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Ranking indoor air health problems using health impact assessment

ANNEXES

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A.1 :LIST OP WORKSHOP PARTICIPANTS

Name		Institute
Baden	R.	Ministry of Health, Department of Environmental Medicine
Bouland	C.	Brussels Region - Department Health and Indoor Pollution
Braubach	M.	WHO - European Centre for Environment and Health
Capouet	M.	FPS - Public Health
Constandt	K.	Flemish Goverment, Environment and Health
Daümlingen	C.	Federal Environment Agency
De Brouwere	K.	VITO - Flemish Institute for Technological Research
D'Hooghe	B.	European Panel Federation
de Oliveira Fernandes	E.	University of Porto
Degallaix	L.	BEUC - the European Consumers' Organization
Deschamps	C.	Test-achats
Fuchs	M.	DG Enterprise
Gallo	G.	European Commission, DG SANCO
Garny	V.	CEFIC – Euro Chlor
Giersig	M.	CEFIC - Bayer Material Science
Ghinea	L.	CEFIC - European Chemical Industry Council
Goelen	E.	VITO - Flemish Institute for Technological Research
Jantunen	M.	National Public Health Institute
Jensen	G.K	Health and Environment Alliance
Karjalainen	T.	European Commission, DG Research
Kephalopoulos	S.	Institute for Health and Consumer Protection
Kheradnand	H.	Rohm and Haas ER
Klotz	G.	CEFIC - European Chemical Industry Council
Kotzias	D.	Institute for Health and Consumer Protection
Léonard	P.	Department Environment and Health of the Walloon Region
Logghe	P.	BIM - Brussels Institute for Environmental Management
Lolova	D.	National Center Public Health Protection
Luecke-Brunk	G.	Federal Ministry for the Environm., Nature Conserv. and Nuclear Safety
Maziarka	D.	National Institute of Hygiene in Warsaw
Putus	T.	Ministry of Social Affairs and Health
Rudnai	P.	National Instute of Environmental Health
Smedje	G.	Uppsala University - Dpt of Occupational & Environmental Medicine
Spruyt	M.	VITO - Flemish Institute for Technological Research
Thielen	F.	Belgian DG Environment
Torfs	R.	VITO - Flemish Institute for Technological Research
Van Damme	K.	Fedustria
Van Teunenbroek	T.	Ministry of Housing, Spatial Planning and the Environment
Van Tongelen	B.	European Commission - DG Environment
Vanluijk	P.	Ministry of Housing, Spatial Planning and the Environment
Vernon	P.A	MP Europe - Management Partners Europe
Viegi	G.	CNR - Institute of Clinical Physiology

A.2: AGENDA OF THE WORKSHOP

AGENDA

Day 1: 29th March 2007

Review existing actions/policy in the context of action 12 of the Commission's Environment and Health Action plan 2004-2010

Start: 10h00

Morning session (chairman: Eddy Goelen, VITO)

1. **Introduction: 10h00-10h15 (DG Environment + VITO)**
   - Objectives of the workshop

2. **What's going on in the EU concerning the theme IAQ ? 10h15-12h30**

   - the INDEX-project: Critical Appraisal of the Setting and Implementation of Indoor Exposure Limits in the EU (D. Kotzias)
   - the THADE-project: Towards Healthy Air in Dwellings in Europe (G. Viegi)
   - ECA (European Collaborative Action) on Urban air, indoor environment and human exposure (S. Kephalopoulos)
   - The Indoor Air Expert Working Group and ETS policies (G. Gallo)
   - The EnVIE - project : a European co-ordination action interfacing science and policy making (M. Jantunen, E. de Oliveira Fernandes)

12h30-13h30: lunch

Afternoon session (chairman: Rudi Torfs, VITO): 13h30-17h00

1. **EU legislation on indoor air: overview (Katleen De Brouwere, VITO)**
2. **national policies on indoor air in different Member States**:

For this session, invited participants of the different Member States were requested to make a short (10 -15 minutes) presentation, outlining the following topics:

1. the Member States indoor air quality policy: legislation (+ relation to EU directives and EHAP);
2. the Member States IAQ priorities, monitoring programmes and control actions;
3. the Member States plans for the future for indoor air quality policy.

The following persons are invited to give a presentation on their Member State policy. This list is limited to 11 out of 25 Member States because of the need to have an equal geographical distribution of Member States in Europe..

the Netherlands	T. Van Teunenbroek
Belgium	C. Bouland
Germany	G. Luecke-Brunck/C. Daümlingen
Finland	T. Putus
Sweden	G. Smedje
Italy	G. Viegi
Portugal	E. de Oliveira Fernandes
Hungary	P. Rudnai
Bulgaria	D. Lolova
Poland	D. Maziarka

The presentations were be followed by a round table discussion. Workshop participants of Member States which were not included in the above list and did not have the opportunity to present their national policy, were also welcomed to provide their active input in this discussion.

Day 2: 30th March 2007:

The future of indoor air health priorities in the EU: recommendations

1. *morning session: 09h00-12h00*

In two parallel sessions, the further needs on indoor air quality actions, control, monitoring and research needs on two topics were discussed in a round-table discussion.
session 1 (chairman : Eddy Goelen, VITO): indoor air pollutant sources: chemicals and consumer product emissions, smoking (ETS),…

session 2 (chairman : Rudi Torfs, VITO): exposure to indoor air pollutants: exposure assessment, exposure-health relations, ventilation and energy efficiency,…

12h00-13h30: lunch

2. *afternoon session: 13h30-15h00*

The outcome, recommendations and conclusions of the 2 morning sessions will be presented and discussed.

15h00: end of the workshop

A.3: DISCUSSION TEXT

INTRODUCTION AND SCOPE OF THE DISCUSSION PAPER

What is the main purpose of the workshop?

The workshop on 29 and 30 March 2007 is part of the study "Ranking of indoor health problems using health impact assessment" on behalf of the European Commission. The Commission's Environment and Health Action plan 2004-2010 includes a specific action on indoor air (action 12). In 2007 the Commission will proceed to a mid term review of the implementation of the Action Plan. With this study the Commission aims at obtaining an overview of:

- the current Member States' policies and activities on indoor air monitoring and control programs
- important knowledge gaps on indoor air quality, exposure and health impact
- the Member States' future approaches and recommendations on monitoring and control programs of indoor air quality

For this project the input from Member States' policy makers and experts in the domain of indoor air quality is of great importance. We aim to elicit this information from you during this workshop in order to develop recommendations for the Commission.

In brief, what we expect from participants is a short overview of national policies on indoor air quality, the limits of the approach and their ideas on how to overcome these limitations. The workshop will start from this existing knowledge developed in European studies, and from the existing legislation in the EU and in Member States. It is intended to take the information from both international studies and Member States' policies a step further, in order to provide

(1) recommendations for future (EU-wide) policies;
(2) recommendations on strategies to control and monitor indoor air quality;
(3) a focussed list of priorities for further research.

How do we want to structure this workshop?

Day 1 is intended to take stock of both European actions and studies, and national initiatives. We acknowledge the fact that information presented on day one – especially on the EU projects- will already be known to some participants. We therefore ask the presenters of these studies to include some (personal) considerations on the gaps and recommendations that can drawn from their study.
In a European workshop like this it is difficult to squeeze all the information of national policies, studies and lessons learnt in an afternoon session. We try to structure this by means of the questionnaire. We foresee the opportunity to present about 10 cases in the afternoon.

Day 2 will be devoted to monitoring and control strategies, and to research needs for two topics: (a) sources and source reduction; (b) exposure and exposure reduction.

What will we do with your contributions?

There are two separate issues here:

1. your contribution during the workshop. On day two it is the intention to come up with a set of recommendations. These recommendations will be reported to the Commission, with reference to the workshop, and where necessary to national examples.
2. your contribution through questionnaires will be used in a summary of exposure and risk data of indoor air pollutants and sources in Europe, and in an overview of the national policies related to indoor air.

'Rules of engagement'

1. Share their thoughts constructively, to have an open discussion of achievements, but also on the limits encountered:
2. Listen generously to other people's ideas/comments/suggestions/views; keep an open mind to different perspectives;
3. Help each other to overcome language difficulties. The Workshop language will be English, but this may not be a limiting factor in sharing information and discuss/oppose to ideas.
4. Focus on subjects relevant to the objective of the workshop

Purpose of discussion text

This text serves as a guidance text to enhance the discussion of the day 2 workshop session. In the text below, we depict the current priorities, policies, actions and further needs on indoor air quality in the EU. It's a discussion note: it is therefore not authoritative, sometimes a bit provocative but mainly a tool to focus the discussion. We also acknowledge that is incomplete, given the many initiatives in Europe and in the Member States.

PRIORITIZATION OF INDOOR POLLUTANTS

'Indoor air quality' refers to a wide range of pollutants (chemical, biological, physical factors). In order to establish indoor air quality policies, it is essential to identify the priority of pollutants, and thus to figure out for which pollutants a policy plan is mandatory and urgent.

On overview of explicit (INDEX[1], SCHER opinion[2], indoor air expert working group[3]) or implicit (THADE[4]) prioritization of indoor air chemicals performed in former EU projects or working groups is listed in *Table 1*. WHO assessed the need of indoor air quality guidelines in a workshop in 2006[5]

Table 1: priority indoor pollutant list investigated in EU coordinated studies

Pollutant	**Study**					**Status**
	SCHER	INDEX	THADE	IAEWG	WHO	
ETS	X		X	X		SCHER-high concern
Radon	X			X	X	SCHER-high concern
Formaldehyde	X	X	X	X	X	INDEX-group 1* SCHER-high concern
CO	X	X	X	X	X	INDEX-group 1 SCHER-high concern
Particles	X		X	X	X	
NO_2	X	X	X	X	X	INDEX-group 1 SCHER-high concern
Lead	X					SCHER-high concern
Organophosphate pesticide	X		X			SCHER-high concern

[1] INDEX : report available at http://www.jrc.cec.eu.int/pce/documentation_reports.htm
[2] SCHER opinion http://ec.europa.eu/health/ph_risk/committees/04_scher/docs/scher_o_048.pdf
[3] presentation on Consultative Forum on Environment & Health , 30 November 2006, Brussels
[4] THADE: Towards Healthy Air in Dwellings in Europe, available at http://www.efanet.org/activities/documents/THADEReport.pdf
[5] WHO working group http://www.euro.who.int/Document/AIQ/IAQ_mtgrep_Bonn_Oct06.pdf

Pollutant	**Study**					**Status**
	SCHER	INDEX	THADE	IAEWG	WHO	
Benzene	X	X		X	X	INDEX-group 1
Naphthalene	X	X		X	X	INDEX-group 1
Moulds	X		X	X	X	
Mites	X		X	X		
Dampness/Moistures	X		X	X	X	
CO_2 (indicator for ventilation)	X		X	X	X (ventilation)	
Acetaldehyde		X				INDEX-group 2*
Toluene		X				INDEX-group 2
Xylenes		X				INDEX-group 2
Styrene		X				INDEX-group 2
Ammonia		X				INDEX-group 3*
Limonene		X				INDEX-group 3
α- pinene		X				INDEX-group 3
VOCs			X			
Man-made mineral fibres			X			
Pesticides			X			
Biocontaminants			X			
Viruses			X			
Bacteria			X			
Dander from furred animals			X		X	
Microbial allergens			X		X	
Insects			X			
Green plants			X			
Pollen			X		X	
Halogenated compounds					X	
PAH					X	

INDEX group 1: high priority compounds, group 2: second priority compounds, group 3: chemicals requiring further research with regard to human exposure or dose response

Prioritization of indoor pollutants was the main objective of the INDEX project (Critical Appraisal of the Setting and Implementation of Indoor Exposure Limits in the EU). The prioritization of these compounds in itself is already the result of a an exposure, dose-response and human health impact analysis.

The INDEX project applied a step-wise approach to reach a prioritization of indoor compounds. At a first stage, INDEX applied 4 criteria to select chemical compounds for the available EU-wide scientific literature: 1) only single compounds, 2) the compound should have common indoor sources, which dominates the exposures of at least significant fractions of the population, and 3) the compound should have known health effects, 4) compounds which have been regulated by specific guidelines or regulations have been excluded. The latter applies to radon and tobacco smoke. At the first stage, 40 candidate pollutants were retained. Of these 40 compounds, 15 were excluded in the second phase because of one of the four of the following criteria 1) no expressed concern of health at present levels, 2) compounds already regulated by use restrictions for indoor materials, 3) incomplete or no dose-response data available at present levels and 4) the main route for the exposure to the compound is other than indoor air. In a further phase, the compounds for which a detailed assessment was performed was restricted to 14 compounds. These 14 compounds were classified in a group 1 (high priority chemicals), group 2 (second priority chemicals) and group 3 (chemicals requiring further research with regard to human exposure or dose response) based on a hazard identification process. The **high priority compounds** (group 1) according to INDEX are **benzene, formaldehyde, carbon monoxide, nitrogen dioxide** and naphthalene. Group 2 consisted of acetaldehyde, xylenes, styrene and toluene. Group 3 consisted of - α-pinene, limonene and ammonia.

In addition to the chemical pollutants considered in INDEX, the THADE project expanded the list of investigated pollutants with particulate matter, ETS, man-made mineral fibres, pesticides, and biological pollutants (bacteria, fungi, fungal spores, viruses, algae, parasites, pet dander allergens, dist mite allergens, plant pollen and insect pest allergens). The exposure assessment performed in the THADE project did not include a ranking or prioritization of the various indoor pollutants.

In the recent draft opinion of the SCHER (Scientific Committee on Health and Environmental Risks) on “Risks assessment on indoor air”, the SCHER stated that, at the moment, priority ranking of chemicals and exposure which causes concern is difficult and uncertain due to the scarcity and variability of data. Nevertheless, the SCHER putted **formaldehyde, carbon monoxide, nitrogen dioxide, benzene, naphthalene, ETS, radon, lead and organophosphate pesticides** forward as compounds of concern in the indoor environment. The five former compounds are based on the results of the INDEX-project, the four latter ones were out of the scope of the INDEX project (see above), though need attention when aiming at obtaining an overall picture of indoor air pollutants.

The EU expert group on indoor air mentions ETS, radon, formaldehyde, carbon monoxide, particles, nitrogen dioxide, benzene, naphthalene, moulds, mites, dampness/moisture and carbon dioxide (as indicator for ventilation) as pollutants where available evidence would suggest possible actions.

Taking the common prioritization from SCHER, INDEX, THADE, WHO and the indoor air expert working group for **ETS, formaldehyde, CO, particles, NO_2, benzene, naphthalene, moulds, mites, dampness/moisture and CO_2** (as indicator for ventilation) into account, we recommend to focus the indoor air policy on these compounds. Exposure to other compounds is either less harmful for human health, either requires further research before translation into policy, or exposure reduction by indoor air policy is probably not the most efficient way to reduce exposure (radon, lead).

ETS is included in the list, but the policy approach is different from the other pollutants. The health mechanisms and the exposure to this pollutant are clear, policy papers and measures are in place. Policy options for future strategies against ETS are elaborated in the green paper “Towards a Europe free from tobacco smoke: policy options at EU level.”

Radon is an outsider in the list of indoor pollutants because of completely different sources (gas diffusion from soil to residences where bedrock contains in excess uranium), expertises and policy measures than other indoor pollutants. Mites pose a specific and well described problem, and dampness is also framed in a context of old buildings and poor housing standards. Similar to ETS separate policies and actions can be set up to tackle these problems.

Lead is excluded based on the criteria applied in INDEX, namely, inhalation of indoor air is not the main route for exposure to lead.

Does exposure to organophosphate pesticide require further research, prior to flag it as a high priority compound for policy recommendations?

Finally several documents mention that even the largest exposure or risk studies do not cover the multitude of pollutants that occur in indoor environments (e.g. different organic compounds). This is a problem that can’t be solved in the near future, and basic exposure and toxicological/epidemiological research is needed to gradually fill this gap. At the same time this knowledge gap is no argument to abstain form policy making for the known priority pollutants.

Question 1: do you agree that the EU indoor air quality policy should focus on the list of priority compounds below? Are any priority compounds on this list redundant or others lacking?

Do you agree that policies and measures to tackle ETS, radon, mites and dampness might better be separated from chemical pollution policies?

ETS
formaldehyde
CO
particles
NO_2
benzene
naphthalene
moulds and mites
dampness/moisture
CO_2

EU POLICY ON INDOOR AIR QUALITY

The EC's policy on **ambient** air quality has been implemented since 1970-1980 by means of legislation on both (1) emission sources and (2) air quality standards. It's instructive to look again to the Air Quality framework directive from 1996 (OJ L296/55 November 1996) and subsequent daughter directives. This Framework Directive covers the revision of previously existing legislation and the introduction of new air quality standards for previously unregulated air pollutants, setting the timetable for the development of daughter directives on a range of priority pollutants. Parallels to an approach for indoor air pollutants can be made.
The importance of **indoor** air quality to human health is growing. Indeed, people spend 90 % of their time indoors, and indoor air is in many cases of worse quality than outdoor air. Studies have been pointing to indoor air pollution for decades (see e.g. the ECA reports), and the importance of indoor air quality at the EU level was stressed in the Commission's Environment and Health Action Plan 2004-2010 (EHAP). The EHAP includes a specific indoor air action (action 12) with two key elements: (1) addressing environmental tobacco smoke (ETS) and (2) developing networks and guidelines on other factors affecting indoor air quality by using research and exchange of best practice.

With regard to indoor air policy strategies, three categories of indoor air spaces are to be considered:

1. workplace ~ occupational environment
2. private (dwelling) spaces ~ individual's environment
3. public spaces ~ space with a mix of employees and individuals (e.g. a public bus is an employee environment for the bus driver and a 'individual' environment for passengers)

Options for indoor air quality policies depend on the type of indoor air spaces.
Ad1) Indoor air quality standards are enforceable (and in place) in the workplace environment, and these indoor environments are out of scope of this study. It is however worth mentioning that indoor air quality guidelines applicable for indoor air in dwellings might originate from occupational studies.

Ad2) Due to individual freedom and privacy, air quality limits are difficult to enforce in private spaces. Other, indirect policy options (e.g. product standardization, and building ventilation) are the best way forward to ensure a healthy indoor climate in private (and public) indoor environments. Central is that individual use of products causing indoor air pollution is hardly enforceable, whereas policies restricting the emission of indoor pollutants can be achieved by imposing standards to producers.

Ad3) In public places, emissions can be regulated, and product use can be subjected to certain limits. The best example in this respect is ETS. This is being tackled through the green paper and the proposal of a ban on cigarette smoking in public places. Other indoor pollutants – if any- emitted by individuals present in public indoor environments are not under scrutiny.

Question 2: Agreement on ETS: is there any reason to change the current policy and direction of the EC towards ETS in public spaces? Are there other examples in which the public is both an active polluter and passively exposed in public spaces, that can be

tackled similarly(that are thus easier to enforce)?

Question 3: From a Member States' perspective, is this the logic distinction between micro-environments (private, public, occupational). Is it therefore logic to define different policies and strategies in these three types?

Question 4: From a Member States' perspective, do you agree that the focus should be on public spaces first, and more specific on places like schools, day-care centres and homes for elderly people?

In contrast to the well elaborated and implemented EU ambient air policies (under the form of the Air Quality framework directive 1996), an integrated EU policy on indoor air quality is not available. Currently, indoor air quality is fragmentally tackled in sector-oriented policies (e.g. EC directive on gas appliances, … see below), but a an overall, integrated indoor air policy at the EU level is missing. The idea of a comprehensive legal basis is not new[6], but it is mostly discarded because of practical reasons. However, as with ambient air, envisaging such framework directive might be useful as guidance for both research and future action plans.

Question 5: The establishment of an integrated framework on indoor air quality might be a future objective (Figure 1). Do you agree?

Three cornerstones for an indoor air policy could be (1) indoor air quality guidelines, (2) indoor air monitoring programmes and (3) sanitation plans. This concept is analogous to that of the ambient air quality framework directive 96/62/EC. In fact, indoor and ambient air quality policies should be geared one to another because the same compounds in both indoor air and ambient air affect human health, and indoor air quality is influenced by outdoor air pollution.

[6] see e.g. http://www.umweltbundesamt.de/uba-info-daten-e/daten-e/health/TA-Innenraum_en.pdf

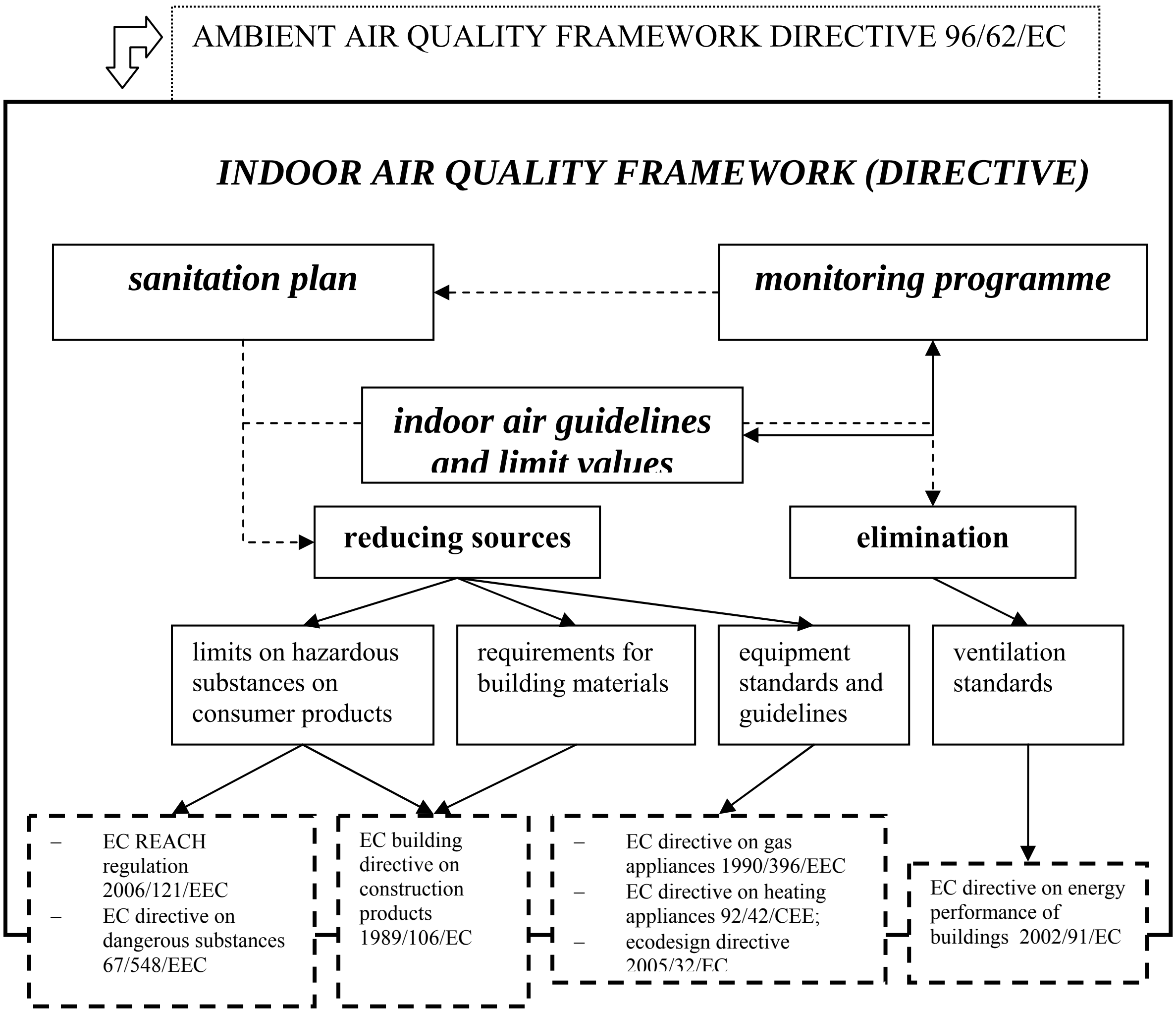

Figure 1: Framework for an integrated indoor air quality policy structure in the context of existing EU legislation

Evaluating the results of indoor air monitoring programs against indoor air quality guidelines and limit values could activate sanitation plans if thresholds are exceeded. The WHO indoor air quality guidelines could serve as a basis for these EU indoor air limit values. Sanitation plans could be either of a source reducing kind or of a indoor air pollution eliminating (exposure reducing) kind. Depending on the compound, measures related to reduce emissions of consumers products, building materials, equipment, … are best in place as a measure to reduce the indoor air pollutant source.
At the moment, EU directives regulating standards for construction products, dangerous substances, gas and heating appliances, ventilation standards,… contain provisions for indoor air quality.

The main EU directives including explicitly a indoor air quality aspect, or indirectly regulate indoor air quality are:

- the construction products directive 89/106/EEC Essential Requirement N°3 "Hygiene, Health and the Environment"
- the energy performance of buildings directive 2002/91/EC
- the gas appliances directive 1990/396/EEC
- the heating appliances directive 1992/42/CEE
- the eco-design directive 2005/32/EC
- the dangerous substance directive 1967/548/EEC
- the general product safety directive 2001/95/EC

The REACH regulation (2006/121/EEC) is also expected to influence indoor air quality. Other EU instruments contributing to good indoor air quality are the eco-labels. These (voluntary) EU eco-labels restrict for example compounds such as VOC's, formaldehydes,… in indoor paints and varnishes, in bedding mattresses, clothes, indoor textiles, …

These fragmented provisions which are part of other EU directives could be embedded as daughter directive(s) of an overall indoor air quality policy. Benefit of this approach is transparency, simplification and it provides a framework to avoid poor air quality due to multiple sources indoor (a combination of building materials, appliances and consumer products).

Question 6: Overall, from experience in EU countries, are regulations stipulated in the current directives sufficient to guarantee a healthy indoor environment?

Notwithstanding that the above mentioned EU directives on indoor air apply to all Member States, some are rather vague defined and Member States have the freedom to choose the form and instruments to implement the EU directives in their national policies. The result is binding, while the form is not.
This approach results in a widely varying state of implementation of directives in the national policies in different Member States. For example, in Germany, the Construction Products Directive 89/106/EEC is converted into German national laws with the "Bauproduktengesetz" (BauPG-1992-08-10). In addition, the programme "Ausschuss zur gesundheitlichen Bewertung von Bauprodukten (AgBB, 2004) has implemented testing procedures for floor covering and floor covering adhesives. The testing procedure includes an extensive list of pollutants for which limits must be complied for admission to the German market. Voluntary schemes are available in other countries, e.g. the Classification of Indoor Climate in Finland. Other Member States have less strict regulations and testing procedures for materials contributing to indoor air pollution. In the United Kingdom, the Building regulations 2000 (Statutory Instrument 2000 No. 2531) apply in England and Wales to ensure the health and safety of people in and around buildings. They also provide provisions for access to and around buildings and energy conservation. Technical Guidance papers include amongst others the maximum emission of formaldehyde from insulation and the minimum ventilation rates in dwellings.

The CPD has been transposed into Belgian national legislation through the Law of 25 March 1996 and the Royal Decree of 19 August 1998 regarding products intended for construction and in France with "Décret n° 92-647" and its amendments. In France, AFSSET has developed a scheme comparable to the AgBB scheme in Germany, but it is not included in regulatory requirements yet.

Question 7: From your experience, does the current approach work? Is there a need for more precise and common interpretation and uniform practical implementation of EU directives? Or do MS prefer the freedom on the way to implement directives? Do the different approaches (e.g. focus on construction products legislation versus focus on ventilation legislation) in the MS lead to the same level of indoor air quality, in other words, do they lead to the same result?
And does a freedom of implementation provide a suitable business environment for industry (common market)?

The major part of the legislations aiming at improved indoor air quality came into force during the last decade. Indeed, indoor air quality is becoming of great importance with tighter building envelopes, lower ventilation rates and the use of wide varieties of different building materials during the last decades. However, some indoor air quality problems (e.g dampness/moisture) could be typical for older buildings, constructed long time before current construction regulations were in force. The same applies to older indoor sources (e.g. old gas appliances, …). Given the long life time of dwellings, a policy to improve indoor air quality of older buildings might be advisable.

Question 8: How do you see this? (new buildings vs. old buildings and appliances (gas, heating system)). Are there policy options to improve indoor air quality in old buildings?

MONITORING AND CONTROL PROGRAMMES

Pursuing indoor air policies should be accompanied by efficient controlling and monitoring to test if policies are successful in complying the aims of good indoor air quality, to alert if a sanitation plan is mandatory, or the steer new policies if aims are not achieved. But, as e.g. COMEAP states[7], *the equipment needed (to monitor) is complex and expensive and likely to be beyond the means of private householders. In such cases, it might be asked whether recommending guidelines is worthwhile on the grounds that compliance cannot be tested.*

What do we mean by monitoring? In ambient air monitoring is set up to evaluate the ambient air quality (daughter) directive's limit values. This generally done in accordance with quality and quantity requirements in the framework and daughter directive. Stationary monitoring stations provide continuous data on ambient air quality. Specific case studies, related to particular problems (traffic, urban air pollution, industrial hot spots) are used to provide additional information, that might be needed to impose additional abatement measures. Air quality modelling is used for complete coverage of a country, in cases where measurements are not required by law, or to provide insight in

[7] http://www.advisorybodies.doh.gov.uk/comeap/PDFS/guidanceindoorairqualitydec04.pdf

the efficiency of additional reduction measures. National bodies have sufficient authority to evaluate ambient air where and when they want.

In public spaces national authorities still have the freedom to intervene and to measure. But country-wide coverage is difficult, given the high number of places and measurements needed. Spot checks and sample surveys might be the best way to monitor indoor air quality in public spaces.

In private homes consent of the inhabitants is needed, unless specific laws enable indoor air quality checks. Even when intervention levels or action levels are defined for private spaces, the problem of monitoring remains.

Control policies generally involve emission control, in the context of product standards and product labelling schemes. In indoor environments exposure control can be accomplished through inspection of ventilation, and health and environmental agencies can perform inspections in public spaces, e.g. with respect to ETS.

Currently, none of the EU directives prescribes explicitly a monitoring and control programme for indoor air quality. For example, Essential Requirement N°3 of the Construction Products Directive 89/106/EEC states that "the construction work, must be designed and built in such a way that it will not be a threat to the hygiene or health of the occupants or neighbours, in particular as a result of any of the following:

- the giving-off of toxic gas,
- the presence of dangerous particles or gases in the air.
- the emission of dangerous radiation
- pollution or poisoning of the water or soil,
- faulty elimination of waste water, smoke, solid or liquid wastes,
- the presence of damp in parts of the works or on surfaces within the works"

without further specifications on how these requirements must be monitored.

To our knowledge, no PAN-European indoor air monitoring system is currently installed, and information on national monitoring strategies is being collected at the moment.

Indoor air monitoring studies in the EU have been performed in the framework of scientific research programmes such as EXPOLIS, INDEX, THADE, AIRALLERG, and many others. National research programmes in Member States (e.g. the FLIES study: Flanders Indoor Air Exposure Survey[8]; report on Indoor Air Quality in Bulgaria[9], various reports from IEH and BRE in the UK, and many others[10]) may also contribute to knowledge on methods.
Though, these studies are generally of a scientific kind aiming at understanding indoor air quality, and generally do not serve as a systematic control mechanism of indoor air quality. Assessment protocols have been described, e.g. in the UK and by ECA, but have not been implemented on a country wide and permanent basis. With this information,

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[8] reports of the FLIES study available at http://wwwb.vito.be/flies
[9] Lolova et al., 1997. Indoor Air Quality in Bulgaria. *Indoor and Built Environment, 6: 237-240.*
[10] The IERIE database contains over 200 different projects related to indoor air pollution http://wads.le.ac.uk/ieh/ierie/index.htm

we'd like to open the discussion on the usefulness and the practical aspects of the set-up of a European indoor air quality monitoring network.

Question 9: Is there an indoor air quality monitoring programme currently installed in your Member State? Is EU wide monitoring feasible? Which efforts need to be taken to harmonize monitoring protocols across the EU?

RESEARCH NEEDS

In the course of the preparation of the Environment and Health Strategy research needs were also elaborated. Initial ideas on research were developed at the Egmond aan Zee consultative forum and in "Research Needs in the framework of the European Environment and Health Strategy (COM 2003)338 final, Proposal for actions" :

- exposure effect assessment, exposure patterns,
- determinants and implications for safety thresholds,
- risk assessments,
- networking exposure data bases,
- modelling of exposures and effects in buildings,
- standardization, harmonization and cooperation across Europe,
- multidisciplinary approaches.

Question 10 remains whether this research need still stands. Is it being tackled? By which programs and member states? Is there a need to have a more practical guidance on research, and how should it look like?

The text of the research on indoor air pollution states the following:

Option for action:
Organize the monitoring of indoor air pollutants to determine the exposure of the general population including sensitive groups at European level

What is happening just now?
Up to now exposure data to indoor air pollutants are collected from various and scarce surveys, for different objectives and are based on very specific designs which cannot give a comprehensive understanding. They very rarely include a representative sampling of population at any level and less likely provide quantitative information useful for risk assessment at policy making level.

What is the problem?
The lack of comparable and representative indoor pollution exposure data at member state levels as well as at European level is missing to quantitative risk assessment and is impairing the establishment of comprehensive and effective health and environment polices regarding air pollution in general, the impact of indoor pollution being very poorly known.

How does this option contribute to the goals of the Strategy ?
1) to the European Integrated Environment & Health Monitoring and Response System :
– Generate synergies and facilitate the sharing of data and methodologies
– Increase the understanding of the environment and health relationship
– Improved data availability, accessibility, comparability

– Enhanced exchange of information
2) to improve public health with respect to environmental risk factors
3) to the research agenda
4) to raise awareness, to educate
This action is a direct contribution to the European Integrated Environment & Health Monitoring and Response system

Main stakeholders affected by the option and how they are affected:
Scientific community will find comparable data to be used in risk assessment
European Commission will directly use data from this action to elaborate policies finding basis for establishing indoor air thresholds, source control measures, incitatives, and population information.
This action should be flexible enough to allow Member states to run specific investigation providing sub data sets taking into account the national characteristics of building stock.
Construction stake holders at large will find information helpful to develop products, techniques, building design, operation and maintenance procedures having a positive effect on indoor air pollution and consequently to health.

What would be the work programme?:
1- Set up a programme involving leading European scientific teams
2- Set up priorities in term of a) buildings b) population c) pollutants
3- Elaborate survey designs and set up data base frame
4- Organize and implement the surveys based on member state implications
5- Collect data and manage data base
6- Result interpretation, dissemination
The general idea is of a "permanent" programme developing along a priority scheme closely interacting with the European Policy Agenda.

A.4: WORKSHOP QUESTIONNAIRE

As stated in the discussion paper, Member States have a relative freedom to implement the European Directives in national legislation. Furthermore, most Member States have there own, national, funding for monitoring campaigns and there own control programs. Where the stock-taking of pan-European legislation, research actions, and initiatives is relatively easy, the set of actions that have been taken in the different Member States is too extensive to be reviewed correctly without input from the different Member States.

To facilitate the discussions at the workshop, we would like you to complete the questionnaire as far as possible. In an European workshop like this, it is difficult to squeeze all the information of national policies, studies and lessons learnt in an afternoon session. We try to structure this by means of the questionnaire. Please provide us your questionnaires by 22 March. We will make an overview. Answers can consist of plain text (summaries) or internet links to public available information (preferably English).

The primary interests of the project and the workshop are the national monitoring- and control programs, with the resulting exposure-, and health assessments; and the policy priorities in the different Member States, with, if possible the subsequent successes and flaws. Your input will be used in a summary of exposure and risk data of indoor air pollutants and sources in Europe (question C), and in an overview of the national policies related to indoor air (question A and B). It will feed into the final report to the European Commission.

We have kept the questionnaire concise. However if you country is very active in the field of indoor air quality, we would appreciate that you would provide as much information as possible.

Question A Priorities in National Policy

A.1	**Which is the determining factor in policy making: national problems associated with IAQ, European directives, or the (National) Environment and Health Action Plan?**
…	
A.2	**Which are the priority pollutants?**
…	
A.3	**Does the national policy concentrate on source reduction (e.g. product policy) or exposure reduction? (e.g. ventilation) (please provide information or links to actual legislation).**
…	
A.4	**Do stakeholders (e.g. NGO, industry) participate in the policy making?**
…	
A.5	**Does the policy focus on mandatory or on voluntary measures?**
…	

Monitoring and Control Programs

Are there active monitoring and/or control programs in the Member State? When not present, can you indicate the primary reason?

