Regulating Product Sustainability

Waste hierarchy — Reduce, Reuse, Repair, Recycle, Recover, Dispose (More desirable / Less desirable)

Product life cycle — Energy & material input, Production, Distribution, Use, Disposal, Waste & emissions
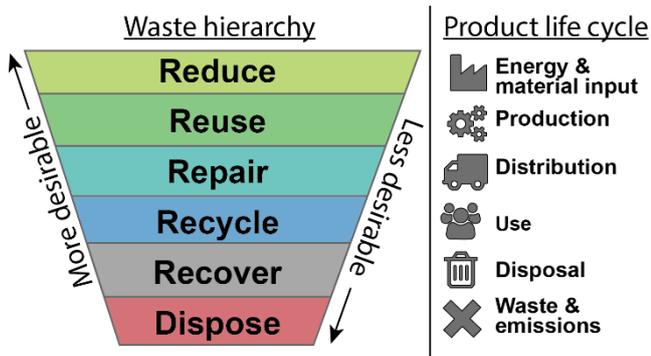
Products can be designed to maximise life cycle energy- and resource-efficiency, from raw material extraction to end-of-life treatment. This POSTnote outlines key aspects of, and consumer attitudes towards, sustainable products. It considers challenges associated with their design, production, regulation and supporting business models as part of a circular economy. 'End-of-life' treatment and value recovery, through reuse, recycling and other methods, are discussed.

Background
Although there is no single accepted definition of sustainability (PN408), this POSTnote uses the EU definition of 'sustainable products', which should be designed to:[2]
- Help save energy during production and operation
- Be free of toxic compounds
- Be made of recycled or reused materials
- Be durable and easily repaired
- Minimise environmental impact during the whole life cycle

The UK Government has pledged to double resource-productivity[3] and eliminate all avoidable waste by 2050,[4] but policy is devolved to the nations of the UK. Sustainable products are important for these goals. However, many products have short lifetimes,[5] reuse, repair and recycling are limited,[6] and regulatory enforcement is insufficient to ensure consistent compliance with product standards.[7] Solutions also need to account for the global nature of many supply chains.[8]

In a circular economy, products and materials are kept in use for as long as possible, waste and pollution are designed out,[9] and materials 'cascade' from one use to the next in a number of closed loops (PN536).[10] The circular economy is an alternative to the current, linear model of 'take, make, use, dispose'.[11]

Overview
- Energy- and resource-efficient products could support the UK's waste reduction and net zero carbon goals, potentially saving 12 $MtCO_2e$/year emissions by 2035.[1]
- Various measures are in place to promote product sustainability, and Ecodesign regulations are expanding to more product attributes beyond energy-efficiency to include durability, repairability, recyclability and material efficiency. Existing EU Ecodesign and Energy Labelling Regulations prevented 306 $MtCO_2e$ in 2020 (equivalent to the annual emissions of Spain).
- Globally, waste is increasing, as is material consumption per person in the UK. New measures, such as better data collection, support for resource-efficient business models and improved enforcement may be important for addressing this.

Despite widespread support from governments and industries for the concept of a more circular economy, global economic activity is becoming less circular due to increased material extraction and relatively low levels of recovery.[12] Reducing average material consumption per person in the UK will require extending the useful life of products, increasing use of recycled materials, and recovering components and materials for reuse at end-of-life.

In 2020, the UK transposed much of the EU's 2015 Circular Economy Package (CEP) with, what the Government describes as, 'relatively small technical changes to the EU Directives'.[13] The Government's Resources and Waste Strategy for England commits to matching or exceeding the EU on ecodesign.[4,14] The Environment Bill, which had its second reading in the House of Lords on 9th June 2021, seeks to provide powers to set legally binding targets related to product environmental standards, resource-efficiency, and waste (LLN-2021-0012).[15]

This POSTnote considers product sustainability within the waste hierarchy, from higher-level activities for waste prevention, repair and reuse, to value recovery and recycling.[16] Resource-efficient business models, ecodesign, data infrastructure, and enforcement of product regulations are also discussed, using electrical and electronic equipment (EEE) as a case study.

