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Low-Carbon Society Scenario toward 2050: Scenario Development and its Implication for Policy Measures

First Stage (2004-2006) Summary Report

S-3-4

Integrated Measures of Technologies and Lifestyles against Global Warming -Ecodesign of ICT (Information Communication Technology) Society-

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Low-Carbon Society Scenario toward 2050
- Ecodesign of ICT (Information Communication Technology) Society -

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Abstract: Discussed here is a scenario of a sustainable society in the year 2050, recently studied for achieving both low carbon emission and an emotionally healthy lifestyle. This scenario has been created by focusing on the influence of ICT diffusion. How ICT is to be developed and utilized towards realizing human's wishes and desires has been investigated. Against this background, 1000 citizens were surveyed on 11 categories: ex. eating-style, working-style, living-style in 2050. Information on future life style was gathered by examining SF-films and animation, and consulting over ten knowledgeable people and two research groups. These ideas were then brainstormed in order to construct a vision of a future-desired ICT society. A presentation of the future-desired ICT society was created using text and illustration focusing on the lifestyle in 2050.

1. Introduction

Industry tries to manufacture highly functional goods cheaply and in large quantities. Consumers then purchase a comfortable lifestyle supported by large resource consumption. This cycle has caused several kinds of environmental problems. "Global warming" is a typical one. Against this background, symptomatic treatment of the individual conditions of environmental problems would not produce any demonstrable results with respect to either the environment or the economy. We should instead tackle a causal approach and reform industrial activities and lifestyles, which are the root cause of the problem, by transforming them into new activities and lifestyles whose environmental loads are smaller.

The first great step to prevent global warming was taken by Kyoto Protocol which came into effect on Feb.16, 2005. But it is necessary to reduce GHG (Greenhouse gases) emissions drastically to stabilize climate change. It would be possible to propose concrete policy packages including institutional change, technology development, and lifestyle change toward low carbon society. The research project on “Establishing of Methodology to Evaluate Middle to Long term Environmental Policy Options toward Low Carbon Society in Japan (Japan Low carbon society scenarios toward 2050) “ has been studied in order to assess its long-term global warming policy[1-2]. This project focuses on the following issues: 1) long-term scenario development study to integrate environmental options consistently using simulation models, 2) long-term GHG reduction target setting considering effectiveness and validity, and 3) assessment of environmental options considering future socio-economic conditions in a) urban system, b) information communication technology (ICT) society and c) transportation system.
This paper focuses on one research issue: ICT influence on Low Carbon Society with regard to the possibilities of social structural change and methods of application.

2. ICT Revolution and Sustainable ‘Low Carbon Society’

With the development and diffusion of information and communication technologies (ICT), we can obtain various benefits in all aspects of society. In industry, we have obtained efficiency improvements in materials supply, physical distribution, and office work, and achieved the globalization of business. In daily life, we have obtained many benefits from novel approaches to communication with other people, information acquisition for hobbies and entertainment, and the purchase of commodities. These changes are expected to accelerate with increasing communication capacity and simplified access to networks in the future. Great structural changes in society will occur (i.e., an ICT revolution).

As the consumption of resources depends on the social structure, the ICT revolution will make it possible to apply a large influence on the environmental load of society. At present, as we start moving toward an ICT revolution, adding environmental consciousness will lead to the causal treatment of environmental problems, which will in turn reform industrial activities and lifestyles through more sustainable approaches (Fig. 1). This is our research perspective[3].

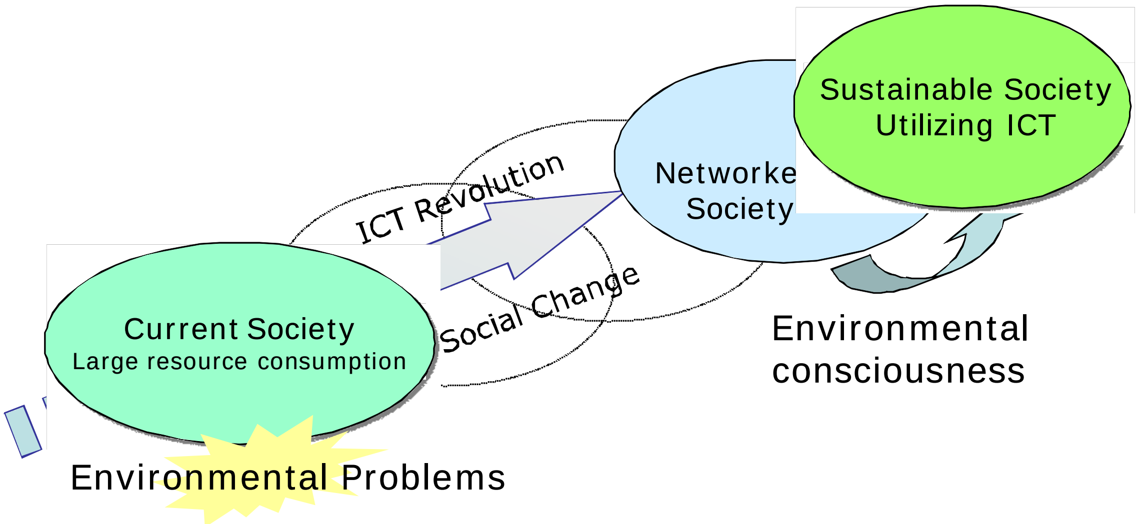

Fig.1 Application of the EcoDesign method to a networked society

2.1. Environmental Influence of ICT

Concerning the environmental influence of ICT, we can see both the positive and negative sides. The negative impact (increase in environmental load) increases resource and energy consumption, and the amount of waste resulting from the increase in ICT equipment. In addition, the money and time gained through the greater efficiency of an ICT society leads to excessive economic activity, which results in an increase in re-source and energy consumption (the rebound effect).

In contrast, the positive impact of ICT diffusion is a reduction in resource and energy consumption through “dematerialization” and “efficiency improvement”. Dematerialization means the replacement of conventional materials and human mobility, which were once needed to carry information, with electrons. For example, electronic newspapers and books, and the delivery of music through the internet render paper and plastic discs, useless. TV meetings and internet shopping make human movement unnecessary. Efficiency improvement means avoiding the waste of resources and energy, which are thrown into system operations, by achieving closer communication between individual components of the system, such as human, organization, equipment and so forth. For example, Supply Management System (SCM) attempts to avoid the waste of materials, parts, and products related to manufacturing, by means of adequate communication between the demand-side and individual manufacturing divisions. Home Energy Management system (HEMS) reduces the unnecessary activity of home appliances, such as air conditioners, and lighting, through communicating the room's circumstance, ex. human is present or not, to the appliances controller. Eco-Drive systems lead drivers to consume less energy when driving. This is achieved by informing the drivers of energy consumption conditions and methods of driving.

Furthermore, ICT distribution causes changes in the industrial form (i.e., the growth of low-energy consumption industries). This would lead to reducing energy consumption in the industrial sector of Japan. In addition, ICT enables people to get a concrete image of environmental problems from various points of view. We don't know the relation between daily actions in our life and the environmental impact, and also the actual condition of environmental problems. ICT will be able to give us a true feeling of the reality of environmental problems. This would lead people to an environmentally conscious life.

2.2. How Much CO_2 Can Be Reduced by Utilizing ICT

It is difficult to estimate the CO_2 reduction by utilizing ICT quantitatively. The reason for this is that the effect of ICT is indirect and too diverse, for example spread over production, distribution, and sales. However many research institutions have estimated CO_2 reduction effects of 2010, and found a reduction CO_2 of 2-3% of Japan's total emission.

Furthermore, the reduction effect of 2020 was clarified in this research project. The results were as follows:

-By introducing HEMS etc. it would be possible to reduce CO_2 by 15-20 million tons in the commercial and domestic sector in comparison with 2000 year's emission[4].

-By encouraging the use of public transportation systems it would be possible to reduce CO_2 by 10million tons in the transportation sector[5].

