QFD
IN SETTING THE GUIDELINES
FOR A DEMONSTRATION PROJECT

Jyri Nieminen
Pekka Huovila
Jarkko Leinonen

VTT Building Technology

SCOPE

QFD was experimented in an afternoon brainstorming session to set design guidelines for a demonstration project - Villa 2000 - to be constructed for Tuusula Housing Fair 2000. The house of quality matrices were formed to judge how well the client's illusions about what the building will represent in the near future (the requirements set for the project) meet the original design criteria and, on the other hand, to judge how well the ideas for technical solutions meet the customer requirements. The IEA Task 23 design criteria was adopted for the house, and the aims of the demonstration project came from these criteria.

A short description of the project and it's aims are given in the appendix. It should be noted that the first draft proposal of the project was written already nearly two years ago, and the group involved has met several times during the development of the approach and aims of the project.

The exercise was conducted together with ten experts of different backgrounds. The following objectives were set for the working session:
- to share common understanding of the performance-based objectives of the end product (a building to be designed and constructed)
- to prioritise the project objectives
- to strive for innovative design solutions that meet these objectives.

SESSION TEAM

Customers:

Erkki Kuoppamäki (architect)	The Finnish Housing Fair
Liisa Vaahtera-Brunila (architect)	Tuusula Municipality
Oiva Hildén (civil engineer)	The Finnish Housing Fair

Design team:

Joel Majurinen (electrical design)	J.W.Majurinen Oy
Pekka Aromaa (structural systems)	Rautaruukki Oy
Juha Krankka (thermal insulations)	Partek Paroc Oy Ab
Vesa Peltonen (architect)	Arkkitehtitoimisto Wartiainen
Ilpo Kouhia (research)	VTT Building Technology
Jyri Nieminen (research)	VTT Building Technology

Session arrangements:

Pekka Huovila (session chair)	VTT Building Technology
Jarkko Leinonen (QFD)	VTT Building Technology

SESSION EXECUTION

A detailed schedule including timing was prepared for the session, table 1. The aim was to go through two levels of QFD matrices (see tables 2 - 6). All the data was documented online during the session using a computer. The intermediate results were projected to the screen constantly and delivered to the participants in a form of paper prints at the end of the day. The whole session took about four hours.

Table 1. Execution of the QFD exercise (see table 2)

Phase (Table 2)	Activity	Result/Content
1.	Short description of the session program and the QFD method Teamwork and discussion of the main level requirements	IEA T23 design criteria as a QFD matrix Agreement of the starting point/design criteria
2	Importance of criteria by voting [1)]	Prioritisation: weight factors
3	Teamwork: performance properties Filling the properties into QFD matrix Dependency between second level requirements and properties [2)]	Table 3 Part 3a in table 2 → table 4 Part 3b in table 2 → table 4

4	QFD calculation: Importance of each performance property	Weight factors for properties
5	Selection of most important properties by voting [3)]	New requirements for the project
6	New QFD matrix	
7	Importance of new criteria by voting [4)]	Prioritisation: weight factors
8	Teamwork: performance properties for new requirements Filling the properties into QFD matrix Dependency between second level requirements and properties [2)]	Table 5 Part 8a in table 2 → table 6 Part 8b in table 2 → table 6
9	QFD calculation: Importance of each performance property	Prioritisation of project requirements
10	Selection of most important properties by voting [3)]	New performance properties, table 5

1) each participants had 1 + 2 + 3 votes
2) dependency described using 0 (less important), 1, 3, 9 (most important)
3) each participant had 1 + 1 + 1 or 1 + 2 or 3 votes
4) each participant had 1 + 1 or 2 votes

Phase 1

The session started with an overview to QFD-method. The basic QFD matrix was pre-filled with the IEA Task 23 design criteria as customer requirements, table 2. The way of using the matrices and methods of prioritisation were made clear to the participants.

The requirements were discussed using results from teamwork (two persons made a team) as a basis. The content of requirements were understood quite widely. It was decided that the topics are acceptable in spite of different views to the subjects.

Table 2. Session start with a pre-filled QFD matrix.

Phase 2

The importance of design criteria were discussed. A voting gave weight factors for each criteria.

Phase 3

Performance properties for each criteria were innovated using teamwork. Each team produced five properties relevant to the design criteria. The properties were discussed, sorted and grouped under a few topics (table 3). Some of the properties were combined as being close to each other.

Table 3. Ideas for performance properties.

Environmentally friendly	Functionality/ adaptable for use	Indoor environment	Attractive to users	Architecture	Economy/ viability
Environmental impacts 30%	Updating	Quality	Attractiveness, PR	Identity	Total economy
Operation impacts	Removable, reusable	Responds to the environment	Automation vs. manual operations	Unique architecture	Resale value
Resource use	Modifiability		Habitability	Future oriented	Constructability
Total ecology	Reusable demo-			Architecture	

	house				
Autonomy	Simple user interface				

Performance properties from table 3 were transferred into properties in the QFD matrix (table 4). Dependencies between the design criteria (requirements) and the performance properties were discussed shortly and dependency factor 0, 1, 3 or 9 was accepted for each property.

