

Performance Indicators for Comfort, Health and Safety of the Indoor Environment - Main achievements of the European PERFECTION Coordination Action



Jan Desmyter

Belgian Building
Research Institute

Belgium

Jan.Desmyter@bbri.be



Pierre-Henri Lefebvre

Belgian Building
Research Institute

Belgium

phl@bbri.be

Pekka Huovila, VTT, Finland, Pekka.Huovila@vtt.fi
Nikos Sakkas, Apintech, Greece, Sakkas@apintech.com
Stephen Garvin, BRE, United Kingdom, Sakkas@apintech.com

Summary

PERFECTION is a European FP7 Coordination Action for Comfort, Health and Safety of the Indoor Environment which started in 2009 and lasts for 3 years. It was presented as a project for the first time in the SB08 Conference in Melbourne, right before the real start of the project. At the time of the SB11 Helsinki conference the project is in its end phase, a good point to present the most important achievements of the project.

The PERFECTION KIPi Framework presented more in detail in [1-9] forms the basis of an indicator toolbox and a software tool to evaluate the indoor performance of buildings during design or in use. The framework, toolbox and software also allow communicating on the performance of individual building products or services and of buildings itself with reference to the PERFECTION KIPi Framework. Within the project a series of projects have been evaluated in the context of case study work and a lot of attention was given to the interaction with the user community, i.e. the industry and the building users, in order to create awareness and verify market demands.

Based upon the indicator related work the project consortium also undertook policy-oriented work and prepared recommendations and policy papers on indoor environmental technologies, standards and regulations, the use of indicators and RTD needs related to the indoor environment. The project considered not only the evident themes such as comfort, health and safety, but also aspects such as accessibility, adaptability, flexibility and positive stimulation.

Keywords: performance indicator, indoor environment, indoor performance, health, comfort, safety, security, usability, positive stimulation, adaptability, serviceability, decision support

1. The PERFECTION KIPi Framework

The Key Indoor Performance Indicator (KIPi) framework in PERFECTION contains 4 main categories, each composed of 2 subcategories, and 31 performance indicators. The KIPi Framework is presented in detail in Fig 1 and in [1]. The four main categories of the KIPi Framework are:

- Health and Comfort, dealing with items such as mould growth risk, ventilation/CO₂, combustion sources/infiltration, particulate matter, drinking water quality, operative temperature/PPD, illuminance, daylight factor, background noise level and reverberation time.
- Safety and Security, covering safety in use, feeling of safety, meeting current regulation, Building type specific safety issues, personal and material security, security of information and reliability in exceptional cases.

- Usability and Positive Stimulation, with as indicators access to and in the building, wayfinding, adjustability, view to outside, privacy, feelings and sensations and availability and quality of recreational spaces.
- Adaptability and Serviceability, in which versatility and protection, technical service life, adaptability to climate change, branding and cultural heritage, availability of services in the building, cleanliness and maintainability are considered.

From the 4 categories, health and comfort is clearly the one which is most covered by research, technological development and indicators. From the European point of view, health and safety are areas which are well subjected to regulations and standards, both existing and under development. Comfort seems to be less covered by regulations, but is clearly well addressed in standards. The other 5 sub-categories seem to draw in general less attention from policy makers, industry or the public. In the future this may however change, certainly if the indoor performance becomes a well known concept for which business opportunities are demonstrated.

