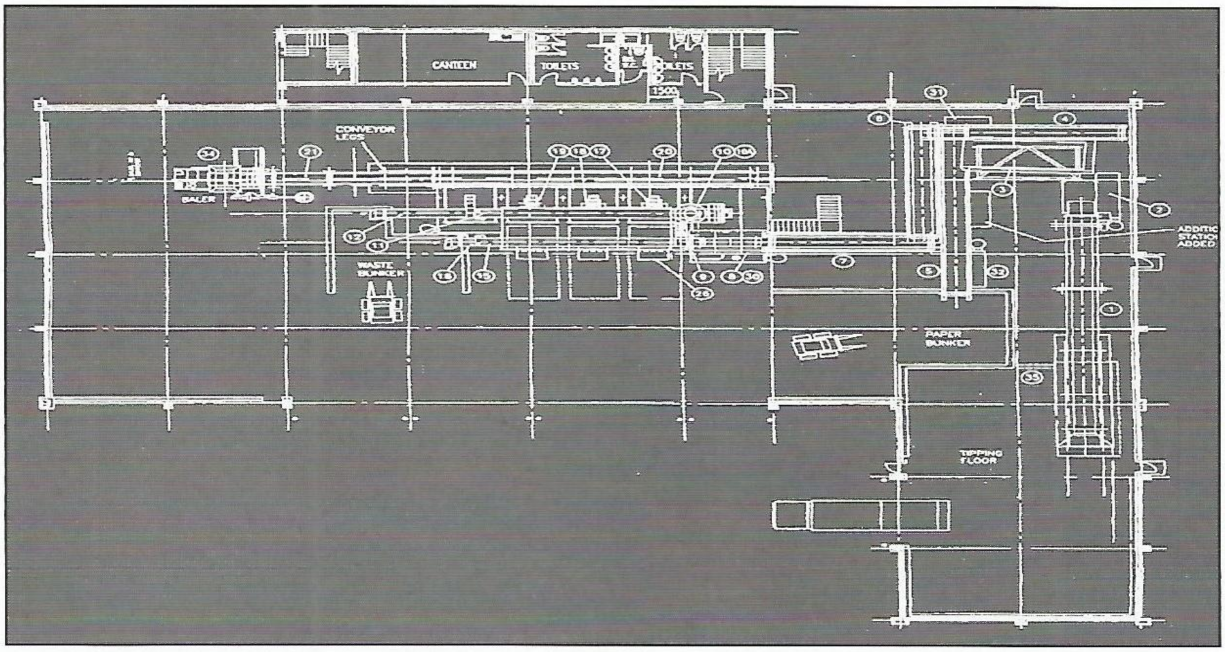


been established that an operative can positively[1] sort about 0.35/0.40 tonnes per hour of source-separated material that includes newspapers, cans, plastics etc. If the newspapers are sorted negatively,[2] however, the sorting rate increases substantially. To calculate the required processing rate, the designer will also need to know the plant's proposed shift pattern.

To avoid any confusion regarding the applicable shift pattern, it is always prudent to rate a MRF in tonnes per hour (Table 4.2) as opposed to tonnes per week, month or year. The Box 4.1 opposite is based on a survey of 51 MRFs in North America.

Flexibility

Over time, throughput and markets will change. A good designer will seek to build flexibility into the design to take account of these changes. Additional volume can sometimes be handled by adding an extra shift or by extending/adding a sorting line. Market changes can often be accommodated simply by ceasing to sort a given product. Conveyors can easily be made to run in a reverse direction to provide other options. The screen sizes of automatic sorting plant can be adjusted by the user to meet changing requirements.

Before proceeding to the layout of the MRF, the designer has to take all of the above design input factors into account. Rarely is it possible to accede to every input requirement. Although compromises will have to be made, perhaps the most significant problem encountered at any MRF is lack of space.

Layout

Reception and storage of incoming material

MRF designers sometimes make the mistake of failing to allow sufficient space for the storage of incoming materials. Ample space is needed not only for normal operations but also for accommodating materials which can accumulate rapidly when the MRF stops or slows for any unscheduled reason. Another point to consider is that the material tends to arrive at the MRF at the middle and end of the working day which further intensifies the pressure on storage space at peak times. In North America, most MRFs allow for 1–2 days storage.

Sorting and segregation

The layout of the sorting system itself depends to a great extent upon the type of system that evolves following consideration of the various input factors discussed above. In this area, the customer's decision between the high-tech or low-tech MRF options is of particular importance. The layouts of typical high-tech and low-tech MRFs will be discussed below.

Storage, conditioning and dispatch of segregated materials

The layout must allow sufficient space for the storage of the individual segregated fractions after the sorting process. The materials can be stored in bunkers under the sorting platform, in containers or stockpiled on site. Materials that have been baled can be stored in orderly form in a dedicated bale storage area.

Every consideration should be given to minimising the risk of materials catching fire. As well as having manual fire extinguishers and smoke/heat detectors, the design should wherever practicable also include sprinkler systems and fire walls. Storing materials under cover also reduces the risk of fire caused by arson. Covered storage has another advantage in that materials that have been exposed to the elements over a long period might prove unacceptable to a reprocessor.

It should be borne in mind that some very light fractions, aluminium cans for example, can take some considerable time before an economic or environmentally efficient load can be accumulated. Considerable storage space has to be allowed for this. In the case of high-value products such as aluminium cans, the storage area should also be secure against the risk of theft.

finished products should not cross the paths of the traffic delivering the incoming material. In a good layout, the finished products would leave the MRF building by a separate exit route. Due to site specific circumstances, however, this is not always possible.

Building design

In the previous sections, emphasis has been placed on the design and construction of the equipment required to sort and classify a particular input into the required fractions. However, the equipment needs to be enclosed in a structure to protect it, and the staff, from the prevailing weather. In addition, the structure should provide designated areas for the various activities taking place on the site whilst promoting good vehicle and safe pedestrian access.

As section indicates, the designer of the MRF is quite often faced with an existing building and asked to fit the equipment into the available space. This approach is not ideal as the MRF designer and operator will be compromised by the resultant layout. The MRF designer should be given as free a brief as possible to ensure an efficient plant layout is achieved. The architect or structural engineer should become involved once the MRF design has been agreed in principle. Ideally, the MRF design must inform the building design.

In designing the building, the architect or structural engineer may not be familiar with the operating environment. Primarily, the building should serve to meet the requirements of the operation. It has to be robust in construction to survive the tough environment of a MRF operation. It is important to give consideration to the questions listed below.

- How high does the building and access doors need to be to accommodate the equipment, delivery and collection vehicles?
- How are the exhaust fumes from the delivery and collection vehicles, mobile plant and other site equipment to be expelled?
- Certain reprocessors require materials to be loaded under cover. Can large vehicles enter the building for loading? Is there sufficient headroom to load the vehicle whilst avoiding lights or fitments?
- Is there provision to cover and uncover a load safely? Is a safety harness system required? Is it possible to reduce the loading height by use of a raised loading floor or vehicle pit?
- Are there any blind or difficult corners?
- Are the storage areas adequately sized for the volumes to be handled whilst allowing sufficient space for the loading shovel, mobile plant and the delivery or collection vehicles to manoeuvre?
- Are the stored materials likely to be affected by the prevailing winds and rain blowing into the building? How far into the building will the rain penetrate through an open door? Will the wind blow material out of the blown material contained?
- Are the walls able to withstand the pressure of the materials and the scraping action of the loading shovel? Should sacrificial steel plates be used in areas of high abrasion? Are there any cosmetic walls and is there mobile plant, other vehicles or stored materials likely to come into contact with them?
- Is there sufficient space for vehicles to service removable storage containers? Is it possible to use a push-through system requiring adequate access to both sides of the collection point?
- Are there any vulnerable parts of the structure that require barriers to protect them from collision damage?
- Where is the switchgear, lighting, alarm call points and sounders? Are they located in vulnerable positions?
- Does the building layout provide separate pedestrian and vehicle routes? Are there any points of conflict and how are they controlled?
- Will members of the general public have access to the building to view the recovery activity? If so, what facilities are required?
- Does the building design allow for good housekeeping? Are there ledges where dust and materials will accumulate? Are there open cavity spaces where material can collect but cannot be retrieved?
- Does the building provide roosting and nesting niches for birds and vermin? Are there areas where weeds will flourish?
- How does the building prevent and control unauthorised access? Are the perimeter fences and gates adequate? What security lighting is required? Are video surveillance cameras or patrols to be used? Is an alarm system to be fitted?
- Does the building have an integral weighbridge facility? What infrastructure is required (i.e. operator cabin, welfare facilities and telephone link)?
- How easy is it to maintain the building? Are emergency stop switches and valves easily accessible for the main services? Can lamps or tubes be replaced easily? Do windows need to be cleaned and how? Do electrically operated doors have a mechanical back-up?

Ultimately, buildings have to comply with planning constraints and those imposed by fire regulations, building legislation and health and safety. It is a bonus if the architect can make it visually attractive as well as functional.

Equipment

MRFs can employ a wide range of equipment. Much of this equipment can be summarised by taking a tour of two MRF plants, one low-tech, the other high-tech.

In a low-tech, labour-intensive MRF, the unsorted material is placed, usually by a mechanical loading vehicle, onto a primary reception conveyor which is often set in the floor to facilitate doze-on loading. Sometimes, even in a lower-tech MRF, the material will be first passed through a trommel or other pre-screen which can be designed to remove beverage cans and small plastic bottles as well as fine materials. The conveyor system then delivers the material stream to a sorting conveyor on an upper sorting platform. Here, sorting operatives will manually remove selected recyclables from the sorting conveyor and throw them down designated sorting chutes. An overband magnet may be included at the end of the line to remove the ferrous cans from the stream and deposit them down a chute. The sorting platform will have access stairways and may be enclosed with a cabin for the comfort of the operators.

The residual material falls from the end of the sorting conveyor to a container or, in some cases, to a compactor. Beneath the sorting chutes will be containers, wheeled cages or bunkers or bunker conveyors where the material will be held temporarily.

Additional plant in a low-tech MRF might include a baler with its feed conveyor and a stand-alone can separator or can flatteners or blowers for processing cans after segregation. The same mechanical vehicle that loaded the materials is normally used to manoeuvre the segregated materials and the bales produced by the baler.

