TECHNICAL FEASIBILITY OF "ECO-PLATFORM"
- Technology Integration for the 21st Century -

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Abstract-**A concept of "ECO-PLATFORM" is proposed for solving environmental problems that people are facing now and will face in and around the coastal area, setting their sight on the contribution from the viewpoint of the sea. The Eco-Platform is a complex on a floating platform and has functions for solving social and environmental problems. The functions installed are generation of heat/electric energy by incinerating combustible waste without introduction of fossil energy, cascade use of heat energy, application of marine bio-technology for processing the sewage and purifying eutrophic seawater, reproduction of material and energy resources from man-made waste and sewage. All the functions installed are integrated systematically and efficiently**

To ensure the realization of the concept, it is necessary to study/investigate the feasibility of systematic combination of functions and facilities installed on the Eco-Platform. The authors have been studying the required function and size of each facility, probable waste/sewage/energy/resource input and output relations. After the studies on the desirable combi-nation and arrangement of installed facilities, they also studied the energy and material balance of the total system from the technical standpoints to implement the Eco-Platform system. The results of the study shows that the Eco-Platform is technically feasible applying technologies mainly developed in the latter half of the 20th century.

I. INTRODUCTION

Arguments about the worldwide degradation of natural environments have been repeated seriously for more than ten years. Problems have been reported with serious evidences, and have been discussed to find out suitable solutions and measures. We have recognized that almost all of the environmental problems arose in the coastal land and sea areas are results of long-period human activities on the coastal area, such as over-population and industriali-zation. So that, we have to reconsider and change the paradigm of human society and activities developed in the 20th century supported by the technical and social system of mass-production, mass-consumption and mass-dumping.

According to a certain prediction, the world population will reach 8,000,000,000 in the former half of the 21st century, and more than 2/3 of the population will be concentrated in the coastal area. It may be easily imagined that the environmental problems will be much more serious in the coastal area throughout the world. We are not allowed to commit solution of environmental problems to the following generation. To find out solutions, ideas and measures supported by sophisticated technologies have been developed and proposed so far, however, utilization of high-technologies often requires the introduction of additional electric/heat energy which may cause the rise of entropy of the earth system. Introduction of new energy is not necessarily acceptable from the viewpoint of long−term sustainability of the earth system.

The final goal for human beings is to establish the symbiotic relations with all the creatures on the earth. The keyword is "Sustainable development" for the achievement of final goal. To put it more definitely, we have to make efforts to maintain the ecosystem of fauna and flora as well as to ensure the human lives and activities. Efficient use/reuse of energy and resources as well as reduction/recycling of waste are the effective measures. However, since people are not able to lower their living-standard and life-style, the amount of waste and sewage have been increasing gradually. Besides, they never accept the construction of waste disposal and sewerage facilities in the neighborhood of their residence. So that, we have been facing difficulties that there are no vacant land available in and around the highly populated urban area to build such annoying facilities. We have to find out a vacant land where necessary conditions are satisfied. One of the possible solutions that will meet the egoistic human demand is finding a space in the sea area for constructing such annoying facilities. The concept of ECO-PLATFORM is thought out after recognizing the current serious situation and the forthcoming critical situation. Especially, it may play an important role as the core facility for realizing the circulated social system in the coastal area[1].

The Eco-Platform is a floating complex on which functions of sewage and waste disposal, energy generation, resource reproduction and purification of eutrophic seawater are highly integrated as introduced above. For the realization of the Eco-Platform, it is necessary to study (1)Environmental problems in the coastal area, (2)Social and technical requirements assigned to the Eco-Platform as the preliminary survey, and (3)Functions assigned to the Eco-Platform and integration of functions and (4)Discussion for feasibility of realization from the technical standpoints. The authors have carried out these researches to solve the environmental problems that have occurred/occurring/will occur in Osaka Bay area; a typical enclosed inner bay and

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surrounding land area, as an example, and show the primary results in the present paper.

II. ENVIRONMENTAL PROBLEMS IN THE COASTAL AREA AT PRESENT AND IN THE FUTURE

The human society has acquired the prosperity through the remarkable advances of science and technology followed by industrialization and economic progress in the latter half of the 20th century. However, those progresses have brought about not only the increase of human activities but also the excessive exploitation of the coastal land and the neighboring sea area. As the results, the coastal urban area has been heavily populated and people's life-style of mass-consumption and mass-dumping has also been accelerated as well as people's attitudes to the surrounding environments have been deteriorated. It has led the increase of industrial waste and effluent as well as rubbish and sewage from residential area. And, the amount of waste and sewage has exceeded the capacity of processing facilities and the final dumping space. Thus, everyone can imagine easily what the problems are at present and will be in the future.

In the previous paper, (1)problems arose from shortage of waste/sewage disposal capacity, (2)problems arose from lack of final dumping site and (3)problems due to decline of environmental awareness and change of life-style were pointed out [1] .

III. SOCIAL AND TECHNICAL REQUIREMENTS ASSIGNED TO THE ECO-PLATFORM

A. Possibility of solving problems in the coastal area

The primary assignment for the Eco-Platform is solving the environmental and related problems mentioned above. For this, it is necessary to discuss briefly about the possibility of solving the problem.

