

Performance Indicators for Health, Comfort and Safety of the Indoor Environment

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Abstract

Under the ambitious acronym PERFECTION a new European coordination action has been launched. The project aims, via the development of an interoperable framework for performance indicators, at enabling the application of appropriate building design and technologies to improve the impact of the indoor built environment on health, comfort, feeling of safety, accessibility and positive stimulation.

A review of performance indicators currently used in design, construction and use will be undertaken. Areas where new indicators for health and safety (including accessibility and indoor environmental quality) should be developed will be defined. Recommendations for building design and technologies will be formulated in line with European directives on construction products and on energy building performance of buildings, the European environment & health action plan, the European green public procurement policies and the recently launched Lead Market Initiative on Sustainable Construction. A support tool should guide the use of correct indicators for a given context.

The project is carried out at an EU scale and the project results will reach every EU country. Next to 11 key partners, a great number of so called network partners representing industry from SMEs to LSEs, academia and research, will actively contribute to the common goal.

Keywords: performance indicators, health, comfort, accessibility, safety, positive stimulation

1. The PERFECTION Objectives

In the recent years, several approaches have been developed in the EU as regards the assessment of the indoor environment and building sustainability and the establishment of respective indicators. It is exactly because of the many activities and elaborations in the area of indoor environment and building sustainability that the potential of a co-ordinated activity is maximized. Learning from each other and setting a common agenda and a common roadmap constitute the obvious reasoning for this.

The aim of the PERFECTION coordination action is to help enable the application of new building design and technologies that improve the impact of the indoor built environment on health, comfort, feeling of safety and positive stimulation. In order to reach this objective, the project will deliver:

- a repository of good indoor performance indicators for health, comfort and safety
- a repository of state of the art environmental technologies that appear to have the potential for an important impact on the indoor performance and sustainability of the built domain
- an interoperable framework for performance indicators qualifying the indoor environment, allowing the successful life cycle management of sustainable buildings and stimulating the exploitation of appropriate technologies
- a decision support tool for different user groups applicable to different building types
- findings from selected pilot cases of the use of the indicators framework and the relevant indoor performance indicators
- recommendations on policies and the future research agenda: a roadmap including incentives and barriers for the application of building design and technologies to improve the quality of indoor environments
- knowledge and good practices on performance indicators for health, comfort and safety in the indoor environment.
- a wide dissemination of findings through an extensive expert network and the organisation of a series of events.

Figure 1 presents the PERFECTION framework, its mission statement and expected impacts and the main tasks to be executed in the 36 month project duration. The project started after a long negotiation period on 1 January 2009 and runs until the end of 2011.

