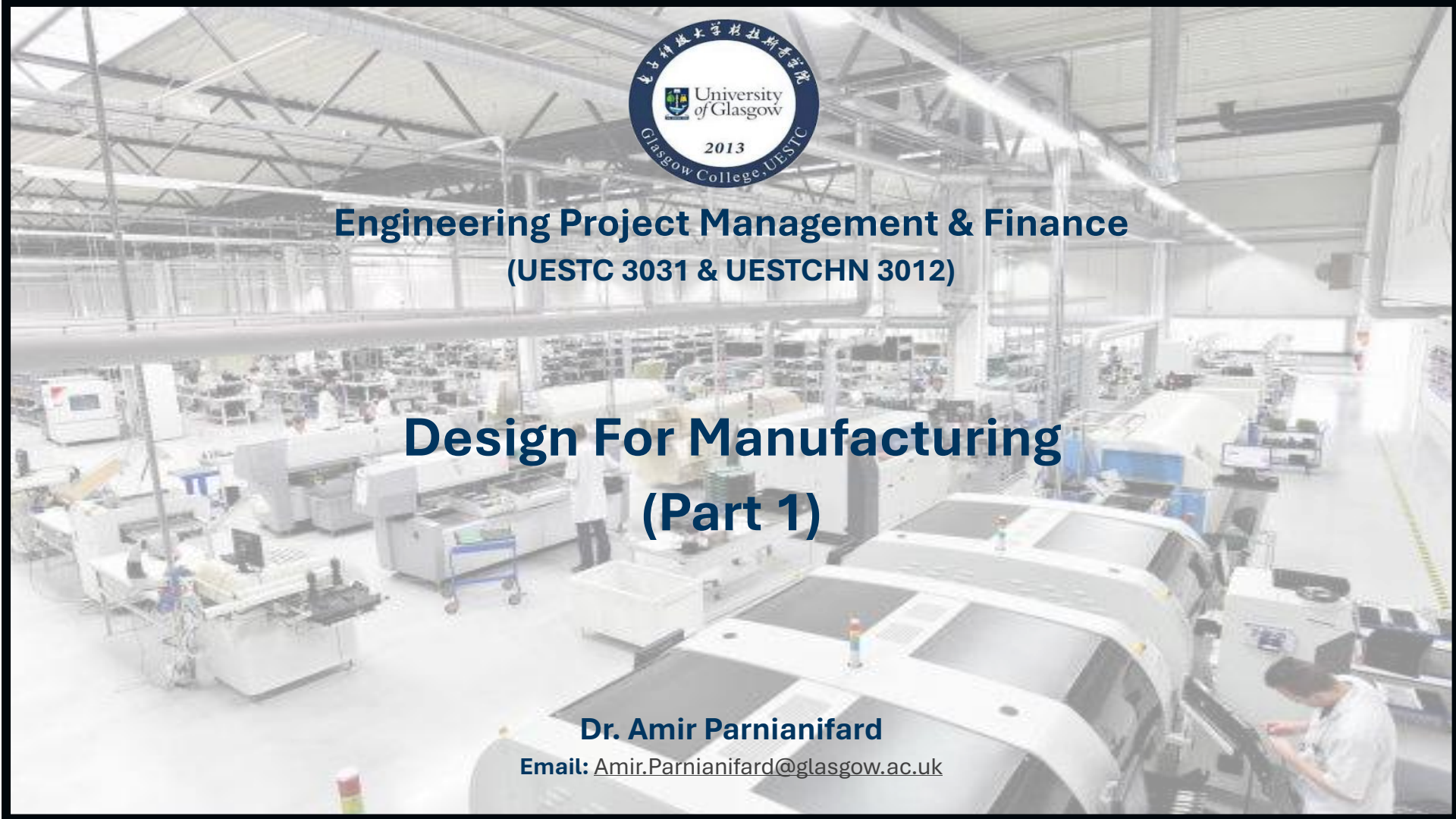

Engineering Project Management & Finance

(UESTC 3031 & UESTCHN 3012)

Design For Manufacturing (Part 1)

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Outline

- **Part 1:** Introduction & Design for Sustainability
- **Part 2:** Quality Control & Cost of Quality
- **Part 3:** Robust Manufacturing Design
- **Part 4:** 6-Sigma & Process Capability

Definition

- Design For Manufacturing (DFM) is the process of designing components of high-quality products for ease of manufacturing at a lower cost.

- This is done by lowering complexity, optimizing performance, and redefining the product.
- DFM has various advantages, including lower production costs, higher product quality, and a shorter time to market.

How do you design something for manufacturing?

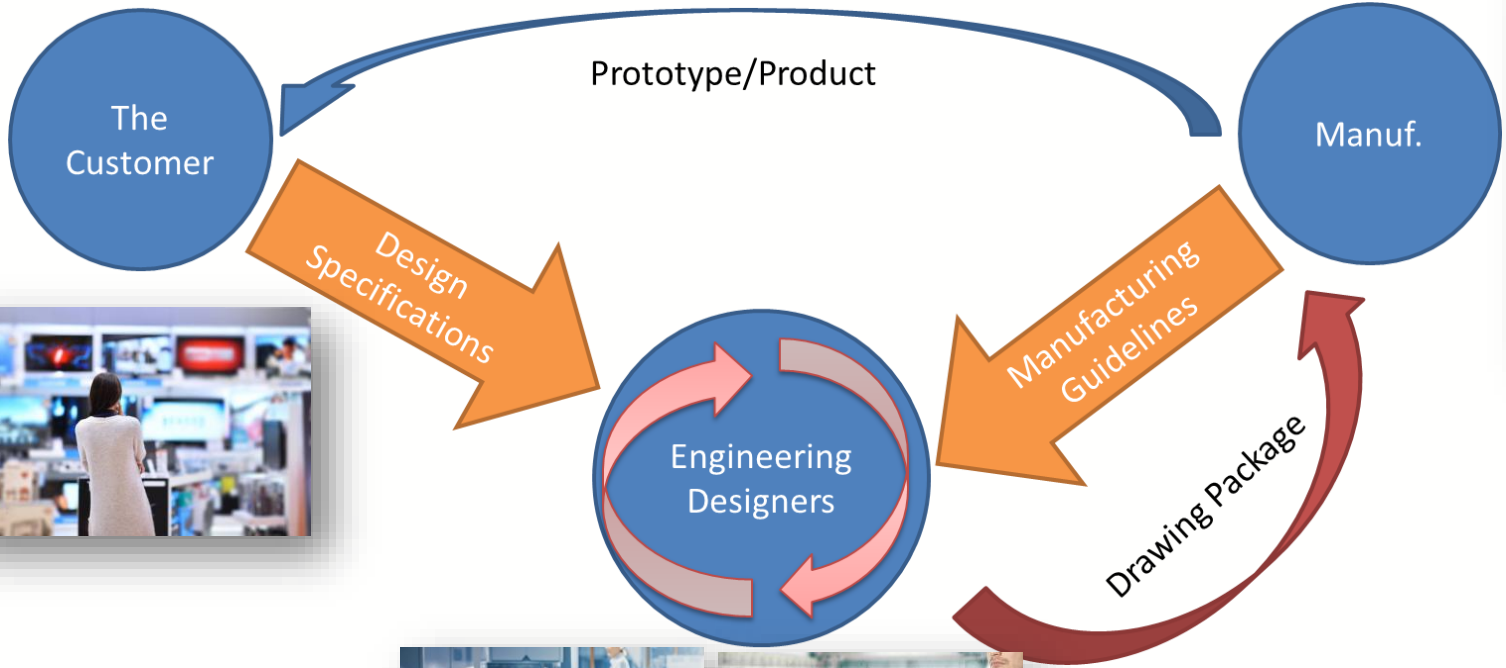
As you develop your design, consider the following:

- ✓ The function of your product.
- ✓ How it will be used?
- ✓ What it will be made of?
- ✓ How long consumers will use your product?
- ✓ Will it require a warranty?
- ✓ How much it will cost to manufacture?
- ✓ Will you be able to make a profit from your product?
- ✓ etc.