(1) Improvement of waste/sewage disposal efficiency and capacities. The advanced waste water/sewage treatment has been improved, and the nutrient salt has been removed about 90 % from 50 % in this several years for example, but the concentration of T-N is still quite high, higher than 10 (*mg/l*) in many cities. The improvement of disposal efficiency is possible if big energy resources are available, and the extension of disposal capacities are also possible if the site for facilities are available, however, it is not easy to introduce higher electric power to the waste/sewage disposal as well as to find out the necessary site in the vicinity of urban area.

(2) Minimization of the final disposal waste. Fig. 1 shows the volume of industrial waste in Osaka Prefecture in 2000 and the rate of recycle, minimization and final disposal in 1996. It is understood that sludge occupies more than half of the industrial waste. The sludge is mainly from sewerage facilities and waterworks. It is dried and burnt at incineration facilities though the sludge from sewerage facilities is organic matters for the most part. It means that we are able to reproduce biomass and then methane gas from the organic sludge. From this fact for an example, it is to say that most of the waste can be utilized as the resources for the next-cycle utilization.

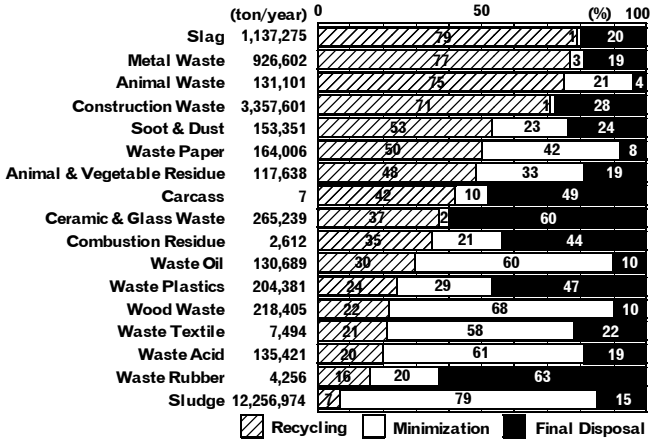

Fig. 1 Volume of industrial waste[4] and state of recycling[5]

It is also understood that almost three million tons of industrial wastes (about 3% of total amount) are dumped every year. Even if the improvement of waste/sewage disposal efficiency and capacities is achieved, the sites for final dumping are no more available on the land area than in a shallow sea area. The only possibility is minimizing the final dumping waste, remembering that all the man-made wastes are resources for the next material/energy cycle. Minimization of final disposal waste/sewage is essential to realize the zero-emission community and finally to establish the circulated social system.

(3) Enhancement of people's mind of environmental awareness. It is most important but most difficult to enhance the people's mind friendly to the natural environments around their daily lives especially in the urbanized and dense-populated area. It may be because people's life-style has been formed in a society of man-made rules and products, so that people cannot understand what is natural and how they are to be symbiotic with natural environments. We have to shift the paradigm of mass-consumption to that of saving resources and energy.

B. Concept for solving problems

The concept for solving problems can be lead from the discussions above.

(1) Technology integration in the 21st century. Functions to process many kinds of waste and sewage should be combined and integrated to develop a disposal complex for processing municipal waste and industrial waste at the same time and for achieving high efficiency of disposal. Functions and corresponding technologies and facilities to

be installed on the Eco-Platform have been developed separately in the latter half of the 20th century, such as shredding facilities for cars and electric appliances, incineration furnaces, plastic recycling facilities, etc., for which electric power is supplied separately. If those functions are integrated in a complex for waste/sewage disposal, the total heat/electric energy for operation will be reduced and the final amount of dumping will be minimized.

(2) No fossil energy. No fossil energy consumption is essential from the viewpoints of saving resources/energy and preventing CO_2 discharge. In order to achieve the lowest electric power consumption with no fossil energy introduction, it is necessary to realize the cascade use of heat energy and the efficient use of high temperature exhaust gas and slag from incineration furnace for producing high temperature steam and hot water.

(3) Cascade use of resources and energy. Plastic products have been flooded around us, and most of them are used for toys, lapping materials, packing stuffs, vessels etc. They are usually discarded after their mission is terminated and burnt at incineration facilities. Now, we have to remember that plastics are the fruit of oil resources and electric power. Even if some impurities may downgrade the quality of the recycled plastics in the process of recycling, there are many ways of practical use.

(4) Cascade use of heat energy in the Eco-Platform. To achieve the full utilization of heat energy from waste incineration furnaces, the cascade use of heat energy should be realized. Especially, the low-exergy heat energy, discharged or used for only hot water supply usually, can be used to purify processed efflux from the sewerage facilities on the land and eutrophic seawater by introducing algae proliferation, an important application of marine bio-technology. The biomass produced from the algae is to be used for reproducing methane gas in the methane fermentation system.

(5) No permanent annoying structures on the coastal land area. Big facilities for processing large volume of waste and sewage discharged from human lives and activities should be built apart from urban area as well as from the residential area. The only site for such a big complex is available on the sea, namely on a floating structure.

(6) Low building cost. To minimize the building cost, it is desirable to establish the disposal facilities on a floating structure where the cost for the land is not required. And, laws and regulations, the fire laws and building code for example, are not strictly applied for floating structures [2].

