Design, Manufacture and Project Module MMME2044

Sustainable and Inclusive Design

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Based on the work of Dr Lin Wang and Simon Lawes

Design, Manufacture and Project

During this session we will have a look at:

- Design in a **context of social, environmental and commercial needs**.
- Definitions of **Sustainability**, **Sustainable Design** and associated concepts/methods;
- Definitions of **Inclusivity**, **Inclusive Design** and associated concepts/methods;
- The importance of the **designer's role** in developing sustainable products and practices;

Engineering is not just about skills and knowledge; also about context

So what is sustainability?

Sustainability ≠ tree hugging

Sustainability ≠ Greenpeace

Sustainability ≠ climate change debate

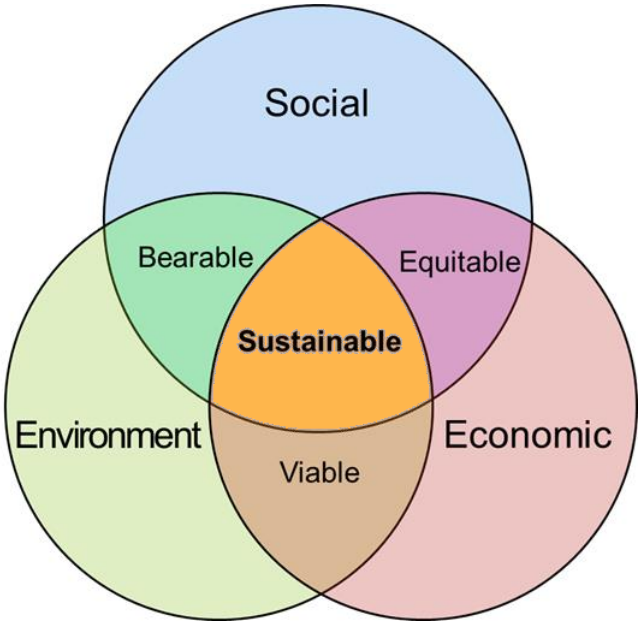
(or at least not just climate change debate)

So what is sustainability?

"Meeting the needs of the present without compromising the ability of future generations to meet their own needs."

Report of the World Commission on Environment and Development (Brundtland commission) to the United Nations General Assembly
11th December 1987

So what is sustainability?



Capacity to endure

Requires a balance between three fundamental domains.

-Triple Bottom Line

Sustainable Design - Design for products that provide **environmental**, **social** and **economic** benefits while protecting social health, welfare and environment throughout their **complete lifecycle** from raw materials extraction, and use, to eventual disposal and reuse.

Why Worry about it?

Humankind used to believe and to act as though the world's resources were infinite. Which made some sense when the world population was much smaller.

What is the current world population?

~8,022,000,000

How long ago was it half that number?

1970

What is the predicted world population in 2050?

Just under 10 billion people

http://www.worldometers.info/world-population/

Human population and resource consumption
https://www.youtube.com/watch?v=V2_LxCLwO2E

Why Worry about it?

The global footprint, often measured by global hectare (gha), is a measurement of biocapacity of the entire earth.

Land required to:

Grow food, make clothes, provide energy, cope with waste.

How do we shape up at current efficiencies?

