PDS PRODUCT DESIGN
SCOTLAND

PRODUCT DESIGN SCOTLAND TOOLKIT

12

SUSTAINABLE DESIGN

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ABOUT US

With a long tradition of innovation, entrepreneurship and commercialisation, the product design sector is one of Scotland's key industries. Through advances in technology, designers are providing innovative products across a number of global markets, including healthcare, energy, communications and mobility. Integration of these technologies into viable, efficient and commercially attractive products is key, and the partnership between technology and product design is becoming ever more important.

Product Design Scotland, managed by Technology Scotland, the representative body for Scotland's Enabling Technologies Sector, has been established to support the product and industrial design sector in Scotland. The network aims to be the focal point for the community, raising awareness of the critical importance of design to future growth and competitiveness and creating a thriving, collaborative network to drive innovation.

By working with companies and organisations across Scotland, we support the sector through:

- Promoting the value of strategic design to government and industry
- Raising the profile of Scotland's product/industrial design sector
- Increasing visibility of those operating within relevant supply chains
- Improving competitiveness through collaboration and knowledge exchange
- Creating new networks to shape the future of design in Scotland.

THE PROJECT AND FUNDING

This guide is an output from the Low Carbon Challenge Fund (LCCF)[1] funded EXTEND project.

A consortium project led by the University of Strathclyde, in collaboration with the Scottish Institute for Remanufacturing, National Manufacturing Institute Scotland, South Ayrshire Council, East Ayrshire Council and South Lanarkshire Council.

The project targets aerospace, rail and renewables sectors, predominantly to support SMEs in South West Scotland, who do not currently operate in these sectors, in their journey from opportunity identification to technical capability demonstration.

This guide has been created to support design and manufacturing considerations for such SME companies seeking to unlock global opportunities around the climate emergency, whilst contributing to Scotland's target of reaching net zero emissions.

LCCF itself is European Regional Development funding administered by Scottish Enterprise.

BACKGROUND

> *"More than 10,000 years of continuous and accelerating progress have brought human civilization to the point of threatening the very condition that made that progress possible: the stability of the earth's climate[2]"*

It is the modern human's ingenuity and desire to solve problems which has created the industrialised civilisations we live in today.

However, this has brought challenges:

- Since 1850, industrial emissions have driven CO_2 levels from 280 ppm to 410 ppm CO_2 (46% increase)

- The world's population doubled between 1959 and 1999 from 3 billion to 6 billion

- UN world population projections:
    - 2030 - 8.5 billion (8% increase on today)
    - 2050 - 9.7 billion (23% increase on today)
    - 2100 - 11.2 billion (42% increase on today)

By 2050 70% of the world's population, 6.8 billion people, will live in cities. That's equivalent to 86% of the current global population.

Humans have done more damage to the planet in the last 200 years than their ancestors over the previous 195,000 years combined.

The planet cannot sustain current rates of industrialisation and the corresponding demands of a growing population.

This is a challenge at a global scale, action is required at all levels, this includes considering our individual purchasing and consumption behaviours and considering the products we develop.

We've all heard of COP26 which was in Glasgow in 2021, 6 years previously, the Paris Agreement, a legally binding international treaty on climate change, was adopted by 196 parties at COP21 in Paris, 2015.

The goal of the Paris Agreement is to limit global warming to below 2°C, preferably to 1.5°C by 2050.