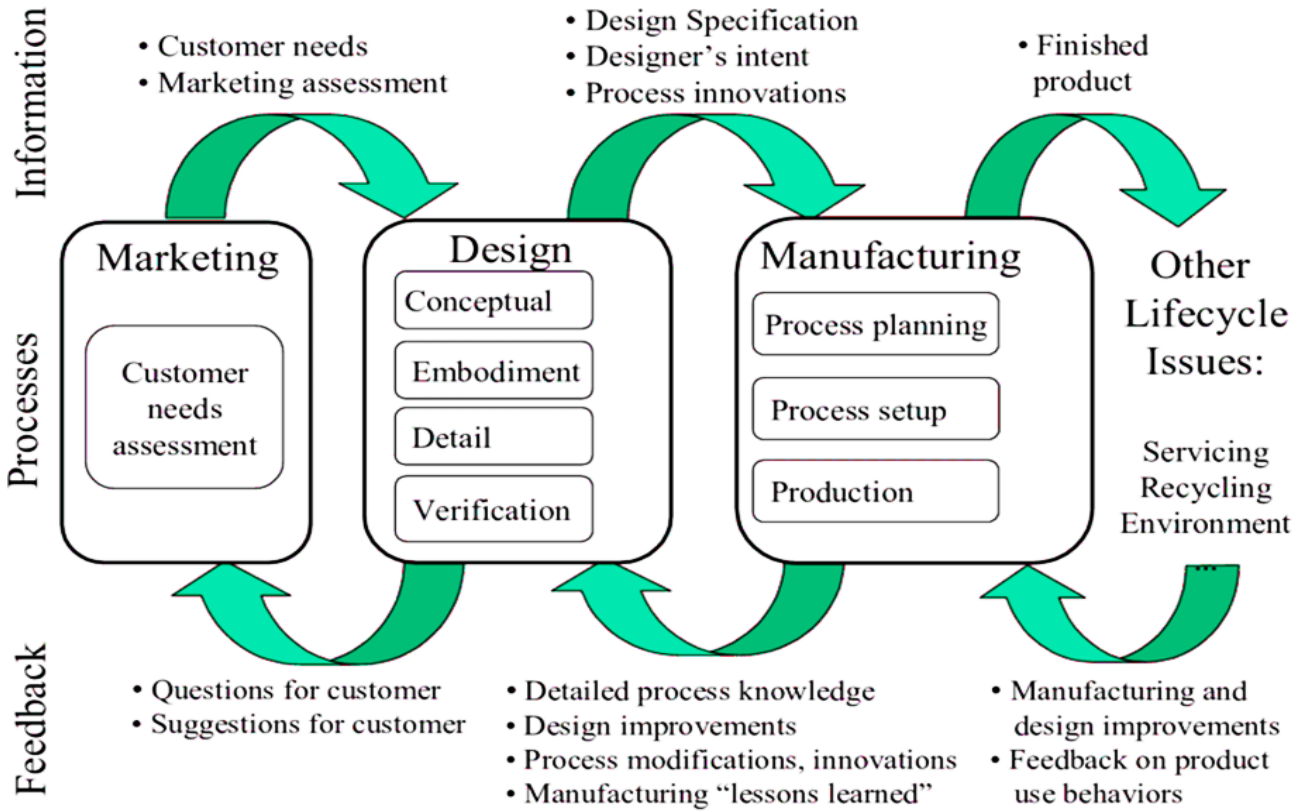
History

- DFM has its roots in the post-World War II era when companies were looking for ways to improve their competitiveness in the global market.
- While manufacturers were facing with strong competition by other manufacturers (rivals), at the time, they were under pressure to reduce costs, enhance the quality of products, and increase production efficiency.
- In response, companies began to adopt a more systematic approach to product design, incorporating consideration of production processes, tooling, and other manufacturing factors into the design process.

Flow of Design Knowledge

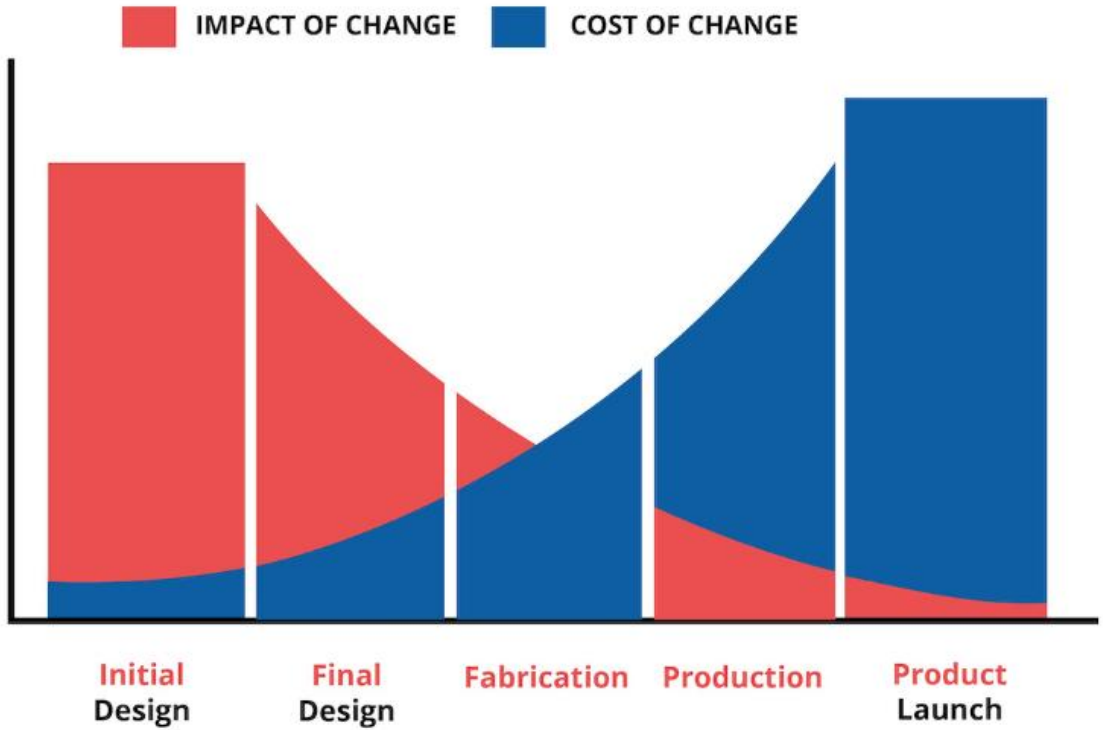


Product Development Lifecycle



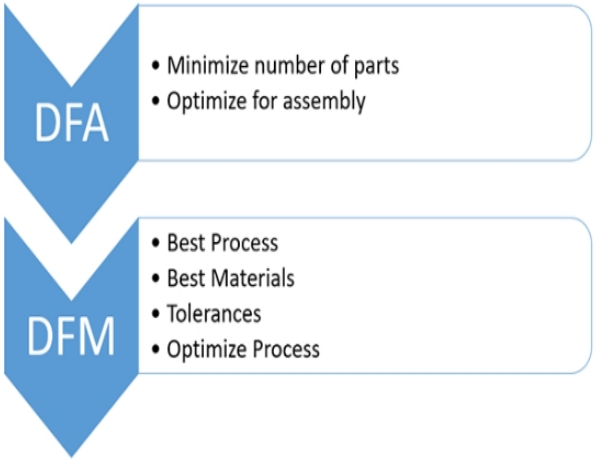
Why is DFM Important?

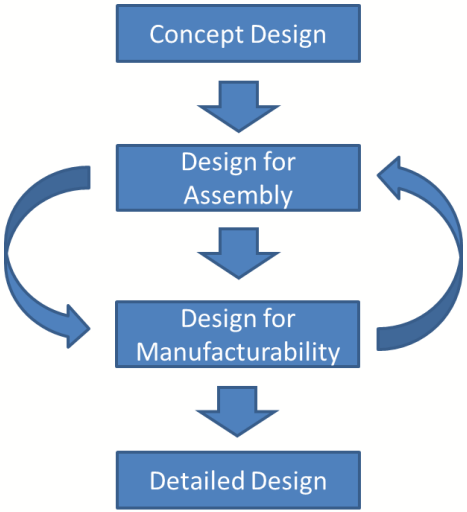
- It is usually accepted (demonstrated) that 70% to 80% of production costs are determined by design decisions.



