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WHOLLY ELECTRIFIED INFRASTRUCTURES AS THE MOST VITAL FIRST STEP TOWARDS THE SUSTAINABLE REGIONAL SOCIETY

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At first this paper presents the list of basic infrastructures of the sustainable regional society, concerning these aspects of reduction of the greenhouse gases emission, adaptation for climate change, production and steady supply of food, conservation of natural ecology. These infrastructures are illustarated on a drawing.

Implementation plan for the contents of this paper is written up as the environmental system master plan, which is thought to have the same weight as the comprehensive national development plan.

When the whole system is looked down, the key point to pull them forward is found to be the electrification. It is said that wholly electified infrastructures pull society towards the sustainable state.

First phase for enhancement of electric power supply should be development of the power transmission lines, and next-generation most advanced power transmission lines is fervently desired.

Key Words : *infrastructure, environmental system master plan, electrification, power transmission line, sustainability*

1. BASIC INFRASTRUCTURES OF THE SUSTAINABLE REGINAL SOCIETY

No methodology to synthesize whole basic infrastructures of the sustainable regional society has been proposed until now. A method for this purpose is developed by the author, along the lines of the sewer planning.

That is, starting with presentation of the original conceptual plan, remediation is repeatedly made following checks by various quarters. Thus, results of synthesis are evolved and justified[1)2)].

Obtained results[1)2)] are illustrated in **Figure 1**. Items of this figure are explained in Chapter 2.

In this Chapter 1, basic infrastructures for the purpose of reduction of greenhouse gases emission, adaptation for climate change, food production and conservation of natural ecology are concurrently listed.

Infrastructures for reduction of the greenhouse gases emission and for adaptation towards the climate change should be constrained by the preposition "land use for conservation of natural ecology is severe competitive to food production and natural energy exploitation", which is thought to be the basic axiom in the environmental science field concerning the global environmental problems. Therefore, infrastructures for food production and for conservation of natural ecology should also be listed concurrently.

Environmental system master plan is demanded to describe the disposition of all these infrastructures, and outline of this plan is presented in Chapter 3.

(1) Infrastructures to reduce the greenhouse gases emission and to perform the adaptation program for climate change

Basic infrastructures of the sustainable regional society have already been listed as below to reduce the greenhouse gases emission and to perform the adaptation program for climate change[1)2)]. This list is drawn up based on many previous studies, especially Cool Earth Energy Innovative Technology Plan of METI and Wise Adaptation for Climate Change reported by Global Warming Impacts & Adaptation Committee of MOE.

(Reduction of the greenhouse gases emission)

High-efficiency coal/natural gas fired power generation with carbon dioxide capture and storage (CCS).
(Advanced) nuclear power generation. Dumping grounds for radioactive wastes must be acquired.
CCS at the steel plants and the cement factories.
Compact city planning.
Co-generation.
Natural gas supply pipelines.
Transportation of less energy use.
Modal shift.
Plug-in hybrid vehicle/electric vehicle.
Biofuel plant farming plants and its filling station.
High-efficiency heat insulation of houses and buildings, such as multi-ceramics layer heat insulation materials and room air quality improving.
Next-generation high-efficiency lighting such as high-efficiency LED, organic EL and micro cavity.
Further reduction of power consumption may be achieved by combining them with optical sensors, human sense sensors, HEMS, BEMS and so forth.
Promotion of reinforced concrete apartment buildings and restriction of detached houses. Promotion of long-term usable (more than 200 years) residence.
Innovative photovoltaic power generation and solar thermal utilization.
Ultra high-efficiency heat pump applied for the air conditioning, hot water supply and cooling/ heating process used in the industrial and consumer sectors, sometimes making use of solar heat and geothermal heat via air or ground.
Relocation of data-centers to the remote rural area.

(Adaptation for climate change)

Agriculture withstanding high temperature, making use of breed improvement and change of crop species.
Increase of food self-sufficiency taking advantage of global warming.
Crop species are changed to the one suitable for feed grains and double cropping in western and southwestern regions. Hokkaido and Tohoku regions are changed to the center of rice cropping. Turnover rate of farmland is increased with the use of plant factory technology.
Creation and enhancement of green belt.
Planted forests are changed to natural ones. Gene conservation is promoted.
Bank protection and consolidation works. Coastal levee raising.
Construction of circle levee and back levee.
Relocation of people from vanishing settlements to the central compact city.
Mosquito control. Heat prostration control.