The Intergovernmental Panel on Climate Change (IPCC)[3], a UN body for assessing the science relating to climate change have prepared numerous reports for policy makers.
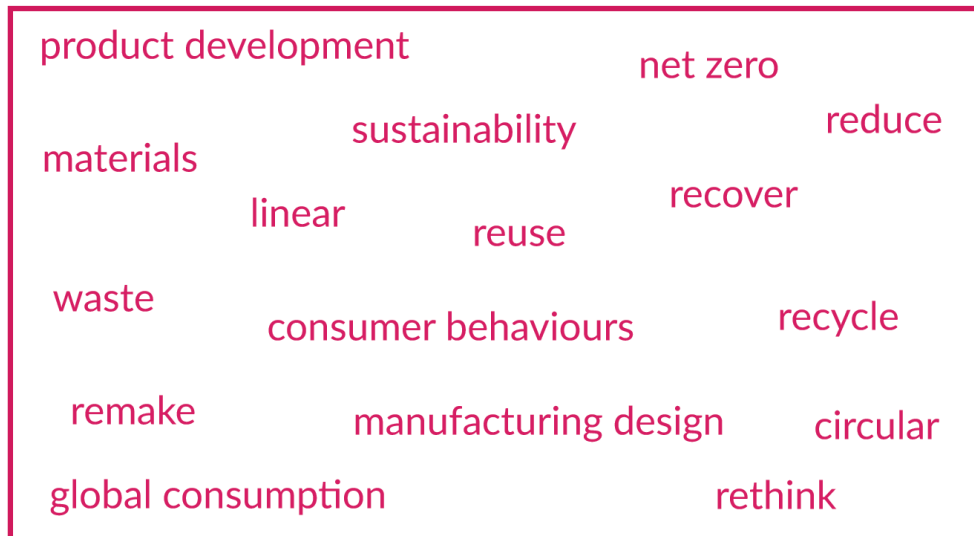
Some key considerations highlighted by IPCC are as follows:

- **To limit global warming to 1.5°C requires unprecedented changes in all aspects of society**

- **Limiting global warming to 1.5°C compared to 2°C could ensure more sustainable and equitable society**

- **Limiting global warming to 1.5°C compared to 2°C would mean by 2100 sea levels would be 10cm lower**

- **At 1.5°C an Arctic ocean free of ice would happen once per century as opposed to once per decade at 2°C**

- **Coral reefs would decline by 70-90% at 1.5°C and >99% at 2°C**

It is clear that without robust action now the world will be a very different place within the lifetime of current generations. Critical decisions need to be made now to ensure a safe and sustainable world going forward.

TOPIC INTRODUCTION

product development

net zero

reduce

sustainability

materials

recover

linear

reuse

waste

consumer behaviours

recycle

remake

manufacturing design

circular

global consumption

rethink

This guide will introduce the reader to the concepts of net zero, sustainability, linear and circular models. Also, going on to introduce strategies for circularity.

Discussing how design and hardware product development provide the best opportunity to impact a product's sustainability.

Some of the language and considerations, in the context of sustainable product development, used within this guide are highlighted above.

WHAT DO WE MEAN BY NET ZERO?

Net zero has been spoken of publicly more in the last decade than ever before.

Net zero essentially means reducing the amount of greenhouse gases produced by way of human activities through reduction in emissions and introduction of methods to absorb carbon dioxide from the atmosphere.

Action needed now, to achieve Net Zero by 2050

Limiting global warming to 1.5°C requires global human caused emissions of CO_2 to fall by 45% between 2010 and 2030 to reach net zero by 2050.

WHAT DO WE MEAN BY SUSTAINABILITY?

Sustainability is ultimately the ability to prevent depletion of resources so they remain available long term.

In an environmental context, this tends to focus on:

