Name:

International School of London Qatar

DP DESIGN TECHNOLOGY

TOPIC 2

RESOURCE MANAGEMENT AND SUSTAINABLE PRODUCTION

NOTES & GUIDANCE BOOKLET

2022-2023

This booklet contains the Notes, and teaching support material for Topic 2

DP DESIGN WITH

MR MONEEB

Contents Page

CORE TOPICS		Topic Covers	Approx Lessons hours on each topic	Total Lesson Hours	Checklist (✓)	Exam Mark	Exam (%)
2	**Resource management and sustainable production**	2.1 Resources and reserves	4	24			
		2.2 Waste mitigation strategies	4				
		2.3 Energy utilization, storage and distribution	4				
		2.4. Clean technology	4				
		2.5. Green design	4				
		2.6. Eco-design	4				

Teaching & Learning Presentations

Topic 2.1. Resources and Reserves

Essential Idea

Resource management and sustainable production carefully consider three key Issues— consumption of raw materials, consumption of energy, and production of waste—in relation to managing resources and reserves effectively and making production more sustainable.

Essential Understanding

As non-renewable resources run out, designers need to develop innovative solutions to meet basic human needs for energy, food and raw materials. The development of renewable and sustainable resources is one of the major challenges of the 21st century for designers.

Principles and concepts

- Renewable and non-renewable resources: Comparison of renewable and non-renewable resources
- Reserves: The economic and political importance of material and land resources and reserves. Considering set-up cost, efficiency of conversion, sustainable and constant supply, social impact, environmental impact and decommissioning.
- Renewability

Renewable resources

Task 1: Define Renewable resource

- Resources that are naturally replenished within a human timescale

Task 2: List examples

- sunlight, plantation timber, wind, water, waves, and geothermal heat.
- Some resources such as wind, solar and tidal energies are perpetual - they are deemed inexhaustible.
- Other resources such as geothermal power, water and plantation timber require careful management.

Notes / Activities

Renewable energy

Task 3: Research the pros and cons of renewable energies

Consider set-up cost, efficiency of conversion, sustainable and constant supply, social impact, environmental impact and decommissioning

http://www.renewable-energysources.com/

Renewable Energy	Set up cost	Efficiency of conversion	Social impact	Sustainable and constant supply	Environmental impact	Decommissioning
Wind						
Solar						
hydropower						
Biomass						
Geothermal						





Student handout
https://docs.google.com/document/d/1q4L7SpEdcjdGJ6ofU7-UDT6p4d7ANYFFs9T8Vn0Bd40/edit?usp=sharing

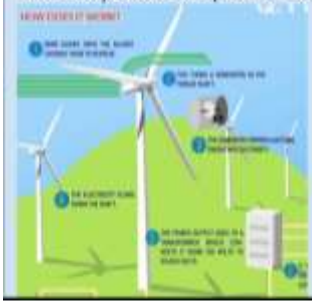
Notes / Activities

Wind Power

Wind is caused by the uneven heating of the atmosphere by the sun, variations in the earth's surface, and rotation of the earth. Mountains, bodies of water, and vegetation all influence wind flow patterns.

Wind turbines convert the energy in wind to electricity by rotating propeller-like blades around a rotor. The rotor turns the drive shaft, which turns an electric generator.

Companies are required for turbine removal at the end of its life. The towers are usually salvaged and recycled. Lifespan are around 20 to 25 years.

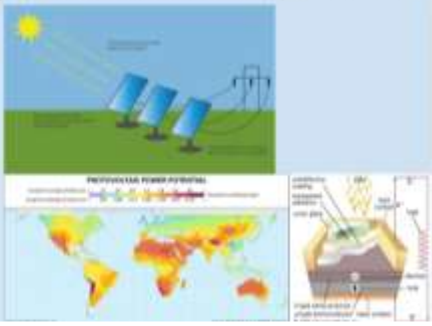


Advantages
- Always available
- converting it into electricity does not create greenhouse gases or air pollutants

Disadvantages
- Very high initial cost (bigger than fossil fuels)
- Not all places have constant wind - problems with constant supply
- Concerns it might kill wildlife such as birds
- Generates noise - so usually placed in rural areas
- Cost of transporting electricity from rural areas to where is needed

Solar energy

Solar cells, also known as photovoltaic (PV) devices, directly convert the electromagnetic radiation into electricity in the form of DC voltage. These cells can be combined into panels, which in turn can be connected into arrays. Solar electricity is used to feed various electric loads from small calculators to large power plants. When solar panels get outdated, the infrastructure needs to be removed and replaced by more current technology. Metal parts components are scrapped and old panels resold to less developed countries. Lifespan of 25 to 30 years old.



Advantages
- Always available even on cloudy days can generated energy
- No pollution created
- Cost effective for water heating

Disadvantages
- Not sure how much energy can be generated due to sunlight and exposure
- High initial cost
- Need a battery if you want to store it otherwise energy has to get into the main power grid

Hydropower

Water that moves quickly in a river possesses a large amount of usable kinetic energy. The fast moving water can be sent through a pipe called a penstock. Inside the pipe, the water causes blades in a turbine to spin. The turbine's mechanical energy is then transferred through a drive shaft to the electric generator. In the generator, the rotational energy is transformed into electricity. The water flow can be made artificially through dams that release it into the pipes when electricity is needed. The systems can be "run-of-river" without a reservoir, or can include reservoir storage capacity. Is estimated a dam life is 100 years and when decommissioned it will release greenhouse gases of the sediment organic carbon (around 11%).

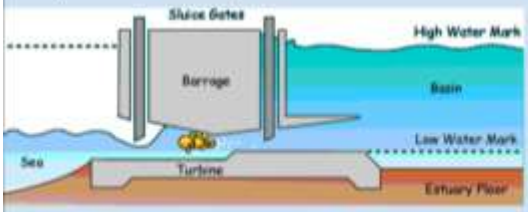
Advantages
- Renewable
- Fairly clean way of producing electricity
- Highly efficient

Disadvantages
- Affects the environment - some organisms and fish get killed in the process
- Water reservoirs occupy large areas of land
- Depends on rainfall

Notes / Activities

Tidal energy

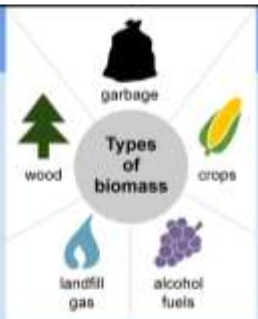
Tidal power or tidal energy is the form of hydropower that converts the energy obtained from tides into useful forms of power, mainly electricity. Tides are caused by the interaction of the gravitational forces and the movement of the sun, moon and earth. The ocean moves toward the moon on the side facing the moon. This results in an up-and down movement of water along the coast. The seawater can be trapped with a dam in a bay at high tide. During low tide, it can be released from the bay to the ocean. As it falls, it can turn the turbine of an electric generator.
Although not yet widely used, tidal energy has potential for future electricity generation. Tides are more predictable than the wind and the sun.
Lifespan is 75 to 100 years old.



Advantages
- Renewable
- Doesn't emit any gases
- Predictable as there is always tides
- More effective with low speeds

Disadvantages
- Not sure how it affects wild marine life
- Expensive
- Need to be build close to land
- physical presence of a barrage may affect other activities occurring in the area

Biomass & Biofuel



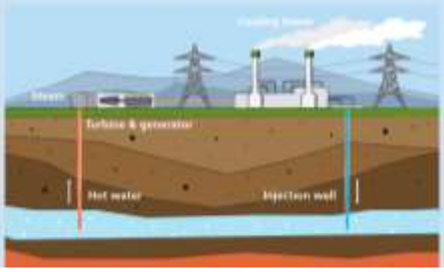
Biological material used as fuel. It can be something as simple as a wooden log or more complex like alcohol. Plants are a common source of biomaterials. Since they can be grown again, this energy source is fully renewable. Another important source of biomass in the home is garbage, which is approximately 60% biomass.
The easiest way to use biomass as energy is to burn it. When it is burned, a part of the internal chemical energy convers to heat. Biomass can also be burned in special plants called waste-to-energy plants. These plants use the heat energy to create steam, which is then used to either heat buildings or create electricity. Life span at least 30 years.
In addition, biomass can also be used to create methane gas, ethanol, and biodiesel. Methane gas, the primary component of natural gas, comes from rotting waste, and this gas can be harvested.
Sugar cane and corn are converted into ethanol, a fuel used to power vehicles. Leftover oils and fats are used to make biodiesel, another fuel used to power vehicles.

Advantages
- Renewable fuel
- Reduces waste

Disadvantages
- Uses large amount of water
- Produces air pollution
- Farmland use

Geothermal Energy

Is the thermal energy generated inside the Earth. Is used primarily for electricity production or heating. There are a number of various physical processes that contribute to generation of GTE: the decay of radioactive materials, volcanic activity, and even absorbed solar energy.
There are several available geothermal resources: the heat in shallow ground, hot water and rock a few miles below the Earth's surface, and high-temperature magma deep in the Earth.
GTE power plants generally use the hot water or steam from the ground to spin a turbine of an electric generator, which produces electricity in the process. Old petroleum wells are used for geothermal energy. Lifespan of Geothermal plants are around 25 years.



Advantages
- Renewable
- One of the cleanest form of energy available
- Lower maintenance costs

Disadvantages
- Large set up cost
- Surface instability
- CO2 below the earth's surface that is released
- Disputes over land rights, considerably noise, odor

Notes / Activities

Non-renewable energy

Task 3: Research the pros and cons of non- renewable energies

Consider set-up cost, efficiency of conversion, sustainable and constant supply, social impact, environmental impact and decommissioning

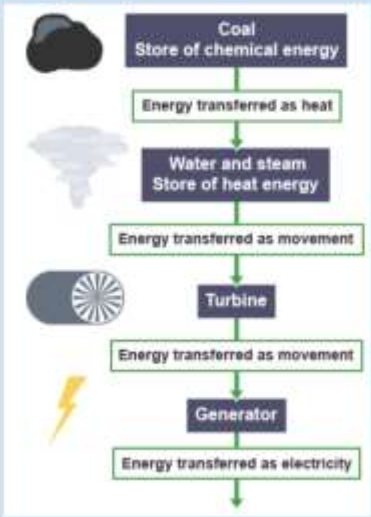
http://www.renewable-energysources.com/

Renewable Energy	Set up cost	Efficiency of conversion	Social impact	Sustainable and constant supply	Environmental impact	Decommissioning
Coal						
Oil						
Nuclear						
Gas						

Student handout
https://docs.google.com/document/d/1RQqwml2brXkBV6ViigCrk2MAQvNcXzen9Pg_2toz24k/edit?usp=sharing

Notes / Activities

Coal



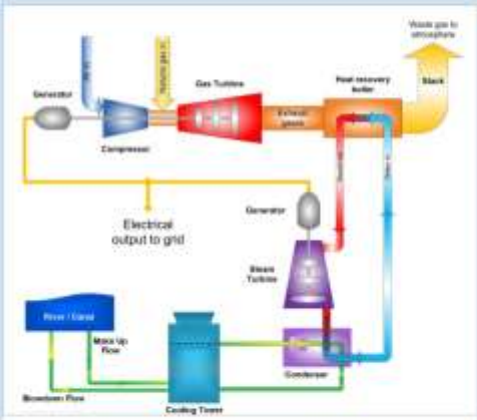
A coal-fired power station or coal power plant is a thermal power station which burns coal to generate electricity. Coal-fired power stations generate over a third of the world's electricity but cause hundreds of thousands of early deaths each year, mainly from air pollution.

Advantages
- Is abundant
- Cheaper than oil and gas
- Does not depend on the weather
- Investment is low

Disadvantages
- Combustion of coal worldwide emits over 10 Gt of carbon dioxide each year, almost ⅓ of total emissions, so are the single largest source of the greenhouse gases
- Coal mining leads to land sliding, deforestation, climatic change
- In underground mining, miners life is under risk at most of the time

Natural gas

A gas-fired power plant or gas-fired power station or natural gas power plant is a thermal power station which burns natural gas to generate electricity. Natural gas power stations generate a 1/4 of world electricity.



Advantages
- Easier to store
- Not as pollutant as other fossil fuels
- Reliable
- Cheaper than oil
- Plenty of reserves
-

Disadvantages
- Highly combustible
- Source of violence and terrorism - as exploration occurs in countries with the worst records of dictatorship
- Emits CO2 contributing to greenhouse gases

Oil

Power plants that burn oil to produce electricity are called oil-fired plants. They are no different in general principle and operation from their fossil-fueled cousins, the coal-fired and natural gas-fired plants, and are even similar to geothermal and nuclear power plants in some respects.

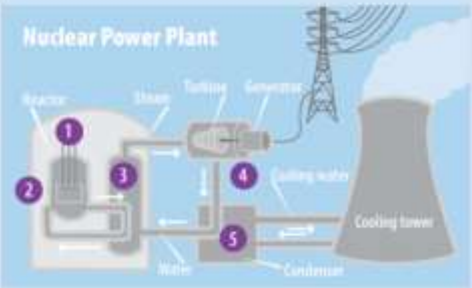
Advantages
- Oil can easily be transported by a network of pipelines
- Used in almost all industries
- High density energy - a small amount of oil can product a large amount of energy

Disadvantages
- Releases CO2 contributing to greenhouse emissions
- Can cause water pollution
- Oil Refining Produces Highly Toxic Substances
- Producing electricity from crude oil is expensive compared to other fossil fuels such as coal or gas
- Finite resource

Notes / Activities

Nuclear energy

The process used to produce nuclear energy is called fission. Nuclear fission occurs when the atom of a nucleus is split, releasing very large amounts of energy.
In nuclear power plants, atoms are continuously split, creating chain reactions that provide high amounts of sustainable energy for a long period of time.
Nuclear energy, much like other power sources, certainly doesn't come without its drawbacks. Disposal of radioactive waste, high up-front construction costs, and public safety are key factors that need to be evaluated.



Advantages

- Lowest fair of greenhouse gases when comparing with other non renewable sources
- High power output
- very inexpensive electricity once up and running
- Economic impact - due to employment it generates

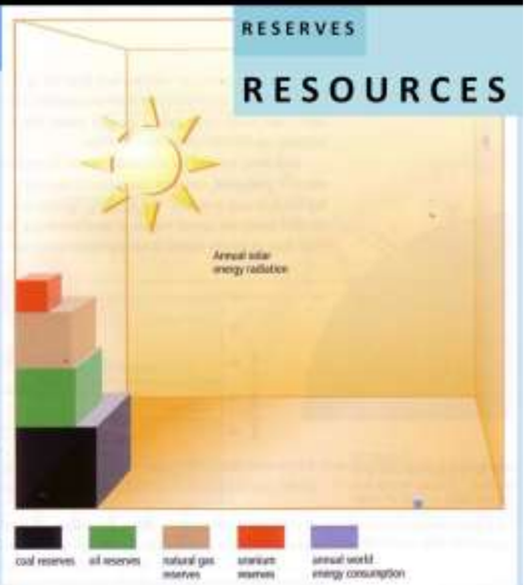
Disadvantages

- Disposing high toxic fuel
- Possibility of nuclear accidents
- High set up cost and dismantling at the end of its life

Reserves

Resources are the stock or supply of materials that are available in a given context. We already saw renewable and non-renewable resources. Identified resources are those whose location, grade, quality and quantity are known or estimated from specific geologic evidence.