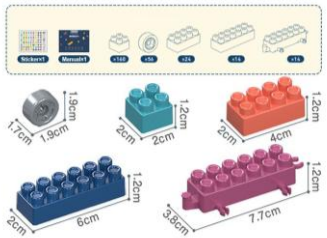
DFM vs DFA

- DFM is a design method to reduce the complexity of manufacturing operations and the overall cost of production including the cost of raw materials.



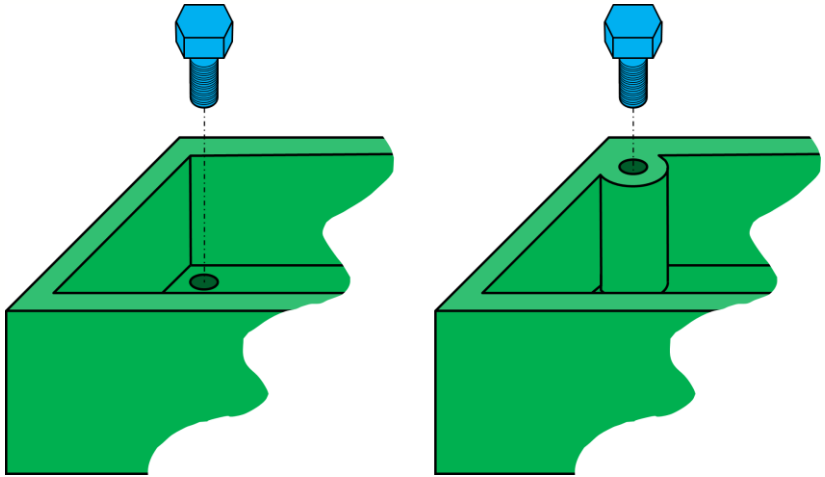


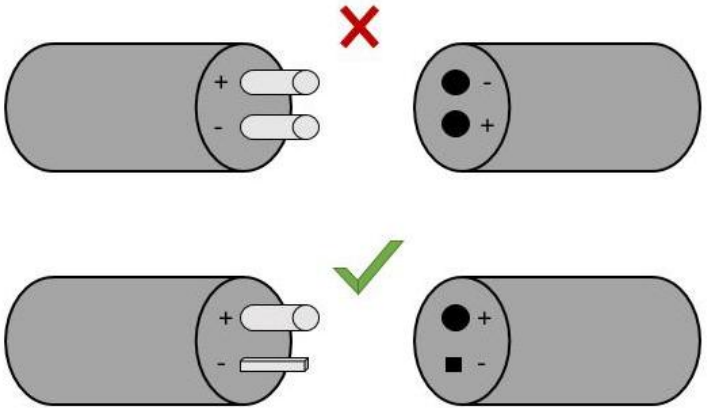
- Design for Assembly (DFA) is a design method to facilitate or reduce the assembly operations of parts or components of a product.



Principles of DFM (1/6)

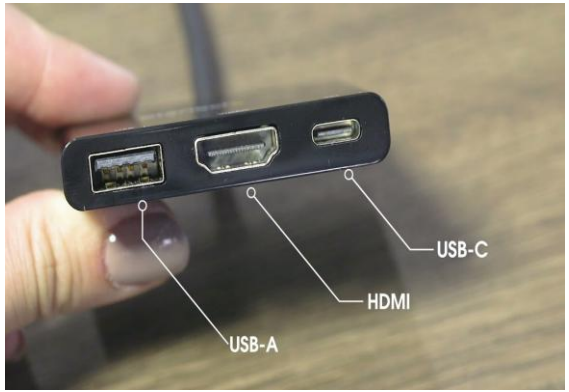
- **Simplicity:** The design should be kept simple with as few parts as possible and use straightforward shapes and structures to make production easier and more cost-effective.

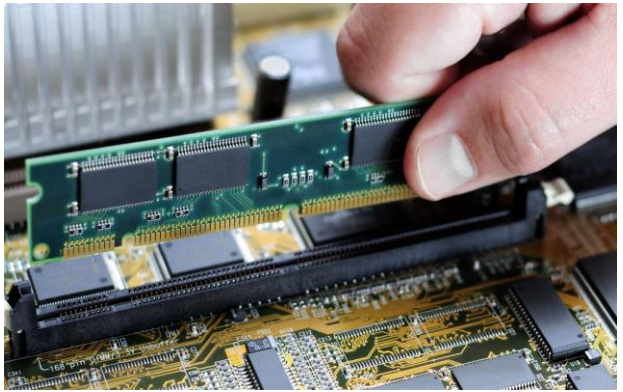




Principles of DFM (2/6)

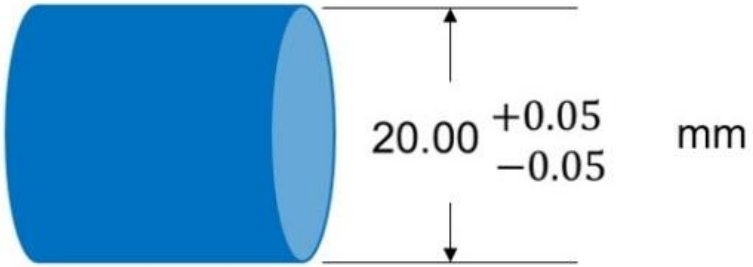
- **Standardization:** Whenever possible, standard components and manufacturing processes should be used in the design, as this can save time and reduce production costs.

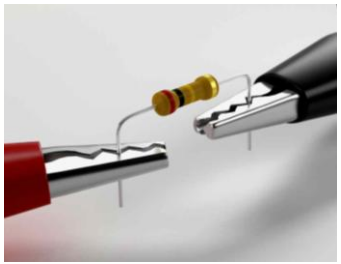


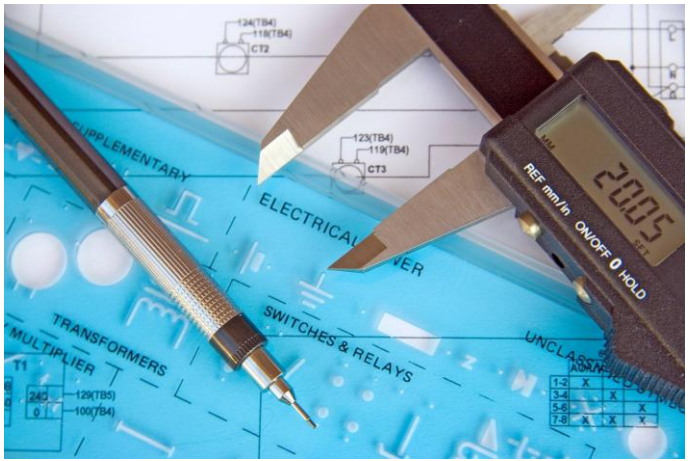


Principles of DFM (3/6)

- **Tolerance**: Proper tolerance design is critical in ensuring that the product fits and functions as intended. Tolerances must be carefully considered to balance the need for precision with the cost of manufacturing.

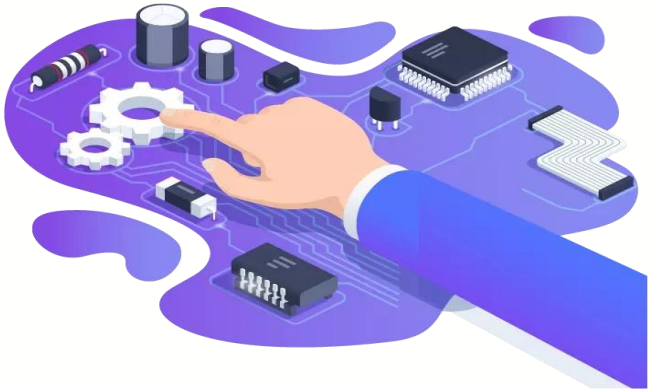


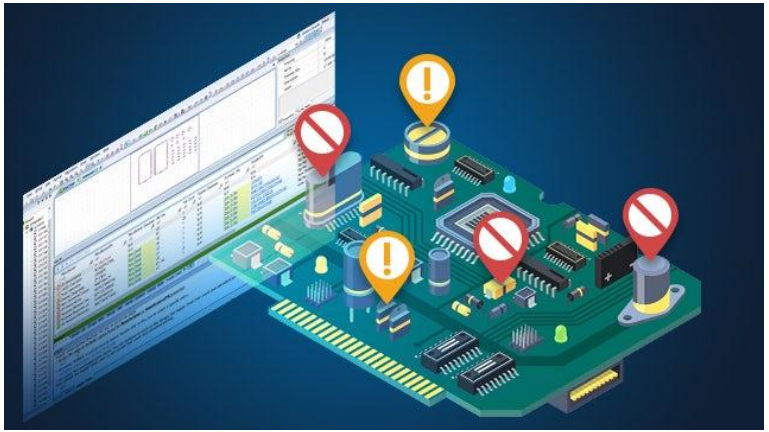




Principles of DFM (4/6)