Reducing over exploitation of natural resources

Reducing energy usage

Reducing pollution

Sustainability is very dependent on society, human factors and behaviours such as wealth, lifestyle and purchasing behaviour. Each of which may be enablers for or barriers to sustainability.
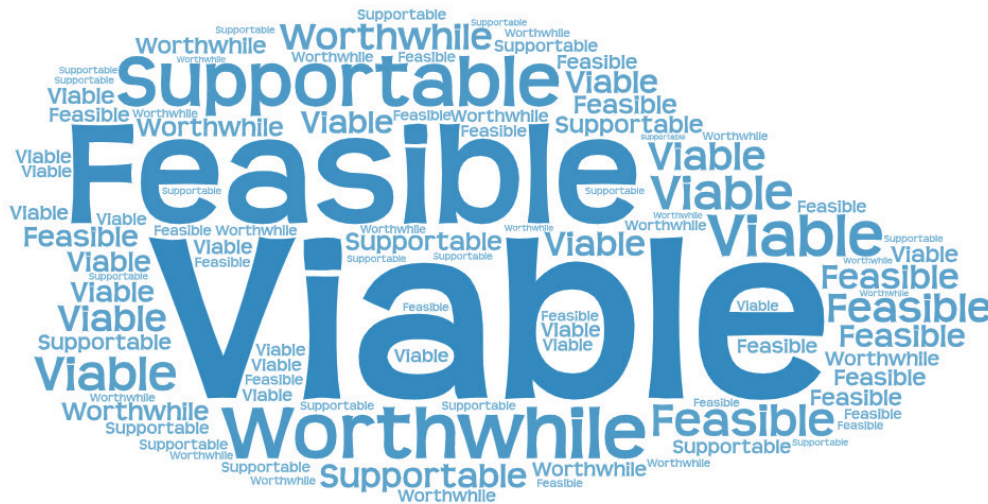
SUSTAINABILITY IN PRODUCT DESIGN

The 3 pillars of sustainability are often considered to be environmental, social equity and economic development.
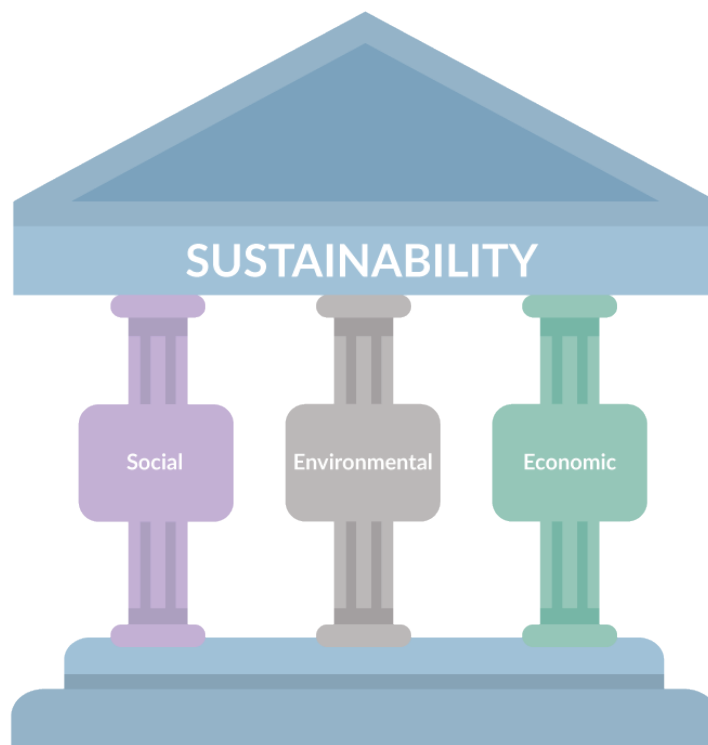
If you consider these together in a product development context, at the front end you may think of it as responsible design. In other words, it could be viewed as irresponsible to ignore any one of these pillars when developing new products or systems.

Curiously, if you look at synonyms for 'sustainability' they help focus the mind somewhat, the most powerful of which being:

Again in a product development context, imagine your end user's or prospective investor's perspective, they will often be looking at the sustainability when deciding whether they wish to invest in your technology. In other words, sustainable designs are arguably more worthwhile, more feasible, more viable and more supportable than those that are not.

> "We're noticing in our work with numerous clients across all sectors, that sustainable designs are increasingly more likely to attract investment"
>
> Rory Ingram, NMIS Design Engineering Team Lead.

A Deloitte survey[4] on sustainability and consumer behaviour in 2021 found the following five sustainable brand practices most valued by consumers:

Waste Reduction

Reducing carbon footprint

Respecting human rights

Committing to ethical work practices

Providing sustainable packaging

"In the UK, demand for sustainable products has increased eightfold over the past 5 years[5]"

TRADITIONAL LINEAR MODELS

How your product is marketed, sold, used, maintained, repaired and disposed of will dictate how sustainable your product is.

