Impact Assessment of Advancing IT Orientation on Forms of Energy Use[1]

Hiroki Kudo
Group Manager, Environment Group

Introduction

Advances in IT can change our home life and economic activity drastically by prompting increased ownership of energy-consuming appliances, particularly electricity-powered ones, and getting information upgraded. Resultant drastic changes are likely to have a massive impact on energy use in both qualitative and quantitative terms. But, until recently few in-depth analyses have been condusted on whether ownership of energy-consuming appliances leads to more energy use, or if the increasing number of IT-based energy-efficient appliances cause energy consumption to shrink.. With such efforts having just started, accumulating and considering IT-energy impact assessment has become a matter of increasing importance.

This paper summarizes the impacts that advances in IT have on energy consumption in the years until 2020. In specific terms, we first imagine the future of communications infrastructure, and we try to figure out the magnitude of impacts yielded by advancing communication net on social systems and energy consumption. Assuming a society with well-installed communication net, we quantitatively assess the likely impacts on energy use by sector (manufacturing, financial services, distribution system, retailing, offices, public services, medical services, school education, home life, traffic system).

1. Objective of Analysis

In recent years, society has been undergoing rapid changes by virtue of so-called IT (information technology), which takes such forms as advancing information & communications technologies, progress in communication net, a greater ownership of personal computers, and mushrooming new services, notably via the Internet. Awash with such changes, firms are searching for ways to be more efficient and new business operations, while consumers have begun seeking fresh benefits from information gathering and exchanges via the Internet. These moves, among others, are now

[1] This paper outlines our findings of a report on "Impact Assessment of Advancing IT Orientation on Forms of Energy Use," a FY2001 research project awarded to IEEJ by the Committee for Energy Policy Promotion. For details, see the report.

revamping our time-honored social system and lifestyle itself. The advance in IT orientation and resultant changes in both social system and lifestyle consequently affect the forms of energy use. Any firm increasing its profitability by taking advantage of communication net can also be an efficient energy consumer by endeavoring to increase efficiency at its manufacturing plant and trim surplus stocks at the distribution stage. Consumers who want to enjoy benefits of IT need to own and use IT appliances that enable them to receive a variety of services, which means the greater ownership and longer running hours of such energy-consuming appliances can send energy consumption up more than ever. If impacts prove to be negative or positive depends on various factors, including direction of communication technology development, degrees of dissemination, and for what and how individual sectors are using IT technologies and software.

Given these impacts, what will the future be like? Our assumption is that these trends would continue ahead and promote the development and spread of appliances designed to utilize IT technologies in a broader scope than now, whereby greatly changing our social structure and lifestyle.. In that process, the penetration of IT-based energy-consuming appliances and also upgrading of information could alter consumer behaviors and economic activities considerably, thus having a significant impact on energy consumption.

In this research, we attempted to quantify what impacts the increasingly IT-oriented society and lifestyle could produce on energy consumption, and how. We preparedscenarios over the next 20 years or so in reference to current changes. Actually, computer technologies and the Internet applications are advancing so fast that even a couple of years ahead can is difficult to prodict. . Albeit such constraints, we imagine the future shape of each energy-consuming sector and extract the most critical items affecting the sector's energy consumption in an attempt to assess the magnitude of impacts and deduce their implications.

2. Scope and Method of Analysis

(1) Definition of "advances in IT "

What are advances in IT , or the "IT revolution"? This is the most important definition in the scenario-making process. The most obvious characteristics are the penetration of personal computers, technology innovation of communications netand a surging volume of information processed, diversification of communications tools,

proliferation of the Internet users, and diversifying services offered to them. Yet, on top of these “physical” changes, we should not overlook “qualitative” changes in the entities on user side, regardless of firms or consumers.

