect actions in design, construction and management should be analysed to reveal the underlying causes to the problems and new, better procedures should be developed, tested and disseminated into practise. However, rather few projects have been related to this second goal. In the future, more focus should be given to how this goal may be attained.

The societal relevance of many of the projects is apparent, especially in the field of exposure and health effects of microbial and chemical agents. The best results have been achieved from large projects with good collaboration between scientific disciplines and institutions. There were, however, several projects funded in the Key Action that were too scattered and small in size to make significant contributions to the overall goals of the programme. More emphasis should have been given to the most relevant problems. Within these problems, the Key Action should have analysed which are the most important missing links in the chain of actions (exposure – health impacts – evaluation – remedial measures – practical implication – follow up) to improve the situation.

New Methods of Investigation

The area of damp buildings and presence of mould is for time being one of the most important indoor climate problems with unexplained health effects. The development of new tools for investigating micro-organisms (Larsson (16), Tagesson (32)) contributes significantly to the goals of the key action, if the tools can be disseminated into practical use. Another significant result is the standardised, validated questionnaire for assessing indoor environment in dwellings (Engvall & Norbäck, 7). The development of the Stockholm Indoor Environmental Questionnaire tool is also a good example of including the user organisation to the development project. Important new methods have also been developed for studying the contents of indoor dust and ultra fine particles (Bjørsteh (3), Ekberg (6)), but the practical use and implementation of these tools need still to be demonstrated.

Exposure Assessments

Most relevant new information about exposure to indoor air pollutants was gained for volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs) in indoor air and dusts (Jansson (10), Lundgren (17), Lundgren (19), Tagesson (32)). These data may in the future be used to assess the health

effects and to set target values. Analysis of the exposure to PCBs from sealants (Johansson, 12) is an example of a research area which has so far received little attention, but where information will be highly valuable for risk management decisions. Chemical and physical interactions in the indoor environment may play an important role in health effects, but the science related to that field is still at a very early stage for definitive conclusions.

Health Effect Assessments

The Key Action has done its most relevant work in assessing the health effects and mechanisms of the damp building/mould problems. The project by Rylander (26) gives a possible explanation for increased inflammations in mouldy buildings and Larsson's study (16) similar results for asthmatic symptoms. Although no causal relations can be demonstrated based on these studies, they may help in finding the "missing link" between damp buildings and health effects. Norbäck (34) demonstrated how intervention studies, in combination with clinical tests, could generate useful and applicable information. This approach may also be valuable for establishing causal relationships, which would significantly improve the health of the thousands of people suffering from unexplained symptoms in damp buildings.

The possible association of phthalates with allergic symptoms would also have a significant societal effect. It might explain some of the increase in allergies and, if remediated, yield to a future decrease in the number of allergic people. On the other hand, the use of plastic materials containing phthalates is so widespread that replacing them with other materials would mean significant costs to society. More studies on the matter are certainly needed.

Assessments of Occupant Reactions to Noise

Noise is the environmental risk factor that disturbs most people in Sweden, but only one project, addressing low frequency noise (Persson Waye, 25) was included in the Key Action. Low frequency noise is so far a poorly studied environmental stressor and findings from the project indicate that present legislation may not provide adequate protection. The findings will be of value for environmental impact assessments in relation to infrastructural planning and provide relevant information for future legislative work and guidance. More emphasis on noise within the Key Action, especially seen in conjunction with other exposure factors, would have been desirable.

Assessements/Risk Constructions/Risk Solutions

Even if our understanding of causal relationships in the indoor environment still is weak, it is important to try to quantify the health impacts of the (reasonably well) identified risk factors. For example, from the study of Bornehag and co-workers (4) a preliminary estimate of the increased risk for childhood asthma in relation to damp buildings can be drawn and used in estimates of the number of individuals affected. Such estimates are important for our understanding of the dimension of the problem in relation to other environmental risk factors, and they are also necessary for cost-benefit analysis, etc. Apart from this example, the Key Action does not give significant contributions to risk assessment/risk reduction.

Behavioural, Social and Physical Interactions

Complaints related to the indoor environment are known to be more common in certain sub-groups of the population, but much more knowledge is needed to explain such differences. Within the Key Action it was shown that the psychosocial climate, as well as the perception of the environment, added significantly to the explanation of complaints. It was also demonstrated that symptoms were more frequently reported from people in low status groups. To perform relevant remedial measures, it is important to use methods with which "true" physiological indoor environmental problems can be separated from problems generated by other circumstances. The Key Action has contributed to our understanding of how social aspects interfere with the frequency of self-reported symptoms (Barmark & Lindén (2), Engwall & Norbäck (7), Laike (14), Lundin (20)), but further work is needed, especially regarding methodology.

Ventilation and Air Treatment

The role of ventilation in indoor climate problems was clearly demonstrated in several of the projects (Bornehag (4), Engvall & Norbäck (7), Mathisen (21)). This, in accordance with the fact that ventilation is known to be inadequate in dwellings and classrooms, should heavily focus future work on improving the situation. The measures needed for this are more in the field of the use and maintenance of the ventilation systems. In the Key Action, interesting new information was gained from the role of filters and materials in supply devices (Norbäck, 24), possibilities for seasonal adaptation (Engvall & Norbäck, 7) and air cleaning (Hygge & Mattson, 8). In general, the contribution of the Key Action to decreasing the inadequate ventilation is

not sufficient. The question is what types of further actions are needed to make the building owners understand the need of adequate ventilation. Another important question is why the present requirements on ventilation are not met.

Damp Buildings

The research related to damp buildings has the highest societal relevance in the key action. These research activities have covered the first steps of chains of actions (exposure – health impacts – evaluation) in scientifically profound manner. Of course, more work will be needed in developing diagnostic tools and effective and economical remedial measures, but the projects in the Key Action give a solid foundation for this work. This area could have received even more emphasis so that the chain of actions could have been completed. Also, increased co-operation within the key action may have improved the progress.

Legal and Economical Conditions

The building legislation in Sweden as in many other European countries is demanding for new buildings and consists of a range of essential requirements to be fulfilled. These requirements are, however, often not met, not even when the building is taken into use. An analysis of factors such as surveillance would be relevant to understand these circumstances. Furthermore, many of these requirements are not performance-based criteria today, but this should be the goal in the future. To achieve this, we need a lot more of knowledge in how to prove that the performance is correct. This programme has not given us much new information in this area.

The problems exist in the current building stock, and new construction is not a practical way to improve the situation in existing buildings. The most essential thing is to find good solutions for remedial actions. The indoor environment of the existing building stock is in Sweden regulated under the Environmental Code. It might be necessary to take into consideration new legislation for the existing building stock, possibly under the Code. This programme has produced several new, important results within this area. Of highest relevance are the results of the Damp Buildings and Health project.

As mentioned earlier, the legislation of new construction buildings is not of highest importance. It has, however, relevance as it defines the quality level of good building practice, also in renovation projects, and shows the users of buildings examples

of possible health and comfort levels. For new constructions, the most relevant new findings to consider are related to emissions from materials. Especially the information about the possible health effects of plasticizers and flame-retardants need to be taken into account when setting criteria for material emissions. PCBs have been banned for many years, but to give relevant guidance in cases where PCB-containing building materials are found, perhaps in the form of new legislative acts, information from the Key Action can be used.