Reserves are the portion of an identified resource that can be economically and legally recovered. Reserves can be divided in 2 groups - proven reserves and probable reserves.
A proven reserve are those resources that can be economically and technically extracted.
Reserves exist but it might not be viable at this moment such as gold in seawater are considered probable reserves.



Renewability

Renews itself at a rate that is faster, or equal to the rate of consumption.
Resources that are dependent of regrowth can sometimes be depleted beyond the point of renewability - such as deforestation leading to desertification or species harvested to extinction.
Pollution can also make a renewable resource such as water unusable in a particular area.

Reverse Osmosis System for renewing water

Trees are a renewable resource but take time to grow

Notes / Activities

Economic & political importance of material & land resources

The extraction of oil has been at the centre of may issues removing around resource security and international treaties. Students need to understand the issues/impact surrounding resources security for Nations/Governments and international treaties.

- Governments need to balance the economic benefits and political impact (including social aspects) of resource extraction. The Invasion of Kuwait in 1990 is one such example. Iraq was accusing the Kuwait government of 'slant drilling' from the border into Iraqi reserves thus stealing Iraqi oil. It is also thought to be that Iraq invaded in order to procure Kuwaiti oil that were considered to be 20% of the global reserves. A third reason was that Kuwait was over producing oil this dropping the price of global oil which affect the Iraqi economy.
- Often, multinational companies licensed to extract resources have limited consideration for the local population.

Oil companies are often brought into country to explore possible new fields and then develop them. The oil companies pay the government a set amount which can develop wealth. This can produce local employment and other opportunities.
Rare earth minerals which are highly desired/needed and valuable came with a set of issues. For the countries that have them can receive a financial windfall, local communities gain skilled employment, however, the environmental impact for local communities is damaging.

Guiding questions

1. Define non-renewable resources.
2. List the different types of renewable resources and non-renewable resources.
3. Explain why some resources such as geothermal power, plantation timber and water require careful management, while others such as wind, solar and tidal are thought to be unlimited.
4. Why might a government, which already produces its electricity from burning fossil fuels considers commissioning a nuclear power plant.
5. Outline what is meant by the term reserves.
6. Compare and contrast resource and reserves.
7. Define with examples renewability
8. Outline the reluctance of some people to adopt biofuel as an alternative.

Exam questions

2017
5. What describes the quantity of material that is ready and available for production?

	Reserve	Resource
A.	No	No
B.	No	Yes
C.	Yes	No
D.	Yes	Yes

2016
10. The consumption of which renewable energy source results in carbon emissions?
A. Wind
B. Solar
C. Nuclear
D. Biomass

Notes / Activities

Exam questions

2018

1(d) (i) Define the term renewable resource. [1]

2017

1(b) (i) Outline the difference between a renewable and non-renewable source of energy. [2]

Exam questions

2017

1(c) (i) A consumer who already has solar panels on their roof is considering whether to purchase the Powerwall. The solar panels generate 2,760 kWh per year. The cost of the solar panels was US$4,000.

Calculate the time it would take for the Powerwall to pay for itself using energy generated from the solar panels. [2]

Figure 2: Powerwall data

Technology	Wall mounted, rechargeable lithium ion battery with liquid thermal control
Electricity generated by solar panels	3,000 kWh
Cost of electricity from Network	US$0.30 per kWh
Cost including installation	US$4,000
Warranty	10 years
Efficiency	92 % at time of installation
Max power provided	3.3 kW peak
Voltage	350 – 450 volts DC, connects to national grid using a DC/AC convertor
Current	5.8 amp nominal, 8.6 amp peak output
Installation	Requires installation by a trained electrician
Weight	100 kg
Dimensions	1 300 mm x [illegible] mm x 180 mm
Safety Certification	Recognized Testing Laboratory listed to Underwriters Laboratories standards and meeting United States electrical standards

[Source: [illegible]]

Exam style questions

2.The image shows biomass crops being grown

2a) Outline why Biomass is considered a renewable resource. [2 Marks]

2b) Outline why biomass might not be considered as environmentally friendly as solar power. [2 Marks]

Notes / Activities

Exam style questions

3. The image shows a timber plantation/forest to be used for manufacturing paper.

Explain why, in order to be considered a renewable resource, the timber plantation would require careful management. [3 Marks]

Exam style questions

4. The image shows some minerals that are used in Smartphones

Outline one positive and one negative impact that the development of smartphones may have for the country where these minerals can be found. (4 marks)

Exam style questions

5. The image shows a remote village in Lesotho, in southern Africa. Lesotho has very few natural resources

Discuss the political and economic importance of a country such as Lesotho generating electricity through local solar and local wind power rather than buying in energy from another country.
[6 Marks]

Notes / Activities

Exam style questions

6. The image shows the Bellefonte nuclear power plant located in Hollywood, Alabama

Outline one positive and one negative consideration of generating electricity using nuclear power. [4 Marks]

Exam style questions

7.The image shows PV cells on the roof of a home in Germany. Although considerably cheaper today than 10 years ago, the German government still provides homeowners with interest free loans to assist with the set-up costs of installing the PV cells.

Consider the economic and political importance for the German government in encouraging people to move away from a reliance on fossil fuels for generating power
[6 Marks]

Notes / Activities

Topic 2.2. Waste Mitigation Strategies

Essential Idea

Waste mitigation strategies can reduce or eliminate the volume of material disposed to landfill.

Essential Understanding

The abundance of resources and raw materials in the industrial age led to the development of a throwaway society, and as resources run out, the many facets of sustainability become a more important focus for designers. The result of the throwaway society is large amounts of materials found in landfill, which can be considered as a new source to mine resources from.

Principles and concepts

- Re-use
- Recycle
- Repair
- Recondition
- Re-engineer
- Pollution/waste
- Methodologies for waste reduction and designing out waste
- Dematerialization
- Product recovery strategies at end of life/disposal
- Circular economy—the use of waste as a resource within a closed loop system

Circular economy

Linear **economy** = make, use, dispose

Circular economy = keep resources in use for as long as possible. Extract the maximum value from them whilst in use. Then recover and regenerate products and materials at the end of each service life.

Notes / Activities

Circular economy

Designers must ask themselves the question

- How can this product be made to be made again?

There are some ideas of reasoning with this dilemma

- Cradle to cradle design thinking (see more sub topic 2.6)
- Design for disassembly (see more sub topic 4.5)
- Design inspired by nature - biomimicry

Innovative design techniques might include the use of smart memory screws, adhesives and circuit boards that can be dissolved, the use of clips rather than adhesives, and biological materials that can be safely returned to the biosphere with no toxic dyes or other materials.

- How will the materials or components be recovers and made use again?

One way is to develop different business models where users buy performance through leasing rather than purchasing. This offers interesting job opportunities in creating reverse supply chains as well as engaging design opportunities and challenges.

Waste mitigation strategies

Re-use

This is reusing a product in the same context or in a different context.

Reusing is utilising an object more than one time.

An example of reusing is using glass bottles to drink water from over again.

Recycling

Recycling refers to using the materials recovered from the waste stream for use in the form of raw materials in the manufacture of new products.

It decreases the consumption of unsullied raw resources, trims down energy usage, lowering air and water pollution by dropping the need for "usual" waste discarding, and lastly lowering greenhouse gas emissions. A good example is recycled paper.

Thus not include reclaiming materials for use as fuel for energy processing.

Waste mitigation strategies

Repair

Is the reconstruction or renewal of any part of an existing structure or device.

Repairs may be functional or cosmetic.

Examples include: mending clothes, replacing faulty components in appliances, etc.

The cost of repair has become such that replacement is cheaper. Many items todays are produced with planned obsolescence - it is expected they will have a limited useful life.

Notes / Activities

Waste mitigation strategies

Reconditioning

Reconditioning is rebuilding a product so that it is in an "as new" condition, by repairing it, cleaning it, or replacing parts. Reconditioning products generally come with a renewed warranty.
Examples include: reconditioned car engines, retreaded tyres, upgrading computers with replacement modules

Re-engineer

Modification of an existing product, sometimes through reverse engineering.
To optimize product's performance by adding new functionalities and taking advantage of emerging technologies.
Examples are F1 cars were aerodynamics is changed and lighter materials used.

Waste Stream

Task: Define Waste Stream

Can take place during any stage of the manufacturing process - extraction of raw material, manufacture, transportation, packaging, and use.

A **waste stream** is the complete flow of **waste** from domestic or industrial areas through to final disposal.

The intervention of recycling may act to lessen the content of a **waste stream** as it moves down the line.

Waste Stream

Task:
Discuss the potential waste stream of a plastic bottle

Notes / Activities

Waste mitigation strategies

Pollution/waste

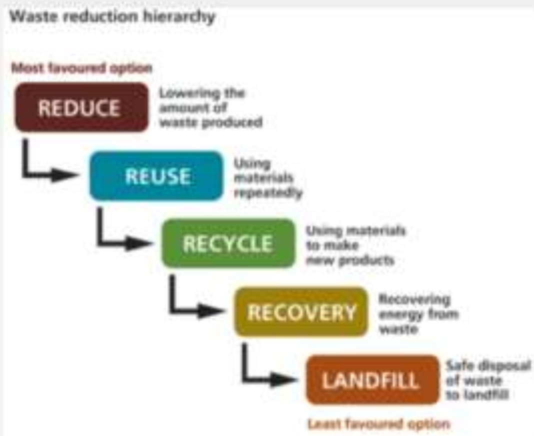
Most production processes result in the creation of pollution and or waste during the various stages of manufacture from raw material extraction to transport, processing, manufacture and packaging. Pollution and waste come in many forms such as excess heat, exhaust gases, chemical discharges, product rejects and left over packaging.

Methodologies for waste reduction and designing out waste

In order to move toward sustainable manufacturing designers are increasingly focusing on reducing waste that otherwise find its way to landfills or as environmentally pollution. See below the waste management hierarchy, moving from the least favoured option waste disposal all the way to prevention.

Methodologies for waste reduction and designing out waste

Discuss the role of design for making these methodologies possible - give examples



Notes / Activities

Methodologies for waste reduction & designing out waste

Define Dematerialization
& find some more examples

Dematerialisation literally means the use of less materials.
Dematerialisation is defined by UNEP as "the reduction of total material and energy throughput of any product and service, and thus the limitation of its environmental impact. This includes reduction of raw materials at the production stage, of energy and material inputs at the use stage, and of waste at the disposal stage."

Dematerialization Strategies

- Design and manufacture of a smaller product e.g. miniaturization
- Design and manufacture of lighter products e.g. using alternative construction
- Replacement of material goods by non-material substitutes (for instance a letter on paper replaced by an email)
- Reduction in the use of material systems or of systems requiring large infrastructures (for instance using telecommunications instead of using a car to go to work)

Task: Identify more examples of these strategies

Product recovery strategies at end of life/ disposal

The processes of separating the component parts of a product to recover the parts and materials.
Traditionally disposal of products such as cars and refrigerators have been the responsibility of governments. These unwanted items have been buried in landfill or incinerated. This generated problems such as

- Release of pollutants into the soil and groundwater systems
- Generation of odours, flammable and toxic gases.

Now the responsibility for recycling is being directed towards the manufacturers of the goods. Producers have to collect 'take-back' their products at the end of life (EOL). The aims of this legislation are

- Reduce amount of hazardous wastes sent to landfills
- Increase availability of scrap, reducing the demand for virgin new material
- Encourage design changes that reduce waste and improve recyclability

Notes / Activities

Product recovery strategies at end of life- ELV

95% of a car can be recovered, reused or recycled. Parts are separated to recover parts and materials.

How it works

1 - the car is drained of all fluids

2 - Airbags and belt tensioners are deactivated and the battery is neutralised

3 - All parts are removed - some parts such as doors can sold to garages to be reused

4 - The body of the card is compacted into a cube

5- The cube ie shredded into small pieces and then sorted to separate metals from plastics

6 - Pieces can be reused as raw material

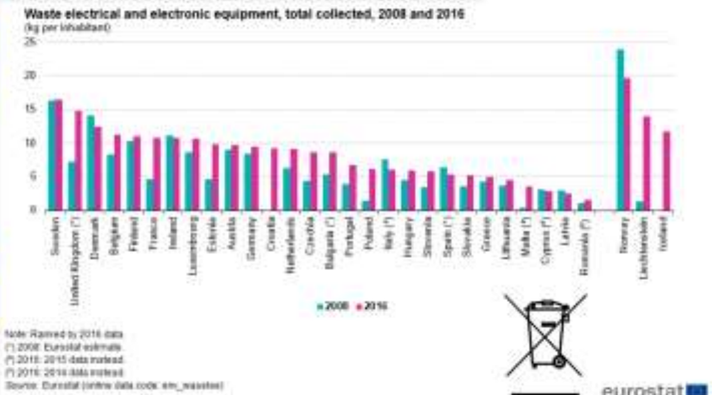
In 2000, EU introduce the ELV (End of life Vehicle) directive. Car manufacturers are required to re-use or recover 85% of the weight of the car. In 2015, it has risen to 95%.

Product recovery strategies at end of life -WEEE

In 2005, the EU issue a directive for requiring manufacturers of electrical and electronic equipment had to establish collection systems.

Explain how The 'WEEE Directive' (The Directive on waste electrical and electronic equipment) is reducing waste at the disposal stage.

Discuss the impact The 'WEEE Directive' would have had at the design stage



The Story of Electronics

E-waste problem

Recycling of valuable elements contained in e-waste such as copper and gold has become a source of income in developing or emerging countries.

However, primitive recycling techniques such as burning cables for retaining the inherent copper expose workers to a range of hazardous substances. E-waste is connected to health risks such

- direct contact with harmful materials such as lead
- inhalation of toxic fumes
- accumulation of chemicals in soil, water and food
- Risk of injury for no protective clothing worn.

Notes / Activities

Product recovery strategies at end of life/ disposal

The processes of separating the component parts of a product to recover the parts and materials.

- Use and recovery of standard parts at the end of product life.
- Recovery of raw materials.
- Ensure recycling and dismantling is done safely and with trained personnel.
- Take back legislation.
- Trade in.
- Recycling bins/locations.
- Employ a circular economy.

Guiding Questions.

1. Explain how natural resources can be conserved if 'Reuse' is adopted worldwide
2. Explain, with reference to obsolescence, why products are not repaired as a matter of course these days
3. Outline the difference between: recycle, reuse, recondition, repair and re-engineer
4. List some of the waste / pollution that might be produced during the various stages of a product's life cycle [additional research is required]
5. Explain why waste management practices are not uniform among countries (developed and developing nations)
6. Explain the principle of the waste management hierarchy.
7. Outline how waste can be reduced and designed out of products
8. Outline how dematerialization can improve product efficiency by saving, reusing or recycling materials and components
9. List the impacts of dematerialization on each stage of the product life cycle including: material extraction; eco-design; cleaner production; environmentally conscious consumption patterns; recycling of waste
10. Outline the potential results of successful dematerialization
11. List with, examples, the different methods for reducing waste
12. Compare and contrast historical methods for disposal of end-of-life products and recovery strategies
13. Explain the benefits of the closed-loop economy and what it has to do with design
14. Explain what is meant by 'waste as a resource'

Exam style questions

2018

6. Alfredo Moser invented a lamp, see Figure 2, to provide lighting to homes without access to electricity, using nothing more than a plastic bottle, water and bleach. Figure 2: The Moser lamp. What waste mitigation strategy describes the use of the bottle in this invention?