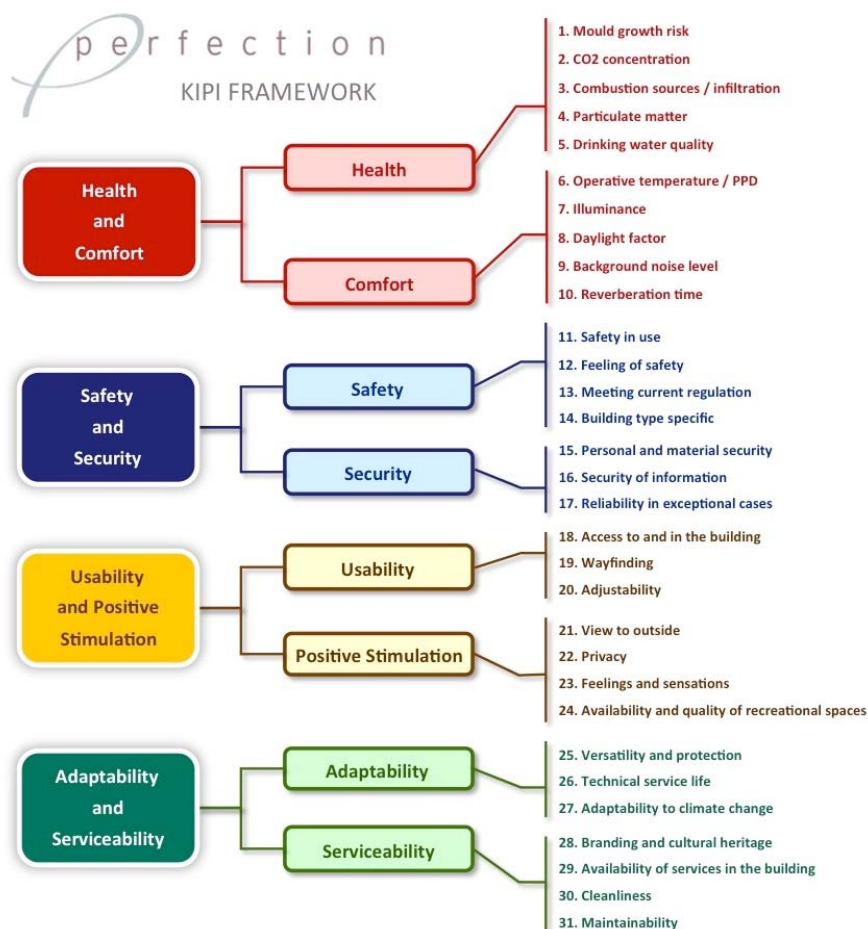


Fig 1. The final Perfection KIPi Framework

2. The PERFECTION Products and Technologies Database

The PERFECTION (products and technologies) service aims to provide a commercial platform, a search engine for locating all sorts of manufacturers, distributors, resellers of products that are, in some way, affecting positively a subset of the PERFECTION KIPi Framework and are, in this way, contributing to a better indoor environmental quality. The PERFECTION products platform directly brings into contact indoor environmental quality product providers and potential product buyers.

The web site dedicated to the promotional tool is available since September 2010. It is on line at <http://products.indoorperformance.net>, but currently protected with a username and password. A screenshot is taken up in figure 2.

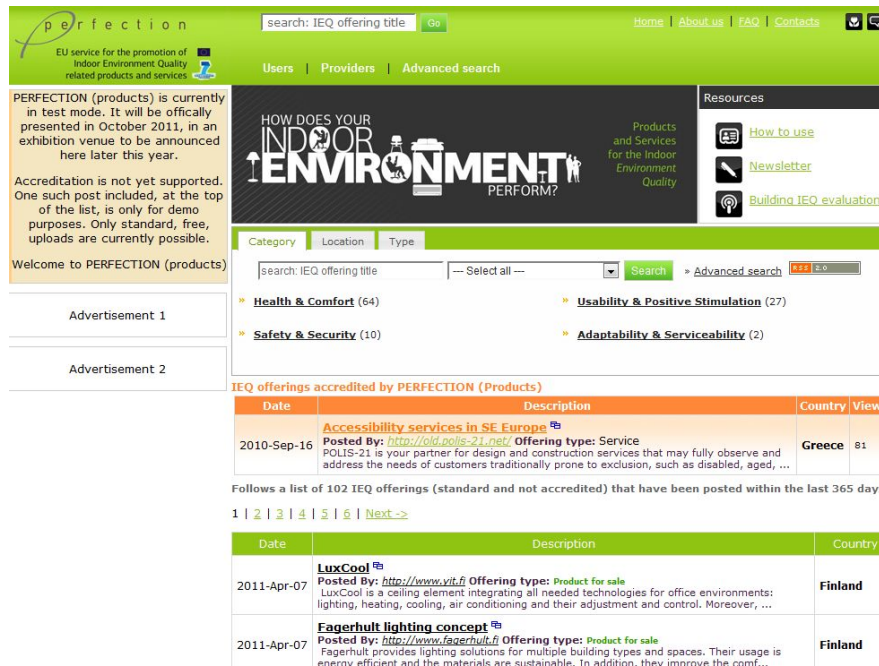


Fig. 2. A screenshot of the PERFECTION Products and Technologies Promotional Service.