1.9 global hectares available per person

World average person uses 2.3 global hectares

Average UK person uses **5.5 global hectares**

Average USA person uses 9.6 global hectares

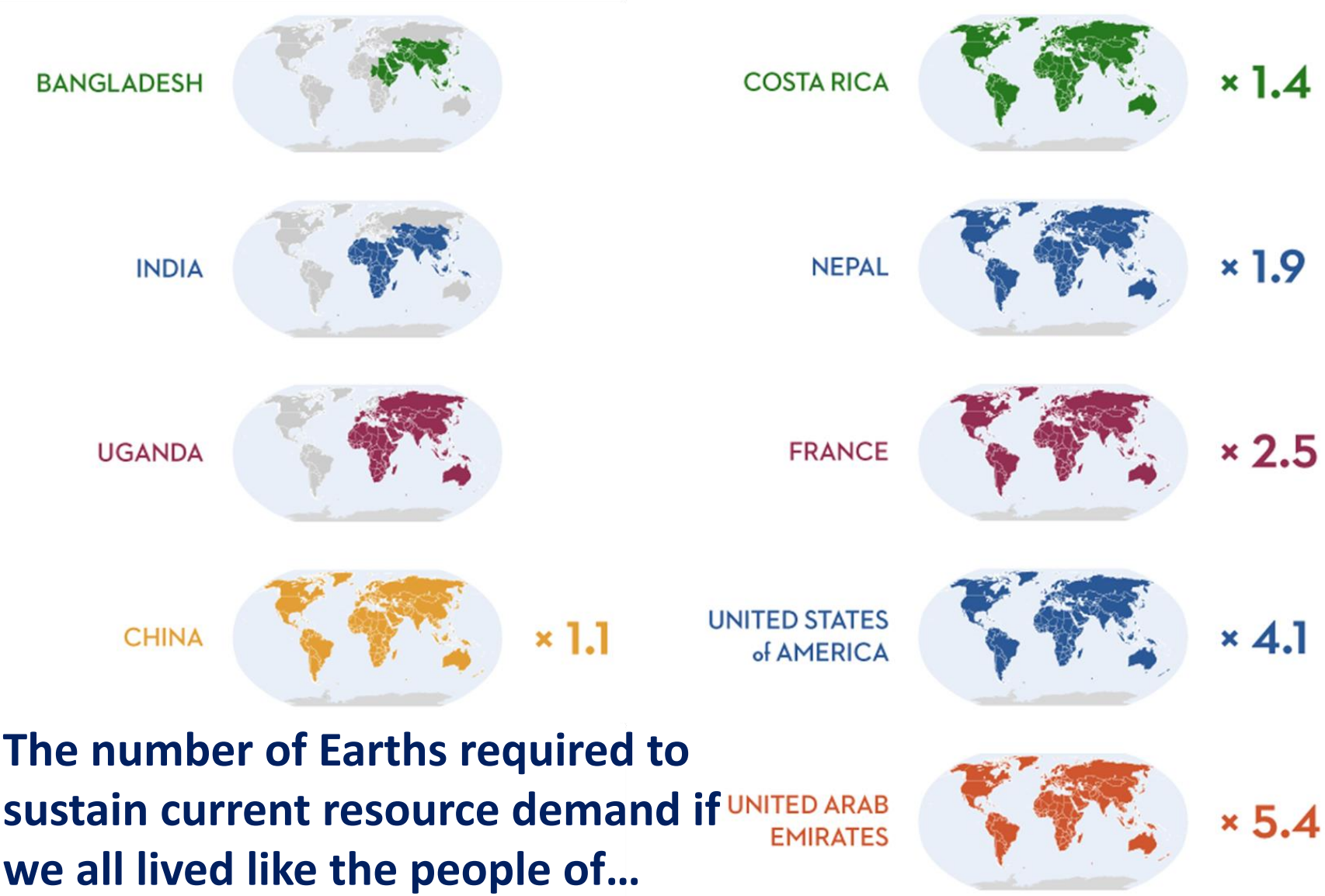
Based on 2003 data

Why Worry about it?

The number of Earths that would be required to sustain current demand if we all lived like the people of…

Based on 2003 data

Why Worry about it?

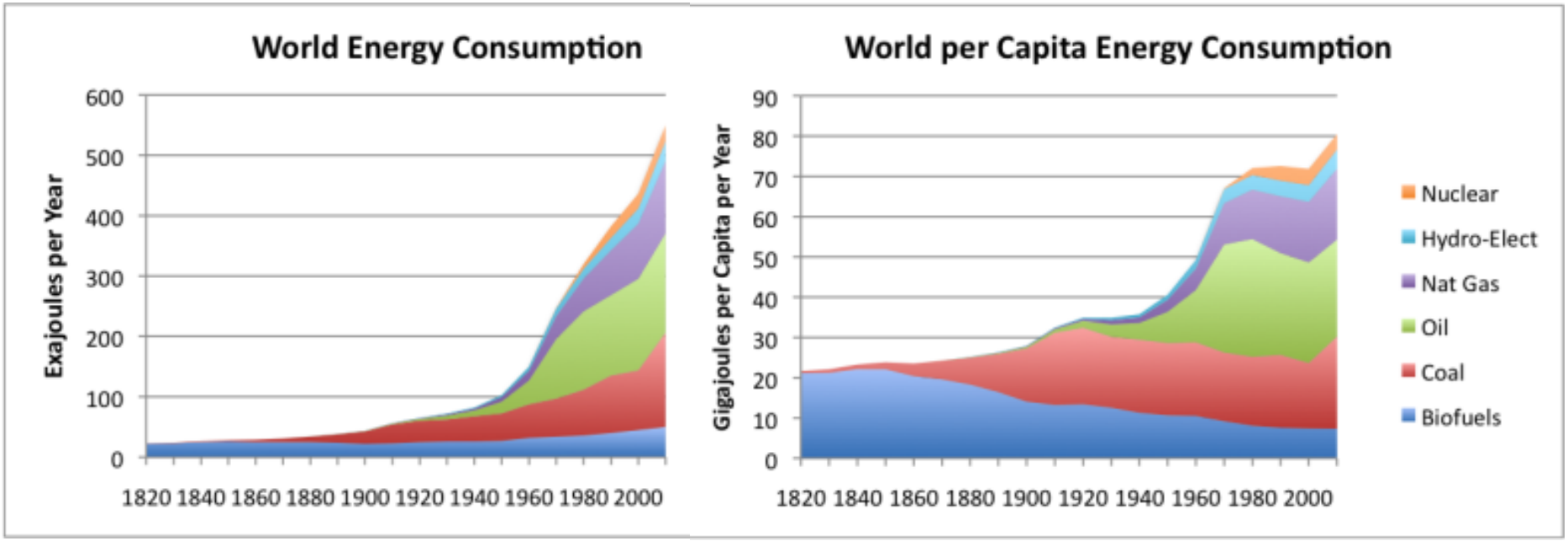


The number of Earths required to sustain current resource demand if we all lived like the people of…

Tim De Chant, based on Global Footprint Network (2003)

Why Worry about it?