A. Recondition
B. Recycle
C. Repair
D. Reuse

7. Which of the following has the hierarchy of waste in the right order (from most to least desirable)?

A. Landfill, incineration, resource recovery, recycling, reuse, source reduction
B. Source reduction, reuse, recycling, resource recovery, incineration, landfill
C. Landfill, resource recovery, recycling, reuse, source reduction, incineration
D. Source reduction, resource recovery, recycling, reuse, incineration, landfill

Notes / Activities

Exam style questions

2017

6. What is a definition of re-use?

A. Changing waste material into a new product
B. Application of a product in the same or different context
C. The reconstruction or renewal of any part of a product
D. The return of a product to working order

26. Many countries have introduced legislation to take back electronic products at their end-of-life. Why do governments enforce such legislation?

I. To reduce the amount of waste going to landfill
II. To encourage the recovery of non-renewable resources
III. To create a market for used electronics

A. I and II only
B. I and III only
C. II and III only
D. I, II and III

Exam style questions

2017

7. Unilever recently redesigned the packaging of their deodorants, see Figure 4 below, reducing both the amount of packaging material and the amount of gas used.

Figure 4: Compressed gas packaging

What is the environmental impact of this particular dematerialisation strategy?

I. Reduced waste
II. Reduced material usage
III. Reduction in energy consumed

A. I and II only
B. I and III only
C. II and III only
D. I, II and III

Exam style questions

2016

5. Figure 3 shows a symbol widely used on plastic products made of polyethylene terephthalate (PETE).

Which waste mitigation strategy does the symbol shown in Figure 3 promote?

A. Repair
B. Reuse
C. Recycling
D. Reconditioning

Figure 3: A symbol used on plastic products made of polyethylene terephthalate (PETE)

Notes / Activities

Exam style questions

Specimen paper

9. What would not necessarily be reduced by a manufacturer adopting a dematerialization strategy?

A. Depletion of natural resources

B. Waste to landfill

C. Energy consumption

D. Product efficiency

Exam style questions

2019

1 (a) Describe the difference between recycling and reusing. [2]

2019

4. Designers often strive to design products that enable the principles of the circular economy to be met. However, products are designed so that they cannot be easily disassembled.

Explain why some products are designed so they cannot be easily disassembled. [3]

2016

1(e) (i) Outline one implication of dematerialization for the design of the Tetra Pak carton. [2]

1(e) (ii) Outline one effect on the environment of the production of cardboard cartons. [2]

Notes / Activities

Topic 2.3. Energy Utilization, Storage and distribution

Essential Idea

There are several factors to be considered with respect to energy and design.

Essential Understanding

Efficient energy use is an important consideration for designers in today's society. Energy conservation and efficient energy use are pivotal in our impact on the environment. A designer's goal is to reduce the amount of energy required to provide products or services using newer technologies or creative implementation of systems to reduce usage. For example, driving less is an example of energy conservation, while driving the same amount but with a higher mileage car is energy efficient.

Aim

As we develop new electronic products, electrical energy power sources remain an ever-important issue. The ability to concentrate electrical energy into ever-decreasing volume and weight is the challenge for designers of electronic products.

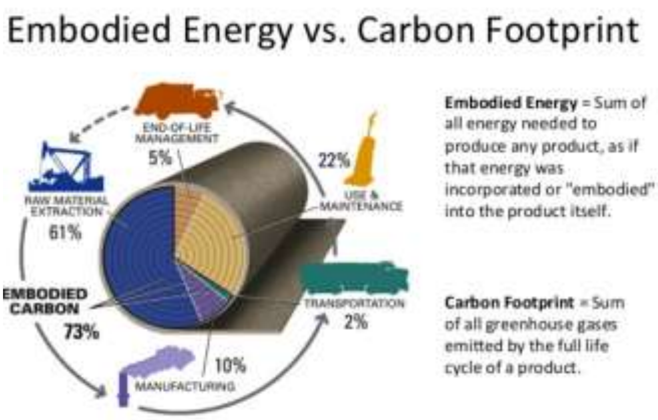
Principles and concepts

- Embodied energy
- Distributing energy: national and international grid systems
- Local combined heat and power (CHP)
- Systems for individual energy generation
- Quantification and mitigation of carbon emissions
- Batteries, capacitors and capacities considering relative cost, efficiency, environmental impact and reliability

Guidance

- Total energy consumed in production (cradle to [factory] gate) and throughout the lifecycle of a product (cradle to grave)
- Batteries are limited to hydrogen fuel cells, lithium, NiCad, lead acid, and LiPo batteries

Embodied Energy



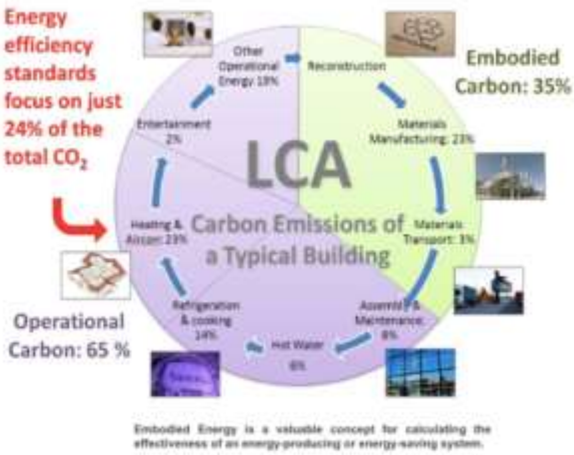
What is embodied energy?
Watch the video

Notes / Activities

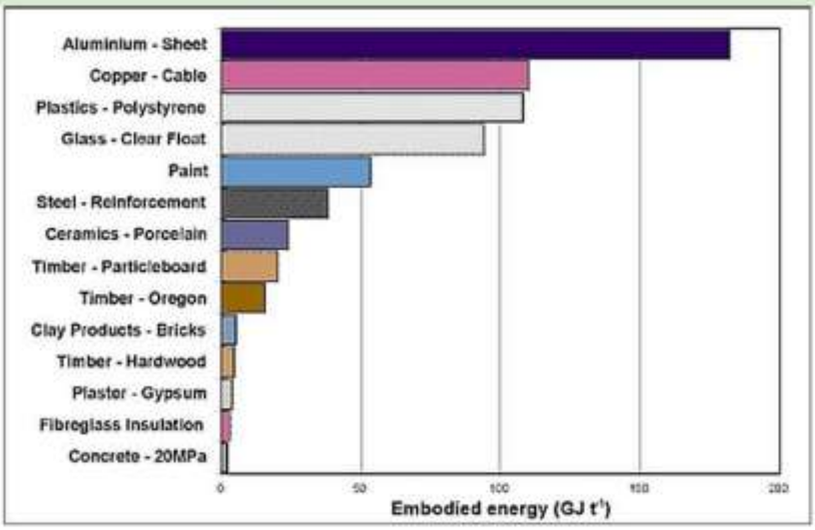
Embodied Energy

If we look at a building over its entire design life (image) we can see the embodied energy is broken down into the following components:

- Materials - energy used to extract the raw materials and process them into useable stock forms
- Transport - energy used to transport the building materials from the factory to the building site
- Assembly - energy used to construct and create the building
- Recurring - energy used to maintain and replace certain building elements over its lifespan
- Demolition and recycling - energy used to demolish and recycle the building and feed the resultant materials back into the building industry.



Embodied Energy of common materials



Embodied Energy

Task:

Compare the impact of reuse and recycling in terms of embodied energy

Notes / Activities

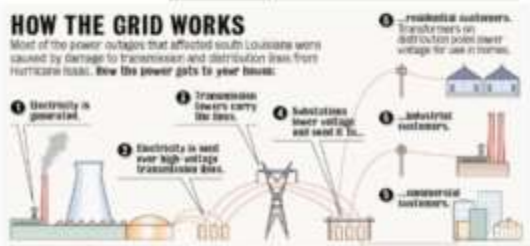
Embodied Energy

Task : Identify strategies to reduce embodied energy?

Danielle Tensley Tingley podcast on the circular economy of construction materials. The feasibility of designing for deconstruction, reuse of existing buildings and down cycling of construction materials. How to improve the efficiency of material use in structural design. Danielle is a Professor of Architectural Engineering at the University of Sheffield, UK.

Distributing energy: national & international grid systems

Define Electrical Grid



Example to show the distribution of electrical energy

Distributing energy: national & international grid systems

A Smart Grid, however, uses information technology to provide a real-time picture of energy production and consumption. Smart grids make use of sensors and software to manage electricity distribution and consumption. A home dishwasher, for example, could be set to operate in the evening when power costs are lower, thus saving money.

The generation of electrical energy results in large amounts of excess heat that is typically lost to the atmosphere during production. The efficiency of electricity is only 37%. These heat losses increase with more loses during the transmission and distribution of electrical energy to customer.

Notes / Activities

Local combined heat and power (CHP)

In an attempt to recover the energy lost during electrical generation in waste heat, local combined heat and power (CHP) systems also known as cogeneration are becoming more popular.

These systems collect the heat waste from electricity production and pass it through a heat exchanger where it can be used to heat air or water heating system. Using CHP can bring efficiencies up to 75% .

Local combined heat and power (CHP)

What can be the benefits of CHP?

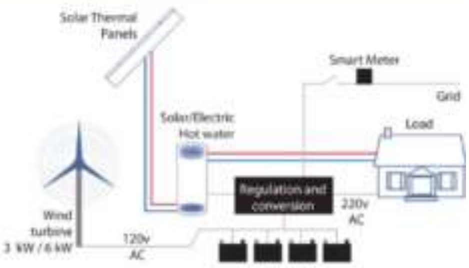
- Reduced fuel costs
- Less C02 emissions
- Reduced energy costs to the consumers

CHP is great to be used in large buildings and industrial sites which operate their own electrical generators – making this system able to produce hot water and air conditioning.

Systems for individual energy generation [microgeneration]

Microgeneration refers to small scale systems that generate electricity and/or heat for domestic use.
This happens has sometimes there is unreliable grid power or the distance to the electrical grid is long therefore to expensive for an individual or community to take on. Or it can also be motivated by environmental conscious approaches that aspire to zero or low carbon footprint and cost reduction.

Off the grid systems require a battery backup to store energy for use when energy generation is not available.



Micro generation of energy - off the grid

Energy generation in remote places: varied, solar, wind turbine, geo-thermal

Notes / Activities

Systems for individual energy generation [microgeneration]

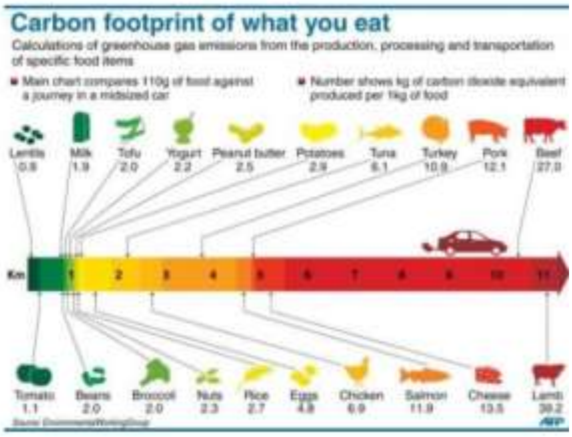
Recently, individual energy generation has started to play an increasing role in smart grids (see above). Homeowners install solar panels or wind turbines on their property and sell any excess energy back into the grid. In this way, it is possible to recoup the cost of the system through the sale of excess energy.

Benefits	Considerations
▪ supplement to grid-power system ▪ lower environmental impact (see below) ▪ Typically use renewable energy such as solar or wind ▪ can be scaled to meet the needs of a single user ▪ possible to live "off-grid" (no connection to power distribution infrastructure)	▪ high initial cost ▪ may require owner to carry out maintenance

Quantification and mitigation of carbon emissions

Almost every process involved in the life cycle of a product generates CO2. As climate change has increased, focus has shifted towards minimizing carbon emissions. Central to this is accounting for the sources of carbon- **quantification**. This is often referred to a product's **carbon footprint.**

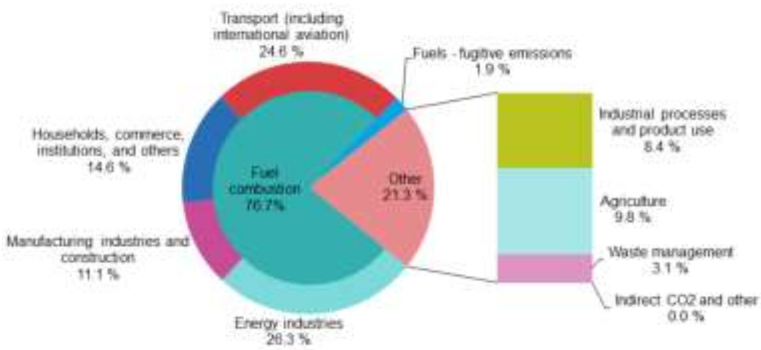
As designers, we have a moral and environmental responsibility to design in a manner which mitigates or eliminates the environmental impact of our design. Quantifying the carbon footprint of our designs is an important step towards



Quantification and mitigation of carbon emissions

Task: Identify the sectors responsible for more greenhouse gas emissions?

Greenhouse gas emissions by IPCC source sector, EU-28, 2017



Source: EEA, republished by Eurostat (online data code: env_air_gge)

eurostat

Notes / Activities

Batteries

Batteries allow devices and machines to be portable. The batteries in mobile phones allow them to be portable and be used for long periods of time without being recharged.

Batteries convert chemical energy into electrical energy. Batteries contain heavy metals, which when disposed of improperly can cause pollution, soil, air, and water contamination, as well as health problems.

Designers should consider several things when selecting a powersource;

- Power demands for the design
- Physical size of the battery
- standard battery sizes
- rechargeability
- environmental impact of disposal of the battery.

Batteries and Supercapacitors video

Batteries

Recycling batteries is good as it keeps them out of landfill, where heavy metals may leak into the ground when the battery casing corrodes, causing soil and water pollution. If batteries are incinerated with household waste, the heavy metals in them may cause air pollution. Here are main batteries used.




Lithium Ion Batteries (LiPo)	Coin or Button Batteries	Lead Acid Batteries	Ni Cd Batteries	H2O Batteries
Contains: Manganese Dioxide Lithium Copper	Contains: Mercuric Oxide Lithium Silver Oxide Zinc-air	Contains: Lead Sulphate Lead	Contains: Nickel Oxide-Hydroxide Cadmium Potassium Hydroxide	
Deemed to be non-hazardous by governments, these can be taken to standard recycling centres. The LiPo is known for its volatile reaction to heat	Deemed to be hazardous by governments, these should be taken to household hazardous waste recycling centres.	Deemed to be hazardous by governments, these should be taken to household hazardous waste recycling centres due to the sulphuric acid inside. The refillable versions can be sold for scrap	Cadmium is a heavy metal and thus an environmental hazard. Highly toxic to all life. Cadmium is expensive to mine and dispose of. These batteries are mostly banned in Europe	As Hydrogen and Oxygen pass through a ion electrolyte or PEM, Carbon Sheet, the Hydrogen loses an electron and Water is formed. **Energy is needed to separate the hydrogen**

Rechargeable Batteries

Rechargeable batteries have a chemical reaction that is reversible with a rechargeable battery: when electrical energy from an external source (e.g., a charger) is applied to the battery's secondary cell, the negative-to-positive electron flow that occurs during discharge gets reversed. As this happens, the cell's charge gets restored.

