plan/design in the construction cost, it will still be financially feasible enough if the tipping fee is established at more than 350 bahts per ton of waste.

9.4 Proposal Concerning Standards and Regulations

9.4.1 Classification of Industrial Waste

Factories generate the following types of waste.

1. Non-hazardous waste
2. Hazardous waste
3. Waste similar to municipal waste not from production lines but from office works, canteens, etc.
4. Medical waste from health care facilities of factories (except for Item 3)
5. Radioactive waste

List of characteristics of waste and unusable materials attached to the Notification of Ministry of Industry No. 1 (B.E. 2541 or A.D. 1998) classifies non-hazardous waste into 2 groups, and each group is classified into sub-groups.

- Group 1: Non-hazardous waste characterized by type
- Group 2: Waste from specific production processes

Group 2 includes the following types of waste.

1. Ash generated from combustion process of fossil fuels, biomass and combustible material
2. Automotive parts and auto shredder wastes
3. Dust from air pollution control system including baghouse, electrostatic precipitator, cyclone and scrubber
4. Used catalyst from petrochemical production processes
5. Dust from cement kilns
6. Dewatered sludge from industrial wastewater treatment plant
7. Dewatered sludge from wastewater treatment plant in tannery
8. Drilling mud from petroleum exploration
9. Used refractory materials from industrial furnaces, kilns and ovens
10. Sand from sand blasting
11. Slag from coal gasification process
12. Sulfur dioxide scrubber waste from air pollution control system in fossil fuel combustion processes
13. Residuals or dust from tannery
14. Tailings from extraction, benefaction and processing of ores and minerals

The team proposes that DIW should exclude Group 2 (waste from specific industrial processes) from the category of Non-HW for the following reasons.

1. Since any type of waste in Group 2 is possible to be HW, treating these wastes as non-HW could result in serious consequences. It is safer that these wastes in Group 2 are classified as HW and treated/disposed of as non-HW only if they can be proved non-HW by tests such as leachate test;

2. There is some possibility that the leachate extraction procedures prescribed in the Notification of the Ministry of Industry shows the different result at each test.
3. There is some doubt whether waste generators (factories) submit a certificate or result of analysis to show that generated wastes are non-HW every time they discharge wastes.
4. There is some doubt whether waste treatment/disposal facilities carefully check the certificate or result of analysis or conduct a test to check if wastes they receive are non-HW or not when they receive wastes.
5. Since municipal waste disposal sites are not prepared to receive HW, a priority should be given to avoid possible influx of HW.

9.4.2 Licensing System to Control the Private IWM Business

a. Control by the License

In order to control the entire flow of waste from the discharge point to the final disposal point, not only factories but also waste collectors/transporters and waste buyers have to be under control.

DIW has been controlling the discharge of Non-HW from factories located in 14 provinces including the study area of the present study by obligating them to apply for the transport permits as stipulated in MOI Notification No.1 B.E.2541 (1998). In order to strengthen this, the team proposes the development of a licensing system to control waste collectors/transporters and waste buyers (see Section 9.2.5).

That DIW has control over factories, waste collectors/transporters and waste buyers all together means that DIW has authority to impose a liability for illegal dumps or improper treatment. This should be effective to prevent illegal dumps and promote proper treatment.

Types of license for the transporters and the waste buyers should be established separately. The license will help the control over them at the following aspects.

- The collectors/transporters and waste buyers must have licenses if they wish to buy or transport waste of their client factories. Then they will be controlled under the licensing system.
- The transport permit is no more necessary if the licensing system works properly. *Instead, Selling Record or Discharge Record of the waste must be prepared and kept for at least 5 years for factory inspection.* In case of hazardous waste, it must be attached to Ro Ngo 6.

b. Requirements

b.1 Requirements to Waste Buyers

Waste Buyers are those who pay money to factories in exchange of their waste or unusable material. Requirements to them will be as follows:

- Waste buyers must have the license issued by DIW to buy waste or unusable material from factories for a recycle or selling purpose.

- Secondary or tertiary waste buyers, who buy waste or unusable material from other buyers, also must have the license.
- Waste buyers must give the factory a receipt when they buy the waste. The receipt specifies the type and quantity of waste. Waste buyers themselves must keep a copy of the receipt.
- Waste buyers shall make a Waste Purchasing and Selling Record describing the type and quantity of waste (bought or sold), client's name and other necessary data. The Record shall be kept for at least 5 years for factory inspection by the DIW.
- Waste buyers shall report the type and quantity of waste which they dealt with to DIW once a year.

b.2 Requirements to Waste Collectors/Transporter

It is supposed that there are 4 types of the waste collectors/transporters as follows:

- If the waste discharger himself transports waste to others by his own car, he must have the license.
- If he is a waste buyer who transports waste by his own transport means, he must have the license.
- If the waste treater or the user of recycled material himself transports waste by his own car, he must have the license.
- If the transporter just only transports waste under other's instruction, and he himself does neither buy nor sell waste to the other parties, he must have the license.

c. Changes in the Control over Factories

c.1 Requirements to Waste Dischargers (factory)

- No transport permit is required.
- When the factory sells waste to waste buyers, they must be licensed waste buyers.
- When the factory asks transporters to take their waste out of the factory, they must be licensed transporters.
- The factory must prepare the Selling Record or Discharge Record of the waste and keep it for at least 5 years for factory inspection. In case of hazardous waste, it should be attached to Ro Ngo 6 to be submitted to DIW.
- Discharge Record shall also be made when the factory asks a local administrative organization such as municipality to collect the waste.

It is recommended to amend the MOI Notification No.1 B.E.2541 (1998) that at present requires factories to get transport permits so as to regulate the requirements listed above, and to apply it to the whole country.

c.2 Requirements to Users of Recycled Material

Users of recycled material include factories of Code 105 that sort waste and factories of Code 106 that recycle waste. In either case, they are to be controlled as follows.

- Factories that use recycled material to sort and/or recycle shall prepare the Waste Purchasing Record. They must submit Ro Ngo 5 to DIW once a year with attaching the Waste Purchasing Record.

d. Action Required to the DIW

- Licensing system development
- Training for the transporters as a condition to give a license
- Close check of Ro Ngo 5 with respect to the material used
- Close check of Ro Ngo 6 with respect to the method of waste disposal
- Promotion of the registration of the factories as those of Code 105 and 106

At present, the Ro Ngo 5 report is submitted not to DIW but to the Office of Industrial Economies, but they should share the data.

9.4.3 Standards for non-HW treatment/disposal facilities

Basically, collection, transportation, reuse, recycling, intermediate treatment and final disposal of non-HW can be thought in the same way as those of municipal wastes. Therefore, standards for municipal waste treatment/disposal facilities can be applied to non-HW treatment/disposal facilities.

Standards for treatment/disposal of wastes including IW should be based on the following principles: (1) Wastes should be treated safely and sanitarily; (2) Wastes should be treated (including reused/recycled) for the purposes of reducing volume, stabilizing quality and making waste non-hazardous; and (3) Wastes should be disposed of paying enough attention prevent pollution problems. The basic flow of treatment/disposal of wastes is shown in Figure 9-5.

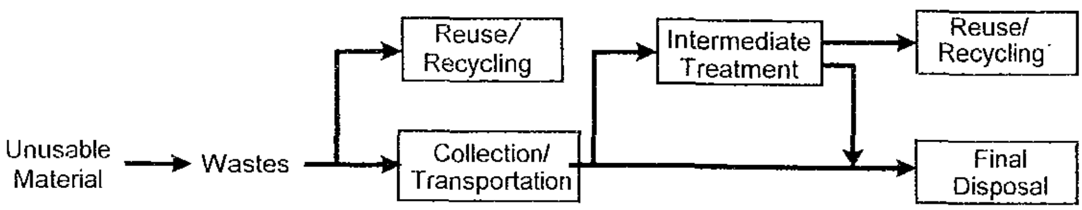


Figure 9-5: Basic flow of treatment/disposal of wastes

Minimum standards for facilities concerning collection, transportation, reuse, recycling, intermediate treatment, and final disposal of non-HW are summarized in the table below. They are referred to relevant standards in Japan.

The main responsibility of the government is to direct, monitor, and control the whole process of non-HW treatment/disposal. To direct all the business concerned to conduct proper IWM, and to monitor and control the whole process, it is necessary for the government to make standards clear. DIW need to draw up standards for each process of non-HW treatment/disposal and to prepare monitoring and control systems. Since it is in general very difficult to control on-site final disposal, DIW has to tighten regulation on on-site final disposal and to eliminate improper disposal.

Table 9-9: Operational Standard of IW disposal facilities

Standards for collection and transportation	1.Necessary measures to prevent litter and spillage of wastes from a vehicle and a container in the process of collection and transportation have to be taken.
	2.Necessary measures to prevent nuisances caused by odour of waste or noise/vibration by collection and trasnportation vehicles have to be taken.
	3.If wastes need to be transhipped, the following measures should be taken: • to fence around the transhipment place and put a bulletin board to show the purpose of the land use clearly; • to prevent litter/spillage of waste and penetration of leachate to underground; • to prevent odour; and • to prevent propagation of mice, mosquitoes and flies at the transhipment place.
	4.Storage of waste at the transhipment place is prohibited in principle.
Standards for reuse, recycle and intermediate treatment	1. Necessary measures to prevent litter and spillage of waste at the process of reuse/recycling or intermediate treatment have to be taken.
	2. Necessary measures to prevent nuisance caused by odour and noise/vibration from reuse/recycling and treatment process have to be taken.
	3. If wastes need to be incinerated, incineration facilities with proper structure and equipments have to be used.
	4. If waste is stored, storage place have to be fenced and a bulletin board have to be put to show the purpose of the land use clearly.
	5. If wastes need to be stored, the following measures should be taken: • to fence around the storage place and put a bulletin board to show the purpose of the land use clearly; • to prevent litter/spillage of waste and penetration of leachate to underground; • to prevent odour; and • to prevent propagation of mice, mosquitoes, and flies at the storage place:
Standards for land-filling	1. Necessary measures to prevent litter and spillage of waste by landfilling work have to be taken.
	2. Necessary measures to prevent nuisance caused by odour and noise/vibration brought with landfilling work have to be taken.
	3. For landfill operation, the following measures should be taken: • to fence around the landfill site and put a bulletin board to show the purpose of the land use clearly; • to prevent pollution of public water area and ground water by leachate from landfill site, if necessary; and

	• to prevent propagation of mice, mosquitoes, and flies at the landfill site.

9.4.4 Site Selection Procedures and Standards

According to the DIW the only existing evaluation criteria for the site selection of waste management facilities are the one set by the MOSTE for municipal solid waste management facilities. In addition there is a HW landfill site selection criteria proposed by consultants employed by the DIW. The team studied these criteria. According to the information the team received the existing criteria do not indicate a site selection method and detailed evaluation aspects. In order to supplement the existing criteria the team drafts a site selection method and its evaluation criteria for Non-HW landfill.

a. Existing Criteria for Site Selection

a.1 Criteria of MOSTE

According to the DIW, there is only set of criteria used in site selection for solid waste management, which is made by MOSTE, but it is not the criteria for IW but for the Municipal solid waste. The criteria are as shown in Table 9-10.

Table 9-10: Site Selection of MOSTE for Solid Waste Management Facilities

1	Criteria of the area selection for the solid waste transfer station and recycling facilities
1)	Locate outside catchment area, class 1 and 2 in accordance with the Ministerial Resolution (28 May B.E.2528 (1985)) related to the requirements of catchment area quality.
2)	Locate not less than 1 km away from the archaeological site in accordance with the Archaeological Objects and Arts, and National Museum Act.
3)	Locate not less than 1 km away from the municipal area.
2	Criteria of the area selection for the waste incinerator facilities and composting facilities.
1)	Locate outside catchment area, class 1 and 2 in accordance with the Ministerial Resolution (28 May B.E.2528 (1985)) related to the requirements of catchment area quality.
2)	Locate not less than 1 km away from the archaeological site in accordance with the Archaeological Objects and Arts, and National Museum Act.
3)	Locate not less than 2 km away from the municipal area.
4)	Location of waste incinerator facilities should be open area.
3	Criteria of the area selection for the solid waste landfill
1)	Locate outside catchment area, class 1 and 2 in accordance with the Ministerial Resolution (28 May B.E.2528 (1985)) related to the requirements of catchment area quality.
2)	Locate not less than 1 km away from the archaeological site in accordance with the Archaeological Objects and Arts, and National Museum Act.
3)	Locate not less than 5 km away from the airport area
4)	Locate not less than 700 m away from present drinking well or water supply plant.
5)	Locate not less than 300 m away from existing natural or man-made water resources.
6)	Geological or underground condition should be firm for waste dumping
7)	Should be located in high lands, in case of low lands may be effected by flash flood or wild water which protected measures need to be set up.

8)	Should be located in areas where underground level is deep. In case of the underground water level is short distance from the ground surfaced, the protection measures need to be set up.
9)	Should be a single piece of land and adequate size for landfilling for not less than 20 years.

a.2 Criteria applied by the Selection of HW Landfills

DIW is now conducting study on the sites suitable for the construction of HW landfill called "Study Project on Potential Sites for the Construction of Countrywide Industrial Waste Landfill" and the appointed consultant proposed the criteria for the selection of landfill sites as shown in Table 9-11.

Table 9-11: Site Selection Criteria for HW Landfill

1	Criteria based on engineering field
1)	The site has enough area to dispose waste till all operation life.
2)	The site locates near waste generation sources as much as possible in order to reduce transportation cost and It should be located far from water supply source at least 500 feet.
3)	The site locates in convenience place with all-weathered access road.
4)	The site topography should be less changed as much as possible. It should avoid the place with low pressure and valley that water source will be contaminated easily.
5)	The site locates in suitable geography such as avoid earthquake area, land slide, hole and mineral like, etc.
6)	The bottom soil of disposal site should be natural clay or fill by clay or liner.
2	Criteria based on environmental field
1)	Surface Water: locate outside of flood area within 100 years. It is not close to river, ship route and avoid wetlands etc.
2)	Groundwater: not close to groundwater, the bottom of cell must over groundwater level
3)	Air: locate in area that less impact from air and odour.
4)	Land and water ecology: avoid area that will be impact to ecology and wetlands
5)	Noise: locate in area that less noise impact from truck and heavy machine operation
6)	Land Use: avoid community area and possible conflict area such as public park and science area
7)	Cultural place: avoid historical and cultural places
8)	Law/regulation: consider permission conditions in local, regional and national level.
9)	Public/Politic: to be accepted from local representative and local interesting group.

The studies are consisted from two phases, Phase 1 covers the sites for central, southern and eastern regions and Phase 2 will cover the sites for remaining three regions.

b. Objectives and Limitation of the Proposed Criteria

b.1 Objectives

Evaluation criteria for site selection for facilities to treat or dispose of non-HW from industries do not exist yet. Generally speaking, the MOSTE's existing criteria for MSWM facilities could substitute them, but the MOSTE's criteria do not indicate a site selection method or detailed evaluation items, which are very important for decision-making.