A linear model is focused on the user, taking raw materials and converting them into products, selling these to single users who use them until they break or upgrade to the latest model, at which point they are discarded, often ending up in landfill.

UNSUSTAINABLE LINEAR MODEL

Take

Make

Use

Dispose

Waste ✗

Generally with such models manufacturers seek to sell as many units to as many users as possible.

As it stands, where this is still the norm, the global population are consuming at 175% of the level the world can sustain, and this will hit 300% by 2050 without step change in behaviours of consumers, manufacturers, sectors and governments.
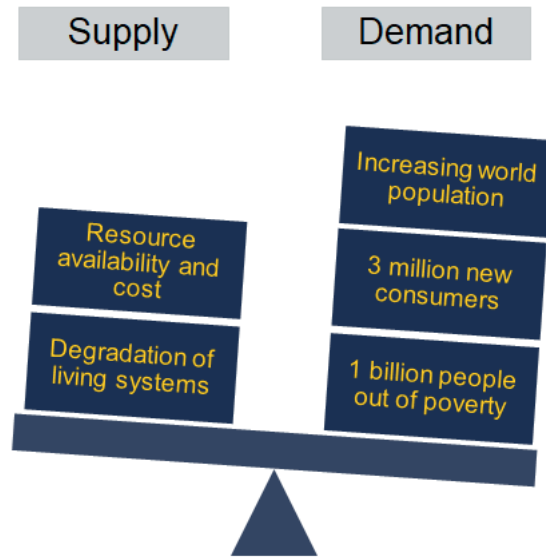

SUSTAINABLE LEVEL

CURRENT RATE OF CONSUMPTION

PROJECTED 2050 CONSUMPTION LEVELS

As the global population increases and less of the population live in poverty the demand for products increases, consequently linear models become more and more unsustainable.


Urgent step change away from linear models is required

A CIRCULAR ECONOMY

"A circular economy is a manifestation of economic models that highlight business opportunities where cycles rather than linear processes, dominate. It is restorative and regenerative by design and aims to keep products, components, and materials at their highest utility and value at all times.[6]"
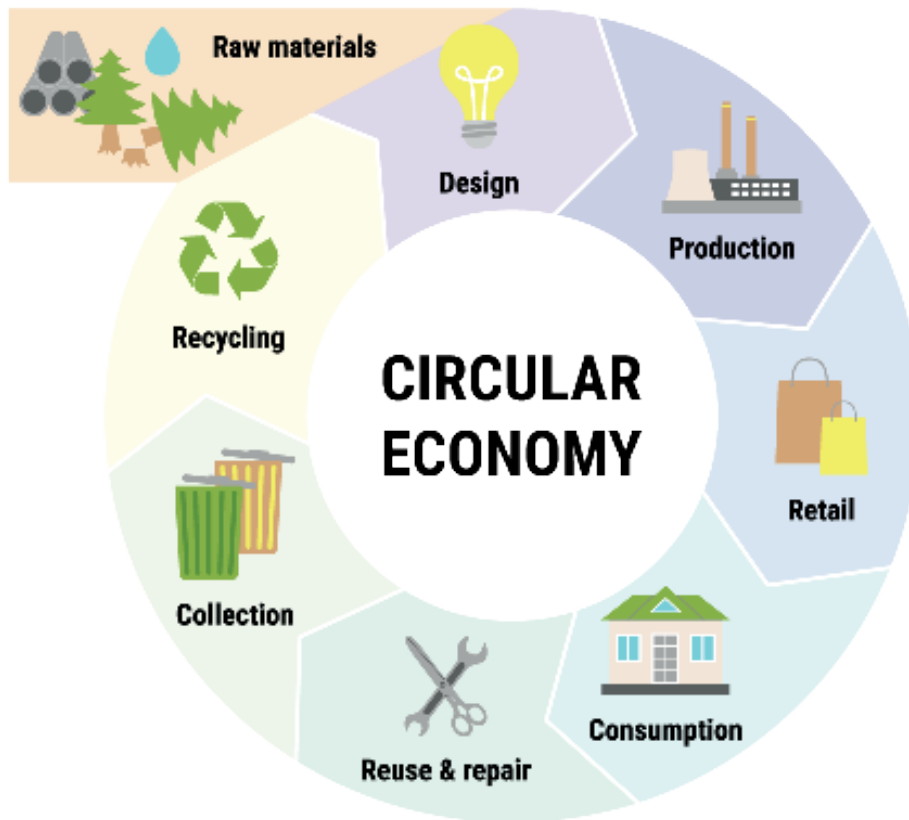
Through better design, material selection, creation and use of local supply chains we can reduce the carbon footprint of a product.