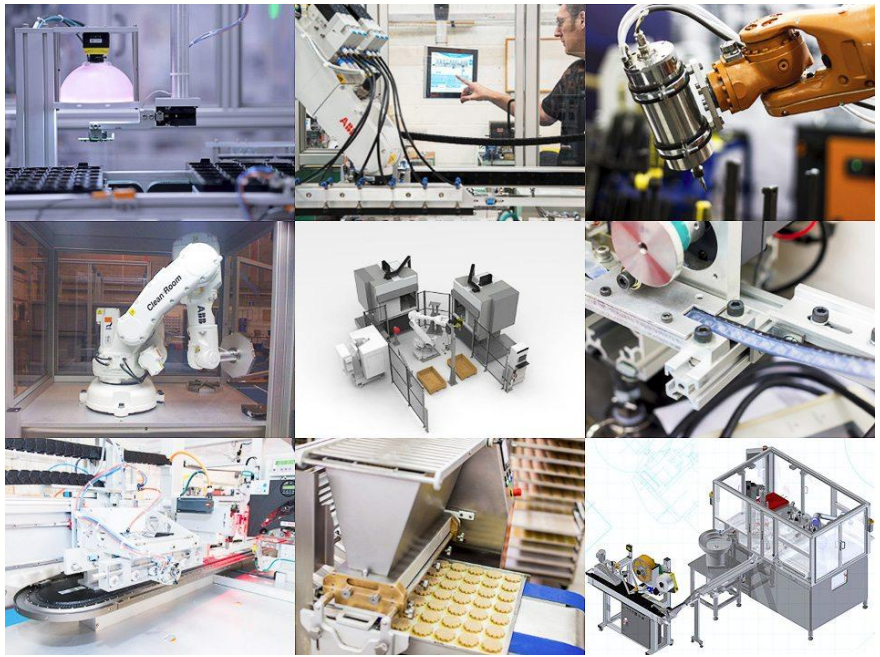
- **Material Selection:** The choice of materials greatly impacts production costs and the final product quality. We must consider the properties of the materials, such as strength, durability, and manufacturability, when selecting the materials for a product.





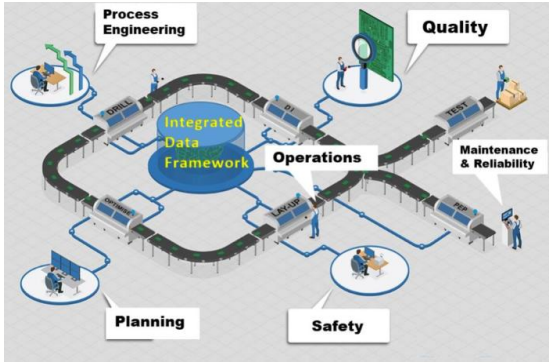
Principles of DFM (5/6)

- **Automation:** Automated processes can significantly improve production efficiency, reduce labor costs, and improve product quality. The project expert must carefully consider the type and level of automation to be implemented in the production process.



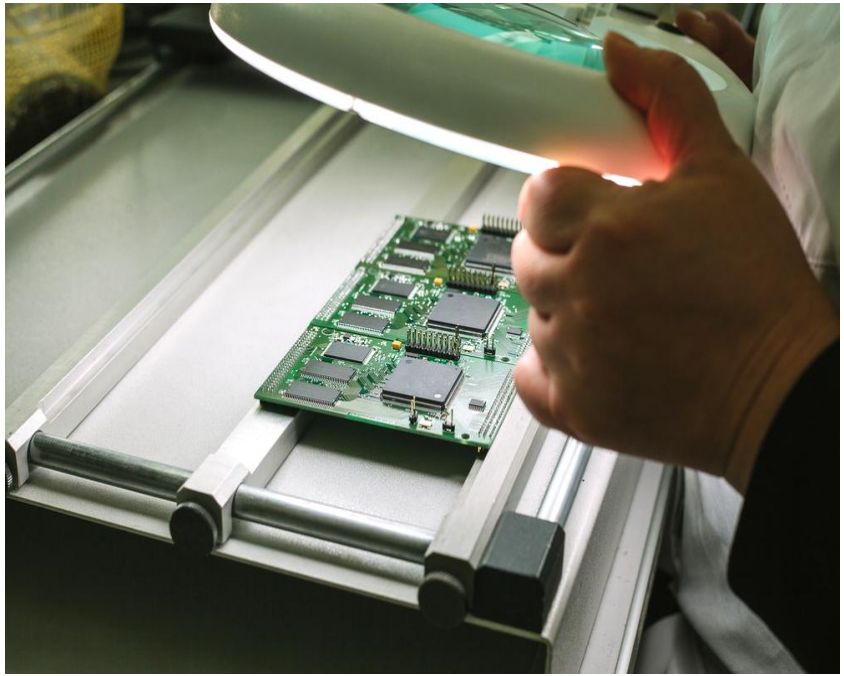
Principles of DFM (6/6)

- **Process Integration:** Integrating product design, manufacturing processes, and quality control are crucial in improving production efficiency and reducing costs. A project expert has to work closely with other professionals, such as industrial designers and process engineers, to ensure that the design, manufacturing, and quality control processes are appropriately integrated.



Benefits of Product Development with DFM

- Lower Manufacturing Costs
- Improved Production Efficiency
- Improved Product Quality
- Streamlined Product Development Process
- Better Supply Chain Management
- Enhanced Competitiveness
- Compliance with Regulations

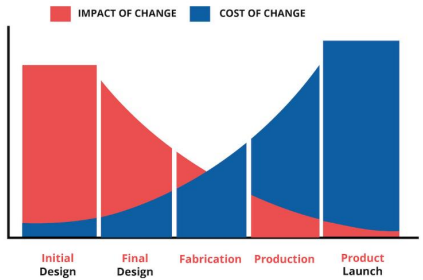


Who is Responsible for DFM?

- Design Engineers
- Manufacturing Engineers
- Quality Control
- Procurement
- Management

How Long Does DFM Take?

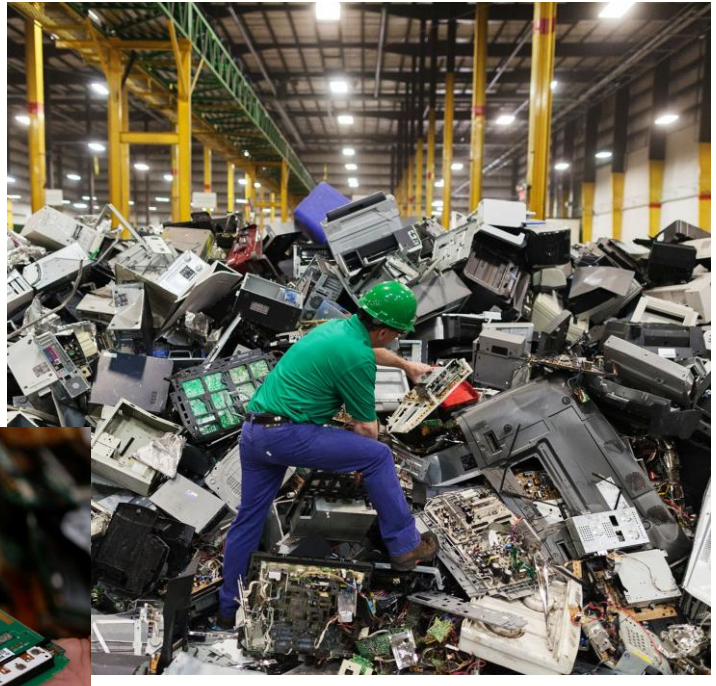
- The time required for design for manufacturability is determined by the product's complexity, the organization's size, and the resources available.
- As a general rule, DFM is a continuous process that continues through the entire product lifecycle.