(7) Consideration to surrounding environments. No toxic matters and gasses are allowed to be discharged from the disposal facilities and no land reclamation by waste are allowed to consider human health as well as the health of fauna and flora in the coastal land and sea area. Therefore, the disposal facilities should be offshore. There lies an anchorage area outside a port/harbour governed by a city concerned in Japan. So that, the disposal facilities usually governed by the city can be set up there several miles away from urbanized area.

(8) Recovery of marine eco-system in shallow sea area. One of the important functions assigned to the Eco-Platform is to recover the depressed marine eco-system in the shallow sea area. For this purpose, it is necessary to improve the quality of seawater and bottom sediment that have been degraded by organic pollution, eutrophication due to the inflow of pollution load from the land through rivers. Application of marine biotechnology such as algae proliferation will make it possible to achieve the improvement.

C. Waste acceptable to the Eco-Platform

The municipal waste from residential area and a portion of commercial waste are to be accepted as general waste. Sewage sludge and processed efflux usually discharged to public water area are included in the industrial waste. The general waste consists of resource waste, bulky waste, noncombustible waste and combustible refuse. And, these are collected separately. So that it is supposed that they are conveyed to the Eco-Platform in different forms.

From Fig. 1, it is understood that several items of industrial waste such as slag, metal waste, animal waste and construction waste have been recycled at higher rate. On the other hand, the recycling rate of ceramic and glass waste, combustion residue, waste plastics and waste rubber are not high enough but are dumped in the mountains or at the land reclamation sites. The minimization rate of sludge is very high because it contains water in large volume.

It is reasonable to select the acceptable waste to the Eco-Platform providing 50 % for the upper limit of recycling rate. The amount of carcass is considered negligible, and the combustion residue is considered worthless for recycling. And, since the disposal processes for waste oil and waste acid are rather complicated and treated in special facilities, they are not acceptable to the Eco-Platform.

Consequently, waste paper, animal and vegetable residue, ceramic and glass waste, waste plastics, wood waste, waste textile, waste rubber and sludge are selected as the acceptable waste to the Eco-Platform.

IV.FUNCTIONS ASSIGNED TO THE ECO- PLATFORM

The concept of Eco-Platform is thought out for finding out a possible solution under the situations of facing difficulties mentioned above. Furthermore, the Eco-Platform is planned to be a core of the circulated social system for a community concerned, such as Sakai city of

population 800 thousand, located in the Osaka Bay Area, Japan. Functions to be installed on the Eco-Platform are (1)Incineration of combustible waste, (2)Heat energy and electric power generation, (3)Resource/material reproduction from waste, (4)Assimilation of CO_2 and nutrients from processed efflux and eutrophic seawater by algae proliferation, (5)Thermal decomposition of sewage-sludge to organic acid in subcritical hot water, (6)High-temperature methane fermentation in bio-reactor system using bio-mass from proliferated algae, (7)Electric power generation by gas-turbine generator using produced methane gas, etc. as shown in Table 1. No toxic gases and matters are allowed to discharge into surrounding environments from the Eco-Platform.

A. Incineration of waste and heat-energy/electric power generation

(1) Incineration facility. In Sakai city where the popula-tion is 800 thousand and the industrial area lies along the coast line, the amount of general waste from residential area and commercial area is 830 ton a day, and the industrial waste 60 ton a day[3]. The amount of industrial waste seems too small, however, most of the industrial waste is processed at special disposal facilities and dumped at the PHENIX sites by special disposal companies, according to the statistics. The processed efflux from sewerage facilities is 300 ton and the volume of sewage sludge is 1700 ton a day. Since the city authorities have recently changed the municipal waste collection system from mixing collection to collection of source separated, general waste can be separated to combustible waste (600t), non-combustible waste (100t), bulky waste (50t) and resource waste (80t). So that, process capacity of the incineration facility should be at least 600 ton a day.

(2) Heat-energy/power generation. After the sorting, crushing, etc., combustible waste including waste plastics are obtained to incinerate. Using the high temperature heat energy(300^{o}C), subcritical hot steam(350^{o}C), hot and warm fresh water(60 – 120^{o}C) are produced and electric power is generated by steam turbine-power generator system. Introducing the cascade use of heat energy, the temperature of finally discharged efflux from the Eco-Platform is very low (<30^{o}C).

Subcritical hot steam (350^{o}C) is used in the thermal decomposition system using subcritical hot water. Hot water (60 – 120^{o}C) is used in the boiler system and the high temperature methane fermentation system. And, low temperature water (<60^{o}C), namely low-exergy heat energy, is used in the algae proliferation system, to achieve the cascade use of heat energy.

Electric power generated is delivered to facilities and systems operated on the Eco-Platform, and surplus power if obtained, is to be transmitted to the land area.