Therefore the team elaborated draft site selection criteria for the management of non-HW and proposes them here based on its experience in the several countries including Japan. In addition the World Health Organization regional publication[1] is referred as a background material.

b.2 Limitation

Although the evaluation criteria may differ from each waste management facilities such as a transfer station, an incinerator and a landfill, the criteria for a landfill cover most of aspects required for the other facilities. Therefore, in order to supplement the existing criteria the team drafts a site selection method and its evaluation criteria for non-HW landfill.

An actual site selection work should be conducted fully taking regional conditions into consideration. Therefore, the team recommends the relevant organizations, which concern the selection work, examine the draft criteria and modify/improve the criteria to adopt local conditions in Thailand.

c. Proposed Site Selection Process

The site selection is a dynamic process where a lot of people with different positions and interests are involved. Administrative problems among the different administrative levels such as central, provincial and municipal governments in terms of cooperation, coordination and integration are not solved by a static model. The model that is proposed in this report will not give the ultimate answer where to locate a new landfill but should be considered as a method to make the decision clearer and more transparent.

In the model, the site selection for a new landfill will take place in three phases as follows:

1. Phase 1: Preliminary selection with excluding criteria

   In the first phase, the search area is defined and consequently a number of candidate areas is reduced by excluding (strict) criteria.

2. Phase 2: Secondary selection with reducing criteria

   In the second phase, the areas that are identified as suitable for a landfill site according to the criteria of phase 1, are further reduced by using less strict criteria (reducing criteria). The effect and reach of the most reducing criteria can be adjusted according to needs and local conditions. After application of reducing criteria approximately 5 suitable locations for a landfill site should be left. If the number of the site is still much, reducing criteria should apply more strictly and try to reduce the number of site further.

3. Phase 3: Final selection with arranging criteria

   In the third phase, approximately 5 possible locations for a landfill site will be given scores based on the arranging criteria. The arranging criteria are divided

[1] "Site selection for new hazardous waste management facilities", WHO Regional Publications European Series No46.

into 5 subjects. According to their scores on each criterion, a separate ranking score will be given to each location for each subject. The ranking scores are accumulated in an overall scoring table. A weighing factor can be applied to each subject if required. The sum of the (weighed) ranking scores defines the most suitable location for the landfill site.

In many cases, not all the excluding, reducing, and arranging criteria can be used. Some criteria might be irrelevant or there might be no information available. In case no information is available, the criteria can either be skipped or additional data can be obtained through field inspections.

It is expected that field inspections will be necessary in many cases to obtain data on soil and groundwater characteristics in the third phase of the selection process since these data are important to the overall environmental impact of the landfill site and the availability of these data is scarce.

The process of these site selections for a new landfill is illustrated in Figure 9-6.

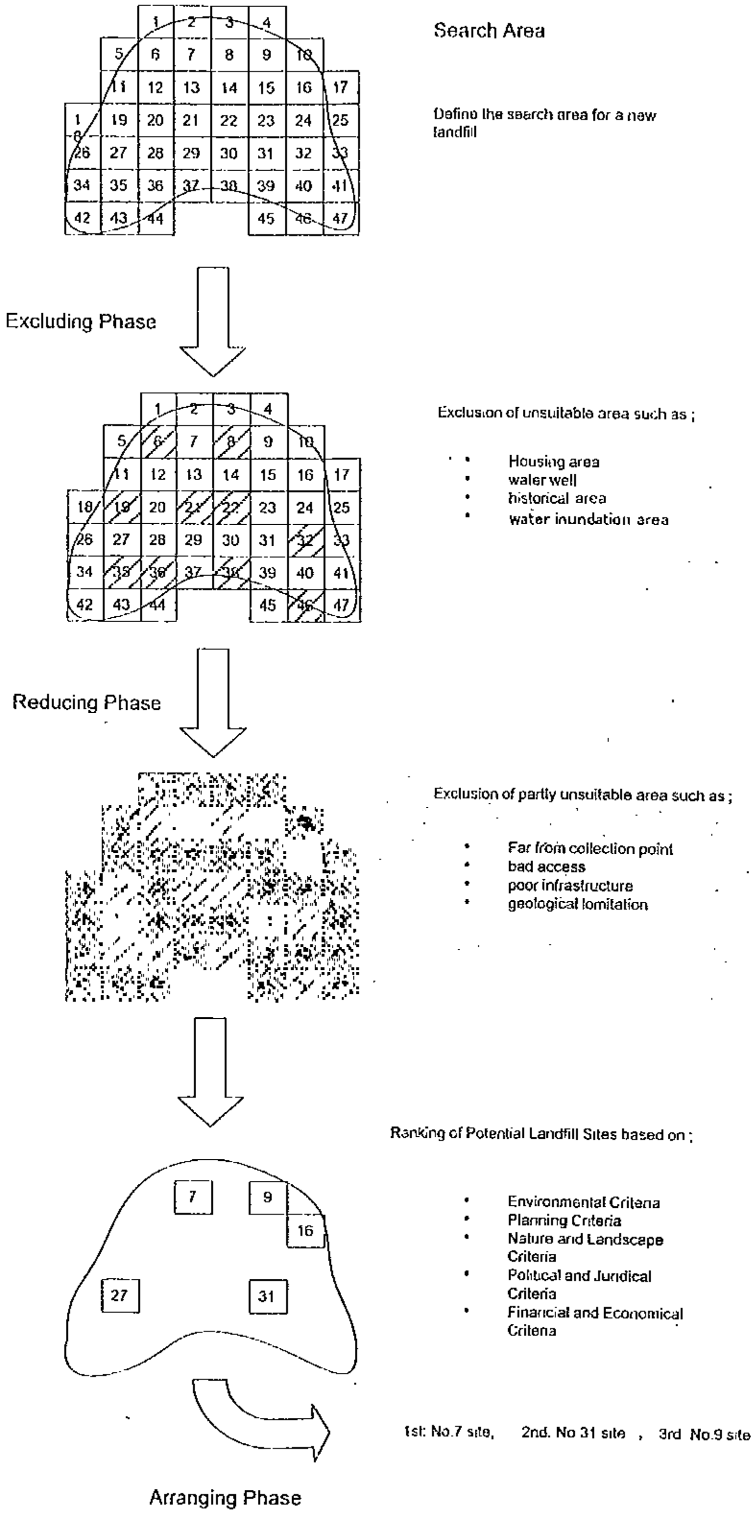


Figure 9-6: Site Selection Process for a new landfill

d. Proposed Evaluation Criteria

d.1. Excluding Criteria for Preliminary Selection

As the phase 1 of the site selection, following criteria will be used for excluding certain locations, which are not suitable for the landfill.

1. Housing area

   A landfill within a city or village is unfit and not desirable because of the hindrance for the population.

2. Buffer zone around housing area

   It is recommended not to construct new landfill within several hundred meters (to be determined based on the regional conditions, etc.) of a housing area because of the dust and odour emission.

3. Influence zone around water wells

   A landfill should not be planned within the influence zone of an area where the groundwater is used for drinking purpose. It depends on local circumstances how large the influence zone is.

4. Areas of special ecological, scientific or historical value

   Especially national parks and natural conservation areas (including areas along seas, lakes, rivers) are unfit for the location of a landfill. Also for these areas, a buffer zone of certain width (to be determined based on the regional conditions, etc.) should be provided for a location of landfill.

5. Military areas

   Areas where are used for the testing of military equipment or training of military are not fitted for the location of a landfill.

6. Inundation areas

   Areas which are regularly inundated by rain water, river water or ground water are not fitted for the location of landfill.

7. Nearby an airport

   The presence of birds is a real danger for aeroplanes. Because birds are attracted especially by organic waste, it is recommended that within 5 kilometres of an airport not to locate a landfill that contains organic parts.

8. Cemeteries

   Cemeteries (actual and former) and nearby vicinity (a distance shall be determined based on the regional conditions, etc.) should be excluded of a location of a landfill.

9. Land acquisition

   If land acquisition in certain areas is impossible because of disagreement with the owner or the lack of legal means to expropriate land, these areas are excluded from the search area for a new landfill.

Sample of summary of the result considering excluding criteria is shown in Table 9-12.

Table 9-12: Summary sheet for excluding criteria

Is the searching area of a landfill located:	Answer
1. in a housing area	Yes / No
2. within XXX m around a housing area	Yes / No
3. within the influence zone around a water well	Yes / No
4a. in a protected area with ecological, historical or scientific value 4b. Within XXX m of such protected area	Yes / No Yes / No
5. in a military area	Yes / No
6. in a water inundation area	Yes / No
7. within 5 km from an airport	Yes / No
8. within XXX m from a cemetery	Yes / No
9. with impossibility of land acquisition	Yes / No

Note: "XXX" should be determined by relevant authorities.

d.2. Reducing Criteria for Secondary Selection

The aim of the reducing criteria is to reduce the search area for a new landfill once more using reducing criteria. Reducing criteria is not always leading to a limitation of the search area. The result of using the reduction criteria should be that there are 5-6 potential locations are left for a comparison about the most suitable location.

1. Far from collection area

   If the new landfill site will be too far from the collection area, transport costs are rising too much. This is specially the case when new (or more) transfer stations are needed to reduce the costs of collection and transportation.

2. Bad accessibility

   A bad accessibility is caused e.g. by lack of good roads to reach the landfill, access roads which are too hilly for waste transport trucks or roads passing housing areas.

3. Difficult infrastructural provisions

   If the location of the new landfill is interfering with existing infrastructural provision e.g. cables, roads or existing plans for drainage, it is very difficult to make the location suitable for the use as a landfill.

4. Geological limitations

   Geological limitation is needed for the possibility of geological hazards and the characteristics of bedrock. Sensitivity of an area for seismic displacement, volcanic activity, and landslides makes the area less favourable for an location of a landfill. If bedrock will serve as part of foundation of the landfill, joints and other discontinuity of the bedrock can provide hydraulic conduits and constitute pathways for migration of contaminants.

5. Hydro geological and soil limitation

   Although hydrogeological and soil characteristics play an important role in the comparison of suitable locations during the next phase of selecting process, some characteristics are making search areas (or parts of it) unfavourable for a landfill because of the high risk of polluting the groundwater or significant aquifers. Examples are: high permeability of the soil (very gravely sand), high susceptibility of soil consolidation (peat and clay), non-existence of impermeable layers in the subsoil, low depths to groundwater, negative groundwater up gradient of the subsoil (infiltration), natural recharge areas (ground water recharge to significant aquifers).

6. Availability of bottom/cover material

   The availability of soil of proper characteristics for the construction of bottom liners, of cover systems, or both is usually an important factor in the process of selecting a landfill. If in or nearby the site there is sufficient quantities, time and expenses are saved. Also, if importation is needed, the site should have enough space for storing the soil.

7. Within a tourist/recreation area

   Normally, a location of landfill is conflicting with a tourist area or a recreation area. However, some kinds of recreation as car/motor racing are not conflicting. Also the final use of a landfill can be planned as a recreational destiny.

8. Within an industrial area

   Industrial areas are not principally excluded as location of a landfill. Dependent of the kind of industry (e.g. no industry sensible for dust or food factories) an industrial area (or the proximity) is suitable for a landfill. An advantage of an industrial area is the presence of infrastructural provisions.

   Example of summary of the result considering excluding criteria is shown in Table 9-13.

Table 9-13: Summary sheet for reducing criteria

Is the searching area of a landfill located:	Answer
1. far from collection area	Yes / No
2. in a bad accessibility	Yes / No
3. with difficult infrastructural provisions	Yes / No
4. with geological limitations	Yes / No
5. with hydrological and soil limitations	Yes / No
6. with availability of bottom/cover material	Yes / No
7. within a tourist/recreational area	Yes / No
8. within an industrial area	Yes / No

Each "Yes" in the above table doesn't mean that search area is not suitable in an absolute sense. The search area is less favorable for choosing a potential landfill location, especially if the search area will get more "Yes" answers in the reducing phase.

d.3. Arranging Criteria for Final Selection

The arranging criteria are meant for the comparison of several potential sites which are the outcome of phase 1 and 2 of the selection process. It is recommended not to compare more than 5 potential sites. If the outcome of the phase 1 and 2 has resulted in more than 5 sites, the criteria of phase 1 and 2 should be applied more strictly, in such a way that 5 potential sites are left.

It is also possible that after phase 1 and 2, several potential sites are not left. The outcome could be that there are one or more large areas, which are in principal suitable for a potential landfill, independent where the location should be situated in the area. The large area should be divided in parts, which are large enough to locate a landfill. Therefore it is needed to know how large the size should be for the new landfill site.

The size of the site depends on:

- The usage of the site
- Quantity and characteristics of actual waste to be landfilled
- Estimation of future quantity and characteristics of wastes
- The depth of fill
- The maximum altitude of the fill
- The operating practice
- Area needed for office, garage, repair, parking, soil stockpile, weigh bridge and so on.

Arranging criteria will be further divided into 5 sub-categories as follows.

1. environmental criteria
2. planning criteria
3. nature and landscape criteria
4. political and juridical criteria
5. financial and economic criteria

If 5 potential landfill locations are compared, within each category, the different locations can get a ranking score for each criteria in a range from 1 to 5. The location which scoring best will get 5 points and the worst location will get 1 point.

d.3.1. Environmental criteria

1. Permeability of soil

   A high permeability of soil will result in a fast seeping of the leachate into the groundwater. The location where the subsoil has the lowest permeability will get the highest-ranking score. (5 points if there is comparison with 5 different locations)

2. Presence of impermeable layers in the subsoil

Impermeable layers in the subsoil are minimising the risk of polluting groundwater. Especially clay layers have a low permeability. The location with subsoil layers, which have a high impermeability, will get highest ranking score.

3. Susceptibility to soil consolidation

   A high susceptibility to soil consolidation (peat and clay soils) is causing an unstable foundation of the landfill. An unstable foundation can lead to damages of the bottom liners and/or the drainage system. The location with the lowest susceptibility to the soil consolidation will get highest ranking score.

4. Position of vulnerable objects

   Potable water wells and natural areas, which are dependent of groundwater, are very vulnerable when they are located in he direction of ground water movement nearby landfills. The potential landfill location with the least vulnerable objects will get the highest-ranking score.

5. Velocity of ground water flow

   A high velocity of ground water flow is increasing the spreading of eventually leachate beneath the landfill. The velocity of then ground water flow is dependent of porosity of the soil and the filtering speed. The potential landfill location with the lowest velocity of the groundwater flow will get the highest ranking score.

6. Groundwater and river levels.

   A high groundwater level or nearby high water river level will cause more risk to pollute the groundwater or river water. The potential landfill location with the lowest groundwater level or river level will get a highest-ranking score.

7. Odour and dust nuisance for neighbouring area

   A new landfill should not locate within several hundreds meters of a housing area (refer to excluding criteria). Potential landfill locations with the longest distance from the housing area are more favourable than those nearby housing areas. However, if the distance to a housing area is more than 500 meters (to be determined based on the regional conditions, etc.), there may be no discriminating difference anymore.