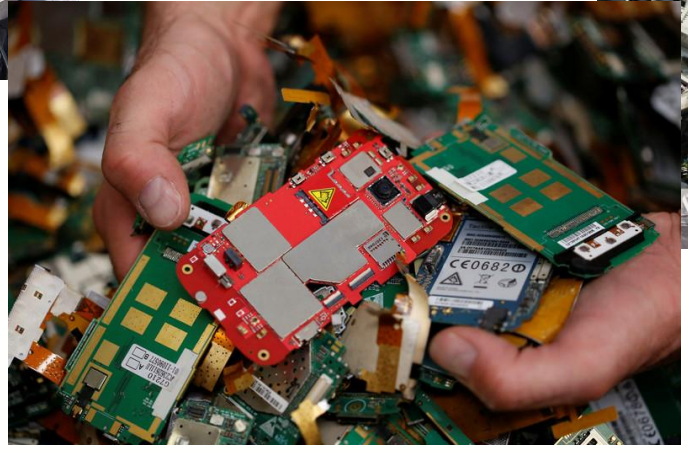


Other Methods Joint with DFM

Design for Sustainability (DFS)

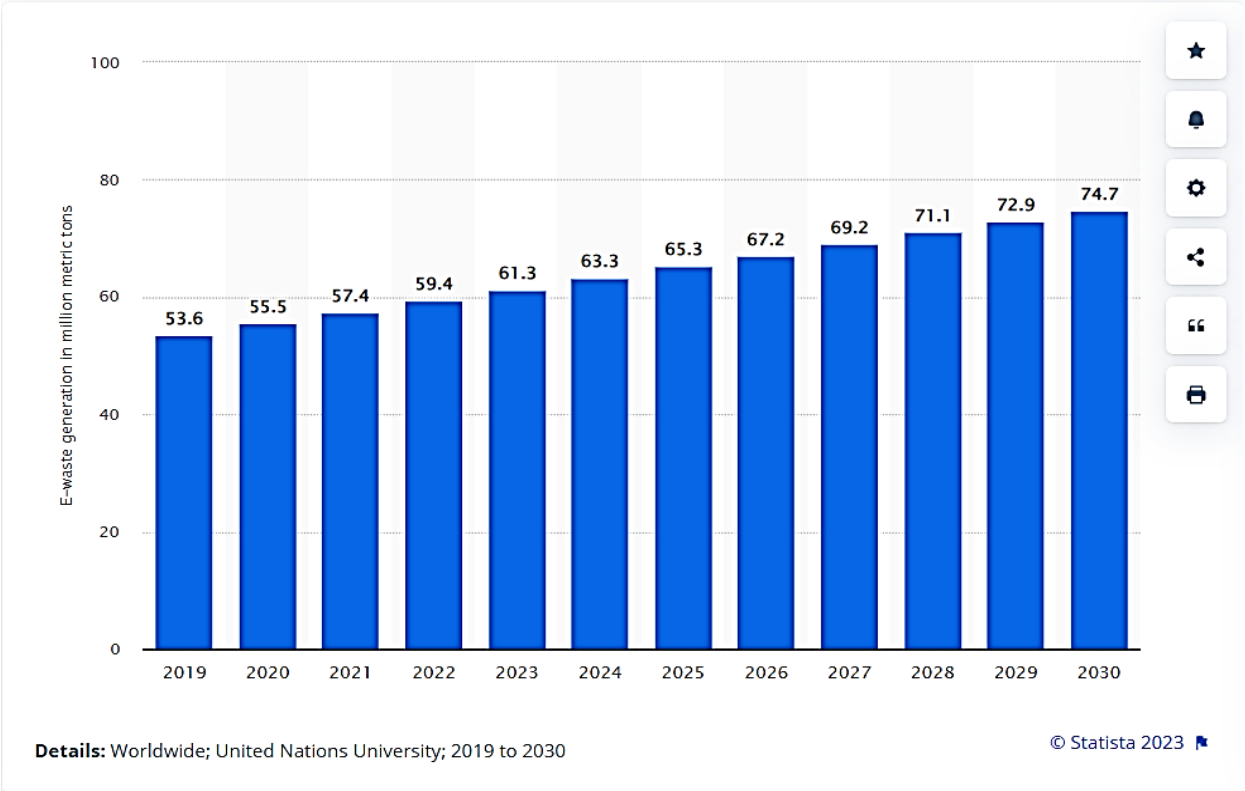
What do you think regarding these photos?





Electronic Waste (E-Waste)

Projected electronic waste generation worldwide from 2019 to 2030 (in million metric tons)



Sustainability Definition

- Sustainability consists of fulfilling the needs of current generations without compromising the needs of future generations, while ensuring a balance between economic growth (Economic pillar), environmental care (environmental pillar),and social well-being (Social pillar).

What Is Design for Sustainability?

- DFS (also known D4S) is a subset methodology under the DFX family (Design for Excellence) with its main focus on developing sustainable products.
- All of the sustainability strategies have either one or both of the following objectives:
  - Use fewer resources
  - Prefer eco-friendly alternatives

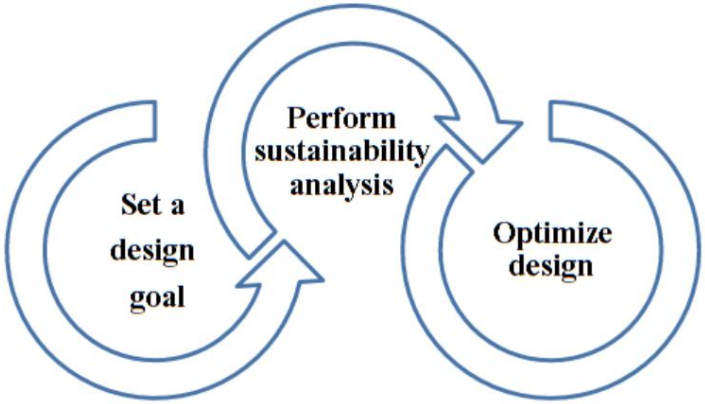
- These resources could mean raw materials, processes, systems, distribution methods and anything else that is necessary for a product to exist.

Responsible for Sustainability

- It is not right to shift all the responsibility to the end-user.
- Manufacturing companies and their designers have to take the most responsibility for the environmental effects of their products and work actively on designing more sustainable products.
- Consumers can make an environmental impact when preferring socially responsible products to minimize waste and their carbon footprint.

The Importance of Design Stage for Sustainability

- Almost all of the resource choices are affected by its product design stage.
- In other words, the design stage is the most influential in determining how a product will affect the environment through its raw materials, manufacture, distribution, usage, maintenance and disposal.



- Sustainable Product Policy by the European Commission states that as much as 80% of a product's negative impact on the environment is finalized at the design stage.

