Chapter 1

Solid waste engineering: Perspectives

1. Integrated solid waste management

- All creatures, humans included, constantly make decisions about what to use and what to throw away.
- A chimpanzee
  - the banana is good, and that the peel is not, and throws it away.
- A paramecium – small unicellular organisms
  - uses certain high-energy organic molecules
  - discharges its products
- Humans
  - buy a can of soft drink with the full understanding that the can will become waste.

Integrated solid waste . . .

- Waste is a consequence of everyday life—of all creatures

- The challenge for society
  - to minimize how much waste is generated and
  - to convert waste into a resource

- A solid waste engineer must play an important role if society is going to achieve zero waste

2. Solid waste in History

- **Solid waste:**
  - to distinguish it from the waste we emit into the atmosphere or the waste we discharge into the sewerage system
  - Around 10,000 BC:
    - humans abandoned nomadic life and began to live in communities,
    - Resulting in the mass production of solid waste.
  - In 1600 BC, the sanitary laws were written by Moses
    - By 800 BC, old Jerusalem had sewers and a primitive water supply.

- By 200 BC,
  - The cities in China had “sanitary police” whose job it was to enforce waste disposal laws
- In 500 BC,
  - Athens passed a law to require all waste material to be deposited more than a mile out of town

- The cities in the Middle Ages in Europe were characterized by unimaginable filth.
- In 1300, the Black Death:
  - was to a great degree a result of the filth,
  - reduced the populations in cities and alleviated the waste problems
  - the industrial revolution in the mid-1800s brought people back to the cities.
- Industrial production and the massing of wealth governed society, and human conditions were of secondary importance.
  - Thus, the living conditions of the working poor in 19th-century European cities was difficult

- For example, Manchester, England had on average one toilet per 200 people
- People often lived around small courtyards where human waste was piled and which also served as the children's playground.

- In 1934, the fouling of beaches forced the passage of federal legislation
  - Making the dumping of municipal refuse into the sea illegal
- In 1959, the American Society of Civil Engineers published the first engineering guide to sanitary landfilling

- Some significant events that changed the characteristics of residential and commercial municipal solid waste
  - 1908 Paper cups replace tin cups in vending machines.
  - 1913 Corrugated cardboard becomes popular as packaging.
  - 1924 Kleenex facial tissues are first marketed.
  - 1935 First beer can is manufactured.
  - 1944 Dow Chemical invents Styrofoam.
  - 1953 Swanson introduces the TV dinner.

- 1960 Pop-top beer cans are invented.
- 1963 Aluminum beer cans are developed.
- 1977 PETE soda bottles begin to replace glass
- 1982 Plastic grocery bags start to replace paper bags
- 1983 First generation LCD TV become available on market
- 1991 Producer responsibility principle is implemented in Germany
- 1999 The Council of European Commission sets targets to systematically reducing biological wastes in the land fill
- 2000 Switzerland prohibits landfilling of MSW
- 2006 Europe enforced higher recycling rate

- In today's cities,
  - solid waste is removed and either is sent to disposal or is reprocessed for subsequent use.
  - There is the change in paradigm shift in solid waste management and engineering in nearly 2000 years.
- "Waste Reduction Revolution"
  - the idea that it is bad to create waste in the first place.
  - Reason: both economics and a change in public attitude.

3. Economics and Solid Waste

- Adam Smith (1723–1790), through his concept of *the invisible hand*,
  - introduced an element of positive faith and optimism in economic development .
- As early 1778, scientists begins
  - to realize that our planet is finite and has only limited resources and living space.
  - The scarcity of land and nonrenewable resources could indeed have the ultimate devastating effect on the economic system our current usage of resources is not sustainable.
- Thus, the world should begin to seek alternative life systems in order to have more assurance that these disasters can be avoided

4. Legislation and Regulations

- **USA experience:**
  - 1899 *Rivers and Harbors Act*: prohibited the dumping of large objects into navigable waterways.
  - Municipal solid waste was commonly thrown into unlined open dumps, which were intentionally set on fire to reduce volume.
  - In larger communities, solid waste was sent to incinerators, which had minimal air emission controls and did a poor job of reducing the volume of waste.

