能源及環境學院
SCHOOL OF ENERGY AND ENVIRONMENT

香港城市大學
City University of Hong Kong
專業 創新 胸懷全球
Professional·Creative For The World

SEE 1003
Introduction to Sustainable Energy and Environmental Engineering

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Module 7 – Waste management and Circular Economy

April 4, 2022

Overview

- Waste Management
- Circular Economy
- Teaching and Learning Questionnaire (TLQ)
- Quiz next week
- Project Report
- Project Presentation
- Project deliverable 5 (optional)

Week	Topics	Assignment issued	Key dates
Week 1	Course introduction; Climate Change and the Engineering approach		**Quiz 1**
Week 2	**MODULE I** Introduction to Sustainability Energy, Natural Resources and pollution, Electromagnetic energy; Electrical energy – Lighting, Light pollution, Policy	**Semester-long Project**	
Week 3		**Project deliverable 1.1**	
Week 4	**MODULE II** Energy and Environmental Implications– Transportation Human-Environment Impacts		
Week 5		**Project deliverable 1.2**	**Project deliverable 1.1**
Week 6	**MODULE III** Noise Pollution in Urban Environment	**Project deliverable 1.3**	**Quiz2**
Week 7	**MODULE IV** Urban Sustainability and Resilience		**Project deliverable 1.2**
Week 8	**MODULE V** Tools: Systems Analysis for Sustainability Cost-Benefit Analysis		
Week 9			
Week 10	Material Flow Analysis, Life Cycle Assessment		**Project deliverable 1.3; Quiz3**
Week 11	**MODULE VI** Advances in Environmental and Energy Engineering	**Project deliverable 1.4**	
Week 12	**MODULE VII** Waste management and Circular Economy	**Project deliverable 1.5 (Now this is extra credit-BONUS!)**	
Week 13	**Review and Individual Presentations (5-mins)**		**Quiz4** **Final Project Report (merged with Project deliverable 1.4)** **5 min Presentation**
April 18th			**Project deliverable 5 due 18th April**

Waste - Overview

- What are the various types of waste that our society generates?
- What are the environmental impacts and costs of this waste?
- What waste management practices are employed and how effective are they?
- What potential does waste have as a source of raw materials and as an energy resource?
- What are zero-waste processes and how effective are they?

Solid waste is material, which is not in liquid form, and has no value to the person who is responsible for it.

Synonyms to solid waste are terms such as "garbage", "trash", "refuse" and "rubbish".

Waste Problem in Hong Kong

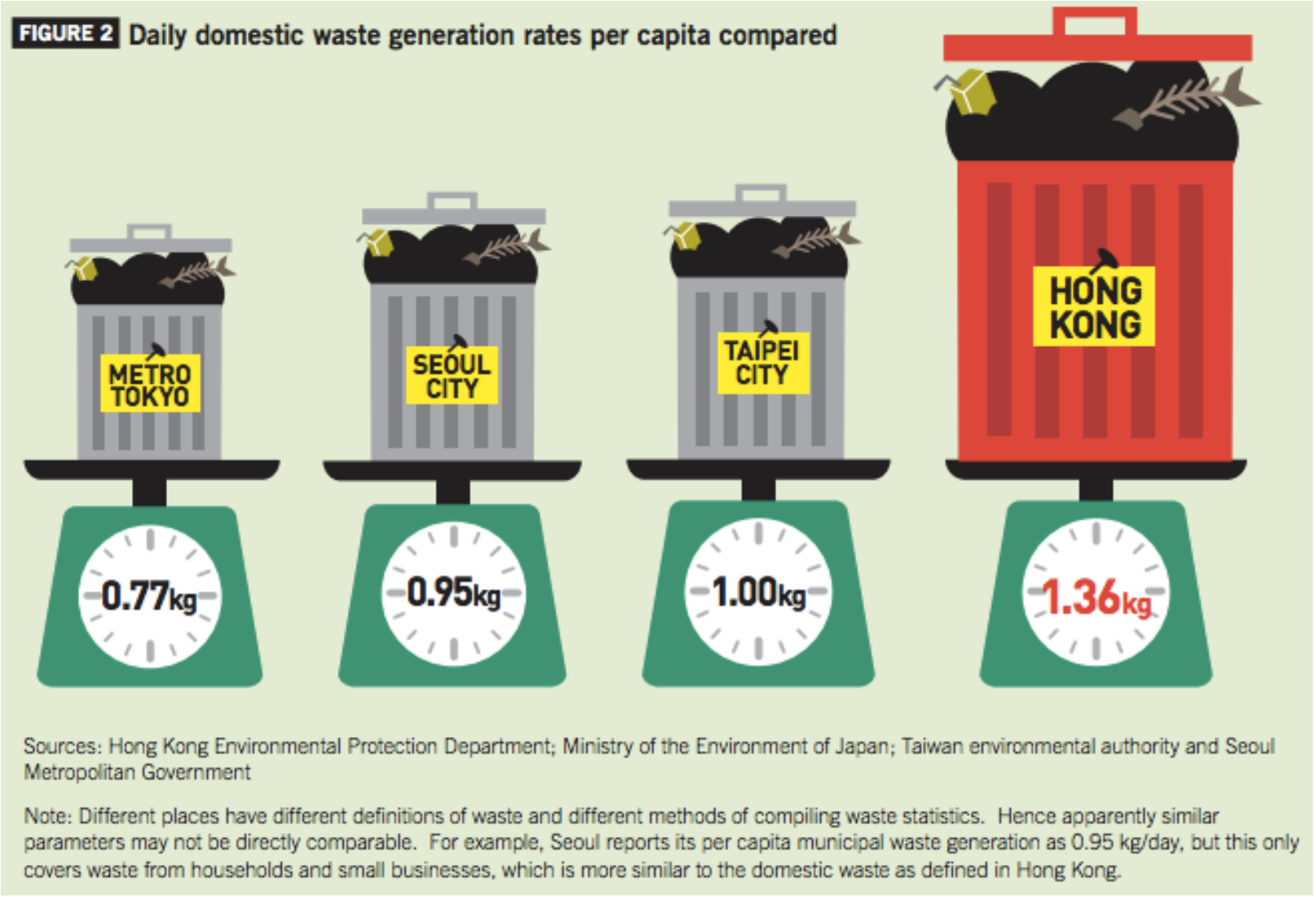
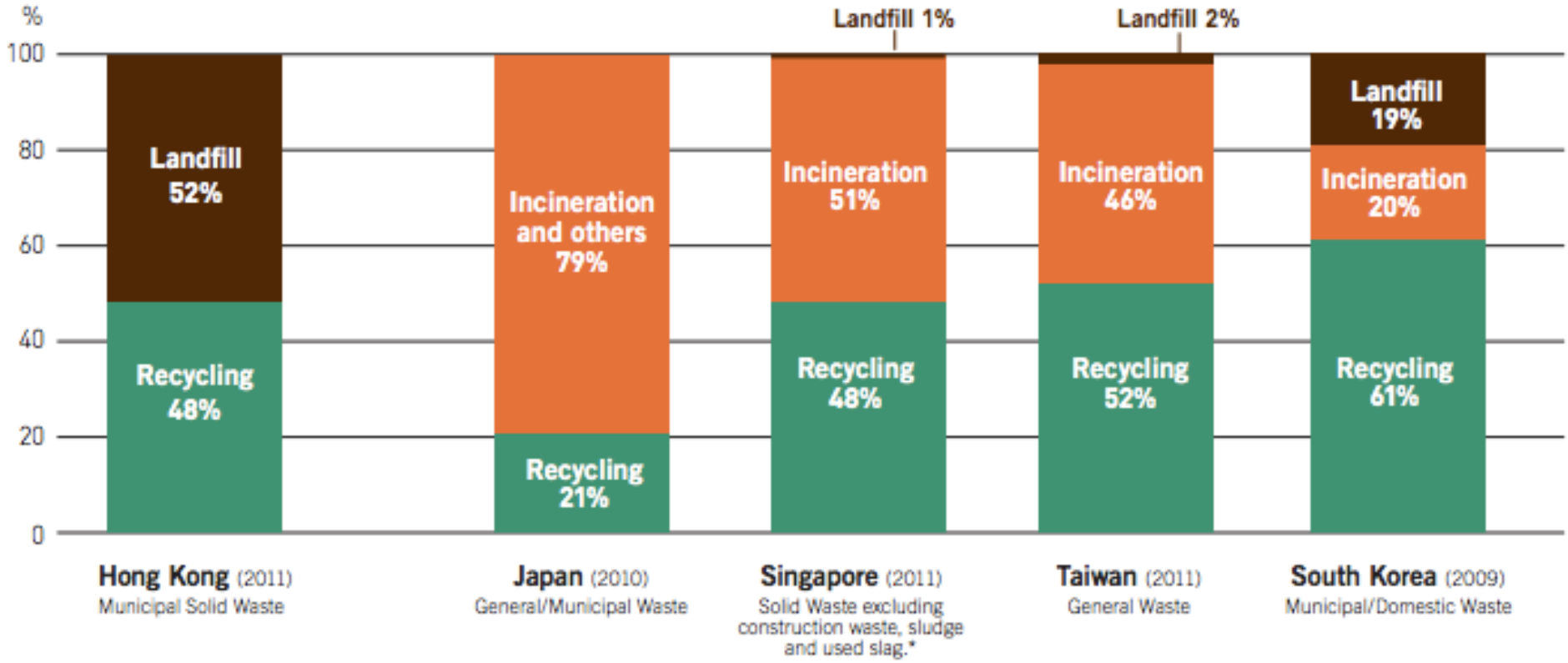


FIGURE 6 Comparison of waste management structure with other Asia areas



Hong Kong Waste Problem

Hong Kong's Solution to the Waste Problem

Characteristics of Solid Waste

Broad categories are:

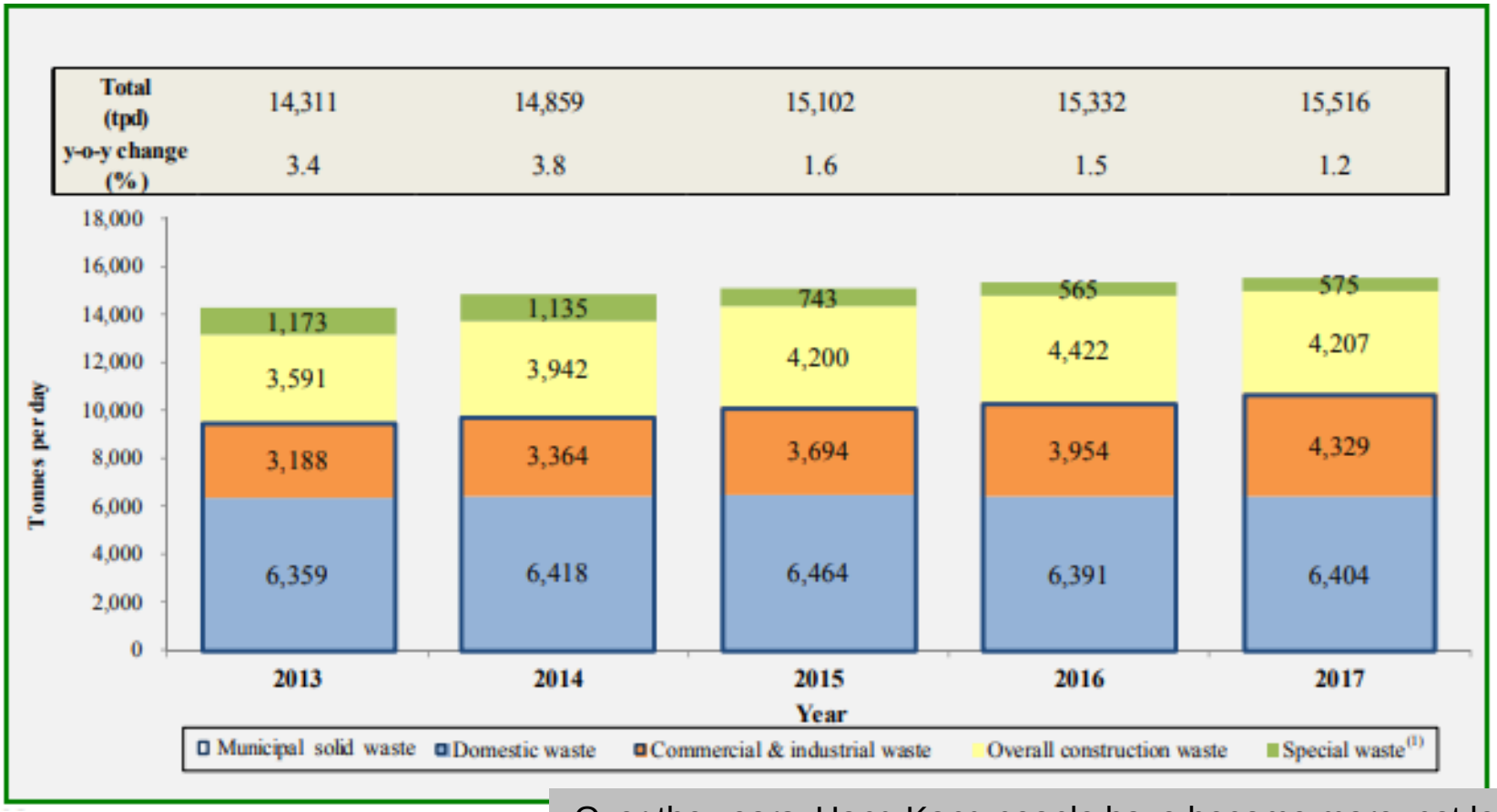
i. **Putrescible Organic waste**: kitchen waste, vegetables, flowers, leaves, fruits.

ii. **Toxic waste**: old medicines, paints, chemicals, bulbs, spray cans, fertilizer and pesticide containers, batteries, shoe polish.

iii. **Recyclable**: paper, glass, metals, plastics.

