EUROPEAN PROJECT HOPE (HEALTH OPTIMISATION PROTOCOL FOR ENERGY-EFFICIENT BUILDINGS)

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ABSTRACT
In January 2002, a new European project named HOPE (Health Optimisation Protocol for Energy-efficient Buildings) started with 14 participants from nine European countries. The final goal of the project is to provide the means to increase the number of energy-efficient buildings that are at the same time healthy, thus decreasing the energy use by buildings, and consequently, resulting in a reduction of CO_2 emissions from primary energy used for ventilation, heating and humidity control. The outcome will comprise of a methodology for assessing the performance of buildings according to a set of health-energy integrated defined criteria, to improve unhealthy or low energy efficient buildings. This paper presents the background and the methods applied for this three-year European project.

INDEX TERMS
Healthy buildings, energy-efficient buildings, multi-disciplinary study, European investigation

INTRODUCTION
From the perspective of the occupants of a building, the ideal situation is an indoor environment that satisfies all occupants (i.e. they have no complaints) and does not unnecessarily increase the risk or severity of illness or injury. The current situation is far from this ideal (Bluyssen et al., 1995; Preller et al., 1990; Fisk, 2000; Sundell, 2000, Institute of Medicine, 2000, Jantunen et al., 1999) and the potential from improving the indoor environment is high.

The potential for energy reduction in buildings is also quite high. It is possible to find office and housing buildings in the Nordic latitudes with the same level of annual energy consumption (mostly for heating) of the order of 150 kWh/m^{2}year, while in the Mediterranean area there are buildings consuming more than twice for offices (heating and cooling) and less than one tenth for housing. However, there are cases at high latitudes where figures of around 50 kWh/m^{2}year have been reached.

In principle, it is economically feasible to create buildings that are both energy-economic and healthy, and are therefore truly sustainable and energy-efficient. For example, its is possible to select materials having both a low embodied energy and low emissions so that the energy required for ventilation is low. In some climates, this will consequently reduce energy use for other purposes, such as heating, cooling and humidifying. This will, in turn, result in a reduction in capital expenditure and embodied energy in an HVAC (Heating, Ventilating and Air-conditioning) plant. In the longer term, healthier buildings will lead to a reduced need for expenditure of money and energy on remedial measures and medical treatment.

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For the US (270 million inhabitants), the estimated annual savings and productivity gains are 2 to 4 billion dollars from reduced allergies and asthma, 10 to 30 billion dollars from reduced sick building syndrome symptoms and 20 to 160 billion dollars from direct improvements in worker performance that are unrelated to health (Fisk, 2000). Extrapolating these figures to the European Union (375 million inhabitants), this would result in savings and gains of 3 to 6 billion Euro from reduced allergies and asthma, 15 to 45 billion Euro from reduced sick building syndrome and 30 to 240 billion Euro from direct improvements in worker performance that are unrelated to health (1 Euro = 0.94 Dollar). This makes a total savings and productivity gain of 50 to 290 billion Euro per year.

It is known that energy used in buildings represents more than 40% of the total primary energy used in Europe (500 Mtoe (millions of oil equivalent) or $2x10^{10}$ GJ for energy use in buildings). Approximately 20-50% of the consumption is related to heating and cooling purposes, depending on climate and economical development of the different EU countries. Energy use to compensate for ventilation loss is about 30% of heating and cooling energy in buildings, and may reach 50% in modern, well-insulated buildings (Alvarez, et al., 1996). Efficient energy recovery on ventilation loss may reduce this loss by 70%. However, the situation is such that, despite the growing demand for energy recovery equipment, the current efficiency in practice often turns out to be much lower than expected or claimed to be.

The achievement of healthy buildings can be pursued by designers, constructors, building owners and building occupants, through the application of a number of qualitative and quantitative health-based criteria. Although there is a rich scientific literature and several national experiences on this subject, a uniform set of criteria across the European countries has not yet been defined. These health-based criteria can be prescriptive, relating to technical aspects of the building design and construction and its operation and maintenance, or can be performance-based, relating to the achieved conditions in terms of indoor environment, effective air change rate, exposure to pollutants or hazardous conditions, acoustic and lighting comfort, etc.
Also for the achievement of energy-efficient buildings, a uniform approach across Europe does not exist, on account of remarkable geographic, cultural and climatic differences. Prescriptive energy efficiency criteria make reference to the use of specific design and construction schemes, the adoption of specific operation and maintenance regimes, or the installation of particular technical solutions or equipment in the buildings. Performance-based criteria relate to parameters such as the actual amount of energy used per unit of space or per occupant as explained above, or, more globally, the life-cycle energy balance of the building. Some guidelines or protocols are available to improve the performance of buildings with respect to health and energy efficiency. But none of these are agreed at European level or are complete with respect to energy efficiency or health aspects. Some protocols to measure the health and energy efficiency status have been developed, such as the protocols developed within the European IAQ-Audit, the TOBUS and EPIQR projects (Bluyssen et al., 1995; Caccavelli et al., 2000).