A.6	**What is your definition of a monitoring or control program? Can you provide information on the programs, or direct us (link) to information?**
…	
A.7	**Is an evaluation of policy measures implemented in the member state?**
…	
A.8	**Which policy measure were most effective/efficient to improve IAQ? (summary or links)**
…	
A.9	**Which policy measure were least effective/efficient to improve IAQ ? (summary or links)**
…	
A.10	**Can you indicate the most urgent policy measures that should be initiated? (summary)**
…	

Specific national exposure and health impact studies / research

Which studies in your country do you consider relevant for EU policies?

A.11	**Are the resulting data used for exposure assessment, if so can you summarize or direct us to that information?** (e.g. statistics on product uses, living habits, pollutant concentrations, time patterns in micro-environments such as dwelling, school, transport)
…	
A.12	**Are the resulting date used for health impact assessment, if so can you summarize or direct us to that information?** (e.g. sensitive groups, input of indoor air quality on morbidity?, **key problems with indoor air**)
…	
A.13	**Can you indicate what the missing data (e.g. exposure, baseline health,….) are that should be assessed? (summary)**
…	

A.5: OUTCOME OF THE ROUND - TABLE DISCUSSION

On the final day two separate discussions groups were set up, focussing on a set of 10 open questions (see discussion note in annex A3), but looking to the indoor air quality issue from two perspectives: from the point of view of emissions, sources and source reductions, and from the point of view of exposure and exposure reduction. The two groups came up with quite similar suggestions and recommendations. Most answers and recommendations were the shared opinion of the Group. It was not the intention of the workshop to come up with definite answers and conclusions. And although the recommendations are the overall result of a discussion, some issues were not resolved. Mainly because some issues were out of scope (eg. The question whether it is useful to tackle indoor air separately from "the indoor environment"), or because the discussion resulted in an open ended list of suggestions and possibilities. It is interesting to keep especially these issues in mind where no complete consensus could be reached, as they indicate the issues and areas where more research or policy action might be needed in the future to bridge the different opinions. The first draft of the workshop has not yet been reviewed by WS participants. Therefore in the following table the distinction between the two discussion groups is kept. Some additional interpretation is given in the table.

The 10 key questions listed in the questionnaire which was sent to the participants in advance to the workshop were discussed in a round table discussion in 2 parallel sessions. One session (3A) answered the questions from an exposure assessment point of view, whereas the same 10 questions were discussed in session 3B from a perspective of sources and emissions. The outcome of discussion in session 3A and 3B is listed in *Table 2*.

Table 2: outcome of round table discussions on 10 key questions posed in the discussion text. The same 10 questions were tackled in 2 parallel sessions (3A: viewpoint of exposure and 3B: viewpoint of emission sources)

outcome of session 3A (exposure) discussion	outcome of session 3B (emission from sources) discussion
A do you agree that the EU indoor air quality policy should focus on the list of priority pollutants below? Are any priority pollutants on this list redundant or others lacking? (1) ETS, (2) formaldehyde, (3) CO, (4) particles, (4) NO_2, (5) benzene, (6) naphthalene, (7) moulds and mites, (8) dampness/moisture and (9) CO_2	
General comment: • On a general, broad scale, this list indeed mentions the most important priority compounds. However, in individual cases or buildings, exposure to other pollutant(s) not on this list may be of higher concern for exposure and related health effects • It not possible to disentangle 'indoor environment' and 'indoor air quality'. The former is broader and considers also indoor dust, and other physical indoor environment parameters (noise, temperature). It should be kept in mind that 'indoor air quality' and 'indoor environment' do not stand alone, however, the complete picture of 'indoor environment' is beyond the scope of this study, and the discussion will be limited to 'indoor air quality'. No full agreement with the proposed list was found. Specific comments on the selected pollutants are: • Pb: the criteria for excluding Pb (i.e. inhalation was no major pathway for Pb) was questioned as one should start from health effects, and not from sources? The problem of Pb exposure in a study performed in Brussels revealed that Pb exposure in old buildings was attributable to Pb present in old paints. Nevertheless, it is proposed to exclude Pb from the list because it is more related to indoor dust, thus it falls under the issue of 'indoor environment' rather than	• ETS is a source (which emits a combination of compounds). Therefore it should not be on a list of priority pollutants but treated separately. Furthermore, ETS is regulated indirectly when formaldehyde, benzene and particles are tackled as they are part of ETS. • The particle fractions should be defined. • Moulds and mites is too specific. It is better to include: "moisture indicating microbes (mould)". • The number of VOC's to be included is an issue. Adding VOC (C_6-C_{16}, general) would enable the member states to tackle specific IAQ problems. In that context, adding SVOC (C_{16}-C_{22}) might also be included as there is a tendency to replace VOC with SVOC. • Persistent organic compounds, such as brominated flame retardants were also mentioned. But while this category of compounds has a negative impact on IAQ quality, they also save lives, and there are no sufficient health data to balance both aspects. It was decided only to include compounds where the health impact has been proven (same for glycol ethers). TVOC is added as a general indicator.

'indoor air quality'. When assessing the 'indoor environment' exposure to Pb on dust certainly needs to be considered. However, it would lead too far to consider all 'indoor environment' pollutants. • Radon: The question arose why radon was not in the list. It is still a big problem in various regions in the EU. However, different policies and sources (soil, rocks) apply to radon compared to other indoor air pollutants. By omitting radon from this list, we do not want to deny the radon problem, but rather separate the indoor air policy from other indoor air pollutants. • Particles: the pollutant 'particles' should be defined more specifically: It is proposed to stick to the size definition, and to choose for small particles (PM2.5) since the larger fraction PM10 is more outdoor related. Instead of a definition based on size (PM2.5), a combustion related particle definition could be applied. • Particles: The choice for PM2.5 or combustion related particles is OK for most indoor environments. However, for schools and kindergartens, PM10 should be added. PM10 levels in schools can be elevated due to personally produced PM10. • CO_2: CO_2 should be removed from the list of 'priority compounds'. CO_2 in itself is not a health threatening pollutant. However, CO_2 should not be fully excluded as it is an important proxy for ventilation. Therefore, it is proposed to list CO_2 as a 'priority *subject*' next to the list of priority pollutants. • Organophosphate pesticide: this pollutant should not yet be included in the list of 'priority pollutants'. At the moment, not enough data are available to push policy on this	

<table>
<tr><td>compound. More research is needed prior to recommend policy on this pollutant.</td><td></td></tr>
<tr><td colspan="2">discussion; agreement or disagreement between opinion of session 3A and 3B?
o There was a strong disagreement on ETS: session 3B decided to omit ETS from the list (reasons: see above). Session 3A advised to keep ETS on the list, because it would be a big political mistake to remove it. Removing ETS from the list would give the wrong signal to the uninformed public who considers ETS as a pollutant, and this would counteract the current successful EU policy on ETS.</td></tr>
<tr><td colspan="2"><u>Question 1</u>:B Do you agree that policies and measures to tackle ETS, radon, mites and dampness might better be separated from chemical pollution policies?</td></tr>
<tr><td>Yes (nearly general agreement). The effect of mixtures should first be cleared out on the scientific level before, before integration at policy level is possible. A step by step approach (first science, than policy) is advised.</td><td>• Radon, dampness and mites should not be separated from chemical pollution policies.</td></tr>
<tr><td colspan="2"><u>Question 2</u>: Agreement on ETS? is there any reason to change the current policy and direction of the EC towards ETS in public spaces? Are there other examples in which the public is both an active polluter and passively exposed in public spaces, that can be tackled similarly (that are thus easier to enforce)?</td></tr>
<tr><td>• OK, agreement on ETS policy.
• Other examples that can be tackled similarly are:
1) candles, 2) incenses and 3) wood burning in public spaces such as restaurants.
• Comments on the combined presence of active and passive polluters:
small children are always passively exposed to ETS
the responsibility of dwelling owner and dwelling inhabitants (tenants) is similar (active versus passive polluter)</td><td>• There is no reason to change the current policy on ETS.
• Most issues are related to public behaviour, and due to the right on privacy, it can be very difficult to regulate these aspects, source control might be the only way forward.
• Next to ETS, a number of other sources that should be prioritised were identified:
Building and Construction Products (possibly tackled through CPD Essential Requirement N° 3)
Heaters (gas/kerosene/coal) and open fireplaces.
Cleaning Products and Air Fresheners (other?). Would it be suited to change “cleaning” into the broader “Household”?.
Moisture
Office Equipment and Furniture</td></tr>
</table>

<table>
<tr><td colspan="2"><u>Question 3</u>: From a Member States' perspective, is this the logic distinction between micro-environments (private, public, occupational). Is it therefore logic to define different policies and strategies in these three types?</td></tr>
<tr><td>• yes, public spaces are easier to manage. For occupational exposure, well defined rules are in place
• yes, it is logic to define different policies and strategies in these three types.
• some consideration on mixed public - occupational environments:
o In most cases, if standards for occupational exposure are met, the exposure to the public is expected to be acceptable because the former normally exceeds the latter. For example, in public spaces such as shopping malls, swimming pools, the employees spend much more time in these environment than customers or swimmers.
o For some cases, the protection of employees by the limits on occupational exposure does not guarantee protection of (vulnerable) non-occupational individuals spending time in the same environment. For example, children in schools and patients in hospitals are more vulnerable and may spend more time in these environments than employees.</td><td>• The distinction between different micro-environments is logic.
• Policy should distinguish into "work" and "not work"</td></tr>
<tr><td colspan="2">Question 4: From a Member States' perspective, do you agree that the focus should be on public spaces first, and more specific on places like schools, day-care centres and homes for elderly people?</td></tr>
<tr><td>• yes, and more in detail, one should start from relevance to exposure in setting priority of environments. We could enumerate many different spaces with many different risks, all relevant to some extent. However, the total exposure (or dose) should be significant for putting on the list of priority environments
• priority environments are:
o <u>schools:</u> should be on top of the list of priority environments (children: sensitive groups; schools important in the time budget of children; in schools: very often bad indoor environment)</td><td>• Yes, a focus on public places at first is logic.
• Hospitals should also be added, and possibly also public transport.
• For public transport, the cost/benefit relation should be analysed first. There are possibly higher concentrations, but also little time spent.</td></tr>
</table>

o day-care centres o homes for elderly people o hospitals, and more in general health care buildings (nursing homes). Micro-organisms are generally the main indoor problem in these buildings. This is a huge problem and causes many deaths in hospitals in the EU. o transport environments: public transport in general, with special attention to metro systems. Aircrafts should also be considered notwithstanding the limited time spent generally in metro systems, extreme high concentrations have been reported for metro systems (e.g. in New York, Sweden). For example, children travelling daily by metro to school were 10-fold higher exposed to PM than children not never taking the metro. It should be noted that indoor pollution in metro systems can vary largely between systems and cities. o indoor sport facilities: perfect spaces for indoor pollution if badly ventilated, and the high ventilation (breathing volume) of exercising persons can aggravate the influence of air pollutants on the health	
Question 5: The establishment of an integrated framework on indoor air quality might be a future objective (Figure 1 of the discussion text). Do you agree?	
• yes, this could be a long term perspective, but should be seen as a tool, not as an objective as such. • a framework is desirable, a framework 'directive' is a step much too far. The concept 'indoor air framework **directive**' should be avoided (do not use the word 'directive' in vain) • integration between indoor air, ambient air, and energy is strongly advised. These aspects are related to each other, and integration is strongly needed. They do not only influence each other, they contribute together to total exposure	• An integrated and harmonised approach should be attempted. • It might improve the coherence between the existing legislation. • Proposed outline: o All related directives should be taken into account. o Alternative for "Elimination" • There are also other important instruments, such as public awareness that should taken into account.

• when establishing an integrated framework to reduce exposure to air pollutants, there should be a feed-back loop in the system (cfr. methodology of the Envie project) • in such an integrated framework, the focus should be on major, essential components, to protect the people for common pollutants • **the information platform** is lacking in the figure of the discussion note: stimulating the public awareness of indoor air, environmental education (information campaign), or in general improving the human behaviour (relevant for indoor air) is important, especially for private houses (product use, cooking mode, …), the information platform is the major tool to reduce indoor exposure • Factual, objective information needs to be strengthened: consciousness raising without creating unnecessary panic • In the information platform, doctors or other medical staff, social workers etc. could play an active role: inform their patients about the indoor air stressors of their disease, ask patients to describe the indoor environments of their dwelling. Medical staff who visit patients in their homes could also play an important role • Horizontal approach from the EU within the different directives would be highly welcomed. These Directives all tackle indoor air, but in different ways. Harmonisation of EU directives is necessary. This is a main task for the Commission, not for the participants of this workshop. • In such a framework, topics where no actions are needed should be explicitly included	
Question 6A : Overall, from experience in EU countries, are regulations stipulated in the current directives sufficient to guarantee a healthy indoor environment	
• No, is it utopian to protect everyone in every place. The majority of potential exposures requires a 'DIY' solution. The public should be	• To allow a comprehensive answer to this question, a "healthy indoor environment" should be defined. (WHO definition of healthy, IA vs.

<table>
<tr><td>informed to understand the risk, manage the risk and reduce the risk themselves. It is out of the question that a government can do that for you.
There is no way that we ever can guarantee safe indoor environment in every circumstances. Product regulations should be conservative, at least to minimize the risks from misuses.
Misuses cannot be covered by any regulation.
Labelling is the best option to enhance the indoor air quality. However, labelling alone might be insufficient and not reach people who do not understand the labels.</td><td>IE).
The current directives only partly guarantee a healthy indoor environment.
A consistent review of existing legislation is needed to optimise/harmonize the current directives.</td></tr>
<tr><td colspan="2">Question 6B: Does the current approach lead to an overall safe indoor environment. How do you assess the possibility that current legislation might lead to total indoor exposure that is above ‘safe’ thresholds? The fact that we have no healthy indoor environment, is it a matter of regulations? More a matter of behaviour?</td></tr>
<tr><td>it was stressed that regulation are only useful if they are <u>implemented.</u> Implementation is often lacking
If the products are used at what they are aimed at, problems are not expected. However, it is also a matter of behaviour and (mis)use.
EU regulations should have common basis, but flexible at the same time because of large differences in cultural habits between different EU regions (e.g. isolation, ventilation, heating, … of houses in S versus N Europe)
For labelling a harmonised scheme is mandatory (common EU market!)</td><td>There seems to be a need from the Member States for more precise and common interpretation;
But, Member States should have the freedom of implementation. There are large differences in climate and culture amongst the different Member States. Choice of building materials and ventilation practices amongst others can be very diverse. The best measures and the optimal implantation will be not be uniform in all Member States.</td></tr>
<tr><td colspan="2">Question 7: From your experience, does the current approach work? Is there a need for more precise and common interpretation and uniform practical implementation of EU directives? Or do MS prefer the freedom on the way to implement directives? Do the different approaches (e.g. focus on construction products legislation versus focus on ventilation legislation) in the MS lead to the same level of indoor air quality, in other words, do they lead to the same result?
And does a freedom of implementation provide a suitable business environment for industry (common market)?</td></tr>
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- harmonisation between directives would be greatly welcomed (see answer on question 5)
- a standardized EU labelling system is the best way forward (see question 6)
- Harmonised approach on other areas than products labelling (emission testing) (e.g. also in ETS) necessary. ETS is not a harmonised approach. Although the ETS approach might look appealing and efficient there remains a market disturbance between member states. Even on issues like ETS there is no 'level playing field'.
- On the other hand Member States prefer the freedom to implement, given the cultural differences between different regions in the EU

</td><td>

- Up to now, there is no general overall approach
- Although a complete uniform policy is not the way to go, standardisation should be should attempted where possible. The emissions from a particular building material for instance, should be regulated to same level in every member state.
- Overall, common European regulation, where the member states have freedom to choose which options to implement might prove to be the best solution.
- The effect of the freedom of implementation on the (sustainable) building environment. It might be dependant of the range (across member states?) of export of the companies in question. Consistent planning of implementation, and clarification of regulation might have more effect on the sustainability of the business environment.

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Question 8: How do you see this? (new buildings vs. old buildings and appliances (gas, heating system)). Are there policy options to improve indoor air quality in old buildings?

</td></tr>
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- A strong plea to take into account the existing building stock, although more difficult to manage, this is important from a socio-economic perspective. Those who can afford it build or renovate their house.
- A lot of information is missing for old buildings. A monitoring system for old buildings would be useful. Regulations stipulating monitoring system for (old) buildings could help.
- A very simple monitoring system for private houses (e.g. with indicators for CO and humidity; analogous to smoke detecting devices) could improve the indoor quality. If such a devices would be commonly installed in private houses, it would also greatly contribute to the awareness of the pubic for good indoor air quality.
- Member States could perform a policy on improving air quality for renovation works of old buildings: e.g. information campaigns on how to improve IAQ when replacing windows

</td><td>

- There are policy options to improve the IAQ of old buildings, but this issue should be tackled at a national level.
- Although obtaining the same level of IAQ in old as in new buildings should be the goal, measures to improve the IAQ in old buildings should be implemented gradually.
- The measures taken should be positive. The oldest dwellings, with the largest IAQ problems are likely inhabited by sensitive people (health and/or socio-economic). It will be more opportune to reward (e.g. tax exemptions) improvements than 'punish' people who do not take measures.
- Earlier actions to improve potable water (elimination of lead piping) and asbestos abatement were successful, an might be a starting point.

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<tr><td>(attention to ventilation).</td><td></td></tr>
<tr><td colspan="2">Question 9: Is there an indoor air quality monitoring programme currently installed in your Member State? Is EU wide monitoring feasible? Which efforts need to be taken to harmonize monitoring protocols across the EU?</td></tr>
<tr><td>
• Not all Member States have national monitoring programs.
• Monitoring systems (especially for private dwellings) are often based on services for dwellings with complaints (e.g. green ambulances), and thus do not depict the overall status of the IAQ (biased dataset). Demand based data should not be used as monitoring data
• Monitoring systems for private buildings: more difficult than for public buildings
• For cheap monitoring: we do need more innovative tools
• Very simple monitoring systems are required: qualitative criteria rather than complex, expensive quantitative measuring devices. A qualitative monitoring system could be based on observations from occupants. E.g. with standard questionnaires: e.g. do you have mould grow? Observation from occupants; do you smell smoke in your building,…?
• A cost benefit analysis on monitoring systems is required
• It was mentioned that a mandatory, regular check-up of private homes might be a good idea (currently: in most Member States: no control of IAQ at all). Such a regular check-up is not a foolish idea: for our cars, we need an annual technical check-up, and not a all for our dwellings: striking difference!
• Statistics on IAQ: Eurostat? The health sector could be involved in establishing statistics on IAQ
• Professionals who come in the homes of people could play a role in monitoring systems (health care people, chimney cleaners)
</td><td>
• Not all member states have national monitoring programs. From the member state present, there are currently no monitoring programs in Portugal, Finland and Bulgaria. In other member states, monitoring programs exist, but there are designs. In the Netherlands, the IAQ of every building must be assessed prior to delivery (mandatory). In Belgium (2/3 communities) an assessment can be requested (voluntary). There is also a monitoring program (voluntary?) in Germany.
• In Belgium, measurement of indoor TVOC and formaldehyde concentrations is also provided by a consumer organisation.
• At a EU- level, monitoring programs exist on a project basis, awaiting implementation of monitoring programs by the member states. The are no standardised methodologies available. An example of this is the Airmex project (JRC).
• Standardised methodologies should be developed to conduct uniform Europe wide monitoring programs.
</td></tr>
<tr><td colspan="2">Question 10 remains whether this research need still stands. Is it being tackled? By which programs and member states? Is there a need to have a</td></tr>
</table>

more practical guidance on research, and how should it look like?	
• The assessment for a the methodology for combined exposure is a key research need. Some scientific data already exist (first look at these) but need to be expanded • There are not enough longitudinal studies on indoor air • RA methodology of specific spaces should be established (metro,…) • At the moment, it is hard to make meta-analyses, due to the very different methods used in different studies, which renders the comparability of the results low. We need harmonised methods! Harmonised methods exist for ambient air (APHEA): central methodology and statistical harmonised methods). An analogous harmonised methodology for indoor air is mandatory • Lack of data on the new MS • Lack of studies on outcome of implementation, and more research on public perception and awareness (funding such projects is experienced as difficult!).	• The relation between compounds and health impact should be reinforced, to expand to list of regulated compounds. This should be done from both sides of the relation, i.e. expand the knowledge of health impact of compounds and try to allocate sources for certain diseases. • The effect combined exposure (multiple pollutants) should be investigated,, not only for chemicals, but also the combined effect with physical or biological exposure. • Indoor air chemistry (e.g. secondary reactions) should be investigated. • Carry out epidemiological studies and bio-monitoring programs. • Development of a bio-assay to assess IAQ. • New emerging substances should be monitored, with attention for the related analytical methods (e.g. long term sampling methods).

ANNEX B: REVIEW OF EXPOSURE DATA FOR INDOOR AIR POLLUTANTS

1. *Formaldehyde*

1. sources

Main sources of formaldehyde in the indoor environment are cigarette smoke, insulating materials, particle board or plywood furniture containing formaldehyde-based resins, water based paints, fabrics, household cleaning agents, disinfectants, pesticide formulations, paper products and adhesives containing formaldehyde used for plastic surfaces, parquet, carpets and other building materials containing urea-formaldehyde resins. Also gas cookers and open fireplaces emit formaldehyde to indoor air (source: INDEX-report).

2. indoor concentrations and personal exposure

a. dwellings and personal exposure

Indoor levels formaldehyde vary substantially between different countries and studies.
An overview of indoor concentrations measured in the EU is listed in *Table 3*.
Average formaldehyde concentrations in dwellings are between 10-60 µg/m³ for normal conditions (if biased datasets of houses with complaints excluded). This concentrations can amount to > 1000 µg/m³ in dwellings where complaints of inhabitants have been registered (*Table 3*).
Indoor residential air concentrations in different Member States are difficult to compare given differences in measuring strategies, age of the study, number of sampling locations, sampling averaging time,…between the various studies.
Though, some publications revealed some trends in formaldehyde indoor concentrations:
Formaldehyde concentrations were slightly higher in bedrooms of single-family houses than in apartments in Sweden (Gustafson et al., 2005). Formaldehyde concentrations were higher in bedrooms than in living rooms in French dwellings (Marchand et al., 2006). It revealed from the recent UK study that newer homes had higher indoor formaldehyde concentrations than older homes (Raw et al., 2004). Indoor concentrations in houses built before 1960 were 2-fold lower than of houses built after 1980 (Raw et al., 2004).
It was also proven that season had a significant effect: among the 4 seasons, indoor concentrations were highest in autumn (mean: 26.1 µg/m³) and lowest in winter (mean: 19.5 µg/m³) (Raw et al., 2004).
Some studies reported personal exposure in addition to residential concentration. The personal exposure is the result of the integrated exposure that a person experiences during a fixed time during his stay in different micro-environments during that time. The personal exposure thus depends on the concentrations of the various micro-environments and on the time pattern. Generally, the dwelling is the micro-environment in which people spent most of the their time.

b. public spaces

The French study of Marchand et al. (2006) provided information on indoor formaldehyde concentrations in public spaces: indoor concentrations in shopping centres (average: 15-28 µg/m³) were near those of dwellings reported previously by others, while indoor formaldehyde concentrations in train stations and airport halls were at the lower end (7-11 µg/m³). In contrast, indoor concentrations in libraries were elevated (34-56 µg/m³) compared to the other investigated public spaces.

In the ongoing AIRMEX (European Indoor Air Monitoring and Exposure Assessment Project, Kotzias et al., 2007) project, 1 week average indoor formaldehyde concentrations from 8.4 µg/m³ (Arhnem) to 25.6 µg/m³ (Thessaloniki) were measured in 2003-2005 in public buildings (town halls and guild halls) in 7 European cities.

It is noted that schools also fall under the public spaces category. Though, data for schools are handled in a separate section (see below).

c. transport

Indoor car concentrations were higher for cars in heavy traffic circumstances (27 µg/m³) compared to parked cars (14 µg/m³) or cars in fluid traffic (17 µg/m³) (Marchand et al., 2006).

Albeit, under normal circumstances, the concentrations in cars were not above typical concentrations for dwellings under normal thermal conditions.

However, formaldehyde concentrations inside cars increase drastically with increased temperature. Under normal thermal conditions (23 °C) inside car concentrations of 48 µg/m³ have been reported by Schupp et al. (2005) while at 65 °C, the inside car concentration can be as high as 1470 µg formaldehyde/m³. This is 10-fold above the acceptable exposure levels inside cars as proposed by Schupp et al. (2005), based on a toxicological analysis. This shows that cars parked in the sun, for which high inside temperatures are not unrealistic, indoor formaldehyde concentrations can be of concern and a reduction may be necessary (Schupp et al., 2005).

d. environments of sensitive groups

The few available data on concentrations in schools indicated elevated indoor formaldehyde concentrations (compared to dwellings). Cavallo et al. (1993, cited in INDEX) reported maximal indoor concentrations in Italian schools up to 210 µg/m³.

High formaldehyde concentrations in schools were reported for 20 classrooms of 10 schools in Athens: mean concentrations attributed 306, 208 and 223 µg formaldehyde/m³ respectively in May 2000, December 2000 and January 2001 (Siskos et al., 2001). Maximal concentrations amounted to 630 µg/m³ (Siskos et al., 2001). All the schools had been constructed with new materials after 1970.

Siskos et al. (2001) attributed the higher concentrations measured in May compared to December and January to higher emission rates of formaldehyde from indoor sources at times of relatively higher temperatures and relative humidity. Siskos et al. (2001) hypothesized that penetration of outdoor ozone to into the indoor environment during the summer season and its reaction with different indoor surfaces and building materials might have lead to an increase in the formation of indoor formaldehyde.

In an indoor school measuring campaign performed in 1993-1995 in 100 schools in Sweden, much lower indoor formaldehyde concentrations (mean: 8 µg/m³ ; min: <5 µg/m³ - max: 72 µg/m³) were measured (Smedje et al., 2001).

In the ongoing AIRMEX (European Indoor Air Monitoring and Exposure Assessment Project) project, 1 week average indoor formaldehyde concentrations from 6.1 µg/m³

(Nijmegen) to 29.1 µg/m³ (Leipzig) were measured in the period 2003-2005 in schools and kindergartens in 6 European cities.

Although a balanced comparison between different EU regions is difficult at the moment because of non-comparability of most study designs, sampling periods across studies in different EU regions, there is an indication that higher indoor concentrations prevail in regions with a warmer climate than in colder regions. The preliminary results of the AIRMEX PAN-European study confirm this trend.

Table 3: Indoor air concentrations and personal exposure of formaldehyde reported in different studies across the EU

country	year	environment	averaging time	# samples	concentration (µg/m³) mean	median	min	max	source	ref.
RESIDENTIAL (OR PERSONAL)										
Austria		indoor (residential)		160	31	25	8.8	115	INDEX	Hutter et al., 2002*
Denmark	before 1990	indoor (apartments)			10				INDEX	ECA, 1990*
France (Paris)		indoor (refurbished flats)			25				INDEX	Clarise et al.,2003*
Finland (Helsinki)	1996-1997	indoor		15	41			50	INDEX	Jurvelin et al., 2001*
		personal			27			78		Jurvelin et al., 2003*
Finland	1999-2003	indoor, NEW dwellings	2-h	4	19					Järnström et al., 2006
		indoor, 6 months old dwellings	2-h	4	21					
		indoor, 12 months old dwellings	2-h	4	26					
France	before 1990	indoor (dwellings)	24-h		22			<70	INDEX	ECA, 1990*
	before 1990	indoor (apartments with complaints)			600			2800		
Germany		indoor (residential)	1 week	58	36				INDEX	Ullrich et al., 2002*
Germany	before 1990	indoor (dwellings)	48-h		56			279	INDEX	ECA, 1990*
Greece	before 1990	indoor (dwellings)	30 min		6-9			22	INDEX	ECA, 1990*
Norway	before 1990	indoor (dwellings)			<60			110	INDEX	ECA, 1990*
the Netherlands	before 1990	indoor (50 % of the dwellings with complaints)			>120			1000	INDEX	ECA, 1990*
Slovakia		indoor (dwellings with chipboard constructions)					12.7	336	WS	Fabianova et al.,**

Sweden		personal	24-h	24	47				INDEX	Gustafson et al., 2004
		indoor (bedroom)	24-h	24	26					
		personal	6-day	40	31					
		indoor	6-day	40	35					
Sweden		indoor (residential)		27	8				INDEX	Sakai et al., 2004*
Sweden	2000-2001	personal			9		3	18		Glas et al., 2004
Sweden	1996-1997	indoor (residential)	48 h	15	42			50		Jurvelin et al., 2003*
		personal	48h		27			78		
Switzerland	before 1990	indoor (dwellings)					480	2760	INDEX	ECA, 1990*
	before 1990	indoor (new dwellings)						840		ECA, 1990*
UK		indoor	3-day	833	22			171	INDEX	Brown VM et al., 2002*
						24	1			Raw et al., 2004
UK		indoor	1 year	174			7	76	INDEX	COMEAP, 1997*
UK	before 1990	indoor (buildings without UFFI)			57				INDEX	ECA, 1990*
	before 1990	indoor (buildings with UFFI)			114					
UK		indoor dwelling, living room non-smokers		88		40				Gee et al., 2005
		indoor dwelling, living room, with smokers		112		40				
		indoor dwelling, bedroom, non-smokers		88		54				
		indoor dwelling, bedroom, with smokers		112		54				
PUBLIC SPACES										
France	2004-2005	commercial centre, hall 1		2	28		28	28		Marchand et al., 2006
		commercial centre, hall 2		2	15		13	17		
		commercial centre, hall 3		2	22		19	24		
		train station, hall		4	7		5	9		

		airport, hall		4	11	9	13		
		underground park		4	19	18	21		
		library 1		7	56	48	62		
		library 2		4	34	31	37		
		library (3)			16	5	31		Righi et al., 2002*
Italy (Catania)	may 2003	public buildings	1 week		13	9	22	AIRMEX	
Italy (Catania)	october 2003	public buildings	1 week		16	11	23	AIRMEX	
Greece (Athens)	decmber 2003	public buildings	1 week		20	11	26	AIRMEX	
Greece (Athens)	October 2005	public buildings			21	11	27	AIRMEX	
Greece (Thessaloniki)	2004	public buildings	1 week		26	14.1	30	AIRMEX	
Belgium (Brussels)	2004	public buildings	1 week		17	8	27	AIRMEX	
the Netherlands (Nijmegen)	2004	public buildings	1 week		9	5.1	13	AIRMEX	
the Netherlands (Arnhem)	2004	public buildings	1 week		8	3	11	AIRMEX	
Germany (Leipzig)	2005	public buildings	1 week		21	5.6	35	AIRMEX	
TRANSPORT									
France	2004-2005	car indoor, parked		2	14	12	16		Marchand et al., 2006
		car indoor, heavy traffic		2	27	23	30		
		car indoor, fluid traffic		2	17	12	21		
?		car, indoor at 23°C			48				FAT, 1998, cited by Schupp et al. (2005)
?		car, indoor at 65°C			1680				FAT, 1998, cited by Schupp et al. (2005)
ENVIRONMENTS OF SENSITIVE GROUPS									
France	before 1990	indoor (nursery school)	30 min		29			INDEX	ECA, 1990*
Italy		indoor (schools)				8	210	INDEX	Cavallo et al., 1993*
Greece	May 2000	indoor (schools)	30 min	20	306	106	630		Siskos et al., 2001

	December 2000	indoor (schools)	30 min	20	208	25	429		
	January 2001	indoor (schools)	30 min	20	223	49	450		
Italy (Catania)	may 2003	indoor (schools and kindergartens)	1 week		13	9	16.2	AIRMEX	Kotzias et al.
Italy (Catania)	october 2003		1 week		15.7	8.5	22.3	AIRMEX	Kotzias et al.
Greece (Athens)	decmber 2003		1 week		18.3	10.5	28.2	AIRMEX	Kotzias et al.
Greece (Athens)	October 2005		1 week		20.2	9.8	30.5	AIRMEX	Kotzias et al.
Greece (Thessaloniki)	2004		1 week		13.9	12.6	16.1	AIRMEX	Kotzias et al.
the Netherlands (Nijmegen)	2004		1 week		6.1			AIRMEX	Kotzias et al.
the Netherlands (Arnhem)	2004		1 week		11.8			AIRMEX	Kotzias et al.
Germany (Leipzig)	2005		1 week		29.1	12.5	49.7	AIRMEX	Kotzias et al.

* cited in the INDEX study (original references were not systematically screened by VITO, and references to these studies are not taken up in the reference list of this report.

** information gathered from the workshop participants

Carbon monoxide

1. sources

Tobacco smoking is a major source of indoor CO concentrations. Faulty domestic cooking and heating appliances, inadequately vented to outside air may cause high indoor concentrations. Also gas stoves, water heaters and exhaust from vehicle in attached garages might be important indoor sources (source: INDEX-report).

2. indoor concentrations

Indoor CO concentrations in various indoor environments (dwellings, transport) in the 5 EXPOLIS cities are reported in *Table 4* , together with results of other studies included in the INDEX and THADE reports.
The update of the scientific literature published between 2004 and 2007 revealed only very few relevant new studies.

a. dwellings and personal exposure

The PAN-European study EXPOLIS investigated CO indoor and personal concentrations in locations and for individuals in Greece (Athens), Switzerland (Basle), Finland (Helsinki), Italy (Milan) and the Czech Republic (Prague) in the period 1996-1999.
Residential indoor concentrations of CO were typically lower in Northern Europe than in Central Europe, and were again lower than in Southern Europe (Georgoulis et al. 2002, cited in the INDEX-report).

Mean indoor exposure varied from 0.4 mg CO/m³ to 1.8 mg CO/m³ in the EXPOLIS study. This is in accordance with ranges reported for other studies (which were mainly restricted to one country)(see *Table 4*). It should be mentioned that not only the mean exposure, but also exposure at the higher side of the distribution curve should be considered in the further risk assessment.

The report of the INDEX-project includes cumulative distribution curves of indoor air concentrations of carbon monoxide in Helsinki, France and Milan and of CO concentrations in kitchens in the U.K.
Short-time (1 hour) exposure in the same study were about 10-fold higher than corresponding 48-h exposures.
Personal exposure to CO for pre-school children was maximally 80 (max. 15 min), 69 (max. 1-hour), 28 (max. 8-hour) mg /m³ (Alm et al., 2000, cited in INDEX). Personal exposure in Helsinki was on average 9.0 (ETS), 7.1 (non ETS) on max 15 min basis and 2.6 (ETS) and 2.0 (non ETS) mg/m³ on max. 8-hour basis. (Scotto di Marco et al., 2003, cited in INDEX). Personal exposure in Milan was on average 12 (on max 15 min basis) mg/m³ and 3.8 (max. 8 h-hour) mg/m³. (Bruinen de Bruin, 2003; cited in INDEX).

b. public spaces

In the report of the INDEX-project, an overview of CO concentrations in public spaces is listed.

In Italian bars and restaurants, average CO concentrations is quite high: average concentrations of 13 - 23 mg/m³ were reported. Indoor ice arenas are spaces with elevated indoor CO concentrations (20-33 mg/m³).

c. transport

In the EXPOLIS study, CO concentrations in various indoor transport components have been measured: bus, tram, metro, car and taxi. Differences in indoor CO concentrations between these different motorized transport compartments were minor compared to differences between the cities. For example, in Athens, indoor concentrations in bus-tram (4.4 mg CO/m³) were very close to concentrations in cars and taxis in Athens (4.2 mg CO/m³), whereas corresponding concentrations were much lower in Helsinki (bus-tram: 0.7 mg CO/m³; car-taxi: 1.2 mg CO/m³).

d. environments of sensitive groups

Three recent publications on indoor CO concentrations deal with CO levels in schools in Athens (Chaloulakou et al., 2002; Chaloulakou et al., 2003; Siskos et al., 2001). The average concentrations fall in the range 1.3 – 6.2 mg CO/m³, while maxima up to 16 mg CO/m³ were noted. The indoor CO concentrations in winter were 2-fold higher than summer indoor CO concentrations (Chaloulakou et al., 2002).