Table 1 Functions/Facilities to be installed on the Eco-Platform

INPUT	PROCESS/FACILITY	OUTPUT
Industrial waste, General waste	Incineration	Heat energy, Slag
High temperature heat energy	Steam turbine/Generator, Heat exchange	Electric power, Steam, Hot water
Industrial waste, General waste	Sorting, Crush, Wash, Dry, Storage, Recycle	Fe-scrap, Al-scrap, Glass curret, Plastic pellet
Sewage-sludge, Bio-mass	Subcritical water, Thermal decomposition	Organic acid, Slag, High temp. fresh water
Processed efflux, Eutrophic seawater	Algae proliferation	Algae(Bio-mass), Purified seawater
Organic acid	Methane fermentaion	CH_4 gas, CO_2 gas
Purified seawater	Desalination	Fresh water
High temperature fresh water	Deionization	Pure water
CH_4 gas	Gas turbine	Electric power
CO_2 gas	Photo-synthesis	Algae, Phytoplankton

B. Disposal of sewage sludge and efflux from sewage works

(1)Thermal decomposition using subcritical hot water. As mentioned above, the volume of sewage sludge discharged from sewerage facility is enormous and contains organic sludge of about 10 %. It is dehydrated and burnt in the incineration furnace usually, though the organic sludge can be decomposed to produce energy resources of next-cycle. In the Eco-Platform, thermal decomposition system using subcritical hot water is to be installed to decompose the organic sludge to organic acid. And the organic acid is easily digested in the high temperature methane fermentation system to methane gas and CO_2 gas. The basic decomposition process has been ensured recently, and the efficiency of the decomposition is proved very high[4,5]. The practical system is under development.

(3) Algae proliferation. The volume of processed efflux discharged from sewerage facilities to public water area is also big and contains quite high concentration of nitrogen compound and phosphate which are the causes of the eutrophication of seawater in the stagnating sea area like an inmost part of the Osaka bay[6,7].

Since very big electric power is needed to assimilate the nutrients by an artificial measure, a new concept for assimilation is introduced in the Eco-Platform. Using marine biotechnology with natural energy such as solar and wind energy, a system of algae proliferation is introduced. Under the optimally controlled conditions of the light and seawater temperature, some kind of algae such as *Ulva Linnaeus* (sea lettuce) and/or some kind of phytoplankton are proliferated in tanks having wide area. After finished the proliferation, grown-up algae are harvested as biomass, and the seawater left is no more eutrophic. The biomass is used as the raw material for the subcritical water thermal decomposition and the water is used for producing fresh water. The efficiency of the system is not high, but in order to make the entropy increased and to achieve the cascade use of heat energy, this kind of system will be

recommended for the sustainable development of the earth system.

(3)Methane fermentation. The organic acid produced is processed in a high temperature methane fermentation system. The high temperature methane fermentation has been made practicable, and the fermentation efficiency is ten times higher than the ordinary one[4]. Sixty percent of the organic acid is decomposed to methane gas and 40 % to CO_2 gas. The methane gas is used as the secondary energy resource. In the Eco-Platform, only a small portion of methane gas is to be used for generating auxiliary electric power.

V. INTEGRATION OF FUNCTIONS INSTALLED ON ECO-PLATFORM

After the discussions above, the functions installed on the Eco-Platform listed in Table 1 can be integrated to be a highly sophisticated complex as shown in Fig. 2. Since the Eco-Platform is planned to be a core of the circulated social system, functions and missions assigned to a society/ community are also shown in the figure. As shown in the figure, the functions onboard are combined and integrated to three main systems: (1)Stockyard, (2)Waste incineration/ Energy generation system and (3)Waste disposal/Recycle/ Resource reproduction system.

The functions of Stockyard are (1)Storage of unloaded waste from waste barge and received sewage sludge and processed efflux from sewerage facilities through pipeline, (2)Primary sorting of waste to recyclable materials, combustible waste and non-combustible waste, (3)Crushing bulky waste, (4)Rinse impurities, smudges and toxic matters from waste, (5)Drying waste, etc.

The functions of Waste incineration/Energy generation system are (1)Incineration of combustible waste, (2)Heat energy generation and (3)Electric power generation by steam turbine-generator system, (4)Subcritical-high-temperature steam/water production making full use of high temperature exhaust gas and slag from incineration furnace.

The Waste disposal/Recycle/ Resource reproduction system consists of two subsystems: Solid waste disposal system and Liquid waste disposal system. The functions of solid waste disposal system are as follows: (1)Sorting of resource waste to metal waste such as ferrous metals and aluminum, glasses and plastics: PET (polyethylene telephtharate), PE (polyethylene), PP (polypropylene), PS (polystyrene) and PVC(polyvinyl chloride), (2)Volume reduction of metal materials by press machine, (3)Sorting of coloursof glass bottles, (4)Crushing of glasses into cullet and (5)Production of pellet from plastic waste. The primary functions of Liquid waste disposal system are (1)Thermal decomposition of sewage sludge to organic acid using subcritical hot water, (2)Assimilation of processed efflux and eutrophic seawater in algae proliferation system using low-exergy warm water (< 60°C), (3)Methane production by fermentation of organic acid.

Other important functions to be installed are (1)Production of hot fresh water which is used onboard the Eco-Platform, (2)Utilization of natural energy: solar energy, solar heat energy and wind energy, (3)Auxiliary power generation applying the produced methane gas to gas turbine-power generation system, (4)Operation control of functions/facilities and (5)Monitoring of environments of air and water around the Eco-Platform.