Resource-efficient business models

Resource efficiency has been defined as decoupling material consumption from economic growth.[4,17,18] The Waste and Resources Action Programme (WRAP) charity's resource-efficient business model (REBM) hierarchy outlines sustainable approaches to products and services. These range from the development of long-life products to complete product-service systems (PSSs), where ownership is replaced by access (such as leasing) to increase the use of individual products.[19] PSSs have operated for many years in business-to-businesses markets (PN536) and are spreading to business-to-consumer markets for some products (e.g. car sharing and fashion subscription services). REBMs may increase profitability,[19] as the same product can be 'sold' multiple times, and manufacturing and consumption of raw materials are reduced.[20] WRAP estimated that their Resource Efficient Business (REBus) project (2013-17) delivered ~£5 million in financial benefit, saved ~63kT of materials and prevented ~2,000T GHG emissions across 26 EU REBM pilot projects in a range of sectors (including Argos's gadget trade-in scheme).[21] Defra's Waste Prevention Programme for England, which was recently consulted on (until 10th June, 2021), aims to reduce waste by increasing repair, reuse and remanufacture of products. The desired outcomes include new business models such as PSSs.[22]

In the UK, a network of 'Libraries of Things' lends tools and other intermittently used items,[23] but all rely on external funding and volunteer support.[24] The sharing economy may improve resource-efficiency. For example, 91% of a power drill's environmental impact occurs during production and only 2% during use,[25] as the average household power drill is used for only 18 minutes.[26,27] Research shows public support for resource-efficient product-service systems and the sharing economy.[28,29] However, many people have concerns around hygiene, trust and liability for products, amongst other things.[25,29] Studies show that consumer purchasing is based more on quality and price than circular economy concerns.[30]

Design to reduce environmental impacts

Product manufacture and use account for 45% of global greenhouse gas emissions.[31] Several approaches have been suggested to address this, including 'circular design',[32] 'ecodesign'[33] and 'design for environment'.[34] For electrical and electronic equipment (EEE), the EU Ecodesign Directive and Energy Labelling Regulations (which cover 24 categories of goods in the UK)[35] have pushed the least efficient products off the market (Box 1). It is estimated that these policy measures prevented 306 MtCO$_2$e of emissions (equal to the annual emissions of Spain) and saved ~£55 billion on consumer energy bills across Europe in 2020.[36] The UK Government has recently consulted on the regulation of additional product categories, including electronic displays and more types of white appliances.[37] Greater energy-efficiency during use would help reduce emissions in support of the UK's climate change obligations.[1,18,38,39] The Resources and Waste Strategy for England (2018) pledged to match or exceed the EU on ecodesign,[4] which will be extended to material efficiency.[40] Other retained EU legislation, such as the 'Waste Electrical and Electronic Equipment (WEEE)', 'End of Life Vehicles (ELV)', 'Batteries and Accumulators', and 'Restriction of Hazardous

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Box 1: Product sustainability labelling
- Energy Labelling Regulations identify more energy-efficient products.[36] To clarify which are the best-performing products, the UK and EU rescaled labels from A to G in March 2021 (replacing A+++ to D ratings) for certain white goods and electronic displays.[41]
- Commentators suggest that clear labelling is required to improve recycling in sectors such as IT equipment and packaging.[4,42,43] The On-Pack Recycling Label is an initiative that provides a binary (Recycle/Don't recycle) label for packaging. The labels are recognised by 75% of consumers, although there is no data to show whether the labels have improved recycling rates.[44]
- EU research shows that durability and repairability labelling can significantly increase consumer preferences for longer-life and easier-to-fix products.[30]
- Other sustainable product 'eco-labels' (resource stewardship, responsible sourcing, no CFCs etc.) have been used increasingly since the 1980s.[45] Although 80% of UK shoppers identify themselves as 'environmentally friendly'[46] and 30% claim to be 'very concerned about environmental issues', this may not affect purchasing behaviours.[47] The range of self-declared, 3rd party-certified and life-cycle-based eco-labels can be confusing, lack consumer trust and suffer from low market uptake.[48,49]

Substances (RoHS)' Directives, contain targets related to recycled content, waste collection and safety for specific product types (PN536).[50–53] Some of this regulation will likely need to be updated to accommodate the shift to electric vehicles.[54]