The tool should be publicly available around June 2011. Indeed, the consortium has been filling the database of this tool with technologies and products identified by the consortium and the CES members. A letter has been prepared and sent to the manufacturers and companies involved requesting editing and approval of information.

The aim is to develop based upon the feedback a business case for this promotional service for indoor environment products, tools and technologies, which is now only available in a kind of prototype version. If necessary, the tool will be adapted in order to allow products.indoorperformance.net developing a transparent, long-term relationship with its users, which are on the one hand product and technology providers and on the other hand users and potential clients.

- indoor environmental quality product providers will be able to access the service in order to add information about their products and their contact data while potential buyers can search or express their interest for a related product.
- Visitors to the service will be able:
 - To freely browse through all the service content; this includes all the product information published as well as all its provider related information.
 - To search and find products that are impacting upon a given KIPi indicator, that the visitor will select upon his interests.

3. The PERFECTION Toolbox and Case Studies

The PERFECTION case studies and toolbox form a significant element of the project and were used in the first phase of the project to provide input to the development and understanding of the KIPi indicators and how they can be used in practice.

3.1 The toolbox

The first step consisted in the development of a model and an experimental testing toolbox. The tool served for the evaluation of the case studies based upon the performance indicators listed in the KIPi Framework. The indicators list that was initially included in the toolbox was derived from the first version of the indicator framework but, during the project, the tool followed the evolution of the KIPi framework.

The indicators used in the toolbox (see figure 3) can be assessed into two different phases of the building life. They can be assessed during normal operations that are performed inside the building (assessment in operation), or they can be assessed during the design phase (assessment in design), when a new building is being built or is undergoing a renovation process.

The indicators can be assessed in a simple way, by means of site visits, user surveys or reviews of design plans (simple assessment). However, for some indicators it can also be useful to perform a more detailed assessment (detailed assessment), provided that additional information is available. Whatever assessment method is selected, the indicators are evaluated against five performance level (from A to E, where A is the highest and E the lowest).

Some indicators defined in the framework cannot be applied or are simply not relevant to all the building types. In order to deal with this a first estimation of the indicator impact on different building types was provided.

The first version of the toolbox that was created is based on an Excel sheet. It is composed of two main sections:

- General Information, containing some general information in order to provide a synthetic description of the building under analysis.
- Indicator Evaluation, with a separation regarding the assessment during the design phase and the assessment in operation.

The Excel sheet also contains a column for comments related to each indicator and a weighting cell. However, with the evolution of the project, it was decided to include in the last version of the Excel, a new section with a weighting system. The user has now the choice to select the default weighting system applicable to the kind of studied building and proposed by the PERFECTION consortium, or to use a personal weighting system (according to his own agenda and priorities).

		Design					Operation																																																																													
Indicator		E	D	C	B	A	Comments	E	D	C	B	A	Comments	Weights																																																																						
Health and comfort	Health	1					X								3.6%																																																																					
		2					X								4.2%																																																																					
		3						X							3.2%																																																																					
		4					X								3.1%																																																																					
		5						X							3.4%																																																																					
	Comfort	6						X							3.8%																																																																					
		7						X							2.9%																																																																					
		8						X							3.6%																																																																					
		9						X							3.2%																																																																					
		10						X							1.8%																																																																					
Safety and security	Safety	11													3.7%																																																																					
		12						X							3.3%																																																																					
		13						X							4.1%																																																																					
	Security	14					X								1.3%																																																																					
		15						X							3.7%																																																																					
		16						X							3.3%																																																																					
		17						X							3.4%																																																																					
Usability and positive stimulation	Usability	18					X								4.5%																																																																					
		19					X								4.0%																																																																					
		20					X								3.1%																																																																					
	Positive Stimulation	21					X								3.8%																																																																					
		22					X								3.6%																																																																					
		23					X								3.3%																																																																					
		24					X								2.4%																																																																					
Adaptability and serviceability	Adaptability	25					X								2.7%																																																																					
		26					X								3.3%																																																																					
		27					X								2.4%																																																																					
	Serviceability	28					X								1.3%																																																																					
		29					X								3.4%																																																																					
		30					X								3.4%																																																																					
		31					X								3.0%																																																																					
		<table border="1"> <tr> <td colspan="11">Total KIPi score</td> <td>93</td> </tr> <tr> <td colspan="11">Health and comfort</td> <td>90</td> </tr> <tr> <td colspan="11">Safety and security</td> <td>99</td> </tr> <tr> <td colspan="11">Usability and positive stimulation</td> <td>92</td> </tr> <tr> <td colspan="11">Adaptability and serviceability</td> <td>90</td> </tr> <tr> <td colspan="11">KIPi coverage</td> <td>100%</td> </tr> </table>											Total KIPi score											93	Health and comfort											90	Safety and security											99	Usability and positive stimulation											92	Adaptability and serviceability											90	KIPi coverage											100%
Total KIPi score											93																																																																									
Health and comfort											90																																																																									
Safety and security											99																																																																									
Usability and positive stimulation											92																																																																									
Adaptability and serviceability											90																																																																									
KIPi coverage											100%																																																																									