And finally by introducing SCM systems it would be possible to reduce CO_2 by 47 million tons in the industrial sector[6].

In addition to these reduction effects, it is necessary to consider the negative impact, and then evaluate total reduction effect, i.e. 5 % reduction in comparison with Japan`s total emission in 2000. Table 1 summarizes these results around the year 2020. The last column shows the impact forecast from previous studies regarding the impact in the year 2010. These numerical values, which indicate ICT impact in the year 2020, were obtained from our studies.

In 2050, we expect more CO_2 reduction due to ICT, its value would increase from 5% in 2020 to 10% in comparison to Japan’s total emission in 2000 year. The above argument is based on ICT used in conventional social systems. However if ICT creates new social systems, the level of CO_2 may be further reduced.

Table 1 CO2 reduction to the Japan’s total emission in 2000

	Industry	Freight transport	Passenger transport	Office	Home	Recycling	Impact on CO2 emmisions	
Diffusion of ICT equipment	Resource consumption			Electric power	Electric power	Waste	Negative I	+1~2%
Supply chain management (B to B)	Resource consumption	Transport					Positive I	~-3%
Internet shopping (B to C)	Resource consumption	Resource consumption		Number of shops			Negative/Psotive	
Teleworking			Transport	Number of offices	Electric power		Positive III	-1%
Advanced traffic utilization system (modal shift in commuting, ETC, etc.)		Transport	Energy consumption				Postive II	
Dematerialization system (newspaper, magazine, and CD)	Resource consumption	Transport		Number of shops		Waste	Positive III	-1%
Energy-management system (HEMS, BEMS)				Electric power	Electric power		Positive II	-1~-2%
Eco-life guidance system			Energy consumption	Electric power	Electric power	Waste	Positive I	
A product and manufacture management	Resource consumption						Positive I	
Recycling information system	Resouce consumption					Waste	Negative/Psotive	
E-government			Transport			Wastes	Positive III	

	Rate to the total 2020' emissions
I	3-5%
II	1-3%
III	0-1%

	Reduction
	Unknown
	Increse

3. Toward a Low Carbon-Society by Utilizing ICT

The rapid progress of ICT may make it difficult to imagine what kind of ICT will be developed, and how such advanced ICT will be disseminated in 2050. However, after examining the dreams and desires of people with regard to future society, it will become possible to understand how to utilize advanced ICT in such a society. And so we can imagine how ICT is to be developed and utilized towards realizing human's wishes and desires.

3.1. Methodology Depicting Future Desired Society

Figure 2 shows the flow of our creation method of a 2050 sustainable low carbon society.. As shown, 1000 citizens were surveyed on 11 categories: ex. eating-style, working-style, living-style in 2050. Information on future life style was gathered by examining SF-films and animation, and consulting over ten knowledgeable people and two research groups. These ideas were then brainstormed in order to construct a vision of a future-desired ICT society based on a new 'social model' which represents the relationship between human society and technology. A presentation of the future-desired ICT society was created using text and illustration focusing on lifestyle in 2050.

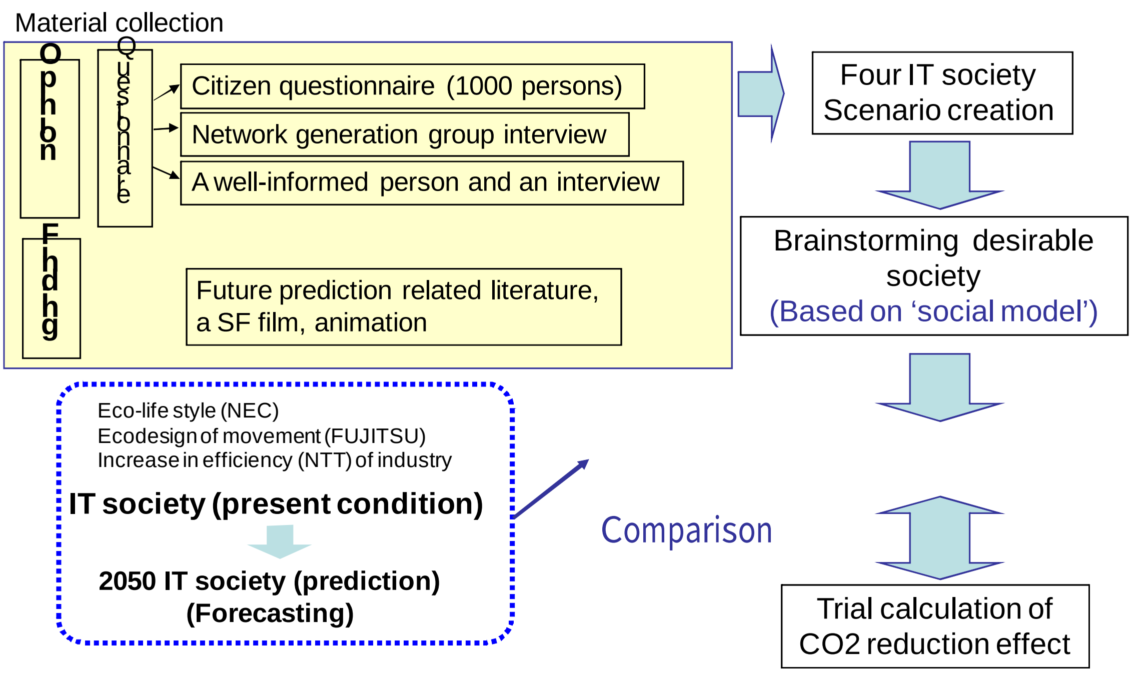

Fig.2 Flow of creation method of a 2050 sustainable low carbon society

From the survey a number of keywords were gathered, for example:

<u>Techno - rural</u>: The business elite and the technical elite, country revolution,

decentralization migration.

Ground work : Activities which aim at the natural reproduction of a community, and cultural reproduction by citizen partnership.

Second skin : Clothing in which body temperature and sweat are adjusted automatically, environment in the living body is kept comfortable. Whatever the situation one suit can be adapted year-round.

Mediability: Capability of each individual to consider himself as media, and to carry out full practical use of the possibility of the media of ‘clothes embedding’, a net homepage, and television, to convey self value, and to advertise ones own existence

Virtual(VR) taste: While the taste and the sense of smell become realizable by VR eating, healthy food diet, delicious food and gluttony can be enjoyed.

Mixture mobility system: A one-person riding car, a cart for welfare, a large-sized diesel physical distribution vehicle, a bicycle, an air floating suit wearer, etc. are intermingling and passing with consideration of environment, aging, etc. The system which also utilizes the underground and the air and controls these various vehicles appropriately using IT.

Personal chair: A car-like-an-office chair. A life space and habitation space can also be entered.

The future-desired ICT society was created from these keywords and the following ‘social model’.

3.2. Social Model

There is no doubt that ICT diffusion can help decrease CO_2 emission, but in order to sustain a low-carbon lifestyle, we must also be aware of the possible effects an ICT revolution will have on human social, spiritual and mental conditions, and examine how these conditions may contribute to the culture of over-consumption prevalent in today’s society. It’s necessary to consider not only the development of technology and social systems but also the issue of maintaining spiritual and emotional health in a low carbon society. We have constructed a new social model which integrates these concerns. Figure 3 shows two ‘social models’ –actual ‘Technological’ approach and desired ‘Techno-ontological’ approach.

The Technological approach puts priority on the ‘technology’ itself, without considering the implications such technology has for mental/spiritual, social and environmental conditions. With regard to ICT diffusion in the 'technological' approach, there are two points to be aware of:-

Facile Lifestyle

Facile lifestyle encourages the mass consumption of resources and energy by making it easier to consume. Internet shopping, for example, makes buying products convenient. From the comfort of our armchair we can buy products from all over the world. The ease by which we can do things can reduces feelings of satisfaction and having more free-time can lead to feelings of boredom and a lethargic lifestyle. Over consumption becomes easier and therefore less satisfying.