- 1965 *Solid Waste Disposal Act*, which provided technical assistance to the states through the U.S. Public Health Service
- In 1970
  - the *National Environmental Policy Act* (NEPA), which led to the creation of the Environmental Protection Agency (EPA).
  - *Clean Air Act: Control of t*he combustion of solid waste – which led to closing burning dumps and uncontrolled incinerators.
- In 1976, the *Resource Conservation and Recovery Act* (RCRA): mainly addresses the problem with hazardous waste but also specifies guidelines for nonhazardous solid waste disposal.
- In 1980, *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA)—the *Superfund* act. CERCLA created a financial means of cleaning up old hazardous waste sites by tapping into the coffers of present chemical companies
- In 1991 under Subtitle D, the EPA adopted regulations to establish minimum national landfill criteria for all solid waste landfills.

- USA – States
  - Most states have passed strong legislation encouraging and promoting recycling.
  - In the 1990s, over 40 states established recycling goals.
  - For example, California mandated:
    - 25% of waste be diverted from landfills by 1995
    - 50% be diverted by 2000.
  - In Pennsylvania, every community with a population of over 5000 is mandated to set up a recycling program.
  - Often local problems in siting new landfills drive the recycling effort.
  - If a substantial amount of solid waste can be diverted from the landfill, then either the planned landfill can be smaller in size or it will last longer.

- European Union
  - An April 26, 1999 Landfill Directive stated that municipal waste must be treated prior to being landfilled.
  - The intent was to prevent or reduce the adverse effects of the landfill of waste on the environment.
  - In November 2008 (European Union Directive 2008/98/EC): set up a revised waste management framework.
  - The goal continued to be the reduction in landfilling by applying the following waste hierarchy:
    - Prevention
    - Preparing for reuse
    - Recycling
    - Other recovery (e.g., energy recovery)
    - Disposal

- **Elimination of solid wastes generation**
  - One (of many) possible potentially beneficial alternatives toward attaining global stability is to eliminate solid wastes generated by our materialistic society that are now deposited on increasingly scarce land.
  - The recovery of the resources from solid waste would be a positive step toward establishing a balanced world system where society is no longer dependent on extraction of scarce natural ores and fuels.
  - Recycling of wastes has to be evaluated in economic terms.
  - If need be appropriate policy should be introduced that encourage recycling over use of virgin materials.

5. Materials flow

- Emphasizes the fact that we do not *consume* materials; we merely use them and ultimately return them (often in an altered state) to the environment.
- The production of useful goods for eventual use by those people (so-called *consumers)* requires an input of materials.
- materials originate from one of four sources:
  - raw materials gleaned from the face of the earth and used for the manufacture of products,
  - Scrap materials produced in the manufacturing operation,
  - materials separated by users for recycling,
  - materials recovered after the product has been discarded
- Industrial operations are not totally efficient, producing some waste that must either be disposed of or used again as raw material