Fig. 3. Excel tool screenshot

3.2 The Case Studies (T2.4)

The case studies have been set up in two phases. In the first phase, a number of buildings have been evaluated in a kind of iterative process during the development work associated with the framework and toolbox:

- A housing renovation project in Belgium
- A new build hospital and an existing hospital in Finland
- An office building in France
- A redeveloped historic building in Italy
- A university office and teaching building in the Netherlands.

Further case studies have been addressed in the second phase. This phase has been undertaken over the period June 2010 to May 2011. The case studies include shopping centers, further offices and domestic premises. The Phase 2 case studies have been analyzed using the toolbox described before.

Both Phase 1 and Phase 2 case studies will be evaluated again once the PERFECTION DSS software is finalized and up and running (see §4). The full findings from Phases 1 and 2 will then be taken together in order to produce the final summary report.

4. The PERFECTION Decision Support System (DSS) for Buildings

The framework and evaluation methods form the basic elements of the PERFECTION DSS. The target groups for this tool will be end users (individuals, builders, designers, etc.), whose design decisions will be supported. It is in this sense that we refer to the tool as a decision support tool. The DSS has been developed as an online tool based upon the KIPI framework and the KIPI toolbox. It can be accessed at <http://www.indoorperformance.net>.

This web site hosts the KIPI based building evaluation tool, a help section, a FAQ, a contact and a showcase section where some evaluated cases are presented in order to illustrate the scoring method (see Fig 2.). The tool is operational, but the software is still being adapted. The aim is to finalize the work in June 2011.

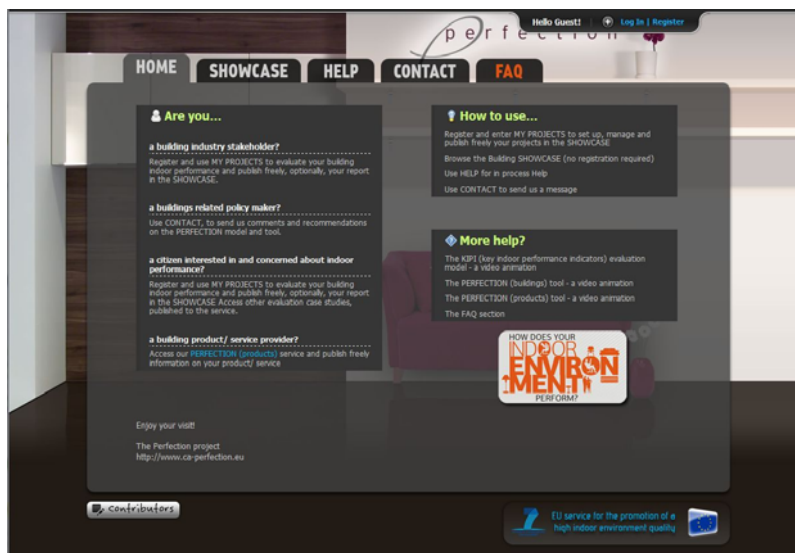


Fig 4. The Perfection Decision Support System (Evaluation Tool)

The evaluation tool gives to registered users the possibility to execute an evaluation of their buildings. The evaluation process is currently as follows:

- The user has to input generic data such as the project name, the city, the type of building, the life cycle stage, the gross area, the height, etc...
- Then he has to select the indicators that have to be evaluated and to determine the importance of the categories (for instance the Health and comfort could be a critical category and the Adaptability and Servicability could be of marginal importance).
- The third step in the evaluation process is to give to every selected indicator a rating. This rating has to be determined in accordance with the methods developed in parallel with the framework.
- The user is also asked to indicate the relative importance of the evaluated indicator (Critical, Important, Standard, Marginal). If the user needs it, it is also possible to add comments to the chosen rating.
- Finally, based on these elements the system will produce a report in which the indicator coverage, the scores and the weights are clearly written.