High-tech MRFs

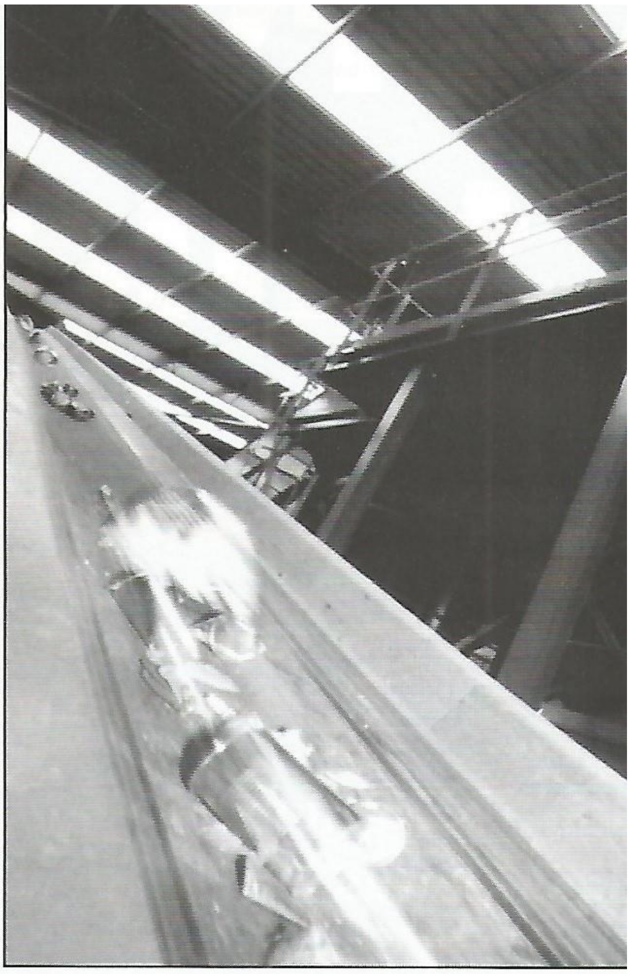
In a high-tech capital-intensive MRF, the unsorted material is again placed onto a primary reception conveyor. The material may then pass through a bag splitter/opener and then to a pre-sort station where contraries and oversize material would be manually removed. The next stage in the process might be a horizontal screen which would remove fines. The removal of fines cleans the remaining material leaving the residual grade – often newspaper – suitable for negative sorting (negative sorting refers to the sorting of a grade by leaving it as the single residual grade on the conveyor system, all other grades and contaminants having been positively removed earlier.). Next an inclined conveyor, paper grader or star/disc screen will separate the newspaper and cardboard from the plastic bottles and metal cans.

Even in a high-tech MRF, sorting personnel are needed for some tasks such as purifying grades by removing rogue items. Plastics separators and glass separators are available but due to their high cost are held to be economic only in very large plants where the volume is sufficient to justify them.

In a high-tech MRF, a high-capacity baler will certainly be required and will be fed by a collector conveyor which, as its name suggests, collects the sorted material dozed out of the bunker areas. Other items of equipment that may be found in the high-tech MRF are eddy-current separators and air classifiers.

Equipment common to all MRFs

Conveyors are a fundamental part of all MRFs. In high-tech MRFs, the conveyors are subject to a sophisticated electrical control system that dictates when conveyors start and stop in conjunction with each other and with other items of plant.



Conveyors start up in cascade sequence with the last conveyor starting first. Conveyors usually run at sequentially increasing speeds to ensure appropriate material levels on all conveyors, thereby facilitating the sorting process whether manual or automatic.

The benefits of designing a conveyor system to allow for separate feed conveyors so that speeds can be utilised to level material flow on the sorting conveyors should also be noted (e.g. separate in-floor, incline and sporting conveyors that run at increasing speeds).

A weighbridge will be required for all but the smallest MRF as a means of monitoring the weights of materials entering and leaving the facility.

Educational facilities

Increasingly, organisations commissioning MRFs are having educational facilities incorporated into the design. These facilities usually consist of a room where groups, often school children, can be given an insight into recycling activities. Displays often include examples of incoming material, examples of products made from recycled materials and literature or videos describing the recycling process.

Some MRFs have viewing windows which allow visitors to observe the workings of the MRF whilst other MRFs permit guided access to the work floor. Increasingly, however, there is a reluctance to allow visits to the MRF work area due to concerns over health and safety.

Innovation and new technology

As in any branch of industry, there is constant innovation in the MRF sector, and as both EU and UK waste management policy drives up the volumes of material coming to MRFs, there will be an increasing requirement for improved methods of mechanical separation of waste materials. For larger tonnages, manual sorting simply may be unable to cope or prove too costly. Furthermore, mechanical sorting will be given added impetus by growing health and safety concerns for sorting personnel working at first hand with all but the cleanest waste materials. Recent sorting technologies, some of which have already been referred to, are considered below.

Air classifiers

Air classifiers separate out the lighter fraction of the material stream such as aluminium, glass and plastic. Air is used to lift these lighter elements that are then taken away by a cyclone system.

Bag splitter and opener

With much of today's waste, including recyclable waste, arriving in bags, there is a growing demand for machines to break the bags open and liberate the contents. Such is the anticipated volume that the manual opening of bags is likely to be unrealistic for all but the smallest operations.

There are several machines which split or open bags, although with varying degrees of success. Some use a high-speed hammer-mill principle to break up the bags with the attendant disadvantages of noise and destruction of the product which makes sorting more difficult. Other more sophisticated machines attempt to slit and empty the bags individually and even collect the bag itself.

Bucket screens

Bucket screens are conveyors that are tilted to one side and have an extremely steep elevating angle. The conveyor's belt consists of a series of small pockets. The incoming waste is fed onto the bucket screen from one side. The small, fine element of the material falls into the pockets and is carried up the conveyor's slope and leaves the conveyor via the head in a conventional manner. The over-size material that cannot sit in the pockets cannot negotiate the steep slope of the conveyor. Instead, as intended, it rolls at the foot of the slope moving slowly across the tilted conveyor before falling off on the opposite side to that at which it entered. In principle, the bucket screen fulfils the same task as a trommel. However, it is said to be more effective and more productive because, unlike a trommel, it rarely requires cleaning or unblocking.

Eddy-current separators

Eddy-current separators (ECS) are designed for the automatic segregation of aluminium cans. Using a sophisticated system of counter magnetic forces, the ECS causes the aluminium cans to leap from the conveyor and fall into a separate collection chute. The considerable cost of an ECS is usually justified because of the relatively high price that is paid for recycled aluminium.

tables – are conveyors that are tilted laterally to the left or right. Mixed materials are fed to the conveyor on its high side. Rounded materials like cans and plastic bottles fall or roll to the lower side of the conveyor where they are collected for separate processing. Mechanical beaters under the machine compel the cans and bottles to roll. On the other hand, flat items like newspapers remain at the top of the conveyor and are also segregated. Sometimes, chain curtains are used to achieve more refined degrees of sorting.

Optical sorting machines

Lighter materials can be sorted using optical means to identify the individual constituents of the material stream. In a typical system, an optical overhead scanning device reads the contents of a moving conveyor belt. It identifies the individual constituents of the material stream and sends a corresponding signal to a computer. The computer, having calculated the position and speed of the target item, activates a removal mechanism situated downstream which directs the item to its designated stockpile. Removal mechanisms can be air jets or mechanical pusher devices.

Paper graders (star screens)

Paper graders consist of a series of turning shafts to which shaped discs are fixed. Material, usually newspaper, is passed over the grader (or screen). The smaller fraction immediately falls between the shafts while the larger fraction continues over the top being passed from one disc to the next without falling through. The screens can work at elevating angles of up to 35°. At one size, the screens will separate junk mail from newspapers. At another size, they will separate newspapers from cardboard.

Plastic separations

Plastics separators use optical scanners which can identify different types of plastic containers on a conveyor. The containers have first to be evenly distributed by the conveyor system so that the scanner can work efficiently. Once identification has been made, a signal is passed to a series of air jets. As the identified container passes the appropriate sorting chute, the corresponding air jet is activated to blast it off the conveyor and down the chute.

Sorting robots

Some work has been carried out on the development of robots for sorting waste materials. In one system, individual recyclable pieces are identified for type by an optical scanner after having first been evenly distributed by the conveyor system. The scanner passes a signal to a robot arm which is able to replicate the work of a human; picking up the piece (by suction) and depositing it in the appropriate collection container. Accuracy is said to be over 95%.

At the present stage of development, one robot arm can work at roughly the same rate as one human sorter. However, due to the substantial cost of producing the robots, it is considered unlikely that they will provide an economic alternative to existing means of sorting in the near future.

Sieve screens

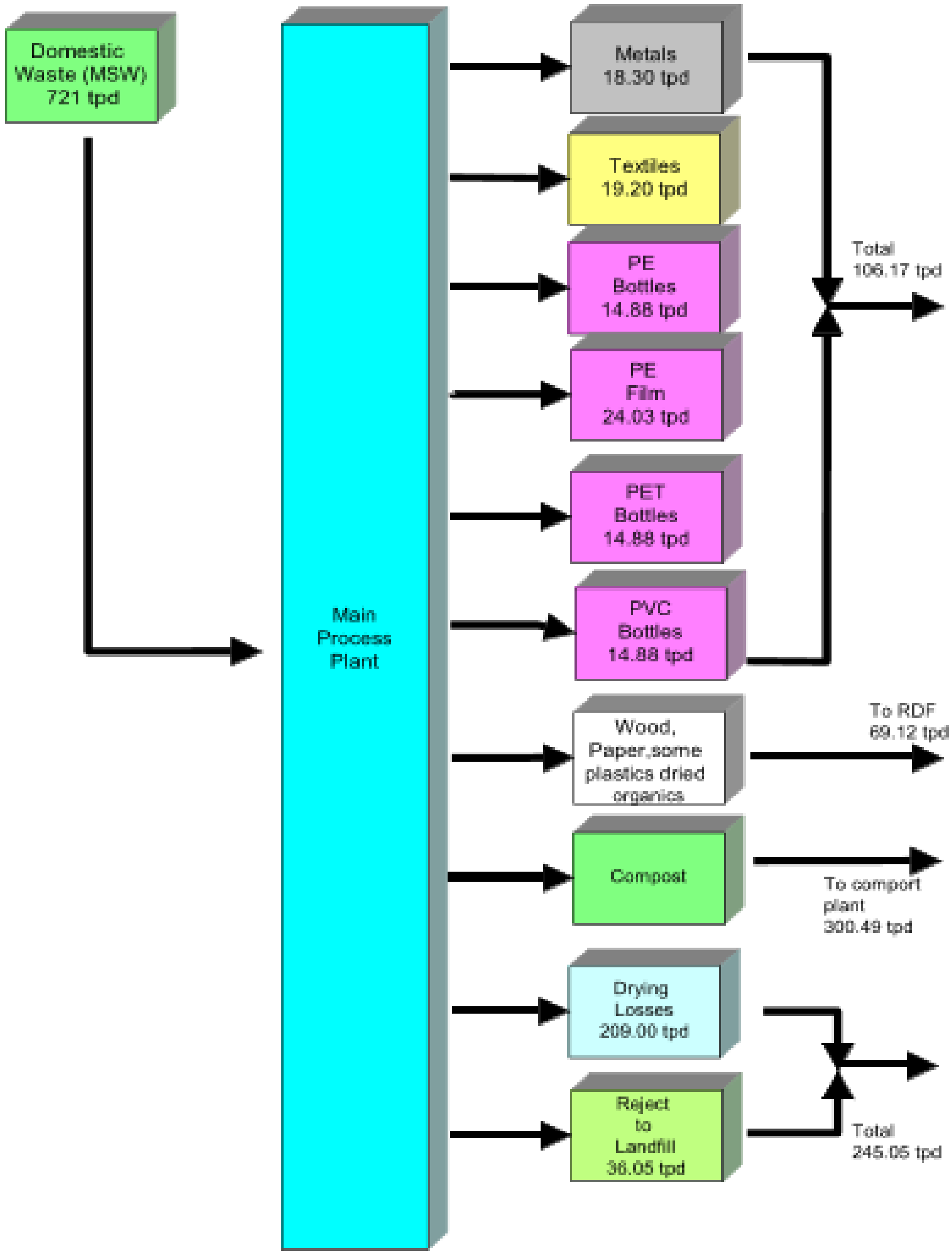
Sieve screens are used to remove the fines at the front end of a MRF. Removing the fines and other contaminants

Integrated Waste Management Plant – MRF based in Winchester in the UK (example)

Details here to page 99 relate to our Winchester City proposal made in 2004 in the UK

Resource Centre - Integrated Waste Management Plant –
Possible Inputs & Outputs based upon a larger tonnage of 250,000 tpa of MSW for the purposes of an example.