Involving the building owners in the process is extremely important. According to the building legislation, the owner is responsible for the building during its whole lifecycle. The owner acts on economical aspects. That is why it is so important to produce cost efficient methods of investigation and remedial actions. This programme has produced good examples in this field (Engvall & Nordbäck (7) and Persson Waye (25)). Good results have been achieved in these projects where the stakeholders have participated.

Remedial action under threat of legislative pressure happens too late, as the building user may already suffer from health problems. To prevent severe problems, incentives for healthy or sanctions for unhealthy buildings would be needed. To achieve this, investigation and declaration procedures should be developed. The Healthy Buildings Key Action gives some input to these procedures as well.

Programme Collaboration including International Activities

Overall, the Key Action has had a rather limited collaboration between projects, institutions and disciplines. However, the 'Dampness in buildings and health (DBH)' project is an important exception in this respect. The project has had a very good collaboration between scientific disciplines and institutions; especially noteworthy is the good Swedish-Danish collaboration. The Key Action has funded two Norwegian and one Finnish research projects, but none of these projects have had any collaboration with Swedish investigators.

There are few connections of the Key Action projects to EU-funded research, however, this may in part be due to the limited availability of resources especially within the EU 4th Framework Programme for this type of research.

Several of the projects have had good collaboration with other funding institutions and interest groups, such as Swedish Building Industry Development Fund, The Foundation for Research into Health Care and Allergy and The Ventilation, Climate and Environment Society. It is somewhat remarkable that only one of the research projects has had any collaboration with building owners (Engwall & Norbäck, 7).

Dissemination of Results

A review of the dissemination of results from the 24 projects that mainly focussed on health effects and social science aspects (these are projects 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 13, 14, 15, 16, 20, 23, 24, 25, 26, 29, 30, 32, 33 and 34), shows that all but one project have presented results in some way. However, only 15 out of 24 projects have so far published their results in scientific papers. On the other hand, not all of these projects had been terminated at the time of reporting. Thirteen of the project leaders report that they have written popular articles in the technical press, prepared reports or discussed their results with the building sector. In one case the results from a project is being used in practise, and the results from another project are disseminated within a specific information project. Many of the investigators state in their report that they intend to disseminate results at a later state.

A review of the dissemination of results from the 13 projects that mainly focussed on technical issues (these are 1, 11, 17, 18, 19, 21, 22, 27, 28, 31, 35, 36 and 37) shows that only 7 of 13 projects have published scientific papers at the time of reporting. Scientific publications should be one target for projects in a scientific research programme. Even other products than scientific articles and handbooks are quite rare. Some of the researchers state that they intend to publish scientific articles later. Only two projects report on finalised PhD theses within the project. Two projects (35, 37) are still ongoing and are therefore without dissemination activities and are not included in this summary. Furthermore, there are several ongoing dissemination activities that have not been reported yet.

A few projects, notably those by Iwarsson (9), Engvall & Norbäck (7), Norbäck (24) and Persson Waye (25), have resulted both in extensive scientific publications and in a dialogue with relevant stake-holders (building sector e.g. building owners and authorities concerned).

The project by Andersson (37) is an information project, but the disseminated results were not generated within the "Healthy Building" programme.

Dissemination Activities of the Reviewed Projects.

Project type	"Type" of dissemination					
	Scientific publications	Articles in technical magazines	Reports, handbooks, etc	Co-operation with stake-holders	Special projects, courses, etc	Results used in teaching
Health-related and social science projects (23 in total)	15	9	6	6	2	2
Technical projects (11 in total)	7	2	2	3	-	1

Concluding Remarks on Results Disseminations

The dissemination of scientific results is essential in order to achieve the goal of the Key Action. Scientific documentation is an important pre-requisite for dissemination, both nationally and internationally. As mentioned earlier, too many projects failed to produce peer-reviewed results. It is, furthermore, not enough to only publish the results to the science community. Researchers should have good contacts to the legislative bodies, national and local authorities, real estate owners and building industry, and the users of building. The dissemination activities from the various projects within the Key Action have been quite uneven. In the best cases, the future users of the information are included already in the planning and execution of the project. This was the case in the Engvall & Norbäck (7) study, where the Stockholm Environment Questionnaire (SIEQ) was developed in cooperation with the building owner in an economical way. There are also other good examples of dissemination activities, e.g. Björseth (3) has in his project clear statements and use of it in lecturing, articles and discussions with end users of the information. The handbook written by Skogsberg (34) is also a good dissemination activity, provided that the leaflet will be distributed to the tenants.

It is also important to include the latest research results into teaching in all levels. For university level this has been indicated in three projects, but lower levels of education should also be

included. Furthermore, the projects should have connections to organisers of professional training so that the practical applications could be taken into use.

Piloting, i.e. studying new solutions in real life settings, is also a powerful tool in disseminating information. This type of activity was included in Mathisen's school improvements (21), but unfortunately that project failed to present other dissemination activities. This tool could have been used more in the Key Action.

Many of the results achieved in the Healthy Building Key Action are impressive, but will lack societal relevance if the results are not disseminated more effectively.

Measures Taken after the previous Evaluation of Stage 1 of the Key Action

After the finalisation of Stage 1 of the Key Action (1998–2000), the evaluations expressed the following expectations for Stage 2 (2001–2004):

- Intensify intervention-type studies
- Better co-operation between disciplines
- Improved competence in behavioural research
- More and better exposure studies
- Further development of new analytical methods and prediction models
- More studies on small particles in the indoor air
- Development of adequate means for quality assurance

Fortunately, many of these expectations have been met during the second stage of the Key Action. There are several projects that have examined whether interventions, especially in schools, have led to improvements in the indoor environment (8, 21, 22, 24, 35). As stated above, there has been very good inter-disciplinary co-operation in the DBH-project, whereas in other projects this has not been very well developed. Stage 2 has obviously improved the competence in behavioural research (2, 7, 9, 14, 20). There have been a number of valuable exposure studies and investigations applying new analytical methods and predictions, but some of these have unfortunately had poor scientific productivity. Two projects (6, 17) have addressed small particles in indoor air. It is obvious that many projects involve aspects of quality assurance, but this has not been specifically highlighted in any of the projects.

Overall Conclusions

New Methods of Investigation

The Key Action contains valuable new developments of chemical and microbiological analytical methodologies and questionnaires, but there is a need for practical experience with the methods in order to evaluate how good they really are. Most of these are not yet commercially available, but the Stockholm questionnaire is ready from the scientific level. Method development has been an important and interesting part of many projects.

Exposure Assessment

It has been a general problem in the health-based projects that it is difficult to know which parameters to measure in order to gain enough information to perform a detailed exposure characterisation. On the other hand, measurement of specific components such as PCBs, should give important exposure information. It is unfortunate that projects related to semi-volatile organic compounds in indoor air have not been completed. It would have been quite interesting to have more research on comparisons between ambient air and indoor air exposure situations, in order to have better estimates of overall exposure assessment.

