

EEE116 (17/18)

Week 8 Introduction to sustainability

Dr. Yang Du



Xi'an Jiaotong-Liverpool University

西交利物浦大學

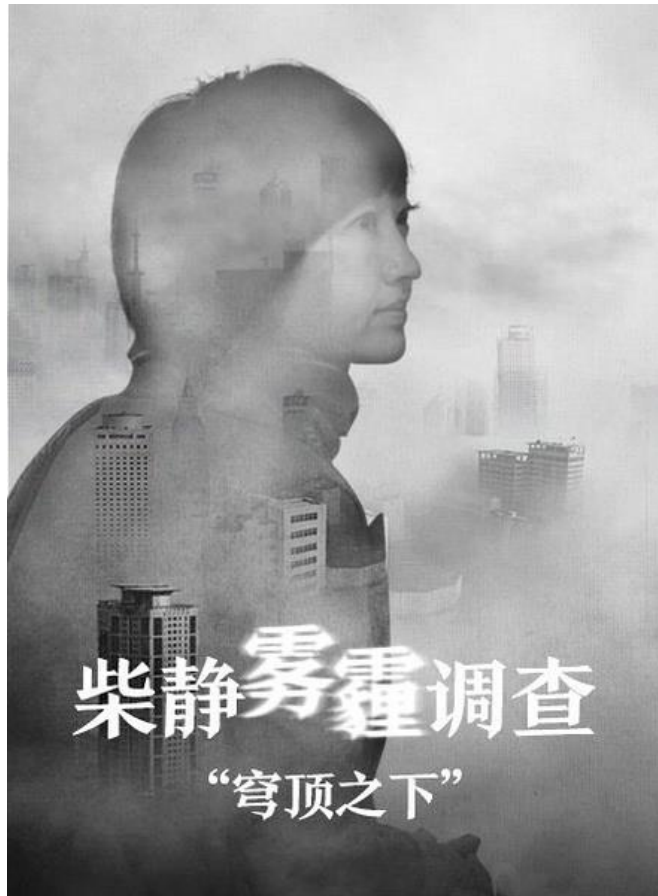
Assessment

- Activities
 - Choose a product from a list
 - Research its sustainability issues
 - Submit a report on product sustainability
 - Address a sustainability problem in Open Project (optional)
- Work on this assignment week by week
- This week
 - Choose a product
 - Think about cradle-to-grave issues
 - Discuss with your group member about the open project
- Due on week 10

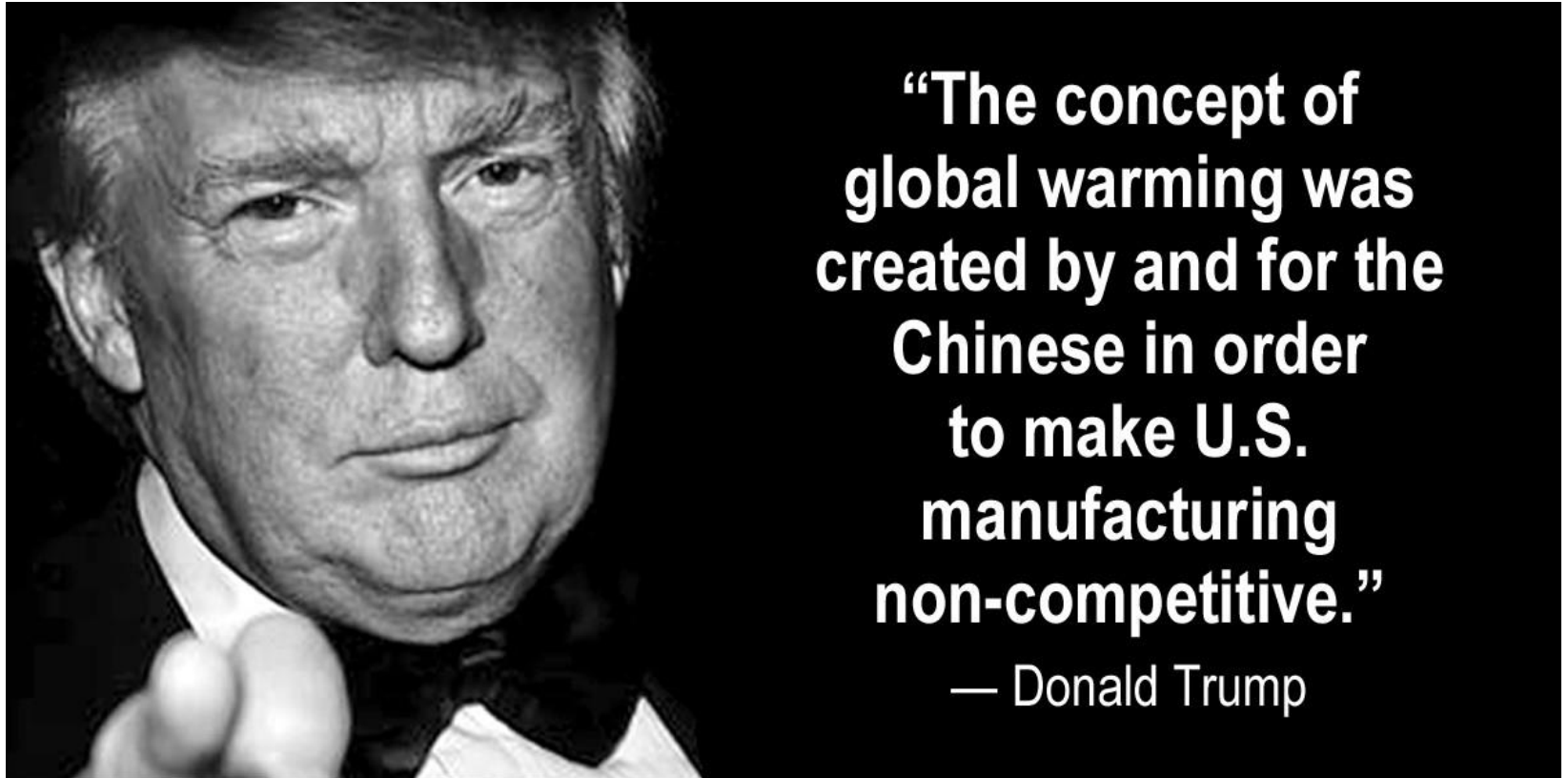
Products for the assignment

- 3D printing
- AA disposable batteries
- Acoustic guitars
- Beer cans
- Air conditioners
- Aircraft fuel
- Airline seats
- Aluminium cans
- Aluminium foil
- Artificial grass
- Ballpoint pens
- Basketballs
- Bicycles
- Bricks
- Car batteries
- Car tyres
- Ceramic tiles
- Chewing gum
- Chopsticks
- Cigarette filters
- Combs
- Concrete
- Condoms
- Copper wire
- Crisp packets
- Drilling tools
- Disposable nappies
- Disposable cups
- Disposable razors
- Duct tape
- Earphones
- Electric kettle
- Footballs
- Glass
- Golf balls
- Hair extensions
- Hovercraft
- Hydrogen vehicles
- Jeans
- Jet engines
- Keyboards
- Laptops
- Lithium-ion batteries
- Microwave ovens
- Milk packaging
- Paper towels
- Pencils
- Plastic bottles
- Printer ink
- Shampoo bottles
- Skateboards
- Skis
- Solar cells
- Sports tape
- Syringes
- Tennis balls
- Toasters
- Toilet paper
- Umbrellas
- Wall insulation
- Wallpaper
- Washing machines
- Water desalination
- Wet wipes
- Wind turbines
- Wood flooring
- Your choice

You may heard about it...



You may heard about it...



An engineer

...is a professional practitioner of engineering, concerned with applying scientific knowledge, mathematics, and ingenuity to **develop solutions** for technical, societal and commercial problems.

The work of engineers forms the link between scientific discoveries and their subsequent applications to human needs and quality of life.

[Bureau of Labor Statistics](#), U.S. Department of Labor (2006). "[Engineers](#)". Occupational Outlook Handbook, 2006-07 Edition. Retrieved 2006-09-21.

Sustainable?



www.deviantart.com



loveforlife.com.au

UN Definition

*“Sustainable development is development that meets the **needs of the present** without compromising the ability of **future generations** to meet their own **needs**. ” [1]*

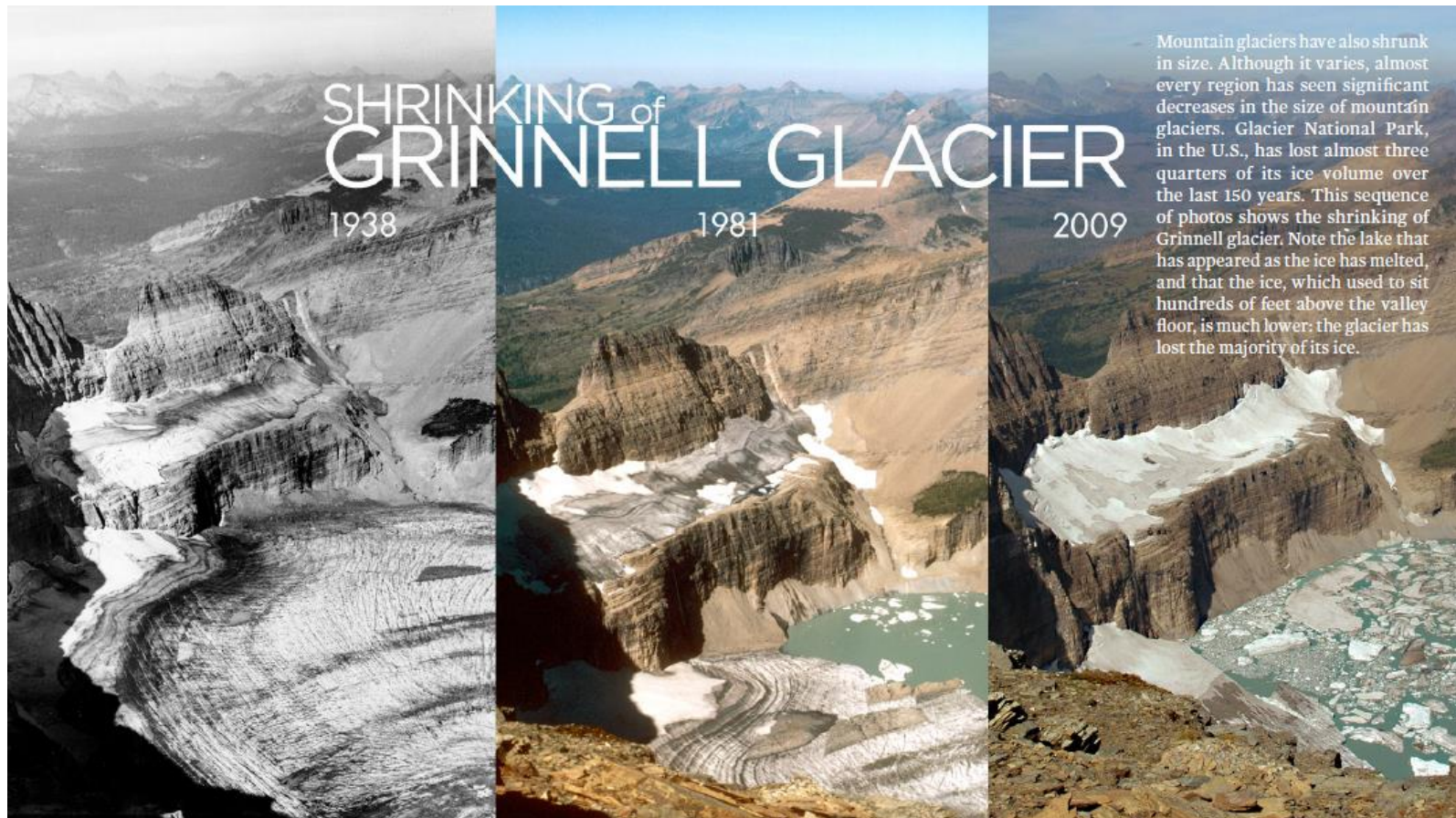
It contains within it two key concepts:

- the concept of **needs**, in particular the essential needs of the world's poor, to which overriding priority should be given; and*
- the idea of **limitations** imposed by the state of technology and social organization on the environment's ability to meet present and future needs.*

[1] World Commission on Environment and Development (WCED). *Our common future*. Oxford: Oxford University Press, 1987 p. 43.