Fig 14. Based on a UK Plant proposal for Winchester



Waste Oils

Waste oil from automotive, industrial and other sources must also comply with recovery rates and Waste Oil Directive regeneration targets.

The IMGroup have chosen Waste-to-Energy Ltd. – Lowest EU Emission Gasification process to manage this waste stream. Most lubricating oils contain additives, which produce specific performance from the oil. Additives may include rust inhibitors, detergents or alkaline compounds and constitute 5% to 25% of their formulation. Waste oils can contain traces of the additives and contaminants following use, including metals or waste combustion gases.

There are a number of sources of waste oils;

Automotive engines

Transformer and cutting oils

Marine oils

Aviation oils

Recycling Glass

Glass can be recycled without the loss of properties and the use of cullet has a number of significant benefits:

Conservation of raw materials.
Reduce waste going to landfill, thus reducing costs for local authorities.
Reduce energy usage in glass manufacturing.
Reduce atmospheric emission.

The European average for recycling container glass is over 50% and some EU countries such as Austria, Denmark, Germany, Belgium and the Netherlands already achieve 70% recycling rates.

The capacity for recycling Green cullet is very different to that for the flint or amber coloured glass.

The IMGroup intend to recommend having a small scale manufacturing plant onsite, if required, which can produce glass wool insulation products. Any manufacturing on site will enable the revenue stream to increase significantly to off set any additional capital costs involved in additional plant.

Glass Wool Manufactured Products

On site in Resource Centre

Construction and Demolition Wastes

Recycling Construction and Demolition Waste.

Winchester City Council could demonstrate construction material recycling, on a small scale and bring in companies to deal with this waste stream in order to produce aggregates and useful products for re-use and help prevent Fly Tipping. Construction and demolition waste including clay and sub-soil represents a significant proportion, approximately 16.5 % of all wastes arisings. The majority of this waste is bulky and inert and is not susceptible to treatment such as incineration or biodegradation. There remains, however considerable potential for using recycled construction and demolition waste material as a substitute for primary aggregates. Using construction and demolition waste in this way has a two-fold benefit;

Reduction in both the amount of waste landfilled.

Less environmental impact as a result of less quarrying of the primary minerals.

In the UK, during 1989 it was estimated that 70 million tones of construction and demolition waste, including clay and soil, arouse annually in the UK and a further study published in 1994 found that 29% of the 70 million tones was used on-site possibly after coarse crushing, 30% used as landfill engineering and 30% deposited on landfill. Only 4% was crushed to a graded product, the remaining 7% was disposed of illegally or used for agricultural purposes. The UK policy on the use of construction and Demolition waste is set out in the Minerals and Planning Guidance Note 6, published in April 1994. Aggregates and products made from aggregates should be recycled wherever possible and where technically, economically and environmentally acceptable, construction and demolition wastes should be used instead of primary materials. Once more the IMGroup plant could have a small on site manufacturing unit in order to produce Briquettes and other construction materials such as breeze blocks from the Energy From Waste (EFW) ash.

Winchester City Council may already have policies for recycling of construction and demolition wastes, the following list of measures indicate the action that the UK Central London Government have taken in support of the UK policies;

- The setting up of an Aggregates Advisory Service

- Establish a monitoring database for recycled materials

- Introduction of an Internet based waste exchange to provide builders, civil engineers and demolition contractors to trade in surplus construction and demolition waste materials.

Production of an industrial sector Handbook on the use of recycled materials in construction.

- Production of Guidance on waste reduction and recycling in the Construction Industry.

- Consider the introduction of a Central Government Landfill Tax on inert waste.

The above list only is meant to serve as an example of what could be put in place by the Winchester City Council. The UK construction and demolition industries have responded positively to the policy of the encouraging the use of recycled products and the enthusiasm shown is being directed into producing a more Sustainable Construction Industry in the UK.

Batteries

These can be classified into two main types:

Automotive
Consumer

Automotive batteries are often recycles, however, the consumer batteries are often thrown away in the household rubbish (MSW).

The European Union regulations indicate that these batteries should be recycled.

Automotive Batteries.

Winchester City Council may, like the UK have a problem with Automotive Batteries. In the UK approximately 10 million automotive or SLI – starting, lighting, ignition batteries are sold each year and a similar number scrapped each year. There is a strong economic incentive for these to be recycled, because of the value of the 100,000 tonnes of lead metal which their electrode plates contain. Large lead smelters also can arrange for the plastic casings to be recycled.

Consumer Batteries.

Consumer batteries can be categorized into primary – single life types such as zinc carbon, alkaline-manganese and various button cells, and secondary – rechargeable varieties, such as nickel cadmium and nickel metal hybrid. It has been estimated that in the UK 600 million consumer batteries are thrown away each year, representing between 20,000 and 400,000 tonnes. The UK has no facilities for recycling these batteries and there is little value in the materials, which they contain. General purpose battery recycling plants in Switzerland charge £2,000 per tonne for processing.

At present, only the nickel cadmium batteries are being collected and recycled in any numbers, which are being shipped to France for recycling processing, with a target of 1550 tonnes per annum in the UK.

Recycling will become more commercial viable when mixed battery feed stocks become mercury free, and with the adoption of the less mercury levels in batteries being adopted in the European Union will hasten this process.

Electrical Items – Televisions, Computers, Radios etc.

Plastics

Plastics are a family of materials based upon long chain organic molecules called polymers and they are manufactured using hydrocarbons such as oil, natural gas and other chemicals.

Plastics are lightweight, durable and resistant to moisture, chemicals and decay. They remain relatively inexpensive to produce and very versatile.

Table 8 Plastic types in European Household waste

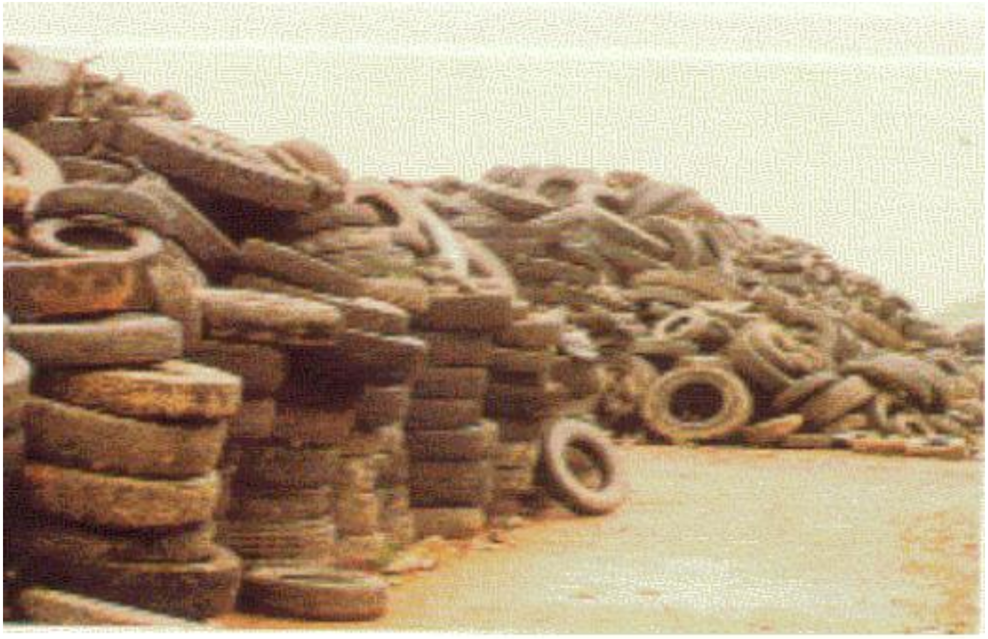
Plastic Type	Percentage
Low Density Polyethylene (LDPE)	23
High Density Polyethylene (HDPE)	17
Polypropylene (PP)	19
Polystyrene (PS) / Expanded PS (EPS)	12
Polyvinyl Chloride (PVC)	11
Polyethylene Terapthalate (PET)	8
Others	10

Source: "A Way with Waste", A Draft Strategy for England & Wales, Part two, DETR, UK Government, pp101,June 1999.

In the UK as an example there is estimated to be 2,800,000 tonnes of various types of plastic waste generated each year. In Europe, packaging accounts for approximately in 60% of this plastic waste, although the arisings in the construction and electronics sectors are expected to increase rapidly. Plastics account for approximately one fifth of waste packaging materials, the split between domestic and industrial packaging waste is assessed at 200,000 tonnes and 500,000 tonnes for industrial plastics.

Plastic, on average makes up 7% of material within the Municipal Solid Waste stream by weight, although in terms of volume the perception can be considerably higher. The main disposal route in the UK of plastics is currently landfilled, but for Winchester City Council it is recommended that the majority of this waste is recycled with partial energy recovery in Low Emission Energy Recovery Plant, part of the IMGroup proposals. In the UK to indicate the mix used in plastic waste disposal management 100,000 tonnes of plastic was recycled in 1997 and 150,000 tonnes incinerated with energy recovery.

Traditionally, plastics have tended not to be recycled as the cost of recycling and decontamination have militated against the process. The IMGroup consortium company chosen again for this is either HLC Henley Burrowes or O.Kay Engineering Services Ltd.



Recycling methods include;

Direct recycling to virgin plastic which is difficult due to contamination, mixture of grades and the type of original product, thus selective collection and sorting is required.

- Re-melting and extrusion, using certain types of plastics as raw materials for making objects such as street signs, garden tables and benches together with vehicle parts, mats etc. This process can only be used on thermoplastics, which soften when heated and harden when cooled. More than 80% of plastics are of this type. The main drawback is that the melting temperature must be kept below 200 o C, at which polyvinyl chloride (PVC) decomposes.

Grinding down the plastics mixture with fillers and adhesives, followed by high pressure extrusion to produce low quality plastics where finish and appearance are relatively unimportant. This process is used on thermoset plastics, which are hardened by curing and cannot be re-melted or moulded.

