Construction of the resource circulation system which used the factory as the core

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Abstract: Sekisui House, Ltd. constructed a zero-emissions recycling system which enables 100% recycling of construction wastes discharged from the company's construction sites. In this system, all construction wastes are recovered at the company's plants, completely sorted, and consigned to recycling facilities for treatment. Sekisui House has maximized sorting accuracy by adopting a 2-stage sorting system consisting of sorting into 27 types at the construction site, followed by sorting into 60 types at the company's factories. The sorted wastes are then consigned to the most appropriate facility for treatment, depending on the individual properties of the material, which makes it possible to trace wastes effectively in all processes from generation to recycling as raw materials. A zero-emissions system which secures traceability can be considered an ideal form for recycling systems. From the viewpoint of supply chain management (SCM), the company is endeavoring to establish SCM for the physical distribution of waste.
Keywords: Zero emission, Sorting, Traceability, Supply chain management (SCM)

1. Introduction

1.1 Sekisui House's Environmental Future Plan

In 1999, Sekisui House, Ltd. announced its Environmental Future Plan, with the establishment of an Environmental Charter and Basic Environmental Policy as key points, aiming at sustainable coexistence of people, urban communities, and the global environment. Based on this plan, the company began activities with the objectives of acquiring certification under ISO14001 at its factories and achieving zero emissions of factory wastes.

As a result of these activities, ISO certification was completed at all factories in 2001, and the zero emissions goal for factories was achieved in May 2002, well ahead of the target date in fiscal 2005 (January 2006).

Based on these results, the company began zero-emissions activities for new construction sites in January 2004. Although these activities targeted achievement of zero emissions by January 2006, this was fortunately achieved in July 2005. Following on these activities, zero emissions were also achieved in the after-sale service division in April 2006, and activities are currently underway in the remodeling division.

1.2 Declaration of Sustainability

In April 2005, Sekisui House announced its "Declaration of Sustainability" as its vision for realizing a sustainable society.

To realize a sustainable society, a company must conduct its business activities based on the concept of the "triple bottom line" (Note 1), which evaluates the aspects of environmental performance, economics, and social contribution. As a company whose primary business is creating residential environments, which also has high social significance, Sekisui House added the unique concept of "a home and its inhabitants," or resident's value (Note 2) to these three values in order to make the greatest possible contribution to society. The Declaration of Sustainability lays out the goal of realizing a sustainable society by enhancing all four values in a well-balanced manner.

1.3 Environmental Value

Among the four values mentioned above, in the environmental aspect, Sekisui House has established policy guidelines for the four areas of "energy, resources, chemical substances, and the ecosystem," and is implementing measures to reduce environmental loads in each of these areas.

1.3.1 Energy Policy

In the area of energy, the company's aim is to realize energy utilization which does not depend on fossil fuels.

The life cycle of housing in Japan is generally considered to be around 30 years. Of the CO_2 generated during this 30 year period, 70% is attributable to occupancy, while approximately 30% is generated either in production or in activities related to waste. In the breakdown of CO_2 attributable to occupancy, lighting and electrical appliances, hot water heating, and heating/air-conditioning each accounts for about 30%.

Therefore, in addition to proposing various measures to extend the life of housing, Sekisui House is also promoting measures for reducing CO_2 emissions during occupancy, which include popularization of next-generation heat insulation-type housing, positive adoption of photovoltaic power generation systems, and full adoption of high efficiency water heaters. The company is also encouraging improvement of heat insulation in openings and exterior walls and conversion to latent heat recovery-type water heaters in the 700,000 homes which it has already constructed.

Sekisui House is also making efforts to reduce CO_2 emissions from its factories, for example, by introducing biomass power using wood powder generated in the production stage as fuel, purchasing green power, and expanding and improving solar power equipment. As a result of these efforts, in fiscal 2005, the company succeeded in reducing CO_2 emissions by approximately 21,550 tons.

1.3.2 Resources Policy

To realize resource utilization which does not exceed the capacity of the natural ecosystem to renew those resources, Sekisui House's policy is to construct a system which does not generate waste through implementation of the 3Rs (Reduce, Reuse, Recycle) and establish resource utilization within the limits of sustainable supplies. The recycling system which is the subject of this paper is based on this policy.