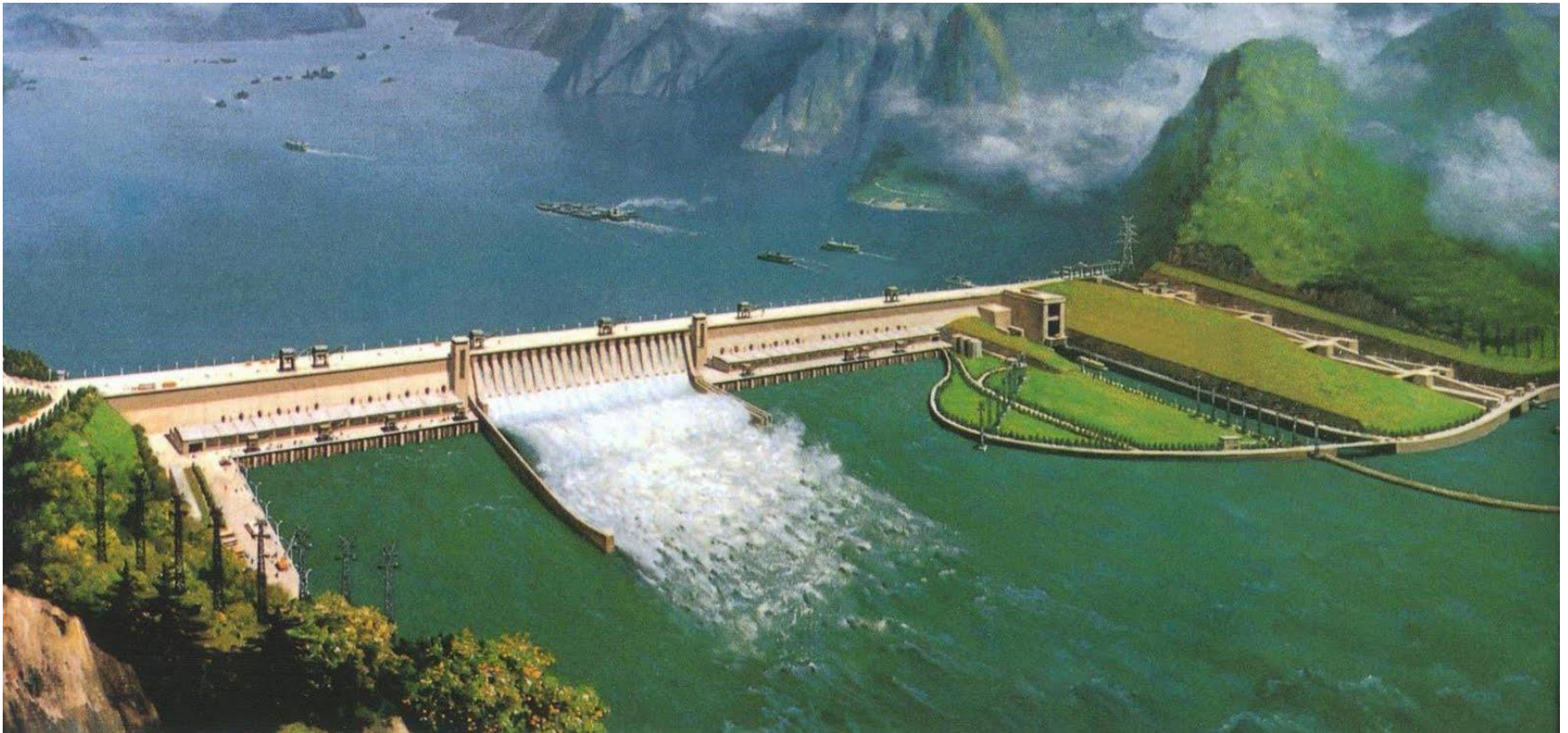
Reflection:

The Natural world



Reflection:

How should we comment on these projects?



www.chinatouronline.com

Reflection:

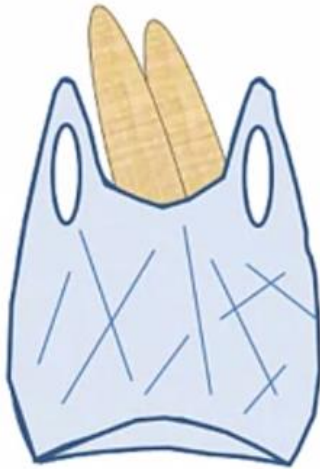
How should we comment on these policies?



Reflection:

Which one do you pick?

if you want to do the right thing for the environment



Plastic grocery bags?

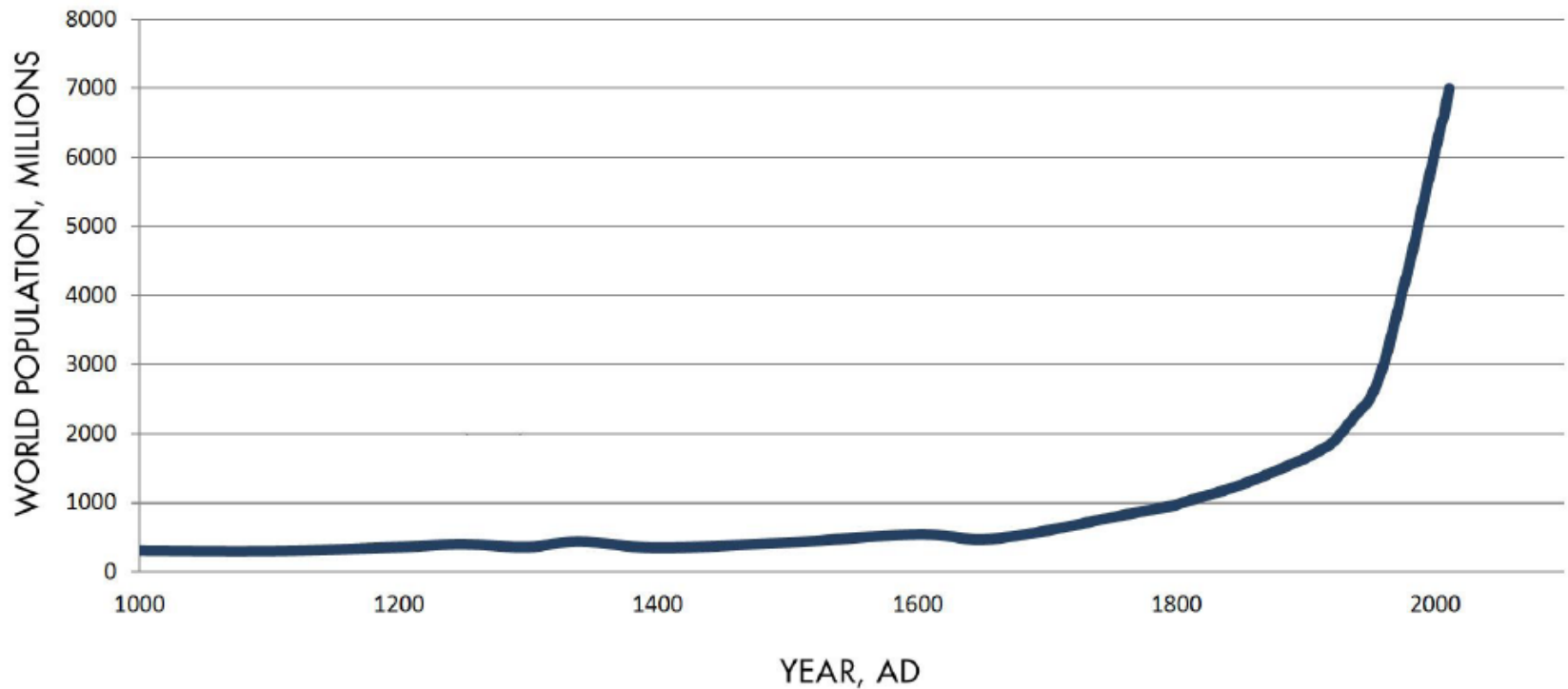
OR



Paper grocery bags?

Sustainability and population growth

WORLD POPULATION



Question

Why do people worry about **population** so much when we talk about sustainability?

Why do people worry about **consumption** so much when we talk about sustainability?

IF THE WORLD'S POPULATION LIVED LIKE...

PER
SQUARE
MILE

How much land would 7 billion people need to live like the people of these countries?