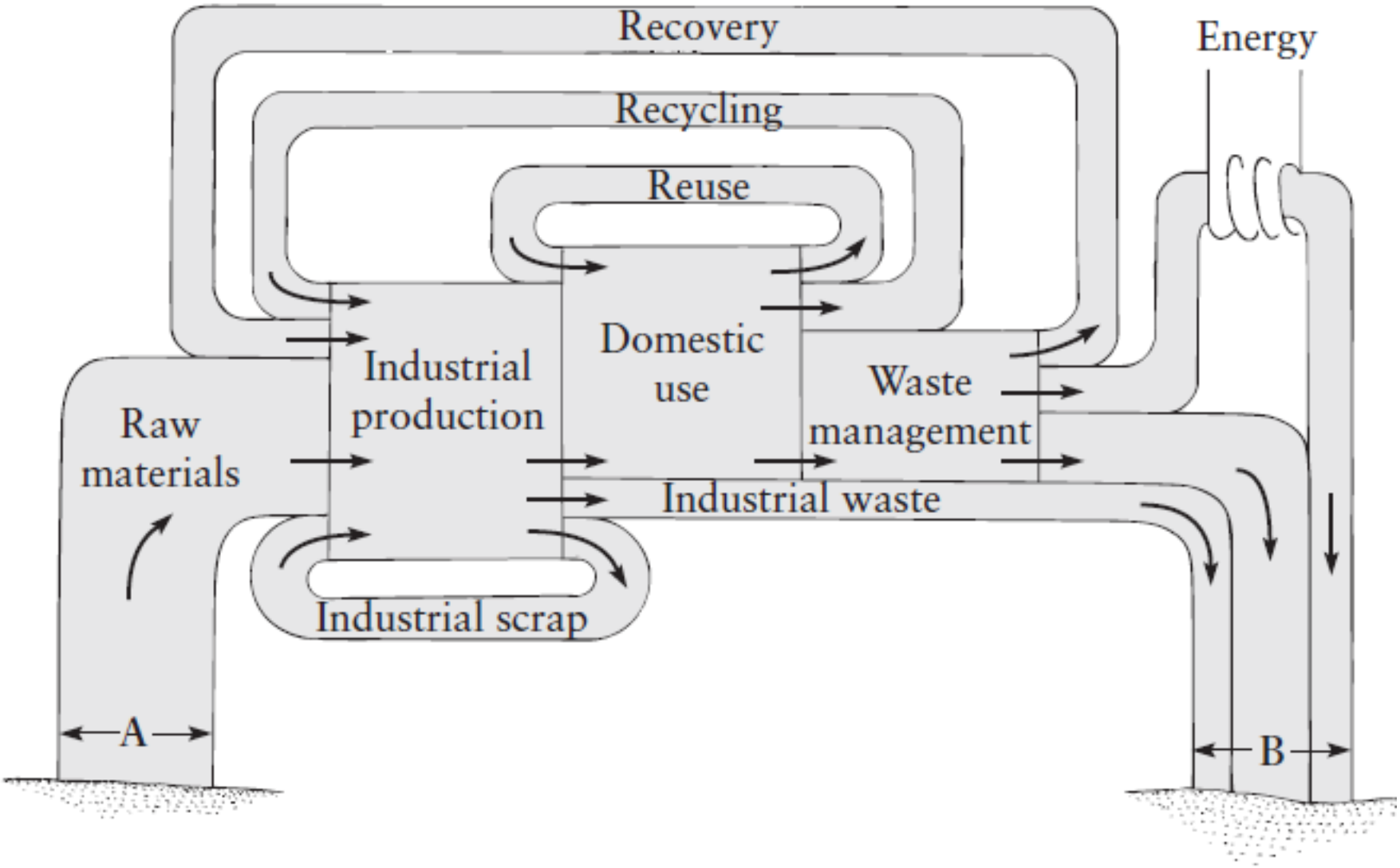

Figure 1-2 Materials flow through society.

- Minimization of A and B streams:
  - A large raw material input means that great quantities of non-replenishable raw materials are extracted (often using less than environmentally sensitive methods, as exemplified by strip mining).
  - A high rate of raw material extraction can eventually lead to a problem in the depletion of natural resources.
  - Large quantities of waste can have a significant detrimental effect, such as land areas used for waste disposal or air pollution created from the burning of waste in combustors.

- **Note:**
  - Developed countries, their domestic supplies of some nonreplenishable materials (such as copper, zinc, and tin) are exhausted and are importing a substantial fraction of these materials
  - If the rest of the world were to attain the standard of living that the developed nations have at the present, the raw materials supply would not be adequate to meet the demand.
  - Our present lifestyle is based on obtaining these materials from concentrated sources (ores), and in using them, we are distributing the products over a wide land area.
  - Such a distribution obviously makes recovery and reuse difficult.