The Packaging Regulations require a considerable increase in the amount of plastic waste to be recycled by 2001. Plastic must meet the 15% materials specific recycling target within the overall 50% recovery target for packaging waste, for the UK this amounts to 255,000 tonnes in 2001.

Surveys in the UK have indicated that each household generates each week approximately 0.6kg of dense plastics waste - bottles, food packaging and other non-film items and 0.6kg of plastic film. This amounts to 1.3 million tonnes of household plastic waste per annum.

The breakdown of plastic in this household waste stream has been estimated in the UK as being:

Food packaging	**17%**
Refuse sacks	**10%**
Bottles	**17%**
Other film	**37%**
Other dense plastic	**19%**

In 1998 in the UK 11,000 tonnes of post consumer plastic packaging were recovered from this household waste stream.

There are two methods of recycling plastic:

mechanical recycling
feedstock recycling

Mechanical recycling is the physical separation and treatment of the plastic waste, mainly by single polymer types, where the original plastic or polymer characteristics are retained.

Feedstock recycling is the conversion of the plastic waste back to its original hydrocarbon base. This can be conducted in one of two ways according to the polymer type: chemolysis with conversion from single polymer type e.g. PET, PU back to intermediate building blocks for condensation polymers; or thermolysis where heat and or pressure is used to convert mixed plastic waste e.g. PE, PP, PS PVC back to original hydrocarbon building blocks. Almost all UK plastics material is recycled mechanically, feedstock recycling being comparatively a new process.

STEEL

It may help Winchester City Council to understand current recycling activity in the UK for this Steel waste stream in Tyres and in general.

There are economic, environmental benefits associated with recycling steel.
Energy savings and process emissions are significantly reduce, if recycled steel is used in products manufacturing. The IMGroup will utilize HLC Henley Burrowes technology or Okay Engineering Services for this recycling.

Steel scrap is traded globally and approximately 350 million tonnes of steel scrap are consumed annually throughout the World, constituting an estimated 46% of total World steel production. Steel is produced in one of two ways: Basic Oxygen Furnace (BOF) or the Electric Arc Furnace (EAF) process. For both of the production methods a requirement exists for scrap steel input to the process, between 17% and 27% by weight.

World wide there is a tendency for the increased use of steel-dependant steel making processes, which has been made possible by the advances in steel process technologies. In recent years the steel processing industry has developed and invested much money in sophisticated scrap processing and grading equipment to enable the preparation of steel to clearly defined specifications. The development of International Ferrous scrap markets had facilitated investment into the new scrap dependant steel technologies. It is estimated that the Global steel consumption has reached 50% of World Steel making capacity.

Barriers identified to increase recycling and proposals to overcome them:

The steel market is functioning well and the only barrier to overcome to increased recycling rates appeared to be the quantity of metal collected. More metal could be used provided it could be recovered economically. The issue therefore is how to increase collection rates for steel in Winchester City Council.

Aluminium

Aluminium packaging represents the major part of non-ferrous metal in household waste. Approximately 70% of all the 7.5 million drink cans sold in the UK are made of

Aluminium, probably with a similar ratio in UK. The IMGroup will utilize once more HLC Henley Burrowes or Okay Engineering Services for this process recycling of Aluminium.

Current Recycling Rates in the UK.

Due to Aluminium's intrinsic high value, it is economically viable for smelters to recycle all grades of plain aluminium scrap. The use of secondary aluminium compared to primary may save up to 95% of the energy used in the production process, the capital cost associated with the production of secondary aluminium is only a fraction of the cost of a primary smelter. Secondary aluminium is equivalent to primary in composition and quality and is price competitive.

The Winchester City Council and County Council and Central Government should consider investing into increasing the recycling of Aluminium packaging recycling rates. Any investment could fund consumer education, develop a collection infrastructure, support of collection programmes and the provision of reprocessing capacity, backed up by guaranteed end-use markets.

Barriers identified to increase recycling rates and proposals to overcome them.

Technically, it is feasible to recycle all grades of aluminium scrap. It is, however, costly to remove contaminants or minimize their adverse effects. Apart form the problems of the quality of the metal collected for recycling the only other barriers identified were the amount of aluminium collected for recycling. More aluminium could be collected and recycled if it could be collected economically. Like steel, aluminium recycling rates is dependant upon the amount of recycled material collected.

The Waterlooville Resource Centre would be designed on the basis of the following criteria, the Resource Centre plant could be designed to handle 3,000 tonnes per annum of domestic and other suitable solid wastes (MSW) as well as the normal wastes collected at the old Waterlooville site.

Plant Operational Period: - 8 hrs/day, 7 days/week, 347 days/year.

Waste Input - 3,000 tonnes i.e. average per annum

Plant Design Capacity - Requirement (average over 168 hours/operating week)

Maximum period of operation, allowing 0.95 availability.

Separation plants, similar to this, have an availability factor better than 0.90. Hence there is sufficient time to maintain the plant without affecting the production capacity.

The waste reception area could be of sufficient size to store a three-day's supply of MSW to allow time for maintenance of equipment without the need to divert waste directly to the landfill.

The principal separation processes are as follows;

(i) Manual picking facilities for the removal of textiles and plastics (plastic sorting can be augmented by mechanical means)
(ii) Recovery of ferrous and non-ferrous metals
(iii) Removal of glass and minerals
(iv) Separation of organic and combustible materials suitable for composting or RDF in the Biomass plant.
(v) Screening and Crushing of small Construction & Demolition Waste.
(vi) Processing of Fridges
(vii) Processing of Electrical items
(viii) Processing of waste oils
(ix) Tyre shredding and crumbing
(x) Manufacturing of plastic & glass products onsite

As with process plant where it is not possible to clearly define the input material, it is extremely important that maximum flexibility is in-built into the selected flow line to allow for considerable swings in the input at any one time. It is therefore, possible to cater quite large seasonable fluctuations. All prime items of equipment, such as screens, pulverisers, etc., in the main core line are generously sized to cater for relatively large fluctuations in throughput, analysis and rate. Flexibility also assists in the commissioning of the plant where sections of the process can be systematically tested.

Pre-screening is an essential part of waste processing particularly when resources recovery is required. This screen allows a degree of size selection that improves the efficiency and reduces the size of the pulverisation stage by screening –50mm size material from the process stream to the pulverisers. It also allows the retrieval of several products.

Estimated waste component size distribution in MSW.
Based upon waste analysis from Hampshire – 2003.

Table 9 Estimate waste component size distribution in MSW

Component	Input % as received	-50mm	+50mm - 300mm	+300mm
Organics	60.55	45	15.55	0
Paper	9.29	0	9.29	0
PE Film	3.23	0	0	3.23
PE Bottles	2.00	0	2	0
PET Bottles	2.00	0	2	0
PVC Bottles	2.00	0	2	0
Metals	2.46	1.23	0	1.23
Glass	8.61	2	6.61	0
Textiles	2.58	0	0.58	2
Other	7.28	2	2.28	3.0
Total	100%	50.23%	40.31%	9.46%

Refuse Derived Fuel (RDF) for use in the Biomass Plant

The RDF Biomass plant is separate to the Resource Centre, which handles combustible items such as paper, cardboard, wood and some plastics, identifies the items by shredding them to –50mm.

Also, organic material, which has been dried and stabilised in the composting plant, is also fed to the RDF plant for mixing and storage with the other combustible materials. The plant will operate 24 hours per day, 7 days per week and 347 days per annum. It is anticipated that all the RDF, having a calorific value of about 13.9 MJ/Kg, will be used in the plant gasification process for heat and electricity production.

Compost

All the organic material will go to the composting plant for drying and stabilisation. It is anticipated that a maximum of tonnes per annum of compost could be sold locally in Hampshire and hence the majority of the dried organic material will be fed to the compost plant. This design can be altered to suit local requirements.

A recent Sustainable Development Investigation Group in the United Kingdom discussed the serious issues facing the UK in waste management. If Ghana wish to meet the present and future international obligations and deliver its domestic policy objectives on the " Environment and Sustainable Development" then a significant expansion in demand for recycled products is essential to secure the level of increased recycling activity in the respective countries.

The development of current uses of recycled products will not by its self achieve the step change required, a new and more radical approach is required.

New Approach

The new approach for Ghana should set out to identify and develop new and innovative uses or applications for recycled material that would complement the existing, established uses, through the development of technology, standards and procedures in conjunction with business and industry. The new objective should be to identify a broad range of more diverse, higher value outlets in sectors outside those that produced the recycled material.
As an example: Glass containers should not necessarily be returned to glass manufacturing industries, but could be recycled into a variety of other products in a range of industrial sectors, on site in small manufacturing units.

This approach would also emphasize that the recycled material has certain engineering and other properties that give it value, in addition to the value already present in the recovered materials. This is in contrast to the traditional attitude towards many recycled materials that, because they are waste derived, they are of intrinsically poor quality and necessarily low value.

Expanding Use of Recycled Material and Increasing Recycling Rates.

As well as achieving increased recycle rates an expansion of the uses of recycled materials into new products would help to achieve greater market penetration and price stability for some materials. At present recycling in the UK relies heavily on a small group of reprocessors, which may result in the instability of the market and the volatility of prices. When the demand for material is high, prices rise rapidly, but when demand falls, even marginally, prices collapse. An expansion of recycling into non-traditional sectors, involving an increasing number of reprocessors and manufacturer's, may help to mitigate these negative effects.