iv. **Hospital waste** such as cloth with blood

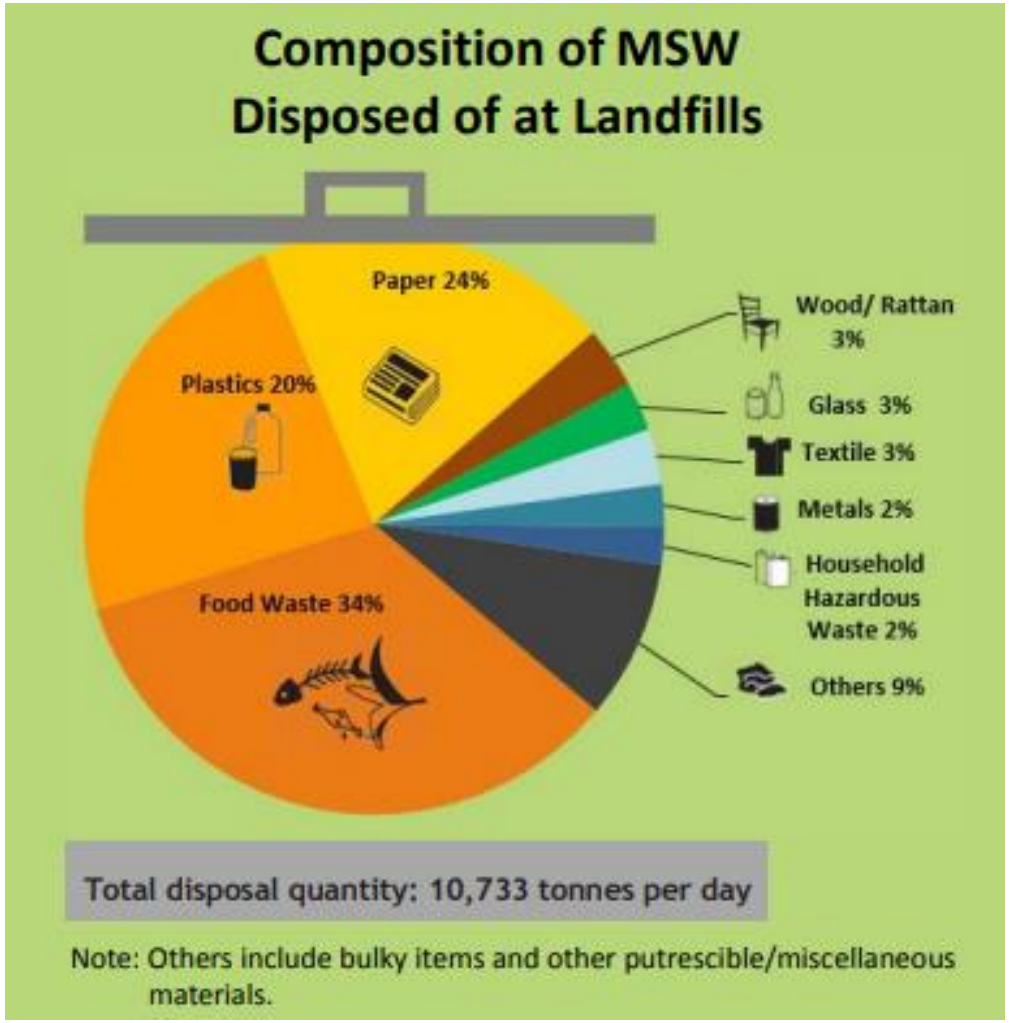
Disposal of total solid waste at landfills from 2013 to 2017



Over the years, Hong Kong people have become more, not less, wasteful!

(1) The quantity does not include special wa
major sewage treatment works managed b
the residue and ash of incineration have been disposed of at WENT.

Waste Composition in Hong Kong



What is Solid Waste Management?

It includes all activities that seek to minimize the health, environmental and aesthetic impacts of solid wastes.

Life Cycle of Waste

Solid Waste Management: Functional Elements

The activities involved with the management of solid wastes from the point of generation to final disposal have been grouped into six functional elements.

(i) Waste generation

(ii) On site handling, storage and processing

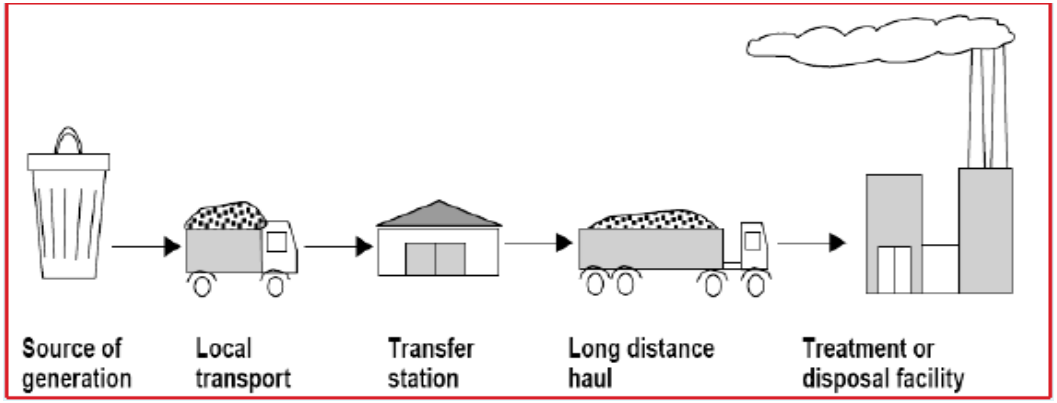
(iii) Collection

(iv) Transfer and transport

(v) Processing and recovery

(vi) Disposal

Functional element	Description
Waste generation	Materials are identified **as no longer being of value** and are either thrown away or gathered together for disposal
On site handling, storage and processing	**Handling, storage and processing of solid wastes** at or near the point of generation
Collection	**Gathering** of solid wastes **and the hauling of wastes** after collection to the location where collection vehicle is emptied
Transfer and transport	**(i) Transfer** of wastes from the smaller collection vehicle **to larger transport** equipment and **(ii)** subsequent **transport** of the wastes, usually over long distance, **to the disposal site**
Processing and recovery	Techniques, equipment and facilities used both to **improve the efficiency** of other functional elements **and to recover usable materials,** conversion products
Disposal	**Ultimate disposal of solid wastes**, including wastes collected and transported directly to a landfill site, semisolid waste from treatment plants



Methods of Disposal

Traditional methods for disposal of the solid waste:

- LANDFILL

Burying Wastes

- Landfills most common method of waste disposal - cheap and convenient.
- Open pits no longer acceptable.
- Complex impermeable bottom layers to trap contaminants
- Daily deposits are covered by layer of dirt.
- Methane gas and leachate monitoring wells

Sanitary Landfills: Trade-offs

Trade-Offs

Sanitary Landfills

Advantages	Disadvantages
No open burning	Noise and traffic
Little odor	Dust
Low groundwater pollution if sited properly	Air pollution from toxic gases and volatile organic compounds
Can be built quickly	Releases greenhouse gases (methane and CO_2) unless they are collected
Low operating costs	Groundwater contamination
Can handle large amounts of waste	Slow decomposition of wastes
Filled land can be used for other purposes	Discourages recycling and waste reduction
No shortage of landfill space in many areas	Eventually leaks and can contaminate groundwater

Main Design Phase

The main design phase includes

- Design of liner, leachate collection and treatment
- Gas collection and treatment
- Cover System
- Landfill Stability
- Surface Water Drainage
- Environmental Monitoring

Site Selection

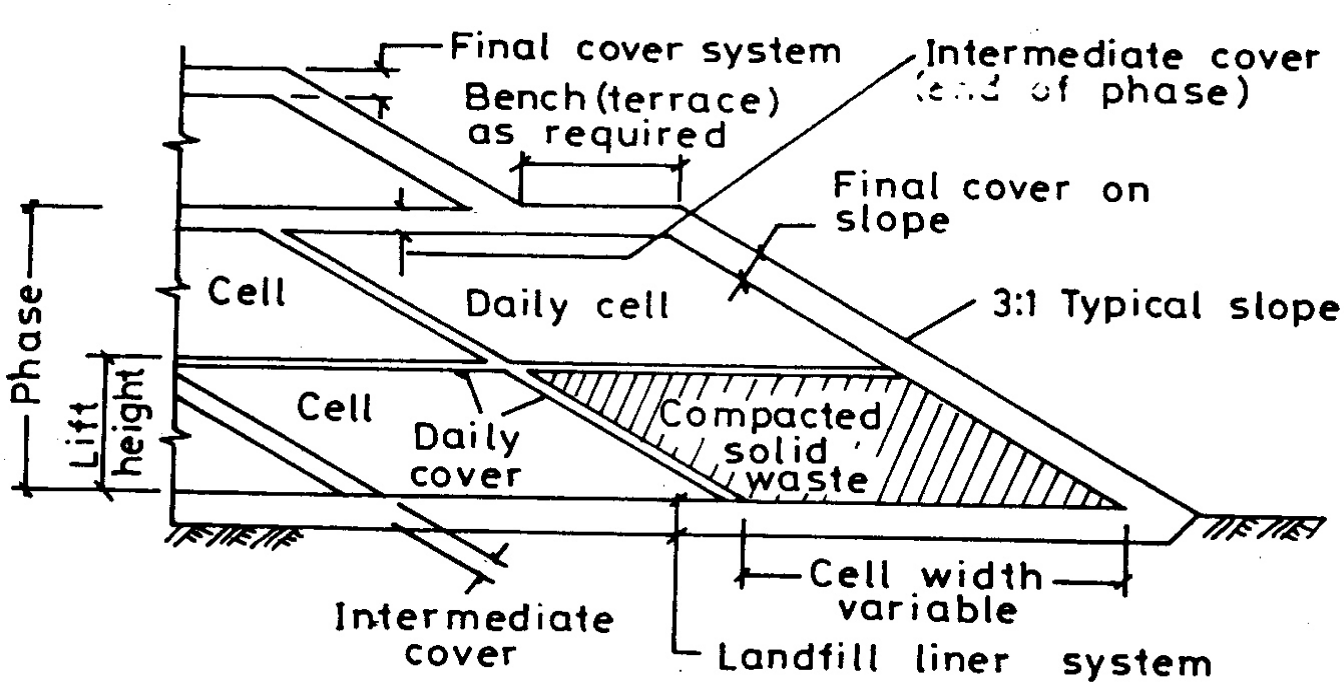
Site for development of landfill to be located preferably in areas having

- low population density
- low alternate land use value
- low GW contamination potential
- having clay content in the sub-soil

Factors to be Considered in Site Selection

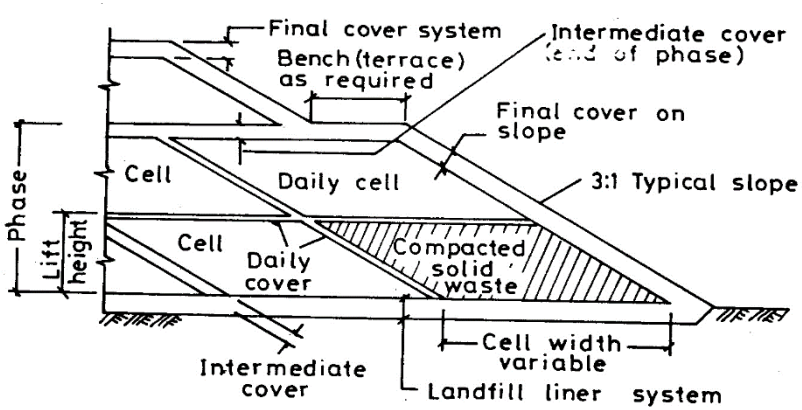
Receptor Related Attributes

- Population within 500 m
- Distance to nearest drinking well
- Use of site by nearby residents
- Distance to nearest office building
- Land use
- Critical Environment



Phase:- It is the sub area of the landfill. A phase consists of cells, lifts, daily cover, intermediate cover, liner and leachate collection facility, gas control facility and final cover over the sub-area. Each phase is typically designed for a period of 12 to 18 months.

Cell:- It is used to describe the volume of material placed in a landfill during one operating period usually one day.



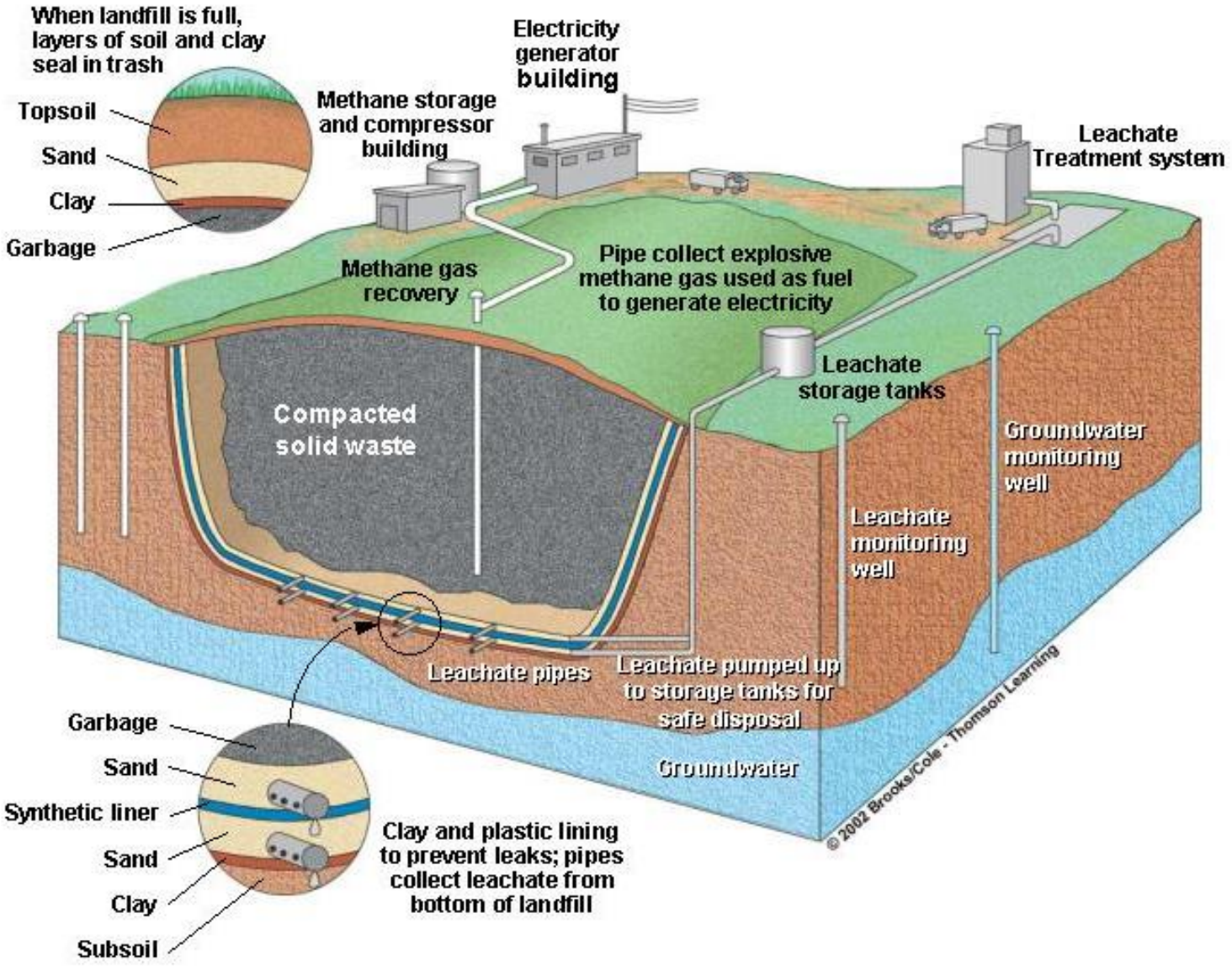
Daily cover:- It consists of 15 to 30 cm of native soil that is applied to the working faces. The purpose of this cover is

- To control the blowing of waste materials
- To prevent rats, flies and other disease vectors from entering or exiting the landfill
- To control the entry of water into the landfill during operation

Lift:- It is a complete layer of cells over the active area of the landfill. Typically each landfill phase is comprised of a series of lifts. Intermediate covers are placed at the end of each phase; these are thicker than daily covers and remain exposed till the next phase is placed over it.