Table 4: Indoor air concentrations and personal exposure of carbon monoxide (CO) reported in different studies across the EU

Country	year	environment	averaging time	# samples/persons	concentration (mg/m³)				source	ref.
					mean	median	min	max		
RESIDENTIAL (OR PERSONAL)										
Greece (Athens)	1997-1998	pers. Exp$^{\$}$; smokers	48-h	2	4.0		3.5	4.5		Georgoulis et al., 2002
Greece (Athens)	1997-1998	pers.exp.; non-smokers	48-h	41	1.7		0.2	11.5		Georgoulis et al., 2002
Switzerland (Basle)	1997-1999	pers. exp; smokers	48-h	6	1.1		0.1	4.7		Georgoulis et al., 2002
Switzerland (Basle)	1997-1999	pers.exp.; non-smokers	48-h	44	0.8		0.1	7.5		Georgoulis et al., 2002
Finland (Helsinki)	1996-1997	pers. exp; smokers	48-h	35	0.4		0.0	4.3		Georgoulis et al., 2002
Finland (Helsinki)	1996-1997	pers.exp.; non-smokers	48-h	160	0.5		0.0	4.4		Georgoulis et al., 2002
Italy (Milan)	1997-1998	pers. exp; smokers	48-h	18	2.3		1.4	4.4		Georgoulis et al., 2002
Italy (Milan)	1997-1998	pers.exp.; non-smokers	48-h	30	2.2		0.8	3.8		Georgoulis et al., 2002
Czech Republic (Prague)	1997-1998	pers. exp; smokers	48-h	5	1.6		0.5	3.3		Georgoulis et al., 2002
Czech Republic (Prague)	1997-1998	pers.exp.; non-smokers	48-h	18	2		0.46	3.81		Georgoulis et al., 2002
Greece (Athens)	1997-1998	indoor	15 min	43	1.5					Georgoulis et al., 2002
Switzerland (Basle)	1997-1999	indoor	15 min	50	0.6					Georgoulis et al., 2002
Finland (Helsinki)	1996-1997	indoor	15 min	193	0.4					Georgoulis et al., 2002

	Italy (Milan)	1997-1998	indoor	15 min	48	1.8				Georgoulis et al., 2002
	Czech Republic (Prague)	1997-1998	indoor	15 min	23	1.1				Georgoulis et al., 2002
	Italy		pers. Exp. (office workers)			2.2			INDEX	Maroni et al., 1996*
	UK		dwellings	1 week	14		0.2	2.7	INDEX	Ross, 1996*
	Finland		pers.exp. (preschool children)	15 min		8.4			INDEX	Alm et al., 2000*
			pers.exp. (preschool children)	1-hour		6.0				
			pers.exp. (preschool children)	8-hour		3.3				
	UK		indoor (kitchen)			0.47		4.45	INDEX	Raw et al.,2002*
	UK		indoor (kitchen), rural		235	0.34				Raw et al.,2004
			indoor (kitchen), suburban		339	0.52				
			indoor (kitchen), urban		222	0.54				
			indoor (kitchen), central urban		31	0.72				
			indoor (bedroom), rural		234	0.28				
			indoor (bedroom), suburban		336	0.41				
			indoor (bedroom), urban		220	0.50				
			indoor (bedroom), central urban		31	0.69				
			indoor (bedroom), overall dataset			0.39	<0.01	3.9		
			indoor (kitchens), overall dataset			0.47	<0.01	4.45		
PUBLIC SPACES										
	Italy		bars, restaurants			13-23		35	INDEX	Maroni et al., 1995*
	Finland		indoor ice arenas	max. 1h		20-33			INDEX	Pennanen et al., 1997*
	Italy (Genoa)		shops	8-hour				15	INDEX	Valerio et al.,*

			bars	8-hour			18	INDEX	
	Switzerland		concert hall	5.5h		3.5	5.2	INDEX	Junker et al., 2000*
	Greece(Athens)		public building office	1h		3.7		INDEX	Chaloukalou et al., 2003
TRANSPORT									
	Greece (Athens)	1997-1998	bus-tram	15 min	11	4.4			Georgoulis et al., 2002
	Switzerland (Basle)	1997-1999	bus-tram	15 min	19	0.9			Georgoulis et al., 2002
	Finland (Helsinki)	1996-1997	bus-tram	15 min	71	0.7			Georgoulis et al., 2002
	Italy (Milan)	1997-1998	bus-tram	15 min	29	2.7			Georgoulis et al., 2002
	Czech Republic (Prague)	1997-1998	bus-tram	15 min	18	1.3			Georgoulis et al., 2002
	Greece (Athens)	1997-1998	metro-tram	15 min	2	2.4			Georgoulis et al., 2002
	Switzerland (Basle)	1997-1999	metro-tram	15 min	4	0.8			Georgoulis et al., 2002
	Finland (Helsinki)	1996-1997	metro-tram	15 min	29	0.5			Georgoulis et al., 2002
	Italy (Milan)	1997-1998	metro-tram	15 min	16	2.0			Georgoulis et al., 2002
	Czech Republic (Prague)	1997-1998	metro-tram	15 min	11	0.6			Georgoulis et al., 2002
	Greece (Athens)	1997-1998	car-taxi	15 min	35	4.2			Georgoulis et al., 2002
	Switzerland (Basle)	1997-1999	car-taxi	15 min	27	1.5			Georgoulis et al., 2002
	Finland (Helsinki)	1996-1997	car-taxi	15 min	130	1.2			Georgoulis et al., 2002
	Italy (Milan)	1997-1998	car-taxi	15 min	40	3.6			Georgoulis et al., 2002
	Czech Republic (Prague)	1997-1998	car-taxi	15 min	19	1.4			Georgoulis et al., 2002

	Greece (Athens)	1997-1998	motorcycle	15 min	6	4.6		Georgoulis et
	Switzerland (Basle)	1997-1999	motorcycle	15 min	5	1.8		Georgoulis et al., 2002
	Finland (Helsinki)	1996-1997	motorcycle	15 min	6	1.0		Georgoulis et al., 2002
	Italy (Milan)	1997-1998	motorcycle	15 min	4	3.3		Georgoulis et al., 2002
	Czech Republic (Prague)	1997-1998	motorcycle	15 min	0			Georgoulis et al., 2002
	Greece (Athens)	1997-1998	walk-bicycle	15 min	25	2.0		Georgoulis et al., 2002
	Switzerland (Basle)	1997-1999	walk-bicycle	15 min	46	0.7		Georgoulis et al., 2002
	Finland (Helsinki)	1996-1997	walk-bicycle	15 min	129	0.5		Georgoulis et al., 2002
	Italy (Milan)	1997-1998	walk-bicycle	15 min	40	2.4		Georgoulis et al., 2002
	Czech Republic (Prague)	1997-1998	walk-bicycle	15 min	18	1.4		Georgoulis et al., 2002
ENVIRONMENTS OF SENSITIVE GROUPS								
	Greece (Athens)	1999	school	10 min	1	4.25	16	Chaloulakou et al., 2003
	Greece (Athens)		school, weekday summer	10 min		2.21		Chaloulakou et al., 2002
			school, Saturday summer	10 min		1.71		Chaloulakou et al., 2002
			school, Sunday summer	10 min		1.34		Chaloulakou et al., 2002
			school, weekday winter	10 min		4.55		Chaloulakou et al., 2002
			school, Saturday winter	10 min		3.77		Chaloulakou et al., 2002
			school, Sunday winter	10 min		3.52		Chaloulakou et al., 2002

Greece (Athens)	May 2000	schools	30 min	6.22	0.19	7.98	Siskos et al., 2001
	December 2000	schools	30 min	1.98	0.21	3.3	Siskos et al., 2001
	January 2001	schools	30 min	1.89	0.16	3.48	Siskos et al., 2001

$ personal exposure

* cited in the INDEX study (original references were not systematically screened by VITO, and references to these studies are not taken up in the reference list of this report.

Particles

1. sources

ETS is the most important indoor air particulate matter (PM) source and more than half of the non-ETS PM indoors usually originates from ambient outdoor air. Particulate air pollution is - in sampling, regulation and research - usually divided according to particle size into coarse (2.5 - 10 μm aerodynamic diameter), fine (PM2.5 < 2.5 μm) and ultrafine (< 0.1 μm) fractions.

Coarse particles (> 2.5 μm diameter) are produced by resuspension of floor dust, handling of textiles and cleaning activities. They contain mostly soil minerals, non-volatile organics and textile fibers. Much of the coarse PM settles rapidly out of the air, but is also easily resuspended. Outdoor air coarse particles are generated by mechanical erosion, wind, traffic, and materials handling and they penetrate poorly into indoor environments.
Fine particles (< 2.5 μm) are produced by tobacco smoking, cooking, unvented kerosene heaters and wood burning, but there is also a significant mineral dust source of PM2.5 indoors. They contain mostly semivolatile organics (SVOC), polyaromatic hydrocarbons (PAH) and elemental carbon (soot, EC) and inorganic minerals. Fine particles do not settle out of indoor air. They move freely with air currents, stick to any surface they touch and are only poorly resuspended. PM2.5 from outdoor air they penetrate effectively indoors through most ventilation systems.
(source: ECA report N°25).

2. indoor concentrations

    a. dwellings and personal exposure

Studies on PM levels in indoor environments are reported in *Table 5*. Most of these studies mention the presence of smoking as significantly increasing PM concentrations.

The concentration of PM in the indoor environment is highly variable in time and space due to various influencing factors like type of the source, building and room characteristics, the activities of the users and the airing behaviour (Fromme, 2006).

A review on indoor air PM levels in dwellings was reported in the THADE report (Franchi et al., 2004). The THADE study reported the lowest levels of PM was measured in Finland (9.5 μg/m³) and the highest in Italy (mean about 50 μg/m³). In other European countries, PM levels in dwellings were below 40 μg/m³.

More recently, Fromme (2006) made an extensive review on indoor PM levels in residences, public spaces and schools. Fromme reported a range of 10- 87 μg PM2.5/m³ across the consulted studies. The studies listed in the review article of Fromme and not included in the THADE rapport were amended to *Table 5*.

The EXPOLIS study allows a comparison of PM levels across the EU. There seems to be a trend of higher indoor PM levels in Southern EU countries compared to Northern EU countries. This trend was also suggested from the comparison of different studies in the EU (though this comparison is more uncertain given the different methodologies used in the different studies).

b. public spaces

Fromme (2006) also reviewed indoor PM levels in public spaces in Europe. Indoor PM concentrations in bars and restaurants are significantly elevated compared to other common indoor spaces such as dwellings (generally 10-fold higher levels compared to dwellings), and these elevated indoor PM levels were reported for different EU regions. Smoking is probably the main contributor to elevated indoor PM levels in these public spaces. It is remarked that extreme high PM indoor levels were measured in German discotheques (median of 10 discotheques: 869 µg/m³: min – max: 219- 4475 µg/m³).

c. transport

Aarnio et al. (2005) investigated PM2.5 levels in the Helsinki subway system in 2004. The average daytime PM2.5 concentrations were 47 µg/m³ and 60 µg/m³ at the two underground subway stations and 19 µg/m³ at the ground level station and 21 µg/m³ in subway cars.
In the Prague underground tube, average concentrations of 125 µg/m³ (PM10) in winter and 82 µg/m³ (PM10) in summer were recorded in 2002-2004 (Branis et al., 2006).
Mean PM concentrations during weekdays between 7 am and 7 pm were 258 µg/m³ (PM2.5) and 469 µg/m³ (PM10) in the Stockholm underground in February 2000.
High PM2.5 concentrations were also reported for the underground of London: 246 µg PM2.5/m³ in 1995-1996. The personal PM2.5 exposure of office workers commuting by underground in London was 36.8 µg PM2.5/m³, i.e. 1.5-fold higher than personal exposure of office workers commuting to the office by another transport mode than the underground (Pfeifer et al., 1999). Personal PM2.5 exposure of taxi drivers (33.4 µg/m³) of the London study was similar to that of London office workers (Pfeifer et al., 1999).
It should be remarked that for most of the investigated underground systems in the EU (i.e. London, Prague, Stockholm), very high (>100 µg PM2.5/m³) were recorded, except for the Helsinki subway.
Further, composition (and thus probably toxicity and health effects) of PM in the underground system is very different compared to that of above ground transport systems. The former consists mainly of iron oxide particles, released through wear of steel and brakes, while the latter are combustion generated particles (Johannson et al, 2003).
Adams et al. (2001) also investigated PM2.5 exposure in transport micro-environments in London. One field campaign investigated exposure during different transport modes during July 1999; a second similar field campaign was performed during February 2000. The mean exposure during a bicycle trip was 34.5 µg/m³ (min-max: 13.3 – 68.7 µg/m³), during bus trip 39 µg/m³ (min-max: 7.9-97.4 µg/m³), and during car trip 37.7 µg/m³ (15.1 – 76.9 µg/m³) in the July 1999 measuring campaign. Persons travelling by the underground tube (238.7 µg/m³) were exposed to 8 times higher levels than other modes' mean journey exposure. In contrast, travelling by above ground line (mean: 29.3 µg/m³; min-max: 12.1 – 42.3 µg/m³) did not lead to higher exposures than other modes' journey exposure (Adams et al., 2001).
The results of the London winter (February 2000) field campaign were similar to those of the summer season, namely means of 23.5 µg/m³ (bicycle), 38.9 µg/m³ (bus), 33.7 µg/m³ (car) and 157.3 µg/m³ (underground tube).
In the paper of Adams et al. (2001), an overview of results from previous studies related to PM levels in transport micro-environments is listed. The relevant (EU) studies mentioned by Adams et al. (2001) are also included in *Table 5*. The high PM concentrations in the underground in London (> 200 µg/m³) are persistent over the various studies.
It is noted that a few studies report also very high PM levels inside buses in a UK study (Gee and Raper, 1999; cited by Adams et al., 2001) and a German study (Praml and Schierl, 2000; cited by Adams et al., 2001).

As a summary, among the various transport modes, PM indoor levels are highest in underground tubes (about 8 times higher than other transport modes).

d. environments of sensitive groups

PM indoor levels in schools and kindergartens are generally above common levels in dwellings, though still below PM indoor levels in restaurants and pubs.
Elevated levels of PM in schools were ascribed to the resuspension of particles caused by the activity of children (Roorda-Knape et al., 1998).

Indoor PM10 concentration in 12 Dutch schools was on average 92 µg PM10/m³. The results of the recent German study of Fromme (2007) showed very similar results for PM10. The major fraction of PM of the latter study existed of coarse particles: PM2.5 indoor concentrations were on average 2-5 fold lower than PM10 concentrations. In addition, PM indoor concentrations were lower during summer than during winter season.
In 7 primary classrooms in Athens, mean PM2.5 and PM10 of respectively 82.6 µg/m³ and 236 µg/m³ were recorded.
In schools in the U.K., indoor PM concentrations (mean: 30 µg PM2.5/m³ and 80 µg PM10/m³, Wheeler et al., 2000 cited in Diapouli et al., 2007) were remarkable lower than in Athens.

No data on PM concentrations in hospitals and old men's homes for the EU were found in the literature.

Table 5: Indoor air concentrations and personal exposure of particles (PM) reported in different studies across the EU

country/city	year	environment	PM fraction	sampling time	# samples/persons	concentration (µg/m³) mean	median	min	max	P95	source	ref.
RESIDENTIAL												
Italy/Pisa	1991-1994	dwelling	PM 2.5	48h mean	282 homes	57					THADE	Simoni et al, 2002[a]
					139 homes	63						
Greece/Athens	1996-1998	dwelling	PM 2.5	48h mean	43 homes	35.6	21				THADE/Fromme (2006)	Gotschi et al, 2002[a] and Hänninen et al., 2004[a]
Switzerland/Basel					41 homes	21	26					
Finland/Helsinki					82 homes	9.5	13					
Czech Republic/Prague					20 homes	34.4	36					
Italy/Milan	1996-1998	dwelling	PM 2.5	48h mean	39 homes	42.7					THADE	Maroni et al., 2002[a]
UK, Manchester	2000-2001	dwelling living room	PM 2.5	5 days mean	69 homes	28.4					THADE	Gee et al, 2002[a]
		dwelling bedroom	PM 2.5			19						
France (Paris, Nice, Grenoble)	1998-2000	dwelling	PM 2.5	48 h mean	44 homes	22.5					THADE	Zmirou et al., 2002[a]
the Netherlands/ Amsterdam	1983-1988	dwelling	PM 2.5	24 h mean	36 homes	28.6						
Finland/Helsinki					46 homes	11						
Zwitserland/Zurich	1996	dwelling (winter)	PM 2.5		17 homes		18.3				Fromme, 2006	Monn et al, 1997[b]
		dwelling (winter)	PM 10				10.8					

		dwelling (spring)	PM 2.5	17 homes	26				
		dwelling (spring)	PM10		32.8				
the Netherlands/ Amsterdam	1998-1999	dwelling	PM 2.5	A + H: 80 homes	14.1			Fromme, 2006	Janssen et al., 2005[b]
Finland/Helsinki		dwelling	PM 2.5		9.8				
Germany, Berlin	1997-1998	dwelling (winter, smoking)	PM 4	in total: 122 homes	66			Fromme, 2006	Fromme et al., 2005[b]
		dwelling (summer, smoking)	PM 4		57				
		dwelling (winter, no smoking)	PM 4		30				
		dwelling (summer, no smoking)	PM 4		27				
Germany, Baden-Würtemberg	2001-2002		PM 2.5	126	19			Fromme, 2006	Link et al., 2004[b]
Denmark, Copenhagen	1999-2000	dwelling (outside temp < 8°C)	PM 2.5		13.4			Fromme, 2006	Sørensen et al., 2005[b]
		dwelling (outside temp > 8°C)	PM 2.5		9.5				
PUBLIC SPACES									
France		restaurant	PM 4		194	56	312	Fromme, 2006	Bohanon et al., 2003[b]
Switzerland		restaurant	PM 4		75	0	277		
U.K		restaurant	PM 4		201	62	391		
Switzerland		smokers pub	PM 2.5	1 pub	164			Fromme, 2006	Künzli et al, 2003[b]

UK	2004	pubs with snacks	PM 2.5	33 pubs		167	54	1395	Fromme, 2006	Edwards et al., 2006[b]
		pubs without snacks	PM 2.5	31 pubs		217	15	1227		
Germany	2005-2006	restaurant		18 restaurants		195	55	1250	Fromme, 2006	Bolte et al., 2006[b]
		discotheque	PM 2.5	10 discotheques		869	291	4475		
TRANSPORT										
Finland/Helsinki	2004	underground subway station	PM2.5	2 stations	53.5		47	60		Aarnio et al., 2005
		groundlevel subway station	PM2.5		19					
		subway cars	PM2.5		21					
U.K./London	1996	personal exposure taxi driver	PM 2.5		33.36					
		personal exposure office worker no underground	PM 2.5		24.02					
		personal exposure office worker underground	PM 2.5		36.77					Pfeifer et al., 1999
		in the underground	PM 2.5		246					
U.K./London	1999 (July)	bicycle	PM 2.5	40	34.5		13	68.7		Adams et al., 2001
		bus	PM 2.5	36	39		7.9	97.4		
		car	PM 2.5	42	37.7		15.1	76.9		

		underground tube	PM 2.5		44	247.2		105.3	371.2		
		tube above groundline	PM 2.5		10	29.3		12.1	42.3		
	2000 (Feb)	bicycle	PM 2.5		56	23.5		6.8	76.2		
		bus	PM 2.5		32	38.9		5.9	87.3		
		car	PM 2.5		12	33.7		6.6	94.4		
		underground tube	PM 2.5		12	157.3		12.2	263.5		
Slovenia/ Ljubljana		bus	EC					10	40	Adams et al., 2001	Bizjak and Tursic (1998)[c]
U.K./London		underground tube	PM 9					500	1200	Adams et al., 2001	Priest et al., 1999[c]
U.K./London		bicycle	PM 5		4	33.75		14	89	Adams et al., 2001	Sitzmann et al.,1999[c]
		underground tube	PM 5		2	801		709	893		
U.K./Manchester		car	PM 4	av. 10 journey s	31	42		19	65	Adams et al., 2001	Gee et al., 1999[c]
U.K./Manchester		bus	PM 4	3 h	34	338					
		bicycle	PM 4	3 h	8	54					
Germany/Munich		bus	PM 10	4 h	117	153				Adams et al., 2001	Praml and Schierl, 2000[c]
France/Paris		taxis	black smoke	8h	28	168				Adams et al., 2001	Zargury et al., 2000[c]
Czech Republic/Prague	2002-2004	underground tube, summer	PM 10			82.3	71.3				Branis et al., 2006
		underground tube, winter	PM 10			125.5	107.5				
U.K./Northampton	1999-2000	in car	PM 10			43.16					Gulliver et al., 2004

		in car	PM 2.5			15.54					
		in car	PM 1			7.03					
		walk	PM 10			38.18					
		walk	PM 2.5			15.06					
		walk	PM 1			7.14					
Sweden/Stockholm	2000 (Feb)	underground tube, weekday	PM2.5	mean 7 am -7 pm		258		105	380	Johansson et al., 2003	
		underground tube, weekday	PM 10	mean 7 am -7 pm		469		212	722		
ENVIRONMENTS OF SENSITIVE GROUPS											
the Netherlands	1993	school, classroom	PM10		12 schools	92	73	51	106		Roorda-Knape et al., 1998
Germany (Munich)	2004-2005	school, classroom, winter	PM 2.5		92 classrooms	38.9	36.7	4.3	73		Fromme et al., 2007
		school, classroom, winter	PM 10			105	91.5	16.3	313		
	2005	school, classroom, summer	PM 2.5		75 classrooms	22.1	20.2	9.8	55		
		school, classroom, summer	PM10			71.7	64.9	18.3	178		
Greece (Athens)	2003-2005	school, classroom	PM 2.5		7 classrooms	82.6					Diapouli et al., 2007
			PM 10			236					
UK (London)		school, classroom	PM 2.5			30				Diapouli et al., 2007	Wheeler et al., 2000[d]
			PM 10			80					

[a] cited in THADE; [b] cited by Fromme (2006); [c] cited by Adams et al. (2001); [d] cited by Diapouli et al.(2007)(original studies not listed in reference list here)

NO_2

1. sources

The most important indoor sources of NO_2 include gas appliances such as stoves, ovens, spaces, water heaters, and unflued kerosene heaters. Especially gas stoves with pilot light have been found strong indoor sources of NO_2 (source: INDEX-report).

2. indoor concentrations and personal exposure

NO_2 is one of the most widely studied indoor pollutants in the EU. The studies on NO_2 indoor concentrations discussed in the INDEX and THADE reports, together with the most recent studies, are listed in *Table 6*.

a. dwellings and personal exposure

Notwithstanding the large variability in geographical regions, age of studies, dwelling types, sample duration time …, the average residential indoor NO_2 concentrations of all studies are within a relative narrow range: 6-64 µg NO_2/m^3, with the major part of the studies reporting average concentrations of 20-30 µg NO_2/m^3. However, maximal (short time) exposure can largely exceed these ‘typical’ concentrations: maximal concentrations exceeding 1000 µg NO_2/m^3 are not uncommon.

Indoor concentrations vary depending on the presence of special indoor sources of NO_2. Elevated indoor NO_2 concentrations were typically related to gas cooking, gas heating and incense burning (INDEX). Concentrations in homes without NO_2 sources are typically lower than outdoor concentrations and in those cases indoor levels are driven by outdoor sources (INDEX-report).

In addition the effect of indoor sources, the season also affected slightly NO_2 indoor concentrations in the study of Raw et al. (2004): in kitchens, NO_2 levels were lower in spring (mean: 17.2 µg/m³) than in other seasons (mean: 22.3-23.7 µg NO_2/m^3).

Typical indoor air concentrations in homes with gas cooking vary between 25 and 200 µg/m³ over a period of several days. Maximum indoor 1-hour peaks may reach up to 2000 µg/m³.

b. public spaces

Whereas information on indoor NO_2 concentrations of common public indoor sources (shopping centres, train stations, libraries,…) is lacking, indoor NO_2 concentrations in a very specific public space, namely ice arenas have been investigated. Average indoor NO_2 concentrations of 283 and 396 µg NO_2/m^3 (1 week averaging time) and maxima between 270-7740 µg/m³ (1-hour) have been measured in Finnish ice arenas (Pennanen et al., 1997; Pennanen et al., 1998, cited in INDEX). Propane and gasoline driven ice resurfacers probably cause these high NO_2 concentrations.

c. transport

Piechock-Minguy et al. (2006) performed an unique study on NO_2 personal exposure in France. A new sampling device allowed to divide the personal exposure into four micro-environmental categories (home, other indoor place, transport and outdoors). By replacing the porous cartridge each time the participant changed the micro-environment and registering the corresponding time and micro-environment, personal exposure could be stratified according to micro-environment.

During working days, average NO_2 exposure during transport was 114 µg/m³ (min: 71 – max: 159 µg/m³), and during weekend, this was 2-fold lower: 56 µg/m³ (min-max:31-77 µg/m³).

Using Multiple Correspondence Analysis (MCA), it was revealed that during journeys by train, exposure was 20-50 µg/m³, by tramway or underground 33-68 µg/m³, by bicycle 69-96 µg/m³, and by car or motorcycle 97-125 µg/m³.

d. environments of sensitive groups

Van Roosbroeck et al. (2007) investigated NO_2 indoor concentrations in schools located near busy roads. Indoor NO_2 concentrations in a school located near a ring road was 18.45 µg NO_2/m³, in a school near a ring freeway: 23.8 µg/m³, and in 2 schools located in background areas: 16.4 and 38.94 µg/m³.

Table 6: Indoor air concentrations and personal exposure of NO_2 reported in different studies across the EU

country	year	environment	averaging time	# samples/persons	concentration (µg/m³)				source	ref.
					mean	median	min	max		
RESIDENTIAL										
UK										
Czech Republic (Prague)	1996-1997	residential		35	43				INDEX	Kousa et al, 2001[a]
Switzerland (Basle)	1996-1998	residential		50	27				INDEX	Kousa et al, 2001[a]
Finland (Helsinki)	1996-1999	residential		201	18				INDEX	Kousa et al, 2001[a]
Czech Republic (Prague)	1996-1997	personal		35	43				INDEX	Kousa et al, 2001[a]
Switzerland (Basle)	1996-1998	personal		50	30				INDEX	Kousa et al, 2001[a]
Finland (Helsinki)	1996-1999	personal		201	25				INDEX	Kousa et al, 2001[a]
Italy (Po, rural area)	1991-1994	kitchen, summer			38				INDEX	Simoni et al, 2002[a]
	1991-1994	kitchen, winter			62				INDEX	Simoni et al, 2002[a]
Spain	1996-1999	dwellings		340	12.5				INDEX	Garcia-Algar et al, 2003[a]
	1996-2000				14.7					
		dwellings without gas stoves					13	40	INDEX	COMEAP,1997[a]
		dwellings with gas stoves					25	70	INDEX	COMEAP,1997[a]

the Netherlands	kitchen with gas appliance	1 min				400-3808	INDEX	Lebret et al.,1987[a]
	kitchen with gas appliance	1 h				230-2055		
	kitchen with gas appliance	24 h				53-478		
the Netherlands	kitchen with gas stove					2500	INDEX	Noy et al, 1990[a]
UK	gas stove	1 week		28-107			INDEX	Ross,1996[a]
		max 1 hour				342-1585	INDEX	
	electric stove	1 week		23-26			INDEX	
		max 1 hour				38-55	INDEX	
Sweden	homes	24 h		6.7		11	INDEX	Sakai et al, 2004[a]
Sweden	personal (schoolchildren, urban)	24h			13		INDEX	Berglund et al, 1984[a]
	personal (schoolchildren, rural)	24h			7		INDEX	Berglund et al, 1984[a]
Finland (Kuopio)		48 h	30	10.3			THADE	Levy et al, 1998[b]
Norway (Kjeller)		48 h	30	14.7			THADE	Levy et al, 1998[b]
Switzerland (Geneve)		48 h	33	15.6			THADE	Levy et al, 1998[b]
Germany (Erfurt)		48 h	29	17.0			THADE	Levy et al, 1998[b]
Germany (Berlin)		48 h	31	23.1			THADE	Levy et al, 1998[b]
UK (London)		48 h	117	40.4			THADE	Levy et al, 1998[b]
Poland (Sosnowiec)		48 h	15	64.7			THADE	Levy et al, 1998[b]
Sweden	residential urban (no presence of gas appliances)	24h	23		11		THADE	Hagenbjork-Gustafsson et al, 1996[b]

		residential rural (no presence of gas appliances)	24h	30		6			THADE	
Italy (Genoa)	2000	kitchen		89	47				THADE	Gallelli et al, 2002[b]
		bedroom			24.8				THADE	
UK	1997-1999	kitchen	2 weeks	812	21.8				THADE	Coward et al, 2002[b]
		bedroom			11.9				THADE	
UK (Manchester)	2000-2001	living room	5 days	69	27.2				THADE	Gee et al., 2002[b]
		bedroom			20.3				THADE	
France	1998-2000	residential	48h	109	36.1				THADE	Zmirou et al,2002[b]
									THADE	
Germany, Hamburg	1995-1996	residential	1 week	201		17			THADE	Cyrys et al, 2000[b]
Germany, Erfurt		residential		204		15			THADE	
France (southern)	1998	residential	1h		41				THADE	Saintot et al, 2000[b]
									THADE	
Slovakia	1991-1998	residential, flats					7.6	341	WS	Fabianova et al.[c]
Sweden		personal			28		0.3	84		Glas et al, 2004
UK		kitchen (total dataset)		876	21.8		0.8	620		Raw et al, 2004
		bedroom		876	11.9		0.4	752		
		kitchen, cooking fuel gas oven		338	42.8					
		kitchen, natural gas cooking but no gas oven		128	22.4					
		kitchen, no fossil fuel cooking		356	11.5					

UK		dwelling, living room non-smokers		88			24.4				Gee et al., 2005
		dwelling, living room, with smokers		112			24.3				
		dwelling, bedroom, non-smokers		88			20.1				
		dwelling, bedroom, with smokers		112			20.1				
France		residential, working day	24h	44		22	19.0	11	38		Piechocki-Minguy et al., 2006
		residential, weekend	24h	44		27	20.0	10	60		
PUBLIC SPACES											
Finland		ice arenas	15 min						320-7530	INDEX	Pennanen et al.,1997[a]
			1 hour						270-7440		Pennanen et al.,1998[a]
TRANSPORT											
France	2001	transport, working day	24h		45	114	104	71	159		Piechocki-Minguy et al., 2006
		transport, weekend				56	60	31	77		
		train				20-50					Piechocki-Minguy et al., 2006
		tramway or underground				33-68					
		bicycle				69-96					

		car or motorcycle			97-125			
ENVIRONMENTS OF SENSITIVE GROUPS								
Greece	May 2000	schools	30 min	20	56	10	80	Siskos et al., 2001
	Dec 2000	schools	30 min	20	49	10	80	
	jan/2001	schools	30 min	20	41	10	70	
the Netherlands		school near ring road (schools)	48h		18.45			Van Roosbroeck et al., 2007
		school near ring freeway (schools)	48h		32.8			
		school, background	48h		16.4			
		school, background	48h		38.95			

[a] cited in INDEX; [b] cited in THADE; [c] information from workshop participants (2001) (original studies not listed in reference list here)

benzene

1. sources

Probably the most important indoor source is cigarette smoking. Other remarkable indoor sources are emissions from consumer products, including off-gassing from particle board. Similarly, living in the vicinity of hazardous waste sites or industrial facilities may increase exposure to benzene (source: INDEX).

2. indoor concentrations and personal exposure

   a. *dwellings and personal exposure*

Mean indoor concentrations are typically higher than the respective outdoor levels all over Europe.
In Northern European cities, the mean benzene indoor concentrations seen to be lower than in Southern European cities (see *Table 7* and see discussion of the INDEX and MACHBETH study).

The report of the INDEX-project also records the MACBETH study (Cocheo et al., 2000). In the MACBETH study, 5-day average indoor air concentrations in Antwerp, Athens, Copenhagen, Murcia, Padova and Rouen has been measured. In each city, 50 indoor environments have been sampled. The cumulative distribution curves were rather similar to those of the EXPOLIS study: P50 indoor concentrations varied from 4 µg/m³ (Copenhagen) to 10 µg/m³ (Murcia) The range of P90 indoor concentrations were slightly lower than those of EXPOLIS, namely from 8 (Copenhagen) to 25 µg/m³ (Murcia).

In the recent PEOPLE project (acronym for Population Exposure to Air Pollutants in Europe, Field et al., 2005), one-day cross-sectional benzene indoor concentrations in six European cities have been measured. Median benzene concentrations in dwellings in the PEOPLE study were from 1.6 µg/m³ (Dublin) to 7.9 µg/m³ (Bucharest).

Benzene concentrations of garages of dwellings where regularly a car was parked in the garage attributed to 101 µg benzene/m³. Not only for the garage itself, but also for the living compartments of dwellings with an attached or integral garage, the benzene concentrations were greatly affected by the presence of cars inside the garage: from 3.7 µg/m³ in one home where the car was rarely parked in the garage to 40 µg/m³ for a home where a care with high benzene emissions was frequently parked (Mann et al, 2001).

   b. *public spaces*

The benzene indoor concentrations were lower in public spaces where a smoking ban was installed compared to public spaces where smoking was allowed. For example, smoking was reported to be very likely in the shops in Bucharest (17.9 µg/m³) and Madrid (8.8 µg/m³) an the bars in Madrid (19.4 µg/m³), whereas smoking was not allowed in the 'clean' shops (pharmacies, …) sampled in Lisbon (1.6 µg/m³) where smoking was prohibited (PEOPLE-project).

In the ongoing AIRMEX (European Indoor Air Monitoring and Exposure Assessment Project) project, 1 week average indoor benzene concentrations from 2.0 µg/m³ (Leipzig)

to 10.9 µg/m³ (Athens) were measured in 2003-2005 in public buildings (town halls and guild halls) in 7 European cities.
In the basis of these preliminary results, it revealed that indoor benzene concentrations in public buildings (and schools and kindergartens) were generally higher in Southern European cities compared to cities in Central Europe.

c. transport

Schupp et al. (2006) recently made a literature review of benzene concentrations in automobiles. Among the various studies, they found a range between 13 - 560 µg benzene/m³. The higher end of this range exceeds the maximum exposure levels for chronic exposure (called 'ELIA': 83 µg/m³), not for short term exposure (called 'STELIA': 16 mg/m³), proposed by Schupp et al. (2006). The authors concluded that benzene exposure inside cars seems to be problematic, and this should not be underestimated since benzene is a genotoxic carcinogen that probably acts by non-threshold mechanisms. Interestingly, the conclusion of a comparable exercise for toluene, xylene and trimethyl benzene was that exposure inside cars to the latter components are unlikely to pose a risk to the health of drivers.

The highest personal exposure of all participants of the study of Edwards et al. (2005) was 217 µg/m³. This participant spent 9.5 h in the car during the 48-h measuring period, and high indoor taxicab benzene concentrations caused this high exposure.

In the PEOPLE study (Field et al., 2005), indoor concentrations in taxis (median: 14.8 -27.5 µg/m³) were elevated compared to other indoor environments. Median indoor benzene concentrations in buses and metro stations in Lisbon were respectively 9.2 µg/m³ and 5.7 µg/m³.

The personal exposure of commuters in Brussels had the higher level for car users (median value of 5.3 µg/m³) compared to public transport users (median 4.3 µg/m³). Similar trends were found in Bucharest: median exposure of car users was 18.8 µg/m³ compared to 12.5 µg/m³ for public transport users. Also for Lubljana, Madrid and Dublin, a comparable trend was observed.

Rank et al. (2001) compared benzene exposure to 2 cyclists versus 2 car drivers while driving for 4 hours on 2 different days in the morning traffic of Copenhagen. The benzene concentrations in the cabin of the cars were about 3 times greater than in the cyclists' breathing zone (car: 11.0- 17.5 µg benzene/m³; bicycle: 4.5-5.6 µg/m³).

The benzene concentration in enclosed parking garages were found to be on average 366 µg/m³ in Athens (Soldatos et al., 2003)

d. environments of sensitive groups

Janssen et al. (2001) measured inside and outside benzene concentrations in 24 schools located within 400 m proximity of motorways in the Netherlands. The mean inside benzene concentrations were 3.2 µg/m³, with a range from 0.6-8.1 µg/m³.

