

The 'Intelligent Office' Concept Makes the Difference

by Mervi Lehto

The 'intelligent building' concepts developed at the beginning of the 1980s formed the starting point for the construction of 'smart homes' and 'intelligent offices'. Now intelligent concepts are becoming established as the target level for all buildings, and the focus has shifted to the introduction of sustainable intelligent solutions. The study of intelligent offices by VTT proved the intelligent office concepts to have good energy efficiency. It proved also them to be, from the users' point of view, capable of increasing work efficiency and to some extent diminishing job related trips. Simultaneously, intelligence means an advantageous and comfortable working environment.

The advantages are due to the intelligent architecture and the technical solutions installed. According to the study, it seems that simply the use of the intelligent concept as a holistic approach to the building design, makes the difference between a high quality office building and the intelligent office. Consequently, the message for building managers is that even the idea of integrated and user oriented concept in planning is enough. Work efficiency, reduction of traffic, energy efficiency, health issues and cost benefit ratio, all speak for intelligent offices.

THE CLARIFICATION OF AN INTELLIGENT BUILDING concept is a development process which brings an awareness of both the needs of a modern building purchaser or real estate developer and the possibilities of combining hi-tech building solutions. The aim of this process is to achieve an intelligent overall system of building solutions that will serve the building user, in either the residential or office context.

A long list of technical equipment is no guarantee that a building will be intelligent; intelligent building must include the characteristics of being:

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- modifiable and flexible
- structurally active
- capable of structural and functional integration
- informative
- interactive
- secure
- comfortable and service-oriented
- healthy and therapeutic
- economic and productive
- based on correct fundamental solutions.

The essence of the concept

The intelligent building concept can be understood as a metaphor. The intelligence indicates a human being, and a building an artificial item. To understand the intelligence of the building, and in some cases even to accept the building as intelligent, it is helpful to understand the human intelligence. It is good also to be aware of the results of artificial intelligence research. This issue is worth an article of its own, and I am mentioning it in this context only for the sake of its importance in the definition of the intelligent building concept.

Something old and new in intelligence

Human welfare and nature conservation mean a renaissance of traditional solutions, but also favour many life-enhancing hi-tech applications. For example, cableless and portable technologies are increasing the possibilities of home-based working and mobility without losing contact with important people or loved ones. These technologies are liberating us from the constraints of timetables, and are blurring the line between work and leisure time.

The use of well thought out window locations is an example of traditional means of workplace planning. In the intelligent office, natural light not only creates a lighting of high quality, but also takes the role in lighting control and in meeting the demands of sustainable technology. The window design can solve the various needs of lighting during the day using only some help from artificial lighting controlled by the building automation or without it altogether. The good u-values and technical specialities of intelligent window architecture are increasing freedom in window design in the office of the information era.

There are many other examples of the kind in the intelligent building technology solutions. Typical intelligent features in the Finnish offices are assembly floors, adjustable walls, special lighting, personally regulated indoor climate, advanced advice and security systems, automatically operated doors and windows, other active structures, job-specific work sites, green spaces and communal spaces promoting the free flow of information. They all are known in other countries as well.

Figure 1. Three examples of the buildings studied. Both intelligent and non-intelligent offices were of high quality and built at the end of 1980's and in the beginning of the 1990's. Two multi-user intelligent office buildings: Pilotti in Tapiola Espoo (1b) and Innopoli in Otaniemi Espoo (1c) were compared to the non-intelligent multi-user office buildings: Maari's house in Otaniemi Espoo (2c) and Teollisuuskatu 33 in Helsinki (2b). The Helsinki Telephone Co. intelligent office building (1a) is very comparable to the RAY Headoffice in Keilaniemi Espoo (2a), while they are both for one user only.



Productivity is success coming true

The primary aim of the intelligent office building study has been to find the features that will best promote the competitive benefits of the construction industry and its customers.

Intelligent building features will improve real estate management, energy efficiency and operational economy. In addition to the lowering of real estate expenses, the revenue-generating potential of commercial properties will be improved, thereby increasing the incomes of both the owners of buildings and the firms that make use of them. Having a house does not necessarily only mean costs for tenants, but a good office building can be considered as a source of income as labor, equipment and capital have been seen. Productivity through user-oriented building technology observes the old wisdom: by helping others, such as your customers (in this case tenants) to succeed you are helping yourself most.