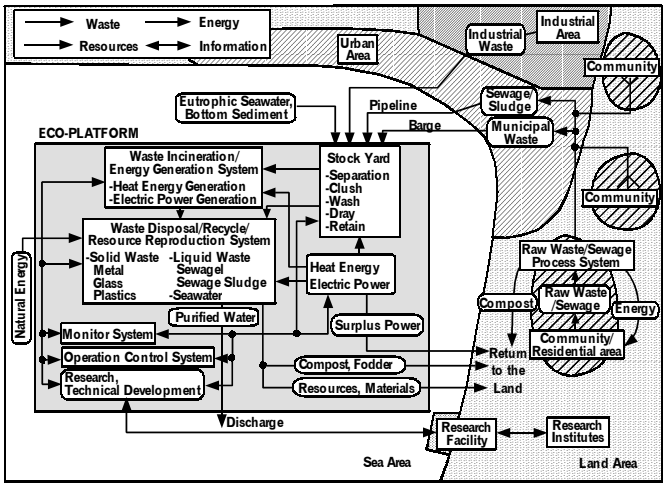

Fig. 2 Integration of functions onboard Eco-Platform

VI. FEASIBILITY OF THE ECO-PLATFORM

In order to evaluate the feasibility of the total system, it is necessary to study the material and energy flow through the systems onboard and to study whether the balance of waste input and resources and energy output is achieved or not.

A. Material and energy flow on the Eco-Platform

Subsystems that consist in the Eco-Platform are shown in Fig. 3, with material and energy flow between subsystems. As shown in the figure, the Eco-Platform is composed of 8 primary subsystems that are to be linked and arranged efficiently.

It is supposed that the amount of discharged waste is comparable to that of Sakai city, namely, 830 ton/day for municipal waste and 60 ton/day for industrial waste. The volume of sewage sludge is 1,700 ton/day and the volume of processed efflux from sewerage facilities is about 70,000 ton/day. In addition to these waste, the Eco-Platform is to accept eutrophic seawater of 10,000 ton/day from surrounding sea.

Solid waste accepted is stored, and then sorted to combustible waste, plastics, metals and glasses and ceramics in the stockyard. About 30 % of solid waste is recycled to

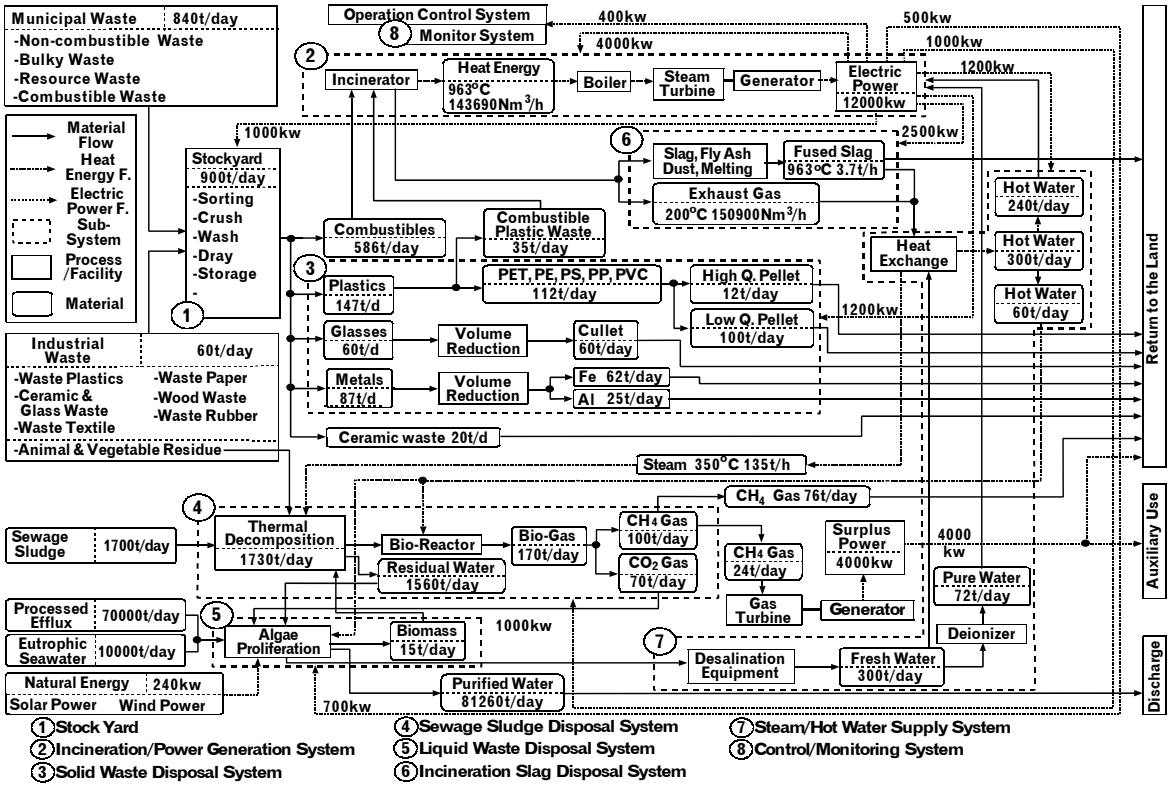

Fig. 3 Subsystems consist in the Eco-Platform and flow of material and energy

plastic pellets, grass cullet and lumps of metals. The remainder of the waste is burnt in the incinerator, and converted to heat energy and high temperature exhaust gas and slag of small amount. The heat energy is used for heating boiler first, and then used for heating steam and hot water in the incinerator-steam turbine-generator system.

