

## CHAPTER 4 DATA COLLECTION AND ANALYSIS

### Data collection

This study made use of data from both primary sources e.g. questionnaire, interview, etc. and secondary sources such as studies done by others e.g. PCD or DIW and factory permit.

First step of data collection was to review the selected reports and technical papers, operational permit submitted to Bangpoo Industrial Estate to get insight into waste management practice of all

factories in Bangpoo Industrial Estate. After that factories were asked to answer the questionnaire which is shown in Appendix A to update data and get more information regarding waste exchange. And selected factories which had high possibilities to exchange waste were visited and interviewed.

### Results of Survey

Questionnaires have been sent to all factories in Bangpoo Industrial Estate. Only 26 factories in General Industrial Zone (GIZ) and 8 factories in Export Processing Zone (EPZ) returned the questionnaires. When these figures were compared with the total number of factories located in Bangpoo Industrial Estate, information in GIZ, and EPZ represented only 8.58%, and 19.51% of total amount of factory respectively.

The results in part four of the questionnaire which involve the attitude of waste exchange are summarised as follows:

- 24 factories or 70.59% of returned questionnaires know about waste exchange;
- 32 factories or 94.12% of returned questionnaires were willing to exchange their waste if it is possible;
- no factory in returned questionnaires has exchanged waste within the Estate;
- 30 factories or 88.23% of returned questionnaires had plan to improve their production processes in order to reduce their wastes;
- 27 factories or 79.41% of returned questionnaires had plan to reuse their waste within their own factories;
- 25 factories or 73.53% of returned questionnaires thought that costs incurred from waste exchange would hinder waste exchange;
- 14 factories or 41.17% of returned questionnaires thought that inconvenience in sorting wastes from production processes would hinder waste exchange;

- 7 factories or 20.59% of returned questionnaires thought that knowing of secrecy in production by competitors would hinder waste exchange;
- 17 factories or 50% of returned questionnaires thought that scare of technology to utilise waste would hinder waste exchange;
- 12 factories or 35.29% of returned questionnaires thought that uncertainty in legal aspect would hinder waste exchange; and
- 5 factories or 14.7% of returned questionnaires thought that other factors such as impossibility to use waste as raw material, low quality of product produced from waste material, no economical feasibility, etc. would hinder waste exchange.

To have more information for analysis, the following information from secondary sources was included.

- Information from the survey of Industrial Estate Authority of Thailand of factories in Bangpoo Industrial Estate in B.E. 2540 which has information on raw material used, produced finished products, number of employee, generated wastes, and current waste management was collected. There were information from 137 factories in GIZ and 20 factories in EPZ.
- Information from the operational permission documents submitted to Bangpoo Industrial Estate was used for analysis. This information was obtained from 262 factories in GIZ and 31 factories in EPZ. Raw materials used, finished products produced, generated waste materials, number of employees, production processes, and waste management could be acquired from this information.
- Reports from 139 factories in GIZ submitted to Department of Industrial Work, Ministry of Industry under the Notification of Ministry of Industry No. 6 B.E. 2540 were collected. This information involves generated wastes, and waste handling methods.

From all above information, some waste users and waste generators who have possibilities to exchange wastes were selected for interview. The Table 4-1 shows the list of factory which were chosen.

The results in part four from interview when combined with the results from questionnaires can be summarised in the followings:

- 44 factories (62.86%) of total samples or 20 factories (55.56%) from sampling interview knew about waste exchange;
- 68 factories (97.14%) of total samples or 36 factories (100%) from sampling interview are willing to exchange their waste if it is possible;
- no factory from interview had exchanged waste within the Estate;

- 64 factories (91.43%) of total samples or 34 factories (94.44%) from sampling interview had plan to improve their production processes in order to reduce their wastes;
- 61 factories (87.14%) of total samples or 34 factories (94.44%) from sampling interview had plan to reuse their waste within their own factories;
- 55 factories (78.57%) of total samples or 30 factories (83.33%) from sampling interview thought that costs incurred from waste exchange would hinder waste exchange;
- 29 factories (41.43%) of total samples or 15 factories (41.67%) from sampling interview thought that inconvenience in sorting wastes from production processes would hinder waste exchange;
- 17 factories (24.28%) of total samples or 10 factories (27.78%) from sampling interview thought that knowing of secrecy in production by competitors would hinder waste exchange;
- 22 factories (31.43%) of total samples or 5 factories (13.89%) from sampling interview thought that scare of technology to utilise waste would hinder waste exchange;
- 24 factories (34.28%) of total samples or 12 factories (33.33%) from sampling interview thought that uncertainty in legal aspect would hinder waste exchange; and
- 12 factories (17.14%) of total samples or 7 factories (19.44%) from sampling interview thought that other factors such as impossibility to use waste as raw material, low quality of product produced from waste material, no economical feasibility, etc. would hinder waste exchange.

*Table 4-1 List of factories which were chosen for interview*

Name of Factory	Location	Role in waste exchange
1. ABB Capacitor Co., Ltd.	GIZ	Waste generator
2. ACT Leather (Thailand) Co., Ltd.	GIZ	Waste generator
3. Bamco (Thailand) Co., Ltd.	GIZ	Waste generator
4. Chin I Metal Co., Ltd.	EPZ	Waste generator
5. Dura Fasteners Co., Ltd.	EPZ	Waste generator/user
6. ES Manufacturing Co., Ltd.	GIZ	Waste generator
7. Evergreen Textile Co., Ltd.	GIZ	Waste generator/user
8. KCE International Co., Ltd.	EPZ	Waste generator
9. Lion Tyres (Thailand) Co., Ltd.	GIZ	Waste generator
10. Mae Mae Industrial Co., Ltd.	GIZ	Waste generator/user
11. Marygot Jewellery Co., Ltd	EPZ	Waste generator/user
12. Minami and Verbina Industry Co., Ltd.	GIZ	Waste generator
13. Nestle Asian (Thailand) Co., Ltd.	GIZ	Waste generator
14. Nestle Manufacturing (Thailand) Co., Ltd.	GIZ	Waste generator
15. Ocean Glass Public Co., Ltd.	GIZ	Waste generator/user
16. PSC Recondrum Co., Ltd.	GIZ	Waste user

Table 4-1 Lists of factories who are chosen for interview (cont'd)

Name of Factory	Location	Role in waste exchange
17. Rodia Thai Industry Co., Ltd.	GIZ	Waste generator
18. Sangasi Thai Co., Ltd.	GIZ	Waste generator
19. Siam Container Industry Co., Ltd.	GIZ	Waste generator
20. Siam Kraft Industry Co., Ltd.	GIZ	Waste user
21. Siam Occidental Electrochemical Co., Ltd.	EPZ	Waste generator/user
22. Siam Tableware Co., Ltd.	GIZ	Waste generator/user
23. SPI Canning Co., Ltd.	GIZ	Waste generator
24. SPI Feed Co., Ltd.	GIZ	Waste generator/user
25. Soot Suwan Co., Ltd.	GIZ	Waste generator/user
26. Steel Thai Development Co., Ltd.	GIZ	Waste generator/user
27. Sundy Co., Ltd.	GIZ	Waste generator/user
28. Taiyo Fastener (Thailand) Co., Ltd.	EPZ	Waste generator/user
29. Tanio Thai Co., Ltd.	GIZ	Waste generator
30. Thai Negero Co., Ltd.	GIZ	Waste generator/user
31. Thai Refrigeration Components Co., Ltd.	GIZ	Waste generator
32. Thai Storage Battery Public Co., Ltd.	GIZ	Waste generator
33. Thep Siam Co., Ltd.	GIZ	Waste generator/user
34. Tira Thai Co., Ltd.	GIZ	Waste generator
35. Toyo Valve (Thailand) Co., Ltd.	GIZ	Waste generator
36. Zeneka Agro Asiatic Co., Ltd.	GIZ	Waste generator/user

### Type of Industries in Bangpoo Industrial Estate

From the information obtained from IEAT there were two industrial area in Bangpoo Industrial Estate; i.e. General Industrial Zone (GIZ) and Export Processing Zone (EPZ). And there were 303 factories in GIZ and 41 factories in EPZ.

All industries in Bangpoo Industrial Estate were categorised by using industrial code issued by Ministry of Industry in Ministerial rule B.E. 2535 (1992 A.D.), dated 24 September B.E. 2535 (1992 A.D.). The results are shown in Appendix F and Appendix G which are information of factories in both General Industrial Zone and Export Processing Zone.

The followings will describe production process, and types of raw material and waste material of each category in both GIZ and EPZ.

#### **General Industrial Zone (GIZ)**

There were 61 different types of industrial code in General Industrial Zone. Some factories could be classified to many types of industrial code. Detailed descriptions of each category starting from highest number of factories are listed below.

***Industrial code 42 : Basic Industrial Chemicals-except Fertiliser***

There were 43 factories classified in this industrial code. Four out of them do not involve with production of chemicals. They are places to change the containers of chemicals or to be a filling station. The rests involve mixing chemicals and promoting chemical reaction to make products.

Raw material used in these factories can be many kinds of basic chemical such as acid or base solution, and base oil.

Waste generated from industries under this categories normally are wastewater from cleaning storage tank, mixing tank, or reaction tank when types of finished products have been changed or when those tanks are maintained and sludge from wastewater treatment system.

***Industrial code 64 : Other Fabricated Metal Products***

There were 40 factories in this category that produce tank, container or filing cabinets from steel or stainless steel. Six factories have plating process for wire, steel plate, and jewellery products. There is one factory in this industrial code which produce 180 l steel drums from used drums. The rest are making steel or other metal products for example roller, pipe & pipe fittings, spring, knife, and valve. Production processes of these factories are cutting, ovening, rolling, casting, grinding, welding, painting, plating, cleaning, and assembly.

Raw materials used are steel or stainless steel plate, plating solution, acid, base for cleaning, other chemicals, and sand for making mould.

Industries in this category generate waste in the form of wastewater; i.e. rinse water, spent acid, spent base, spent plating solution which contains heavy metals and other contaminants, other wastewater from cleaning process and solid waste; i.e. scrap metals e.g. steel or stainless steel from cutting and finishing process, sand from casting process.

***Industrial code 43 : Fertilisers & Pesticides Manufacture***

Twenty five factories were categorised in this industrial code. There are two different activities under this categories. One is mixing technical grade of substances with solvent to make a fertilisers or pesticides. Another is changing container size and keeping finished product for delivery to customer. Sixteen factories are doing the first activity and eight factories are doing the other.

If factories just only change container size, raw materials required is tank or container, packing material, and labels. For factories which have to mix raw material to make the finished products, they require technical grade of each finished product, solvent e.g. xylene or toluene, sand as a medium for fertiliser and pesticide, and some chemicals e.g. wetting agent, emulsifier.

Contaminated bags, wastewater from cleaning activities, and returned expired pesticides are waste generated from factories under this category.

Solvent used for mixing tank cleaning normally are kept for producing same product in next operation.

#### ***Industrial code 53 : Manufacture of Plastic Products***

There were 24 factories under this category. Most activities of factory under this categories were involving container making e.g. tank or bag, and other plastic products making. Processes used are injection or blow moulding processes. Other activities are making plastic sheet, some parts of shoe, and plastic cap etc.

Both types of polyethylene; HDPE and LDPE, and PVC in the form of pallet are the major raw materials. Other types of polymer being used are acrylic sheet, and polypropylene.

Most wastes produce from cutting, trimming and finishing processes. But there are products or some parts for making products which are under quality standards discarded as waste. Most of these wastes are crushed and returned to the upstream of production process to make new products. Raw material bag is the waste generated from factories in this category.

#### ***Industrial code 48 : Manufacture of Other Chemical Products***

There were 20 factories classified under this industrial code. Production processes of factories in this category are chemical reaction and mixing of chemical to form glue, resins for textile, tannery, and paper industries, match, synthetic wax, and ink. They range from simple process i.e. only one mixing tank to complicate process i.e. reaction in many tanks under controlled pressure and temperature.

Raw materials are many types of chemical such as sodium tripolyphosphate, trisodium phosphate, aluminium sulphate, castor oil, isopropyl alcohol, soda ash, and acid and base solution.

Waste materials mostly are wastewater from cleaning tank, sludge from wastewater treatment plant, resin residue, match stick, packaging, and empty containers.

#### ***Industrial code 77 : Motor Vehicle Manufacture***

There were 15 factories classified in this industrial code. There are many activities in production processes to produce parts for motor vehicle that are air filter, oil filter, mirror, disc brake, shock absorber, chassis etc. Those activities are machining process, welding process, assembly process, painting process.

Raw materials in this category are steel, filter paper, oil, paint, mould, and plastic.

Scrap steel is the common waste found from factory under this category. Sludge from painting process is also produced under this category.

***Industrial code 22 : Spinning, Weaving & Finishing Textiles***

There were 12 factories classified under this category. Major production processes of factories in this category are spinning, carding, winding, quilting, punching, weaving, cleaning, laundering, bleaching, burning, and dyeing filament, thread and fabric.

Raw materials used are polyester filament, fabric, yarn, cotton, sodium hydroxide, nylon, wetting agent, soaping agent, fixing agent, softening agents, sodium sulphate, acetic acid, glue, thread, paper bobbin, dyed pigments, hydrogen peroxide, and starch.

Waste materials are wastewater from dyeing, washing, bleaching, laundering and scouring processes, scrap polyester, scrap fabric, scrap thread, scrap cotton, and empty pigment containers.

***Industrial code 71 : Electrical Industrial Machinery & Apparatus, Transformer, Generator***

There were 12 factories categorised in this industrial code. Activities in production process of factories in this category are similar to that of Industrial code 77. Finished products mostly are transformer, switch gear, and electrical control panel.

Major component to produce finished product under this category is steel. Other parts such as aluminium paper, insulator, electrical components are required.

Waste material produced from factories under this category are paint sludge and scrap steel.

***Industrial code 45 : Paints, Varnishes & Lacquers Manufacture***

There were 11 factories categorised in this industrial code. Production processes of factories in this categories are similar to that of industrial code 42 except finished products are paints, vanishes, and lacquers. These production processes are mixing, dissolving, milling, filtration and filling.

Raw material are various types of chemicals i.e. vanish, resin, additives, solvents, binders, alkyd resin, titanium oxide, mother colour powder, white clay, pigment, molasses, china clay etc.

Waste materials are spent solvents, wastewater from tank cleaning, sludge from wastewater treatment plant, empty chemical containers, and expired finished products.

***Industrial code 74 : Other Electrical Apparatus & Supplies***

There were 11 factories classified under this code. These factories produce lamp, fin of transformer, coated copper wire, and batteries. Production processes to produce these products are cutting, forming, pressing, drilling, painting, decorating, mixing, injection, melting, curing,



pasting, washing, ovening, drawing, annealing, enamelling, stranding, coating, electrical charging, and assembly.

Raw materials used are galvanised steel, white powder, polished aluminium, steel, pigments, lead, lead mix, battery casing, separator, polypropylene, barium sulphate, sulphuric acid, pure copper, formaline, phenol, asbestos, vanish, lignin, natural rubber, and fibre.

Waste materials are scrap steel and galvanised steel, scrap aluminium, wastewater from process, sludge from wastewater treatment plant, slag from lead melting process, damaged electrode, scrap battery casing, and containers.

#### ***Industrial code 39 : Containers & Boxes of Paper & Paperboard***

There were 9 factories categorised under this industrial code. These factories produce paper boxes and sheets such as corrugated paper box, corrugated paper sheet, and paper box. Production processes are cutting, printing, stapling, and assembly.

Raw materials are craft paper, corrugated paper, card paper, starch, staple, glue, paint, and other chemicals such as toluene.

Waste materials are scrap paper, used solvent, paint sludge, sludge from wastewater treatment plant, and packaging.

#### ***Industrial code 59 : Iron & Steel Basic Industries***

There were 7 factories categorised in this code. These factories produce steel products such as stainless steel wire, billet, steel pipes, steel grit, and steel shot. Production processes of these products are cutting, drawing, melting, casting, finishing, ovening, sand blasting, rolling, coating, heat treatment, straightening, and polishing.

Raw materials used are stainless steel wire rod, stainless steel sheet, ferro silicon, ferro manganese, nickel, graphite, carbon, slag, scrap steel, aluminium, coke, calcium oxide, and sand for mould making.

Waste materials are scrap stainless steel, slag, and packaging.

#### ***Industrial code 68 : Special Industrial Machinery & Equipment***

There were 7 factories classified in this industrial code. These factories repair machine and mechanical equipment for paper and textile industries. They also produce winding shaft, machine, concrete mixing equipment, waste water equipment such as screening, tanning tank, dyed tank, and leather oven. Production processes for making these products are machining, cutting, welding, painting, hardening, drilling, bending, punching, polishing, cleaning, and assembly.

Raw materials used are shaft steel, cast iron, nut, screw, steel, paint, motors, stainless steel, and bearing.



Waste materials are scrap steel and stainless steel, packaging, and containers.

***Industrial code 28 : Wearing Apparel-except Footwear***

There were 6 factories designated under this industrial code. These factories produce women and men suits, blouses, trousers, and jackets. Production processes are cutting, sewing, trimming, and ironing.

Raw materials are fabric, zips, buttons, nylon, polyester, sponge, lining, and thread.

Waste materials are scrap fabric, scrap thread, and packaging.

***Industrial code 33 : Footwear Manufacture-Except Rubber & Plastic***

There were 6 factories classified under this code. These factories produce shoes, safety shoes, and shoe components are finished products made from these factories. Production processes to make these products are cutting, pressing, sewing, gluing, ovening, and punching.

Raw materials used are leather, synthetic leather, fabric, and other components for instance zip, and sponge.

Waste materials are scrap leather, and packaging.

***Industrial code 44 : Synthetic Resins, Plastics & Fibres***

There were 6 factories categorised under this industrial code. These factories produce many kinds of resin for instance alkyd resin, UP resin, melamine resin, and epoxy resin, polyester, and nylon filament. Production processes to make these products are reaction, dilution, drying, crystallisation, extrusion, spinning, heating, cutting, polymerisation, melting, winding, reeling, carding, forming, and washing.

Raw materials used are propylene glycol, soybean oil, diethylene glycol, styrene monomer, acrylic monomer, melamine, other chemicals e.g. white spirit, alkynerine, and acetic acid, waste polyester, waste nylon, carpolactum, filament yarn, and solvents such as xylene, and toluene.

Waste materials are spent solvents, packaging, and containers.

***Industrial code 78 : Motorcycles, Tricycles, Bicycles & Parts***

There were 6 factories classified in this industrial code. These factories produce parts and components for motorcycles and bicycles. Examples of these products are sprocket, air filter, bead wire for making wheel, mirror, and disc brakes. Production processes to make them are punching, pressing, shearing, shot blasting, stamping, levelling, cutting, hobbing, heat treatment, drilling, painting, chamfering, grinding, lathe turning, mixing, injection and assembly.

Raw materials used are Rolled sheet steel, polypropylene (PP), PVC, plastic pallets, mirror, brass wire, and stainless steel.

Waste materials are scrap brass wire, stainless steel scrap, scrap steel, scrap PP and PVC, and packaging.

***Industrial code 32 : Leather & Fibre Products-Except Wearing Apparel***

There were 5 factories classified under this code. These factories produce cushion cover, wallet, furniture, bag, luggage from leather. Production processes are cutting sewing, gluing, labelling, and assembly.

Raw materials used are leather, synthetic leather, sponge, glue, wood frame, synthetic filament, thread, carton, and other components such as rivet, tape, and spring.

Waste materials are scrap leather, scrap sponge, scrap synthetic leather, scrap filament, and packaging.

***Industrial code 37 : Furniture, Fixtures & Floorings-except by Metal & Plastic***

There were 5 factories designated under this code. Furniture for example chairs, tables, beds, cabinet, and sofa are the products produced by these factories. Production processes to make these products are cutting, drilling, painting, lacquering, sewing, and assembly.

Raw materials are wood, nails, fittings, glue, wood pin, paint, sponge, leather, fabric, PVC, and other components for instance springs, staple, and plastic legs.

Waste materials are saw dust, scrap wood pieces, scrap leather, scrap fabric, containers, and packaging.