(2) Infrastructures for production and steady supply of food

Infrastructures for production and steady supply of food are listed as below[1].

Producing not only rice for humankind but feed grains at the paddies to increase the food self-sufficiency ratio.
Currently this ratio in Japan is around 40%, and increasing it towards more than 50% level is planned with such changes of cultivation style as shown above.
Leading edge farming plants with the plant factory technology and the genetically modified plants.
Currently these farming plants are mainly used for cultivation of vegetables, fruit trees and flowers. This method is also proposed to be used for cultivation of crops and pulses, as the security guarantee for famine or importation blocking.

(3) Infrastructures for conservation of natural ecology

Infrastructures for conservation of natural ecology are listed as below.

Regeneration of tideland/sea grass bed and enlargement of the natural conservation area on the vacant land.
This vacant land is made available after city zones are downscaled with the use of the compact city planning and after agricultural land is shrinked with the increase of the unit crop on each land.
Securement of the rare species protected zones.
This zone is defended at all costs to prepare for regeneration of natural ecosystem in future. Gene capsules are constructed to back endangered species up.
Creation and enhancement of green belt. Change of planted forests to natural ones.
These policies have already been listed to adapt for climate change.
Appropriate zoning of natural forests from the planted ones.

These infrastructures as listed in this chapter for reduction of the greenhouse gases emission, adaptation for climate change, production and steady supply of food, and conservation of natural ecology are illustrated on **Figure 1**.