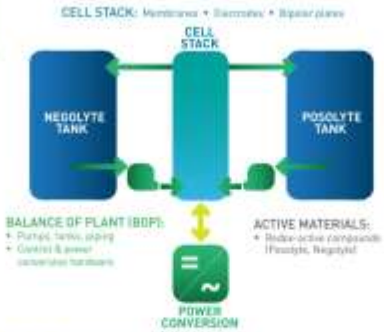
Rechargeable batteries will not last forever. They do eventually die, though it typically takes several hundred charges before this actually happens.

The benefit to using rechargeable batteries is that it cuts down on the amount of regular batteries that you use. This, in turn, reduces the amount of environmentally harmful regular batteries that get thrown away. However they need to be properly disposed off as they still contain toxic substances.

Notes / Activities

Flow Battery technology

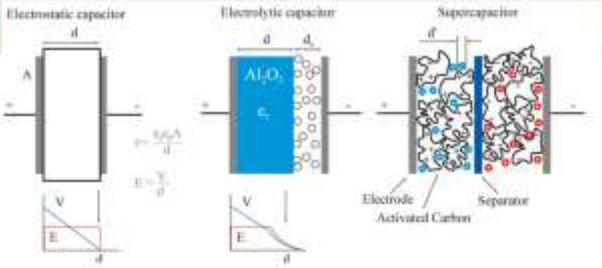
In this technology, 2 different electrolyte materials are stored and are pumped either side of a vessel with a central membrane.
Increasing the capacity is a simple as adding additional storage tanks. Vanadium redox and zinc-bromine are 2 of the more familiar types of flow batteries. Spent electrolyte can be later recharged.



Commercial flow batteries, such as this zinc-bromine system.

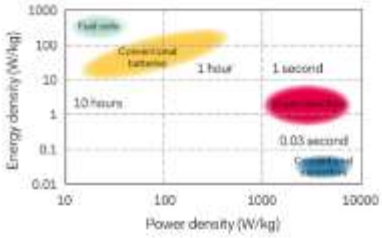
UniEnergy Brings Next-Gen Vanadium Flow Battery to Commercial

Capacitors



Capacitors store energy temporarily as an electrostatic charge between 2 plates that are separated by a non conductive material such as glass. The main advantage is of rapid charging and discharging and typically used to smooth voltage supplies.

Newer capacitors – also known as super or ultra capacitors offer the potential of storing much higher levels of energy. LIC (Lithium-ion capacitors) offer energy densities similar to rechargeable batteries but with faster charge/recharge rates. Applications are regenerative braking systems in hybrid vehicles, as protection for CMOs logic chips, in UPS systems and solar power arrays and to smooth power generated by wind turbines.



Exam style questions

2019

8. Which of the following battery types is the most efficient?
A. Lithium
B. Lead acid
C. Hydrogen fuel cell
D. NiCad

9. As an energy generation process, CHP (Combined Heat and Power) is fuel neutral. What does this mean?
A. It can clean fuels
B. It can neutralise fuels
C. It can be applied to renewable and fossil fuels
D. It can take subsidies from fossil fuels

2018

9. What best describes a combined heat and power approach?
A. A national energy distribution system
B. A macro energy policy
C. A sustainable energy strategy
D. An efficient way of generating electrical and thermal energy from a single source

2016

6. What best describes the embodied energy within a product?
A. The energy consumed throughout the entire product life
B. The energy within a product's batteries
C. The energy required to recycle a product
D. The reduction in the amount of wasted energy achieved through clean production

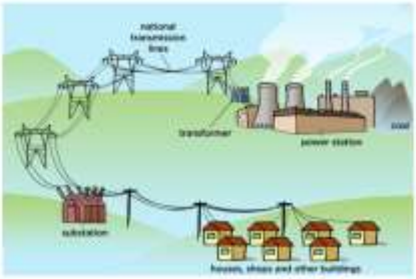
Notes / Activities

2017

1b (ii) Poor battery management/storage reduces battery life. Outline why the efficiency of the lithium ion battery will not remain at 92%. [2]

3. State which waste mitigation strategy would be most effective at reducing a product's embodied energy. [1 Mark]

4. The image illustrates the basic layout of the electricity grid



a) Outline the reason why power stations are usually located far from residential areas [2 Marks]

b) Identify two areas where energy is 'lost' [2 Marks]

c) Outline why national electricity grids were created [2 Marks]

5. The image shows a schematic drawing of a local CHP unit (Combined Heat and Power). Outline the benefits of local CHP. [2 marks]

6. The image shows a wind turbine for individual household energy generation

a) Identify one limitation to relying on a wind turbine for individual household energy generation. [2 mark]
b) Identify a reason the local community might object to a neighbour installing a wind turbine to generate energy. [2 Mark]

7. Compare the benefits of individual energy generation for a house in this type of location rather than connecting to the national electricity grid.
[3 Marks]

Notes / Activities

Topic 2.4. Clean Technology

Essential Idea

Clean technology seeks to reduce waste/pollution from production processes through radical or incremental development of a production system.

Essential Understanding

Clean technology is found in a broad range of industries, including water, energy, manufacturing, advanced materials and transportation. As our earth's resources are slowly depleted, demand for energy worldwide should be on every designer's mind when generating products, systems and services. The converge of environmental, technological, economic and social factors will produce more energy efficient technologies that will be less reliant on obsolete, polluting technologies.

Aim

The legislation for reducing pollution often focuses on the output and, therefore, end- of-pipe technologies. By implementing ideas from the circular economy, pollution is negated and waste eliminated.

Concepts and principles

- Drivers for cleaning up manufacturing promoting positives impacts, ensuring neutral impact or minimising negative impacts through conserving natural resources, reducing pollution and use of energy, reducing wastage of energy and resources.
- International legislation and targets for reducing pollution and waste
- End of pipe technologies
- Incremental and radical solutions – advantages and disadvantages
- System level solutions

Guidance

- The role of legislation to provide impetus for manufacturers to clean up manufacturing processes
- Advantages and disadvantages of incremental and radical solutions
- How manufacturers react to legislation
- How legislation can be monitoring and policing

Clean Technology

Clean technology is a broad term that describes products and processes that reduce waste and use as little non-renewable materials and energy as possible. This can encompass a range of technologies and strategies, all with the goal of minimizing environmental impact.

What can I do as a designer?

Clean technology is focused on sustainable production. Concepts and strategies such as cradle-to-cradle, circular economy, life cycle analysis (LCA), lightweighting, use of recycled materials, etc, play a role in clean technology to meet the goal of sustainable, non-polluting production.

As the world's non-resources continue to be consumed, and the associated environmental, economic, and social pressures grow, designers can play an important role in designing for a sustainable future.

Notes / Activities

Drivers for cleaning up manufacturing

Manufacturers may choose to implement clean technology for a variety of reasons.

- promoting positive impacts of the company's products or services.
- ensuring neutral impact or minimizing negative impacts through conserving natural resources:
- reducing pollution and use of energy
- reducing wastage of energy and resources: installing

Drivers for cleaning up manufacturing can be divided into 3 groups:

Social drivers	Political drivers	Economic drivers
- Communities create pressure as they don't want harmful industries - Pressure groups and organizations such as greenpeace help communities understand the risks This can sometimes force legislation to be developed and enacted	- Legislation for clean air and water targets set conditions on acceptable levels of pollution as well as timelines for compliance	- Governments offer incentives such as tax relief or subsides - Manufacturers want to avoid penalties from taxes, etc

The role of legislation

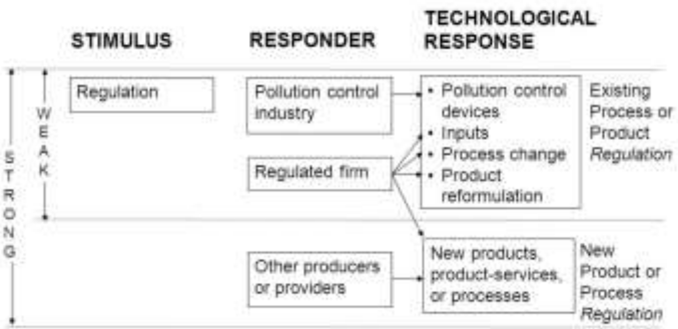
Outline how legislation can act as a driver for a company to clean up manufacturing

The role and scale of legislation are dependent upon the type of manufacturing and the varied perspectives in different countries. The use of international targets for reducing pollution and waste are difficult to get all nations to agree on - as many nations are at different stages of economic and social development, attitudes to the the environment, or placing more value on economic gain than the environment.

Manufacturers react to the legislation by cleaning up there act or ignoring it (this happens in some countries as legislation not be forced). Manufacturers don't want to pay to clean up production as this cuts into profits.
However many countries have introduced stricter legislation this has proven to increase the lead in exploring new clean technologies - with more efficient processes, reduced pollution but also cost effective competitiveness.

The role of legislation

A Model for 'Weak' (Porter) and 'Strong' (MIT)
Forms of the Regulation-induced Hypothesis



Notes / Activities

International targets

The Earth Summit- Rio 1992

The UN sought to help Governments rethink economic development and find ways to halt the **destruction of irreplaceable natural resources and pollution** of the planet.

The summit has produced results, making eco-efficiency a guiding principle for business and governments alike:

-Alternative sources of energy are being sought to replace the use of fossil fuels.
-New reliance on public transportation systems in order to reduce vehicle emissions, congestion in cities and health problems caused by polluted air and smog;
-Greater awareness of and concern over the growing scarcity of water.

The Kyoto Protocol 1997

The United Nations Framework Convention on Climate Change

An international treaty that sets binding obligations on industrialised countries to **reduce emissions of greenhouse gases.** The treaty was agreed in 1997 and came into force in 2005:

-Developed countries have agreed to legally binding limitations/reductions in their emissions of greenhouse gases.
-Developing countries do not have binding targets but are still committed to reduce their emissions.
-Actions taken to reduce emissions include support for renewable energy, improving energy efficiency, and reducing deforestation.

The Copenhagen Accord 2009

As part of the 2009 Copenhagen negotiations, a number of countries produced the Copenhagen Accord.

The Accord states that global warming **should be limited to below 2.0°C** (3.6° F).This may be strengthened in 2015 with a target to limit warming to below 1.5°C.

The Accord does not specify what the baseline is for these temperature targets (e.g.relative to pre-industrial or 1990 temperatures).

According to the UNFCCC, these targets are relative to pre-industrial temperatures.

International targets

Paris Agreement 2016

Is a agreement within the United Nations Framework Convention on Climate Change (UNFCCC), dealing with greenhouse-gas-emissions mitigation, adaptation, and finance, signed in 2016. As of February 2020, all UNFCCC members have signed the agreement, 189 have become party to it, and the only significant emitters which are not parties are Iran and Turkey.

The Paris Agreement's long-term temperature goal is to keep the increase in global average temperature to well below 2 °C above pre-industrial levels; and to pursue efforts to limit the increase to 1.5 °C, recognizing that this would substantially reduce the risks and impacts of climate change.

It also aims to increase the ability of parties to adapt to the adverse impacts of climate change, and make "finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development."

Under the Paris Agreement, each country must determine, plan, and regularly report on the contribution that it undertakes to mitigate global warming. No mechanism forces a country to set a specific emissions target by a specific date, but each target should go beyond previously set targets.

In June 2017, U.S. announced it's intention to withdraw from the agreement. Under the agreement, the earliest effective date of withdrawal for the U.S. is November 2020.

International targets

- Reduction of sulphur in air emissions in Europe and Asia - reduction of air pollution could avoid as much as 0.5°C of warming and prevent 2.4 million premature deaths from air pollution
- Strategic Approach to International Chemicals Management: A voluntary, non-binding approach - Its global approach covers all agricultural and industrial chemicals throughout their life cycle
- Eliminating lead in fuels and paint through partnerships - Now that lead in automobile fuels has been almost completely phased out, decorative paint is one of the largest sources of exposure to lead. They are used in homes and schools, on furniture and toys, exposing children to this dangerous neuro-toxic pollutant. As of April 2017, regulation on lead paint is in place in 65 countries. The Lead Paint Alliance is working towards the goal of having regulation in place in all countries by 2020.
- Climate and Clean Air Coalition: A voluntary partnership model - This is delivered through 11 initiatives targeting transformational change in household energy, cooling, bricks production, oil and gas production, agriculture, transport, solid waste, and national/local planning.
- Healing the ozone layer - The ozone treaties have ensured that to date more than 99 per cent of the historic baseline levels of consumption and production of harmful ozone-depleting substances have been phased out. As a result, the ozone layer is healing; it is expected to be restored by the middle of the century. Health impacts: Up to two million cases of skin cancer may be prevented each year by 2030. Ecosystem impacts: Averting dangerous climate change and reducing the exposure of wildlife and plants to ultraviolet light will also have enormous benefits for ecosystem functioning.

Info taken from
https://wedocs.unep.org/bitstream/handle/20.500.11822/21800/UNEA_towardspollution_long%20version_Web.pdf?sequence=1&isAllowed=y

International targets

Table 2: Selected examples of multiple benefits of tackling pollution

Pollution area	Intervention	Benefits of interventions
Air pollution	Regulation	United States Environmental Protection Agency regulations issued between 2004 and 2014 to limit air pollution generated benefits of between $157 billion and $777 billion (2010 prices). Costs of implementation were estimated to be between $37 billion and $44 billion. This is a clear indication that benefits outweighed costs by a ratio of at least 4 to 1 (World Bank and Institute for Health Metrics and Evaluation 2016).
	Air pollution reduction	The health welfare benefits of reducing air pollution in China in the period 2015 to 2025 were estimated at $125 billion (2015 prices). (Sun et al. 2016)
	Shipping emissions	A review of the health impacts of shipping emissions found that on-time (2020) implementation of a global low-sulphur fuel cap for shipping would prevent some 200,000 premature deaths due to a reduction in toxic fumes, mainly in coastal communities in the developing world (Seas at Risk 2016).
Freshwater	Access to clean drinking water and sanitation	Access to improved drinking water can yield substantial welfare gains to many developing countries. The World Health Organization (2012) estimates the benefits of avoided mortality from universal access to improved drinking water to be $3 billion per year (2015 prices) for sub-Saharan Africa, Asia (East, South, South-East and West), Latin America and the Caribbean. The benefits of water pollution control amounted to 7.4 billion (2015 prices). This includes averted mortality from unsafe drinking water, externality effects from agriculture, and other costs.
Chemicals and waste	Strengthened governance of chemicals management	In Uganda, the benefits of strengthening the governance of chemicals management for the agriculture sector are estimated to be $1.98 billion over the period 2011 to 2025. Crop yield gains are estimated at 20 per cent in the cultivated areas concerned (Kateregga 2010).
	Reduction of global mercury emissions	If global mercury emissions could be reduced by 50 per cent to 60 per cent before 2020, the resulting prevention of water and fish contamination, and exposures to pregnant women and children, could reap global economic benefits of between $2.2 billion and $2.7 billion in 2020 (Sundseth et al. 2010).