BANGLADESH



INDIA



UGANDA



CHINA



× 1.1

COSTA RICA



× 1.4

NEPAL



× 1.9

FRANCE



× 2.5

UNITED STATES
of AMERICA



× 4.1

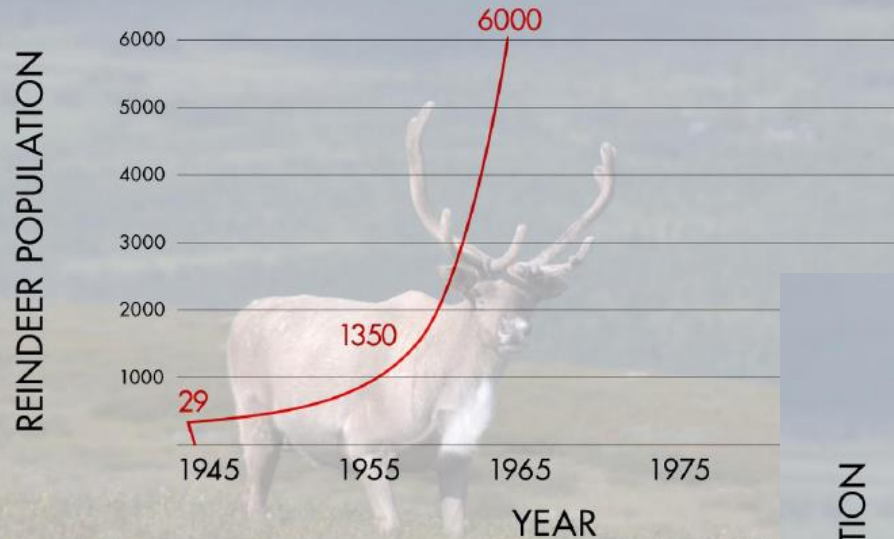
UNITED ARAB
EMIRATES



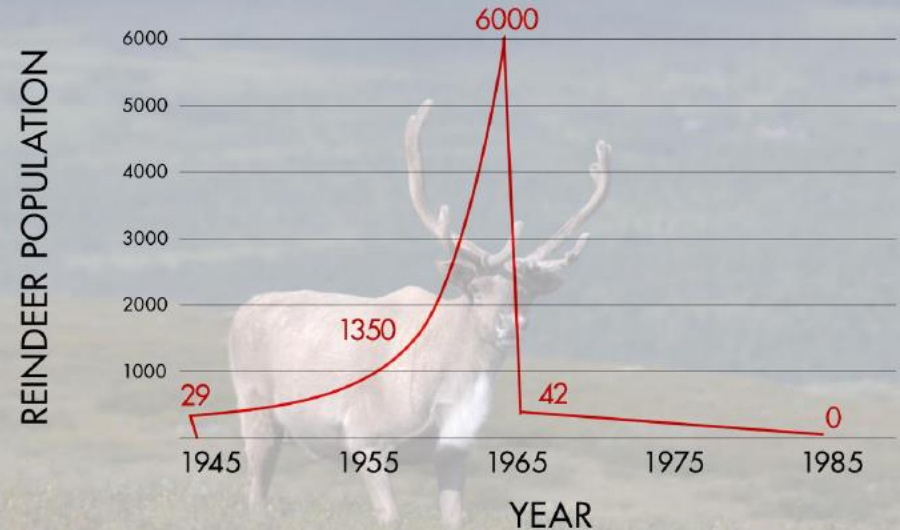
× 5.4

Reindeer example

REINDEER POPULATION:
1945-1962

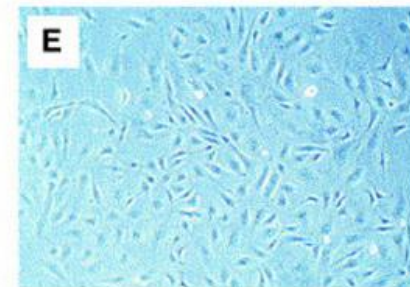
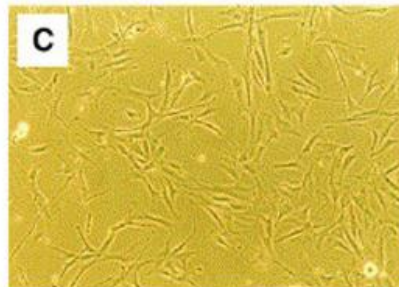
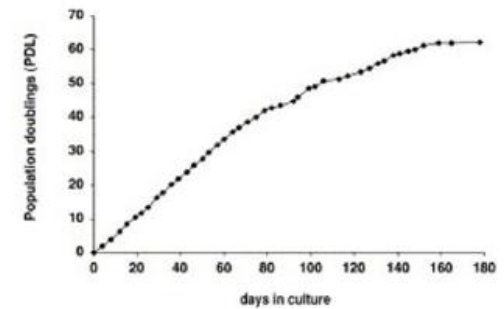
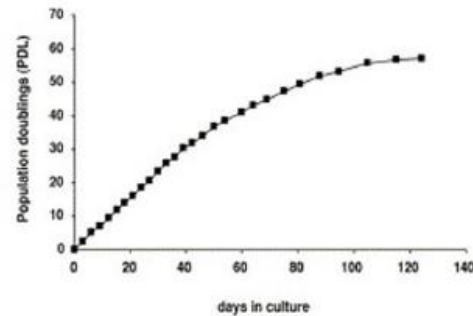


REINDEER POPULATION:
1980's

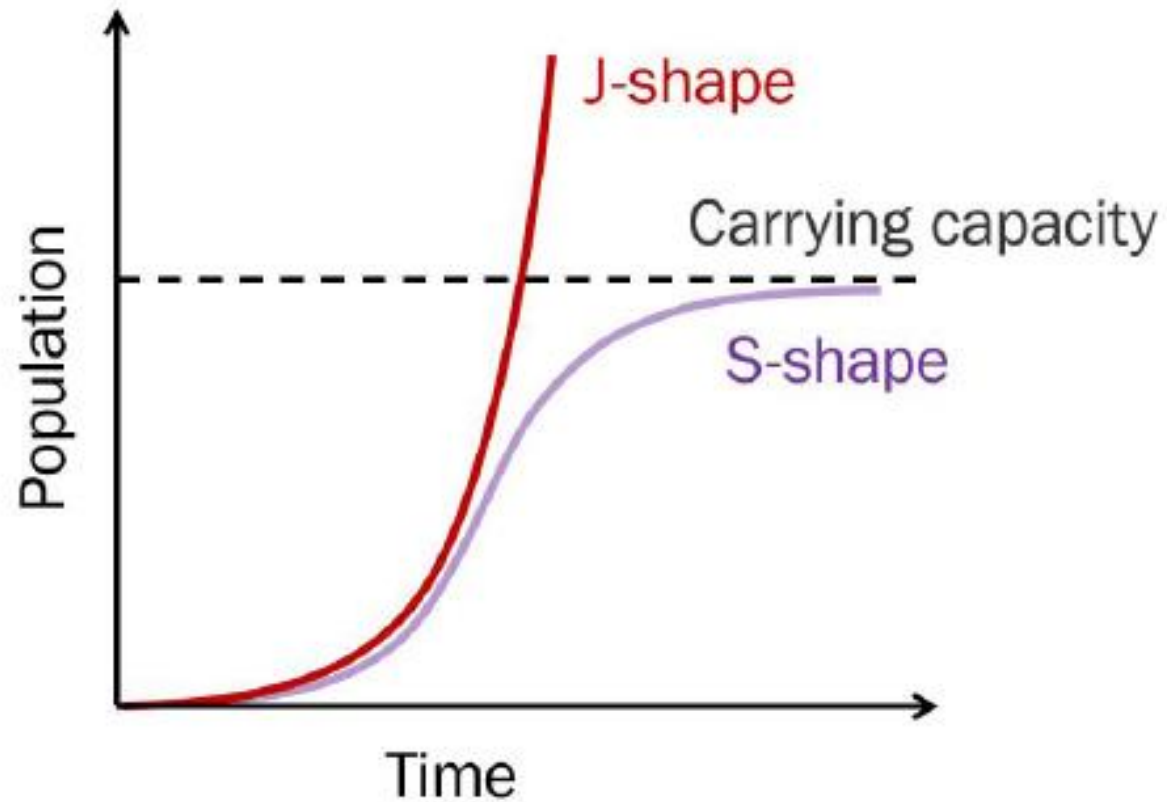


Cell example

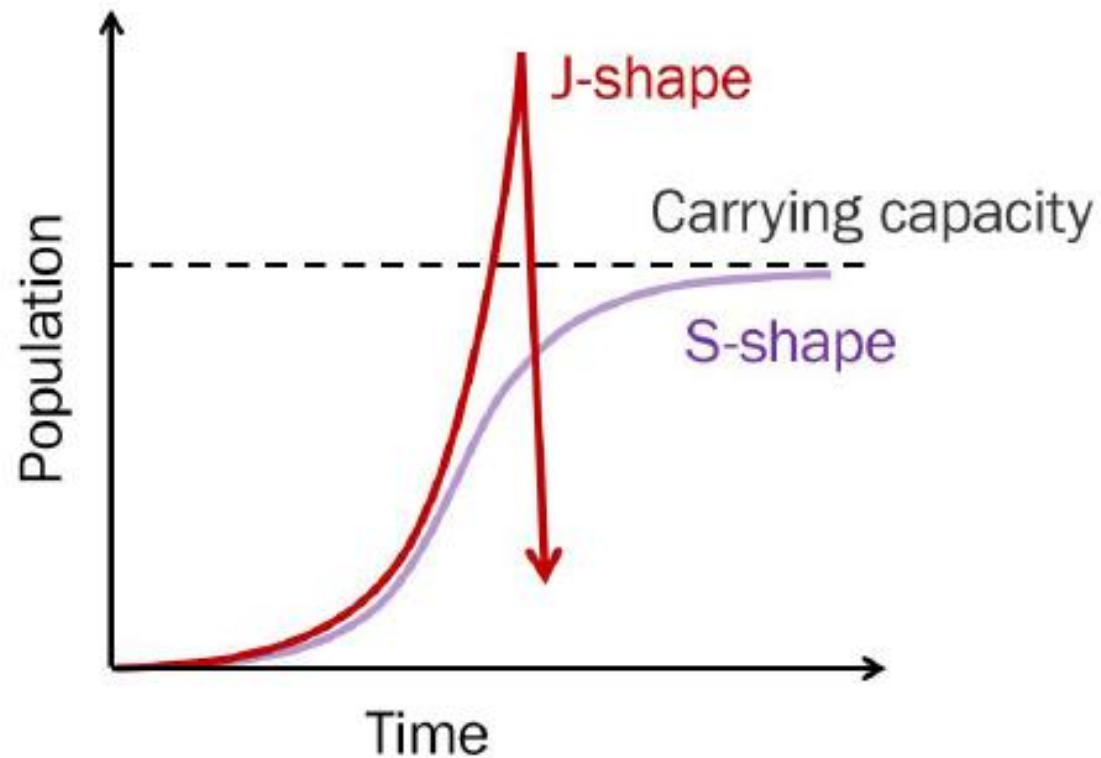
CELL POPULATION CURVES



Growth curves

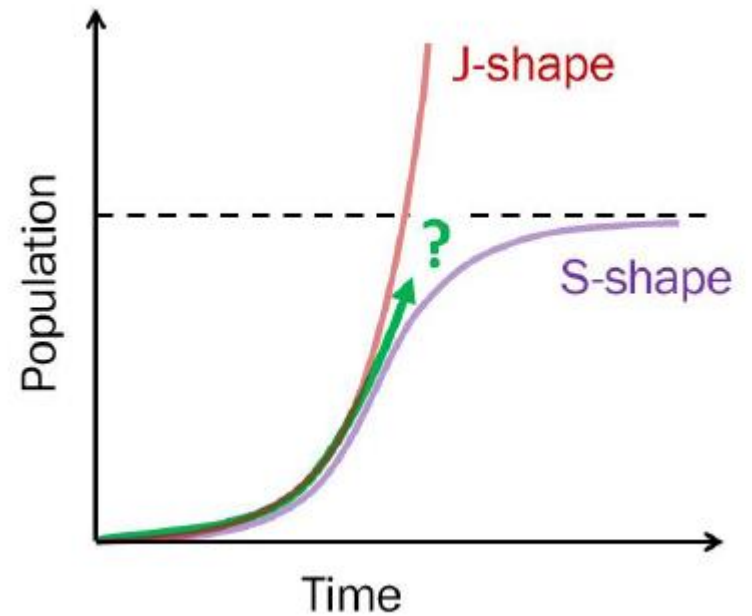
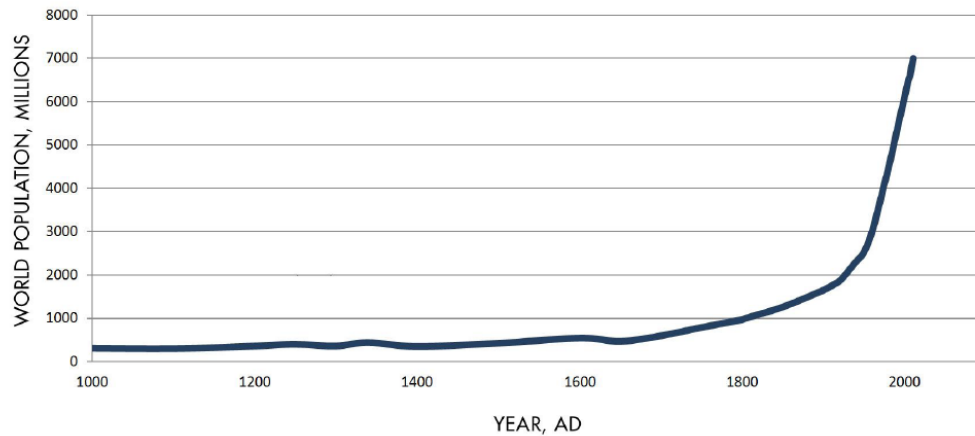