The Need for Sustainability

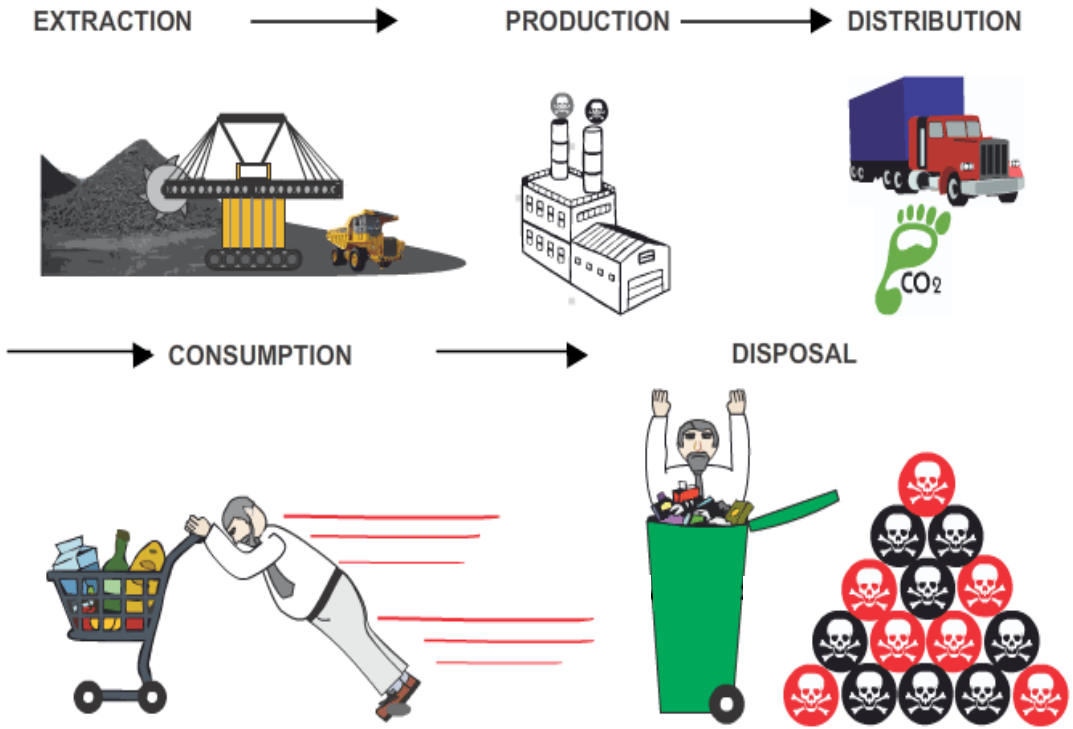
- Sustainability in production and in the use of products has become increasingly important in the past few decades.
- Without sustainability, we will likely

➢ run out of natural resources,

➢ and damage environment that are not recoverable.

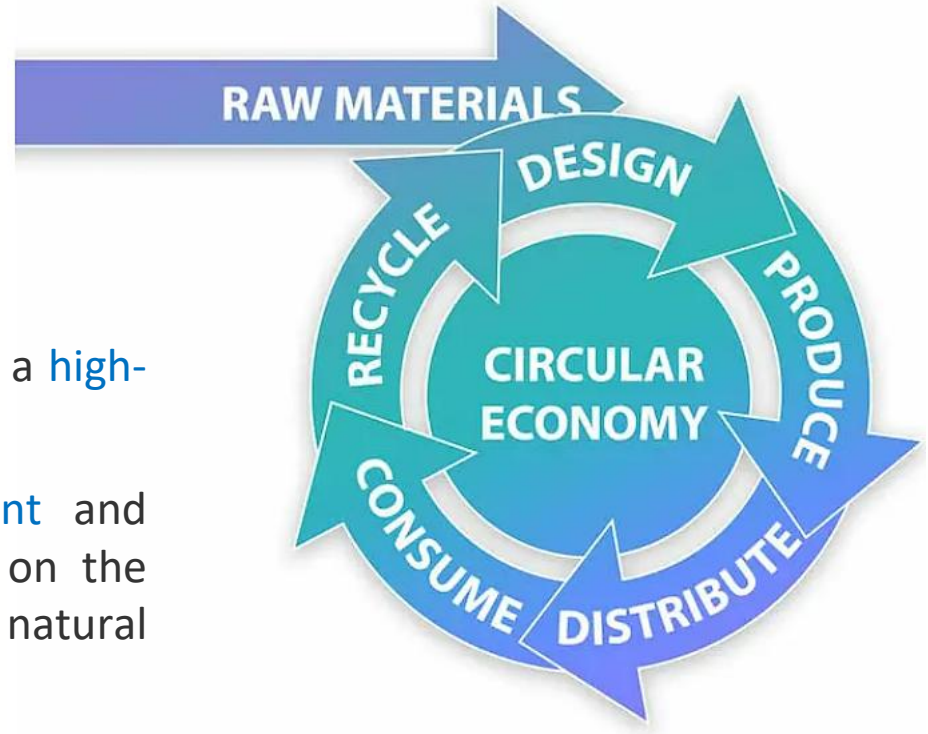
Linear Economy

- Traditionally, the economy has followed a straight-line pattern.
- This kind of system is highly unsustainable and needs to change.
- A sustainable alternative to this system is the circular economy.



Circular Economy

- The main focus of this type of economic model is to reintroduce used parts as raw materials for new products.
- The intent is to move from a high-waste to a high-value model.
- Such a system is highly resource-efficient and reduces the effect of consumer demand on the exploration, pollution, and wastage of natural resources.

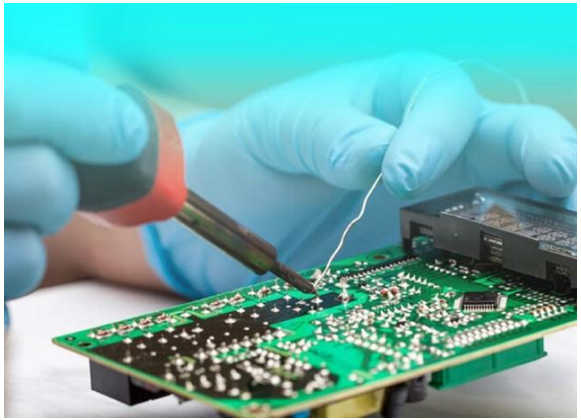


Circular Economy

- The 4Rs in particular is a very effective tool in building a circular economy. It includes four principles that can be applied by almost every individual and have an exponential effect. These principles are:
  - ✓ Reduce
  - ✓ Reuse
  - ✓ Repair
  - ✓ Recycle

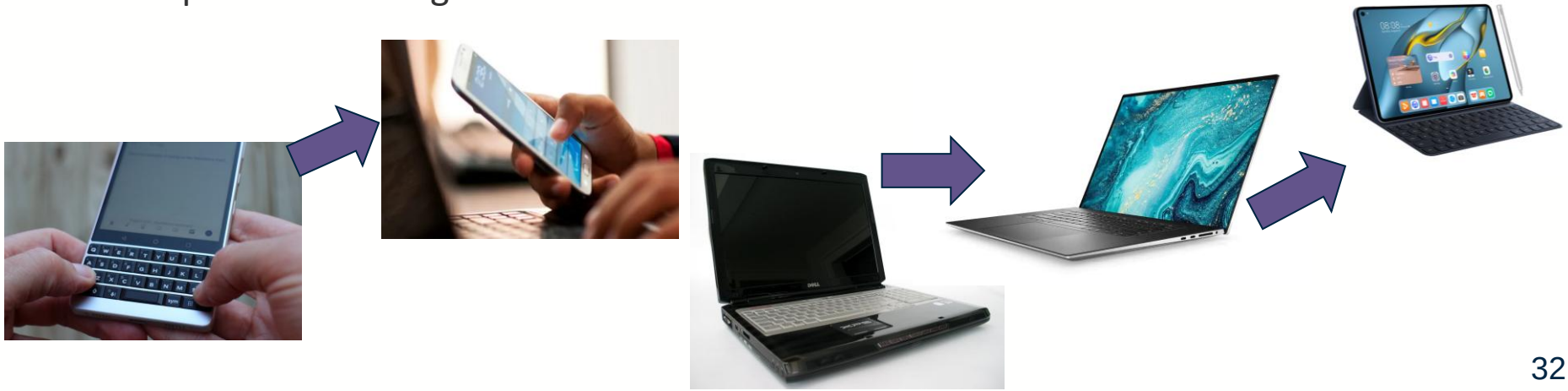
Design for Sustainability Principles

- Using appropriate strategies can help us get closer to the concept of true sustainability.
- Some actionable sustainable design principles that can be implemented to create better designs are:
  - ✓ Dematerialization
  - ✓ Modular design
  - ✓ Prefer renewable energy
  - ✓ Migration to product-service systems
  - ✓ Design for longevity
  - ✓ Limit or eliminate long-distance outsourcing
  - ✓ Invest in simulation