Health Effect Assessments

The DBH-study with all its subprojects has been very successful generating very interesting results and excellent collaboration between research groups with complementing competence. However, there is still a mechanistic challenge to explain why living in damp dwellings is associated with respiratory health outcomes. One way to move forward in this area should be to continue studies incorporating both clinical and physiological endpoints related to building dampness, also chamber studies may be a methodology to use more in elucidating this association between dampness and health. Through the DBH-project interesting ideas have been generated for further follow-up research.

Assessments of Occupant Reports and Behaviour

The findings related to low frequency noise have been important. In general there is a need for more research related to noise in indoor research. Noise should not be looked upon primarily as an annoyance problem, but is a clear health-related problem.

Assessements/Risk Constructions/Risk Solutions

Several research projects have contributed to a better possibility for assessing the increased risk of respiratory allergy and asthma in the population. However, there is a further need to include more toxicological and mechanistic considerations in the research projects, so that a better basis for risk characterisation can be made. The programme has not focussed very much on issues related to risk constructions and risk solutions.

Behavioural, Social and Physical Interactions

Several projects have contributed significantly to a better understanding of complaints related to the indoor environment. This relates both to how the complaints relate to socio-economic variables, and to what types of psychological structures influence the reporting. Thus, it has been valuable to include such projects in the programme. Further work is needed for understanding how social aspects interfere with self-reported symptoms. There is a lack of a better foundation of the projects in the social sciences.

Ventilation and Air Treatment

Most of this research has been part of larger epidemiological studies and the findings have been confirmatory, rather than generating new knowledge. Since ventilation is known to be inadequate in dwellings, future work should focus on improving the situation. This research should be coupled with legal, economical and behavioural research in order to gain understanding on why the regulatory advice does not seem to be followed in practice.

Damp Buildings

This research has been very important and generated new knowledge and hypotheses (see above). Important new insights have been gained with respect to epidemiological methods development, exposure characterisations and health effects.

Legal and Economic Conditions

This is an important research area, but not very much activity has occurred within the programme. Thus, there is a clear need for future research activities. This may be seen under a separate

research agenda, but could in some instances preferably be integrated in several of the types of research projects within the Key Area.

Collaboration

It is seen as very positive that the programme has financed research in the Nordic countries beyond Sweden. There has been an excellent Danish-Swedish collaboration in the DBH-project, whereas the Norwegian and Finnish projects have not had a Swedish counterpart in their projects. The EU-connections have been limited.

Productivity

The overall scientific productivity of many of the projects within the Key Action has been good. However, for some of the projects that have been well funded, the research productivity has not been acceptable.

Quality

The scientific quality of the Key Action has in general been good, but variable. Some of the projects have shown very good quality, whereas some projects have been rather poor in quality.

Dissemination

In the best cases, the future users of the information were included already in the planning and execution of the project. There are also other good examples of dissemination activities, but from some of the projects the dissemination activities are totally missing.

Goal achievement

The Healthy Building Research Key Action has significantly increased our knowledge about the causes and mechanisms of indoor environmental problems. The overall programme goal is judged to be rather unrealistic, so that it is not unexpected that the Key Action has not met these goals. The width of the programme has been in accordance with the goals, with a number of projects addressing different important issues related to healthy buildings. The programme could perhaps have been more concentrated on fewer research themes. There is a clear need to strengthen the social sciences research in the indoor environment area. The best projects in the Key Action have been the large projects with larger inter-disciplinary collaboration. A detailed dissemination plan should be made at least for the most important results in order to ensure that the goals of the Key Action will be met.

Recommendation

Many problems related to buildings have obviously not been solved by the Key Action, reference is here given to the in-depth description of the problems presented in the appendix of the report in conjunction with starting the Stage 2 (G8:2000). Thus, there is an obvious need for more research in this area. Furthermore, the dissemination of the research results should be improved. The Evaluation Group has not seen it within their mandate to detail any future research agenda, but has pointed to certain issues which merit scientific scrutiny in this 'Overall conclusions' chapter. However, the evaluators recommend that a conference be arranged in the near future for researchers, users, regulators etc. where one can discuss and plan a future research programme in this important area.

Appendix
Scientific Quality of Individual Projects

1. Evaluation of standard methods for measuring the emission characteristics of composite floor structures

Karvel Andersen, GBR Service AB

Project funding: SEK 150,000
Project time: 2001–2004

Project description: The project is based on an earlier development of an industry protocol for measurement of emission characteristics from composite floor structures. As a second step, this project has tested the validity and reproducibility of the protocol. Emission measurements have been carried out with reference and test materials at accredited laboratories. There were large variations in the emission measurement data, which led to a presentation of results as sum of alcohols in three categories. A revision of the test procedures and system for classification of composite floors has been performed.

Scientific productivity: There are no scientific publications from this project, so the productivity is poor.

Scientific quality: The scientific quality of this project is poor since it has not produced any scientific new knowledge. However, the evaluation of the standard methods has been of some utility.

2. The sick building syndrome – a sociological analysis of social and structural aspects

Mimmi Barmark and Anna-Lisa Lindén, Department of Sociology, University of Lund

Project funding: SEK 1,300,000
Project time: 2001–2003

Project description: The purpose of the project is to get better understanding of to what extent different parts of the population, according to socio-economic and demographic descriptions, have reported the so-called sick-building syndrome (SBS). The methods used are a postal survey including approximately 2,000 individuals living in Malmö. The project points towards satisfaction and control regarding housing condition as a main factor in explaining SBS. Compared to other studies the project reports on lower frequencies of SBS than in Stockholm, but similar to those reported for Sweden as a whole, and furthermore the project highlights that SBS symptoms are more common among immigrants. It is intended that 5-10 in-depth interviews will supplement the quantitative material in the project. Theoretical considerations on "Risk Society" in a popular article seems promising, but is not further developed in the scientific publications.

Scientific productivity: A working paper from the Department of Sociology, Lund University, is published as well as a paper in the Formas Status of Research Report. The intention is that the project will conclude in a doctoral thesis in spring 2005. There are no plans of further scientific publishing.

Scientific quality: The project is interesting at this stage and it has already produced valuable results, but it cannot be fully evaluated with respect to scientific quality before the doctoral thesis is made available.

3. Indoor aerosols – physical/ chemical characterization and health effects

Olav Bjørseth, NTNU, Trondheim, Norway

Project funding: SEK 600,000
Project time: 2001–2003

Project description: The project has characterised indoor dust before and after hot surface contact with respect to physical and chemical changes. Ultra fine particles emitted during high speed polishing of PVC floors have also been studied. Further, in vitro cellular effects of heated indoor dust have been compared to non-heated indoor dust. Also, the emissions generated during heating of indoor dust have been investigated in vitro. The project has given partial financial support to two PhD-students. Large numbers of sub-micron particles were emitted after heating of dusts to 70 degrees or higher. Dusts with higher content of organic material produced greater particles emissions compared to more low-organic dust. Several volatile organic chemicals were emitted from the dusts, starting at 150 degrees. The emissions were tested for cellular effects in peripheral blood mononuclear cells and lung epithelial cells.

Scientific productivity: The project has resulted in a good production of scientific papers in international journals with peer review. The project has also supported research presented in two doctoral theses.