Bench:- A bench is a terrace which is used when the height of the landfill exceeds 15 to 20 m. The final lift includes the cover layer.

Sanitary Landfill



Landfills in Hong Kong

- Hong Kong had operated 13 landfills which are now closed
  - six have already been restored for community greening and activities
- Three large, modern state-of-the-art strategic landfills established in three corners of Hong Kong:
  - North East New Territories (NENT)
  - South East New Territories (SENT)
  - West New Territories (WENT)
- These three landfills began operation in the 1990s and they will reach their designed capacities by 2019 if not planned for extension

Receives
- Municipal waste
- Construction waste
- Special waste

Receives
- Municipal waste
- Construction waste
- Special waste

Only receive construction waste

Waste-to-energy

- Waste-to-energy is the process by which the energy content of wastes is converted into heat or electricity using various types of technologies.
- Major types of waste-to-energy technologies
  - Landfill gas utilization
  - Anaerobic digestion
  - Thermal treatment with energy recovery

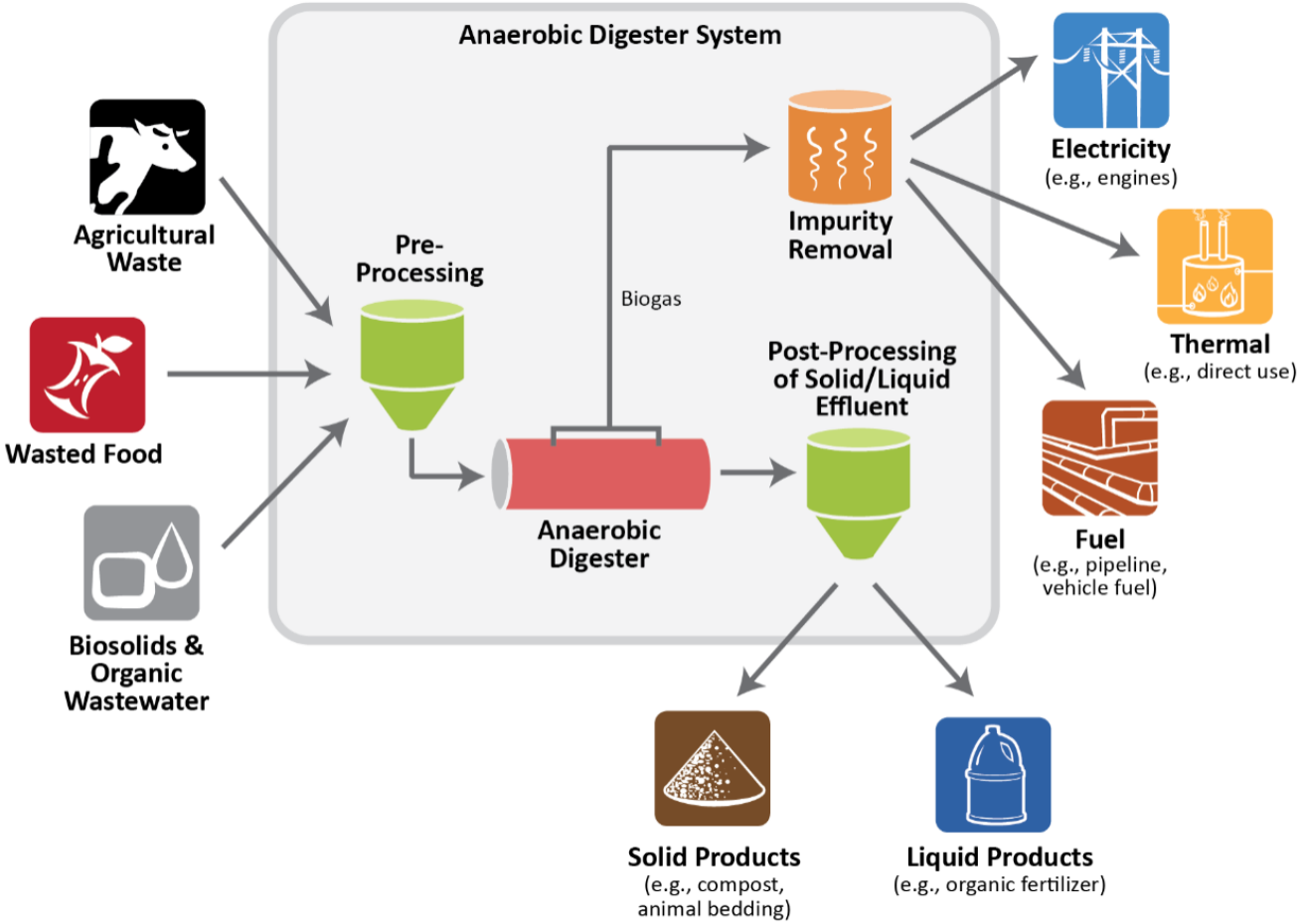
Landfill Gas

- Landfill gas can be used beneficially to generate electricity and energy for site use or as a substitute for towngas.
- Decomposition of organic portions of the solid wastes produces carbon dioxide, methane gas and other organic compounds and gaseous products.
- Landfill gas can form an explosive mixture with air, when mixed with air in certain proportions.
- Methane (a major constituent of landfill gas) is a greenhouse gas with a global warming potential over 100 years of 23
  - Averaged over 100 years each kg of methane warms the Earth 23 times as much as the same mass of carbon dioxide
- In the advanced landfills, gas collection systems are installed to collect the landfill gas.

Anaerobic Digestion

- Anaerobic digestion is the process in which organic matters are **decomposed by micro-organisms** in the absence of air to produce biogas comprising mainly of carbon dioxide and methane.
- Anaerobic digestion involves **biogas generation under a controlled environment** in a specially designed facility.
- Under these conditions, the **gas yield can reach its theoretical maximum** and the digestion process can be shortened to be within days rather than years as in the case of landfill gas formation.
- Besides, the residues can be used for the **production of compost for agricultural applications**.

- Anaerobic digestion involves a combination of processes:
  - The **first is hydrolysis**, where complex organic molecules are broken down into simple sugars, amino acids, and fatty acids with the addition of hydroxyl groups.
  - The **second is acidogenesis** where a further breakdown into simpler molecules occurs, producing ammonia, carbon dioxide and hydrogen sulfide as by-products.
  - The **third is acetogenesis** where the simple molecules from acidogenesis are further digested to produce carbon dioxide, hydrogen and mainly acetic acid, although higher-molecular-weight organic acids are also produced.
  - The **fourth is methanogenesis** where methane, carbon dioxide and water are produced.



- **Pretreatment facility:** preparation of the organic fraction of the substrate for anaerobic digestion. This may include receiving, sorting, separating and compressing of wastes.
- **Digester:** It is the bio-reactor where organic matter is decomposed to produce biogas. It is an oxygen-free container that provides an anaerobic environment for the activities of methanogenic bacteria.
- **Biogas storage:** Biogas generated can be stored in the digester or in a gas storage unit. The biogas is then piped to the power generation facility.

Products of AD

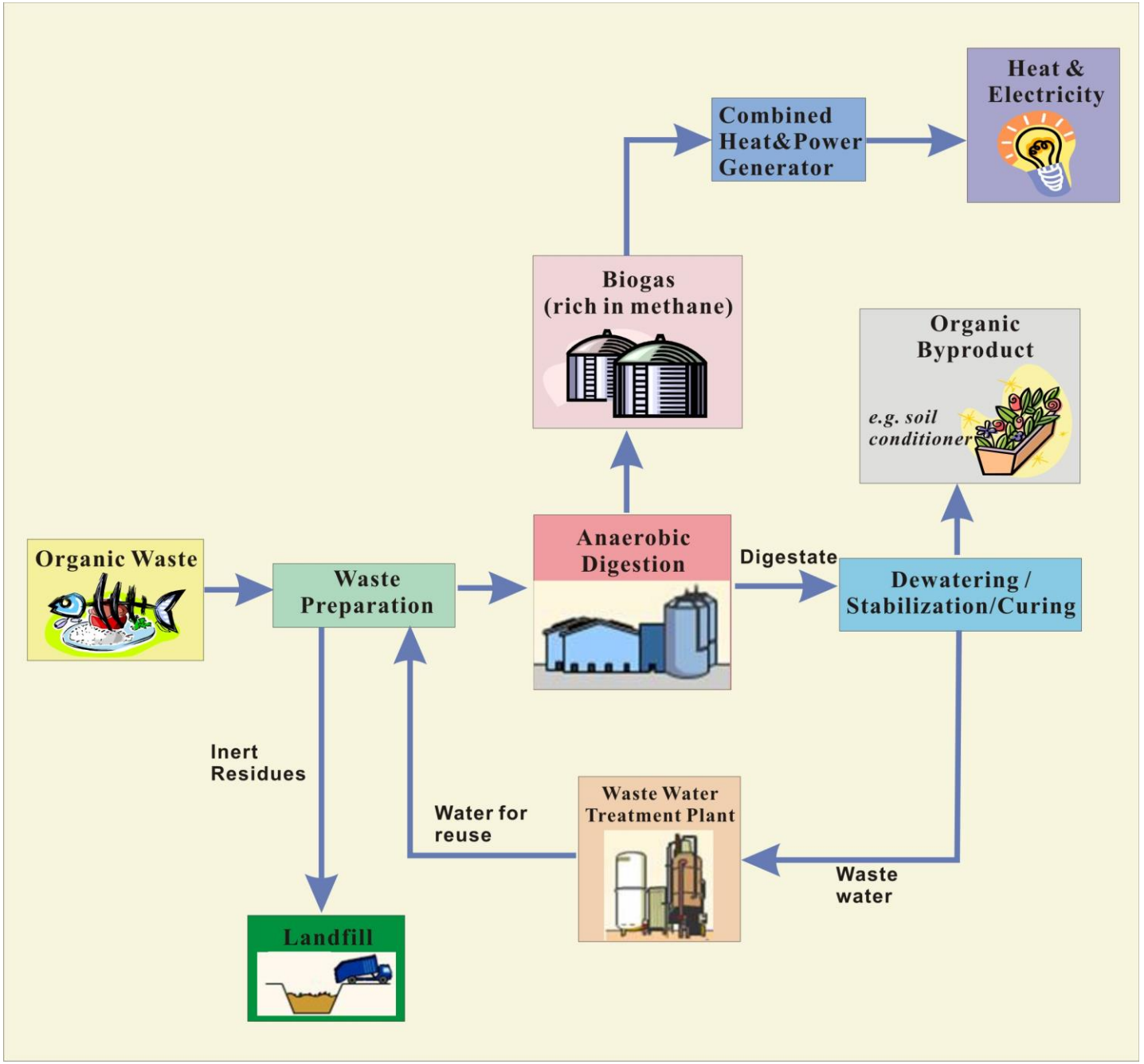
- **Biogas:** mainly made up of methane (50 -60%) and carbon dioxide (40 -50%), can be used for heat production or electricity production, or for both in the case of combined heat and power systems.
- **Liquid digestate:** liquid-rich short-chain organic compounds that can be used as soil conditioner.
- **Fiber digestate:** residues that can be used for the production of compost.

Types of AD

- Anaerobic digestion systems can be categorized into the following categories:
  - **Continuous process**
    In a continuous process, the substrate is added to and removed from the digester continuously. Since fresh substrate is added continuously, all reactions involved in biogas generation will occur at a fairly constant rate.
  - **Batch process**
    In the batch process the substrate is put in the digester and then the digester is sealed for the entire period without adding additional substrate until the decomposition process is near completion.
  - **Semi-continuous process**
    In a semi-continuous process, the digester initially works under the batch process. A small fraction of the digester contents is then released. After the release process, fresh material is injected to make up the contents and the digestion process is allowed to run for a while until the next release.

Organic Waste Treatment Facilities (OWTF) in Hong Kong

Organic Resources Recovery Centre

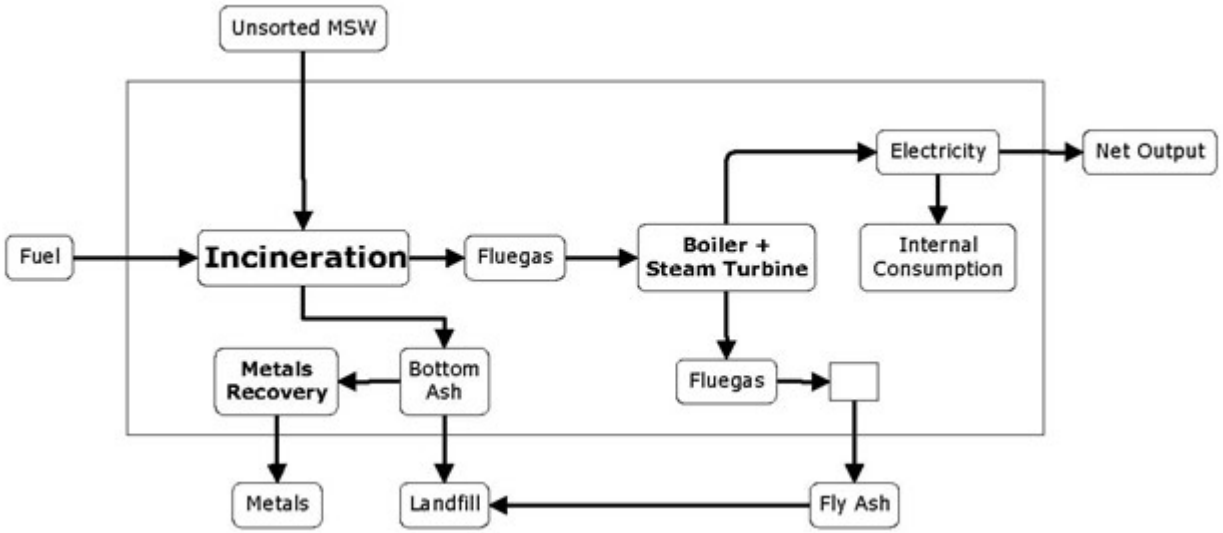

Heat &
Electricity
Combined
Heat&Power
Generator
Biogas
(rich in methane)
Organic
Byproduct
e.g. soil
conditioner
Organic Waste
Waste
Preparation
Anaerobic
Digestion
Digestate
Dewatering /
Stabilization/Curing
Inert
Residues
Water for
reuse
Waste Water
Treatment Plant
Waste
water
Landfill

Thermal treatment with energy recovery

- Thermal treatment with energy recovery is the application of heat under controlled conditions to extract energy from organic wastes.
- The primary function of thermal treatment is to reduce the volume of municipal solid wastes (MSW), with the recovered energy being a by-product of the treatment process.
- Thermal treatment system can be an integral part of an integrated MSW management facility, with a recycling facility to serve as a pre-treatment system.
- The recycling facility can increase the material recovery percentage and also enhance the overall efficiency of the thermal treatment process.
- In a thermal treatment system with energy recovery, MSWs are used to produce heat and gas using various types of technologies such as MSW combustion and MSW gasification.