The development of communication infrastructure and the spread of IT equipment now enables firms and consumers to take different behaviors from conventional ones. Distribution of commodities can be a good example. Now that a staggering amount of production, inventory and sales data can be shared and processed via communication net, IT is bringing about structural changes in distribution itself, typically retrofitting operation systems and marketing patterns. Consumers used to achieve their objective such as buying goods and services by checking data gained through information exchanges with others or from such media as TV and printed matters. Today, while sitting in their room, consumers can get and analyze (judge) a host of information via the Internet with a few clicks in a blink. They can order and receive any goods and services without visiting a store. Even payment can be settled at home. Thus, consumer lifestyle is changing. Expansion of this “sharing and utilization of information” creates new needs for information equipment and networks among firms and consumers, which then encourages the development and spread of not only required equipment but also communication net to help increase performance of such equipment. Thus, social structure itself is changing. This flow is likely to continue and lead to a society where consumers achieve their object behaviors by better using new communication net and information equipment, or where higher degrees of consumer satisfaction are assured. These changes/improvements in the use of information, as well as “physical” and “qualitative” changes in the entities as information users, are interpreted as “advances in IT” in our research.

The image of 2020, the target year of our research, is twofold. One is further expansion and enrichment of communication net, and the other is realization of an access-free information society. Namely, we assume that, with information and communication net expanding and becoming enriched thanks to more advanced technology development, everybody is given free opportunities to use them. Though it is difficult to assume the future information-transmission technologies/tools, as discussed in Chapter 2, we imagine a future world well equipped with infrastructure capable of offering richer information faster than now in good surroundings for easy-to-access upgraded information. On the user side, what’s assumed is a society rich in IT equipment through which every entity can access and achieve its objective.

(2) Impacts on energy consumption

a) Scope of impacts

Consumption of energy is determined by characteristics and operation of energy-consuming appliances used by firms or consumers in their activities, which means energy use itself cannot be an object in principle. For this reason, the impact of advancing IT on energy consumption is related to what equipment is developed and spread in the future and how altered corporate or consumer behaviors by the newly developed equipment can change running hours of such equipment. These impacts can be divided into two groups for closer examination.

i. Primary impacts

The primary impacts are those on energy consumption that result from expansion of communication net, penetration of information equipment, and expansion of such equipment using time. Given factors such as commercialization of optical-medium communications tools and growing radio-based information exchanges in the future, communication net is expected to have a much greater information-transmission capacity than now, and become diversified as well. Primary impacts reflect to what extent energy needs for maintaining such a future communications system differ from those for running its existing counterpart.

On the information user side, subject to the analysis is how energy consumption will change along with running manner, hours and other newly developed equipment in the future. As unveiled in recent trends, IT equipment, notably personal computers, are becoming amazingly energy-efficient. To what extent this efficiency improvement will continue is a very critical factor to predicting energy consumption in the future. Actually, one study contends that, depending on the magnitude of efficiency gains, energy consumption of information equipment can decline even when an increasing number of such equipment is in use for longer hours[3]. This time, in preparing scenarios for quantification, we assume more remarkable progress to be made in energy efficiency improvement of information equipment than general energy-consuming appliances.

ii. Secondary impacts

Secondary impacts represent how energy consumption of information infrastructure and equipment varies depending on changing patterns of activity and

[3] Kurt W. Roth, et al., “Energy Consumption by Office and Telecommunications Equipment in Commercial Buildings, Vol. I: Energy Consumption Baseline”, 2002

object achievement as a result of IT advances. For example, by introducing information equipment and accompanying systems, a firm can increase efficiency of its business activity, and thus expect such effects as curtailing production/distribution stocks and reducing of office space. In addition to changing energy consumption directly related to the introduction of information equipment, energy use in lighting, airconditioning and transportation (fuel use) can be affected by availability of such systems and resultant changes in activity level. Also, as an increasing number of consumers who get various services via the internet pose a non-hardware factor to send energy consumption up at residential level. The spread of communication net allows telecommuting, which not only changes working patterns but also makesworkers lengthen their stay-at-home hours, extra energy consumption due to working at home, and longer running hours of energy-consuming appliances for meeting various needs of those who work at home, instead of the office. On the other hand, in the case of telecommuters who can achieve their object behaviors at home through information exchanges with the outside, less time is required going outside which contributes to lowing energy needs for moving. Among others, an increasing ratio of telecommuting can trim working hours at the office, and thus has the effect of reducing office energy consumption.