Ecodesign also relates to characteristics such as durability, reusability and recyclability.[4] Key considerations are material choice and modular design for ease of disassembly, repair and separation for more cost-effective end-of-life treatment.[55,56] Under the European Green Deal[57] and Circular Economy Action Plan,[58,59] the EU's Sustainable Products Initiative sets out the ambition to expand ecodesign regulation, which England is committed to matching or exceeding.[4] The initiative will cover these additional product attributes and do more to address the presence of harmful chemicals in various durable goods.[60]

Trade-offs and life cycle assessment (LCA)

Trade-offs occur during product development when competing aspects of sustainability are considered.[61] This is problematic for product sustainability frameworks, as the most sustainable choice for one aspect may conflict with another.[62] For example, a glass coffee jar is recyclable, yet plastic refill pouches are 97% lighter and less energy intensive to produce.[63] Lifecycle assessments (LCAs) consider all aspects of a product to determine its environmental impact (e.g. the United Nations Environment Programme's Life Cycle Initiative).[64] However, no universal standards exist for weighting or normalising different aspects of sustainability in LCAs.[65] Shortly after announcing programmes of carbon footprint labelling in 2007, Tesco and other producers gave up on this commitment,[66] as thorough LCAs can be expensive and time-consuming.[66] Barriers to LCAs are increased if products are regularly changed or updated, and if limited upstream supply chain transparency prevents accurate data being available.[67]

Product lifetimes for EEE

WEEE is the fastest growing type of waste in Europe.[68,69] Globally, the UK generates the most WEEE per capita after Norway; 23.9kg per year.[36] The 'throwaway society' has been attributed to factors such as premature obsolescence and market oversaturation for consumer goods.[70] Research suggests that between 2000 and 2010, product lifetimes in Germany decreased by 17% for consumer electronics, 10% for IT equipment and 7.8% for large household appliances.[71] Although some obsolescence occurs with innovation,[72] most consumers in the UK want more durable and repairable products.[73] Using products for longer increases resource efficiency and helps offset embodied carbon emissions associated with production.[74] The current average lifetime for a washing machine is 6.3 years. However, Green Alliance estimate that it would take 17 years for the energy saved by an energy-efficient machine to be equivalent to the energy used for production of a new machine.[36] Regulation can set minimum standards for products placed on the market. For example, the Ecodesign Directive stipulates that electric motors in vacuum cleaners must function for at least 500 hours during testing.[75] Without information on expected lifetimes consumers are generally unwilling to repair an item if the cost will exceed 30% of the purchase price.[76,77]

Repairing products to extend their lifetime

Barriers to repair include: design features that prevent disassembly (such as the use of glue, or the need for special tools); lack of manuals and spare parts; warranty and safety concerns (especially with regard to white goods); and the availability and cost of repair services relative to the purchase price of new products.[68,76,78,79] In 2020, the Environmental Audit Committee recommended the UK should reduce VAT on EEE repairs.[68] Although the Government stated that it is unable to do this in the current economic situation,[80] several EU countries have set a precedent by introducing fiscal policies to promote repair. Sweden has halved VAT on repair services and enabled citizens to claim back 50% of labour costs against income tax.[81] In Austria, VAT on repairs to some products has been cut to 10% and some regions offer small grants to cover up to 50% of repair labour costs.[82] France's Repairability Index, implemented in January 2021, scores a limited range of products based on ease of disassembly, price and availability of spares, and access to repair information;[83,84] and 92% of Europeans are in favour of an index that covers durability.[85] From summer 2021, the UK Government plans to implement limited 'right to repair' regulations.[86] Producers will be responsible for ensuring some durable goods can be repaired using widely available tools for up to 10 years, in addition to providing manuals.[87] But, the decision to only allow registered repairers to carry out work has been criticised as a cost barrier by right to repair groups.[88]

Industry concerns around right to repair (and other information sharing policies such as product passports) focus on protection of intellectual property[89] and liability for any issues arising from non-sanctioned repairs.[90] Some companies (e.g. Ikea, Unilever, M&S and Kingfisher) are integrating circular concepts into their business models (PN536), including making spares available for a wider range of products than mandated by incoming 'right to repair' rules.[91] Mandatory warranties (Box 2) could support the development of more durable and repairable products.[92]