Growth has been empowered by Energy and Technology, i.e. by Engineers



World energy consumption and per capita world energy consumption - based on Angus Maddison data.

Why should Engineers be interested in Sustainability?

Sustainability is the capacity for a practise to endure.

Sustainable practises must consider the Triple Bottom Line.

Society – Environment – Economy

The world isn't going to get any bigger. We need to improve our efficiency, reduce our waste and adjust how we think.

As Engineers you have a professional responsibility to contribute to sustainable development.

Why should Engineers be interested in Sustainability?

- Sustainability is a key driver for Technology and Engineering.
- It will create new jobs and new opportunities.

https://www.youtube.com/watch?v=d133WtFQ8R0

So what is Inclusivity?

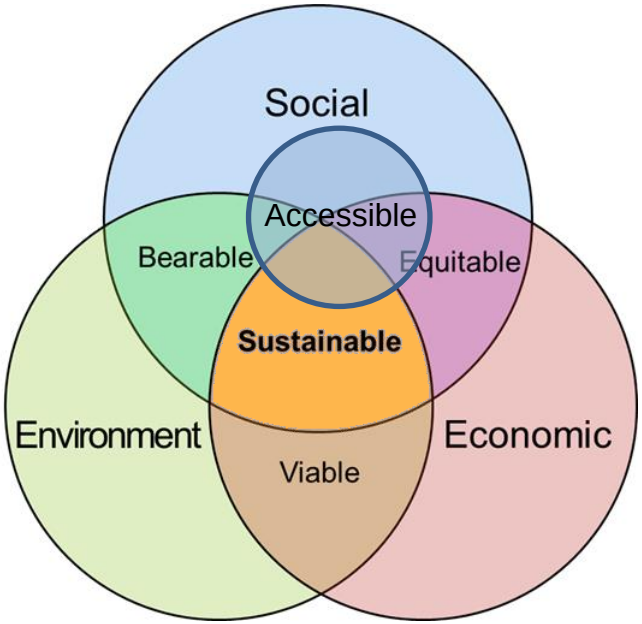
*"The design of mainstream products and/or services that are **accessible** to, and **useable** by, **as many people as reasonably possible** on a global basis, in a wide variety of situations and to the greatest extent possible… without the need for special adaptation…"*

BS 7000-6:2005 Design management systems. Managing inclusive design

- The test of what is reasonable may change with new technologies, public opinion or the result of legal judgements.
- **What is acceptable today may not be acceptable in future.**

So what is Inclusivity?

- Inclusive design aims to accommodate for the **diversity** of users.
- When we are talking about design for inclusivity we often make the assumption we're discussing accommodation of physical diversity, i.e. disability, but there are many aspects.



- We might consider Inclusivity to be an aspect of a sustainable product or service, in the area of the **Social Domain**.

BS7000-6:2005

Design management systems.
Managing inclusive design

Inclusive design recognises diversity by addressing the ability and preferences of users; not limited to;

- Impaired vision and /or hearing (including colour blindness, etc)
- different cultures
- Have language difficulties and/or speech impairments
- Have physical limitations
- Different age
- Dietary requirements
- Gender requirements

Inclusivity and disability

Accommodation of physical disability is often the easiest for Engineers to approach with our problem solving skills

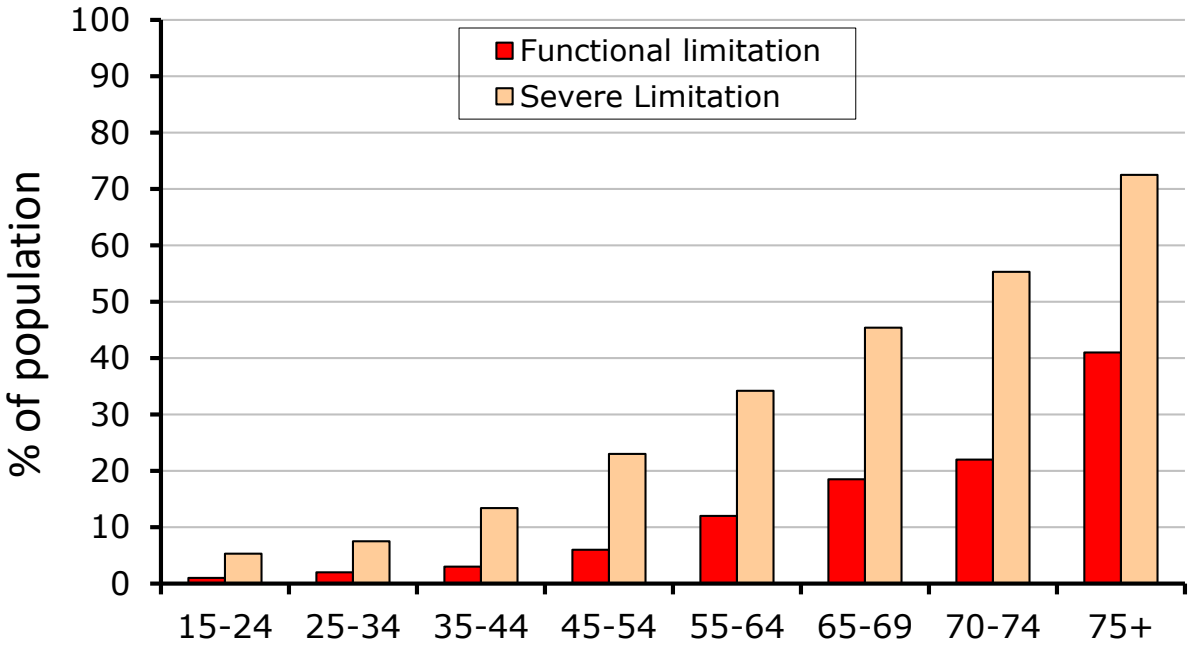
Disability prevalence disaggregated by impairment for Great Britain (millions)