1.3.3 Chemical Substances Policy

The objectives of the company's policy in this area are to reduce both the kinds and amounts of chemical substances used and to limit the effects of using chemical substances to the natural environment's capacity to decompose those substances, with the aim of preventing the continuing buildup of hard-to-decompose substances which do not exist in nature. At present, the company is inventorying the types and amounts of substances used and establishing voluntary guidelines which are stricter than framework of legal regulations.

1.3.4 Ecosystem Policy

This policy mandates protection of natural circulation and biodiversity. Among concrete measures to protect Japan's rich ecosystem, when considering garden and town creation, the company proposes planting of original species and indigenous or native species of trees suited to the respective climates. The objective of this plan, which was christened the "5 Tree Plan," is to restore the forested areas neighboring on towns and cities which are the source of Japan's diverse ecosystem. The "5 Tree Plan" has received wide support from society at large, as well as from Sekisui House. The breadth of activities related to the plan can be seen in environmental NPO activities, education and support activities, and the like.

2. DEFINITION OF TERMS

2.1 Zero Emissions (Note 3)

As defined by Sekisui House, "zero emissions" means that no waste is disposed of by burial in landfills or by simple incineration without accompanying heat utilization. In principle, this is achieved by material recycling. Thermal recycling is performed in cases where material recycling is impossible or the energy cost of material recycling would be prohibitively large.

2.2 Material Recycling

In addition to ordinary material recycling, in which a material is utilized as-is as a raw material in a succeeding process, cases where a material is utilized as a raw material necessary in manufacturing a product, including processes which utilize heat in the product manufacturing process, such as the calcining process in cement manufacturing and the reduction process in steel manufacturing, are categorized as "material recycling."

2.3 Thermal Recycling

Cases where a material is utilized directly as a fuel, as in fuels for power-generating boilers, and cases where fuel gases generated by gasifying and melting furnaces and similar facilities are input to production equipment and used as supplementary fuel in the cement and steel manufacturing processes are classified as "thermal recycling." For convenience, recycling of materials such as waste plastics, which are utilized as a reducing agent or calcining material, while also having the characteristics of a supplementary fuel, is classified as "material recycling."

2.4 Traceability

Here, "traceability" refers in particular to obtaining an accurate grasp of all processes from the generation to recycling of wastes. As a general practice, construction waste is frequently discharged in its existing mixed condition, and in virtually all cases, this waste is mixed and treated with wastes from other companies at the treatment facility to which it is consigned. For this reason, it is extremely difficult to determine the subsequent route of residues after treatment. Sound implementation of zero emissions requires a system which makes it possible to identify all of the treatment processes in waste treatment.

2.5 Sorting

"Sorting" means separation of wastes by individual types and individual materials. Because the composition of construction waste is stable and the waste does not exist in a condition which would be harmful to the human body or the natural environment, recycling can be realized easily by implementing complete sorting. However, detailed sorting had been considered difficult at home construction sites, because numerous types of wastes are generated in small amounts and the types of waste which are discharged change depending on the work process.

2.6 Decentralized Discharge Mode

At large home manufacturers such as Sekisui House, the number of home construction sites reaches as many as 25,000 each year. As other distinctive features, the work period at each site is short, at about 3 months, and the types of waste discharged change depending on the work process. On average, a total of approximately 1.9 tons of waste is discharged from each site. This mode, in which wastes are discharged from numerous scattered small-scale sites, is termed the "decentralized" discharge mode.

The law related to wastes in Japan (Waste Disposal Law; see Note 4) is based on the precondition that a set type of waste is discharged at all times from a fixed location such as factory. The law did not envision in any way the decentralized discharge mode typical of construction site wastes, which has given rise to major discrepancies between the requirements of the law and the realities of the site.

2.7 Regional Authorization System

The “regional authorization system” is an exceptional system under the Waste Disposal Law. In cases where the treatment of industrial waste is consigned to another party, the law stipulates that it must be consigned to an approved contractor.