Developing New Markets

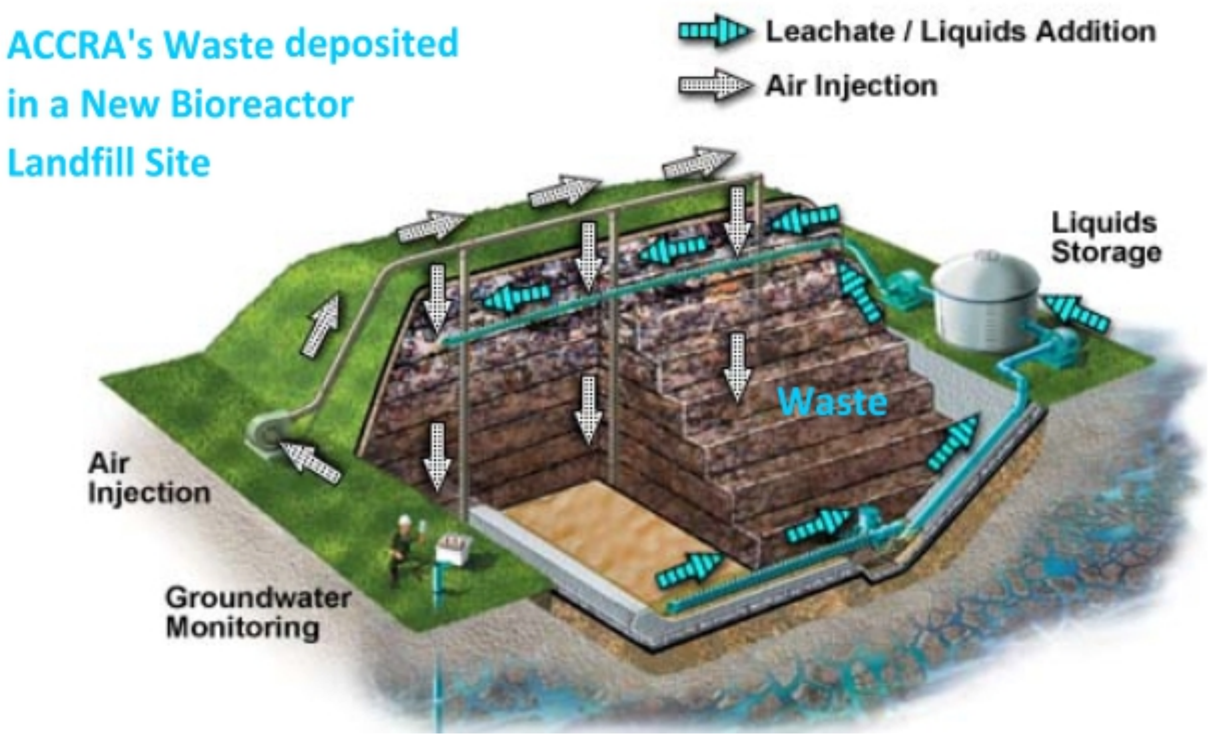
Developing the markets for recycled material will have both National and Regional benefits for Winchester City Council. There are advantages to finding new uses locally, since this adds significantly to reducing environmental additional impacts such as atmospheric pollution emanating from transportation, also adds to the value of the material by keeping transport costs down and the Life Cycle Analysis (LCA) of recycling reduces manufacturing energy use and further atmospheric emissions finally it will create local employment opportunities in reprocessing and manufacturing.

In conclusion, the work on the development of new markets should be taken forward urgently as a priority measure, recognizing that this was a long-term solution and that new uses for recycled materials would take time to develop.

The respective UK Government could develop grant systems to organizations as a measure to encourage the take up of the increased use of recycled materials in those organizations and to encourage new manufacturing, production and research activities. National the focus for using recycled materials should be given a high profile; this may be the role of the National Government – such as Central & Winchester City Council Local Government with Regional County Governments like Hampshire and the HNRI, taking forward the initiative.

6. *Oblogo Landfill - Clearing existing Landfill sites – Clearing process & Utilising products*

We should close the Oblogo landfill site and cap it and then site another new Bioreator landfill site close to ACCRA where waste from ACCRA Transfer Stations can be stored and electricity produced. We can of course add two of the other landfill sites from the list in your original brief if required as a choice for the Government. The New Energy Plant should be sited by one larger transfer Station with Zero new waste going to Landfill in the future, with Zero emissions and Revenue generation over a twenty-five-year period. The four temporary Landfill sites in this programme together with existing Landfill sites could be cleared and the resources within the Landfill such as Organics, Plastics, Metals etc can then be recycled and RDF produced as a feedstock to the Integrated Waste Management Plants and Energy Plant.



Oblogo Landfill site

Accra generates over 2,000 metric tonnes of waste a day - 730,000 tpa, much of this waste goes to Oblogo Landfill. PENNGATE recommend closure, on health and environmental grounds of the the Oblogo landfill site and cap it and then site another new Bioreactor landfill site close to ACCRA where waste from ACCRA Transfer Stations can be stored. We can of course add two of the other landfill sites such as Sekondi-Takoradi or from the list from the Governments original brief if required as a choice for the Government. with Zero new waste going to Landfill with Zero emissions and Revenue generation over a twenty-five-year period.

Oblogo landfill is the main recipient of waste from the city of Accra-Ghana. It is situated near an ecologically important wetland where the Densu River which supplies water to most part of the city runs through. The study was carried out to assess and evaluate the appropriateness of the location and operation of this landfill, to determine the composition of the solid waste dumped at the landfill and the extent of contamination of the landfill leachate to the surrounding environment (water and soil). Field measurements were carried out to determine the concentration of nutrients and metals in the landfill leachate, water and soil using UV spectrometer and Atomic Absorption Spectrometer. The landfill is not well located as it is close to a residential area, school and cattle farms.It is also located on a slope which ends in an ecologically important wetland, the Densu wetland. The landfill generates nuisances such as bad odour, scattering of waste by scavenger birds, flies and noise from vehicles carrying waste. Industrial and hospital waste are not pre-treated before disposal into the landfill. The concentration of most of the variables (nutrients, heavy metals) recorded especially for the metals were low. Nutrient values recorded in the leachate taken from the leachate canal were relatively high. The leachate has a high organic strength as the BOD/COD ratio was greater than 0.7 and this shows the higher biodegradability and acidic phase of decomposition of the landfill. Although there is accumulation of metals in the sediments and water, the concentration has not reached toxic levels to humans.


Graphic Online

The existing landfill sites in Accra are reaching full capacity and the acquisition of land for the construction of landfill sites has become very difficult due to rapid developmental activities in Accra. However, with the current rate of development which will cause the construction of landfill sites to be far from the source of generation, there is urgent need to get an intermediate facility, that is, waste transfer station where waste would be processed and compacted in long distance trucks to reduce the cost of waste transport and disposal. The objective of the study was to determine suitable places that could be used as waste transfer stations in relation to location of landfill sites using Geographic Information System (GIS). In this study, coordinates of all the container sites in Accra were determined with the Geographic Positioning System (GPS). The coordinates were then converted into points using ArcGIS and Microsoft Excel 2007 to help analysed the data collected. From the study, four transfer stations were located with the help of the GIS, namely: Ablekuman and Amomola (Transfer station 1),Oblogo and Weija (Transfer station 2),Ashongman and Agbogba (Transfer station 3), AshaleyBotwe and Ogbozdo (Transfer station 4).

The Sekondi-Takoradi Metropolitan Assembly (STMA) is negotiating to reactivate a project with World Bank funding and a company is currently re-finalising the design of the landfill site at Sekondi-Takoradi. PENNGATE would advise contunue this project and to make this a temporary solution over the next two years and then an Energy plant could be sited at this site in the future to take the existing waste as a feed-stock to the Energy Plant.

Fig 15 Map of World Bank Waste survey in ACCRA

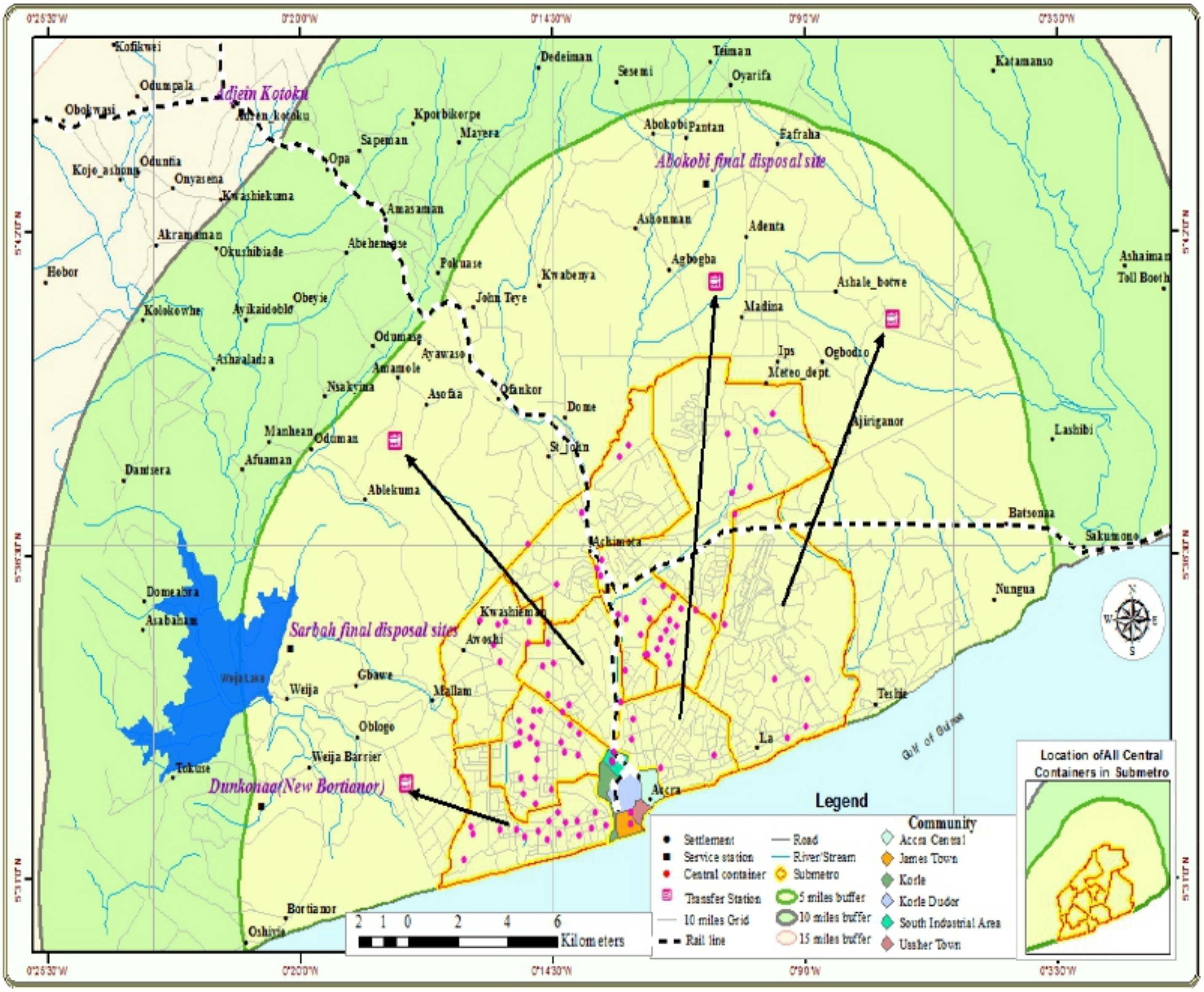


Figure 5. The arrows in the map indicate location of all container sites in the sub-metros and location of transfer stations.

The arrows in the map indicate location of all container sites in the sub-metros and location of transfer stations.

Table 10 Distance to final disposal site from Trabsfer Stations

The average distances to final disposal site, nearby transfer Stations, and transfer stations to final disposal site.