Since the exhaust gas is kept in very high temperature, it is utilized for heating steam and hot water for operating systems on the Eco-Platform. And finally, the exhaust gas of low temperature is taken into the basin to assimilate the CO_2 by algae proliferation. The very high temperature slag is used for producing high temperature steam and hot water that are required for the thermal decomposition using subcritical hot water and other systems on the Eco-Platform.

The volume of sewage sludge is very big, but it contains water about 90 % in weight. So that, remaining 10 % of sewage sludge consists of organic matter and is introduced to the thermal decomposing system using subcritical hot water to produce organic acid such as acetic acid. About 97 % of the organic sludge is assimilated and converted to organic acid according to recent research report[4]. The organic acid is easily converted to methane gas and carbon dioxide gas applying the high temperature methane fermentation system.

The volume of processed efflux from sewerage facilities is also very big. Usually, the efflux is quite eutrophic and contains nitrogen compounds of about 30 ppm and the concentration of phosphates is also very high. Algae proliferation system, an application of marine biotechnology, is considered as one of the best methods to assimilated dissolved nitrogen, phosphate and carbon dioxide simultaneously. It is because that the system can be operated without introducing high-technology and high electric power and that it does not increase the entropy of the earth system. The sunlight is fully utilized for algae proliferation to promote the photosynthetic function of algae. Grown-up algae or phytoplankton is a biomass of good quality, and is used for producing organic acid.

The total electric power generated in the power generation by waste heat system is supposed 12000 kw. One third of the generated electric power (4000 kw) is used in the system, and remainder is used for solid waste disposal system (1200 kw), for slag melting system (2500 kw), for sewage sludge disposal system (1000 kw), for hot fresh water producing system (1200 kw), for operation control and monitoring systems (400 kw), and for algae proliferation system (700 kw). Remainder (1000 kw) is to be transmitted to the land area. The natural energy is also utilized on the Eco-Platform; namely, solar power and wind power of 240 kw in total is used in the algae proliferation system.

Surplus power is generated for the auxiliary use on the

Eco-platform, such as starting the system, using the gas turbine-generator system with methane gas produced. The generated electric power (4000 kw) is used in the system and the remainder power (3000 kw) is transmitted to the land area at ordinary times.

B. Material and energy balance on the Eco-Platform

In order to realize the Eco-Platform, it is necessary to meet the social and technical requirements assigned to the total system as well as to each subsystem. As mentioned above, the industrial waste and general waste of 880 ton/day, sewage sludge of 1700 ton/day, processed efflux of 300 ton/day and eutrophic seawater of 10,000 ton/day can be processed. And about 30 % of solid waste can be recycled to resources of next stage. It was also shown that big amount of methane gas can be produced from the sewage sludge. Therefore, it can be said that the maintenance of input and output balance of materials is easily achieved by effective arrangement of subsystems onboard. Then, material flow and energy balance in each subsystem are necessary to be investigated.

(1) Waste incineration and power generating system. Fig. 4 shows the incineration and heat energy production system using flammable waste and electric power generation system. The lower calorific value of the waste is estimated by analysing the composition of the waste.

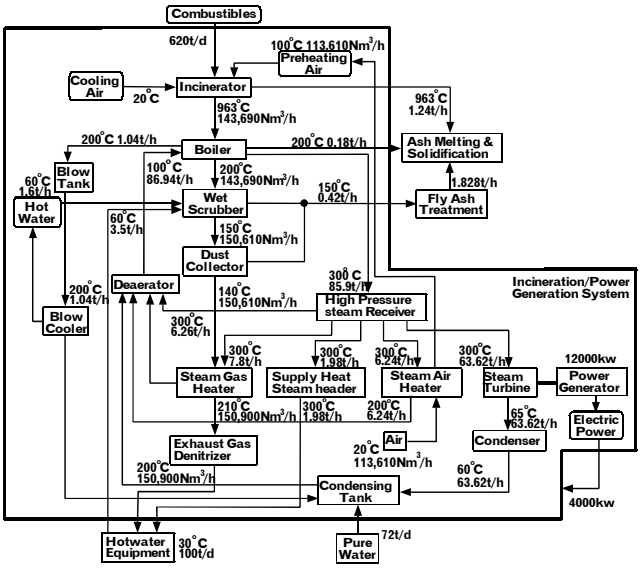

Fig. 4 Waste incineration and power generation system

The estimation of heat balance depends on type and structure of the incineration furnace. Here, the heat balance is estimated, supposing the continuous firing incinerator system. After the calculations of heat generated by the furnace, and heat consumption for the power generation, leakage and discharge from the system, it was made clear that the difference of input-output heat balance is very small. The high temperature heat energy taken into the boiler is converted to steam of quantity 85.9 ton, temperature 300°C and pressure 25kg/cm^2. Using the heat energy, electric power is generated by condensing turbine-generator system. The total electric power generated is 12000 kw, and 4000 kw out of the generated power is used inside the system, and the remainder is distributed to all other systems to maintain their functions. As shown in the figure, however, it is understood that utilizable heat energy is discharged with hot or warm effluent, exhaust gas and high temperature slag and ash.