Efficiency improvements will also be felt by society as a whole, for instance, as a result of reduced commuting and traffic. In addition to economic productivity, enhancement of social and mental welfare in accordance with the objective of harmonic development is also an aim in the construction of smart houses and the information society.

The secondary goal of the study, the development of a customer-oriented needs analysis in connection with intelligent offices, has provided a good starting point for an examination of the productivity of technical building solutions in other areas of activity, e.g. trade and care centers, hospitals, schools, etc.

Twelve offices in Finland – the Study of Intelligent Office Features

The functionality of intelligent building features can be witnessed first hand in buildings already constructed. Twelve offices in Finland have been studied since 1993, within a three year study on monitoring intelligent office buildings. Half of them are



	assembly floor and adjustable walls	a glass roofed lobby of several floors' height	advanced advice and security	LAN (local area net work)	special
Innopoly 1991, multi-user intelligent office bldg for 508 workers	+	+	+	+ ¹⁾	smart card for doors and charging in restaurant, automated meeting room reservation system
Finnida 1993, Foreign Ministry for 185 workers	-	+	+	+	
Siemens Nixdorf 1993, intelligent head office bldg for 249 workers	+	+	+	+	stand by power plant, personal control for lighting, heating and ventilation
Spektri's Pilotti 1991, multi-user intelligent office bldg for 70 workers	+	+	+	+ ¹⁾	special lamps designed for the house (direct and indirect light)
Helsinki Telephone Co, 1988, intelligent office bldg for 340 workers	-	+	+	+	stand by power plant, interhouse video broad casting, intelligent telephone switchboard with flexiwork facilities, room for leisure time activities

1. a LAN for each company and a LAN for the whole building. 2. a LAN for each company

Table 1a. Summary of the intelligent offices studied.

intelligent offices and the other half are offices of high quality, studied to draw a comparison (please see Tables 1a and 1b).

In Finland there are (1994) in the greater Helsinki region app. 20–30 office buildings called intelligent. Intelligent office buildings have been built in other cities as well, in Tampere, Turku, Oulu and Lahti for example. When selecting buildings for the study, it was one criterion that they are all located in the same region for reasons of comparison. The Helsinki region was selected.

There are office hotel type buildings, teleports, science parks, head office buildings and offices made according to the Digital Future Office concept (please see figure 1). The researchers considered a building intelligent, if the building owner considers or calls it intelligent. All selected offices had been designed with the intelligent building concept as the basic idea to follow.

The new office buildings are similar, and naming them intelligent or not intelligent is not simple. Thus, this method, relying on the building owners' opinion proved to be trustworthy. There was a building without contractors' intelligent label on it, which had so many intelligent features that it was difficult for the researchers to analyze it among the non-intelligent offices. Anyway, the contractor's view was correct, the results of that building were in many cases more similar to those of the non-intelligent than those of intelligent building.

Two of the intelligent offices studied are headquarters of private companies in telecommunication and in the information service sec-

tor, one is a building of the Ministry of Foreign Affairs, and two are multi-user buildings. For each intelligent building was selected one of the same size and with a corresponding number of companies using the building.

A Holistic Approach

The study consists of a questionnaire about users' opinions, an economic survey, energy calculations and indoor air measurements.

The cost information of the intelligent building projects was gathered for the economic study. This information was compared to the average office building costs in Finland. The energy calculations were based also on the gathered information of the energy use in the intelligent offices measured by building management systems.

The indoor air quality was measured in four buildings, of which two were intelligent ones. The measurements were done according to the IAQ-Audit method elaborated in the EU JOULE II-project and carried out in eleven European countries in 1992–1994. The indoor air rate and temperatures, polutions (TVOC, CO₂) and particles were measured, and also a sensory panel was used for indoor air evaluation.

The indoor air quality measurements provide the result of the questionnaire made among the end users of the buildings with complementary information. They support the opinions of the users, which seem to be very correct and rational.

The questionnaire covers such subjects as: indoor air, intelligent building features (image of the building, spaces and structures, building automation), telematics, office automation, telecommunication. The over 500 answers for the questionnaire of 166 variables give a good idea how efficient the intelligent building concept is for office workers.

Experts in different fields worked on the questions. Ready made questions were available on indoor air, noise, illumination, work psychology, telecommuting, clothing, furniture and design methods. New areas were office and building automation, image of the building, workplace plans, use of shared services and shared spaces, and intelligent building structures such as assembly floor, adjustable walls.