For further impact there are some additional circular economy strategies to consider.

CIRCULAR ECONOMY STRATEGIES

You may have heard people talk of R strategies, whether it be 3, 5, 7 or 9R's, the R's can stand for different things but the principle is generally the same.

The NMIS Design Engineering team apply the following 5R's:

The hierarchy shows the order of precedence and impact each R can have, the higher up the pyramid the greater the impact.

Note that recycling sits quite low in the pyramid, so if you think using recyclable material is all you need to do, think again.

5R'S: RETHINK

Improving the utilisation of a product, e.g. moving away from the linear model, where its typical to sell a product to every user, considering alternative models.

- Is the product idea inherently unsustainable?
- Should a product be for individual users?
- Instead, should a more robust product be developed and accessed via service partners?
- Could additional functionality be built in to a product so it negates the need for other products?
- Could the product be offered on a lease or hire model?
- Could your business be a service provider as opposed to a traditional manufacturer?

5R'S: REDUCE

Optimising and minimising the energy and material use during a products manufacture

- Reduce material and size as much as possible
- Remove material which is non functional where practical
- Reduce number of fasteners and part count
- Every feature should have a function, otherwise remove
- Every component should have at least one function
- Reduce use of rare or scarce materials
- Reduce or remove use of hazardous materials
- Reduce energy required to operate product
- Reduce reliance on virgin materials
- Reduce or remove the use of materials which are not easily repaired or recycled

5R'S: REMAKE

Repair, Remanufacture, Repurpose & Refurbish end-of-life pathways

- Select materials which have repair options
- Design for disassembly
- Use standard parts wherever possible
- Design for ease of inspection
- Design for ease of cleaning
- Design with modularity in mind
- Design with future functionality in mind, allowing for upgrades

5R'S: RECYCLE

Reprocessing a product, component, or material for use in a future product, component, or material. (Source: BS 8905:2011 (British Standards Institution, 2011))

- Use materials which are easy to recycle
- Avoid use of additives which make material harder to recycle
- Avoid use of coatings and painted finishes
- Avoid mixed material components
- Design for ease of separation of dissimilar parts / materials

5R'S: RECOVER

Incinerating material with the aim of recovering energy

- Avoid materials which give off harmful fumes when incinerated
- Use materials which have high combustion energy

DESIGN FOR SUSTAINABILITY

By now it is hopefully clearer how design activities and considerations lock in decisions which dictate the environmental impact of a product, much like they impact product cost.

Several sources such as the Ellen McArthur Foundation and the European Commission state that over 80% of all product-related environmental impacts can be influenced during the design phase.

In the design phase criteria such as material selection, manufacturing methods, bills of materials, service life, robustness and reliability are just some of many considerations.

DESIGN

DESIGN CONSIDERATIONS & INFLUENCES

STANDARDS	MATERIAL SELECTION	MANUF'G PROCESS
REGULATIONS	RAW MATERIALS	ENERGY TO MAKE
SERVICE LIFE	MINING / EXTRACTION	CONSUMABLES
SIZE & WEIGHT	PROCESSED MATERIALS	PRE-PROCESSING
PACKAGING	MATERIAL UTILISATION	POST-PROCESSING
LOGISTICS	BUSINESS MODEL	EASE OF REPAIR
MODULARITY	CIRCULARITY	EASE OF RE-USE
EMISSIONS	SERVITISATION	EASE OF RE-PURPOSE
TRANSPORT & HANDLING	© University of Strathclyde 2021	RECYCLABLE

The NMIS Design Engineering team prepared the above graphic ahead of COP26 to help convey design considerations and influences.

