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SOME REMARKS ON ENERGY AND RESOURCE CONSUMPTION OF NEW INFORMATION TECHNOLOGIES

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ABSTRACT

Current research into the application of information technologies is largely focused on technological and socio-psychological issues. The following paper offers some remarks on the consumption of energy and other resources by these technologies. It is concluded that while in principle, new methods of telecommunication and information technology require fewer materials and less energy than traditional ones, but carelessly designed systems and applications could cause tremendous increases in such use. The design of a new technological system together with human attitudes toward changing modes of communication will be primarily responsible for its consumption of energy and materials.

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1. INTRODUCTION

In the literature of studies assessing information technology, interest is currently focused on human considerations (i.e., impacts on individuals, meaningful communication, employment,working conditions, privacy, society, etc.). An investigation of the literature in the field of Viewdata-like systems shows that at present approximately 6.5% of the publications deal with assessment and social implications. (1). In this paper we want to add some remarks on the energy and material demands of new information technology.

The paper deals first with the special situation of communication technology with respect to energy/resource accounting. The basic result is that communication technology could save a great deal of energy and material if it were designed to do so. On the other hand, in practical applications the implementation of a new communication technology might well have the opposite effect and result in a waste of energy and materials of unknown proportions. Since communications technology has uncertain consequences with regard to energy/material use, it should be implemented and used in a way that takes maximum care of its resource/energy saving possibilities.

2. THE RESOURCE CONSUMPTION OF TELECOMMUNICATION AND INFORMATION SYSTEMS

Assessments of particular technologies usually focus on at least one of five main limited resources: water - energy - land - material and manpower (2). In the case of telecommunications the impact on manpower and society is regarded as the most important topic and has already been labeled with a specific term: "information assessment" (3). Information assessment is defined as "research work, dealing with the political, economical and social consequences of actions of information policies". The direct impact (if any)of communication technology on land and/or water is usually regarded as negligible and will be omitted from this brief paper. The information of some major inventions determines no major impact of communication technology on water, land or air in the last 150 years (4). However, we believe that the absence of major (negative) impacts on the environment is a very important advantage of communications technology; e.g. compared to transportation technologies. The following considerations call attention to the last two factors: energy and materials. With regard to these resources, the basic problems of telecommunications are quite different from those other of large new technologies, for the following principle reasons:

a) Substitution of Resource Demanding Systems

Telecommunications systems are often introduced to substitute for other large resource-consuming systems. Thus, where its introduction is successful, the new system necessarily consumes less energy and/or materials than the traditional one being replaced. Examples of this are the French Electronic Directory System, which was introduced to substitute for expensive and resource-consuming telephone books (paper), or IIASA's CAITR experiment, which aims at saving travel costs (energy) by supplementing personal meetings with teleconferencing (5). While in such cases the amount of energy or material used by the newly introduced telecommunications system is often high in absolute terms (and is the very important cost factor), it is still much lower than that of the technology it replaces.

b) Rapid Development of New Systems

The resource and energy usage of telecommunications technology has the same rapid innovation rate as the technology itself, and is moving very rapidly towards lower energy/resource needs. For example:

- The equipment is becoming smaller and less dependent on other systems (e.g., air-conditioning), and is itself requiring less energy. (An example is the microprocessor technology where over the past years the number of electronic components in each unit has grown at a rate of 75% per year and the capacity of semiconductor storage has increased by 90% per year, while energy/material demand has remained approximately constant), (6).

- Resource-intensive infrastructure (cable-based networks) is being used much more efficiently through technological inventions, (e.g. multiplexing), or is being substituted by other less resource demanding systems (satellites and broadcasting). This development often occurs rapidly enough that a highly material-consumptive technology can be substituted by another technology before the occurrence of a severe shortage of a certain resource.

c) General Trend Towards Less Energy Consuming Procedures with Existing Systems

Furthermore, there is a general trend towards less energy consumption in existing systems either through better technological processes or through the use of less energy demanding material:

- The energy needed for one telephone call changed from 1.5 10^{-2} kWh in 1975 to 1.2 10^{-2} kWh in 1978 (7).
- The quotient between input and output-energy for broadcasting changed from 2.4 to 1.3 in the same period of time (7).
- Copper cable-based networks are being substituted by fiberglass: copper needing 21000 kWh/t, glass 7200 kWh/t, and plastics 2900 kWh/t. Boxes for equipment are no longer being made of steel(12600 kWh/t) and aluminum (67200 kWh/t) but with plastics (2900 kWh/t) (8).