Bertoni et al. (2002) performed BTX monitoring campaign in 2002 in Rome, including investigations for schools. Average indoor benzene concentrations in the 15 schools varied from 1.8 µg/m³ to 4.1 µg/m³ (average of the 15 schools: 2.96 µg/m³).

Schools were also included in the PEOPLE project. Indoor benzene concentrations measured in the PEOPLE measuring campaign (1.6 - 6.0 µg/m³) were in the same range as of the studies of Janssen et al. (2001) and Bertoni et al. (2002).

In the ongoing AIRMEX (European Indoor Air Monitoring and Exposure Assessment Project) project, 1 week average indoor benzene concentrations from 1.4 µg/m³ (Leipzig) to 7.4 µg/m³ (Athens) were measured in 2003-2005 in schools and kindergartens in 7 European cities.

Table 7: Indoor air concentrations and personal exposure of benzene reported in different studies across the EU

country	year	environment	averaging time	# samples/persons	concentration (μg/m³)					source	ref.
					mean	median	min	max	P95		
RESIDENTIAL											
Finland (Helsinki)		indoor (no smoking)			2.24					INDEX	Edwards et al., 2001[a]
Central Europe (Basel, Erfurt, Hamburg, Prague and Antwerp)		indoor			2.3-12					INDEX	Jantunen et al.1999; Cocheo et al.,2000)[a]
Southern Europe (Milan and Athens)		indoor			10-13					INDEX	Jantunen et al.1999; Cocheo et al.,2000)[a]
Germany		indoor	1 week		1.6			7		INDEX	Ullrich et al., 2002[a]
England		indoor	28-day		3			93.5		INDEX	Brown et al., 2002[a]
Germany (Hamburg)	1995-1996	indoor, winter	1 week	5		2.5					Schneider et al.,2001
Germany (Erfurt)	1995-1996	indoor, winter	1 week	20		2.9					
Germany (Hamburg)	1995-1996	indoor, summer	1 week	5		1.2					
Germany (Erfurt)	1995-1996	indoor, summer	1 week	20		0.9					
Germany (Hannover)	1994-1997	indoor, rural			2.2					Schneider et al.,2001	Levsen et al, 1999[b]
Germany (Hannover)	1994-1997	indoor, urban			3.3					Schneider et al.,2001	Levsen et al, 1999[b]
Germany (Hamburg)	1994-1997	indoor			2.3					Schneider et al.,2001	Levsen et al, 1999[b]
Germany (Erfurt)	1994-1997	indoor			2.5					Schneider et al.,2001	Levsen et al, 1999[b]

Germany (Leipzig)	1994-1997	indoor			5.9				Schneider et al.,2001	Herbarth and Rehwagen, 1998[b]
Belgium (Brussels)	2002	indoor	1 day	52		6.3	32	22	PEOPLE - project	Field et al, 2005
Lisbon	2002	indoor	1 day	18		3.5		9	PEOPLE - project	Field et al, 2005
Bucharest	2003	indoor	1 day	30		7.9	26	24	PEOPLE - project	Field et al, 2005
Ljubljana	2003	indoor	1 day	21		2.2		4	PEOPLE - project	Field et al, 2005
Madrid	2003	indoor	1 day	13		5.3		24	PEOPLE - project	Field et al, 2005
Dublin	2004	indoor	1 day	10		1.6		5.5	PEOPLE - project	Field et al, 2005
PUBLIC SPACES										
Brussels	2002	indoor, shop	1 day	10		6		29	PEOPLE - project	Field et al, 2005
Lisbon	2002	indoor, shop	1 day	9		1.6		8	PEOPLE - project	Field et al, 2005
Bucharest	2003	indoor, shop	1 day	2		22.5			PEOPLE - project	Field et al, 2005
Ljubljana	2003	indoor, shop	1 day	10		3.8		6	PEOPLE - project	Field et al, 2005
Madrid	2003	indoor, shop	1 day	4		8.8		19	PEOPLE - project	Field et al, 2005
Brussels	2002	indoor, bar	1 day	4		10.8		13	PEOPLE - project	Field et al, 2005
Lisbon	2002	indoor, bar	1 day	8		4.4		12	PEOPLE - project	Field et al, 2005
Bucharest	2003	indoor, bar	1 day	1		18			PEOPLE - project	Field et al, 2005
Ljubljana	2003	indoor, bar	1 day	5		5.8		14	PEOPLE - project	Field et al, 2005
Madrid	2003	indoor, bar	1 day	5		19.4		26	PEOPLE - project	Field et al, 2005
Dublin	2004	indoor, bar	1 day	9		2		4.2	PEOPLE - project	Field et al, 2005

Ljubljana	2003	indoor, restaurant	1 day	5		2.9			12	PEOPLE - project	Field et al, 2005
Italy (Catania)	may 2003	public buildings	1 week		3.9		2.8	4.8		AIRMEX	
Italy (Catania)	october 2003	public buildings	1 week		7.4		4.9	17.1		AIRMEX	
Greece (Athens)	decmber 2003	public buildings	1 week		10.9		5.6	12.9		AIRMEX	
Greece (Athens)	October 2005	public buildings	1 week		8.8		5.6	12.9		AIRMEX	
Greece (Thessaloniki)	2004	public buildings	1 week		33		8	63.7		AIRMEX	
Belgium (Brussels)	2004	public buildings	1 week		2.9		1.9	3.9		AIRMEX	
the Netherlands (Nijmegen)	2004	public buildings	1 week		4.3		3.1	5.4		AIRMEX	
the Netherlands (Arnhem)	2004	public buildings	1 week		3.5		1.8	6.2		AIRMEX	
Germany (Leipzig)	2005	public buildings	1 week		2		1.5	2.9		AIRMEX	
TRANSPORT											
Brussels	2002	taxi	1 day	5		27.5			43	PEOPLE - project	Field et al, 2005
Madrid	2002	taxi	1 day	7		14.8			30	PEOPLE - project	Field et al, 2005
Lisbon	2002	bus	1 day	4		9.2			20	PEOPLE - project	Field et al, 2005
Lisbon	2002	metro	1 day	5		5.7			8	PEOPLE - project	Field et al, 2005
Italy (Parma)		taxi	24h	37	7.71						Manini et al, 2006
? (undefined)		taxi (personal exposure taxi driver)	48h					217			Edwards et al., 2005
?		car, passenger compartment					13	560			Schupp et al., 2006
Athens	2001	parking garage			366						Soldatos et al. 2003

Copenhagen	1998	car	4h	4	14.4		11	17.5			Rank et al, 2001
Copenhagen	1998	bicycle	4h	4	5.2		4.5	5.6			
Germany (Berlin)	1994	car inside			21			31.9			Fromme et al., 1998
	1995	car inside			21.5			26.3			Fromme et al., 1998
	1996	car inside			21.6			35			Fromme et al., 1998
	1994	subway inside			8.4			16			Fromme et al., 1998
	1995	subway inside			5.4			7.4			Fromme et al., 1998
	1996	subway inside			7.4			10.3			Fromme et al., 1998
ENVIRONMENTS OF SENSITIVE GROUPS											
Brussels	2002	indoor, school	1 day	4		1.6			28	PEOPLE - project	Field et al, 2005
Lisbon	2002	indoor, school	1 day	9		4.2			12	PEOPLE - project	Field et al, 2005
Bucharest	2003	indoor, school	1 day	1		4.3				PEOPLE - project	Field et al, 2005
Ljubljana	2003	indoor, school	1 day	10		2.5			7	PEOPLE - project	Field et al, 2005
Madrid	2003	indoor, school	1 day	3		6				PEOPLE - project	Field et al, 2005
the Netherlands	1997-1998	indoor school	6h	24	3.2	2.9	0.6	8.1			Janssen et al., 2001
Italy (Rome and Monterotondo)	2002	indoor school	12h	15	2.96	3.1	1.8	4.1			Bertoni et al., 2002
Italy (Catania)	may 2003	indoor (schools and kindergartens)	1 week		2.6		2.3	2.8		AIRMEX	Kotzias et al.
Italy (Catania)	october 2003	indoor (schools and kindergartens)	1 week		3.8		3.1	4.4		AIRMEX	Kotzias et al.
Greece (Athens)	decmber 2003	indoor (schools and kindergartens)	1 week		7.4		4.9	10.7		AIRMEX	Kotzias et al.
Greece (Athens)	October 2005	indoor (schools and kindergartens)	1 week		5		2.9	6.1		AIRMEX	Kotzias et al.

Greece (Thessaloniki)	2004	indoor (schools and kindergartens)	1 week	5.8	2.6	7.5	AIRMEX	Kotzias et al.
the Netherlands (Nijmegen)	2004	indoor (schools and kindergartens)	1 week	2.1			AIRMEX	Kotzias et al.
the Netherlands (Arnhem)	2004	indoor (schools and kindergartens)	1 week	3			AIRMEX	Kotzias et al.
Germany (Leipzig)	2005	indoor (schools and kindergartens)	1 week	1.4	1	1.8	AIRMEX	Kotzias et al.

[a] cited in INDEX; [b] cited by Schneider et al., 2001; (original studies not listed in reference list here)

naphthalene

1. sources

The principal end use for naphthalene is an intermediate in the production of phthalate plasticizers, resins, phtaleins, dyes, pharmaceuticals insect repellents and other materials. It is also used in the production of the insecticide carbaryl used in home yards and gardens, and in paints, dyes and resins. Crystalline naphthalene is also used as a moth repellent and as a solid block deodorizer for toilets. Wood smoke, fuel oil and gasoline also contains naphthalene.

2. indoor concentrations and personal exposure (*Table 8*)

   a. *dwellings and personal exposure*

The report of the INDEX-project includes cumulative distribution curves of indoor air concentrations of naphthalene in Athens (n = 42), Basel (n = 47), Helsinki (n = 188), Milan (n = 38), Oxford (n = 40) and Prague (n = 46). From these graphs, indoor concentrations to 10% (P10), 50 % (P50) and 90 % (P90) of the population was read. The P10 indoor naphthalene concentrations were below 1 µg/m³ for all cities, the P50 indoor naphthalene concentrations were below 2 µg/m³ for all cities except Athens (40 µg/m³). The average indoor levels in Athens were 90 µg/m³. Personal exposure to naphthalene ranged from 1 µg/m³ to 3 µg/m³ elsewhere in the EU (Jantunen et al., 1999 and Hoffman et al., 2000, cited in INDEX), but in Athens, average exposure was 46 µg/m³.
In the INDEX-report, it was concluded that exposures to naphthalene were usually low in Europe, except in Athens.
The same EXPOLIS database is used in the study of Edwards et al. (2005). These authors discussed more in detail the elevated naphthalene concentrations and exposures for Athens. Multiple linear regression on the Athens database revealed, in the following order, 1) time actively smoking, 2) presence of attached garage, 3) home locations in the downtown area (~ emissions from automobiles) and 4) time using gas stove as predictor for the indoor naphthalene concentrations.
Maroni et al. (1995) (cited in INDEX) reported typical median and P90 naphtalene concentrations in indoor being 2 µg/m³ and 5 µg/m³ respectively. Kostiainen et al. (1995) detected slightly lower indoor concentrations in Helsinki having 0.44 µg/m³ as a mean and 1.63 as maximum concentrations.
In an Italian study, average indoor naphthalene concentration was 11 µg/m³ and maximum concentration of 70 µg/m³ was reported (DeBortoli et al., 1986, cited in INDEX).

An update of the scientific literature related to indoor naphthalene concentrations in indoor environments in the EU did reveal new information.

   b. *public spaces*

No specific information for public spaces was available in the literature. Given the main sources of naphthalene (mothballs), it is unlikely that naphthalene concentrations are higher in public spaces than in dwellings.

   c. *transport*

No specific information for transport micro-environments was available in the literature (+ same remark as for public spaces) *d. environments of sensitive groups*

No specific information for schools and other micro-environments of sensitive groups was available in the literature (+ same remark as for public spaces).

CO_2/ventilation

1. sources

Carbon dioxide (CO_2) is an exception in the list of 'priority pollutants', in this way that CO_2 itself is not a toxic substance (unless at very extreme concentrations coupled by oxygen). Instead, CO_2 concentrations are used often as a surrogate of the rate of outside supply air per occupant.

The WHO guideline for indoor CO_2 concentrations is 1800 mg/m³.

Breathing is the main sources of indoor CO_2. The more crowded and unventilated an indoor space, the higher the indoor CO_2 levels are

2. indoor concentrations

e. dwellings

Only one study performed in the EU (namely in Sweden and Estonia) reported CO_2 levels at home. The mean CO_2 concentration among 97 homes in Sweden (Örebro) was 1556 mg /m³ and in 98 homes in Estonia (Tallinn) 1665 mg/m³ (Frisk et al., 2002, cited in THADE).

f. public space

no information (see schools)

g. transport

no information

h. environments of sensitive groups

schools

Siskos et al. (2001) investigated CO_2 concentrations 20 classrooms in Athens in 2000. The average CO_2 concentration was slightly higher in winter (2537 mg/m³) compared to summer (2263 mg/m³). The range of CO_2 concentrations in the different classrooms over different seasons was 604-5532 mg/m³.

Two Swedish schools (Norback, 1995, cited by Daisey et al., 2003) were reported to have average CO_2 concentrations of 1420 and 1850 ppm[11] CO_2. Median CO_2 concentrations were 1070 ppm (range 800 – 1600 ppm) in a study of 10 Swedish non-complaint schools and 1100 ppm (range 875 – 2150 ppm) in 11 schools with higher prevalence of sick building syndrome symptoms (Willers et al., 1996, cited by Daisey et al, 2003). Nielsen (1984, cited by Daisey et al, 2003) reported a measurement showing a CO_2 range of 500 – 1500 ppm (average: 1000 ppm) in 11 Danish schools. Daisey et al. (2003) report that many of these European measurements were made with colorimetric indicator tubes over a very short time interval.

Pointing et al. (1987, cited by Daisey et al., 2003) measured CO_2 levels in 7 Dutch schools (3 with complaints and 4 without complaints) constructed after 1980. Classroom CO_2 levels

[11] 1000 ppm CO_2 = 1.8 g CO_2/m³

in all of these schools exceeded the Dutch standard of 1200 ppm during 27-97 % of the school time.

Smedje et al. (1996, 1997, cited by Daisey et al., 2003) reported average CO_2 levels of 990 ppm among 38 schools (maximum: 2800 ppm)

All data expressed in ppm CO_2 units are converted to mg/m³ by multiplication of factor 1.8

Table 8: Indoor air concentrations and personal exposure of naphthalene reported in different studies across the EU

country/city	year	environment	averaging time	# samples/persons	concentration (µg/m³)				source	ref.
					mean	median	min	max		
RESIDENTIAL										
Athens		personal exposure	48h	42	54	22.6		469		Edwards et al., 2005
		indoor, dwelling	48h					989		Edwards et al., 2005
Prague		personal exposure	48h	46	2.4	1.8				Edwards et al., 2005
			48h						INDEX	
Helsinki				188		<2			INDEX	
Basel				47		<2			INDEX	
Milan				38		<2			INDEX	
Oxford				40		<2			INDEX	
Helsinki	before 1995	indoor, dwelling			0.44			1.63	INDEX	Kostiainen et al, 1995[a]
Italy	before 1986	indoor, dwelling			11			70	INDEX	DeBortoli et al., 1986[a]
PUBLIC SPACES										
no data										
TRANSPORT										
no data										
ENVIRONMENTS OF SENSITIVE GROUPS										
no data										

[a] cited in INDEX; (original studies not listed in reference list here)

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ANNEX C: OVERVIEW OF MEMBER STATES POLICIES, LEGISLATION AND MONITORING NETWORKS

Stock – taking of Member States' indoor air policies, legislatively frameworks, and monitoring programs

Compared to outdoor air and to workplace air, the quality of indoor air has been studied and regulated to a much lesser extent. In spite of the growing interest in the quality of indoor air, there are only few countries in the world having set up a legal act specific to indoor air. In most cases, legislations established for other purposes were applied to the indoor environment. The indoor environment however, differs in a large degree from ambient air and from workplaces. First of all, people spend their majority of their time indoors. Persons who are particularly vulnerable to air pollutants (infants, elderly and sick persons) spend also much time in confined spaces.

In addition to legislative frameworks, the Member States monitoring programs were reviewed. The need for surveillance monitoring of indoor air quality in public spaces for the protection of human health is an effective tool (among others) to battle indoor pollution, it is evident that enforcement through monitoring needs to be considered.

In contrast to the well elaborated and implemented EU ambient air policies (under the form of the Air Quality framework directive 1996), an integrated EU policy on indoor air quality is not available. Currently, indoor air quality is fragmentally tackled in sector-oriented policies, but a an overall, integrated indoor air policy at the EU level is missing.
Studies have been pointing to indoor air pollution for decades (see e.g. the ECA reports), and the importance of indoor air quality at the EU level was stressed in the Commission's Environment and Health Action Plan 2004-2010 (EHAP). The EHAP includes a specific indoor air action (action 12) with two key elements: (1) addressing environmental tobacco smoke (ETS) and (2) developing networks and guidelines on other factors affecting indoor air quality by using research and exchange of best practice.

Additionally, the reduction of emissions from building products and adequate elimination of combustion products generated indoors have been taken down in the conclusions Dutch Presidency Conference (2004 Egmond aan Zee).

The overall actions that were taking since then are listed in the *"Mid Term Review of the European Environment and Health Action Plan 2004-2010"* {Sec(2007) 777}.

Improving indoor air quality was done by several activities. The Commission adopted the Green paper "Towards a Europe free from tobacco smoke: policy options at EU level " in January 2007 and launched a broad consultation process, on the best way to tackle assive smoking in the EU. Currently, the Commission is preparing a follow-up initiative on smoke-free environments, due to be adopted in 2008 and a report on the implementation of the Council Recommendation on the prevention of smoking and on initiatives to improve tobacco control.

In May 2005 the Commission mandated the SCHER to deliver an opinion on a possible risk assessment strategy to support policy on the indoor air issue, to identify potential areas of concern in relation to the different pollutants and to consider risks associated with the use of on air fresheners in January 2006. On air fresheners. The SCHER issued a separate opinion the other questions of the mandate the Committee issued a preliminary report for public consultation in January 2007.

An expert working group was established in October 2006 to follow up the opinions of the Scientific Committee and to fulfil the expectations from the political side, Member States and other stakeholders who asked the Commission to use a wide approach and take concrete actions on a number of pollutants/areas.

2 FP6 projects (ENVIE/PRONET) are focused on issues related to indoor air quality. Measuring campaigns in several European cities were carried out by the JRC to monitor indoor/outdoor and personal (AIRMEX) exposure concentrations of selected substances . In 2006, the JRC issued a milestone report describing strategies to determine and control the contribution of indoor air pollution to total inhalation exposure (STRATEX).

Indoor air Policies and Legislatively Programs

To influence the member states' legislative programs, one needs to know what the incentives are for these programs. Several incentives can exist that initiate the national policy. Most important categories are national (local) problems, National Environment and Health Action Plan initiated by the WHO and national implementation of European Directives.
The first question of the questionnaires distributed at the VITO workshop addressed this issue: *Which is the determining factor in policy making: national problems associated with IAQ, European directives, or the (National) Environment and Health Action Plan?*

Table 9: Summarised Response from the questionnaire (Question A1)

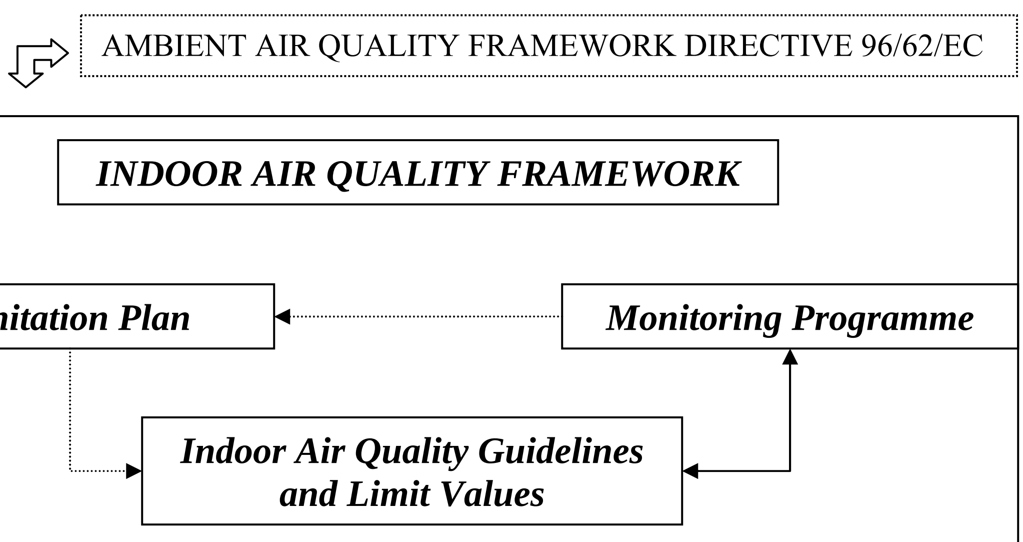
Member State	National Problems	European Directives*	(N)EAP
Bulgaria		x	x
Finland	x		
Hungary	x	x	
Italy		x	x
Poland	x		
Portugal		x	
Slovakia	x		x
Sweden	x	x	
The Netherlands			x
*All tough European Directives are not mentioned as driving force, it should be noted that every European Directive must be implemented nationally once it has been accepted.			

As can bee seen from Table 9, European Directives play an (important) role in the member states national policies. The European initiatives should therefore be taken into account in the stock – taking of the member states' policies.

Three cornerstones for an indoor air policy could be:

1. Indoor air quality guidelines,
2. Sanitation plans and
3. Indoor air monitoring programmes.

This concept is analogous to that of the ambient air quality framework directive 96/62/EC. In fact, indoor and ambient air quality policies should be geared one to another because the same compounds in both indoor air and ambient air affect human health, and indoor air quality is influenced by outdoor air pollution.



With regard to indoor air policy strategies, three categories of indoor air spaces are to be considered:

1. Workplace ~ occupational environment
2. Private (dwelling) spaces ~ individual's environment
3. Public spaces ~ space with a mix of employees and individuals (e.g. a public bus is an employee environment for the bus driver and a 'individual' environment for passengers)

Options for indoor air quality policies depend on the type of indoor air spaces.

Ad1) Indoor air quality standards are enforceable (and in place) in the workplace environment, and these indoor environments are out of scope of this study. It is however worth mentioning that indoor air quality guidelines applicable for indoor air in dwellings might originate from occupational studies, when divided by an appropriate factor.

Ad2) Due to individual freedom and privacy, air quality limits are difficult to enforce in private spaces. Other, indirect policy options (e.g. product standardization, and building ventilation) are the best way forward to ensure a healthy indoor climate in private (and public) indoor environments. Central is that individual use of products causing indoor air pollution is hardly enforceable, whereas policies restricting the emission of indoor pollutants can be achieved by imposing standards to producers.

Ad3) In public places, emissions can be regulated, and product use can be subjected to certain limits. The best example in this respect is ETS. This is being tackled through the green paper and the proposal of a ban on cigarette smoking in public places. Other indoor pollutants – if any- emitted by individuals present in public indoor environments are not under scrutiny.

Table 10: Summarizing Policy Options for Indoor Space (enforceability)

	Guideline Values	Sanitation		Monitoring Programme
		Direct	Indirect	
Workplace	Yes	Yes	Yes	Yes
Private Space	Yes	Partially*	Yes	Yes
Public Space	Yes	Yes	Yes	Yes
* An exception can be made for rental dwellings. To protect the housing quality for tenders, standards and laws can be set				

C.1 Indoor Air Quality Guidelines Values and Limit Values

Indoor air quality guidelines for factors (chemical/physical) should be the basis for any legislative framework. It is the only scientific interface between sanitation (in the context of IAQ) and health impact.

On an international level, the WHO is preparing indoor air quality guidelines. In a report of a working group meeting. (WHO Europe, Development of WHO Guidelines for Indoor Air Quality, Report on a Working Group Meeting Bonn, Germany, 23-24 October 2006), a number a factors was selected to be included in the guidelines for IAQ. (Table 11)

Table 11: Summary Factors to be included in the Guidelines on IAQ (WHO)

Group A Pollutants	Group B Biological Agents	Group C Indoor Combustion
Formaldehyde		**Stove Venting**
Benzene		- flues
Nathphalene		-hoods
Nitrogen Dioxide		
Carbon Monoxide	**Ventilation**	**Ventilation**
Radon (Rn)	- natural	- natural
Particulate Matter ($PM_{2.5}$ & PM_{10})	- forced/mechanical	- forced
		Combustion Quality
Halogenated Compounds	**Allergens**	Fuels
PAH, especially BaP	- from house dust mites	- solid
	- from pets	- processed solid
		- liquid
		- gas
		- electricity

As mentioned before, an integrated EU policy on indoor air quality is not available, although there is al lot of work being done on this issue. . Next to the items mentioned in the EHAP (action point 12), there are other main research projects that are ongoing or have been finished.

The **INDEX project** (Critical Appraisal of the Setting and Implementation of Indoor exposure Limits in the EU) started in December 2002 and had a duration of two years, until December 2004.The project was financially supported by DG SANCO and it was coordinated and carried out by the JRC in collaboration with a Steering Committee of leading European experts in the area of indoor air pollution. Scope of INDEX was to identify priorities and to assess the needs for a Community strategy and action plan in the area of indoor air pollution by:

- setting up a list of compounds to be regulated in indoor environments with priority on the basis of health impact criteria
- providing suggestions and recommendations on potential exposure limits for these compounds, and
- providing information on links with existing knowledge, ongoing studies, legislation etc. at world scale.

Table 12: Index – Project: Priority Pollutants

Priority Chemical	**Guideline Values**	
Formaldehyde	NOEL 30 µg/m³ (30 – minutes average	
Nitrogen Dioxide	Short term guideline value 200 µg/m³	Long term guideline value 40 µg/m³ (1-week)
Carbon Monoxide	30 mg/m³ (1-hour average)	10 mg/m³ (8-hour average)
Benzene	As low as reasonably possible	
Naphthalene		Long term guideline value 10 µg/m³

A number of publications provide overviews containing European Indoor Air Quality Guidelines.

- January 2006: "Final Report of the INDEX Project, Critical Appraisal of the Setting and Implementation of Indoor Exposure Limits in the EU", Dimitrios Kotzias et al, EUR 21590 EN 2005
- *Strategic approaches to indoor air policy-making*. Copenhagen, WHO Regional Office for Europe, 1999 (EUR/ICP/EHBI 04 02 02).
- Spruyt et al. 2006. Product Policy in the Context of the Indoor Environment Quality. VITO, 2006/MIM/R/021

The following tables have been reproduced from the reports referred above.

There is also an AIVC technical note (TN 55) available, but the guidelines values included primarily focus on workplace environments: 2001: “A Review of International Ventilation, Airtightness, Thermal Insulation and Indoor Air Criteria”. Mark J. Limb, AIVC.

Table 13: Overview of Indoor Air Guidelines for Private Spaces that are into place in several member states

		Formaldehyde	CO	NO_2	Naphthalene	Toluene	Styrene	NH_3	Monoteroene (a-pinene)
		µg/m³	mg/m³	µg/m³	µg/m³	µg/m³	µg/m³	µg/m³	µg/m³
Belgium (Flanders)[1]	GL	10	5.7	135		260			
	IV	100 (30-min)	30	200 (1-h)					
Finland[2]	S1	30	2					30	
	S2	50	3					30	
	S3	100	8					40	
Germany[3,4,5]	GVII		15 (8-h)	60 (1-w)	20	3000 (1-w)	300 (1-w)		2000 (1-w)
	GVII		60 (30 -min)						
	GVI		1,5 (8-h)		2	300 (1-w)	30 (1-w)		200 (1-w)
	GVI		6 (30 -min)						
Norway[6]		100 (30 -min)	10 (8-h)	100 (1-h)					
			25 (1-h)						
Poland[7]	Cat B	100	6		150	250	30	300	
	Cat A	50	3		100	200	20	300	
UK[8]		100 (30 -min)	100 (15 -min)	300 (1-h)					
			60 (30 -min)	40 (1-y)					
			30 (1-h)						
			10 (8-h)						
WHO[9]		100 (30 -min)	100 (15 -min)	200 (1-h)		260 (1-w)	260 (1-w)		
			60 (30 -min)	40 (1-y)					
			30 (1-h)						
			10 (8-h)						
Abbreviatons for averaging time (-min) = -minute; (-h) = -hour; (-w)=-week and (-y) = -year									

1	Flemish Indoor Decree (BS: 19/10/2004); GL: Guideline Value; IV, intervention Value
2	Target values for indoor air quality and climate; S1 = very good indoor air climate (Individual Indoor Climate), S2 = good indoor air climate, S3 = satisfactory indoor air climate. Values given in the table are maximum values for S1, S2 and S3. Source: Finnish classification of indoor climate. Finnish Society of Indoor Air Quality and Climate (FiSIAQ), 2000 (in English).
3	Guidelines values (GV) for indoor air pollutants; GV II is a health-related value based on current toxicological and epidemiological knowledge. If the concentration corresponding to GV II is reached or exceeded immediate action must be taken because permanent stay in a room at this concentration level is likely to represent a threat to health especially for sensitive people. GV I is the concentration level at which a substance, taken individually, does not give rise to adverse health effects even at life-long exposure. An exceedance of GV I is linked with an exposure beyond normal which is undesirable from a hygienic viewpoint. GV I and GV II are given as 1-week average, except carbon monoxide, which was given as 8-hour (8-h) and 30-minute (30-min) average. Source: Seifert B. et al. (1999). Guidelines values for indoor air pollutants, Proceedings of Indoor Air '99, Edinburgh, vol 1: 499-504.
4	Sagunski H, Heger W (2004). Richtwerte fur die Innenraumluft: Naphthalin. BundesgesundheitsblGesundheitsforsch – Gesundheitsschutz. 47:705-712 (in German).
5	Sagunski H, Heinzow B (2003). Richtwerte fur die Innenraumluft: Bicyclische Terpene (Leitsubstanz Pinen). Bundesgesundheitsbl – Gesundheitsforsch – Gesundheitsschutz. 46:346-352 (in German).
6	Becher (1999). Recommended Guideliens for Indoor Air Quality, Proceedings of Indoor Air '99, Edimburgh, Bol 1:171-176
7	Category A – exposure up to 24 h per day; Category B – exposure limited to 8-10 h per day
8	COMEAP (2004) Guidance on the effects on Health of Indoor Air Pollutants. Committee on the medical Effects of Air Pollutants (COMEAP). December 2004
9	WHO (2000). Air Quality Guidelines for Europe. WHO Regional Publications, European Series, N° 91, Regional Office for Europe, Copenhagen

Table 14: presence of selected Substances in principal priority substances databases

	Danish EPA	French OIAQ *	Finnish SYKE list	Swedish PRIO	Swedish BASTA **	Ger LCI ***
Acetaldehyde	-	X	-	X	X	-
Benzene	-	X	-	X	X	-
Tetrabromobisphenol A	X	-	-	-	-	-
Hexabromocyclododecane	X	-	-	X	-	-
Pentabromodiphenyl ether	X	-	-	X	-	-
Octabromodiphenyl ether	X	-	-	-	-	-
Decabromodiphenyl ether	X	-	-	X	-	-
Formaldehyde	X	X	-	X	X	-
Certain glycol ethers	X	X	-	X		
Ethyl glycol (EG)			-			X
Ethyl glycol acetate (EGMEA)	X		-			X
Methyl glycol (EGMM)			-			X
Methyl glycol acetate (EGMMA)			-			X
Limonene	X	X	-	X	-	X
Methylene-di-isocyanate	X	-	-	X	-	-
Alpha-pinene	-	X	-	-	-	X
Permethrin	-	-	-	-	-	-
Toluene	-	X	-	-	-	X
Trichloroethylene	X	X	-	X	X	-
Triclosan	-	-	-	-	-	-
Trimethylbenzene	-	X	-	-	-	X
Vinyl chloride	-	-	-	X	X	-

In some other member states, guideline values are in place that were not already mentioned in ***Table 13***.

Table 15: Guideline Values for Indoor Air (RW, Germany)

Compounds	**RW II (mg/m^{3})**	**RW I (mg/m^{3})**	**Year of Imple-mentation**
Toluene	3	0.3	1996
Dichloromethane	2 (24 h)	0.2	1997
Carbon monoxide	60 (1/2 h)	6 (1/2 h)	1997
	15 (8 h)	1.5 (8 h)	
Pentachlorophenol	1 µg/m^3	0.1 µg/m^3	1997
Nitrogen dioxide	0.35 (1/2 h)	-	1998
	0.06 (1 Week)		
Styrene	0.3	0.03	1998
Mercury (as metallic vapour)	0.35 µg/m^3	0.035 µg/m^3	1999
Tris(2-chloroethyl)phosphate	0.05	0.005	2002
Bicyclic terpenes (principal constituent alfa-pinene)	2	0.2	2003
Naphthalene	0.02	0.002	2004
Aromatic hydrocarbon mixtures (C9-C14)	2	0.2	2005

The Finish Ministry of Environment issues the Building Code which contains binding regulations and guidelines for designing, building, construction work, ventilation, and indoor air quality (Ministry of the Environment, 2003). The chapter concerning air quality states that "buildings shall be designed and constructed in such a way that the indoor air does not contain any gases, particles or microbes in such quantities that will be harmful to health, or any odours that would reduce comfort". Apart from this general statement, the Building Code gives limit values for several substances:

Table 16: Values for concentrations of impurities in indoor air for the purpose of designing and implementing indoor climate of buildings (from Indoor Climate and Ventilation of Buildings Regulations and Guidelines, National Building Code of Finland, 2003)

Substance	Maximum allowed concentration
Carbon dioxide	2 160 mg/m³ (1200 ppm)
Ammonia and amines	20 µg/m³
Asbestos	0 fibres /cm³
Formaldehyde	50 µg/m³
Carbon monoxide	8 mg/m³
Particles PM10	50 µg/m³
Radon	200 Bq/m³
Styrene	1 µg/m³

Table 17: Limit Values In Portugal

Pollutant	Limit Value
Particles	0.15 mg/m³
Carbon Dioxide	1800 mg/m³
Carbon Monoxide	12.5 mg/m³
Ozone	0.2 mg/m³
Formaldehyde	0.1 mg/m³
VOCs	0.6 mg/m³
Bacterias	500 CFU
Fungi	500 CFU
Legionella	100 CFU
Radon	400 Bq/m

Table 18: Maximum allowable concentration of harmful substances in indoor air for Poland

	Substance	Allowable concentrations [µg/m^3]	
		Category A	Category B
1	Acrylamide	1	3
2	Acrylonitrile	2	3
3	Ammonia	300	300
4	Benzene	10	20
5	Buthadiene	100	300
6	Buthanol	300	300
7	Chlorobenzene	15	40
8	Chlorophenols (without pentachlorophenol)	15	20
9	Chloronaphthalenes	15	30
10	Cyclohexane	250	250
11	Cyclohexanone	40	100
12	Dichlorobenzene	30	50
13	Ethylobenzene	100	150
14	Phenol	20	50
15	Formaldehyde	50	100
16	Dibuthylphthalate	100	150
17	Phthalate anhidrine	40	80
18	Ethylene glycol	15	50
19	Cresols	25	50
20	Xylene	100	150
21	p-cumene phenol	40	80
22	Maleinic anhidride	50	100
23	Naphtalene	100	150
24	Butyl acetate	100	150
25	Ethyl acetate	100	150
26	Vinyl acetate	50	100
27	Ozone	100	150
28	Pentachlorophenol	5	10
29	Mercury	1	3
30	Styrene	20	30
31	Carbon monoxide	3000	6000
32	Toluene	200	250
33	Trichloroethane	75	150
34	Trichloroethylene	150	200
35	Vinyl chloride	5	10

Note: Category A – exposure up to 24 h per day
Category B – exposure limited to 8-10 h per day

The prioritisation of pollutants can be a determining factor for the availability of indoor air quality guidelines. Therefore, the information from the questionnaires (question A.2) has been summarised.

Table 19: Summary of Responses to Question A.2 of the Questionnaire

Member State	ETS	SO_2	NO_2	CO	CO_2	O_3	NH_4^+	PM	Formaldehyde	Benzene	VOC	Asbestos	Radon	Biological	Water Vapour and Damp
Bulgaria		x	x					x	x						
Finland	x			x					x				x	x[1]	
Hungary	x		x									x			
Italy	x			x						x		x	x		
Poland				x					x		x[2]				
Portugal	x			x	x	x		x	x		x		x	x[3]	
Slovakia	x		x[4]				x	x	x[5]		x			x[6]	x
Sweden	x				x			x	x				x		x
The Netherlands	x			x				x	x		x				

1; microbial

2; phthalates; organic solvents used in paints/ varnishes and aromatic hydrocarbons, like xylene and toluene; aliphatic amines.

