# MANAGING PERFORMANCE IN THE BUILT ENVIRONMENT

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## ABSTRACT

This paper describes experiences from requirements management using the performance approach. Development of the building and real estate cluster, roles and objectives of key players (owners, users and the society), new features of building commissioning (progressive procurement methods) and decision-making issues are first discussed.

A unified classification of building properties, VTT ProP®, is then introduced as a framework to control the life cycle behavior of spaces, systems and products consisting of technical solutions. The performance of the facility is also judged against life cycle costs and environmental pressure.

A novel tool, EcoProP, is presented as an interface to support setting objectives and verifying conformity to the desired qualities. EcoProP provides a path for the realisation of a thorough performance-based project definition. The selected approach facilitates 1) tendering based on the bidders' core competence, 2) innovations in design and technical solutions, 3) improved exploitation of architects' and engineers' competence.

Finally, findings from implementation are analyzed. Based on the piloting experiences, EcoProP has proven to increase discussion and commitment to the objectives early in the design process, thus supporting value-adding teamwork. The original needs of the stakeholders become documented and the essential requirements are not missed during iterative cost-optimising design and decision-making processes.

## KEY WORDS

Life cycle design, performance concept, requirements management.

## INTRODUCTION

Performance of the built environment is important not only for its users and owners, but also for the whole society. Defects during its operation and deficiencies with adaptability to meet changing needs cause needless costs, environmental pressure and dissatisfaction. That lessens the quality of life, gives bad reputation to the sector and decreases investors' interest towards that asset.

In many cases the desired performance is not explicitly expressed and recorded in the design brief and in design documents. In addition, building design is often imperfectly and unproductively constructed. The conformity of the end product may be poorly verified and appearing faults incompletely corrected. Sometimes the built environment is also disadvantageously operated and maintained in an unskilled way.

Each expert in the building process may have his or her own conception of a performance requirement that may be appropriate and achievable when formed. Unfortunately these requirements are often lost and replaced by technical solutions that can be changed later on without perceiving their consequences to the life cycle performance. Requirements management in this paper means capturing, formalising and maintaining both expressed and unexpressed demands related to the facility.

Real professionals and best companies can master these challenges and most of the facilities function at least satisfactorily, but certain development potential in the processes still remains. One way of improving these deficiencies is to structure the content of the performance, to improve ways of verifying the conformity and to encourage different actors to a learning curve e.g. introducing tools that force them to think about right things at a right time, and to use their expertise there. If some incentives can be engendered so that better performance leads to higher profit, that's even better.

This paper describes the approach where the needs of the owners, users and the society are defined in relation with the planned first and later use of the facility with location aspects included. The objectives are then expressed in a form of performance of indoor conditions, service life, adaptability, safety, comfort and accessibility. The restrictions with life cycle costs and environmental impacts are verified, and appropriate procurement method is selected with the operation and maintenance, even demolition, recycling and waste issues included.