d) Resource-Intensive Components in the System are not Necessarily the Most Important Ones

Finally, the most energy consuming parts of telecommunications systems are not necessarily the crucial ones from a technological point of view. As an example take a comparison of the energy consumption of broadcast videotex and interactive videotex. One million videotex participants using the system for one session a day would consume:

- 1.2 10^4 kW hours (1.2 10^{-2} per session) using interactive videotex,
- 1.4 10^2 kW hours (energy per broadcast-hour on TV) using broadcast videotex.

The difference in energy usage of 1.18 10^4 kW hours is only 1-3% of the total energy usage of such a system and is due mainly to the fact that the energy of the videotex-terminals ranges between approximately 0.3 and 1 kW per unit (0.3-1 10^6 kW in total). This energy is used mainly for the screens, cooling devices, hard copy facilities, etc., which form the man/machine interface but are irrelevant to the system configuration itself.

Thus, from an energy and material point of view, when constructing a system such as videotex the design of the equipment and the environment of the system are far more important than the design of the logic of the system itself.

3. THE IMPORTANCE OF THE ACTUAL IMPLEMENTATION

For the user, of primary importance in the implementation of a communication system is the interface between man and system. At present, the man/machine interface of new technology is usually designed to resemble traditional communication behavior, (in order to make the systems more readily acceptable). This often plays a major role in the energy/material - usage of the system.

3.1 Paper

Paper is still the most important communications medium. It is, to a certain degree, renewable (by recycling) and is produced from a (theoretically) renewable resource. Nevertheless, the production of paper requires large amounts of energy, water and wood: approximately one cubic meter of wood, 0.5 to 1 million liters of water, and 6400 kWh energy (9) are needed to produce one ton of paper. Thus, paper is one of the most energy consuming materials in use.

This fact together with the so-called "information-explosion", (actually a "paper-explosion"), make it reasonable to regard paper-savings as a main motive for technological development in telecommunications. This is true mainly in business, where the "office of the future" is often used synonymously with the "paperless office" (10).

Videotex systems are a good example of how "paperless offices" could be realized even now: if a local videotex system is installed in a company and each office employee gets his own terminal and a special "mailbox" (storage place) in the system, most communications could be handled through the system. Systems such as videotex could, for the time being, only be used as an internal communication device rather than outside the organization (due to the absence of technology compatible with most other communication partners, like private households or other offices), but could still result in a tremendous cutback in the paper demand of the office, since at present 80% (11) to 90% (12) of office mail is produced for internal office use only.

The following rough calculation shows how important an electronic message sending system could be for the energy used in an office.

The energy demand of one hour work with:

-- an electric typewriter is approximately 40 Wh and uses, say, 10 pages of paper (this means an additional 320 Wh for the production of the paper);

-- a low speed printer is approximately 100 Wh and needs approximately 50 pages (with an additional energy demand of 1600 Wh for the production of the paper);

-- a screen terminal is approximately 300 Wh and needs no paper at all.

Therefore, in each configuration that relies on paper as a main output medium, the energy usage for the production of the paper far exceeds the energy usage of the system. Thus, from an energy and material point of view, (disregarding other technical parameters like possibilities of storage, retrieval, communication, etc.), new telecommunications equipment is preferable to traditional paper-based systems.

The energy and material consumption of new telecommunication equipment in the office is therefore due mainly to the use of paper. Reduction of paper consumption could be realized if, either:

a) The main output device for communication changes from paper to screen (without hard copy!), or

b) there were new developments in "re-useable paper" (13).

However, at present, when electronic office systems are introduced,their screen terminals are in most cases supported by hard copy devices to make the human interface look and behave more like a traditional system and, probably, thus be more acceptable to the user (14). The result is that at the moment,electronic office systems need much more paper than traditional approaches (15). This is mainly true in the introductory phase of a new telecommunications system. If the system is not very reliable, (or even if users are apprehensive that it might not be), users tend to build a "back-up-system" in the traditional form. This not only hinders the new system from coming into full operation, it also causes a tremendous increase in energy and material consumption.

The paper saving aspect of videotex for example is mainly due to the use of the medium as information systems. When videotex terminals are used as transaction - or message sending devices, the tradeoff between communication and transport are relevant.