8. Nuisance by traffic generation

   A new landfill will generate more traffic. How much more traffic are depend on the distance to the collection area, kind of transport, use of transfer station and so on. How much hindrance will be caused, is not only related to the quantity of transport but also to the routing. An access road passing through the housing area will cause more nuisance than access roads through the open countryside. The potential landfill location with the slightest nuisance will get the highest-ranking score.

9. Risks for neighbouring area

Because of the presence of the landfill gas, there is a chance for explosion and/or fire. The potential landfill location with the highest distance from individual houses will get the highest-ranking score. However, if the distance is more than 500 metres (to be determined based on the regional conditions, etc.), there may be no discriminating difference anymore in case of an explosion or fire.

10. Other nuisance for neighbouring area

Vermin, such as rats, mice, birds and insects, that is attracted by the organic parts of the waste on the landfill is considered as one of other nuisances. Windblown litter, noise caused by construction, compaction or trucks on the landfill will be the other nuisances. Potential landfill locations with the highest distance from a housing area are more favourable than those nearby housing area. However, if the distance is more than 500 metres (to be determined based on the regional conditions, etc.), there may be no discriminating difference anymore for other nuisance.

Summary of the scores on environmental criteria is shown on Table 9-14.

Table 9-14: Summary of the scores on environmental criteria

Environmental Criteria	Locations				
	A	B	C	D	E
1. permeability of the subsoil					
2. presence of impermeable layers in the subsoil					
3. susceptibility to soil consolidation					
4. position of vulnerable objects related to the direction of groundwater movement					
5. velocity of ground water flow					
6. groundwater and river levels					
7. odour and dust nuisance for neighbouring area					
8. nuisance by traffic generation					
9. risks for neighbouring area					
10. other nuisance for neighbouring area					
Total Score					
Average Ranking Score					

d.3.2. Planning criteria

1. Shape of the area

A potential landfill surface with a size of 150 meters length and 140 metres width is more favourable than a potential landfill site of 250 meters length and 90 meters width. The potential landfill location with the most square shape will get the highest ranking score.

2. Infrastructural use

The potential landfill location with the slightest limitation of infrastructural provision or use will get the highest ranking score. How many limitations and how severe they are, depend very much on local conditions

3. Distance to the housing area

   The distance to a housing area is more important in terms of planning. Possibilities of extension of housing area and construction of new infrastructure are limited by nearby landfills. The longest distance will be more favourable for a landfill location.

4. Distance to the industrial, tourist/recreational area

   Because of odour and dust from landfill site, potential landfill sites should be located on a minimum distance of several hundred metres (to be determined based on the regional conditions, etc.) from tourist/recreational area and also from some kind of industries which are sensitive to dust. The longest distance from industrial and tourist/recreational area is more favourable for a landfill location and is getting high-ranking score.

5. Distance to the natural conservation area

   In the excluding phase, potential landfill site, which distance from natural conservation area is less than several hundred metres (to be determined based on the regional conditions, etc.) , are excluded already. Potential landfill locations with the longest distance from a natural conservation area are more favourable than those nearby that kind of area. However, if the distance to a natural conservation area is more than 500 metres several hundred metres (to be determined based on the regional conditions, etc.) , there may be no discriminating difference anymore in terms of distance.

6. Distance to main road

   Because main roads are more suitable for waste transport trucks, it is an advantage when landfill is located nearby main roads. The potential location where the use of main roads is the most will get the highest-ranking score.

7. Distance to waste generator

   Especially for relatively small landfills, this criteria is important. The distance from the landfill to the sources of waste generations is important in two ways. Firstly, because of shorter transport distances, emissions and nuisances caused by the waste trucks are less. Secondly, shorter transport distances are making transportation to the landfill cheaper.

8. Possibilities for a usage after closure

   The surface of a landfill after closure can be utilized as limited purposes. In general, the use of the landfill site after closure is suitable for recreational facilities such as golf courses, parks, cross-countries, etc. The potential landfill location with most possibilities for a useful final use will get the highest-ranking score.

Summary of the scores on planning criteria is shown on Table 9-15.

Table 9-15: Summary of the scores on planning criteria

Planning Criteria	Locations				
	A	B	C	D	E
1. shape of the area					

2. hampering infrastructural use					
3. distance to the housing area					
4. distance to the industrial, tourist and recreational area					
5. distance to the national conservation area					
6. distance to the main road					
7. distance to the waste generator					
8. possibilities for a usage after closure					
Total Score					
Average Ranking Score					

d.3.3. Nature and Landscaping Criteria

1. Ecological value of the flora

   Ecological value is based on: diversity, naturalness (complete and undisturbed ecosystem) and characteristics feature. The potential landfill location with the most valuable vegetation will get the lowest ranking score.

2. Ecological value of the fauna

   In terms of the fauna, mammals and breeding birds are important. There are direct and indirect effects from the landfill operations. An example of indirect effect is the disturbance of the quietness in the surroundings caused by the activities on landfills. Ecological value is based on: diversity, naturalness and characteristics features. The potential landfill location with the most ecological value of the fauna will get the lowest ranking score.

3. Harmful effect on ecosystem

   The groundwater related ecosystem has to be paid attention. Examples are valleys or rivers and streams, hillsides with water sources and so on. Important things are the direction of the ground water flow. The location where the construction of a landfill will result in a serious harmful effect of typical ecosystem will get the lowest ranking score.

4. Cultural-historical value of the landscape

   Aspects of the cultural-historical value are national rarity, functional relations within the landscape, purity (measure of changes), age and characteristic feature. The potential landfill which is located in a area with the most cultural-historical valuable landscape will get the lowest ranking score.

5. Possibilities for visual incorporation in the landscape

   During the construction, usage and after completion, the landfill should be incorporated as much as possible in the surrounding landscaping. Important aspects of these incorporation are the slope of landfill, the altitude, wave design on the cover and slope, vegetation on the cover material. The features of the surrounding landscape are also important for the possibilities of incorporation. The potential location with the best possibilities for a visual incorporation in the landscape will get the highest ranking score.

Summary of the scores on nature and landscape criteria is shown on Table 9-16.

Table 9-16: Summary of the scores on nature and landscape criteria

Nature and Landscape Criteria	Locations				
	A	B	C	D	E
1. ecological value of flora					
2. ecological value of the fauna					
3. harmful effect on ecosystem					
4. cultural, historical value of the landscape					
5. possibilities for visual incorporation in the landscape					
Total Score					
Average Ranking Score					

d.3.4. Political and Juridical Criteria

1. Acceptance by the regional government

   Sometimes, potential landfill sites are located in different regions. The political acceptance of a new landfill location can differ in each region. The level of political acceptance has influence on the willingness of the regional government to adapt their regional physical plans and to give a permit for the construction of a landfill. A minor willingness will lead to a delay of the definite decision on the landfill location.

   The potential landfill, which is located in the region with the highest political acceptance, will get the highest-ranking score.

2. Acceptance by the local authority

   Not only the regional government is playing an important role in the decision process but also cooperation of local authorities is important. They can have influence on the regional government or they can ignore the responsibilities to contribute for finding a landfill sites at their own area. The potential landfill sites, which are located in the area with the lowest cooperation of the local authorities, will get the lowest ranking score.

3. Hampering effect of other plans

   If there exists other planning of land use for the potential landfill sites, it will be more difficult to choose as a landfill site or change the land use plan to landfill. The potential landfill location with the most conflicting future land use plan will get the lowest ranking score.

4. Acceptance by the pressure groups involved.

   The acceptance by the public to realise a landfill in their own regions or municipality is an important factor in the decision making process. The so-called NIMBY (Not In My Back Yard) syndrome is becoming a common attitude. The influence of the public is significant if there is local groups which are well organised and having good relations with the local authorities and the media (papers, radio and TV). The level of public acceptance can be measured how far the local pressure groups are succeeding to delay the decision making process.

The potential landfill, which is located in the area with the lowest public acceptance, will get the lowest ranking score.

5. Ownership of the landfill area

   It will have the big influence that is the owner of the new landfill sites. Public owner ship is easier to handle it. A lot of time, private ownership will give problems with the acquisition. Sometimes, expropriation is needed and this procedure will cause delays in the realization.

   The potential landfill site where the acquisition of needed property is most difficult will get the lowest ranking score.

Summary of the scores on political and juridical criteria is shown on Table 9-17.

Table 9-17: Summary of the scores on political and juridical criteria

Political and Juridical Criteria	Locations				
	A	B	C	D	E
1. acceptance by the regional government					
2. acceptance by the local authority					
3. hampering effect of other planning					
4. acceptance by the pressure groups involved					
5. ownership of the landfill area					
Total Score					
Average Ranking Score					

d.3.5. Financial and Economic criteria

1. Costs of land acquisition

   Costs of land acquisition depend on the land prices, which can differ from each location. It is important to find out what is the actual use of the land because this is influencing the level of compensation for the owner or actual users.

   The potential landfill with lowest costs for land acquisition will get the highest-ranking score.

2. Costs of the access of the landfill

   Costs for the access of the landfill depends on the presence of the roads close to the landfill and how suitable they are to use for the waste trucks. If construction of new access roads is needed, the costs will increase.

   The potential landfill with the lowest costs for access roads (new or to be renovated) will get the highest-ranking score.

3. Transport costs

   The transport costs are determined by the transport distances from the waste generation sources, the way of transport and the way of collection. Whether Transfer station is planned to construct and possibility to use railways also affect the cost of transport.

The potential landfill with the lowest transport costs will give the highest ranking score.

4. Operation and maintenance costs

   Probably the costs for the personnel, such as manager, operator, mechanic, driver, bookkeeper, will not differ so much between the different potential landfill sites. Operation and maintenance depends very much on the availability of soil that is necessary for the daily or regular covering and for the stability of the landfill. If the soil is not available in the area, it should be imported and maintenance costs will increase. Monitoring the drainage system and the quality of the leachate and surface water are also important factors in the maintenance costs.

   The potential landfill with the lowest expected maintenance costs will get the highest ranking score.

5. Extra costs for environmental protection

   To avoid the pollution of the soil, ground and surface water, it is necessary to place extra technical provisions at the landfill. The collection of the leachate is the main factor and, therefore, the following provisions should be placed: undercover by clay and/or a synthetic layer, upper cover, a drainage system, leachate pond, sewage system and /or leachate transport, monitoring well and so on.

   The potential landfill with the lowest costs for environmental protection will get the highest-ranking score.

6. Costs for after-care

   Costs for the after-care of the landfill should be included in the disposal price/tonnage. These costs are consisted not only of the kind of the final use but also of the provisions to monitor the ground water quality, existence of gas and stability of the completed landfill. Necessary provisions are depending on the characteristics of the filled waste, the kind of subsoil, the hydrogeological situation, and the kind of final use.

   The potential landfill with the lowest costs for after-care will get the highest-ranking score.

Summary of the scores on financial and economic criteria is shown on Table 9-18.

Table 9-18: Summary of the scores on Financial and Economic criteria

Financial and Economic Criteria	**Locations**				
	A	**B**	**C**	**D**	**E**
1. cost of land acquisition					
2. cost for the access of the landfill					
3. transport cost					
4. operation and maintenance costs					
5. extra cost for environmental protection					
6. cost for the after-care					
Total Score					

Average Ranking Score					

d.4. Summary of final score

For an overview and comparison all the average ranking scores of each criteria category for the different locations are brought together in table. Dependent how important a specific category, in comparison with other categories, is judged as essential in the decision making process, it is possible to give each category a different weighing factor. If environmental criteria is judged in such a way that they are twice as much more important than the planning criteria, the average ranking scores for the environmental criteria should be multiplied with two. Normally the weighing factors have a range of 0.5 to 2.5. The sample of this calculation sheet will be presented in Table 9-19.

Table 9-19: Final score for each location

Categories	Weighing Factor	Locations				
		A	B	C	D	E
Environmental Criteria						
Planning Criteria						
Criteria on Nature and Landscaping						
Political and Juridical Criteria						
Financial and Economic criteria						
Final Score						

The final score of each location is the sum of the weighing scores on the 5 categories of criteria. The location with the highest final score is most suitable as location choice for the new landfill.

For a good use of this methodology and for understanding and checking the scores, it is recommended not only to fill in the scores in the different tables but also to give a good description how the different potential landfills are related to each criterion (what are the characteristics of each location in relation to a specific criterion. Also an explanation is needed how weighing factors are applied.

Chapter 10

HW Management Action Plan

10 HW Management Action Plan

10.1 Selection of Action Plan

10.1.1 Scope of Work of The Study Concerning A/P

The Master Plan on HW (M/P) is under discussion at DIW and even the draft of M/P has not prepared yet. The Scope of Work (S/W) of the present JICA study, signed by the both governments in November 2000, stipulates that one of the study objectives is "to formulate an action plan on hazardous waste management in the field of HW reuse/recycling, industrial cluster and zero emission concepts".

10.1.2 Selection of Action Plan

An action plan is to show a specific process of necessary actions to achieve the goal of the M/P. However, the HW M/P is still being developed by DIW and even the draft is not yet available.

According to the HW flow in 2001 obtained from the result of the factory survey, the reuse/recycling rate of HW is 18.2%, only one fourth of that of non-HW (more than 78%). On the other hand, more than half (54.3%) of HW is treated (32.8%) or disposed (21.5%) on-site, while only 15% of non-HW is treated or disposed on-site.

Taking all theses consideration into account, the study team decided to propose the following three A/Ps, while emphasizing the reuse/recycling of HW.

Reuse/Recycling Promotion Plan

Each type of HW has its own reuse/recycling methods. The reuse/recycling promotion plan aims at promoting further reuse/recycling for each category of HW (12 in total), based on its own waste flow.

Waste Exchange Plan

The A/P on waste exchange is formulated, with an idea of industrial cluster[1] in mind, in order to make the best use of the waste exchange program and Waste Utilization Data Center, both of which are initiated in the study.

Waste Minimization Plan

The idea of "zero-emission" is to minimize discharge of waste as much as possible in order to achieve sustainable development, by promoting minimization of waste generation and reuse/recycle of materials. Waste Minimization Plan is formulated to promote waste minimization under the concept of "zero-emission", while taking effective use of waste exchange program into account.

[1] In this study, an industrial cluster is defined as a group of factories (A, B, C, ...) which exchange (i.e. reuse and/or recycle) waste each other.

10.1.3 Target Year, Targets and Strategies of A/P

Since the HW M/P has not formulated yet, the team set the target year, target and strategies based on the result of the survey. The target year is set as 2005, same as non-HW M/P, considering the short-term implementation.

