IMPACT OF TELEWORKING ON INDOOR CLIMATE AT HOME

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ABSTRACT

The greater availibility of information and telecommunication technologies and the trend towards flexible working practices allow the home and the workplace to coexist. Many studies mainly emphasize economic and social consequences of teleworking. However, there is no assessment of energy and indoor climate impact of teleworking at home.
Furthermore a professional activity is usually not envisaged at home, and home is not built according to the same building design process as offices. Consequently, teleworking at home raises new questions about the evolution of dwellings.
Thus, the purpose of this article is to show how teleworking can be one factor of change for the futur building. It presents how a systemic approach provides indications of different changes on energy performance and comfort at home.

KEYWORDS

New technologies, teleworking, home, building, indoor climate, energy performance.

1. INTRODUCTION

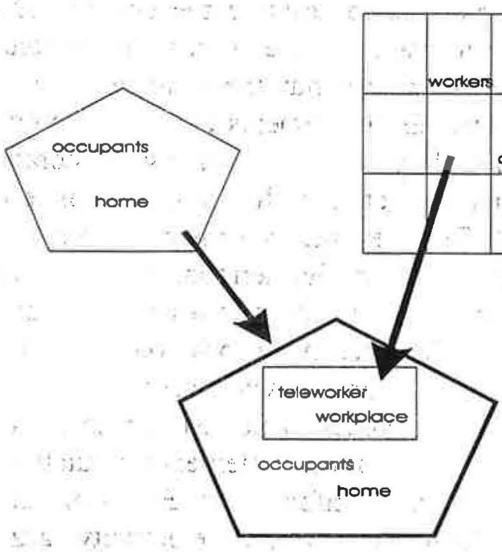
Several surveys indicate that an increasing number of people are teleworking [4]. In Europe, they were valued to more 1 million in 1994. In US, they were about 6 millions in 1992, then there were more than 9 millions in 1996 [5]. Among the indicators, the sales of computers and faxes or increasing communications confirm new working practices [3][7].
Teleworkers are working from home, either on a full or part time basis, either as employees or as self-employed peoples. There are studies that emphasize economic and social consequences of teleworking but the impact of teleworking on indoor climate at home is not known. Furthermore, a professional activity is usually not envisaged at home, and home is not built according to the same building design process as offices. Besides, it is difficult to give a global description of home. Home is a complex system which means the building as well as its occupants.
In order to identify changes on energy performance and comfort at home, a systemic method is used to model this complex system. With an analytical approach, systemic method allows a transversal approach which considers numerous variables and their interrelations. It enables to

describe several impacts of teleworking on indoor climate at home and the implications for planning and house design or equipments.

2. HOME COMPLEX SYSTEM

2.1. Teleworking at home problem

Since some years, the development of information and telecommunication technologies assigns the way of life of many people : personal computer, software, hardware, internet, cyberspace, numeric systems, on line, off line, networks, etc.
Besides, working practices change with increasing of tertiairy sector [4] and the greater availibility of information and telecommunication technologies. New forms of working are attractive to businesses which seek to improve flexibility and efficacity [3]. Teleworking at home is one of these new working practices. The benefits to the employer may be an increasing productivity, a wider pool of potential employees or reducing costs. It allows reduction of accomodation costs for employers. The motivation for organisation to implement telework may be the direct economic benefits derived from downsize in floor space requirements [7]. Governments indicate a possible reduction of atmospheric pollution generated, particulary, in big towns where people use to go to work by car. Teleworking reduces or canceles travel time. The physical transport of people is changed by information and telecommunication supports. It appears as a new tool for territory policy [4].



Impact of teleworking

New relations between employees and organisations appear with telework. The professional activity is transfered at home. An increase of teleworking at home raises new questions about the evolution of dwelling. It is a fact that in office buildings, the exigencies of workplaces design often answer to social and economic constraints. The exigencies in dwellings are not the same that in offices. A dwelling is not usually designed to work. Neverless, a teleworker has to work at home. The development of teleworking put the question of a new relation home-work. In building parc, the dwelling functions were still recently separated from the working functions. Indeed, it was possible to distinguish home place and work place. In spite of reports and numerous studies [7], there is no assessment of energy and indoor climate impact at home.

In fact, the meaning of home is complex. Its meaning is both heritage, historic continuity, identity, individual expression, privacy, social, etc. Many meanings may be set forth. An analytic approach is not sufficient to describe this complexity of home. There is not on one side, buildings, and on the other side, occupants. The interrelations between the building and its occupants have to take in account, particularly in a study of indoor climate. A dwelling and its occupants have to be considered as an unified complex system instead two individual systems. A new approach taking account a global vision is necessary to tackle this complex problem.