This report may be exported as a pdf document and can be edited later if needed. A screenshot of such a report is shown on Fig 4.

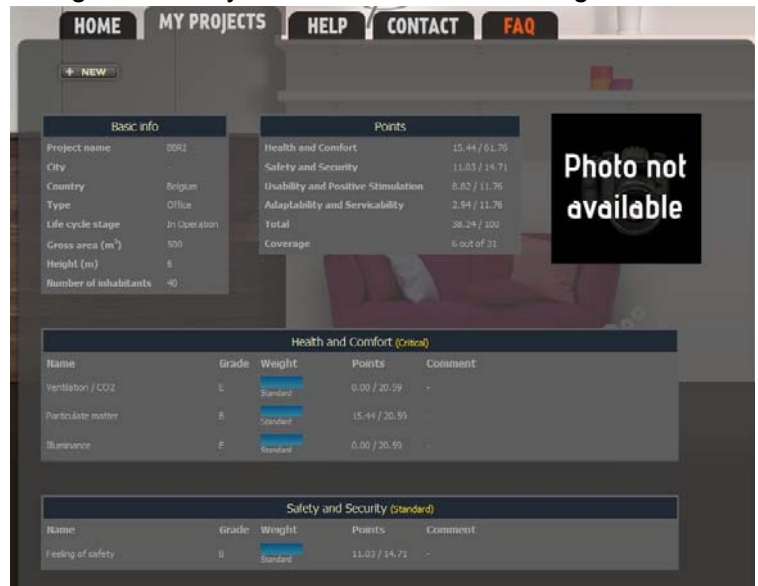


Fig 5. A screenshot of the report generated by the perfection DSS

In the final version of the tool, the user of the tool will have to make a choice. Either he will evaluate the project according to a fixed PERFECTION procedure (including all indicators and pre-set weights for instance) or he will do it according to his personal or organisational preferences. In the latter case the user will not be able to claim conformity with PERFECTION standards.

5. The PERFECTION Policy Paper and Roadmap

5.1 The Context

One of the work packages defined in the PERFECTION work program is devoted to the formulation of policy recommendations. At the time of writing this paper the work is still in progress, and as such, the results presented here only give a preliminary view. As the PERFECTION project is a EU-funded project, the aim was to make reference to European regulations and initiatives, such as the Energy Performance of Buildings Directive (or EPBD Recast), the Construction Products Directive (in the near future Construction Products Regulation, CPD or CPR), the European Environment & Health Action Plan (EEHAP) and the Green Public Procurement Policy.

Having a look to the 8 sub-categories of the PERFECTION KIPI Framework it seems logic to make a distinction between those categories which have to be addressed by regulations and/or policies because they refer to the physical integrity of the users and occupants of the building and those categories which have more to do with the quality of the building in terms of well-being, impact on sustainability and design. Health and Safety clearly belong to the first group, while the other sub-categories are part of the second group. The difference between both groups is that they are treated differently in policy matters. Chances are big that this will remain so in the future.

5.2 The PERFECTION KIPI Sub-Categories in Policy and Regulations

The **Health** category refers clearly to 2 regulatory frameworks, the first one linked to the CPD, and more specifically the third essential requirement hygiene, health and the environment, the second one being the Drinking Water Directive (98/83/EC). As the protection of the consumer or user stands central in these directives, it seems logic that most indicators falling under this sub-category are regulated, either on the European or at the Member State level.

The **Safety** sub-category has a similar aim. Demanding safety in indoor environments has everything to do with the protection of the user of the building (and the objects which are present in the building). As such, it is logic that regulations and standards address safety of buildings and indoor environments in all its aspects. The CPD addresses safety through at least 3 of the essential requirements, i.e. mechanical resistance and stability, safety in case of fire and safety (and accessibility) in use. The safety of the indoor environment is also addressed by other regulatory frameworks, such as those addressing the single markets for goods and the safety of consumer products (such as the Machinery directive for instance).