Sub-metro	Average distance to final disposal site	Average distance to nearby transfer station	Average distance from transfer station to final disposal Site
Ablekuma North	28	8	20
Ablekuma South	33	8	25
Ablekuma Central	31	6	25
AshieduKeteke	36	10	26
Ayawaso Central	26	13	13
Ayawaso East	28	15	13
Ayawaso West	29	7	22
La	37	13	24
Okaikoi North	22	11	11
Okaikoi South	32	11	21
OsuKlottey	32	16	16

Source: http://www.academicjournals.org/journal/AJEST/article-full-text/C32D5A757374

Waste transfer stations are usually established to ensure effective collection and also help in reducing the cost of operations. It is generally less expensive to deliver collected Municipal Solid Waste (MSW) to transfer stations where it can be consolidated into large loads that can be transported by trailer trucks, rail cars, or barges to large-scale management facilities than transporting the same amount of MSW in substantially smaller vehicles. The latter increases fuel consumption and number of trips needed to transfer waste to final disposal sites. To establish the construction of waste transfer station, distance is very important.

In view of this, the sub-metro boundary obtained from the AMA with the help of ArcGIS software, various buffers (3, 6, and 9 km) were created from the external boundary of the merged sub-metro. These were done to inform decision or policy makers as to the acceptance of the concept of waste transfer stations.

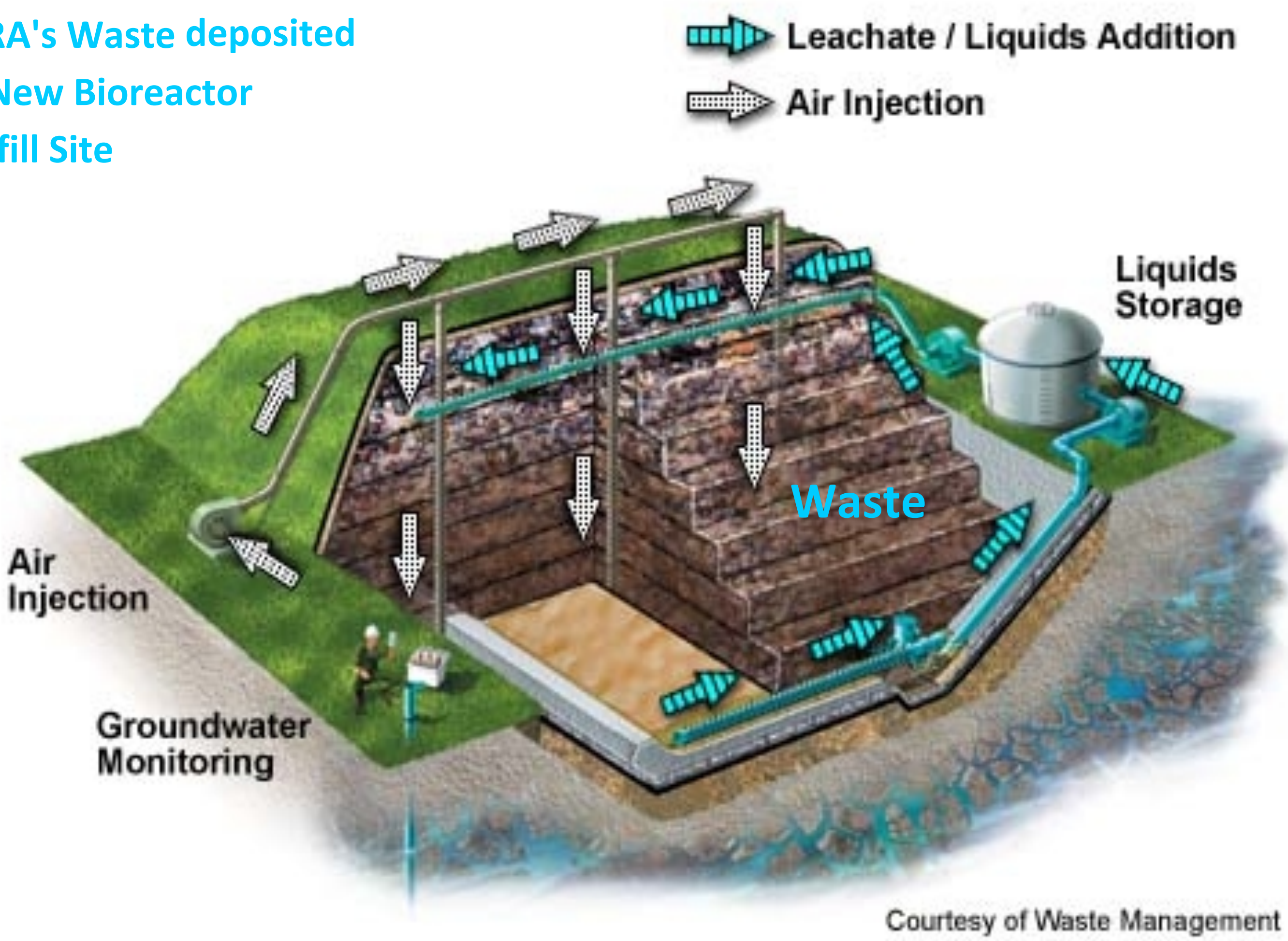
Technically, it has been established that ideally transfer stations are considered when the source of waste generation is 6 km from the final disposal site, which then makes it economically more viable (US EPA, 1995). from the categorisation made on the maps, it was realised that most of the current dumping sites are within the 6 km range except the compost and recycle plant being constructed by Zoomlion Ghana Ltd. at Adjei Kotoku which was beyond 6 km. But most of the dump sites currently being used are full and looking at the rate at which Accra is developing, there is greater tendency that landfill or dump sites to be acquired will go beyond the 6 km. This information then prompts the need to consider waste transfer station concept to enable solid waste to be managed effectively. In the location of the various transfer stations depended on the necessary factors used to selected a suitable place for the establishment of a waste facility. In this re-search, maps of all these information were collected and super imposed on the map of Accra to get the maps in Figure 5.

From the categorisation made on the maps, it was realised that mostof the current dumping sites are within the 6 km range except the compost and recycle plant being constructed by Zoomlion Ghana Ltd. at Adjei Kotoku which was beyond 6 km. But most of the dump sites currently being used are full and looking at the rate at which Accra is developing, there is greater tendency that landfill or dump sites to be acquired will go beyond the 6 km. This information then prompts the need to consider waste transfer station concept to enable solid waste to be managed effectively

The New Bioreactor Landfill for ACCRA would turn the waste into a valuable resource - electricity production from the Bioreactor.

PENNGATE propose the New Bioreactor Landfill for ACCRA that would deal with the current 730,000 tpa of waste per year, producing electricity until the New Energy Plant is operational.

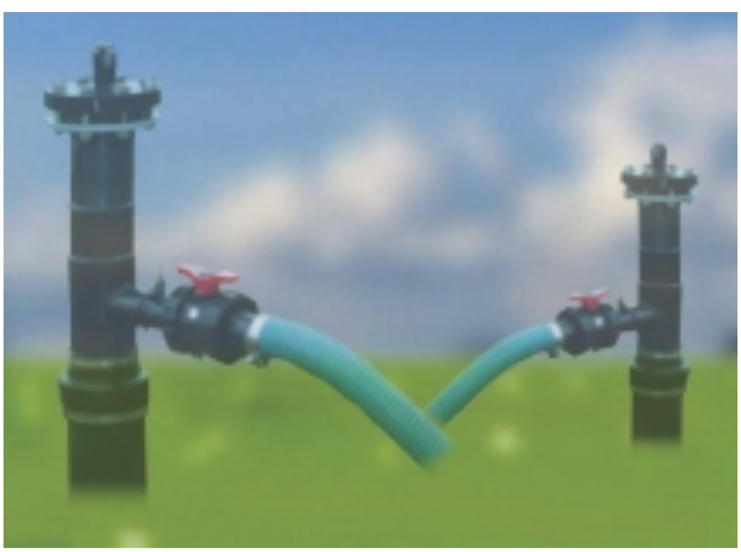
ACCRA's Waste deposited in a New Bioreactor Landfill Site



• *make a valuable contribution to the sustainability, environmental and carbon mitigation goals and reporting of your organisation*
• *offset power produced from fossil fuels*
• *usefully control greenhouse gas emissions*
• *financial savings through inclusive gas management on the landfill*
• *financial savings of the electrical costs of flare operation*
• *potential for low cost electricity to drive other site loads, or even nearby premises by a private wire*
• *heat can be provided for leachate treatment, wood chip drying etc.*
• *extend the usefulness of a resource otherwise considered a burden*

Remote monitoring

Remote monitoring and control plays a key role in the operation, augmenting regular site visits. Real time data allows remote checking of the operational parameters of the generating sets and the general 'health' of the gas field. Alarms are raised to alert technicians to specific events requiring immediate attention, and the system can be remotely stopped and started as necessary. Downtime is reduced to a minimum and sustainable gas yield results.



WASTE TO ENERGY

Method Statement for Clearing Existing Landfill Sites

The environmental and political pressures to eradicate existing land fill sites need innovative solutions being developed, and together with New Centre Energy's MSW to Energy solution, there is a environmentally sound technical solution to this problem.

New Centre energy are able to offer a complete MSW land fill solution which will work by creating RDF from the old landfill sites, to become a feed stock for blending with fresh MSW for their Waste to Energy Plants.

After detailed analysis of several existing MSW landfill sites in general, NCE are confident they are able to introduce eradication programs for landfill sites where one of their UHTH WTE Plants are sited.

The analysis of the generic MSW landfill sites shows that a large potion of these sites consist of soil and stone and old building materials, together with large quantities of plastics, particularly in the form of plastic shredded bags as well as paper, cardboard, wood and clothing.

NCE's solution would be to install mobile treatment machines and facilities based on the following approach:

- Install the Landfill Treatment Equipment on the dump site, and collect the MSW materials from the landfill site using front loaders.
- Process all of the waste material through a large shredder machine to ensure waste reduction size is down to a 200mm particle size.
- Shredded waste material is converyored to an adjacent mobile trommel machine to ensure good waste material separation occurs.
- After the waste has been through the trommel, the materials are conveyor fed to a manual picking station to enable any items to be separated for recycling or large items to be removed.
- The waste is now converyored for final auto separation via a Material Classifier and Air Separator Machine. This will segregate earth and stone materials, plastics and paper, clothing items and metals etc for disposal.

A more detailed explanation of the equipment to be used is as follows and based on the following Landfill Dump Site Treatment Plant Diagram:

MSW Dump Site Shredder:

This equipment is based on a tracked or static free standing machine that can be placed anywhere on site. It is remotely operated by the operator who works beside the machine, and it will be fed via front loaders collecting the landfill materials from the site.

The shredding capability is immense, an all type of waste can be shredded, including:

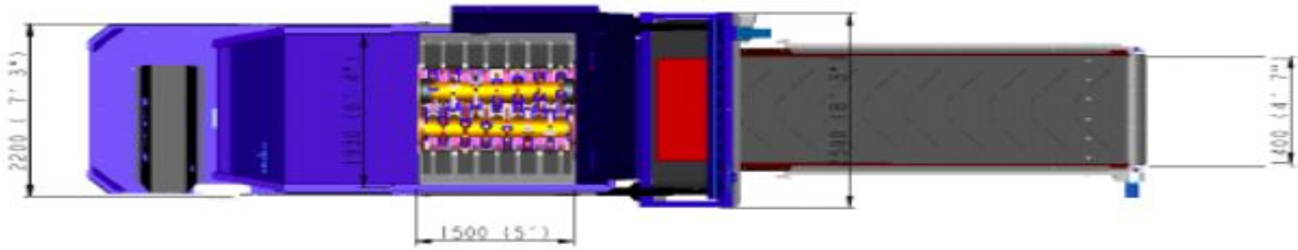
- Vehicle Tires
- Mattresses
- Wood
- Trees
- MSW
- Landfill Materials
- Building Construction Materials
- Stones and Rocks
- White Goods, such as Fridges, Washing Machines and Cookers etc.

