Final Report Summary - ENVIE (Co-ordination action on Indoor Air Quality and Health Effects)

The aim of the ENVIE project was to increase the understanding of the Europe-wide public health impacts of indoor air quality by identifying the most widespread and significant indoor causes for these health impacts and evaluating the existing and optional building and housing related policies for controlling them. It addressed in particular how indoor air quality might contribute to the observed rise in asthma and respiratory allergy, together with other acute and chronic health impacts. The intention was not to conduct new experimental or field research, but rather to build on the broad scientific experience and the wealth of accumulated literature from the domestic and international indoor air research projects as well as the EU, WHO, ISIAQ and CIB committees and expert groups during the past 20 years.

Buildings play a multitude of roles in air pollution exposure:
(i) Depending on the national energy 'mix', climate zone, typology, quality and age of the building stock, circa 40% of the primary energy is used to heat, light and ventilate buildings and to run a variety of electrical equipment in buildings from elevators to personal computers. Consequently, buildings are
directly and indirectly responsible for a similar proportion of air pollution from heat and power generation by burning conventional fossil fuels. 

(ii) The building structure and materials as well as other sources in buildings - from invisible dirty air ducts and water damaged mouldy insulation materials to unflued combustion appliances, candle burning and the use of organic solvents, hypochlorite and ammonia containing cleaning agents, for example - contaminate the air inside the buildings where people spend most of the time.

(iii) 20 to 100 % of the concentrations of outdoor air pollutants are transferred inside the buildings - depending strongly on the pollutant of concern and the ventilation or air conditioning system - and, consequently, most exposure to so-called outdoor air pollution occurs indoors. For traffic pollution, about half the total exposure, on average, occurs indoors and the other half while in transport or outdoors. In summary, buildings have a large impact on both outdoor and indoor air quality (IAQ) and, relative to outdoor air pollution; buildings may significantly increase or decrease people's air pollution exposures. Buildings are, therefore, the most important factor in air pollution exposure and associated health effects.

The complexity of indoor pollution sources, effects pathways and the multitude of parties responsible for generating and respectively controlling indoor air pollution make the coherent development of risk reduction strategies a challenge. To be effective, policies directed at improving IAQ need to be part of a comprehensive, internally and externally consistent management strategy involving governments, institutions, professional bodies and individuals. Plans need to be directed at both new and existing buildings and involve action at both local and national levels. Important considerations include outdoor climate and air quality, building materials and styles, knowledge and behaviour patterns of the occupants, energy and sustainability policies, and building system technologies. Requirements for the establishment of a successful strategy include prior justification, goal setting, appraisal of management options, and political willingness.

Many previous indoor air quality and policy assessments have taken specific contaminants or indoor sources as the starting point. The logic behind this is the flow of molecules from sources via the environment to exposure, whole body dose, target organ dose, and the consequent health outcome. ENVIE follows an opposite logic, starting from consideration of the most pronounced indoor air related health outcomes (which may have also other sources and causes), then identifying the most widespread indoor air exposures that are likely to cause these health outcomes and the most common sources which dominate the indoor air exposures. The intention was to focus from the start on those indoor air quality issues that have the highest Europe-wide health relevance. Having defined a shortlist of such 'reverse' indoor health-exposure-source chains, the project evaluates the policy alternatives for minimising both unwanted health consequences, in terms of achievable public health benefits, and invasiveness, while taking into account political, legal, technological, economical and social feasibility. A further outcome is the identification of a set of highly advisable and feasible indoor air quality policy options for Europe. Europe-wide applicability brings the benefits of enhanced competition in a broader marketplace.

The selection of issues for and the structure of this report is based on the ENVIE concept, starting from (i) the selected shortlist of high priority indoor air quality related public health concerns, identifying (ii) the key indoor exposures that are believed by most experts to significantly contribute to these health outcomes, (iii) identifying the sources which are known to significantly contribute to these indoor exposures and finally, (iv) identifying and assessing the existing and missing policies to control these sources (and consequently
Identifying and assessing the existing and missing policies to control these sources (and consequently the health outcomes) as well as the critical new research that would be needed to develop the missing policies. The first three issues were covered in the ENVIE WP1, WP2 and WP3 final reports. The WP4 (final) report concentrates on the last issue, that is, the indoor air policies.

The ultimate outcome of the WP4 report is a list of proposed IAQ policies. Most policies affect one or multiple indoor air pollution sources and activities. At first, however, the exposures and sources of interest, and policy assessment objectives are defined.

Although many IAQ policies depend on and/or overlap with others, the public health benefits that could be achieved by each policy are here each assessed individually. This assessment does not consider the costs or political feasibility of the policies, and it is assumed that each policy is fully implemented throughout the building stock.

The assessment follows the ENVIE concept from starting with the shortlist of health impacts: SBS, sensory irritation, asthma and respiratory allergy, infectious diseases, lung cancer, cardiovascular disease, COPD, acute intoxication; then the ENVIE shortlist of exposures: VOCs, combustion products, bio-aerosols, pathogens, radon, carbon monoxide; and finally the ENVIE shortlist of sources: AAQ (implications for building envelope, ventilation and air cleaning), radon (implications for building envelope, ventilation and air cleaning), building materials, fixed heating and combustion equipment/appliances, ventilation and air conditioning systems, water systems, dampness and mould, furnishings, interior surface materials and electrical appliances, cleaning and other household products and smoking (cooking hobbies, pets).