***Industrial code 46 : Drugs & Medicine Manufacture***

There were 5 factories classified under this code. Medicines and vitamins are the products from these factories. Production processes to make these products are mixing, capsulation, printing, filtration, milling, drying, lamination, pasteurisation, crystallisation, and centrifugation.

Raw materials used are sugar sorbitol, alcohol, corn starch, ampicillin trihydrate, amoxylin trihydrate, soybean oil, vitamin A, COD lever oil, EPO, coco condensate, salicylic acid, acetic anhydride, sulfamic acid, nonyl phenol, SMCA, and other chemicals vegetable oil hydrogenated, and fractionated coconut oil.

Waste material are expired medicines, aluminium hydroxide, oil sludge, wastewater from tank cleaning, sludge from wastewater treatment plant, and containers.

***Industrial code 63 : Structural Metal Products Manufacture***

There were 5 factories categorised under this code. These factories produce car carriers, transformer tank, chassis, fabricated steel, motorcycle & car parts window handle, and steel structure for construction work for

example beams, studs, and plates. Production processes are drilling, forming, welding, bending, milling, shot blasting, casting, machining, polishing, plating, painting, and assembly.

Raw materials used are galvanised steel, steel, zinc alloy, zinc ingot, sodium hydroxide, hydrochloric acid, sodium dichromate, welding solid wire.

Waste materials are scrap galvanised steel, scrap steel spent, scrap welding solid wire, spent sodium hydroxide and hydrochloric acid, rinse water, wastewater from tank cleaning, and sludge from wastewater treatment plant.

#### ***Industrial code 72 : Radio, Television & Communication Equipment***

There were 5 factories categorised under this industrial code. These factory produce radios, televisions, and capacitors. Production processes are stuffing, soldering, touching up, encasing, ageing, forming, welding, finishing, winding, zinc spraying, cleaning, treatment, wrapping, shrinking, and assembly.

Raw materials used are cathode & anode foil, terminal, aluminium cans, rubber sheet, electrolytic paper, electronic components, lead, solder tin, vermiculite, plastic cabinet, coil, printed circuit board, flux, and other components such as tape, paints, terminal, nut, bolt, and washer.

Waste materials are capacitor elements, zinc powder from paint booth, scrap wire, and scrap solder tin.

#### ***Industrial code 91 : Packing Operations-No Production Activity***

There were 5 factories categorised under this industrial code. There is no production processes for these factories. Factories have just refilled products into smaller container sizes.

Raw materials used are styrene butadiene rubber (SBR) latex, styrene acrylic latex, synthetic wax, sodium chloride, sodium hydroxide, solvent IPA, wetting agent, dye stuff, and different sizes of containers.

Waste materials are packaging, containers, and wastewater from tank cleaning.

#### ***Industrial code 40 : Other Pulp, Paper & Paperboard Articles***

There were 4 factories classified in this industrial code. Factories in this category produce paper bobbin for pre-oriented yarn (POY) and draw twist yarn (DTY), diaper for children and old people, and compacting scrap paper. Production processes are slitting, gluing, winding, cutting, finishing, mixing, assembly, and compacting.

Raw materials are paper sheet, wood pulp, tissue, absorbent, and scrap paper.

Waste materials are scrap paper, scrap diaper, and packaging.

***Industrial code 41 : Printing, Publishing & Allied industries***

There were 4 factories categorised under this industrial code. These factories produce books, printings, files, and holders. Production processes are photo copying, plate making, printing, cutting, gluing, binding

Raw materials are index paper, polypropylene sheet, polypropylene resin, art paper, ink, film, plate, and solvent.

Waste materials are scrap paper, scrap polypropylene, ink solution, spent solvent, wastewater from cleaning, sludge from wastewater treatment plant, and containers.

***Industrial code 47 : Soaps, Cleansers, Cosmetics, Toiletries, etc.***

There were 4 factories designated in this industrial code. These factories produce solution for cleaning, detergent, filling cosmetic in capsules, and solution for maintenance buildings. Production processes are mixing, and filling.

Raw materials used are sodium hydroxide, soda ash, phosphoric acid, hydrochloric acid, alcohol, surfactant, capsule, non-ionic, and other chemicals

Waste materials are wastewater from tank cleaning, sludge from wastewater treatment plant, and containers.

***Industrial code 58 : Other Non-metallic Mineral Products***

There were 4 factories categorised under this code. These factories produce abrasive equipment, ready mixed concrete, metal jacket, and compressed fibre sheet. Production processes are bending, forming, cutting, welding, mixing, and pressing.

Raw materials used are phenolic resin, carbon black, aluminium oxide, silicone carbide, cryolite, iron oxide, fibre glass net, concrete, stone, sand, binders, and chemicals for instance methanol.

Waste materials are spent solvents, concrete waste, and containers.

***Industrial code 73 : Electrical Appliances & Housewares***

There were 4 factories designated under this industrial code. These factories produce fans, and centrifugal fans. Production processes are cutting, punching, rolling, forming, welding, painting, and assembly.

Raw materials used are steel plate, paints, and sub-assembly parts.

Waste materials are steel scrap, and packaging.

***Industrial code 89 : Gas Manufacture & Distribution***

There were 4 factories classified under this code. These factories produce gases. One factory uses gas which is by-product from factory who produce sodium chloride, sodium hydroxide and hydrochloric acid from salt. One factory produce gas products by changing container's size. Production

processes of the rests are drying, distillation, separation, filtration, and compression.

Raw materials are air, crude hydrogen gas, liquid oxygen, liquid nitrogen, liquid carbon dioxide, molecular sieve, and activated alumina.

#### ***Industrial code 5 : Manufacture of Dairy Products***

There were 3 factories classified under this industrial code. One factory produces drinking yoghurt. The others produce non-dairy cream and instant drinking chocolate. Production processes for making drinking yoghurt are mixing, homogenising, ultra heat treatment, and filling. Production processes of non-dairy cream and instant drinking chocolate are mixing, pasteurising, homogenising, and drying.

Raw materials used for producing drinking yoghurt are juice concentrate, sucrose or fructose, and yoghurt. Raw materials for non-dairy cream and instant drinking chocolate are syrup, wholemilk powder, cocoa powder, palm oil, lactic acid and other chemicals.

Waste materials are wastewater from tank cleaning and containers.

#### ***Industrial code 6 : Fish, Shellfish & Seafood (Canning etc.)***

There were 3 factories classified under this code. These factories produce tuna fish in cans both for human food and cat food, and frozen shrimp. Production processes are butchering, grading, pre-cooking, cleaning, retorting, can filling, and freezing.

Raw materials are many kinds of fish and shrimp, cans, salt, oil, wheat, sodium hydroxide, sodium hypochlorite, and calcium hypochlorite.

Waste materials are fish bone, skin & heads, scrap fish tissue, shrimp head & shell, wastewater from cleaning, and sludge from wastewater treatment plant.

#### ***Industrial code 10 : Manufacture of Baked & Steamed Products from Starch***

There were 3 factories designated under this code. These factories produce snack and bread. Production processes are drying, frying, cooling, seasoning, roasting, sifting, mixing, baking, and freezing.

Raw materials are cracker, potato flour, sugar, wheat flour, starch, salt, yeast, milk, chocolate chip, cheese, almond cheese, and blueberry.

Waste materials are scrap bread, wastewater from tank cleaning, sludge from wastewater treatment plant, containers.

#### ***Industrial code 27 : Manufacture of Other Textiles***

There were 3 factories designated under this industrial code. These factories produce synthetic leather, thermobond non-woven, stitchbond non-

woven, and synthetic fibre sheet. Production processes are opening, blending, carding, weaving, needle punching, slicing, cutting, and rolling.

Raw materials are polyester filament, nylon fibre, glue resin, and synthetic filament.

Waste materials are scrap fibre, scrap fibre sheet, non-woven scrap, and packaging.

#### ***Industrial code 61 : Cutlery, Hand Tools & General Hardware***

There were 3 factories categorised under this industrial code. These factories produce mould for making products. Production processes are pressing, machining, and finishing.

Raw materials used are steel, parts and components.

Waste materials are scrap steel and packaging.

#### ***Industrial code 65 : Manufacture/Repair of Engines & Turbines***

There were 3 factories classified under this code. Electrical motors, concrete mixing equipment, manifold gasket, general gasket, and rubber coating metal sheet (RMS) are products produced by these factories. Production processes are assembly, wedge making, balancing, grinding, wiring, painting, banking, cutting, curling, pressing, surface treatment, heat treatment, trimming, degreasing, embossing, printing, and rubber coating.

Raw materials used are steel, stainless steel, machine parts, nuts, screws, paint, shaft steel, cast iron, stators, rotors, cable, fans, asbestos plate, paper plate, asbestos reinforced with steel plate, copper plate, and solvents.

Waste materials are steel and stainless steel scrap, scrap cable, spent solvents, scrap asbestos, scrap cast iron, paint sludge, wastewater from degreasing, sludge from wastewater treatment plant, and containers.

#### ***Industrial code 4 : Slaughtering, Preparing & Preserving Meat***

There were 2 factories classified in this industrial code. One factory produces partridge's egg in can. Another produces meat sauce. Production processes are boiling, shell removing, pasteurising, mixing, and steaming.

Raw materials used are partridge's eggs, cans, meat, and spices.

Waste materials are egg shell, and wastewater from tank cleaning.

#### ***Industrial code 8 : Fruits, Vegetables (Canning & Preserving)***

There were 2 factories categorised under this industrial code. One factory produces red bean in can and another produces fruit juice. Production processes are boiling, mixing filtering and pasteurising.

Raw materials used are red beans, sugar, cans, juice concentrate, and syrup.

Waste material are wastewater from tank cleaning, packaging materials, and containers.

***Industrial code 13 : Dressings & Food ingredients***

There were 2 factories classified under this industrial code. These factories produce seasonings and sauce such as tomato sauce and chilli sauce. Production processes are mixing, sifting, and filling.

Raw materials used are starch, sugar, tomato, chilli, other ingredients, and containers.

Waste materials are wastewater from tank cleaning, scrap vegetable, and containers.

***Industrial code 23 : Made-up Textile Goods-Except Wearing Apparel***

There were 2 factories designated under this industrial code. These factories produce toys, dolls, gifts, and presents made from fabric. Production processes are cutting, sewing, and gluing.

Raw materials used are fabric, thread, silk cotton, and glue.

Waste material are scrap fabric, and scrap silk cotton.

***Industrial code 29 : Leather Tanning, Currying, Finishing, etc.***

There were 2 factories classified in this industrial code. These factories are tannery. Production processes are liming, deliming, pickling, chrome tanning, vegetable tanning, shaving, dyeing, oiling, drying, glazing, pressing, polishing, and ironing.

Raw materials are snake hide, crocodile hide, ghost hide, lamb hide, desert monitor hide, chrome solution, lime, oil, dyed pigments, and other chemicals.

Waste materials are fur, scrap leather, scrap hide, wastewater from liming, deliming and tanning processes.

***Industrial code 34 : Wood Processing***

There were 2 factories categorised under this industrial code. These two factories process wood and plywood into wood pallet and wood cabinet. Production processes are cutting, sawing, boring, and assembly.

Raw material are wood, ply wood, and nails.

Waste materials are saw dust and wood pieces.

***Industrial code 36 : Other Wood and Cork Products***

There were 2 factories categorised under this industrial code. These factories produce tables, chairs, and beds from wood. Production processes to make these products are cutting, finishing, and lacquering.

Raw materials used are wood glue, nails, other fittings, and lacquer.

Waste materials are saw dust, and wood pieces.

***Industrial code 51 : Tires & Inner Tubes, including repairs***

There were 2 factories classified in this industrial code. These factories produce inner tubes and tyres for bicycles and motorcycles. Production processes are mixing, extrusion, vulcanisation, cutting, threading, and gluing

Raw materials used are natural rubber, synthetic rubber, glue, bead wire, carbon black, and other chemicals.

Waste material are scrap tyre, scrap inner tube, and containers.

***Industrial code 52 : Manufacture of Other Rubber Products***

There were 2 factories classified in this industrial code. These factories produce rubber products for instance shoes and rubber rollers from rubber. Production processes are mixing, cutting, sewing , and gluing.

Raw materials used are natural rubber, synthetic rubber, fabric, glue, and chemicals.

Waste materials are scrap rubber, and containers.

***Industrial code 54 : Glass & Glass Products Manufacture***

There were 2 factories classified under this industrial code. These factories produce glassware. Production processes are mixing, melting, forming, annealing, decorating, and pressing.

Raw materials used are sand, dolomite, antimony, soda ash, cullet, selenium, alumina, cobalt, and selenium.

Waste materials are cullet, used oil, and containers.

***Industrial code 67 : Wood & Metal Working Machinery***

There were 2 factories designated in this industrial code. These factories produce dies. Production processes are pressing, forming, sintering, and rapping.

Raw materials are cast iron, mild steel, steel plate, and semi-finished diamond die.

Waste materials are steel scrap and packaging.

***Industrial code 81 : Scientific & Medical Instrument and Equipment***

There were 2 factories designated under this industrial code. These factories produce medical instruments and measuring machines. For the factory which make medical instrument, detailed information regarding production process is not available. Production processes for making measuring machine are casting, finishing, heat treatment, machining, and assembly.

Raw materials are aluminium alloy, cast iron, cast aluminium, steel, lead, and roller bearing.

Waste materials are steel scrap, and aluminium scrap.



***Industrial code 87 : Manufacture of Other Products not classified***

There were 2 factories categorised under this industrial code. These factories produce plastic toys, metal toys, electronic toys and Christmas trees. Production processes are plastic injection, decoration, slitting, cutting, pressing, branch making, and assembly.

Raw materials are polystyrene, plastic resin, metal parts & components, rigid PVC sheet, iron wire, iron rod, iron tube, and nylon twine.

Waste materials are scrap plastic, packing materials, and containers.

***Industrial code 2 : Miscellaneous Agricultural Activities***

One factory was designated under this category which have process to prepare agricultural seed. The production process is to cleaning, drying, grading, and packing raw seed.

Raw materials used are many types of seed for agricultural use.

Dust and seed bags are the waste which generated from this factory.

***Industrial code 7 : Manufacture Vegetable and Animal Fat & Oils***

There was one factory under this category. Detailed information for this factory is not available. However, from information which this factory registered at Bangpoo Industrial Estate, it produces edible oil.

***Industrial code 15 : Manufacture of Prepared Animal Feeds***

There was one factory under this category. This factory receives waste materials from the same group of company to produce shrimp feed. Production process of this factory is not available.

Raw materials which are waste materials are crushed fish, shrimp shell, and soybean fibre. Other raw material is wheat.

Since there is no information of production process, expected waste shall be wastewater from tank cleaning activities, dust from raw materials, and raw material containers.

***Industrial code 24 : Knitting Mills***

There was one factory under this category which produce nylon in form of pallet, filament, and sheet. The production processes are involving polymerisation, cutting, dyeing, drying, scouring, weaving, and coating.

Raw materials used are carpolactum, filament yarn, stretch yarn, polyester, and dyed pigment.

Waste materials are scrap filament, scrap yarn, bags, containers, and sludge from wastewater treatment system.

***Industrial code 25 : Carpets & Rugs-except from Rubber & Plastic***

There was one factory classified in this industrial code. Production processes of this factory is to make carpet from used PET bottle. They start

from making crushed used PET bottle to be a fibre. Then fibre is dyed and weave to be a carpet.

Raw materials used are crushed PET bottle, cloth, glue, and dyed pigment.

Waster material are scrap PET fibre, sludge from wastewater treatment plant, empty tanks, and raw material bags.

***Industrial code 31 : Manufacture of Fur & Skin Rugs, Mats. etc.***

One factory was classified under this category. But this product is not produced at present.

***Industrial code 50 : Miscellaneous Products of Petroleum & Coal***

There was one factory categorised in this industrial code. This factory produce asphalt used for leakage protection by mixing clay calcium chloride with latex and other chemicals. As a consequence of this, production process is to heat asphalt and mix it with other ingredients.

Raw materials used are asphalt, clay calcium chloride, latex ,and other chemicals such as polyacrylic, toluene, and phenol.

Waste materials are scrap asphalt, bags, and packing materials.

***Industrial code 55 : Pottery Manufacture***

One factory was classified in this industrial code. This factory produce handle and knob from clay and zinc alloy. Production processes involve with casting , polishing, plating, lacquering, drying, and assembly.

Raw materials used are zinc alloy ingot, clay, and other chemicals.

Waste materials are scrap zinc alloy, wastewater, and sludge from wastewater treatment plant which contains heavy metal such as metal cyanide.

***Industrial code 62 : Furniture & Fixtures primarily of Metal***

There was one factory designated in this category. No detailed information of production process of this factory is available. But information from Bangpoo Industrial Estate reveals that this factory produce furniture from brass. From this reason, raw material should be brass and waste material should be scrap brass.

***Industrial code 70 : Other Machinery/Equipment/except Electrical***

One factory was classified in this industrial code. Detailed information of this factory is not available. Only information from Bangpoo Industrial Estate shows that this factory produce packaging equipment and packaging machine. And there is information of waste materials generated from this factory. They are steel, stainless steel, and brass. Consequently, raw materials

have to be the same as waste materials. It should use steel as raw material and have scrap metal from production process.

***Industrial code 82 : Photographic & Optical Goods***

There was one factory classified in this industrial code. There is no available detailed information regarding production process. Only products information is available i.e. this factory produce lens and components for glasses, and glasses.

***Industrial code 83 : Clocks & Mechanism for Timing Devices***

One factory was designated under this category. Detailed information of production process is not available. Information obtained from Bangpoo Industrial Estate reveal that this factory produces clocks.

***Industrial code 97 : Repair of Other Types not Classified***

One factory is categorised under this category. No detailed information regarding production process is available. According to information from Bangpoo Industrial Estate, this factory assembly and repair cabin.

***Industrial code 100 :Finishing or Modifying Product or Component without Production***

One factory was designated in this industrial code. Detailed information regarding production process of this factory is not available. Obtained information from Bangpoo Industrial Estate specifies that this factory has process to paint parts made from steel or plastic.

**Export Processing Zone (EPZ)**

Twenty two different types of industrial code can be categorised in Export Processing Zone. Actually, There are 41 factories in this zone as mentioned above. Some factories can be classified to many types of industrial code. Detailed descriptions of each category starting from highest number of factories are listed below.

***Industrial code 53 : Manufacture of Plastic Products***

There were 9 factories categorised under this industrial code. These factories produce plastic products for instance plastic parts for calculator, and plastic sheet. Production processes are plastic injection, finishing, cutting, punching, assembly, and printing.

Raw materials are polystyrene, acrylonitrile butadiene styrene (ABS), ethylene vinyl acetate copolymer, plastic sheet, polyethylene (PE), polypropylene, PVC sheet, and other plastics.

Waste materials are scrap PVC, scrap PE, scrap ABS, scrap PP, and other scrap plastics.

***Industrial code 72 : Radio, Television & Communication Equipment***

There were 7 factories classified under this industrial code. Products of these factories are printed circuit board, monitor, computer part housing, EMI, CD-ROM drive. Production processes of these factories are shearing, drilling, deburring, imaging, plating, stripping, etching solder marking, levelling, thermal printing, polishing, cleaning, ovening, cutting, lathing, milling, pressing, washing, winding, vanishing, soldering, and assembly.

Raw materials used are dry film, laminate, backup board, printed circuit board, case, CRT, IC, aluminium, tinplate steel, brass plate, solder, plating solution, cleaning solution e.g. acid, base other chemicals, and other components such as sockets, wire, and core.

Waste materials are aluminium scrap, steel scrap, spent solution, spent acid and base, wastewater from cleaning, sludge from wastewater treatment plant, and containers.

***Industrial code 32 : Leather & Fibre Products-Except Wearing Apparel***

There were 6 factories designated under this industrial code. These factories produce cushion cover, wallet, furniture, bag, luggage from leather. Production processes are cutting sewing, gluing, labelling, and assembly.

Raw materials used are leather, synthetic leather, sponge, glue, wood frame, synthetic filament, thread, carton, and other components such as rivet, tape, and spring.

Waste materials are scrap leather, scrap sponge, scrap synthetic leather, scrap filament, and packaging.

***Industrial code 33 : Footwear Manufacture-Except Rubber & Plastic***

There were 5 factories classified under this code. These factories produce shoes, shoe components, and safety shoes. Production processes to make these products are cutting, sewing, gluing, and punching.