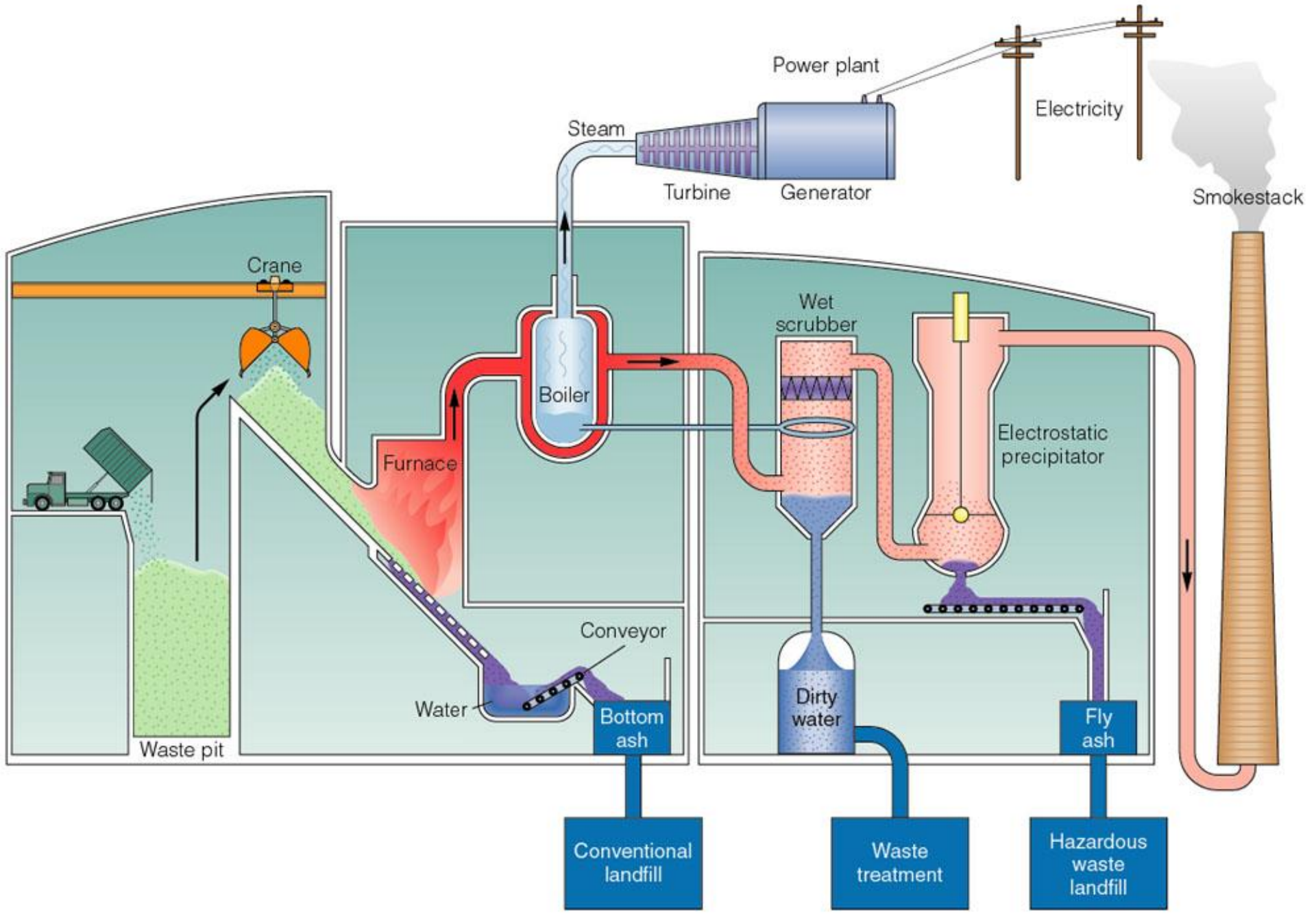
MSW combustion with energy recovery

- MSW combustion produces flue gases with high temperature, and the thermal energy can be used to raise steam to drive a turbo-generator to produce electricity.
- In a modern waste-to-energy facility, MSW combustion and energy recovery are accomplished in an integrated design.



MSW gasification

- The gasification process turns carbon-based substances into energy-rich fuel by heating under controlled conditions to produce a syngas which is the mixture of carbon monoxide and hydrogen.
- Gasification of MSW involves a number of processes:
  - **Pyrolysis process**
    Organic substances are split into gaseous, liquid and solid fractions through a combination of thermal cracking and condensation reactions under an oxygen-free environment.
  - **Oxidation process (combustion process)**
    Gaseous and liquid products derived from the pyrolysis process will be further oxidized by oxygen to produce carbon dioxide and carbon monoxide.
  - **Reduction process (gasification process)**
    The char derived from the pyrolysis process will be furthered heated up in order to produce a syngas mainly composed of carbon monoxide and hydrogen.



Incineration in Hong Kong

- **T ▪ PARK**
  - Energy from sewage sludge treatment
  - T ▪ PARK was fully commissioned in April 2016 and is currently the largest WTE generator in Hong Kong.
  - It reduces the volume of dewatered sewage sludge by 90% and the heat generated by the incineration process is used to provide electricity to meet on-site operational needs.
  - The surplus electricity is exported to the power grid for meeting the needs of up to 4,000 homes at maximum design throughput (2,000 tonnes of sludge per day), which is expected by 2030.
  - The current quantity being treated per day is about 1,200 tonnes.

- Process: https://www.tpark.hk/en/process/

Incineration: Burning Wastes

Mass burn incineration

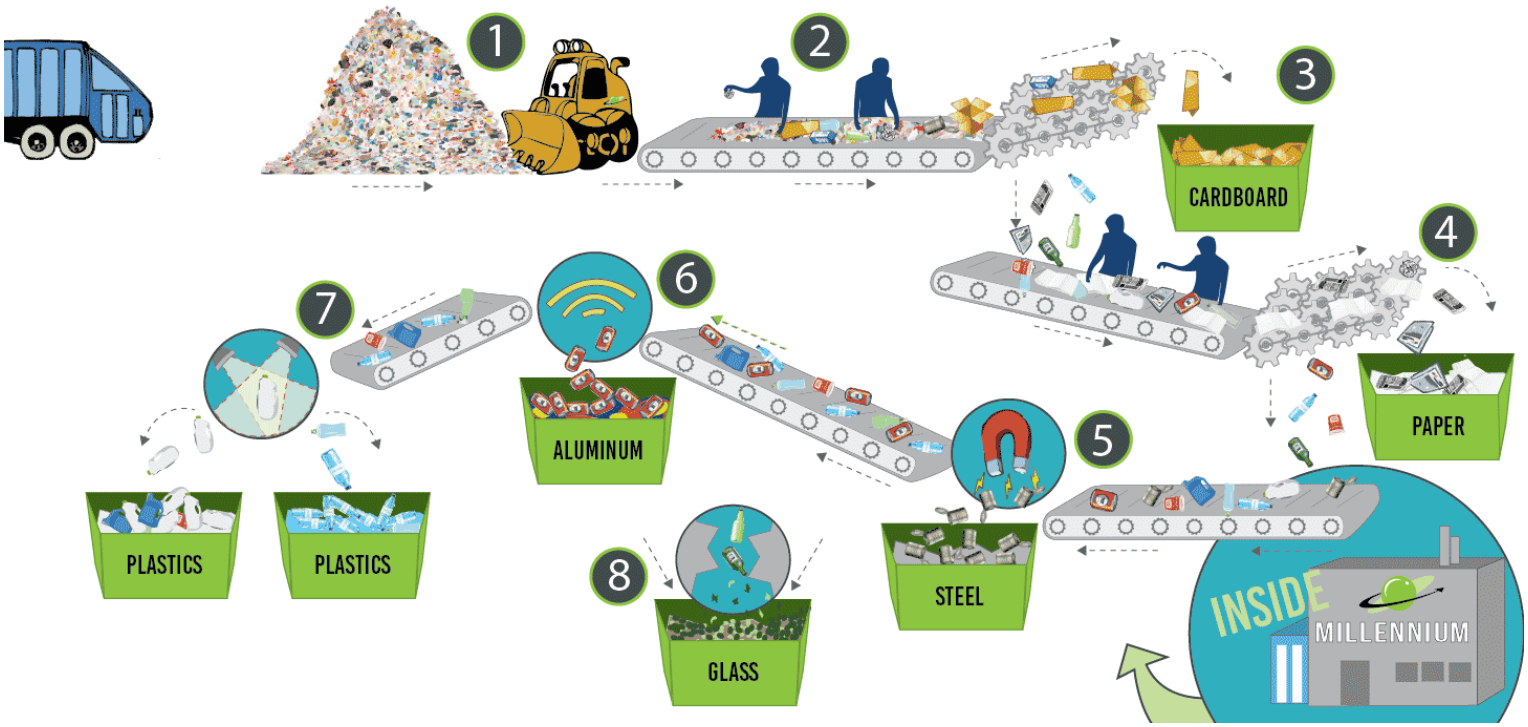
- Air pollution
- Waste to energy

Recycling

- Primary (closed-loop)
  - **Closed-loop systems**: all of the materials in manufactured goods can be recycled, usually for use in the same type of product

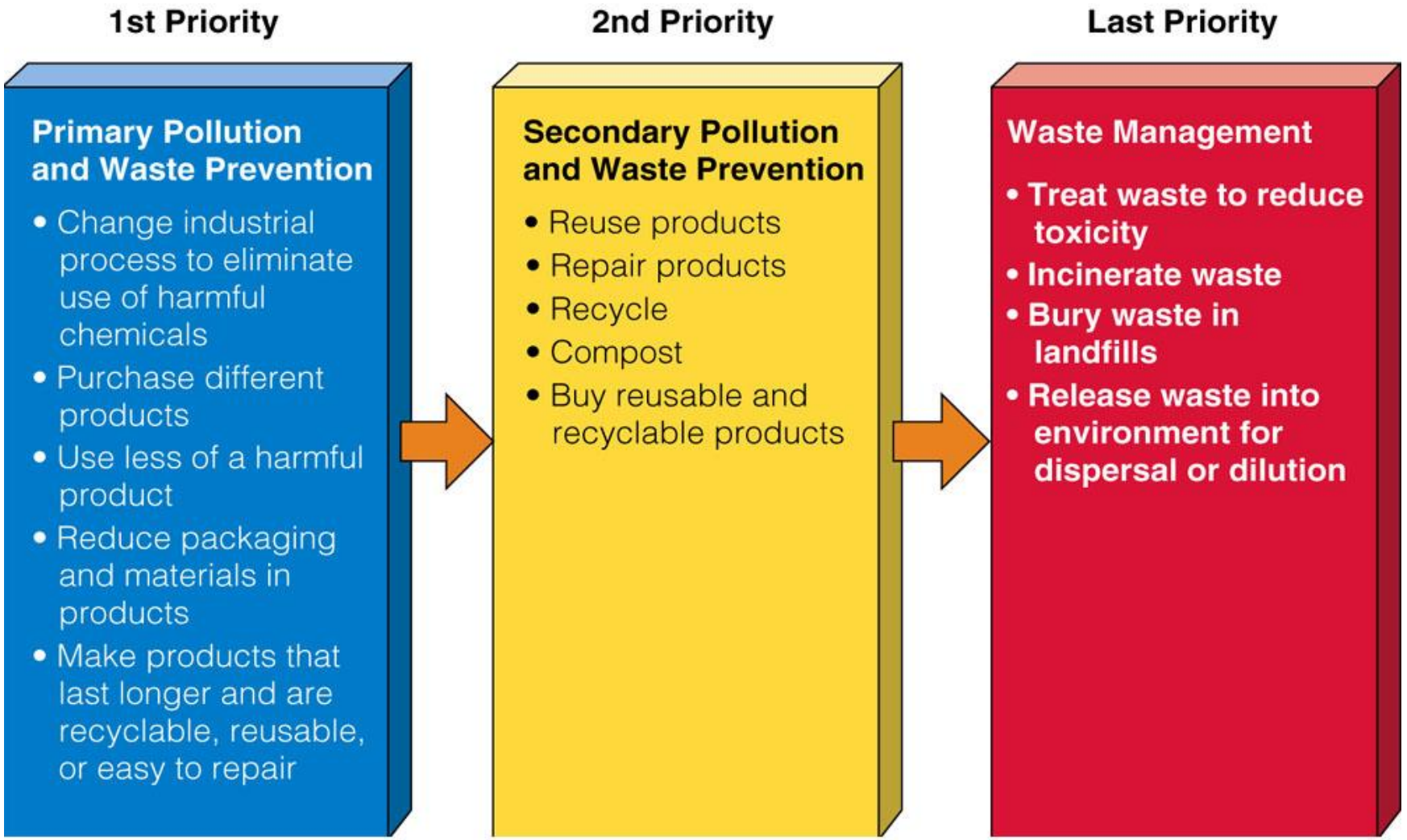
- Secondary (open loop)
  - **Open-loop systems**: materials recycled go on to be used for purposes different from their former, pre-recycled purpose
    - Pre-consumer waste: reclamation of waste materials that were created prior to their delivery to a **consumer**
    - Post-consumer waste: recovered from waste destined for disposal after the product has served its intended use