	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12
Mobility	6.3	6.2	6.0	6.2	6.2	6.3	6.4	6.3	6.4	6.5
Difficulty with Lifting, carrying	5.8	5.9	6.0	6.1	6.0	6.0	6.1	6.0	6.1	6.3
Manual dexterity	2.4	2.6	2.5	2.5	2.6	2.6	2.7	2.6	2.7	2.8
Continence	1.2	1.3	1.2	1.6	1.5	1.5	1.5	1.5	1.7	1.8
Communication	1.3	1.7	1.9	2.0	1.9	2.0	2.0	2.1	2.0	2.2
Memory/ concentration/ learning	1.7	2.0	2.0	2.0	1.9	2.0	2.2	2.2	2.3	2.5
Recognising when in danger	0.4	0.6	0.6	0.6	0.7	0.7	0.7	0.7	0.8	0.8
Physical co-ordination	N/A	N/A	2.2	2.2	2.4	2.4	2.4	2.4	2.6	2.7
Other	1.4	1.9	2.5	3.2	3.2	3.4	3.5	3.8	3.9	4.1
At least one impairment	10.4	10.1	10.1	10.8	10.4	10.6	10.9	11.0	11.2	11.6

Disability prevalence estimates taken from the UK GOV Family Resources Survey 2011/12

Inclusivity and an aging population

- By 2030 22% 0f Britain's adult population (16+) will be aged 65 or over
- Over the course of the 20th Century life –expectancy rose in excess of 2.5 years per decade on average



Why be Inclusive?

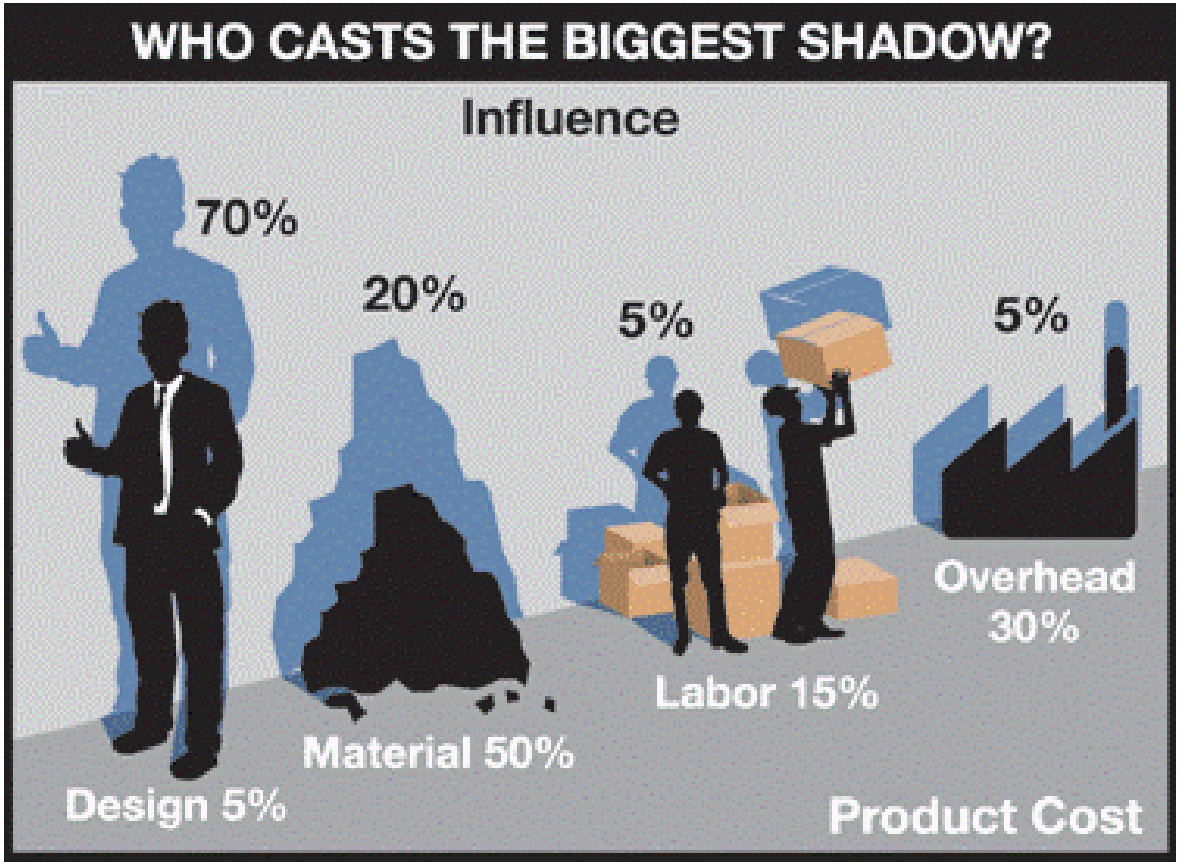
- Social Responsibility - Social Justice
- Grand Challenge - Changing Demographics
  - National or International initiatives
- Legal requirement – Legislation
  - Disability Discrimination Act 1995 (DDA)
  - DDA Code of Practice 2004
  - BS7000-6:2005 Design Management Systems
- Opportunity for Innovation - Market opportunities