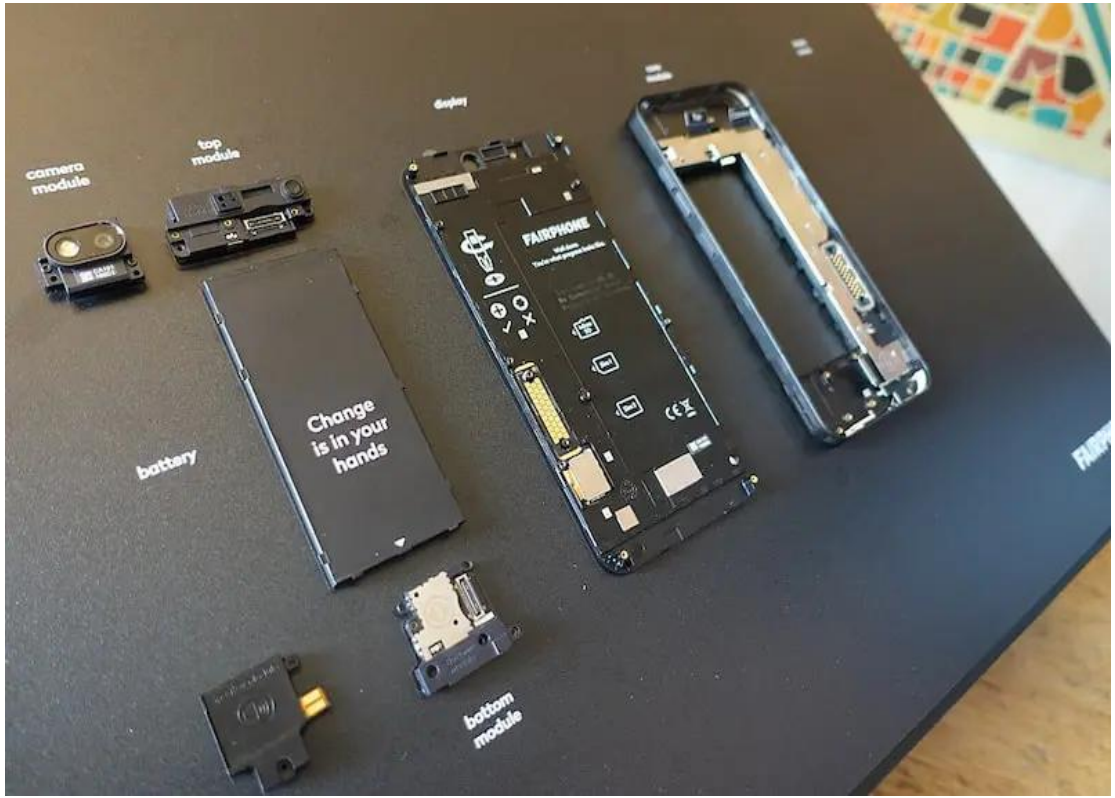
Design for Sustainability Principles: Dematerialization

- The reduction of total material and energy throughput of any product and service, and thus the limitation of its environmental impact.
- There are many ways to achieve this. One way is the miniaturization of the product. A product with a smaller form also requires reduced packaging, storage area, transportation and delivery costs and minimizes carbon emissions involved in each of the product life stages.



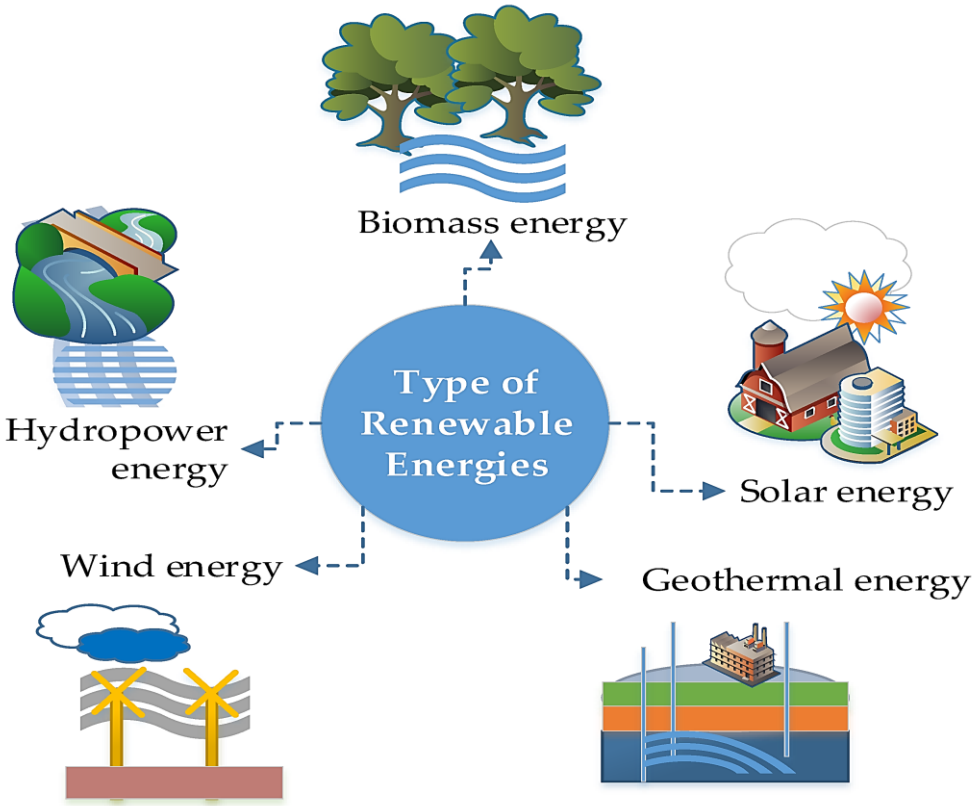
Design for Sustainability Principles: Modular design

- A modular design refers to the use of components as modules that can be used in multiple products. Modules are predesigned components with a specific function. The advantages include cheaper and easier manufacturing, assembly, replacement, repair and disposal.



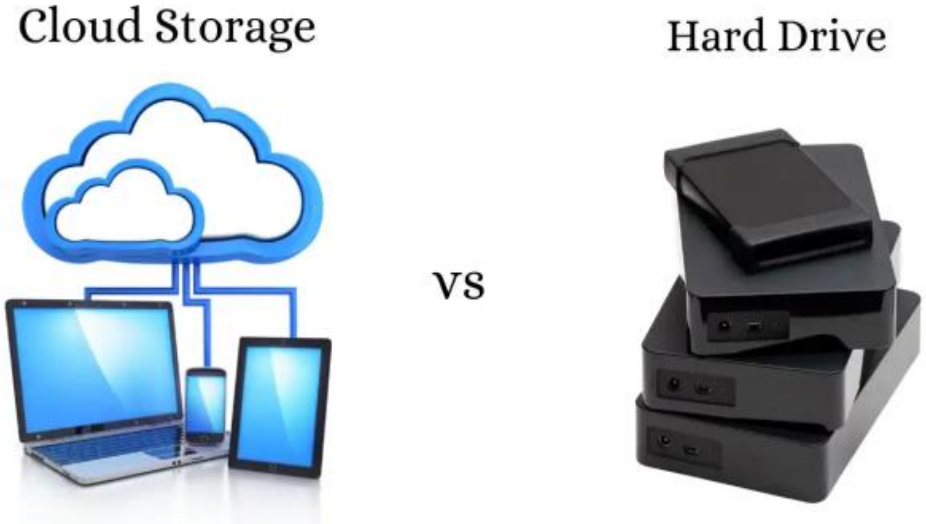
Design for Sustainability Principles: Prefer renewable energy

- Greater reliance on renewable alternatives, such as wind, solar power and hydroelectricity (instead of petrol, diesel, gas and coal), propel us towards sustainable development while allowing us to maintain similar energy usage levels.



Design for Sustainability Principles: Migration to product-service systems

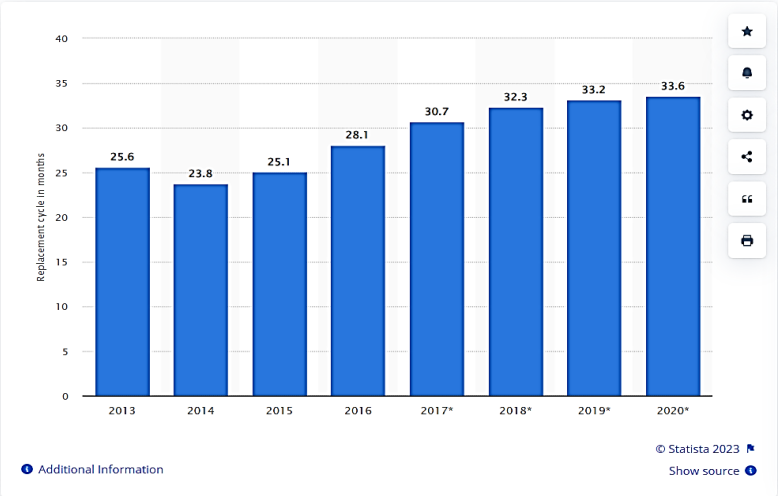
- Product service systems refer to a business model where the company provides services besides the product to improve their environmental performance and sales. In such systems, a company leases its products to the consumer instead of selling them for good.