Loss of authentic human contact

The use of ICT can make global communication easy and convenient, but how 'authentic' is such communication? Can people truly feel 'touched' by others through e-mail, or internet 'chat-rooms'? If we can shop and work from the comfort of our own homes via internet technology, does this mean we go through the whole day without physically meeting anyone? Indeed, face to face contact is important for measuring emotions and understanding feelings. The negative impact that feelings of isolation and loneliness can have on the mental/spiritual condition of people can be profound-leading to an increase of mental disorders and perhaps even the loss of moral values. As shown, both these factors could accelerate various pre-existing 'forms of emptiness'. People try to superficially fill this 'emptiness' by consuming products, which in turn accentuates feelings of 'emptiness', leading to more consumption and thus further adding to the culture of over-consumption already existing in society today.

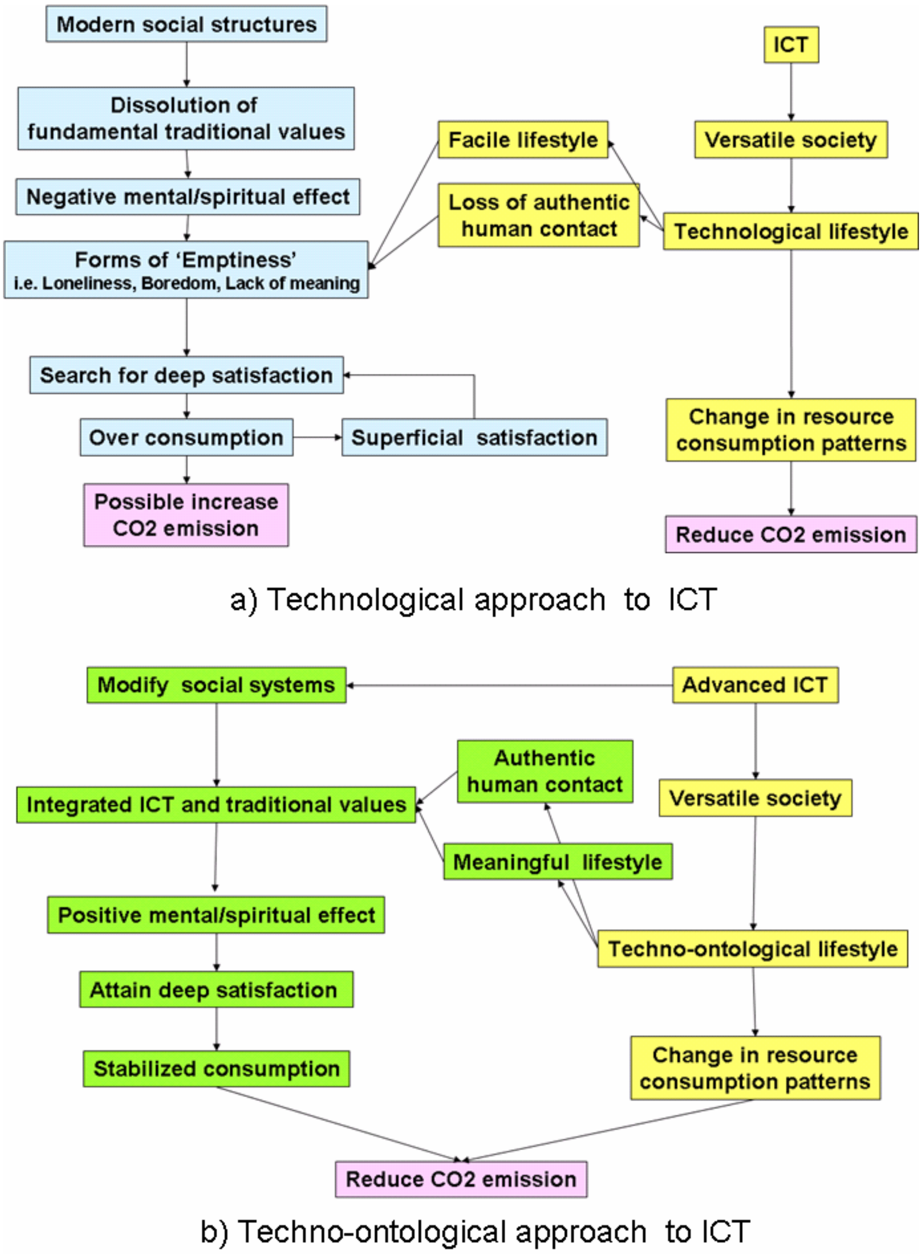

Fig.3 Social model

The Techno-ontological approach, however, considers how a fusion of ICT with mental/spiritual and social conditions can help realize a truly sustainable low carbon society. Techno-ontology can also examine possible deeper metaphysical resonances and connections that a fusion of technology and spiritual concerns may lead to, for example, the possibilities of transcendence in a dematerialized society.

The 'techno-ontological' approach to ICT diffusion considers the effect advanced ICT may have on society. It proposes that an ICT revolution can not only create a versatile society, but also has the potential to radically modify pre-existing social structures and help create a society in which advanced ICT and the traditional values of family, community and spirituality can be integrated.

For example, it has already been suggested that face to face contact is necessary to authentically connect with people. In a techno-ontological lifestyle advanced ICT can help create opportunities for more authentic human contact by using advanced holographic and audio technology. Even if family and friends are separated by great distances, they can still 'exist' holographically in the same space. Having a versatile lifestyle means that people can have the freedom to find a more meaningful way of life. A husband or wife can follow their dream and work in a foreign country and yet still be in the same room as his or her family for dinner via advanced internet technology, thus maintaining traditional family values. By promoting a 'techno-ontological' lifestyle, where mental/spiritual concerns are promoted through positive applications of advanced ICT, it is also possible to stimulate the market for ICT products, thus having a positive impact on the economy. -Ultimately, technology is a tool, and we must look under the surface of technological advances to understand how the usage of such tools influence society and human behaviour- individually and collectively- by shaping our thinking, feeling and Being.

4. Scenario of a Future-Desired ICT Society

In creating this scenario, two future uncertain factors were chosen, each uncertain factor was expressed by two axes and four quadrants, and the future society scenarios were performed in each quadrant. We chose the governance and the personal life style as an uncertain factor, and then considered the personal life scenario of a future-desired ICT society. It has been clarified in this scenario creation that the whole "desirable society" could not be expressed by one quadrant. A desirable quadrant differs with individual life-related elements, i.e., amusement and leisure, dwellings, work, education, food, etc. Therefore the position considered to be "desirable" for an individual life element was defined, and then one desired society was depicted by integrating these life elements (Fig. 4). Following are examples of life scenes in the future-desired ICT society.

Authentic Communication (Fig. 5)

In the life style of 2050, commuting to company and school takes 10 minutes or less thereby obtaining freedom to work anywhere and attaining self-actualization, 'without separating' from family. When actual separation is required in order to attain this, authentic communication can be realized and conversation between families becomes lively and rich through a 'virtual door system'. For example, a family shares everyday life experience, as if they live actually together. Missing family time is regained by shortening the daily commute.

Authentic communication between families is increased compared to the current situation. 'Living together' via virtual UI (user interface) and advanced information systems can lead to a more pleasant family lifestyle.