What can we do as designers?

Design has a strong influence on final cost ~ 70%.

Design has an even bigger influence on environmental impact and accessibility of a design.

- Select concept
- Determine details
- Select materials & manufacturing methods
- Determine methods for maintenance and disposal



Sustainability

Towards Sustainable Design

- By integrating sustainability concerns into design, there is potential to bring far-reaching benefits.
- For design to be most effective, ecological and social considerations have to be built into the **earliest stage**.

How do we know what's wrong with our current product?

How do we know our design is best?

How do we generate new design concepts?

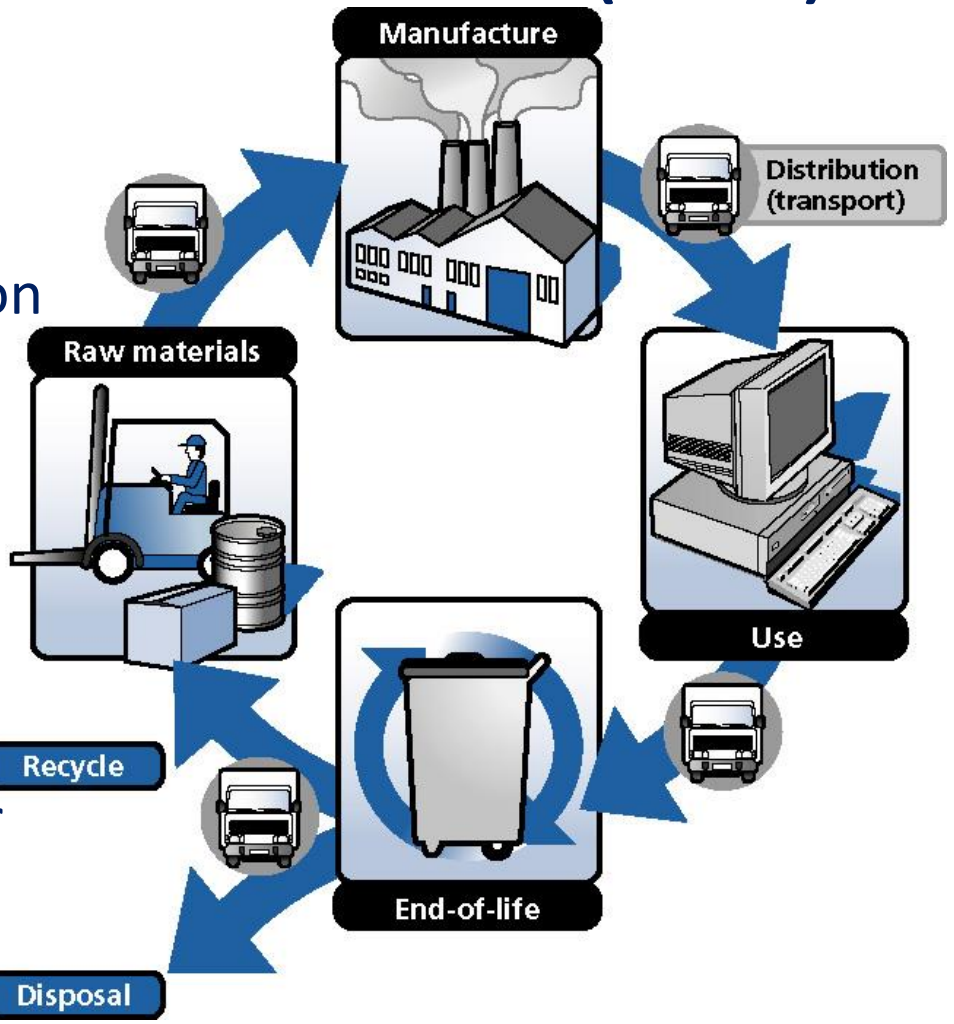
How do we select concepts?

Life cycle assessment **Fast Five**

The Six Rs

Product lifecycle assessment (LCA)

- Life cycle assessment/analysis tries to identify all of the inputs and outputs at each stage in a products life. From the extraction of raw materials for production, through to decommission and potential recycling or reuse.
- Highlighting conflicts.
- E.g. Electric cars offer an alternative to emissive petrol or diesel, but the production of lithium-ion batteries also has environmental impact



Product lifecycle assessment (LCA)

Life cycle assessment for vehicle emissions

https://www.youtube.com/watch?v=UF_bvj0cQoo

What to do with LCA results?