The overall health risk (sum of the listed health risks) reduction potential of each policy is then evaluated according to its potential for reducing each of the exposures from each of the listed sources. Because smoking, when present, is such an important source of indoor air pollutant and, health risk, separate analyses were done including and excluding ETS.

As the first step loss of healthy life (expectancy), expressed as 'disability adjusted life years' (DALY), for each country in Europe was assessed for each health impact due to indoor exposures originating from each of the listed sources - 24 assessments in all.

The reference level of all these estimations is ideal IAQ, not good IAQ, i.e. zero risk from zero exposure, no indoor emissions and no transmission of outdoor air pollutants or radon to the indoor environments. Consequently, the report is on the health impacts, causal agents and sources of non-ideal IAQ rather than poor IAQ. The reason is that zero is a clear and unambiguous reference level, albeit not a realistic one. The alternative reference level, borderline between poor and good IAQ, in contrast, is far from solid, being neither commonly agreed nor easily defined. Indoor air quality guidelines, which aim at giving some qualified answers to the question of good versus poor IAQ have been developed in the INDEX report, are currently being updated in a DG SANCO funded and JRC coordinated revision of the INDEX and also are the focus of an ongoing WHO programme. This should be kept in mind when interpreting the data. On the other hand, the presented results can be easily interpreted into more realistic estimations. As an example, reducing radon entry from soil to indoor air by 25% instead of 100% would similarly reduce the lung cancer risk attributable to Radon by 25% of the presented estimates.
Each estimate was calculated as a product of:
(i) underlying national burden of disease (BoD) for each health impact (e.g. asthma) in each country;
(ii) population attributable fractions of the disease (e.g. asthma) caused / aggravated by the indoor air contaminants in the ENVIE shortlist of exposures, which originate from indoor and outdoor environments (0 - 1.0);
(iii) proportion of the indoor air contaminants in the ENVIE shortlist of exposures originating from each of the ENVIE shortlist of sources in the (0 - 1.0).

For each country, this analysis produces a list of 24 DALY estimates for the BoD attributable to the ENVIE diseases linked to the ENVIE exposures and the respective sources. The list is reduced from the theoretical 336 (7 diseases x 6 exposures x 8 sources) to the more manageable 24 because most diseases are caused by only a few or only one exposure from few or single sources, and by summing up for each source and disease the DALYs from multiple exposures.

On average, about half of asthma and respiratory allergies are caused by indoor air exposures, and about half of these from exposures of indoor origin. At any rate, most of the changes which could explain the increase in asthma have occurred in the indoor environment. Sick building syndrome comes in third position, but it is also the most unspecific block of symptoms with the largest uncertainties. Arguably, all SBS DALYs can be attributed to indoor environments, but the prevalence of SBS as well as the severity valuation of the symptoms carries both large uncertainties and inconsistencies between countries. Its DALY significance is more likely over- than underestimated, but its economical significance is, nevertheless, very large due to its impact on work productivity and absenteeism. The high contribution of indoor air to lung cancer is primarily due to radon and secondarily to combustion generated particles from both indoor and outdoor sources. The more than 100 000 DALYs due to CO poisoning are certainly an underestimation CO exposure shortens individual life more than any other IAQ related factor and the CO-dependent DALYs are among the most cheaply and easily preventable. Tobacco smoke, which remains outside of this evaluation, contributes significantly to all of the above diseases except CO poisoning (although tobacco is also a source of indoor air CO).

The recommendations on policies can be grouped and summarised as:

Policies concerning energy efficiency, building materials, products and maintenance
- integration of IAQ into the EPBD procedure for buildings;
- development and application of European harmonised protocols for IAQ testing, reporting and labelling for building materials, equipment and products (common IAQ monitoring procedures) (REACH, GPSD);
- providing for each building systematic documentation and operating, inspection and maintenance manuals for all installations and assigning a sufficiently qualified person with control of all documentation and responsibility for all building tasks.

Policies concerning the impacts of outdoor environment
- mandating radon-safe construction for all new buildings;
- applying tight building envelopes, balanced ventilation and air cleaning for all new / renovated buildings when ambient air quality is below WHO.

Policies concerning specific building constructions and equipment
Policies concerning specific building constructions and equipment:
- banning of all unflued combustion heaters, equip gas stoves with exhaust hoods and fans, mandating CO detectors regular maintenance / inspection for all combustion devices (integrate with EPBD procedures);
- development of health based ventilation guidelines to control exposure to pollutants from indoor and outdoor sources, including indoor moisture, and ensure comfortable indoor temperature;
- mandating regular inspection and maintenance of all ventilation and air conditioning systems. (integrate to EPBD);
- developing moisture control guidelines for building design and maintenance, to prevent persistent dampness and hidden and visible mould growth, and keeping domestic hot water (tap water) temperatures above 55 degrees Celsius;
- providing kitchens, bath- and laundry rooms with controlled extract ventilation, bath and laundry rooms also with waterproofed surfaces;
- avoiding spaces, structures and materials that would not dry by convective airflows.

Related documents

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