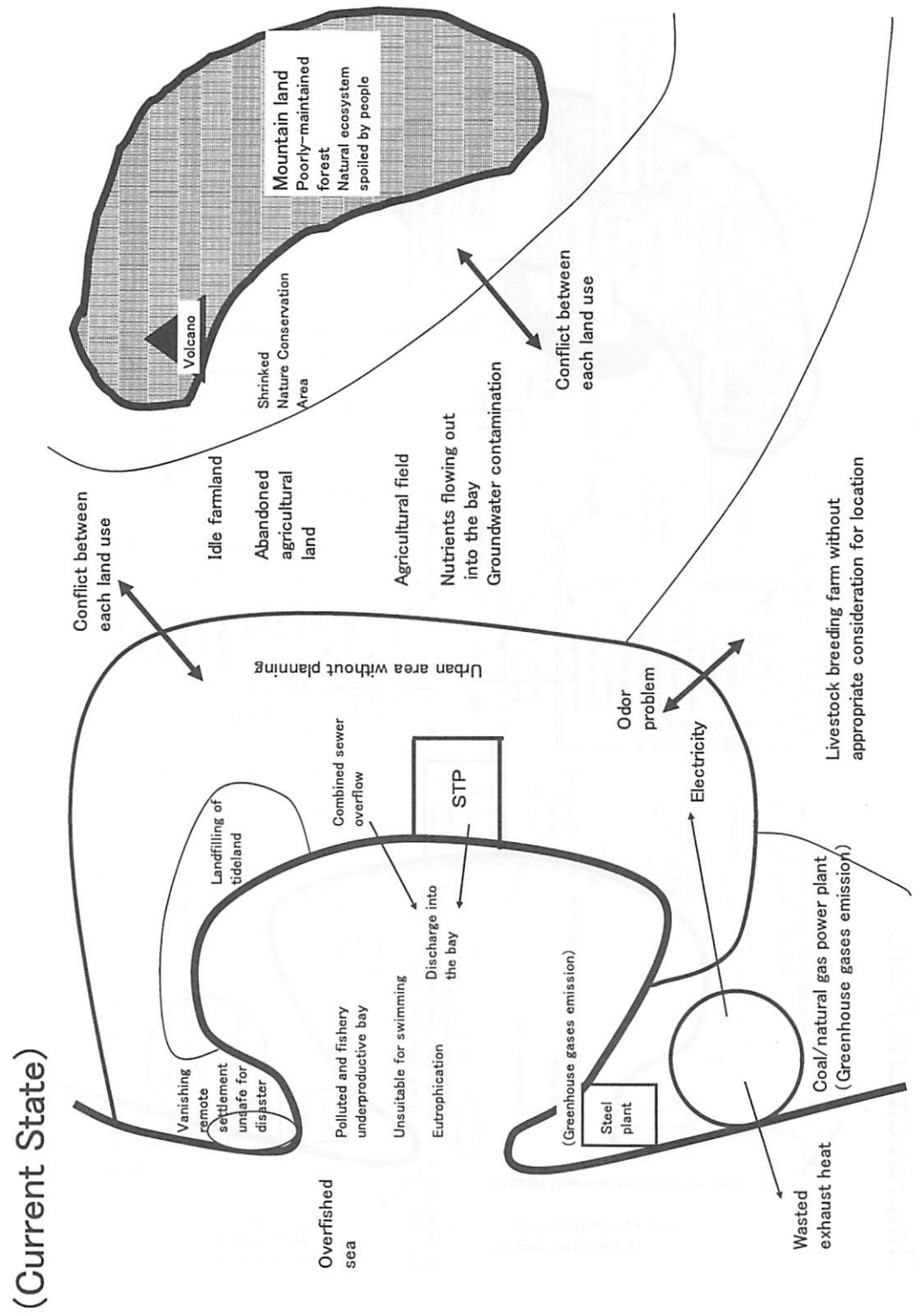

Figure 1-1 Basic infrastructures of the sustainable regional society (Current state)