Crash

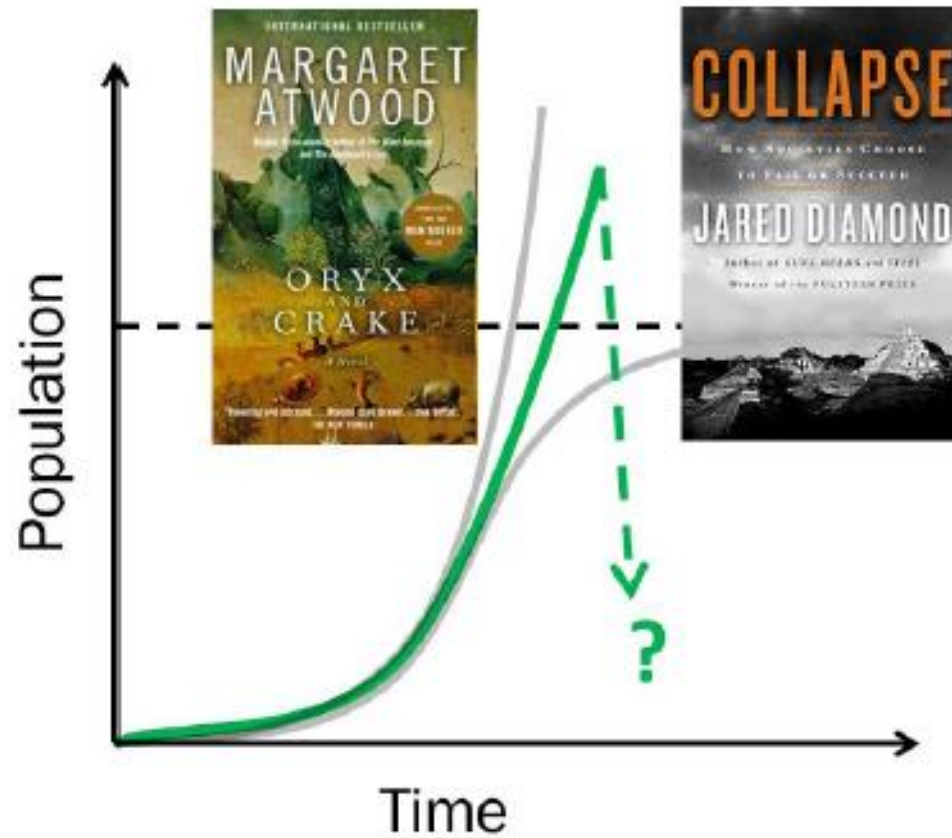


Population

WORLD POPULATION



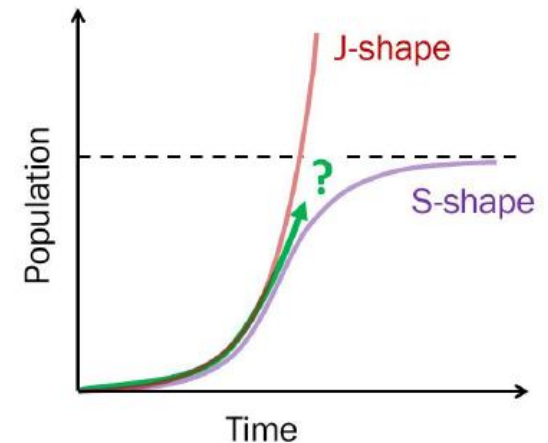
J-type crash?



Vote for your prediction

The Current state of humanity on Earth?

1. S-curve at or below carrying capacity
2. J-curve *below* carrying capacity
3. J-curve *above* carrying capacity



MALTHUSIAN CATASTROPHE

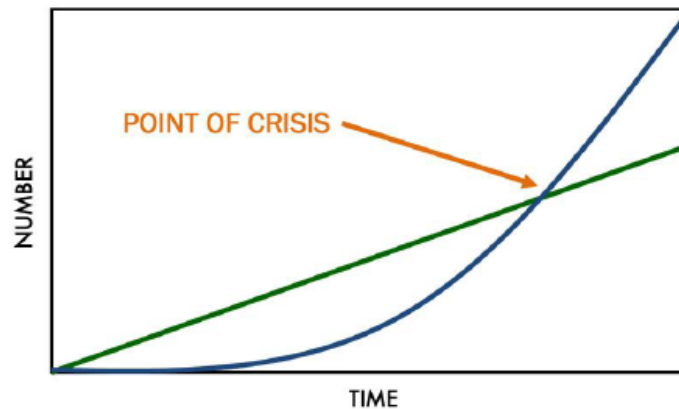
Time	1	2	3	4	5
Amount	1	2	4	8	16

Exponential (population)

Time	1	2	3	4	5
Amount	2	4	6	8	10

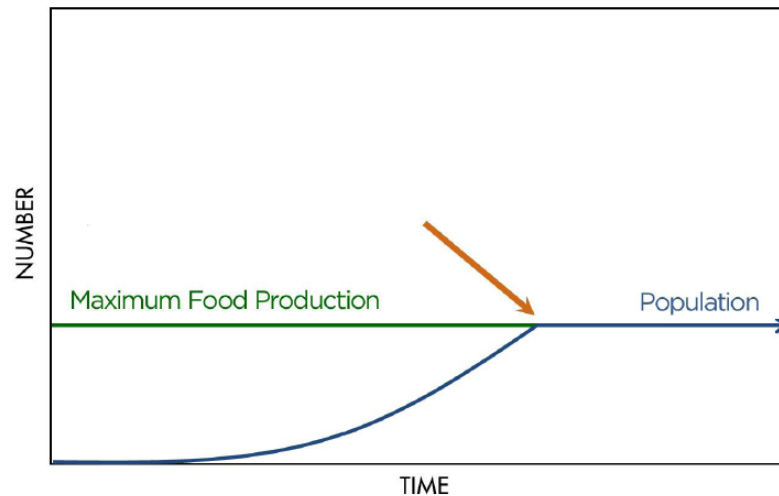
Arithmetic (food)

- FOOD PRODUCTION
- POPULATION



Two types of "checks" that could reduce the population

- “preventive checks”— Population control
- “positive checks” — Malthusian catastrophe



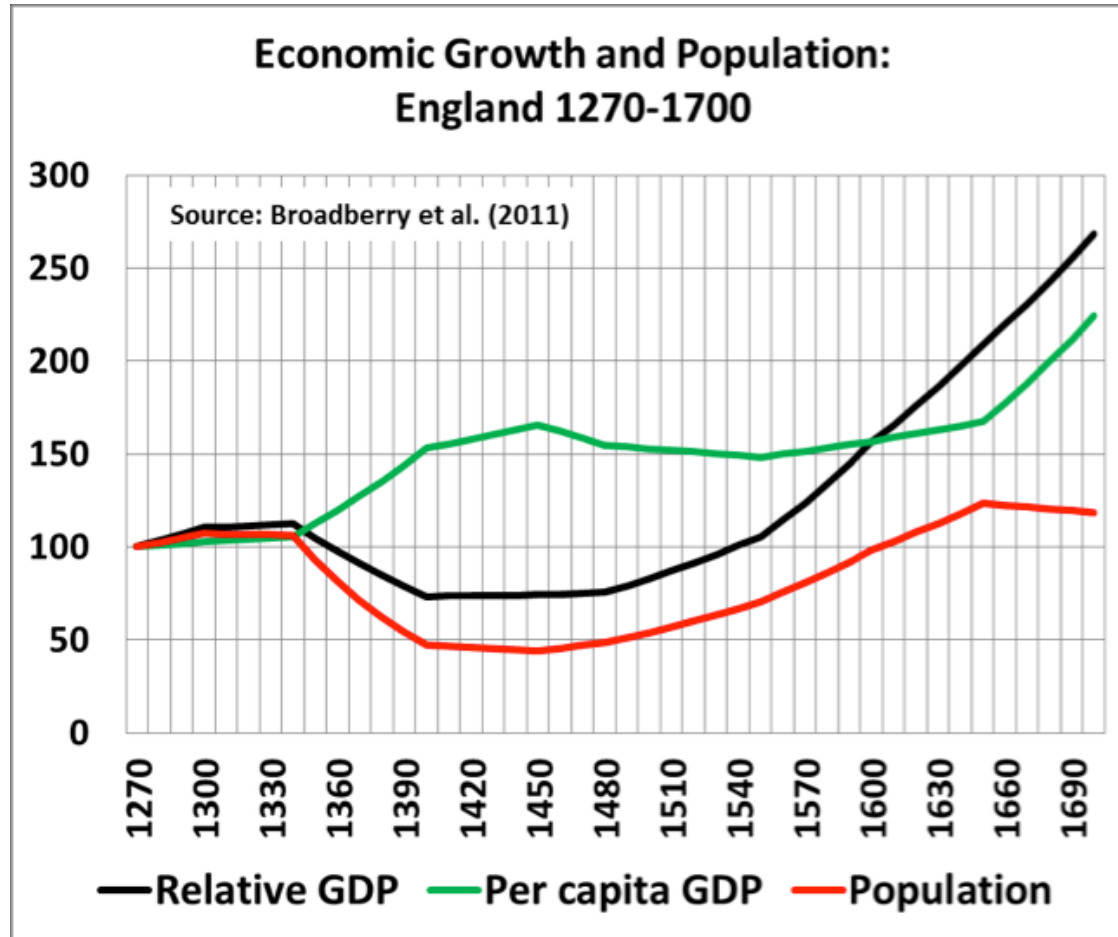
18th century poverty

URBAN POVERTY IN 18th C. BRITAIN

ENGLAND in 1800 versus THE STONE AGE

MATERIAL LIFE STYLE	ENGLAND c. 1800	FORAGER SOCIETIES
CALORIES PER DAY	2,322	2,340
PROTEIN PER DAY (g)	48	61
MALE HEIGHT	67"	66.5"
MALE HOURS OF WORK PER DAY	8.5	5.9
LIFE EXPECTANCY AT BIRTH	38	33
LIFE EXPECTANCY AT 20	34	39
CALORIES PRODUCED PER WORKER PER HOUR	2,600	4,740