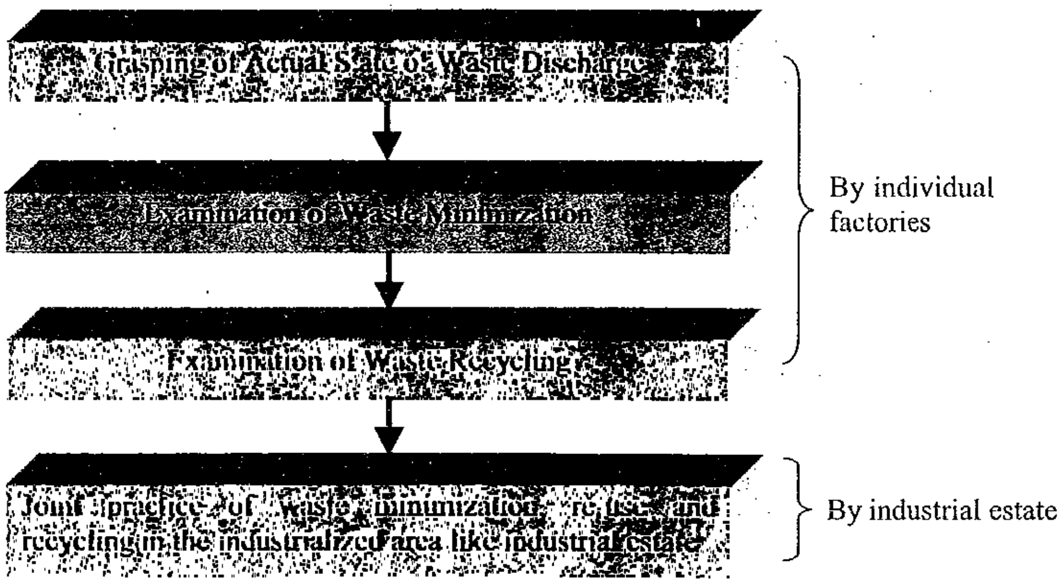
The targets of 3 A/Ps are expressed numerically as much as possible, considering the nature of these plans, and strategies are also prepared in each A/P.

10.2 Waste Minimization Plan

10.2.1 The Concept of Waste Minimization

The fundamental approach to HW minimization at source is divided into the following steps.

1. Understanding the actual state of waste discharge accurately by generators themselves
2. Examination of waste minimization
3. Examination of waste reuse/recycling
4. Joint practice of waste minimization, reuse and recycling in the industrialized area such as industrial estates



a. Understanding of Actual State of HW Discharge

The minimization and recycling of HW cannot be promoted unless HW generators grasp the actual state of their own waste discharge from the aspects listed below. It is also expected that the waste generators obtain knowledge about industrial waste and consciousness about proper management through this process.

- State of segregated storage (Attention should be paid particularly to the separation between HW and non-HW)
- Examination of the minimization and reducing of HW

- Amount and types of waste from each process
- Characteristic of HW (Physical composition and Chemical composition)

Many factories will know the volume and types of waste discharged by themselves. However, in order to reduce the volume of the HW and recycle it at source, it is necessary to go back to the manufacturing processes and to understand the volume, types, and physical properties of waste discharged from individual waste discharge processes.

b. Examination of the minimization and reducing of HW

b.1 Materials

The quality of raw materials and energy resources are to be reviewed from the viewpoint of minimizing waste generation and items listed below will be studied. For this purpose, overall study is also needed in view of production processes and costs.

- Shift to higher-purity materials
- Promotion to use recycled material
- Shift to raw materials and energy resources generating less waste
- Reduction of hazardous substances to be used

b.2 Production Process

Similar to the above, he production processes and equipment are to be reviewed from the viewpoint of controlling waste generation. The items listed below will be studied.

- Examination of such production processes that generate less wastes (Attempt to 100% recovery rate)
- Examination of energy-saving and resource-saving production processes.
- Examination of using equipment and devices generating less waste
- Examination of costs and benefits of improving or changing production processes, equipment and devices.

Furthermore, review of processes, equipment, and devices from the viewpoint of waste generation controlling is expected to be also effective in promoting recycling as follows:

- Improve production processes so that waste can be easily recycled either on-site or off-site.

c. Examination of HW recycling

If waste cannot be minimized adequately even through waste generation from individual processes is controlled, then recycling inside the factory should be promoted.

- Isn't it possible to use HW from a process as raw material for another process?
- Studying effective use of HW components: possibility of using as by-products

- Studying effective use of energy that waste has

d. HW Minimization/Re-use/Recycling inside Industrial Estate

In an industrial estate, many factories are concentrated in a limited area. This vicinity allows for the factories to promote joint work to minimize, reuse and recycle industrial waste. For example, even non-HWs common to factories, such as garbage, waste paper, and waste plastics that are generated from the cafeterias, can be gathered and recycled economically. This also makes it possible to reduce the volume of waste and to cut waste treatment costs.

Since such waste is discharged also from factories near the industrial estate, a recycling system involving areas surrounding the industrial estate might be built in the future. Meantime, concerning HW, reducing and recycling, which is difficult for a single factory, may become possible if the whole industrial estate make efforts for the recycling and minimization of waste.

d.1 Outline of Zero Emission Industrial Estate

The study team introduces Zero Emission Industrial Estate as an example of minimization/re-use/recycling inside an industrial estate

Name:	Kokubo Industrial Estate
Area:	95.84 ha
Location:	Near Kofu city, Yamanashi Prefecture, 2 hours from Tokyo
Tenant:	24 companies as of April 2001
Employee:	5,075 as of April 2001
Annual sales:	2 billion US$ as of 1999
History:	Completion of Industrial Estate, 1986 Commencement of a study group of Zero emission Industrial Estate, 1992

The group for zero emission industrial estate founded in 1992 had three basic concepts.

1. Waste Minimization: Each factory should make efforts for waste minimization at source.
2. Waste Collection/Re-use/Recycling: HW that generates although each factory makes efforts for the minimization should be collected, reused and recycled in cooperation with the tenants in the industrial estate.
3. Waste Reduction through intermediate treatment: The HWs that are unable to be reused and recycled should be reduced through intermediate treatment such as neutralization.

The Industrial Estate pursues the creation of a circulating recycle system, where waste circulates inside the industrial estate not being discharged out aiming at zero-emission.

d.2 Measures taken

The Industrial Estate started the first phase with building a joint waste paper recycling system, which is a task easy to start. Waste paper, which had been burnt in incinerators of individual factory, is segregated into quality paper, cardboard, newspaper and magazine paper, brochures, etc. and collected by "Recycle Promoting

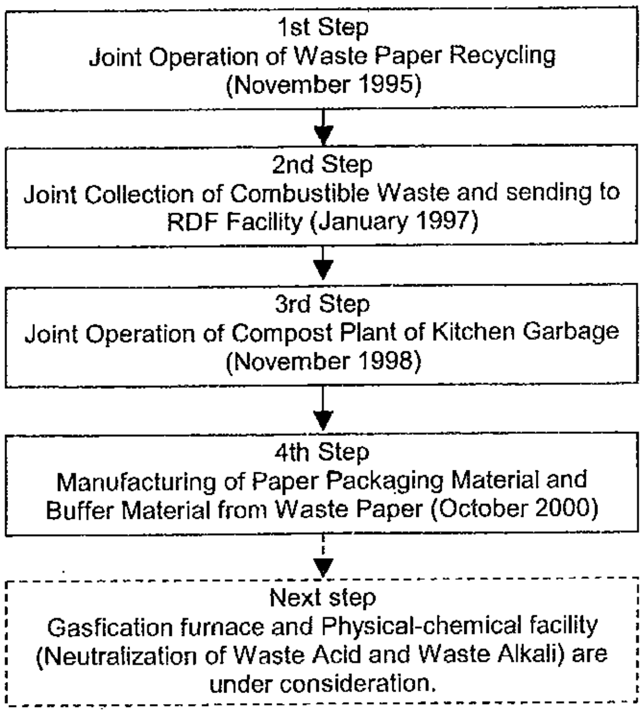
Vehicle" jointly managed by the industrial estate. Waste quality paper is recycled back into quality paper, waste cardboard is also returned into cardboard, and newspaper, magazine and brochure paper is recycled into toilet paper. By purchasing this toilet paper by the member companies of the society themselves, the circulating system completed.

Thereafter Industrial Estate started to collect jointly waste plastics and other combustible non-HW. Collected waste is converted into RDF (Refuse Derived Fuel) with RDF plant built in the same prefecture, and the product RDF is supplied to cement kilns.

In November 1998, Industrial Estate started joint treatment of garbage discharged from the cafeterias of the companies. The garbage is converted into manure at a joint compost facility. Then the compost is supplied to neighboring farming families. In 2000, Industrial Estate started fabrication of packaging and cushioning material, utilizing waste paper. The waste paper discharged from factories is converted into a new environmental friendly product replacing styrene foam. The product goes back to the factories. This is another circulating recycle system.

Industrial Estate is studying the feasibility of a recycling system metal and waste heat with a gasification melting furnace. It is also studying a waste acid and a waste alkali neutralizing system. The collection of waste and operation of the facilities is managed by a joint union organized by the industrial estate member companies.

It is important that the industrial estate member companies have been autonomously attempting at zero emission, one step to another, starting with tasks that are easy to tackle.



10.2.2 Action Plans of Waste Minimization at Source

a. Proper Management of HW and Action Plan of Waste Minimization at Source

The action plan to promote proper management of HW and waste minimization at source is shown below.

1. Thorough Implementation of the Manifest System

- According to exiting manifest sheet, the factories themselves should manage the HW discharge properly and report to DIW.

- As soon as the HW manifest system enforced by PCD/MOSTE is legislated, the factories should fulfil their responsibility of HW as generators and cooperate PCD in running the system effectively.

2. *Implementation of Waste Audit*

- The factories themselves should start the investigation to grasp the characteristics of HW and pollutants.
- The generators should obtain knowledge about HW and consciousness about proper management through grasping the actual status.
- Segregation of recyclable waste and un-recyclable waste should be completed.

3. *HW Minimization and Reduction*

- The conversion of materials, fuel and non-hazardous substances should be promoted.
- The conversion of process should be facilitated.
- The introduction of energy-saving and resource-saving facility and process should be promoted.

4. *Recycling*

- The recycling of HW inside the factory should be promoted.
- The introduction of unused and/or waste heat utilization system should be considered.

5. *Facilitation of Zero-emission Industrial Estate*

- The zero-emission plan in a model industrial estate should be drawn up.
- The zero-emission pilot projects in the model industrial estate should be implemented.

6. *Formulation of IWM Improvement Plans for Individual Industrial Sectors*

- Specific improvement measures for IWM can be different from sector to sector (and from factory to factory). IWM improvement plans should be formulated for each industrial sector. (The team presents the sector investment plan taking an example of the paint industry in Chapter 12.)

b. Measures necessary for A/P

For the achievement of the A/P, the following measures are necessary.

- Preparation of guidelines and manuals for waste management and waste audit inside factory
- Provision of information in terms of waste management and waste audit inside factory
- Promotion of ISO 14001(Environmental Management System)
- Preparation of guidelines for use of recycled material

- Reviewing and provision of technology in terms of waste Reduce/Re-use/Recycling
- Examination of introduction of flowing economic incentives regarding waste minimization and recycling
  - Effluent Tax
  - HW Tax
  - Virgin Material Tax
  - Landfill Tax
  - Tax reduction of use of recycled material
  - Incentives for the investment to install and/or improve facilities for waste minimization and recycling (Low rate loan, Special depreciation, Tax reduction)
- Support for the planning and construction of facilities regarding waste material recycle and thermal recycle in the industrialized area like an industrial estate.

10.3 Reuse/Recycling Promotion Plan

10.3.1 Targets and Strategies

a. Target

The targets of main components of A/P in the target year of 2005 were determined based on the following objectives, paying an attention to reuse/recycling of HW. Numerical targets are summarized in Table 10-1.

1. To try to keep the increase rate in the amount of HW generation up to 4.2% from 2001 to 2005, by promoting waste minimization at factories
2. To decrease the on-site disposal rate from 21.6% in 2001 to 8.3% in 2005, by tightening regulation on on-site disposal, in order to prevent further environmental degradation by inappropriate on-site disposal.
3. To increase the HW reuse/recycling rate from 18.2% in 2001 to 28.2% in 2005, while encouraging factories change the disposal method, from on-site to off-site, in order to achieve the above target.

Table 10-1: Targets of HW A/P

Item	Present (2001)	Target year (2005)
Generation Amount (ton/year)	557,456	580,909
Reuse/recycling rate (%*1)	18.2	28.2
On-site (%*1)	4.0	4.0
Off-site (%*1)	14.2	24.2
On-site final disposal rate (%*1)	21.6	8.3
Off-site treatment/final disposal rate (%*1)	37.3	41.2
Reduction (%*1)	22.2	22.3
On-site storage (%*1)	0.7	0

*1: The figure is the ratio to the total generation amount.

HW flow in 2005, which is realized if targets of A/P are achieved, is shown in the following figure.

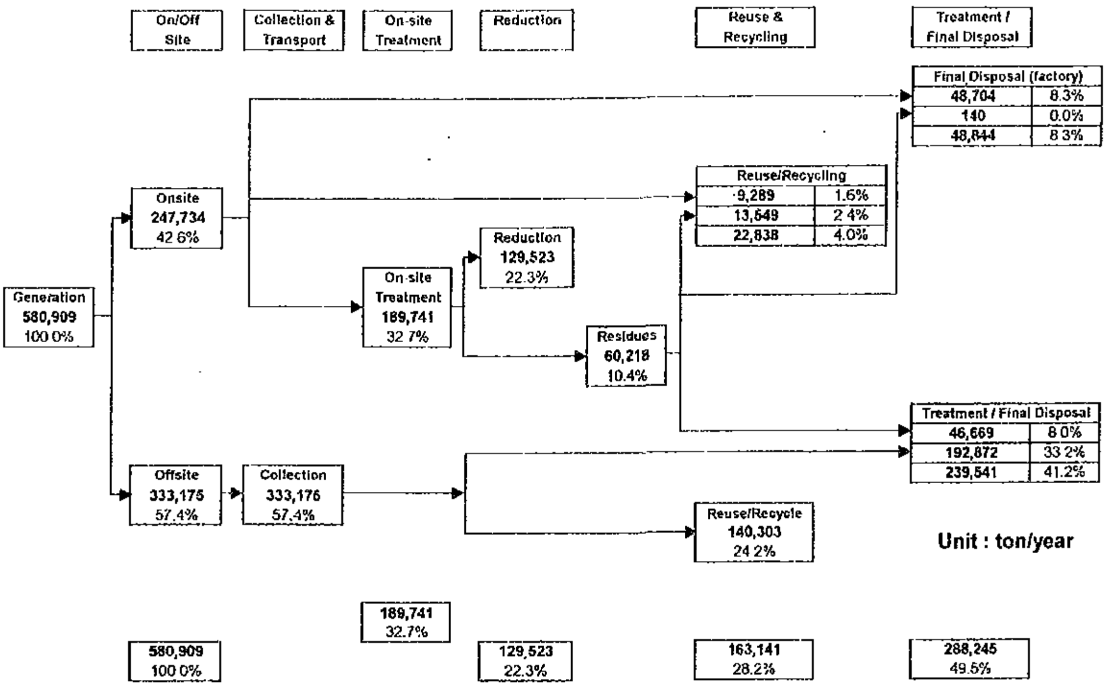


Figure 10-1: HW flow in 2005

b. Strategies

In this section, strategies to achieve the above mentioned targets, e.g. to increase the reuse/recycling rate from 8.2% to 28.2%, are shown. The team strongly recommends the following steps.