Security seems to be different as a sub-category compared to Health and Safety. Indeed, whereas health and safety clearly focus on the physical integrity of the users themselves, the security sub-category refers to a series of other aspects. Personal security is for instance only in a number of buildings (such as public or defence related buildings) really relevant. The importance given to material security and security of information will highly depend on the type of building. As such, it seems logic that the security sub-category is less covered by regulatory requirements. The initiative to put requirements for a particular building and/or indoor environment is left to the market.

The **Comfort** sub-category is from the viewpoint of the user a very relevant one as it directly affects well being. As such, the relevance of the performance indicators addressed in this sub-category will be quite apparent to most users. From the regulatory point of view, comfort-related issues may be addressed, but much will depend on the type of building or the comfort issue under consideration. Lighting requirements are for instance to be found in regulations affecting the quality of the working environment. On the other hand, acoustical requirements are considered in the CPD through the essential requirement protection against noise, and are sometimes integrated in member states' building regulations. The EPBD itself deals partly with the comfort issue through its article 1, in which it is stated that the directive is promoting the improvement of the energy performance of buildings while taking into account indoor climate requirements. As the term 'requirements' is used, the focus is probably more on health-related issues than on comfort. Indeed, for the regulator protecting health is a major and priority issue whereas comfort is more situated in the market play: comfortable buildings will have a higher market value.

With regard to the **Usability** sub-category most of the elements covered are not integrated in regulations, but are considered in voluntary initiatives and standards. The topic of adjustability is for instance quite interesting when you are discussing sustainability aspects of indoor environments and buildings. The exception is of course the access performance indicator, which addresses amongst others the level of accessibility towards people with disabilities or ageing. This particular indicator is covered by regulation, as both the CPR and the EPBD address accessibility as an important topic and most member states have defined specific regulations addressing the built environment and the buildings accessible to the public. From the societal point of view usability seems to be an important topic for future policy work. First of all, the general objectives defined in European directives and regulations need to be translated in practical requirements and standards. Secondly, as buildings and built environments have a long life and a slow replacement frequency, addressing usability in regulatory frameworks and initiatives may have important consequences in the long run on all dimensions of sustainability.

Together with adjustability, **Adaptability** of indoor environments is clearly an important performance indicator category if you think about the long term existence and use of buildings. Buildings

and indoor environments (can) become part of the cultural heritage of the future, and need to be designed and built with an adequate technical service life. Moreover, they have to be robust enough in order to be resistant and adapted to the effects of climate change. Most of these concerns are not dealt with in current regulatory frameworks.

The same holds for the sub-categories **positive stimulation** and **serviceability**. Both aspects offer clear advantages for owners and/or users of buildings and indoor environments, but are not addressed in regulations. The economic value of buildings with indoor environments having a good performance should however be positively influenced. As such, improving serviceability and positive stimulation in buildings is mainly a market concern, and less a policy objective. Although it must not be neglected that in specific building types, such as hospitals and rest homes, there are also clear benefits for society with for instance a better and faster revalidation and/or integration.

5.3 Recommendations to Improve Indoor Performance in the Future

If one aims to improve the indoor performance of buildings through developing or improving policy and regulations, one has to take into account the multiple dimensions of the indoor environment, which are themselves only a part of the many dimensions determining the sustainability of the building or built environment under consideration. Improving the indoor performance therefore demands a policy approach dealing on the one hand with the overall concept and on the other hand with the individual sub-categories and performance indicators.

A project as PERFECTION does help to put forward and increase the visibility of the indoor environment quality concept. It is not the first and probably not the last time that we have to clarify that PERFECTION aims the quality of the indoor environment, which is more than the quality of the indoor air. Promoting the indoor performance concept remains therefore an important action point for the future. It can be realised amongst others:

- By stimulating indoor environment research and development of appropriate technologies.
- By promoting standardisation and developing assessment methodologies for individual performances and for global evaluations (being part of overall sustainability evaluations for instance).
- By issuing guidelines and codes of good practice.
- By integrating indoor environment quality in technical specification for public buildings and works, such as for instance schools, hospitals, etc.
- By developing educational programs and courses on indoor performance for specific target groups such as architects and designers, building professionals and students for the different building professions.

