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Can we achieve a
more sustainable
economy by better
management of our
resources?



Michael J Cullis

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Low carbon economy

Low fossil fuel economy

Decarbonised economy



An economy based on low carbon power sources that therefore has a minimal output of greenhouse gas (GHG) emissions into the biosphere

Refers to the greenhouse gas carbon dioxide.

GHG emissions due to anthropogenic (human) activity are the dominant cause of observed global warming (climate change) since the mid-20th century

Continued emission of greenhouse gases may cause long-lasting changes around the world, increasing the likelihood of severe, pervasive and irreversible impacts for people and ecosystems.

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Resources...

- land
- labour
- capital

...also...

- energy
- entrepreneurship
- information
- experience
- time
- management



Maybe an answer lies with effective and efficient management!

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- Are we able to be effective?

Efficient use of resources

- Are we able to be efficient?

Cleaner technologies

Renewable resources

- ...doing the right thing!

Design with nature in mind

- ...doing the right thing...
right!

Less waste

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The current model is
not working!

Economics

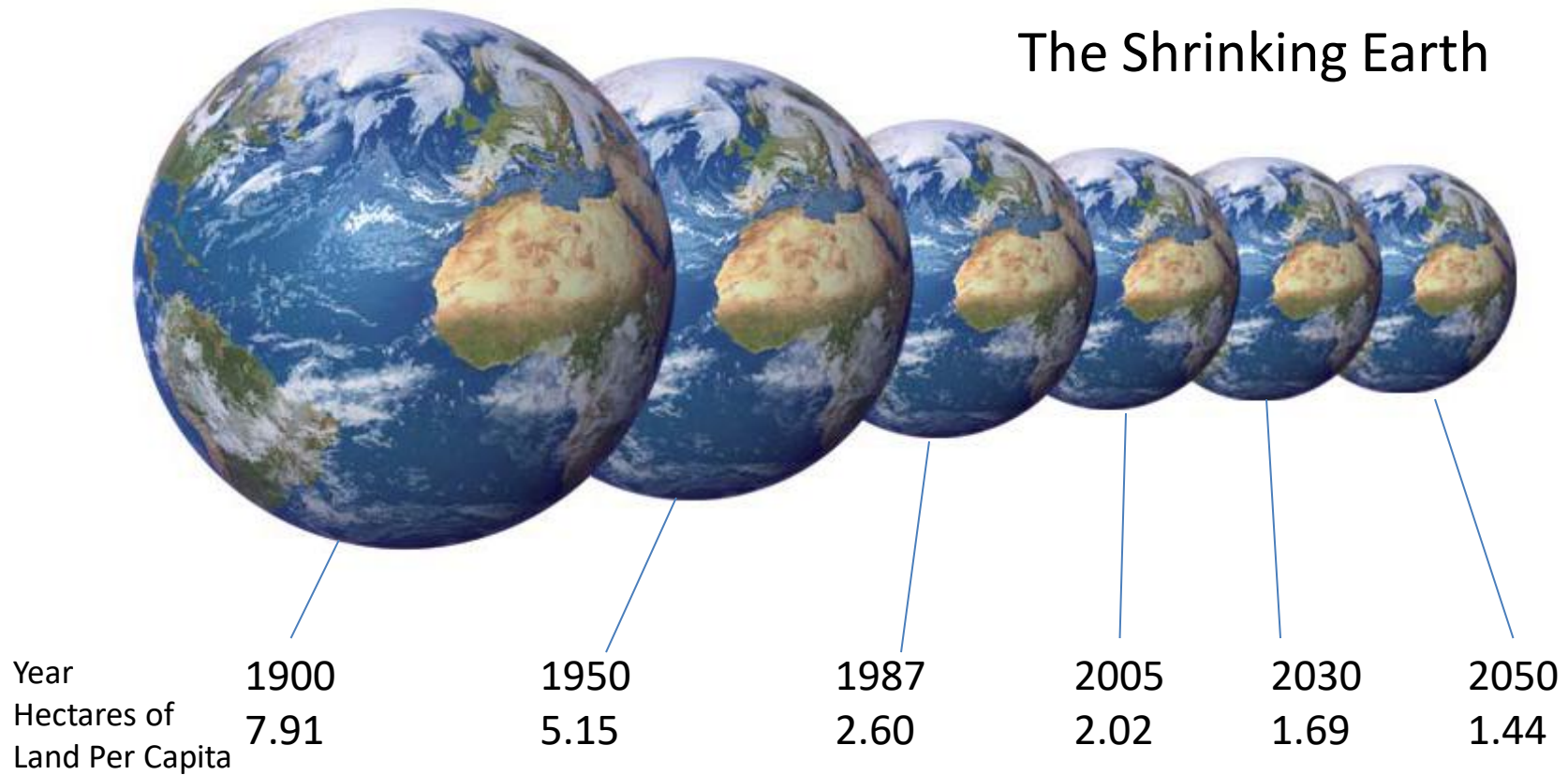
- Non-renewable resources
- Pollution
- Eco-system
- Growth
- Waste



Source: Guardian, Beijing's waste

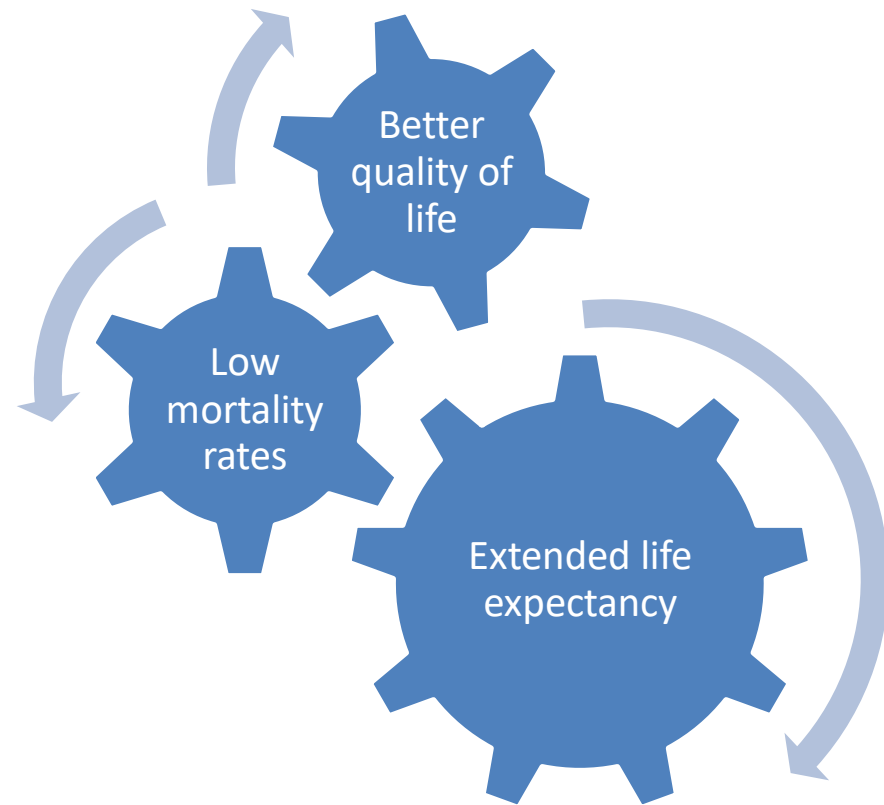
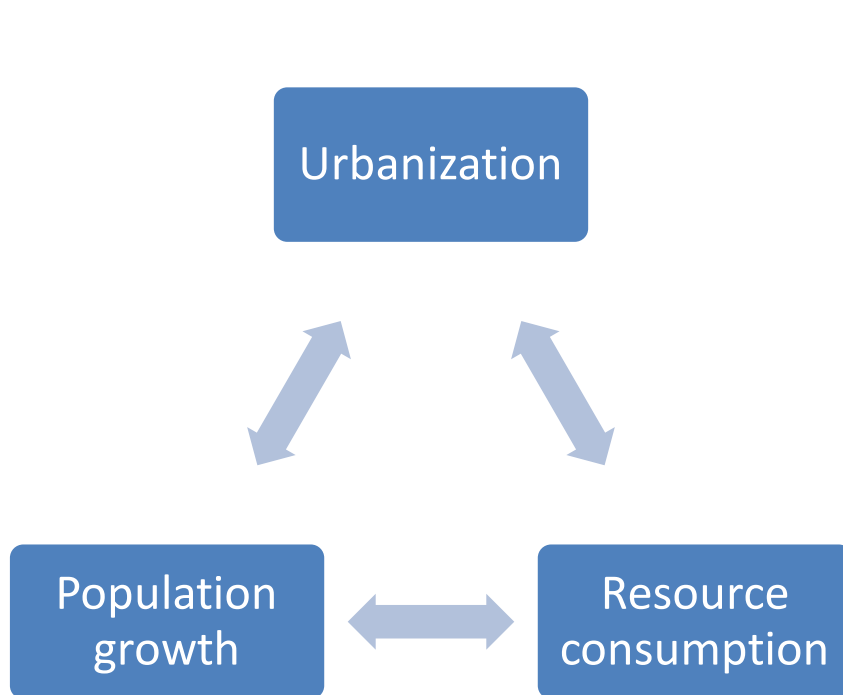
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The Shrinking Earth