Figure 2. The intelligent offices were compared to office buildings of high quality such as Maari's house in Otaniemi Espoo (2c) and Tellisuuskatu 33 in Helsinki (2b), both multi-user office buildings.

	assembly floor and adjustable walls	a glass roofed lobby of several floors' height	advanced advice and security	LAN (local area net work)	special
Housing and Environment Building 1987, 65 + 90 for workers	-	+	+	+ ²⁾	
RAY, 1987, head office bldg for 100 workers	-	+	+	+	stand by power plant, interhouse video broad casting, swimming pool
RAY, 1978/-85/-92, office bldg for 70 workers	-	-	+	+	stand by power plant (+UPS), interhouse video broadcasting
Social Care Center of Southern Helsinki, 1989, office bldg for 100 workers	-	-	+	-	special lamps designed for the house (direct and indirect light)
Espoo Energy 1989, multi-user office bldg for 250 workers	+	-	+ ¹⁾	+	stand by power plant, interhouse video broad casting, intelligent telephone switchboard with flexiwork facilities, room for leisure time activities
Teollisuuskatu 33 1992, multi-user office bldg for 117 workers	+	+	+ ¹⁾		
Maari's House 1991, multi-user office bldg for 60-70 workers	-	-	+ ¹⁾	+ ¹⁾	

1. a LAN for each company and a LAN for the whole building 2. a LAN for each company

Table 1b. Summary of the offices studied for comparison

The result of the Intelligent Building in Europe study (1991-1992) by DEGW (London), Teknibank (Milan) and the Intelligent Building Group was not available for the preparation of this questionnaire. Equivalent information to the results of this study was found in the American BOSTI Office Survey carried out in the middle of the 80's by Michael Brill with Stephen T. Margulis.

In this article the most important discoveries of the study are reported, except for the results of the indoor air measurements. The quantity of detail information cannot be covered.

Who Works in an Intelligent Office?

In the intelligent office, there are more male workers than female. There are numerous employees with good educational background, and they have a supervisor's position more often than in those companies located in other kinds of office building.

Although those who answered the questionnaire were selected according to the building they were working in, there were no special differences found in the sample compared to average Finns.

Amount of (percentage/%)	IB	Non-IB
male	58	45
age (average)	37	39
education (academic degree)	58	45
supervisor	24	13

Table 2. Office workers (IB=Intelligent Building)

The personnel of the companies located in the intelligent buildings work overtime more often for compelling reasons than workers in the other offices. However, the workers in the IB-offices are more satisfied with their work, that is, position, company, supervisors, co-workers, salary and occupation. The co-worker is the only variable with significant statistical difference. The IB-office workers take less sick leave, but they do have more symptoms, which were asked for in the definition of indoor air quality, than those working in the other type of high quality offices.

Good working space or meeting point?

The size of the Finnish office workplace is app. 10–13 m². Office space per person is altogether 25–35 m². In the intelligent offices less than average working space is needed. In contrast, the meeting rooms and space for office services take double the space in the intelligent office buildings than they take in the other type of offices.

In those offices studied, 15 % of the working hours were spent out of the office, and 38 % of the working time staff are not in their own rooms. In spite of the good and spacious conference and seminar rooms, workers in the IB-offices spend more time in their own workspace. Workers do not consider working areas significantly good in intelligent offices.

On the other hand, lobbies and reception, show rooms and meeting rooms, parking and green rooms are valued in profit making. They are valued when evaluating spaces according to the importance for the working efficiency. In the statistical study several variables showed significant differences in this respect, proving the power of intelligent building space design.

Calculations show considerable savings in customer events, if they are held in the companies' own building instead of a restaurant or a rented (show) room. In some cases, in the intelligent offices the meeting, show and customer rooms are shared with many companies. This makes customer service even more cost effective. The workers in Finnish intelligent offices are very satisfied with the quality of office space when considering the possibilities of impressing customers.



Figure 3. The glass roofed lobby of several storeys height is very typical of intelligent offices. It is used as a meeting place and show-room or the restaurant is located there. The restaurant in the glass roofed lobby of a multi-user intelligent office building, Pilotti in Tapiola Espoo.

There are few libraries and sports rooms, and not much room for other hobbies in the Finnish intelligent offices. People miss most a gym and a swimming pool, and improvements in the rooms for taking short breaks.

Plenty of natural light, green plants and a view of vegetation from the office room window are examples of the soft elements that are mentioned as pleasant. Beauty in the office is important and almost as important for male as for female workers.