Raw materials used are leather, nyred, insole, and other components.

Waste materials are scrap leather, and packaging.

***Industrial code 87 : Manufacture of other Products not classified***

There were 5 factories categorised under this industrial code. Theses factories produce plastic trees and flowers, umbrella and umbrella frame. Production processes of these products are cutting, sewing, and gluing.

Raw materials used are plastic, umbrella frame, unassembled frame parts and handle, nylon cloth, PVC sheet, and glue.

***Industrial code 64 : Other Fabricated Metal Products***

There were 4 factories designated in this industrial code. These factories produce bolts, nuts, screw, stainless steel screw, fork, spoon, and knife. Production processes of these factories are drawing, cleaning, threading, heading, slotting, forming, tapping, blanking, rolling, trimming, degreasing, stamping, emery, polishing, and cleaning.

Raw materials used are stainless steel wire, wire rod, stainless steel plate & coil, polypropylene, acrylonitrile butadiene styrene (ABS), and sodium hydroxide,

Generated waste materials are stainless steel scrap, plastic scrap, spent sodium hydroxide solution, wastewater from cleaning, and sludge from wastewater treatment plant.

***Industrial code 69 : Office, Computing & Accounting Equipment***

There were 4 factories categorised under this industrial code. These factories produce cartridge for laser printers and dot metric printers, key pad of computer key boards, electronic calculator, micro computer, and components of micro computer. Production processes of these factories are dis-assembly old cartridge, cleaning, filling ink, mixing, heating, printing , cutting, laminating, stamping, and assembly.

Raw materials used are aluminium cap, zinc cap, PVC cap, used and new empty cartridges, nylon fabric, cartridge kits, and toner powder.

Waste materials are scrap toner powder, and containers.

***Industrial code 86 : Sporting & Athletic Goods Manufacture***

There were 4 factories classified under this code. Sport suits and sport equipment such as basketball, foot ball, and volley ball are products produced from these factories. Production processes of these factories are cutting, sewing, gluing, inserting, assembly, mixing, winding, laminating, curing, colouring, pressurising, painting, and finishing.

Raw materials used are polyurethane (PU) wheels, plate, PU body, EVA tounge, synthetic rubber, natural rubber, stearic acid, calcium carbonate, magnesium carbonate, white carbon, zinc oxide, polyester yarn, PVC leather, PU leather, pigments, glue, other chemicals, and solvent for instance toluene.

Waste materials are scrap rubber, scrap leather, spent solvents, and containers.

***Industrial code 48 : Manufacture of other Chemical Products***

There were 2 factories designated under this industrial code. These factories refill ink in cartridges for laser printers and dot metric printers. Production processes are filling ink in empty cartridge and nylon fabric.

Raw materials used are used and new empty cartridges, nylon fabric, and toner powder.

Waste materials are scrap toner powder, and containers.

***Industrial code 84 : Jewellery & Related Articles Manufacture***

There were 2 factories classified under this industrial code. These factories produce accessories such as earrings, rings, necklace. Production processes are mould making, casting, grinding, cutting, drilling, vibrating, polishing, degreasing, plating, coating, and stone setting.

Raw materials used are rubber for mould making, lead, synthetic stones, rhodium solvent, paradium solvent, degreaser for example trichloroethane, and accessories.

Waste materials are spent degreaser, spent plated solutions, sludge from wastewater treatment plant, and scrap metal alloy.

***Industrial code 6 : Fish, Shellfish & Seafood (Canning etc.)***

One factory was designated in this industrial code. Production process of this factory is involving cleaning, removing some parts of marine foods, boiling, frying, and cooling.

Raw materials used are marine food such as fish, squid, shrimp, starch, can, packaging materials, and edible oil.

Waste materials are wastewater from cleaning and boiling, edible oil from frying, and some parts of marine foods.

***Industrial code 23 : Made-up Textile Goods-Except Wearing Apparel***

There was one factory classified in this industrial code. Detailed information regarding production process of this factory is not available. Information from Bangpoo Industrial Estate shows that this factory produces weave gloves for using in factory.

***Industrial code 28 : Wearing Apparel-except Footwear***

One factory was categorised under this category. No detailed information regarding production process is available. According to information from Bangpoo Industrial Estate, this factory made leather products such as cushion cover. Hence, production processes should be cutting, sewing, gluing, and assembly. And raw materials and waste materials should be leather, and scrap leather respectively.

***Industrial code 37 : Furniture, Fixtures & Floorings-except by Metal & Plastic***

One factory was classified in this industrial code. Factory under this industrial code produce furniture from leather. Production processes to make this product are cutting, sewing, and assembly.

Raw materials used are leather, fabric, glue, sponge, and others.

Waste materials are scrap leather sponge, and fabric.

***Industrial code 52 : Manufacture of Other Rubber Products***

There was one factory designated in this category. Gaskets are the products produced from this factory by mixing, vulcanising, cutting, and joining process.

Raw materials used are natural rubber, SBR, and chemicals.

Waste materials are scrap rubber, and empty containers.

***Industrial code 54 : Glass & Glass Products Manufacture***

There was one factory categorised in this industrial code. This factory produce fibre glass sheet. Production processes to make this product are mixing, spraying up, lamination, trimming, and assembly.

Raw materials used are unsaturated polyester resin, calcium carbonate, gelcoat, and chopped strand material.

Waste materials are scrap fibre glass, and empty containers.

***Industrial code 55 : Pottery Manufacture***

One factory was designated in this industrial code. This factory produce glass lid, fry pan cover and glass for copy machine. Production processes are involving plating, cleaning, and ovening.

Raw materials are float glass, and stainless steel coil.

Waste materials are crushed glass and stainless steel scrap.

***Industrial code 67 : Wood & Metal Working Machinery***

There was one factory categorised in this industrial code. There is no available detailed information regarding production process. Obtained information from Bangpoo Industrial Estate reveal that this factory produce keyboard for computer. From this reason, raw material should be plastic and waste material should be scrap plastic.

***Industrial code 71 : Electrical Industrial Machinery & Apparatus, Transformer, Generator***

One factory was categorised under this category. Electronic equipment is the product of this factory. Production processes are coil winding, soldering, vanishing, and assembly.

Raw materials are printed circuit board (PCB), case, wire, socket, and solder.

Waste materials are scrap wire, vanish, and containers.

***Industrial code 73 : Electrical Appliances & Housewares***

There was one factory categorised in this industrial code. Detailed information of this factory is not available. Information from Bangpoo Industrial Estate reveal that this factory produces fixed resistors and micro motors.

***Industrial code 74 : Other Electrical Apparatus & Supplies***

One factory was categorised under this category. This factory produces small lamp. Production processes used to produce this product are cutting, cleaning, drying, mounting, sealing, chemical treatment, and welding.

Raw materials used are glass tube, dumet, filament, basement, and cable.

Waste materials are glass scrap and containers.

***Industrial code 81 : Scientific & Medical Instrument and Equipment***

There was one factory categorised in this industrial code. Accessories for medical equipment such as PVC tube for saline injection are the products of this factory. Production processes are cutting and assembly.

Raw materials are PVC tube, and plastic parts.

Waste materials are scrap plastics and containers.

**Current waste management practices**

***Wastewater***

The Industrial Estate Authority of Thailand (IEAT) does not allow any industry located in industrial estate to discharge its wastewater into the public watercourse without treated by central wastewater treatment plant. Even though factory has its own wastewater treatment system and qualities of treated wastewater meet the required effluent standards, treated wastewater still has to be discharged to central wastewater treatment plant owned by industrial estate. And factory has to pay wastewater fee according to the strength and amount of wastewater.

Quantity of wastewater used for calculation wastewater fee is 80% of quantity of water consumption. Although any factories generate quantity of wastewater less or higher than this amount, it still has to pay wastewater fee calculated base on this value. The IEAT has issued wastewater fee equation in Notification of the IEAT no. 63 B.E. 2538, dated July 21, B.E. 2538 as follow:

$$T_c = 100 + 4.80V_i + 9.48V_iS_i/1000 + C_{p^*}$$

where

$T_c$  = waste water fee, baht/month

$V_i$  = quantity of wastewater, m<sup>3</sup>/month

$S_i$  = BOD of wastewater, mg/l

$C_{p^*}$  = additional wastewater fee in case of qualities wastewater to central treatment plant are higher than standards.



Table 4-2 Summary of waste generated by each industrial code from factories in General Industrial Zone (GIZ) of Bangpoo Industrial Estate

MOI Code	Type of industry	No. of factories	Type of Waste
42	Basic Industrial Chemicals-Except Fertiliser	43	wastewater, sludge
64	Other fabricated metal products	40	wastewater, sludge, scrap metal, spent sand
43	Fertilisers & Pesticides Manufacture	25	wastewater, contaminated bag, return expired products, spent solvent
53	Manufacture of plastic products	24	plastic scrap, packaging
48	Manufacture of other Chemical Products	20	wastewater, sludge, spent resin, match stick, packaging, empty containers
77	Motor vehicle manufacture	15	wastewater, sludge, steel scrap
22	Spinning Weaving & Finishing Textiles	12	wastewater, sludge, polyester scrap, thread scrap, fabric scrap, empty containers
71	Electrical industrial machinery & apparatus, transformer, generator	12	wastewater, sludge, steel scrap
45	Paints, Varnishes & Lacquers Manufacture	11	wastewater, sludge, spent solvent, expired finished product, empty containers
74	Other electrical apparatus & supplies	11	wastewater, heavy metal sludge, metal scrap, slag, damaged electrode, scrap battery casing, empty containers
39	Containers & boxes of paper & paperboard	8	wastewater, sludge, paper scrap, spent solvent, packaging
59	Iron & steel basic industries	7	steel scrap, slag, packaging
68	Special industrial machinery & equipment	7	steel scrap, slag, packaging, empty containers
28	Wearing Apparel-except Footwear	6	fabric scrap, thread scrap, packaging
33	Footwear Manufacture-Except Rubber & Plastic	6	leather scrap, packaging
44	Synthetic Resins, Plastics & Fibres	6	spent solvent, packaging, empty containers
78	Motorcycles, tricycles, bicycles & parts	6	metal scrap, plastic scrap, packaging
32	Leather & Fibre Products-Except Wearing Apparel	5	leather scrap, sponge scrap, filament scrap, packaging
37	Furniture, fixtures & floorings-except by metal & plastic	5	wood scrap, saw dust, leather scrap, fabric scrap, empty containers, packaging

Note : Some factories can be identified more than one type of MOI code

Table 4-2 Summary of waste generated by each industrial code from factories in General Industrial Zone (GIZ) of Bangpoo Industrial Estate (cont'd)

MOI Code	Type of industry	No. of factories	Type of Waste
46	Drugs & Medicine Manufacture	5	wastewater, sludge, expired medicine, empty containers
63	Structural metal products manufacture	5	wastewater, sludge, metal scrap, spent acid, spent base
72	Radio, television & communication equipment	5	capacitor element, zinc powder, wire scrap, solder scrap
91	Packing Operations-No Production Activity	5	wastewater, sludge, empty container, packaging
40	Other pulp, paper & paperboard articles	4	paper scrap, diaper scrap, packaging
41	Printing, publishing & allied industries	4	wastewater, sludge, paper scrap, PP scrap, ink waste, spent solvent, empty containers
47	Soaps, Cleansers, Cosmetics, Toiletries, etc.	4	wastewater, sludge, empty containers
58	Other Non-metallic Mineral Products	4	spent solvent, concrete waste, empty containers
73	Electrical appliances & housewares	4	steel scrap packaging
89	Gas Manufacture & Distribution	4	spent oil, spent molecular sieve
5	Manufacture of Dairy Products	3	wastewater, sludge, packaging
6	Fish, Shellfish & Seafood (Canning etc.)	3	wastewater, sludge, fish tissue & bone, shrimp head & shell
10	Manufacture of Baked & Steamed Products from starch	3	wastewater, sludge, bread scrap, empty containers
27	Manufacture of other textiles	3	fibre scrap, non-woven scrap, packaging
61	Cutlery, hand tools & general hardware	3	steel scrap, packaging
65	Manufacture/repair of engines & turbines	3	wastewater, sludge, metal scrap, cable scrap, spent solvent, asbestos scrap, empty containers
4	Slaughtering, Preparing & Preserving Meat	2	wastewater, sludge, egg shell
8	Fruits, Vegetables (Canning & Preserving)	2	wastewater, sludge, empty containers, packaging
13	Dressings & Food ingredients	2	wastewater, sludge, vegetable scrap, empty containers
23	Made-up Textile Goods-Except Wearing Apparel	2	fabric scrap, silk cotton
29	Leather Tanning, Currying, Finishing, etc.	2	wastewater, sludge, hide scrap, leather scrap
34	Wood processing	2	wood waste, saw dust
36	Other wood and cork products	2	wood waste, saw dust

Note : Some factories can be identified more than one type of MOI code

Table 4-2 Summary of waste generated by each industrial code from factories in General Industrial Zone (GIZ) of Bangpoo Industrial Estate (cont'd)

MOI Code	Type of industry	No. of factories	Type of Waste
51	Tires & inner tubes, including repairs	2	tyre scrap, empty containers, packaging
52	Manufacture of other rubber products	2	rubber scrap, empty containers
54	Glass & Glass Products Manufacture	2	cullet, used oil, empty containers
67	Wood & metal working machinery	2	steel scrap, packaging
81	Scientific & Medical instrument and equipment	2	metal scrap
87	Manufacture of other Products not classified	2	plastic scrap, empty containers, packaging
2	Miscellaneous Agricultural Activities	1	dust, packaging
7	Manufacture Vegetable and Animal Fat & Oils	1	N/A
15	Manufacture of Prepared Animal Feeds	1	wastewater, sludge, packaging
24	Knitting mills	1	wastewater, sludge, filament scrap, empty containers, packaging
25	Carpets & rugs-except from rubber & plastic	1	wastewater, sludge, fibre scrap, empty containers, packaging
31	Manufacture of Fur & Skin Rugs, Mats. etc.	1	N/A
50	Miscellaneous products of petroleum & coal	1	asphalt scrap, empty container, packaging
55	Pottery Manufacture	1	wastewater, heavy metal sludge, zinc alloy scrap
62	Furniture & fixtures primarily of metal	1	brass scrap
70	Other machinery/equipment/except electrical	1	metal scrap
82	Photographic & Optical Goods	1	cullet
83	Clocks & Mechanism for Timing Devices	1	N/A
97	Repair of other Types not Classified	1	N/A
100	Finishing or modifying product or component without production	1	paint sludge, empty containers

Note : Some factories can be identified more than one type of MOI code

Table 4-3 Summary of waste generated by each industrial code from factories in Export Processing Zone (EPZ) of Bangpoo Industrial Estate

MOI Code	Type of industry	No. of factories	Type of waste
53	Manufacture of plastic products	9	plastic scrap, packaging
72	Radio, television & communication equipment	7	wastewater, sludge, spent solution, spent acid, spent base, metal scrap, empty containers
32	Leather & Fibre Products-Except Wearing Apparel	6	leather scrap, sponge scrap, filament scrap, packaging
33	Footwear Manufacture-Except Rubber & Plastic	5	leather scrap, packaging
87	Manufacture of other Products not classified	5	plastic scrap, packaging
64	Other fabricated metal products	4	wastewater, sludge, steel scrap, plastic scrap, spent base
69	Office, computing & accounting equipment	4	toner powder, containers, packaging
86	Sporting & Athletic Goods Manufacture	4	rubber scrap, leather scrap, spent solvent, empty containers
48	Manufacture of other Chemical Products	2	toner powder, containers, packaging
84	Jewellery & Related articles Manufacture	2	wastewater, heavy metal sludge, spent degreaser, spent plated solution, metal scrap
6	Fish, Shellfish & Seafood (Canning etc.)	1	wastewater, sludge, edible oil, food waste
23	Made-up Textile Goods-Except Wearing Apparel	1	N/A
28	Wearing Apparel-except Footwear	1	Leather scrap, packaging
37	Furniture, fixtures & floorings-except by metal & plastic	1	leather scrap, sponge scrap, fabric scrap
52	Manufacture of other rubber products	1	rubber scrap, empty containers
54	Glass & Glass Products Manufacture	1	fibre-glass scrap, empty containers
55	Pottery Manufacture	1	stainless steel scrap, cullet
67	Wood & metal working machinery	1	N/A
71	Electrical industrial machinery & apparatus, transformer, generator	1	wire scrap, spent vanish, empty containers
73	Electrical appliances & housewares	1	N/A
74	Other electrical apparatus & supplies	1	cullet, empty containers
81	Scientific & Medical instrument and equipment	1	plastic scrap, empty containers

Note : Some factories can be identified more than one type of MOI code

If qualities of wastewater is higher than standards one time but not more than 1.5 times,  $C_p^*$  can be calculated by using the following equation.

$$C_p^* = 3(C_g + C_f + C_v)$$

$$\begin{aligned} \text{where } C_g &= 100 \\ C_f &= 4.8V_i \\ C_v &= 9.43 V_i S_i / 1000 \end{aligned}$$

If qualities of wastewater is higher than standards 1.5 times,  $C_p^*$  can be calculated by using the following equation.

$$C_p^* = 5(C_g + C_f + C_v)$$

Since standards of wastewater discharged to central waste water treatment plant of Bangpoo Industrial Estate are specified, some industries such as dyeing factory, plating industries, food industries or chemical manufacturer have to treat their wastewater to meet these standards before sending it to central wastewater treatment plant. If their discharged wastewater do not meet the requirement set by Bangpoo Industrial Estate, they have to pay additional fee calculated by above equation.

Minimum wastewater fee per cubic metre per month ( $T_c'$ ) which factory has to pay calculated based on  $BOD_5$  equal to 20 mg/l is

$$\begin{aligned} T_c' &= 100 + 4.8 \cdot 1 + 9.48 \cdot 20 / 1000 \\ &\cong 105 \text{ Baht/m}^3/\text{month} \end{aligned}$$

Information from Bangpoo Industrial Estate reveal that there are three central wastewater treatment plants. One plant is only used for treatment of wastewater from factories located in EPZ. This plant is Rotating Biological Contact System (RBC). Designed capacity of this plant is 2,300 m<sup>3</sup>/d. At present average flow rate to this plant is approximately 2,000 m<sup>3</sup>/d. The others are used for treatment of wastewater from factories located in GIZ and commercial area. The system of one plant is aerated lagoon which has capacity of 23,000 m<sup>3</sup>/d. There is approximately 3,000 m<sup>3</sup>/d of wastewater treated by this plant. Amount of wastewater treated by this plant is higher than design capacity of this plant. IEAT has plan to upgrade this plant in the future in order to improve the efficiency of this plant. Another is activated sludge system which has capacity of 3,600 m<sup>3</sup>/d. At present, approximately 55 m<sup>3</sup>/d of wastewater treated by this plant. This plant will only treat wastewater from factories located in expansion area A which is in GIZ. There are 17 factories in this area.

According to the standards of wastewater discharged to central wastewater treatment plant, insecticide is not allow to discharge to the sewer system. Consequently, Some factories who produce insecticides have incinerators to burn contaminated raw material containers, returned expired products or wastewater contaminated with insecticides or sent to off-site facilities treatment facilities.

### *Solid wastes*

Most Solid wastes such as sludge contaminated with heavy metals will be sent to General Environmental Conservation Co., Ltd. (GENCO) for further treatment at Samaedam Treatment Plant or Ratchaburi Secured Landfill Site. This Company is owned by private company; GCN Holding Co., Ltd., Map Ta Put Industrial Estate, and Department of Industrial Work (DIW) of Ministry of Industry. It is the operator to handle hazardous waste at both mentioned sites. Costs of treatment of solid waste by GENCO depend on types of contaminants in that waste. Table 4-4 shows treatment cost of each solid waste.