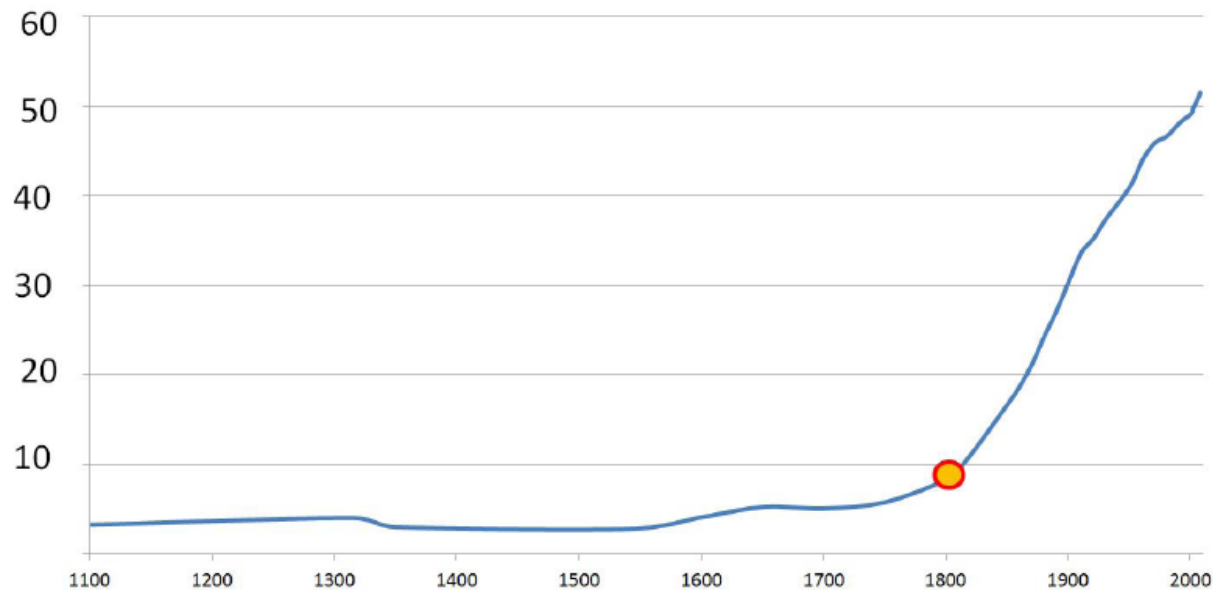
Black death in England



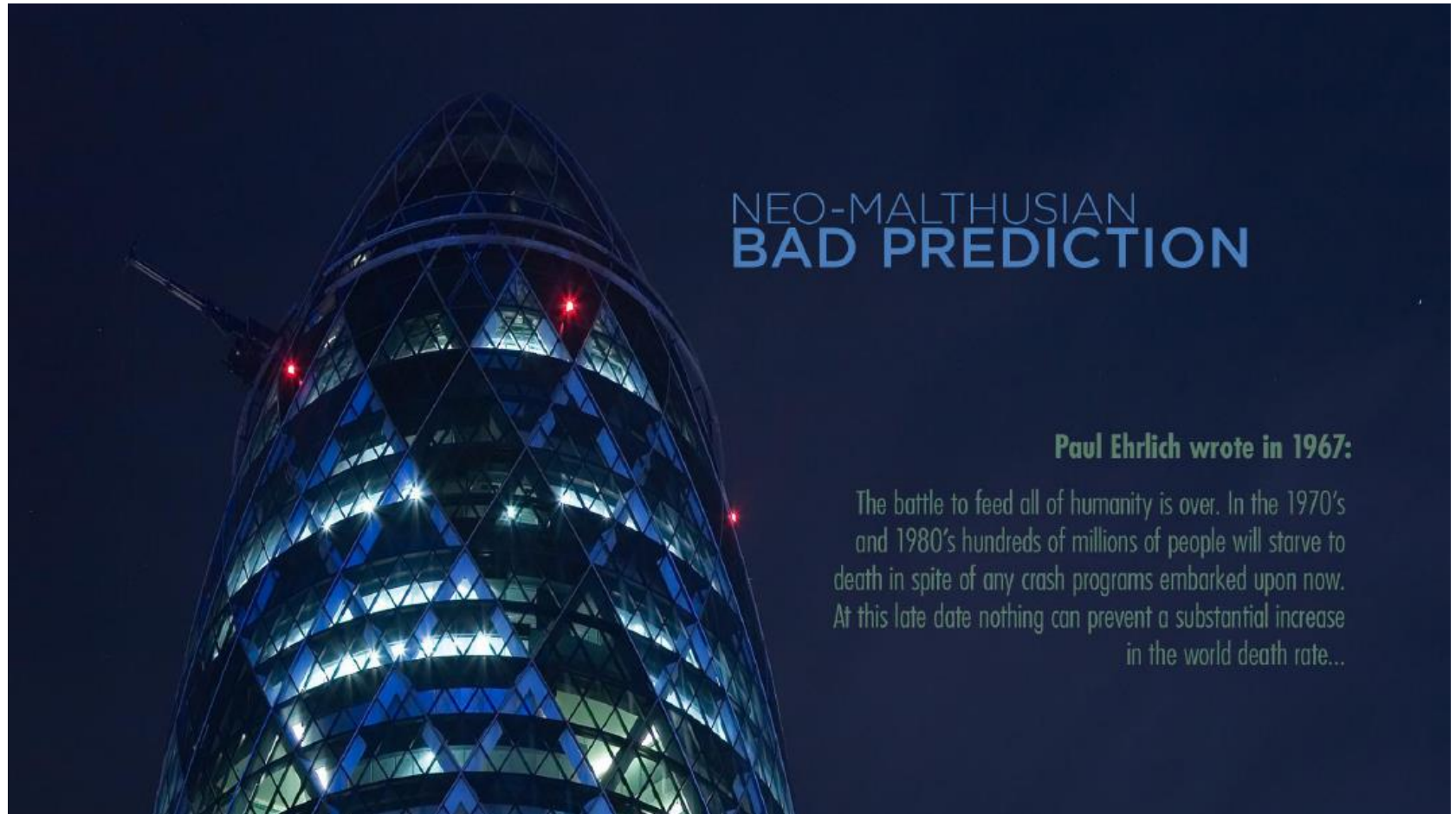
thebreakthrough.org

Do you believe Malthus?

ENGLISH POPULATION

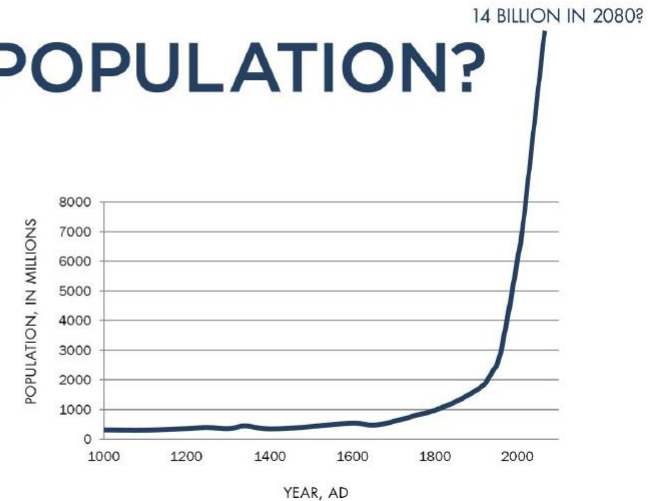
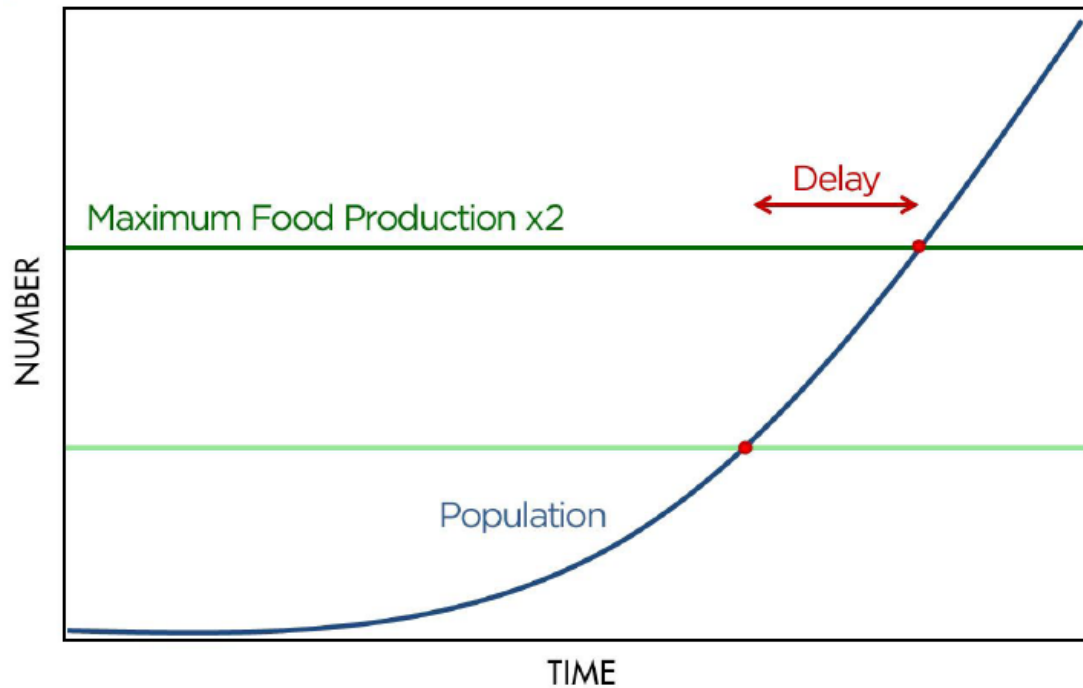