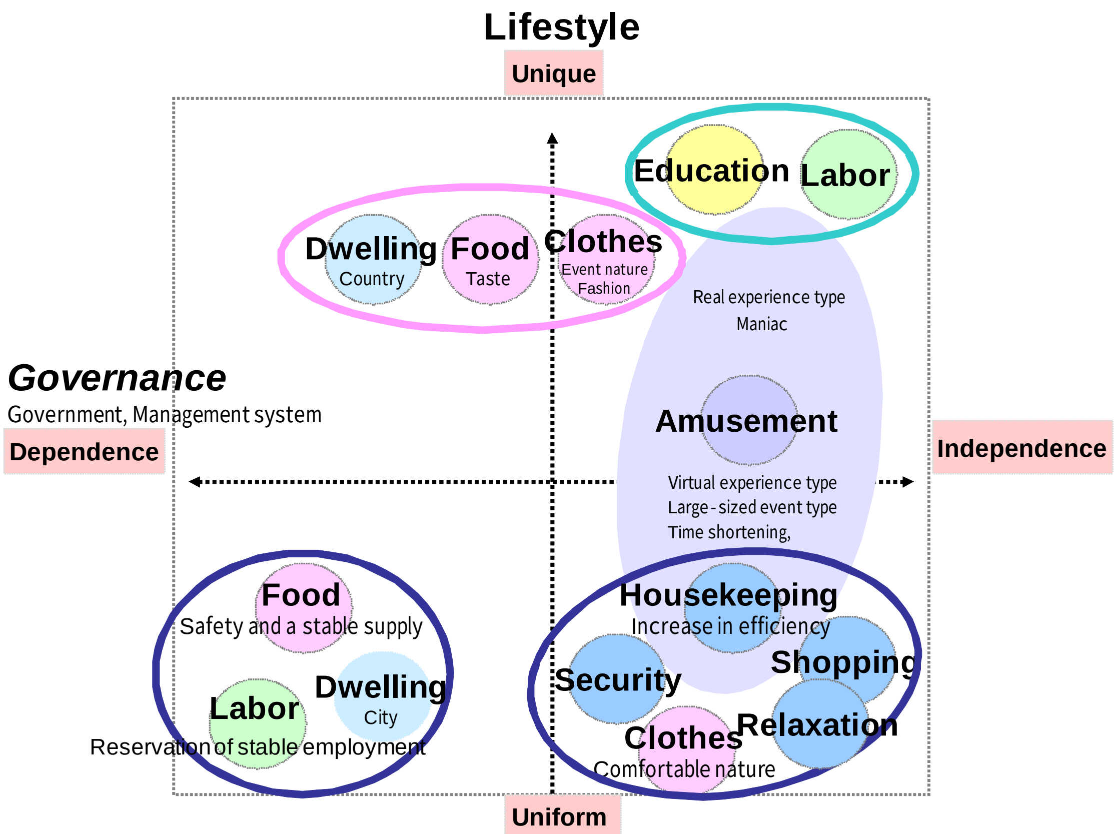

Fig. 4 Scenario matrix

Fig. 5 An example of family lifestyle

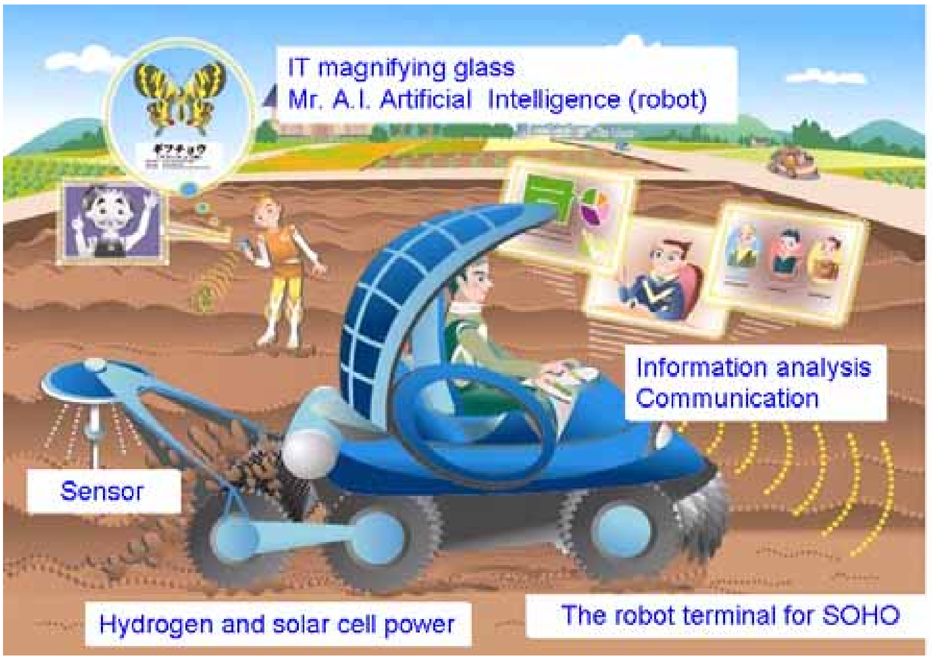

Fig. 6 An example of country agricultural work

<u>Meaningful Lifestyle (Fig. 6)</u>

Physical labor and long hours are lost in the business scene of 2050. A robot supports the secretarial functions, an analysis functions, and heavy labor through artificial intelligence. Therefore, people have time to regain their'humanity' by thinking, imagining and feeling in a work environment. Companies and ventures can produce advanced technical development and services (high addition value) according to various needs. Due to the network of information, business dialogue and information gathering can be carried out anywhere. This can lead to a versatile work style where the worker can consider things, from agricultural products to the development and sale of new food.

5. CO_2 Reduction Effect of Future-Desired ICT Society

From the above social scenario, how much it would be possible to reduce CO_2 was estimated by the "Snapshot tool" which had been developed for usage in this project[1-2].

The CO_2 emissions of the apartment type in the city in 2000 were 4,149 kg-C / household, those in the rural detached house in 3,698 kg-C / household. From macroscopic view points, the value which divided Japan's total CO_2 emission in the year 2000 by the total number of households was 6,774 kg-C / household. As a result, the CO_2 emission of household origin is about 60 percent.

It was clarified from our estimation that the CO_2 emission of household origin in the future-desired ICT society of 2050 is 2,484 kg-C / household in the apartment type in the city, and 2,389 kg-C / household in rural detached house. The result was shown that the CO_2 emission of household origin in the future-desired ICT society of 2050 can be potentially reduced by about 40 percent in comparison to Japan's total CO_2 emission in the year 2000.

Figure 7 summarizes ICT diffusion influence on Japan's total CO_2 emission. In 2050, our forecasting-estimation was about 10% reduction. On the contrary, the back casting one, was over 20% (40% reduction in household origin). These results suggest that drastic greenhouse gas reduction and a comfortable lifestyle could be compatible.

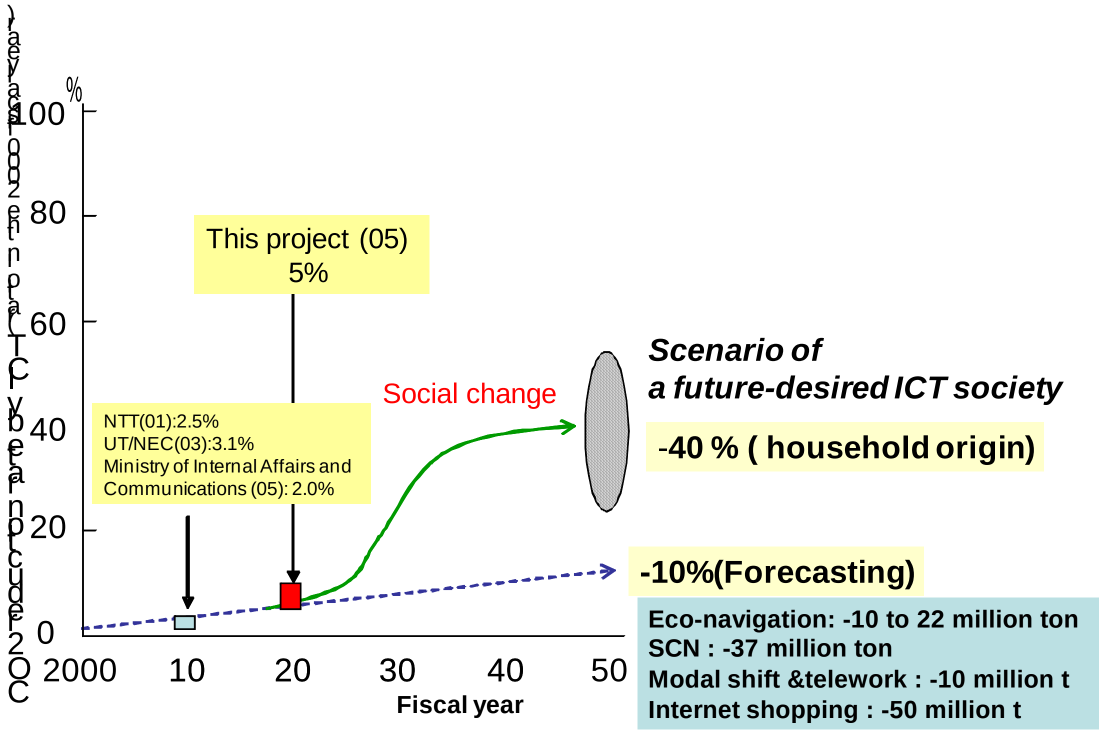

Fig. 7　Environmental influence of ICT in the future

6. Summary

ICT influence on Low Carbon Society with regard to the possibilities of social structural change and methods of application was studied. The results were summarized as follows.