Moving, flexibility and modification

In the intelligent office, it is easy to have more space for extra people, or to change spaces when needed for organizational reasons. It is possible to modify the office rooms or get more room, if there are changes in the company size. This is not the case in offices in general.

Furthermore, the intelligent possibility to modify each piece of furniture and the furnishing layout is evaluated as significantly better than those possibilities in the other type of offices.

Moreover, a result of the study is that moving into the intelligent building is easy, as expected, since it has been a target in the intelligent building design.

The possibility to work overtime in good conditions, is an advantage gained through the flexibility of the office building. In this study, it was unfortunately impossible to gather information on the amount of overtime work done in various companies. Thus, we cannot calculate the significance of overtime work in the grand total of the intelligent building performance.

How many computers?

In Finland as in other industrial countries with high working costs, automation has taken a strong role in business life, and this includes office automation, building automation and telecommunication. The need for computers, telefaxes and printers in offices is undisputed. The thing that matters is the quality; speed, capacity and user friendliness. Finland and Sweden are leading countries on the ranking list of mobile phone users. In every fourth Finnish home there is a computer, but 66 % of the office workers have a home office and 80 % of them a home computer. In the office, phone and video conferencing equipment are communications systems with a very low use frequency (in 1994). The few users come from buildings, where there is a video conference room or from companies where the use of teleconferencing is supported in other ways.

From the users' point of view, one can make the most of office automation in the intelligent offices. There is every kind of good working

high-technology, such as LAN (local area network), telematics and personal computers, and the telecommunication systems in the reception area and in secretarial work or in information services. The technology is not very different from that of the modern office building. Is the intelligent concept the only factor that makes the difference? The integration of the devices and structures has its positive influence on the performance of the equipment too.

In every case, the advanced advice and security system is the only one not very well valued. Its controlling nature might be the reason for this. The software design might solve the problems with these systems.

There were only a few female supervisors in the intelligent offices, as not many exist. Their opinion of office automation was more positive than that of the others. The discussions with the staff of the property owners confirm this conclusion.



Information Efficiency

Can we take advantage of this stock of ever-advancing technical equipment? It seems obvious that it would be good to pay attention to the human ability to learn new things like new versions of computer programs. The office workers report in the study that they know only limited ways of employing new technology available to them.

It helps to know, however, that it is the supervisors who appreciate the office services and equipment most. In the intelligent offices there are more supervisors, i.e. people with good salaries, than in the other type of offices. This makes it possible to think that the investment in apparatus and services as well as in other intelligent building features can be paid back by the increase in work efficiency. The calculations of the influence of sick leave, which is less among intelligent office workers, will be made later.

The most expensive intelligent feature in Finnish office buildings is the glass roofed, steel and glass curtain-wall lobby of several floors' height. Although, it is not yet very often used for meetings or for other occasions, it is highly appreciated by workers because of the increase in the work efficiency. In order to pay back the investment in it, app. 5 % increase in working efficiency is needed, depending on the case.

Another costly feature is good air quality. According to other studies the investment in air conditioning in the working environment is worthwhile. Surprisingly, air quality is not particularly good in the in-



Figure 4. In the intelligent office building there is space available (see 4a) and you buy or rent as much as you need. Access to all services is convenient (4b) and you make your own office layout (4c), which is easy to change. These pictures are from the Siemens Nixdorf Headquarters in Helsinki.

telligent offices. At least, it is not good enough from the user's point of view, if we look at the average values. Actually, three intelligent offices out of five have as good indoor air quality as that of the non-intelligent ones, but two of them constitute a not so good exception. The control and regulation of heating and air conditioning is not good either.

A reason for this might be the use of new integrated technology in many cases in intelligent buildings (please see Tables 1a. and 1b.), and designers and contractors are not yet mastering it well enough. The another reason could be the image of intelligence being of high standard, which does not allow any kind of imperfection, not at least in basic technology such as in heating and ventilation. Finally, it is good to notice that intelligence in buildings does not necessary mean high quality HVAC systems, which was the fact in some cases in the intelligent offices studied.

Balancing the human need to control one's own environment, and the human desire to have it made as easy as possible, is not that simple even when the target in design is to allow as much personal freedom as possible.

Energy Efficiency

The average energy use of electricity in Finnish office buildings is 17 kWh/m³. The intelligent offices use more electricity, 22 kWh/m³. However, the IB-offices are energy efficient, because heating energy use is 25 kWh/m³, far less than the average for offices, 35 kWh/m³.