*Table 4-4 Service fee of Waste treatment by GENCO*

Type of Waste	Service fee (Baht/ton)	Loading fee (Baht/ton)
Wastewater from dyeing factory	105	30
Sludge	755	300
Waste water from metal plating factory	145	30
Transportation fee from factory to Samaedam Treatment Plant	-	2.75 (Baht/ton/km.)
Transportation fee from Samaedam Treatment Plant to Ratchaburi Landfill site	-	288
Wastewater pumping fee	-	30
Tank rental	-	125 (Baht/unit/day)
Landfill fee	-	874

*Source : Industrial Authority of Thailand, 1998*

There are two incinerators for burning general solid wastes generated from factories in Bangpoo Industrial Estate. One is used for waste generated from factories located in EPZ which has capacity of 250 kg/hr. Another is used for factories located in GIZ which has capacity of 750 kg/hr. These

incinerators are operated by Bangpoo Industrial Estate. If any factory would like to use this service, it has to pay the fee. This fee is 3,500 Baht/ton.

Most factories do not use the service of Bangpoo Industrial to burn general solid waste since cost of treatment is higher than landfill cost which is operated by municipality, sanitary districts, or private companies. Landfill cost of general solid waste is 168 Baht/m<sup>3</sup> or 840 Baht/ton (assume density of general solid waste is 0.2 t/m<sup>3</sup>). And factory has to pay another cost i.e. tank rental which is 420 Baht/unit/month. Reports from Pollution Control Department in Environmental Qualities Report show that there is always illegal dumping of hazardous waste with general solid waste at landfill site.

Information from factory survey and Department of Industrial Work, Ministry of Industry reveal that many factories try to sell their solid waste, if possible. These solid wastes are scrap steel and other metals, scrap plastic, scrap paper, spent lubricant oil, containers, and some sludge which contained heavy metal such as metal sludge, and lead sludge. Some wastes are donated to some people who want to use that wastes such as wood pallet. Most wastes are sold to agencies or brokers who collect wastes from many sources before selling to the waste users. Some wastes are directly sold to waste recyclers such as used oil, and spent solvents.

### Waste quantities and quality

Information of both types of waste and quantities from interview, secondary data, and questionnaire are summarised and kept in the file industrial information in Bangpoo Industrial Estate.mdb. Details how to retrieve information from this file are explained in Chapter 6 Database System.

Not all factories corporated in giving all required information. Some factories are willing to give the information but they do not record or have incomplete information. From these reasons, there are some amounts of factories which are not included in the analysis. Lists of factories which cannot be included in the analysis are shown in Appendix H.

Above problems may be overcome by using waste unit generation rate i.e. unit of waste/unit of raw material/year, unit of waste/unit of product/year, or unit of waste/employee/year to estimate wastes base on figure from factories in the same industrial category, or the same type of product. Waste unit generation rates used to calculate waste from some factories are shown in Appendix J.

There are still some problems in estimation of wastes by using unit generation rate. This estimation can be done only for wastes generated from the production processes. Packaging or empty containers cannot be estimated by using the this approach. Furthermore, some factories can be categories in

more than one industrial code. This code is specified based on type of production process or type of product. If information regarding portion of each production process or finished product is not available, waste cannot be estimated by using unit generation rate.

Unit generation rate can be calculated from unit generation rate of all factories in the same industrial category or the same types of product which have information and then average all these value by the following equation.

$$\bar{x} = \frac{\sum_{i=1}^n x_i}{n}$$

where  $\bar{x}$  = average value, unit is the same as the unit of x  
 $x$  = Unit generation rate of each factory  
 $n$  = number of factory  
 $i$  = factory 1,2,3,...,n

### Demand and Supply of waste

From the collected information, there are 11 factories which use wastes as raw materials. These factories are listed in the Table 4-5.

*Table 4-5 Lists of Factories in Bangpoo Industrial Estate which use waste as raw material*

Company	Type of waste	Quantity (t/y)	Type of product
1. Evergreen Textile Co., Ltd.	Cotton scrap	3,780	Thread
2. Mae Mae Industrial Co., Ltd.	Fabric scrap	3	Sign, Paper box, Sticker
3. Metropolis Development Engineering Co., Ltd.	Steel scrap	480	Casting products
4. Ocean Glass Public Co., Ltd.	Cullet (glass scrap)	15,990	Glassware
5. Ocean Sasaki Glass Public Co., Ltd.	Cullet (glass scrap)	7,614	Glassware
6. PSC Recondrum Co., Ltd.	Used 200 l Steel drum	300,000 (unit/y)	New steel tank
7. PT Brothers Industries Co., Ltd.	Polyester scrap, Nylon scrap	30, 20 respectively	Board



Table 4-3 Lists of Factories in Bangpoo Industrial Estate which use waste as raw material (cont'd)

Company	Type of waste	Quantity (t/y)	Type of product
8. Siam IKK Co., Ltd.	Steel scrap	1,000	Steel shot, steel grit
9. Siam Kraft Industry Co., Ltd.	Paper scrap	20,000	Pressed paper for recycled
10. Soot Suwan Co., Ltd.	Aluminium scrap	60	Aluminium bar
11. SPI Feed Co., Ltd.	Fish tissue scrap, soybean sludge, and shrimp shell & head	975, 450, 450 respectively	Pet food
12. Steel Thai Development Co., Ltd.	Steel scrap	165,000	Billet
13. Sundy Co., Ltd.	PVC scrap	12	PVC fittings
14. Thai Negero Co., Ltd.	PET scrap	3,000	Carpet
15. Thai United Glass Fibre Co., Ltd.	Glass scrap	2,640	Glass fibre sheet
16. Thai Win Fibre Industries Co., Ltd.	Polyester scrap	2,400	Polyester filament
17. Tong Nam Industrial (Thailand) Co., Ltd.	Cotton scrap	70	Fabric

As explained above, most factories try to sell their wastes as much as possible. Hence, there are supplies of waste available enough. Wastes which can be sold or donated in Bangpoo Industrial Estate are :

- steel scrap;
- stainless steel scrap;
- copper scrap;
- brass scrap;
- aluminium scrap;
- paper scrap and paper box;
- plastic scrap;
- leather/synthetic leather scrap;
- foundry sand;
- spent oil/lubricant;
- fish tissue/bone/head;
- shrimp head/shell;

- wood piece and particle board scrap;
- paper/plastic bag;
- plastic/steel tank;
- used towel;
- spent solvent;
- spent paint;
- flour scrap;
- sludge contained heavy metals;
- lead scrap;
- battery casing;
- polyester scrap;
- fabric scrap;
- cotton scrap;
- thread scrap
- carpet scrap;
- spent catalyst;
- solder scrap;
- non-diary cream scrap;
- zinc dust;
- cable scrap;
- foam scrap;
- sponge scrap;
- rubber scrap; and
- gypsum.

Wastes which have potential to be exchanged among factories in Bangpoo Industrial Estate are spent acid, and spent base.

Factors which have an effect on the demand and supply of waste materials from the survey are summarised as follow:

#### **Demand side**

- *Reduction in production costs* If contribution cost of raw materials is high, potential to use waste as raw material will be high.

- *Continuous supply of waste materials* If supply of waste is not continuously, it cause difficulty to waste users in production planning. Possibilities of waste users to consider waste as a raw material will be reduced;

- *Quality of waste materials* If there are many contaminants in wastes so that purifying or separation techniques will be required to modify wastes for further using. ; and

- *Procurement problems* If potential users have to buy waste materials from many waste generators to acquire the desired quantity, it may cause

some difficulties to waste users. These difficulties may reduce the interest in consideration of waste as raw materials.

### Supply side

- *Gained benefits from reuse or recycling waste* If the benefits gain from reuse or recycling of wastes is not high enough when it is compared with benefits from traditional methods, waste generators will not interest to change their traditional waste management;

- *Environmental laws and regulations* New laws and regulations regarding hazardous wastes and non-hazardous wastes are currently used, this make waste generators to clearly specify their wastes whether they are hazardous or non-hazardous wastes. When type of wastes is known, they have to be treated by methods specified in the Notifications of Ministry of Industry. These new laws and regulations allow waste generators to reuse or recycle wastes. However, reuse or recycle of waste has to obtain the permission from Ministry of Industry. For example, Ministry of Industry do not allow waste generator to burn their used oil or spent solvent in boiler since this method may create air pollution problems.

Table 4-6 to Table 4-24 list factories who can supply wastes such as scrap steel, stainless steel, copper, aluminium, plastic, and empty containers.

Table 4-6 List of factory which can supply PP scrap

Factory Name	Type of Waste	Quantity (t/y)
ABB Capacitor Co., Ltd.	PP film scrap	1.5
Agri Pack Co., Ltd.	PP scrap	6
Bamco (Thailand) Co., Ltd.	PP scrap	0.468
Eastern Abric International Co., Ltd.	PP scrap	1.5-4.5
ES Manufacturing Co., Ltd.	Battery casing (PP)	2.4
Kokuyo IK (Thailand) Co., Ltd.	PP scrap	10.2-30.6
Siam Chokboonma Co., Ltd.	Battery casing (PP)	15
Srithai Superware Public Co., Ltd.	Battery casing (PP)	16.8
Thai Storage Battery Public Co., Ltd.	Battery casing (PP)	27

Table 4-7 List of factory which can supply PVC scrap

Factory Name	Type of Waste	Quantity (t/v)
ACT Leather (Thailand) Co., Ltd.	PVC scrap	36
Applied Chemical Industry Co. Ltd.	PVC scrap	60
Ase Co., Ltd.	PVC scrap	15.12
Ho Thai Plastic Co., Ltd.	PVC scrap	1.5-4.5
May Ao Food Co., Ltd.	PVC pipe	1.44
Thai Fukuvi Co., Ltd.	PVC scrap	60
Thai Ho Sheng Packing Co., Ltd.	PVC scrap (black)	14.4
Thai Ho Sheng Packing Co., Ltd.	PVC scrap (clear)	12
Triump Tree Co., Ltd.	PVC scrap	108

Table 4-8 List of factory which can supply polyethylene scrap

Factory Name	Type of Waste	Quantity (t/y)
Apple Film Co., Ltd.	LDPE scrap	123.6-370
Bamco (Thailand) Co., Ltd.	LDPE scrap	0.624
MC Plastic Co., Ltd.	LDPE scrap	2-6
MC Plastic Co., Ltd.	LLDPE scrap	2-6
MC Plastic Co., Ltd.	HDPE scrap	9-27
Maxi Plast Co., Ltd.	HDPE scrap	6.26
Siam Sunrise Enterprises Co., Ltd.*	PE scrap	0.891

Note : \* This factory is located in EPZ.

Table 4-9 List of factory which can supply other plastic scrap

Factory Name	Type of Waste	Quantity (t/v)
Crown Cork and Seal (Thailand) Co., Ltd.	Plastic scrap	7
Macro Cutting Board Co., Ltd.*	Plastic scrap	10-30
Nestle Asian (Thailand) Co., Ltd.	Plastic scrap	1.92
Nestle Manufacturing (Thailand) Co., Ltd.	Plastic scrap	1.92
NHK Spring (Thailand) Co., Ltd.	Plastic scrap	74.4
Paibul EPC Co., Ltd.	Plastic container	1.2
Sew Lamination Co., Ltd.	Plastic scrap	4
Siam Tableware Co., Ltd.*	Plastic scrap	11.5
SIK (Thailand) Co., Ltd.	Plastic scrap	120
TIK Manufacturing Co., Ltd.	Plastic scrap	3
Thai Cast Film Co., Ltd.	Plastic scrap	48

Note : \* This factory is located in EPZ.

Table 4-10 List of factory which can supply leather scrap

Factory Name	Type of Waste	Quantity (t/y)
ACT Leather (Thailand) Co., Ltd.	Leather	28.8
Ase Co., Ltd.	Leather	13.44
Diamond Leathercraft Co., Ltd.*	Leather	10.32
NHK Spring (Thailand) Co., Ltd.	Leather	96
Simon and Associate Co., Ltd.	Leather	8.8
Srithai Autoseat Industry Co., Ltd.	Synthetic leather	0.5
Thai Simon Safety Industries Co., Ltd.	Leather	18
Tilico Co., Ltd.*	Leather	4.5
Tilico Co., Ltd.*	Synthetic leather	4.5

Note : \* This factory is located in EPZ.

Table 4-11 List of factory which can supply spent solvent

Factory Name	Type of Waste	Quantity (l/y)
Compast East Industry Public Co., Ltd.	Spent solvent	7,620
Crown Cork and Seal (Thailand) Co., Ltd.	Spent lacquer	3,200
Cabin Paint Industry Partnership Ltd.	Spent thinner	2,400
Mattel Bangkok Co., Ltd.	Spent solvent	4,500
Srithai Autoseat Industry Co., Ltd.	Spent thinner	882
Vegaball Manufacturing Co., Ltd.	Toluene	1,500
WR Grace Co., Ltd.	Spent thinner	24,500

Table 4-12 List of factory which can supply aluminium scrap

Factory Name	Quantity (t/y)
ABB T&D Co., Ltd.	0.8
Airtech Industry Co., Ltd.	3
Crown Cork & Seal Co., Ltd.	11.132
May Ao Food Co., Ltd.	0.36
Sootsuwan Co., Ltd.	8.4-25.2
Thai Fujioka Co., Ltd.	0.6
Thai Refrigeration Components Co., Ltd.	336
Yen Tung Industrial (Thailand) Co., Ltd.*	5

Note : \* This factory is located in EPZ.

Table 4-13 List of factory which can supply stainless steel scrap

Factory Name	Type of Waste	Quantity (t/y)
Advance Stainless Steel Co., Ltd.	Stainless steel scrap	3-9
Chiao Pao Metal Co., Ltd.	Stainless steel wire scrap	7.25-21.75
Dura Fasteners Co., Ltd.*	Stainless steel scrap	70
Kijthaworn Co., Ltd.	Stainless steel wire scrap	4 -12
May Ao Food Co., Ltd.	Stainless steel scrap	0.72
Nas Toa (Thailand) Co., Ltd.	Stainless steel scrap	60
NHK Gasket (Thailand) Co., Ltd.	Stainless steel scrap	5.4
Siam Tableware Co., Ltd.*	Stainless steel scrap	360
Thai Nishe Co., Ltd.	Stainless steel scrap	51.5-154.4
Thai Sesen Co., Ltd.	Stainless steel wire scrap	3.6
TTA Co., Ltd.*	Stainless steel scrap	15

Note : \* This factory is located in EPZ.

Table 4-14 List of factory which can supply copper scrap

Factory Name	Quantity (t/y)
ABB Distribution Co., Ltd.	3.24
ABB T&D Co., Ltd.	2.3
Airtech Industry Co., Ltd.	50.05
NHK Gasket (Thailand) Co., Ltd.	0.6
Schneider (Thailand) Co., Ltd.	1.8-5.4
Sew Lamination Co., Ltd.	1
Siam Electric Industry Co., Ltd.	960
SPC Electric Co., Ltd.	0.12-0.36
Tasco Trafo Co., Ltd.	0.23
Thai Nikko Metal Industry Co., Ltd.	1.2
Thai Union Switchboard Co., Ltd.	15
Tira Thai Co., Ltd.	1.15
Vana Switchboard Co., Ltd.	1
Wo Pornsin Industry Co., Ltd.	2.16

Table 4-15 List of factory which can supply galvanised steel scrap

Factory Name	Quantity (t/y)
General Rollform Co., Ltd.	5
Thai Nishe Co., Ltd.	30.9-92.8

Table 4-16 List of factory which can supply steel scrap

Factory Name	Quantity (t/y)
ABB Distribution Co., Ltd.	19.2
ABB T&D Co., Ltd.	5
Airtech Industrv Co., Ltd.	0.1
Ampas Industry Co., Ltd.	120
Asia Fibre Public Co., Ltd.	4.8
Bangkok Teapo Electronic Co., Ltd.	2.4
Buriboon Steel Industry Ltd.	500-1,500
Central Metal Co., Ltd.	960
Chin I Metal Co., Ltd.*	12
Construction Cost Consultant Partnership Ltd.	0.032-0.096
Crown Cork and Seal (Thailand) Co., Ltd.	175.59
Daiwa Circuit Module (Thai) Co., Ltd.	15.6-46.8
Ito (Thailand) Co., Ltd.	240
Hong Yang (Thailand) Co., Ltd.	0.84-2.52
Hwa Fong Rubber (Thailand) Co., Ltd.	8.4
Kallawis Auto Parts Industry Co., Ltd.	100-300
King Fisher Holdings Co., Ltd.	2,000
Kobe Migwire Co., Ltd.	43-129
KSP Industry Co., Ltd.	14.7
Lunesa Iron Wire Factory Co., Ltd.	30-90
Matsui (Asia) Co., Ltd.	18
May Ao Food Co., Ltd.	2.16
Meisei (Thailand) Co., Ltd.	15.1-45.3
New Bangpoo Manufacturing Co., Ltd.	480
Nestle Asian (Thailand) Co., Ltd.	2.88
Nestle Manufacturing (Thailand) Co., Ltd.	4.32
NHK Gasket (Thailand) Co., Ltd.	12
NHK Spring (Thailand) Co., Ltd.	60
Pan Mechanic Engineering Co., Ltd.	13-39
Pantila Co., Ltd.	3.4-10.2
Phillip Electronics (Thailand) Co., Ltd.	0.12
PSC Recondrum Co., Ltd.	10
PSC Steeldrum Co., Ltd.	11
Raja Engineering Co., Ltd.	11-33
Samart Machinery Co., Ltd.	6
Sangasee Thai Co., Ltd.	330-990
Schneider (Thailand) Co., Ltd.	3.6-10.8
Shinpack (Thailand) Co., Ltd.	29.8

Note : \* This factory is located in EPZ.

Table 4-16 List of factory which can supply steel scrap (cont'd)

Factory Name	Quantity (t/y)
Siammetic Co., Ltd.	6
SPC Electric Co., Ltd.	3-9
Srithai Autoseat Industry Co., Ltd.	4.3
Srithai Miyakawa Co., Ltd.	0.26
Sunstar Engineering (Thailand) Co., Ltd.	14 -42
Tasco Trafo Co., Ltd.	0.6
Tira Thai Co., Ltd.	2.3
Thai Corrugate Co., Ltd.	1-3
Thai Fujioka Co., Ltd.	12
Thai International Die Making Co., Ltd.	3,000
Thai Kobe Welding Co., Ltd.	55.6
Thai Match Co., Ltd.	1.2
Thai Nikko Metal Industry Co., Ltd.	6
Thai Steel Products Co., Ltd.	2.4
Thai Union Switchboard Co., Ltd.	9
Thai Universal Office Products Co., Ltd.	120
Thonburi Oxygen Co., Ltd.	120
Tong Nam Industrial (Thailand) Co., Ltd.	100
Toyo Fastener (Thailand) Co., Ltd.*	112
Tri Petch Isuzu Sales Co., Ltd.	60
Triump Tree Co., Ltd.	10.8
Universal Steel Drum Co., Ltd.	30.5-91.5
Valcao Industries (Thailand) Co., Ltd.	14
Vana Switchboard Co., Ltd.	2
Wo Pornsin Industry Co., Ltd.	14.4
Zeneka Agro Asiatic Co., Ltd.	6

Note : \* This factory is located in EPZ.