Besides the overall concept, policy initiatives can also address the individual sub-categories and performance indicators of the KIPi framework. As illustrated in the former paragraph health and safety are already well integrated in the existing regulatory framework, but this does not mean that further work is not necessary. Research and technological development remains important in both of these areas. With regard to health a lot of work remains for instance to be done to better understand the effects of the different contaminants present in the indoor environment. Translating the safety requirements in practical guidelines and standards and in economic feasible designs stays an important challenge for the future.

Most of the other sub-categories can only be partially addressed by regulations. Setting minimal requirements for comfort, security, usability, positive stimulation, adaptability or serviceability is less evident for a regulator than for the health and safety sub-categories, where the risk for human beings is far more important. However, depending on the categories of buildings and the specific performance considered, the legislator may take particular initiatives. Examples are the accessibility requirement for public buildings which is present in most regulations of member states or the acoustical comfort and noise protection addressed sometimes in building regulations. Next to addressing and completing the regulatory framework, policy makers may stimulate the market to de-

velop and use new technologies and designs in order to improve the quality level of the built environment by stimulating and financing RTD-work and voluntary initiatives, for instance through financial support or tax deductions.

6. Conclusion

The PERFECTION project enabled the consortium to put indoor performance as a concept on the forefront. The project resulted in a number of deliverables which have been presented here shortly. The PERFECTION KIPI Framework, the toolbox and DSS software and the promotional tool for products and technologies have been applied in a series of case studies with positive results from the point of view of assessment and monitoring. The policy work of PERFECTION will help to include indoor performance in future regulatory work or policy initiatives. The work with regard to the indoor performance is certainly not yet finished. Rather we are at the start of a new evolution.

7. Acknowledgement

PERFECTION is a Coordination Action supported by the European Commission within the Environment Programme of FP7. It is coordinated by the Belgian Building Research Institute and involves 10 other participants (VTT, Apintech, CTU, ARMINES, Bauphysikburö Kornadt, ICTAF, SiTI, TU Eindhoven, ASM and BRE).

8. References

- [1] Loomans M., Huovila A., Lefebvre P.-H., Porkka J, Huovila P., Desmyter J. and Vaturi A., Performance indicators for the indoor environment, SB 11 World Sustainable Building Conference Proceedings, Helsinki, Finland, 18-21 October 2011 (to be published)
- [2] Desmyter, J. & Huovila, P. (2008) **Indoor Performance Indicators for Health, Comfort and Safety of the Indoor Environment**. In: SB08 Proceedings, Melbourne 21-25 September 2008.
- [3] Järnstrom H., Huovila, P., Lupíšek, A., Botsi, S., Hájek, P., Sakkas, N., Hodková, J., Lefebvre, P.-H., Desmyter, J., Steskens, P. & Loomans. M. (2009) **Indoor Indicators**. In: Perfection Workshop, Krakow, December 2009
- [4]Huovila, P., Lupíšek, A., Lefebvre, P-H. & Steskens, P. (2010) **Indoor Performance and Sustainability**. In: Portugal SB10 Proceedings: Sustainable Building Affordable to all Conference, Algarve, Portugal 17–19.3.2010
- [5] Desmyter, J. & Huovila, P. (2010) **Performance Indicators for Health, Comfort and Safety of the Indoor Environment**. In: CIB World Congress 2010 Proceedings, Manchester 10–13.5.2010
- [6]Olivero, S., Huovila, P., Porkka, J. & Stirano, F. (2010) **Managing the Indoor Security and Safety in Historical Buildings**. In: CESB10 Prague Proceedings, 30 Jun - 2 Jul 2010
- [7]Desmyter, J., Huovila, P. & Lefebvre, P.-H. (2010) **Designs and Technologies for a Safe, Accessible and Stimulating Indoor Environment – The Impact of Policy**. In: SB10 Finland, pp. 60-61
- [8]Porkka, J., Huovila, A., Huovila, P. & Stirano, F. (2010) **Tool for assessing Indoor Performance. Case Study Examples from Perfection project**. In: SB10 Finland, pp. 204-205
- [9]Huovila, A. (2010) **Key indoor performance indicators contributing to health, comfort and safety of the indoor environment**. In: The 7th International Conference “Indoor Climate of Buildings 2010”, Strbske Pleso Slovakia, 28th November - 1st December 2010. pp. 91-98.