UN environment assembly

Info taken from https://wedocs.unep.org/bitstream/handle/20.500.11822/21800/UNEA_towardspollution_long%20version_Web.pdf?sequence=1&isAllowed=y

End of pipe technologies

End of pipe technologies represent the traditional approach to pollution reduction and involve in addition of technology at the end of the process to remove the pollutants from the waste stream.
Materials removed from the waste stream are typically sent to landfill site although some are recycled.
Many approaches can be taken - mechanical, biological and chemical - however the best approach is to minimise the waste stream and pollutants before they are generated.
Reduce emissions and waste saves on resourced in terms of raw materials and energy requirements. Cleaner production technologies also reduces the need for managing pollutants.
It's more economic viable to prevent any potential environmental damage and deal with these issues at the source rather than try to mitigate its effects after production.

Trash Traps

Carbon Capture

Incremental and radical solutions

An incremental solution for dealing with waste is a gradual improvement of technologies or approaches to manufacturing over time. While a radical solution is new and often untried approach.

	Incremental solutions	Radical solutions
Advantages for manufacturers	▪ Able to exploit existing technologies; no need to develop new solutions ▪ Minimal changes to manufacturing processes and technologies. ▪ Respond to some aspects of legislation quickly and efficiently ▪ Low risk ▪ Improvement to competitiveness	▪ Opportunity to innovate with associated benefits (patents, first to market, fewer competitors) ▪ High potential for market growth ▪ Innovative approaches can develop new technologies
Disadvantages for manufacturers	▪ Small changes need to be made frequently in order to comply with new or evolving regulations. ▪ Low potential for market growth as the marketplace is crowded with competitors offering similar solutions	▪ Research and development (R&D) can be costly and lengthy ▪ High level of risk

Notes / Activities

System level solutions

System level solutions embraces the idea of a solution to the problem of pollution and waste as a whole and is concerned with the interrelationship rather than individual elements. It helps policy makers and energy planners understand the impacts of existing and proposed legislation, policy, and plans on renewable energy development and deployment at the local, state, regional and national levels.
Favourable tax concessions may be offered to those industries that integrate pollution controls into the process , reducing waste as opposed to end-of-pipe technologies that deal with pollutants at the end of a process.

System level solutions, like cradle-to-cradle design and circular economy solutions, are complex and require participation from a range of stakeholders, some of who may have opposing interests.

Guiding questions

State the overall aim of Clean Technologies

1. Explain why international - rather than national - legislation and targets for reducing pollution and waste are necessary
2. Explain why it is sometimes hard to get some countries to agree to lower their emissions
3. Outline the consequences to the environment of end-of-pipe technologies
4. Outline the differences between end-of-pipe and clean technologies

Exam style questions

2018
10. Which of the following is an advantage of radical solutions to clean energy development?
A. Benefits from patenting new solutions
B. Quick response to legislation
C. Low levels of uncertainty
D. Limited investment required

2017
9. What is an advantage of incremental design?
A. No need to invest in large operational changes
B. Benefits from patenting new solutions
C. Provides competitive advantage by being first to market
D. Provides a response to a significant change in legislation

2016
7. Although new environmental legislation can be highly disruptive, it can sometimes lead to benefits for manufacturers.
What are the potential benefits of environmental legislation for a manufacturer?
I. Reduced energy costs
II. Reduced material costs
III. Reduced waste

A. I only
B. I and II
C. II and III
D. I, II and III

2016
11. What is both a driver and a barrier to clean technology adoption by manufacturers?
A. Market expectations
B. Legislation
C. Cost
D. Research and development

Notes / Activities

2019

3. Explain why end-of-pipe technologies may not be the most effective strategy to reduce pollution. (3)

5. The images show an incandescent light bulb on the left and a LED bulb on the right. LED light bulbs typically use 75% less energy than traditional incandescents.

Outline why a company changing the lightbulbs it uses from incandescent to LEDs would be considered an incremental solution [2 Marks]

6. The image shows a diesel car with diesel fumes being emitted from the exhaust contributing to pollution and greenhouse emissions

Outline why a car powered by hydrogen batteries would be considered a clean technology alternative [2 Marks]

7. The image shows an Earthship home. Earthship homes generate their own resources such as fresh water, electricity and heating, by using nature. Living in an Earthship also involves growing your own food. Explain how this might be considered an example of a radical solution. [3 Marks]

8. The image shows the industrial chimneys from a factory emitting pollution into the air.

a. Outline why a filtration system added onto the chimneys would be considered an example of an end-of-pipe technology. [2 Marks]

b. Outline the limitations of implementing end-of-pipe technology as a method of reducing pollution [2 Marks]

Notes / Activities

Topic 2.5. Green Design

T2.5: Green Design

Essential Idea
Green design integrates environmental considerations into the design of a product without compromising its integrity.

Essential Understanding -
The starting point for many green products is to improve an existing product by redesigning aspects of it to address environmental objectives. The iterative development of these products can be incremental or radical depending on how effectively new technologies can address the environmental objectives. When newer technologies are developed, the product can re-enter the development phase for further improvement.

Aim
The purpose of green design is to ensure a sustainable future for all.

Principles and concepts

- Strategies for green design (incremental and radical)
- Green legislation
- Timescale to implement green design
- Drivers for green design (consumer pressure and legislation)
- Design objectives for green products
- Strategies for designing green products
- The prevention principle
- The precautionary principle

Guidance

- How strategies for green design often involve a focus on one or two environmental objectives when designing or re-designing products
- How green legislation encourages incremental rather than radical changes
- How environmental legislation has encouraged the design of products that tackle specific environmental issues
- How design objectives for green products address three broad environmental categories— materials, energy and pollution/waste
- Evaluating products in terms of: consumption of raw materials; packaging; incorporation of toxic chemicals; energy in production and use; end-of-life disposal; production methods; and atmospheric pollutants

What strategies can you use as a designer to accomplish a green design?

Green Design: Definition

Green design refers to the development of products to have a reduced impact on the environment.

What are the strategies for green design

Sustainable products provide social and economic benefits while protecting public health, welfare and the environment throughout their life cycle—from the extraction of raw materials to final disposal.

Most strategies for green design involve focusing on one or two environmental objectives when designing or re-designing a product, for example, the use of recyclable materials.

Strategies can be radical and incremental.

Notes / Activities

Strategies for green design - Incremental strategies

Truong Thanh Furniture Corporation (TTFC) in Vietnam Truong Thanh is a leading Vietnamese company in wood product manufacturing.

This product was subject to the following improvements:

- 40% of this product is now made from leftover wood from other production processes
- Use of wood in the product has been reduced
- All wood used has Forest Stewardship Council Certificate
- The BBQ functions have been increased and accessories added to increase the usability and therefore the value of the product
- The size of detailed parts was reduced
- The new bar is foldable for easy transport and storage.

Incremental strategies may focus on:
- Material: switching to a non-toxic or more sustainable, recyclable, environmentally friendly material for the product
- Manufacturing Process: Switching to more sustainable processes that use less energy and generate less waste
- Energy: Increasing the energy efficiency of the product; switching to more sustainable, renewable energy sources
- Engineering: Designing for disassembly; Use of standardized parts across the product line to reduce the need for many different parts

Incremental changes are lower risk because changes are smaller and predictable. These changes are often driven by legislation requirements or financial considerations.

Strategies for green design - Radical strategies

Kamworks is a solar company in Cambodia.

Cambodia receives on average five solar hours a day, so Kamworks saw the country's solar capacity as an opportunity for local production of solar lighting products that fit the purchasing power of rural households. Many people in Cambodia use kerosene fuel lamps as a mobile light for purposes in - and outside the house. The light is not very bright, the lamp cannot be used in windy or rainy conditions, and fuel costs are high. For the Kamworks lighting project, the goal was to provide a sustainable lighting solution for low-income rural households, the vast majority of which do not have access to the public electricity grid.

Radical strategies aims to make bold changes in the design that leap well ahead of competitors. Because of the degree of changed involved it is also described as disruptive innovation.
Radical innovation involves greater risk as success is not guaranteed.
Radical strategies may focus on:
- Completely changing the manufacturing process
- The result is a completely new product or service that meets the needs of the user in a unique way.

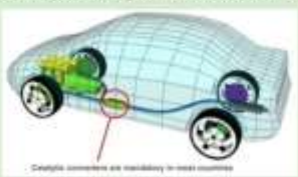
Radical changes are higher risk, especially in the early iterations because of the novel nature of the design decisions. These changes are often driven by a need to innovate in order to enter/create a new market or meet a new need.

Drivers for green design - Legislation

Legislation

Most legislation for minimizing or reducing environmental impact of products is based on a green design approach. It's effective because it usually involves incremental changes to a design - makes it relatively easy to implement. Example: catalytic converters for cars. The legislation encouraged the design of
a product that tackled a specific environmental issue

Raised awareness of environmental issues is increasing legislation in many countries. This can lead to financial penalties on companies who do not demonstrate environmental responsibility. Many people will not behave responsibly unless forced to do so, therefore, legislation forces the issue.



Notes / Activities

Green Legislation

Eco-labelling is a legislated requirement within the EU.
In 1992, it was introduced to certify products that strict criteria related to production and disposal of manufactured goods.
An eco label is a trustworthy symbol that manufacturers can put on the products they sell to demonstrate that they are genuinely better for the environment than comparable products.
The International Standards Organisation - ISO has created standards for labeling practices within the ISO 14000 schema. ISO 14020 to 14025 series deals with environmental labels and declarations.

Drivers for green design - consumer pressure

Consumer pressure
Demands and pressure by consumer groups can also significantly influence a company's decision to adopt green design strategies.
Consumers may speak with their wallets, by only purchasing products that meet their expectations. Consequently, companies may implement green design solution in order to meet market demands and maintain market share.
As the public has become more aware of environmental issues such as climate change, pollution, and plastic waste, manufacturers listen carefully to consumer demands.

Notes / Activities

Design objectives for green products relate to three broad environmental categories: materials, energy and pollution/waste. Name detailed examples in the table below.

Materials	Energy	Pollution and Waste

Strategies for designing green products

Aimed at reducing the impact of the product on the environment.

Can include design for:

- longevity,
- disassembly,
- reduced waste,
- energy efficiency,
- dematerialization,
- systems integration,
- recyclability and repair,
- reduced embodied energy

The environmental impact of the production, use and disposal of a product can be modified by the designer through careful consideration at the design stage.

The Prevention principle and the precautionary principle

Two principles should guide designers in how they make decisions:

The Prevention Principle

The avoidance or minimization of waste production. Designers should endeavor to avoid or minimize waste in all its forms with regards to the production, use, and disposal of the product. Designers should make decisions in the design process that strive to meet this principal.

Example - A number of risk assessment tools can be used by companies to assess their operations for risk and introduce management systems to protect the health and safety of employees and minimise waste.

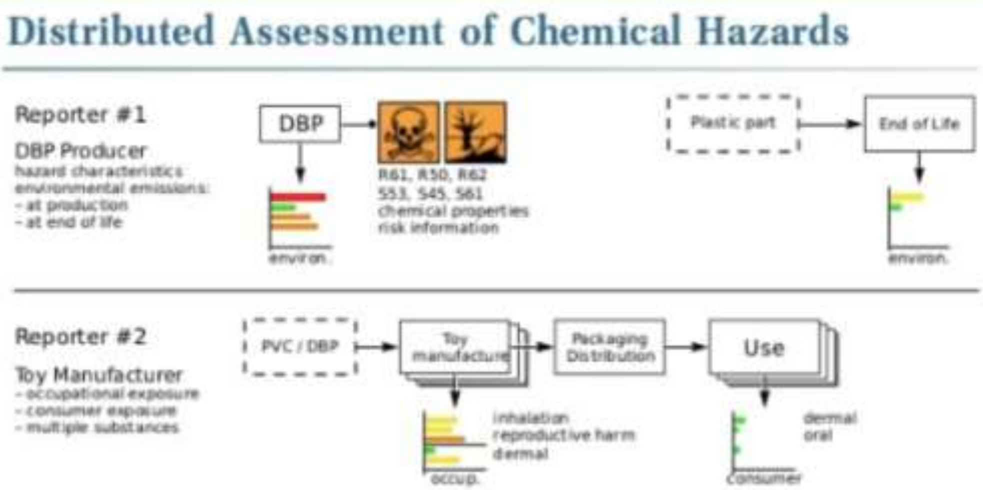
The Precautionary Principle

The anticipation of potential problems.

Designers should anticipate problems related to the production, use and disposal of their product and take measures to mitigate or eliminate them. In other words, designers should think ahead, inquire, predict any negative environmental impacts of their designs—we cannot be complacent.

Principle adopted by the UNCED in 1992, also known as the Rio Earth Summit.

The Prevention principle



Hazard assessment determines probable causes for injury and indicates ways to eliminate the hazards. The example here shows risk in producing, use and disposal of plastic products.

Notes / Activities

Guiding questions

1. Discuss the implication of incremental and radical solutions
2. Explain how consumer pressure and legislation can drive Green design
3. Explain three design objectives for Green design
4. Discuss the differences between the prevention and precautionary principle
5. List how products can be evaluated to measure how environmentally friendly they are (how 'green')

2017

4. Plan Toys is a company that markets itself on its environmental credentials. Figure 3 below shows their production and distribution process. What best describes the company's sustainability strategy?

Figure 3: The production and distribution process for Plan Toys

A. The use of renewable resources
B. The promotion of recycling
C. Undertaking dematerialization
D. The use of product recovery

2016

9. Which principles would help a designer to reduce the environmental impact of a product?

I. Mechanical principle
II. Precautionary principle
III. Prevention principle
A. I only
B. I and II
C. II and III
D. I, II and III

2018

1e(ii) The objectives for Green design fall into three categories:
• materials
• energy
• pollution and waste.
Explain how the use of bioplastics in the Kuskoa Bi chair fit into one of these categories. [3]

Specimen paper

4. Discuss why the use of thermoplastic renders a product green but not sustainable. [3]

5. The image on the left shows a closeup of a section of double glazing window. The space between the two layers of glass helps to reduce the amount of heat transfer. A school decides to replace all the windows with double glazing to reduce the amount of money spent on air conditioning.
Explain how this is an example of Incremental Green design. [3 Marks]

Notes / Activities

Topic 2.6. Eco Design

Essential Idea

Eco-design considers the design of a product throughout its life cycle (from cradle to grave) using lifecycle analysis.

Essential Understanding

Consideration of the environmental impact of any product, service or system during its life cycle should be instigated at the earliest stage of design and continue through to disposal. Designers should have a firm understanding of their responsibility to reduce the ecological impact on the planet. Eco-design concepts currently have a great influence on many aspects of design.

Aim

The smart phone is an innovative example of converging technologies that combines multiple technologies into one space-saving device. The resultant reduction of materials, and energy used in production and distribution has environmental benefits.

Principles and concepts

- Timescale for implementing eco-design
- The "cradle to grave" and "cradle to cradle" philosophy
- Life cycle analysis (LCA)
- LCA stages: pre-production; production; distribution including packaging; utilization and disposal
- Environmental considerations
- Environmental impact assessment matrix
- Product life cycle stages: the role of the designer, manufacturer and user
- The major considerations of the United Nations Environmental Programme Manual on Eco-design
- "Design for the environment" software
- Converging technologies

What is the difference between green design and eco design

The terms Green Design and Eco-Design have different characteristics, particularly with regard to the timescale and complexity.

Green-Design
Focus is on the re-engineering of a design to reduce it's environmental impact and increase its sustainability. Green design focuses on making changes that are typically incremental in nature: switching to a recyclable material, reducing energy in manufacturing or use, increasing durability of the product.
Green Design typically focuses on one or two environmental objectives, such as switching to sustainable materials or reducing energy usage.