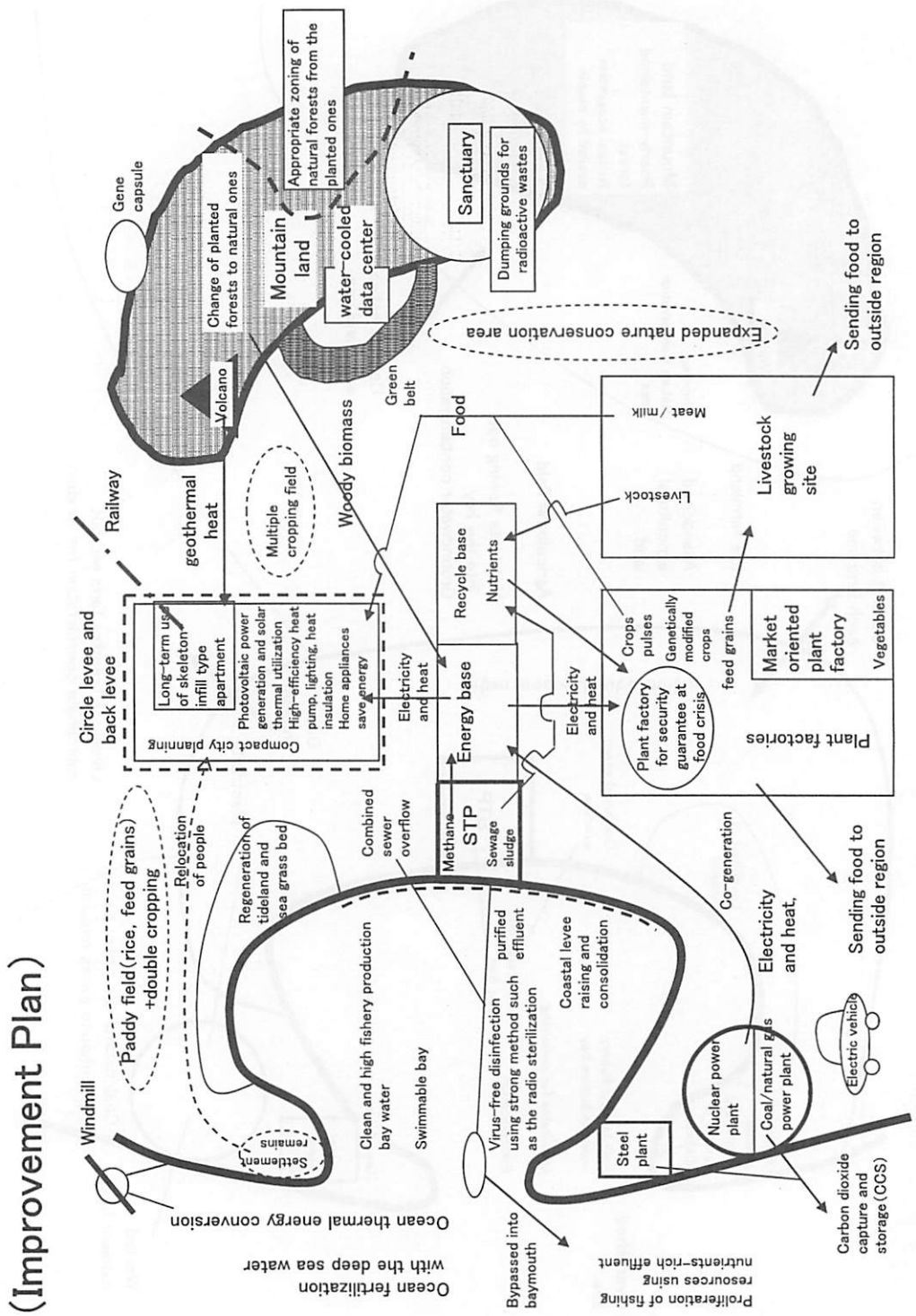

Figure 1-2 Basic infrastructures of the sustainable regional society (Improvement plan)

2. ILLUSTRATION OF BASIC INFRASTRUCTURES IN THE SUSTAINABLE REGINAL SOCIETY

Main points presented in **Figure 1** are as follows. This figure also shows infrastructures for bay water quality control, nutrients recycle, sustainable transportation and securement of rare metals other than those items presented in chapter 1.

(1) Food supply infrastructures

Not only rice for humankind but feed grains are produced at the paddies to increase the food self-sufficiency ratio towards more than 50% from the current level of around 40%. The rest portion is imported with much cheaper price.

Campaign to consume more rice is stepped up. Concurrently, people are encouraged to reduce leftover food.

Second generation bio-fuel using cellulose as the raw material is developed and promoted.

Leading edge farming plants with the plant factory technology and the genetically modified plants are promoted for cultivation of crops and pulses, as the security guarantee for famine or importation blocking.

Such leading-edge farming plants can increase the unit crop drastically, and enable reduction of agricultural land area. As a consequence, huge vacant space is left and can be changed to natural forest or ecological land.

Scientifically appropriate ceiling is imposed on fish catches. This ceiling must be strictly enforced, however, suffered damage of fishing people should be compensated for long-term stop of fishing or reduction of operating ships.

Ocean fertilization with the deep sea water is conducted to proliferate the fishery resources. Inner bay fishery is promoted with improvement of bay water quality and regeneration of the tideland and the sea grass bed.

Nutrient-rich effluent such as the treated sewage is bypassed into the baymouth, and is used for proliferation of fishing resources. The effluent must be disinfected to the level of virus-free using strong disinfection method such as the radio sterilization.

(2) Habitation infrastructures

Decentralized compact city planning is employed to improve the efficiency of water works, sewerage service, transportation, housing service and welfare service. Decentralized urban area enables securement of the open space in the neighborhood, and will greatly improve the housing environment.

Compact city can be located on narrow but safer land, and is excellent for disaster prevention of flooding, landslide, earthquake and tsunami. Relocation of people from the unsafe remote settlements to the safer compact cities is promoted.

Apartment houses of skeleton-infill type are constructed in each area for the low-income families to live cheaply. Skeleton parts can be used for long period, and infill parts are more frequently modified as needed. Therefore, long-term use of buildings is made possible.

High-efficiency heat insulation of houses and buildings are promoted with new materials such as the multi-ceramics layer and the room air quality improving.

Next-generation high-efficiency lighting is promoted with the use of high-efficiency LED, organic EL and micro-cavity. Further reduction of power consumption may be achieved by combining them with optical sensors, human sense sensors, HEMS, BEMS and so forth.

Reinforced concrete apartment buildings are promoted and detached houses are restricted.

Bank protection and consolidation work, coastal levee raising and construction of circle levee/back levee are promoted to adapt for climate change.

(3) Energy infrastructures

Undermentioned measures are promoted to reduce the greenhouse gases emission.

High-efficiency coal/natural gas fired power generation with CCS.