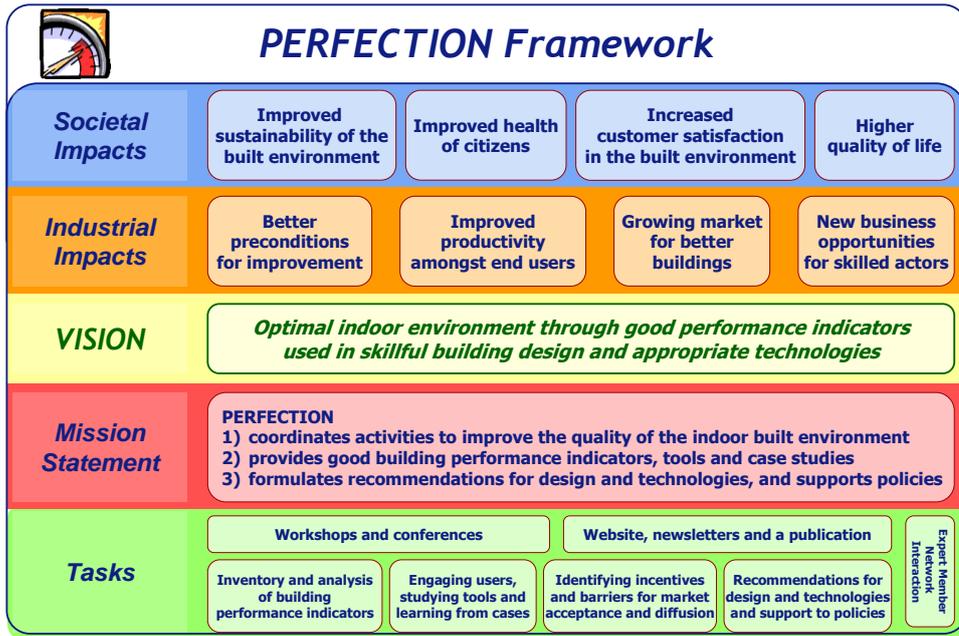


Figure 1: The PERFECTION framework and its expected impacts

2. The scope of PERFECTION

The PERFECTION project focuses on health, comfort, feeling of safety and positive stimulation indicators including accessibility and indoor environmental quality indicators integrated within a sustainable, low-energy built environment. In addition to these, other important indoor performance indicators are contemplated as part of a generic framework, such as adaptability, service life or usability. The following figure 2, which references to the ENV 3.1.5.2 call PERFECTION addresses, illustrates this approach.

Performance indicators for health, comfort and safety of the indoor built environment	
Indicators named in the ENV 3.1.5.2 Call	Potential supplementary indoor performance indicators
<ul style="list-style-type: none"> • Health • Comfort • Feeling of safety • Positive stimulation • Accessibility • Indoor environmental quality • Sustainable, low-energy built-environment 	<ul style="list-style-type: none"> • adaptability / flexibility • service life • usability • life cycle costing • environmental pressure

Figure 2: Performance indicators covered by PERFECTION

In order to start up the discussions and clarify the scope of PERFECTION a draft framework illustrating the different areas the project is covering, was developed. The draft framework, taken up in figure 3, will be gradually elaborated during the running of the project. Currently, 5 main areas of activity were defined, i.e. indoor air quality, comfort, health and indoor environment, accessibility

and positive stimulation, safety and security. Not all of these areas have been equally covered by scientific literature, standardisation or regulations. The first work package of the project should deliver by 2011 a generic framework for core building performance indicators, as well as an analysis of optimal (existing and missing) performance indicators for the indoor environment.

Indoor Air Quality		Health and Indoor Environment		
Indoor air pollutants	<i>Tobacco smoke</i>	Electro-magnetic fields		
	<i>Radon</i>		Biotic factors – bio-aerosols	
Classical pollutants	<i>Man-made vitreous fibres</i>	Quality of Drinking Water	<i>Guanine</i>	
	...		<i>Cockroaches,</i>	
	<i>Nitrogen oxide</i>		<i>Micro-organisms</i>	
Inorganic Pollutants	<i>Ozone</i>	Safety and security	<i>Mould</i>	
	<i>Particulate Matter</i>		<i>Mites, rats and mice</i>	
	...		<i>Microbial contamination</i>	
Organic Pollutants	<i>Asbestos</i>	Structural stability	<i>Water pollutants</i>	
	<i>Lead</i>			
	...		Flood risks	
	<i>Formaldehyde</i>		Fire safety	<i>Alarms</i>
	<i>Benzene</i>		Fire fighting provisions	<i>Evacuation</i>
	<i>Toluene</i>		Lightning	
	<i>Tetrachloroethylene</i>		Prevention of crime	
	<i>Trichloroethylene</i>		Static Electricity	
<i>Acetylaldehyde</i>	Personal Safety			
...	...			
Comfort		Accessibility and positive stimulation		
Thermal Comfort		Access-for-all, incl. disabled, children, ageing.		
Acoustic Comfort		Positive stimulation in different environments (school, work, independent living, ...)		
Visual Performance				
Vibrations				
Access to the facility				

Figure 3: Draft framework for indoor environment performance indicators

3. Other PERFECTION objectives

3.1 Use of technologies and designs

Creating an indicator framework is merely the first step of the PERFECTION coordination action. An important work package WP2 will focus on the use of indicators and the way they could stimulate the development and the uptake of new designs and technologies (Huovila et al. 2010). In that regard, a PERFECTION user decision support tool will be developed. It should comprise 2 modules:

- an evaluation module of specific technologies, services, etc. against metrics and benchmarks defined in the indicator framework

- a promotional module where solutions that are related to the PERFECTION scope and achieve a building enhancement mark above a certain level will be publicised against a defined template.