3; bacteria + fungi and legionella

4; and other combustion products

5; and other aldehydes

6; fungi and mould; house dust mites

C.2 Sanitation and Control Plans

Several options exist to implement sanitation plans of different kinds, as was presented on the first EnVIE conference.

> ***Fist EnVIE Conference on Indoor Air Quality and Health for EU policy***
> ***Draft Proceedings***
> ***Session 6 Indoor Air Policy Perspectives, Paul Harrison***
>
> …
>
> MANAGEMENT OPTIONS
>
> Risk management for indoor air quality can involve regulatory or non-regulatory strategies. Examples of possible regulatory strategies include bans of chemicals or products, emissions limits, labelling requirements, exposure limits, building design standards, building operation and maintenance requirements and ventilation standards. Non-regulatory approaches include guidelines, market and fiscal incentives, population information campaigns, training and education of involved parties, support of sustainable non-polluting technologies.
>
> Legal tools
>
> Nationally there is little specific legislation aimed at the regulation of indoor air (one primary exception being the ban on smoking in public places now implemented in several countries). Those regulations that do exist are largely associated with building codes (including ventilation provision), control of dangerous appliances, and product safety - for example there are rafts of national and international legislation to regulate the quality, marketing and use of construction products, consumer products and chemicals. The applicability of current regulation and its effectiveness in improving indoor air quality is generally rather limited, and only relatively recently has concerted attention been given to approaches for specifically measuring, assessing and reducing emissions from construction products into indoor air. Certainly it is problematic to deal with all the facets of indoor air quality in one regulatory system because of the wide range of pollutants, sources and causes.
>
> …

Next to the national initiatives, most regulations concerning IAQ are based on European directives.

At the moment, EU directives are mostly sector oriented policies and regulating standards for construction products, dangerous substances, gas and heating appliances, ventilation standards,… contain provisions for indoor air quality.
The main EU directives including explicitly a indoor air quality aspect, or indirectly regulate indoor air quality are:

- the construction products directive 89/106/EEC Essential Requirement N°3 "Hygiene, Health and the Environment"
- the energy performance of buildings directive 02/91/EEC
- the gas appliances directive 90/396/EEC

- the heating appliances directive 1992/42/CEE
- the eco-design directive 2005/32/EC
- the dangerous substance directive 1967/548/EEC
- the general product safety directive 2001/95/EC

These European Directives have been implemented in national legislation to some extent.

The measures taken by member states can focus on mandatory or voluntary measures. Generally, in most member states voluntary measures are used for private spaces, and mandatory for public spaces. When mandatory measures are used for private places, they generally apply to new buildings. The most common voluntary measures are information guides, and eco-labels of several kinds

Restriction of emissions form buildings products is the most frequent form building products is the most common form of source reduction. Ventilation standards are the most common form of exposure reduction. Whether historic legislation focuses on source - or on exposure reduction depends on several environmental and cultural factors. In Portugal, ventilation was not an issue since there was enough natural ventilation due to the people's habits, while this was quit the opposite in Sweden.
Most member states are implementing (or have implemented) measures on source- and exposure reduction for new products and buildings.

<u>The construction products directive 89/106/EEC Essential Requirement N°3 "Hygiene, Health and the Environment"</u>
The construction work, must be designed and built in such a way that it will not be a threat to the hygiene or health of the occupants or neighbours, in particular as a result of any of the following:

- **the giving-off of toxic gas**,
- **the presence of dangerous particles or gases in the air,**
- the emission of dangerous radiation,
- pollution or poisoning of the water or soil,
- faulty elimination of waste water, smoke, solid or liquid wastes,
- the presence of damp in parts of the works or on surfaces within the works.

The CPD is only providing a harmonised tool for evaluating the product performance in order to satisfy national regulations - It cannot and shall not introduce new regulations (already covered by other EU or MS regulations – e.g. AgBB scheme). For standardisation, the release into indoor air shall be characterised instead of content. The framework for the standardisation are technical specifications. According to the CPD, European *Technical Specifications* are European Product Standards, adopted by CEN under a mandate of the Commission (harmonised standards) and European Technical Approvals issued by a member body of *EOTA*. An overview (snapshot) of the drafts/standards linked with the CPD and cited in the Official Journal (mandated, the so called "harmonized standards") is given in Figure 2. (Lor M. et al. 2007, HEMICPD: *Horizontal evaluation method for the implementation of the Construction Products Directive - Emissions to indoor air, draft report*).

CEN - Construction Sector

Date: 2007-04-20

Snapshot of the current situation for Standards to be cited in the OJ under the CPD

Page 1

Summary*:

Concerned Standards**:	471
Approved ENs	
Approved Standards cited in the Official Journal:	247
Approved Standards not yet cited in the Official Journal***:	79
Approved Standards not yet available:	2
Total Approved Standards*	328
Drafts which have completed FV or UAP	
Voted Drafts waiting for Voting Report:	5
Failed Formal Vote or Unique Acceptance Procedure Drafts:	0
Drafts in preparation or undergoing FV or UAP	
Drafts underoing Formal Vote or Unique Acceptance Procedure:	17
Drafts received in CEN Management Center for Formal Vote preparation:	18
Drafts received in CEN Management Center for Unique Acceptance Procedure:	9
Drafts before FV or UAP	
Drafts passed CEN Enquiry:	48
Drafts undegoing CEN Enquiry:	3
Drafts received in CEN Management Center for Enquiry preparation:	9
Drafts not yet received in CEN Management Center for Enquiry or UAP:	34

* Snapshots from 2005-06 and later consider the total of "Standards" rather than the related Work Items (amendments, corrigenda, etc.)
** The Total Concerned Standards may change due to: creation of new items, answers to (new) mandates or status changes in some standards
*** Their could be a slight registration delay

Figure 2: Snapshot of the current situation for standards to be cited in the OJ under the COD (date: 2007-04-20)

Up to now, Germany is the only country where a mandatory evaluation scheme is in place (AgBB protocol for flooring materials). Other Countries, e.g. Denmark, Finland, France, Norway, Portugal, Sweden, have voluntary schemes. ECA report N° 18 describes a standardised test method and is the basis for most of these emission schemes.

An overview of the most frequent indoor emission labelling systems in the EU provided in ECA report N° 24. (ECA 2005, Harmonisation of indoor material emissions labelling systems in the EU EUR 21891 EN).

Table 20: ECA Report N° 24, Table 1

	AgBB	CESAT	MI	ICL	LQAI scheme	Natureplus, examples: Linoleum + carpets	Blue Angel, example: RAL UZ 120 floor coverings	Austrian Ecolabel, example: b UZ 42 resilient floor coverings	GUT	EMICODE EC1, example: adhesives	Scandinavian Trade Standards
General											
Origin	Germany	France	Finland	Denmark	Portugal	Germany	Germany	Austria	Germany	Germany	Sweden
Source for more information	http://www.umweltbundesamt.de/building-products/agbb.htm	www.cstb.fr	www.rts.fi	www.indeklima.org	www.markelink.org	www.natureplus.org	www.blauer-engel.de	www.umweltzeichen.at	www.gut-ev.de	www.emicode.com	www.golvbransch
Legal status	basic concept for Germany	voluntary, complement to French technical Agreement	voluntary (private), promoted by government	voluntary (private), promoted by government	voluntary (association between private organization and public institution)	voluntary (private), promoted by several retailer chains	voluntary (private), promoted by government	voluntary (private), promoted by government	voluntary (private)	voluntary (private)	trade agreement
Scheme/label is based on	ECA report 18	ECA report 18	N/A	N/A	ECA report 18	AgBB	AgBB	ECA report 18	AgBB	N/A	N/A
Product types covered	meant for all types of construction products relevant to indoor air	several types of construction products	all type of "construction products	open to all types of products relevant to indoor air	several types of products for indoor use	several types of construction products	several types of products for indoor use	several types of construction products	textile floor coverings	products for installation of floor coverings	several types of construction products

	AgBB	CESAT	MI	ICL	LQAI scheme	Natureplus, examples: Linoleum + carpets	Blue Angel, example: RAL UZ 120 floor coverings	Austrian Ecolabel, example: b UZ 42 resilient floor coverings	GUT	EMICODE EC1, example: adhesives	Scandinavian Trade Standards
Testing procedures and standards											
Sampling and Test specimen	based on EN 13419-3	EN 13419-3	similar to EN 13419-3	EN 13419-3	EN 13419-3	EN 13419-3	based on EN 13419-3	EN 13419-3	like DIBt, based on EN 13419-3	similar to EN 13419-3	specified for each type of product, principally similar to EN 13419-3
- Chamber operation	EN 13419-1	EN 13419-1/-2	EN 13419-1/-2	EN 13419-1/-2	EN 13419-1	EN 13419-1 / ENV 717-1	EN 13419-1	EN 13419-1	EN 13419-1	EN 13419-1	EN 13419-2
- Chamber type	EN 13419-1/2	EN 13419-1/-2	EN 13419-1/-2	EN 13419-1/-2	EN 13419-1	EN 13419-1 / ENV 717-1	EN 13419-1	EN 13419-1	EN 13419-1	EN 13419-1 but minimum 100 litres	EN 13419-2
- Analyses / VOC	similar to ISO 16000 6	ISO 16000-6	ISO 16000-6	ISO 16000-6	ISO 16000-6	ISO 16000-6	similar to ISO 16000-6	ISO 16000-6	ISO 16000-3/-6	similar to ISO 16000-6	similar to ISO 16000-6
- Analyses / aldehydes	ISO 16000-3	ISO 16000-3	ISO 16000-3 or ENV 717-1	ISO 16000-3	special method	ENV 717-1	ISO 16000-3	ISO 16000-6	ISO 16000-3	ISO 16000-3	ISO 16000-3
- First testing	3 days	24 h carcinogens	28 days	3 days	3 days	24 h carcinogens	3 days	24 h	3 days	24 h carcinogens	28 days after manufacturing
- Second testing	28 days	3 days	N/A	10 days	28 days	3 or 28 days	28 days	28 days	N/A	10 days	26 weeks
- Third testing	N/A	28 days	N/A	28 days	N/A	28 days (carpets / SVOC)	N/A	N/A	N/A	N/A	N/A
- Odour test	no, but intended later	CLIMPAQ, intensity	CLIMPAQ 28 days, acceptance >0	CLIMPAQ, acceptance>0, intensity<2	no	desiccator test < 3	no, but intended later	no •	desiccator test < 3	no	for self-levelling compounds only

	AgBB	CESAT	MI	ICL	LQAI scheme	Natureplus, examples: Linoleum + carpets	Blue Angel, example: RAL UZ 120 floor coverings	Austrian Ecolabel, example: b UZ 42 resilient floor coverings	GUT	EMICODE EC1, example: adhesives	Scandinavian Trade Standards
					Emission evaluation						
- TVOC definition applied	based on ISO 16000-6 but modified	ISO 16000-6	ISO 16000-6	no TVOC monitored	ECA report 19	ECA report 18	based on ISO 16000-6, but modified (AgBB)	ECA report 18	ECA report 18	GEV specific, based on ISO 16000-6, sum of TWOC+TVOC+TSVOC (ca. C5-C22)	based on ISO 16000-6, but modified C6-Cie,
- TVOC	(3rd day) TVOC 10 mg/m , (28th day) 1,0 mg/m'	TVOC 5000 µg/m^3 (3 days), 200 µg/m^3 (28 days)	TVOC 200 µg/m^{2}h (28 days)	all VOC after calculation for model room below 0,5 OT and 0,5 IT	TVOC 5000 pg/m^{2}h (3 days); 200 µg/m^{2}h (28 days)	TVOC 200 or 300 µg/m^3(28 days)	(3rd day) TVOC 1200 µ/m^3 , 28th µg(day) 360 µg/m^3	380 µg/m^{2}h (28 days)	TVOC 300 pg/m' (3 days)	TVOC 500 µg/m^3 (10 days)	declaration of TVOC at 28 days and at 26 weeks, no limits specified
- SVOC	(28th day) TSVOC 100 µg/m,	no	no	no	not included in TVOC; Comparison with respective LCI	TSVOC (ISO) 100 µg/m'^{3}(28 days)	(28th day) TSVOC 40 µg/m^3	no	TSVOC 30 µg/m^3 (3 days)	included in TVOC	no
- WOC	no	no	no	no	comparison with respective LCI	no	no, but intended later	no	no	included in TVOC	no
- Aldehydes, additional requirements	DlBt: 120 µ/m^3 day 28	formaldehyde 10 µg/m^3 after 28 days	formaldehyde 50 µg/m^{2}h (28 days)	all aldehydes after calculation for model room below 0,5 OT and 0,5 IT	formaldehyde 10 µg/m^3 after 28 days	formaldehyde 36 µg/m^3 after 3 or 28 days	(28th day) formaldehyde 60 µg/m^3	hexanal 70 pg/m^{2}h , nonanal 20 µg/m^{2}h	formaldehyde 10 pg/m^3 after 3 days	formaldehyde, acetaldehyde each 50 µg/m^3' (24 h)	formaldehyde according to WHO recommendation for se lf-levelling compounds

	AgBB	CESAT	MI	ICL	LQAI scheme	Natureplus, examples: Linoleum + carpets	Blue Angel, example: RAL UZ 120 floor coverings	Austrian Ecolabel, example: b UZ 42 resilient floor coverings	GUT	EMICODE EC1, example: adhesives	Scandinavian Trade Standards
list with target compounds	NIK, updated yearly, and R value	LCI as of 1997 and R value	no	database with IT and OT (VOCBASE)	list of identified compounds with respective LCI as of 1997 and R value	several limits for single VOC and groups of VOC	NIK (AgBB), updated yearly, and R value	some limits for single VOC and groups of VOC	NIK (AgBB), updated yearly, and R value	no	all > 5 µg/m³
restricted emission of unknown or not assessable VOC	100 µg/m³	as considered in ECA report 18	no	no	sum of identified compounds without respective LCI < 20 µg/m³ after 28 days	no	100 µg/m³	no	100 µg/m³	no	no
-restriction of other emitted compounds	no	no	ammonia 30 µg/m²h (28 days) and restriction on casein in the products	all compounds below 0,5 OT and 0,5 IT	no	no	N-nitrosamine	no	vinyl chloride, vinyl acetate	no	no
- restriction of carcinogenic VOC	C1+C2 3rd day: 10 µg/m³ , 28th day: 1 µg/m³	as considered in ECA report 18	Cl: 5 µg/m²h (28 days)	Cl n.d. (any time)	C1+C2 as considered in ECA report 18	CMR (1+2) and national classifications: 1 µg/m³ (24 h)	C1+C2 3rd day: 10 µg/m³, 28th day: 1 µg/m³	no	C1+C2 n.d. (3 days)	list of 5 substances (Cl - 2 µg/m³, C2 - 10 µg/m³, C3 - 50 µg/m³)	no

	AgBB	CESAT	MI	ICL	LQAI scheme	Natureplus, examples: Linoleum + carpets	Blue Angel, example: RAL UZ 120 floor coverings	Austrian Ecolabel, example: b UZ 42 resilient floor coverings	GUT	EMICODE EC1, example: adhesives	Scandinavian Trade Standards
					Quality assurance						
- control system for labelled products p	DIBt: control test lx/year, full test every 5 ears	depends on duration of Technical agreement	Control measurements of two randomly chosen products /year	full test every 5 years plus random site control	control test 1x/year, full test every 3 years	control test 1x/year, full test every 3 years 3	renewal every 4 years	full test every 4 years	market control of 10% of labeled products 1x/year	random market control tests 1x/year	no
requirements for testing labs	DIBt: List of approved laboratories	no	list of approved laboratories	list of approved laboratories	no	of approved laboratories	list of approved laboratories	17025 accredited and listed bv	list of approved laboratories	ISO 17025 accredited	ISO 17025 accredited preferred
- round-robin tests	yes	no	only in the past	only in the past	no	planned	yes	no	yes	yes	yes
					Management						
- criteria and test method published	in detail	in general terms	in detail	in detail, partly only in Danish	presented in PhD thesis in detail	in detail	in detail	in detail, partly only in German	in general terms	in detail	test methods published
- costs for application	no	fee per application	fee per application	fee per application	fee per application	membership + fee per application	fee depending on sales volume	fee per application	membership + fee per application	membership in GEV	regular testing fees at the testing laboratory

The energy performance of buildings directive 2002/91/EC

Several incentives (climate change, heating costs) have led to the implementation of the energy performance directive (EPBD).

Article 4 (Setting of energy performance requirements) stated that Member States shall take the necessary measures to ensure that minimum energy performance requirements for buildings are set. These requirements shall take account of general indoor climate conditions, in order to avoid possible negative effects such as inadequate ventilation, as well as local conditions and the designated function and the age of the building.
The methodology of calculation of energy performance of buildings shall include amongst other the aspect of ventilation. Minimum ventilation rates have been set in most European member states. An overview has been included in two international reports:

- ECA (1996). Report N° 17, Indoor Air Quality and the Use of Energy in Buildings. EUR 16367
- AIVC technical note (TN 55) (2001). “A Review of International Ventilation, Airtightness, Thermal Insulation and Indoor Air Criteria”. Mark J. Limb, AIVC.

Table 3.1 of AIVC TN55 summarises the minimum ventilation criteria for dwellings. The reports are available on a website (http://www.aivc.org, after registration). It is however prohibited to copy the table from the document (copyrighted). The criteria range from 17 – 50 l/s or 5-8 l/s per person.

Table 21: ECA Report N° 17, Appendix 1

	Ventilation rates calculated according to ECA (1992) [2]		DIN 1946[3] 1994	CIBSE guide 1978	French Values[6]	SCANVAC Guidelines and specifications 1994	NKB No.81E Indoor climate air quality 1991	Finnish national building code D@ 1987
	achievable in low pollution buildings[4]	**needed in average pollution[5] buildings**						
Type of building or space	required ventilation rate [1/(s m² floor area)]	required ventilation rate [l/(s m² floor area)]	minimum ventilation rate [1/(s m² floor area)]	minimum ventilation rate [1/(s m² floor area)]	minimum ventilation rate [1/(s m² floor area)]	minimum ventilation rate [1/(s m² floor area)]	minimum ventilation rate [1/(s m² floor area)]	minimum ventilation rate [1/(s m² floor area)]
Single office	3.3 1.4 0.8	7.2 4.6 2.3	1.1	---	0.7	3.2 1.4	1.1	1
Landscaped office	2.8 1,2 0.7	6.7 4.2 2.1	1.6	1.3	0.5	2.7 1.2	1.0	1.5
Conference room	10.0 4.3 2.4	14.3 9.1 4.6	2.8-5.6	6.0	2.5	9.6 4.2 --	3.5	4
Class room	12.5 5.4 3.0	17.0 10.8 5.4	4.2	---	2.1	9.6 4.2	4.9	4
Kindergarten	11.7 5.0 2.8	17.9 11.4 5.7	---	---	2.1	9 .6 4.2	4.9	2
Department store	5.8 2.5 1.4	13.4 8.5 4.3	0.8-3.3	3.0	1.2	5.6 2.5	1.2	2

1	adapted from CEN/TC 156/WG6 Doc N 66;
2	required ventilation rates depend on outdoor air quality, occupancy, material pollution load, tobacco smoking and ventilation efficiency; the values reported below are based on no smoking and refer to three comfort categories - A, B and C which correspond to 10, 20 and 30% dissatisfied respectively;
3	DIN 1946 allows as an alternative a calculation similar to the one described in draft document N 66 of CEN./TCI56/WG6.
4	values based on French standards and particular assumptions.
5	values based on clean outdoor air, mean occupancy in spaces, a recommended target value of the pollution load for low polluting buildings (from ECA,1992) and a ventilation efficiency of one;
6	values based on mean outdoor air quality and material pollution load (from ECA,1992) and a ventilation efficiency of 0.8 (see also Joppolo and Sanvito, 1994)

Table 22: ECA Report N° 17, Table II. Summary of National Energy and IAQ Regulations/Guidelines/Standards

Aspects of IAQ and RUE*	Danish Building Regulation	UK Building Regulations	CIBSE, UK	Indoor Climate & Energy - Norway	Warmeschtttz-Verordnung[1)], 1994 (D)
1.. Does the document cover IAQ, RUE or both ?**	IAQ and RUE	IAQ and RUE	IAQ and RUE	IAQ and RUE	IAQ and Rue
2. Does the document consider energy efficiency (design standards, etc.) ? Thermal insulation - Boiler efficiency Air tightness Ventilation rate - Lighting - Passive solar - Shading	 Yes Yes No Yes Yes Yes Yes Yes	 Yes No Yes Yes Yes No No No	 Yes Yes No Yes Yes Yes Yes Yes	 Yes No Yes Yes Yes (No) (Yes) Yes	 Yes No Yes Yes No Yes Yes Yes
3. Does the document include prediction models ?	Yes	Yes	Yes	Yes	simplified model
4. If "yes" to question 3, does the document display or reference the underlying assumptions or data ?	Yes	Yes	Yes	Yes	Yes
5. Have the heating loads been identified and guidance given on the reduction ?	Yes	No	Yes-no guidance on reduction	Yes	Yes
6. (a) Has consideration been given to pollutant source control ? (b) Are the major source categories identified and considered ?	Yes Yes	Implicit Implicit	Yes Yes	Yes Yes	No No
7. Does the document support a good maintenance strategy for buildings and systems?	Yes	No, concerned with design	Yes.	Yes	No
8. Does the document include design of ventilation systems ? Mechanical - Natural	 Yes Yes	 Yes Yes	 Yes Yes, to a limit	 *No* *No*	 No No
9. Does it take into account variability's of : Climate - Occupancy - Building types	 No Yes Yes	 No No Yes	 Yes Yes Yes	 Yes Yes Yes	 No No Yes
10. Does the document include building design ?	Somehow	Yes	Yes	No	Yes
11. Does the document include lighting ?	Yes	Yes	Yes	Yes	No
12. Does the document include noise ?	Yes	Yes	Yes	No	No
13. Is the balancing between costs and benefits discussed ?	No	Implicit	No	(No)	Yes
14. References	Building Regulations	The Building Regulations	CIBSE	Melding HO-2/93,BE	Anonymous, 1994

* RUE = rational use of energy
** the highlighted initials are those emphasized in the document
1) Heat protection directive

Table 23: ECA Report N° 17, Table II. Summary of National Energy and IAQ Regulations/Guidlines/Standards (cont.d)

Aspects of IAQ and RUE *	French Rules for Ventilations	Le Manuel du Responsable Energie (B)	Portugese Thermal Rules	Tech. Anforderungon an Lüftungstechnische Anlagen, 1992	Bedarfsermittlung für liiftnngstechn. Anlagen, 1992
1. Does the document cover IAQ, RUE or both 7**	**IAQ and RUE**	**IAQ and RUE**	**RUE**	**IAQ and RUE**	**IAQ and RUE**
2. Does the document consider energy efficiency (design standards, etc.) ?	No	Yes	Yes	No	Yes
- Thermal insulation	No	Yes	Yes	No	No
° Boiler efficiency	No	Yes	No	No	Yes
- Air tightness	Yes	Yes	Yes	Yes	Yes
- Ventilation rate	No	Yes	Yes	No	Yes
- Lighting	No	Yes	Yes	No	Not directly
- Passive solar	No	Yes	Yes	No	Yes
- Shading	No	Yes	Yes	No	Yes
3. Does the document include prediction models ?	No	simplified models	Yes	No	Yes
4. If "yes" to question 3, does the document display or reference the underlying assumptions or data ?		Yes	Yes		Yes
5. Have the heating loads been identified and guidance given on the reduction ?	No	Yes	Yes	No	Yes
6. (a) Has consideration been given to pollutant source control ?	Yes	Yes	No ...	Yes	Yes
(b) Are the major source categories identified and considered ?	Yes	Yes (approx)		Yes	Yes
7. Does the document support a good maintenance strategy for buildings and systems?	No	Yes	Yes	Yes	No
8. Does the document include design of ventilation systems ?					
- Mechanical	Yes	Yes	Yes	Yes	Yes
- Natural	Yes	Yes	Yes	No	No
9. Does it take into account variability's of :					
- Climate		No	Yes	Yes	Yes
- Occupancy		Yes	Yes	Yes	Yes
- Building types		Yes	Yes	No	Yes
10. Does the document include building design ?	No	No	Somehow	Yes	Yes
11. Does the document include lighting ?	No	Yes	Somehow	No	Yes
12. Does the dcoument include noise ?	No	No	No	only mentioned	No
13. Is the balancing between costs and benefits discussed ?	No	Yes	Yes	No	No
14. References	AICVF, 1991, 1992	De Herde, 1992	Maldonado et al., 1989	SIA, 1992	SIA, I992c

* RUE = rational use of energy
** the highlighted initials are those emphasized in the document

The gas appliances directive 1990/396/EEC

Article states that 3.2.3 “Appliances intended to be used in indoor spaces and rooms must be fitted with a special device which avoids a dangerous accumulation of unburned gas in such spaces or rooms”.

Some member states mentioned this directive to be important through the questionnaires either directly or indirectly through the priority pollutants: Bulgaria, Hungary, Italy Portugal, Slovakia.

Next to the evaluation schemes (emissions) of building products, several laws exist on the content of building products, which indirectly influence indoor air quality. The most important/wide spread are the national bans (or maximum content) of asbestos and radon.

Other European directives that that regulate the contents of products and indirectly influence the IAQ are amongst others

- the dangerous substance directive 1967/548/EEC
- the general product safety directive 2001/95/EC

The REACH regulation (2006/121/EEC) is also expected to influence indoor air quality. Other EU instruments contributing to good indoor air quality are the eco-labels. These (voluntary) EU eco-labels restrict for example compounds such as VOC’s, formaldehydes,… in indoor paints and varnishes, in bedding mattresses, clothes, indoor textiles, …

Other Europeans that regulate contents (such as the cosmetics or the biocides directive) are not mentioned as IAQ is currently outside their scope.

Next to the different labelling systems, information guides can be very efficient measures to raise public awareness. Persons that are well informed can better protect themselves against harmful influence of certain substances present indoors. They can also influence the market by choosing low emitting products or avoiding purchase of products containing toxic substances. Germany, for instance, has a quite extensive set of guides to increase the awareness of the general public. Interesting examples are: the mould guidelines (“*Hilfe Schimmel im Haus”)*, black soot deposition (“*Attacke des schwarzen Staubes”),* Indoor Air Quality in Schools (“*Leitfaden für die Innenraumlufthygiene in Schülgebäuden”*), Products for wood protection (“*Verbraucherleitfaden Holzschutzmittel”)*, a general leaflet about healthy housing (“*Gesünder wohnen – aber wie? Praktische Tipps für den Alltag”*). These documents can be consulted online (UBA or APUG).

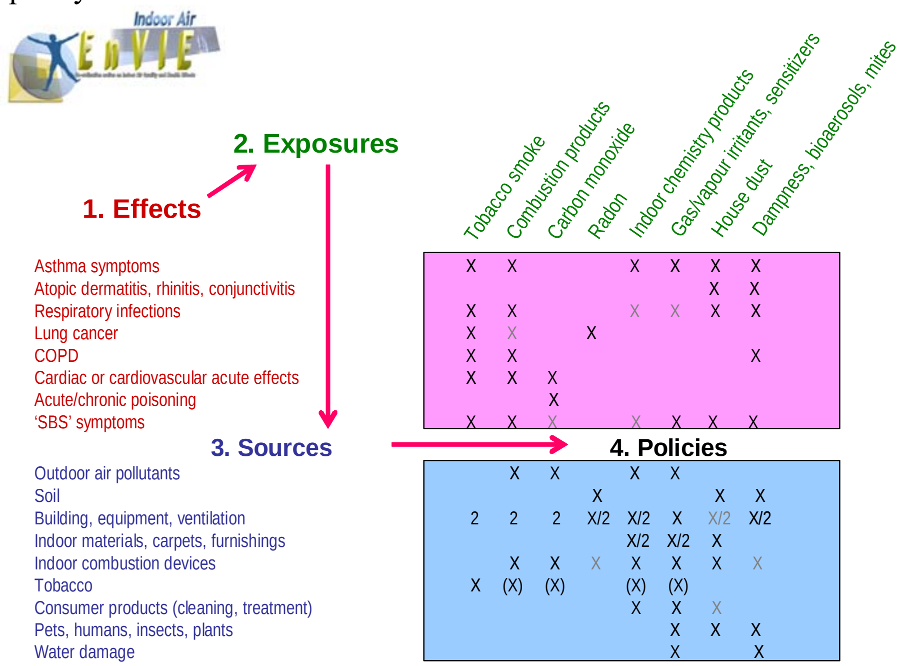
In most member states, stakeholders participate to some extent in policy making. (Table 24).

Table 24: Summary of Responses to Question A.4 (Stakeholde Participation) of the Questionnaire

Member State	Yes	No
Bulgaria	X	
Finland	X	
Hungary	x	
Italy	X	
Poland	X[1]	
Portugal	X	
Slovakia		x[2]
Sweden	X[3]	
The Netherlands	X	
1, Legally included, but usually not very active		
2, Have possibility to manifest there opinion		
3, Very intense for voluntary actions, small for mandatory legislation		

There are a number of research project (finished and ongoing) where IAQ policies are evaluated.

EnVIE is a European Co-ordination Action interfacing science and policy making in the field of indoor air quality (http://www.envie-iaq.eu/). EnVIE is collecting and interpreting scientific knowledge from on-going research, in particular from EU funded projects and Joint Reserch Center activities, to elaborate policy relevant recommendations based on a better understanding of the health impacts of indoor air quality.



'X, X, X' denote different levels of impact. '2' denotes secondary influences.

Figure 3: Schematic Overview EnVIE (Jantunen. M, 2007, EnVIE-project, Workshop Indoor Air - Health – Priorities, 29-30 March Brussels)

THADE

(Viegi G., 2007, THADE-project, Workshop Indoor Air - Health – Priorities, 29-30 March Brussels)

Aims:

1. Review the data and evidence-based information related to exposure and to the health effects of air pollution in dwellings particularly as regards allergies, asthma and other respiratory diseases.
2. Review legislation and guidelines on air pollution and air quality in dwellings.
3. Produce maps of pollutants in dwellings.
4. Review cost-effective measures and technology to improve air quality in dwellings.
5. Recommend an integrated strategy that defines appropriate indoor air quality policies for implementation in Europe, and identify appropriate technology.

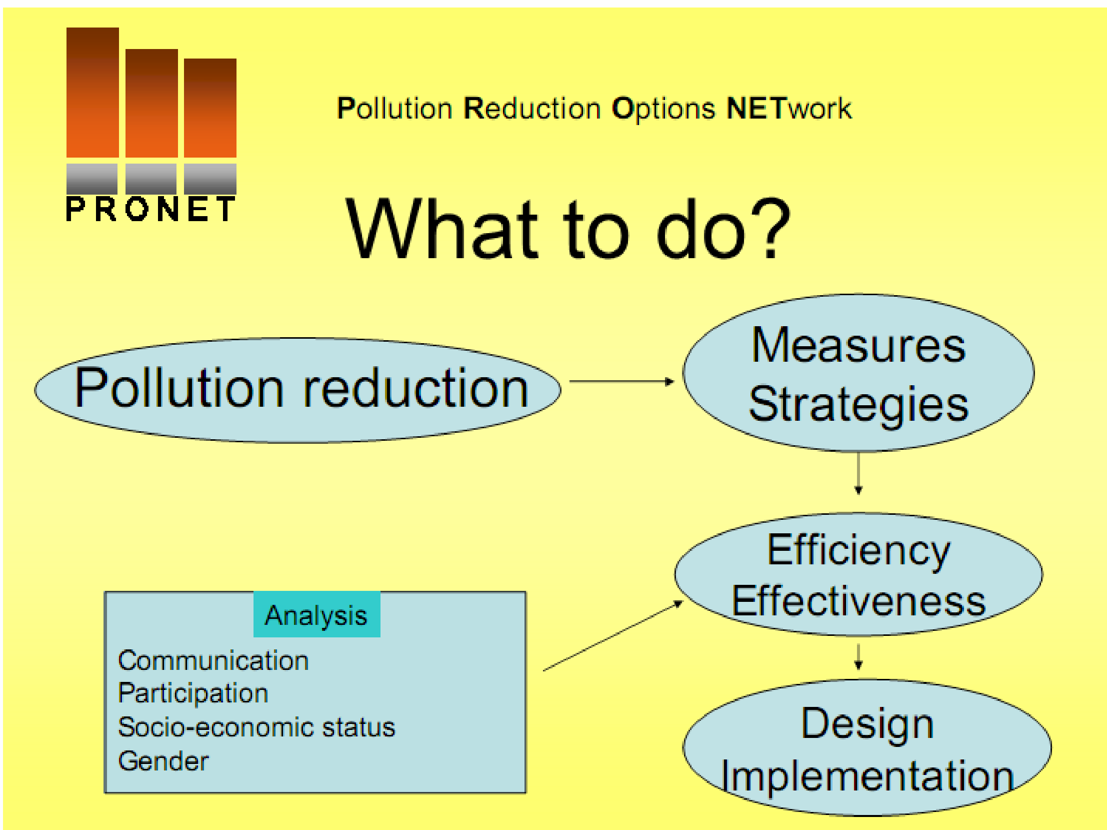
PRONET

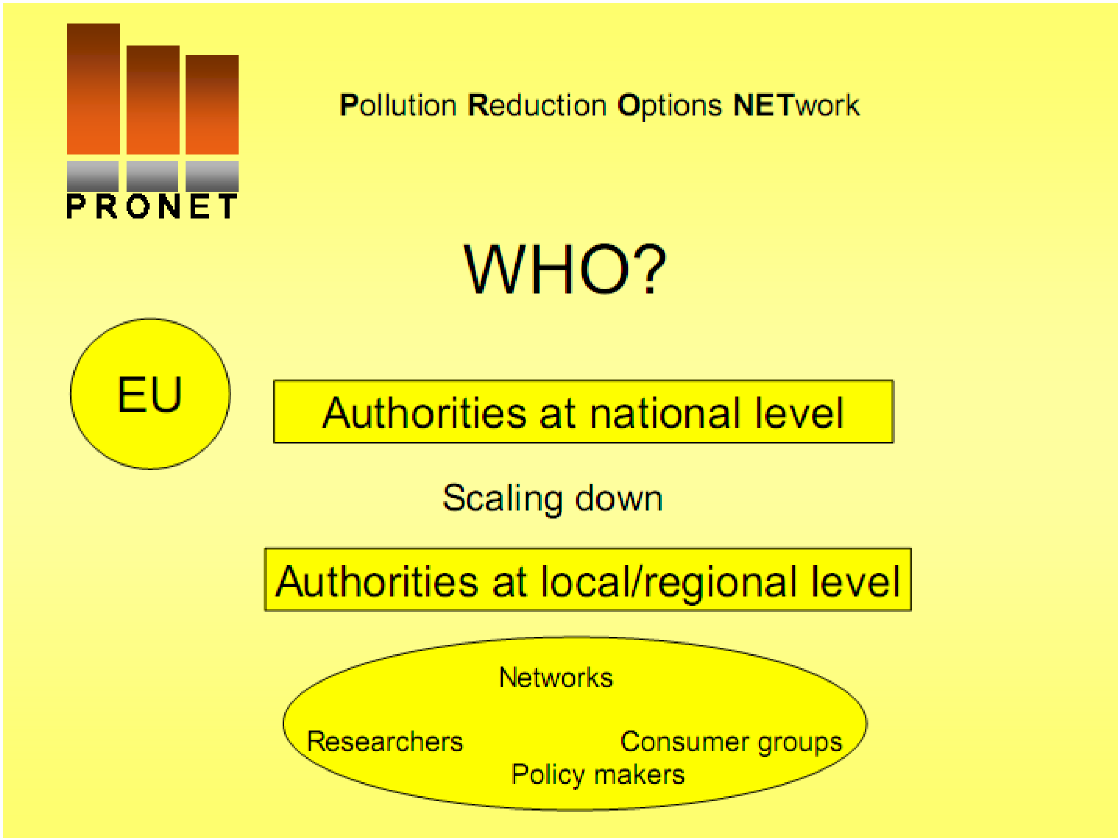
The main objective of the PRONET project is to facilitate exchange and evaluation of interventions on environment and health exposure reduction measures on a regional level and promote implementation of successful initiatives in other regions of Europe. This project will focus on the exchange of useful practices in two areas:

- The reduction of traffic-related health hazards (air pollution and noise)
- Improvement of indoor air quality.