b) Selected sectors for impact assessment

Basically all sectors are counted as using communication net and information equipment. From now on, the makeup of information equipment is likely to change in response to characteristics and objectives of individual sectors. This time, we select the sectors subject to our impact assessment (manufacturing, residential, commercial, traffic and transportation) based on the categories in energy statistics, so that our impact assessment can be usable for energy policy, including energy forecasting. Particularly, prior to scenario preparation and quantitative impact assessment, the commercial sector, where the ways of using communication net and information equipment are diverse, is fragmented further (offices, medical, education, finance, wholesale/retailing) in reflection to their characteristics.

c) Factors excluded from impact assessment

The items listed below are excluded from our impact assessment this time.

- Resultant industrial structural shifts from Information Technology

Advances in information technology are likely to help expand production size of the semiconductor and PC, increase the weight of service sector. These shifts in

industrial structure bring about secondary structural changes in various fields, such as varying product mixes and changing investment behaviors/sizes of individual industries, and changing locations of manufacturing plants (ups/downs in overseas production ratio). As a result, patterns and amounts of energy consumption can naturally be affected as well. But, it is excluded from our assessment this time, because its impact assessment can hardly be made with the methodology of adding up sector-by-sector impacts.

- Rebound effect

The rebound effect refers to any effect that offsets the effect of reducing energy consumption, which primary impacts bring about by raising activity levels through the benefits (cost reductions, energy cost cuts thanks to improved fuel economy) gained by firms or consumers from their use of IT technologies. For example, when a firm achieves reduction of number of staff as a result of IT system introduction and moves them to other business operations, or when a consumer spends the saved hours of moving by IT in other behaviors, such diversions can involve energy use of other energy-consuming appliances. This sort of effect, located in the next step to the secondary impacts, is also excluded from our assessment.

3. Future Scenarios and Impacts on Energy Consumption

(1) Communications infrastructure

a) Shape of future communications infrastructure

The maturity of currently advancing broadband introduction is likely to advance high-speed communications and peripheral-equipment links. Optical services, expected to be widely available from approximately 2005 onward, will allow the penetration of broadband-based high-speed telecommunications in individual households (FTTH: fiber-to-the-home) by 2010, thus getting them wired round the clock. Then, by 2015, Ubiquitous Computing will be available. By 2020, linked to more matured and high-speed peripheral equipment, a wide variety of information/communications services are likely to begin unrolling.

In this way, broadband communications networks will reach individual households, where progress is likely in household-appliances LAN by virtue of radio, etc. This allows remote control, VR (Virtual Reality) and others combined with mobile units, which help realize a society where information/communications can be practical without from any distance and time zone. Also, superconducting technology, if introduced, enables elements that can work faster on less electricity

consumption, thus greatly contributing to energy conservation.

In a highly advanced society in communications, communication net can be given a different positioning. It can be ranked higher as social infrastructure so as to ensure all members of society have easy access to high-speed communications. Enriched universal services will narrow the digital divide and allow communications such as a TV-conference system, where participants virtually feel as if they were talking to each other in the same room. This could have a dramatic impact on our social life in the way we move and spend time.. Real-time communication, such as a TV-conference system, enables participants to share the same time, yet they are not bound by a single location . In the case of entertainment broadcasting, like movies, viewers can access just when they want to, thus being freed from time constraints as well. Moreover, introduction of larger-capacity communications will facilitate penetration of equipment with built-in communication functions, which means personalization of information equipment. This can lead to an explosive proliferation of information transmitted by the public at large. Thus, distribution of peer-to-peer information will surge.