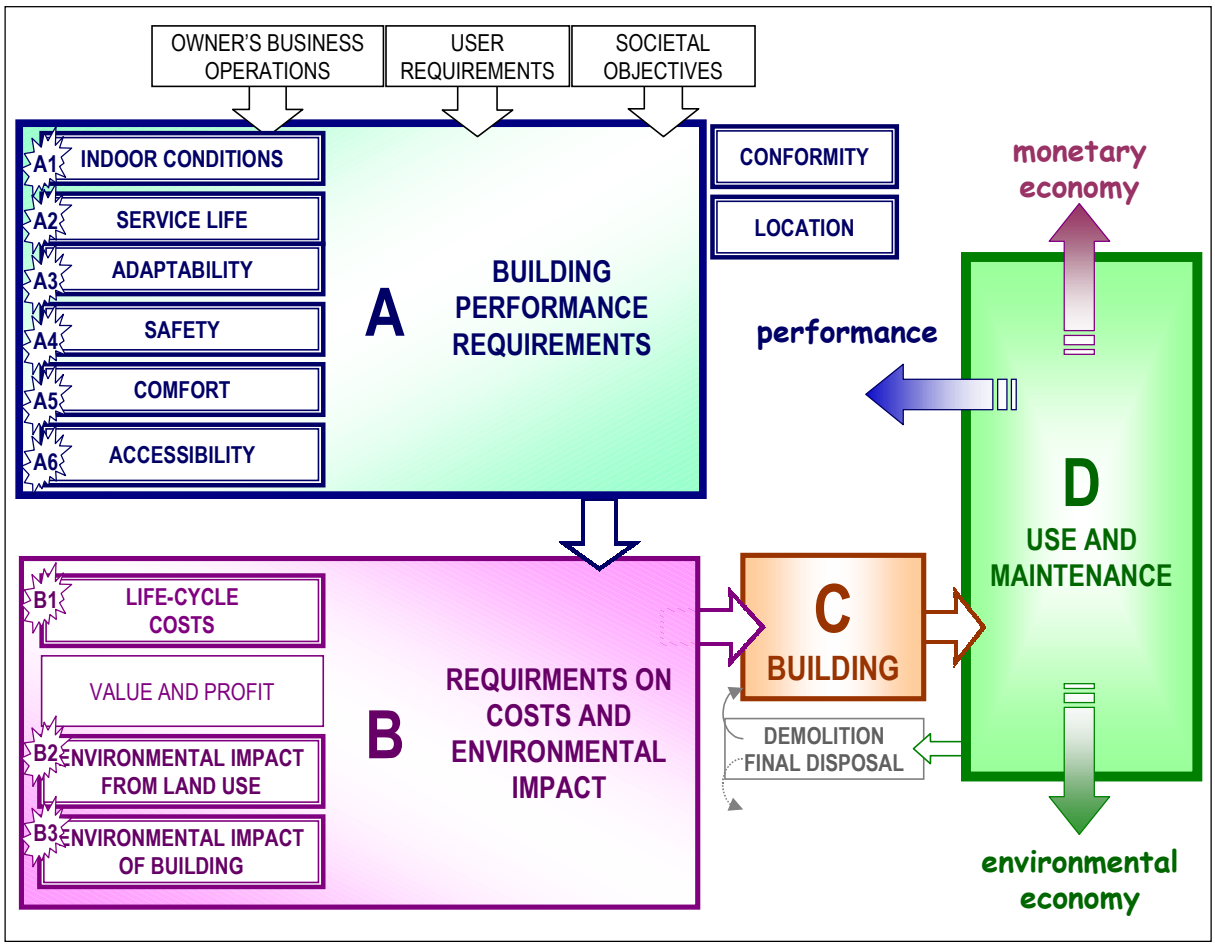


*Figure 1 - The performance approach in the building process.*

In practise, dramatic changes seldom take place suddenly. The improvements are partial and incremental. The objective is, however, that life cycle thinking and the life cycle performance of the built environment is seriously taken as a starting point. The consequences may then be to reorganise the building process accordingly, to look at new ways for briefing, procuring, partnering, commissioning, developing, learning and profiting.

## PERFORMANCE APPROACH

Performance approach is concerned with what the building is required to do, and not with describing the technical solutions i.e. how it is constructed. (CIB 1982). A preliminary study of applying the performance concept was done in Finland, partly based on experiences from the Netherlands. It emphasized that the approach forces the clients to think what is really needed to support their business processes. The main identified potential advantages of the approach are (Huovila 1999):

- better exploitation of the suppliers' expertise
- design emphasis moves earlier in the process
- communication between stakeholders improves
- competition between different technical solutions based on the same performance specifications is possible.