As they are key areas in environmental policy, the health of the population will benefit significantly from exposure reduction measures.
The results will be used to make recommendations for policies at regional level.

(van den Hazel P., 2007, PRONET, http://www.proneteurope.eu/index.php?page=presentations)




PRONET
Pollution Reduction Options NETwork
WHO?
EU
Authorities at national level
Scaling down
Authorities at local/regional level
Networks
Researchers
Consumer groups
Policy makers

Detailed responses from the delegates of the different member states at the workshop

Question A Priorities in National Policy

Question A.1 Which is the determining factor in policy making: national problems associated with IAQ, European directives, or the (National) Environment and Health Action Plan?	
Bulgaria	The determining factors in policy making for Bulgaria in regard to IAQ are European Directives and the National Environmental Health Action Plan.
Finland	National IAQ Problems
Hungary	European directives as well as everyday need of domestic regulations (most of which are still missing, but they are in a preparatory phase)
Italy	Both European directives and National Environment and health Action Plan
Poland	In Poland, the need for establishing the framework for national policy within the scope of IQA and for setting the indoor air quality guideline values occurred about 40 years ago as a result of frequent cases of indoor air pollution due to common use of building materials containing substances harmful for human health.
Portugal	Basically European Directives and, generally, the international context, what means putting the advancements in knowledge into practice
Slovakia	National priority problems: - A marked increase in the use of chemical substances in building material, furniture and other furnishings in non-industrial indoor spaces and the absence of data on the possible concentrations of these substances in indoor spaces; - An increase in the number of apartments with moisture and mould problems due to technical and constructional shortcomings in the construction and maintenance of buildings; - The absence of legislation in the area of air quality assessment and guidelines for air in non-industrial indoor spaces; - Insufficient public awareness of the significance and importance of healthy air in dwellings. To establish legislation of emission limits for the assessment of IAQ was one of the priority action of NEHAP of Slovak Republic II.

Question A.1 Which is the determining factor in policy making: national problems associated with IAQ, European directives, or the (National) Environment and Health Action Plan?	
Sweden	- European directives are usually readily implemented in Sweden. However, as regards IAQ there are few applicable directives. - So far, national problems have been the main determining factor in policy making. There is a long tradition of legislation concerning building construction including regulations to ascertain a healthy indoor environment in new buildings. Likewise, there are separate recommendations concerning some aspects of IAQ in older houses. - In the late 1990ies, the Swedish Parliament decided on a number of environmental quality objectives, one of which includes a 'healthy indoor environment', and there are extensive activities to implement and evaluate the achievement of these goals. We regard relevant parts of this work as the Swedish NEHAP.
The Netherlands	NEAP

Question A.2 Which are the priority pollutants?	
Bulgaria	The priority pollutants in Bulgaria for IAQ are SO_2, NO_2, fine particles PM10 and PM2.5, Formaldehyde.
Finland	Microbial and other releases form microbial combination of water damages building materials, RN, HCHO, CO
Hungary	ETS, NO2 (due to gas heating), asbestos
Italy	Environmental Tobacco Smoke, Radon, Benzene and asbestos (may substantially contribute to the increase in the incidence of cancer n the population) Carbon. Monoxide (acute intoxication)
Poland	Taking into account the frequent detection of elevated levels in indoor air and the health risk resulting from prolonged exposure the most important pollutants are: formaldehyde; phthalates; organic solvents used in paints/ varnishes and aromatic hydrocarbons, like xylene and toluene; aliphatic amines. In Poland, carbon monoxide still remains a substantial problem and a relative common cause of poisoning due to gas combustion at inadequate ventilation. Approximately several dozens of person die annually from carbon monoxide poisoning, mainly caused by leaking gas installations and heating systems.

Question A.2 Which are the priority pollutants?	
Portugal	The ETS issue has been tackled through growing restrictions on smoking. By the way, the public acceptance was excellent. Otherwise, most pollutants are referred in the Regulation for Buildings Energy Systems Performance (RSECE): particles (PM10), carbon monoxide, ozone, formaldehyde, carbon dioxide and volatile organic compounds, fungi and bacteria, legionella and radon.
Slovakia	Formaldehyde and other aldehydes, Nitrogen dioxide and other combustion products, PM10, PM2.5, water vapour and damp, fungi and mould, Ammonium, VOC, ETS, house dust mites
Sweden	- Only to a small extent Swedish policies give threshold values for specific compounds. Rather, Swedish policies aim at ascertain that property owners and building constructers work systematically to choose and maintain constructions and materials so that the concentration of pollutants be low. There is also a tradition of prioritising voluntary agreements between stakeholders before legislation. - However, there are specific rules and recommendations including target values for radon, carbon dioxide (as ventilation indicator), and emission of formaldehyde from wooden building materials. There are also target values for room temperature and ventilation rate. Furthermore, there are limits for the concentration of common outdoor air pollutants in the supply air of mechanical building ventilation system. There are also policies on building dampness and mould. - In recent years, there is increasing concern about health effects of particulates (including pet allergens) in indoor air of public buildings. To address this problem, there are recommendations for cleaning of children's public indoor environments such s schools, day care centres etc. - There is also awareness of chemical emissions from building products, but no specific regulations (apart from the one on formaldehyde). - Lastly, in order to reduce ETS, tobacco smoking is forbidden in public buildings including restaurants and bars and many employers do not allow smoking in their premises. The latter is especially common in the health care sector
The Netherlands	VOC, CO, Formaldehyde, Particles, ETS

Question A.3 Does the national policy concentrate on source reduction (e.g. product policy) or exposure reduction? (e.g. ventilation) (please provide information or links to actual legislation).	
Bulgaria	The national policy concentrate on limits on hazardous substances on consumer products, requirements for building materials, equipment standards and guidelines, ventilations standards. In April 2005 the Government approved the framework Convention for Tobacco Control. The Parliament' Bulgaria ratified Convention in November 2005. A new Programme for Tobacco Smoking Restraint was adopted by the Government in February this year.
Finland	Primarily on source reduction, albeit with mandatory ventilation standards (building code, part D-Z)
Hungary	Act on smoking ban in public places is a kind of source reduction direction. Ventilation rate is rather restricted due to energy conservation

Question A.3 Does the national policy concentrate on source reduction (e.g. product policy) or exposure reduction? (e.g. ventilation) (please provide information or links to actual legislation).	
Italy	1. Elimination or containment by law of exposure to the most severe health risk factors; 2. Information of the population for the voluntary containment of exposure to less severe health risk factors; 3. Incentives to the market for healthy building achievement; 4. Health education to promote active role of population in health prevention (information campaigns, particularly on ETS exposure of children at home) Links to actual legislation: **Prevention Plan for Health Protection and Promotion in the indoor Environment** **Prepared by a national Committee created by the Health Minister on 8 April 1998, released in July 1999, and approved by the Superior Health Council at the end of 1999, from which:** - Agreement of September the 27th 2001 among Health Ministry, Regions and autonomous Districts: guidelines to protect and promote health indoor (GU 27.11.2001,n.276, SO 252) - National Radon Plan (an extracting of the Plan was proposed to Regions and financed by the Ministry and CCM) - National Plan about domestic accidents (CCM project) - Agreement of October the 5th 2006 among Health Ministry, Regions and autonomous Districts: Guidelines to define technical protocols of air-conditioning plants predictive service (GU 3.11.2006, n. 256, SO 207) - Guidelines for Legionnaire's disease prevention and control - Law n. 3/2003, about no smokers' health protection National Health Plan for the triennium 1998- 2000, till NHP 2006-2008 : The improvement of the environment as key priority objective for public health Laws about asbestos (e.g. 257/92 which bands asbestos use in Italy)

Question A.3 Does the national policy concentrate on source reduction (e.g. product policy) or exposure reduction? (e.g. ventilation) (please provide information or links to actual legislation).	
Poland	Most of the measures taken in order to protect people against indoor air pollution are aimed to ensure the conformity of a product (building materials, construction products) with detailed requirements specified in regulations that reduce the possibility of emission of harmful substances. The exposure reduction is of greater importance in newly constructed buildings of higher standard. The most important regulation on products quality requirement are as follows: 1. Ordering of the Ministry of Health of 12 March 1996 on acceptable levels and intensity of factors harmful for human health emitted by building materials, equipments and furnishing inside buildings; Polish Monitor, 1996.19.231. This regulation precises the acceptable content of highly toxic substances in building materials and acceptable levels of many substances in indoor air. It is still very important as a basis for hygienic certification of building materials and construction products and for the assessment of the health safety of indoor air quality. 2. Regulation of the Minister of Economy and Work on reduction of emission of volatile organic compounds due to organic solvents use in certain paints and varnishes. Dz. U. (Polish Official Journal), 05.216.1826 (implementation of the directive 2004/42/EC) **3.** Regulation of the Council of Ministers of 6 April 2004 on safety and labelling of textile products. Dz.U. (Polish Official Journal), 04.81.743
Portugal	Source control: ETS, asbestos. Exposure reduction fixing limits on the concentrations of some substances indoors and through ventilation (rates fixed). ***The regulation implies that, by default, for new buildings, when it cannot be stated that building materials or finishing materials are not 'clean' the ventilation rates should be increased by 50%.*** For monoxide carbon there are specific regulations for combustion devices, e.g. the installation should be made by certified technicians. Concerning dampness there is another regulation (RCCTE – Regulation for Building Thermal Performance) that establishes the insulation levels for buildings based on either comfort or/and risk of condensation criteria.

Question A.3 Does the national policy concentrate on source reduction (e.g. product policy) or exposure reduction? (e.g. ventilation) (please provide information or links to actual legislation).	
Slovakia	Legislation has been developed for more general purposes such as: - human health protection - building regulations - environmental protection - environmental impact assessment - clean air act etc. or is part of specific regulations and technical norms e.g. directives on products. New legislation aims at eliminating the sources of indoor pollution and limiting the use of polluting material. Actual legislation : - Act of the National Council of the Slovak Republic No.126/2006 Coll. on Public Health - The law enacts the rights and obligations of authorities of state administration, communities, other legal persons and physical persons, actions of the state administration and the state health inspectorate in charge of the section on protection of human health. Among general obligations of this law is, that health must be also protected by care of indoor spaces in living environment and other non-industrial buildings and public accessible places (§13 of this law establishes general requirements for light, insulation, microclima, ventilation , heating, physical, chemical and biological indoor air pollution). - Direction by the Government of the Slovak Republic No. 353/2006 Coll. about requirements on indoor environment of buildings - The Direction enacts concrete demands in non- industrial buildings on: temperature and moisture of indoor air, ventilation, heating, light, insulation and other kinds of optical radiation and limit values of chemical, microbiological and biological indoor pollution and particulate matter. - Act of the National Council of the Slovak Republic No. 377/2004 Coll. on protection of non-smoking people.

Question A.3 Does the national policy concentrate on source reduction (e.g. product policy) or exposure reduction? (e.g. ventilation) (please provide information or links to actual legislation).	
Sweden	- Traditionally, exposure reduction through ventilation has been focussed, and relevant legislation to a great deal concerns ventilation; air exchange rates, quality of supply air and maintenance of ventilation systems. For more information, please visit www.boverket.se and www.socialstyrelsen.se. - However, there is also a development towards more source oriented legislation. Since many years, the substitution principle has been prescribed in the legislation on chemical products safety and environmental health. For more information please visit www.sweden.gov.se, www.naturvardsverket and www.kemi.se. - There are also increasing efforts to reduce chemical emissions from building materials. So far, however, this has been relying on voluntary testing at the request of the different manufacturers.
The Netherlands	Both Source + effect

Question A.4 Do stakeholders (e.g. NGO, industry) participate in the policy making?	
Bulgaria	Ministry of Health, Ministry of Environment and Water, Energy, Industry and NGO participate in the policy making
Finland	FISIAQ is a very active policy developer, patient organisations and governmental fushinitions play dominant roles in addition to FISIAQ.
Hungary	Yes, there are some instances
Italy	Yes
Poland	In fact, with the accepted framework of national public health policy this possibility is realised in a very restricted manner, although it is legally warranted. All projects of legal acts and regulations in this area are available for public comments and independently sent to consumers organisations and industry representatives before being adopted. However, their participation usually is not very active. The only exception is a situation when a product use is a subject of some restrictions, which causes sometimes a great pressure on public health services.
Portugal	Yes, intensely, even in the drafting process of regulations.
Slovakia	According to my knowledge they did not participate in the policy making directly, but they have opportunities to manifest their opinion in different stages before legalization of the prepared policy.
Sweden	As pointed out before, in Sweden there is a tradition of prioritising voluntary agreements between stakeholders before legislation. To a certain extent, legislation is not enforced until such agreements are unsatisfactory. As concerns IAQ, the construction industry and the Swedish Asthma and Allergy Association have been very active in public discussion and stimulating emissions testing of different products. Their direct involvement in the legislating process is however small.
The Netherlands	Yes

Question A.5 Does the policy focus on mandatory or on voluntary measures?	
Bulgaria	The policy focuses on mandatory (legislative) measures
Finland	FISIAQ develops voluntary IAQ – management systems which play a big role. Guidance an information materials are much more important than mandatory measures, except in occupational locations.
Hungary	It depends of the area (public or private)
Poland	Generally, mandatory measures are preferred as more efficient and more easily controlled by governmental agencies. Moreover, people complaining of inappropriate indoor air quality and consumers organisations strongly demand obligatory regulations in this area. However, it is necessary to stress that mandatory measures shall ensure the adequate protection level but on the other side, shall not to be unnecessarily too numerous or too restrictive.
Portugal	Mandatory. The issue then is the political/administrative practice on the reinforcement of its implementation and the guarantee of its credibility.
Slovakia	The above mentioned policy focuses on mandatory measures, only in private places, e.g. families which do not offer services to other people are measures voluntary.
Sweden	Most of the nationally initiated policies aim at voluntary measures, especially regarding older buildings. However, for new or for public buildings and work places there are some mandatory measures, e.g. concerning radon concentrations, ventilation rate and maintenance of ventilation systems.
The Netherlands	Voluntary for private, voluntary and mandatory for public places

C.3 Monitoring and Control Programmes

Pursuing indoor air policies should be accompanied by efficient controlling and monitoring to test if policies are successful in complying the aims of good indoor air quality, to alert if a sanitation plan is mandatory, or the steer new policies if aims are not achieved. But, as e.g. COMEAP states[12], *the equipment needed (to monitor) is complex and expensive and likely to be beyond the means of private householders. In such cases, it might be asked whether recommending guidelines is worthwhile on the grounds that compliance cannot be tested.*

What do we mean by monitoring? In ambient air monitoring is set up to evaluate the ambient air quality (daughter) directive's limit values. This generally done in accordance with quality and quantity requirements in the framework and daughter directive. Stationary monitoring stations provide continuous data on ambient air quality. Specific case studies, related to particular problems (traffic, urban air pollution, industrial hot spots) are used to provide additional information, that might be needed to impose additional abatement measures. Air quality modelling is used for complete coverage of a country, in cases where measurements are not required by law, or to provide insight in the efficiency of additional reduction measures. National bodies have sufficient authority to evaluate ambient air where and when they want.

In public spaces national authorities still have the freedom to intervene and to measure. But country-wide coverage is difficult, given the high number of places and measurements needed. Spot checks and sample surveys might be the best way to monitor indoor air quality in public spaces.
In private homes consent of the inhabitants is needed, unless specific laws enable indoor air quality checks. Even when intervention levels or action levels are defined for private spaces, the problem of monitoring remains.
Control policies generally involve emission control, in the context of product standards and product labelling schemes. In indoor environments exposure control can be accomplished through inspection of ventilation, and health and environmental agencies can perform inspections in public spaces, e.g. with respect to ETS.
Currently, none of the EU directives prescribes explicitly a monitoring and control programme for indoor air quality.

Currently, no PAN-European systematic indoor air monitoring system are currently installed. Indoor air monitoring studies in the EU have been performed in the framework of scientific research programmes such as EXPOLIS, INDEX, THADE, AIRALLERG, AIRMEX, and many others
Though, these studies are generally of a scientific kind aiming at understanding indoor air quality, and generally do not serve as a systematic control mechanism of indoor air quality. Assessment protocols have been described, e.g. in the UK and by ECA, but have not been implemented on a country wide and permanent basis.

[12] http://www.advisorybodies.doh.gov.uk/comeap/PDFS/guidanceindoorairqualitydec04.pdf

Monitoring data could be used as a reference for inspection. Although without clinical relevance in se, percentiles of concentrations measured in large scale monitoring campaigns, could indicate if the indoor air quality is 'normal' or at extreme values referencing against the data obtained during large-scale measuring campaigns.
Data on emerging pollutants (e.g. organophosphate pesticides) are needed to strengthen the risk assessment of these pollutants. A well elaborated risk assessment is a prerequisite to build a policy on IAQ of such new emerging pollutants.

Major scientific gaps exist however in methodologies to assess risk from and define measures against combined exposures, toxicology and synergies. The knowledge on chemical reactions between pollutants, or with indoor surfaces, the mixed composition and properties of (mixed) house dust is lacking at the moment. The further elaboration of integrated exposure assessment (human biomonitoring, source attribution, impact pathway) is necessary to evaluate health effects of poor IAQ and to evaluate the policy. Tools and methodologies are there, interpretation (e.g. for biomonitoring) towards health relevance, inhaled or ingested doses and main responsible sources of pollution is still difficult.

European projects are ongoing (e.g.EnVIE) to identify the most widespread and significant indoor causes for public health impact.
A standardised methodology for a monitoring program was developed in the EU project AIRMEX (JRC):
Measuring campaigns are being carried out in selected European cities to estimate indoor/outdoor relationships and personal exposure concentrations for selected volatile organic compounds (aromatics, carbonyls, terpenoids). The measuring objects comprise public buildings (town halls, guild halls), schools and kindergartens. Personal exposure measurements are conducted with employees and teachers working in the selected environments. The first results showed that total VOC concentrations inside buildings are higher and/or similar to outdoor concentrations. There is almost no difference between indoor and outdoor pollutant levels in buildings located in the city centre. Personal exposure concentrations are almost always higher than those indoors and outdoors, indicating the presence of unknown sources of VOCs

In FP7, the European Commission has published calls for proposals for a European Network on biomonitoring. (http://www.eu-humanbiomonitoring.org/index.htm)
An integrated environment and health information system (http://www.enhis.org) has been launched to determine exposure to the main pollutants, the health impacts of the exposure and the sources of exposure.

In the THADE – project, several control strategies have been identified for different risk factors:
(Viegi G., 2007, THADE-project, Workshop Indoor Air - Health – Priorities, 29-30 March Brussels)

Table 25: THADE Indoor Air Risk Factors

Risk factor	**Source characterization**	**Availability of control technology**	**Control strategy**
1. Moisture related bioaerosols	Mould spores, particles, mites, MVOC´s	Available	Building codes and standards
2. ETS	Gases, particles, secondary sources	Available	Information, smoking policies
3. Nitrogen oxides	Gas fired cooking and heating applainces, outdoor sources	Available	Alternative methods, source control
4. Pets and cockroaches	Dogs, cats and other furred animals	Available	Avoid furred pets, improve the hygiene and cleanliness
5. VOC´s	Building materials, cleaning products	Developing	Control of sources (building products, consumer products)
6. Non bio-particulates	Textiles, outdoor sources	Partly available, partly developing, difficult	Source control (material selection), cleaning, out door pollution, planning

Table 26: Health Determinants in the Indoor Environment , their source and Control Methods (THADE Table 6.1)

Health determinant	**Source**	**Control methods**	**Potential actions at EU and national level**
Carbon monoxide (CO)	Incomplete combustion in fireplaces, ovens and other heating appliances, and tobacco smoking.	Ensure sufficient combustion air, use chimneys to remove flue gases, and control pressure differences to avoid back draft. Limit smoking indoors.	Inspection and control of small heating appliances. Proper design guidelines and building codes.
Carbon dioxide (CO_2)	The metabolism of building occupants and pets.	$C0_2$ concentrations can only be controlled with ventilation rates. An increase of ventilation will decrease the indoor concentration of CO_2.	Include CO, limit values in ventilation standards. Develop methods of CO2 measurements as an indicator of ventilation.
Nitrogen oxides (NO_x)	Sick product of combustion. Indoor sources: gas fires, cooking and heating appliances, smoking	Avoid open-flame fires indoors. Remove flue gases. Use chimneys. Use effective ventilation.	Encourage the use of electrical kitchen appliances, central heating and kitchen ninge hoods. Discourage the use of unvented heating appliances. Devise ventilation guidelines.
.Indoor-generated particulate matter and dust	Carpets, textiles, food, animal and plant proteins in dust, and occupants (especially in buildings with a high density of occupants).	Avoid dust generating materials. Avoid carpets especially in public spaces. day-care centres, schools etc. Improve cleaning and ventilation and airing.	Encourage the use of vacuum cleaners. Develop performance criteria for vacuum cleaners. Encourage the use of central vacuum cleaning systems. Encourage cleaning outside school and office hours.
Chemicals, volatile organic compounds (VOCs)	All man-made building materials emit VOCs, especially when new. Cleaning products.	Limit the use of high emitting products. Air new buildings and furniture before use. Provide Adequate ventilation	Devise labelling systems for building materials, furniture and household products.
Formaldehyde	Building materials, particle boards, household chemicals, EIS, and carpets and other household textiles,	Limit the emission from sources by developing and using low-emitting products. Use only particle boards labelled for low emission. Limit smoking indoors,	Devise product control and labelling stems for building products and household chemicals.
Environmental tobacco smoke	Secondary smoke is in particle and gaseous form. Small particle size. Absorption to and desorption from surfaces. Difficult to remove from air and surfaces. combustion.	Abolish smoking indoors, no smoking in homes. Provide smoking rooms where smoking is still all owed.	Prohibit smoking in public buildings and in the workplace. Campaign against smoking at homes. Provide smoking rooms where smoking is allowed.

Health determinant	Source	Control methods	Potential actions at EU and national level
Man made mineral fibres (MMMF)	indoor sources: gas fires, cooking and heating appliances, gas fires, cooking and heating appliances, MMMF are used in insulation materials, and acoustic linings. Fibres are irritants.	indoors: Remove flue gases. Use chimneys. Use effective ventilation. Limit the use of uncoated mineral wools indoors. and in ventilation systems.	electrical kitchen appliances, central heating and kitchen range hoods. Discourage the use of unvented heating Limit the release of fibres by coating. Stop using uncoated mineral wool indoors. Develop testing methods.
Mould (fragments, mouldy material, spores, microbial VOC)	Mould growth depends on moisture: wet structures, water leakages, condensation, high indoor humidity.	Prevent and repair moisture damages and leakages. Improve ventilation. Control pressure differences between the exterior and interior surfaces of structures. Control indoor moisture sources. Provide adequate ventilation.	Better building codes for new constructions. Improved indoor environment in the existing building stock.
Dust mites	Fragments of mites and the fecal pellets. Fragments mites and faeces stored in carpets and textiles etc. Dust mites require high relative humidity indoors.	Reduce indoor relative humidity: - increase ventilation. - reduce indoor moisture. - use dehumidification.	Better building codes for new constructions. Improved indoor moisture control in the existing building stock. Use mite-resistant bedding materials.
Pets	Skin and hair fragments, dander from cat, dog etc. All furred animals are risk factors in homes and have high allergy potential. Small particle size. Can be transported on the clothing of pet owners. Difficult to eliminate with cleaning	Avoid furred pets in homes where there are seriously allergenic people. Thorough cleaning. Air cleaners.	Inform the public about the risks and benefits of furred pets at homes. Limit pets on public transport. Use easy to clean furniture in public spaces. Restrict pet exhibitions in public places (schools etc). Do not take outdoor clothing into classrooms.
Cockroaches	Related to low housing hygiene	Improve housing hygiene: cleaning, ventilation, moisture control	Public campaigns for better housing hygiene. Improve the quality of low-income housing.
Pollen	Relatively large particle size, but small fragments of plants may carry allergens: birch, alder, linden, oak, beech, olive, grasses, mugwoft etc.	Tight building envelope and filtration of incoming outdoor air. Indoor air cleaners	Develop and apply tested methods to protect against pollen. Develop testing and labelling procedures for air cleaners

In most member states, there are no systematic monitoring and control programs. In some countries, monitoring studies occur on a project basis, most of them through European projects.
Major difficulties are sampler size (methodology), privacy concerns. Further more, the building industry is very disperse and as such difficult to influence through policy.

In Germany, the German Environmental Survey (GerES - http://www.umweltbundesamt.de/survey-e/objectives.htm) started in 1985 and is currently at its 4th edition.

One of GerESs main objectives is to generate, update, and evaluate representative data in order to facilitate an environmental health related observation and reporting of information at the national level.
Up to 5000 subjects are questioned and analysed in every survey. The resulting data can also serve:

- as a basis for establishing reference values,
- to indicate trends over time and regional differences in contaminant levels,
- to identify and quantify contamination routes.

GerES thus makes it possible to design and evaluate preventive, interventive and control strategies within the framework of policy measures related to health and environment.

GerES IV is conducted in cooperation with the National Health Survey for Children and Adolescents (KiGGS) that is conducted by the Robert Koch-Institute. Using data of both surveys (the Environmental and the Health Survey) it is possible to evaluate relations between environmental conditions and health of the children, e.g., between the occurrence of mould fungi in homes and allergic sensitisation.

In France, the French Indoor Air Quality Observatory (Observatoire de la qualité de l'air intérieur) was funded in 2001.
The purpose of the OQAI (French Indoor Air Quality Observatory), appointed by the public Authorities in the framework of a convention, is to improve knowledge about indoor pollution and its origins and dangers, in order to finalise recommendations in the building field to improve the quality of indoor air. The Observatory organizes measurement campaigns to provide appropriate solutions for prevention and quality control of indoor air through actions to increase awareness of professionals and to inform the general public. The Observatory provides information about policies to be adopted in terms of regulations on
http://www.air-interieur.org/

In Italy, the necessary facilities for a control programme are being set up, and in Sweden a national register is being set-up to monitor the implementation of the Energy Directive. In the Netherlands, monitoring programmes have been stopped and they will have participating projects in Human Biomonitoring Studies.

Evaluation of the policy measures taken is not a general practice in most member states. From the member states present at the workshop, only Italy and The Netherlands has evaluation in practice. In Hungary, the smoking ban is constantly evaluated and in Sweden measures that are related to environmental objectives are continuously evaluated (http://www.miljomal.nu/english/english). In Portugal, policy evaluation is to be implemented in the forthcoming years.
In Poland, the follow up of registered complaints can be taken as an evaluation of policy, is must however be taken with care as not all complaints are approved. Monitoring systems (especially for private dwellings) are however often based on services for dwellings with complaints, and thus do not depict the overall status of the IAQ (biased dataset).

Feedback on Policy Measures

In some cases, there are no specific criteria to directly verify the effectiveness of indoor policies. The French National Environmental Health Action Plan (PNSE) established three criteria to be able to verify if the objectives of the action plan were fulfilled:

- carbon monoxide intoxications: 30% reduction within 2008
- 50% building products with consumer information on health characteristics (indoor emissions) within 2010
- 20 000 dwellings renovated every year.

In fact, every policy program should use particular criteria corresponding to expected results and implemented measures.

Motivating stakeholders, and involving all concerned partners in establishing the policy can be crucial elements in the process of developing a product and indoor environment policy. Cooperation between the government and representatives of the manufacturers is quite well developed in certain countries, for example in Sweden. Informal contacts established by the Swedish government with a number of representatives of the building and property sector have conducted to a unique project trying, on a voluntary basis, to reduce environmental impact of the building sector. The program provides that the use of hazardous substances within the building sector should be reduced to a minimum by the year 2010, and that by the year 2006 the main part (more than 75 %) of the relevant building products on the Swedish market should have building product declaration.

Generally spoken, the most successful legislative seem to be ventilation standards, voluntary actions, such as material emission schemes, and especially the Anti Smoking Ban.

The guideline values of ventilation help designers and constructors of buildings to select adequate ventilation systems in order to prevent high concentrations of harmful substances. However in practice, the ventilation systems exist only in the design stage of building preparation. As ventilation means also additional energy costs, the systems are not finally installed or simply not used by occupants of the buildings (A. Pien, CSTC - personal communication). In Sweden, a nation-wide check-up containing measurements and assessment ventilation systems, in existing buildings, has been performed. This obligatory survey of ventilation systems has revealed many situations where the functioning of these systems was not at all satisfactory (WHO, 1999), especially for older buildings. The results of the survey conducted in Sweden prove the importance of verification of applied methods and measures. Inspection and verification systems are non-existent or ineffective in most countries. In Poland, even in the case of buildings that obviously do not meet the requirements, the inspection system is not able to prove the fault and to punish the designer or builder. In Portugal ventilation, while being apparently a familiar strategy still represents more a potential for IAQ than a solution in current practice.

At present, there are many different labels in the world, and even several labels in a single country (e.g. Sweden). The results of this policy was e.g. in Finland, that manufacturers and importers of construction materials have improved the quality of their product so much that the measured emissions have decreased by a factor of thousand or more in some cases.

In Finland, radon policies are failing because the new building stock (low rise, concrete stab, tight envelope, ions ventilation has in general higher Rn-levels than the old (high-rise or leaky with cellats) which it replaces.
In Italy measures that perform sectorial interventions to reduce indoor exposure to one pollutant without considering total human exposure (indoor – outdoor) have proven unsuccessful.

Taxes or green taxes are most often used economic measures aiming to improve the quality of the environment. Taxes were used in some countries to reduce usage of chlorinated solvent. Denmark and Norway implemented taxes on most dangerous often used chlorinated solvents: trichloroethylene, tetrachloroethylene and dichloromethane. In both cases, the use of these substances has been drastically reduced, with, for example, 60 %-drop in consumption over three years in Denmark. When preparing legislation regulating usage of chemical substances, special attention should be paid on possibilities to replace them by others, less dangerous compounds. A good knowledge on the proprieties of the substances, the possibility to use them in particular products, their compatibility with other components of finished products, the technology of production, etc. is essential in taking the decision on substitution. Unfortunately, not all policies have such positive image, and excellent results. The total ban on trichloroethylene in Sweden was rather a failure because it did not result in a complete phase out of the substance. The use of trichloroethylene was reduced, but the same effect, if not better, could be probably achieved at lower cost using another kind of policy (e.g. taxes). The reactions of the producers were very negative, and even violent. In fact, many companies were protesting against the ban using all available means: articles, petitions, protests, finally reference to the European Court of Justice.

Legislative Needs

The most urgent measures to be taken are mainly the extrapolation of the smoking ban to private spaces, how challenging it may be, and EU wide uniform emission schemes and labels whether mandatory or not. This emission schemes should also be known (Education) by the construction sector. Harmonisation of emission testing procedures (ECA, CEN) are welcomed. The introduction of harmonisation on monitoring requirements (which pollutants, analytical techniques, measuring locations (schools were frequently mentioned), periods and frequencies) could improve our knowledge on IAQ in Europe. The European Collaborative Action can serve as knowledge centre, within CEN prenormative work can be done, so the facilities are there.

Furthermore, existing measures should be implemented, and harmonised monitoring programs should be developed to evaluate the measures taken. It might be useful to consider an approach in which a priority is to focus on the implementation of existing policies and legislation, and to target some clear priorities EU-wide. This needs to done while finding a balance between harmonisation and an equal approach across the EU, and the Member States' freedom of implementation. It needs to be considered to which extent the subsidiary principle applies in the field of indoor air quality. The EU policy/ legislation on IAQ should take into account cultural differences and should anticipate when society asks for measures. An integration between between indoor air, ambient air, and energy is strongly advised. These aspects are related to each other, and integration is strongly needed. They do not only influence each other, they contribute together to total exposure.

Stimulating the public awareness of indoor air, environmental education (information campaign), or in general improving the human behaviour (relevant for indoor air) is important, especially for private houses (product use, cooking mode, …), the information platform is the major tool to reduce indoor exposure. Factual, objective information needs to be strengthened: consciousness raising without creating unnecessary panic

Question B National monitoring and control programs,

Question B.1 What is your definition of a monitoring or control program? Can you provide information on the programs, or direct us (link) to information?	
Bulgaria	Ambient air monitoring network in Bulgaria is set up to evaluate the ambient air quality directive's limit values. Ambient air monitoring is conducted jointly by the Ministry of Health, Ministry of Environment and Water and the National Center for Hydrology and Meteorology. The aims of ambient air monitoring at national level are follows: - obtaining data on ambient air pollution in terms of effect on the health population and on environment, related to particular problems (traffic, urban air pollution, industrial hot spot); - providing data on air quality in order to study and assess the behavior and the interaction of pollutants necessary to prepare the mathematic models for the diffusion of these pollutants; - submitting data to establish standards for ambient air quality; - health risk assessment; - control for the execution of the programmes at lower levels.
Finland	In reference to the general IAQ – very difficult issue – monitoring studies can be only very small samplers of all indoor environments (GerES and the French IAQ observation come to mind)
Hungary	There is a control program on the ban of smoking in public places (generally not measured, just visually evaluated). Public Health Service has to decide whether a gas heater with exhaust pipe under the window can be applied in a flat (polluting the neighbouring flats)
Italy	Italy does not have an indoor monitoring program at the national level. There are few examples of research carried out by research institutions. The efforts so far have been address to control, i.e. to know the existence of the problem and to set the organisational conditions to face it. Due to the Italian constitution, there shall be consensus between the State and the Regions (Conferenza Stato Regioni) as mentioned above regarding the national guidelines.

Question B.1 What is your definition of a monitoring or control program? Can you provide information on the programs, or direct us (link) to information?	
Poland	Regular monitoring of indoor air quality have been never planned, organised and performed in Poland. The reason for this are: - It has been accepted that the priority in access to laboratory tests exists in situations where indoor air quality is questionable or the presence of elevated levels of toxic or irritating substances is suspected. The laboratories of Sanitary Inspection perform about 2 000 tests annually. - Small number of laboratories able to participate in such a programme. The labs of public health services are also involved in food and drinking water safety tests, as well as water in bathing sites and swimming pools. The necessary equipment and trained personal are lacking, and financial support is also insufficient. - There is also some problem with principles of such monitoring, for example difficulties in selection dwellings where samples are taken and the limited access to private houses and dwellings.
Portugal	Policies must be credible and enforceable. That means that they must be not only scientifically sounded but should be able to be implemented in practice and in a verifiable and controllable way. IAQ is dealing with consumers' behaviour and privacy, which represents a serious obstacle to implement IAQ policies in houses. In addition, the building construction is probably the most disperse industry in terms of technology development level used and of the expertise of the different actors involved. Therefore, this economic sector represents everywhere a difficult field to apply policies with success in a short period. Besides, regarding the impact, it must be recalled that new constructions and renovations represent only a few percentage of the building stock. In addition, new materials emerge all the time in the market very often without enough characterization of its composition. http://www.adene.pt/ (Energy Agency) http://www.adene.pt/sce.asp?tab=5#t (Information on the legislation concerning Buildings Energy Systems Performance; Buildings Thermal Performance; Indoor Air Quality) http://www.lqai.com/ (Indoor Air Quality Laboratory; labelling of building materials)
Slovakia	There is no regular national monitoring or control program in Slovakia now. We have data about IAQ in Slovakia mostly from international studies: - Central European Study on Air Pollution and Respiratory Health (CESAR study) in CE countries funded

Question B.1 What is your definition of a monitoring or control program? Can you provide information on the programs, or direct us (link) to information?	
	by European Commission. Objective of the study was to assess the effects on respiratory health of indicators of indoor air quality, parental smoking habits and other indoor factors (descriptive identification of sources of Indoor Air Pollution) - project WHO " Health Related Living Conditions in Panel Block Buildings in Slovak Republic(descriptive identification of sources of Indoor Air Pollution) - National Indoor Air Environment Project in Slovak Republic for investigation of the IAQ in dwellings has been conducted in 1999-2001. For this descriptive project, a standardised questionnaire has been prepared that included items on characterization of: living area, building materials, combustion devices, pests control, tobacco smoke, presents of fungi and mould. Participants were randomly selected from urban and rural area - Local Intervention programme of asthma and respiratory allergy prevention to reduce the negative health impact of the indoor environments in 10 kindergartens through a better understanding of the influence of indoor risk factors as cause of allergic morbidity. Measurement of concentration of total count of micro-organism and total count of fungi has been realised and sources of indoor air risk factors have been evaluated by means of questionnaires. Questionnaires have been filled in by teachers and directors of the involved kindergartens. - School Environment and Respiratory Health of Children – SEARCH project. As a follow up of the Italian – Hungarian IAQ project new cooperation developed for 8 countries, including Slovakia. Objectives: o to assess the associations between the school environment and the children's respiratory health o to make recommendations for improving the quality of school environment Exposure assessment of the study: o measurement of the indoor air quality in the school: temperature, relative humidity, CO_2, CO, NO_2, VOC, HCHO, PM o questionnaire on school building and maintenance o questionnaire on the home environment Assessment of the children's health status o symptoms questionnaire o lung function measurements? This project is in the preparation stage, we plan to start in 2007.