Figure 4 gives a view on how the PERFECTION Key Indoor Performance Model and website will look like. The website which is of course in development and which will only be fully operational by the middle of 2011 is currently accessible at <http://ieq.apintech.com>.

Products and buildings will be evaluated against a set of predetermined metrics through an online interactive software tool. People interested in using the tool will have to register. If the user of the model chooses in the end to publish results, the products and buildings will be taken up in the showcase part of the portal. The aim is indeed to allow producers to promote products and technologies contributing to an improvement of the indoor environment. Also the promotion of good indoor environment designs will be enabled by the model and tool. In order to give credibility to the PERFECTION KIPi (Key Indoor Performance Indicator) Model and Tool, users will also be able to get a kind of certification for their declared results. As such, 2 categories of showcases will be available: those without a check, and those with a check and associated certificate.

In principle products will be evaluated against a pre-selected set of indicators, and not against the generic framework. Products are generally used within indoor environments to improve some specific elements of the indoor environment, such as indoor air quality or thermal comfort. Buildings will be normally evaluated against the generic framework, as the quality of the building is determined by all parameters. An overall view of the indoor environmental quality of the building is therefore a necessity.



Figure 4: Screenshot of the draft PERFECTION key indoor performance model

As the aim is to create a portal of good indoor environmental practice, a part of the website will be publicly available. As such the showcase part will be open to all interested. The showcase part will be developed through an intensive cooperation with the user community and the case study work within the project. All PERFECTION participants will use the KIPI model and tool to evaluate some case study buildings. It is provided that different categories of buildings will be covered by this exercise, such as hospitals, schools, office buildings and dwellings.

In order to have an intensive interaction with the user community and the stakeholders, PERFECTION is establishing a forum for communication. It will be temporarily operated through <http://forum.building-21.net/>. Through the forum, the PERFECTION network members and the broader user and stakeholder community will be able to interact on the KIPI model, the KIPI Tool and the KIPI case studies. In order to develop this forum, the WP2 members are currently developing a PERFECTION user engagement documentation in which they address questions such as:

- which users does PERFECTION address?
- what can PERFECTION provide them with?
- what use cases does the PERFECTION tool support?
- how can building stakeholders engage with PERFECTION?

3.2 Policy recommendations

PERFECTION also has important policy related objectives. As a matter of fact, PERFECTION hopes to be able by the end of the project:

- To formulate a set of recommendations to the EC and the Member States with regard to incentives and barriers to new designs and technologies. As a matter of fact, the application of new and innovative designs and technologies allowing ameliorating the quality of the indoor environment is often hindered by existing standards and regulations or by the conservatism in the sector. On the other hand, the uptake of such designs and technologies may be accelerated by incentives developed by the authorities such as green procurement or pilots at government associated buildings.
- To formulate a set of recommendations to the EC, the Member States and Industry with regard to the needs and priorities of the future. Reference is essentially made to the urgent technological needs in the short and medium term. As an example one could for instance name the need for sensors, technologies and designs to make sure the indoor CO₂ concentration is always below the threshold values, taking into account the human interaction.

- To deliver a Policy Support Paper with regard to the CPD, EPBD, EEHAP, standards and regulations. This paper will certainly deal with the lack of knowledge and the lack of uniformity around Europe.
- To describe an Indoor Core Performance Indicator Roadmap that describes various development paths towards the desired future state taken cognisance of different time frames, technology maturity and relevant policy action plans (barriers and incentives).