Bad prediction

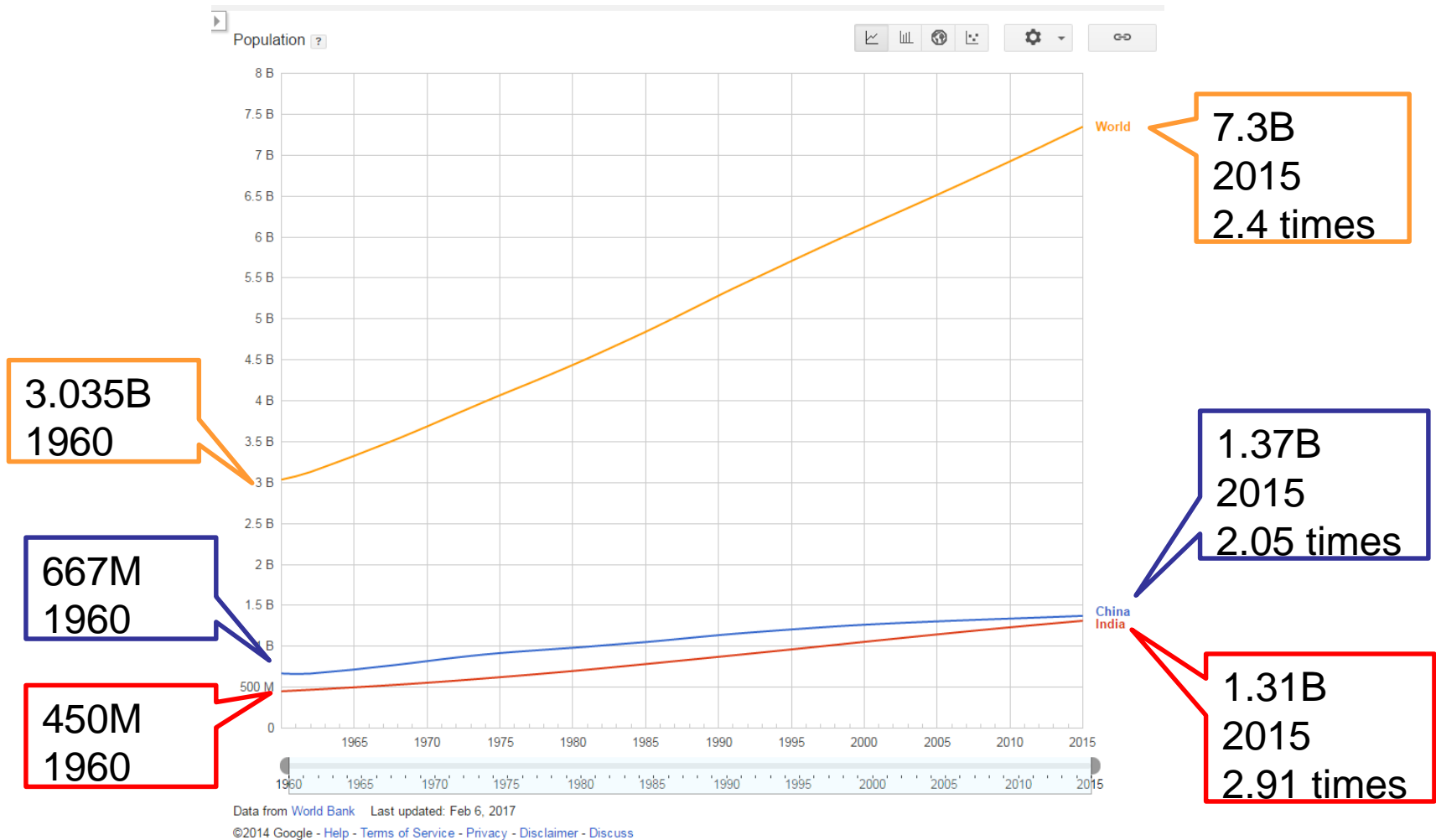


Do you believe Malthus?

FUTURE WORLD POPULATION?



What happened in last 55 years



Reflection:

How should we comment on these policies?



Sustainability in engineering

- Engineering is responsible for development and implementation of nearly all aspects of modern life
 - power, water, construction
 - industrial and consumer goods
 - and just about everything else
- All of these things use the world's finite resources



WHAT IS “SUSTAINABLE DEVELOPMENT”

EXAMPLE



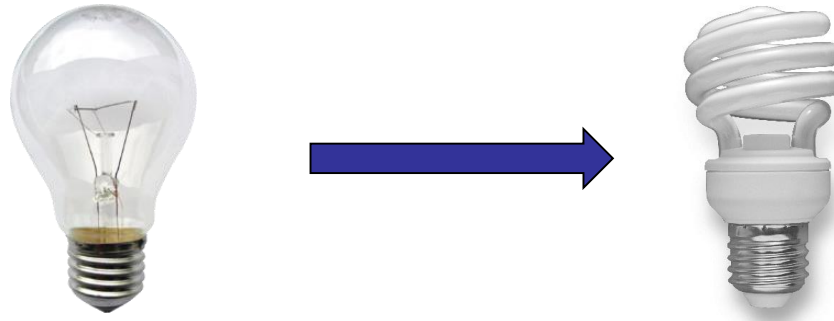
EXAMPLE

COMPACT FLUORESCENT LAMPS

But ...what is “sustainable development”

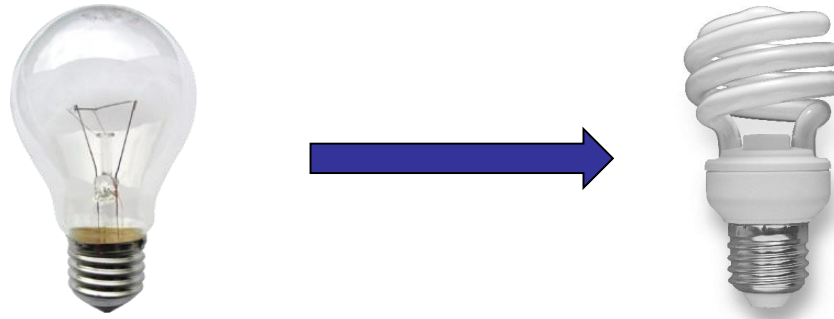
- Economic sustainability
 - maintenance of stable levels of growth
 - maintenance of employment
 - maintenance of profitability

Light bulbs and sustainability



Cost		
Lifetime		
Efficiency		
Hazardous materials		

Light bulbs and sustainability



Cost	< £1	£4
Lifetime	1 year	10 years
Efficiency	< 10%	40 - 50%
Hazardous materials	not really	small amount of mercury

But ...what is “sustainable development”

1. Economic sustainability



- Can the more environmentally sustainable lamp be made at a reasonable cost?
- Can the lamp manufacturers make money with this product?

But ...what is “sustainable development”

2. Environmental sustainability

- protection of the environment
(mining/manufacturing etc.)
- most effective use of scarce resources
- waste/disposal

But ...what is “sustainable development”

2. Environmental sustainability



- Is the new lamp more energy efficient?
- Are there any problems with dangerous materials?

But ...what is “sustainable development”

3. Social sustainability

- social progress that recognises nation-wide and world-wide needs
- acceptance by the “general public” that a process or outcome is acceptable (or not)

But ...what is “sustainable development”

3. Social sustainability



- Is lower power consumption is a shared goal?
- Are people willing to make the change?

But ...what is “sustainable development”

- Sustainable in
 - an economic sense
 - an environmental sense
 - a social sense
- Different groups in society have different viewpoints on each of these aspects of sustainability

Again, why are you studying this?

- Engineering is responsible for development and implementation of nearly all aspects of modern life
- It is the responsibility of engineers to understand the problems and to develop solutions
- Understanding sustainable development is part of your training as a professional engineer

In these lectures, you will learn how to think
systematically about sustainability

EXAMPLES OF “SUSTAINABLE DEVELOPMENT”



EXAMPLE 1

**COMPACT FLUORESCENT
LAMPS**

Sustainability issues

- 10-15% of world electricity production used for lighting
 - total electrical power consumption increasing over time
 - desire to make lighting more efficient
- UK electrical power production
 - ~ 70 power stations (non-renewable – gas, coal, etc)
 - 10% improvement in lighting efficiency → ~ 1 closed power station

Change in technology

Old technology: incandescent lamps

- low efficiency
- most power converted to heat



New technology: compact fluorescent lamps

- high efficiency: 5 ~ 7 x improvement
- higher cost
- uses mercury vapour to generate light



Stakeholders

Consumers	<ul style="list-style-type: none">• Is the new lamp as effective?
Lamp manufacturers	<ul style="list-style-type: none">• Can they make money from the new lamps?
Government	<ul style="list-style-type: none">• Reduced load on power network• Disposal of the lamps
General Public	<ul style="list-style-type: none">• Less consumption of fossil fuels• Less CO₂ production• More mercury in the environment

Another look at the benefits

- 15% of power used for lighting (residential + commercial)
 - change to CFL technology affects residential use
 - 7 % of power used residential lighting
- Improvement in efficiency of 350% reduces 7% → 2%
 - reduction of up to 5% in total power consumption

5% reduction --- WOW

Another look at the problems

- More mercury in the environment
 - extremely toxic
 - remains for many years in the environment
 - gets into food chain (birds, fish, livestock ...)
- BUT ...
 - mercury is already present in normal fluorescent lamps
 - can the increase be justified?