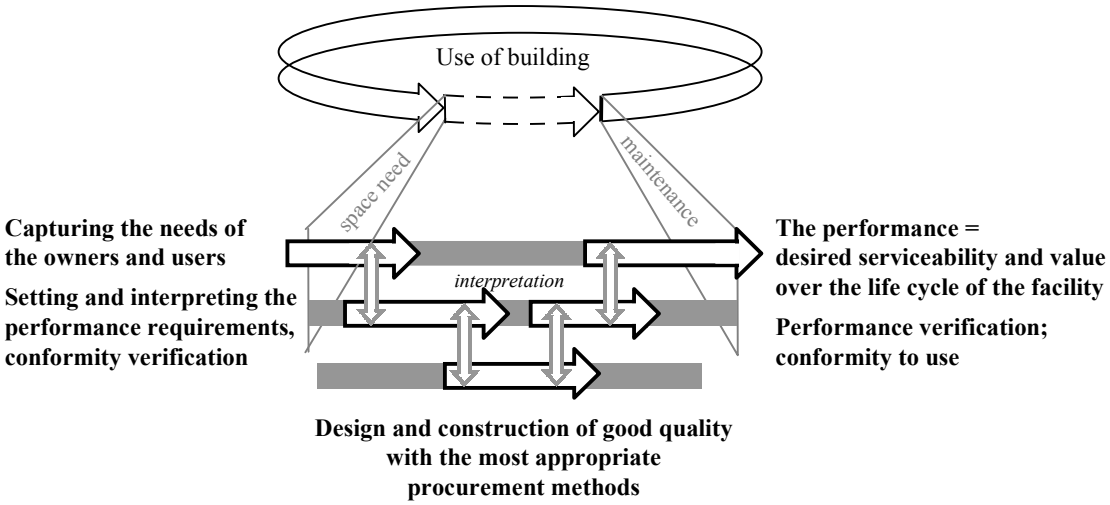


*Figure 2 - The performance approach in the building process*[1]

The performance approach should force clients to think what they really need. It should also lead towards profitable product development and finally help customers to receive a product that meets their needs. Its successful implementation may also require:

- extension in time used for planning at the beginning of the project
- changes in traditional working methods
- new forms of competition and contracts and
- defining a common language and increase in communication.

A requirements management system is needed to enable control over life cycle requirements. The performance of facilities should be outlined individually in each project, so that those requirements can be directed to meet desired characters. The mission of design process is then to find suitable solutions to fulfil these defined requirements. There can be several solutions to fulfil the task, each of which have certain consequences – both environmental and cost related.

To appoint life cycle requirements is easier, if they can be specified as numbers or values (e.g. maximum energy consumption per year) or categories (e.g. certain indoor climate category). In order to appoint requirements successfully, there needs to be some mechanism also to verify the achieved level. This verifying systematic is needed to be applicable in every phase of the life cycle process. The found inappropriate solutions may lead to changes in design or construction, or changes in requirements. It is important to validate the changed situation in case of modification of requirements.

[1] adapted from illustrations produced by Government Building Agency, the Netherlands

It is also important to validate conformity at the commissioning or operation phase. Design iterations are very much favoured towards early phases of design because of cost effects.

## ECOPROP

VTT Building Technology has developed a method and a tool, EcoProP, to set and manage performance requirements in a building construction project. It is based on an extensive building property classification, VTT ProP®. In addition to building performance properties, VTT ProP® also contains environmental and cost properties and requirements for the realization process. EcoProP provides a path for a thorough performance based project definition (Figure 3). When requirements are performance based the variety of procurement methods is larger. The contractors can improve design and also benefit from this (Lahdenperä 1998). EcoProP has been implemented in different building projects consisting of nurseries, office buildings and housing projects.