- A great example of this practice is how IBM shifted to renting servers instead of selling units directly to customers, or cloud services.

Design for Sustainability Principles: Design for longevity

- Designers have the power to maximize how long a product can be used through its design.
- Durable products can considerably relieve the pressure on the environment by reducing the amount of raw material and energy required to create new products.



Average lifespan (replacement cycle length) of smartphones worldwide from 2013 to 2020 (in months)

Lifespan of Smartphones

Design for Sustainability Principles: Limit or eliminate long-distance outsourcing

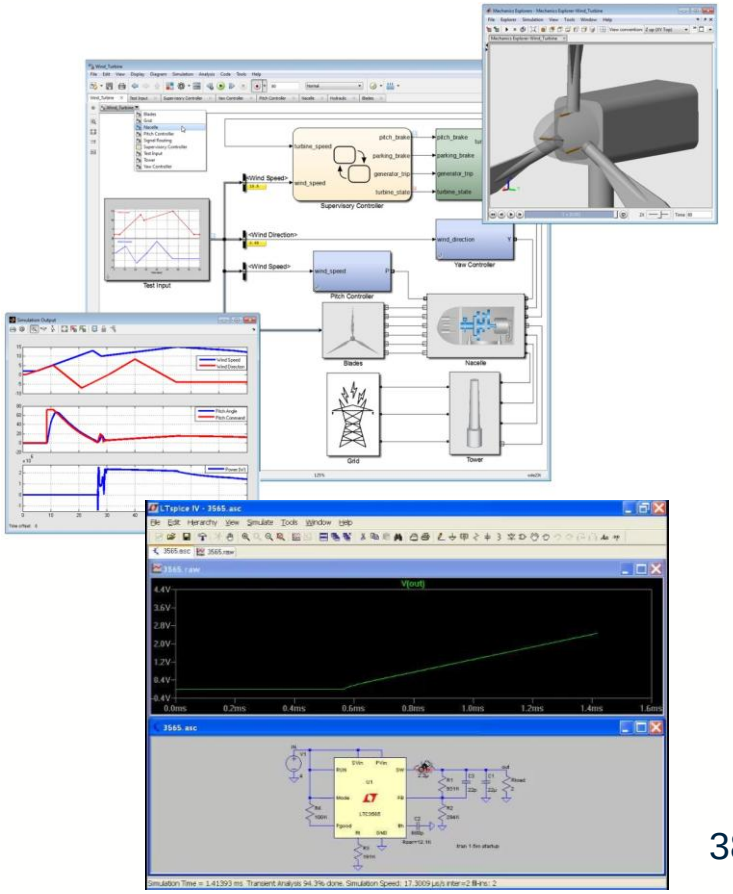
- Increasing shipping capacities have made freight more affordable. This has resulted in outsourcing manufacturing operations to countries with lower labor rates.

- The effect on the environment, however, is negative since the resources required to manufacture the product are the same either way but now, we have added several tones of extra emissions due to intercontinental transport (extra Greenhouse gases).

- It is important to prefer local suppliers when designing for sustainability. Besides lowering the environmental impact, eliminating outsourcing would support local industries.

Design for Sustainability Principles: Invest in simulation

- Traditionally, many trial-and-error loops would be required to arrive at the most optimal design.
- But with simulation, all these loops can sometimes be completed in a matter of hours, saving precious resources in terms of raw materials, time and overhead energy costs related to electricity, water etc.
- It also reduces wastage as only a small number of products are out of spec when the part goes into actual production. Such a production method is, therefore, highly sustainable as well as profitable.




Q
A

Design for Manufacturing (DFM) is an important part of any product development cycle (e.g., initial design, final design, fabrication, production, and product launch). Which item below is correct:

A – The DFM is more effective to be applied in the production stage because of the higher impact and lower cost of changes due to the product being manufactured and can be changed promptly.

B – The DFM is more effective to be applied during product launch because of the highest impact and lowest cost of changes.

✓ C – The DFM is more effective to be applied to the initial design because of the highest impact and lowest cost of changes.

D – The DFM is more effective to be applied after the initial design and before production when the final design is being finalized and can effectively implement required changes according to customer requirements.

E – The DFM is more effective to be applied in all stages after design because we are sure that the customer requirements are recognized completely and any changes in the future do not impose higher costs of changes.

There is a variety of actionable sustainable design principles that can be implemented to create better designs. Some of them are below except:

A – Dematerialization.

B – Migration to product-service systems.

C – Limit or eliminate long-distance outsourcing.

D – Design for a shorter period of usage.

E – Invest in simulation.

Which of the following statements best describes the three pillars of sustainability?

A – Sustainability involves meeting the current generation's needs without consideration for future generations, emphasizing economic growth, environmental care, and social well-being.

B – Sustainability entails achieving economic growth, environmental care, and social well-being simultaneously, fulfilling the needs of current generations without compromising the needs of future generations.

C – Sustainability primarily focuses on economic growth, with minimal consideration for environmental and social aspects, to fulfill the needs of the current generation.

D – Sustainability prioritizes environmental care over economic growth and social well-being, neglecting the importance of balancing all three pillars.

E – Sustainability emphasizes social well-being as the sole pillar, with economic growth and environmental care being secondary considerations in fulfilling the needs of current and future generations.

Design for Manufacturing (DFM) is an important part of any product development cycle. Which item below is not correct regarding DFM:

A – The time required for design for manufacturability is determined by the product's complexity, the organization's size, and the resources available.

B – As a general rule, DFM is a continuous process that begins at the initial stages of product design and continues through the entire product lifecycle.

C – The DFM is more effective to be applied to the initial design because of the highest impact and lowest cost of changes.

D – The DFM may impose higher manufacturing costs, instead can benefit from higher customer satisfaction because of improved product quality.

E – The DFM consists of some main principles such as Simplicity, Standardization, Tolerance, Material Selection, Automation, and Process Integration.

Describe briefly any two of these DFM principles.

Accept any two of the below:

- **Simplicity:** The design should be kept simple with as few parts as possible and use straightforward shapes and structures to make production easier and more cost-effective.
- **Standardization**: Whenever possible, standard components and manufacturing processes should be used in the design, as this can save time and reduce production costs.
- **Tolerance:** Proper tolerance design is critical in ensuring that the product fits and functions as intended. Tolerance must be carefully considered to balance the need for precision with the cost of manufacturing.
- **Material Selection:** The choice of materials greatly impacts production costs and the final product quality. We must consider the properties of the materials, such as strength, durability, and manufacturability when selecting the materials for a product.
- **Automation:** Automated processes can significantly improve production efficiency, reduce labor costs, and improve product quality. The project expert must carefully consider the type and level of automation to be implemented in the production process.
- **Process Integration:** Integrating product design, manufacturing processes, and quality control are crucial in improving production efficiency and reducing costs. A project expert has to work closely with other professionals, such as industrial designers and process engineers, to ensure that the design, manufacturing, and quality control processes are appropriately integrated.

The 4Rs in particular are very effective tools in building a circular economy for sustainable products. It includes four principles that can be applied by almost every individual and have an exponential effect. List any two of these principles

Accept any 2 of the below:

- Reduce
- Reuse
- Repair
- Recycle

The product development cycle in general consists of the initial design, final design, fabrication, production, and product launch. Which stage is more effective in DFM regarding the impact and cost of changes?

The DFM is more effective to be applied to the initial design, because of the highest impact and lowest cost of changes.

Sustainability can make a balance between three main pillars. List any two of these pillars.

Accept any two of the below:

- Economic pillar
- Environmental pillar
- Social pillar

In the Next Lesson:

Part 2: Quality Control & Cost of Quality


thank you