Scientific quality: The project has generated interesting information on physical and chemical characteristics, emissions and cellular effects of heated dusts. The accomplishments of the present project show good scientific quality.

4. Dampness in buildings and health (DBH)

Carl-Gustaf Bornehag, Swedish National Testing and Research Institute

Project funding: SEK 2,528,000
Project time: 2000–2004

Project description: This project is a part of a large multicentre epidemiological study examining various exposures in buildings and their relevance for asthma and allergic symptoms in small children and their parents. In the first phase of the study, a cross-sectional questionnaire investigation on housing and health on 14,077 pre-school children in Värmland was undertaken in 2000. In the second phase, a nested case-control study was performed on 198 children with symptoms and 202 controls including detailed clinical examinations in parallel with extensive inspections and measurements within the subjects' homes in 2001-2002. Further phases of the overall study are being planned. Moisture-related problems in the buildings were strongly associated with asthma and allergic symptoms and with airway infections among children and adults. Risk factors for allergic symptoms were inspector-observed dampness, low ventilation rate, endotoxin in dust, Penicillium in dust and phthalates in dust.

Scientific productivity: The scientific productivity of this project has been excellent with a large number of publications in international journals and conference proceedings with peer view, as well as other publications and manuscripts in preparation.

Scientific quality: The scientific quality of this project is very good. The project has produced many important findings linking building dampness and ventilation rates to respiratory allergic symptoms, as well as generated interesting new hypotheses on causative factors.

5. Economical and legal conditions for healthy buildings in sustainable environment

Per-Olof Carlson and Johnny Andersson, Ramböll Sweden AB

Project funding: SEK 750,000
Project time: 2001–2003

Project description: The purpose of the project was to answer questions of how legal and economic incentives and contracts should be developed in order to increase the demand on healthy building from consumer and producers, builders and property owners. The methods were co-operation with Finland, literature studies and interviews. The project has realised that there is a very low demand on the market today for healthy buildings. Following from this fact it seems as the projects has not really gained any knowledge on how to increase the demand or any other results within economic and legal conditions for healthy buildings which is of value within the purpose of the program.

Scientific productivity: The only written result from the product seems to be a paper in the Formas Status of Research Report. There is no publication in scientific journals or from interna-

tionally refereed conference proceedings. Furthermore, there is no other kind of reporting from the project. There is mentioned a list of publications from the two project leaders, which, however, seems to concern other projects.

Scientific quality: Based on the material available for this review the scientific quality, as well as the scientific productivity, is not satisfactory, even though the original purpose of the project may have been relevant.

6. Ultrafine particles in the indoor air – the exposure to ultrafine particles in different types of buildings and at different activities

Lars E. Ekberg, CIT Energy Management AB and Building Services Engineering, Chalmers Technical University

Project funding: SEK 2,216,000
Project time: 2002–2004

Project description: Field measurements of UFPs and the ratio between indoor and outdoor concentrations in eight residential and office buildings in urban and rural areas.

The objective of the projects has been to clarify whether indoor concentrations of ultrafine particles generally can be expected to differ substantially from outdoor concentrations and to clarify under what circumstances such differences occur. The results show that the content of ultra fine particles differs substantially between indoor and outdoor environments. Large differences can also occur between different building types. Office buildings typically show lower concentrations than outdoors and than residential buildings, in part due to the frequent use of efficient air filters and sometimes due to absence of strong indoor sources. Activities such as cooking and candle burning are examples of strong indoor sources of ultra fine particles.

Scientific productivity: Very good production with several publications and submitted manuscripts to internal journals with peer-review, in addition to a number of other publications. A lic.eng.-examination has been finished within the project and a doctoral thesis has been approved.

Scientific quality: The outcomes of this project have shown good scientific quality. Very useful publications have been generated presenting systematic overviews of occurrence and measurement of ultra fine particles in indoor and outdoor air. More work will be necessary in the future to elaborate on the particle generation, their origin and the physical effects of the particles.

7. Indoor environment in dwellings, sick building syndrome (SBS) and discomfort among occupants

Karin Engvall and Dan Norbäck, Department of Medical Science/-Occupational and Environmental Medicine, Uppsala University

Project funding: SEK 864,000
Project time: 2001–2003

Project description: The principal aim of the project was to study aspects of indoor environment and their association with sick-building syndrome, SBS. The main method was a validated questionnaire using sociological principles and test procedures mailed to 14,243 multifamily dwellings in Stockholm. The comprehensive statistically material has been fully utilised and a number of interesting results have been documented. In addition, a questionnaire has been developed which seems relevant for both practical use in the municipality and for further research. However, the project somehow lacks proper sociological theoretical considerations.

Scientific productivity: The project has a very good scientific productivity with several articles in peer-reviewed international journals and conference proceedings, in addition to a doctoral thesis (mainly based on the published articles).

Scientific quality: The selection of methods used in the project is acceptable, although he theory of social sciences could have been included more. Overall, the accomplishments of the project show good scientific quality.

8. Intervention studies to improve the indoor environment in classrooms – effects of airborne allergens and particles on the cognitive performance in school children

Staffan Hygge and Magnus Mattson, Centre for Built Environment, University of Gävle

Project funding: SEK 3,886,000
Project time: 2002–2004

Project description: Electrostatic filters have been used to reduce the level of particulate matter in classroom air and the effect of this intervention has been examined with respect to cognitive performance, perceived comfort and emotional effects in 11-year old pupils. Later these findings are planned to be compared to noise from irrelevant speech, which has been shown to impair cognition. The results from the project indicate that the more sensitive the pupils state themselves to be, the less irritation they feel when the air cleaners are active. Also with respect to semantic memory, there is an indication that the more sensitive the pupils say they are, the better they perform.

Scientific productivity: No publications in scientific, peer-reviewed journals have appeared from this project, although two conference presentations are reported.

Scientific quality: Limited results have as yet come from this project. Pair-wise allergen sampling in the classrooms performed with one type of samplers showed unexpectedly low correlation. Another type gave less variation, but this type did not have a particle size cut-off in the respirable size magnitude and its flow-rate was difficult to control.

9. The home environment – a determinant for health and well-being? Perspectives of activity, accessibility, and participation

Susanne Iwarsson, Department of Clinical Neuroscience, Faculty of Medicine, Lund University

Project funding: SEK 2,300,000
Project time: 2002–2005

Project description: The aim of this project has been to study the home environment and its impact on activity, health, well-being and participation among persons with functional limitations such as the elderly, in particular specific positive or negative person-environment constellations, in terms of accessibility and usability problems in housing. This research has been carried out in four sub-projects, one of these has been a part of a major EU-funded activity involving five European countries. The results consistently reveal significant relationships between subjective and objective aspects of housing, as well as between different health variables and aspects of housing.

Scientific productivity: The productivity from this project has been excellent with a large number of peer-reviewed articles, international refereed conference proceedings, papers and other publications.

Scientific quality: The project has developed, tested and applied multi-dimensional methodology covering objective aspects of housing and health in convincing fashion. The validity and reliability for evaluation of housing adaptations have been clearly documented. The results have also contributed significantly to develop validation of accessibility and usability constructs for this research field. A significant conclusion is that accessibility is an important aspect of housing, related to many different aspects of health.