- Inform decision-makers, who will then make a decision based on the balance of information for different (competing) priorities

- Use a structured approach to “weight” different impacts, including financial costs

Energy return on investment

- **Energy Return on Investment (EROI)** – trade-off between upfront energy use for capital, and in-use energy consumption
- Measure the net energy use impacts of a decision, based on **additional upfront energy use** and **in-use energy savings**

$$EROI = \frac{In-use\ energy\ savings}{Additional\ upfront\ energy\ use}$$

Green house gas (GHG) return on investment

- In the same way that we might consider the upfront investment in Energy against lifetime savings, we can consider the upfront investment in GHG release.
- Measure the **additional upfront GHG release** and **in-use GHG emissions savings**

Integrating LCA with financial decision-making

Is higher cost appropriate for the avoided damage?
We can calculate the **cost-effectiveness** of avoiding a particular impact:

$$Cost - effectiveness = \frac{additional\ cost}{environmental\ benefit}$$

With this information, we can:

- compare options to achieve the desired benefit at the lowest cost
- compare with willingness to pay to avoid negative environmental consequence

Fast Five

Philips use the fast five system as a quick way to asses products, by asking five YES/NO questions .

- **Energy** - does the proposed design use less energy than the reference product?
- **Recycling** - is the new product more easily recycled than the reference product?
- **Hazardous waste** - does the proposed product contain less chemical waste than the reference product?
- **Product value** - does the new design contribute to a longer product life, increase the desirability of the product and make it easier to repair?
- **Service** - is this a new way to provide a service with less environmental impact?

All Yes = Excellent alternative
3 out of 5 Yes = Interesting idea worthy of more investigation
1 out of 5 Yes = Consider another alternative

The Six Rs

Rethink: Alter the way the product is used, provided, or the choice of lifestyle that motivates its use in order to reduce impact.

Reduce: Alter the design of the product to directly reduce the amount of materials or energy that go into its production, transport and use.

Replace: Make use of alternative materials or practices that have lower environmental or social impact.

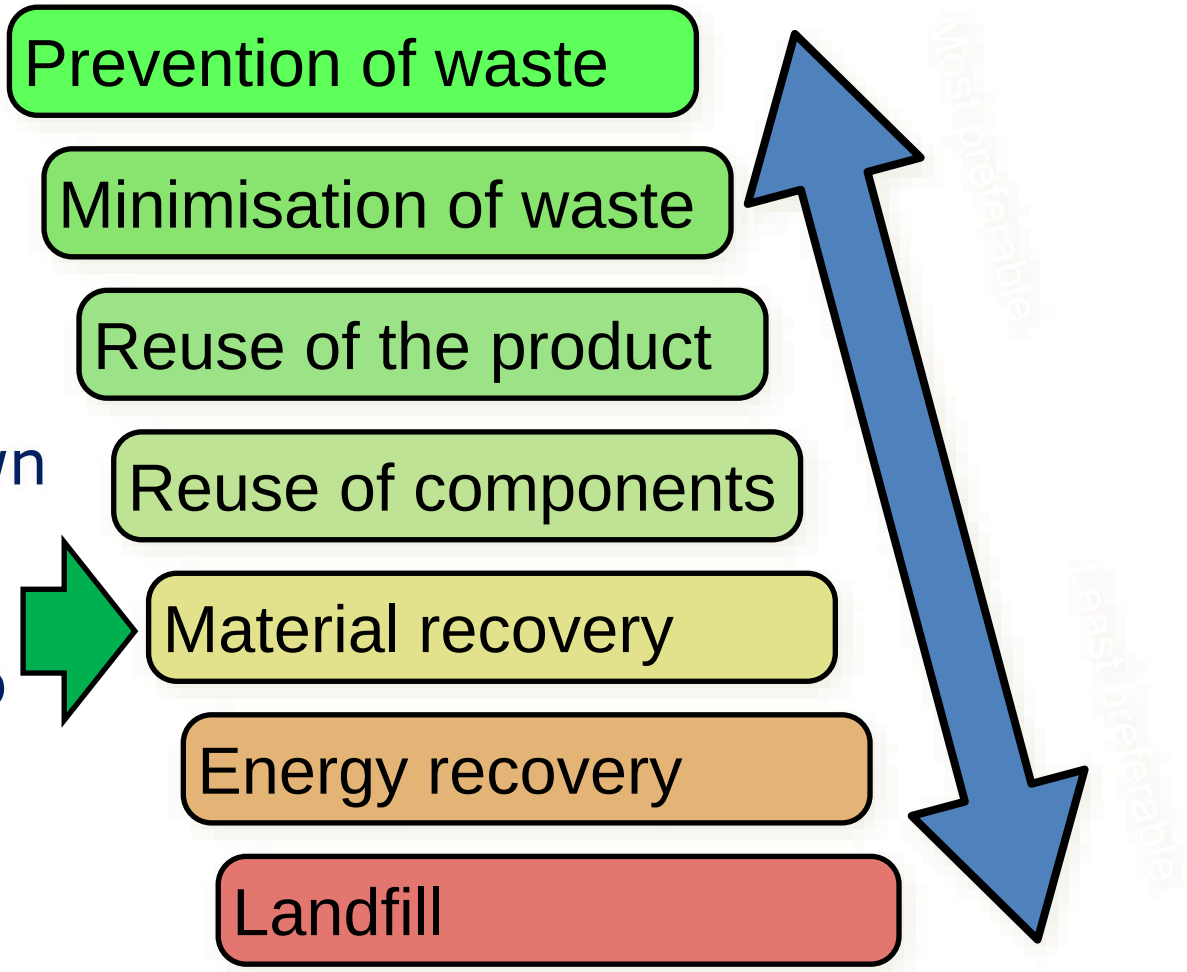
Recycle: Find use for the reprocessed and reclaimed materials, typically requiring a change in the design to make recycling economically viable.