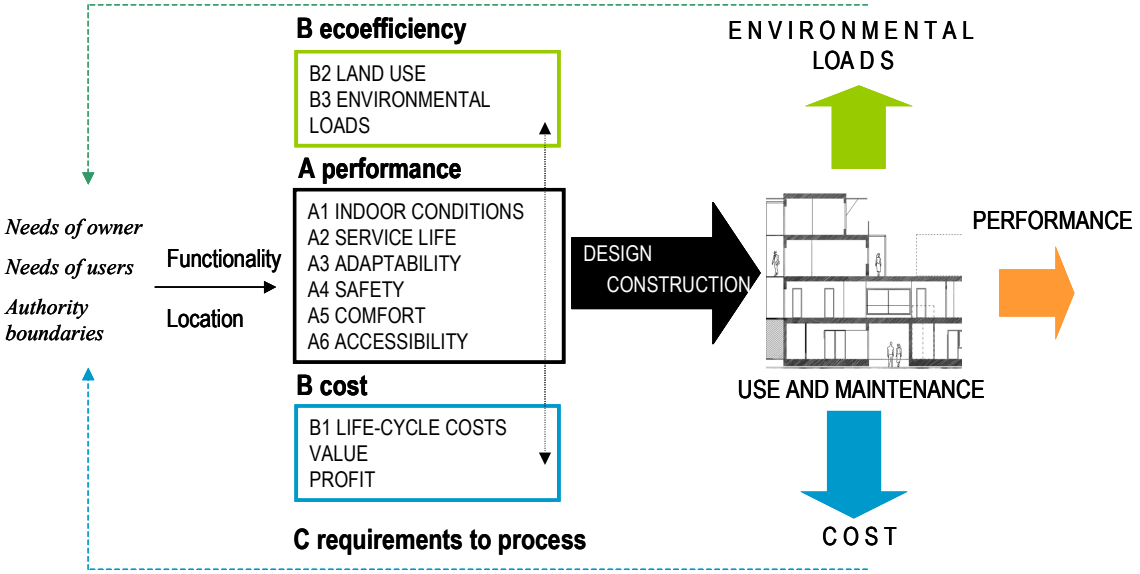


*Figure 3 – Performance based project definition*

The end-result of an EcoProP based requirements setting is a performance-based project brief. Selected requirements are collected to a single, colour-coded Excel sheet. Colour-codes give a quick view of the requirements level of the project. This sheet can be saved as a separate file that can be distributed via e-mail or published in the project web site. Furthermore, selected requirements can be automatically copied to Word to offer a possibility to edit requirements in a text file. This Word file acts as a 'project memory' when in the later phases of the project requirements will be changed. A profile of the selected requirements can be created after the user has set targets for the project. The profile shows the average requirement level of each property. The profile contains also a reference line. Company or organization can set a reference level to validate requirements of a single project. (Figure 4)