2.2. Systemic method

Systemic approach gives tools to tackle this complex system [6]. This approach depends on cybernetics and system theory [9]. This methodology uses fundamental concepts of interaction, totality, organization, finality and complexity [10]. There are different definitions of the word system but Rosnay's definition is suit for the purpose: « A system is a set of elements in dynamic interaction organized for a goal » [12]. Two factors are important in the concept of complexity : the large variety of components or elements that possess specialized functions and the non-linear interactions between these elements. This definition also introduces the concept of finality (the goal of the system). Home is a complex system which unify building and its occupants. Moreover, these two elements may be organized in internal hierarchical level linked by a great variety of bonds.

Two groups of features make it possible to describe the system [12]. First, the structural aspect concerns the organization in space. Elements can be counted and assembled. For instance, it may be the building, the room, the flat, the walls or the windows, occupants, etc. In addition, there are reservoirs in which the elements can be gathered and in which energy, information and materials are stored. In particular, a heating oil storage, a refrigerator and a library are reservoirs. A communication network allows the exchange of energy, matter, and information between the elements. This network can assume the most varied forms : pipes, wires, cables, electric transmission lines, etc. Furthermore, there is a limit that describes the boundaries of the system. The limit allows to identify several environments in which home has finalities : economic, social, physical, technical, physiological, etc.[11]. For instance, it can be the physical envelop of the building or the living space.

Secondly, the functional aspect concerns process dependent on time (exchange, transfer, flow, growth, evolution). Flows of energy, information or elements circulate between reservoirs. For example, there are flows of money, people, information. Flows of energy raise or lower the levels in reservoirs. In building, these flows can be electricity, gaz, water, informations, wastes, etc. Besides, valves control the volume of various flows. Each valve is a center of decision that receives information and transforms it into action. Feedbacks loops play a decisive part in the behavior of a system through integrating the effects of reservoirs, delays, valves and flows. For instance, the thermostat or the envelope of the building operates a thermic regulation. Delays result from variations in the speed of circulation of the flows or in the time of storage in the reservoirs. For example, there is the thermic inertia of the building or the bell of telephone [11]. The structural and functional aspects of system make it possible to understand better the role of interactions and identify finalities of the home.

Together with a analytic approach, systemic method allows a transversal approach of home system. Thus, several finalities of the home system can be identify [11]. Among their finalities, there is a physiologic finality which take into account indoor climate adapted to occupants. This finality is to optimizise the physiological environment of the occupants according to their activities. An economic finality insures a balance of costs in which the energy costs are included. Teleworking at home involves a professional finality of the home system and affects all the others, particularly physiologic and economic finalities. This impact directly concerns two levels : indoor climate and energy performance.

3. SEVERAL IMPACTS OF TELEWORKING

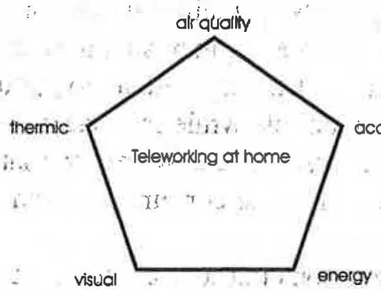
3.1. Indoor climate

One main finality of the home system is to create a space which is in accordance with the activities of its occupants. For the comfort of teleworker, it is not sufficient that every equipment is suitable and high performance. It has to be situated and modeled on the teleworker [7][8]. The building, the workplace and the occupants have to be considered together.

In tertiary activities which imply visual functions, the lighting quality and the quality of the work environment influence the productivity. For instance, the workplace at home have to respect several constraints as following exigencies :

- the screen is put to control the dazzle and to avoid the reflects of daylighting, and the artificial lighting is adapted in the same goal ;
- lighting is adjusted with desk light or indirect light ;
- the hight of the table, of the seat, of the keyboard is determined from the screen;
- the supports of documents, the printer, phone, fax are spread around the teleworker on a work place;
- every adjustement has to easy accessible for the teleworker ;
- the broadcasting radiation of the screen which intensify visual trouble (blurred vision, headache) has to reduce [8].

A minimal lighting level, on the work plan, is valued to 500 lux in offices, 750 lux on a drawing board. The recommanded value in a bedroom is 200 lux and 500 lux in a kitchen. Lighting in office ranges from 10 to 30 W/m2 [2].



Indoor climate and energy performance

Besides, the physic comfort parameters, usually considered, are air temperature, radiation temperature, humidity and speed of air. The occupant is caracterised by clothes and activity. Thermic comfort is considered acceptable if the PMV is between -0,5 and +0,5. It is obvious that teleworking activity at home influence these parameters.