1. Promotion of HW recycling at cement factories

It is urgent issue to construct HW treatment/disposal facilities in Thailand, but it is extremely difficult to construct new facilities in the short-term due to strong opposition from local people. One of alternative plans is to utilize existing cement plants to treat HW. It can be said that utilization of existing cement factories is an effective way to promote HW reuse/recycling while making up shortage of HW treatment/final disposal facilities, because there is no need to construct new facilities and there are few residue from cement production process.

In the case of Japan in 1999, to produce 82,000,000 ton of cement, cement factories received 25,580,000 ton of waste as input materials, equivalent to 31% of production amount[2]. Considering the current production amount in Thailand,

[2] Tadahiro Mihashi, "Challenge to Zero- Waste Factory", Japan Institute of Plant Maintenance, September 2000.

46,000,000 ton/year[3], Thai cement factories could receive up to 14,260,000 ton/year of waste.

Therefore, the team proposes to utilize existing cement plants as a short-term improvement plan to make up the shortage of HW treatment/final disposal facilities and to promote reuse/recycling of HW. In the first step, it is necessary to conduct a feasibility study to find out necessary improvement measures at the cement plants so as to promote waste utilization at cement factories without affecting the quality of cement products.

2. **Nurturing waste analysis, adjustment and blending industries (waste blender)**

To promote utilization of waste at the cement factories, it is necessary to establish the system to guarantee the quality and quantity of wastes as input materials. In Japan, there are a lot of mediators (waste blenders), who analyze, adjust and blend wastes to guarantee the quality and quantity of wastes as input materials or fuels for cement production.

It is urgent in Thailand to nurture waste blending industry that can work as a mediator, as well as providing such service as analysis, adjustment, and blending of wastes, in order to promote waste utilization at cement plants.

3. **Promotion of HW reuse/recycling at other facilities**

There are other facilities, which can accept HW as input materials or fuels, and it is necessary to promote HW reuse/recycling there. In this case, priority should be given over improvement of existing facilities. In the first place, therefore, it is necessary to conduct a preliminary survey in order to make sure of the existence of facilities, which have a potential to receive HW, and then it needs to conduct a feasibility study to know quantity and quality of wastes which these facilities can accept, pollution control abilities, and feasibility of business.

4. **Improvement of the reuse/recycling system affecting the environment**

One of the major objectives of waste reuse/recycling is to avoid environmental burden given by the discharge of unnecessary material from production activities. Waste reuse/recycling can, however, affect the environment unless it is properly carried out. In the study area, there are found cases where economic benefit, another objective of waste reuse/recycling, comes first and waste reuse/recycling gives severe impacts on the environment. The environmental impacts are serious particularly when waste reused/recycled is hazardous and such reuse/recycling system should be urgently improved.

In the present study, the team carried out a case study of waste oil and waste batteries recycling, and proposed improvement measures (see Chapter 11).

10.3.2 Improvement Plan of Cement Factories

The purpose of the plan is to realize further utilization of wastes at cement factores in order to make up the shortage of HW treatment facilities and to promote HW reuse/recycling simultaneously. In this section, the necessary improvement measures

[3] It is from the result of factory survey in July 2001.

and their costs for cement factories to receive more waste without affecting the quality of products are examined.

a. Current situation of approval and registration

At present, two factories, the Kaeng Khoi Plant of Siam Cement Industrial Co., Ltd. and Siam City Cement Plc., have already gotten approval and registered at 101 of MOI factory code. The following 4 factories applied to DIW for registration and are now operating their plants as a trial.

1. Siam Cement (Thaluang) Co., Ltd.
2. Siam Cement (Tung Song) Co., Ltd.
3. Siam Cement (Lampang) Co., Ltd.
4. Siam Lime Cement Co., Ltd.

b. Quantity and quality of acceptable wastes at cement factories

b.1 Quantity of acceptable wastes at cement factories

Considering the ratio of wastes used for cement production as raw materials to the total production amount in Japan, 31%, the Kaeng Khoi Plant of Siam Cement Industrial Co., Ltd. could receive up to 1,700,000 ton/year of waste mathematically, with the production capacity of 5,700,000 ton/year[4].

b.2 Quality of acceptable wastes at cement factories

b.2.1 Japanese Case

The types, uses and volume of wastes that cement factories in Japan received in 1999 are summarized in Table 10-2[5]. Various types of wastes are utilized at cement factories in Japan.

Table 10-2: Type, use and volume of wastes received by cement factories in Japan in 1999

Waste	Utilization	Weight '000 ton
Blast Furnace Slag	Raw Material, Mixing Material	11,449
Coal Ash	Raw Material, Mixing Material	4,551
By-product Gypsum	Raw Material (Additive)	2,567
Low Quality Coal from Mine	Raw Material, Fuel	902
Non-iron Slag	Raw Material	1,256
Revolving Furnace Slag	Raw Material	882
Sludge	Raw Material, Fuel	1,744
Soot & Dust	Raw Material, Fuel	625
Molding Sand	Raw Material	448
Used Tire	Fuel	286
Reclaimed Oil	Fuel	250
Waste Oil	Fuel	88

[4] According to the factory interview survey in July 2001, the Kaeng Khoi Plant has 4 kilns and their total daily production amount is 19,000 ton/day. Therefore the yearly production amount is calculated in the following way. 19,000 ton/day x 300 days = 5,7000,000 ton/year.

[5] Tadahiro Mihashi, "Challenge to Zero- Waste Factory", Japan Institute of Plant Maintenance, September 2000.

Spent Activated Clay	Fuel	109
Construction wastes	Raw Material, Fuel	2
Others	----	423
Total		25,582

b.2.2 Cement production process and reuse/recycling of waste

The cement production process consist of various processes, and among them wastes are put in such 3 processes as the raw material blending process, the calcination process, and the finishing process. Table 10-3 and Figure 10-2 shows the types of wastes which can be put in these three processes. The type and amount of waste that can be actually received vary with factories.

Table 10-3: Processes at which Waste is Received

Process		Waste	
		Material	Fuel
1. Raw material blending process	Before raw material mill	Blast furnace slag	Coal Ash
		Sludge	Non-ferrous metal slag
		Steel manufacture slag	Refuse (coal waste)
		Cast iron sand	
2. Calcination process	Pre heater	Refuse (coal waste)	Waste clay
		Waste oil	Waste plastic
		Waste tire	
	Material feeder side of kiln	Sewer sludge	Waste Tire
		Refuse Derived Fuel (RDF)	
	Burner side of kiln	Recycled oil	Recovered CFC
3. Finishing process	Before finishing end mill	Desulfurization gypsum	Chemical gypsum
	Before mixer	Slag powder	Fly ash

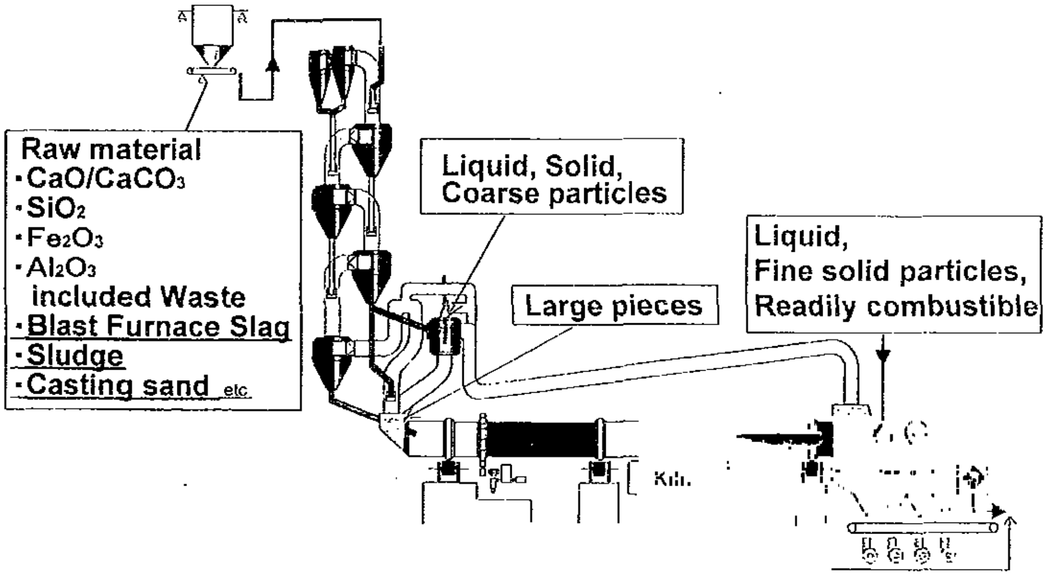


Figure 10-2: Waste utilization in the cement production process

b.2.3 Quality of acceptable waste

In the cement production process, raw materials are mixed in the raw material blending process, and mixed materials are calcined in the calcinaton process to produce cement clinker, which is shipped as final product after getting finishing treatment such as milling. In the cement clinker producing process, various types of wastes can be used as raw materials or fuels.

Main components of cement clinker are CaO, SiO2, Al_2O_3, Fe_2O_3, and wastes, which contain a certain amount of these elements, can be used as raw materials. The percentage of these main components should be within a permissible range. Wastes have to meet the following conditions to be accepted by cement factories.

- To keep the necessary level of product quality
- To keep the component ratios of main ingredients within a permissible range.
- To control emission gas less than emission standard.

Therefore, if the content of chlorine, alkalis, and heavy metal, which could affect the quality of cement, or heavy metal and sulfur, which could cause emission gas problems, are more than permissible level, cement factories cannot accept there wastes.

The acceptance inspection standards of Industrial waste, which the Japanese cement factories set, are summarized in Table 10-4.

Table 10-4: Acceptance inspection standard of Industrial waste in Japan[6]

Name of Industrial Waste	Acceptance inspection standard of Industrial waste	
	Quality and Property	Type of packing and Method of Transportation to the Plant
Waste tire	Car tire (any tire is accepted) Cut tire or tire without cutting	Bulk
Waste oil	Liquid or mud, Low volatile matter, Chlorine content < 1000 ppm, Heat generation > 12.5 Mj/kg (3,000 kcal/kg), Water < 20 %	Tank lorry or Drum (Tank lorry is preferable)
Petroleum oil, Heavy oil, Naphtha, Unburnt dust	Water < 25 % heat generation > 12.5 Mj/kg	Bulk vehicle with pressurized air unloader or container bag (Bulk vehicle is preferable)
Sludge	Water < 25 %, R_2O < 1 %, Chlorine < 100 ppm	Bulk dump truck (Moisture control is essential to dusty waste)
Waste sand from cast iron process	SiO2 > 75 %, R_2O < 1 %, Water < 10 %, Without any foreign matter	
Waste wood, Waste plastics	Chlorine < 1000 ppm, Water < 10 %, Size < 250 x 250 x 250 mm	Bulk dump truck or container bag
Coal ash, Evacuated waste from furnace	Chlorine < 100 ppm, R_2O < 1 %	Bulk vehicle with pressurized air unloader
Aluminum sludge or	Al_2O_3 or Al > 60 %,	Bulk vehicle with pressurized air loader

[6] Hiroshi UCHIKAWA, Cement and Concrete Industry Orienting Toward Environmental Load Reduction and Waste Recycling, The International Conference of IUPAC, 1996 in Seoul, Korea

aluminum ash	Chlorine < 100 ppm, Water < 70 %	Bulk dump truck (Moisture control is essential to dusty waste)
Materials containing iron	Fe_2O_3 or Fe > 30 %, Chlorine < 100 ppm, Only small amount of metal as Cr, etc. Powder, cotton-type or grind able material	Bulk dump truck or container bag

Other condition: No bad odor, Content of harmful component (Hg, R-Hg, Cd, Pb, Cr^{6+}, As, CN, R-P or PCB) should be under the legal limit, No foreign matter such as metals, etc.

c. Possibility of recycling HW at cement factories

As mentioned before, cement factories could increase the ratio of wastes/by-products as raw materials to the production amount up to 30% mathematically. However, cement factories cannot accept the wastes, which contain more than certain amount of harmful elements such as heavy metal and chlorine. Therefore, there needs to find another way to recycle these types of wastes.

In Japan, here is one example, in which cement factories recycle these types of wastes by modifying existing plants and improving pollution control measures. Cement factories began to produce a new type of cement product, called "Eco-cement", main components of which are wastes. Even though the quality of Eco-cement is low due to high content of chlorine, it is confirmed that as long as the use of Eco-cement is limited to concrete without reinforcing bar it does not cause problems.

Through the experience of developing Eco-cement production technology, important matters for improvement of cement plants became clear. These matters are explained later in this section.

d. Improvement plan of cement factories

d.1 Outline of improvement plan

The improvement plan should be divided into two part; improving cement plants (hardware) and enhancing management ability to receive and utilize wastes (software).

The main components of improvement plan concerning hardware can be summarized as follows.

- Installation of equipment to control grain size of solid waste by, for example, crushing
- Installation of waste feeder equipments
- Installation of burner for waste oil
- Installation of by-pass equipment for chlorine gas

The main components of improvement plan concerning software can be summarized as follows.

- Enhancement of ability to stabilize waste such as waste oil and sludge in terms of both quality and quantity by adjustment or blending

In this plan, those who are in charge of the latter (software) are waste blenders while cement factories are in charge of plant modification (the former, hardware).

d.2 Improvement items

The items and their outlines of the improvement plan at the cement production process are summarized in Table 10-5. Equipments for waste blending do not always have to be constructed in the cement factory. In Japan, waste blenders usually have facilities in their own factories. Figure 10-3 shows the improvement plan at the cement production process graphically. The numbers in the column of improvement items correspond to numbers in the figure.