10. Semi-volatile organic compounds in indoor air – damp buildings and health (DBH 5.4.3)

Bo Jansson, Institute of Applied Environmental Research, Stockholm University

Project funding: SEK 350,000
Project time: 2001–2002

Project description: The project constitutes a part of the large multidisciplinary investigation regarding pulmonary disorders in relation to damp buildings and ventilation status. A passive polyethylene-film sampling device has been used to sample persistent lipophilic semi-volatile organic compounds in indoor air of children's room in 237 residential buildings. The gas chromatographic data have been processed by computer-based software for retention time correction and conversion to in-data for multivariate data evaluation software (SIMCA). No identification and quantitative evaluation of the individual compounds have as yet been performed.

Scientific productivity: There are no scientific publications reported from this project.

Scientific quality: The project has so far applied state-of-the-art sampling and measurement methodologies. However, the quality of this project is difficult to evaluate, as there is no detailed reporting and no scientific publications available.

11. Analysis and development of schools with fan improved natural ventilation

Lars Jensen and Birgitta Nordquist, Building Services, Lund Institute of Technology

Project funding: SEK 1,066,000
Project time: 2002–2003

Project description: The goal of the project has been to study the technical and physical conditions required to ensure a satisfying ventilation of classrooms ventilated with fan-assisted natural ventilation. Another goal has been to provide guidelines and recommendations for the design and operation of the ventilation systems. The performance of the ventilation system in combination with the school building has been studied by theoretical calculations and measurements. The project is ongoing at the time of reporting so that no definite conclusions have been presented.

Scientific productivity: There has been no scientific productivity from this project, but it is stated that publications in international scientific journals and in conference proceedings are being planned.

Scientific quality: It is not possible to evaluate the scientific quality of this project, as there have been no scientific publications so far.

12. Do PCBs in sealants contribute to a higher PCB exposure among occupants in residential buildings?

Niklas Johansson, Institute of Environmental Medicine, Karolinska Institute

Project funding: SEK 390,000
Project time: 2001–2004

Project description: The aim of the present project has been to investigate if persons living in buildings containing PCB sealants have a higher PCB exposure compared to that of the general population. And if so, it was of interest to see if there were qualitative differences in the exposure patterns. Air samples have been collected with the aid of active samplers in 13 study and 4 control flats in a residential area built in the early 1970s with building with and without use of PCB-containing sealants. In addition, blood samples were taken from 21 individuals who had lived in buildings containing PCB-sealant and from 25 control individuals. Considerably higher levels (up to two orders of magnitude) of PCB have been found in flats where sealants have been used to flats where no such material was evident. The results of blood measurements are not yet available.

Scientific productivity: At the time of reporting the project is still ongoing. So far, only two extended abstracts have been published.

Scientific quality: The project is of considerable scientific interest. It has applied state-of-the-art sampling and measurement methodologies. It is not yet possible to fully judge the quality of the scientific outcome.

13. Mould growth on new and used construction timber

Pernilla Johansson, SP Swedish National Testing and Research Institute

Project funding: SEK 400,000
Project time: 2001–2002

Project description: The growth of mould on building materials varies in both rate and extent, depending on the nutrients in the material and on the local conditions. This investigation has compared the growth of mould on new and on used timber under high humidity conditions in a climate test chamber. The used timber was more quickly attacked by mould than was the new timber. When the surface of the used timber samples was sawn off, it behaved in the same way as new timber.

Scientific productivity: There are no scientific publications from this project.

Scientific quality: The outcome of this project has a practical value, but the scientific quality is limited.

14. A new holistic method to assess the origin of building and work related symptoms (BWRS) in office buildings

Thorbjörn Laike, Environmental Psychology, Department of Architecture, Lund Institute of Technology

Project funding: SEK 1,500,000
Project time: 2001–2004

Project description: The purpose of the project was to develop a new method for assessing the total building environment's influence on building- and work-related symptoms (BWRS). The method used included objective descriptions of the building environment, subjective and objective work characteristic and subjective descriptions of the psychosocial climate. Statistical analysis of data related to two buildings covering different kinds of modern office work showed that questions concerning experiences of environmental disturbances with light, air and noise have a higher correlation with experienced BWRS than the objective physical measurements and individual factors. However, the method has to be tested at workplaces with larger proportions of BWRS before the researchers are able to draw final conclusions.

Scientific productivity: The project has been delayed because of changes in the project group. So far there has been no scientific production, but the investigators state that they are now preparing papers for scientific journals and are planning a seminar.

Scientific quality: The project appears interesting, however, it is not possible to judge the scientific quality before they have published scientific papers.

15. Airborne moulds and mycotoxins in Swedish problem houses

Carl Johan Land, Department of Wood Science, SLU, Uppsala

Project funding: SEK 900,000
Project time: 2001–2004

Project description: The aim of this project has been to develop a PCR-based method for the detection and identification of fungi on construction materials. Special attention has been given to gypsum boards frequently contaminated with *Stachybotrys chartatum*. The method has been set up using specific primers on the Tri5 gene. Species identification of wood decay fungi in construction wood has been approached by means of sequencing ribosomal DNA. A number of important wood decay fungi have been identified from fruit bodies and directly from wood samples.

Scientific productivity: The project has a reasonable scientific productivity with generation of two publications with rather limited content.

Scientific quality: The project has applied straightforward sequencing methodology for identification of various decay fungi in construction timber. The scientific quality of the project is acceptable.

16. Identification of unhealthy indoor environments – novel method for the determination of microorganisms

Lennart Larsson, University of Lund, Sweden

Project funding: SEK 800,000
Project time: 2001–2003

Project description: The goal of this project was to investigate whether analysis of monomeric markers of micro-organisms by using gas chromatography-mass spectrometry (GC-MS) method would represent a health-relevant way of characterising microbial communities in indoor environments. An integrated procedure has been developed that includes an extraction and analysis scheme for 3-hydroxy fatty acids as markers of endotoxin, muramic acid as a marker of peptidoglycan/bacterial biomass, branched-chain fatty acid as markers of certain Gram-positive bacteria and ergosterol as a marker of fungal biomass. Also, microbial volatile organic compounds adhering to particles have been studied by using solid-phase micro-extraction in combination with GC-MS. A large heterogeneity of microbial exposure has been found when comparing school environments in three very different climatic regions (Jordan, Poland, Sweden). It was further documented that bacterial endotoxin appeared to be protective against respiratory disease, whereas fungal biomass was related to adverse health effects.

Scientific productivity: The project has shown very good scientific productivity with a number of peer reviewed journal articles and papers in international refereed conference proceedings. The project has also resulted in on doctoral thesis in medical microbiology.

Scientific quality: The application of chemical-analytical methods for the description of the microbiology of indoor environments has been proven to be very valuable. The scientific quality of this work is very good.