Work in this work package WP3 just started with the first PERFECTION workshop, which took place on the 1st of December 2009 in Krakow, Poland and which was attended by 60 persons. It was the first time the PERFECTION consortium met with the network of experts and stakeholders associated to the PERFECTION project, in short the CES network. This CES network includes 33 members representing nearly all member and associated states and covering industry, academia and authorities. Besides the CES network, the workshop was open to all interested, but it was mainly attended by local organisations from Poland and the neighbouring countries. After introductory speeches, two of them by invited keynote speakers, the discussion was launched by the CES Chairman Oliver Kornadt. With regard to policy, following points were put forward:

- It was stressed that indoor environment research should not only address indoor air quality and comfort, but also should also consider accessibility, feeling of safety, security and positive stimulation. That the EC stimulated this research by starting up a coordination action was welcomed.
- The quality of the indoor environment, and especially the quality of the indoor air, is generally determined by multiple factors, such as the construction products used, the products and appliances used within the building during the use phase, the human being and its activities, animals, etc. Dealing with one of them without taking into consideration the overall picture, is not really sensible. Thanks to CEN TC 351 a standardisation framework for emissions from construction products is under development, partly because it is feasible to measure and limit concentration and emission levels. The question is however if other factors, which may be more problematic, but difficult to measure or for which knowledge is lacking, are currently dealt with. Some issues were raised during the workshop: for secondary emissions coming from interactions between construction materials and emissions from furniture, perfumes, appliances or ventilation systems the situation is less clear than for construction products.
- An important point put forward during the discussion is that indoor environment issues are not only relevant for new and energy-efficient buildings, but also for the existing building stock and for cultural heritage. Indeed, finding equilibrium between energy efficiency and indoor environment quality as defined above may be already hard to find in new buildings, but for renovations or restorations it will certainly be difficult as renovating or restoration changes the indoor environment conditions. When focussing on energy efficiency during construction and renovation, other elements relevant for the overall building quality may be forgotten or deteriorated. And in cultural heritage buildings and museums, the indoor

environment may be of particular importance for protecting the heritage inside the building, such as paintings or sculptures.

- The relation between health and indoor environment quality should be further researched as there is clearly a lack of knowledge in this area. Also in the area of social and psychological sciences, research work is necessary, for instance for distinguishing between positive and negative stimulation drivers.
- The connection between the outdoor and indoor environment was also debated. As far as the scope of PERFECTION is concerned, outdoor environment falls clearly out of scope. But it is a fact that the outdoor environment, certainly in urban environments, heavily influences the quality of the indoor environment. Examples include pollution from outdoors, communication in the virtual area, electro-magnetic fields.
- It was recommended that PERFECTION should not only address the policies itself, but should also name the responsibilities for developing them, both on the European and on the regional level. With regard to accessibility for instance, it was illustrated that more can be achieved with a thorough anti-discrimination policy (generally developed within a department of Justice) than with a stringent building permit policy (normally issued by building authorities).

Work in WP3 will continue in the coming months. In this context, 2 more policy-oriented events are scheduled for the end of 2010 and 2011. By the end of 2010 a report on barriers and incentives for the use of indicators, design and technologies should be available.

3.3 PERFECTION dissemination activities

As already mentioned before, the project is carried out at an EU scale and the project results will reach practically every EU country. More than 40 experts from over 30 countries were carefully selected to the PERFECTION team to ensure the necessary depth and width. 11 of them belong to the PERFECTION consortium, 33 of them are associated to PERFECTION as members of the CES network (CES = Committee of Experts and Stakeholders). The network consists of experts from various domains named within the ENV.3.1.5.2 call; such as indoor health issues, acoustics, universal design, performance metrics and tools, sustainable design and construction, etc.

The CES network will be invited to participate to the workshops organised by PERFECTION and will contribute to the different deliverables of the project, mainly through surveys. As a matter of fact, most of the CES members contributed actively to the first survey which addressed standardisation, regulations and technologies.