Table 10-5: Improvement items at the cement production process

Process	Improvement items	Outline of improvement	Responsible organization
1. Raw material blending process	1. Solid waste shredding and feeding process	To install equipments to crush solid wastes to pieces small enough to put in the feeder.	• Cement factories • Waste blender
2. Calcination Process	2.1 Waste conveying and feeding process	To install equipments to feed waste into kiln. Several types of feeders are needed due to the size, shape and feeding point of wastes.	• Cement factories
	2.2 Waste oil injecting process	To install waste oil storage tanks and burner for waste oil. For this purpose, part of kiln requires remodeling.	• Cement factories • Waste blender
	2.3 Chlorine bypass system	To get rid of compounds containing high chlorine (KCl, chlorinated heavy metals, etc.) from the production process and to control the quality of cement product.	• Cement factories

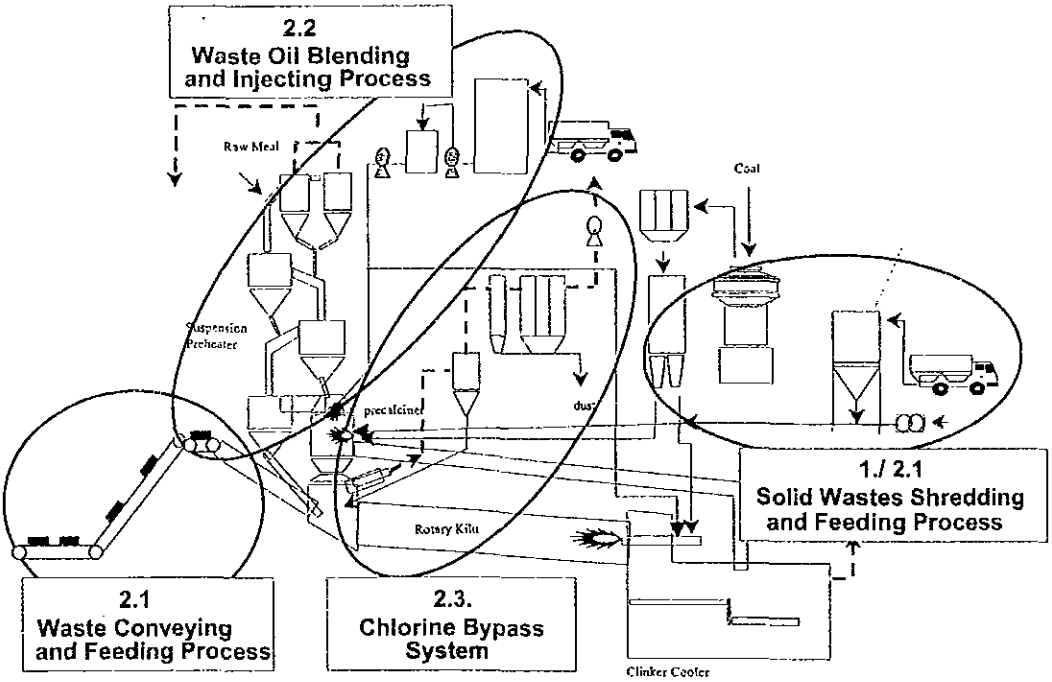


Figure 10-3: Concept of cement plant improvement

10.3.3 Plan of nurturing waste analysis, adjustment and blending industries (waste blender)

a. Analysis of wastes

Cement factories strictly control the quality of raw materials to guarantee the quality of products. In addition, they check the contents of such elements as chlorine, which could affect the quality of products, and always try to monitor the effect of these harmful elements on the product quality. Therefore, it is indispensable for cement factories to require the detailed information on the composition of wastes, which usually vary each other. Accurate analysis of wastes is one of important factors for the promotion of further waste utilization at cement factories.

For the utilization of wastes as fuels, it is important to analyze calorific value, water content, and heavy metal contents of wastes so as to operate culcination kiln smoothly, to control emission gas, and to guarantee the quality of cement product.

b. Adjustment and blending of waste

b.1 Guarantee of quality and quantity as raw materials and fuel

The qualities of wastes discharged from factories vary each other. In addition, the quantity of wastes is not constant. Cement factories cannot utilize wastes as raw materials or fuels unless they can secure wastes of the same quality and quantity as raw materials and fuels that they are using now. It is rare for cement factories in Japan to use wastes from specific factories for cement production. The biggest bottleneck for cement factories to utilize waste as raw materials or fuels is to secure the quality and quantity of wastes.

b.2 Adjustment and blending of waste

It is possible to guarantee the quality and quantity of wastes as raw materials or fuel for cement production by collecting, storing, adjusting and blending various types of wastes.

In Japan, waste oil and oil sludge are usually blended with other materials based on the result of waste analysis, before supplied to cement factories as fuels. There are some examples in which sludge are adjusted by other types of sludge to improve and stabilize the quality.

c. Waste blender

As mentioned above, if there is enough information on wastes discharged from various factories, it is possible to guarantee the quality and quantity of wastes as raw materials and fuels for cement production by adjusting and blending these wastes. Those who do these businesses are supposed not to be cement factories but to be waste blenders, because it is very difficult for cement factories to collect wastes from different sources and control their quality and quantity along with cement production. Cement factories are run their business not for recycling but for cement production. Here is the need for waste blending industry.

In Japan, waste blending industries play a decisive role for the utilization of wastes at the cement factories. Almost all wastes that are supplied to cement factories as raw materials or fuels are treated at waste blenders' factories. In addition, they have accumulated knowledge on property of wastes, treatment systems, and recycling method and developed technologies and know how to treat wastes. In Thailand, only some companies such as GENCO has just started to work as waste blenders with such expertise, and the waste blending industry should be further encouraged.

The point to be stressed is that turning waste into alternative raw material or fuel by waste blenders enables industrial sectors whose business is not recycling oriented to incorporate recycling activities into their production lines, and the cement industry is not the only example. The zinc smelting industry introduced in the next section is another. In this way, waste blenders are expected to take a leading role in the whole recycling system by collecting, transporting, mixing, adjusting and supplying waste, and to formulate an industrial cluster in which waste circulates effectively.

The current recycling system and future recycling system with waste blender taking a leading role are shown in Figure 10-4 and Figure 10-5, respectively. In the present industrial cluster, waste dischargers (factories) and conventional recycling factories are linked via waste buyers, and waste that is hard to recycle is discharged out of the cluster to be disposed of. As the waste blending industry develops, such hard-to-recycle waste starts to be supplied to existing industrial facilities such as cement kilns and zinc smelters, and the industrial cluster expands and gets closer to the zero-emission concept.

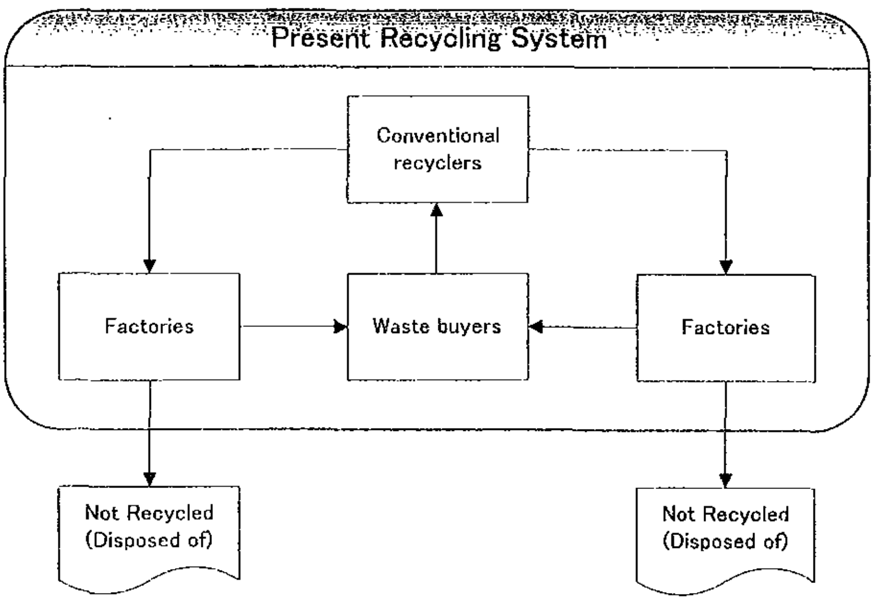


Figure 10-4: Current Recycling System

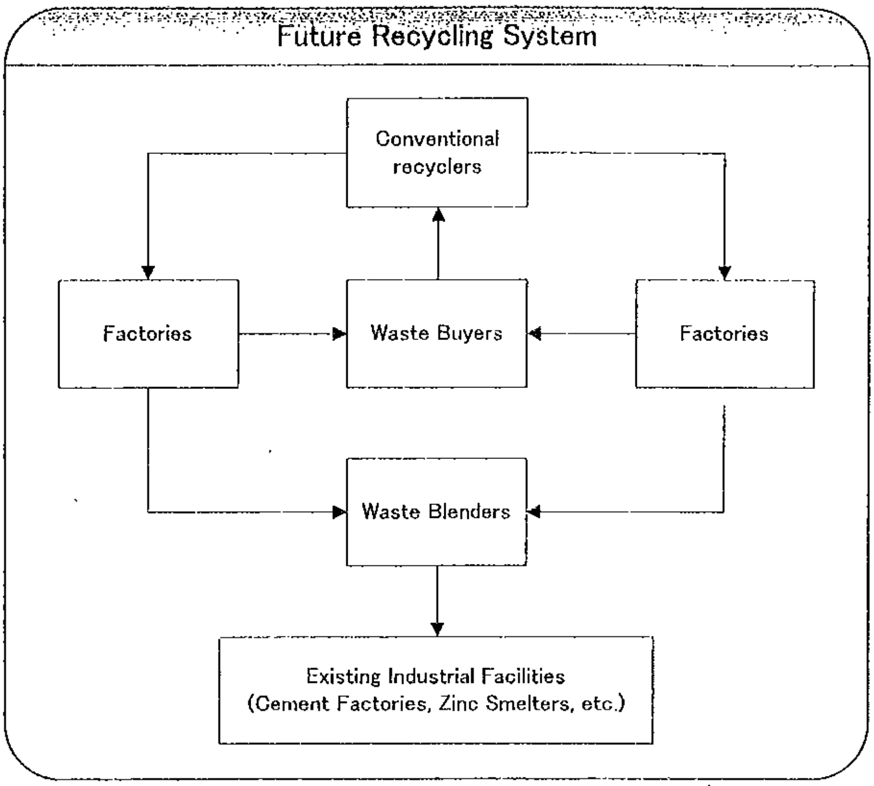


Figure 10-5: Future Recycling System

d. Example of facilities necessary for waste blender

To analyse and blend HWs to be suitable for recycling in cement factories, HW blending industry is required to have the facilities and equipment given in Table 10-6 below. Figure 10-6 and Figure 10-7 illustrate the conceptual images of waste oil mixing and solid waste crushing facilities respectively.

Table 10-6: Facilities and Equipment for HW Blending Industry

Types of Facilities & Equipment	Specification
Waste oil mixing	- Oil & Solvent Receiving Tank - Agitation Tank - Wet Crusher - Vibration Screen - Cooling Tower - Production Tank
Solid waste blending	- Waste crushing equipment - Waste mixing/blending equipment - Waste Storage - Temporary storage for blended waste

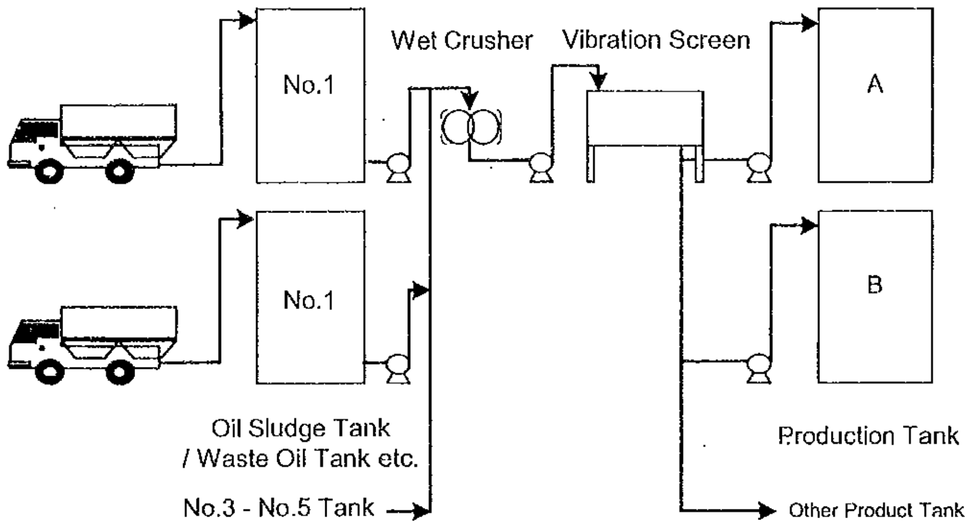


Figure 10-6: Conceptual Image of Waste Oil Mixing Facility

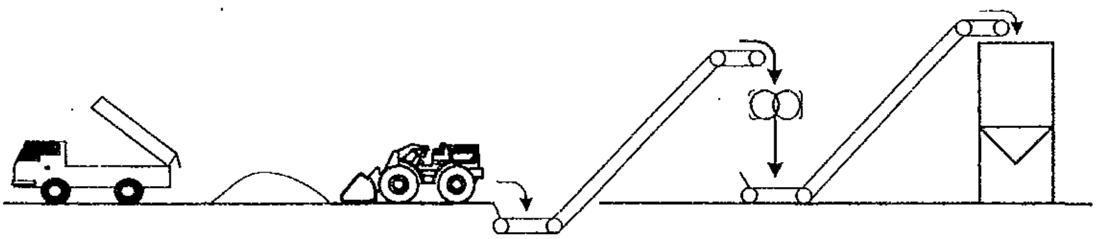


Figure 10-7: Conceptual Image of Solid Waste Crushing Facility

e. Study on the Use of Waste Blenders in Japan

In order to propose approaches to nurture waste blenders in Thailand, the team studied how waste blenders are utilized in Japan with particular attention to regulations. The study is described in a separate report "the study on the use of waste blenders in Japan with particular attention to regulations" in Thai and English. As a result, the team recommends DIW to foster and lead the waste analyze, blending and adjusting industry in the following way.

1. In order to stimulate the demand of the waste generators for the waste blending industry, DIW should strengthen the requirement to factories for proper IWM. As a result, the needs for the waste generators to supply waste that is currently difficult to recycle and has to be disposed of on-site or off-site will increase.

2. DIW should provide to the cement factories with information about the demand of the waste generators for waste recycling at the cement factories. Information will include information on what kinds of waste can be recycled at cement factories, and how such waste is currently treated and disposed of in Thailand. Also, DIW should promote and support the cement factories to prepare waste reception standards.

3. In order to promote the waste blending industry, DIW should publicize waste blending technologies used in Japan and other countries.

4. DIW should introduce a licensing system that does not only control the waste collection/transportation system, but also officially authorize the ability of the blenders so that their clients will trust them.

10.3.4 Plan of Zinc Recovery from Electric Arc Furnace Dust (An Example of HW Reuse/Recycling at Factories other than Cement Factories)

The HWs containing zinc, lead, copper and other heavy metals cannot be recycled in cement industry. In the case of Japan, such HWs are recycled by returning them to the non-ferrous metal industry, in which heavy metals in are reused as raw materials.

Although the HWs containing heavy metals are categorized as W03 (Heavy metal compounds) or W11 (Filter materials and treatment sludge) in the Study, other HWs such as W04 (Liquid inorganic compounds) and W10 (Pickling waste) may also include heavy metals. According to the estimation in the Study, the total amount of the above 4 categorized HWs that are not currently recycled reaches about 230 thousand tons per year.

Taking the above into account, the team here examines a plan of recycling heavy metals including zinc in electric arc furnace dust, copper and lead in sludge and so forth by making use of the existing non-ferrous metal smelting facilities in Thailand.

a. Outline of the Project

In Thailand, scrapped irons generated from factories are presently collected together with those from other sources (household, stores, etc.) and recycled by electric arc furnaces as steel materials. The dust generated by recycling them in such electric furnaces is mostly disposed of inside their factory site by landfill. Since the electric arc furnace dust (EAF dust) contains hazardous substances such as zinc, which is used for anti-corrosive treatment of steel materials by hot dip zincing, hot dip zincing used for corrosion protection of steel, and lead, chrome, chlorine, which may come from PVC (polyvinyl chloride) or other plastic materials and mix with scrapped irons, they may be eluted from EAF dust disposed of at the landfill. In terms of saving natural resources, collection and reuse of such heavy metals needs to be promoted as far as it is environmentally safe.