Phase 4

The QFD calculation gave a weight factor for each property showing the importance of a property with regard to all the design criteria, table 4.

Phase 5 & 6

The group had a possibility to re-consider the QFD weight factors. It was decided that six of the most important properties are processed further. The final selection was made by voting. As a result only three of the six most important properties from QFD calculation were selected. The voting gave a possibility to emphasise the importance of other topics, e.g. architecture, as the architects in the group focused their votes to architecture.

Again, the properties close to each other were grouped, so that, e.g., environmentally friendly, autonomy and total ecology formed one of the new requirements (see table 5) for further processing.

Table 4. The first QFD results

Phase 7

The new requirements were prioritised.

Phase 8

Ideas for performance properties for the new requirements were produced in teamwork, table 5. Each team produced three properties relevant to the design criteria. The properties were discussed, sorted and grouped under a few topics. Some of the properties were combined as being close to each other. At this stage, the properties were handled as groups, and only the headline of table 5 was filled into the QFD matrix, table 6. The dependencies between requirements and properties were filled in.

Table 5. Performance properties for the second level QFD matrix.

Process	Rooms/spaces	Structures	Energy	Building services	Materials
well designed with time	Technical zone (all HVAC equipment)	Simple foundation	Free energy, solar	Own energy source	Choice of materials
Prefabrication	Room height	Glass (daylight)	Heat recovery	Noiseless IMS	Wood
	Sound insulation	Simple, well insulated , durable building envelope	Minimisation of heat losses		
	Removable walls (envelope and interior)		Total energy solution		

Phase 9 & 10

The QFD calculation gave a weight factor for each property showing the importance of a property with regard to all the design criteria, table 6. The final selection was made by voting.

Table 6. The profile of the demonstration project Villa 2000 achieved with QFD method.

PHASE 2							
Properties / Requirements	space	process	structures	materials	energy	equipments	**Importance factor (P1)**
adaptability, simple interfaces, re-usable fair house	9	9	9	3	3	1	**3**
indoor conditions, responds to the environment	9	9	9	9	9	9	**4**
economy, resale value	9	9	9	9	9	9	**1**
environmental,autonomy, total ecology	9	3	9	9	9	9	**5**
constructability	1	9	3	1	1	1	**3**
architecture	9	9	3	9	1	0	**2**
Weight factor (P1)	138	134	133	120	104	95	**724**
Weight factor %	###	###	###	###	###	###	**####**
Votes	4	10	6	2	5	0	**27**
Weight factor %	###	###	###	7 %	###	0 %	**####**

SESSION CONCLUSIONS

Session results

- The goals of the project were made clear to all the participants, also the guidelines for the project were set.
- The session results do not restrict the planing and the designing of the house (architecture, systems, structures), rather the whole design and construction process was emphasised.
- The session showed that the terminology within 'sustainability' is not clear and the terms are understood rather widely: In the beginning there was still a wide misunderstanding of the original goals of the project (after two years of discussions)
- Architecture was rather difficult as a starting requirement, since it includes almost all and at the same time none of the other requirements. The participants' view to architecture was very subjective which affected the working process.
- New objectives and innovations were introduced but not selected into final processing
- The results are rather close to original aims

Method

- Positive reaction by all the participants
- Afternoon brainstorming enabled to focus on two requirement/ property-levels.
- Clients were forced to react on requirements and to formulate and express their view to the goals of the project.
- Designers influence on results may be too high: choice of the working group members
- The exercise was conducted to analyse the whole project. The effectiveness of the process would probably be better if each criteria was analysed separately. In practice, a restricted number of user requirements should be selected and analysed using QFD

VILLA 2000 -project

The purpose of the project is to analyse requirements for future housing from ecological, social and technical point of view - a sustainable approach of housing. The purpose of the demonstration building is to serve as a bridge to environmentalism. The focus is on the other hand, in marketing the future by establishing a demand for new design solutions, and, on the other hand in building a tool in which future oriented companies can demonstrate their innovations.

The house will be built for the annual housing fair to be opened in July 2000. The housing fair 2000 is the 30th anniversary fair, and more than 300 000 visitors are expected to visit the fair grounds.

The aim of the project is to design and build a house for future housing that supports and demonstrates a new housing concept. The house is considered as a part of natural environment with an ideal self-organising natural re-generation according to the user's needs. The house is also a social stage for future housing development.

The house is designed by architect Kai Wartiainen, presently also a professor at KTH, The Royal Institute of Technology in Stockholm, Sweden.

To fulfil the ecological and social aims the following technical aims are considered, figure 1:
- The house is fully adaptable for different actions and functions. The interior of the house can be converted , e.g., from a dwelling into two or three dwellings or an office and a dwelling.
- The use of natural resources during the life cycle of the house is only one third of those of an average house of today.
- The emissions caused by construction and use of the house are only one third of the emissions of an average house. The aim is high self-sufficiency in terms of energy and utility services (water supply and sewage disposal).
- The life cycle costs of the house are only one third of those of an average house.
- Good and comfortable indoor environment, especially in terms of indoor air quality, daylight and thermal comfort.
- The house is a show piece of a good and new experimental architecture.

CRITERIA FOR FUTURE HOME: VILLA 2000 PROJECT