Treatment can be broadly divided into the collection/transportation function and the actual treatment function. When operating a business, it is necessary to obtain approvals corresponding to the respective businesses from local governments. Nationwide, a total of 103 local governments have independent approval authority. When a company wishes to treat wastes on a regional basis, approvals must be obtained from each of the local governments concerned.

However, under the regional authorization system, these individual approvals from local governments are not required if “regional authorization” is obtained from the national government. This system is referred to as the “regional authorization system.” In cases where the products which a manufacturer or other company produces, processes, or sells become waste and the company itself recovers and recycles the product, if the company’s recycling system is recognized as effective by the national government, this system allows the company to obtain authorization upon application. The system was created to support extended producer responsibility on the part of manufacturing companies, and has made it easier for companies to fulfill their responsibilities for products from production through end-of-life disposal.

3. SEKISUI HOUSE CONSTRUCTION SITE WASTE RECYCLING SYSTEM

3.1 Profile of Sekisui House, Ltd.

Sekisui House, Ltd. is engaged mainly in the manufacture, construction, and sale of manufactured detached homes, with business in virtually all parts of Japan with the exception of some island regions. The annual number of units constructed by the company is approximately 25,000.

Sekisui has six factories in Japan and nine component assembly plants. Recycling centers which treat waste have been established at all 15 of these facilities.

As bases for collecting wastes from construction sites, the company has created waste collection bases at 56 locations throughout Japan. Some of these bases are located at distribution centers.

3.2 Characteristics of Construction Site Waste

A total of approximately 47,000 tons of waste is generated at the company’s construction sites each year. At present, the average amount per site is about 1.9 tons (actual value, 2005). The average amount of waste per construction site before the start of construction site zero-emissions activities was approximately 3 tons (actual value, 2000). Thus, during this 5-year period, the amount of waste generated at construction sites has been reduced by approximately 35%.

The material inputs per housing unit total approximately 100 tons (average floor area: approx. 145m^2). From this, the ratio of waste to material inputs can be calculated at around 2%.

3.3 Conventional Waste Disposal System

Before the start of construction site zero-emissions activities, the wastes generated at each site were consigned to waste treatment facilities located in each area for treatment. Wastes were discharged from construction sites in a mixed condition and were sorted into roughly 2-8 types for treatment at the respective treatment facilities. With the exception of some outstanding facilities, the recycling ratio of these waste treatment facilities was substantially less than 50% in almost all cases. However, even among these facilities, no small number advertised themselves as “Zero emissions facilities” with a 100% recycling capability.

Furthermore, some contractors also engaged in improper disposal practices. As a result, in fulfilling its social responsibilities as a discharging company, enormous costs were incurred in guaranteeing proper disposal.

3.4 Construction Site Waste Recycling System

3.4.1 Recovery System

At Sekisui House, building components are supplied to the construction site mainly by direct delivery from the company’s factories or by delivery by way of a distribution center. The number of deliveries averages 10-13 per site. Small trucks are generally used in deliveries to the site, and large trucks for transportation between factories and distribution centers.

In the company’s recycling system, in principle, wastes are recovered using the same trucks. Wastes are recovered from the construction site to the waste collection base using small trucks, and the wastes accumulated at the waste collection base are recovered by the factory using large trucks. Thus, while improving transportation efficiency, the company has also established a safe, stable recovery system.

The legal basis for this system is the above-mentioned regional authorization system. By utilizing this system, it was possible to construct an effective, highly-reliable waste recovery system.

3.4.2 Sorting System

Sekisui House uses approximately 60,000 individual components in the construction of one home. Because the discharged waste is similarly diverse, discharge in a mixed condition was an unavoidable condition with the conventional system.