Table 4-17 List of factory which can supply polyester scrap

Factory Name	Type of Waste	Quantity (t/y)
Asia Fibre Public Co., Ltd.	Polyester filament scrap	600
Herei Co., Ltd.	Polyester yarn scrap	4.2
Shinih (Thailand) Co., Ltd.	Polyester scrap	84
Thaiwin Fibre Industry Co., Ltd.	Filament scrap	120



*Table 4-18 List of factory which can supply cotton scrap*

Factory Name	Type of Waste	Quantity (t/y)
Evergreen Textile Co., Ltd.	Cotton scrap	1,260
Tong Nam Industrial (Thailand) Co., Ltd.	Cotton scrap	900

*Table 4-19 List of factory which can supply fabric/thread scrap*

Factory Name	Type of Waste	Quantity (t/y)
Asia Fibre Public Co., Ltd.	Warp scrap	180
Asia Fibre Public Co., Ltd.	Fabric scrap	420
Bangkok Vanicha Textile Co., Ltd.	Thread scrap	16.4
Bangkok Vanicha Textile Co., Ltd.	Fabric scrap	2.2
Bangpoo Fashion Co., Ltd.	Fabric/Thread scrap	12
Evergreen Textile Co., Ltd.	Thread scrap	6
Kasama Toys Co., Ltd.	Fabric scrap	0.0682
Rueng Siam Industry Co., Ltd.	Fabric scrap	7.2
Siam United Textile Industry Co., Ltd.	Thread scrap	2.5
Suntex Industrial Co., Ltd.	Fabric/Thread scrap	15.36
Thai Simon Safety Industries Co., Ltd.	Thread scrap	2.52
Tong Nam Industrial (Thailand) Co., Ltd.	Fabric scrap	60
Tong Nam Industrial (Thailand) Co., Ltd.	Thread scrap	310
WA Industry Co., Ltd.	Fabric/Thread scrap	51.75
Wonderful Apparel Industries Co., Ltd.	Fabric/Thread scrap	33.6
Wonderfulkids Co., Ltd.	Fabric/Thread scrap	33.25

Table 4-20 List of factory which can supply empty steel drum (180 l)

Factory Name	Quantity (unit/y)
Asia Fibre Public Co., Ltd.	2,000
Cemedine (Thailand) Co., Ltd.	180
Clariant Chemicals Co., Ltd.	1,200
Daiversy Thailand Co., Ltd.	2,400
Formosa Organic Chemical Industry Co., Ltd.	3,600
Mae Mae Industrial	480
NHK Spring (Thailand) Co., Ltd.	360
Rhone-Poulenc Agro (Thailand) Co., Ltd.	800
Sew Lamination Co., Ltd.	2,000
Thai International Die Making Co., Ltd.	120
Thai Simon Safety Industries Co., Ltd.	36
Thai Union Switchboard Co., Ltd.	360
Thai Washin Co., Ltd.	200
Thep Siam Co., Ltd.	150**
Thep Watana Chemical Co., Ltd.	120**
WR Grace Co., Ltd.	9,000
Zeneka Agro Asiatic Co., Ltd.	100

Note \*\*This factory has pesticide, insecticide or fungicide as finished product.

Table 4-21 List of factory which can supply wood waste &amp; saw dust

Factory Name	Type of Waste	Quantity (t/y)
ACT Leather (Thailand) Co., Ltd.	Wood waste	54
ACT Leather (Thailand) Co., Ltd.	Saw dust	72
Ase Co., Ltd.	Wood waste	23.52
Ase Co., Ltd.	Saw dust	31.92
Crown Cork and Seal (Thailand) Co., Ltd.	Wood waste	3
Minami and Verbina Industry Co., Ltd.	Saw dust	6,000 (m3/y)
NHK Spring (Thailand) Co., Ltd.	Particle board scrap	120
NHK Spring (Thailand) Co., Ltd.	Wood dust	18
Pato Chemical Industry Public Co., Ltd.	Wood waste	2.4
Samart Machinery Co., Ltd.	Wood waste	3.6
Simon and Associate Co., Ltd.	Saw dust	20.9
Simon and Associate Co., Ltd.	Wood waste	15.4
Thai Bizon Cabinets Co., Ltd.	Saw dust	120 (m3/y)
Thai Match Co., Ltd.	Match stick	9.6
Thai Nikko Metal Industry Co., Ltd.	Wood waste	4.26
Thai Union Switchboard Co., Ltd.	Wood waste	12
Tira Thai Co., Ltd.	Wood waste	0.864

Table 4-22 List of factory which can supply used oil

Factory Name	Type of Waste	Quantity (l/v)
ABB T&D Co., Ltd.	Transformer oil	1,000
Byer Thai Co., Ltd.	Spent lubricant	360
Compast East Industry Public Co., Ltd.	Spent oil	16,764
Global Chemical Co., Ltd.	Spent oil	270
Kamol Air Gas Co., Ltd.	Spent oil	666.67
KSP Industry Co., Ltd.	Spent oil	2,352
Liang Hong Co., Ltd.	Spent lube oil	10,000
NHK Spring (Thailand) Co., Ltd.	Foam scrap	1,200
NHK Spring (Thailand) Co., Ltd.	Spent oil	2,400
Ocean Glass Public Co., Ltd.	Spent lube oil	6,000
Ocean Sasaki Glass Public Co., Ltd.	Spent lube oil	6,000
Siam Oxydental Electrochemical Co., Ltd.	Spent lube oil	1,800
Takahashi Plastic	Spent lube oil	240
Thai Industrial Gas Co., Ltd.	Spent compressed oil	2,400
Thai Oxydental Chemical Co., Ltd.	Spent lube oil	355
Thai Oxydental Chemical Co., Ltd.	Spent gasoline	200
Thai Refrigeration Components Co., Ltd.	Spent lube oil	50
Thai Sesen Co., Ltd.	Spent oil coolant	360
Thonburi Oxygen Co., Ltd.	Spent machine oil	4,000
TIK Manufacturing Co., Ltd.	Spent oil	1,500

Table 4-23 List of factory which can supply spent acid &amp; base

Factory Name	Type of Waste	Quantity (t/v)
Airtech Industry Co., Ltd.	Spent nitric acid	1.75
Airtech Industry Co., Ltd.	Spent NaOH	0.7
Compast East Industry Public Co., Ltd.	Spent acid	733
Compast East Industry Public Co., Ltd.	Spent base	187
Medicap Co., Ltd.	NaOH	0.3
Medicap Co., Ltd.	HCl	0.96
Pacific Manufacturing Co., Ltd.	NaOH	18,000
PSC Coated Steel Co., Ltd.	HCl	24
Senka (Thailand) Co., Ltd.	Hydrochloric acid	0.108
Senka (Thailand) Co., Ltd.	Acetic acid	0.108
Senka (Thailand) Co., Ltd.	NaOH	0.108
Siam Electric Industry Co., Ltd.	NaOH	5.4
Siam Electric Industry Co., Ltd.	HCl	4.5
Thai Sesen Co., Ltd.	Spent nitric acid	0.12

Table 4-24 List of factory which can supply paper scrap

Factory Name	Type of Waste	Quantity (t/v)
ABB T&D Co., Ltd.	Paper scrap	0.2
ACT Leather (Thailand) Co., Ltd.	Paper scrap	10.8
Airtech Industry Co., Ltd.	Paper scrap	0.3
Ase Co., Ltd.	Paper scrap	5
Asia Fibre Public Co., Ltd.	Paper box/bobbin	72
Bamco (Thailand) Co., Ltd.	Paper bag	4.68
Bangkok Teapo Electronic Co., Ltd.	Paper scrap	1.2
Calby Thanawat Co., Ltd.	Paper scrap	2.4
Hwa Fong Rubber (Thailand) Co., Ltd.	Paper scrap	14.4
Jin Mei Paper Co., Ltd.	Paper scrap	15.6
Jin Mei Paper Co., Ltd.	Paper bobbin	156
Mae Mae Industrial	Paper scrap	120
May Ao Food Co., Ltd.	Paper scrap	1.8
Nestle Asian (Thailand) Co., Ltd.	Paper bag	76.8
Nestle Manufacturing (Thailand) Co., Ltd.	Paper bag	72
NHK Spring (Thailand) Co., Ltd.	Paper scrap	36
Paibul EPC Co., Ltd.	Paper box	4
Pato Chemical Industry Public Co., Ltd.	Paper scrap	0.36
Phillip Electronics (Thailand) Co., Ltd.	Paper scrap	109.1
Produra Paint Co., Ltd.	Paper scrap	8.4
Rueng Siam Industry Co., Ltd.	Paper scrap	1.8
Siam Container Industry Co., Ltd.	Paper scrap	9,000
Siam Electric Industry Co., Ltd.	Paper box	12
Siam Printing and Packaging Co., Ltd.	Paper scrap	5,550
Siam Tableware Co., Ltd.*	Paper scrap	240
Siam United Textile Industry Co., Ltd.	Paper scrap	6.5
SIK (Thailand) Co., Ltd.	Paper bag	72
Superior Chemical Industrial (Thailand) Co., Ltd.	Paper scrap	0.36
Suroj Co., Ltd.	Paper scrap	20-60
Tanio Thai Co., Ltd.	Paper box	1.2
Tawana Container Co., Ltd.	Paper scrap	2,400
Thep Siam Co., Ltd.	Paper box	600 (unit/v)
Thai British Security Printing Public Co., Ltd.	Paper scrap	4.74-14.22
Thai Match Co., Ltd.	Paper scrap	18
Thai Nikko Metal Industry Co., Ltd.	Paper scrap	1.2
Thai Nisshin Seifun Co., Ltd.	Paper scrap	3.6
Thai Union Switchboard Co., Ltd.	Paper box	2.4
Thai Watana Panich Press Co., Ltd.	Paper scrap	27-81
Tilico Co., Ltd.*	Paper scrap	0.6
Tira Thai Co., Ltd.	Paper scrap	0.864

Note : \* This factory is located in EPZ.

Table 4-25 List of factory which can supply spent sand

Factory Name	Quantity (t/y)
Metropolis Development Engineering Co., Ltd.	360
Siam IKK Co., Ltd.	180
Toyo Valve Co., Ltd.	450

Table 4-26 List of factory which can supply glass scrap

Factory Name	Type of Waste	Quantity
Thep Siam Co., Ltd.	Glass bottle scrap	10,800 (unit/y)
TTA Co., Ltd.*	Glass scrap	900 (m <sup>3</sup> /y)
Guang Hong Electronic (Thailand) Co., Ltd.*	Glass scrap	45 (t/y)

Note : \* This factory is located in EPZ.

Table 4-27 List of factory which can supply fish and shrimp scrap

Factory Name	Type of Waste	Quantity (t/y)
Frionor (Thailand) Co., Ltd.*	Shrimp head & tail	150
Frionor (Thailand) Co., Ltd.*	Fish head & bone	150
May Ao Food Co., Ltd.	Shrimp shell	1.08
May Ao Food Co., Ltd.	Shrimp tail	0.18
RS Cannery Co., Ltd.	Fish scrap	180 (m <sup>3</sup> /y)
SPI Canning Co., Ltd.	Shrimp head & tail	720
SPI Canning Co., Ltd.	Fish head & bone	720

Note : \* This factory is located in EPZ.

Table 4-28 List of factory which can supply nylon scrap

Factory Name	Type of Waste	Quantity (t/y)
Herei Co., Ltd.	Nylon yarn scrap	8.4
Hwa Fong Rubber (Thailand) Co., Ltd.	Nylon scrap	3.84

Table 4-29 List of factory which can supply other scraps

Factory Name	Type of Waste	Quantity (t/y)
ABB Distribution Co., Ltd.	Cable scrap	1.8
ACT Leather (Thailand) Co., Ltd.	Fibre scrap	7.2
ACT Leather (Thailand) Co., Ltd.	Sponge scrap	90
Ase Co., Ltd.	Fibre scrap	3.36
Ase Co., Ltd.	Sponge scrap	40.32
Calby Thanawat Co., Ltd.	Food scrap	15
Carbotex Co., Ltd.	Nylon fabric scrap	8,000 (m/y)
Chiao Fu Enterprises Co., Ltd.	Sponge scrap	16.2
Citric Acid Industry Co., Ltd.	Gypsum	5,400
Concept Manufacturing Co., Ltd.	Tin scrap	0.06
Concept Manufacturing Co., Ltd.	Lead scrap	0.173
ES Manufacturing Co., Ltd.	Lead scrap	36
ES Manufacturing Co., Ltd.	Lead sludge	0.54
General Rollform Co., Ltd.	Concrete scrap	2
German Bead Wire Industries (Thailand) Co., Ltd.	Brass wire scrap	1.65-4.95
Global Chemical Co., Ltd.	Zinc powder waste	96
Herei Co., Ltd.	SP varn scrap	1.68
Herei Co., Ltd.	Rayon yarn scrap	2.52
Hwa Fong Rubber (Thailand) Co., Ltd.	Outer rubber scrap	395,952 (unit/y)
Hwa Fong Rubber (Thailand) Co., Ltd.	Inner rubber scrap	755,568 (unit/y)
Kamol Air Gas Co., Ltd.	Spent molecular sieve	2.8
Lamsoon Public Co., Ltd.	Bleach powder	20
Lion Tyres (Thailand) Co., Ltd.	Defected rubber tyre	210,000 (unit/y)
Medicap Co., Ltd.	Gelatin/Glycerine	17.5
May Ao Food Co., Ltd.	Meat scrap	0.72
Mattel Bangkok Co., Ltd.*	Zinc alloy ash	40
Minson Enterprises (Thailand) Co., Ltd.*	Sponge scrap	300 (m <sup>3</sup> /y)
Nestle Asian (Thailand) Co., Ltd.	Non-diary cream scrap	8.64
Nestle Manufacturing (Thailand) Co., Ltd.	Non-diary cream scrap	12.96
NHK Spring (Thailand) Co., Ltd.	Sponge scrap	192

Note : \* This factory is located in EPZ.

Table 4-29 List of factory which can supply other scraps (cont'd)

Factory Name	Type of Waste	Quantity (t/y)
Pacific Manufacturing Co., Ltd.	Zinc/Zinc alloy scrap	0.65-1.95
Paibul EPC Co., Ltd.	Solder scrap	0.35
Royal ABP Co., Ltd.	Flour waste	0.1
Senka (Thailand) Co., Ltd.	Isopropyl alcohol	0.36
Senka (Thailand) Co., Ltd.	Formaline	72 (m <sup>3</sup> /y)
Shinih (Thailand) Co., Ltd.	Interlining scrap	10.5
Shinih (Thailand) Co., Ltd.	Non-woven scrap	10.5
Siam Chokboonma Co., Ltd.	Lead scrap	18
Siam Chokboonma Co., Ltd.	Lead sludge	7.2
Siam Electric Industry Co., Ltd.	Vanich	24
Siam Printing and Packaging Co., Ltd.	Ink waste	4.8
Siam Sunrise Enterprises Co., Ltd.*	Rubber gasket scrap	14.85
Siam Sunrise Enterprises Co., Ltd.*	Rubber scrap	1.485
Sicpa (Thailand) Co., Ltd.	Ink waste	51.2
Simon and Associate Co., Ltd.	Sponge scrap	26.4
Srithai Autoseat Industry Co., Ltd.	Sponge scrap	0.05
Srithai Superware Public Co., Ltd.	Lead scrap	252
Srithai Superware Public Co., Ltd.	Lead sludge	3.36
Thai Industrial Gas Co., Ltd.	Catalyst	0.04
Thai Kawaken Co., Ltd.	Spent Ni catalyst	10.8
Thai Negoro Co., Ltd.	Filament scrap	120
Thai Negoro Co., Ltd.	Carpet scrap	12
Thai Storage Battery Public Co., Ltd.	Lead scrap	384
Thai Storage Battery Public Co., Ltd.	Lead sludge	6
Thai Union Switchboard Co., Ltd.	Solder core scrap	0.6
The Concrete Product and Aggregate Co., Ltd.	Concrete scrap	960
Tilico Co., Ltd.*	Sponge scrap	1.5
Tilico Co., Ltd.*	Synthetic filament	1.5
Udom Pipat Monkol Partnership Ltd.	Rubber scrap	12
Uenofine Chemicals Co., Ltd.	Sorbitol	30
Vana Switchboard Co., Ltd.	Cable scrap	1
Watyl Dimet (Siam) Co., Ltd.	Xylene, MEK	19,200 (l/y)
Watyl Dimet (Siam) Co., Ltd.	Low quality paint	2,400 (l/y)
Wo Pornsin Industry Co., Ltd.	Lacquer	200 (l/y)
Wo Pornsin Industry Co., Ltd.	Brass scrap	4.8

Note : \* This factory is located in EPZ.

Table 4-30 Summary of quantities of waste supplied from factories in Bangpoo Industrial Estate

Type of Waste	Quantity (t/y)
PP scrap	80.868-104.268
PVC scrap	308.46-311.46
LDPE scrap	126.224-376.624
LLDPE scrap	2-6
HDPE scrap	15.26-33.26
PE scrap	0.891
Other plastic scrap	282.94-302.94
Synthetic leather scrap	5
Leather scrap	179.86
Spent solvent	88.002
Aluminium scrap	365.292-383.092
Stainless steel scrap	580.47-711.87
Copper scrap	1,039.85-1,043.69
Galvanized steel scrap	35.9-97.8
Steel scrap	8,469.87-12,440.07
Polyester scrap	808.2
Cotton scrap	2,160
Fabric scrap	510.4682
Fabric/ Thread scrap	663.38
Empty steel drum (180 l)	22,106 (unit/y)
Wood waste	249.644
Saw dust	1,917.62
Spent oil	36,707.67
Spent acid	764.546
Spent base	18,193.508
Paper scrap	17,917.424-18,020.904
Spent sand	990
Glass scrap	1,847.16
Shrimp head & tail	871.26
Fish scrap	966.3
Nylon scrap	12.24
Cable scrap	2.8
Sponge	414.47
Fibre scrap	12.06
Brass scrap	6.45-9.75
Gypsum	5,400
Lead scrap	690.173
Lead sludge	17.1



Table 4-30 Summary of quantities of waste supplied from factories in Bangpoo Industrial Estate (cont'd)

Type of Waste	Quantity (t/y)
Food waste	37.42
Bleach powder	20
Solder scrap	0.95
Ink waste	56
Zn alloy scrap	40.65-41.95
Zn powder waste	96
Rubber scrap	164.487
Sorbitol	30
Low quality paint	2.4
Spent catalyst	10.84
Concrete waste	962
Formaline	72
Gelatine/Glycerine	17.5
Others	19.42

There are existing networks in Bangpoo Industrial Estate to exchange finished products, by-products, or wastes between factories. The followings are the list of existing networks.

- Lamsoon Public Co., Ltd. sends empty bottle scrap to Sundry Co., Ltd. for PVC fitting making.
- Siam Container Industry Co., Ltd. sends waste paper to Siam Craft Co., Ltd. to compact it before sending to recycle.
- Siam Oxydental Co., Ltd. sends sodium hydroxide 50% and 32%, hydrochloric acid 35%, sodium hyprochorite 10% to BS International Co., Ltd. and Banharn Silapaachar's factory for repackaging.
- Siam Oxydental Co., Ltd. sends hydrogen gas to Thai Industrial Gas Co., Ltd. for purifying and filling in containers.
- SPI Canning Co., Ltd. sends shrimp shell, and fish tissue to SPI Feed Co., Ltd. for making shrimp foods.
- Thonburi Oxygen Co., Ltd. sends some portion of product i.e. oxygen to Steel Thai Development Co., Ltd. to produce billet from steel scrap.
- TS Chemical Co., Ltd. sends glycerine to Thai Kawaken Co., Ltd. to concentrate and purify for making finished products.

### Proposed Waste Exchange Models

To consider the possibilities of exchanging waste from factories in Bangpoo Industrial Estate with other factories in other industrial estate, there are many factors involve. These factors are

- types of industry;
- transportation costs;
- quality and quantity of waste;
- waste value; and
- production processes.

The possibilities of matching industries which located in Bangpoo Industrial Estate can be considered in two ways. One is considering factories in GIZ and EPZ separately in order to reduce the complexities of custom matter. The other is to consider factories in both GIZ and EPZ as a whole.

In first choice the proposed models of exchanging wastes are shown in Figure 4-1 to Figure 4-14.

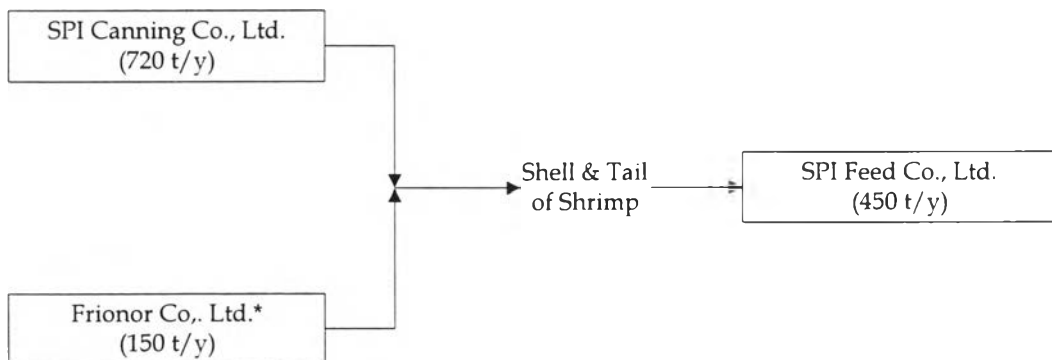


Figure 4-1 Proposed exchange model for wastes from shrimp frozen manufacturers in Bangpoo Industrial Estate

Note : \* This factory is located in EPZ.