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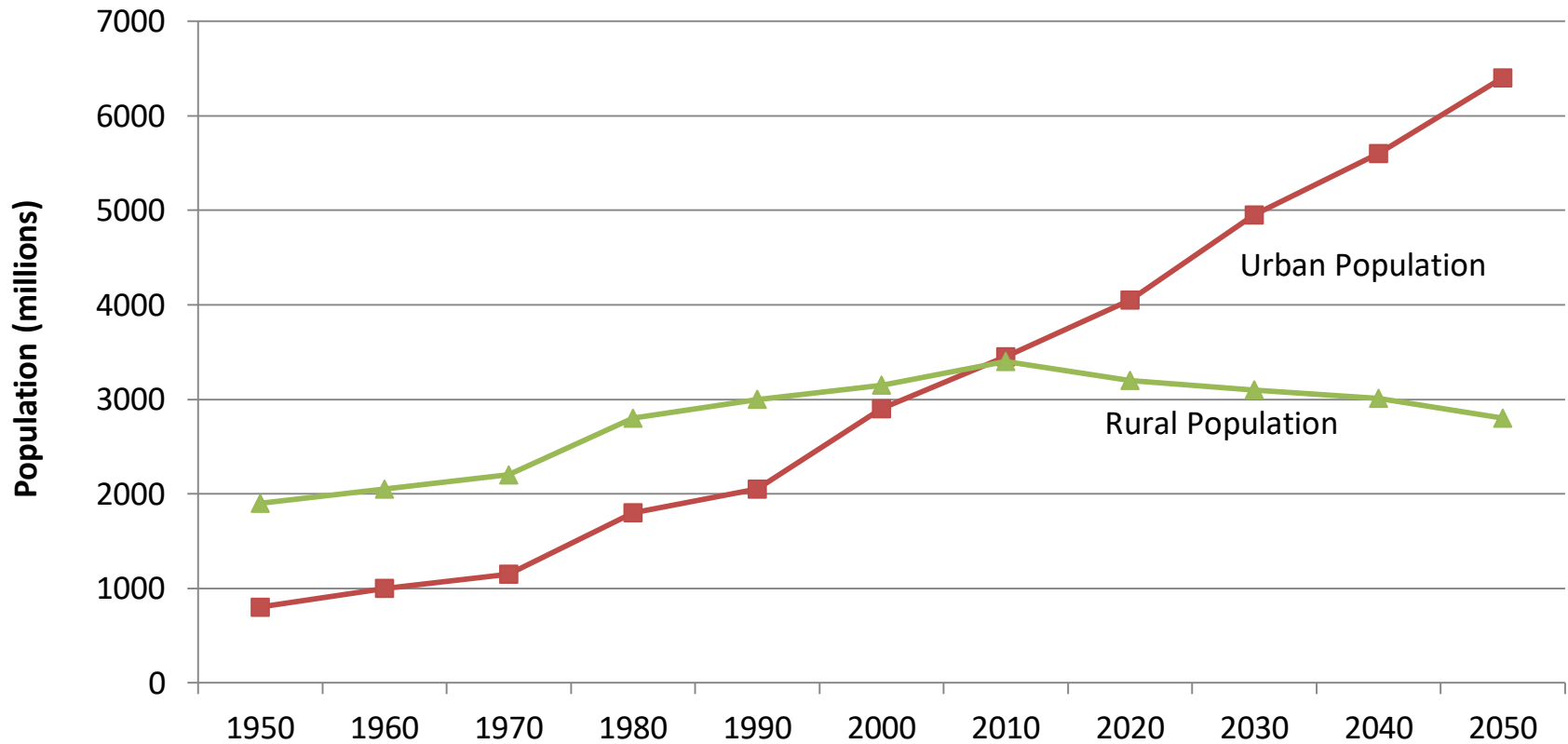
Significant impacts



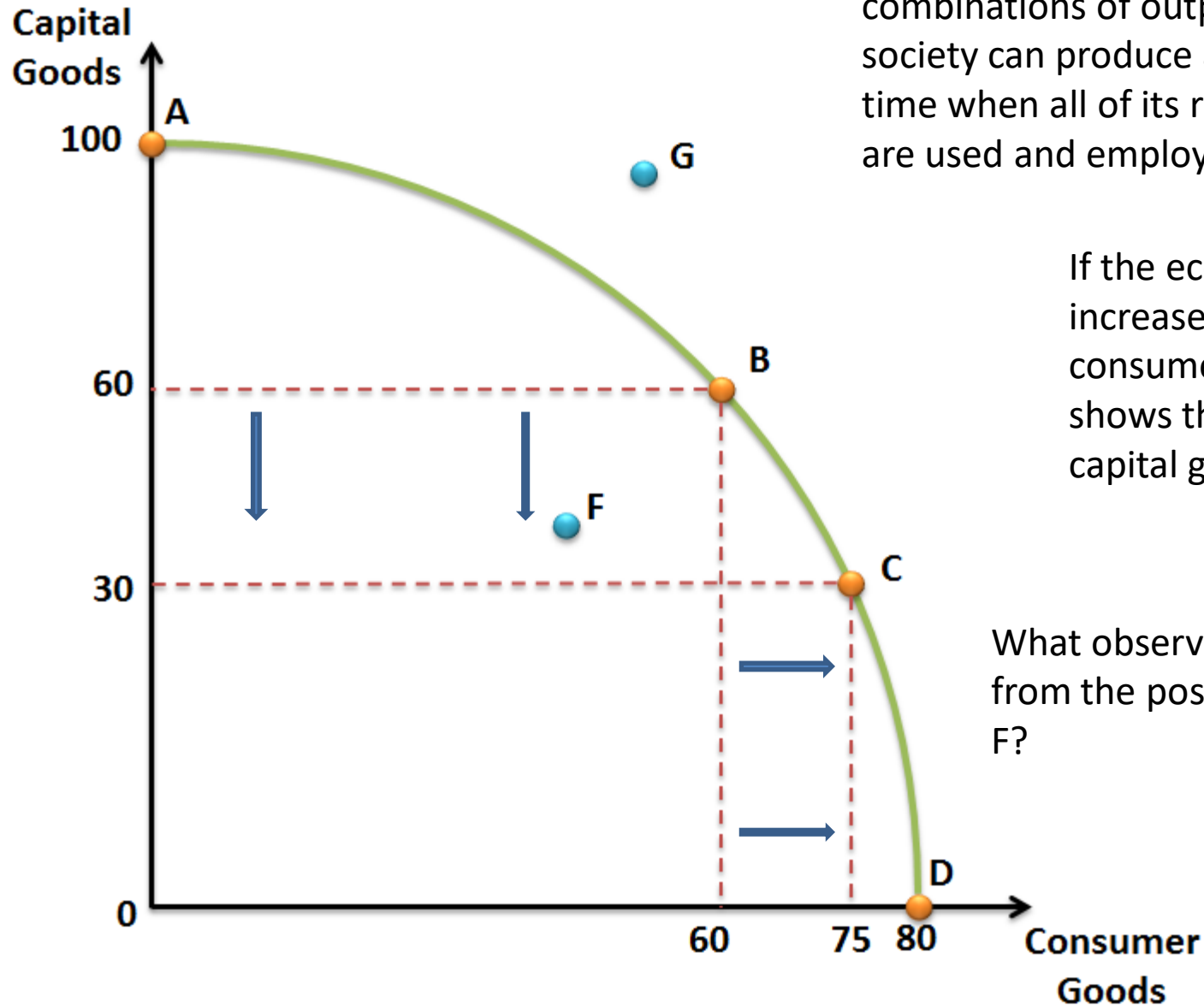
Drivers for urbanization

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Global Urban & Rural Populations 1950 - 2050



Production Possibility Curve



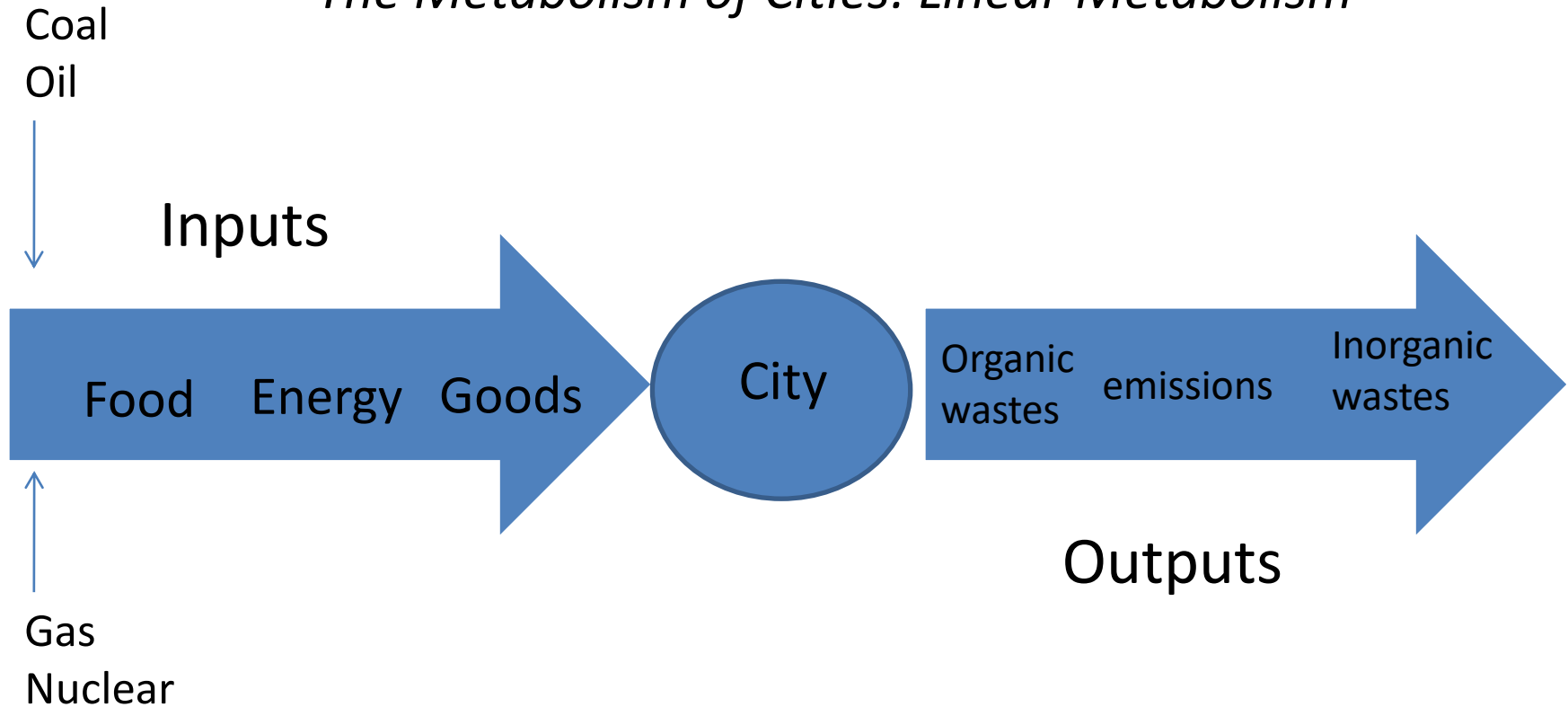
The PPC shows the different combinations of output that society can produce at any one time when all of its resources are used and employed.