Under the provisions of the Waste Disposal Law, industrial wastes discharged from construction sites are classified in 7 types (waste wood, waste paper, waste metal, waste fiber, waste plastics, waste glass, ceramics, and concrete, and rubble). In general, sorting at construction sites is frequently preconditioned on these 7 types. However, rather than simplifying the sorting process,

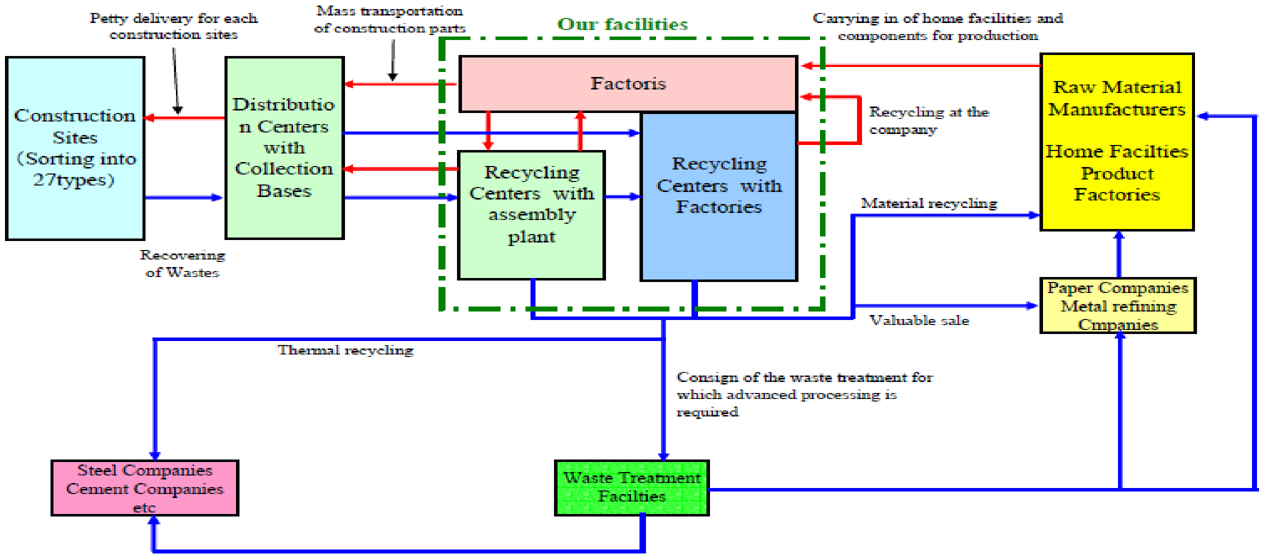

Figure 1 Sekisui House's recovery System basic concept

sorting in 7 types requires a high level of judgment due to the diversity of the generated waste and large amount of composite building materials. This was one reason for the low adoption of sorting at construction sites.

In promoting zero emissions at construction sites, Sekisui House conducted a variety of sorting experiments at construction sites, and carried out an exhaustive study which included participation by skilled craftsmen. The results confirmed that sorting by individual component or concrete name is easier than sorting by material type. Based on this, the company adopted a method of sorting into 27 types for its construction sites.

Wastes which have been sorted into 27 types at construction sites are recovered at the factory and are then sorted in detail into approximately 60 types. This is done because sorting in basic material units is an essential condition for effective material recycling.

Figure 2 Sorting the plastics using the cell method.

In this sorting process, there were many cases were plastics were diverted to thermal recycling due to poor sorting accuracy. Therefore, in the case of plastics, particularly thorough sorting is performed using a cell method. As a result, it has become possible to sell many plastics as raw materials without further processing, at prices which would be inconceivable in ordinary waste treatment. Because wastes other than plastic can also be sorted into virtually basic materials, consignment to treatment corresponding to the purpose is possible, and traceability can be reliably guaranteed. It should be noted that Sekisui House's current material recycling ratio exceeds roughly 90%.

3.4.3 Recovery Containers

Recovery containers were also studied. As a result, the company made a decision to use containers of a unified size, which are either transparent or semi-transparent, making it possible to confirm their contents.

At housing construction sites, wastes are also generated in areas with poor footing, for example, in work on the roof. It was found that a bag-shaped container of a size that can be held in one hand is preferable for collecting waste in these situations. Based on this, in principle, transparent sandbags approximately 90cm x 60cm are used as waste recovery containers.

Unification of recovery containers made it possible to set per-bag weight coefficients for each of the 27 types of construction site waste, which also provided a simple method of determining the weight of the generated waste by counting the number of bags. Because this makes it easy to understand the waste reduction effect at the site, effective utilization of resources is also being encouraged from this direction.