1. New social model based on radical methodology depicting the desires of people was developed.
2. A presentation of the future-desired ICT society was created using text and illustration focusing on the lifestyle in 2050.
3. New society makes it possible to reduce CO_2 emission to about 40 percent in comparison to Japan’s total CO_2 emission in the year 2000.
4. The compatibility of drastic CO_2 emission reduction and desired sustainable lifestyle was suggested.
5. CO_2 reduction effect only -10% was obtained by forecasting.
6. “Techno-ontology” which considers the fusion of technology and spiritual/mental matters is needed in order to deal with the problem of over consumption and to realize a

sustainable low carbon society.

It was also suggested that current back-casting approaches in policy making may be inadequate. In current back-casting approaches target values (e.g. 70% CO_2 reduction in 2050) are decided and then these values are divided into individual sectors. Finally, methods of how to reach these targets using visible advanced technology are considered. However, this current approach lacks an awareness of fundamental changes in social structures caused by the radical nature of ICT revolution. Also this approach doesn't take into account mental/emotional issues which, as shown in this study, create a mechanism leading to energy-resource overconsumption. It is therefore necessary to take more radical methodological approaches when depicting a sustainable low carbon society in 2050.

It must also be noted that this study used Japan as a model of a modern industrial society understanding that, due to the global nature of ICT, these results can be applied to other industrial countries. However it is also necessary to consider the unique culture of individual countries, especially with regard to their views on the environment and nature. For example in Japan, there is a "mottainai" traditional spirit. Mottainai spirit basically means that, 'it is so wasteful when things are not made full use of their value.' For example, following the mottainai traditional spirit, people try to make full usage of household goods, for example. When a product breaks, we fix it, rather than simply disposing of the product and buying a new one. This mottainai spirit has a positive impact on the environment.

Why have Japanese people lost this spirit? Is it due to the lack of extended family communication especially with regard to the transmission of traditional values? It must therefore be pointed out that, even though ICT is global, it is also important to consider the cultural uniqueness of each individual country when examining methods of ICT utilization.

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Case study about Eco-designed movement model to achieve a low-carbon society

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Abstract: A survey using the Internet has been performed on the current circumstances of commuting and work as well as the possibility of reducing commuting through a modal shift in the modes of commuting via ICT or telework, and the potential to limit CO_2 emissions caused by commuting through the development of ICT has also been evaluated. Based on these results, a proposal is made as to the modes of movement of people in sustainable cities and situations where ICT can be utilized.

Key-Words: - CO_2 emissions, ICT, Commuting, Telework, Private car, Global warming

1 Introduction

The development of ICT (Information and Communication Technology) has caused dramatic changes in the structure of society, while also exercising various effects, both positive and negative, on global warming [1]. It is thus important to direct these changes in society caused by the development of ICT towards a sustainable society. Since the coming into force in February 2005 of the Kyoto Protocol, taking countermeasures to deal with global warming has become a pressing political issue. At the same time, there is growing awareness that planning and prompt implementation of medium and long term countermeasures should be made [2] [3].

In the case of Japan, the transportation sector generates 20.7% of total CO_2 emissions, of which nearly 90% are due to the utilization of private cars [4]. This tendency also holds true in other advanced countries, and it is generally agreed that a substantial decrease in CO_2 emissions in the transportation sector, and more particularly in the use of private cars is urgently required. OECD-EST, for example, has a challenging target, whereby overall emissions due to transportation modes in 2030 should not exceed 20% to 50% of that in 1990, depending on each country [5].

In terms of reducing CO_2 emissions coming from automobiles, measures to reduce CO_2 emission per car utilization demand (per kilometrage per car), such as the use of fuel-efficient vehicle and the introduction of carbon neutral energy or optimization of traffic flow using ITS (Intelligent Transport Systems), are quite effective. At the same time, as medium and long term countermeasures, it is also vital to fundamentally reduce the car utilization demand by changing the lifestyle and sense of value of each private car driver.

Thus, with a view to reducing the environmental load caused by movement, and in particular, reducing CO_2 emissions due to private cars, with around 2050 as a target year, we are proposing an eco-design based on ICT for the movement of individuals and society, and are also performing provisional calculations on the effect of CO_2 reduction [6] .

In this study, a survey using the Internet has been conducted on the current circumstances of the commute to work as well as the potential to reduce commuting via a modal shift in commuting modes via ICT or through telework. In addition, based on these results, there has been consideration of the potential to restrict CO_2 emissions generated by commuting through the development of ICT.

2 Internet Questionnaire Survey

A survey has been made using the Internet to estimate the substitutability of automobile based commuting, when promoting a modal shift or telework using ICT.

Thirteen community groups were selected as survey sites from various regions, taking the number of automobile commuters and high density into account. Moreover, respondents were solicited from among monitors registered in a research company, with a view to collecting 150 answers from each community group. Eventually, 2,337 responses were collected (of which 1,737 were employees). The outline of the questionnaire is as follows:

- Current circumstances on the transport mode used for commuting, distance & time for movement, work pattern (yes or no for telework)
- Distance & time for movement if commuting there than by car
- Reason for not adopting (or for being unable to adopt) telework, and intention for performing telework
- ICT necessary for performing a modal shift from automobile commuting or telework

3 Commuting Modes and Work Circumstances

3.1 Modes of Transportation for Commute

The result of a questionnaire about modes of transportation for commuting is shown in figure 1. Among various modes of transportation for commuting, "private cars" come first, occupying 48.3%, then "trains" (34.7%), and "on foot" (26.9%). When changing the mode of transportation, those currently using a "private car" for commute will take "route buses" (41%) as the first alternative modes of transportation, followed by a "bicycle" (33.0%), "trains" (32.8%), and then "motorbikes" (24.4%).

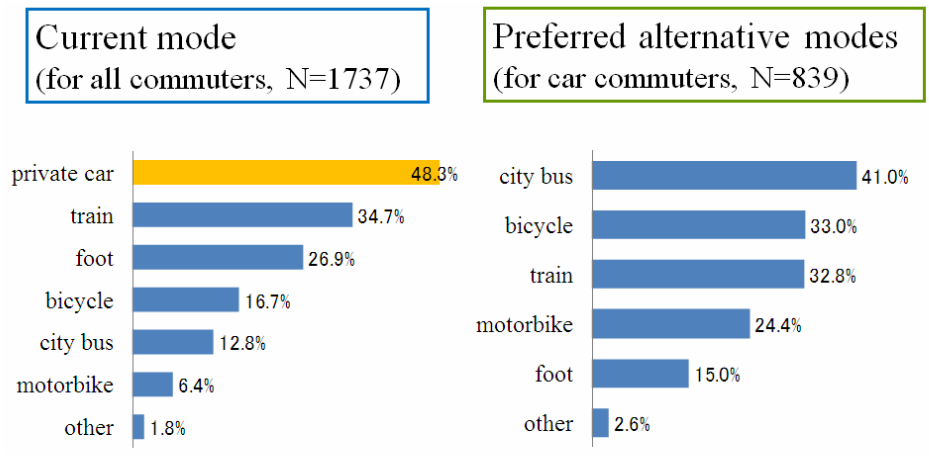

Fig. 1 Commuting modes

Among several reasons for taking a private car as a modes of transportation, the first is "it is convenient as it directly connects home to a workplace" (68.3%), then comes “transportation time shorter than by public transportation” (45.1%), “far from the nearest station or bus stop, or unavailability of traffic lines” (41.8%); these responses point to the unavailability of convenience of public transportation modes. Subsequent answers concern the convenience and comfort of private cars, such as “the ability to secure private space and comfort in movement” and “convenient as luggage can be transferred at the same time” (both 39.3%).