Within the PERFECTION framework, 6 workshops will be organised. At the time of the CIB 2010 conference 2 of these events took already place: the Krakow (Poland) policy-oriented workshop on 1 December 2009 and the Espoo (Finland) research-oriented one on 4 February 2010. Future events

will address respectively policy, research, business and EC needs. Except for the last event, which will focus on EC policies in the areas of environment, enterprise, transport and energy, employment, social affairs and equal opportunities and which will be addressed to EC officers, all of these events will be open; more information on the different events can be found at the PERFECTION website <http://www.ca-perfection.eu>.

4. Building the generic indicator framework

Most of the work realised in the first year relates to the first work package (WP1) of the project, in which a generic framework for core building performance indicators for the indoor environment has to be defined. Main activities until now dealt with:

- inventorying standards, regulations, guidelines, research activities and policies in which performance indicators and the indoor built environment are addressed
- a review of health and comfort related indicators
- a review of accessibility, safety and positive stimulation related indicators.

The inventory work was based upon an online set of questionnaires (web-based survey) which was distributed to the consortium and the network partners. The aim was to get a compilation of European and Member States standards, regulations, policies, technologies and ongoing research activities. By the end of 2009 more than 300 inputs (figure 5) were available and were analysed by a team consisting of CTU, API, KOR and SiTI.

Survey	Number of obtained inputs
Standards	114
Regulations	95
Technologies	21
Research	55
Policies	28
Total	313

Figure 5: Results of the PERFECTION inventory tasks

As far as standards, regulations and research are concerned, the survey clearly provided a sufficient basis for our future work. For the policy and technology area, work clearly remains to be done. The technologies currently covered relate to comfort or health objectives, but to no surprise inputs for safety, positive stimulation and accessibility are missing. The same holds for the policy work: Also in this area health and comfort are well covered, but no attention is given to accessibility, safety and positive stimulation. With regard to policy, this may be associated to the fact that policies are not always well known in all circles. It may well be that local, regional or national authorities apply certain policies with regard to accessibility, safety or positive stimulation, but these policy documents

are not always published or communicated to all stakeholders. Certainly in the area of accessibility, this might be the case: Stimulating accessibility of the built environment may be a high priority for social-oriented agencies, but these do not always dispose of the proper communication channels to the economic actors who design and build infrastructure and buildings.

The review work on indicators has well progressed in the health and comfort area. The group responsible for this review is headed by Marcel Loomans and Paul Steskens from TU Eindhoven. First of all, based upon past work, a.o. in PeBBu, they elaborated together with the consortium members some definitions:

- A core indicator was defined as an essential aspect of a building with respect to a specific topic: It has to be defined by one or a set of performance indicators.
- Performance indicators describe a property of a product, building component or building that closely reflects or characterises its performance (state or progress towards an objective) in relation to the performance requirement that has been set. The indicator should be a quantitative, qualitative or descriptive parameter that can be readily assessed.
- A set of indicators is a non-structured list of indicators.

In a second stage they started to review indicators related to health and comfort and prepared an extensive report. The concept of health was defined as in the HOPE-project (Cox, 2005): A building is defined as healthy if it does not cause or aggravate illnesses in the building occupants and if it assures a high level of comfort for the building occupants. A high level of comfort is therefore a minimum, but not sufficient, requirement to arrive at a healthy indoor environment. Comfort needs in itself also a definition: it expresses the status to which a building is able to provide a comfortable indoor environment and relates to the physical, chemical and biological aspects that have a physiological effect on the human body, and possible psychological responses to that (such as comfortable feeling with temperature). In order to make a distinction with positive stimulation aspects, non-common, active adaptation of the indoor environment (for instance use of fragrances) and design related interventions (for instance use of light) are not considered as comfort related.

As core indicators for comfort and health 5 categories are currently distinguished: acoustic comfort (with 3 performance indicators), visual comfort (characterized by 7 performance indicators), indoor air quality (defined by 4 performance indicators, each in itself defined by a set of related indicators), quality of drinking water (with 7 performance indicators) and thermal comfort (defined by 5 performance indicators).