Characteristics of Recyclable Materials



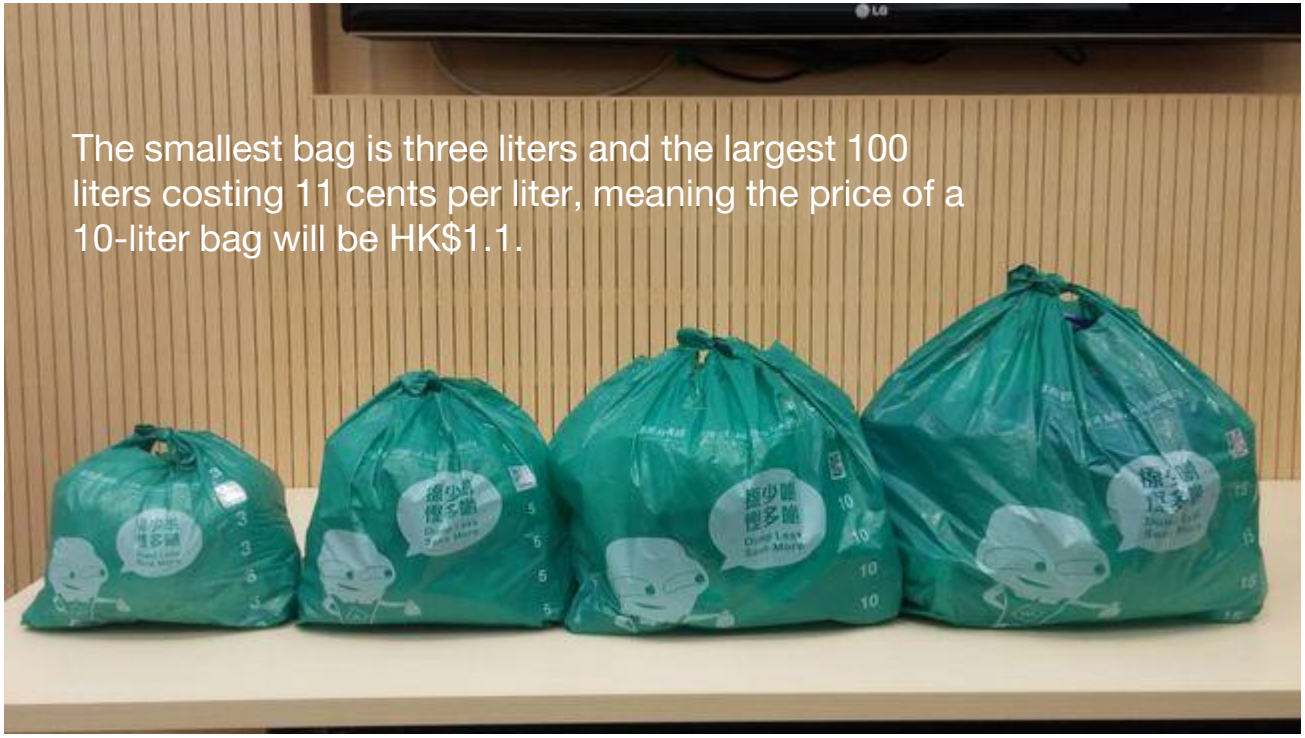
- Easily isolated from other waste
- Available in large quantities
- Valuable

Dealing with Material Use and Wastes



Waste Reduction by Waste Charging

- Each household to use pre-paid designated garbage bags and take them out at a designated time and place every time for disposal under monitoring
- To be introduced by late 2022.



http://www.thestandard.com.hk/section-news.php?id=180983

Reuse

- Extends resource supplies
- Saves energy and money
- Reduces pollution
- Creates jobs
- Reusable products

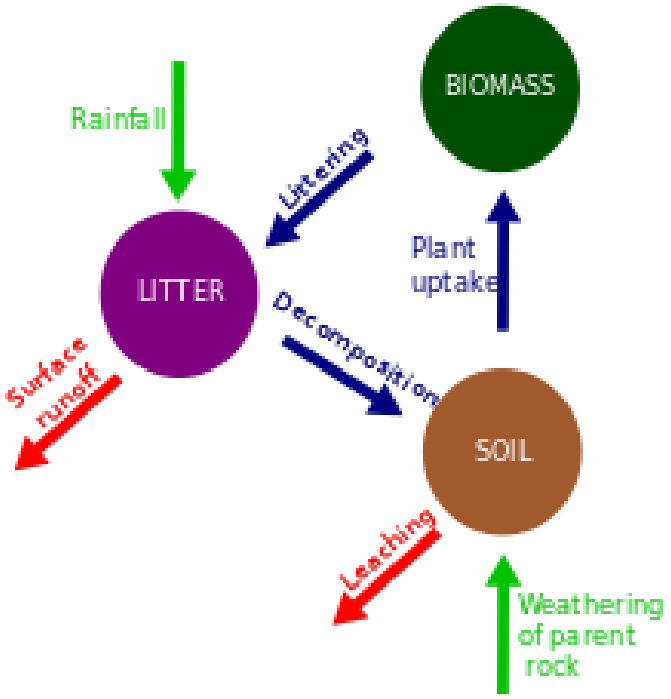
What Can You Do?

Reuse

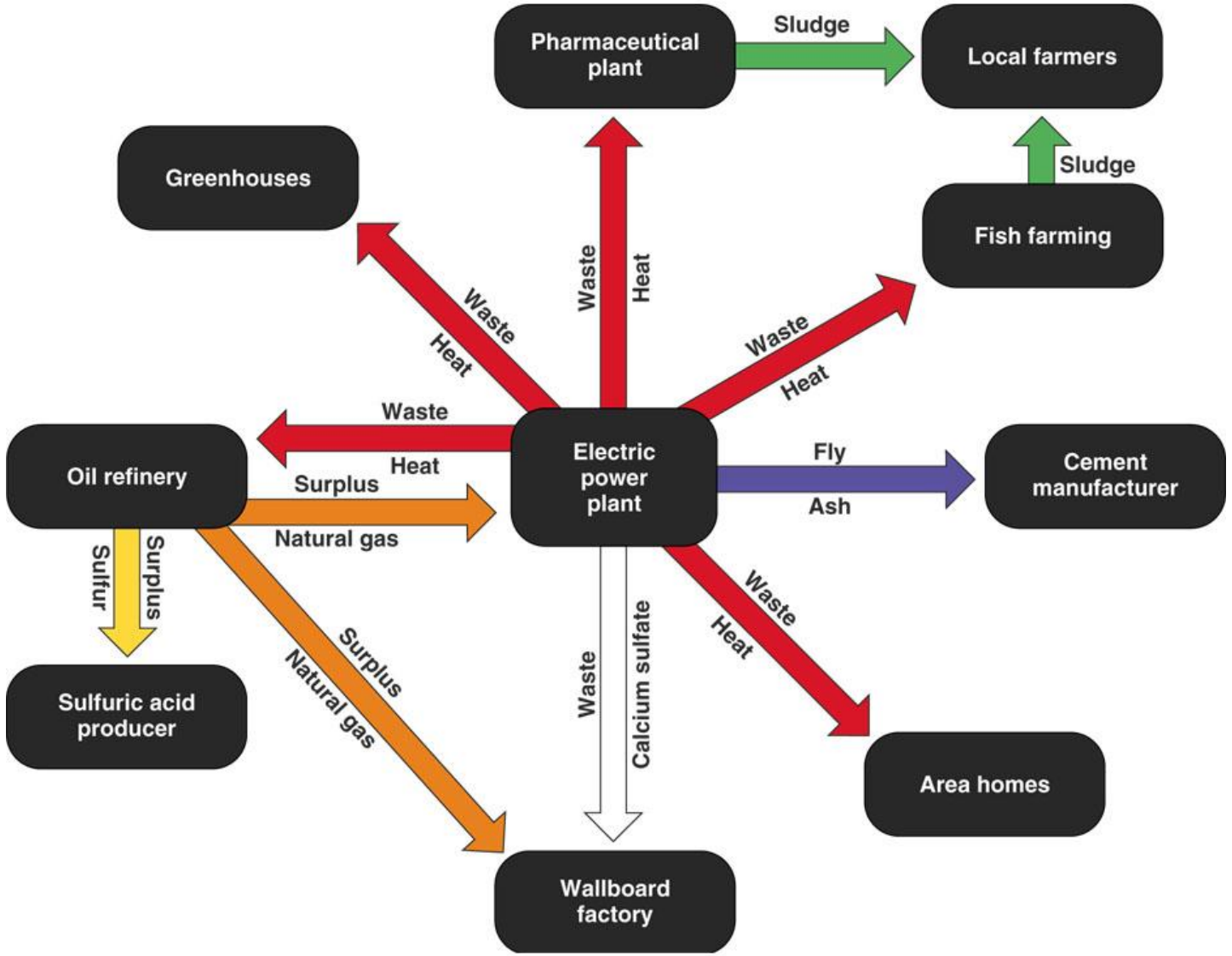
- Buy beverages in refillable glass containers instead of cans or throwaway bottles.
- Use reusable plastic or metal lunchboxes.
- Carry sandwiches and store food in the refrigerator in reusable containers instead of wrapping them in aluminum foil or plastic wrap.
- Use rechargeable batteries and recycle them when their usefull life is over.
- Carry groceries and other items in a reusable basket, a canvas or string bag, or a small cart.
- Use reusable sponges and washable cloth napkins, dishtowels, and handkerchiefs instead of throwaway paper ones.

Solutions: Cleaner Production

- Eco-industrial revolution
- Resource exchange webs
  - Waste from one industry is raw material for another
  - Biomimicry (mimic nature)
  - No waste in nature
- Service-flow economy

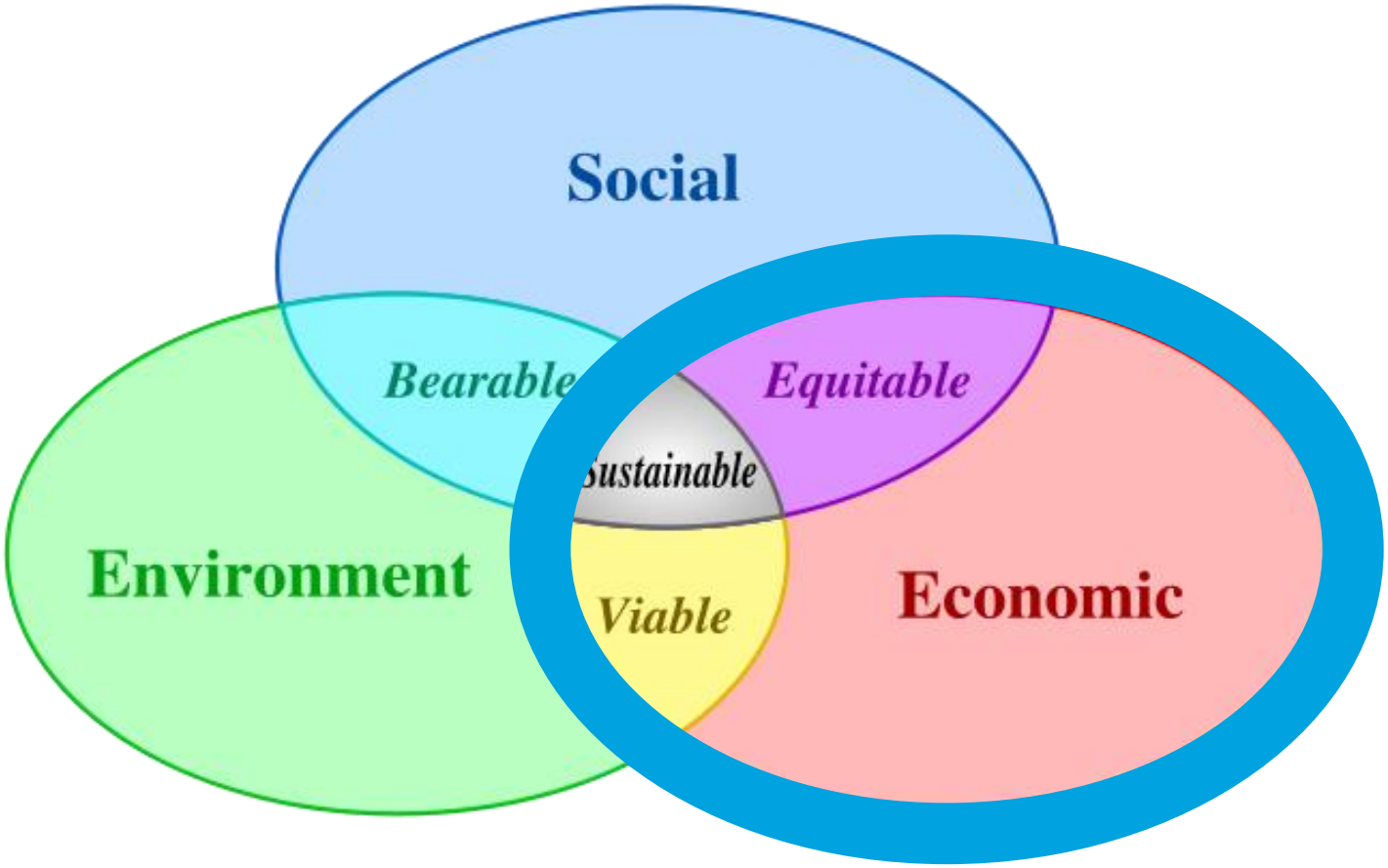


Industrial Ecosystem in Denmark



Kalundborg Symbiosis

Sustainability: Approaches



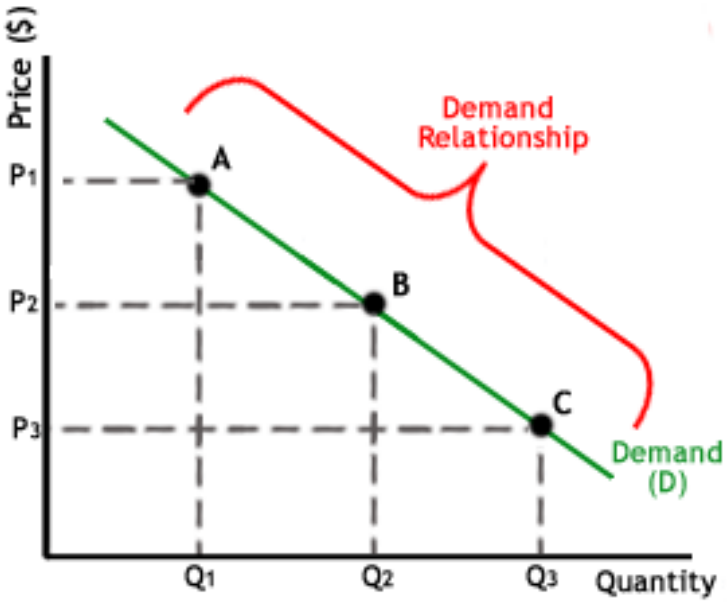
E.g. Circular Economy

Basics of Economics: Supply and Demand

- Supply and demand is perhaps one of the most fundamental concepts of economics and it is the backbone of a market economy
- **Demand** refers to how much (quantity) of a product or service is desired by buyers.
  - The quantity demanded is the amount of a product people are willing to buy at a certain price; the relationship between price and quantity demanded is known as the **demand relationship**.
- **Supply** represents how much the market can offer.
  - The quantity supplied refers to the amount of a certain good producers are willing to supply when receiving a certain price. The correlation between price and how much of a good or service is supplied to the market is known as the **supply relationship**.
- Price, therefore, is a reflection of supply and demand.