(Advanced) nuclear power generation.
Pluthermal, nuclear breeder and nuclear fusion technology is actively studied to achieve the sustainable and low greenhouse gases emission power source.

Securement of the dumping grounds for radioactive wastes in the region.
Such site can be put under the strict nature reserve, because both facilities request off-limits zone.

Promotion of photovoltaic power generation and solar thermal utilization in the urban area.

Promotion of the biofuel produced from the cellulose material, ocean thermal energy conversion, geothermal energy development and wind-power generation.

Promotion of the natural gas supply pipelines. Co-generation with such fuel is also promoted.

Promotion of save energy of home appliances with LED and organic EL. High efficiency heat pump is applied in the air conditioning, hot water supply and cooling/heating process, with the use of solar heat and geothermal heat via air or ground.

(4) Infrastructures for bay water quality conservation

Effluent such as the treated sewage or the combined sewer overflow is bypassed into the baymouth to reduce the pollution load into the bay. Advanced treatment of sewage is not sufficient if effluent volume is too large compared with the bay size. Effluent bypass is also excellent as the pathogenic microbe's control.

Nutrient-rich solution can be easily recycled in the plant factories, and nutrients from the agricultural sector are greatly reduced if the plant factory is more widely used.

Bay water quality will be improved with these measures.

(5) Nature conservation infrastructures

Vast vacant land is left when urban area is changed to compact city configuration and the unit crop is increased on agricultural land. Tideland and sea grass bed will be regenerated and nature conservation area will be enlarged on this vacant land.

Rare species protecting zones should be secured and defended at all costs to prepare for regeneration of natural ecosystem in future. Gene capsules are constructed to back endangered species up.

Creation and enhancement of green belt and change of planted forests to natural ones is promoted.

(6) Nutrients recycle infrastructures

Nutrients resources are extracted chemically out of the sewage sludge and livestock waste, and are used as fertilizers in the plant factories. Phosphorus resource will be gone off if these extracted nutrients are applied on the soil, because phosphorus is easily fixed on soil particles.

Nutrients recycle will be promoted if nutrient rich effluent such as the treated sewage is bypassed into the baymouth and is used for the proliferation of fishing resources.

With these measures, almost complete recycle of nutrients resources will be made possible.

(7) Transportation infrastructures

Automobiles, railway, ships and aircrafts continue to be used for the intercity or long-distance traffic. More energy-saving means must always be selected, employing the modal shift strategy and so on.

Electric/hybrid car is promoted as the next generation automobile. Low-emission diesel vehicle using the bio-fuel is an option. Non-contact electric power supply may be available in the highways for the electric cars to extend the cruising distance.

Reduction of fossil fuel consumption is also demanded for ships. Hybrid engine may be an option, and nuclear power will be widely used in future. Save-energy using the regenerative braking system will be possible for the railway systems.

Save-energy of aircrafts is currently under-developed, even though usage of the bio-fuel is being studied. Therefore, demand for aviation should be restricted, and freight is shifted to railways and vessels. Teleconference is said to be an option to restrict the transportation demand.

For inner-city traffic public transportation such as subways, streetcars and (electric) buses should be developed. Simply walking and (electric) bicycles are also promoted. However, vulnerable traffic users are still in a mess, and low-speed three-wheeler or mobile-suit type electric car should be developed in the future.

(8) Infrastructures for securement of rare metals

Basic metals/materials should be secured to implement without any hitch the measures/policies presented in this paper. Especially, some materials such as the rare metals are concerned with their depletion. Every measures/policies intended to global environmental protection should also care for this issue.

Strategy for securement of these metals/materials includes relying on more universal materials, product design of less rare metals usage, decrease of each material amounts at their atomic level and improvement of retrieval techniques. Technologies of detection, analysis, preparation and storing should be established to carry these strategies through.

Development of new mineral deposits is of course necessary.

Equally excellent materials without/slightly using rare metals are becoming available as material physics are making great advance. This is thought to be the ultimate strategy for securement of rare metals, and its further development is expected in future.

3. ENVIRONMENTAL SYSTEM MASTER PLAN

Today it is well recognized that environmental system master plan is demanded to synthesize the various environmental policies. This master plan should have the same weight as the comprehensive national development plan.