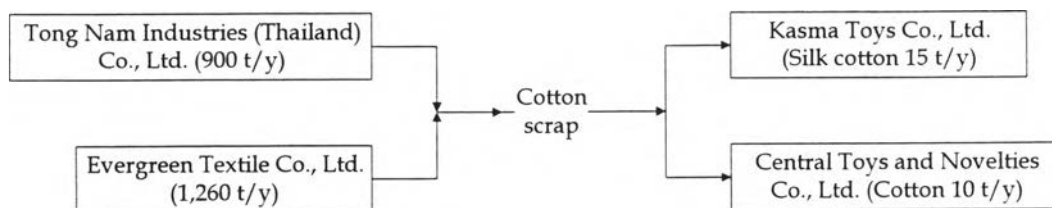


Figure 4-2 Proposed exchange model for cotton scrap from factories in Bangpoo Industrial Estate

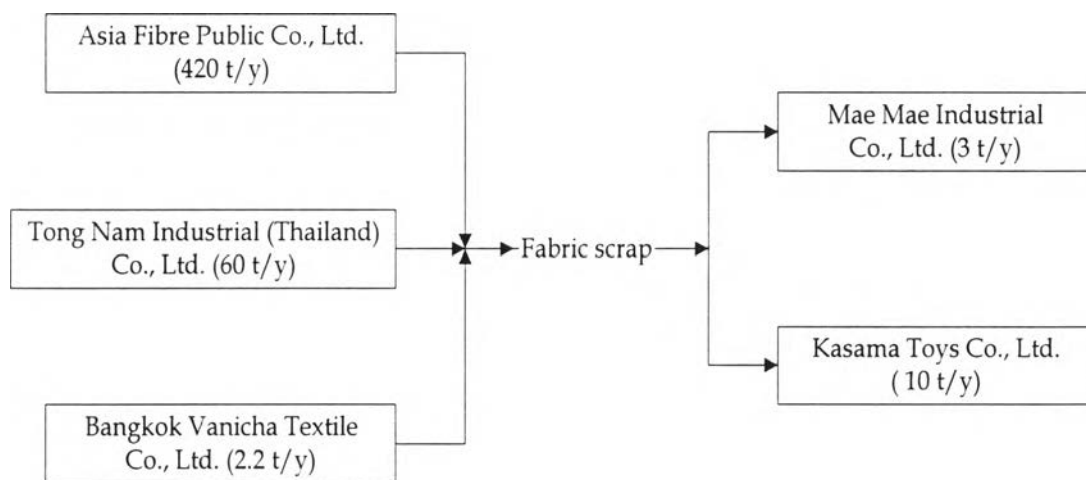


Figure 4-3 Proposed exchange model for fabric scrap from factories in Bangpoo Industrial Estate

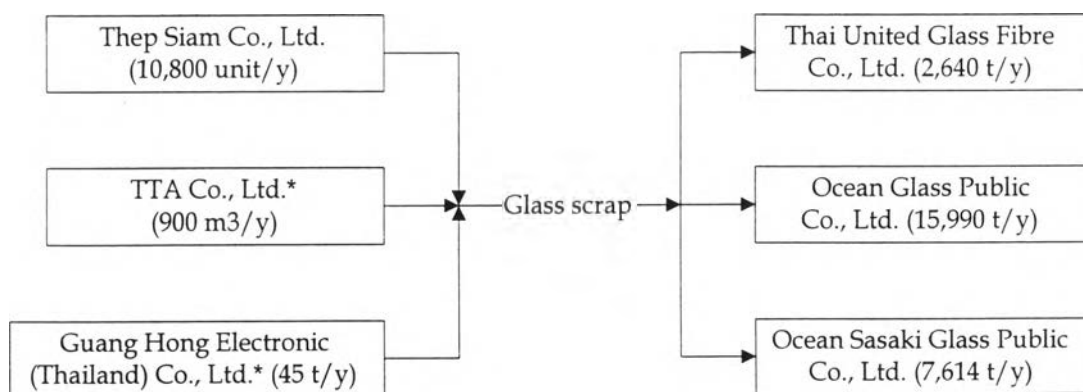


Figure 4-4 Proposed exchange model for glass scrap from factories in Bangpoo Industrial Estate

Note : \* This factory is located in EPZ.

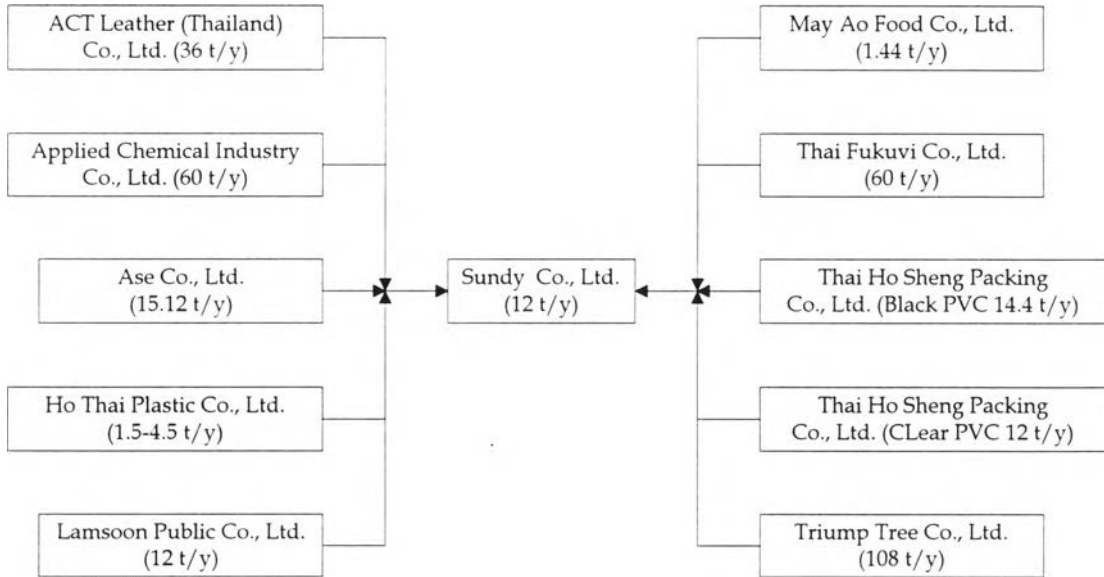


Figure 4-5 Proposed exchange model for PVC scrap from factories in Bangpoo Industrial Estate

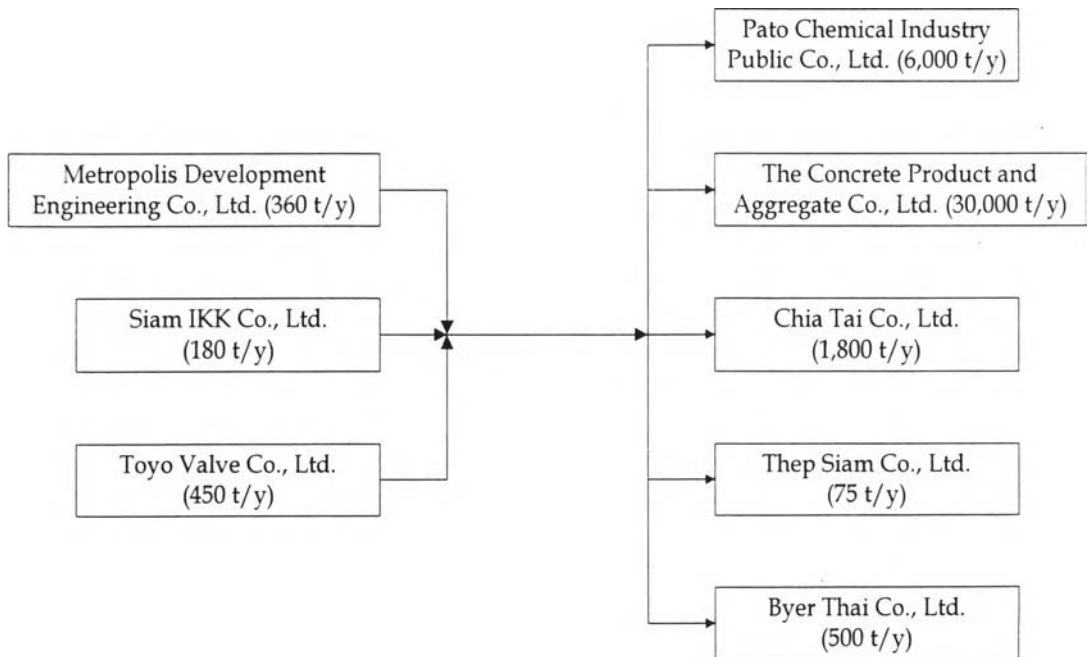


Figure 4-6 Proposed exchange model for spent sand from factories in Bangpoo Industrial Estate

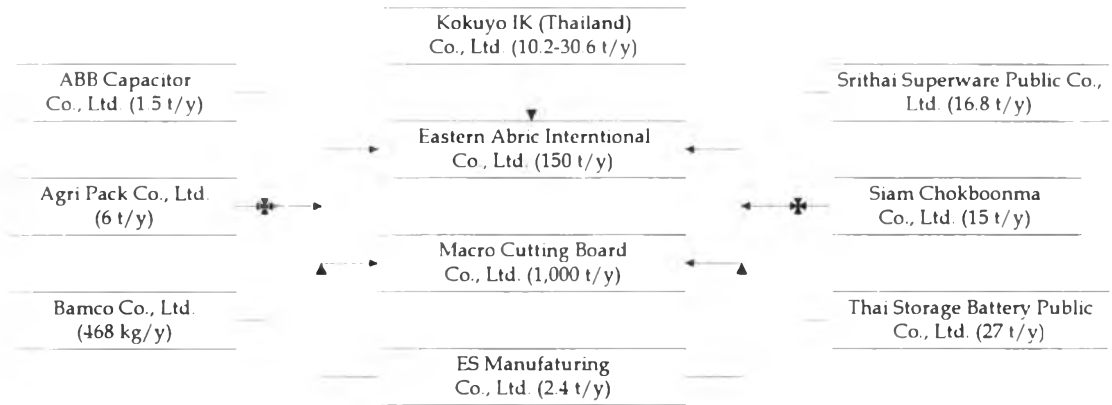


Figure 4-7 Proposed exchange model for PP scrap from factories in Bangpoo Industrial Estate

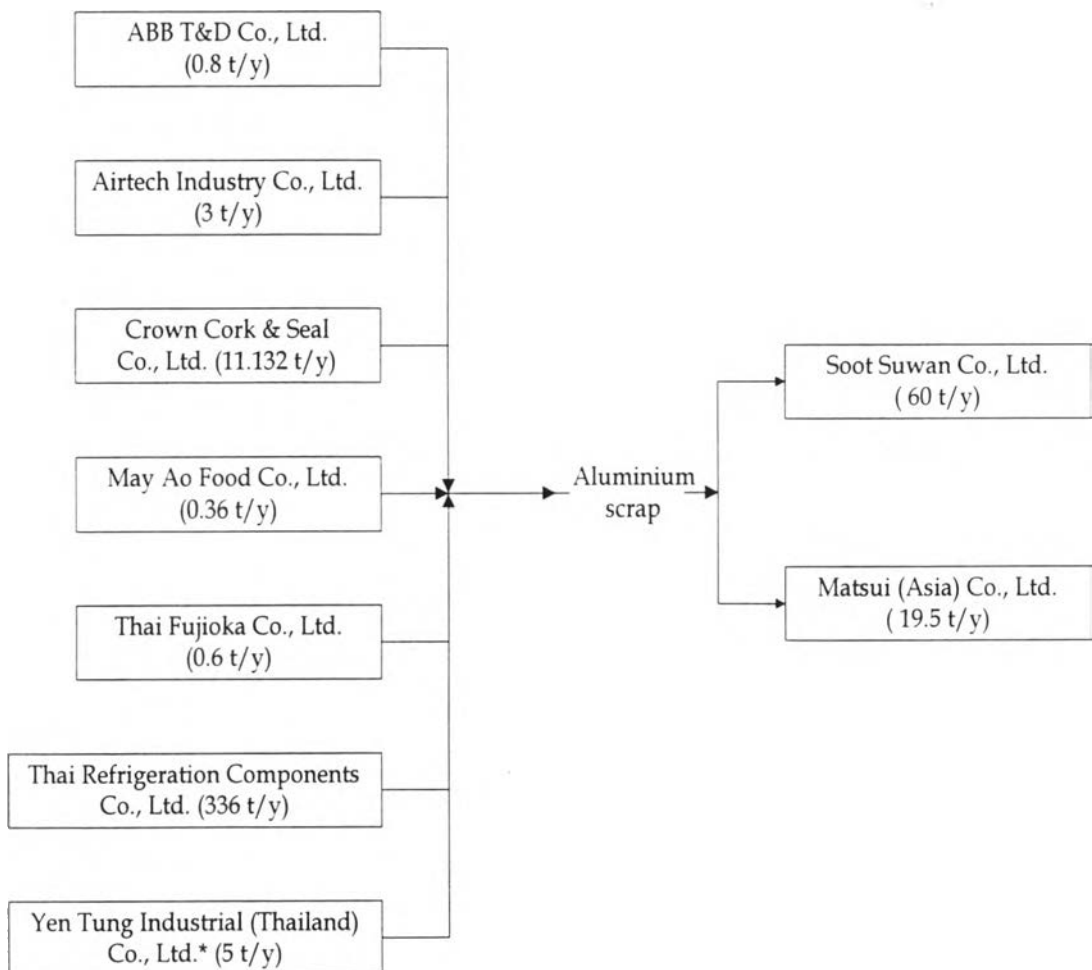


Figure 4-8 Proposed exchange model for aluminium scrap from factories in Bangpoo Industrial Estate

Note : \* This factory is located in EPZ.

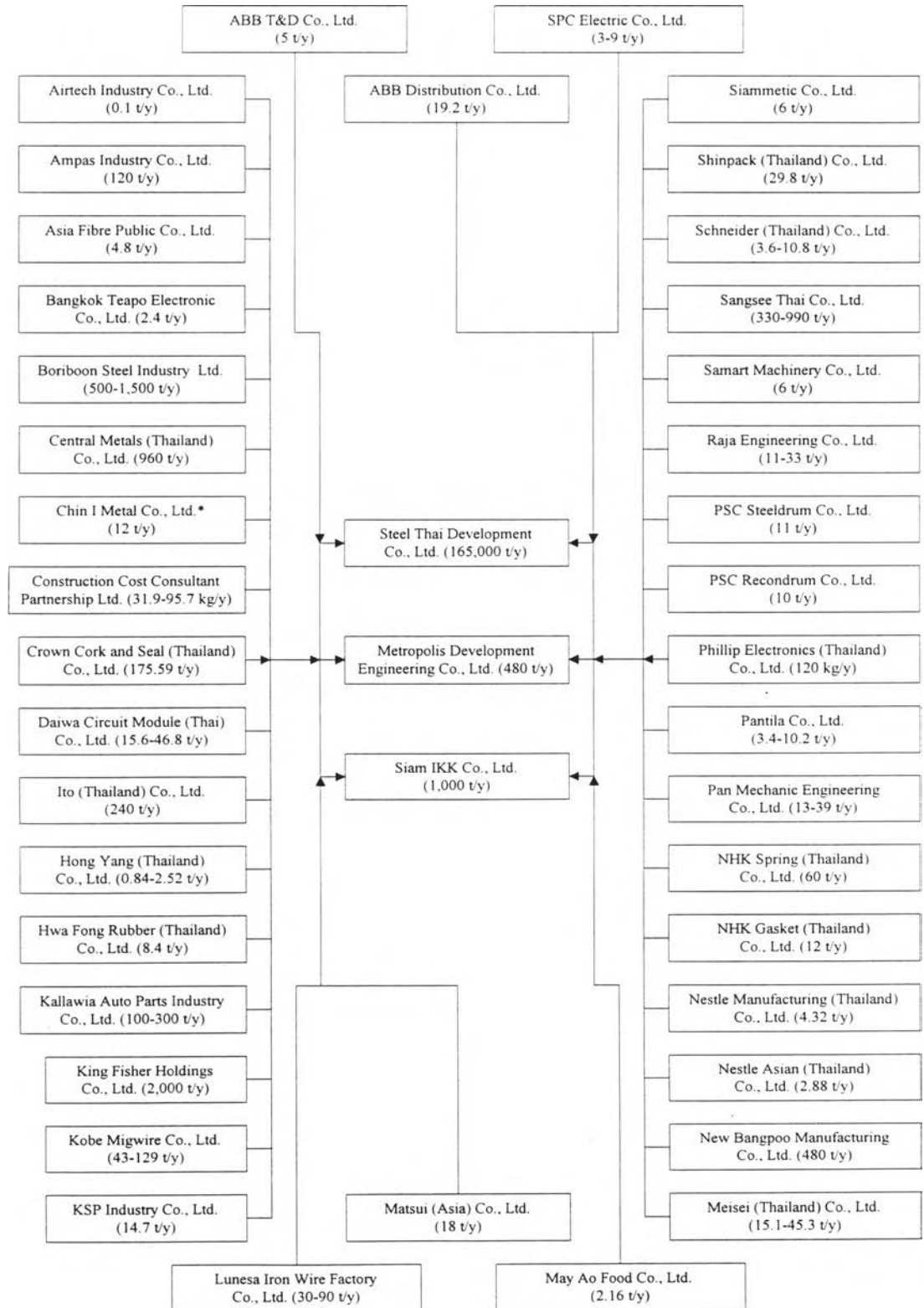


Figure 4-9 Proposed exchange model for steel scrap from factories in Bangpoo Industrial Estate

Note : \* This factory is located in EPZ.

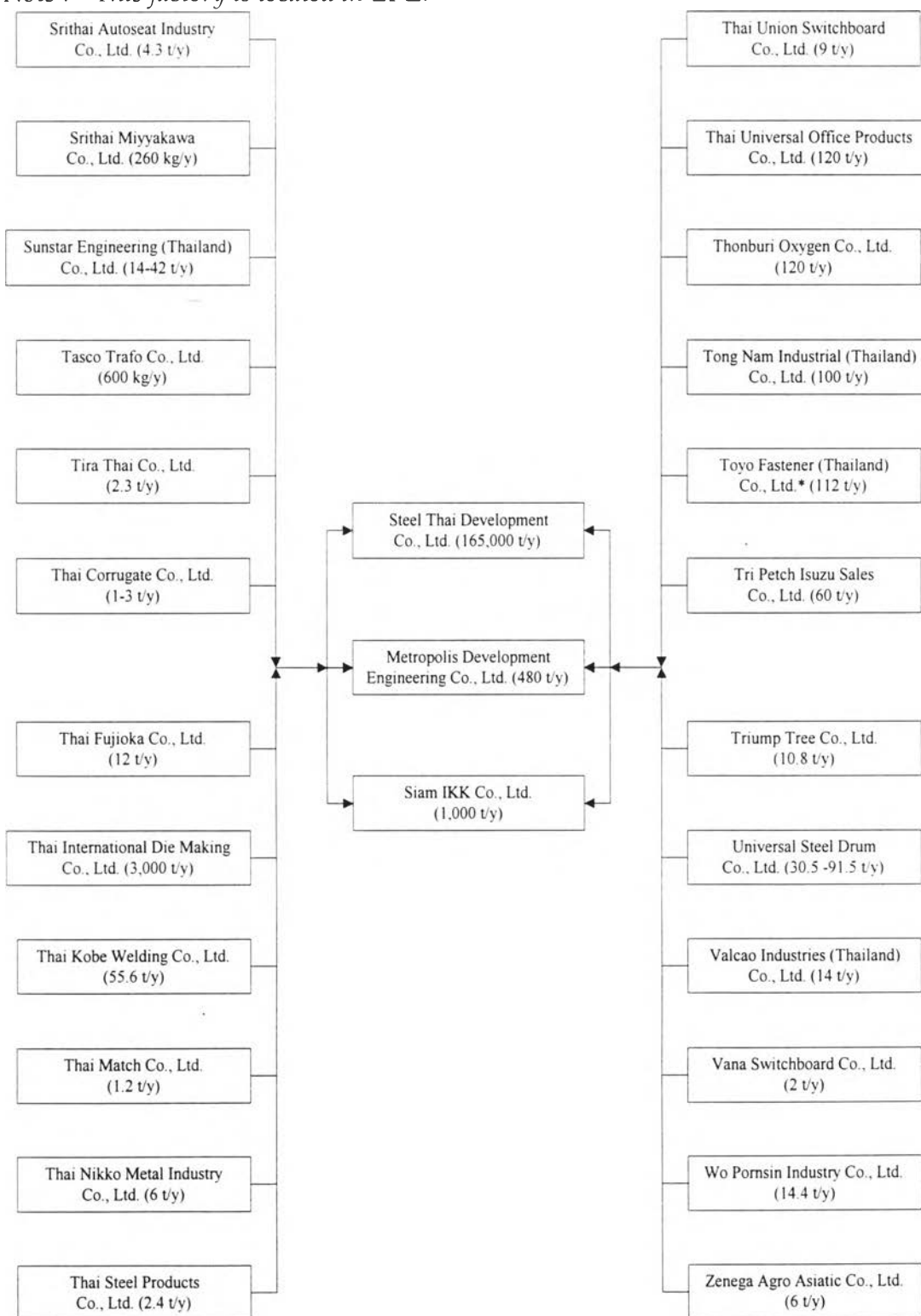


Figure 4-9 Proposed exchange model for steel scrap from factories in Bangpoo Industrial Estate (cont'd)

Note : \* This factory is located in EPZ.