On the other hand, modes of public transportation, such as trains and route buses, are mainly selected for commuting because of punctuality and convenience such as “the most convenient because of virtually constant commuting time” (71.6%), and “availability of nearest station & bus stop for both workplace and home” (43.6%). It is also noted that many of them see public transportation as “free time available for a nap or reading books” (30.0%).

3.2 Current Circumstances on Work Patterns

The result of a questionnaire about working place is shown in figure 2. Telework is very rarely adopted, as more than 80% of responders are “working in a normal workplace (not adopting telework)”, while 3.2 % of them are “working partly at home and partly in the business place”, and 2.1% “at home”, namely mostly at home.

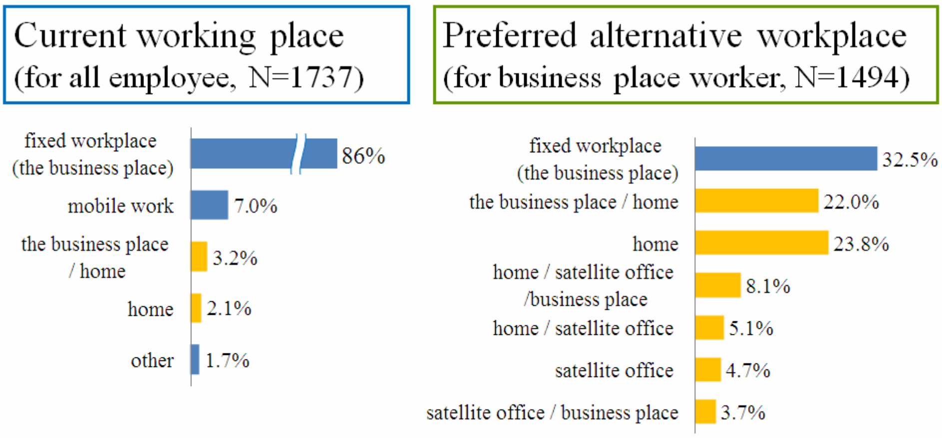

Fig. 2 Working place

The two biggest reasons for not adopting (or for being unable to adopt) telework: first “the company does not adopt such a system” (72.9%), then the second:

“the kind of work is not suited for telework” (37.3%).

Provided that the reasons for being unable to adopt telework were resolved, the first choice would be to work at home (23.8%), then “working partly at home and partly in the business place” (22.0%), followed by “a combination of home, satellite office and business place” (8.1%), which indicate their intention of working at home. On the other hand, the highest rate (32.5%) is for “working at a normal business place (not telework)”.

4 Substitutability of Movement by ICT

4.1 Substitutability of Transportation in Commute

Table 1 shows the disposition of using the modes of public transportation to be offered by each category of public transportation-related ICT (nine types) that are likely to be realized in the near future. An ICT in which private car commuters show the

Table 1 Preferred real-time information on public transportation from the proposed ICT (MA)

N= 839

Public transportation-related ICT (likely to be realized in the near future)		Interested in modal shift	
		[people]	[%]
1-1	Single card payment for several modes	215	25.6%
1-2	Real-time bus arrival information at bus-stop	213	25.4%
1-3	Time schedule of transfer trains or buses	255	30.4%
1-4	**Route information from the current place to the destination**	283	33.7%
1-5	Possible routes based on personal schedule	232	27.7%
1-6	**Transfer routes reflecting traffic conditions**	264	31.5%
1-7	**Shortest transfer routes**	274	32.7%
1-8	Information on all transportation modes including car sharing	189	22.5%
1-9	**A system for reducing bus operation time (ex.PTPS)**	272	32.4%

greatest interest for use as a mode of public transportation is “a service for automatically presenting routes from the current place to a destination” (33.7%). Then, “a service for displaying the shortest transfer routes" (32.7%), "a service for reducing bus operation time" (32.4%), "a service for preparing and showing transfer routes immediately reflecting current operating conditions" (31.5%), and "a service for displaying time schedules of transfer trains or buses upon arrival at each station or bus stop" (30.4%). These data indicate that ICT to provide information on transfer routes and the required time will encourage disposition for the utilization of modes of public transportation.

4.2 Effect of Modal Shift of Private Car Commute

Provisional calculations have been made on changes in CO_2 emissions before and after the shift from the private car commute to ICT-based alternative public transportation commute. These calculations are based on "commute distance using current transportation modes" and "commute distance after shift from private car commute to alternative public transportation commute", which are multiplied by the unit volume of CO_2 emission for each type of transportation modes as shown in Table 2.

Table 2 Unit volume of CO_2 emission

Transportation mode	Unit volume of CO_2 emission
Automobile	0.17 kg-CO_2/person・km
Route bus	0.094 kg-CO_2/person・km
Railway	0.024 kg-CO_2/person・km
Bike	0.058 kg-CO_2/person・min

The unit volume for automobiles used here corresponds to the average values for "private cars" and "private light cars" prepared based on material from the Land, Infrastructure and Transportation Ministry [7], while that for railways corresponds to the average values for "railroads", "subways", "streetcars" and "new transportation systems". Thus, the CO_2 emission per person has been estimated, both for the current mode of transportation and after a modal shift.

The above calculation results are shown in Table 3. If, out of private car commuters (839 persons), those (473 persons) having disposition to use alternative transportation modes through any form of ICT make a modal shift, the reduction in CO_2 emission per current individual private car commuter will be 0.56 kg-CO_2/person (reduction rate: 25.1%). Should all private car commuters (839 persons) make a modal shift, the reduction in CO_2 emission per person will be 1.01 kg-CO_2/person (reduction rate: 45.6%).

Table 3 CO_2 emission reduction due to modal-shift (for private car commuters)

N= 839

	No. of modal shift performed	CO_2 emission [kg-CO2/person･day]			Reduction rate
		Current	After shift	Reduction	%
Performed only for those interested	473 (56%)	2.22	1.66	0.56	25.1
Performed for all car commuters	839	2.22	1.21	1.01	45.6

4.3 Substitutability of Work Patterns

Table 4 shows the results of a questionnaire on the disposition of adopting telework for each category of telework-related ICT likely to be realized in the near future. The ICT most attractive for business place workers in providing possible patterns of telework are “a mobile environment allowing for the use of all systems” (57.6%), which indicates that the majority of them are expecting the introduction of all types of ICT in order to promote the adoption of telework. In terms of each form of ICT, the first with 55.6% is “System to perform all work control on webs”, followed by “satellite office equipped with infrastructure compatible with that in a normal business place” (52.9%) and “visual communication system” (48.5%).

Table 4 Preferred type of telework from the proposed ICT (MA)

N= 1494

Public transportation-related ICT (likely to be realized in the near future)		Interested in telework	
		[people]	[%]
2-1	Visual communication system	724	48.5%
2-2	All work control on webs	831	55.6%
2-3	Remote working system (using robots for example)	444	29.7%
2-4	Satellite office with infrastructure as equal as that in a business place	791	52.9%
2-5	Mobile environment allowing for the use of all	861	57.6%

Out of 1,494 persons, 486 persons (32.5%) have replied that they "prefer working in a normal business place (not adopting telework)", even if the reasons for being unable to adopt telework are resolved. For these 486 persons, a survey by questionnaire has been made as to the disposition of adopting telework in the case of ICT realization. The results are: an ICT most attractive to offer telework opportunity is "System to perform all work control on webs" (24.3%), followed by "Mobile environment allowing for the use of all systems" (22.6%), and "Visual communication system" (19.3%). These data might imply that a maximum 25% of those who are no longer interested in telework nowadays may, depending on the type of ICT, have the intention of adopting telework.