Environmental system master plan must

encompass a broad range of global warming, food issues and natural ecology conservation, because planning with only one or two aspects of them may lose the balance and become inappropriate. Land use for conservation of natural ecology is usually severe competitive to food production and natural energy exploitation.

Environmental system master plan should have the following items.

A: Current state of emission and yield, and targets for quantity of reduction and production.

Quantity of the greenhouse gases emission out of a region, quantity of pollutants (nutrients & germs) load into a bay, quantity of food production out of a region, quantity of lumber production out of a region etc. are grasped.

Targets for reduction of the greenhouse gases emission, reduction of pollutants load, production of food, production of lumber are set.

B: Achievement scenario of these targets for each reduction and production.

Ways for greenhouse gases reduction and reduced quantity is shown. Adopted ways include: save energy achieved with compact city planning, co-generation, modal shift, public transportation, low-carbon vehicles, save-energy of buildings and houses, reinforced concrete apartment complex, save-energy of consumer electronics, heat-pump, and detachment of data centers.

CCS and related matters.

Nuclear power generation.

Photovoltaic power generation and use of solar heat.

Ways for pollutants reduction into a bay and reduced quantity is shown. Adopted ways include: effluent bypass, advanced treatment of effluent.

Ways for food production and produced quantity is shown. Adopted ways include: existing paddy field and outdoor culture field, plant factories.

Ways for lumber production and produced quantity is shown. Adopted ways include: thinning operation, tall-grown trees.

C: Image for natural ecology conservation.

Quantitative goal is first set.

Arrangement plan for green belt, tideland, sea grass bed and rare species protecting zones. Gene preservation plan for gene capsules.

Partition of planted forests and natural ones.

Change of planted forests to natural ones.

Designation of the strictly nature conservation area.

D: Statement of adaptation for climate change.

Bank protection and consolidation work.

Basin area flood control and construction of circle levee and back levee.

Relocation planning of people from vanishing settlements to the central compact city.

E: Arrangement plan of environmental systems

Arrangement plan of environmental systems as shown above is worked up. Land use for each environmental system should be checked not to interfere with others. Covered items include: compact city, public transportation, CCS site, dumping grounds for radioactive wastes, site for photovoltaic power generation, nature conservation area, site for planted forests, tideland and sea grass bed, paddy field, outdoor culture field, plant factories, livestock breeding farm, effluent outflow points, ocean fertilization points using the deep sea water, site for bank protection and consolidation work, site for coastal levee raising, site for circle levee and back levee, relocated unsafe remote settlement.

F: Execution planning

Target for food self-sufficiency ratio.

Target for farmland turnover rate.

Size and capability of security guarantee for famine and food import blocking.

Partition plan of idle land into agricultural land, planted forests and nature conservation area. Plan for change of planted forests to natural ones.

Conservation plan of fishery resources.

Disinfection plan of effluents.

Sea water quality conservation plan of bays.

Plan for rare species protecting zones and gene capsules.

Plan for nutrients recycle.

Plan for rare metals securement.

Green IT program.

Implementation plan of compact city.

Plan for long-term building use.

Management plan of CCS.

Construction plan of nuclear power generators.

Save-energy plan.

Modal shift plan.

Installation plan of next-generation vehicles.

CDM plan.

Plan for trading of domestic greenhouse gases emissions.

Protection plan of vulnerable road users.

Basin wide flood control.

G: Communication with citizens

Campaign to consume more rice.

Dietary habit changing to reduce leftover food.

Setting upper limit of fish catches.

Harmonious co-existence with nature conservation area.

Nuclear power safety.

Dialogue with people about the dumping grounds of radioactive wastes.

Environmental assessment of CCS.

Discussion about pedestrians and bicycle users.

Environmental tax.

Recycle as a measure for rare metal securement.

Heat-prostration control.

4. WHOLLY ELECTRIFIED INFRASTRUCTURES PULL SOCIETY TOWARDS THE SUSTAINABLE STATE

List of basic infrastructures in the sustainable regional society are shown in chapters 1 and 2. Arrangement drawing of these infrastructures is illustrated in **Figure 1** and explained in chapter 2. Environmental system master plan in chapter 3 is the implementation plan for the contents of this paper.

When the contents of this paper are looked down, the key point to pull the whole system forward is found to be the electrification.