- **National security for each country**
  - is predicated on the nation's ability to obtain reliable supplies of raw materials.
  - In the 1970s, we experienced the problems that can be created by relying on other countries for such necessities as oil.
  - Cartels will be developed by nations that have large deposits of other non-replenishable materials, and in the future, the cost of such products as aluminum, tin, and rubber will increase substantially.
  - Thus, reducing the wastes disposed of into the environment to the smallest quantities practical, and redesigning our economic system to achieve is becoming necessity

- Looking first at the **A** component,
  - a reduction in raw materials demand could be achieved by increasing the amount of industrial scrap reprocessed, by decreasing the amount of manufactured goods, or by increasing the amount of recovered materials from the post-consumer waste stream
  - Increasing industrial scrap would involve increasing either *home scrap* (waste material reused within an industrial plant) or *prompt industrial scrap* (clean, segregated industrial waste material used immediately by another company).
- Note:
  - scrap represents inefficiency, and an ultimate goal of industry is to produce as little scrap as possible

- Feasible options for achieving reduced material use and waste generation are known as the four R's:
    1. Reduction
    2. Reuse
    3. Recycling
    4. Recovery

Reduction

- Waste reduction can be achieved in three basic ways:
  - Reducing the amount of material used per product without sacrificing the utility of that product,
  - Increasing the lifetime of a product,
  - Eliminating the need for the product.
- Waste reduction in industry is called *pollution prevention*
  - an attractive concept to industry
  - in many cases the cost of treating waste is greater than the cost of changing the process so that the waste is not produced in the first place.
  - Pollution prevention is the process of changing the operation in such a manner that pollutants are not even emitted

- Reduction of waste on the household level is called *waste reduction* (as *source reduction*).
- Typical alternative actions that result in a reduction of the amount of municipal solid include:
  - fusing bags at stores,
  - using laundry detergent refills instead of purchasing new containers;
  - bringing one's own bags to grocery stores,
  - stopping junk mail deliveries,
  - using cloth diapers

Reuse

- Reuse is an integral part of society
  - church rummage sales to passing down
  - children's clothing between siblings
  - Many of products are reused without much thought given to ethical considerations.
  - They have utility and value for more than one purpose
- For example:
  - paper bags obtained in the supermarket are often used to pack refuse for transport from the house to the trash can or to haul recyclables to the curb for pickup.
  - Newspapers are rolled up to make fireplace logs, and
  - coffee cans are used to hold bolts and screws.

Recycling

- Many of the components of municipal solid waste can be
  - recycled for remanufacturing and subsequent use,
  - the most important recyclable components: paper, steel, aluminum, plastic, glass, and yard waste

- In 2008,
  - about one-third of municipal solid waste was recycled.
  - by recycling and composting, greenhouse gas emissions were reduced by an amount equivalent to the annual greenhouse gas emissions from 33 million passenger vehicles

- The process of recycling requires
  - the owner of the waste material first separate out the useful items so that they can be collected separately from the rest of the solid waste
  - The separation relies on some readily identifiable characteristic or property (*code*) of the specific material that distinguishes it from all others
  - code is used to separate the material from the rest of the mixed refuse using a *switch*.

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- The success of recycling programs has been in spite of the severe obstacles that our present economic system places on the use of secondary materials.
  - *Location of wastes*. The transportation costs of the waste may prohibit the implementation of recycling and recovery.
  - *Low value of material*. The reason that an item is considered waste is that the material (even when pure) has little value.
  - *Uncertainty of supply*. The production of solid waste depends on:
    - the willingness of collectors to transport it
  - *Administrative and institutional constraints*.
  - *Legal restrictions*.
  - *Uncertain markets*.

Recovery

- Recovery is defined as the process in which the refuse is collected without prior separation and when the recyclable materials in the refuse are separated from the nonrecyclable materials at a central facility.
- A typical mixed-waste materials recovery facility (MRF) is shown in Figure 1-5.