There may be a conflict between strategies to reduce energy use and to create healthy buildings. While there is a strong logic to improve energy performance by attention to healthy indoor environments, more needs to be done to realise the potential. Action needs to be directed at both improving guidance on how to realise the potential, and making a convincing case for the building industry to make changes.

Therefore, the European project named HOPE (Health Optimisation Protocol for Energy-efficient Buildings: Pre-normative and socio-economic research to create healthy and energy-efficient building: contract no.: EUK6-CT-2001-00505) was started in the beginning of 2002. The fourteen participants from nine European countries have the challenge to answer the following questions in this three-year project:

- What is a healthy building and what is an energy-efficient building?
- What is an energy-efficient healthy building?
- Are buildings with energy saving measures energy-efficient? And what is the health status of buildings with energy saving measures as compared to buildings without energy saving measures?
- How can we assure that buildings are healthy and energy-efficient at the same time?

OBJECTIVES

The scientific objectives of the European project HOPE are to:

- Solve the conflict between strategies to reduce energy use and strategies to create healthy buildings;
- Identify European agreed parameters to describe the health status of occupants and energy efficiency status of buildings;
- Develop European agreed techniques to assess the health status of occupants and the energy efficiency of buildings;
- Develop methods to relate the health status of occupants and energy efficiency status of buildings.

The technical objectives are as follows:

- To define a set of qualitative (prescriptive) and quantitative (measurable) performance criteria for healthy and energy-efficient buildings for Europe, bearing in mind the different European climatic conditions, for direct input into standardisation activities. Criteria will relate to parameters of energy use, the indoor environment and health. Health in this project is defined according to the WHO “health is a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity” (WHO, 1999).
- To determine a protocol for testing performance criteria for healthy and energy-efficient buildings.
- To check performance criteria in existing buildings by:
  - a multi-disciplinary study in 180 office buildings and multi-apartment buildings of which 75% are designed to be energy-efficient;
  - a detailed investigation on at least 32 of the above buildings.
- To create a database of the health and energy efficiency status of 180 offices and multi-apartment buildings in Europe, which will offer bench-marks. The database will comprise information on:
  - energy consumption and energy efficiency;
  - comfort and health status of the occupants, in relation to acute symptoms, productivity and sick leave for office buildings and in relation to symptoms of illness such as allergy and asthma in multi-apartment buildings.
- To develop a protocol for improving a building that is unhealthy and/or not energy-efficient, into a healthy and energy-efficient building. The protocol will be relevant to buildings from the north to the south of Europe, and from the east to west.
- To create a web-site for the public, which will include:
  - the progress of the project;
  - the database with the health and energy efficiency status of tested buildings;

- a protocol for testing the performance of a building according to the defined set of criteria;
- the possibility for non-participants to add data on their own buildings into the database and characterise how healthy and energy-efficient their own building is as compared to the investigated buildings;
- a protocol for improving a building.

METHODOLOGY

The project HOPE comprises of five work packages (WPs). WP 1 comprises the co-ordination and management of the project. The logic of the remaining four packages is as follows.

In WP 2, a first set of performance criteria for healthy and energy-efficient buildings will be developed, based on available knowledge. The health-related prescriptive and performance criteria will be based on expert assessment of the available information in standards, guidelines and research papers. Performance criteria will be defined for building design, indoor climate, indoor air quality (in relation to chemical, physical and biological pollutants), ventilation, cleanliness of HVAC systems and components, emissions from building materials, and requirements for commissioning, operation and maintenance.

The energy-efficiency-related prescriptive and performance criteria will also be based on expert assessment of the available information in standards, guidelines and research papers. Performance criteria will be defined for, among others things, energy for heating, cooling, air conditioning, cooking and office appliances, lighting, building services, the building automation system, domestic hot water).