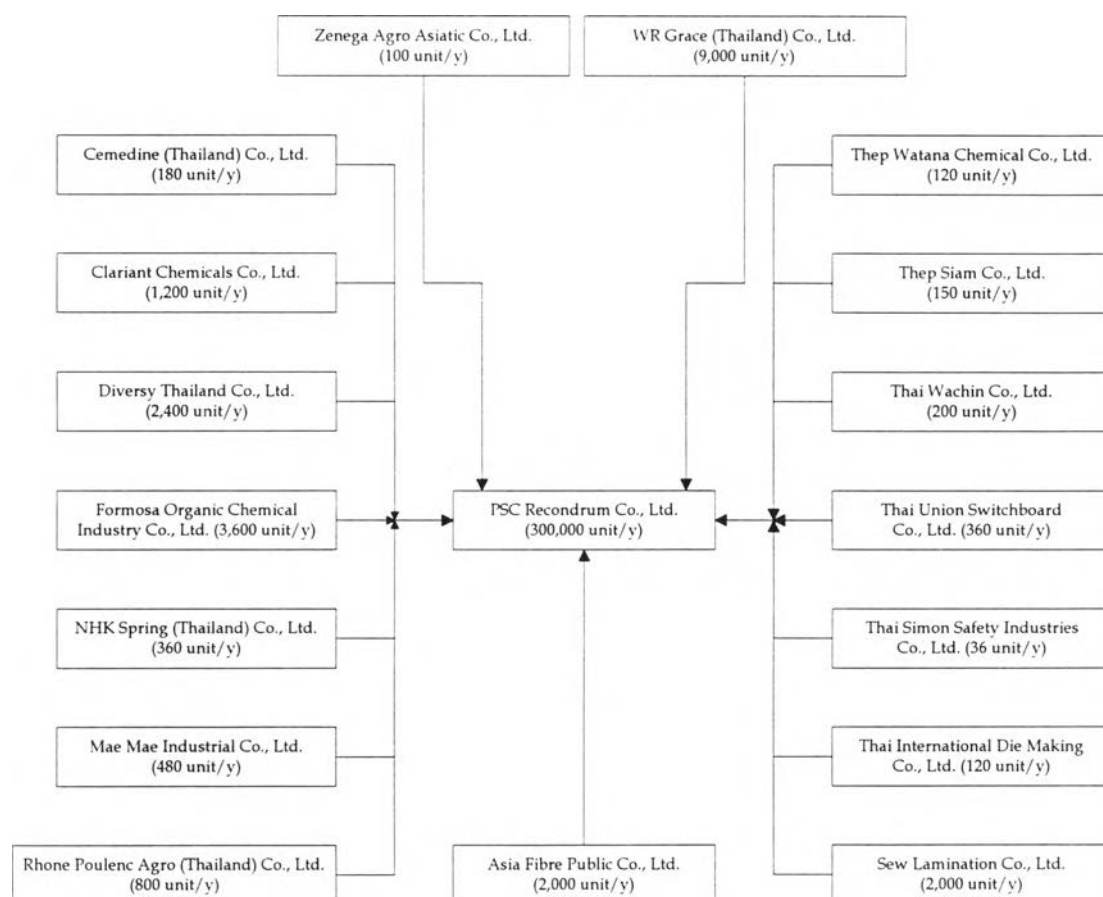


Figure 4-10 Proposed exchange model for empty steel drum (180 l) from factories in Bangpoo Industrial Estate

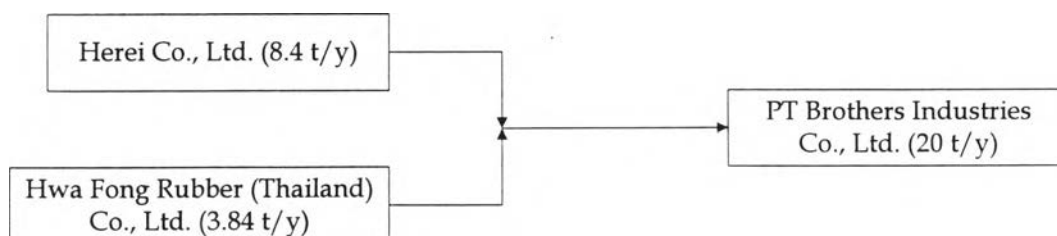


Figure 4-11 Proposed exchange model for nylon scrap from factories in Bangpoo Industrial Estate



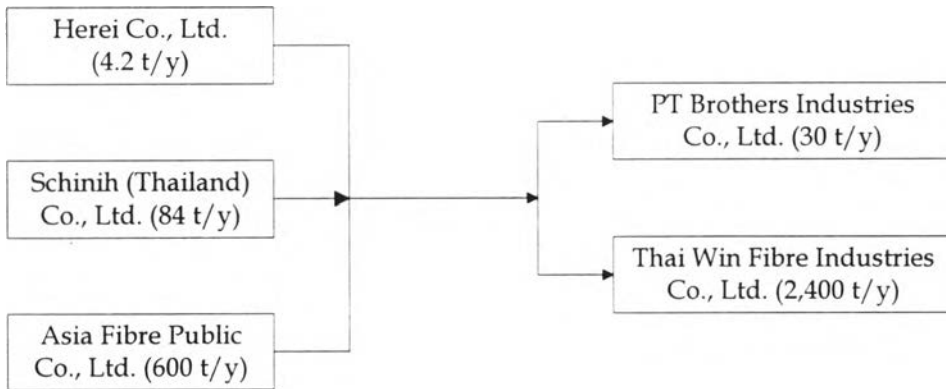


Figure 4-12 Proposed exchange model for polyester scrap from factories in Bangpoo Industrial Estate

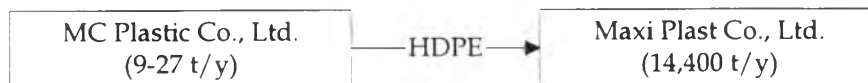


Figure 4-13 Proposed exchange model for HDPE scrap from factories in Bangpoo Industrial Estate

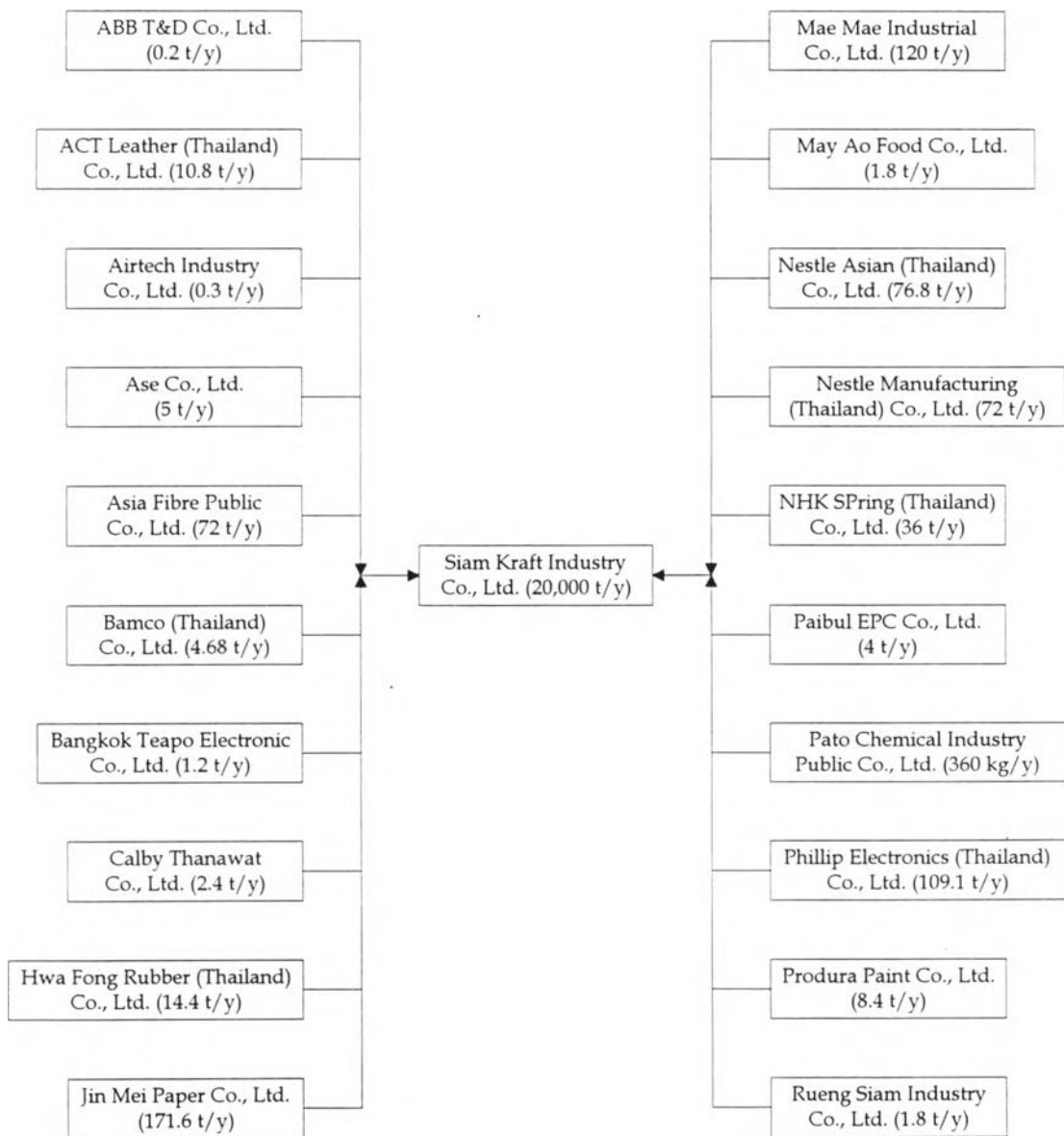


Figure 4-14 Proposed exchange model for paper scrap from factories in Bangpoo Industrial Estate

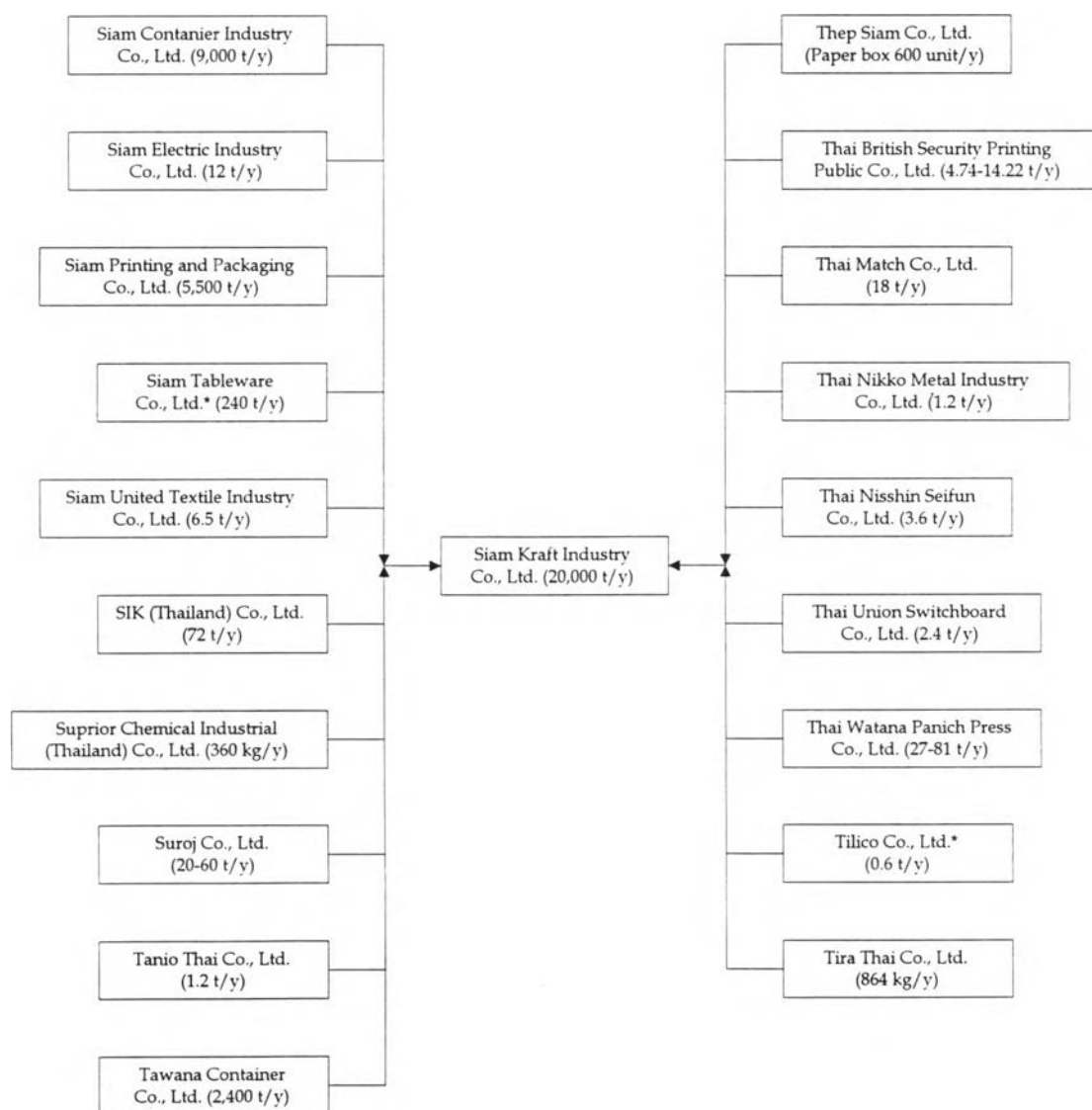


Figure 4-14 Proposed exchange model for paper scrap from factories in Bangpoo Industrial Estate (cont'd)

Note : \* This factory is located in EPZ.

Proposed models of waste exchange of second choice are similar to the proposed model in first choice. Only factories in Figure 4-1, 4-4, 4-8, 4-9 and 4-14 which are located in EPZ are excluded from the proposed models.

### Technical aspects

Possibilities of waste exchange in view of technical aspect will be investigated only direct reuse or small modification of waste before reuse. The followings will explain how waste can be exchanged among factories in Bangpoo Industrial Estate for reuse and recycle. Potential reuse or recycle waste generated from factories in Bangpoo Industrial Estate with factories or any waste users located outside this estate is also identified.

Some factories have capabilities to use waste as raw material as mentioned above. For example, some plastic manufacturers have crushers to crush defected product for reusing in the injection machines and animal feed manufacturer use shrimp head and tail from shrimp frozen manufacturer to produce finished product. The followings will explain the technical possibilities of exchanging waste generated from factories in Bangpoo Industrial Estate for reuse or recycle.

Study of NEB (1989) show the possibilities of reuse and recycle waste in Thailand. Wastes which relevant to generated wastes from factories in Bangpoo Industrial Estate are described below.

- Wood piece and saw dust can be used for picture frame, souvenir, particle board, fuel, making pulp, fuel core and joss stick production. Saw dust can be used as absorbent to absorb spill of pesticide or insecticide before burning by incinerator and for mushroom plantation.
- Aluminium scrap can be used as raw material for furniture, containers, packaging, door and window frame, part of vehicles, and equipment of machine.
- Scrap polymer before weaving to be filament can be recycled in process. Short and long filament scrap can be substitute for silk cotton to make pillows and beds.
- Rubber scrap can be used to produce canvas, sandals, or glue.
- Sponge scrap can be used for bicycle cushion production.
- Slag from steel melting can be use for producing cement, or materials for making roads.
- Fabric and thread scrap can be used to produce cushion, rug, or roofing material.
- Spent bleach powder from vegetable oil manufacturer can be used as lubricating material in tapioca starch industry.

Foundry sand can be used in construction fill application such as earth fill material or highway construction fill. (USAEP, 1997) It may also possible to be used in insecticide production and used as absorbent to absorb spill of pesticide or insecticide.

From report of Dr. Kumar (1992), the summary of reuse solid waste from tanner industries are shown in the following table.

Tanned leather shavings and trimmings can be converted into leather board for making insoling material, acoustic insulation, counters and toe-puffs used in shoe making, tool box etc. (Dr. Kumar, 1992)

Chrome sludge from wastewater treatment plant of leather industry can be used for agricultural purpose if concentration of chrome in sludge is less than 800 mg/kg of sludge (dry weight basis). (Bureau of Industrial Environmental Technology, DIW, 1997)

Table 4-31 Utilisation of Solid waste from Tannery industries

Type of solid waste	Generation Source	Application
Hide & Skin trimmings	Hide go-down and Soaking Bath	Use for glue and gelatine manufacture
Limed fleshing and trimmings	Beam House	Use for glue manufacture, fish/shrimp feed or manuring of fields
Limed splits	Beam House	Tanned and converted into cheap leathers. Use for dog chew and sausage skin manufacture

From National Hazardous Waste Management Plan (NEB, 1989), potential of spent oil for utilisation is 50% per year of total generated spent oil, potential of spent solvent for utilisation is 80% per year of total generated spent solvent, potential of heavy metal sludge & solids for utilisation is 20% per year of total generated heavy metal sludge & solids.

Spent solvent or lube oil can be used as fuel for incinerator.

Concrete scrap can be used as soil filling in construction site.

Ink wastes can be mixed together and used as black ink for printing industry.

Food scrap for example fish tissue or meat scrap can be used as animal feed.

All above information can be evidence to support the technical possibility of proposed exchanged models as follows:

- SPI Feed Co., Ltd. use shrimp shell and head of SPI Canning Co., Ltd. as raw materials to produce animal feed. Hence, it can use same wastes generated from Frionor Co., Ltd. Frionor Co., Ltd. is located in EPZ, exchanging these waste to factory in GIZ is required a permission from Department of Custom. This may cause some difficulties. From information of capacity of waste user, it use 450 t/y of shrimp shell & tail to produce finished product. This waste is sent from SPI Canning Co., Ltd. which generate 720 t/y of this

waste. If production capacity of waste user is not increased, it cannot receive waste from the others.