Box 2: Warranties and legal guarantees
- Mandatory extended warranties may indirectly promote more durable products, although current evidence suggests that warranties are used for marketing and that extending them may not lead to improved durability.[93–95]
- The EU Directive on Consumer Rights provides a minimum 2-year legal guarantee on sold goods.[96] Unlike many EU countries, UK implementation of the legislation (the Consumer Rights Act 2015) placed the onus on consumers after 6 months to prove the product was faulty at the point of purchase.[97,98]
- Warranty length could be used as a determinant of fees, to incentivise better design under extended producer responsibility schemes.[99]

Tech UK suggest that right to repair may require businesses to stockpile, store and distribute spares, with costs passed on to consumers. Accurate forecasting of demand for spare parts may be needed to avoid these becoming waste.[100] Alternative business models (e.g. enabling third party repair through open-source specifications for spares) could address these issues.[101]

Closing material loops

Durable, repairable and reusable products are insufficient to bring about a circular economy. Closing material loops requires investment in infrastructure for collection, sorting and recycling to produce high quality recycled materials.[6] Market support for recycled materials may be required to maximise resource recovery and increase the recycled content of products.

Investing in infrastructure

Under the CEP and updated Waste Management Plan,[102,103] England is committed to recycling 65% of municipal waste and sending less than 10% to landfill by 2035.[13,104] Since 2010, recycling rates have increased in Wales and Scotland, yet have stagnated in England despite 94% of the UK population supporting recycling.[105,106] As a result, the CEP targets may be missed by more than a decade.[107] Government and industry have committed £3 billion to Defra's Waste Infrastructure Delivery Programme which runs up to 2042.[108] However, this funding is primarily for non-recyclable waste treatment – predominantly generating energy from waste (EfW).[109] While some view EfW as the best available option to treat residual waste,[110] it has been criticised for impeding progress toward net-zero targets,[6] with suboptimal sorting and separation of materials in complex products leading to incineration of plastics and waste electrical and electronic equipment (WEEE).[111,112]

At present, there is no substantial public funding available for development of REBMs or repair infrastructure to support higher levels of the waste hierarchy, despite commitments to waste prevention.[6,113] Investment in recycling is hindered by an unstable market for recycled materials, and collection targets and systems that do not guarantee availability of high quality recyclate.[107] However, Green Alliance notes that processing 1000 tonnes of material creates two jobs in recycling compared to 0.1 jobs in waste treatment and disposal, and recycling already employs four times more people in the UK.[6] Policy may increase producer responsibility for goods placed on the market and promote greater circularity (Box 3), though consumers also need clear product end-of-life information.[114,115]

Market support for recycling

The 2016 UK Industrial Strategy aimed to promote recycling and support markets for recycled materials,[4,116] although there is currently little to incentivise manufacturers to reduce virgin material consumption. The incoming Plastic Packaging Tax (2022) will charge £200/tonne for plastic containing <30% recycled material to promote increased use of recycled plastic in packaging.[117] An escalator approach to the tax and recycled content threshold could stimulate continued innovation once capacity is established to satisfy demand at 30%.[118] The Government is considering how to audit recycled content standards, but this may be technically challenging .[119] The EU is taking a different approach, applying a levy of ~£700/tonne to all non-recyclable plastic packaging placed on the market.[120]

For the UK to reach net zero carbon emissions and increase use of recycled materials, more comprehensive carbon pricing may be required.[121–123] The EU's carbon border levy is expected to tax high-emission imports in specific sectors such as steel by 2023, and expand to cover more sectors in the future.[124,125] If indirect taxes on the carbon emissions of material production, or direct taxes on virgin materials are set high enough, they may support markets for recycled materials.[126]

Monitoring material stocks and flows

Measurement of progress toward resource-efficiency targets and monitoring the effectiveness of product sustainability regulation (including on chemicals) will require granular data on national material stocks and flows. However, the UK has limited oversight of imports, exports, products on the market, and waste,[127] hindering progress towards a more circular economy[128] and limiting oversight of chemicals in products.