Question B.1 What is your definition of a monitoring or control program? Can you provide information on the programs, or direct us (link) to information?	
	- Data about IAQ from small local studies aimed on measurement of pollutant concentrations: NO2, formaldehyde, PM10, total count of micro organisms and total count of fungi measured by aeroscop, house dust mites - Topics of Indoor Air Quality is included also in the updated Action Plan for Environment and Health of the population of the Slovak Republic - part CEHAPE (Children Environmental Health Action Plan) which was approved by the Government of the SR by Resolution No. 10 from January 2006.
Sweden	- A monitoring program should include surveying the present status and/or the development of general or specific topics in a sample of population or environments that are representative of the nation. It should be performed in close collaboration with national authorities and it is aimed that the result be the basis for evaluating and developing national policies. - The work with the environmental objectives includes follow up through a large number of environmental indicators, and the progress is reported to the government every year. For more information please visit: http://www.miljomal.nu/english/english - Perceived environmental health and exposures are monitored every 4th year through a national 'Health Environment Questionnaire' which is given to a population sample. This questionnaire includes questions on IAQ of the home and health problems attributed to IAQ. Data from the questionnaire is one basis for the assessment of the progress of the environmental objectives. - Recently, the government has decided on a national survey of 'Buildings' Energy, Technical Status and Indoor environment' (BETSI), which will be performed 2007-2009. The survey will focus on homes, but will include also other types of buildings. It will include questionnaires to the occupants, and inspections and measurement of certain pollutants conducted by professionals. Both IAQ and energy consumption will be surveyed. The survey is partly a follow up of a previous survey conducted in the beginning of the 1990ies, and should also be seen in the context of the work with the environmental objectives and the Energy Directive. - To monitor the implementation of the Energy Directive a national register of buildings are presently being set up, which will contain data on energy use, ventilation and radon.
The Netherlands	Has stopped monitoring. Projects will participate in HBM (Human Biomonitoring Programme)

Question B.2 Is an evaluation of policy measures implemented in the member state?	
Bulgaria	No
Finland	The approach of actually evaluating the effectiveness and impact of policy measures is still very rare – in ETS ban, maybe?
Hungary	The above mentioned (ETS) policy is regularly evaluated by the Chief Public Health Officer
Italy	Yes
Poland	The only available control measure of indoor air quality is the number of registered complaints of indoor air quality, although it is of limited importance because not all complaints are approved.
Portugal	Not really. But there are some experiences already and there is such a policy to be implemented in the following years.
Slovakia	No
Sweden	The measures which are related to the environmental objectives are continuously evaluated. For other policies, systematic evaluation of measures has been scarce. However, through sources like research projects on IAQ some information that may give an indication of effectiveness of some policy measures may be obtained (as a 'by-product')
The Netherlands	Several al on topics

Question B.3 Which policy measure were most effective/efficient to improve IAQ? (summary or links)	
Bulgaria	Most effective policy measures are the legislative ones. Web link to the legislation:. http:/www.mrrb.government.bg/indexen.php
Finland	- The antismoking policies, smoking ban in work places and resulting cultural change which drastically reduced non-smokers exposures in the homes. - Voluntary FISIAQ developed IAQ management systems
Hungary	/
Italy	- Information campaigns, particularly on ETS exposure - Standards IAQ - IAQ labelling of materials
Poland	Polish experiences clearly indicate that surveillance of building materials health safety can contribute to substantial improvement of indoor air quality and can effectively reduce threats for health.

Question B.3 Which policy measure were most effective/efficient to improve IAQ? (summary or links)	
Portugal	Impressive is the way the policy on smoking restrictions is implemented. For the rest applies the concerns/cautions expressed under B1.
Slovakia	- Building regulations - Act of the National Council of the Slovak Republic No.126/2006 Coll. on Public Health - Direction by the Government of the Slovak Republic No. 353/2006 Coll. about requirements on indoor environment of buildings - Act of the National Council of the Slovak Republic No. 377/2004 Coll. on protection of non-smoking people
Sweden	- Some research projects indicate that policies on ventilation in public buildings have been effective in improving IAQ in schools and day care facilities. - The ban on smoking in public buildings has also been a success, with (after coming into force) a high acceptance among the public.
The Netherlands	Depends on the topic

Question B. 4 Which policy measure were least effective/efficient to improve IAQ ? (summary or links)	
Bulgaria	/
Finland	Radon policies, because the new building stock (low rise, concrete stab, tight envelope, ions ventilation has in general higher Rn-levels than the old (high-rise or leaky with cellats) which it replaces.
Hungary	/
Italy	Perhaps to perform sectorial interventions to reduce indoor exposure to one pollutant without considering total human exposure (indoor – outdoor)
Poland	/
Portugal	Ventilation, while being apparently a familiar strategy still represents more a potential for IAQ than a solution in current practice: it not only can control exposure of pollutants as it can control some at the source level as it happens with moisture and mould which represents a serious problem in a large share of the low income housing.
Slovakia	It is short time to evaluate effectiveness of the policy. Enforcement of the policy is sometimes, somewhere not very effective. Actual legislation helps us to do measures and to prepare decisions of responsible authorities at local or central level in the field of IAQ. Related conflicts limit the action that can be taken – e.g. right to personal freedom and control of indoor air.

Question B. 4 Which policy measure were least effective/efficient to improve IAQ ? (summary or links)	
Sweden	The monitoring related to the environmental objectives indicates that policies on ventilation and radon in older homes have had a very limited success.
The Netherlands	/

Question B.5 Can you indicate the most urgent policy measures that should be initiated? (summary)	
Bulgaria	Development and implementation of legislative measures and rising public awareness.
Finland	1. Stop exposing children in the lowest to tobacco smoke in the home – urgent – but very challenging 2. Develop and mandate moisture safe building constructions not sealed, but self drying.
Hungary	Public health criteria of indoor air quality
Italy	1. Definition of minimum IAQ requirements and recommended IAQ values for: offices and public buildings, Schools, hospitals, residences, and transport means, ventilation standard setting 2. Specific actions for sources or pollutants (Tobacco smoke, radon [Inclusion of radon preventive measures in building codes], construction and furnishing materials biological agents, allergens, chemical commodities); definition of reference measurement methods for indoor air pollutants 3. Setting reference methods for emission testing 4. Health protection of the most vulnerable groups of the population (Kids, atopics, asthma, etc) 5. Integration of health into know-how of architecture, engineering, managerial and political sciences (multidisciplinary approach) 6. Knowledge of the housing conditions and lifestyles of the population and promotion of healthy lifestyles
Poland	1. Appropriate education of building engineers, making them able to better understand the impact of building materials on indoor air quality and health, 2. Cooperation of public health institutions with agencies dealing with construction technologies, 3. Studies on safety of products containing recycled materials,
Portugal	1. Rigorous implementation of the Regulations recently approved (DL 78, 79 and 80/2006 of April 4); 2. Creating a label system; 3. Creating a permanent monitoring system for some critical environments (smoking at home, moisture occurrence houses, etc.) regarding, in particular, the ventilation status.

Question B.5 Can you indicate the most urgent policy measures that should be initiated? (summary)	
Slovakia	1. Guidelines, recommendations on limit values of Indoor Air pollution, microclimatic factors at EU level 2. Remedial actions depend on knowledge, financial resources and ownership, awareness of the population in existing buildings 3. To propose the main purpose and contents of monitoring and/or control program at EU level 4. Indoor Air pollution and children's health - guidelines, recommendations 5. Education and training in the field of IAQ is needed. 6. Education of the general population is needed
Sweden	1. During the last 10 years, there have been extensive investments in children's public buildins like schools, and IAQ has improved. Today, the main problems in such environments concern particulates and (lack of) cleaning. 2. Today, the most urgent measures are needed in homes rather than in public buildings. Ventilation in older private homes is still often unacceptable low and finding incentives to improve this is urgent. There is also a need to monitor the presence of building dampness and mould problems in homes. Radon is still an urgent problem in many homes. With the achievements concerning ETS in public spaces, preventive measures should try to find means to address ETS in homes. 3. There is also a need to continue to standardize testing and labelling of chemical emissions from construction products and building materials.
The Netherlands	Ban on indoor open emissions of boilers and heaters

Question C Specific national exposure and health studies, research

Question C.1 Are the resulting data used for exposure assessment, if so can you summarize or direct us to that information? (e.g. statistics on product uses, living habits, pollutant concentrations, time patterns in micro-environments such as dwelling, school, transport)	
Bulgaria	Bulgaria participates in a two years International study on air pollution and children's respiratory health. The project has been funded by the EU within the Environment and health Key Action of the Quality of Life Programme. The project has been set up to contribute to improve understanding of the magnitude of health impacts of outdoor and indoor air pollution (tobacco smoke, gas fumes, mould) as well as socioeconomic factors on children's health. The final report will be prepared by the end of this year. Among the activities within the National Environmental Health Action Plan for 2007 a study on kind of pollutants and their level in public buildings and health risk assessment will be curried out. As a result a proposal for development of a system for control, assessment and management of the IAQ in public buildings and dueling will be prepared.
Finland	Expolis study results are used directly and they are representative and fully comparable between 7 countries
Hungary	In the frame of NEHAPs and CEHAPE, the National Institute of Environmental Health has been carrying out epidemiological studies among school children on the association between their respiratory health and the home environment for many years. About 20,000 children from 30 towns and 80 villages were included in the studies during the past 10 years. Identification of problem areas and recommendations for improvements were the main objectives met.
Italy	PUBMED (http://www.ncbi.nlm.nih.gov/entrez/query.fcgi) Indoor AND Italy: 213 references Indoor pollution AND Italy: 138 references Indoor AND Italy: 111 references
Poland	Most of research performed in Poland will probably not contribute to formulate EU strategy in the area of IAQ. The majority of studies has been performed by the Institute of Building Technology in order to determine the emission of volatile substances from building materials into the air.
Portugal	The existent data on product uses, living habits, pollutant concentrations, time patterns in micro-environments such as dwellings and schools is still scarce. Several projects tried to relate indoor air quality and health, specifically on childrens at school ('Environmental Health in Shools'; 'Infantasma', 'SaudAR', 'Epiteen', 'Indoor Air Quality in Swimming Pools', 'QUAES',…).

Question C.1 Are the resulting data used for exposure assessment, if so can you summarize or direct us to that information? (e.g. statistics on product uses, living habits, pollutant concentrations, time patterns in micro-environments such as dwelling, school, transport)	
	The EPITeen (Epidemiological Health Investigation of Teenagers in Porto) research project was designed to study growth, development and health in a population-based cohort of urban adolescents, from 13 years of age until young adulthood. The evaluation at school included measurements of anthropometry (weight, height, waist and hip circumference, and skinfolds thickness), blood pressure, lung function and bone mineral density. Some cities in Portugal took part of the WHO/Europe 'Housing & Health' programme which seeks to assess and quantify the health impact of housing conditions. It puts the focus on: - home safety and accidents; - indoor air quality and comfort; - thermal comfort and energy; - pests in homes and cities; - the quality of residential environments and physical activity; - effects on mental health; - the challenge of ageing populations; With international experts, it evaluates the evidence on health gains from implementation of local action plans for housing rehabilitation, and sets health priorities related to various technical aspects of housing. http://www.euro.who.int/Housing http://www.cm-ferreira-alentejo.pt/oms/index.htm Some data on Indoor Air Quality in private buildings (residential and office buildings) also exists as result of EC project HOPE for example. http://hope.epfl.ch/ The results of these projects are usually used to improve the indoor environment quality of spaces trying to improve indoor air quality and not yet to create databases on exposure and health impact assessment.

Question C.1 Are the resulting data used for exposure assessment, if so can you summarize or direct us to that information? (e.g. statistics on product uses, living habits, pollutant concentrations, time patterns in micro-environments such as dwelling, school, transport)	
	Concerning the source control emissions by building materials, Portugal has the so called Laboratory of Indoor Air Quality (LQAI) that is one of the 11 European laboratories and the only one in Portugal which material labelling system was recognised (Report 24 ECA-IAQ/EU JRC; annex 5). http://www.lqai.com http://www.jrc.cec.eu.int/pce/modnoiseca_ecareport24_annexes.htm

Question C.1 Are the resulting data used for exposure assessment, if so can you summarize or direct us to that information? (e.g. statistics on product uses, living habits, pollutant concentrations, time patterns in micro-environments such as dwelling, school, transport)	
Slovakia	- Cesar project –Central European Study on Air pollution and respiratory health in 2000 primary school children. A questionnaire based survey was conducted in three cities in Slovak Republic in 1996. The questionnaire consisted of seven parts, including house and smoking characteristics (including type of house, number of rooms, number of people in house, maternal smoking during pregnancy, type of heating and cooking system, presence of moisture or moulds in house ever in life of child, presence of pets with fur or feathers in house ever...) Data management and validation were conducted using CESAR manuals and quality assurance/quality control protocols. - WHO project on health-related living conditions in panel block buildings. The purpose of this project was to identify potential measures and remedies and to identify recommendations for integrating aspects into projects of building renovation. To obtain this goal, two basic tasks were realized: - *Risk identification* – by an analysis of the existing data in three study countries a screening of the main housing condition problems were approached when undertaking the field work was performed - *Risk assessment* – based on the findings of the residential data a housing surveys were held in three cities of each case country. This survey can be seen as a scooping of current situation. - Description method for evaluation of the presence of sources of chemical, microbiological and biological health risk factors in dwellings in Slovak Republic was made. Sample size was indicated as a 3 ‰ of total number of permanent occupied flats in rural and urban areas. Name less questionnaires with 35 questions about presence of possible sources of indoor air pollution were used: localization, type and age of house, building materials, furniture, pets, smoking, moisture, mould, presence of allergic diseases, asthma. Data from 4655 questionnaires were put into the database in epi info and used for analysis. - Concentration of total count of fungi and concentration of total count of micro-organism measured by aeroscop in the kindergartens and dwellings and evaluated according to EUR 14988, Report No.12: Biological particles in Indoor Environments, Commission of the European Communities, Report No.12, Luxemburg, 1994. - Some statistics data on product uses can be obtained from Statistical Office, Census of population and Housing, Bratislava, Slovakia
Sweden	All the studies mentioned include measurement of a number of exposures such as e.g. formaldehyde and other volatile organic compounds, micro-organisms, particulates and dust-borne chemicals, allergens from furry pets and house dust mites, nitrogen dioxide, and carbon dioxide, as well as ventilation rates, and these may be regarded as representative of the specific indoor environments.

Question C.1 Are the resulting data used for exposure assessment, if so can you summarize or direct us to that information? (e.g. statistics on product uses, living habits, pollutant concentrations, time patterns in micro-environments such as dwelling, school, transport)	
The Netherlands	A2q will provide study report; €1029 dwellings

Question C.2 Are the resulting date used for health impact assessment, if so can you summarize or direct us to that information? (e.g. sensitive groups, input of indoor air quality on morbidity?, key problems with indoor air)	
Bulgaria	Web link : http://en.ncphp.government.bg
Finland	no
Hungary	Associations between indoor air risk factors and respiratory morbidity have been assessed.
Italy	PUBMED (http://www.ncbi.nlm.nih.gov/entrez/query.fcgi) Indoor AND health AND Italy: 57 references
Poland	In Gdańsk, where in the early 1970-ties a numerous cases of indoor air pollution in new dwellings were encountered, an attempt has been made to examine the influence of indoor air pollution on children health and development; however, due to inappropriate methodology the results may not be regarded as reliable and conclusive.
Portugal	It is the case of EPITeen. (not concluded yet)
Slovakia	Cesar project –Central European Study on Air pollution and respiratory health in school age children: - Analyses of the impact of the indoor factors were made for bronchitis, chronic bronchitis symptoms and for asthma and asthmatic symptoms such as cough, wheeze - After adjusting for other relevant factors these indoor factors were recognised as significant risk factors for chronic bronchitis: smoking history of mother, moulds on the walls, traffic intensity, gas stove for winter heating and chipboard furniture - As for asthma or spastic obstructive bronchitis the significant risk factors were: smoking history of mother, mould, damp in the last 2 years, traffic intensity and use of gas heater - WHO project on health-related living conditions in panel block buildings: - Priority problems were identified: heating, indoor air quality, pests and infestations, noise, dwelling size, deterioration/decay of building elements - Problem with dampness, humidity or water condensation and chronic diseases or long-term health problems: asthma, allergies, respiratory symptoms, coughing

Question C.2 Are the resulting date used for health impact assessment, if so can you summarize or direct us to that information? (e.g. sensitive groups, input of indoor air quality on morbidity?, key problems with indoor air)	
Sweden	- The data are used to investigate the relation between exposure and health, usually presented as odds ratios. However, there are few attempts to use the data for health impact assessments for the whole populations, although it should be possible. - In summary, in homes ETS, mould and dampness, indoor painting and plasticizers have been found to be related to increased prevalence of asthma. In schools, the critical exposures seem to be low ventilation rates, pet allergens and dust.
The Netherlands	Upon Request

Question C.3 Can you indicate what the missing data (e.g. exposure, baseline health,….) are that should be assessed? (summary)	
Poland	/
Sweden	There is a need to follow the development of presence of e.g. moisture damage and mould, particulates, radon and ventilation rates. Furthermore we need baseline data on presence of plasticizers, flame retardants, PCB and *Legionella* in tap water systems.
Slovakia	- Early life exposure of chemical/microbes and lifestyle factors for development of athma and allergies – phthalates from plasticized PVC and organic compounds associated with e.g. cleaning products - Legionella spp.- sources, measurement and evaluation methods, concentrations, health impact assessment - Indoor sources and concentration of pesticides
Bulgaria	Data from monitoring indoor air quality, exposure and health effects
Italy	The priority for research should be to enrol a cohort (representative of the general population) of subjects to be followed up with indoor monitoring systems and with health outcome indicators. This should be done at family and school levels.
Portugal	Almost everything. Portugal is in the beginning of a huge work in this field relating IAQ & Health.
Hungary	Now we are going to study the impact of indoor air quality in schools on the health of the children.
The Netherlands	Depends on the topics. Information is available at "EU working Group on Exposure Databases" Arjen e.a. 1997; Arba

Question C.3 Can you indicate what the missing data (e.g. exposure, baseline health,….) are that should be assessed? (summary)	
Finland	Representative studies, using European Harmonised methodologies that would relate outdoor contaminants to indoor air levels, personal exposures and human biomonitoring data, for the purpose of perspective assessives the constitutions of different sources to body odours, and the chemical body odours, which could exceed the avtive level (level of interest for health).

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ANNEX D: TECHNICAL ANNEX OF HEALTH IMPACT ASSESSMENT OF INDOOR AIR POLLUTANTS

D1: Identification of appropriate health outcomes

D2: Overview of exposure-response functions for each indoor air stressor

D3: Population baseline frequency measures for the health outcomes under consideration

D4: Health impact assessment calculations

D1: identification of appropriate health outcomes

This table is based on the INDEX study for formaldehyde, CO, NO_2, benzene and naphthalene, on WHO, PINCHE and others for PM and based on the study of Seppänen et al. (2004) for ventilation.

Table 27: identification of appropriate health outcomes required in the second step of health impact assessment (HIA)

	non-carcinogenic effects		carcinogenic effects	
	short-term exposure	long-term exposure	IARC[$] carcinogenicity class	effect
formaldehyde	respiratory symptoms nasal and eye irritation	nasal and eye irritation lower airway discomfort histopathological nasal lesions	group 1*	nasopharyngeal cancer
CO	from subtle cardiovascular and neurobehavioral effects to unconsciousness and death	not enough reliable information on effects of chronic exposure to low concentrations	not listed by IARC	-
PM	mortality diseases of the lower respiratory system diseases of the upper respiratory system chronic bronchitis asthma cardiovascular diseases	life expectancy loss cardiopulmonary disorders	PM as such not classified by IARC, some PM sources are carcinogenic, e.g. tobacco smoke and soots, group 1; diesel engine exhaust: group 2A**	bronchopulmonar cancer
NO_2	increase in airway reactivity increased responsiveness to bronchioconstrictors respiratory symptoms	excess of lower respiratory illness	not listed by IARC	
CO_2/ventilation	respiratory illnesses sick building syndrome symptoms task performance and productivity respiratory allergies and asthma	-	-	-
benzene	developmental effects (~ animal tests) haematological effects	haematological effects blood cell depression neurological effects	group 1*	leukemia
naphtalene	respiratory symptoms (~animal tests) hemolytic anemia	respiratory symptoms (~animal tests)	group 2B***	inadequate evidence of naphtalene in humans

	cataracts

* IARC: International Agency for Research on Cancer
* group 1: is carcinogenic to humans (IARC)
** group 2A: probably carcinogenic to humans (IARC)
** group 2B: possibly carcinogenic to humans (IARC)

D2: overview of exposure-response functions for each indoor air stressor

An overview of exposure-response functions is given in *Table 28*. In this paragraph, some more explanation about the background of the exposure-response functions is given:

a. Formaldehyde

No meta-analysis of ERFs for indoor formaldehyde has been performed yet. Several separate indoor air formaldehyde – health outcome studies have been published. Exploring the literature, reports showing divergent results.
No significant effect of indoor formaldehyde concentrations on asthma in children was reported by Garrett (1999) In another study, formaldehyde levels were significantly associated with hospitalization for asthma in children aged six months to three years, after ruling out confounding from other indoor air pollutants. No effects were found in children exposed to 10 to 29 µg/m^3 and 30 to 49 µg/m^3 formaldehyde, a non-significant increase of risk was observed at 50 to 59 µg/m^3 and a significantly increased risk was observed at concentrations exceeding 60 µg/m^3 (Rumchev et al., 2002). Venn et al. (2003) reported no (significant) effect on asthma prevalence (wheezing) among children in a case-control study (e.g. odds ratio (OR) of highest formaldehyde category (>32 µg/m³) versus the lowest (<16 µg/m³): adjusted odds ratio (AOR) = 1.04 (95 % CI: 0.59-1.82)). The study of Venn et al. (2003) found an effect on the severeness of wheezing in wheezing children (looking at wheezing frequency at night and day: AOR = 3.33 (low formaldehyde < 16 µg/m³ versus high formaldehyde >33 µg/m³).
The study of Garrett et al. (1999) found an insignificant effect of formaldehyde exposure on atopy among children (AOR: 1.4 (95 % CI: 0.98 – 2.00) per 10 µg/m³ formaldehyde).

Exposure response functions from occupational exposure studies are excluded because of not relevant in this context. Occupational studies generally measure effects at concentrations one or more orders of magnitude above residential exposure. They are used to identify the relevant health endpoints and to derive exposure limits. Since it is not known if the health effect –exposure response function is linear outside the concentration range, it is prefer not to transfer ERF to residential scenarios. In addition, in the group of exposed persons (workers) in occupational studies might have a different sensitivity to the pollutant than the general population.

Not all health endpoints identified as affected by formaldehyde (see *Table 27*) are covered by the available studies reporting ERFs for formaldehyde. The endpoints investigated in *Table 27* are, in contrast to ERF functions, not limited to epidemiological studies, but can also be based on clinical studies, based on occupational studies, or based on results from animal tests. The latter are however not directly useful to derive ERF functions in order to do a HIA.

carcinogenicity

The IARC classifies formaldehyde in group 1: carcinogenic to humans. Formaldehyde causes nasopharayngeal cancer in humans.

The lifetime risk for carcinogenicity via inhalation of formaldehyde is expressed as the Unit Risk: 1.3 x 10^{-5} $(\mu g/m^3)^{-1}$ (US-EPA), which can be seen as a dose response function.

b. carbon monoxide

No indoor specific CO ERF were retrieved from a literature survey.
Instead, ERF of indoor CO *sources* (ETS, Anderson and Cook, 1997) have been reported in the literature. However, these ERFs are not quantitative enough in terms of CO concentrations and cannot be used in this context.
Instead, outdoor CO can be used as an approximate for indoor CO ERFs. Significant associations between outdoor CO and health outcomes such as asthma, cardiac diseases, COPD and pregnancy outcomes have been reported in the literature (von Klot et al.,2005; Liu et al., 2003; Hwang et al., 2006; Fusco et al., 2001) risk of indoor CO poisoning, can simply not be calculated by an ERF function because of lack of exposure data for these events. Instead, the HIA (see below) for CO is based on recorded statistics of CO poisoning.

c. PM

The vast majority of epidemiological particulate matter-health studies is related to ambient PM. Much less is known about health effect of indoor generated PM (Jones, 1999).

According to Schneider et al. (2003), who reviewed the literature of indoor PM and associated health effects, there is inadequate scientific evidence that PM measurements (mass or numbers) are useful as predictors of health risk of indoor PM, and thus no indoor PM – ERF can be derived. More research is necessary to address the indoor PM toxicity and health effects. Fromme et al. (2006) advised that for a reliable risk assessment it is also essential to characterize the chemical and, particularly, toxicological properties of both indoor and outdoor PM samples

Extrapolating the ambient PM ERF to indoor PM assumes that ambient and non-ambient PM are equally toxic. This assumption is however questionable since the composition of indoor PM may deviate of outdoor PM.

Numerous (epidemiological) studies relating ambient PM to health outcomes have been published in the last decades. It is not our intention to make an inventory and to re-analyse all these individual studies. Instead, ERFs of large-scaled research programs, like the APHEA study can be used.

In addition to mortality associations and PM, in the report of the PINCHE study, risk estimates of (ambient) PM for other health endpoints for children (respiratory symptoms, lung function impairment, …) were summarized from the literature (see also *Table 28*).

VITO is involved in the 6th FP project NEEDS (Torfs et al., 2007). In this study, an recent update of ERFs of ambient PM and several health outcomes (chronic mortality, infant mortality, acute mortality, several morbidity endpoints- has been made. It is suggest to evaluate upon discussion of this draft report, if applications of the ERFs for indoor PM is desirable.

d. NO_2

Indoor NO_2 ERF is one of the most widely studied among indoor pollutants. Nevertheless,

evidence from three decades of epidemiological studies linking NO_2 exposure to adverse health effects has been inconsistent. Some inconsistency may be explained by differences in methods of exposure assessment. Populations studied have also varied and include healthy children and infants, as well as children with asthma, or children/infants at risk for developing asthma (Belanger et al, 2006).
A review paper (Basu et al., 1999) concluded that there was inconsistent evidence of adverse effects.
The most important reports with ERFs are listed in *Table 28*.
The paper of van Strien et al. (2004) reported significant adverse effects of NO_2 on the number of days with respiratory symptoms (wheeze, persistent cough, shortness of breath) in young children (0-1 years) above 9 µg/m³ compared to <0.6 µg/m³. This is one of the studies with the lowest thresholds for NO_2 related effects. However, some data were lacking in the paper to allow a HIA based on this study. Moreover, the study objects were recruited from a group with at least 1 older sibling with physician-diagnosed asthma, which cannot be extrapolated to the overall population since this type of background demographic or health data is lacking.

e. CO_2/ventilation

Kim et al. (2002) found a significant increased risk for wheeze attacks among children at increasing CO_2 indoor concentrations. (OR = 1.12 per 12.5 mg CO_2/m³: 95 %CI: 1.02 – 1.28). In contrast, Frisk et al. (2002) reported no significant influence of CO_2 on children's health. Norbäck et al. (1995) found a negative influence of CO_2 on nocturnal breathlessness among adults (OR = 20 per 1830 mg CO_2/m³ (95 % CI: 2.7-146)).

Seppänen et al. (2004) reviewed the literature concerning human responses to ventilation. These authors concluded that ventilation has a significant impact on several important human outcomes including (1) communicable respiratory illnesses, (2) sick building syndrome symptoms, (3) task performance and productivity, (4) perceived air quality, (5) respiratory allergies and asthma. In addition, in many studies, prevalence of SBS have also been associated with characteristics of HVAC-systems. Often, the prevalence of SBS symptoms is higher in air-conditioned buildings than in naturally ventilated buildings.
Further, health effects due to poor ventilation are intrinsically related to other indoor air pollutants. On the one hand, ventilation can dilute indoor generated pollutants, and on the other hand, ventilation may bring indoors harmful substances.
Most of the studies related to ventilation are however related to office environments, commercial and institutional buildings, and not to residences.
Seppänen et al. (2004) listed a series of available studies with ORs of SBS symptoms ventilation classes. Notwithstanding the large availability of data, Seppänen et al. (2004) concluded that the available data are not sufficient to quantify an average dose-response relationship. In addition, Seppänen et al. (2004) advised that for future research, emphasis should be put on 1) dose-response relations useful for quantitative risk assessment, and 2) association of health outcomes with ventilation rates per unit floor area. They stressed that there is a great demand for research on ventilation in residences, schools, and other environments with susceptible occupants: the young, the elderly and people not in good health.

f. benzene

Rumchev et al. (2004) reported that, based on a case-control study evaluating the effect of domestic exposure to VOCs with asthma in young children, that for every 10 µg/m³ increase in the concentration of benzene, the risk of having asthma increased by almost three times (OR = 2.92 per 10 µg/m³ (95 % CI: 2.25 – 3.80).
Delfino et al. (2003) found small positive associations between asthma symptoms and breath concentrations of benzene (OR = 2.03). Recently, Arif et al. (2007) published a study relating personal exposure to volatile organic compounds, including benzene, to asthma among US adult population (OR for benzene: 1.33 (95 % CI: 1.13 – 1.58)
Benzene is know to be carcinogenic (leukaemia). The IARC classifies benzene in group 1: carcinogenic to humans.
A range of 2.2×10^{-6} to 7.8×10^{-6} is mentioned for the increase in the inhalation lifetime risk on cancer of an individual who is exposed for a lifetime to 1 µg/m^3 benzene in air (US-EPA). The WHO handles a inhalation lifetime cancer risk for benzene of 6×10^{-6}.

g. naphtalene

No epidemiological data on risks of non-occupational exposure to naphtalene are availabe in the literature, thus no quantitative exposure response functions for non-carcinogenic effects are available in the literature.

the IARC classifies naphtalene in group 2B: possibly carcinogenic to humans.

An inhalation unit risk estimate for naphthalene was not derived by US-EPA because of the weakness of the evidence (observations of predominant benign respiratory tumors in mice at high dose only) that naphthalene may be carcinogenic in humans.[13] In contrast, the California office of environmental health hazard assessment does applies the following unit risk factor: $3.4 * 10^{-5}$.

[13] http://www.epa.gov/iris/subst/0436.htm

Table 28: overview of exposure response functions for the various substances. The studies marked in bold are taken forward for health impact assessment. Other studies (in italic) were unsuitable (e.g. lack of reported data, or inappropriate concentration range) to perform indoor air HIA.

substance	indoor/outdoor	health effect	receptor		Exposure Response Function (ERF)	study
FORMALDEHYDE	indoor	asthma	children (7-14 years; Australia)	diagnosed asthma	no sign. Effect (no numerical OR published)	Garrett et al., 1999
	indoor		children (6 m -3 years; Australia)	diagnosed asthma (prevalence)	**aOR = 0.96 (0.8-1.1) for 10- 29 vs <10 µg/m³**	Rumchev et al., 2002
					aOR = 0.98 (0.8 -1.2) for <10 vs 30-49 µg/m³	
					aOR = 1.21 (0.9-1.6) for 50-59 vs <10 µg/m³	
					aOR = 1.39 (1.1- 1.7) for >60 vs. <10 µg/m³	
					OR = 1.003 (1.002 -1.004) per 10 µg/m³	
	indoor	asthma	children (6-8 years)	self-reported wheezing (prevalence during past year)	**aOR = 1.04 (95 % CI: 0.59 - 1.82) between <16 and >33 µg/m³**	Venn et al., 2003
			atopic children (6-8 years)	more frequent nocturnal wheezing frequency (among atopic children)	**OR = 1.45 (95 % CI: 1.06 - 1.98) for interquartile range (16-32 µg/m³)**	Venn et al., 2003
	indoor	asthma			*prevalence ratio: 2.0 if in kitchen > 75 µg/m³*	Krzyzanowski et al., 1990
	indoor	chronic bronchitis			*prevalence ratio: 8.2 if in kitchen > 75 µg/m³*	Krzyzanowski et al., 1990
	indoor	respiratory symptoms		peak expiratory flow	*decrease of 22 % per 75 µg/m³*	Krzyzanowski et al., 1990
	indoor	lower airway inflammation		exhaled NO (marker)	*RR = 1.8 for > 62 vs. < 62 µg/m³*	Franklin et al., 2000
	indoor	respiratory symptoms		variability in PEFR	*28 % increased risk with conc > 30 µg/m³*	Quackenboss et al., 1989
	indoor	atopy	children (7-14 years; Australia)	skin prick tests (atopy prevalence)	**AOR = 1.4 (95 % CI: 0.98 – 2.00) per 10 µg/m³**	Garrett et al., 1999

	indoor (school)	asthma	children (mean age =10 at start and 14 at end of the study); Sweden (school study)	diagnosed asthma **incidence** (over 4 years period)	OR = 1.2 (0.8 -1.7) per 10 µg/m³ in classroom air	Smedje and Norbäck, 2001
		cancer		unit risk factor	0.000013	US EPA
CO*	ambient	cardiac diseases	persons with previous cardiac infarction, and aged > 35 (mean age: 60-70 y); EU-study	hospital readmission for cardial causes	**RR (rate ratio) = 1.014 (95 % CI: 1.001 -1.026) per 200 µg/m³ CO**	von Klot et al. 2005
	ambient	pregnancy outcome		low birth weight	**OR = 0.96 (0.88-1.04) per 1 ppm CO (during first month pregnancy)**	Liu et al., 2003
				preterm birth	**OR = 1.08 (1.01-1.15) per 1 ppm CO (last month pregnancy)**	Liu et al., 2003
				intrauterine growth retardation	**OR = 1.06 (1.01-1.10) per 1 ppm CO (during first month pregnancy)**	Liu et al., 2003
	ambient	asthma	children (Taiwan)	prevalence of allergic rhinitis	**aOR = 1.05 (1.04 -1.07) per 100 ppb CO**	Hwang et al., 2006
	ambient	asthma	all ages	hospital admission	**5.5 (0.9 - 10.4) % increase per 1.5 mg CO/m³**	Fusco et al., 2001
		respiratory symptoms	all ages	hospital admission	**2.8 (1.3 - 4.3) % increase per 1.5 mg CO/m³**	
		acute respiratory infections	all ages	hospital admission	**2.2 (0.0 - 4.4) % increase per 1.5 mg CO/m³**	
		COPD	all ages	hospital admission	**4.3 (0.0 - 4.4) % increase per 1.5 mg CO/m³**	
	ambient	asthma		GP consultation	*11.4% for 10-90 % percentile increase in warm season*	Hajat et al., 1999
				GP consultation	*6.2% for 10-90 % percentile increase in cold season*	
PM**	ambient	total mortality		total mortality (acute)	0.6 (0.4 -0.8) % increase per 10 µg/m³ PM10	APHEA2
	ambient	COPD	> 65 years	hospital admission	1.5 (1.0 - 1.9) % increase per 10 µg/m³ PM10	APHEA2
	ambient		children	postneonatal respiratory mortality	20 % (annual mean) increase per 10 µg/m³ and 10 % (daily mean) per 10 µg/m³ PM10	PINCHE

			children	postneonatal total mortality	5 % (long term) increase per 10 µg/m^3 PM10	PINCHE
			children	respiratory symptoms	5 % (daily mean) increase per 10 µg/m^3 PM10	PINCHE
			children	lung function parameters	1 % (daily mean) increase per 10 µg/m^3 PM10	PINCHE
			children	lung function growth deficit	1 % (annual mean) increase per 10 µg/m^3 PM10	PINCHE
			children	hospitalisation	1- 5 % (daily mean) increase per 10 µg/m^3 PM10	PINCHE
			children	school absenteeism	3 % (daily mean) increase per 10 µg/m^3 PM10	PINCHE
NO_2	indoor	asthma	children (0-2 y)	recurrent wheezing during first 2 years of life (prevalence)	*aOR = 0.96 (0.52-1.77) for <8.4 vs. 8.4-11.6 µg/m^3*	Emenius et al. (2003)
					aOR = 1.08 (0.57-2.03) for <8.4 vs. 11.7-15.6 µg/m^3	
					aOR = 1.51 (0.81-2.82) for <8.4 vs. >15.6 µg/m^3	
					aOR = 1.06 (0.74 - 2.82) per 10 µg/m^3 for continous NO_2 levels	
	indoor	asthma	children (9-11 y)	self-reported wheezing	**aOR = 0.67 (0.38 - 1.18) for 0-22 vs. > 58 µg/m^3**	Venn et al., 2003
	indoor	respiratory symptoms	children		*OR = 1.5 (1.2 -1.8) per 15 ppb NO2*	data of Neas et al (1991), re-evaluated by Li et al.,2006
	indoor	respiratory symptoms (self-reported prevalence during one year)	children (7-14 y); Australia	cough	**OR =1.47 (0.99 -2.18) per 10 µg/m^3**	Garrett et al., 1998
	indoor			shortness of breath	**OR = 1.23 (0.92 -1.64) per 10 µg/m^3**	
	indoor			waking short of breath	*OR = 1.04 (0.71 -1.53) per 10 µg/m^3*	
	indoor			wheeze	**OR = 1.15 (0.85 -1.54) per 10 µg/m^3**	
	indoor			asthma attacks	**OR = 1.06 (0.77 -1.46) per 10 µg/m^3**	
	indoor			chest tightness	**OR = 1.12 (0.81 -1.56) per 10 µg/m^3**	

	indoor			cough in the morning	*OR = 1.25 (0.92 -1.69) per 10 µg/m³*	
	indoor			chest tightness in teh morning	*OR = 1.32 (0.95 -1.84) per 10 µg/m³*	
	indoor	lower respiratory tract symptoms	children (0-18 months)	wheeze and wet cough	*OR not sign. elevated with NO_2 exposure*	Samet et al. (1993)
	indoor	lower respiratory tract symptoms (number of days of respiratory symptoms)	children (0-1years)	wheezing	*aRR (rate ratio of number of days with symptoms) = 2.2 (1.4 - 3.4) for >17.4 ppb vs. < 5.1 ppb NO_2*	van Strien et al. (2004)
				cough	*aRR = 1.8 (1.2 -2.7) for >17.4 ppb vs. < 5.1 ppb NO_2*	
				shortness of breath	*aRR = 3.1 (1.8 -5.6) for >17.4 ppb vs. < 5.1 ppb NO_2*	
CO_2	indoor	asthma	children	increased risk for wheezing attacks	**OR = 1.12 (95 % CI:1.02 - 1.28) per 12.5 mg/m³**	Kim et al., 2002
	indoor		children	difference in CO2 conc of houses of asthmatic versus non-asthmatic children	no difference	Frisk et al., 2002
	indoor		adults	nocturnal breathlessness	**OR = 20.0 (95% CI: 2.7 - 146) per 1830 mg/m^3**	Norback et al., 1995
BENZENE	indoor	asthma	adults	physician-diagnosed asthma (prevalence)	OR ('aromatics') = 1.63 (1.08-2.61)	Arif et al., 2007
	indoor (domestic exposure)	asthma	young children (0.5 - 3 yrs)	asthma (prevalence)	**OR = 2.92 (2.25-3.79)**	Rumchev et al.,2004
	ambient or breath air	asthma	asthmatic children	degree of asthma symptoms (bothersome or severe versus no or not bothersome symptoms)	*OR = 2.03 (0.80-5.11) for benzene in breath air. for an increase of 2.19 ng/l (= µg/m³) in breath benzene*	Delfino et al.,2003

			OR = 5.93 (1.64-21.4) for benzene in ambient air. for an increase of 5.67 ng/l (= µg/m³) in ambient benzene	Delfino et al.,2003
	cancer (leukaemia)	unit risk factor	2.2 - 7.8 10^{-6}	US EPA
			group 1	IARC
NAPHTALENE	cancer	-	?	US EPA
			group 2B	IARC
		unit risk factor	3.4 10^{-5}	California Office of Env. Health Hazard Assessment

* no ETS studies included here (see Anderson, 1997, Thorax, 52; 1003-1009)

** According to Schneider et al. (2003), there is inadequate scientific evidence that PM measurements (mass or numbers) are useful as predictors of health risk of indoor PM, and thus no indoor PM – ERFs can be derived. Therefore, by lack of indoor PM-ERFs, outdoor PM ERFs are applied.