17. Effects of small particles of pollutants mainly containing plasticizers on indoor environment and health

Björn Lundgren, SP Swedish National Testing and Research Institute

Project funding: SEK 800,000
Project time: 2001–2003

Project description: Part of a large study covering persistent allergic symptoms in children based on the concentration of phthalates in dust collected from homes. From a cohort of 10,852,198 cases with persistent allergic symptoms and 202 without symptoms were selected. The study shows that phthalates are associated with allergic symptoms. It is believed that the different symptoms are related to three major phthalates and explained by a combination of chemical physical properties and toxicological potential.

Scientific productivity: Two identical proceeding papers covering validation of measuring methods and one detailed journal article.

Scientific quality: Valuable study of good quality with potentially global perspectives and implications with regards to understanding of, and giving means to improve, indoor environment.

18. Effects of sorption and ozone on perceived air in the indoor environment

Björn Lundgren, SP Swedish National Testing and Research Institute

Project funding: SEK 1,000,000
Project time: 2001–2004

Project description: The objective of this project was to clarify to what extent ozone (O_3) and O_3/limonene in interaction with surface materials have an impact on the perceived and measured indoor air quality in typical offices without specific contamination sources, and at typical outdoor exchange rates. A full scale intervention setup was designed to vary air change rates, ozone, limonene and general background contamination from interior sources. In all, eight environmental conditions were tested over a total period of twelve weeks. Ozone alone or in combination with limonene did not affect perceived air quality and indoor chemistry at higher air change rates. At a rate of 0.3 air changes per air the perceived air quality deteriorated considerable and increased the ratio of reactive compounds to stable compounds.

Scientific productivity: The productivity from this project has been acceptable with two conference papers and one paper submitted for a peer-reviewed international journal. However, the content is roughly identical in all three papers.

Scientific quality: This is a valuable study, which has increased the understanding of mechanisms behind indoor air chemical transformations due to reactive species. The test programme has been rather ambitious with probably too many covariates. The results indicate that indoor air chemical transformations cannot be ignored as modifiers of indoor air quality. However, the study fails to quantify the role of chemical transformations in relation to air change rates.

19. Effects of short-lived and reactive compounds on indoor air quality

Björn Lundgren, SP Swedish National Testing and Research Institute

Project funding: SEK 1,000,000
Project time: 2001–2003

Project description: A project proposal is described aiming to identify, explain and assess health effects of short-lived and reactive compounds in indoor environments. The project has not been started and no outcomes are available. A student thesis on indoor chemical reactions with peroxyacetylnitrate (PAN) as outcome is presented. However, the project description presents a scientific background and important basis for the study. If this project is completed the results may close some important knowledge gaps on whether short-lived reactive compounds play a role in inflammatory and sensory airway responses among particularly sensitive subgroups (such as hay-fever patients) in residences.

Scientific productivity: Except from the student thesis no scientific production has been produced. A valuable summary of references and a plan for the research study is presented. In all, the scientific productivity of this project poor.

Scientific quality: The scientific quality of this project cannot be evaluated, since no specific publications or other scientific outcomes have been produced.

20. School environment in theory and practice

Lena Lundin, Kristianstad University

Project funding: SEK 900,000
Project time: 2001–2003

Project description: The goal of the project was to develop a model for how general impressions of the environment is formed by the physical environment together with contextual and constitutional factors. In one part (n=290) selected individuals (17-62 years) were asked to judge air quality in typical locations as grocery, florist shop, a smoking-area in restaurant etc. and in classrooms. In a second part (n=5,651) pupils aged from 10 to above 17 years were asked questions on SBS, study situation, stress etc, and furthermore there was psychical measurements of air quality in some of the schools. Results show that when people are asked how they generally think about air quality in classrooms, they judge it more negatively than when they are

asked in specific settings, and that within the judgement in the specific situation, the pupils combine expectations of environment and their actual experience.

Scientific productivity: The only product from this project is a description in the Formas Status of Research Report. It is stated that publications are being planned, but besides a final report for Formas, there is no indication where the project participants plan to publish their project outputs. Thus, the scientific productivity is not satisfactory.

Scientific quality: The project goals and methods are relevant and the preliminary results seem interesting, but it is not possible to judge the scientific quality of the project outputs before publications are made available.

21. Preventive measures in schools for asthmatic and allergic children

Hans Martin Mathisen, SINTEF Energy Research, Department of Energy Processes, Indoor Environment and Energy Use, Norway

Project funding: SEK 270,000
Project time: 2001–2002

Project description: This project is based on an earlier intervention study in eleven elementary schools covering 1,100 children aged 12 – 13 years and 400 teachers. The interventions consisted of upgrading of poor ventilation systems and replacing carpets with vinyl flooring. Three schools with poor ventilation standard, four schools with carpets and four reference schools participated. Health related symptoms where registered with the aid of questionnaires before and after the interventions, including a questionnaire on symptoms and asthma management in order to identify hypersensitive children. Compared to reference schools, the results from the intervention schools showed that the number of health related symptoms were reduced for both children with and without hypersensitivity.

Scientific productivity: The only publication made available for evaluation is a paper from an international conference. Judged from this material the scientific productivity is limited.

Scientific quality: Based on the limited reporting it is difficult to judge the scientific quality of this work.

22. Ventilation for reduced allergen exposure in classrooms

Magnus Mattson, Centre for Built Environment, University of Gävle

Project funding: SEK 700,000
Project time: 2001–2002

Project description: The project has compared mixing ventilation and displacement ventilation as to their efficiency in reducing exposure of 12-year old pupils in four classrooms. Switching between the two ventilation types was performed according to a cross-over design and particles, cat allergen, carbon dioxide and temperature were measured in the classroom air at different levels above the floor during regular school lessons. Symptoms

were registered with the aid of questionnaires, inflammatory markers were measured in nasal lavage and nasal congestion was measured using acoustic rhinometry. There did not appear to any large differences between the two main ventilation principles as to their efficiency in extracting airborne contaminants from the classrooms.

Scientific productivity: The publication rate from the project is limited. Two papers from international conference proceedings with very concrete conclusions are presented.

Scientific quality: The scientific quality of the available publications is acceptable. The results are very applicable and give useful knowledge in order to design well-functioning ventilation systems.

23. Sensitization of occupants of water damaged buildings (SENOC)

Lars Mølhave, Department of Environmental and Occupational Medicine, University of Aarhus, Denmark

Project funding: SEK 450,000
Project time: 2002–2005

Project description: Human volunteers have been experimentally exposed in chambers to dust from dry and water damaged buildings. The study is doubly blinded, the subjects were exposed once every week and the design is replicated three times on three groups of subjects each including nine individuals. The study has passed the experimental stage, whereas analysis of biological and dust samples is ongoing.

Scientific productivity: There have been no publications from this project yet.

Scientific quality: The testing regimen is interesting and scientifically sound. It is not possible to evaluate the scientific quality of the outcomes of this project at the present time.

24. Experimental studies on physiological effects of the indoor environment – intervention studies that can generate medically based knowledge to create a healthy built environment

Dan Norbäck, Department of Medical Sciences/Occupational and Environmental Medicine, Uppsala University

Project funding: SEK 900,000
Project time: 2001–2003

Project description: The aim of this project has been to develop and apply clinical-physiological tests and symptom registration in intervention studies. The project included seven sub-projects covering health effects of building dampness and microbial growth, propylene glycol aerosol 'disco smoke', contaminated supply air filters, and different types of material and design of supply-exhaust ventilation systems. The studies support previous findings indicating that building dampness and microbial growth, including building dampness in the floor construction, may lead to ocular and respiratory symptoms and physiological responses. The results from the ventilation studies show that the design and use of material in the ventilation system may have health consequences.