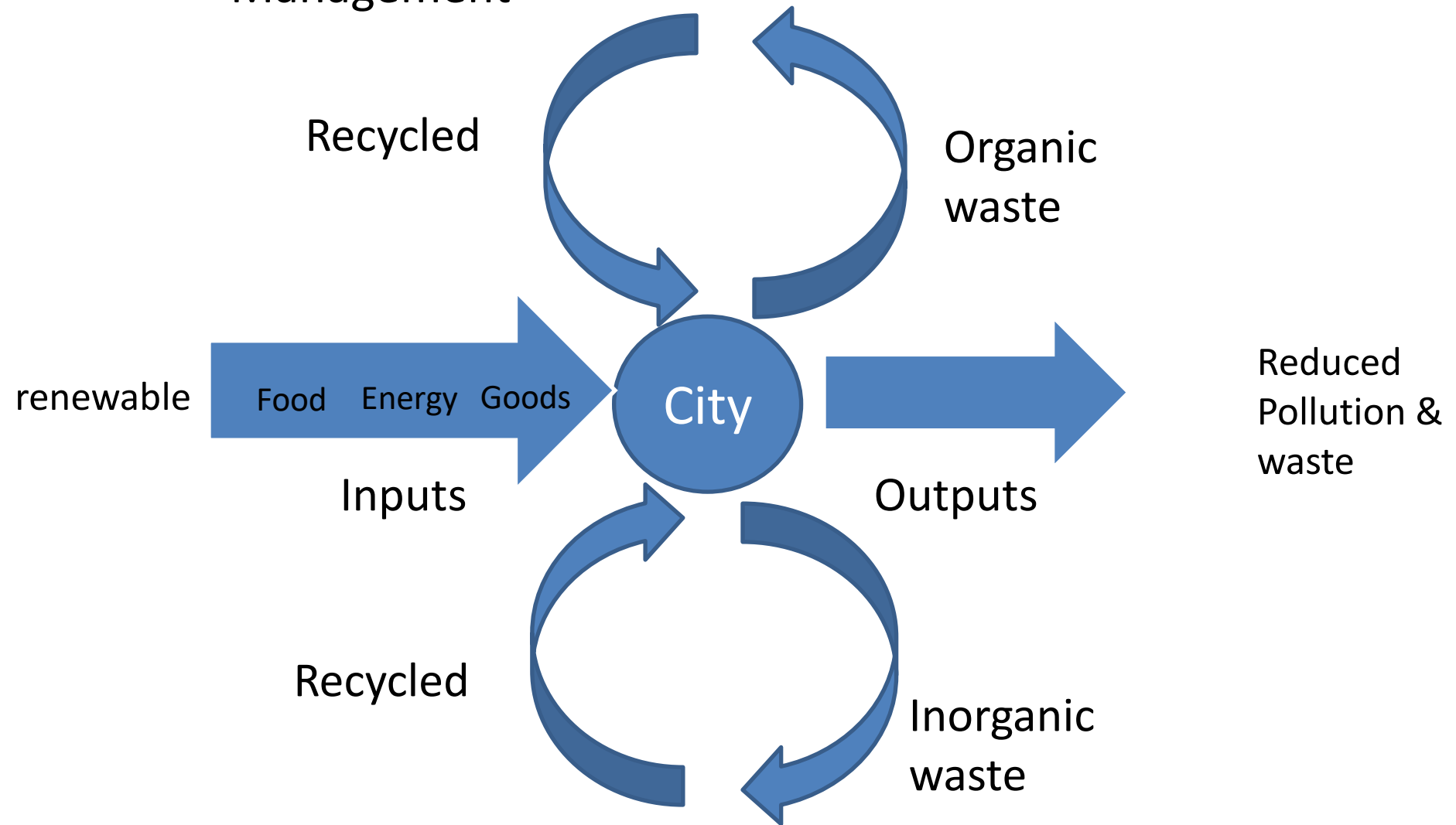
If the economy wished to increase its output of consumer goods, then it shows that the output of capital goods would decrease.

What observations are made from the position of points G and F?

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The Metabolism of Cities: Linear Metabolism





The Metabolism of Cities: Circular Metabolism

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A significant amount of our scarce resources are wasted...

Some facts about waste (UK 2017)...

- Total waste 222.9 MT
- Waste from households(WfH) 26.9 MT
- Recycling 12.3 MT
- BMW (landfill) 7.4 MT
(Total Waste 15.3 MT)
- Packaging waste 11.5 MT
- Commercial & Ind 41.1 MT
- Construction & Dem 66.2 MT

Waste generation split by source, UK, 2016

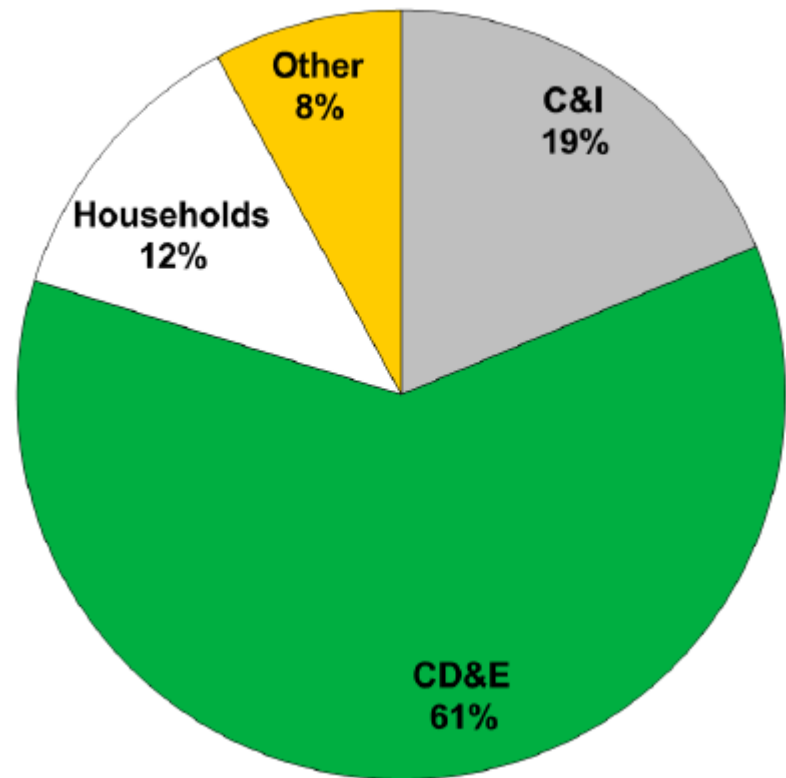
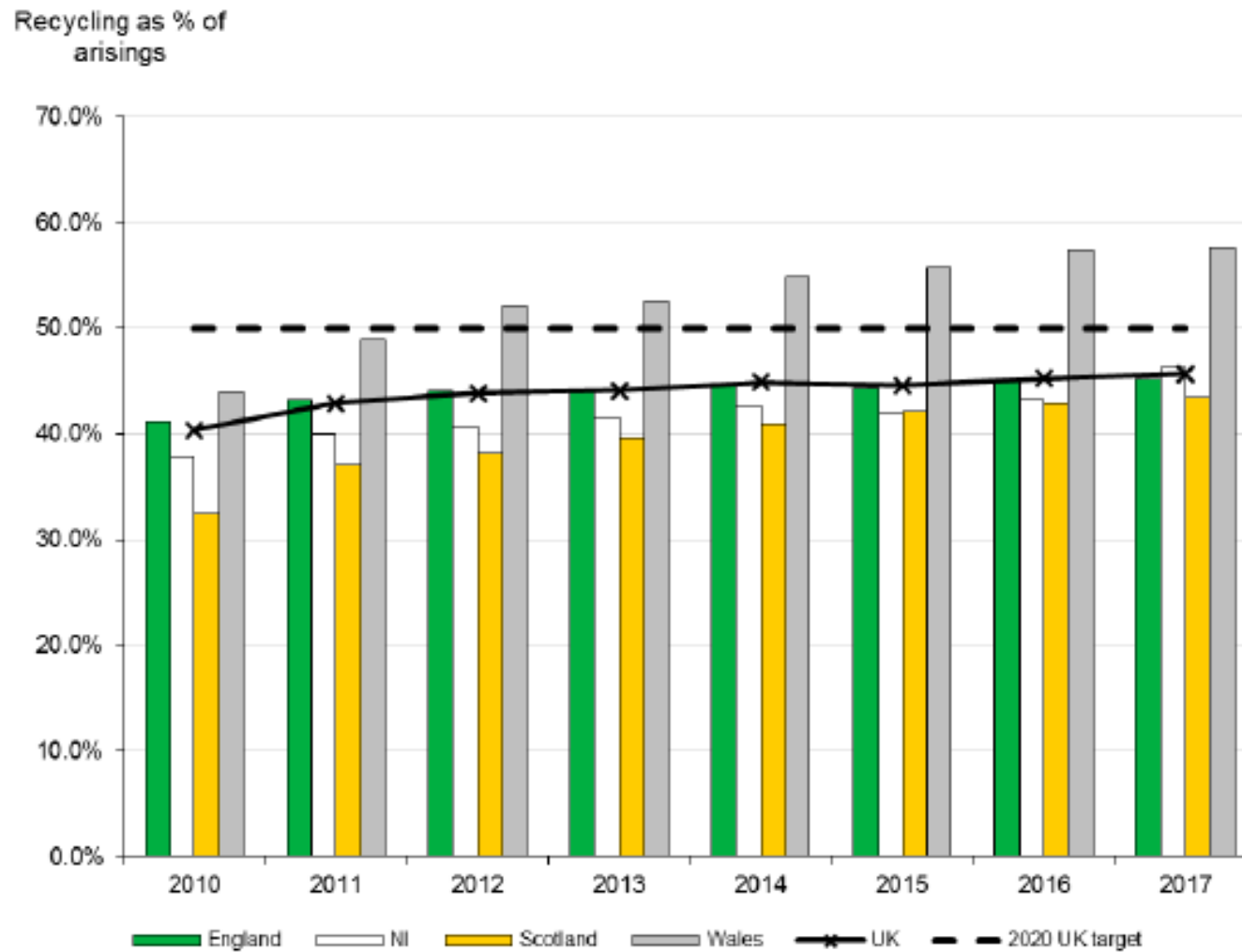