(2) Solid waste disposal/recycling system. In Fig. 5, material flow and necessary power in operating the solid waste disposal and resource recycling system are shown in detail. All of the industrial wastes are supposed to be sorted and carried into the stockyard, and the resource waste among the general waste is also supposed to be collected separately. So that, primary sorting in the stockyard does not need big power as indicated in the figure. All the functions/facilities applied in the system have been already developed for the disposal on the land. The necessary developments are the enlargement of facility scale, stability of functions when the system is operated on the floating structure, etc.

The values of electric power indicated in the figure are estimated after investigating specifications of existing facilities[8]. Summing up the necessary power for functions of disposal and recycling, the total power required is about 1170 kw. From the estimation, the power to be supplied to the system is determined 1200 kw.

(3) Sewage sludge and liquid waste disposal system. Fig. 6 shows the material flow and required electric power in operating the sewage sludge and liquid waste disposal systems. For the efficient operation of these two systems, it is necessary to combine their functions with the utilization of natural energy and high temperature steam produced in the incineration slag disposal system. The natural energy, solar and wind power of 240 kw in total with sunlight are utilized in the algae proliferation system. Required power to perform function is listed in the figure after obtained from the existing facilities. Summing up in the thermal decomposition system, the total required power is 970 kw, including the related functions outside. To meet the power requirement, it is determined to allocate 1000 kw in operating the system. For the algae proliferation system, the total power required as well as allocated is 700 kw. The output from the system is 100-ton methane gas a day and 10000-ton seawater of low nutrient concentration. Surplus power of 4000 kw is generated using the methane gas (24 ton/day) produced from sewage sludge.
The required electric power is investigated after surveying that of existing facilities for all of individual functions and facilities.

The allocated power indicated in Fig. 3 is determined to meet the power required. Further more, electric power of 1000 kw from waste heat and surplus power 3000 kw from