Eco-Design
It is a more complex approach to sustainability. Think "ecology": The design fits into a system. Cradle-to-Cradle design (C2C), Circular Economies, etc. are examples of eco-design. For designers, eco-design is more than just using green materials. It considers the entire lifecycle of the product and its impacts.

- Long timescale approach
- More complex and higher risk

Notes / Activities

Timescale for implementing eco-design

Eco design also known as Design for the Environment.

In 2005 the EU issued an Eco-design directive that obliges manufacturers to reduce energy consumption and other environmental impacts that might otherwise occur throughout the product life cycle. An eco-design label is applied to products that meet this directive.

Other factors which might influence the timescale:

- Cost
- Available technology
- Radical or whole system overhaul

Cradle to grave and cradle to cradle philosophies

Cradle to grave is a design philosophy that considers the environmental effects of a product all the way from manufacture to disposal.
It is a key principle of the linear economy.

Cradle to cradle is a design philosophy that aims to eliminate waste from production, use and disposal of a product. It centres on products which are made to be made again.
It is a key principle of the circular economy.

Life Cycle Analysis

- What LCA is?
- List the stages of the LCA

Notes / Activities

Environmental impact in the LCA stages

- pre-production;
  - Incorporating the mining of raw materials, processing and transportation
- production
  - Including energy requirements, waste, cooling and lighting
- distribution including packaging;
  - Counting fuels, emissions, inks, size and density
- utilization
  - Encompassing power requirements, maintenance and in-use emissions
- disposal
  - Involving waste recovery, recycling, reuse and landfill

Environmental affects direct on indirectly in LCA include

- Climate change
- Ozone depletion
- Soil contamination and erosion
- Loss of biodiversity or habitat
- reduction in water quality
- air contamination
- depletion of finite resources
- noise pollution

Product life Cycle

Discuss the roles of the designer, manufacturer and user at the different stages of the a product's life cycle.

LCA Environmental Impact Assessment Matrix

A matrix simply provided a way of assisting with organising and presenting data for analysis. The LCA environmental Impact assessment Matrix allows researchers to identify, collect and value individual environmental impacts over the entire product life

Risk impact rating using 0 - 5 scale or Low, Medium, High Impact					
	Pre-production	Production	Distribution	Utilization	Disposal
[illegible]					
Soil pollution and degradation					
Air contamination					
Noise					
Energy consumption					
Consumption of natural resources					
Pollution					
Effects on ecosystems					

Notes / Activities

United Nations Environmental Programme Manual on Ecodesign

In 1996 the United Nations released an Eco-design manual also known as design for Sustainability (DfS). The major concerns outlined in the document are

- reduce the creation and use of toxic materials
- increase recyclability
- reduce energy consumption
- increase use of renewable resources
- increase product durability – reducing planned obsolescence
- reduce material requirements for products and services

The emphasis of the guidelines will vary depending on the type of product to be designed and the target market.

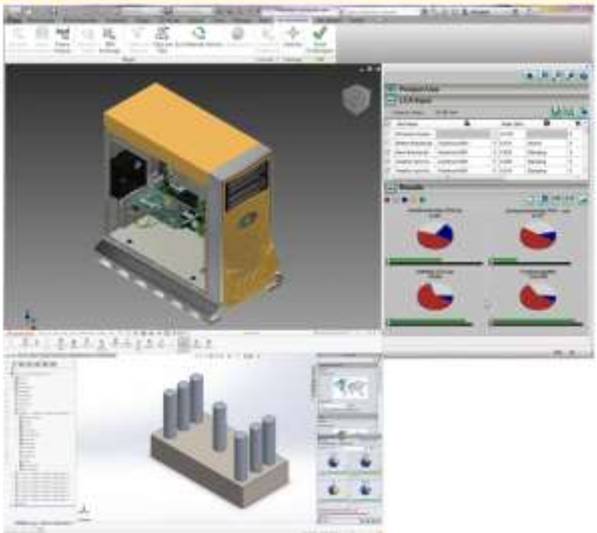
You can see here the latest update from 2009 http://wedocs.unep.org/handle/20.500.11822/8742

Design for Environment Software [DfE]

Design for the environment software is used to assist designers in the assessment of environmental implications and particular parts of a design

Software such as Fusion or Solidworks that:

- allows the designer to carry out LCA
- selects materials and manufacturing techniques that reduce environmental effects.
- runs scenarios that can minimize materials
- optimise designs to get cost effective products that are environmentally concerned



Converging Technologies

Smartphones are an example of a converging technology

1. Define Converging Technology
2. Discuss the advantages and disadvantages of converging technologies - Consider the materials used to create it | energy consumption disassembly | recyclability | portability c the devices it incorporates

Notes / Activities

Converging Technologies

Converting technologies is the amalgamation of existing technologies into new forms that create innovative products and systems that may offer greater convenience, efficiencies or entirely new features and functions not currently in existence.

Medicine
Implants and drug delivery are becoming smaller and more efficient. These include wearable implants that send out data via wireless recorders. Tracking devices that can be bought off-the shelf are now available with heart rate, calorie data, glucose levels, etc.

Telecommunications
Modern telecommunications systems provide better personal access, information, entertainment all through one device on a single platform

Recco person detector in avalanche

Wearable Technology
Technology can be integrated into fashion products to give a vast range of user experience. These include flexible electronics.

Converging Technologies

Advantages	Disadvantages
- A single device with multiple functions - Eliminates the need to buy multiple devices - miniaturization of products increase portability - reduce the need for materials – reduce cost and environmental impact	- if one technology fails could lead to the other contacted tech to fail as well - increased functionality of a device may lead to inefficient use - the converged tech may not work as well as on its own e.g. DVD player vs a dvd player in a game console

Guiding questions

1. Explain the issues of timescale for implementing Green design
2. Outline an example of an environmental impact assessment matrix
3. Explain the stages of LCA
4. Explain design for environment software and how it can help eco design
5. Explain converging technologies and give examples
6. Discuss the differences between cradle to grave and cradle to cradle

Exam style questions

2019
6. Which three categories are focussed on in eco-design?
A. Materials, energy and pollution/waste
B. Production, utilization and distribution
C. Price, quality and service
D. Product, place and price

Figure 4: A typical office chair

Notes / Activities

2016

8. Figure 4 shows a typical example of an office chair.
To design the chair the manufacturer decided to undertake life cycle analysis (LCA).

Which phases in the product life cycle would the designer consider in undertaking LCA in relation to the design of the chair shown in Figure 4?

A. Marketing material, promotion, sales
B. Pre-production, production, distribution and packaging, utilization, disposal
C. Concept design, detail development, prototyping, manufacture
D. Density, conductivity, expansion, hardness

2017

28. What evaluates a product's harmful impact on the environment?

A. Green design

B. Sustainable design

C. Life cycle analysis

D. Triple bottom line

2015

11. Which combination of "environmental impact" and "volume of production" characterizes a product category that would benefit most from life cycle analysis?

	Environmental impact	Volume of production
A.	Low	High
B.	Low	Low
C.	High	High
D.	High	Low

Specimen paper

6. Which phrase reflects the life cycle analysis of a product?
A. Cradle to cradle
B. Cradle to grave
C. Cradle to gate
D. Cradle to site

7.At which stage of the product life cycle would user attitudes and behaviours be likely to have greater impact than those of the designer or the manufacturer?
A. Production
B. Distribution, including packaging
C. Utilization
D. Disposal

8. What aspect of eco-design does design for repair and maintenance optimize?
A. Production
B. Initial lifespan
C. Impact during use
D. End of life options

2017

1. Many homeowners are aware that they are using large quantities of electricity. This is not only costly, but is also harmful to the environment as much of it is obtained from non-renewable sources.

Figure 1 shows Powerwall, a home battery developed by Tesla, an international company with its Head Office in the United States. The Powerwall charges using electricity generated from solar panels, and powers the home in the evening. It also protects the home against power outages by providing a backup electricity supply.
The Powerwall can be easily installed either indoors or outdoors by a professional electrician.
Tesla are well known for their development of batteries for motor cars (automobiles). This is known as adaptation.
(a) (i) State one reason why the Tesla Powerwall needs to be easily accessible. [1]
(ii) Outline how the Powerwall can be seen as an example of eco-design. [2]

Notes / Activities

2017

4. Explain one advantage of a cradle to cradle philosophy over a cradle to grave philosophy. [3]

2016

3. Explain why a small company may not adopt life cycle analysis as a strategy for reducing the environmental impacts of its products. [3]

Specimen paper

3. Explain how the use of "design for the environment" software assists designers in choosing materials. [3]

Notes / Activities

Summary Notes
Q&A

Topic 2
Resource management & sustainable production

2.1 Resource and reserves

Resource management and sustainable production carefully consider three key issues consumption of raw materials, consumption of energy, and production of waste—in relation to managing resources and reserves effectively and making production more sustainable. As non-renewable resources run out, designers need to develop innovative solutions to meet basic human needs for energy, food and raw materials. The development of renewable and sustainable resources is one of the major challenges of the 21st century for designers.

<table>
<tr><td>Resources</td><td>Resources are the stock or supply of materials that are available in a given context.</td></tr>
<tr><td>Renewable resources</td><td>A natural source which can replenish with time they make take place as energy or commodities, some will require careful management i.e. plantation of timber; others are deemed inexhaustible i.e. wind and solar.</td></tr>
<tr><td>Non-Renewable</td><td>A non-renewable resource (also called a finite resource) is a resource that does not renew (replenish) itself at a sufficient rate for sustainable economic extraction, for example, coal, petroleum, natural gas, fossil fuels, minerals and ores.</td></tr>
<tr><td>Comparison of renewable and non-renewable resources</td><td><table>
<tr><th>Renewable Resources</th><th>Non Renewable Resources</th></tr>
<tr><td>1.) Are inexhaustible
2.) Are not affected by human activities
3.) Release less carbon emissions
4.) More expensive to implement.
eg. hydroelectric, geothermal, solar, wind, tidal</td><td>1.) Resources are present in fixed and limited quantities.
2.) Are exhaustible.
3.) Release more carbon emissions.
4.) Less expensive to implement.
eg. coal, timber, natural gas, oil, nuclear</td></tr>
</table></td></tr>
<tr><td>Reserves</td><td>A natural resource that has been identified in terms of quantity and quality.
Energy reserves are projected on the basis of geologic and engineering data and cannot be obtained at present due to economic or technical reasons; i.e. mining of oil sands is currently uneconomical due to current price structure.</td></tr>
<tr><td>Renewability</td><td>Renewability relates to a resource that can be replenished over time or is inexhaustible, for example wood from trees, and fresh drinking water Conserving resources and technologies that improve energy efficiency.</td></tr>
<tr><td>Impact of development may have on the environment</td><td>The impact of multinational companies when obtaining resources in different countries/ regions can be a significant issue for the local population and have major social, ethical and environmental implications.</td></tr>
<tr><td>The development of renewable and sustainable resources is one of the major challenges of the 21st century for designers.</td><td>The economic and political importance of material and land resources and reserves considering set-up cost, efficiency of conversion, sustainable and constant supply, social impact, environmental impact and decommissioning</td></tr>
</table>

2.2 Waste mitigation strategies

Waste mitigation strategies can reduce or eliminate the volume of material disposed to landfill. The abundance of resources and raw materials in the industrial age led to the development of a throwaway society, and as resources run out, the many facets of sustainability become a more important focus for designers. The result of the throwaway society is large amounts of materials found in landfill, which can be considered as a new source to mine resources from.

Waste mitigation strategies	The abundance of resources and raw materials in the industrial age led to the development of a throwaway society, and as resources run out, the many facets of sustainability become a more important focus for designers. The result of the throwaway society is large amounts of materials found in landfill, which can be considered as a new source to mine resources from. Waste mitigation strategies can reduce or eliminate materials directed to landfill. The prevention, monitoring and handling of waste, coming up with solutions to deal with pollution and waste
Re-use	Reuse of the same product in same context or a different context Examples include Water Bottles, Plastic Bags, Glass Bottles, Toothbrush, Clothes
Repair	The reconstruction or renewal of any part of an existing structure or device. To mend/restore/service faulty equipment, the life-cycle of many products is designed so that they/or parts deteriorate over time. Examples: Washing machine belt, Shoe soles, Lightbulb, Cars - bumpers, lights, Fix an inner tube on a bicycle
Re-engineer	To redesign components or products to improve their characteristics or performance. (speed, energy consumption). Examples include F1 cars - where aerodynamics is changed (shape) or lighter new materials used
Recycle	Recycling refers to using the materials from obsolete products (waste) to create other products. Examples include Glass, Paper, Aluminium cans, Thermoplastics, Newspaper
Recondition	Rebuilding a product so that it is in an "as new" condition, and is generally used in the context of car engines and tyres. Examples include car engines, tyres, bearings, etc
Dematerialisation	Reducing the quantities of materials trying to "do more with less". Looking at the constraints of the materials we use, through reduction and reuse of materials. Examples include the changes made to the new Mac Pro vs the old Mac Pro version. Dematerialization improves product efficiency by saving, reusing or recycling materials and products. It impacts on every stage of the product life cycle: in material extraction; eco-design; cleaner production; environmentally conscious consumption patterns; recycling of waste. It may mean smaller, lighter products and packaging; the replacement of physical products by virtual products (email instead of paper, web pages instead of brochures); home working, and so on.
Methodologies for **waste reduction**	Looking into the current management of waste (i.e landfill, incineration) and pollution (i.e. noise, air pollution). • Developing new bio-fuels, self-decomposing materials, building products from recyclable materials, reconditioning products and building products with a "cradle to cradle" life-cycle. • Making consumers and manufacturers aware of pollutants and the effect on the environment, passing acts/legislation to ban/reduce these pollutants i.e. the EU "Take Back" program and the US "Clean Air Act". Eco-labeling products for consumer awareness. • Following ISO (International standards organisations) 14000 a network of national standards spanning the globe, addressing environmental issues.

Methodologies for **designing out waste**	-The prevention, monitoring and handling of waste, coming up with solutions to deal with pollution and waste. -Product recovery strategies at end-of-life/disposal -Energy from waste, reuse of parts of products, recycling from parts of products. -Circular economy-the use of waste as a resource within a closed loop system -Environmentalists have a large influence on product marketability, designers and manufactures often work together to design products which are deemed as Green/Environmentally friendly.
Product recovery strategies **Recycling**	Recycling refers to using the materials from obsolete products to create other products.
Product recovery strategies **Raw material recovery**	The processes of separating the component parts of a product to recover the parts and materials.
Product recovery strategies **WEEE Recovery**	WEEE is a complex mixture of materials and components from electrical products that because of their hazardous content, and if not properly managed, can cause major environmental and health problems.
Product recovery strategies **Energy recovery**	Waste-to-energy (WtE) or energy-from-waste (EfW) is the process of generating energy in the form of electricity and/or heat from the primary treatment of waste. WtE is a form of energy recovery. Most WtE processes produce electricity and/or heat directly through combustion, or produce a combustible fuel commodity, such as methane, methanol, ethanol or synthetic fuels.
Product recovery strategies **Standard parts at the end of product life**	Reduction of total material and energy throughput of a product or service, and the limitation of its environmental impact through: reduction of raw materials at the production stage; energy and material inputs at the user stage; waste at the disposal stage
Life Cycle Analysis (LCA)	Life-cycle assessment (LCA, also known as life-cycle analysis) is a technique to assess environmental impacts associated with all the stages of a product's life from cradle to grave (i.e., from raw material extraction through materials processing, manufacture, distribution, use, repair and maintenance, and disposal or recycling).
Circular economy—the use of waste as a resource within a closed loop system	An economy model in which resources remain in use for as long as possible, from which maximum value is extracted while in use, and the products and materials are recovered and regenerated at the end of the product life cycle.
External drivers and social change	• Increasing supply chain pressure • Public opinion • Energy costs • Waste charges • Take-back legislation • The obligation to provide environment-related information • Norms and standards • Eco-labelling schemes • Subsidies • Environmental competition • Environmental requirements in consumer tests • Environmental requirements for design awards • Increasing cooperation with suppliers

2.3 Energy Utilisation, Storage and Distribution Waste mitigation strategies

There are several factors to be considered with respect to energy and design. Efficient energy use is an important consideration for designers in today's society. Energy conservation and efficient energy use are pivotal in our impact on the environment. A designer's goal is to reduce the amount of energy required to provide products or services using newer technologies or creative implementation of systems to reduce usage. For example, driving less is an example of energy conservation, while driving the same amount but with a higher mileage car is energy efficient.