Table 1. Waste from Households, UK and country split, 2010-17

thousand tonnes and % rate

Year	Measure	UK total	England	Northern Ireland	Scotland	Wales
2010	Arisings	26,954	22,131	829	2,649	1,344
	<i>Of which recycled (excl. IBAm)</i>	10,878	9,112	314	861	591
	Recycling rate	40.4%	41.2%	37.8%	32.5%	44.0%
2011	Arisings	26,792	22,170	810	2,482	1,329
	<i>Of which recycled (excl. IBAm)</i>	11,492	9,596	324	921	651
	Recycling rate	42.9%	43.3%	40.0%	37.1%	49.0%
2012	Arisings	26,428	21,956	783	2,383	1,306
	<i>Of which recycled (excl. IBAm)</i>	11,594	9,684	319	911	681
	Recycling rate	43.9%	44.1%	40.7%	38.2%	52.1%
2013	Arisings	25,929	21,564	781	2,310	1,274
	<i>Of which recycled (excl. IBAm)</i>	11,433	9,523	324	916	669
	Recycling rate	44.1%	44.2%	41.5%	39.6%	52.5%
2014	Arisings	26,795	22,355	806	2,348	1,285
	<i>Of which recycled (excl. IBAm)</i>	12,035	10,025	344	962	704
	Recycling rate	44.9%	44.8%	42.6%	41.0%	54.8%
2015	Arisings	26,675	22,225	818	2,354	1,278
	<i>Of which recycled (excl. IBAm)</i>	11,795	9,752	344	989	709
	Recycling rate (excl. IBAm)	44.2%	43.9%	42.1%	42.0%	55.5%
	<i>Of which recycled (incl. IBAm)</i>	11,898	9,849	z	991	713
2016	Recycling rate (incl. IBAm)	44.6%	44.3%	z	42.1%	55.8%
	Arisings	27,300	22,770	845	2,378	1,307
	<i>Of which recycled (excl. IBAm)</i>	12,198	10,074	366	1,017	741
	Recycling rate (excl. IBAm)	44.7%	44.2%	43.3%	42.8%	56.7%
2017	<i>Of which recycled (incl. IBAm)</i>	12,351	10,219	z	1,020	749
	Recycling rate (incl. IBAm)	45.2%	44.9%	z	42.9%	57.3%
	Arisings	26,897	22,437	843	2,345	1,271
	<i>Of which recycled (excl. IBAm)</i>	12,093	9,959	390	1,018	726
2017	Recycling rate (excl. IBAm)	45.0%	44.4%	46.3%	43.4%	57.1%
	<i>Of which recycled (incl. IBAm)</i>	12,282	10,139	z	1,019	733
2017	Recycling rate (incl. IBAm)	45.7%	45.2%	z	43.5%	57.6%

Recycling rate from Waste from Households, UK and country split, 2010-17



Source : WasteDataFlow, Defra Statistics

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Food waste...

Around 7 MT wasted each year

Farm to plate may increase this to
some 22 MT!

About one third of all food purchased
is thrown away – at least half of this
is edible!

Food produced in the UK amounts to
around 116MT CO₂

Total greenhouse gases amounts to
around 2.2 tonnes /PP /Yr

Some 1.9 Tonnes are avoidable

Landfilling food waste adds some
0.22Tonnes of CO₂ PP/Yr



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“The only place that waste exists is between our ears. It has never existed in nature and never will. Waste is there as a concept because we allow it to be.”

Gerry Gillespie, resource, Vol.1,No.2, 2002

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Waste Management Options: Landfill

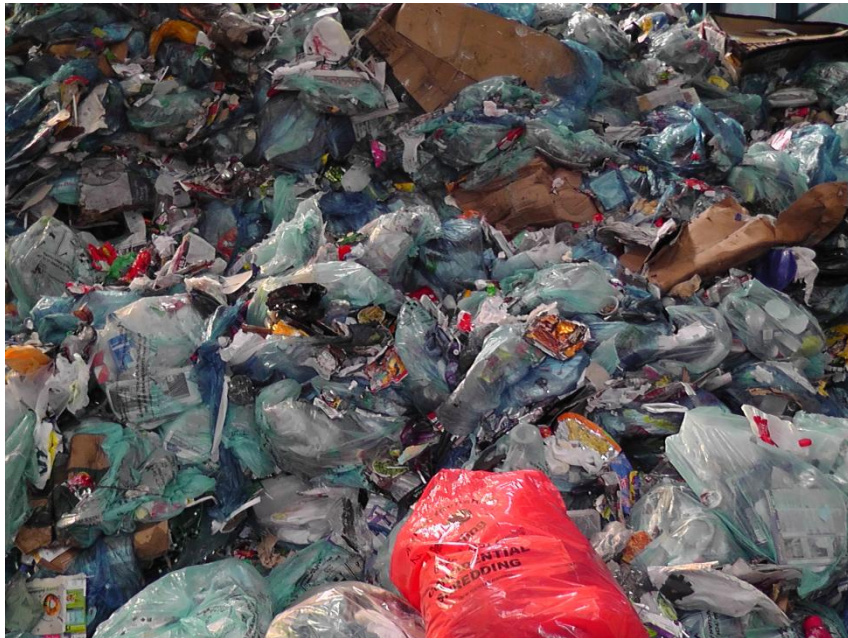
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The EC Landfill Directive

- came into force in July 2002
- The Landfill (England and Wales) (Amendment) Regulations 2005
- Key aims are related to environmental protection & consistency in practice and standards across Europe
- Proposes to reduce the amount of waste going to landfill

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Objective of the Landfill Directive Article 1

'...to provide for measures, procedures and guidance to prevent or reduce as far as possible negative effects on the environment, in particular the pollution of surface water, groundwater, soil and air, and on the global environment, including the greenhouse effect, as well as any resulting risk to human health, from landfilling of waste during the whole life cycle of the landfill.'