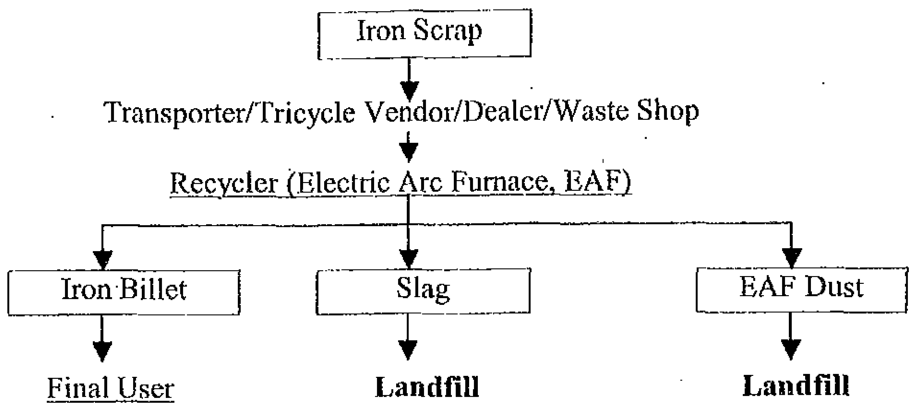


Figure 10-8: Flow of Scrapper Irons Recycling in Thailand

In the case of Japan, recycling of EAF dust is made by the specially designed furnace for extracting zinc in the form of zinc oxide (ZnO). This furnace was developed based on the existing zinc smelting process in the non-ferrous metal industry. Not only collecting zinc from EAF dust, it treats and recycles the sludge containing heavy metals such as lead, zinc, copper, and so forth. Zinc and lead are recovered as zinc oxide while copper is recovered in the form of copper matte.

Furthermore, this type of furnace currently accepts various industrial wastes for treatment and recycling. For example at Miike Smelting in Japan, since it uses silica as a slag production material, it accepts casting sand and waste silica stone that are generated from the casting iron factory and the glass-manufacturing factory. In addition, it uses waste liquid from paper manufacturing factories as a binder to mix raw materials and make briquettes. Treatment of other liquid and medical wastes and recovery of precious metals (gold, silver, etc.) from scrapped integrated circuit (IC) parts furnace utilizes for the treatment of waste liquids and medical waste are also recently carried out by making use of this furnace.

Table 10-7: An Example of analysis of EAF dust in Japan

Element	Content (%)	Element	Content (%)
Zn	22.5	Fe	32.0
C	3.6	Cr	0.36
Cu	0.2	Pb	2.2
Ca	2.6	Cl	3.1
Cd	0.02	F	0.25
Si	1.6	O	24.9

b. Heavy Metal Recovery System from EAF Dust, Sludge and Other HWs

Although there is no available quantity data on EAF dust generation in Thailand, it can be estimated from the data on the amount of recycled scrapped irons and zinc recovery rate from EAF dust in Japan. According to the survey done by Pollution Control Department (PCD) of the Ministry of Science, Technology and Environment (MOSTE), the amount of scrapped iron recycled in Thailand is estimated to be between 0.8 and 3.7 million tons per year on average during 1991-1996. As of

1998, there were 13 electric arc furnaces in Thailand, of which eight were located in Bangkok and Samut Prakarn Province, three in the Eastern Seaboard industrial region, and one in Saraburi Province. Because generation sources of EAF dust are limited in number and concentrated in the nearby area of Bangkok Metropolis as mentioned above, its collection will be much easier than other types of industrial waste, which are generated from various dispersed sources.

Assuming that the amount of scrapped iron recycled is 2.5 million tons per year the amount of zinc recovered is estimated as shown in Table 10-8 below.

Table 10-8: Estimation of zinc recovery potential from EAF Dust in Thailand

Item	Amount	Remark
Amount of scrapped iron recycled	2,500,000 tons/year	Team's assumption
Generation of EAF dust in recycling of scrapped iron by electric arc furnace	50,000 tons/year	2% of scrapped iron
Amount of zinc in EAF dust	10,000 tons/year	20% of EAF dust
Amount of zinc recoverable	8,500 tons/year	Recovery ratio: 85%

On the basis of the current market price of zinc at approximately 46,700 bahts per ton, the income from selling the recovered zinc of the above amount is estimated to be 397 million baths per year.

Figure 10-9 shows the flow of heavy metal recovery in a zinc-smelting factory. Although the entire facilities given in this figure requires totally an initial investment of more than 300 million bahts, some of them such as dryer, wet scrubber, transportation equipment, and tanks may be available in the existing zinc-smelter in Thailand.

Recovered zinc can be sold in the form of zinc oxide or zinc by refining zinc oxide by the smelter. Refining is necessary in order to recover zinc from crude zinc oxide. The smelter can also recover copper in the form of the copper matte by treating the sludge containing heavy metals. Iron-containing slag can be used as a substitute for raw materials for cement manufacturing.

In introducing the process below, it is necessary to find solutions to tasks, such as availability of necessary facilities, the quantity and quality of acceptable EAF dust and heavy metal waste like sludge, and profitability.

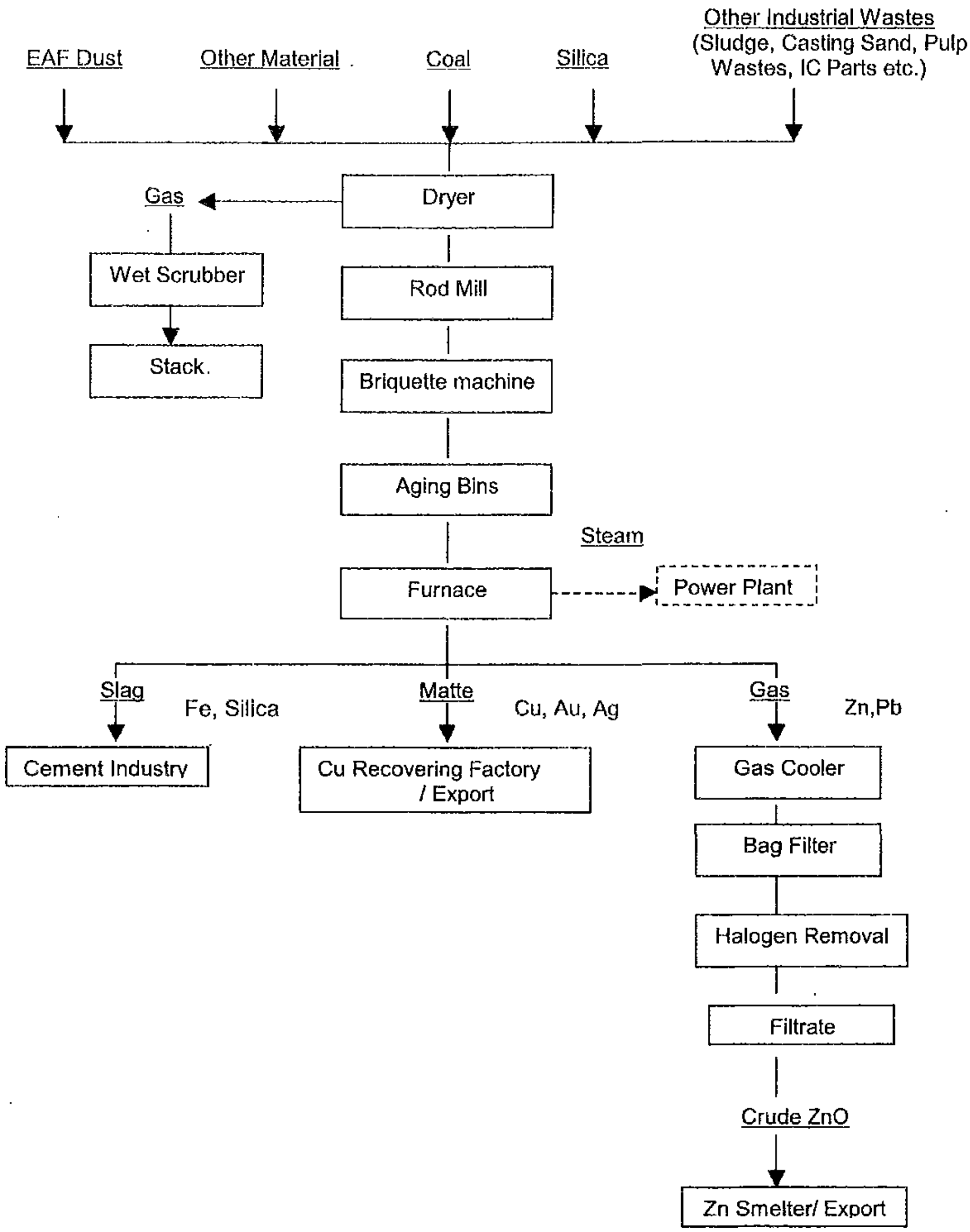


Figure 10-9: Flow of Heavy Metal Recovery from EAF Dust and other HWs

10.4 Waste Exchange Plan

DIW and the team established Waste Utilization Data Center (WUDC) in the pilot project of the present study. WUDC is, however, not fully utilized. The adequate use of WUDC needs to solve such questions as below.

- How to disseminate WUDC
- How to promote the realization of waste exchange

The action plan of measures to be taken in a short-term is proposed below.

10.4.1 Dissemination of WUDC

a. Background

The larger the database of WUDC is, the higher the possibility of successful waste exchange is. In Pilot Project 2, even though there were some factories which were willing to receive waste, waste that meets their requests could not be found in the database. Also, even if one demander joins the WUDC as a user, there can be a number of possible suppliers of the same kind of waste, and there is a chance to find waste that complies with more specific requirements. Therefore, the current database needs to further increase the number of registered waste suppliers and waste demanders.

As of July 2002, WUDC has a registration of 414 factories as a database user. This number is only 1% of all the factories registered in the study area in total. Of these, 377 factories that became a member at the beginning were found from replies to the questionnaires sent to 5,760 factories which were registered at DIW and have more than 50 employees. During a half year since then, some forty factories additionally joined. There should be more potential users in the study area. . Furthermore, there will be also new users if the target area is expanded.

In this manner, there is a large possibility to increase the number of WUDC users and it is required to disseminate the presence of WUDC and merits to use it in order to attract potential users. In the present study, WUDC website was launched for the convenience of the users, but the publicity is necessary to promote as many factories as possible to access it. Simply waiting for new users without doing anything will means little increase in the number of users or substantial time to be consumed before getting new users.

b. Action Plan

Using media close to factories will be the easiest way to disseminate WUDC.

One of such media is FTI, which has a wide network with various industries. WUDC will be disseminated to the member companies through the clubs of industrial sectors, and urge the companies to access to the WUDC website, or to send completed registration forms, supply sheets, and/or demand sheets to the FTI headquarters. The FTI headquarters then deliver those forms, or they may enter the information on the forms on the WUDC website on behalf of the factories that filled in the forms.

The other medium is DIW regional offices, which are 75 over the country and have 600 inspectors in total. Since they inspect factories located in the area, they should have close contact with them including even small or medium size factories which do not have FTI memberships. If the DIW regional offices can gather information on the demand for waste exchange in the area and data can be entered on the internet through them, WUDC will be extended to a national scale program.

Meanwhile, DIW should develop its O&M system as the number of users increases. The team presented a recommended O&M system DIW should have in Chapter 8 of the Main Report. New personnel will be wanted to realize it, but even with the current personnel, DIW has to execute some of its duties.

Considering the fact that WUDC has just opened, such duties will include answering to inquiries as to how to fill in the forms and correcting errors in the website. Referring to the manuals for WUDC users and WUDC administrators prepared by the team, DIW should lean skills to fulfill the work.

10.4.2 Promotion of Waste Exchange

a. Background

In Pilot Project 2 (PP2), waste exchange did not succeed. This will be not only because the data volume of the database was not large enough, but also because the factories could voluntarily make only limited efforts. Factories are operating to manufacture something. Waste is merely by-product which is not expected to produce, and the factories are looking for a luck to give or sell the waste. On the other hand, factories that want to use waste do never intend to treat waste but regard waste as cheap raw material. There is such a large gap of intentions between them, and waste exchange will be possible only when rigid conditions are fortunately met.

In order to assist the negotiation between the two parties, some of governmental bodies in Japan that organizes waste exchange programs have technical committees to give advice to them. Such assistance, however, can tend to put priority on technical matters rather than economics, and is "one shot" without commitment. It is not enough to make waste exchange beneficial for the both parties in a long term.

The measure to overcome the difficulties is to involve private mediating agents who play matchmaker between waste suppliers and waste demanders. The issues of negotiation such as transport method, waste quality and its fluctuation, and waste amount and its fluctuation will be dissolved, or lightened by them. In the study area, waste reuse/recycling among factories (i.e. waste exchange) is considerably active, and waste buyers, recycle shops, recyclers and waste treaters are vital to make it happen. They should be promoted to register as WUDC users.

b. Action Plan

New industrial codes, 105 for waste sorting and landfilling and 106 for waste reuse/recycling, were created in December 2001. Since factories that would be registered at MOI as code 105 or 106 factories can be the aforementioned mediating agents, factories engaged in such business should be strongly encouraged to register themselves.

Once they are registered, then the advantages to use WUDC for their business should be understood and WUDC user registration will be promoted. It will be useful to hold workshops similar to what was held during this study, where participants will learn how to use the WUDC website and how to complete the user registration form and the demand sheet. It will be also desired to receive feedbacks from them so that they can find waste that they really want more easily.

10.5 Financial Appraisal of Projects

This section presented three types of action plans for HW management.

1. Waste minimization plan
2. Reuse/Recycling promotion plan
3. Waste exchange plan

The first item "waste minimization plan" should be implemented by individual factories under their conditions, and the contents and necessary cost vary. The last item "waste exchange plan" is the promotion of the existing program and does not require initial investment. Therefore, the team demonstrates here the financial appraisal of the following three projects in connection with the second item "reuse/recycling promotion plan".

1. HW Recycling by Improved Cement Factory
2. HW Blending Project for Recycling at Cement Factory
3. Zinc Recovery Project from EAF Dust together with Recycling of Waste Containing Heavy Metals

In the financial appraisal presented below, the team had to assume many conditions and the analysis is still rough. In order to implement the projects, it is necessary to conduct a feasibility study, which includes further examination of demand for HW recycling or treatment.

10.5.1 Financial Appraisal of HW Recycling by Improved Cement Factory

As a priority HW treatment project in the A/P, the team here evaluates the financial feasibility of the HW recycling by the improved cement factory.

a. Estimation of the Project Cost

a.1 Outline of the Project

The project aims at recycling HW as alternative fuel (thermal recycling) or raw materials (material recycling) by cement industry through installation of complementary facilities including waste charging equipment, waste oil combustion facility, chlorine bypass, and so forth.

a.2 Amount of HW that can be recycled or reused in cement industry

Out of the target amount of HW recycling and reuse of about 140 thousand tons per year in the year 2005, which is established in the HW A/P, approximately 56 thousand tons are assumed to be recycled at cement factories, as shown in Table 10-9.