Energy utilization, storage and distribution	Efficient energy use is an important consideration for designers in today's society. Energy conservation and efficient energy use are pivotal in our impact on the environment. A designer's goal is to reduce the amount of energy required to provide products or services using newer technologies or creative implementation of systems to reduce usage. For example, driving less is an example of energy conservation, while driving the same amount but with a higher mileage car is energy efficient.
Embodied energy	The **embodied energy** in a product accounts for all of the energy required to produce it. It is a valuable concept for calculating the effectiveness of an energy-producing or energy-saving device.
Distributing energy: national and international grid systems	The way in which electricity is distributed along the grid and the energy loss involved from small source collection and delivery, to large scale and the effect on the environment.
Local combined heat and power (CHP)	Combined heat and power (CHP) is an efficient and clean approach to generating electric power and useful thermal energy from a single fuel source. CHP is used either to replace or supplement conventional separate heat and power (SHP). Instead of purchasing electricity from the local utility and burning fuel in an on-site furnace or boiler to produce thermal energy, an industrial or commercial facility can use CHP to provide both energy services in one energy-efficient step. **Advantages of CHP include:** -Reduced energy costs versus separate heat and electrical generation systems -Reduced emissions versus separate heat and electrical generation systems -Where the capture and use of waste heat is not viable, many industrial facilities may still benefit financially via distributed generation (DG)
Systems for individual energy generation	Systems for individual energy generation such as microgeneration includes the small-scale generation of heat and electric power by individuals, small businesses and communities to meet their own needs, as alternatives or supplements to traditional centralized grid-connected power. E.g. solar power, wind turbines or biogas rainwater harvesting, compost toilets and greywater treatments among others.
Quantification of carbon emissions: **Measuring**	• record carbon emissions • discover how much is being produced • discover who/ where it is produced • track your carbon footprint
Mitigation of carbon emissions: **Reducing**	• Humans intervention in the reduction of carbon emissions • These contribute to global warming • Resulting in melting polar caps, rising seas, desertification, • provide 'Sinks' that can reabsorb carbon emissions • A 'Sink' are forests, vegetation or soils.
Batteries, capacitors and capacities considering relative cost, efficiency, environmental impact and reliability.	An electric battery is a device consisting of two or more electrochemical cells that convert stored chemical energy into electrical energy. Batteries and other electronic components (capacitors, chips, etc) have had a great impact on the portability of electronic products and, as new technologies are developed, they can become more efficient and smaller. Batteries are made from important resources and chemicals, including lead, cadmium, zinc, lithium and mercury. It's important to understand the effects of your decisions as batteries are categorised into High, Medium and Low through the use of a sustainable lens (charging, impact on eco-system, etc).

2.4 Clean Technologies

Clean technology seeks to reduce waste/pollution from production processes through radical or incremental development of a production system. Clean technology is found in a broad range of industries, including water, energy, manufacturing, advanced materials and transportation. As our Earth's resources are slowly depleted, demand for energy worldwide should be on every designer's mind when generating products, systems and services. The convergence of environmental, technological, economic and social factors will produce more energy-efficient technologies that will be less reliant on obsolete, polluting technologies.

<table>
<tr><td>Clean Technology</td><td>Products, services or processes that reduce waste and require the minimum amount of non-renewable resources. Clean technology is found in a broad range of industries, including water, energy, manufacturing, advanced materials and transportation. As our Earth's resources are slowly depleted, demand for energy worldwide should be on every designer's minds when generating products, systems and services. The convergence of environmental, technological, economic and social factors will produce more energy efficient technologies that will be less reliant on obsolete, polluting technologies.</td></tr>
<tr><td>Drivers for cleaning up manufacturing</td><td>Manufacturers may respond to current or impending legislation or pressure created by the local community and media. The reasons for cleaning up manufacturing include:
promoting positive impacts
ensuring neutral impact or minimizing negative impacts through conserving natural resources
reducing pollution and use of energy
reducing waste of energy and resources</td></tr>
<tr><td>Breakdown of environmental problems products can cause and their geographical scale</td><td><table>
<tr><th>Geographical scale</th><th>Types of environmental problem</th></tr>
<tr><td>Local</td><td>Noise, smell, air pollution, soil and water pollution</td></tr>
<tr><td>Regional</td><td>Soil and water over-fertilization and pollution, drought, waste disposal, air pollution</td></tr>
<tr><td>Fluvial</td><td>Pollution of rivers, regional waters and watersheds</td></tr>
<tr><td>Continental</td><td>Ozone levels, acidification, winter smog, heavy metals</td></tr>
<tr><td>Global</td><td>Climatic change, sea level rise, impact on the ozone layer</td></tr>
</table></td></tr>
<tr><td>Legislation</td><td>The role and scale of legislation are dependent upon the type of manufacturing and the varied perspectives in different countries. Consider how legislation provides an impetus to manufacturers to clean up manufacturing processes and also how manufacturers react to legislation. Manufacturers may respond to current or impending legislation or pressure created by the local community and media.

Governments, politicians and businesses have to consider the effects of manufacturing on the environment. In recent years raised awareness of environmental issues is increasing pressure on governments to introduce or comply with legislation regarding environmental issues. These requirements bind companies to legislation and if these requirements are not met then financial penalties can be imposed.</td></tr>
</table>

<table>
<tr><td>International targets for reducing pollution and waste</td><td>Sometimes, agreements are made at an international or continental level to create targets for reducing pollution and waste. These agreements are usually discussed and agreed upon at international summits and meetings. Often conflicts and disagreements arise between countries trying to decide caps or limits on pollution or waste making agreements or settlements difficult to achieve. Some countries may be more affected by such limits than others, and feel that their economy or the profits of companies will suffer as a result.Some recent agreements include Kyoto Protocol, Montreal Protocol and the Carbon Trading Scheme.</td></tr>
<tr><td>End-of-pipe technologies</td><td>An initial response to reducing the emission of pollutants and creation of waste is adding clean-up technologies to the end of the manufacturing process. This is called an end-of-pipe approach. Technology that is used to reduce pollutants and waste at the end of a process. This can entail the treatment of water, air, noise, solid or toxic wastes. Some examples of this approach include: Carbon Capture, Filtration systems, Composting and Catalytic Converters on vehicles
<table>
<tr><th>Incremental solutions</th><th>Radical solutions</th></tr>
<tr><td>Products which are improved and developed over time leading to new versions and generations.</td><td>Where a completely new product is devised by going back to the roots of a problem and thinking about a solution in a different way.</td></tr>
</table></td></tr>
<tr><td>System level solutions</td><td>A System level solution embraces the idea of a solution to the problem of pollution and waste as a whole and is concerned with the interrelationship rather than individual elements. It helps policymakers and energy planners understand the impacts of existing and proposed legislation, policy, and plans on renewable energy development and deployment at the local, state, regional, and national levels.

Agreements are made at an international or continental level to create targets for reducing pollution and waste. These agreements are usually discussed and agreed upon at international summits and meetings. Often conflicts and disagreements arise between countries trying to decide caps or limits on pollution or waste making agreements or settlements difficult to achieve. Some countries may be more affected by such limits than others, and feel that their economy or the profits of companies will suffer as a result.</td></tr>
</table>

2.5 Green Design

Green design integrates environmental considerations into the design of a product without compromising its integrity. The starting point for many green products is to improve an existing product by redesigning aspects of it to address environmental objectives. The iterative development of these products can be incremental or radical depending on how effectively new technologies can address the environmental objectives. When newer technologies are developed, the product can re-enter the development phase for further improvement.

Green Design	The product- role of designer: The starting point for many green products is to improve an existing product by redesigning aspects of it to address environmental objectives. The iterative development of these products can be incremental or radical depending on how effectively new technologies can address the environmental objectives. When newer technologies are developed, the product can re-enter the development phase for further improvement.
Green legislation	Laws and regulations that are based on conservation and sustainability principles, followed by designers and manufacturers when creating green products. Green legislation often encourages incremental, rather than radical approaches to green design. Sustainable products provide social and economic benefits while protecting public health, welfare and the environment throughout their life cycle—from the extraction of raw materials to final disposal. **Incremental innovation** is sometimes referred to as continuous improvement, and the business attitude associated with it is 'inside-the-box' thinking. A simple product may be improved (in terms of better performance or lower costs) through the use of higher performance components or materials. A complex product that consists of integrated technical subsystems can be improved by partial changes to one level of a sub-system. Incremental innovations do not involve major investments or risks. User experience and feedback is important and may dominate as a source for innovation ideas **Radical innovation** involves the development of new key design elements such as change in a product component combined with a new architecture for linking components. The result is a distinctively new product, product-service, or product system that is markedly different from the company's existing product line. A high level of uncertainty is associated with radical innovation projects, especially at early stages.
Timescale to implement green design	Often, legislation requires governments and manufacturers to comply over many years. This can be beneficial to companies and manufacturers as they can adopt incremental approaches to green design therefore minimising the cost, however some environmental concerns, for example carbon dioxide reduction and climate change require immediate action.
Legislation	Environmental legislation has encouraged the design of greener products that tackle specific environmental issues, for example, eliminating the use of certain materials or energy efficiency. Incremental changes to a design and as such is relatively easy to implement, for example, legislation relating to the use of catalytic converters for cars. The timescale for implementing green design is relatively short (typically 2–5 years) and therefore cost-effective.
Consumer Pressure	The public have become aware of environmental issues through media focus on issues such as the destructive effect of chlorofluorocarbons on the ozone layer; acid rain in Northern European forests and the nuclear accident at Chernobyl. Increased public awareness has put pressure on corporations and governments. CFCs were the ideal refrigerants during their time. They were nonflammable, non corrosive, nontoxic, and odorless. Used consumer products during the 70s and 80s, such as refrigerators, cleansing products, and propellants. CFC's were found to be destructive to the Ozone layer.

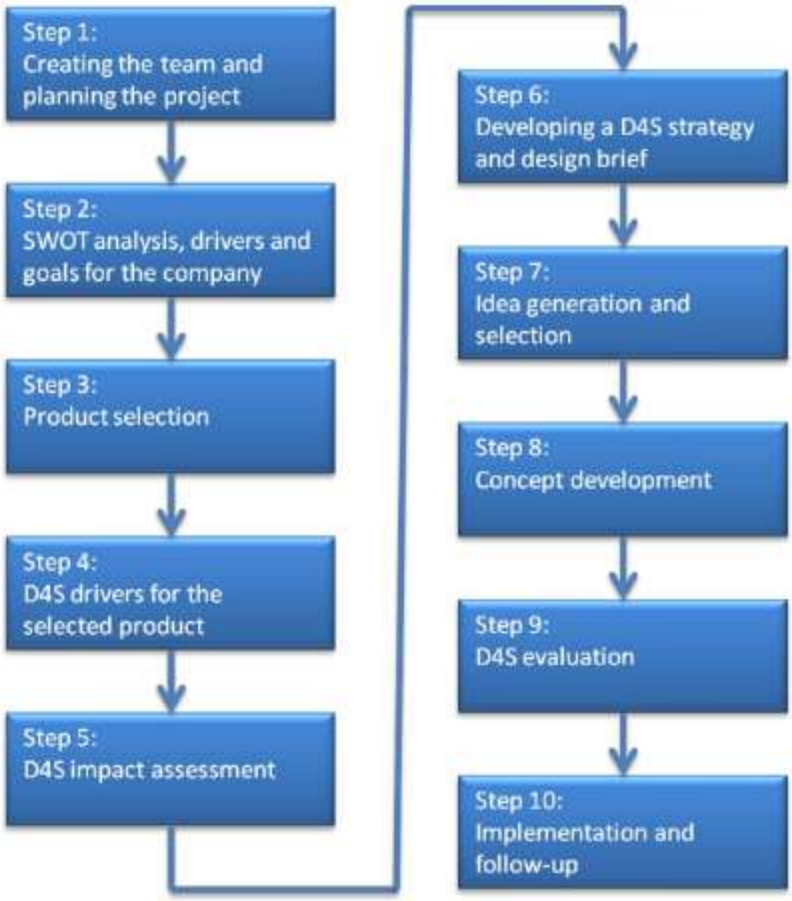
Drivers for green design (consumer pressure and legislation)	Drivers for green design include consumer pressure and legislation, among others. Environmental legislation has encouraged the design of greener products that tackle specific environmental issues, for example, eliminating the use of certain materials or energy efficiency. Unfortunately, many companies value short term profit and value for shareholders over the impact of their activities on the environment. Some companies lobby governments so that they can be exempt from legislation, or to try and persuade them to 'water down' legislation. Sometimes consumer pressure can be just as effective as legislation. Through social media, the bad behaviour of companies can be exposed quickly, reach a wider audience and consumers can decide as a large group to boycott a company. Social media has allowed the influence of consumers to grow exponentially. This can hurt a company's profits greatly, persuading them to clean up their act.
Design objectives for green products	Design objectives for green products will often address three broad environmental categories. • Materials • Energy • Pollution/Waste These **objectives** include: 1. increasing efficiency in the use of materials, energy and other resources; 2. minimizing damage or pollution from the chosen materials 3. reducing to a minimum any long-term harm caused by use of the product 4. ensuring that the planned life of the product is most appropriate in environmental terms and that the product functions efficiently for its full life 5. taking full account of the effects of the end disposal of the product 6. ensuring that the packaging and instructions encourage efficient and environmentally friendly use 7. minimizing nuisances such as noise or smell 8. analysing and minimizing potential safety hazards 9. minimizing the number of different materials used in a product 10. labelling of materials so they can be identified for recycling. When **evaluating** product sustainability, students need to consider: 1. raw materials used 2. packaging 3. incorporation of toxic chemicals 4. energy in production and use 5. end-of-life disposal issues 6. production methods 7. atmospheric pollutants.
Strategies for designing Green Products	The environmental impact of the production, use and disposal of a product can be modified by the **designer** through careful consideration at the **design stage**. When designing Green product consideration must be made for: • raw materials used • packaging • incorporation of toxic chemicals • energy in production and use • end-of-life disposal issues • production methods • atmospheric pollutants.
Materials	How much damage is done to the environment in extracting the raw material? How much energy is needed to process this material? How long will this material last/will it damage easily? Can this material be recycled?
Energy	How can I reduce the amount of energy required to manufacture this product? How can I reduce the amount of energy required to use this product?