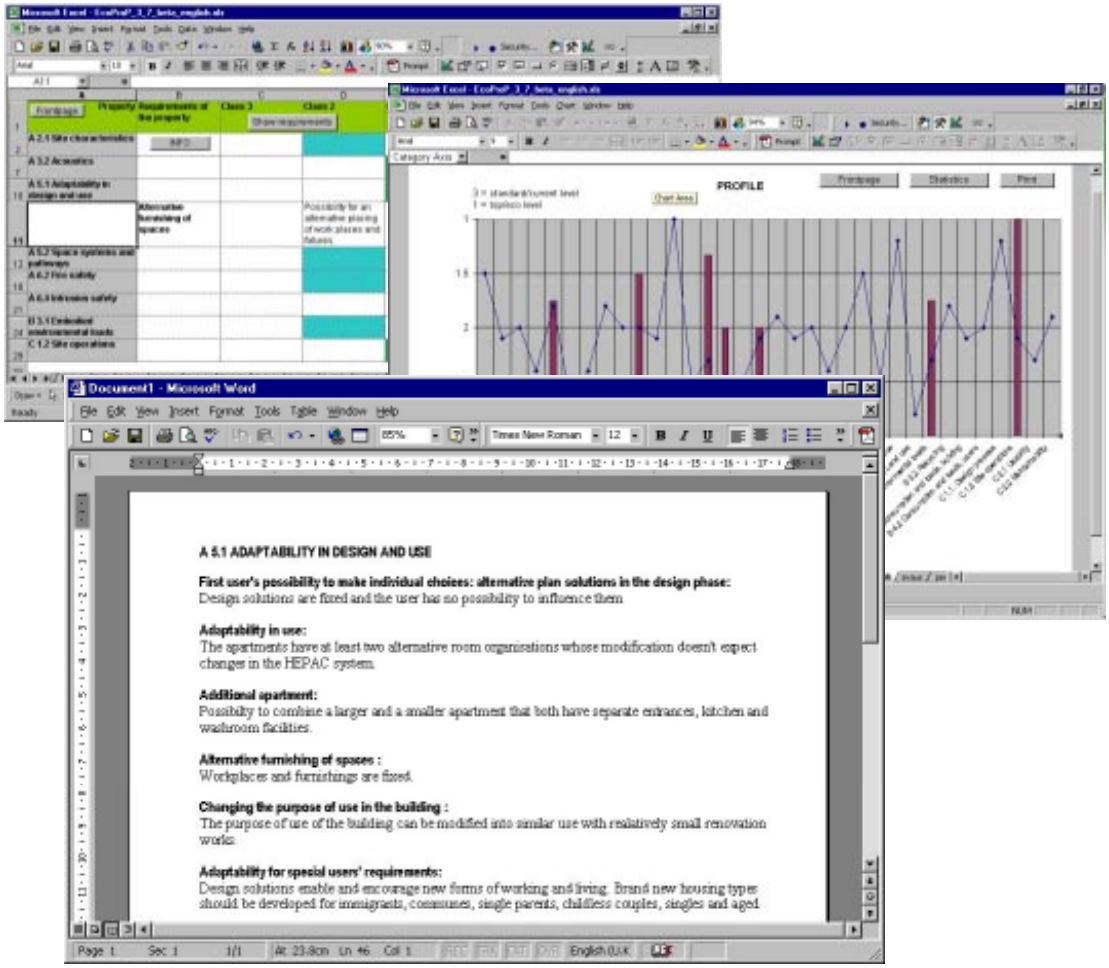


*Figure 4 – Results of requirements setting session with EcoProP*

## EXPERIENCES FROM USING THE TOOL

A Finnish facility developer, Realprojekti, used EcoProP for setting requirements for a large office and business building to be constructed in Helsinki. The floor area of the building, Megahertsi, will be 67.000 $m^2$ and the volume 340.000 $m^3$. The team that set the requirements comprised of the architect, engineers, owner representatives and consultants. In the first session attendees concentrated on setting requirements for building services and the second was for the rest of the requirements. Discussion during session was extensive but eventually when the decision was made, participants seemed to commit to the common target. The pre-set goal of the team was to create a premium environment for demanding clients. The divided performance profile compared to baseline requirements confirms that the requirements were fairly high (Figure 5). The column on the left is the current level and the column on the right is the baseline level.

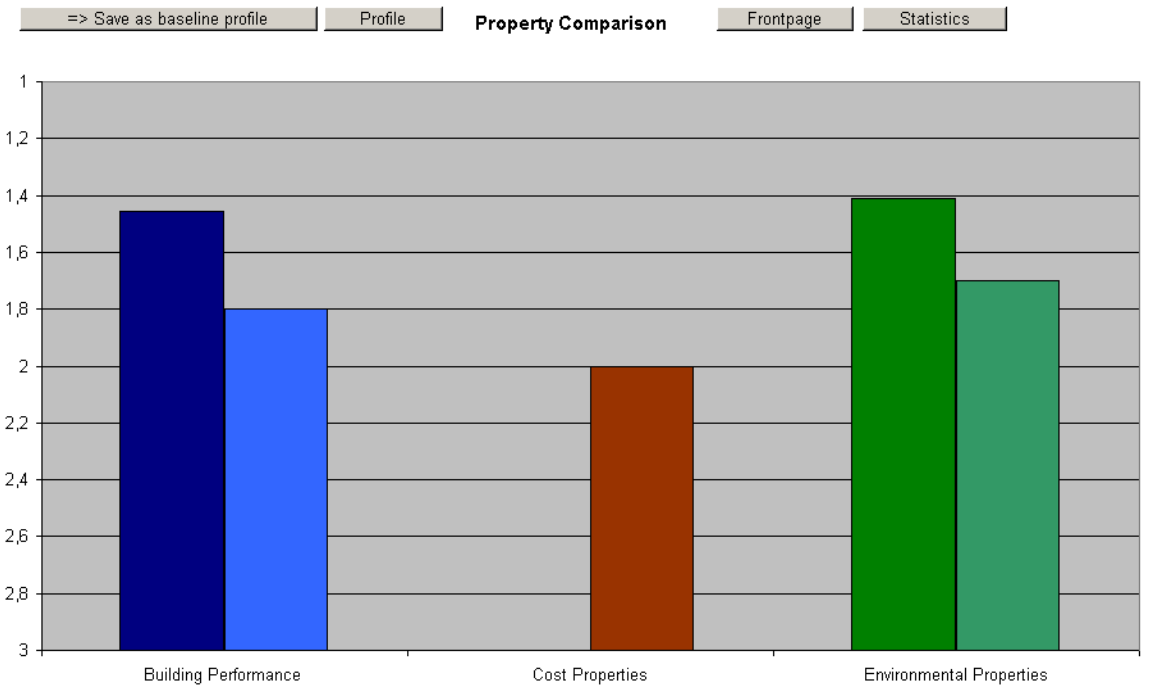


*Figure 5 - Property Comparison during requirements setting session of Megahertsi-project*