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- Landfill Schedules provides guidance and gives advice on...
 - general requirements for landfills
 - details on monitoring landfills
 - transitional arrangements...and...

offers updates to other subordinate legislation



Landfills can be classified as hazardous, non-hazardous or inert sites

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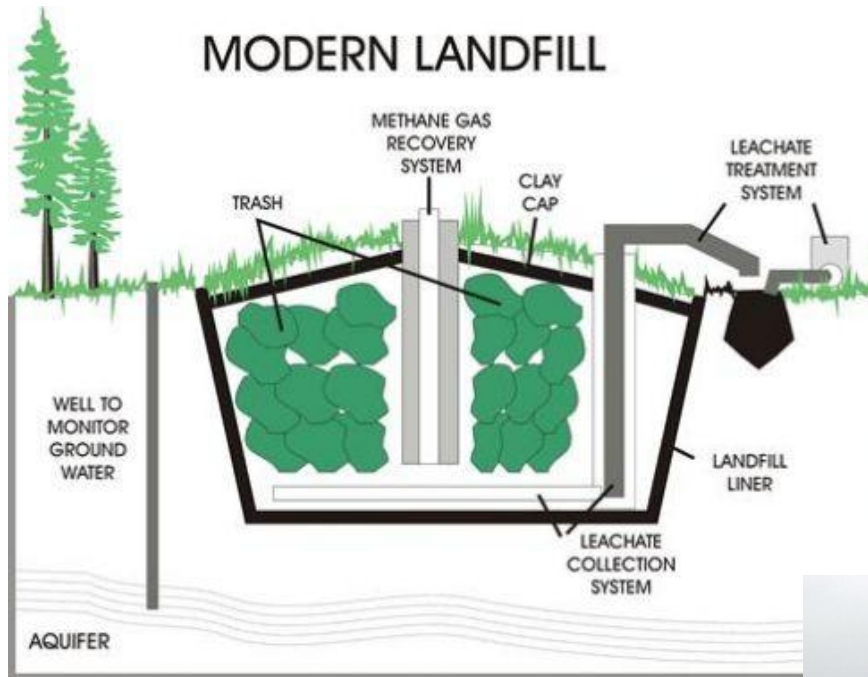
- A landfill site is a **waste disposal site** where waste is deposited onto or into land.
- This includes sites that:
 - receive waste from external sources
 - are used by waste producers to dispose of their own waste on-site. This includes farm dumps.
- It does **not** normally include sites where waste is:
 - intended for disposal, and is stored for less than one year
 - intended for recovery or treatment, and is stored for less than three years
 - prepared for transport for recovery, treatment or disposal elsewhere.

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Landfill Directive Targets

- 2010 reduce BMW landfilled to 75% of 1995 levels
- 2013 reduce BMW landfilled to 50% of 1995 levels
- 2020 reduce BMW to 35% of 1995 levels





Landfill Technology



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Implications for businesses

- Landfill sites must be classified
- Waste must be identified
- Waste must be treated
- Some wastes will be banned from going to landfill



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- Landfill tax is a tax on waste that is disposed of at a permitted landfill site
- Aim to encourage people to reduce the amount of waste they send to landfill
- There are two rates for landfill tax:
 - Standard rate: £91.35 per tonne.
 - Lower rate for inactive waste, such as rocks and soil: £2.90 per tonne.
- Landfill operators must register with HM Revenue and Customs in order to charge landfill tax for waste disposed of at your site.

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Under the Landfill Directive,
all waste going to landfill must
be pre-treated

Exceptions:

Inert waste where it is
technically not feasible to do
so

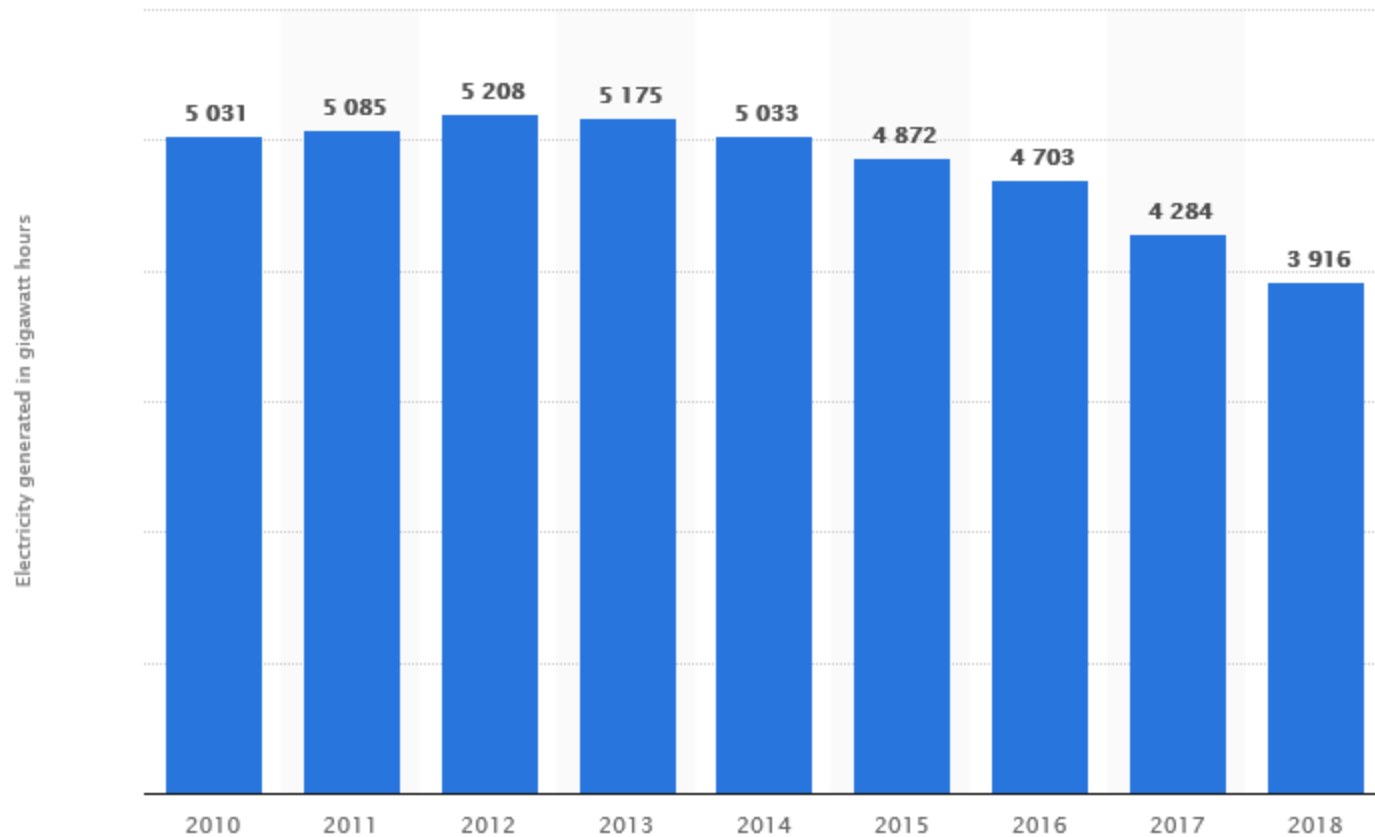
Any other waste where the
quantity or hazardous nature
waste cannot be reduced







Electricity generation from landfill gas in the United Kingdom (UK) 2010-2018



Future Landfill Sites!



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The case for energy from waste!

- the key factor is its comparison with landfill
- Potential contribution to climate change
- Release of greenhouse gases different for each
- Balancing the many factors is complex
- Efficiency is key
- Proportion of renewable waste is significant



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- Energy from waste as an energy source
 - Valuable domestic energy source
 - Decarbonises energy generation
 - Can complement other renewable energy sources
 - Innovation
 - Financial incentives



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- EfW Infrastructure

- Fuel
- Pre-treatments
- Process

- Technologies

- Incineration
- Advanced thermal treatments

Size and site of plant will influence
appropriate technology!

Controversial!

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Waste Incinerator Technologies

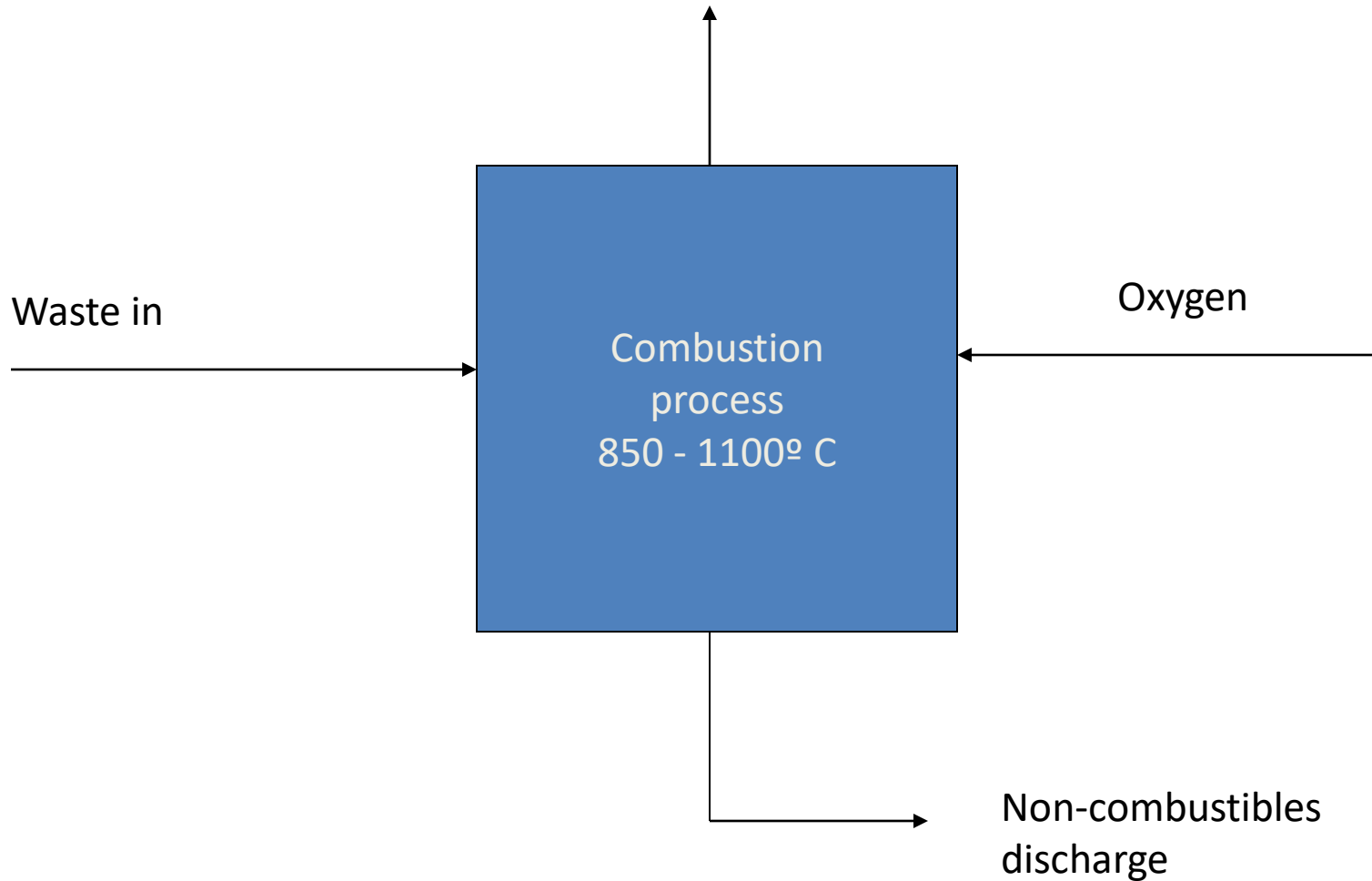
- Mass Burn
- Fluidised Bed Combustion
- Pyrolysis
- Gasification