National Materials Datahub (NMD)

The Office for National Statistics' NMD is an initiative by BEIS and Defra[4] to develop the essential data infrastructure necessary for a circular economy. A 10-year plan for its development has been proposed, although the project is currently on hold.[80] The first objective is to understand critical supply chains, with the ultimate goal of tracking all stocks and flows of materials and their embodied carbon in the UK.[128] It could also help to improve the UK's methodology for estimating WEEE collection rates and improve oversight of other material leakages from the UK economy.[68] A key challenge is determining a standardised protocol for data collection and codification of product types across all sectors.[129]

Sustainable chemistry (UK REACH and SCIP)

Reduction of hazardous substances in products improves safety and supports the circular economy by enabling more recycling.[130] Following Brexit, UK REACH (Registration, Evaluation, Authorisation and restriction of CHemicals) was implemented in January 2021, modelled on the EU REACH system.[131] REACH requires manufacturers to provide information on hazardous substances used in products.[132] To place goods on the EU market, UK companies must be compliant with REACH and report any potentially hazardous substances in their products using a Substances of Concern In Products (SCIP) identifier.[133] SCIP (implemented 2021) is an EU project which aims to promote alternative product chemistry to reduce hazardous waste.[139] The UK cannot access the SCIP

Box 3: Producer responsibility
Producer compliance schemes (PCSs)
- Producers of packaging, EEE and batteries are responsible for contributing to PCSs to cover costs of collection, treatment and recycling.[134–136] PCSs obtain recycling certificates on behalf of producers.
- The 12-month WEEE collection targets, which are based on a proportion of the 3-year rolling average of goods placed on the market, have been criticised for being too short to trigger improvements in collection and recycling.[68]

WEEE Distributor Take-back Scheme (DTS)
- Until 2022, small retailers (<£100K/year sales) and online sellers can use the 5th Phase of Defra's WEEE DTS and contribute financially to local authority WEEE collection and treatment. From January 2021, larger retailers must take back unwanted electricals in store on a like-for-like basis of items sold, which may be a disadvantage.[137]

Extended producer responsibility (EPR)
- Under EPR, producers fund the collection, recycling and disposal of post-consumer goods, in line with the 'polluter pays' principle. The Resources and Waste Strategy identifies five priority areas to consult on EPR: textiles (by 2022), bulky waste, construction materials, tyres and fishing gear (all by 2025).[4] A key consideration is deciding which product features to adjust fees against to motivate improved product design. Defra plan to review the WEEE producer responsibility rules between 2021 and 2024.[102]
- Commentators such as Green Alliance suggest any new extended producer responsibility scheme should extend to e-commerce, which is at present largely unregulated.[138]

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database,[140] although Defra has consulted on setting up a similar, domestic system.[141]

Product passports and comparison tools

Digital product passports detailing chemical composition, efficiency, repair details, reusability, critical raw material content and end-of-life treatment (including recycling) have been suggested.[36] Tech UK suggest such a system could be developed with input from reprocessors, so that information is available in an accessible and useful format.[100] Product passports could be supported by the UK NMD[128] and may inform sustainable purchasing decisions. For IT equipment, energy efficiency comparison tools (INTERACT and EURECA) are being trialled for public procurement in the UK.[142,143]

Enforcement challenges

Enforcement is necessary to ensure a level playing field for UK businesses and requires oversight of goods placed on the market, measurement of their performance, and the capacity to tackle waste crime. However, from 2009/10 to 2016/17, enforcement budgets were cut by an average of 50% and prosecutions by the Environment Agency fell 80%.[7] Ecodesign regulations are enforced in the UK by the Office for Product Safety and Standards,[144] yet 10-25% of EU-wide EEE does not satisfy existing energy efficiency and safety labelling rules.[36] The Landfill Tax faced by businesses increased 700% between 1998 and 2014, which has reduced the amount of material sent to landfill by >65% but may also be driving high levels of waste crime (PN547).[145–148] Under the Basel Convention, export of WEEE is illegal,[68] but unscrutinised export of 'used EEE' may incentivise misclassification.[68,149]