Reuse: Find alternative use of the product or its major components beyond the typical lifetime.

Repair: Extend the useful life of the product by designing for repairs, replacements and upgrades.

The Six Rs cont.

Recycling alone isn't the answer



Recycling is well down the list in the pollution prevention hierarchy. We can do better!

From the Waste Framework Directive (WFD):
European Union Directive of 17 June 2008

Dematerialisation

- “Less is more” – only give the customer the features they really want
- Using less material
- Spend less money (profit)
- Conserve resources (planet)
- Less waste at end-of-life (people)

Dematerialisation - packaging

- Uncle Ben's 500g sauce jars had 285g of glass in them.
- A new jar contains 243g of glass, with the same amount of sauce.
- Reducing the container weight by 6% saved manufacturer Mars "energy equal to taking 192 cars off the road."

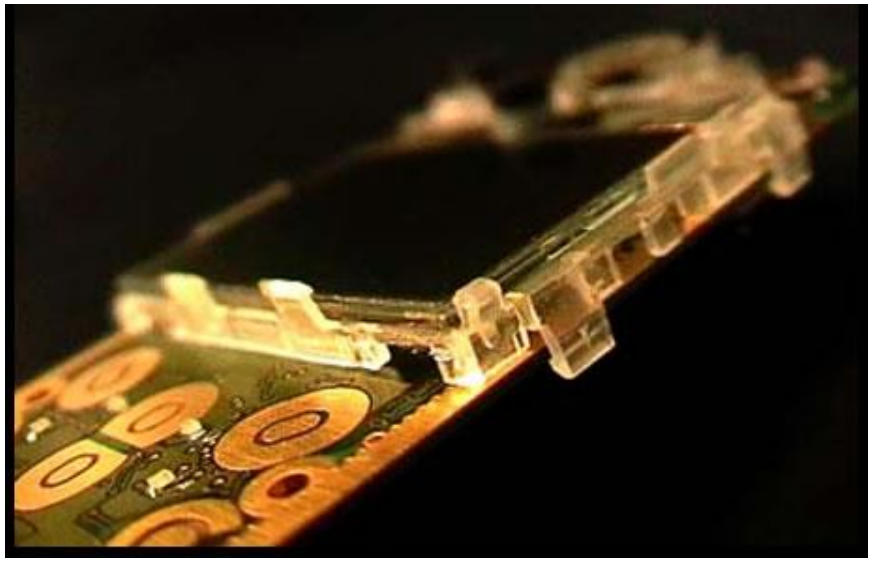
Life extension

- **Upgradeable products** (extra memory, software upgrades) for a longer useful life.
- **Design the product for easy repair**, through design for disassembly, and including instructions or providing labels detailing repair procedures.
- **Avoid replacement** of the product due to damage or loss of aesthetic quality by specifying hardwearing materials and finishes.
- Design a product with both **current and emerging** technologies in mind (digital and FM radio).

Design for disassembly

- Goal: reduced disassembly costs.
- Ease of maintenance is an added benefit.
- Means the product and its components are better suited for re-manufacture or recycling when it has reached its end of life.
- Possible link to modularity - break the component down into logical ‘chunks’ that have greater value when separated.
- Note that Design for Disassembly will sometimes be at odds with Design for Assembly (DFA).

Nokia developed a prototype mobile that would separate into battery, display, printed wiring board and casing parts in just two seconds, when heat was applied.



Design for Sustainability

Synergistic with good design

Design for sustainability		Good design practise
Minimises resources and energy input in manufacture.	⇨	Reduces costs by avoiding energy intensive or wasteful processes.
Minimises energy input during use.	⇨	Operates efficiently, saving the customer money. Giving market advantage.
Limits impact on the environment and society.	⇨	Promotes brand through positive product experiences.
Minimises end of life impact.	⇨	Operates reliably, without failure, over product lifetime.
Minimises conflict with societal and environmental needs.	⇨	Understands the needs of the market. Works for the customer in the way that they want it to.

Design for Inclusivity

When considering the inclusivity of our products or services we should employ 7 principles/objectives

1. Equitable use
2. Low physical effort in use
3. Flexibility of use
4. Simple and intuitive use
5. Perceptible information
6. Tolerance of errors
7. Appropriate size and space for approach and use

1: Equitable Use

The design is useful and marketable to people with diverse abilities.