b) Impacts on energy consumption

Installation of communications infrastructure, under way as already described, is likely to have the following impacts on energy consumption:

i. As a result of the growing awareness of environmental issues, in particular global warming, technological advances are likely to produce information infrastructure that consumes less electricity.
ii. Super-large-capacity communications networks, introduced by virtue of multipath transmission technology, leads to the spread of all-optical processing technologies, like optical switches, optical routing and optical discs, which require no conversion into electrical signals. As a result, communication infrastructure as of 2020 could be entirely be based on optical technology. Infrastructure construction will pause around 2010 when installation of FTTH is virtually over, and data distribution is likely to keep growing afterward. Depending on the quality of contents to be processed, this process is likely to involve growing energy consumption along with expanding data distribution.
iii. A rapid expansion is likely in products with built-in radio communication equipment, which means energy consumption will grow along with installations of equipment such as relay terminals that are necessary for keeping such communication systems running.

(2) Impacts on specific sectors

Table 1 summarizes major scenarios of the impact that advancing Information Technology can have on specific sectors, as well as the items we try to quantify.. Sector-specific impacts of IT advances vary in each sectors. Yet, roughly speaking, the impacts can be categorized into the following groups (1) rationalization/efficiency improvement at the corporate level, (2) evolution of new businesses/services by taking advantage of communication net, and (3) reforms/upgrading of social/living environment by virtue of communication net.

Efficiency improvement at corporate leveland the spread of communication net and information equipment can help integrate business operations, or production, distribution and marketing, into one, while enhanced IT can help realize an optimal production-marketing system to expected sales, thus contributing to increasing corporate profitability. Also, expanded communications infrastructure is likely to decrease “bricks and mortar” retailing, notably the through on line sales, which can promote downsizing of existing stores as well as their effective utilization. In terms of medical services, administration, finance and education, efforts will be made to increase efficiency by taking advantage of communication net and IT equipment. If successful, such efforts will lead to new and additional services offered in each sector. In living-related fields, like household and transportation sector, the spread of communication net and information equipment can help promote more convenient and comfortable lifestyles..

On the other hand, well-established communication net will promote telecommuting. This minimizes the working space required, which menas less energy consumption for airconditioning, lighting, etc. at the office. Energy consumption in commuting can be slashed as well. But, longer stay-at-home hours is likely to increase residential energy consumption in the same ways as it is otherwise required at the office. The same is true in the relationship between retailers and consumers that results from the increase in on line sales, and the correlation between a shrinking store space and longer running hours of personal computers at home as a result of on line banking. In both accounts, the impact of IT advances on energy consumption needs to be assessed from the aspects of not merely changing trends in specific sectors but interactions among all sectors.

Table 1 Impact Assessment Scenarios and Items

Sector	Major scenarios of IT advance	Energy-consumption impact assessment items
Manufacturing	Efficiency gains in production processes Procurement via the Net SCM-based optimization of production	Effect on SCM-based inventory cut at manufacturing sites
Wholesale/retailing	Efficiency gains in distribution Revamped customer management & marketing systems New operations (Net businesses)	Greater OA-machine ownership Higher efficiency of inventory levels Expanding Net marketing (shrinking store space)
Offices	A fully networked office Energy management system Creation of new working style	Greater OA-machine ownership Changing working style
Finance	Shrinking number of stores, replaced by ATM and Net banking	The same as mentioned left
Public services	Emergence of e-government * Electronic processing of administrative information, procedures and routine works	Growing ownership and use of OA machines Indirect impacts of increasingly electronically-processed administrative procedures
Education	Personal computers available for all students Increasing opportunities for learning-at-home (via the Net)	Growing ownership & use of OA machines
Medical	Efficiency gains by electronics-based hospital management & routine works Digital processing & transmission of medical information Remote diagnosis, home care	Impacts of expanding home care on hospitals
Freight transport	Efficiency gains in transportation system * Electronic tags, unmanned transport, demand forecast, etc.	Efficient-ever forwarding service Increase in small-parcel forwarding service IT system-mounted trucks
Transportation	Growing ownership of driver-supporting systems * Car navigation, ETC, etc.	Effect of growing ownership of car navigation and ETC
Residential	Penetration and round-the-clock running of home servers Expanding use of the Net services (longer stay-at-home hours) Energy management system	Growing ownership and use of OA machines Changing running hours of other household appliances due to longer stay-at-home hours