The new low energy building technology has better figures in heating energy. This can be possible in the future in every type of office building. One can presume that the same property developers who are taking advantage of the intelligent building concept will make good use of low energy technology, and increase the lead.

Electricity is used for lighting, building automation and information services. Lighting and computers consume the most energy. The new computer technology, such as STAR computers, will reduce the energy demand of computers 30–50 %.

If we take into account the information efficiency, that is, the increase in information transfer by electrical means, the energy efficiency of the intelligent office will give even better figures. In this study, the quality, but not the quantity of the building and office automation and that of the telecommunication was measured. That is why the effect of good commuting equipment and services on work efficiency and on the grand total of the advantages cannot be calculated precisely. This issue will be studied in more detail in the coming research.

Telecommuting

Most of the workers in the offices studied did not believe that the use of telecommunications reduces work-related trips. Still, a portion of 30 % thought that there is a diminishing effect.

According to the literature, the type of work-related trip has an influence on the possibility to replace the trip by information transfer by such means as telefax or email (Himanen & al. 1995). The most commonly used teleservices seems to have a reductive effect on trips made by car or train. Videoconferencing and video on desk multimedia systems are expected to have an influence on the reduction of flights, which is the most energy consuming and polluting form of work-related trips.

The reduction of work-related trips adds to the energy efficiency of the intelligent office.

The reduction of work trips, from home to work and back again, is more a flexiwork related possibility, and not dependent on the office type. Intelligent office features can promote flexiwork possibilities, and thus, even add to the performance of the building by the reduction of work trips.

The secret of the intelligent building features

The intelligent building concept seems to make the difference. The electrical intelligence in offices in Finland is carried out very sophisticatedly in any type of office. But when this equipment is installed in a office according to the intelligent building concept it works better than in a case traditional office design principles are followed.

The intelligent office workers consider the glass roofed lobby and spaces for shared services to have good impact on work effectiveness. These spaces are not allways the standard in office buildings (please see tables 1a. and 1b.). White collar workers like the green plants, waterfall elements and such, and a new type of illumination, personal control systems and so on – all features put into practice in intelligent offices in a manner, which is of high-class. Intelligent meeting rooms and restaurants are highly valuated, while a beautiful and durable environment meets the customers' needs as regard to flexibility, cost, productivity and in integrity. Quality stands for more than expensive materials, furniture, lamps and so on.

The energy use in IB-offices is different from the norm in various ways. There are a large amount of personal computers and well fitted out telecommunication equipment. The building control systems are many (building automation, doors, inter-office video, etc.). All these are using electricity, and the sophisticated HVAC system with cooling is adding the load.

The glass roofed lobby in a cold climate is both increasing energy use for heating and saving energy, while making possible the use of natural lighting and passive solar energy.

The energy use control and regulation is easy, and changes in energy consumption or interferences in devices can be noticed immediately. They all diminish the heat energy use in IB offices resulting to a grand total less than that of the other type of offices.

Office – the academy of the information era

When the end users of the buildings were asked the most important reason for a company to move into an intelligent office building, the image of the building was essential not its price.

The price is dominant in the other type of high quality office building. Efficiency counts in the quality of the workplace and of the rooms for meeting customers, in commuting and in the number of the work-related trips, and in energy use. Efficiency is traditionally understood as the cost-benefit ratio. One cannot deny that the office is the factory of the information society.

Finally, I would like to point to the next step. How long will mankind only be interested in getting better off, with the progress gained through the means which are the cause of the cost-benefit ratio, or with that which the cost-benefit ratio is describing? Is this kind of progress beneficial? The image of the building, commuting and work related trips are all issues carrying various values. Could it be possible to think that the performance of the office building could also be described by a fun to knowledge ratio, positive experience to wisdom ratio? Benefiting from the material good gained might lead to letting the office become a fertile place for creative knowledge and skills, or an energetic place for satorian insight.

Using the phenomena known in future science, it can be said that weak signals of the next step are seen in the intelligent offices, in hot desking or in flexiwork. Enjoying one's work is totally different from being a 'workaholic'. Enjoyment is based on success gained by recognizing problems not avoiding them.

There is plenty of detailed information on the advantages of intelligent building technology studied, to be discussed later. The study will continue in two European countries in order to compare the Finnish office buildings with the offices in some other European countries. Most probably these countries will be Sweden and Germany.

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Photos: Sami Karjalainen

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