In WP 3 these criteria will be tested in existing buildings by performing a multi-disciplinary study in 180 office buildings and multi-apartment buildings, of which approximately 75% have been designed to be energy-efficient. This will be carried out in nine European countries, and will be followed by a detailed study in at least 32 of the investigated buildings (WP 4).

The multi-disciplinary study (WP 3) will be performed using three kinds of screening methods: (a) an inspection of each building, (b) interviews with management and maintenance personnel and (c) questionnaire surveys of occupants. These studies will provide data to:

- check the first set of performance criteria to determine and to make corrections where necessary;
- make an inventory of information on energy consumption and energy efficiency;
- make an inventory of the health and comfort status of the occupants (expressed, for example, in relation to acute symptoms, productivity and sick leave for office buildings and in relation to symptoms of illnesses such as allergy and asthma in multi-apartment buildings);
- create a database to benchmark the health and energy efficiency status of European buildings.

The detailed study (WP 4) will comprise of a sample selection of the buildings investigated, buildings that have a low energy use, to characterise the differences between those that are healthy and those that are not. The final goal is to determine the presence/absence of a list of illnesses/conditions with reasonable certainty. This detailed study will provide data to:

- check the set of performance criteria to determine whether expectations were accurate, and to make corrections to the list where necessary;
- check the proposed method to measure these performance criteria;

- transform where possible quantitative measured performance criteria into qualitative descriptive performance criteria;
- provide guidelines to improve unhealthy and low energy-efficient buildings;
- determine the presence/absence of a list of illnesses/conditions with reasonable certainty.

And finally, WP 5 will comprise of the dissemination and exploitation of the results of the project. With the outcome of WP 3 and 4, a final methodology for assessing the performance of buildings according to this set of criteria, will be defined. A set of health-energy integrated guidelines to improve unhealthy or low energy-efficient buildings will be generated for direct input in standardisation activities. A Web-site will be created for the public, which will include the results of the project and the possibility for non-participants to make their own multi-criteria analysis of how healthy and energy-efficient their building is, as compared to the investigated buildings. A protocol including the guidelines for improving a unhealthy and low energy-efficient building will be made for architects, building managers and maintenance persons. And, additionally, international and national dissemination activities will be performed.

DISCUSSION

This project appears in a very singular moment. It is now recognised that a great effort is needed to manage the energy consumption from the demand side both reducing the use of fossil fuels and promoting the use of renewable energies and sustainable techniques. While enhancing the ambient air conditions and reducing the environment malfunctions at the global level, it becomes more obvious that more must be done regarding the quality of the indoor environment. If sustainability is a condition of survival for future generations the care of the present generation requires attention to the health and comfort conditions.

Some of the more relevant issues are associated with the fact that this is an interdisciplinary field where some links are of technical character but others are of behavioural and physiological nature.

The innovation of this project is the attempt to reach a comprehensive view of some of the most relevant aspects of the compromise between ‘less energy’ and ‘better environment’ at the level of the comfort, health and productivity of the people.

So far quite some work has been done in the context of each discipline. Some drawbacks of such a biased approach are already classical. That was the case of the health problems in Nordic countries associated with the drastic reduction of the air exchange rates per hour after the oil crisis of the 80’s. But there are many other examples of misjudgement or cultural bias such as the dissemination of air conditioning habits in regions where its use could be very selective. It is well known today that it is possible to distinguish between two kinds of comforts: the ‘air-conditioning based comfort’ which creates somehow the habit and the ‘adaptive comfort’ which allows for much more flexibility.

The challenge is to create a very well confined project with very well known and controlled boundary conditions to be able to get some clear pictures in such a complex issue. If those objectives are met, as it is planned, many new avenues will be opened towards more effective and operative ways of managing the different problems under the different perspectives of each discipline.

The project HOPE will include a comparison between buildings with and without energy saving measures and will include buildings from nine European countries, i.e. with different climatic, cultural, design and construction conditions. However, this study cannot prove causal links between environment and illness. The number of confounders and the behavioural feedback loops, make it impossible with such a small cross-sectional study. Nevertheless, buildings that do not appear to be causing health problems will be identified and characterised. For this, the best balance of health and environment data that the project can afford will be used. The health status of the occupants will be characterised, taking into account what is already known about the aetiology of illness, but it is not expected to produce new knowledge about the aetiology of illness.

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