Source: <https://www.geograph.org.uk/photo/2148313>

Incineration Process

Exhaust gases < 300° C



Furnace Gas Temperatures

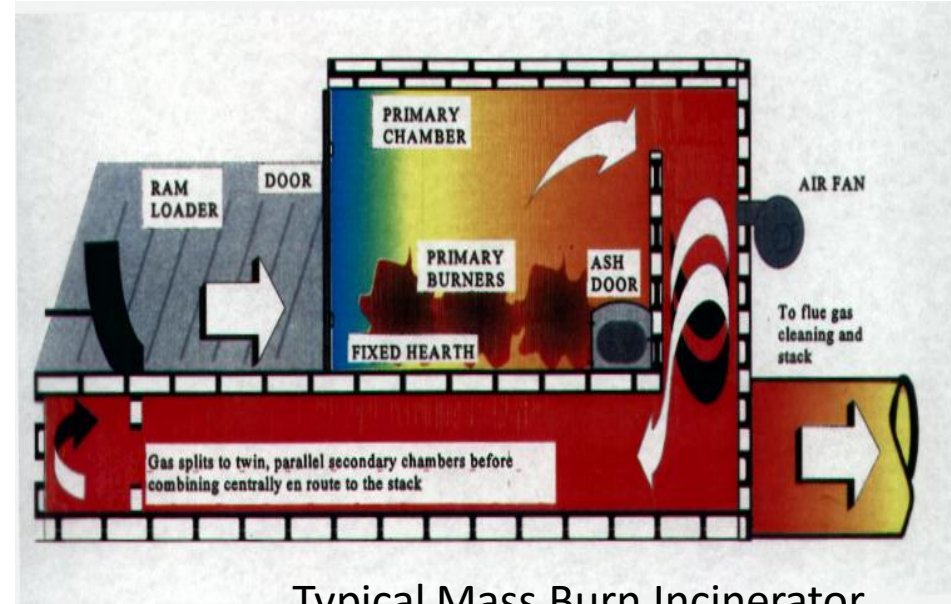
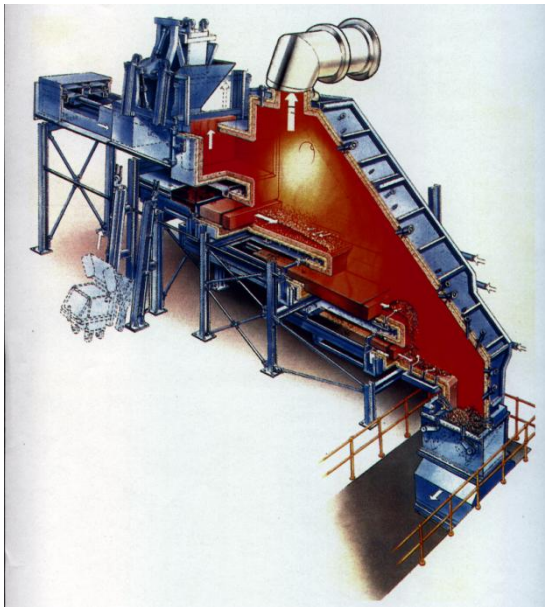
Process	Min. Temp. ° C
Chemical waste	850 (1100)
Clinical waste	1000 (1100)
Municipal waste	850
Animal waste	850
Sewage sludge	850
Drum recovery	850 (1100)

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Criteria which govern efficient
combustion of furnace gases

Adequate oxygen content

High temperature to promote
combustion



Typical Mass Burn Incinerator

Sufficient time to complete
combustion reactions

Turbulence to promote mixing

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Potential Global and Local Environmental Benefits of Incineration

- Reduced consumption of landfill capacity;
- Destruction of potentially harmful substances;
- Where combined with energy recovery, the reduction of releases from fossil fuel consumption.

Potential Disbenefits

- Formation and concentration of harmful substances which could be released to air or which may require special conditions when landfilled
- If inappropriately applied, outside of the waste hierarchy, incineration could lead to the removal of waste streams which should be more appropriately reused or recycled.

Furnace Requirements

- Minimise releases
- Sufficient residence time
- Controlled air supply



Main Pollutants from waste Incineration



- Gases
- Metals
- Organic substances
- Particulate matter

The climate-relevant CO₂ emissions from waste incineration are determined by the proportion of waste whose carbon compounds are assumed to be of fossil origin.

Issues To Be Addressed

- Which chemicals are of concern?
- How are the risks from individual chemicals evaluated:
 - the hazards?
 - exposure considerations?
- Application of standards and guidelines

The risks in context:

Other sources of exposure

Other means of waste management

What are the conclusions?

Source of Chemicals in Emissions

Stack and fugitive emissions to air,
effluent and ash:

Present in the waste stream

Created by the incineration
process

Secondary products

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Health Effects of Particular Concern to Humans

- Carcinogenicity
- Effects on reproduction such as foetal abnormalities
- Effects on young children
- Immunological damage
- Hormonal disturbances*

Some Facts About Dioxins

Several hundred dioxins and related substances (e.g. PCBs), many very persistent in the environment/ body

Wide range of chronic toxicities both in nature and potency

Present in fresh waste, also produced by most combustion processes

Predominant source of exposure is diet (fatty foods)

No air quality standard

Probable threshold for each effect

The Case of PM₁₀

Many sources unclear how effects
vary with nature of particle

Acute effects mainly respiratory and
heart



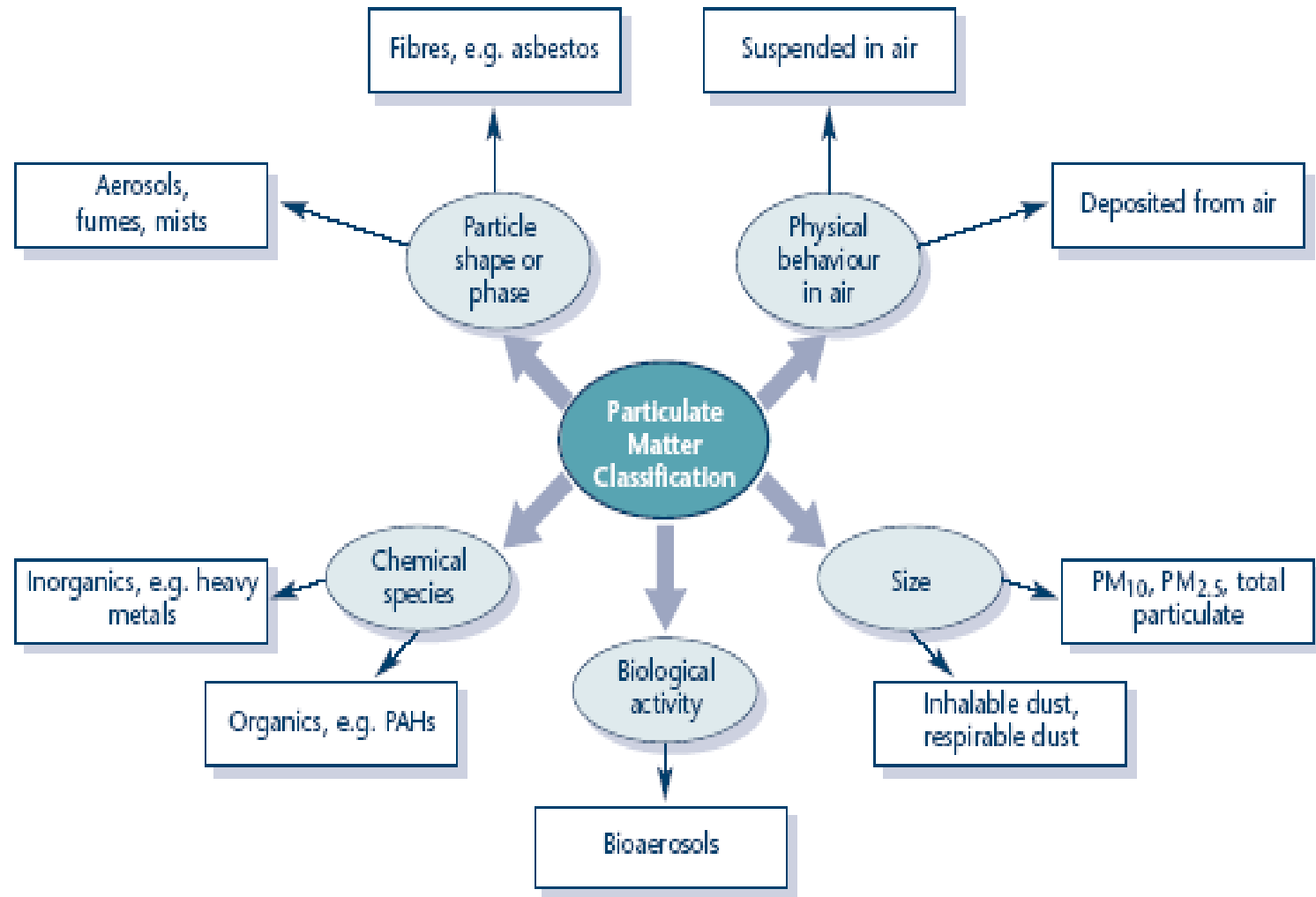
Source: Evening Standard



Source: Daily Mail

Vulnerable groups: those with
severe respiratory and coronary
disease for which there may be
no threshold