Pollution/Waste	What is likely to happen to this product when it is obsolete? How can I reduce the chances of this product ending up in landfill or sent to incineration? How can I increase the chances of this product being repaired, reused or recycled? How can I reduce the amount of pollution given off by this product?
The **prevention principle**	The **avoidance or minimization** of hazards and waste. It aims to address the occupational health and safety concerns through each stage of the product life cycle. A number of risk assessment tools can be used by companies to **assess their operations for risk** and introduce management systems to **protect the health and safety of employees** and **minimise waste.** • Knowledge based • Actual risk of causing harm can be assessed • Occurrence of damage is probable if no measure is taken • Regulation emission framework defines substantial criteria (eg. emissions thresholds) • Definition of acceptable risk is primarily science based
The **precautionary principle**	The **anticipation of potential problems** in relation to the environmental impact of the production, use and disposal of a product. The precautionary principle permits a lower level of proof of harm to be used in policy-making whenever the consequences of waiting for higher levels of proof may be very costly and/or irreversible. • Uncertainty • Risk cannot be calculated and is only a suspected risk of causing harm • Occurrence of damage is uncertain and cannot be predicted clearly • Regulation through procedural requirements • Social acceptance of the risk is considered

2.6 Eco Design

Eco-design considers the design of a product throughout its life cycle (from cradle to grave) using lifecycle analysis. Efficient energy use is an important consideration for designers in today's society. Energy conservation and efficient energy use are pivotal in our impact on the environment. A designer's goal is to reduce the amount of energy required to provide products or services using newer technologies or creative implementation of systems to reduce usage. For example, driving less is an example of energy conservation, while driving the same amount but with a higher mileage car is energy efficient.

<table>
<tr><td>Eco Design</td><td>Eco-design is a more comprehensive approach than green design because it attempts to focus on all three broad environmental categories—materials, energy and pollution/waste. This makes eco-design more complex and difficult to do.</td></tr>
<tr><td>Impact of internal and external drivers for eco-design from an economic perspective</td><td>
<table>
<tr><th>Internal drivers for eco-design</th><th>External drivers for eco-design</th></tr>
<tr><td>Manager's sense of responsibility</td><td>Government</td></tr>
<tr><td>The need for increased product quality</td><td>Market demand</td></tr>
<tr><td>The need for a better product and company image</td><td>Social environment</td></tr>
<tr><td>The need to reduce costs</td><td>Competitors</td></tr>
<tr><td>The need for innovative power</td><td>Trade organisations</td></tr>
<tr><td>The need to increase personnel motivation</td><td>Supplies</td></tr>
</table>
</td></tr>
<tr><td>Cradle to grave</td><td>Cradle to grave design considers the environmental effects of a product all of the way from manufacture to use to disposal</td></tr>
<tr><td>Cradle to the Gate</td><td>Cradle to cradle design is a key principle of the circular economy. Cradle to Cradle® (C2C) is a holistic approach to design popularized by Professor Michael Braungart and William McDonough. Braungart and McDonough offer Cradle to Cradle® certification to products that measure up to the standards they set. According to their website: "The target is to develop and design products that are truly suited to a biological or technical metabolism, thereby preventing the recycling of products which were never designed to be recycled in the first place."</td></tr>
<tr><td>Cradle to the Gate</td><td>Cradle to the Gate (Cradle-to-gate is an assessment of a partial product life cycle from resource extraction (cradle) to the factory gate (i.e., before it is transported to the consumer).</td></tr>
<tr><td>Life Cycle stages:</td><td>Make sure you are able to assess the environmental impact of a given product over its life cycle through LCA (Life Cycle Assessment)-Pre-production, Production, Distribution including packaging, Utilization and Disposal. The complex nature of LCA means that it is not possible for a lone designer to undertake it and a team with different specialism is required. LCA is complex, time-consuming and expensive, so the majority of eco-designs are based on less detailed qualitative assessments of likely impacts of a product over its life cycle. The simplest example is the use of a checklist to guide the design team during a product's design development stages.</td></tr>
<tr><td>UNEP Ecodesign Manual</td><td>In 1996 the United nations released an Eco-design manual also known as Design for Sustainability (D4S). The major concerns outlined in the UNEP Ecodesign Manual were to:
increase recyclability
reduce energy requirements</td></tr>
</table>

	• maximise use of renewable resources • reduce creation and use of toxic materials • reduce material requirements of goods and services • increase product durability and reduced planned obsolescence 
Design for the environment software	CAD Software that allows designers to perform Life cycle analysis (LCA) on a product and assess its environmental impact.
Product life cycle stages: **the role of the designer, manufacturer and user**	The roles and responsibilities of the designer, manufacturer and user at each stage of the product life cycle can be explored through LCA. LCA identifies conflicts that have to be resolved through prioritization. It is not widely used in practice because it is difficult, costly and time-consuming. It is targeted at particular product categories—products with high environmental impacts in the global marketplace, for example, washing machines and refrigerators. However, in the re-innovation of the design of a product or its manufacture, specific aspects may be changed after considering the design objectives for green products, such as selecting less toxic materials or using more sustainable sources. A product may be distributed differently or its packaging may be redesigned.
Environmental impact assessment matrix	Environmental considerations include **water, soil pollution and degradation, air contamination, noise, energy consumption, consumption of natural resources, pollution and effect on ecosystems**
Converging technologies	The synergistic merging of nanotechnology, biotechnology, information and communication technologies and cognitive science. A typical example of converging technology is the smart phone in terms of the materials required to create it, its energy consumption, disassembly, recyclability and the portability of the devices it incorporates.

Topic Questions & Exam Practice

Exam Practice Questions

(a) State how "end-of-pipe" relates to clean manufacturing. *[1]*

. . . .

. . . .

(b) Explain **one** reason why many manufacturers may take an incremental approach to the adoption of clean technology. *[3]*

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

(i) Outline what is meant by "the bamboo timber coming from a sustainable resource". [2]

. . . .

. . . .

. . . .

. . . .

Figures 7a and 7b show the Bladefish BF 3000 diving aid. It is designed for relatively inexperienced divers as the maximum depth of use is 30 m and the maximum speed is 4.25 km/h. The Bladefish can be used for 40 minutes before recharging which takes an hour to charge to 80 % capacity. The Bladefish has a 200 W power rating from an 18 V lithium ion battery. It measures 38 cm × 36 cm × 16 cm and weighs 4.4 kg. **Figure 8** shows the Bladefish packed in a standard suitcase.

Figures 7a and 7b: Bladefish diving aid

Figure 8 : Bladefish packed in luggage

(i) Outline one disadvantage of the Bladefish in relation to green design. [2]

Figure 6 shows the Biolite camp stove, an award-winning camping stove which also provides electricity to charge small devices, such as mobile (cell) phones or LED lights. The stove uses biomass fuel such as twigs or pine cones with 46 g of wood required to boil 1 litre of water which takes 4.5 minutes to boil. The stove can also be used with recycled wood pellets. The stove provides 3.4 kW at low power up to 5.5 kW at high power with 20 minutes of charging sufficient for 60 minutes of talk time on a phone. It weighs 935 g (33 oz) and the packed size is 21 cm × 12.7 cm.

Figure 6: Biolite stove

(i) State one disadvantage of the Biolite stove in relation to green design. [1]

(b) Explain **one** reason why many approaches to clean manufacturing tend to be incremental. *[3]*

(i) Outline the life cycle stage of a life cycle analysis (LCA) in which a car has most impact on the environment. *[2]*

Figure 6 shows a small plate and bowl which are part of the Vegware range of tableware. The disposable products are made mainly from compositable bagasse. These particular plates are made entirely, not mainly, from bagasse. All Vegware products are compostable, not 'compositable'. Regarding mass customization: the bagasse range has very limited print options, but can be embossed. The products are more rigid than paper plates and bowls and are suitable for hot, wet and oily foods. The small plate costs UK£3.92 for a pack of 50 or UK£22.61 for a pack of 500 (2013).

Figure 6: Vegware plate and bowl

Evaluate the environmental effects of the Vegware tableware in relation to the production, distribution and disposal stages of its product life cycle. *[9]*

5. **Figure 3** shows the MK2 Trans Furniture table. It can be used as a coffee table or as a dining table to seat 6 people or as a large desk. It is transformed from a coffee table into a table or desk in two easy moves. The MK2 table is made from a steel alloy and is available with a variety of different coloured surface finishes. A similar version of the MK2 table is made from plywood, also with a variety of different surface finishes.

Figure 3: MK2 Trans furniture steel alloy table

(ii) Explain why the MK2 steel table may contribute to a green design policy. *[3]*

7. **Figure 4** shows the Viber Burst kinetic phone charger concept designed by Australian design student Josh Pell. The charger has various surface designs and could be worn as a piece of jewellery or stored in a handbag or pocket. The Viber Burst has been designed to store energy created by body movements and to have a very long life cycle compared to chemical battery technology, which loses capacity to recharge in a relatively short life cycle time. The Viber Burst is designed to be made from a thermoplastic material which is heat resistant and moisture resistant.

Figure 4: Viber Burst phone charger

(ii) Outline why the charger can be considered a combination of radical and incremental design. *[2]*

(b) (i) Outline **one** green design objective satisfied by the charger. *[2]*

9. **Figure 6** shows a traditional design of a wooden pencil manufactured by the German company Faber-Castell. Faber-Castell have manufactured wooden pencils since 1761. The softwood casing is bonded to the graphite lead with epoxy resin glue. Although wooden pencils are very cheap nowadays, they were extremely expensive in 1761. Since 1761 the company has expanded its range of pencils to include ones with integrated sharpeners and erasers, cosmetic pencils and mechanical pencils. **Figure 7** shows a solid silver mechanical pencil from the Faber-Castell range. The silver casing has a space for a name to be engraved on it. It is an internationally-agreed legal requirement that all solid silver products are hallmarked. A hallmark identifies the manufacturer, the date and place of manufacture, and the silver content.

Figure 6: Faber-Castell wooden pencil

[Used with permission from Faber-Castell]

Figure 7: Faber-Castell solid silver mechanical pencil

[Used with permission from Faber-Castell]

(a) (i) Outline **one** way in which the silver pencil may be considered a green product. *[2]*

(a) Outline **one** reason why hardwood timber may be considered as a non-renewable resource. *[2]*

Figure 5 shows the Minima office bottle and can crusher manufactured by Reduit. The outer casing is made from a thermoplastic material. Inside the casing, metal plates are powered by an electric motor to crush plastic bottles and steel or aluminium cans to 20% of their original size. The crushed cans/bottles then drop into a plastic bag. The crusher is operated by pressing a button on the top surface which also has a digital screen to show how much carbon might have been saved each time it is used.

Figure 5: Minima Office Bottle/Can Crusher

Explain **three** limitations of the Minima as an environmentally friendly product. *[9]*

4. **Figure 3** shows shoes made by the company Terra Plana. The traditional shoe-making industry is not usually environmentally-friendly as: chemicals are used for treating leather; glues are toxic; the process of manufacture is energy intensive. Where possible the parts of the Terra Plana shoe are stitched together rather than glued but if gluing is necessary then water-based glue is used and all dyes are non toxic. However, some shoes feature a lightweight, glueless, changeable sole. The material used for the inner lining of the shoe is made from recycled plastic bottles.

Figure 3: Terra Plana shoes

(ii) Discuss the concepts of reuse, repair and recycling in relation to the Terra Plana shoes. *[9]*

Glossary of Terms

Glossary of Terms

Topic 2 : Resource management and sustainable production

Term	Definition
Circular economy	An economy model in which resources remain in use for as long as possible, from which maximum value is extracted while in use, and the products and materials are recovered and regenerated at the end of the product life cycle.
Clean technology	Products, services or processes that reduce waste and require the minimum amount of non-renewable resources.
Combined Heat and Power (CHP)	A system that simultaneously generates heat and electricity from either the combustion of fuel, or a solar heat collector.
Converging technologies	The synergistic merging of nanotechnology, biotechnology, information and communication technologies and cognitive science.
Cradle to cradle	A design philosophy that aims to eliminate waste from the production, use and disposal of a product. It centres on products which are made to be made again.
Cradle to grave	A design philosophy that considers the environmental effects of a product all of the way from manufacture to disposal.
Dematerialization	The reduction of total material and energy throughput of any product and service.
Design for the environment software	Software that allows designers to perform Life cycle analysis (LCA) on a product and assess its environmental impact.
Eco-design	A design strategy that focusses on three broad environmental categories - materials, energy, and pollution/waste.
Embodied energy	The total energy required to produce a product.
End-of-pipe technologies	Technology that is used to reduce pollutants and waste at the end of a process.
Energy distribution	The method with which energy is transported from a source to where it is used.
Energy storage	The method with which energy is stored for later use.
Energy utilization	The method with which energy is used.
Green design	Designing in a way that takes account of the environmental impact of the product throughout its life.
Green legislation	Laws and regulations that are based on conservation and sustainability principles, followed by designers and manufacturers when creating green products.
Incremental solutions	Products which are improved and developed over time leading to new versions and generations.
Individual energy generation	The ability of an individual to use devices to create small amounts of energy to run low-energy products.
Legislation	Laws considered collectively to address a certain topic.
Life cycle analysis (LCA)	The assessment of the effect a product has on the environment through five stages of its life: pre-production; production; distribution (including packaging; utilization; and disposal.

Linear economy	An economy based on the make, use, dispose model.
Local combined heat and power (CHP)	CHP plants that generate heat and power for a local community - the plant is close enough to the community so that the heat generated can be dispersed through the community efficiently.
National and international grid systems	An electrical supply distribution network that can be national or international. International grids allow electricity generated in one country to be used in another.
Non-renewable resources	A natural resource that cannot be re-made or re-grown as it does not naturally re-form at a rate that makes its use sustainable, for example, coal, petroleum and natural gas.
Product cycle	Also known as the product life cycle, it is a cycle that every product goes through from introduction to withdrawal or discontinuation.
Product recovery strategies	The processes of separating the component parts of a product to recover the parts and materials.
Quantification of carbon emissions	Defining numerically the carbon emissions generated by a particular product
Radical solutions	Where a completely new product is devised by going back to the roots of a problem and thinking about a solution in a different way.
Recondition	Rebuilding a product so that it is in an "as new" condition, and is generally used in the context of car engines and tyres.
Recovery of raw materials	Strategies for the separation of components of a product in order to recover raw materials.
Recycle	Recycling refers to using the materials from obsolete products to create other products.
Re-engineer	To redesign components or products to improve their characteristics or performance.
Renewability	The level at which a resource is renewable. The rate that a resource can be replenished.
Renewable resources	A natural resource that can replenished with the passage of time, or does not abate at all.
Repair	The reconstruction or renewal of any part of an existing structure or device.
Reserves	Reserves are natural resources that have been identified in terms of quantity and quality.
Resources	Resources are the stock or supply of materials that are available in a given context.
Re-use	Reuse of a product in the same context or in a different context.
System level solutions	Solutions that are implemented to deal with the whole system, rather than just components.
The precautionary principle	The anticipation of potential problems in relation to the environmental impact of the production, use and disposal of a product.
The prevention principle	The avoidance or minimization of producing waste in relation to the production, use and disposal of a product.
Waste mitigation strategies	Strategies used to reduce the waste produced by a product or in the production and disposal of a product.

DP DESIGN TECHNOLOGY

WITH

Mr Moneeb

TOPIC 2: Guidance and Notes Booklet
2020 - 2022