Scientific productivity: The project has shown good productivity with several peer- reviewed journal articles and publications in international refereed conference proceedings. Two PhD-students have been involved in the project and are expected to defend their theses the next 2-3 years.

Scientific quality: The results of this are primarily of a confirmatory nature, rather than novel scientific knowledge. The various studies have been well planned, conducted and reported. In addition, the project has generated important practical results related to ventilation design and maintenance.

25. Low frequency noise in the living environment – effects on health and consequences of noise attenuation

Kerstin Persson Waye, Department of Environmental Medicine, University of Gothenburg

Project funding: SEK 2,726,000
Project time: 2001–2003

Project description: The aim of this project has been to increase the knowledge of adverse effects due to low frequency noise in the home environment. Sleep disturbance was studied in a sleep laboratory while subjective reports of annoyance and presence of symptoms were collected in epidemiological studies in home environments with different levels of low frequency noise exposure. It was found that low frequency noise exposure during night can disturb sleep. A finding of an attenuated cortisol response in one study could not be replicated in a second study. Ventilation/compressor noise is perceived as annoying by a large proportion of the respondents exposed to this type of noise. It was in the same range as the prevalence of annoyance due to heavily trafficked urban streets. Some of the sleep variables and health variables occurred more frequently among subjects with bedroom facing a yard with higher noise levels, compared to those with a bedroom facing a yard with lower noise levels.

Scientific productivity: The scientific productive of this project has been very good with a number of articles in peer reviewed journals and publications in international refereed conference proceedings.

Scientific quality: An important finding of this project is that low frequency noise should be factored in to the total noise exposure situation when evaluating adverse reactions to noise. The quality of the publications from this project is good.

26. Indoor moulds – measurements and health effects

Ragnar Rylander, Department of Environmental Medicine, University of Gothenburg

Project funding: SEK 1,200,000
Project time: 2001–2003

Project description: The overall goal of this project was to investigate the relationship between indoor mould exposure and the potential for inflammatory reactions in exposed individuals. In a first study, persons with high levels of the microbial cell wall agent glucan in airborne dust had a lower number of cytotoxic T-lymphocytes in their blood. In a second study persons from the first study were challenged in pure glucan in an exposure chamber. Persons who lived in houses with high levels of glucan had a lower secretion of TNFa from stimulated blood monocytes after inhalation of glucan. In a third study with 26 new persons a relationship was found between the amount of total IgE in serum and the amount of glucan or muramic acid in floor dust. A relationship was also found between the amount of airborne endotoxin and the secretion of IFNg/IL-4. Taken together, the results from the project demonstrate that indoor microbial cell wall agents may cause inflammation and affect the immune system.

Scientific productivity: The productivity of this project has been very good with the publication of a number of articles in peer-reviewed journals and presentations at international scientific meetings.

Scientific quality: The results from this and previous studies carried out by the principal investigator are important since they indicate that there may be a possibility to set threshold values for endotoxin and glucan in airborne dust. The scientific quality of this project is very good.

27. Development of a chamber test for odour emissions of building products

Kristina Saarela, Technical Research Centre, VTT, Finland

Project funding: SEK 500,000
Project time: 2001–2003

Project description: The aim of the project was to set up testing conditions which can be used for both chemical testing and sensory assessment for a broad variety of building materials and furniture. Performance characteristics of a standard sensory (diffuser) 100-litre chamber were compared with a 5m^3 chamber, where sensory as well as chemical tests were performed. A finding was that the size of sensory test panel has a major effect with regards to testing costs and accuracy.

Scientific productivity: A literature study, mainly covering the existing Finnish and international standards and guidelines has been performed. The main work has included a significant number of sensory, as well as, chemical tests, revealing clear differences resulting in practical conclusions, as reported in the status report. However, only one paper has been published in internationally refereed conference proceedings.

Scientific quality: The work performed has covered very important aspects with regards to improving environmental material testing and use, and development of new materials. The scientific work shows both a scientific and practical aim, it has been well performed as judged from the status report, and the quality is acceptable.

28. Building physics measurements in 400 dwellings – partial project within DBH-2

Ingemar Samuelsson, SP Swedish National Testing and Research Institute

Project funding: SEK 1,598,000
Project time: 2003–2004

Project description: This is a partial project within the large study (DBH) covering persistent allergic symptoms in children based on the indoor environment in their homes. Measurements have been performed of temperature, relative humidity and air exchange rates. The general results indicate low air change rates in the homes, and that low air change rate is related to condensation.

Scientific productivity: One report has specifically been presented from this project containing measurement data. However, these data have been included as important information to the scientific reporting from the overall DBH project.

Scientific quality: A typical measurement report without containing new scientific knowledge. It lacks scientific discussion of other research in this area and details around the results obtained. It is obviously an important basis for the health assessments that has been undertaken in other parts of the main DBH project.

29. Medical examination of children – dampness in buildings and health (DBH)

Torben Sigsgaard, Aarhus University, Denmark; Carl-Gustaf Bornehag, Swedish National Testing and Research Institute and Karlstad University; Mikael Hasselgren, County Council of Värmland; Jan Sundell, Technical University of Denmark; Ivan Brandslund, Vejle County Hospital, Denmark and Staffan Janson, Karlstad University

Project funding: SEK 950,000
Project time: 2001–2003

Project description: The project involves a nested case-control study including 198 children with symptoms and 202 healthy controls, and thus is the clinical core project of the second phase of the DBH-study (Dampness in buildings and health) (see also project description 4). Methods included detailed clinical examinations by physicians, allergy testing and determination of inflammatory markers in nasal lavage and in exhaled breath condensate. Methodological issues have been investigated and results have been achieved regarding selection bias in case-control studies on asthma and allergy and validation of questionnaires concerning self-reported symptoms and building characteristics. An interesting finding was the association of concentration of phthalates in dust and rhinitis, eczema and asthma. Data analysis on the impact of volatile organic compounds in air, mould spores in air, allergen in dust, and endotoxins and ergosterol in dust are ongoing.

Scientific productivity: As part of the multi-centre DBH study, this project has already an excellent scientific productivity with a number of articles in peer-reviewed international journals and in conference proceedings, in addition to a number of other publications (see also project description).

Scientific quality: As reported for project 4, the multi-centre study has a very good scientific quality. This part of the study has examined important methodological issues in case control studies, as well as generated interesting new hypotheses on the potential role of phthalates in respiratory allergy and asthma.