State Real Property Agency (SRPA) has recently added procedures to the quality system to enhance the ecoefficiency of their building construction projects. First step was to add 'green forms' between the other descriptions of work to be done in a particular phase of the project. To have also requirements concerning ecoefficiency had become part of normal process. However, the feeling among the project managers was that they needed better tool to tackle to whole requirements setting procedure. Browsing through lists of papers was too time consuming and unproductive. EcoProP was tested in a project where the project manager had already created a brief focusing mainly on the qualitative requirements of various properties like adaptability and energy consumption of the building. The intention was to transfer these requirements to EcoProP to test the tool. However, it became obvious that it is more beneficial to follow the path provided by EcoProP and also to add requirements that were not in the original brief. The general feeling amongst the participants was that EcoProP makes the user to think more precisely. Also the previous abstract and unclear requirements got a more exact definition. The requirements were set in a session where the project manager, the building services specialist, the architect, the environmental expert of SRPA and two experts from VTT Building Technology were present.

Other test cases included nursery developed by the Construction Management Division of The City of Helsinki (HKR). HKR provides building construction services to various departments of the City. HKR manages the building project acquiring designers, engineers and builders. HKR creates the brief from the original project definition. The nursery Merituuli, which is for about 100 children to be built in the year 2000, was used as a test case. Merituuli will be built in a former industrial area that is being changed for a new housing area. The basic infrastructure has already been developed. The location of the area is very close to the city of Helsinki with a good public access to the city. The building will serve as nursery school daytime, and in the evening as a meeting point for local inhabitant activities. The total building area is 1260 $m^2$ in one story. (Figure 6). One challenge for the design process is that in the future the nursery will at least partly act as an old people's home.