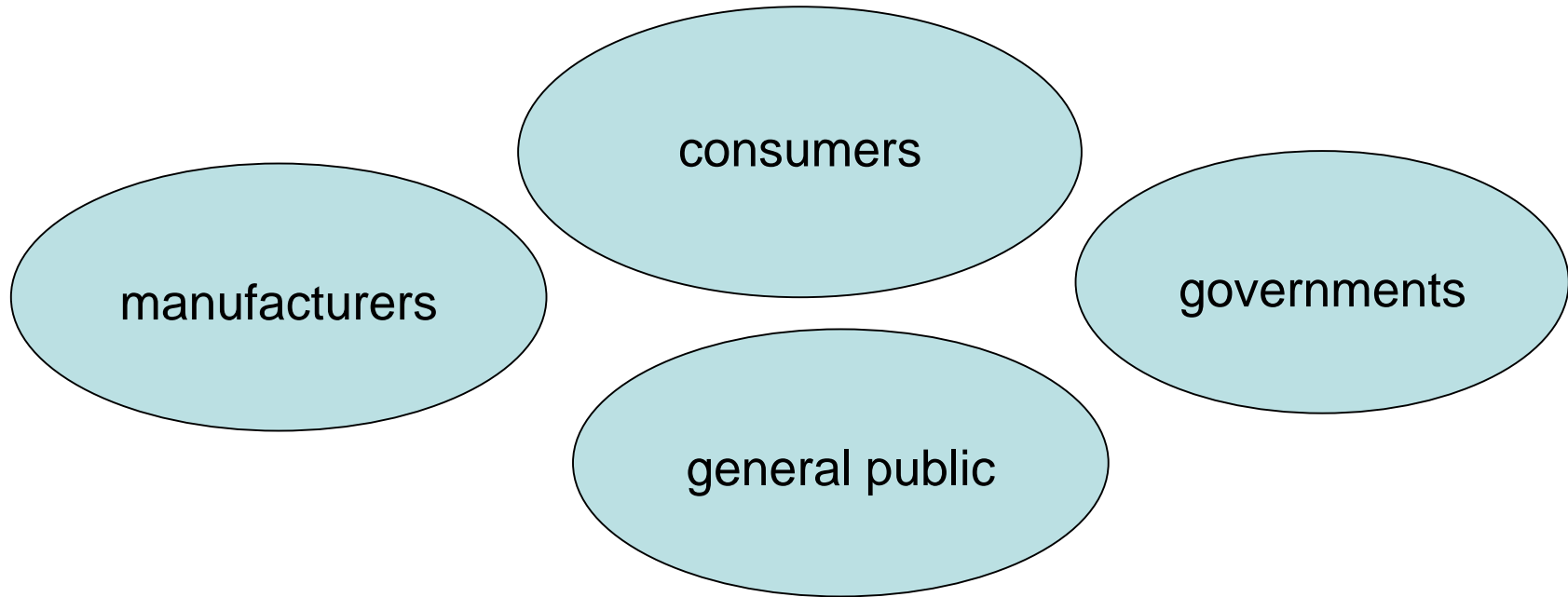
Compact fluorescent lamps



higher efficiency → large impact on power consumption

mercury use → significant environmental impact

Compact fluorescent lamps



higher efficiency → large impact on power consumption

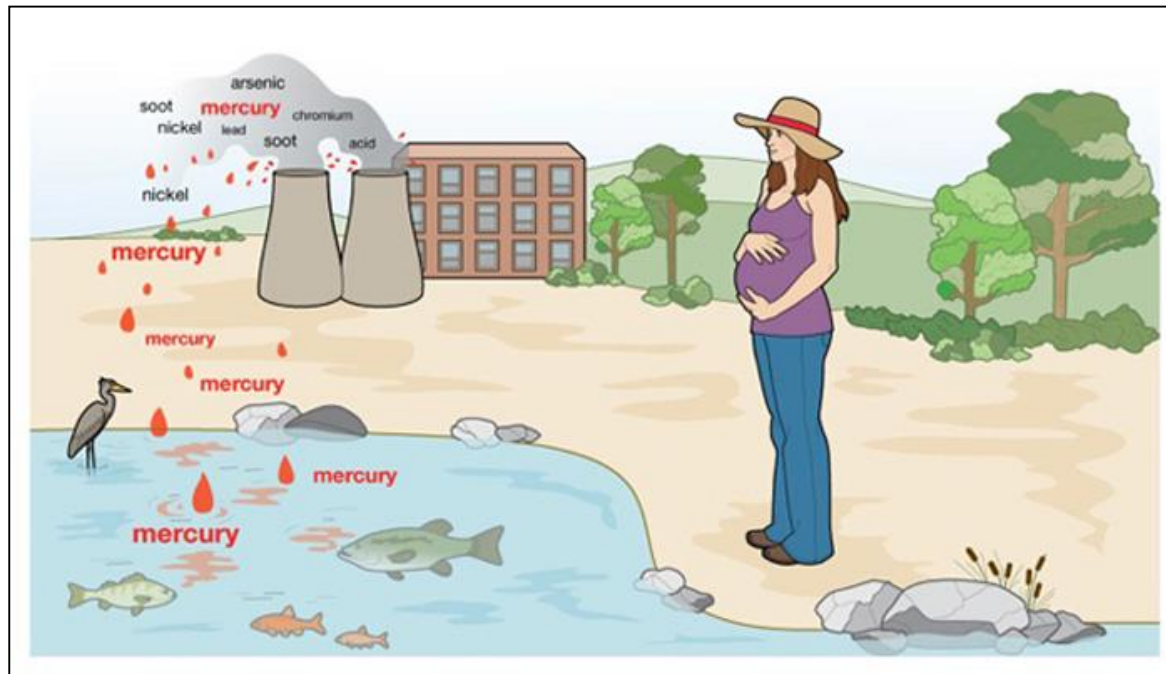
mercury use → significant environmental impact

How does this link with engineering and “sustainability”?

- Engineers must be aware of sustainability issues
- Engineers must be able to evaluate the problems and solutions systematically
- In the real world, engineers must be aware of all the different factors involved in decision making

Lamps - what happened next?

- ❑ Intention to ban mercury from lighting (by 2015??)
 - environmental problem of mercury seen as so important that “something” had to be done



Lamps - what happened next?

- ❑ Intention to ban mercury from lighting (by 2015??)
 - Environmental problem of mercury seen as so important that “something” had to be done

- ❑ Much research into mercury-less lamps
 - No real success - lighting companies request more time





LIGHTINGEUROPE

THE VOICE OF THE LIGHTING INDUSTRY

[ABOUT US](#)

[NEWS](#)

[CALENDARS](#)

[LIBRARY](#)

[PROJECTS](#)

[PARTNERS](#)

[FOCUS AREAS](#)

Hello we are the Voice of the lighting industry in Europe

LightingEurope is an industry association representing leading European lighting manufacturers, national lighting associations, and companies producing materials. We are committed to innovation, sustainability, quality and leadership. We contribute to shape policy and establish industry standards and guidelines. We are dedicated to promoting efficient lighting practices for the benefit of the global environment, human comfort, and the health and safety of consumers.

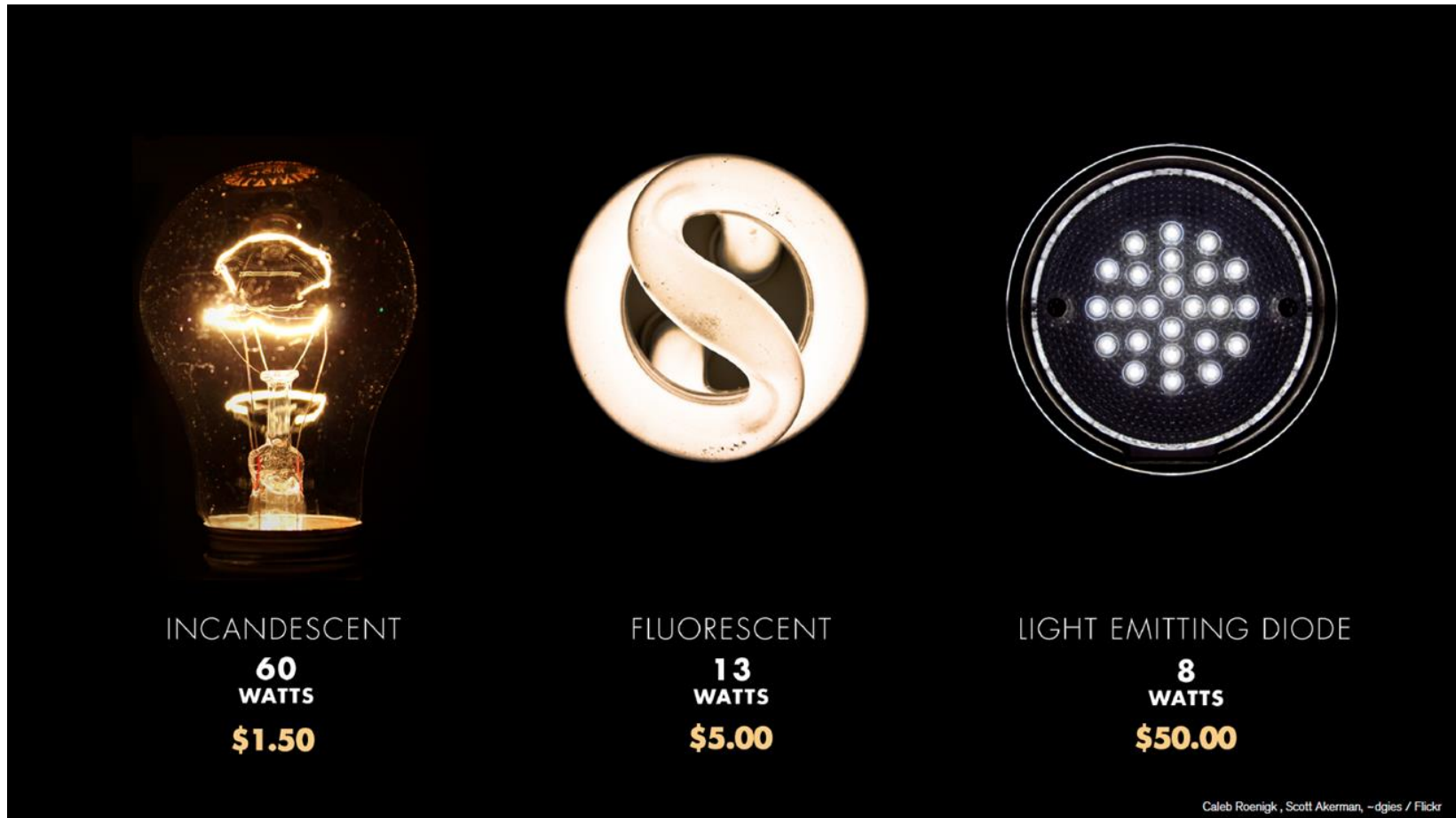
Let's talk

*a series of videos featuring voices
from the lighting industry*

What happened next?

- ❑ Intention to ban mercury from lighting (by 2015??)
- ❑ Much research into mercury-less lamps
- ❑ Development of LED sources of various types
 - Current belief that fluorescent lamps - and their mercury - will die out over time

What happened next?



Compact fluorescent lamps



- ❑ Sustainable development of major consumer or industrial products is very complex.
- ❑ Beware of simplistic approaches



EXAMPLE 2

CHAIRS

Sustainability issues

- Materials
 - wood, plastic, aluminium, fabric, dye
- Manufacturing
 - plastic, aluminium, fabric, may require industrial processing
- Lifetime
- Disposal
 - recycling? land-fill?



Stakeholders

Consumers

--

Chair
manufacturers

--

Government

--

General Public

--

Stakeholders

Consumers

Is the chair suitable for sitting on?

Chair
manufacturers

Can they make money?

Government

Disposal of old chairs (landfill)
Chemicals used in manufacturing

General Public

Consumption of resources
Environmental impact
Costs of disposal

What is a “sustainable” chair?

IKEA's Adam chair



- Materials
 - wood, fabric, padding, metal, glue
- Manufacturing?
 - complex processes done at factory
- Usage
 - lifetime?
- Disposal
 - probably landfill

What is a “sustainable” chair?



Colin Reedy deck chair

- made from recycled plastic, no padding needed

Philip Stark *Louis 20* chair

- made from two materials (aluminium, polypropylene)
- only 5 screws



Michael McDonough bamboo chair

- made wholly from bamboo

Stakeholders

Consumers

Is the chair suitable for sitting on?



Chair
manufacturers

Can they make money?



Government

Disposal of old chairs (landfill)
Chemicals used in manufacturing

General Public

Consumption of resources
Environmental impact
Costs of disposal



What is a “sustainable” chair?

- A sustainable chair might:
 - be made of environmentally friendly materials
 - be made with few resources
 - be manufactured in a simple efficient process
 - have long lifetime
 - be recycled easily
- Some of these factors arise from design



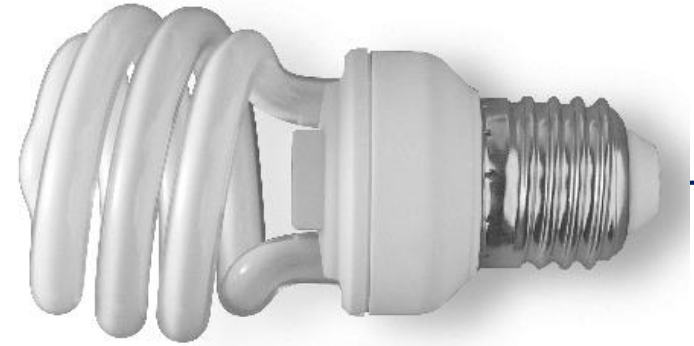
Sustainability issues

- Lamps and chairs raise different sustainability issues
- Can we devise a systematic way to consider sustainable development for a wide range of products or processes??



THINKING SYSTEMATICALLY

Example 1: Lamps



- We focused on
 - energy efficiency in use
 - presence of a dangerous substance
- We could also have considered
 - energy efficiency in manufacture
 - safety during manufacture
 - can you recycle it?
 - ?
 - ?