The Law of Demand

- The law of demand states that, if all other factors remain equal, the **higher the price of a good**, the **less people will demand that good**.
- Amount of a good that buyers purchase at a higher price is less because as the price of a good goes up, so does the **opportunity cost** of buying that good

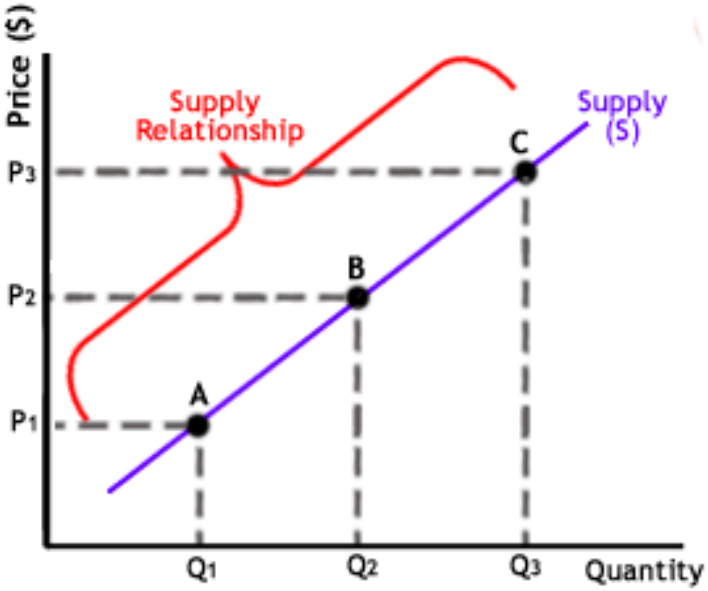


A, B and C are points on the demand curve that reflect a direct correlation between quantity demanded (Q) and price (P)

At point A, the quantity demanded will be Q1 and the price will be P1, and so on

The Law of Supply

- The law of supply demonstrates the quantities that will be sold at a certain price.
  - unlike the law of demand, the supply relationship shows an upward slope => **the higher the price, the higher the quantity supplied**
- Producers supply more at a higher price because selling a higher quantity at a higher price increases revenue.



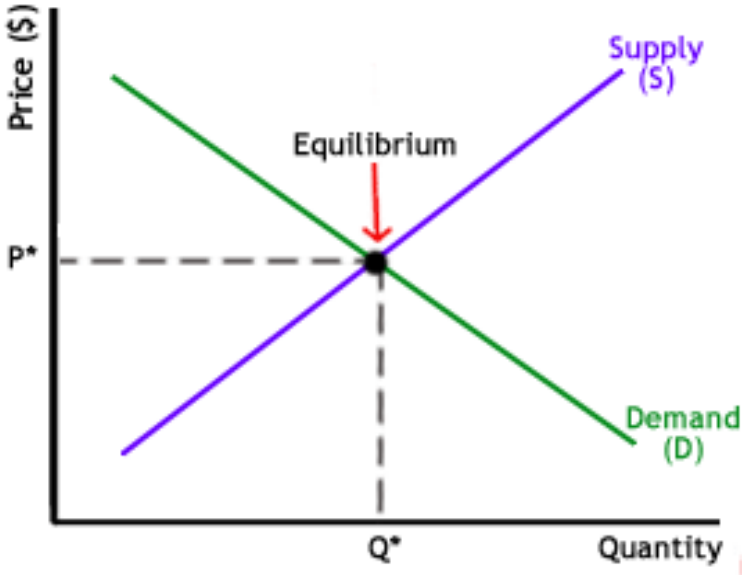
A, B and C are points on the supply curve that reflect a direct correlation between quantity supplied (Q) and price (P).

At point B, the quantity supplied will be Q2 and the price will be P2, and so on.

Time is important to supply because suppliers must, but cannot always, react quickly to a change in demand or price.

Supply and Demand Relationship

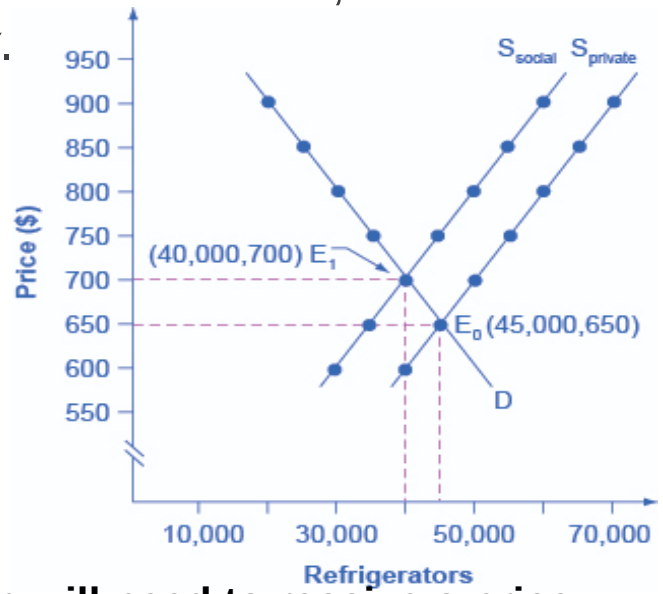
- When supply and demand are equal (i.e. when the supply function and demand function intersect) the economy is said to be at **equilibrium**.



equilibrium occurs **at the intersection of the demand and supply curve**, which indicates no allocative inefficiency. At this point, the price of the goods will be P* and the quantity will be Q*. These figures are referred to as equilibrium price and quantity.

Economics of pollution

- Economic production can **cause environmental damage**.
- Voluntary exchange benefits both buyers and sellers is a fundamental building block of the economic way of thinking.
  - But what happens when a voluntary exchange affects a third party who is neither the buyer nor the seller?
- The effect of a market exchange on a third party who is outside, or external, to the exchange is called an *externality*.
  - Negative externality
  - Positive externality



Externalities represent a case where markets no longer consider all social costs

- Waste and pollution is a negative externality.

Taking external costs of pollution into account, the firm will need to receive a price of $700 per refrigerator and produce a quantity of 40,000.

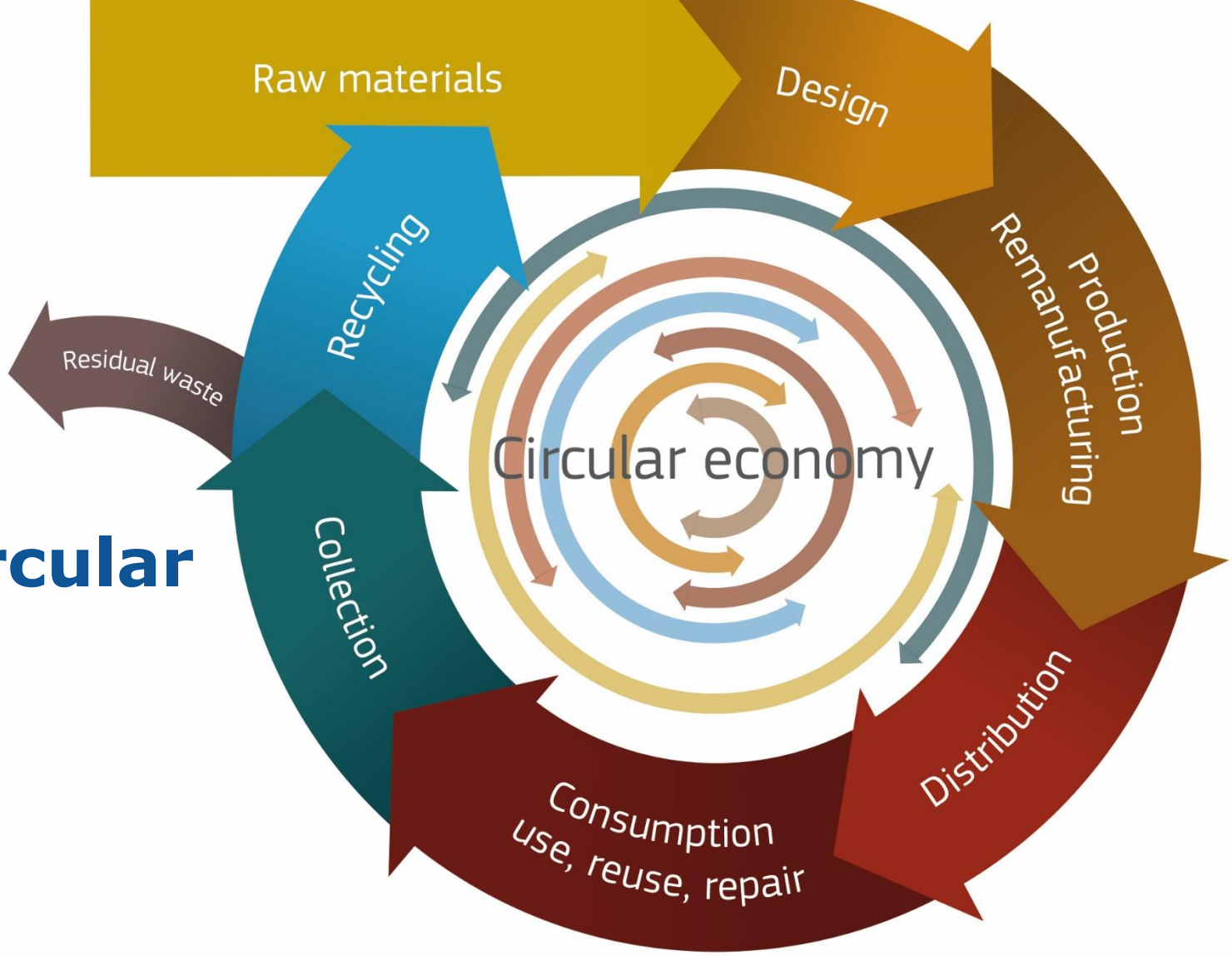
HERE IS A QUOTE WE RATHER LIKE:

"The goods of today are the resources of tomorrow at the resource prices of yesterday"