Endnotes
1. Committee on Climate Change (2020). The Sixth Carbon Budget.
2. European Commission/Directorate General for the Environment. (2016). Green products and services: what's in it for you?
3. HM Government (2018). A Green Future: Our 25 Year Plan to Improve the Environment.
4. Defra (2018). Our waste, our resources: a strategy for England.
5. Meunier, C. (2016). Lifetime of electrical appliances becoming shorter and shorter. Umweltbundesamt.
6. Green Alliance (2019). Building a Circular Economy.
7. Unchecked.uk (2020). The UK's Enforcement Gap 2020.
8. UN Global Compact (2015). Supply Chain Sustainability.
9. Webster, K. (2017). The Circular Economy - A Wealth of Flows. Ellen MacArthur Foundation.
10. Campbell-Johnston, K. et al. (2020). The Circular Economy and Cascading: Towards a Framework. Resources, Conservation & Recycling: X, Vol 7, 100038.
11. Ellen MacArthur Foundation (2016). Introduction to the circular economy.
12. Circularity Gap Reporting Initiative (2021). The Circularity Gap Report 2021.
13. Defra/DAERA/Welsh Government/Scottish Government (2020). Circular Economy Package policy statement.
14. Ecodesign Directive (recast) 2009/125/EC.
15. Environment Bill. (2019).
16. Defra (2011). Waste hierarchy guidance.
17. UNEP (2011). Decoupling natural resource use and environmental impacts from economic growth.
18. Green Alliance (2018). Less in more out: Using resource efficiency to cut carbon and benefit the economy.
19. WRAP (2017). REBus Project: Summary of learnings.
20. World Economic Forum (2014). Towards the Circular Economy: Accelerating the scale-up across global supply chains.
21. WRAP UK [online]. (2015). Argos: Gadget Trade-in.
22. Defra - Citizen Space [online]. (2021). Consultation on the Waste Prevention Programme for England: Towards a Resource-Efficient Economy.
23. Library of Things.
24. Baden, D. et al. (2020). Access Over Ownership: Case Studies of Libraries of Things. Sustainability, Vol 12, 7180.
25. Inside track [online]. (2017). Why hasn't the sharing revolution taken off?
26. Ellen MacArthur Foundation (2019). Accessing consumer products through better means.
27. Statista [online]. Drill: DIY product ownership by age in the UK 2015.
28. Cherry, C. et al. (2018). Public acceptance of resource-efficiency strategies to mitigate climate change. Nature Clim Change, Vol 8, 1007–1012.
29. Cherry, C. E. et al. (2018). Is sharing the solution? Exploring public acceptability of the sharing economy. Journal of Cleaner Production, Vol 195, 939–948.
30. Consumers, Health, Agriculture and Food Executive Agency. et al. (2018). Behavioural study on consumers' engagement in the circular economy: final report.
31. Ellen MacArthur Foundation (2021). Universal Circular Economy Policy Goals.
32. Ellen MacArthur Foundation (2020). Circular design toolkit.
33. Jeswiet, J. et al. (2005). EcoDesign and future environmental impacts. Materials & Design, Vol 26, 629–634.
34. Fiksel, J. (2009). Design for Environment: A Guide to Sustainable Product Development, Second Edition. McGraw-Hill Education.