Example 2: Chairs

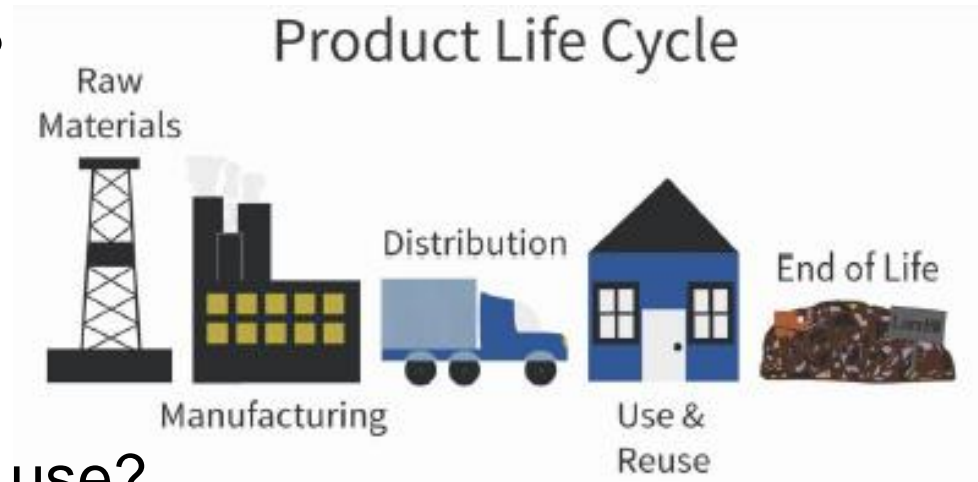


- We briefly discussed
 - materials
 - manufacturing process
 - consumer usage (lifetime issues)
 - disposal
 - influence of design
- This is a slightly more systematic way to consider sustainability issues

Cradle-to-grave process

This is one of the standard ways of considering sustainability issues

- How is the product designed?
- How is it manufactured? (materials, processes)
- How is it packaged?
- How is it marketed?
- How is it used?
- What happens after use?



design



manufacture



marketing

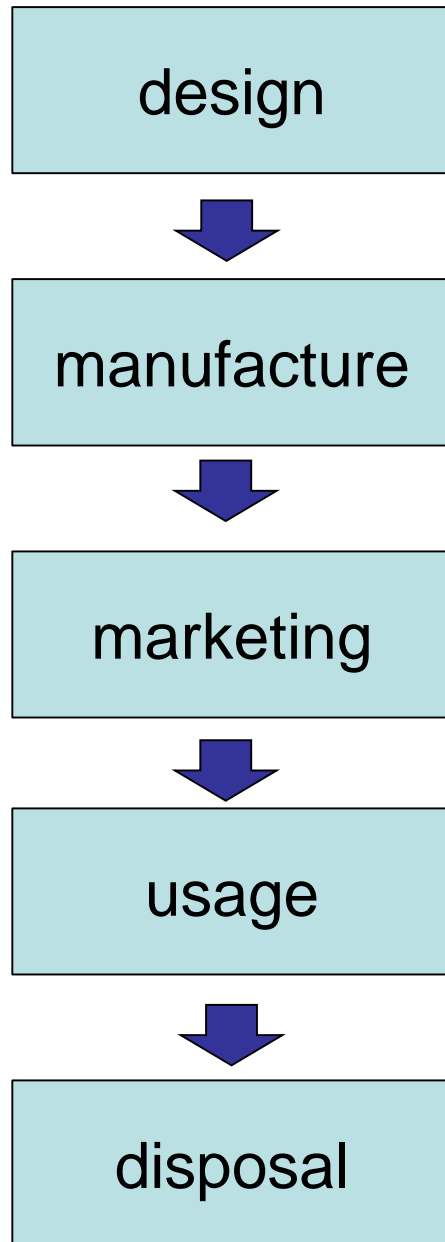


usage



disposal





DESIGN

(i) features

- efficient for generating light
- retrofit into existing fittings

(ii) components

- glass bulb
- metal fitting
- electronic circuit
- filling gas + droplet of mercury
- coating for converting UV → visible



design



manufacture



marketing



usage



disposal

- more efficient mechanism for generating light
- retrofit into existing fittings

- glass, metal, electrical circuits
- mercury (in controlled factory environment)

- energy efficient, long lasting
- money saving

- uses less main power
- small probability of mercury exposure

- legislation for safe disposal (effective?)
- possible landfill problem



design



manufacture



marketing



usage



disposal



design



manufacture



marketing



usage



disposal

- battery can be detached (most models)
- battery can be disposed separately

- hazardous substances in controlled environments
- some materials have limited supplies

- sustainability is not an issue

- ???



- recycling is possible, mostly not done

Sustainability and smartphones

- Most smart phones rely on materials that are mined or processed in unsafe or unethical environments
- The “Fairphone” was developed to provide an alternative that was environmentally and ethically “friendly”

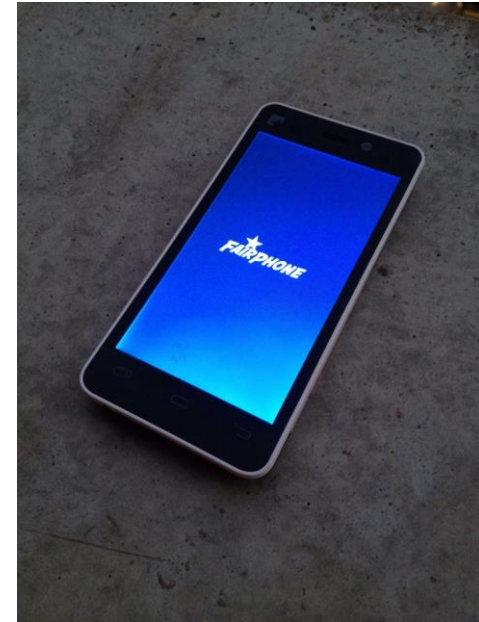


Sustainability and smartphones

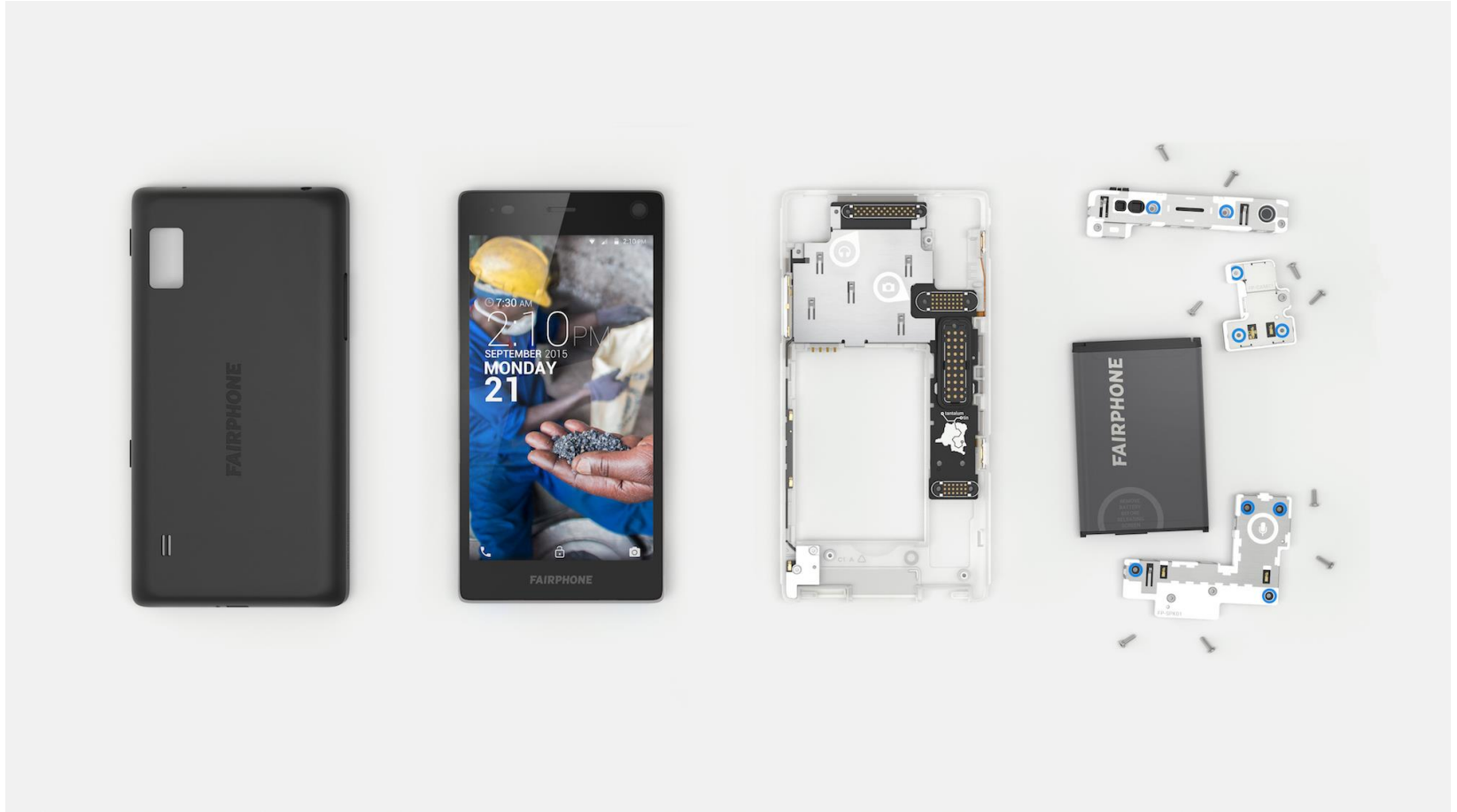


Sustainability and smartphones

- Most smart phones rely on materials that are mined or processed in unsafe or unethical environments
- The “Fairphone” was developed to provide an alternative that was environmentally and ethically “friendly”
- Limited exposure and limited success – perhaps because sustainability is not a consumer issue for smartphones



What happened next?

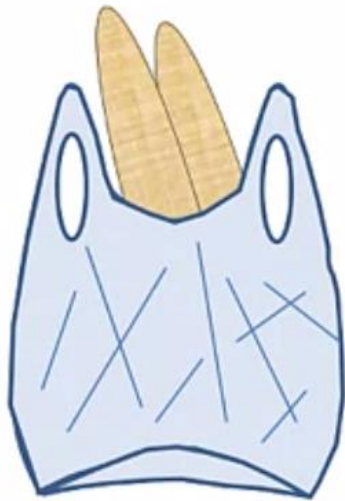


Thinking systematically ...

- For some products and processes, it is easy to identify the sustainability issues
- For some products, it is less straightforward
- The idea of the “cradle-to-grave” approach is to provide a systematic way of approaching this task
- We will return to this approach in future weeks

Plastic VS Paper Bags

Which do you think is the greener product option?



Plastic grocery bags?

OR

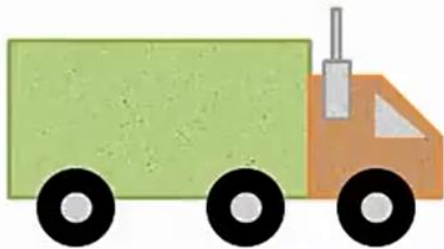


Paper grocery bags?



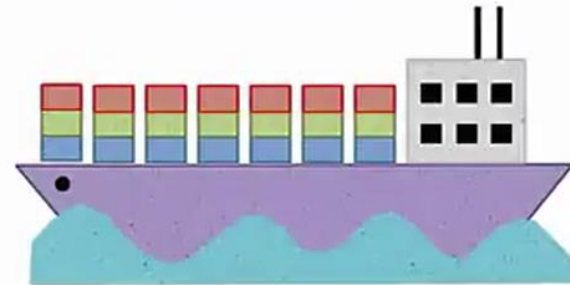
Local VS Imported Food

Which do you think is the greener product option?



Food that is sourced locally?

OR



Food that is imported?



SUMMARY: (part 1)

❑ What is sustainable development??

- Sustainable in
 - an economic sense
 - an environmental sense
 - a social sense

- Different groups in society have different viewpoints on each of these aspects of sustainability

SUMMARY: (part 2)

- ❑ Thinking systematically about sustainable development
 - consider the viewpoints of different parts of society
 - think about the whole life-cycle of a product
 - from raw materials through to disposal

- ❑ Sustainability report
 - Start thinking now – don't leave it all until the last week.