4.4 Effect of Shift to Telework

Provisional calculations of CO_2 emission have been performed to quantitatively estimate the effect of reducing the environmental load in the case of making an ICT-based modal shift to telework from commuting to work in a business place. In these provisional calculations, "the amount of CO_2 emission during commute" used in Section 4.2 is changed to "0" in the case of work at home, and in case of satellite office work, 50% of that for work in a business place. And these figures are multiplied by "the frequency of commute (per week) for each type of telework performed", to obtain the calculation results.

The above results are listed in Table 5. Out of the workers in business places (1,494 persons), there are 1,074 persons who are ready to adopt telework via the realization of the proposed ICT. If these 1,074 persons perform their preferred type of telework, the amount of CO_2 emission per person will be reduced on average by 3.06 kg-CO_2 (43.9%).

Table 5 Reduction in CO_2 emission during commute if telework adopted (for all workers in business places) (N=1494)

N= 1494

	No. of telework performed	CO_2 emission [kg-CO2/person・day]			Reduction rate [%]
		Current	After shift	Reduction	
Performed only for those interested	1,074 (72%)	6.96	3.90	3.06	43.9

4.5 Synergetic Effect of Modal Shift and Telework

From among private car commuters (839 persons) out of workers in business places (1,494 persons), there are 473 persons who are ready to adopt a modal shift through some type of ICT. Provisional calculations for these 473 persons when adopting telework and a modal shift have resulted on average in a reduction in CO_2 emission per person of 5.28 kg-CO_2 (75.9%), which shows a great synergetic impact by the adoption of telework and modal shift.

5 Eco-design of Movement by ICT

It has been clarified to date that the development of ICT will promote a modal shift from the use of automobiles for commute and the adoption of telework, and that the synergetic effect of the modal shift and telework is significant. In connection with the reduction of environmental impact due to transportation modes for commuting and also based on these results, a new eco-design for movement is proposed wherein ICT is utilized mainly for individuals and local society.

This proposal is shown schematically in Figure 3. Through the use of a real-time security traffic system, it allows navigation of various transportation modes based on personal information. Moreover, with the use of distributed & common-use

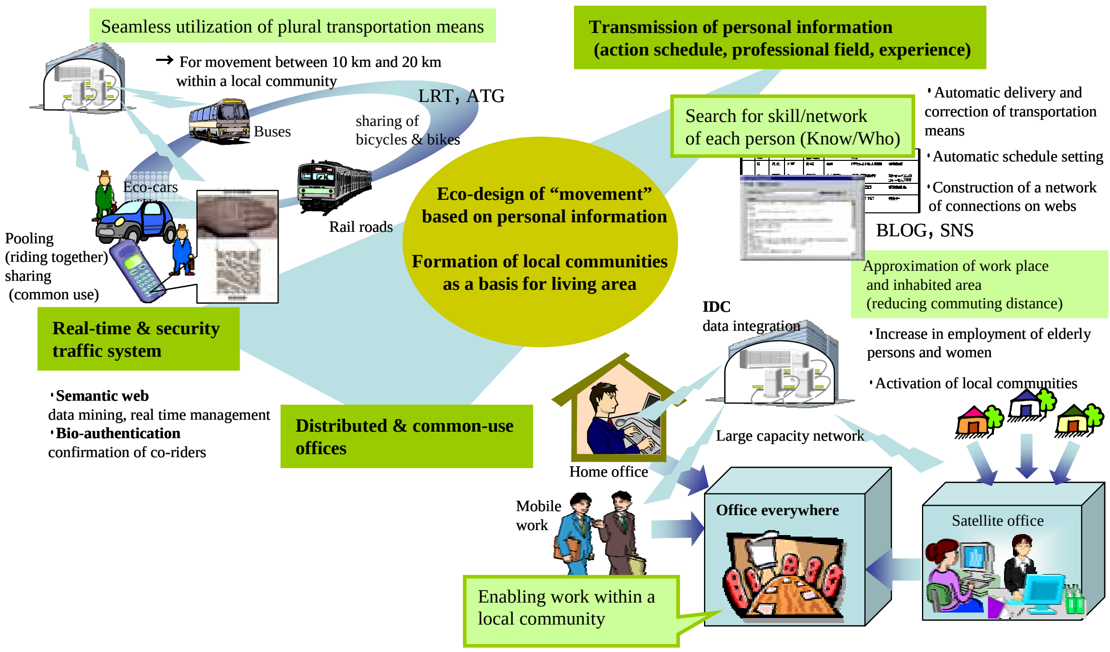

Fig. 3 ECO—design of movement by ICT

offices, it also offers telework-based flexible work patterns best suited for each personal characteristic. By having the inhabited area and the workplace at the same place or nearby, this proposal also allows the establishment of local communities as a basis for a living area. And with an increasing demand on traffic within the local community, it further promotes the development of infrastructures of public transportation modes and the common utilization of private cars, such as car sharing and car pooling. Consequently, it will be possible to reduce the distance for movement during commuting and to make a shift in the modes of transportation to less environmentally burdensome alternatives.

5.1 Real-time Security Traffic System

Through the use of semantic web technology and based on the personal action schedule & situations and also the operating conditions of various traffic organizations, it is possible to automatically offer and correct several transportation modes & schedules in real time, thereby realizing the guidance of efficient movement routes. The exploitation of biological authentication technology and the realization of secure user identification via portable information terminal devices enable the incorporation of car sharing & car pooling in movement routes. Consequently, the seamless utilization of several means of traffic promotes a modal shift to means of public transportation and car sharing/pooling that greatly improves convenience, and also reduces the traffic volume of automobiles.

5.2 Distributed & Common-use Offices

By means of data integration into an IDC (Internet Data Center) and a large capacity network, satellite offices and home or mobile offices are established within a local community. In addition, the cross sectional utilization of these facilities allows seamless work to be implemented, thus offering telework-based work patterns best suited to individual characteristics (sexuality, age, family structure and skill). As a result, a substantial reduction of movement in commute and business trip is expected. It is also possible to resolve useless energy consumption due to traffic congestion in commuting and to save office space. Furthermore, integration of the daily moving range into a local community promotes the development of public transportation modes within the community (buses, LRT, car sharing/pooling).

Technical issues to be solved in meeting the above include the development and widespread use of key technologies such as an online work management system, a communication system with highly realistic sensations, a broadband and mobile network environment, countermeasures for security, ASP (Application Service Provider) and PC without installed HDD. They also cover the universal design of terminals to correct digital divide and establishment of networks like a lifeline (having convenience and reliability in city water and electricity supply). On the other hand, there are social issues such as the development of work-related laws, revision of in-house regulations, and altered awareness for work patterns.

6 Conclusion

A survey using the Internet was performed on the current circumstances of commuting and working as well as the potential to reduce commuting via a modal shift in modes of commuting via ICT or through the realization of telework, and the potential for limiting CO_2 emission generated by commuting through the development of ICT has also been evaluated.

If, of private car commuters, those having a disposition to use alternative transportation modes of any proposed form of ICT adopt a modal shift, the reduction in CO_2 emission per current individual private car commuter will be 0.56 kg-CO_2/person (reduction rate: 25.1%). If, out of workers in business places, those who are ready to adopt telework by the realization of proposed ICT, perform telework of their preferred type, the amount of CO_2 emission per individual employee at the business place will be reduced on average by 3.06 kg-CO_2 (43.9%).

Out of private car commuters working in business places, provisional calculations have been carried out for those who are prepared to make a modal shift by the realization of ICT, in order to estimate the CO_2 reduction effect when adopting telework and modal shift. The above calculations have resulted in the reduction of CO_2 emission per person of 5.28 kg-CO_2 (75.9%), which shows a great synergetic impact by the adoption of telework and a modal shift.