4. Impact assessment of advancing IT orientation on energy consumption

(1) Estimated results

In the assessment items shown in Table 1, we assessed the impact on energy consumption produced by advancing IT orientation as of 2020. The assessment basically deals with ups/downs in energy consumption (ex. raised electricity consumption by a greater equipment ownership) to be realized as of 2020 in respect to given assessment items.

Fig. 1 aggregates quantitative assessment results of individual sectors we gained this time. Adding up sector-specific impacts amounted to a decrease of 3,316 X 10^{10}kcal, equivalent to about 0.8%[4] of final energy consumption projected for 2020[5]. By sector, all sectors do not contribute to reducing energy consumption. The sectors making negative contributions include telecommuting of manufacturing and offices, medical services and wholesale/retailing. Those making positive contributions are communications infrastructure, residential, offices, education, distribution, and traffic system.

The results shown here reveal that the impacts on individual sectors are not one-sided but multifaceted. Taking the offices as an example, the greater use of OA (Office Automation) machines increases energy consumption, while business efficiency gains by IT-system introduction decrease incidental energy consumption (ex. airconditioning, lighting). In wholesale/retailingas well, necessary system introduction for networking pushes energy use up, but efficiency gains at stores, etc. as a result of varying marketing methods and streamlining inventory management indirectly lead to less energy consumption. The Net ends in less energy consumption as well. Also, though not visible in figures, our basic assumption is that information and communications systems, notably personal computers, will become much more energy-efficient than the present. A realized portion of such efficiency gains appears to send the overall effect down in principle.

As implications of these outcomes, following points can be cited.

i. Progress in IT orientation does not increase energy consumption uniformly, but can be both negative and positive contributors depending on sector-specific purposes of IT orientation.
ii. In cases where energy efficiency is minimal, , is possible the IT orientation will