35. Gov.uk [online]. Regulations: ecodesign of energy-consuming products.
36. Green Alliance (2020). Design for a Circular Economy.
37. Department for Business, Energy and Industrial Strategy (2021). Draft Ecodesign and Energy Labelling Regulations 2021: government response.
38. UK Government (2020). The UK's Nationally Determined Contribution under the Paris Agreement.
39. Climate Change Act. (2008).
40. CEN-CENELEC [online]. A new series of European standards addresses the material efficiency of energy-related products.
41. Your Europe [online]. EU energy labelling requirements.
42. Environmental Services Association (2021). Personal communication.
43. On-Pack Recycling Label (2021). Personal communication.
44. The On-Pack Recycling Label.
45. Iraldo, F. et al. (2020). The future of ecolabels. Int J Life Cycle Assess, Vol 25, 833–839.
46. Briggs, F. (2019). Research reveals 80% of UK shoppers describe themselves as 'environmentally friendly'. Retail Times.
47. Young, W. et al. (2009). Sustainable consumption: green consumer behaviour when purchasing products. Sust. Dev., Vol 18, 18–31.
48. Horne, R. E. (2009). Limits to labels: The role of eco-labels in the assessment of product sustainability and routes to sustainable consumption. International Journal of Consumer Studies, Vol 33, 175–182.
49. Coghlan, J. (2011). Greenwashing: can you trust that label? The Conversation.
50. End-of-Life Vehicles Directive 2000/53/EC.
51. European Commission [online]. Waste from Electrical and Electronic Equipment (WEEE).
52. Batteries and accumulators Directive 2006/66/EC.
53. RoHS Directive 2011/65/EU.
54. Dawson, L. et al. (2021). Steering extended producer responsibility for electric vehicle batteries. Environmental Law Review, SAGE Publications.
55. Willems, B. et al. (2005). Design for active disassembly (DfAD): An outline for future research. Proceedings of the IEEE International Symposium on Electronics and the Environment., 129–134.
56. Jovane, F. et al. (1993). A Key Issue in Product Life Cycle: Disassembly. CIRP Annals, Vol 42, 651–658.
57. European Commission [online]. A European Green Deal.
58. European Commission (2020). Circular Economy Action Plan.
59. European Commission [online]. (2016). Sustainable product policy & ecodesign.
60. European Commission [online]. Sustainable products initiative.
61. Byggeth, S. et al. (2006). Handling trade-offs in Ecodesign tools for sustainable product development and procurement. Journal of Cleaner Production, Vol 14, 1420–1430.
62. Prendeville, S. et al. (2016). Uncovering ecodesign dilemmas: A path to business model innovation. Journal of Cleaner Production,
63. Week, M. (2009). Kenco launches reduced packaging initiative. Marketing Week.
64. UNEP [online]. The Life Cycle Initiative.
65. Pizzol, M. et al. (2017). Normalisation and weighting in life cycle assessment: quo vadis? Int J Life Cycle Assess, Vol 22, 853–866.
66. Burrows, D. (2020). Can carbon labelling for food and drink products finally find its feet? The Grocer.

67.   Lake, A. *et al.* (2015). An application of hybrid life cycle assessment as a decision support framework for green supply chains. *International Journal of Production Research*, Vol 53, 6495–6521.

68.   Environmental Audit Committee (2020). Electronic Waste and the Circular Economy.

69.   Forti, V. *et al.* (2020). The Global E-waste Monitor 2020.

70.   Hellmann, K. *et al.* (2018). The Throwaway Society: A look back in the mirror. *Journal of Consumer Policy*,

71.   Defra (2021). WPP evaluation and description of potential waste prevention measures.

72.   Hadhazy, A. (2016). Here's the truth about the 'planned obsolescence' of tech. *BBC*.

73.   Green Alliance (2018). By Popular Demand.

74.   Cooper, T. (2008). Slower Consumption: Reflections on Product Life Spans and the "Throwaway Society". *Journal of Industrial Ecology*, Vol 9, 51–67.

75.   Commission Regulation (EU) No 666/2013. (2013).

76.   Savage, M. (2021). How can we make washing machines last? *BBC News*.

77.   Harrabin, R. (2021). 'Right to repair' law to come in this summer. *BBC News*.

78.   Nazlı, T. (2021). Repair motivation and barriers model: Investigating user perspectives related to product repair towards a circular economy. *Journal of Cleaner Production*, Vol 289, 125644.

79.   Cooper, T. *et al.* (2018). Fix it: Barriers to repair and opportunities for change. *Subverting Consumerism*. 147–165.

80.   HM Government (2021). Electronic Waste and the Circular Economy: Government Response to the Committee's First Report.

81.   Starritt, A. (2016). Sweden is paying people to fix their belongings instead of throwing them away. *World Economic Forum*.

82.   Piringer, M. *et al.* (2020). Austria makes repair more affordable. *Right to Repair Europe*.

83.   Chasson, A. (2020). French repairability index: what to expect in January? *Right to Repair Europe*.

84.   Decree relating to the repairability index of electrical and electronic equipment. (2020).

85.   Chasson, A. (2020). Major steps for durability and Right to Repair taken in France. *Right to Repair Europe*.

86.   First circular economy action plan. (2015).

87.   Smith, A. (2021). New EU 'right to repair' laws require technology to last for a decade. *The Independent*.

88.   The Restart Project [online]. (2021). Do we have a Right to Repair in the UK? Not yet.

89.   McEachran, R. (2020). Right-to-repair laws: rip off or necessary evil? *Raconteur*.

90.   Harrabin, R. (2019). EU brings in 'right to repair' rules for appliances. *BBC News*.

91.   Kingfisher Plc (2020). Kingfisher sustainable home product guidelines.

92.   Maurer, S. *et al.* (2015). Durable goods: More sustainable products, better consumer rights.

93.   Kingfisher Plc (2021). Personal communication.

94.   Murthy, D. N. P. *et al.* (2006). The Role of Warranty in Marketing. in *Warranty Management and Product Manufacture*. 197–216. Springer.