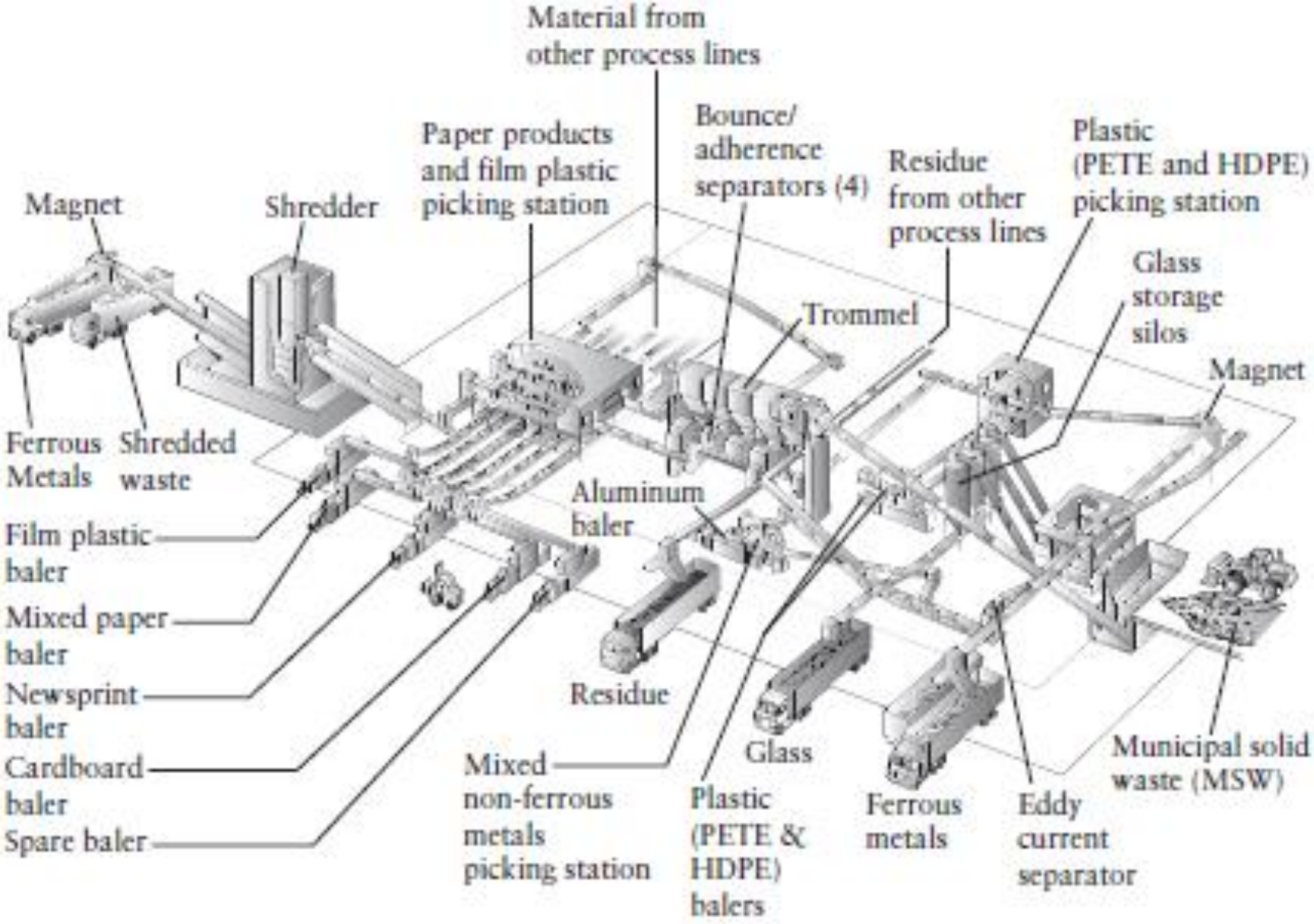

Figure 1-5 Typical mixed-waste materials recovery facility (MRF).

6. Disposal of Solid Waste in Landfills

- The placement of solid waste on land is called a *dump*
- The open dump
  - by far the least expensive means of solid waste disposal
  - thus, it was the original method of choice for almost all inland communities.
- The sanitary landfill
  - are engineered operations, designed and operated according to acceptable standards.
  - The basic principle of a landfill operation is to prepare a site with liners to deter pollution of groundwater