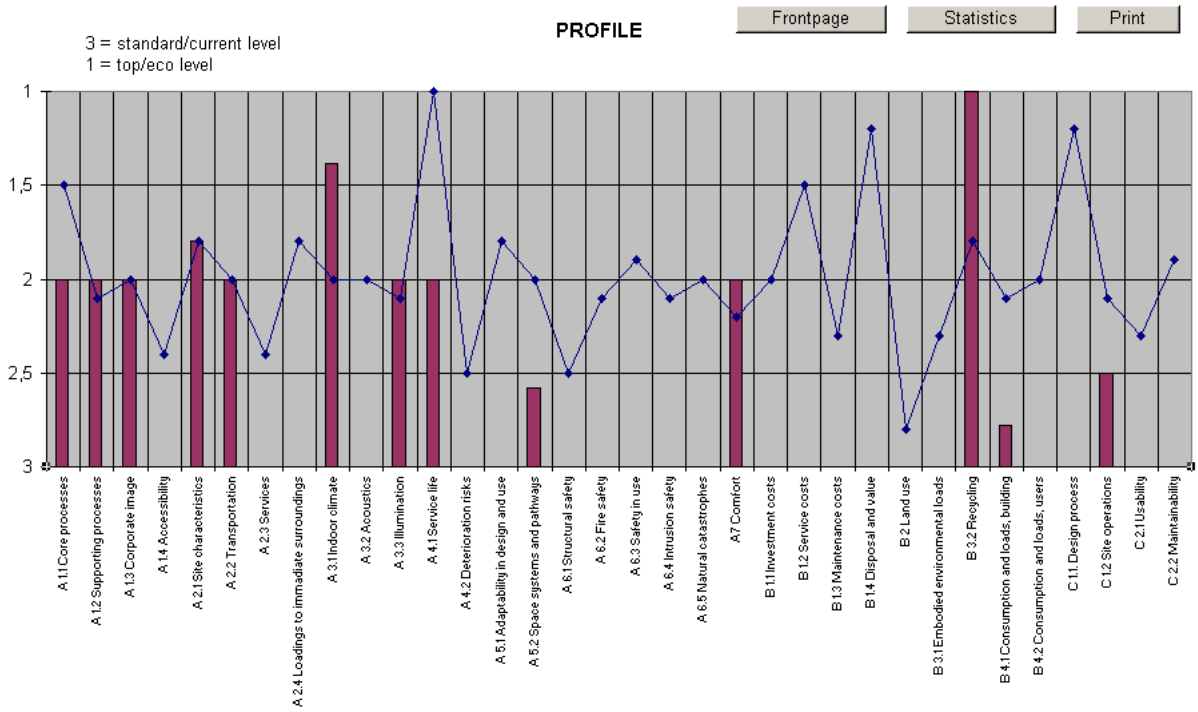


*Figure 6 - Performance profile of the Merituuli nursery*

## FURTHER DEVELOPMENT OF THE TOOL

The requirements, which have been set with EcoProP, need to be validated and verified during the design process. First we need to give feedback to user on how realistic the set requirements are. To attain this, we need to implement several validation methods to EcoProP. At the moment, an ongoing effort is to combine an energy simulation tool developed at VTT Building Technology to EcoProP to estimate the probable energy consumption of the building. When the user compares the results of the simulation of the energy consumption and the energy consumption target set using EcoProP, he/she understands how demanding the target is. Second, an early and continuous verification has to take place in the design process (Ang and Wyatt, 1999, Becker, 1999). The user has to be sure that the desired performance targets will be fulfilled. And if this is not possible, user knows this beforehand.

One logical path for further development is to integrate with existing tools and method. The authors have tested combined EcoProP-method and Quality Function Deployment (QFD). Performance requirements for the project are set using EcoProP. After this, selected parts of the requirements are transferred to QFD to further analyze how to proceed with them. Too often also thorough requirements are not met in the final product. There are various reasons for this; cutting costs in some phase of the project, inability to find suitable design solutions to fulfil the requirement, forgetting the original requirement etc. It helps to have a smooth flow from targets through verified design solutions to realized, fulfilling technical solution if the most important targets are analyzed deeper. This can be done using QFD in resolving EcoProP requirements.

The classification, which is the core of the EcoProP, can be also something else than VTT ProP®. The authors have tested using the criteria provided by the IEA task 23 (architectural quality, functionality, environmental loading, resource use, life-cycle costs and indoor quality). A part of the building related performance requirements typically vary depending on the location. It is obvious that the user needs, building regulations and building practices are different in different continents, countries and areas, thus resulting in need for tailoring the contents.

## CONCLUSIONS

The described approach consists of a classified structure of the building performance, target values in classes, reference information about solutions and verification methods, and a simple tool to manage all that with outputs in the form of a text document to be completed as a design brief, or as a profile that can be compared to given reference data. The first results from validation in live projects covering housing, office and business buildings and nurseries look very promising.

The developed EcoProP tool can be further improved and integrated with other practical tools in order to support successful implementation of the performance approach. It can also be easily tailored to meet better varying needs and constraints, regulations and practices in different economies and environments. The key matter is to involve the needs of the end-users (both fist users that are known and later users that are not yet known) in the process and to increase transparency and communication in decision making.

## REFERENCES

Ang G.K.I, Wyatt D.P. 1999. “Performance concept in the procurement of durability and serviceability of buildings”. Presented in 8th International conference on durability of building materials and components, Vancouver, Canada, May 30 - June 3.

Becker R. 1999. “Ensuring building serviceability at the design stage”. Presented in 8th International conference on durability of building materials and components, Vancouver, Canada, May 30 - June 3.

CIB Report. 1982. “Working with the Performance Approach in Building”. CIB Publication no. 64. Rotterdam, Netherlands. 30 p.

CIB. 1993. “CIB Master List of Headings for the Arrangement and Presentation of Information in Technical Documents for Design and Construction”. CIB Report, Publication 18.

ISO. 1984. “Performance Standards of Buildings, Principles for their Preparation and factors to be Considered”. ISO 6241.

EC. 1989. “The Construction Products Directive”, 89/106/EEC.

Nilsson, N.K. and Cole, R.J. 1998. “GBC '98: Context, history and structure”. Presented in Green Building Challenge '98 Conference, Vancouver, October 26-28, pp. 15-25.

Huovila P. 1999. “Managing the life cycle requirements of facilities”. Presented in 8th International conference on durability of building materials and components, Vancouver, Canada, May 30 - June 3.

Lahdenperä P. 1998. “The inevitable change, why and how to modify the operational modes of the construction industry for the common good”. The Finnish Building Centre Ltd. Tampere, Finland.

Leinonen J, Huovila P. 2000. ”Requirements management in Life-Cycle Design”. ILCDES 2000, Integrated Life-Cycle Design of Materials and Structures, May 22 - 24, 2000 Helsinki, Finland

Leinonen J, Huovila P. 2000. ”House of the rising value”. Presented in the International group for Lean Construction 8th Annual Conference, 17-19th July 2000 Brighton, UK