The above results have prompted us to find the possibility to promote the implementation of a modal shift from private car commuting and the adoption of telework through the development of ICT, and also to reduce the amount of CO_2 emission due to the movement of people during commuting. And on this basis, a proposal has been made on an eco-design for movement through ICT wherein real-time & security traffic system and distributed & common-use offices are integrated.

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Estimations of reducing CO_2 emissions through introduction of ICT in manufacturing and distribution sectors

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Abstract: Information and communication technology (ICT) has a large influence on the environmental, economic, and social aspects of our lives. The objective of this study is to investigate how much influence the environmental impact had when information sharing became more widespread by using ICT in manufacturing and distribution sectors. In this study, we developed the estimation methods with respect to the use of supply chain management (SCM) systems in manufacturing sectors, the use of direct-from-factory and build-to-order (BTO) systems in net retail, as in the Dell model, and the computerization of goods distribution. Items of optimizing industry efficiency by the application of these ICT methods are described. The results of these estimations suggested that the above applications of ICT could have the effect of reducing approximately 11.6 millions t-CO_2, including indirect effects. This is equivalent to approximately 10% of the CO_2 emission throughout Japan in 1990.

Key Words: CO_2, Information and communication technology (ICT), Supply chain management (SCM), Build to order (BTO), Manufacturing sector, Distribution sector

1. Introduction

The environmental issues we now face, such as global warming, are believed to result from our social systems. Information and communication technology (ICT) has the potential to reduce environmental load by enabling more efficient business activities and control of energy and resource usage. NTT's previous research includes evaluation of the effects on energy consumption brought about by the application of ICT [1)- 4)]. This evaluation estimated an energy reduction effect that would occur in 2010 in Japan, which is equivalent to 3.9% of the entire energy consumption in 2000. Approximately 60% of that is a reduction in energy consumption due to e-commerce for business-to-business, and approximately half of that is due to production and distribution management systems, such as supply chain management (SCM), which is the largest amount of an energy reduction effect.

2. Research Objective

The objective of this study is to look for what sort of effects the revolution caused by the use of ICT has, particularly on changes in CO_2 emissions. This study aims at laying the cornerstone of a low-carbon ICT society.

3. Research Methods

We have developed methods that evaluate the environmental impact of reducing CO_2 emissions by using SCM techniques, which consist of three steps.

First of all, we examined the possibility from macro statistics and a company example. We investigated the effect of reducing CO_2 emissions caused by using ICT in production and distribution management systems such as SCM, in the food, textile, medicine, and cosmetics industries. These industries were selected because their dead stocks lead easily to abandonment by constraints such as consumption time limit, change of the seasons and so on. This study has suggested that the reduction in CO_2 emissions was about 3.9 million t-CO_2, corresponding to more than 10% of the amount of total CO_2 emissions in these industries [5), 6)].

Secondly, we used that knowledge to reduce the stock in hand (inventory) of the manufacturing sector. We also designed a methodology of estimating the effect of reducing CO_2 emissions that would be caused by reducing the amount of dead stock by the application of ICT systems such as the SCM technique, thus suppressing unnecessary production. We did that by considering benchmarks that define transitions to optimized business levels with reduced stock in hand for each field within the manufacturing sector [6), 7)]. We have investigated and analyzed rotation periods of stock from financial reports of 1,180 manufacturing companies and assumed that the rotation periods of stock in each industry shifted to the better rotation periods of companies by using ICT. 3EID (Embodied Energy and Emission Intensity Data for Japan Using Input-Output Tables) [8)] was adopted for the estimation of the reduction of CO_2 emissions. This study indicated that the effect of reducing CO_2 emissions caused by unnecessary production by using ICT in production and distribution management systems such as SCM systems was approximately 37 millions t-CO_2.

Finally, we developed the above estimation methods further not only with respect to SCM but also with respect to the use of direct-from-factory and build-to-order (BTO) systems in net retail, as in the Dell model, and the computerization of goods distribution. Items of optimizing industry efficiency by the application of these ICT are described below.

a. Effects due to application of SCM

- Suppression of unnecessary production by reduction of inventories in the manufacturing sector
- Reduction in number of factory buildings due to suppression of unnecessary production in the manufacturing sector
- Reduction of storage space due to inventory reduction in wholesalers
- Suppression of unnecessary production due to inventory reduction in wholesalers
- Wholesalers made unnecessary due to direct transactions between manufacturers and retail stores
- Reduction of storage space due to inventory reduction at retailers
- Suppression of unnecessary production by reduction of inventories at retailers
- Reduction in warehouse building due to inventory reduction
- Reduction in goods distribution due to reduction in returned goods
- Optimization of accounting work

b. Effects due to direct-from-factory and BTO systems

- Wholesalers made unnecessary by direct-from-factory system
- Retail stores made unnecessary by direct-from-factory system
- Increase in inventory space in net-retailers
- Suppression of unnecessary production
- Increase in goods distribution by parcel-delivery services
- Reduction in returned goods distribution
- Reduction in movements of customers because visiting stores is not necessary

c. Effects due to computerization of distribution

- Eco-drive effect due to journey management system
- Improvement in carrying efficiency due to logistic (distribution) management system

4. Results and Discussion

The results of these estimations are shown in Table 1. The largest factor in the effect of reducing CO_2 emissions is the suppression of unnecessary production as inventories contract within the manufacturing sector due to the application of SCM. Optimization of the manufacturing sector is likely to have a greater direct effect on CO_2 emission reduction. The next largest factor is the reduction of storage space as the amount of inventories contract within the wholesalers of goods due to the application of SCM. By their very nature, companies involved with the wholesale distribution of goods easily accumulate inventory; so clearly, any inventory reduction here will be effective in reducing CO_2 emissions. These estimations suggested that these applications of ICT, such as SCM, direct-from-factory and BTO systems and the computerization of goods distribution will have the effect of reducing approximately 11.6 millions t-CO_2 in 2050, including indirect effects. This is equivalent to approximately 10% of the CO_2 emission throughout Japan in 1990. However, we should note that the numerical values obtained by totaling values for each item overlap to a certain extent.

Table 1 Results of calculations of CO_2 reduction effect due to application of ICT (units: 1,000t-CO_2)

Items			2010	2020	2030	2050
a. SCM	Manufacturing industry	Suppression of unnecessary production	16,221	16,221	35,960	41,461
		Reduction in number of factory buildings	84	124	178	202
	Wholesalers	Reduction of storage space	7,777	11,497	16,140	17,875
		Suppression of unnecessary production	443	660	943	1,065
		Wholesalers made unnecessary	2,274	4,724	6,477	8,630
	Retail stores	Reduction of storage space	3,326	4,830	6,848	7,382
		Suppression of unnecessary production	329	480	692	755
	Reduction in warehouse building		2,275	3,308	4,496	4,933
	Reduced distribution of returned goods		1,943	2,819	3,541	4,600
	Optimization of accounting work		1,429	2,382	3,334	4,763
Subtotal			36,100	47,044	78,609	91,665
b. Direct-from-factory and BTO		Wholesalers made unnecessary	2,722	4,084	5,445	8,167
		Retail stores made unnecessary	2,380	3,571	4,761	7,141
		Increase in inventory space in net-retailers	▲ 1,328	▲ 1,992	▲ 2,657	▲ 3,985
		Suppression of unnecessary production	215	323	431	646
		Increase in retail goods distribution	▲ 808	▲ 1,211	▲ 1,615	▲ 2,423
		Reduction in returned goods distribution	28	42	56	84
		Reduction in movements of customers	426	639	852	1,278
Subtotal			3,636	5,455	7,273	10,909
c. Application of ICT to goods distribution		Journey management system	1,588	3,970	6,352	7,940
		Logisitic (distribution) management system	1,295	3,238	5,181	6,476
Subtotal			2,883	7,208	11,533	14,416
Total			42,619	59,707	97,415	116,991

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