Guidelines:

a. Provide the same means of use for all users: identical whenever possible; equivalent when not.

b. Avoid segregating or stigmatizing any users.

c. Provisions for privacy, security, and safety should be equally available to all users.

d. Make the design appealing to all users.

2: Flexibility in Use

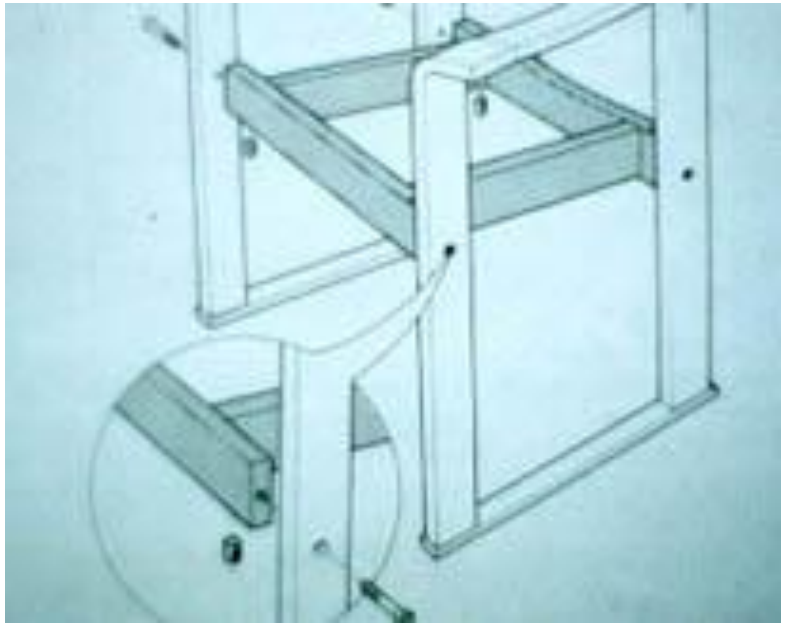
The design accommodates a wide range of individual preferences and abilities.

Guidelines:

a. Provide choice in methods of use.
b. Accommodate right- or left-handed access and use.
c. Facilitate the user's accuracy and precision.
d. Provide adaptability to the user's pace.

3: Simple and Intuitive Use

Use of the design is easy to understand, regardless of the user's experience, knowledge, language skills, or current concentration level.



Guidelines:

a. Eliminate unnecessary complexity.
b. Be consistent with user expectations and intuition.
c. Accommodate a wide range of literacy and language skills.
d. Provide effective prompting and feedback during and after task completion.

4: Perceptible Information

The design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities.

Guidelines:

a. Use different modes (pictorial, verbal, tactile) for redundant presentation of essential information.

b. Provide adequate contrast between essential information and its surroundings.

c. Differentiate elements in ways that can be described (i.e., make it easy to give instructions or directions).

d. Provide compatibility with a variety of techniques or devices used by people with sensory limitations.

5: Tolerance for Error

The design minimizes hazards and the adverse consequences of accidental or unintended actions.

Guidelines:

a. Arrange elements to minimize hazards and errors: most used elements, most accessible; hazardous elements eliminated, isolated, or shielded.

b. Provide warnings of hazards and errors.

c. Provide fail safe features.

d. Discourage unconscious action in tasks that require vigilance.

6: Low Physical Effort

The design can be used efficiently and comfortably and with a minimum of fatigue

Guidelines:

a. Allow user to maintain a neutral body position.
b. Use reasonable operating forces.
c. Minimize repetitive actions.
d. Minimize sustained physical effort.

7: Space & Size for Approach & Use

Appropriate size and space is provided for approach, reach, manipulation, and use regardless of body size, posture, or mobility.

Guidelines:

a. Provide a clear line of sight to important elements for any seated or standing user.

b. Make reach to all components comfortable for any seated or standing user.

c. Accommodate variations in hand and grip size.

d. Provide adequate space for the use of assistive devices or personal assistance.

Example

Example - Ed Roberts Campus

https://www.youtube.com/watch?v=G-tHuD7R8cs

Design for Inclusivity

Synergistic with good design

Design for Inclusivity		Good design practise
Maximises the number of possible users.	⇨	Accesses large markets and growing markets
Creates robust products with long lifetimes	⇨	Positive user experience. Reduces costs for servicing
Creates products that are approachable to a wide range of users.	⇨	Positive reputation for your products
Creates products that do not need expensive modifications	⇨	Reduces cost of after market product development

To summarise

Sustainability is the capacity for a practise to endure.

Inclusivity is the capacity to be used by all.

Sustainable practises must consider the Triple Bottom Line.
Society – Environment – Economy

Inclusive practises must consider accessibility and use for as many people as **reasonably possible.**

As Engineers you have a professional responsibility to develop sustainable and inclusive products/services.

Designers for should consider the context of a product/service early in the design process and evaluate impact at all stages of the life cycle.

Design, Manufacture and Project
Questions or comments so far