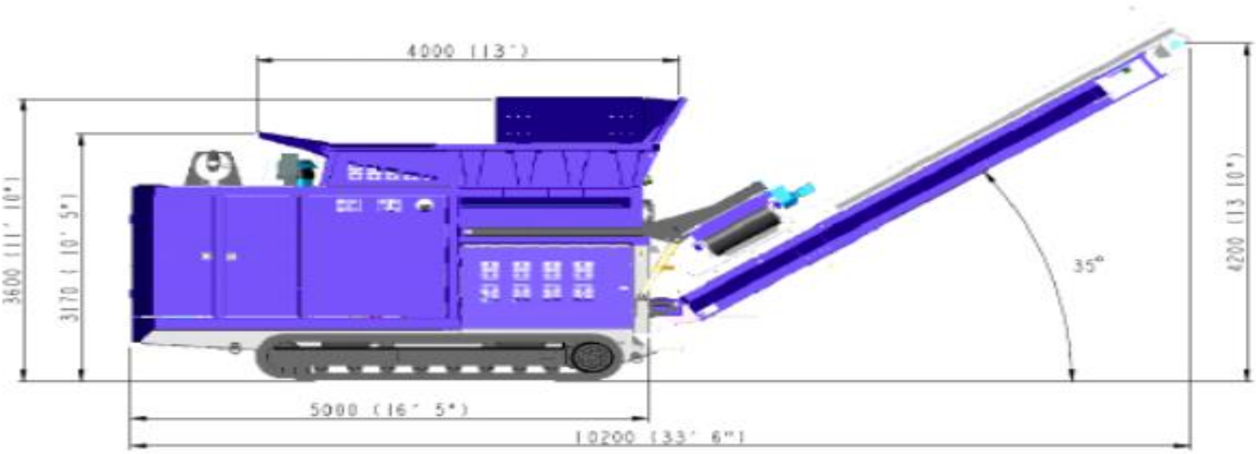
Shredding rates vary with the different type of waste materials to be processed. However, for a dense and compacted landfill dump site we would estimate we can shred and process around 25 MT/hr.

Therefore, if we operate the equipment over a 12 hour period, we would expect to be able to clear and shred around 300MT/day of old land fill material, which could equate to around 100,000MT of existing landfill materials per year from one landfill process line.

For large landfill site, NCE could install and operate two parallel treatment units, possibly treating 200,000MT of old land fill materials per year.

<u>Shredder Details</u>





The shredded machinery conveyor feeds the shredded waste directly onto the trommel's in-feed system as part of the next treatment stage.

Trommel Unit:

9. Trommel Machine is also mobile and can easily be transported to different site locations.

The trommel is used to loosen and separate all waste streams after shredding, to ensure the landfill materials can be easily handled.

The in-feed and out-feed materials are conveyor transported, so there is no manual handling of the waste.

Manual Picking Station:

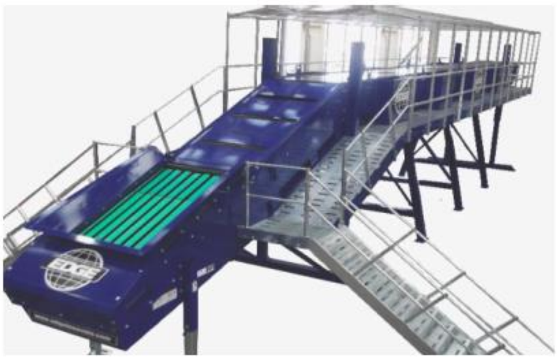
This is an optional facility that can be installed dependent on the type of waist found in the landfill sites.

Modular Picking Station has been designed so that picking bays can easily be added or removed in line with changing requirements of the site.

The facility can be fitted with a multitude of options such as roofing, lighting, insulated / air conditioned enclosures with windows and heating, air separators, over-band magnets plus many more.

Essentially the Picking station can be tailored to the site needs and for local employment of existing pickers etc.

<u>Optional Modular Mobile Picking Station</u>



Items we would expect to be manually picked, include:

- Plastics
- Paper
- Metals
- Glass
- Items of Clothing

Once MSW and other dump site materials have been through the optional manual the Picking Station, that remaining materials are converyored to the next stage of the treatment facilities.

Material Classifier & Air Separator Machine

This machine provides operators the ability to extract impurities from highly contaminated landfill in just one pass, after the materials have been shredded and trommeled.

Utilising controlled air flow as a separation medium, the machine is the ideal solution for the cleaning of compost and biomass fractions with its ability to separate heavy fractions from lights.

With easily adjustable components such as fan speed, feed conveyor belt speed and drum positioning, the machine has the capacity to handle a wide range of applications, and will allow operators to separate up to four different fractions as standard; lights (plastic, paper, film) mid-weight (wood) and heavy fractions (aggregate, glass, etc.).

Ferrous metal will be extracted via the overband magnet found on the heavy fraction discharge conveyor with the option of attaching an additional magnet to the mid-weight conveyor.

Available as track, semi-trailer or static chassis formats, NCE has the option of selecting a unit with a diesel/hydraulic power unit, a diesel gen set or a direct electric drive.

NCE's Material Classifier machine has been design to be shipped via a 40ft container with minimal break down needed for easy relocation.

Simply track in and track out with limited set-up time required.

The advantages are:

- 4 product separation solutions for the waste and organics separation and for converting directly into RDF materials.

- 3 stage separation as standard (Optional fourth stage available)

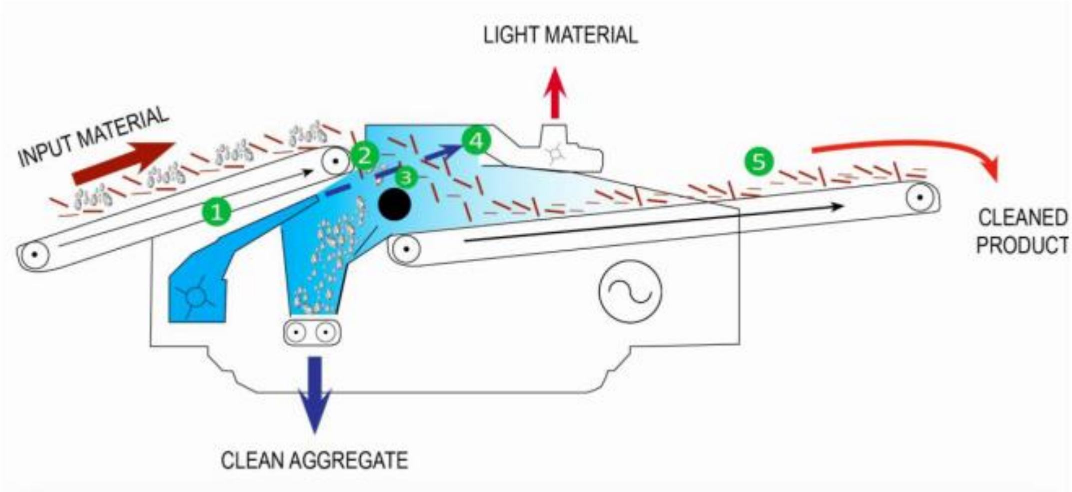
- Vacuum option can be disabled and closed off for applications where light plastics extraction is not required.

- The extremely wide feed conveyor provides an even spread of material for efficient separation.

- Enclosed design helps control air flow and minimises air depressurisation whilst minimising dust creation with reduced spillage.

- Designed for quick and easy transportation via low-loader.

Material Classifier & Air Separator Machine:



How it operates:

- Variable speed, feeder conveyor with 3m³ hopper is available with hardox or rubber liners. Belt speed can be adjusted via the control panel.
- The light plastics, clothing/textiles, wood, soils and stones and other waste materials typically found on the landfill sites material is blown over the drum separator with the plastics being directed towards the cyclone chamber. Heavy material passes through the air stream and drops down to be stockpiled via the heavies discharge conveyor.
- The adjustable drum separator divides the falling material into light and heavy fractions.
- Extracts light plastics, paper and films from the waste stream and allows heavier fractions to carry on via the lights discharge conveyor.
- The lights discharge conveyor, transfers mid -weight light fraction an provides a discharge height of 2.6m.

<u>The final product:</u>

The objective of the eradication programme is to remove all landfill waste materials from the existing dump sites, and to process and reuse as much as is possible from the dump site, and sanitise the remaining items for further use as a hard core type backfill material within the dump site reclamation process, or for the construction industry to utilise.

The main items to be recovered will form the basis for the refuse derived fuel (RDF) that can be recovered from the sites.

Until NCE are able to analysis the MSW and other waste products on the dump site, they are unable to properly assess the kcal/kg energy levels of the final RDF product to fully assess the business case of the project.

The main materials and items to be separate and segregated include:

- Bio Mass
- Plastics
- Paper
- Textiles
- Clothing

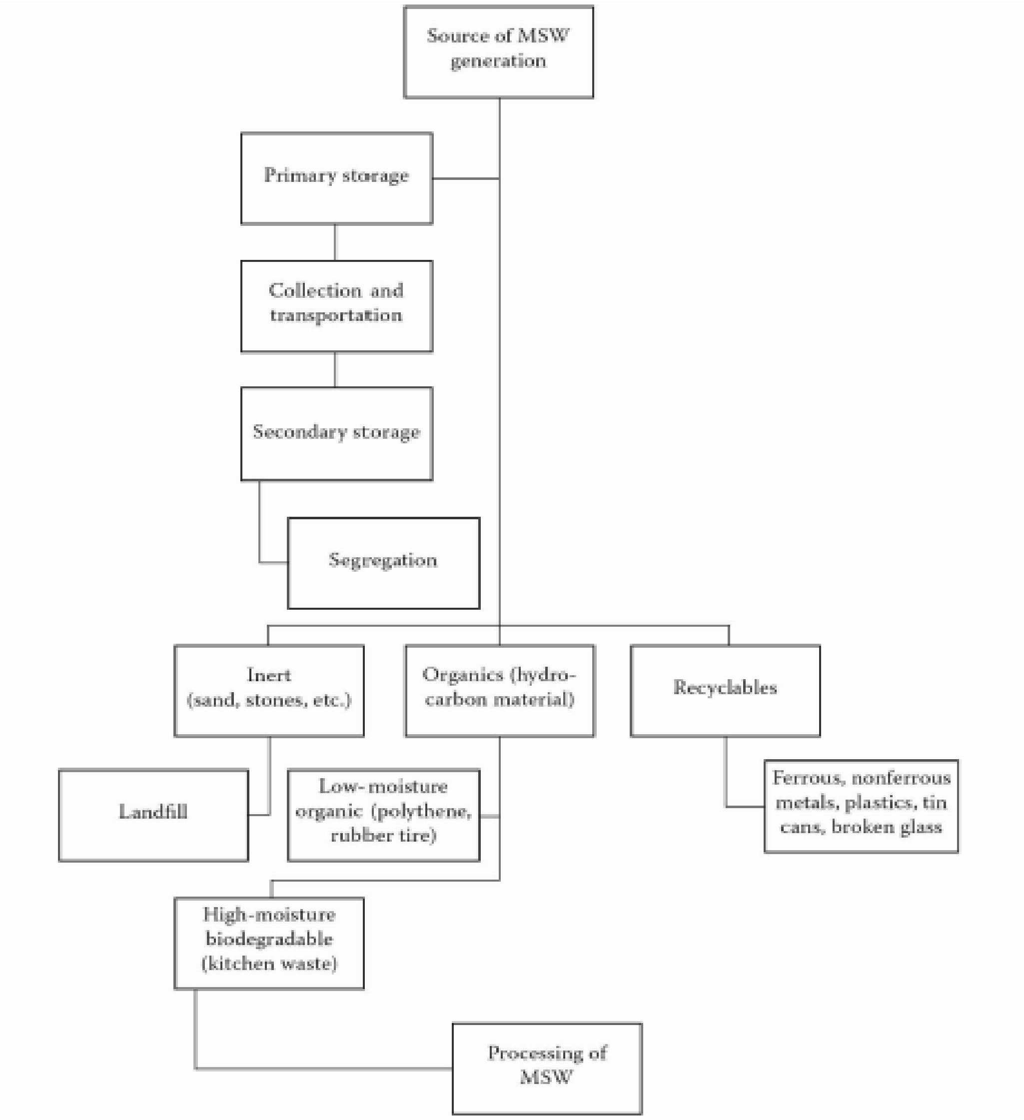
- Sand
- Earth
- Rocks and Stones
- Building Materials
- Metals
- Glass and Ceramics
- Industrial Hazardous Materials

Of the above items, the following items would be converted into RDF for the UHTH Technology Conversion Process:

- Bio Mass
- Wood
- Plastics
- Paper
- Rubber
- Vehicle Tires
- Textiles
- Clothing
- Industrial Hazardous Materials

7. *Waste Management Planning & Long- Term Strategy - PENNGATE wish to indicate the following waste management procedues to adopt towards Waste Sustainability.*

Fig 16. MSW and its Management

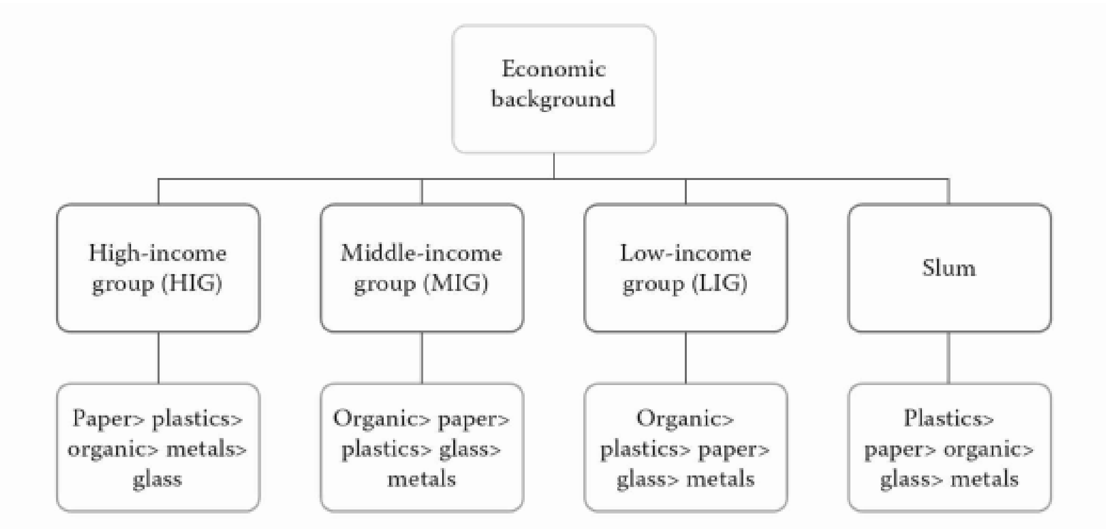


Source: Municipal Solid Waste Management in Developing Countries – 2015 - International Standard Book Number-13: 978-1-4987-3774-6

the waste quantity generated by people, the composition of the waste, and its sources. Information collected periodically from such assessment will help in identifying equipment at the facility, the formulation of plans, and programs for the management system. Waste volume and composition vary from region to region and also depend on the lifestyle and income level of the population. The primary constituents in waste are decomposable organic matter and paper followed by inorganic material comprised of metals, plastics, textiles, glass, and so on. Due to the socioeconomic status of community, waste generation may vary, but the ultimate proportion reaching disposal sites in urban areas remains the same. The composition of waste varies according to the socio-economic status of the community, hence in developing countries a major component of waste is biodegradable and organic, whilst in developed countries, there is a larger component of inorganic waste.

- Composition of paper in solid waste ranges from 1% to 5% in low-income countries whereas, in high-income countries, it varies from 20% to 50%.
- Plastic composition in solid waste varies from 1% to 5% and 5% to 10% in low- and high-income countries, respectively.
- Ash and fine material fractions in solid waste ranges from 15% to 60% and 3% to 10% in low- and high-income countries, respectively.
- In low-income countries, moisture content found in solid waste is around 30%–40% and, in high-income countries, it is 15%–30% (Short Term Course on Solid Waste Management, CED 2012).

Fig 17 *Generation of MSW*

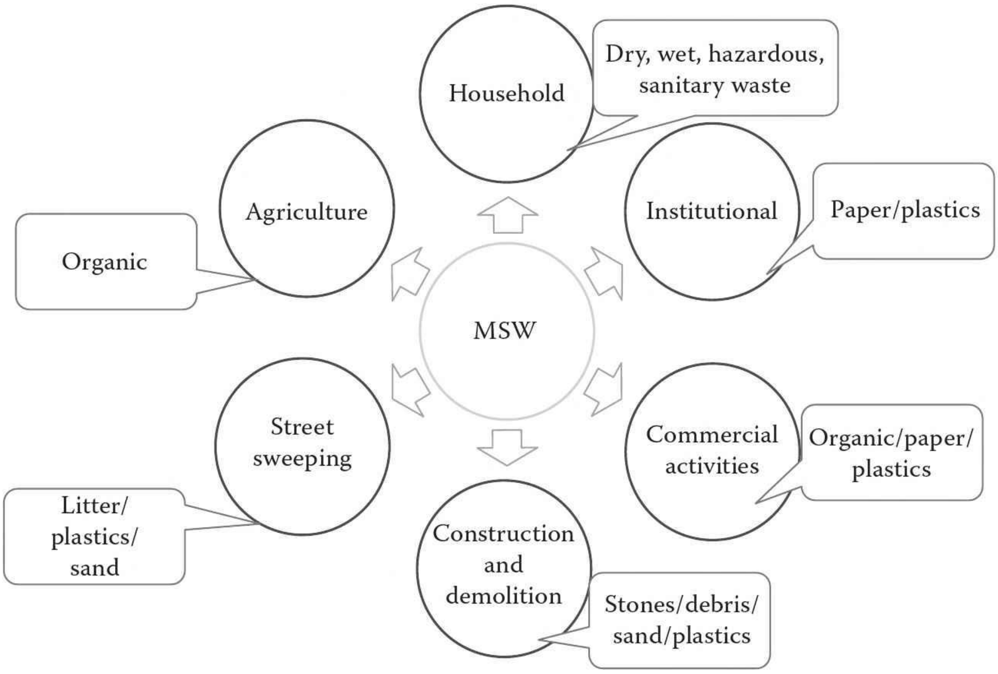


Schematic flow diagram of MSW generation in different economic sectors.

Source: Municipal Solid Waste Management in Developing Countries – 2015 - International Standard Book Number-13: 978-1-4987-3774-6

Variation in waste composition mainly occurs due to density, moisture content, and distribution of waste. Generally, the density of waste changes during transfer from source to disposal facility. During the transfer, many factors such as handling methods, storage of waste at the primary and secondary location, weather exposure, decomposition of waste, and so on affect the density.

Fig 18. Schematic Flow diagram of MSW generation from difference sources.



Source: Municipal Solid Waste Management in Developing Countries – 2015 - International Standard Book Number-13: 978-1-4987-3774-6

- *Street sweeping*: This has been one of the largest sources of MSW generation and is a key facet of solid waste management (SWM) in developing countries. It consists of paper, plastic, litter, sand, stones, spilled loads, and debris from traffic accidents. The waste reaching the streets is due to lack of awareness among the population, littering by pedestrians, from vehicles, and by roadside dwellers. Public education in relation to participation is the key factor in MSW generation on the streets, as shown in Figure 3.4. Waste on the streets creates an adverse visual impact, particularly on visitors, and, thus, indirectly affects the economy of a city.
- *Construction and demolition (C&D) waste*: The trends toward urbanization and industrialization have led to the generation of C&D waste in many developing countries. This type of waste usually includes broken concrete, scrap and wood products, board, glass, old electrical material, tilling and related masonry, metal, and paints.

- *Agricultural waste*: Agricultural waste is one of the largest organic sources of waste generation in most developing countries. It has been found that organic waste from agricultural sources alone contributes to more than 350 MT/year (Asokan 2007). India generates 600 MT of waste from agriculture sources (Asokan 2007). The waste generated from agricultural sources includes waste from crops (wheat straw, bagasse, paddy, husk, vegetable waste, coconut husk, and shells) and other harvests (Sengupta 2002; Gupta 1998; Maudgal 2011). The rate of waste generation from the agricultural sector is dependent on the climatic conditions of the country as these are essential factors in crop production.

Waste characteristics are divided into two categories: physical and chemical. Waste characterization plays a vital role in identifying a suitable processing technology.

Analysis of the physical characteristics of waste provides necessary information for the selection of waste handling equipment and also for designing processing methods and the ultimate disposal of waste. There are three principal components that determine the physical characteristics:

- Moisture content. This is defined as the *weight of water* (wet weight–dry weight) to total weight of wet waste (CED 2012). A great deal of moisture in waste affects various processing technologies that require dry waste. As the moisture content increases, the weight of the waste also increases and this causes problems during collection

and transportation. In addition to this, moisture content determines the economic feasibility of mass burn or incineration technology. To remove excess moisture and to raise the temperature of water vapors, an excess amount of energy is required (Reeb and Milota 1999).

$$\text{Moisture content} = \frac{\text{Wet weight} - \text{Dry weight}}{\text{Wet weight}} \times 100$$