3.2 Transportation

Tradeoffs between telecommunications and transportation play a major role in the influence of information and telecommunication technologies on the consumption of energy and material: certain transportation efforts could easily be substituted by appropriate telecommunications facilities. This is most feasible for certain kinds of office work that (in addition to face-to-face personal meetings) could be performed on a dispersed or "long distance" basis; i.e., each participant stays at a convenient place (e.g., at home) and communicates via a telecommunication network with his co-workers. The communication medium might be computer terminals or videotex systems.

Inherent in this form of communication are several important socio-psychological problems, (less personal contact, no informal communication, changes in the structure of the work as well as of the family, etc.), and it would of course not always be suitable. But in an era of growing transportation costs, such methods are being increasingly discussed and from an energy and cost point of view, their consequences have already been calculated (16).

NILLES et al. (17) for example, show the following: the operating energy costs for a group of commuters, in this case insurance company employees using automobile in Los Angeles in 1976, was 64.6 kWh per person per day. If the same group used normally loaded mass transit systems, (mostly buses, load factor 20%), the corresponding energy consumption would be 24.1 kWh per day. A fully loaded mass transit system, (i.e., if all available spaces were always occupied), would need 4.8 kWh per day for each commuter.

Comparable costs for telecommunication were calculated on the basis of 5 hours terminal use and connect-time and resulted in 0.68 kWh per day per user. However, this figure is the delivered electrical energy to the telecommuter. If we take into account an additional conversion factor in order to refer the energy cost back to the input-fossil-fuel-energy required at a conventional electric power plant, we end up with 2.2 kWh per day per telecommuter, which means that the advantage of telecommuting over commuting via private automobile is 29:1; over commuting via mass transit it is still 11:1.

Another comparison of transportation and telecommuting was performed at IIASA in 1978 (18). In this case, traditional forms of scientific cooperation were compared with similar forms assisted by telecommunications facilities, i.e., "invisible colleges". Without telecommunications the "invisible college" would consist of letters between scientists and one three-day conference with subsequent transcribed and distributed proceedings. The "invisible college" via telecommunication consisted of 15 minute usage of the communication system per day per person for six months, plus one synchronous conference, initial telephone calls, and familiarization sessions. Similar calculations were done for different forms of scientific communication worldwide and within Europe. The results are given in Table 1 (19).

TABLE 1: SUMMARY OF COST COMPARISONS

(in 1977 in Austrian Schillings)

ACTIVITY	ESTIMATED COST INCLUDING COST OF MANPOWER		ESTIMATED COST EXCLUDING COST OF MANPOWER	
	(1) VIA CAITR *	(2) WITHOUT CAITR *	(3) VIA CAITR *	(4) WITHOUT CAITR *
INVISIBLE COLLEGE, WORLDWIDE (50 PARTICIPANTS, 6 MONTHS)	2,471,850	3,897,450	1,534,350	3,417,450
INVISIBLE COLLEGE, EUROPE ONLY (20 PARTICIPANTS, 6 MONTHS)	866,490	1,250,475	476,490	1,070,475

* CAITR: Computer Assisted International Team Research

These calculations show again that telecommunications systems are less energy-consuming, and thus cheaper, than traditional approaches and that the present technology could be used to substitute for them. Again, this does not guarantee that the introduction of telecommunication systems will actually bring about a savings in energy or materials: better means of telecommunication enables contacts between more distant people who may then want to meet personally from time to time. Therefore, in the long run better telecommuting facilities could cause an even higher demand for personal commuting. International scientific institutes, multinational corporations, etc. need certain forms of telecommunications in order to operate. The better the communication technology is, the better and more dispersed international activities are likely to be, and the higher the demand for travel could be, too.

4. CONCLUSION

In principle, new methods of telecommunication and information technology need less energy and fewer materials than traditional ones. This does not necessarily mean that the introduction of new telecommunications systems would lead to a reduced consumption of energy or material: user-system interfaces designed to resemble the traditional approach and improved and increased communication contacts through new types of telecommunications could cause energy/material use to be even higher than it was before.

Difficulties with the man/machine interface and the other negative effects mentioned are due mainly to socio-psychological factors and not to the technical structure of the communication system itself. The responsibility for the energy/material-consumption of a new telecommunication systems therefore mainly lies in the system's design and in human attitudes toward changing modes of communication.

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