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Common means of classifying particulate matter (EA)

INCINERATING LESS, RECYCLING MORE

People are willing to do their bit:

50% would pay £30 each year for more recyclable packaging

70% of people are happy to separate their food waste

Challenge for most; current system is too complicated...

higher levels of recycling, especially plastics, could:

save £6.2 billion from 2020 to 2050

avoid the need to build 20 additional incinerators

reduce GHG emissions

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Maybe increasing the targets...

recycling min 65% of all waste

75% of plastic packaging, both by 2030!



Plastic rubbish collected on the bottom of the Thames.
Photograph: Trustees of the Natural History Museum

clearer labelling: recyclable or not!

reduce / restrict hard to recycle plastics by 2025!

separate food waste collection by 2025!

The Future for Packaging

- Mixed messages
 - Need to push on packaging innovation
 - End-of-life
 - Multiple conflicting signals
 - Convenience
 - Progress



THE COURTAULD COMMITMENT

The Courtauld Commitment is a voluntary agreement aimed at improving resource efficiency and reducing waste within the UK grocery sector.



Courtauld 2025

Our ambitious voluntary agreement brings together organisations across the food system to make food & drink production and consumption more sustainable.

At its heart is a ten-year commitment to identify priorities, develop solutions and implement changes to cut the carbon, water and waste associated with food & drink by at least one-fifth in 10 years.



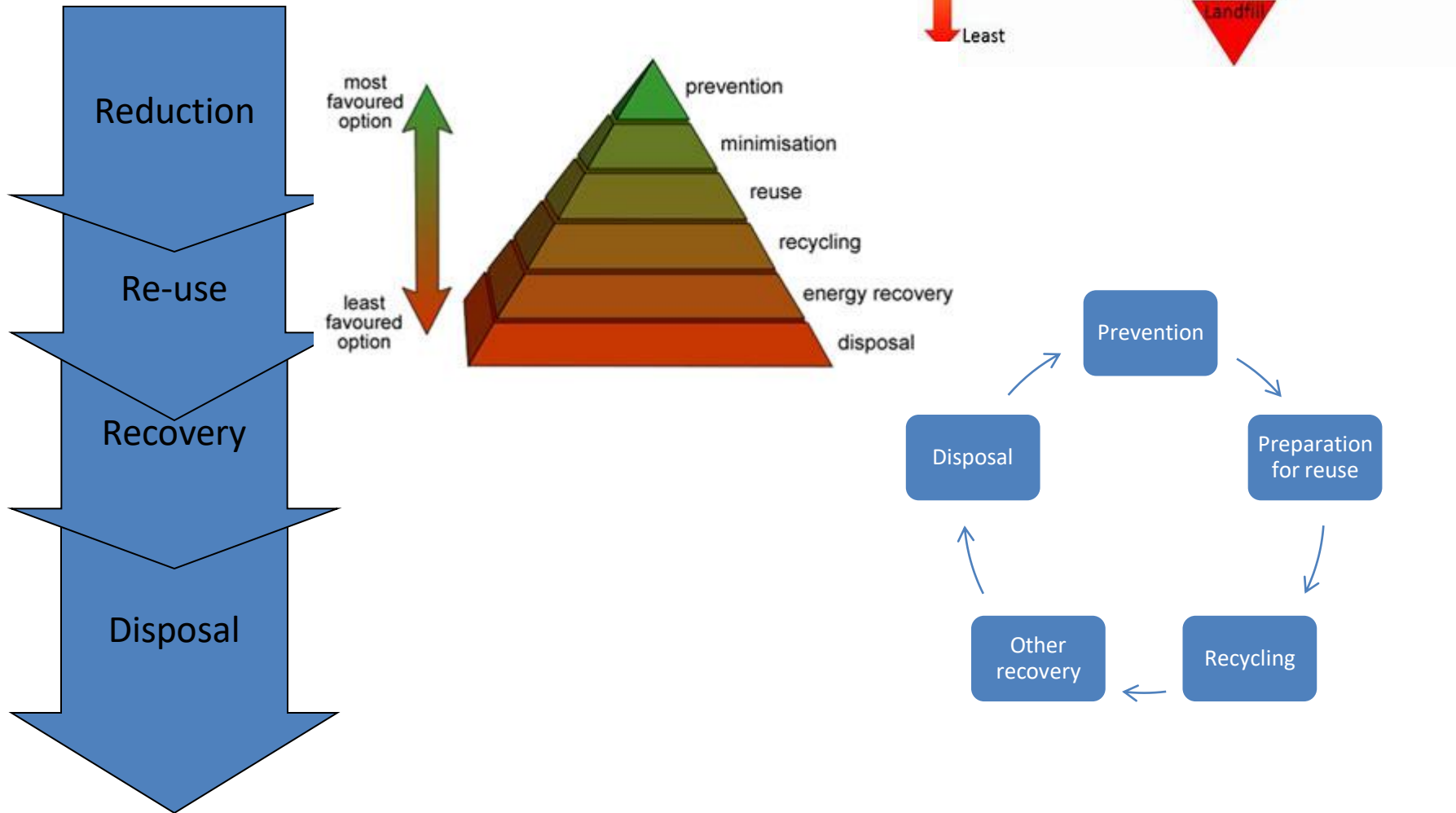
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More on Recycling...



Waste Hierarchies

Provides a framework for waste disposal practices...



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Some benefits of recycling



- Reduces disposal impact
- Consumer participation
- Stimulates employment and the local economy

- Extends the life and maximises the value extracted from raw materials
- Energy savings



Recycling: some disadvantages



- Collection, transporting and reprocessing costs
- Possible higher costs of recycled materials
- Market instability
- Disamenity

Some Challenges for Industry regarding recycling

Construction for example...

technical issues

attitudinal issues



economic issues

administrational issues

Can we Design Waste out of Construction?

- Effective and efficient management of resource use then is needed
 - How?
 - Minimise waste
 - Eliminate waste!!
 - Why?
 - Avoids environmental harm



Designing Waste out of Construction

Key drivers to eliminate / reduce waste

- Landfill Directive
- Hazardous Waste Regulations
- Landfill tax
- Aggregates levy
- Fly tipping
- Regulations for sustainable homes
- Site waste management plans
- Duty of care (EPA 1990)



- Waste costs money!
 - Original purchase price of the material
 - Costs attributed to unloading, handling, storage and movement of the material around site
 - Costs relating to collecting waste or damaged material, reloading, moving and storing waste on site
 - Transportation costs arising from movement of waste off site
 - tipping costs, landfill charges
 - Costs of replacing damaged and wasted materials

Eliminating waste makes sense!