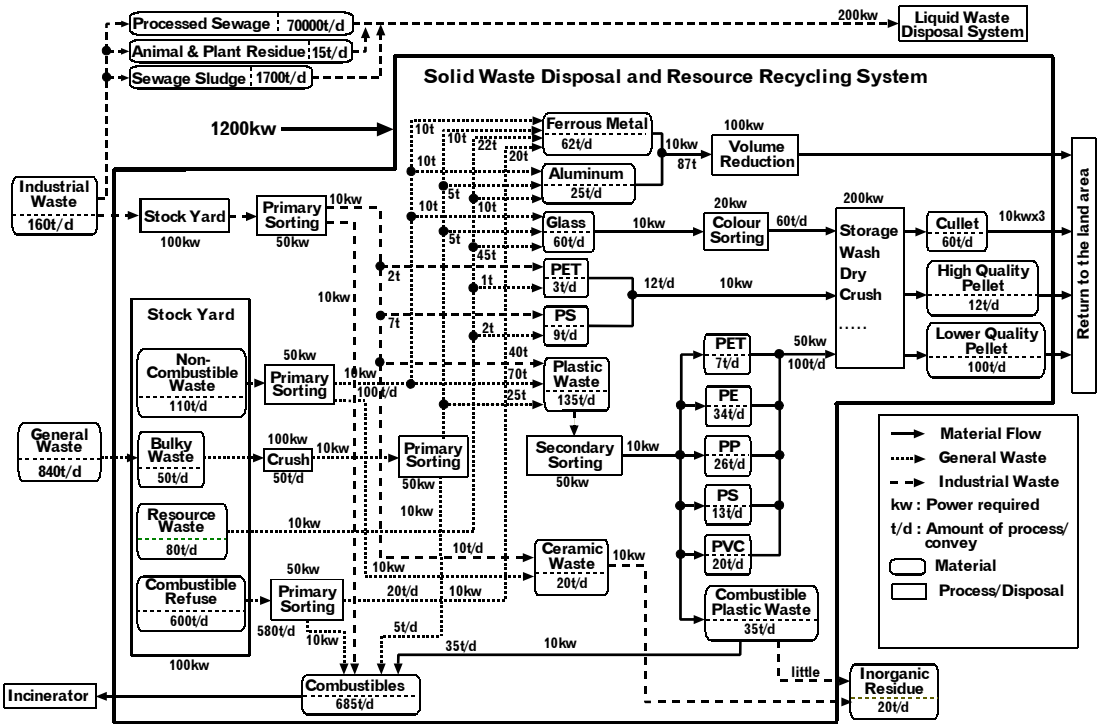

Fig. 5 Solid waste disposal and resource recycling system

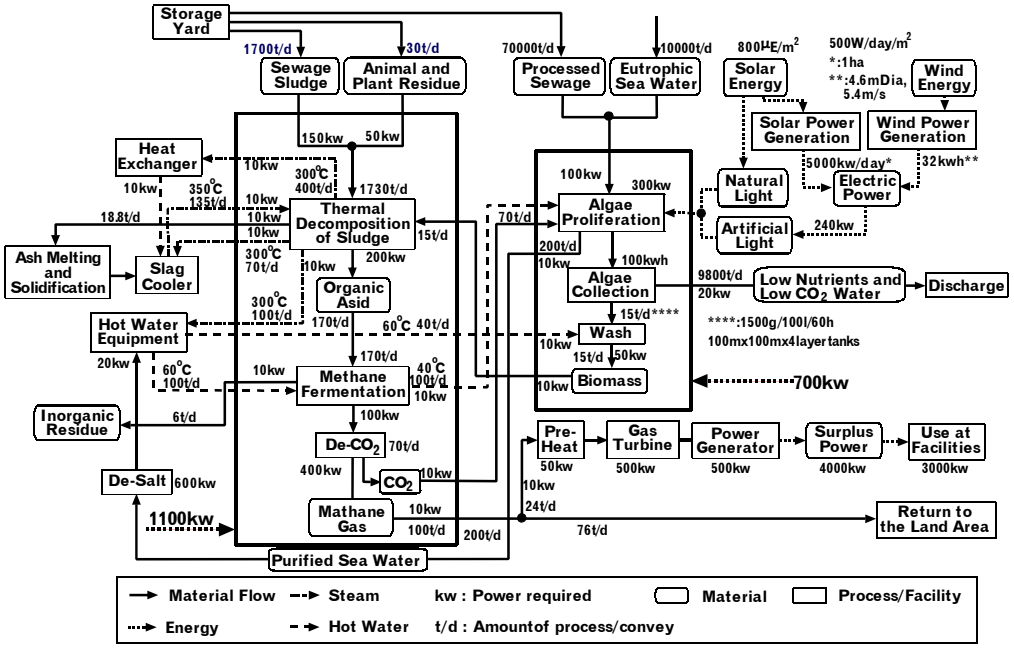

Fig. 6 Sewage sludge disposal system and liquid waste disposal system

methane gas are transmissible to the land area or are available for the auxiliary use on the Eco-Platform. From the discussion about the material and energy flow as well as their input-output balance, the Eco-Platform can be realized technically.

C. Feasibility of weight and size of the Eco-Platform

In order to discuss the feasibility of realization, it is inevitable to estimate the weight and size of the total system onboard the Eco-Platform though the capacity of each facility is not settled exclusively, so that, rough estimation of the weight and size of systems is carried out referring to data of existing facilities [8] . In Table 2, estimated results of required weight and area of space are shown. As shown in the table, the total estimated weight of facilities is about 104,000 ton and the hull weight of the floating platform is

about 36,800 ton without mooring systems. To meet the total weight of the Eco-Platform, the deck area of the platform is assumed 50,000 m^2 (250m × 200m) and then the draft is 6.5 m. Since, the water depth of anchorage area in port/harbour is supposed about 15 m, the estimated draft is considered suitable. The actual configuration and structure of the Eco-Platform are not determined, but the size of the structure (length × beam × depth) = (250m × 200m × 8.0m) is considered quite reasonable.

Table 2 Estimated results of weight and size of Eco-Platform

System/Facility	Specification/Capacity	Weight (ton)	Area (m^2)
Stock yard	3 days storage	3,000	2,500
Waste incineration system			
Incineration/Power generation	600ton/day/12,000kwh	12,600	10,000
Slag treatment facility	1,000°C, 3.9ton/h	500	1,000
Solid waste disposal system			
Primary sorting facility	600ton/day, 50t/day × 3	100	1,000
Secondary sorting facility	150ton/day	30	200
Volume reduction facility	100ton/day	50	100
Cullet production facility	60ton/day	30	400
Pellet production facility	100ton/day, 10ton/day x 2	30	250
Sludge/Sewage disposal system			
Themal decomposition facility	6200ton/day	500	4,000
Algae proliferation facility	80,000 ton/day	240,000*	50,000*
Sludge pipeline	300Φ ×20t × 100m	25	30
Sewage pipeline	200Φ ×20t × 100m	25	20
Water/Steam supply system			
Deslination facility	300ton/day	20	100
Water heating facility	300ton/day	20	100
Pure water production facility	100ton/day	20	50
Water pipeline	200Φ × 20t × 500m	50	100
Natural energy system			**
Solar cell facility	50kg/m^2 ×20,000m^2	1,000	20,000
Wind power facility		10	
Others	Shed, Reserve, Water ballast, etc.	5,190	
Total installation		263,200	
Floating platform	200m ×200m ×6.5m	36,800	
Total		300,000	50,000***

* : 3 -4 layer decks allocated under upper deck ** : Settled on the roof of shed *** : Upper deck area

VII. CONCLUDING REMARKS

In the present paper, the authors have discussed about the problems arose/arise/will arise in the coastal area around the world, about the concept and measures for solving the problems and then proposed the Eco-Plat form. After that, they discussed about the technical feasibility of the Eco-Platform.

They showed that the problems are very serious especially in and around the dense-populated urban area. The solution we can achieve is realization of the Eco-Platform based on the standpoint that (1)most of all the waste discharged by human activity should be utilized as the resources for the next-cycle, (2)technologies highly advanced in the 20th century should be integrated to realize good human lives and good relations between human and surrounding environments and (3)we have to find out suitable solutions from the viewpoint of the sea.

However, since finding out the social, economic and financial solutions are very difficult and sometimes much more important for the implementation, further discussions not only on the technical issues but also on the issues of wide range and scope are necessary.

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