As far as accessibility, safety and positive stimulation is concerned, the review work is currently on going. The aim is to have a draft report available for the February 2010 workshop in Espoo. Accessibility, safety, security and positive stimulation are considered as core indicators, which have to be defined by performance indicators and associated sets of indicators. For accessibility, following performance indicators have for instance been defined: approach to the building (although strictly not

indoor related), entrance to the building, movement inside the building, facilities in the building, evacuation strategy and facilities.

Following the review work a generic framework has to be defined, which includes other performance aspects such as flexibility, adaptability, service life and usability and which may be used to qualify the indoor environment and its contribution to sustainability. The framework, which should be available by the end of 2010, should serve as a solid basis to structure the making of a Compendium for Health and Comfort and Accessibility and Safety Indicators, to make the analysis for indoor performance indicators still to be developed and to formulate later recommendations for design and technologies (Järnström & al, 2009).

An important part of the work will be to review core indicators, performance indicators and sets of indicators and to group or regroup them in order to get a manageable and solid framework. In this regard, different subsets may be defined according to the user of the framework, be it a designer, builder or user for instance. The framework should also allow for limiting the scope of the evaluation: Indeed, with certain evaluations it should be possible to focus during assessments on health or safety for instance. An important prerequisite for the framework is furthermore that it should be usable for different types of buildings, different life cycle stages and different regions of Europe.

Figure 6 illustrates in a scheme how this framework may look like. Tasks 1.3 (on comfort and health) and 1.4 (on accessibility, safety and positive stimulation) will form the main input for this framework which will however be broadened by the other above mentioned issues.

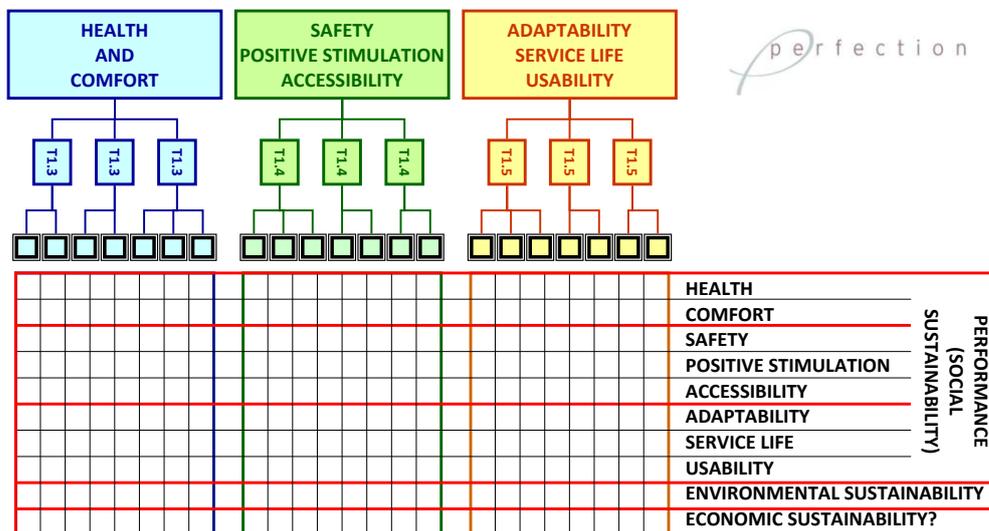


Figure 6: Schematic view on the draft generic framework

5. Conclusion

The PERFECTION project is up and running since January 2009. In a period of 3 years, this ambitious coordination action will deliver a generic framework for performance indicators qualifying the indoor environment, allowing the successful life cycle management of sustainable, healthy, comfortable, safe and accessible buildings and stimulating the exploitation of appropriate technologies. The framework will be integrated in a web-based tool and used in a series of case studies. The tool will be available for producers, designers and users to evaluate products, technologies and buildings with regard to the indoor environment. By creating a database of showcase products, technologies and buildings the project will stimulate good indoor environmental practices around Europe.

In order to communicate with the user community, the PERFECTION consortium is creating a forum for interaction, a web-based evaluation and promotional module and a specific project website (<http://www.ca-perfection.eu>). A couple of events are also organised in order to inform you about the progress of the project, and to discuss some of the results and research work.

Acknowledgements

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