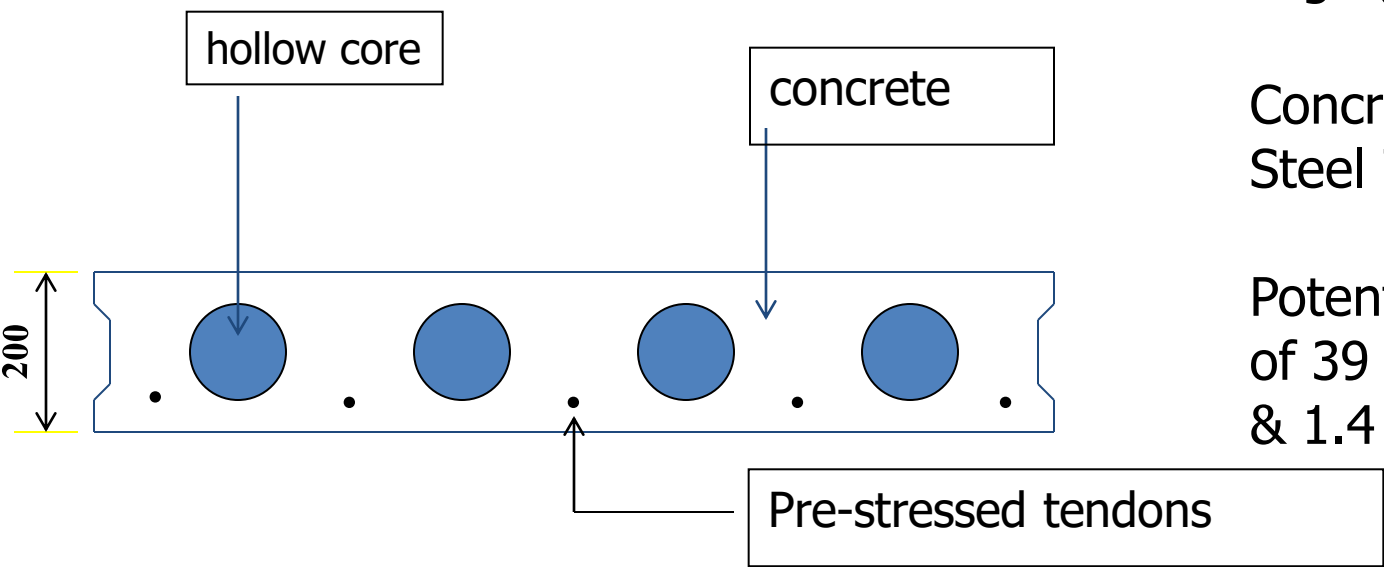


Case study: the BedZED project

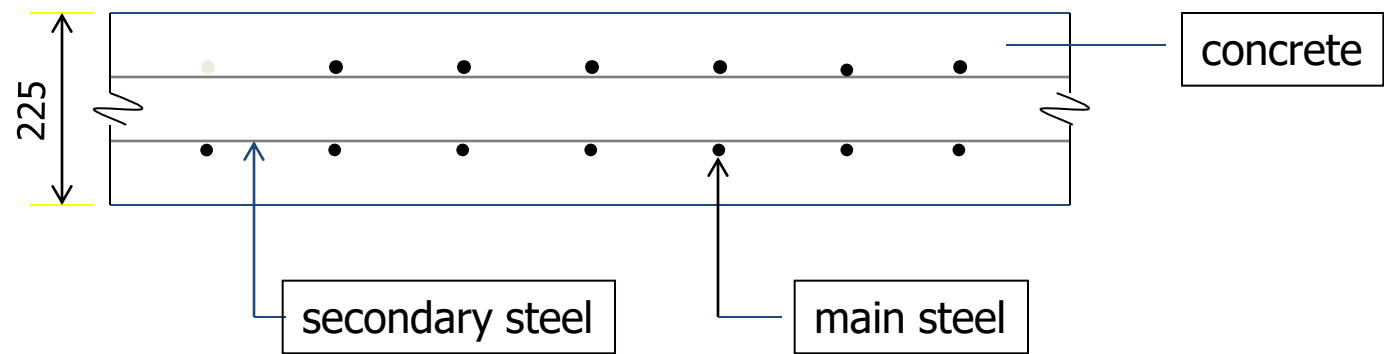
Savings (based on 8000m²)

Concrete 1960 tonnes
Steel 72 tonnes

Potential waste savings
of 39 tonnes concrete
& 1.4 tonnes steel



Pre-stressed Hollow Core Floor Slab



In-situ Reinforced Concrete Floor Slab

Efficient Design

A way forward!

- Renewable resources
- Less waste
- Cleaner technologies
- Design with nature in mind
- Efficient use of resources



Efficient Design with Nature in Mind!



An example of biophilic design at WWF's headquarters, UK.

Photo ©Wood Awards

The drive towards more ecological reasoning

- Ecological economics
- Building ecology
- Biophilic design
- Bioclimatic design
- Sustainable growth
- Natural capital
- Performance efficiency
- Eco-profiling of materials

Look at the work by David Pearce

Resource Efficiency: the challenges...

- Land
- Food
- Water
- Energy
- Raw materials



Productive land

Supply and demand

Water scarcity

Emissions

Consumption

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Reduce



Promote



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Reduce the amount of construction and demolition materials and other construction waste going to landfill sites.

Limit urban sprawl and the use of green-field sites.



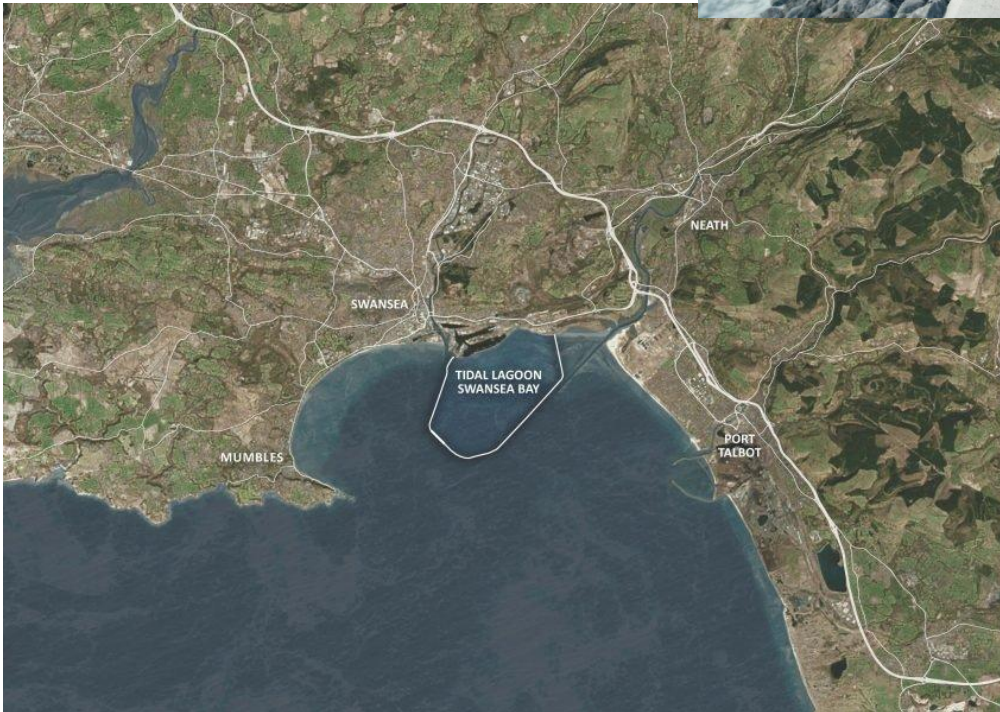
Minimise the ecological impact of development, maximising the enhancement of sites for both new and existing buildings.



Reducing Energy Use



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Swansea Tidal Lagoon

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Earthship Brighton

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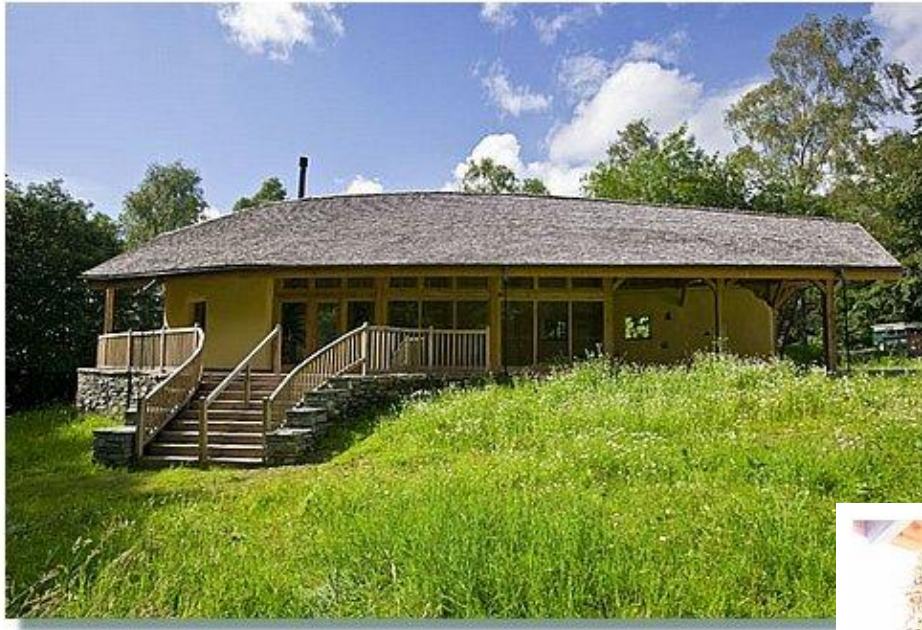
Earthship Brighton

Tyre bale use in embankments



- First UK use
- Alternative to concrete
- Improved drainage and slope stabilisation
- Environmental impact reduced
- Cost and environmental benefits

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The three little pigs...

Approximately 7 million tonnes of straw remain after the production of wheat flour

Up to half this amount is used for animal bedding etc

The 3.8 million tonnes left over could build some 500,000 new homes

An average three-bedroom house used about 7 tonnes of straw

Straw absorbs CO₂ as it grows



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Future Proofing

Availability of resources

Learning from the past



www.alamy.com - A72TWK

New College Oxford

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Maybe...

At least 50% renewable electricity generation by 2030

No more than 1 more contract for new nuclear before 2025



Pilots to test hydrogen and heat pumps as low carbon heating options

Buildings which require less energy to heat

Discussion

Sustainability is much about limiting the use of natural resources.
Put forward a set of indicators that is likely to measure the sustainability of packaging.



Discussion

In groups of three select one of the topics below and prepare a 15 minute presentation to be delivered to your peers after the Christmas break (TBA)

How do you think consumer behaviour might best be influenced in relation to buying more sustainable products and using products in a more sustainable manner?

Recycling waste is an inefficient process, it will never work successfully, it costs too much.

Discuss this statement.

Comment on the main issues that are likely to affect the effectiveness and efficiency of a recycling scheme.

What prevents householders from recycling or recycling more than they could?

Sources of Information

<http://carbonindependent.org>

National Infrastructure Commission (2018) national Infrastructure Assessment

Waste Resource Action Plan

Defra (2019) UK Statistics on Waste Incineration,

WRAP

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Girardet, H. (1999) Creating Sustainable Cities