> As with cost, in terms of sustainability & circularity, design casts the biggest shadow.

As someone considering or involved in new hardware product development, you may have heard of 'Design for Excellence' (DFX) which is a catch all for numerous factors to be considered in the development of a new design, factors such as design for manufacture and assembly (DFMA).

Various guidelines exist to support different DFX categories, sustainable design is one such category surging in demand given challenging global climate targets and the urgent need for action. Simplistically, sustainable design encourages good practices around raw materials used, material processing, part manufacture, assembly, use and end of life.

The greatest opportunity for a product to be sustainable is for specific objectives & requirements, supporting or enabling sustainable design, to be identified early in the business plan or business case (where practical) and again at the product or system definition stage.

The 5R's introduced earlier should be considered early in your business case and design development, to ignore them is neither responsible or sustainable.

TAKEAWAYS

The current linear economy is not sustainable and we must transition towards a circular economy to prevent irreversible damage to our planet and to meet the Scottish government's commitment to achieving net-zero by 2045.

Rethink, Reduce, Remake, Recycle and Recover are 5 strategies that can enable product life cycles to transition from a linear to a circular economy.

The design phase has a large influence on product-related environmental impacts. It is irresponsible not to consider circular strategies by design.

Action is needed now and before 2030 if we are to protect the planet and achieve 2050 targets.

Thank you for taking time to read this introductory guide, please feel free to share and if you have any specific hardware development needs or challenges you'd like to discuss please contact via www.nmis.scot stipulating 'Design Engineering enquiry' to ensure it finds the relevant people.

SOURCES AND LINKS

1. LCCF Extend Project

2. McKinsey & Company, The net-zero transition: What it would cost, what it could bring report

3. IPCC Summary for Policymakers of IPCC Special Report on Global Warming of 1.5°C approved by governments

4. Deloitte survey

5. An Eco-wakening - The Economist

6. Sustainability Guide: Circular Economy

7. National Manufacturing Institute Scotland

8. High Value Manufacturing Catapult

9. University of Strathclyde, Design Manufacturing & Engineering Management department

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OTHER USEFUL SOURCES

10. A series of circular design guidelines prepared by the Technical University of Denmark in collaboration with Bang & Olufsen

11.. Ellen MacArthur Foundation Design Tools

12. Circular Design Methods

13. European Commission Circular Economy Tools

14. PA Consulting, Ellen MacArthur Foundation and University of Exeter Circular Business Model design guide

15. Cradle to Cradle Products Innovation Institute

16. Ellen MacArthur Foundation Circular Economy Procurement Framework

17. Product Design Scotland Toolkit

NMIS PROFILE

NMIS[7] is hosted by the University of Strathclyde and is the only High Value Manufacturing Catapult[8] located in Scotland.

The University of Strathclyde's Engineering Faculty includes the Department for Design, Manufacture, Engineering & Management[9] a unique department in the UK combining end-to-end multidisciplinary expertise from creative design, through engineering design, manufacture and management of an entire product or system.

NMIS is an evolution from the Advanced Forming Research Centre, one of the original UK HVM Catapult centres. The AFRC was founded and hosted by DMEM and many staff, including several within the NMIS Design Engineering Team, studied Product Design Engineering and similar in DMEM before gaining industry experience.

The creators of this guide, the NMIS Design Engineering Team, a sector and technology agnostic team supporting product and system development, are sponsors of Product Design Scotland, a network led by Technology Scotland.

Technology Scotland have also supported the hosting & promotion of this guide to broaden access to Scottish SMEs.

WANT TO KNOW MORE?

PRODUCT DESIGN SCOTLAND'S FULL TOOLKIT SERIES IS AVAILABLE HERE.