3.4.4 Waste Management System

Japan's Waste Disposal Law created a manifest system, which legally requires the use of industrial waste control slips, or "manifests," as evidence of waste collection and transportation, delivery for treatment, and treatment. However, as mentioned previously, this legal system is preconditioned on continuous discharge from fixed locations, as represented by factories. Because the system was introduced without foreseeing the decentralized discharge mode, which is typical of housing construction, the burden of implementing this system at housing construction sites tends to be excessive.

In contrast, the regional authorization system provides an additional deregulatory mechanism, which enables free construction of waste management systems that do not dependent on use of the manifest system, provided that all of the conditions stipulated in the law are incorporated in the system.

As an example, Sekisui House constructed and has begun operation of an original waste management system called "Gurutto Mail"™, ("Circulating Email"), which takes advantage of the email function of cell phones. By realizing simple operation and sharing of information among those concerned, this has proven useful in reducing wastes and is also beginning to show other secondary benefits, such as timely recovery of wastes and cleaner, more attractive construction sites.

3.4.5 Role of Recycling Centers

Recycling Centers occupy a position as the core of Sekisui House's recycling system, and as part of the factory division, they controls key processes from production to recycling.

The Recycling Centers are responsible for important roles in three fields. These can be defined as (1) the treatment function, which includes waste receiving, sorting, treatment, and shipment of treated waste to contractors, (2) the monitoring function, which includes including tracking after shipment (traceability), constant checking of recycling accuracy and the condition of sorting at construction sites, and securing sorting accuracy, and (3) the research function, which includes analysis of the waste recovered at the Recycling Centers and identification of the causes of waste generation/feedback to the production side.

Because the condition of waste generation is closely related to the condition of the production/ and construction system, it has become possible to identify weak points in the production division by analyzing wastes in the research field. Feeding this information back to the production side contributes to improvement of the production/construction system as a stronger and more rational system. Moreover, constant monitoring of the condition of waste generation can also play the role of a barometer of progress in improvement activities.

3.4.6 Consignment of Waste from Recycling Centers

The general condition of consignment for treatment of the 60 types of wastes sorted at the Recycling Centers is shown in the following table. (Data: Apr. 2004~Mar.2005)

Sold to commercial users	Cardboard	15.5%
	Metals	6.4%
	Plastics	2.6%
	Material for papermaking	3.2%
Consigned as raw materials (material recycling)	Material for gypsum board	26.0%
	Material for plywood	8.5%
	Material for concrete products	4.7%
	Roadbed material	8.3%
	Reducing agent for steel manufacturing	2.3%
	Material for cement calcining	6.2%
	Ground improvement material	5.6%
	Other raw materials	3.8%
Thermal recycling	RPF/RDF	2.5%
	Chips for use as fuel	3.0%
	Fuel for power generation	1.5%
	Fuel for boilers	1.3%
	Fuel gas production	0.9%
Total		100%

Table 1 Consignment of waste from recycling centers

These materials are consigned to 92 plants operated by 75 companies. Complete traceability is maintained in all cases, including both the condition of consignment and the condition of treatment.

4. CONCLUSIONS

4.1 Waste Reduction Policy

The construction of this recycling system resulted the establishment of a system for circulating use of resources which had previously been treated as waste. However, an even more important policy for effective utilization of resources is reduction of the amount of wastes generated.

Specifically, this means that measures which reduce the generation of waste as such by inputting proper materials to the construction site are necessary. For this, Sekisui House has launched a project to promote waste reduction in the company, and has established concentrated reduction measures, focusing on materials which generate particularly large amounts of waste, these being gypsum boards, wood materials, and packaging, centering on cardboard.

A discussion of concrete measures would be outside the scope of this paper. However, as an overall goal, the company has targeted a reduction from the present amount of 1.9 tons of waste per housing unit to 1.2 tons/unit by July 2007, and is devoting its concerted efforts to achieving this goal.

4.2 Supply Chain Management

Construction of a recycling system with the factory as its core has enabled integrated management of the wastes generated at construction sites. Seen from the viewpoint of physical distribution, this represents the establishment of supply chain management (SCM) in the physical distribution of wastes.