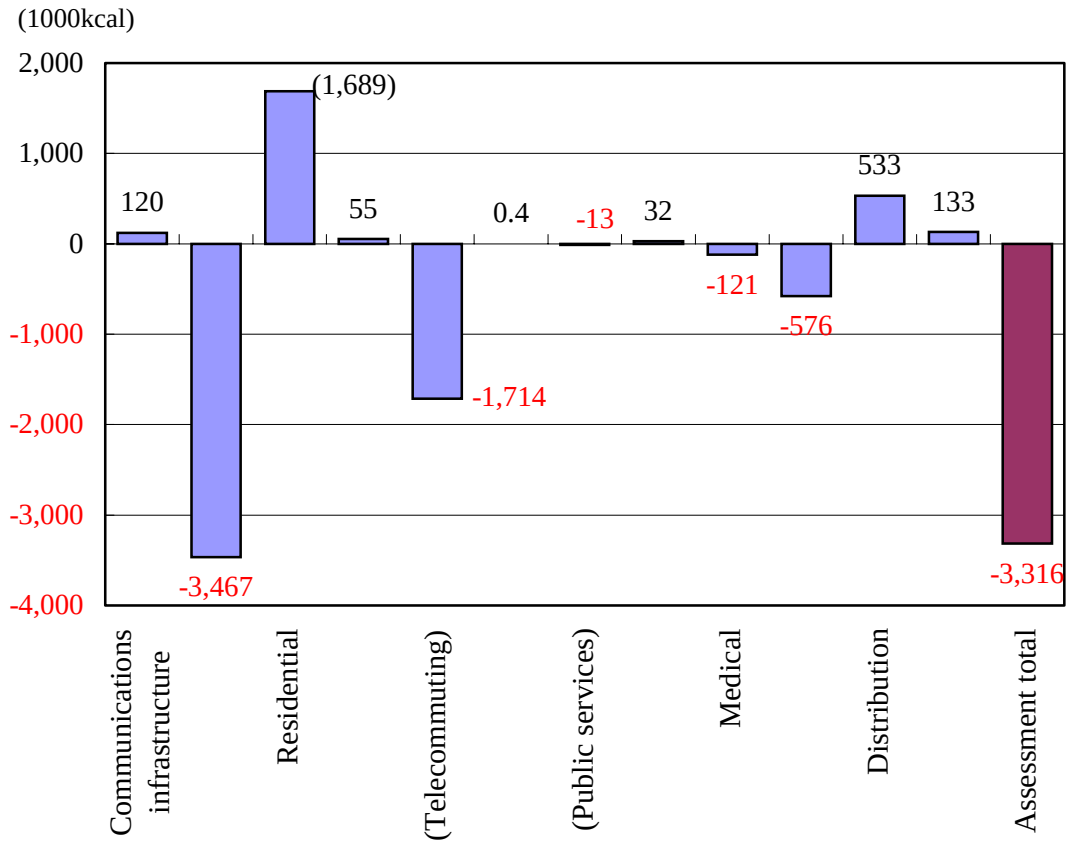
---

4 IEEJ, “The 31st Energy Symposium Reference Material-VI (December 1998), Business-as-usual case

5 It should noted that adding up specific impacts does not always accord to the total due to double counting, like the same efficiency gains counted twice in transportation and distribution sectors, which is inevitable in scenario-setting.

promote energy consumption.

Fig. 1 Impact Assessment Results of Advancing IT Orientation on Energy Use (2020)



(2) Cross-sector impacts

Table 2 shows sector-specific ups/downs in energy consumption, plus the magnitude of quantitative impacts that the sector-specific impacts can have on residential energy use. The growing popularity of telecommuting is effective in axing office energy consumption, but causes a reactionary rise in residential energy needs. Also, getting public services via the Internet sends public sector's energy consumption down, while pushing residential energy use up due to more frequent access from home. Likewise, although the provision of remote medical services can trim energy consumption at clinical fronts, longer stay-at-home hours contribute to greater residential energy consumption. On educational fronts, networking is advancing and the scope of IT-based teaching is expanding.. At the same time students are given a

learning opportunity by accessing school servers from their home. Both situations demonstrate that advancing IT results in growing energy consumption, a strikingly characteristic compared to the other sectors.

What is clearly noted from these assessments is a strong likelihood that any impact on energy consumption produced by advancing IT in a given sector to achieve the sector's object behavior should have a ripple effect on other sectors. Consumers getting services at their home through the introduction of IT will push residential energy consumption up, but concurrently facilitate efficiency gains in the distribution/marketing sectors. Conversely, to increase office efficiency harbors a possibility to transfer energy-consuming opportunities to households. As for the reason, the energy consumption per person in the office exceed the energy consumption per person in household. From now on, whenever assessing energy consumption, special attention needs to be paid to the transfer of energy-consuming opportunities from a sector to another due to advances in IT..

And also, as we recognized on the educational sector's result the possibility of cross-sector synergy is a very significant theme. Consider the following chain of events scenario: (1) growing Internet access from home, (2) surging businesses via the Internet, (3) increasing frequencies of small-parcel forwarding services that hurt transportation efficiency, and (4) growth in total energy consumption. At any rate, when making an impact assessment of advancing IT on energy consumption, it is essential to determine if these cross-sector alliances result in replacement of energy consumption from a sector to another or produce a synergy effect, on top of assuming sector-specific scenarios.