For instance, working place supplies heat. Teleworking equipments supply thermic, hygrometric effects and radiations. The heat supplies by computers is diffused in home. Data processing equipments need specific climate. In addition, a other goal can be to decrease the electrostatic level of the work place. Also, the people being sitting are particularly sensible to the no-symmetric radiations and draughts. Consequently, numerous comfort exigencies change when a occupant turns a room into a workplace.

However, thermic comfort is not an independant component of global comfort of teleworker. About air quality, teleworker is more exposed to inside pollution than outside pollution. The sources of inside pollution depend on the occupation of the rooms and the activities of occupants. Human metabolism supplies H2O, CO2, NH3, smells, micro-organisms and particles [2]. Others sources link to activities are smokes, combustion machine, cleaning activity, kitching, aerosol. Some organic components come from construction materials, varnishes, maintenance products and office equipments. French regulation recommands about $25m^3/h$ for renewal of air for an office of $15m^2$ with one person.
About acoustic comfort, the design and the choice of the equipments is dealing with the goal to reduce noise pollution. For instance, the acoustic level can not exceeded 40 dBA for an office or a library. The maximum level is 50 dBA for a place with office automation materials. At home, the different activities of family are varied and have to considered. There are not always adapted to facilitate a professional activity. The work place has to be isolated because a noisy workplace may also disturb other occupants at home.
Therefore, several impacts of teleworking on indoor climate are identified. They show a possible evolution of indoor climate at home inferred from the great availibility of new technologies and teleworking practice.

3.2. Energy Performance

About energy performance and financial impact, a part of consumption is due to office equipments. Several trends have shown following points [1]:

- energy consumption for microcomputers increases;
- large and colourate screens (about 100W) take place of little monochrom screens (about 50W) ;
- there is an evolution towards a multiused and integrated materials, for example computer + modem + fax ;
- there is a growth of the networks. The new configurations involve more consumption because, for instance, equipments remain switch on and the evolution of message communication involves to maintain equipments on to receive messages ;
- the real electric powerful of the individual computer ranges from 50W to 200W. The electric powerful of a printer can double while the machine is in operation ;

The inside thermic gains are assessed to $20\ W/m^2$ for materials, 20 to $30\ W/m^2$ for lighting and $10\ W/m^2$ for the occupants. Lighting consumption ranges from 30 to 70 kWh/m^2.year for office.
Besides, another part of energy consumption comes from heat water. In an office, about 6 liters of waters at 60 degrees is used by one person/day. It essentially corresponds to toilets uses and involves energy consumption from 40 to 100 kWh/person for one year or from 2 to $5kWh/m^2$.year [1]. Moreover, a teleworker does not usually eat outside but at home. Meals are taken at home. Consequently this new use increases energy consumption for the kitchen.
The home planning of teleworker is not the home planning of a classic worker. Besides, it is not a classic work planning. He has to work in a family environment. Different activities involve different consumptions. Thus, the energy consumptions are moved towards at home while teleworking practices reduce energy costs in a office for the employers.
In addition, teleworker has to communicate with outside environment, with services, companies, customers, etc. A communication network is used to allow flows of informations and datas. The different networks, weak and strong current, have to be separated. A electric network protection is sometimes recommanded for computer equipments. Precabling building has to be considered in order to avoid doing an installation little by little. Only one line is

often not enough to telework. An improvment of the network is necessary to separate private and professional connections.
Different works are necessary to fit up a study in a bedroom: electricity, work place, shelves, etc. These fittings depend on teleworking degree and the disponibility of space at home.
Consequently, new working activities at home influence architectural design. A workplace appears as a specific place or a move place in a dwelling. However, in France, any transformation from home to workplace has to conform regulations and today it raises legal questions [4][7].

4. CONCLUSION

The analytic and the systemic approaches are complementary. The new method considers the home system in its totality, its complexity and in its own dynamics. This original approach takes into account effects of interactions between elements of home complex system.
Some qualitative impacts of teleworking are valued. Elements of a quantitative approach are given. The impact of teleworking at home is estimated in the physiological finality of the home system which is assigned by a new finality, the professional finality. Several impacts are considered in visual, thermic and acoustic comfort. Air quality exigencies are modified as the energy consumption in the home. Experimentations have to valid this study and particularly to allow an quantitative assessment of impacts of teleworking at home.
This study initiates a forecasting approach included in the evolution of energy performance and indoor climate at home. Supposing that an increasing of teleworkers is considered, today estimated to 1 million of teleworkers at home in Europe, impacts on dwelling parc can be important. It is better to anticipate an evolution of buildings than to stay a possible inevitable change, especially as the fast evolution of new technologies is not the same speed than the evolution of the building parc which has an important inerty. The building parc has to be adapted to the new activities of its occupants. It has not to slow down new working practices. The design of building has to consider development of new technologies and new working practices.

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