As a business concept, the purpose of SCM is to synchronize the constraints of capacity, demand, material while maintaining an awareness of bottlenecks, and thereby secure throughput speed. Applying this to Sekisui House's recycling system, it can be understood that the company has created a sorting and treatment system ("capacity") at its construction sites and Recycling Centers based on the conditions at consigned waste treatment contractors ("demand"), and thus has established a system for supplying wastes in individual basic materials ("material").

From analogy with the human body, the physical distribution process involving waste has been called a "venous flow," or more properly, reverse logistics. The recycling system created by Sekisui House is one of the few successful examples of the establishment of SCM in reverse logistics.

5. FUTURE ISSUES

5.1 Rationalization of Material Recycling and Thermal Recycling

As noted previously, in the present stage, the material recycling ratio at Sekisui House exceeds 90%. However, when recycling is examined from the viewpoints of energy costs and CO_2 emissions, there are conceivably cases in which thermal recycling is more rational than material recycling.

Therefore, Sekisui House and an outside think tank are jointly working to establish indexes which will make it possible to evaluate recycling levels. After establishing indexes for recycling levels, the company plans to evaluate and review its recycling system based on those indexes.

5.2 Determination of Amount of Wastes Generated

At present, the amount of wastes generated at construction sites is determined by setting weight coefficients for containers by waste type and then obtaining a weight value from the number of containers. Although this system provides a basically correct grasp of the total weight of generated wastes, the amounts at individual construction sites are limited to rough estimated values.

After realizing a certain level of reduction in the amount of waste generation, it is necessary to determine waste generation individually and in real time if further reductions are to be achieved. For this purpose, Sekisui House plans to begin development of a waste measurement system using IT technology such as RF-ID.

5.3 Implementation of True SCM

As mentioned in the previous chapter, it was possible to establish SCM in reverse logistics. However, the ultimate goal of SCM should be comprehensive, including the full production process. Therefore, in the future, it will be necessary to create an internal system for the establishment of SCM on the forward logistics side, which is far more complex that the physical distribution of wastes.

The challenges which must be overcome in order to achieve this are huge, including unification of design concepts in product design, component design, etc., establishment of an integrated production system, standardization of the construction procedures used at construction sites, and just-in-time supply of components to construction sites, among others. Sekisui House plans to take up this challenge based on this successful example in reverse logistics.

Note 1 Triple bottom line

In conventional accounting, the bottom line is the final line in a statement and means the final result of profit or loss. The "triple bottom line" is a concept which was first proposed by John Elkington of the English environmental consulting firm, SustainAbility for evaluation of corporate activities from a viewpoint which is not limited to economics, but also includes the environment and social contribution. The Global Reporting Initiative's GRI Report Guidelines were also based on this concept.

Note 2 Resident's value

Term expressing the relative values of indicators for evaluating and materializing the necessary conditions for continuing long-term occupancy. Because value in occupancy cannot be grasped using the concept of the triple bottom line, Sekisui House announced this as an original concept in its "Declaration of Sustainability."

Note 3 Zero emissions

Concept proposed by Gunter Pauli of the United Nations University in Tokyo. Referring to the food chain in the natural world, this is a concept for creating a system in which the wastes and byproducts discharged from a certain industry are utilized as resources in other industries, with the result that industry as a whole produces no wastes. As a general practice in Japan, many companies define the achievement of "zero emissions" as satisfying the two criteria of no landfill disposal and no simple incineration of waste.

Note 4 Waste Disposal Law

The official name of this law is the "Waste Disposal and Public Cleansing Law." As it is generally called the Waste Disposal Law, this usage is also adopted in this paper. The Waste Disposal Law classifies the treatment of wastes as "municipal solid waste," which is to be treated under the responsibility of local governing bodies, and "industrial waste," which is treated by companies under their own responsibility, and includes detailed for provisions for each, from treatment methods to methods of obtaining approvals. Unfortunately, the wastes generated by the construction industry were not considered when the law was materialized, resulting in serious discontinuities between its provisions and reality.

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