30. Endotoxins, mould and glucans in dust – dampness in buildings and health

Torben Sigsgaard, Aarhus University, Denmark; Carl-Gustaf Bornehag, Swedish National Testing and Research Institute and Karlstad University; Peter Thorne, Environmental Health Sciences Research Center, University of Iowa, USA; Lisbeth Larsen, Danish Technological Institute, Denmark and Jan Sundell, Technical University of Denmark

Project funding: SEK 700,000
Project time: 2001–2003

Project description: This project is also a part of the multi-centre DBH study (see projects 4 and 29 above). The present project is the microbiological part of the second phase of the DBH study and consists of measurements of endotoxins, glucans and mould spores in the dust samples in the homes of cases and controls. The analyses have been performed in three different laboratories. An increased reporting of symptoms was found for exposure to Penicillium. Analysis of the association between endotoxin and glucan in dust and inflammatory markers and case status is ongoing.

Scientific productivity: As part of the multi-centre DBH study, this project has already an excellent scientific productivity with a number of articles in peer-reviewed international journals and in conference proceedings, in addition to a number of other publications (see also 4 and 29).

Scientific quality: As reported for projects 4 and 29, the multi-centre study has a very good scientific quality. This part of the study has provided the important data on exposure to micro-biological components and their potential for causing persistent allergic manifestations in children.

31. Detailed studies of the sink effect

Hans Stymne and Peter Hansson, Department of Technology and Built Environment, University of Gävle

Project funding: SEK 1,500,000
Project time: 2001–2003

Project description: The project aim has been to develop of mathematical modelling and apply experimental techniques in order to study sink (sorption) effects of and in materials. Two different dynamic chamber methods have been used. The study can be characterised as basic research of methodological nature. Estimated model parameters were shown to be able to yield a reasonably good fit to experimental data for the sorption process, but a less satisfactory fit for the desorption process.

Scientific productivity: The work has been summarised by the researchers in a separate note. The scientific productivity is good including one doctoral thesis and nine reviewed articles and other publications.

Scientific quality: The work shows an acceptable quality when assessing the whole scientific production covering the period 1997–2004.

32. Novel techniques for analysis of microbial and volatile organic compounds in indoor dust

Christer Tagesson, Department of Molecular and Clinical Medicine, Division of Occupational and Environmental Medicine, Faculty of Health Sciences, Linköping University

Project funding: SEK 1,200,000
Project time: 2001–2003

Project description: The project has developed a new analytical technique, gas chromatography/UV-spectroscopy and applied this to the measurement of low molecular weight compounds in indoor dust. This has included analysis of microbial components such as endotoxin and glucan, as well as volatile organic compounds. Quantitative analysis has been performed on dusts from 389 residences, the highest concentrations were found for saturated aldehydes. In addition, a number of alkenals were identified. The analytical method has been used in the multicentre DBH study. In stepwise logistic regression analysis, a number of the volatile organic compounds showed increased odds ratios of symptoms of asthma and/or allergy as was found for nicotine, whereas other compounds were associated with reduced risks.

Scientific productivity: This project has shown good productivity with several articles in peer reviewed international journals and international conference proceedings. A med. lic.-dissertation has been based on this project and two doctoral dissertations are being planned.

Scientific quality: The developed analytical methodology has shown its utility as an adjunct to more classical gas chromatographic/mass spectrometric methods for identification and quantification of indoor air components. The quality of the present project is good.

33. Flame retardants and plasticizers – biologically active air contaminants in indoor environments

Conny Östman, Department of Analytical Chemistry, Stockholm University

Project funding: SEK 900,000
Project time: 2001–2004

Project description: The goal of the present project has been to identify and quantify organic flame retardants and plasticizers in indoor environments and building materials. More specific aims are to develop methods for sampling and analysis of indoor air, measurement of air samples from different environments, measurement of emissions from building materials and measurement of emissions from electronic equipment under controlled conditions.

Scientific productivity: No scientific publications or other outputs have been made available from this project. Based on this, the productivity is not acceptable.

Scientific quality: The scientific quality of this project cannot be evaluated.

34. Legal aspects related to healthy buildings from a user perspective. Description of research needs

Susanna Skogsberg, Hyresgästföreningen, Uppland

Project funding: SEK 350,000
Project time: 2000–2002

Project description: This project is more an assessment of research needs, rather than a proper research project. The point of departure is that the knowledge of sick buildings does not reach practice and that the legal system could meet this problem, both regarding new buildings and regarding existing buildings. However, there has not been any research at all within legal aspects of sick buildings, why the purpose of this project is to uncover the need for legal research regarding sick buildings. The project restricts itself to only focus at existing buildings with rented apartments. The project concludes that research is needed within four areas: 1) cross legal view of the subject, 2) analysis within environmental legislation, 3) analysis within tenants' legislation, and finally 4) analysis with the possibilities of using environmental declaration or labelling of dwellings.

Scientific productivity: The project has resulted in a final report for Formas and a draft of a handbook to be used by tenants, both in Swedish language. There is no reporting from this project in the Formas Status of Research Report:

Scientific quality: Even though the project is not really a research project, the theme is relevant and within the purpose of the programme. As the project has a more elucidating character than being an actual research project, the project outcome is not so relevant to publish in the scientific literature. There are problems with the quality assurance of the reported material.

35. Intervention study of electrostatic air cleaning in class-rooms

Carl-Gustaf Bornehag, Swedish National Testing and Research Institute

Project funding: SEK 125,000
Project time: 2002–2004

Project description: A field intervention study has been carried out to evaluate if air cleaners are an efficient and effective alternative to increased ventilation. A double-blind test is planned to be performed in two rural and two urban schools, and in two classrooms in school settings. Each type of condition will be established over a one-week period. The project will include measurement of classroom air particulate density down to an aerodynamic diameter of 0.3 mm in addition to volatile organic compounds. Symptom registration, including such of allergy and asthma, will be performed with the use of questionnaires.

Scientific productivity: The project has not started so there are no publications available. Thus at present, the productivity is poor.

Scientific quality: No reports have been produced, so the scientific quality cannot be evaluated.

36. Are PCB levels in indoor air lowered by exchanging PCB containing elastic sealants? Remedial actions of PCB containing elastic sealants in indoor environments – methods, techniques and efficiency

Björn Lundgren, Swedish National Testing and Research Institute

Project funding: SEK 590,000
Project time: 2002–2004

Project description: This project has undertaken measurements of air concentrations before, during and after remedial actions to remove PCB in two locations, i.e. a hospital and a school. The work is not completed, but the investigator has drawn some conclusions.

Scientific productivity: An early draft of a scientific summary has been published.

Scientific quality: An evaluation of the scientific quality cannot be undertaken at the present time. Concise conclusions have been drawn from the project out-comes, however, the reporting is incomplete for a comprehensive quality evaluation. Details around filter quality and removal procedures and equipment will improve the possibility for assessment.

37. Market implementation of new knowledge of building water damage

Johnny Andersson, Scandiaconsult Sverige AB/Rambøl Inc

Project funding: SEK 300,000
Project time: 2001–2004

Project description: This is an information project covering water damage in buildings (initiated in 1987). The main focus is on a description of activities and installations to avoid water damage. The scope of the project is to spread the knowledge.

Scientific productivity: Since this is not a research project, but an information project, no scientific publications have appeared. On the other hand, information has been widely spread through papers, booklets, reports, guidelines and conference presentations.

Scientific quality: An assessment of scientific quality is not applicable.

Formas, the Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning, is a governmental research-funding agency. Formas encourages and supports scientifically significant research related to sustainable development.

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