D3 : Population baseline frequency measures for the health outcomes under consideration

The main health outcomes affected by indoor pollution described by above mentioned exposure response functions are 1) lower respiratory symptoms (asthma, atopy,…), and 2) cancer cases for carcinogenics. The occurrence of cancer cases in reported in common EU statistics (EUROSTAT). It is outstanding that drastic increases in asthma and atopy took place in the last decades. Some sources state that 10 % of the children in the EU suffer from asthma[14]. A worldwide country-by-country inventory prevalence of asthma symptoms in childhood was made in the GINA program (Masoli et al., 2004)
Analogously, atopy/eczema is neither included in the DB-HFA database. Williams et al. (1999) made a world-wide overview of the prevalence of atopy. There appeared to be very large variations between different regions. Also within the EU, large variations exist: from 3 % (Greece, Spain), over 5-10 % (Portugal, Austria, Italy, Belgium, Germany, France), to 12 – 15 % for some Northern EU countries (U.K., Ireland, Sweden, Finland) for children 13 – 14 years.
As a very simple abstraction for the EU as a whole (without a balanced analysis accounting for number of inhabitants) in the different Member States, we used 10 % prevalence of atopy patients in this HIA.

[14] http://www.euro.who.int/hfadb

D4 : Health impact assessment calculations

The key issue in this HIA is the application of the ERFs to the prevailing indoor air concentrations in Europe. The ERFs for indoor pollutants which are generally based on a limited study group under the boundaries of the study-specific indoor air concentrations exposure and, need to be extrapolated to a wider group, both in the sense of a wider indoor air concentration range (EU level), and a wider set of persons (EU population level).

The ExternE methodology is here applied to conduct the conversion from odds ratio (OR), to increases in health outcome per unit increase in pollution.

This ExternE methodology is explained below by means of a practical example for the first case study, rather than by here going into theoretical details. For a more theoretical background, we refer to handbooks in epidemiology (Rothman, 2002; Schoenbach and Dosamond, 2000).
Notwithstanding that the ExternE methodology is in fist place developed for outdoor air, it is also applicable to indoor air. The on-going 6th FP HEIMSTRA is currently in the process of improving methodologies for HIA of indoor air quality.

In addition to a conversion of the OR to increase in health come per unit air pollution applicable at the EU-level, the indoor concentrations prevailing in the EU need to be defined. The most suitable dataset of indoor concentrations are these where not only average, and eventually minimum and maximum concentrations, but a complete indoor air distribution is reported. The EXPOLIS study, and other large scaled studies (e.g. French study), reported in the INDEX report provide such information, and will be used in this HIA. It is noted these concentrations were read from graphs in the INDEX project and not from the original databases. This might have lead to small rounding errors, however, this will influence the outcome only very marginally.
The distribution curve of indoor concentrations is broken up in discrete intervals (P0 – P10; P10-P25; P25-P50; P50-P75; P75-P90; P90-P100). For each interval, the health effect is assessed as the point estimate of health outcome for the central value of that interval. Then, the population based health impact is calculated as the sum of the health impacts for each interval, weighted for the contribution of the interval to the total exposure range.

a. formaldehyde

The ORs of the various ERFs listed in *Table 28* are converted to increases in health outcome per 10 µg/m³ following the following ExternE methodology (example given for atopy prevalence in the study of Garrett et al. (1999)).

- the OR (1.4 per 10 µg/m³; 95 % CI : 0.98- 2.00), multiplied by the background prevalence of 0.61 in the study of Garrett et al. (1999), results in *background odds* on prevalence of asthma of 1.564.
The *new odds* on prevalence of asthma is 2.19 (= background odds x new odds), which after conversion to prevalence (logistic transformation) results in a *new prevalence* of 0.686. Substracting the background prevalence of this number results in an *increased prevalence* of 7.6 % per 10 µg/m³. The latter is multiplied for each class by the interval-average concentration, and the increase in atopy is than accounted for the weight of the interval in the indoor concentration distribution graph.
This results in an 17 % increase in atopy at prevailing indoor formaldehyde levels in France
compared to the situation where indoor formaldehyde concentrations would be zero. This 17 % increase is often called the 'attributable fraction'. This French example is shown in *Table 29* for indoor concentrations. It is remarked that there is a large uncertainty on this percentage (95 % CI of the attributable fraction: 0-33 % when taking into account the 95 % CI on the ORs.

Table 29: health impact assessment of indoor formaldehyde in France for atopy, based on the ERF of Garrett et al. (1999) and EXPOLIS indoor formaldehyde concentrations in France. The 95 % confidence interval of the OR is used to calculate 95 % lower and 95 % upper limits of increases in atopy at prevailing concentrations in France.

Concentration interval	average concentration of the interval	increase in atopy per 10 µg/m³ (95 % C.I)	increase in atopy at prevailing indoor formaldehyde level
	µg/m³		
P 0-10	6	7.6% (0 – 14.8 %)	5% (0 – 9 %)
P 10-25	14	7.6% (0 – 14.8 %)	11% (0 – 21 %)
P 25-50	19	7.6% (0 – 14.8 %)	14% (0 – 27 %)
P 50-75	24	7.6% (0 – 14.8 %)	18% (0 – 35 %)
P 75-90	32	7.6% (0 – 14.8 %)	24% (0 – 47 %)
P 90-100	45	7.6% (0 – 14.8 %)	34% (0 – 66 %)

weighted average = increase in atopy in France under the prevailing indoor formaldehyde concentrations	**17%** (0 – 33 %)

Similar calculations with the Garrett et al. (1999) ERF of atopy were run for indoor formaldehyde concentrations in other countries, namely the U.K., Finland (Helsinki), and Sweden (using distributions of indoor formaldehyde in the EXPOLIS databases).

Additionally, this method was applied for ERFs of other studies and endpoints of *Table 28*.
Applying the carcinogenicity unit risk factor of 1.3 10^{-5} (US-EPA) to the prevailing indoor formaldehyde concentrations, figures out that 4 formaldehyde attributable cancer cases per year occur per 1 million inhabitants in France, and 5, 8 and 6 per 1 million inhabitants respectively for the U.K., Finland (Helsinki) and Sweden.

The summary of HIA of indoor formaldehyde in France, the U.K., Finland (Helsinki) and Sweden is given in *Table 30*.

Table 30: health impact assessment of indoor formaldehyde in France, the UK, Helsinki and Sweden

health outcome	study	receptor	France	UK	Helsinki	Sweden
non-carcinogenic effects: increase in adverse health effects under the prevailing formaldhyde exposure in that country/region						
			(95 % CI)	(95 % CI)	(95 % CI)	(95 % CI)
diagnosed asthma (prevalence)	Rumchev	children (0,5-3 y)	0% (0-3 %)	1.6% (0.5-5 %)	2.9% (05 -8 %)	1.6% (0.5 -6 %)
self-reported wheezing (prevalence during past year)	Venn	children (6-8 years)	0.7% (0-11 %)	0.9% (0-13 %)	1.3% (0-19 %)	1.0% (0- 16 %)
more frequent nocturnal wheezing prevalence (among atopic children)	Venn	atopic children (6-8 years)	13% (2-23 %)	16% (2.5 -28 %)	24% (3.8 -42 %)	19% (3 -34 %)
skin prick tests (atopy prevalence)	Garrett	children (7-14 y)	17% (0-33 %)	21% (0-41 %)	32% (0-62 %)	26% (0-50 %)
diagnosed asthma incidence (over 4 years period)	Smedje	children (10-14 y)	1.9% (0-6.4 %)	2.3% (0-8 %)	3.5% (0-12 %)	2.9% (0-10 %)
carcinogenic effects (number of cancer cases per year per 1 million persons)						
number of cancer cases per year per 1 million persons			4	5	8	6

The HIA for formaldehyde points out that the attributable fraction of indoor air formaldehyde concentrations on asthma is rather low, namely from 0 – 2% in France to 3- 4 % Helsinki, and non significantly different from zero under the prevailing formaldehyde exposures in the investigated EU countries/cities. In contrast, the formaldehyde attributable fraction for atopy is substantial: from 17 % (France) to 32 % (Helsinki). Also among the atopic children, wheezing frequency is increased by 13 % (France) to 24 % under current formaldehyde concentrations.

b. carbon monoxide

The health impact assessment of carbon monoxide is performed in a similar way as for formaldehyde, except on one major point: given the lack of an indoor ERF, the outdoor ERFs were used. This puts a larger uncertainty on results, and care should be taken when interpreting these results.

The ERFs of CO (*Table 28*) were applied to the EXPOLIS CO indoor concentration distributions for the cities of Helsinki, Milan and for France. The resulting HIA is given in *Table 31*.

The adverse health effect of CO on newborns (birth weight, preterm birth , intrauterine growth retardation) is near nihil (0 – 1%) at typically prevailing CO indoor concentrations in Helsinki, France and Milan. For adults, indoor CO exposure influences slightly (2 – 4%) the hospital admission rate for respiratory symptoms. Among all investigated effects, indoor CO has probably the largest influence on asthma (hospital admission for asthma for adults, i.e. 4-7 % increase) and on allergic rhinitis in children (prevalence: 4-7 %).

However, the impact of accidental, acute CO poisoning, which is the largest risk of indoor CO exposure, can simply not be calculated by an ERF function because of lack of exposure data for these events. Instead, an additional HIA for CO is based on recorded statistics of CO poisoning.
The U.K. Health and Safety Executive tried to make an inventory of CO incidents in the EU during the past decades[15]. They noticed that not in all Member States statistics on CO incidents were collected (e.g. Italy, Belgium), and if collected and published (in many cases not public available), there was a variety in reporting formats and seriousness of reported as 'CO incidents', making the overall picture incomplete and difficult. Nevertheless, citing few selected data from that report, namely yearly 150-200 serious CO intoxication incidents and 25-30 acute CO caused deaths per year in the U.K., demonstrates that the seriousness of the acute CO poisoning (in the EU).

Table 31: : health impact assessment of indoor carbon monoxide in France, Helsinki and Milan based on outdoor CO ERFs (HIA of CO poisoning at accidentally extreme high CO exposure peaks not included)

health outcome	study	receptor	Helsinki	France	Milan
			(95 % CI)	(95 % CI)	(95 % CI)
non-carcinogenic effects					
hospital readmission for cardiac diseases (prevalence)	von Klot	adults (>35 yrs)	1.8% (0.1 -3%)	0.6% (0- 1.1 %)	2.9% (0.2 -5%)
low birth weight (prevalence)	Liu	newborns	0% (0 -0.2 %)	0% (0- 0.1 %)	0% (0- 0.3 %)
preterm birth (prevalence)	Liu	newborns	0.4% (0.1 - 0.8%)	0.1% (0- 0.3 %)	0.7% (0.1 -1.3 %)
intrauterine growth retardation (prevalence)	Liu	newborns	0.5% (0.1 - 0.9 %)	0.2% (0- 0.3 %)	0.9% (0.1 - 1.4%)
allergic rhinitis (prevalence)	Hwang	children	10% (8 - 14 %)	3.3% (2.6 - 4.6 %)	16% (13 -22 %)
hospital admission for asthma	Fusco	all ages	4.5% (0.7- 8%)	1.5% (0.2 - 2.8 %)	7% (1 -14%)
hospital admission for respiratory symptoms	Fusco	all ages	2.3% (1.1 - 3.5%)	0.7% (0.3 - 1.2 %)	3.6% (1.7 - 5.6 %)
hospital admission for acute respiratory infections	Fusco	all ages	1.8% (0-2.6 %)	0.6% (0-1.2 %)	2.8% (0-5.7 %)
hospital admission for COPD	Fusco	all ages	3.5% (0-3.6 %)	1.2% (0-1.2 %)	5.6% (0-5.7 %)

[15] Reducing carbon monoxide incidents. Contract Research Report 386/2001. Study prepared by Advantica Technologies Limited. 2001, Norwich, U.K.

c. PM

Analogously as for CO, the HIA for indoor PM is based on a outdoor PM based ERF. The transferability of the outdoor PM ERF to an indoor PM ERF is more questionable than for chemically defined substances. However, by lack of any better indoor ERF, the outdoor ERF is used, and the result of is given in *Table 32*.
As input data for PM indoor concentrations, indoor PM data of the EXPOLIS study (Athens, Prague, Basel and Helsinki) are used. While the EXPOLIS study measured indoor PM2.5 and the outdoor PM ERFs are based on PM10 data, a PM2.5/PM10 conversion factor of 0.6 is used (Dockery and Pope, 1994).

Table 32: health impact assessment of indoor PM2.5 in Athens, Prague, Helsinki and Basel (EXPOLIS study) based on outdoor PM10 ERFs

health outcome	study	receptor	Athens	Prague	Helsinki	Basel
			(95 % CI)	(95 % CI)	(95 % CI)	(95 % CI)
non-carcinogenic effects :% increase in adverse health effects under the prevailing formaldehyde exposure in that country/region						
total mortality	APHEA2	all	2.0% (1.3 - 2.7 %)	3.4% (2.3 - 4.6 %)	1.2% (0.8 -1.6 %)	2.5% (1.6 -3.3 %)
hospital admission	APHEA2	all	1.8% (0.4 -3.2 %)	2.9% (0.6 -5.1 %)	1.0% (0.2 -1.9 %)	2.1% (0.4 -3.7 %)
postneonatal respiratory mortality	PINCHE	children	70%	114%	41%	82%
postneonatal total mortality	PINCHE	children	17%	29%	10%	21%
respiratory symptoms	PINCHE	children	17%	29%	10%	21%
lung function growth deficit	PINCHE	children	3%	6%	2%	4%
hospitalization	PINCHE	children	10%	17%	6%	12%

These preliminary results show a very large impact of indoor PM2.5 on postneonatal (respiratory) mortality, hospitalization and postneonatal total mortality for children.
However, these numbers originate from ambient ERFs, and there is a large uncertainty on the transferability of ambient to indoor PM ERFs. In addition, it is very likely that indoor and outdoor effects are double counting in this way. Therefore, this outcome should be considered in a first place as a trigger to improve our insight on indoor PM toxicity than as exact numbers for HIA of PM.

In conclusion, the HIA for indoor PM is hampered by methodological constraints, but is preliminary (uncertain) results, underline the need for a better understanding of indoor air PM health effects.

d. NO_2

Among the various substances, NO_2 is together with formaldehyde, the substance for which a variety of indoor ERFs have been described in the literature (*Table 28*), especially for effects on children.

These ERFs are applied to the EXPOLIS NO_2 indoor data (for Helsinki, Prague, Oxford, the Po delta and Basel), and resulting HIA according to the ExternE method is given in *Table 33*.

Table 33: health impact assessment of indoor NO_2 in Helsinki, Prague, Oxford, the Po delta and Basel based on indoor NO_2 ERFs

health outcome	study	receptor	Helsinki	Prague	Oxford	Po delta	Basel
			(95 % CI)	(95 % CI)	(95 % CI)	(95 % CI)	(95 % CI)
non-carcinogenic effects: :% increase in adverse health effects under the prevailing indoor NO_2 exposure in that country/region							
recurrent wheezing (prevalence)	Emenius	children (0, -2 y)	2.3% (0 - 44 %)	6% (0-115 %)	3.4% (0-65 %)	8% (0-154 %)	3.6% (0-69 %)
wheezing (prevalence)	Venn	children (6-8 years)	0% (0-1.5 %)	0% (0-3.8 %)	0% (0-2 %)	0% (0-5 %)	0% (0-2.3 %)
cough (prevalence)	Garrett	children (7-14 years)	16% (0-30 %)	41% (0-77 %)	23 % (0-44%)	54% (0-103 %)	24% (0-46%)
shortness of breath (prevalence)	Garrett	children (7-14 y)	8% (0-20 %)	21% (0-52 %)	12% (0-30 %)	28% (0-70 %)	12.6% (0-32 %)
wheeze prevalence	Garrett	children (7-14 y)	4.7% (0-15%)	12% (0-40 %)	6.8% (0-23 %)	16% (0-53 %)	7.2% (0-24 %)
asthma attack prevalence	Garrett	children (7-14 y)	1.8% (0-13 %)	48% (0-34 %)	2.7% (0-19 %)	6.4% (0-45 %)	2.9% (0-20 %)
chest tightness prevalence	Garrett	children (7-14 y)	2.4% (0-10%)	6% (0-27 %)	3.5% (0-15 %)	8% (0- 36 %)	3.7% (0-16 %)
wheeze prevalence	Belanger	asthmatic children (<12 y)	0% (0-3.3 %)	0% (0-8.5 %)	0% (0-4.8 %)	0% (0-11 %)	0% (0-5.1 %)
persistent cough	Belanger	asthmatic children (<12 y)	0.7% (0-4.2 %)	1.9% (0-11 %)	1 % (0-6.2 %)	2.5% (0-15 %)	1.1% (0-6.6 %)
shortness of breath (prevalence)	Belanger	asthmatic children (<12 y)	0% (0-2.2 %)	0% (0-5.6 %)	0% (0-3.2 %)	0% (0-7.5 %)	0% (0-3.4 %)
chest tightness prevalence	Belanger	asthmatic children (<12 y)	0.6% (0-3.3 %)	1.6% (0-8.6 %)	0.9% (0-4.9 %)	2.2% (0- 12%)	1.0% (0-5.1 %)

The result of the HIA depends, even for the same endpoint (e.g. cough), strongly on the study used for deriving ERF. Applying the ERF of Belanger et al. (2006) shows a 1- 2 % increase in persistent cough, while the is more than factor 10 higher when using the ERF of Garrett et al. (1999). This again shows that there is no consensus on magnitude of impacts of NO_2 on health.

Comparing the endpoints within one study, shows that effects of NO_2 are more pronounced on cough prevalence, shortness of breath, wheezing prevalence, and less on asthma attacks.
Again, for none of the health outcomes, the impacts are statistically different from zero.

e. CO_2/ventilation

Health impact assessment of CO_2 should be more considered as a reflection of impact of *overall* indoor air quality than of a HIA of CO_2 in se, because CO_2 is used as a measure of IAQ, rather than that CO_2 is a toxic substance at common indoor levels.
No EU-wide CO_2 indoor monitoring data are available, and instead, a fragmented HIA for 2 cities, i.e. Örebro (Sweden) and Tallinn (Estonia) is performed.

Table 34: health impact assessment of indoor CO_2 in Örebro (Sweden) and Tallinn (Estonia) based on a indoor CO_2 ERF

health outcome	study	receptor	Örebro (Sweden)	Tallinn (Estonia)
non-carcinogenic effects			(95 % CI)	(95 % CI)
wheezing attacks (prevalence)	Kim	children	167 % (28 -380 %)	177% (30-405 %)

These results could be interpreted in the following way: wheeze attacks in children are strongly influence by elevated CO_2 concentrations, caused by bad ventilation, which accompanies elevated indoor pollutants.

f. benzene

Although the major health concern of benzene is related to its carcinogenic effect, indoor benzene exposure is also associated with effects on asthma.
Comparing with other IAQ factors (e.g. formaldehyde), the benzene has a larger impact on asthma prevalence. In contrast to most of the other HIAs, the HIA is statistically significant different from zero.
The number of cancer cases per year per million persons associated with benzene vary from 0.1 – 0.3 (Helsinki) to 0.5 – 1.7 (Milan).

Table 35: health impact assessment of indoor benzene in Helsinki, Prague, Oxford, Milan, Basel and Athens (EXPOLIS study) based on indoor benzene ERFs

health outcome	study	receptor	Helsinki	Prague	Oxford	Milan	Basel	Athens
			(95 % CI)	(95 % CI)	(95 % CI)	(95 % CI)	(95 % CI)	(95 % CI)
non-carcinogenic effects								
severeness of asthma	Delfino	asthmatic children	17% (4-28 %)	54% (12-87 %)	28% (6-46 %)	113% (26 -185 %)	17% (4-28 %)	67% (15 -109 %)
asthma (prevalence)	Rumchev	children (0.5-3 years)	6% (5-8 %)	20% (15-23 %)	10% (8-12 %)	41% (32 -49 %)	6% (5-8 %)	24% (19 -29 %)
carcinogenic effects: number of cancer cases per year per 1 million persons								
number of cancer cases per year per 1 million persons (unit risk factor 2,2* 10-6)	US-EPA unit risk factor		0.1	0.2	0.1	0.5	0.1	0.3
number of cancer cases per year per 1 million persons (unit risk factor 7,8* 10-6)	US-EPA unit risk factor		0.3	0.8	0.4	1.7	0.3	1.1

g. *naphthalene*

The HIA of naphthalene is hampered by a lack of consensus on the carcinogenicity of naphthalene. Whereas the IARC classifies naphtalene in group 2B: possibly carcinogenic to humans, the US-EPA did not derived an inhalation unit risk estimate for naphthalene because of the weakness of the evidence that naphthalene may be carcinogenic in humans.[16] Alternatively, one could apply the unit risk factor handled by the California office of environmental health hazard assessment. However, results based on this risk factor (*Table 36*) should be interpreted with caution, especially when ranking with carcinogenicity of other substances. Comparing the results for naphtalene with attributable cancer cases caused by benzene, suggests a similar number of attributable cancer cases (except for Athens). However, the evidence for the carcinogenic effects of benzene is stronger than for naphtalene.

It is outstanding that the concentration ranges of naphtalene, and hence the attributable numbers of cancer cases in Athens is one-two orders of magnitude above that of other investigated EU cities.

[16] http://www.epa.gov/iris/subst/0436.htm

*Table 36: health impact assessment of indoor naphthalene in Helsinki, Prague, Oxford, Milan, Basel and Athens based on a EXPOLIS data and the unit risk factor: 3.4 *10^{-5} (California Office of environmental health hazard assessment)*

health outcome	study	Helsinki	Prague	Oxford	Milan	Basel	Athens
non-carcinogenic effects							
no adequate exposure-response functions available							
carcinogenic effects							
number of cancer cases per year per 1 million persons	OEIHHA* unit risk factor	0.3	0.9	0.6	1.6	0.3	31

* US-EPA does not define a unit risk factor because of the weakness of the evidence that naphthalene may be carcinogenic in humans. In contrast, the California office of environmental health hazard assessment does applies the following unit risk factor: 3.4 *10^{-5}.

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ANNEX E: SURVEY OF RELATED EUROPEAN AND INTERNATIONAL PROJECTS (UP TO 2006)

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Acronym	Date	Contact person	Short description	Internet address
		International Projects		
AIRALLERG	2000 - 2005	B. Brunekreef	Multi-centre birth cohort study; comparison of environmental exposures between sensitised and non-sensitised children	http://www.iras.uu.nl/research/projects_env_and_health/eh06.php
AIR4EU	2006	Prof. Dr. Peter Builtjes	1) To formulate a guidance document on best practices for the combined use of monitoring methods and models to assess Air Quality in Europe from hotspot/street level to continental level for various users on local, regional, national and European level and for various purposes. 2) To prepare maps of air quality in Europe based on the available European wide data sets and best technique of assessment.	http://www.air4eu.nl/index.html
AIRNET	2005	B. Brunekreef	AIRNET is a network project initiated to develop an overarching European-wide framework for air pollution and health research. AIRNET collects, interprets and disseminates data from individual (EU-funded) projects, in order to strengthen the science policy interface and to draw policy-relevant recommendations	http://airnet.iras.uu.nl/

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APHEA	1995	Klea Katsouyanni	i) To provide quantitative estimates of short-term health effects of air pollution, taking into consideration interactions between different pollutants and between pollutants and other environmental factors. This objective will be realised with the use of a very extensive data base from several different European countries which represent various environmental and air pollution situations. ii) To standardise the methodology in the analysis of epidemiologic time series data. This will involve detailed consideration of the methods used so far and suggestions for new approaches as well as standardisation of the exposure (air pollution) measurements and confounding factors to be controlled. iii) To select and develop a meta-analytic approach for epidemiologic time-series studies. iv) To assess the feasibility of creating a European data base of air pollution measurements and of health indicators, recorded on a daily basis. This will allow a continuous surveillance of short-term effects of air pollution in the future.	http://europa.eu.int/comm/research/success/en/env/0267e.html
APHEIS	2004	Sylvia Medina	Monitoring the Effects of Air Pollution on Health in Europe	http://www.apheis.net/
APMoSPHERE	2005	D. Briggs	EU-wide data sets on air pollution emissions, exposures, population - Air Pollution Modelling for Support to Policy on Health and Environmental Risk in Europe	http://www.apmosphere.org/
CLEAR	2003	Prof. Ranjeet S Sokhi	Cluster of European Air Quality Research	http://dev.allez.no/clear/

Acronym	Date	Contact person	Short description	Internet address
ESCODD	2003	Prof. Andrew R. Collins	The Role of food in promoting and sustaining health	http://www.rowett.ac.uk/escodd/
EUROHEIS	2004	L. Jarup	User networks; health impact assessment tools	http://www.euroheis.org/
EXPAH	2001 - 2003	P.B. Farmer	Effects of polycyclic aromatic hydrocarbons (PAHs) in environmental pollution on exogenous and endogenous DNA damage	http://airnet.iras.uu.nl/inventory/project.php?id=2
EXPOLIS	2004	Matti Jantunen	Air Pollution Exposure Distributions of Adult Urban Populations in Europe	http://www.ktl.fi/expolis/
FIRE	2002	Jeff Vos	The overall objective of this multi- and interdisciplinary project is to improve risk assessment of brominated flame retardants (BFRs) for human health and wildlife.	http://www.rivm.nl/fire/
GA2LEN	2004 - 2008	Bert Brunekreef,	Network of excellence in allergy and asthma	http://www.ga2len.net/hp/homepage2.cfm http://www.iras.uu.nl/
GEMS	-	D. Briggs / Michel Cornaert	Long-range air pollution transport models, and EO data sets - Global Monitoring for Environment and Security (GMES)	http://www.apmosphere.org/

Acronym	Date	Contact person	Short description	Internet address
GerES	1985-…	Umweltbundes-ambt	One of GerESs main objectives is to generate, update, and evaluate representative data in order to facilitate an environmental health related observation and reporting of information at the national level. • Up to 5000 subjects are questioned and analysed in every survey. The resulting data can also serve: • as a basis for establishing reference values, • to indicate trends over time and regional differences in contaminant levels, • to identify and quantify contamination routes. GerES thus makes it possible to design and evaluate preventive, interventive and control strategies within the framework of policy measures related to health and environment. GerES IV is conducted in cooperation with the National Health Survey for Children and Adolescents (KiGGS) that is conducted by the Robert Koch-Institute. Using data of both surveys (the Environmental and the Health Survey) it is possible to evaluate relations between environmental conditions and health of the children, e.g., between the occurrence of mould fungi in homes and allergies.	http://www.umweltbundesamt.de/survey-e/

Acronym	Date	Contact person	Short description	Internet address
HEAPSS	2003	Francesco Forastiere	The aim of the study is to determine whether exposure to ambient air pollution increases the risk of acute hospitalisation and the risk of mortality among population-based cohorts of patients who had survived a myocardial infarction (MI). Incident cases of non-fatal MI are recruited through ad-hoc population registries or from available records of hospital admissions in five European cities (Augsburg, Barcelona, Helsinki, Rome, Stockholm) with different air pollution levels and climate. Each subject will be followed for at least one year; outcomes of specific interest will be subsequent hospitalisation for secondary MI, arrhythmia, congestive heart failure or sudden deaths.	http://airnet.iras.uu.nl/inventory/project.php?id=59
HEARTS	2005	M. Martuzzi	Integrated health impact assessment model for road transport	-
HELIOS	1999	Alfred Bernard	Biomarkers for the non invasive assessment of acute and chronic effects of air pollutants on the respiratory epithelium. Development and Application to Adults and Children along a North-South European	http://airnet.iras.uu.nl/products/reports_and_annexes/HELIOS/HELIOS_final_report_Part_A.pdf
HYENA	2006	L. Jarup	Noise exposure and health effects data around airports	-

Acronym	Date	Contact person	Short description	Internet address
INDEX	2002	Dimitri Kotzias	The INDEX project (Critical Appraisal of the Setting and Implementation of Indoor exposure Limits in the EU) started in December 2002 and had a duration of two years, until December 2004. The project was financially supported by DG SANCO and it was coordinated and carried out by the JRC in collaboration with a Steering Committee of leading European experts in the area of indoor air pollution. Scope of INDEX was to identify priorities and to assess the needs for a Community strategy and action plan in the area of indoor air pollution by: - setting up a list of compounds to be regulated in indoor environments with priority on the basis of health impact criteria - providing suggestions and recommendations on potential exposure limits for these compounds, and - providing information on links with existing knowledge, ongoing studies, legislation etc. at world scale.	http://www.jrc.cec.eu.int/pce/pce_documentation.htm
MACBETH	1999	Vincenzo Cocheo	Environment and health - Benzene in the city	http://europa.eu.int/comm/research/rtdinf23/en/envir.html
NHANES	1999	U.S. Department of Health and Human Services Centers for Disease Control and Prevention, National Center for Health Statistics. : National Health and Nutrition Examination Survey		http://www.cdc.gov/nchs/about/major/nhanes/nhanes99-02.htm
PCBRISK	2004	Tomas Trnovec	Evaluating Human Health Risk from Low-dose and Long-term PCB Exposure	http://www.pcbrisk.sk/welcome_web.htm http://dioxin2004.abstract-management.de/pdf/p524.pdf
PEOPLE	2002 - 2004	Emile De Saeger	The Population Exposure to Air Pollutants in Europe	http://ies.jrc.cec.eu.int/Units/eh/Projects/PEOPLE/

Acronym	Date	Contact person	Short description	Internet address
PINCHE	2003 - 2006	Peter van den Hazel/Moniek Zuurbier.	Policy Interpretation Network on Children's Health and Environment	http://www.pinche.hvdgm.nl/
TEAM	1980s	Wallace	The Total Exposure Assessment Methodology (TEAM) was designed by the EPA to develop and demonstrate methods to measure human exposure to toxic substances in air and drinking water. The goals of Volatile Organic Compound (VOC) TEAM were to develop methods to measure individual total exposure (from air, food and water) and the resulting body burden of toxic and carcinogenic chemicals, and to apply these methods within a probability-based sampling framework to estimate exposures and body burdens of urban populations in several U.S. cities. To achieve these goals, air sampling was conducted to measure personal exposure to airborne toxic chemicals and a specially-designed spirometer was developed and used to measure the same chemicals in exhaled breath. The survey design consisted of a three stage stratified probability selection approach to ensure inclusion of potentially highly exposed groups. Related objectives of the VOC TEAM studies were to (i) determine the relationships between personal, indoor, outdoor, and blood, urine, and exhaled breath concentrations and (ii): determine the variability of VOC concentrations within a home; and determine seasonal and multi-year variability. The Study was conducted in three phases were 2–5	

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			times larger than median outdoor concentrations; maximum personal exposures were as much as 100 times corresponding maximum outdoor concentrations. Residence near major point sources had no effect on exposure but many common activities (filling a gas tank, visiting a dry cleaner, smoking) have significant effect on exposures.	
TRAPCA	2001	-	Risk assessment of exposure to traffic-related air pollution for the development of inhalant allergy, asthma and other chronic respiratory conditions in children	http://airnet.iras.uu.nl/products/reports_and_annexes/TRAPCA/TRAPCA_technical_annex_revised.pdf
ULTRA	-	Juha Pekkanen	The goal of the ULTRA project is to improve knowledge on human exposure to particulate matter of different sizes and of different chemical composition in Europe, and to evaluate the associated health risks. These results can then be used to develop standards for air quality in Europe, for better and more efficient monitoring of air quality, and as a base for designing control strategies to improve urban air quality and reduce the health effects associated with exposure to particulate matter in ambient air.	http://www.ktl.fi/ultra/