- Cotton waste from Evengreen Textile and Tong Nam Industries CO., Ltd. is waste that these two factories cannot be reused. It can be used by Kasma Toys Co., Ltd. and Central Toys and Novelties Co., Ltd. in stuffing process of dolls and toys production. It is assumed that 50% of required raw material which is used in stuffing process to make dolls and toys can be substituted by waste material. Consequently, amount of waste will be 7.5 t/y for Kasma Toys Co., Ltd. and 5 t/y for Central Toys And Novelties Co., Ltd.
- Fabric scrap can be considered as using cotton waste for making toys and dolls. Used quantity for making dolls and toys is much lower than amount of generated wastes. 50% of total fabric consumption of Kasma Toys Co., Ltd. and Mae Mae Industrial Co., Ltd. is assumed to be waste from Asia Fibre Public Co., Ltd., Tong Nam Industrial (Thailand) Co., Ltd., and Bangkok Vanicha Textile Co., Ltd.
- There are two factories which produce glassware and one factory produce glass fibre from cullet. Hence, glass scrap from Thep Siam Co., Ltd., TTA Co., Ltd., and Guang Hong Electronic (Thailand) Co., Ltd. can be recycled by glassware and glass fibre manufacturers. Guang Hong Electronic (Thailand) Co., Ltd. and TTA Co., Ltd. are located in EPZ. And glass glassware and glass fibre manufacturers are located in GIZ. There may have some difficulties when glass scrap is exchanged, especially when it is sold.
- Sundry Co., Ltd. normally buys PVC bottle from Lamsoon Public Co., Ltd. for making PVC pipe & fittings. From this reason, it can be used PVC scrap from the PVC waste generators. It will have more resources of its raw material.
- Spent sand which is not sold to metal recycle facilities can be reused by cement manufacturer to produce ready mix concrete, pesticide manufacturer to be used as medium otherwise it will be using for soil filling. When amount of waste generated is compared with amount of required raw material, amount of waste is much lower than that of raw material. From this reason, there will be possibility to use all amount of this waste.
- There are two factories which have equipment to crush PP scrap for producing new products. Consequently, PP scrap generated from the other factories in Bangpoo Industrial Estate can be sent to these two factories for reuse as a raw material. When amount of waste generated is compared with amount of required raw material, amount of waste is much lower than that of raw material. From this reason, there will be possible to use all amount of this waste.

- There is one factory which reuse aluminium scrap as raw material an another factory which have casting process for aluminium products. These two factories can be reused aluminium which generated from other factories in Bangpoo Industrial Estate. It is assume that 50% of required raw material by factory which has casting process can use waste as raw material.
- PSC Recondrum Co., Ltd. produce steel drum from used steel drums so that any factories which generated used steel drums can sell them to this factory. Due to the standards of discharged wastewater to central treatment plant issued by IEAT and no system to treat insecticide and pesticide waste of PSC Recondrum Co., Ltd., empty steel drum from factories who produce insecticide or pesticide have to be cleaned by them before sending it to PSC Recondrum Co., Ltd.
- PT Brothers Industries Co., Ltd. use nylon scrap as raw material. Any factory which have nylon scrap can sent it to this factory for recycle.
- Polyester scrap generated from factories in Bangpoo Industrial Estate can be sent to PT Brothers Industries Co., Ltd. and Thai Win Fibre Industries Co., Ltd. which normally use this waste as raw material.
- Maxi Plast Co., Ltd. normally recycle its defect product which made from high density polyethylene (HDPE) within its factory. From this reason, it can use HDPE waste produced from MC Plastic Co., Ltd. When amount of waste generated is compared with amount of required raw material, amount of waste is much lower than that of raw material. From this reason, there will be possible to use all amount of this waste.
- Siam Craft Industry Co., Ltd. normally buys paper scrap from Siam container Industry Co., Ltd. and reduce the volume of this waste before sending it to be reused by other factories within its group. Amount of paper waste required is higher than amount of supply so that all amount of this waste can be sent to Siam Craft

Table 4-32 is summarised total amount of waste generated, total amount of waste or virgin material required, and total amount of waste which can be exchanged in Bangpoo Industrial Estate.

Table 4-32 Total amount of waste generated and total amount of waste which can be exchanged in Bangpoo Industrial Estate

Type of Waste	Total amount of waste generated (t/y)	Total amount of waste or virgin material required (t/y)	Total amount of waste exchanged (t/y)
Shrimp shell & tail	871.26	450	450
Cotton scrap	2,160	25*	12.5
Fabric scrap	482.2	13*	6.5
Glass scrap	2,206.08	26,244	2,206.08
PVC scrap	320.46-323.46	12	12
Spent sand	990	38,375*	990
PP scrap	80.868-104.268	1,150*	80.868-104.268
Aluminium scrap	356.892	79.5**	69.75
Steel scrap	8,971.402-11,199.546	166,480	8,971.402-11,199.546
Empty steel drum	23,106 (unit/y)	300,000 (unit/y)	23,106 (unit/y)
Nylon scrap	12.24	20	12.24
Polyester scrap	688.2	2,430	688.2
HDPE	9-27	14,400*	9-27
Paper scrap	18,023.364-18,126.444	20,000	18,023.364-18,126.444

Note : \* Amount of required virgin material

\*\* Amount of required virgin material is 19.5 t/y

### Economical and Financial aspects

To investigate the efficient use of resources, economic analysis will be used. If the benefits is higher than costs, it means that there is an efficient use of resources. If the costs is higher than benefits, resources are not efficiently used.

Cost-Benefit analysis is based on a comparison of the costs and benefits of with waste exchange and without waste exchange situation.

With waste exchange situation, some factories will corporate to exchange their wastes and their information as in the proposed models.

Without waste exchange situation, current waste management will be continue. Some wastes for instance spent solvent, acid or base will be treated by waste generators or off-site waste treatment facilities. Some wastes such as steel scrap, and aluminium scrap will be sold to broker who give the highest price to waste generator.

Summary of benefits and costs of reuse waste are listed below.

#### *Benefits*

1. *Reduce raw material use* Substitute portion of raw materials by waste materials can reduce virgin raw material, energy to produce finished



products and raw materials such as using steel scrap can reduce 90% of virgin material use, 50% of energy during melting, 40% of water consumption, 76% of water pollution, 86% of air pollution, and 97% of mining wastes (PCD, 1998).

2. *Reduce cost of waste management* If waste materials are not reused, they have to be treated for example by landfill, chemical treatment, or incineration. Consequently, reuse of waste material can reduce cost to make these facilities and operation & maintenance costs.

3. *Reduce land used* When amount of waste materials to treatment facilities is reduce, land required for construction of waste treatment facility is decreased. Sanction of people to construct waste treatment facilities is also reduced.

4. *Reduce pollution problems* Reuse of waste material can reduce environmental problem due to illegal dumping, air pollution problems from incineration facility, and wastewater problems and odour problems from landfill facilities.

#### *Costs*

1. *Increase pollution problems* Reused of paper required additional wastewater treatment facilities to treat ink and some contaminants from paper scrap. Slag from melting steel scrap also require proper waste handling. If they are mishandling, pollution problems will be increased.

2. *High production costs of using waste materials* Some waste materials have to be treated before reuse such as paper scrap or empty steel tanks. Some treatment system is required high investment costs such as deinking system.

3. *Low quality of recycled products* When paper is recycled many times, length of fibre will be shorten. From this reason, quality of final products will be reduced due to reducing strength and whitening of fibre.

There are many people get the benefits from exchanging wastes such as waste generators can save money for waste treatment and disposal, waste users can save the money of production costs, social can receive the benefits from low amount of waste material going to the environment, and reduction of using virgin materials.

Economical and financial consideration of proposed waste exchange models described below will investigate benefits and costs on waste users side. Table 4-33 shows cost of selling wastes as raw materials and virgin materials using for benefits and costs analysis.

Table 4-33 Cost of waste materials and virgin materials

Unit : Baht/kg

Type of Waste	Cost of waste material bought from broker	Cost of virgin material	Cost of waste material bought from generator
Pieces of meat	1.8 <sup>1</sup>	-	1.5 <sup>1</sup>
Cotton scrap	-	10 <sup>3</sup>	7.5 <sup>1</sup>
Fabric scrap	-	5 <sup>3</sup>	3 <sup>1</sup>
Glass scrap	1.35 <sup>2</sup>	-	1 <sup>2</sup>
PVC scrap	13 <sup>2</sup>	-	11 <sup>2</sup>
Spent sand <sup>3</sup>	-	0.25 <sup>3</sup>	0
PP scrap	-	45 <sup>3</sup>	16 <sup>2</sup>
Aluminium scrap	40 <sup>2</sup>	50 <sup>3</sup>	35 <sup>2</sup>
Steel scrap	3.5 <sup>2</sup>	-	2.7 <sup>2</sup>
Steel tank 200 l	350 (Baht/unit) <sup>3</sup>	-	250 (Baht/unit) <sup>3</sup>
Nylon scrap	2.9 <sup>1</sup>	-	2.5 <sup>1</sup>
Polyester scrap	2.9 <sup>3</sup>	-	2.5 <sup>3</sup>
HDPE scrap	-	43 <sup>3</sup>	16 <sup>2</sup>
Paper scrap	3.5 <sup>2</sup>	-	3 <sup>2</sup>

Source : 1. PCD, (1993)  
 2. PCD, (1998)  
 3. Industrial survey

Other basis for benefits and costs analysis are listed as follows:

- transportation cost is 2,000 Baht/ time;
- 1 officer who has salary of 15,000 Baht per month is required for waste transportation arrangement, and other operation costs such as telephone bill, electricity is assumed to be 250 Baht/ time
- transfer waste will be happened every month;
- waste user is responsible for transportation of waste;
- truck load for steel drum is 40 units per trip; and
- quantity of waste transported by 6 wheels truck is 10 ton, and maximum trip per day is 4.

Summaries results from benefits-costs analysis of proposed exchange model which calculated from waste users side can be described as follow:

#### Shrimp shell & tail

Capacity to be exchanged is the capacity which waste users current received from one factory. If there is no increasing in production capacity, waste users cannot receive more amount of waste than 450 t/y. Consequently, benefit-cost analysis of this proposed model will not be done.

Cotton scrap

Benefit-cost analysis of this proposed exchanged model is calculated from the saving of raw material cost. Two factories is the waste users in this model. Benefit and cost of these two factories are :

- Benefit of Kasma Toys Co., Ltd. from saving of raw material amount of 7.5 t/y is 18,750 Baht/y. Transportation cost of this waste pay to transporter and operation cost are 3,000 Baht/y.
- Benefit of Central Toys and Novelties Co., Ltd. from saving of raw material amount of 5 t/y is 12,500 Baht/y. Transportation cost of this waste pay to transporter and operation cost are 3,000 Baht/y.

Fabric scrap

Benefit-cost analysis of this proposed exchanged model is calculated from the saving of raw material cost. Two factories is the waste users in this model. Benefit and cost of these two factories are :

- Benefit of Kasma Toys Co., Ltd. from saving of raw material amount of 1.5 t/y is 3,000 Baht/y. Transportation cost of this waste pay to transporter and operation cost are 3,000 Baht/y.
- Benefit of Mae Mae Industrial Co., Ltd. from saving of raw material amount of 5 t/y is 10,000 Baht/y. Transportation cost of this waste pay to transporter and operation cost are 3,000 Baht/y.

Glass scrap

Benefit-cost analysis of this proposed exchanged model is calculated from the saving of waste broker's profit margin. Required waste quantity of each factory in this model is higher than supply of waste. Consequently, only one factory is assumed to use this waste. Benefit from saving raw material cost amount of 2205 t/y is 771,750 Baht/y. Transportation cost and operation cost to use this waste are 180,000 Baht/y.

PVC scrap

Capacity to be exchanged is the capacity which waste users current received from one factory. If there is no increasing in production capacity. Waste users cannot receive more amount of waste than 12 t/y. Consequently, benefit-cost analysis of this proposed model cannot be calculated.

Spent sand

Benefit-cost analysis of this proposed exchanged model is calculated from the saving of raw material cost. Only one factory is assumed to use this waste. Benefit from saving raw material cost amount of 990 t/y is 247,500

Baht/y. Transportation cost and operation cost to use this waste are 108,000 Baht/y.

#### PP scrap

Benefit-cost analysis of this proposed exchanged model is calculated from the saving of raw material cost. Only one factory is assumed to use this waste. Benefit from saving raw material cost amount of 80.868 t/y is 2,345,172 Baht/y. Transportation cost and operation cost to use this waste are 36,000 Baht/y.

#### Aluminium scrap

Benefit-cost analysis of this proposed exchanged model is calculated from the saving of waste broker's profit margin and raw material cost. Two factories is the waste users in this model. Benefit and cost of these two factories are :

- Benefit of Soot Suwan Co., Ltd. from saving of raw material amount of 60 t/y is 900,000 Baht/y. Transportation cost of this waste pay to transporter and operation cost are 36,000 Baht/y.
- Benefit of Matsui (Asia) Co., Ltd. from saving of raw material amount of 5 t/y is 146,250 Baht/y. Transportation cost of this waste pay to transporter and operation cost are 6,000 Baht/y.

#### Steel scrap

Benefit-cost analysis of this proposed exchanged model is calculated from the saving of waste broker's profit margin. There are three factories which can use this waste. Total benefits of these three factory of the saving of waste broker's profit margin from waste amount of 8,636.69 t/y are 6,909,352 Baht/y. Total transportation and operation costs are 648,000 Baht/y.

#### Empty steel drum

Benefit-cost analysis of this proposed exchanged model is calculated from the saving of waste broker's profit margin. There is one factory which can use this waste. Benefit of saving waste broker's profit margin from waste amount of 23106 unit/y is 2,310,600 Baht/y. Transportation cost and operation cost to use this waste are 468,000 Baht/y.

#### Nylon scrap

Benefit-cost analysis of this proposed exchanged model is calculated from the saving of waste broker's profit margin. There is one factory which can use this waste. Benefit of saving waste broker's profit margin from waste amount of 12.24 t/y is 4,896 Baht/y. Transportation cost and operation cost to use this waste are 6,000 Baht/y.

Polyester scrap

Benefit-cost analysis of this proposed exchanged model is calculated from the saving of waste broker's profit margin. Two factories can use this type of waste as raw material. Benefit and cost of these two factories are :

- Benefit of Thai Win Fibre Industries Co., Ltd. from saving of raw material amount of 658.2 t/y is 263,280 Baht/y. Transportation cost of this waste pay to transporter and operation cost are 72,000 Baht/y.
- Benefit of PT Brothers Industries Co., Ltd. from saving of raw material amount of 30 t/y is 12,000 Baht/y. Transportation cost of this waste pay to transporter and operation cost are 9,000 Baht/y.

HDPE scrap

Benefit-cost analysis of this proposed exchanged model is calculated from the saving of raw material cost. Only one factory can use this waste. Benefit from saving raw material cost amount of 9 t/y is 243,000 Baht/y. Transportation cost and operation cost to use this waste are 3,000 Baht/y.

Paper scrap

Benefit-cost analysis of this proposed exchanged model is calculated from the saving of waste broker's profit margin. There is one factory which can use this waste. Benefit of saving waste broker's profit margin from waste amount of 17,869.5 t/y is 8,934,750 Baht/y. Transportation cost and operation cost to use this waste are 1,368,000 Baht/y.

Table 4-34 Total Benefits and costs of proposed waste exchange models

Type of Waste	Benefit (Baht/y)	Cost (Baht/y)
Shrimp shell & tail	no calculation	
Cotton scrap	31,250	6,000
Fabric scrap	13,000	6,000
Glass scrap	771,750	180,000
PVC scrap	no calculation	
Spent sand	247,500	108,000
PP scrap	2,345,172	36,000
Aluminium scrap	1,046,250	42,000
Steel scrap	6,909,352	648,000
Empty steel drum	2,310,600	468,000
Nylon scrap	4,896	6,000
Polyester scrap	275,280	81,000
HDPE	243,000	3,000
Paper scrap	8,934,750	1,368,000

Table 4-35 is shown the B/C ratio of proposed waste exchange models. 4 scenarios is used to see how B/C ratio is effected. Description of each scenario is as follows:

Case 1 Basis of calculation

Case 2 20% reduction in amount of waste

Case 3 20% increasing in operation and transportation costs

Case 4 20% reduction in amount of waste and 20% increasing in operation and transportation costs

*Table 4-35 Benefit-Cost ratio of proposed waste exchange models*

Type of Waste	Benefit-Cost ratio			
	Case 1	Case 2	Case 3	Case 4
Shrimp shell & tail	no calculation			
Cotton scrap	5.21	4.17	4.34	3.47
Fabric scrap	2.17	1.73	1.81	1.44
Glass scrap	4.29	3.43	3.57	2.86
PVC scrap	no calculation			
Spent sand	2.29	2.75	1.91	2.29
PP scrap	65.14	52.11	54.28	43.43
Aluminium scrap	24.91	19.93	20.76	16.61
Steel scrap	10.66	10.23	8.88	8.53
Empty steel drum	4.94	5.13	4.12	4.23
Nylon scrap	0.82	0.66	0.68	0.55
Polyester scrap	3.40	2.72	2.83	2.27
HDPE	81	64.8	67.5	54
Paper scrap	6.53	6.62	5.44	5.52

Details of calculation of all figure are illustrated in Appendix K.

From B/C ratio, there is only one waste type which has B/C lower than 1. As a result of this, this type of waste is not feasible to exchange. The rest are higher than 1 which imply that they are feasible in economical and financial terms. There are two types of waste which amount of benefit is not too high. These wastes are cotton scrap and fabric scrap.

There are four proposed waste exchange models which have different benefit-cost ratios as shown above when amount of waste from factories located in EPZ is not included in calculation. Theses are waste exchange models of glass scrap, aluminium scrap, steel scrap, and paper scrap.

For glass scrap, if two factories located in EPZ are not willing to exchanged their wastes with waste users located in GIZ due to the difficulties

in custom clearing, benefit-cost analysis of this proposed model will not be calculated.

For aluminium scrap, benefit-cost ratio will be changed to 23.13, 18.5, 19.27, and 15.42 for case 1, case 2, case 3, and case 4 respectively.

For steel scrap, benefit-cost ratio will be changed to 10.52, 10.1, 8.77, and 8.42 for case 1, case 2, case 3, and case 4 respectively.

For paper scrap, benefit-cost ratio will be changed to 6.44, 6.53, 5.37, and 5.44 for case 1, case 2, case 3, and case 4 respectively.

### Possibilities of exchange with other industrial estates

In this paper preliminary study of the possibility in exchange of waste from Bangpoo Industrial Estate with other Estates will be conducted. Hence, only information of type of industries will be considered. Two nearest industrial estate, i.e. Bang Chan Industrial Estate and Bangplee Industrial Estate are selected to preliminary evaluate the possibilities of exchanging wastes because these two industrial estates is not too far from Bangpoo Industrial Estate.

Bang Chan Industrial Estate is situated on Sukhaphibal 2 Road, Minburi Bangkok. It is far from central Bangkok 25 kilometres. There are 75 factories located in GIZ of this industrial estate. No EPZ is in this industrial estate. Potential waste generators which have potential to exchange their waste materials with other factories in Bangpoo Industrial Estate are :

- aluminium product manufacturer generate aluminium scrap;
- plastic product manufacturer generate plastic scrap;
- printed circuit board manufacturer generate spent acid;
- cloth and fabric product manufacturer generate fabric scrap;
- other manufacturers who generate empty steel 200 l tank; and
- metal products manufacturer generate metal scrap.

Potential waste users in Bang Chan Industrial Estate are:

- plastic product manufacturer use plastic scrap;
- foam product manufacturer use foam scrap;
- glue manufacturer use leather scrap; and
- rubber product manufacturer use rubber scrap.

Bangplee Industrial Estate is located on Bangna-Trad Road Km. 22-23 Bangplee Samutprakarn province. Distance of this industrial estate from south-east of Bangkok is 40 kilometres. There is no EPZ in this industrial estate. Total factories operate in this industrial estate are 133 factories. Wastes which can be used by other factories in Bangpoo Industrial Estate are generated from industry as follow:

- plastic scrap from plastic product manufacturer;
- metal scrap from metal product manufacturer;
- spent acid from electronic component manufacturer;
- paper scrap from paper product and printing manufacturer;
- fabric scrap from cloth manufacturer; and
- empty steel drum (180 l) from other manufacturers.

Economic considering of waste exchange among factories in Bangpoo Industrial Estate with the other Estates will be importance factor. Cost saving from profit margin's of waste brokers have to be compared with increasing cost in transportation. If that will be considered to evaluate the possibilities of waste exchange is transportation costs.

Information from Department of Industrial Work show that numbers of paper, glass, plastic, steel, aluminium, copper, brass, and foam recycling factory in Samutprakarn are 12, 7, 22, 44, 8, 2, 9, and 1 factories respectively. And some wastes mentioned above are sold to waste brokers or some recycling facilities. Hence, there may be some possibilities to exchange wastes from factories in Bangpoo Industrial Estate with other recyclers outside the Estate.