7. The need for integrated solid waste management

- Solid waste professionals recognize that issues related to managing solid waste must
- be addressed using a holistic approach.
- For example, if more waste is recycled, this
- can have a negative financial impact on the landfill because less refuse is landfilled.
- Since many landfill costs are fixed a drop in the incoming refuse can have severe economic ramifications.
- The various methods of solid waste management are therefore interlocking and interdependent.
- the *Integrated Solid Waste Management* (ISWM)
  - Interactive solid waste management
  - Hierarchical solid waste management

➢ Integrated and hierarchical waste management options

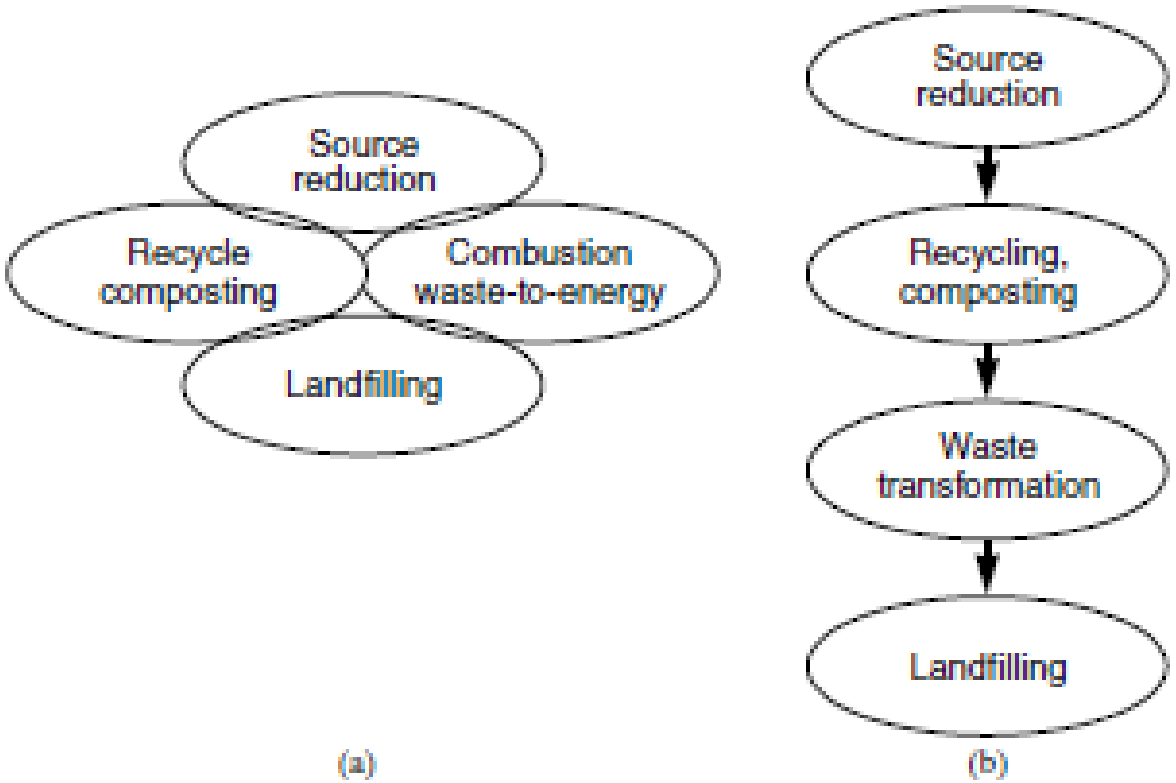

FIGURE 1.3 Relationships between the management options comprising integrated waste management: (*a*) interactive, and (*b*) hierarchical.

8. Final thoughts

- A truly professional engineer will
  - infuse ethics into his or her decision making … environmental ethics
  - play an ever-increasing role in the engineer's professional responsibilities to society
  - is responsible for transforming the industry into a professional field with best practices.
  - reinforces the notion that engineers are optimists in the art of the possible;
  - like to look at a situation and make it better.

- If the engineer cannot communicate information to the public, including decision makers such as public officials, then projects will not be "implemented."
- *Engineers*
  - *see themselves as performing a public service.*
  - *build civilizations.*
  - *serve the public's needs….*
  - *tend to be utilitarian.*
  - *look at the overall and aggregate net benefit, diminishing the importance of harm to the individual.*