High-efficiency coal/natural gas fired power generation with CCS, (advanced) nuclear power generation, co-generation, innovative photovoltaic power generation are without question to supply electricity with less greenhouse gases emission.

Compact city planning, transportation of less energy use, high-efficiency heat insulation of houses and buildings, next-generation high-efficiency lighting, relocation of data-centers to the remote rural area, and promotion of long-term usable residence is to save electric energy.

Securing the dumping grounds for radioactive wastes is to stabilize the electric power supply, and natural gas supply pipelines are to supply the fuel for generators.

Modal shift and plug-in hybrid vehicle/electric vehicle are to change the energy source from the fossil fuels to the electric power.

Promotion of reinforced concrete apartment buildings and restriction of detached houses are for the reduction of heating fuel, and more excellent energy saving can be attained with the ultra high efficiency heat pump technology, which uses electric power. Solar heat and geothermal heat are used for the efficiency improvement of heat pumps.

CCS at the steel plants and the cement factories are for reduction of carbon dioxide emission. Biofuel is the alternative source for carbon rich fuels. They are not directly related to the electricity, though electricity may make their introduction easier.

Concerning adaptation for climate change and natural ecology conservation, most measures are indirectly related with the electricity. However, electric power supply is crucial to perform these adaptation measures successfully.

Concerning food supply, cultivation of cropland needs many sorts of machines. They are currently driven with the fossil fuels; however, electric-powered machines will be universally used for this purpose in future. Heating of plant factories is currently performed with fossil fuel burning; however, electric-powered heat pumps will be used instead in future.

Thus electricity is demanded in most aspects of measures for conservation of global environment. Then constructing the adequate infrastructures of electric power supply is thought to be the most vital step towards the sustainable society.

First phase for enhancement of electric power supply should be development of the power transmission lines. If this is well developed, power supply generators of any type will be set in series. Generators set at the early stage are of course driven with fossil fuels; however, they can be replaced by nuclear, photovoltaic or hydropower generators at the latter phase.

Photovoltaic power generators on the roof of each house and wind-power generators can be connected to the power transmission lines, and can receive the back-up support from them.

Electric power transmission lines served for the above objectives should be the next-generation most advanced type, which is equipped with intelligent, interactive and integrative ability.

Next-generation electric power transmission lines should have the ring-shaped configuration to minimize the voltage drop, and also have the electricity storing capacity or high-capacity batteries.

Superconductive cables will be introduced in these lines to reduce the power transmission energy loss[3].

Electricity driven heat supply equipments will replace fossil fuel or bio-fuel types step-by-step.

Electricity supply stations for electric/hybrid vehicles will be set in series when these type vehicles are well introduced.

For all of these reasons, it is said that wholly electrified infrastructures pull regional society towards the sustainable state, and development of next-generation most advanced power transmission lines is the most vital first step towards this direction.

President Obama of The United States also recognize the importance of electricity transmission lines, and jump-starting the transformation to a bigger, better, smarter grid is the second listed policy

in The American Reinvestment and Recovery Plan[4] next to doubling renewable energy generating capacity.

Care for the urban scenic view must not be forgotten, and laying power lines underground should be steadily executed in parallel.

Considerable amount of thermal energy is currently wasted into the surrounding environment at the thermal or nuclear power stations. This energy can be used for warming of plant factories or houses, and such cogeneration should be promoted in the future.

REFERENCES

1) Mizutani, J.: Basic infrastructures of sustainable regional society -2008 autumn version-, Proceedings of the 36th Annual Meeting of Environmental Systems Research 2008, Committee on Environmental Systems, JSCE, pp. 85-95, 2008.
2) Mizutani, J.: Basic infrastructures of sustainable regional society -2008 summer version-, Proceedings of the 16th Symposium of Global Environment, Committee on Global Environment, JSCE, pp. 103-113, 2008.
3) Grant, P.M., Starr, C., Overbye, and T.: A power grid for the hydrogen economy, Scientific American, July 2008.
4) The American Reinvestment and Recovery Plan-By the Numbers, The White House Web-site, January 24, 2009, http://www.whitehouse.gov/assets/Documents/Recovery Plan Metrics report 508.pdf.

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