Table 10-9: Estimated Amount of HW to be recycled or reused in cement industry (2005)

Type of HW	Amount to be recycled or reused (2005) (ton/year)
Waste oil	22,083
Organic HW (sludge, etc.)	33,927
Total	**55,965**

a.3 Recycling capacity of the existing cement factories

Assuming that all of the 55,965 tons of HW are recycled or reused in cement industry, the existing cement kilns in Thailand are required to have the capacity of accepting the HW of 187 tons per day with 300 working days per year.

According to the result of the Team's interview survey on cement factories, the capacity of cement kilns in Thailand is 4,000 tons per day at the smallest. If this kiln daily receives 74 tons of waste oil and 113 tons of organic HW, the rates of those kinds of waste to the production capacity are 1.8 % and 2.8 %, respectively. The corresponding figures of kilns in Japan are 0.5% and 3.0%. The rate of waste oil exceeds that in Japan, but considering the calorific value required for cement production, the reception of 1.8% of waste oil will not be a problem. Therefore, all the waste oil and organic HW planned to be recycled can be accepted at one kiln with the production capacity of 4,000 ton/day.

The team assumed four kilns use recycled waste in 2005. In this case, 55,965 tons of waste said above is fed to those four kilns.

a.4 Cement kiln improvement works and its estimated cost

The team here estimates the cost of facility improvement in cement factories to recycle HW by making use of the existing cement kilns. Table 10-10 below shows the improvement cost by items per one unit of cement kiln.

Table 10-10: Cost of Facility Improvement in Cement Factories for HW Recycling

Unit: per one unit of cement kiln

Improvement Items	Cost	
	US$	Bahts
Chlorine bypass installation works (2.3)	890,000	38,270,000
Waste conveying and feeding equipment (2.1)	370,000	15,910,000
Solid waste crushing and feeding equipment (1./2.1)	740,000	31,820,000
Waste oil injecting equipment (2.2)	190,000	8,170,000
Total	**2,190,000**	**94,170,000**

US$ 1 = 43 Bahts
Numbers in brackets correspond to Figure 10-3.

b. Financial Appraisal of HW Recycling by Improved Cement Factory

Based on the cost estimation above, the team here made a preliminary financial feasibility assessment of the HW recycling by the improvement cement factory. The preconditions for this financial appraisal are given in Table 10-11 below.

Table 10-11: Preconditions of the Project

Project Period	11 years including 1 year for construction and 10 years for operation
Project Income	Reduction of lignite consumption cost by substituting waste oil for lignite at the amount of 22,038 tons per year equally by 4 kilns

Fuels	Unit price (bahts/kg)	Calorific value (kcal/kg)
Waste oil	0.5	7,000
Lignite	1	5,000

Cost reduction rate by substituting 1kg of waste oil for lignite:

	0.9 bahts/kg of waste oil Amount of waste oil substituted for lignite: 5,500 tons/year Total cost reduction: 4,950,000 bahts/year Treatment fee of organic HWs Treatment fee: established between 1,000 and 2,500 bahts Treatment amount: Equally dividing by 4 kilns 33,927 tons per year organic HWs based on the assumption of the recyclable amount in A/P, about 8,500 tons are accepted by one kiln every year during the operation period.
Project Expenses	Initial Investment for facility improvement: 94,170,000 bahts Operation cost: 941,700 bahts (assumed as 1 % of the initial investment)
Discount Rate	10% (assumed taking into account commercial interest rate, inflation, etc.)

Under the preconditions established in the table above, the team evaluates the financial viability of the project by estimating the NPV and FIRR. Table 10-12 below shows the results of estimation.

Table 10-12: Results of Financial Feasibility Indicators by Cases

	Treatment fee of organic HW (Bahts/ton)	NPV (Bahts)	FIRR (%)
Case 1	1,000	-15,738,101	5.5
Case 2	1,500	8,002,272	12.1
Case 3	2,000	31,742,645	18.1
Case 4	2,500	55,483,018	23.6

As shown in the table above, FIRR of the project exceeds 10% in Case 1 of setting the treatment fee at 1,500 bahts per ton of organic HW. Even taking into account other various possible risks arising in the project, it is estimated to be financially viable in terms of private sector investment if the treatment fee is established at more than 2,000 bahts per ton.

10.5.2 Financial Appraisal of HW Blending Project for Recycling at Cement Factory

The team here makes a preliminary financial appraisal of the HW blending project as one of the priority project in the A/P. HW blending, in this case, defined as the blending of the HW for reuse and recycling in the cement factories.

a. Cost Estimation

The team estimates here the cost of waste oil mixing and solid waste blending facilities respectively as the initial investment required for HW blending industry. In this estimation, the team assumed that two waste blenders supply waste to one cement factory.

a.1 Preconditions for cost estimation

The preconditions established for cost estimation are as follows:

- All the HWs that are planned to be accepted for recycling in the cement factories in 2005 are assumed to be pre-treated by HW blending industry. Therefore, the amount of HW treated in the blending industry will be as shown in Table 10-13 below.

Table 10-13: Estimated Amount of HW Treated by HW Blender

Type of HW	Amount Treated (tons/year)	Amount Treated (tons/day)
Waste Oils	22,038	74
Solid Waste (Organic HW)	33,927	113

Daily treatment amount is estimated based on the annual working days of 300 for both facilities.

- The project cost does not include the costs of land, power receiving and transform stations, offices, and heavy equipment.
- Assuming that 8(eight) blending factories will be built in the study area, the team set up the treatment capacity of each blender as shown in Table 10-14 below.

Table 10-14: HW Treatment Capacity of the Blender

Unit: per blender

Type of blending facility	Treatment capacity (ton/day)
Waste oil mixing facility	10
Solid waste (organic HW) blending facility	25

a.3 Estimation of the Project Cost

Table 10-15 shows the result of preliminary estimated costs of waste oil mixing and solid waste (organic HW) blending facilities respectively. The cost of waste oil mixing facility is 35.69 million bahts per unit while installation of solid waste blending facility costs about 5.246 million bahts per unit.

Table 10-15: Cost of HW Blending Facilities (per unit)

Type of Facilities	Cost (thousand bahts/unit)
Waste oil mixing facility	35,690
Solid waste (organic HW) blending facility	5,246

b. Financial Appraisal of HW Blending Project

Based on the estimated cost of HW blending facilities above, the team here makes a preliminary financial appraisal of HW blending project by estimating NPV and FIRR of the project. Table 10-16 below shows the preconditions of the project established for its preliminary financial appraisal.

Table 10-16: Preconditions of the HW Blending Project

Project Period	11 years including one year's construction and 10 years' operation.
Project Income	Income from the selling of blended waste oil to cement factories for alternative fuel. 500 (bahts/kg) X 3,000 (tons/year) = **1,500,000 (bahts/year)** In receiving waste oil, the blender only charges the cost of collection and transport without any profit. Profit only comes from the selling of blended waste oil to cement factories. Income from charging the treatment fee of solid waste to generators. Treatment fee levied: to be established by cases between 4,000 and 5,500 bahts per ton Treatment amount: 4,500 tons/year The treatment fee includes (i) the cost of transportation from a blending factory to a cement factory and (ii) the fee to be paid to cement factories for final treatment of blended wastes. The waste dischargers shall bear the cost for collection/transportation from themselves to the blenders in addition to the treatment fee.
Project Expenses	Initial investment Waste oil mixing facility: 35,690,000 bahts Solid waste blending facility: 5,246,000 bahts Operation cost (estimated based on the examples of blending industry in Japan) Waste oil mixing facility: 3,569,000bahts/year (10% of initial investment) Solid waste blending facility: 210,000bahts/year (4% of initial investment) Payment of treatment fee to the cement factories (treatment of blended solid waste: 2,000 (bahts/ton) X 4,500 (tons/year) = 9,000,000 (bahts/year) Cost of transporting the blended waste to cement factories 250 (bahts/ton) X 4,500 (tons/year) = 1,125,000 (bahts/year)
Discount Rate	10% (assumed taking into account commercial interest rate, inflation, etc.)

The result of estimating the financial feasibility indicators (NPV and FIRR) is given in Table 10-17.

Table 10-17: Results of Financial Feasibility Indicators by Cases

	Treatment fee of solid waste (bahts/ton)	NPV (bahts)	FIRR (%)
Case 1	4,000	-5,954,563	6.1%
Case 2	4,500	6,613,870	14.0%
Case 3	5,000	19,182,302	21.0%
Case 4	5,500	31,750,735	27.5%

As shown in the table above, the project will obtain more than 10% of FIRR if it collects treatment fee of solid waste from the generators at the rate of 4,500 bahts/ton of waste (the dischargers shall also pay collection/transportation cost to deliver their waste to the blenders). Although the actual initial investment is expected to be larger if including the cost of land acquisition and other miscellaneous expenses, the project will be financially feasible enough as a private investment project if the treatment fee of solid waste is established at 5,000 bahts per ton of waste, which is still lower than the current rate of treatment fee in Thailand.

10.5.3 Financial Appraisal of Zinc Recovery Project

Based on the outline of zinc recovery project given above, the team here made a preliminary financial appraisal of the project in the case of Thailand.

a. Estimation of the Project Cost

Based on the similar cases in Japan, the costs of initial investment and annual operation of the facilities are estimated in Table 10-18 below.

Table 10-18: Estimated Cost of Zinc Recovery Project

Item	Cost (thousand baths)	Remark
(1) Initial Investment	**232,000**	
Zinc oxide (ZnO) recovery plant	232,000	
Lifting and storage facility	29,000	
Dryer	19,000	
Crushing and briquetting facility	49,000	
Furnace and ZnO recovery facility	47,000	
Incidental facilities	49,000	
Buildings, etc.	49,000	
Zinc recovery facility	0	Existing smelter will be used.
Item	**Cost (thousand baths/ton)**	**Remark**
(2) Facility Operation		
Zinc oxide (ZnO) recovery plant	4,850	Per ton of ZnO recovery
Raw materials	2,150	Coal, silica, binders are included
Utility	2,200	
Manpower and maintenance	500	
Zn recovery (refining)	15,000	Per ton of Zn recovery

b. Preliminary Financial Appraisal of the Project

Based on the project cost estimation above, the team made a preliminary financial appraisal of the project by estimating the NPV and FIRR under the preconditions given in Table 10-19 below.

Table 10-19: Preconditions of the Project

Project Period	11 years including 1 year's construction and 10 years' operation
Project Income	Income from selling zinc recovered from EAF dust Unit price of zinc : 46,700 bahts/ton

	Amount of zinc recovered : 8,500 tons/year Annual income : 396,950,000 bahts/year It is assumed that EAF dust is collected from the generators by charging the collection and haulage cost only. Income from treatment of sludge containing heavy metals Treatment fee : to be established by cases between 1000 and 2000 bahts per ton Treatment amount : 15,000 tons/year (to be assumed as 30 % of EAF dust accepted)
Project Expenses	Initial investment : 232,000 thousand bahts Operation cost : 370,000 thousand bahts/year ZnO recovery:4,850 (bahts/ton) X 50,000 (tons/year) = 242,500 (thousand bahts/year) Zn recovery: 15,000 (bahts/ton) X 8,500 (tons/year) = 127,500 (thousand bahts/year)
Discount Rate	10% (assumed taking into account commercial interest rate, inflation, etc.)

Estimation of NPV and FIRR was made on assumption of the treatment cost of sludge at 1000, 1500, and 2,000 bahts per ton respectively. Table 10-20 below shows the result of estimation.

Table 10-20: Results of Financial Feasibility Indicators by Cases

	Treatment fee of sludge (bahts/ton)	NPV (bahts)	FIRR (%)
Case 1	1,000	23,423,355	12.5%
Case 2	1,500	65,317,130	16.8%
Case 3	2,000	107,211,906	20.9%

FIRR of the project is more than 10% in the case of establishing the treatment fee of sludge at 1,000 bahts per ton as shown in the table above. Even though taking into account various possible risks that may arise in the project, the project is estimated to be financially viable if applying the treatment fee of sludge at 1,500 bahts per ton as far as the quantity of EAF dust and sludge is maintained at the level given in Table 10-19 even though electric arc furnace dust is collected only at the expense of collection and haulage.

10.6 Implementation Framework

Table 10-21 shows an implementation framework of the A/P proposed in this chapter.

IWM involves various stakeholders spreading over different sectors. In fact, specific actions should be tailored for each sector and each factory after the real conditions are thoroughly understood. In the present study, however, following the scope of the study and paying attention to what DIW, the Thai authority of IWM, should do in the coming years, the team formulated an overall A/P that covers whole the study area and all industrial sectors. Recognizing such nature of the A/P, the team presents examples of detailed actions for the improvement of IWM in some of the areas concerned.

- Taking waste oil and waste batteries as examples of HW whose recycling has problems, the team studied the current conditions and proposed an improvement plan of waste oil and waste battery recycling (Chapter 11).
- Tanking the paint industry as an example that faces waste problems, the team formulated an improvement plan of IWM for the paint industry. (Chapter 12)
- Furthermroe, the team carried out a pilot project to examine the practicability of the waste exchange program (WUDC) (Chapter 13) and showed what needs to be done.

The team also calculated implementation cost of some of the selected projects as described earlier in this chapter. The calculation is, however, based on assumptions set for several unclear conditions and the result is not included in the table below to avoid any unnecessary misunderstanding. The project cost estimation should be understood after carefully reading assumptions made in the corresponding sections.

Table 10-21: Implementation Framework of HW A/P

		Implementing Body	Year				Notes, Costs
			2002	2003	2004	2005	
A.	Waste Minimization A/P						
1	Thorough implementation of manifest system	DIW/Private sector		After the system legally set up			Close cooperation with PCD.
2	Waste audit	DIW	Guidelines, education, dissemination				
		Private sector		Implementation			
3	HW minimization and reduction	Private sector	Examination and implementation based on waste audit (item 2)				
4	HW Recycling at source	Private sector	Examination and implementation based on waste audit (item 2)				
5	Facilitation of zero-emission industrial estate	DIW・IEAT	Planning, deciding a model IE		Pilot implementation at the model IE		
6	Formulation of IWM Improvement Plans for Individual Industrial Sectors	DIW	Selection of priority sectors	Implementation in order of priority			Example of paint industry in Chap.12.
B.	Waste Reuse/Recylcing A/P						
1	Promotion of HW recycling at cement factories	Private sector	Facility improvement, diversifying types of waste received				Cost estimation in 10.5.1.
		DIW	Code 101 authorization to cement factories				
2	Murturing waste analysis, adjustment and blending industries	DIW	Promotion policy				Cost estimation in 10.5.2
		Private sector		Development of blending business			
3	Promotion of HW reuse/recycling at other facilities	DIW	Investigation and promotion				Cost estimation in 10.5.3
		Private sector			Implementation		
4	Improvement of the reuse/recycling system affecting the environment	DIW	Selection of priority wastes	Implementation in order of priority			Examples of waste oil and waste batteries in Chap.11.
C.	Waste Exchange A/P						
1	Dissemination of WUDC	DIW	P/P continued and developed				See Chap.13 for P/P.
2	Promotion of the realization of waste exchange	DIW	P/P continued and developed				See Chap.13 for P/P.