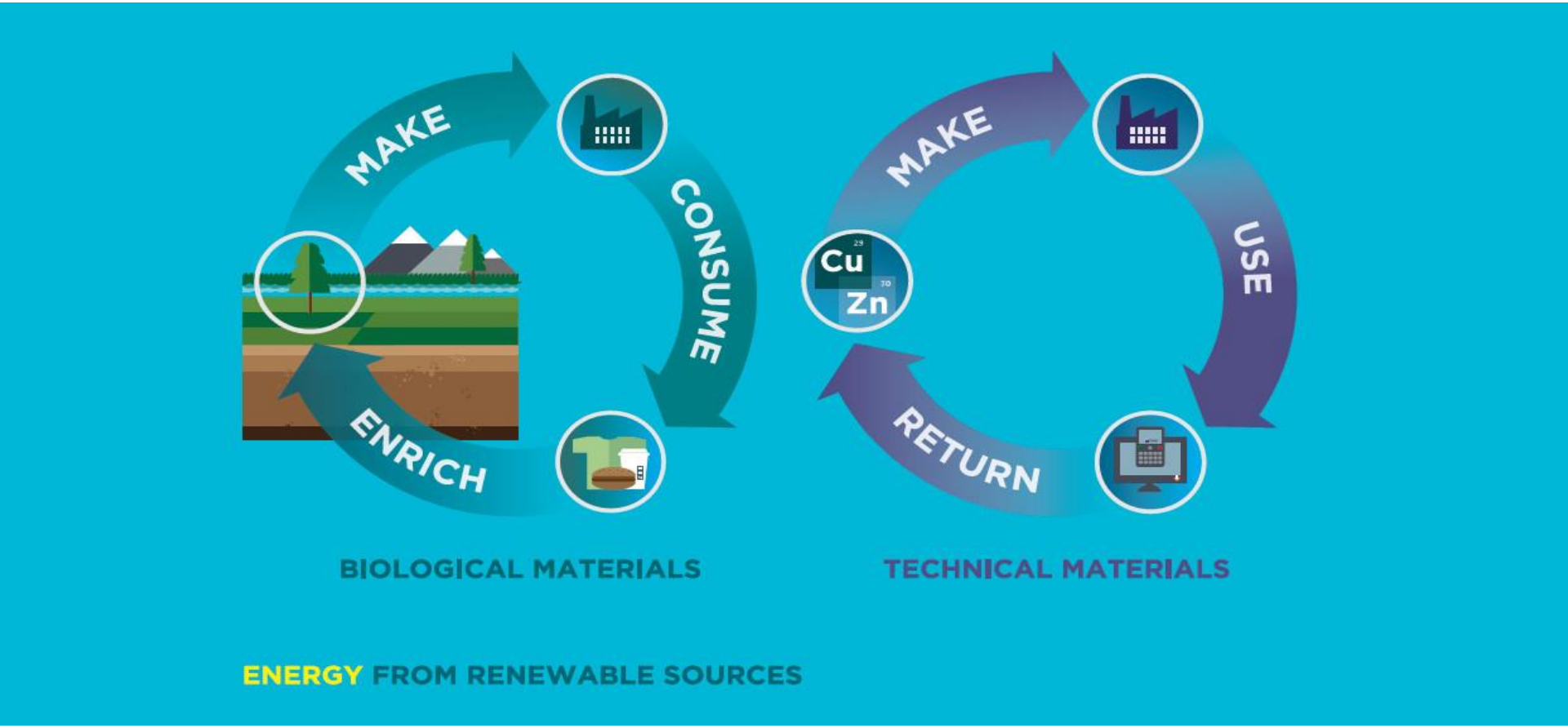
- WALTER STAHEL

From a linear economy …

… to a circular economy



THE CIRCULAR ECONOMY



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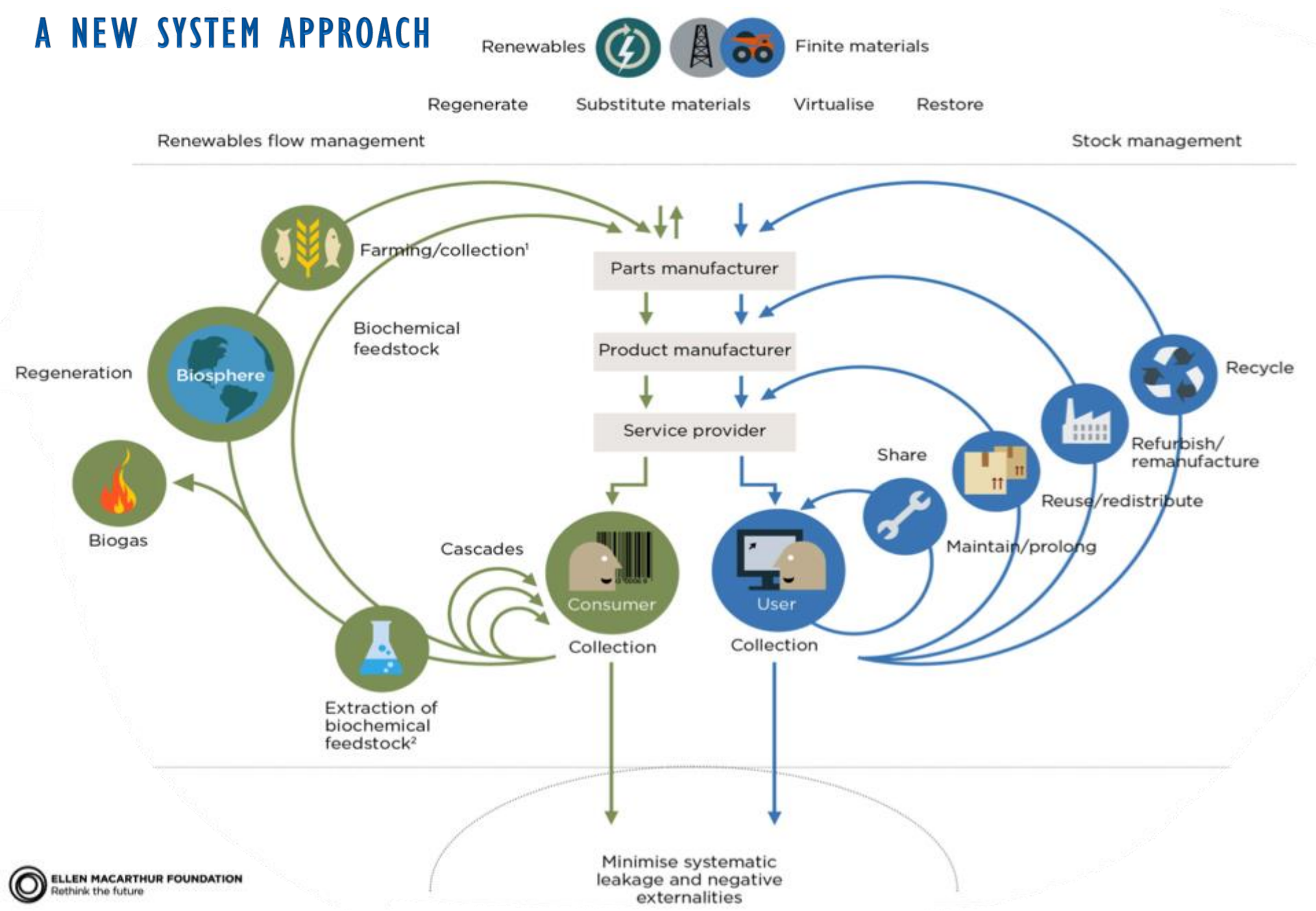
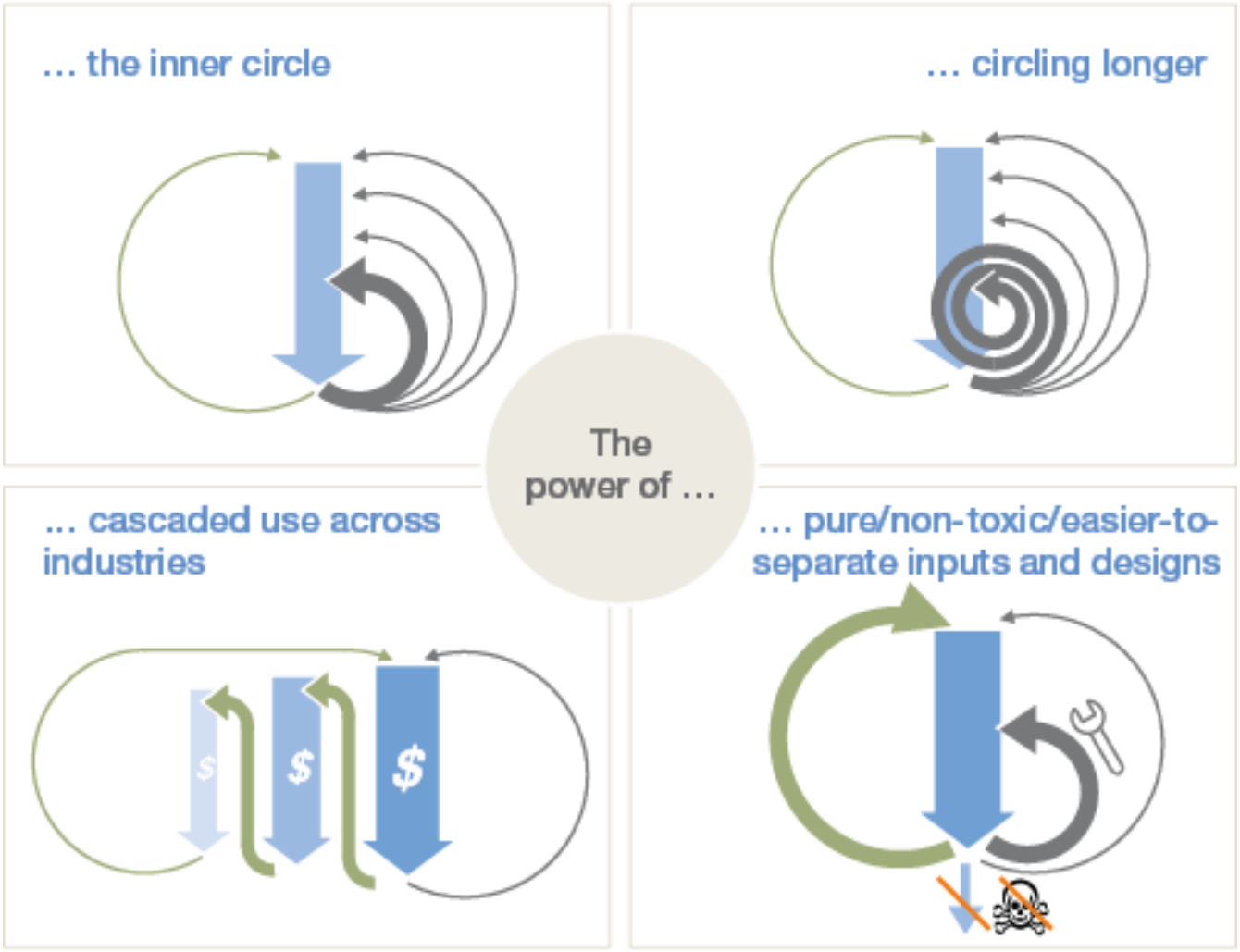
A NEW SYSTEM APPROACH

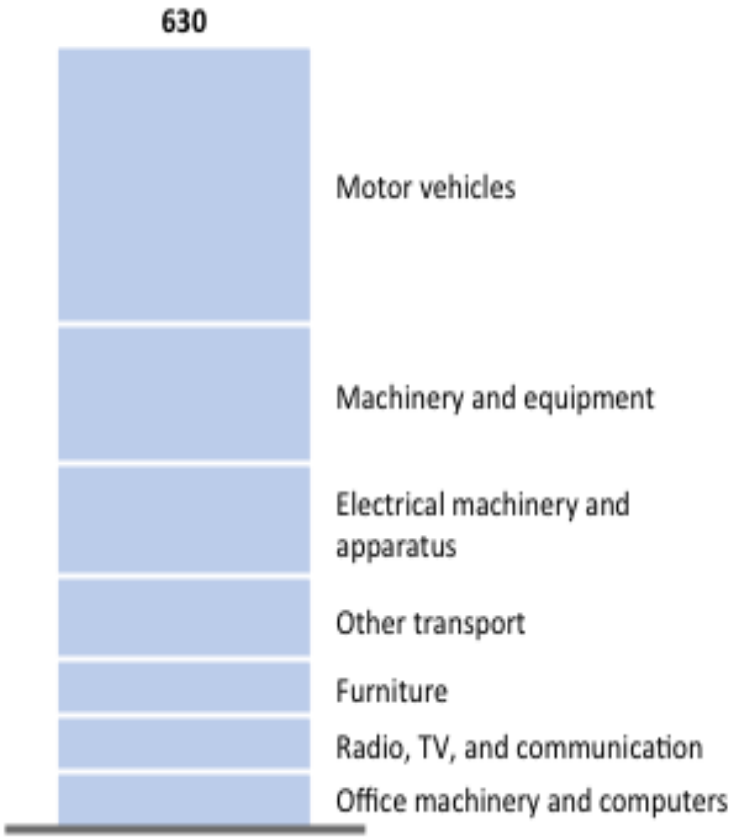


ELLEN MACARTHUR FOUNDATION
Rethink the future


… the inner circle
… circling longer
The power of …
… cascaded use across industries
… pure/non-toxic/easier-to-separate inputs and designs

Net material cost savings in complex durables with medium lifespans

US$ billion per year, based on current total input costs per sector, EU



Net material cost savings in consumers industries

US$ billion per year, based on total material savings from consumer categories, global

EXAMPLE 1 OF 3: PHILIPS AND TURNTOO

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EXAMPLE 2 OF 3: FLOOW2

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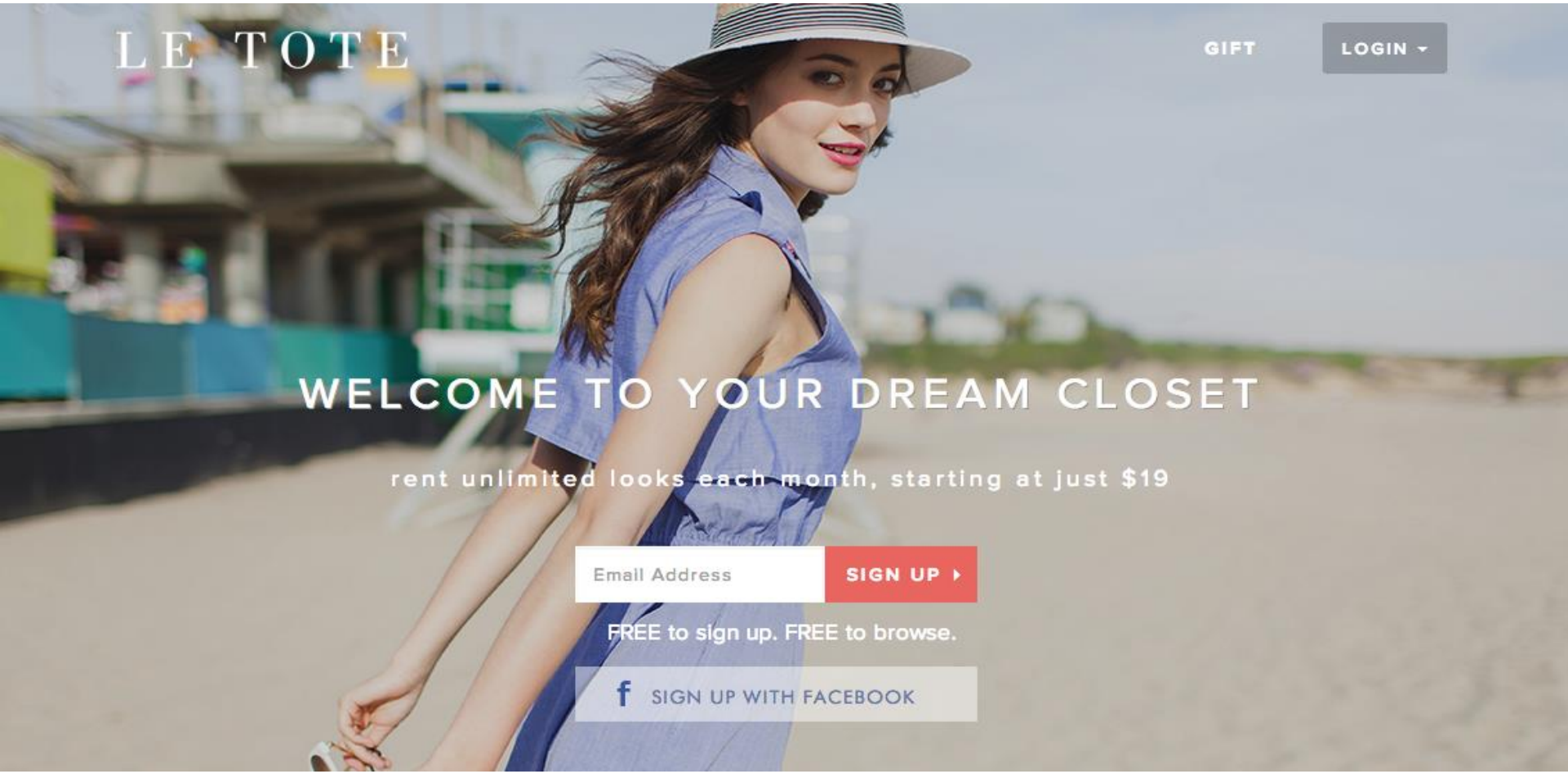
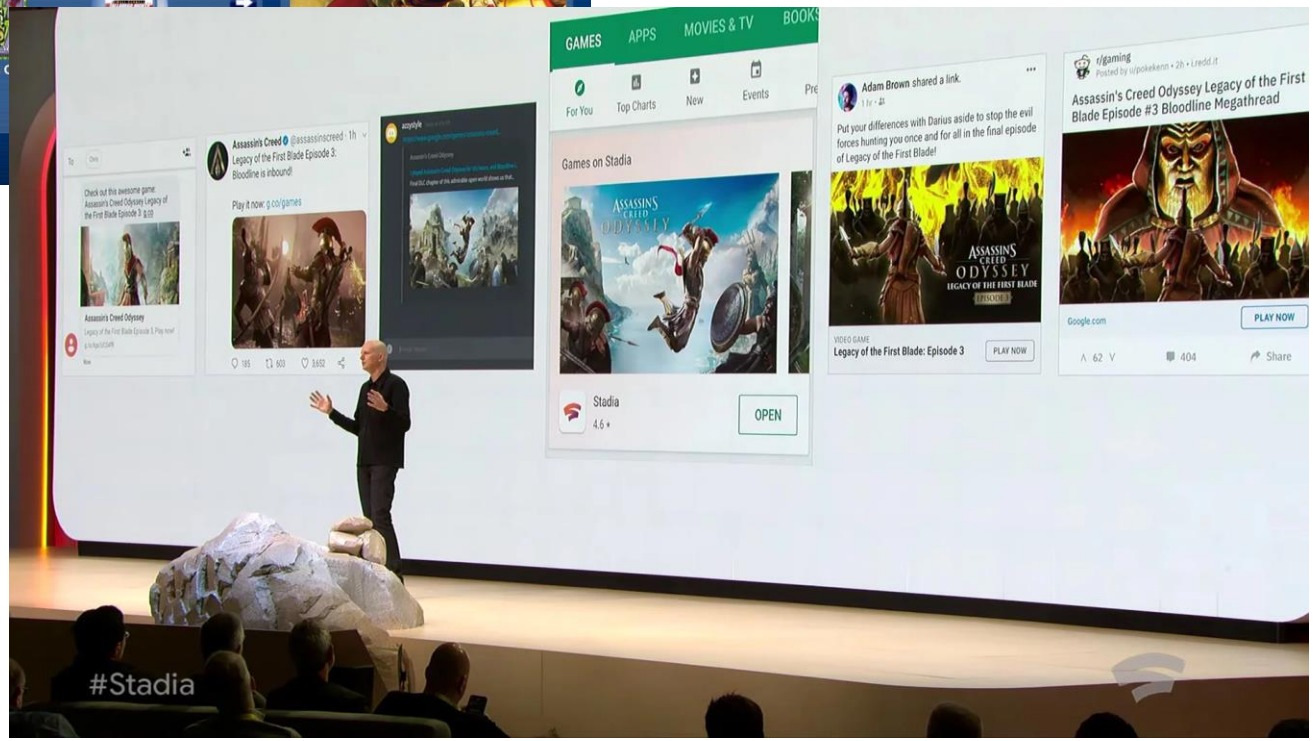
EXAMPLE 3 OF 3: LE TOTE