Table 2 Cross-Sector Impacts

	Up/down in energy use (1,000kcal)	Cross-sector relations	Up/down in residential energy use (1,000kcal)
Communications infrastructure	120		
Manufacturing	-3467		
Residential	1689		
Offices	55		
(Telecommuting)	-1714	Working at home	148.1
(Finance)	0.4	Trade-off with Net banking	4.7
(Public services)	-13	Access from home, shrinking traffic demand	7.4
Education	32	Access from home to school servers	29.9
Medical	-121	Communications with home, shrinking traffic demand	29.3
Wholesale/retailing	-576	(Access from home, shrinking traffic demand)	
Distribution	533		
Traffic system	133	(Impacts on making distribution sector efficient)	
Assessment total	-3316		

5. Implications of Assessment Results and Subjects

(1) Implications of assessment results

Described below are implications gained from our scenario preparation and quantitative assessment:

- **Integrated effects**

  Increasing efficiency of production/distribution/marketing has the potential to reduce energy costs, on top of operators' merits on management.

- **Consumers acting as motive power**

  Diversifying services offered to consumers have ample chances for IT technology introduction into the home, which means the residential sector will be the key sector to energy consumption ups/downs attributable to IT advances.

- **Composite nature to be heeded while outlook/policy reviews**

  If any of its components does not work, the production/marketing sectors can fail to achieve efficiency gains. The residential and service sectors are found in trade-off relationships in many aspects of their energy consumption. For this reason, outlook/policy reviews always require special heed given to such trade-off structure.

(2) Future subjects

- **Direction of IT advance**

  Given the degree of current advancing IT , as well as the prospects for a well-established environment in the future, a social structure of two decades ahead can vary more drastically than envisaged in our scenarios. This time we prepared the scenarios based on the status of technology development and lifestyles at present. In addition to such "realistic" assessment, the possibility of a more "drastically changed structure" scenario needs to be examined as well.

- Preparation of more composite assessment and data

  The impact of IT is not static. It is characterized by transfers to other sectors/multi-applications. In order to make a more accurate impact assessment on energy, such input-output relations have to be identified, while accumulating basic data.

- Impact assessment on nationwide

  The degree of potential impact on nationwide needs to be assessed by examining viable methodologies to quantify the impacts of industrial structural shift and rebound effect, which will not be covered this time.

- Policy implications

  By making micro and macro assessments, it is important to examine an approach that allows for the examination of policy implications.

Conclusions

The single phrase of "advancing IT" is not as simple as it sounds. Expansion of technology innovation and the various fields benefited by IT-armored technologies and services may go beyond ones imagination, with their impact-interrelations difficult to assess assumable in detail. Given the present pace of technology innovation and fast-changing social system, even a future as near as a few years ahead is hard to predict. It appears impossible to foretell now what kind of society IT will bring about in the next ten to 20 years.

Under these circumstances , we described sector-specific scenarios and tried to assess their impact on energy consumption. Unfortunately the selected sectors, or assessment items (scenarios), remain limited. The scope of our assessment, covering primary and secondary impacts of IT technologies and services in use, did not follow further impact that we can consider. And yet, what is clear from our analysis is that technology advances in the form of enhanced IT and accompanying information equipment introduction/utilization does not necessarily produce one-sided impacts. Its impacts are multifaceted, yielding greater energy consumption at times and energy

efficiency gains at others. Good examples include IT-based efficiency gains in the distribution and marketing sectors, personnel streamlining in various services, and shrinking energy consumption at the office.

It may be widely agreed that IT orientation will further advance in diverse fields, with an ever-growing frequency of IT technology use. In the present condition, what impacts can be produced on Japan's energy supply-demand mix by IT-technology evolution and its benefits, notably greater production size and a host of new consumer services? It is important to do the evaluation of the influence by advancing IT orientation on the energy, and the environmental problem continuously from now on.

Contact : ieej-info@tky.ieej.or.jp