A CHALLENGE FOR FUTURE ENGINEERS

RE-THINK AND RE-DESIGN A PRODUCT OR A SERVICE FOR A CIRCULAR ECONOMY

SOME INSPIRATIONS… Gaming without CDs or consoles



SOME INSPIRATIONS… Biodegradable shoes

SOME INSPIRATIONS…

THE RESOLVE FRAMEWORK

		Examples
REGENERATE	• Shift to renewable energy and materials • Reclaim, retain, and restore health of ecosystems • Return recovered biological resources to the biosphere	P-REX, NESPRESSO, IBERDROLA, SLM, SAVORY INSTITUTE
SHARE	• Share assets (e.g. cars, rooms, appliances) • Reuse/secondhand • Prolong life through maintenance, design for durability, upgradability, etc.	airbnb, patagonia, Nearly New Car, autolib', Bla Bla Car
OPTIMISE	• Increase performance/efficiency of product • Remove waste in production and supply chain • Leverage big data, automation, remote sensing and steering	CISCO, wrap, TOYOTA, BSB, The Vauban Quarter
LOOP	• Remanufacture products or components • Recycle materials • Digest anaerobic • Extract biochemicals from organic waste	CAT, patagonia, RENAULT, DELL, PAQUES, VEOLIA, mazuma
VIRTUALISE	• Dematerialise directly, e.g., books, CDs, DVDs, travel • Dematerialise indirectly, e.g., online shopping, autonomous vehicles	kindle, zalando, CISCO, NETFLIX, skype, Google, iTunes
EXPLORE	• Replace old with advanced non-renewable materials • Apply new technologies (e.g. 3D printing) • Choose new product/service (e.g. multimodal transport)	DESSO, PHILIPS, skyTran

CIRCULAR ECONOMY - VALUE & BENEFIT LEVERS

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THE BIG QUESTION…

WHAT WILL YOU REDESIGN?

In-Class Activity:

1. Hong Kong loves Bubble tea!
2. Identify new business models based on the resolve framework that may solve the issue of waste generation from this sector.

TLQ

- TLQ is important for getting money to SEE.
  - Higher TLQ, the more funds given to the department
  - Funds that are used to support UG activities
- Filling out TLQ of SEE1003 Intro to Sustainable Energy & Environmental Engineering to improve teaching and inform personnel decisions.
  - Completion of it is voluntary and does not contribute to the final grade. Please complete with great care - share your valuable opinions NOW!

a. Students can access the TLQ system during the evaluation period in the following ways: a. through a link in an invitation email

b. through the course site on Canvas;

c. by logging into the TLQ system directly (https://onlinesurvey.cityu.edu.hk/);

d. by scanning the TLQ QR Code by smart phones or tablets.

Quiz next week on the 11th April

Quiz will cover

- Lecture slides
- Read report on

"BLUEPRINT FOR SUSTAINABLE USE OF RESOURCES 2013–2022"

  – https://www.enb.gov.hk/en/files/WastePlan-E.pdf

- Don't be late!

Report: Semester-long Project

- Compare and contrast the finding for questions 1-5 with all four types of car technologies:

1) Biofuel-based cars, 2) Electric Cars, 3) Hybrid Cars and 4) Hydrogen Cars.

- Present your findings with respect to the questions below for each type of cars.

1) Research the underlying technology of all four types of car.
   - What is the underlying technology?
   - What is the performance of this technology?

2) Identify the major components and energy source of the technology.
   - What raw materials are needed to manufacture this technology?
   - Is there enough material available to meet the demand?
   - Will the car produced using this technology be cost-effective?

3) Is the infrastructure available to scale up this technology?
   - Can one easily store the energy source of this technology?
   - Is the infrastructure cost of the distribution network high?

4) What are the potential environmental impacts during the operation of this technology?

5) Are there any foreseeable challenges with the disposal of this technology?

- Compare and contrast the four types of car technologies in terms of environmental impacts based on your findings.

(Tip: you can find the best and worst technology for each of the questions; is there a technology that is clearly better?)

Semester-long Project: Report Table

	Q1. Underlying Technology		Q2. Raw materials and energy source			Q3. Infrastructure		Q4. Environmental Challenges	Q5. Disposal Challenges
	Principle	Performance	Raw Materials	RM availability	Cost effective	Energy Storage	Energy Distribution		

Semester-long Project

Sub-assignment	Topics	Released	Due
Project Deliverable 1.1	Module 1: Sustainable Energy	Jan 24th	Feb 14th
Project Deliverable 1.2	Module 2: Environmental Impacts	Feb 14th	Feb 28th
Project Deliverable 1.3	Module 3: Noise Pollution	Feb 21st	Mar 21st
Project Deliverable 1.4	Module 4-6: Systems Analysis	Mar 21st	Apr 4th
Presentation + Final Report	Module 7-8: Policy and Economics	Apr 4th	Apr 11th

- Individual Project: **Report** and **Presentation**
  - No group work allowed.
  - Plagiarism check mandatory: Turnitin or ithenticate
- Final Report is to be submitted in a PDF or WORD format to Canvas.
- Answer to each question to be no less than 500 words and no more than 1000 words, exclusive of the table and bibliography (double spaced, 1-inch margins, 11 or 12 point Times Roman or Arial fonts).
- References used are to be gathered in the bibliography at the end of the paper and cited at the appropriate place in the text of the paper as "(author, date)".

Project Presentation upload on Canvas

- Prepare a 5-minute oral presentation based on your report for your semester-long project.
- Submit you pitch deck over Canvas by 9 am on April 11th.
- Your presentation must compare the following aspects:
  - Underlying technology of all four types of car
  - Raw materials required
  - Environmental challenges during operation of the vehicles
  - Disposal related challenges

- You will be evaluated based on the rubric.
- One slide per question (total 5 slides)

Rubric for the presentation

	SUPERIOR	ADEQUATE	MINIMAL	INADEQUATE
Content	The speaker provides a variety of types of content appropriate for the task, such as generalizations, details, examples and various forms of evidence. The speaker adapts the content in a specific way to the listener and situation.	The speaker focuses primarily on relevant content. The speaker sticks to the topic. The speaker adapts the content in a general way to the listener and the situation.	The speaker includes some irrelevant content. The speaker wanders off the topic. The speaker uses words and concepts which are inappropriate for the knowledge and experiences of the listener (e.g., slang, jargon, technical language).	The speaker says practically nothing. The speaker focuses primarily on irrelevant content. The speaker appears to ignore the listener and the situation.
Delivery	The speaker delivers the message in a confident, poised, enthusiastic fashion. The volume and rate varies to add emphasis and interest. Pronunciation and enunciation are very clear. The speaker exhibits very few disfluencies, such as "ahs," "uhms," or "you knows."	The volume is not too low or too loud and the rate is not too fast or too slow. The pronunciation and enunciation are clear. The speaker exhibits few disfluencies, such as "ahs," "uhms," or "you knows.	The volume is too low or too loud and the rate is too fast or too slow. The pronunciation and enunciation are unclear. The speaker exhibits many disfluencies, such as "ahs," "uhms," or "you knows." The listener is distracted by problems in the delivery of the message and has difficulty understanding the words in the message.	The volume is so low and the rate is so fast that you cannot understand most of the message. The pronunciation and enunciation are very unclear. The speaker appears uninterested.
Organization	The message is overtly organized. The speaker helps the listener understand the sequence and relationships of ideas by using organizational aids such as announcing the topic, previewing the organization, using transitions, and summarizing.	The message is organized. The listener has no difficulty understanding the sequence and relationships among the ideas in the message. The ideas in the message can outlined easily.	The organization of the message is mixed up and random. The listener must make some assumptions about the sequence and relationship of ideas.	The message is so disorganized you cannot understand most of the message.
Creativity	Very original presentation of material; captures the audience's attention.	Some originality apparent; good variety and blending of materials / media.	Little or no variation; material presented with little originality or interpretation.	Repetitive with little or no variety; insufficient use of materials / media.
Length of Presentation	Within two minutes of allotted time .	Within four minutes of allotted time.	Within six minutes of allotted time .	Too long or too short; ten or more minutes above or below the allotted time.

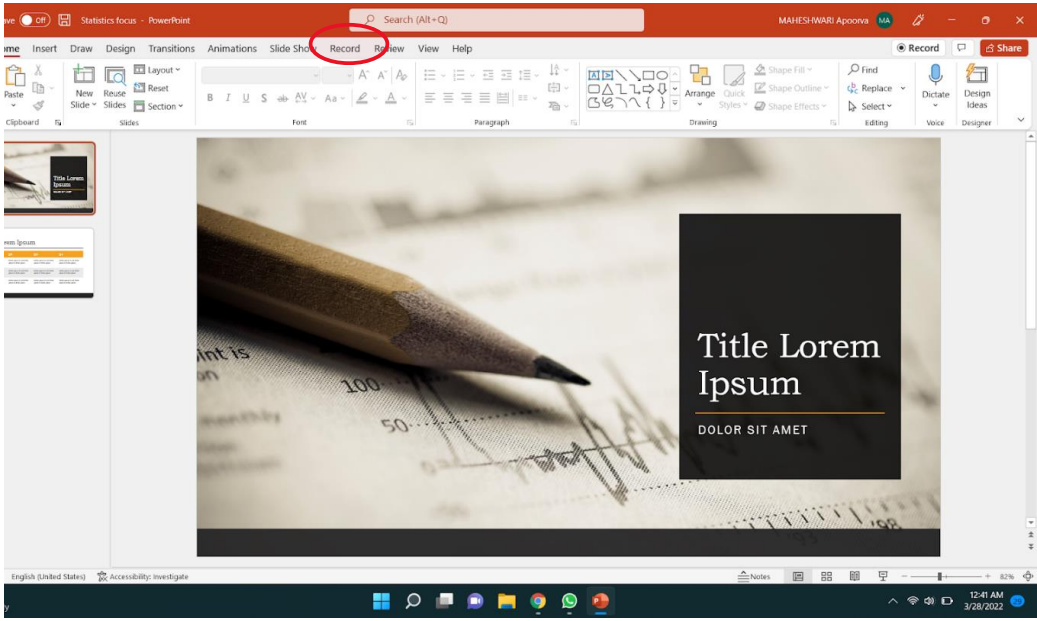
Presentation submission

- Step 1: Create your presentation.
- Step 2: Select the record option on top and you can start recording in your voice.
- Step 3: Once you are done with recording, export your presentation into video format(mp4)

There are two ways to export.

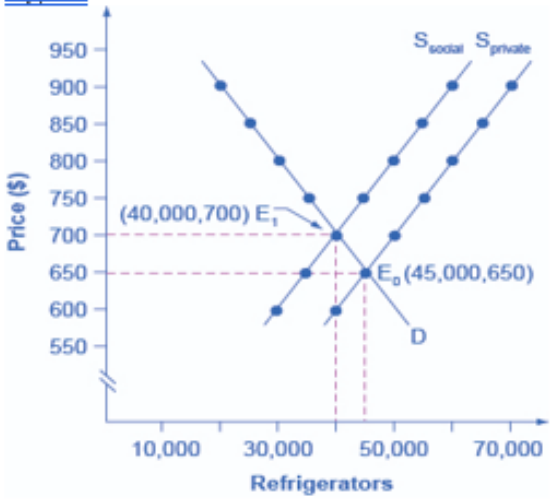
- First Way: Click on Export to Video under record tab.
- Second Way: Click of File >SaveAs and select mp4 as the format

Reference: https://www.youtube.com/watch?v=Y5dgwwa5XRA



Project deliverable 5 (Optional)

1. The social and private supply curves as well as the demand curve for refrigerator are shown in the figure below:



   a. Estimate the cost of pollution due to the production and disposal of each refrigerator based on the analysis. Describe how you determined the cost from the figure. (5 pts)
   b. If the manufacturer sells the refrigerator based on the private supply curve rather than considering the externality, when the economy reaches equilibrium point, how much pollution (in $s) is caused for all the refrigerators produced, but without anyone paying for it. (5 pts)

2. Based on your outcome of In-class activity in terms of the circular economy, identify new business models based on the RESOLVE framework that may solve the issue of waste generation from the bubble tea shops in Hong Kong. Please introduce your idea
(200-300 words; you can also use figure for illustration) (10 pts)