95.   European Parliament (2017). Report on a longer lifetime for products: benefits for consumers and companies.

96.   Your Europe [online]. Consumer guarantees, warranties, claims and returns.

97.   Downes, H. (2021). Faulty product? How to get a refund, repair or replacement. *Which?*.

98.   Consumer Rights Act. (2015).

99.   Prof Tim Cooper (Nottingham Trent University) (2021). Personal communication.

100.   Tech UK (2021). Personal communication.

101.   Hernandez, R. J. *et al.* (2020). Empowering Sustainable Consumption by Giving Back to Consumers the 'Right to Repair'. *Sustainability*, Vol 12, 850.

102.   Defra (2021). Waste Management Plan for England.

103.   The Waste (Circular Economy) (Amendment) Regulations. (2020).

104.   Creech, L. (2020). UK Circular Economy Package to set 65 per cent recycling target for 2035. *Resource Magazine*.

105.   Green Alliance (2017). A new direction for UK resource strategy.

106.   Defra/Government Statistical Service (2020). UK Statistics on Waste.

107.   DS Smith (2019). The Tipping Point.

108.   Resource Recovery from Waste (2019). A circular economy demands a new approach to infrastructure. *Inside track*.

109.   LARAC (2019). Waste Infrastructure Delivery Programme 'moving to new phase'.

110.   Policy Connect (2020). No time to waste: Resources, recovery and the road to net zero.

111.   Circular Online [online] (2021). Study: Remove plastic from waste sent to incinerators to meet net-zero goals.

112.   Resource Magazine [online] WEEE: A burning issue.

113.   Bradshaw, C. (2020). England's fresh approach to food waste: problem frames in the Resources and Waste Strategy. *Legal Studies*, Vol 40, 321–343. Cambridge University Press.

114.   Shevchenko, T. *et al.* (2019). Understanding Consumer E-Waste Recycling Behaviour: Introducing a New Economic Incentive to Increase the Collection Rates. *Sustainability*, Vol 11, 2656.

115.   Suez (2018). A vision for England's long-term resources and waste strategy.

116.   HM Government (2017). Industrial Strategy: building a Britain fit for the future.

117.   Gov.uk [online]. Plastic packaging tax.

118.   Environmental Services Association (2020). HMRC must 'stay the course' on plastics tax plans.

119.   Royal Society of Chemistry (2021). Personal communication.

120.   (2021). Unpacking the EU Plastic Packaging Levy. *Packaging Europe*.

121.   Department for Business, Energy and Industrial Strategy (2020). UK business competitiveness and the role of carbon pricing.

122.   Centre for Climate Change Economics and Policy (2019). How to price carbon to reach net-zero emissions in the UK.

123.   HM Government/Scottish Government/Welsh Government/DAERA (2019). The future of UK carbon pricing.

124.   Taylor, K. (2021). Carbon border levy should be in place no later than 2023, EU lawmakers say. *Euractiv.com*.

125.   Centre for Policy Studies (2020). Carbon Border Tax would stop Britain hiding its true carbon emissions.

126.   Milios, L. (2021). Towards a Circular Economy Taxation Framework: Expectations and Challenges of Implementation. *Circ.Econ.Sust.*,

127.   Office for National Statistics [online]. DSC-69 National Materials Datahub.

128.   Velenturf, A. (2019). The National Materials Datahub Can Improve Governance for Better Material Use by Industry: An Evidence Briefing from the Resource Recovery from Waste Programme.

129.   Office for National Statistics (2021). Personal communication.

130.   European Commission [online]. Removing hazardous substances to increase recycling rates of WEEE, ELV and CDW plastics.

131.   Health and Safety Executive [online] UK REACH Explained.

132.   European Chemicals Agency [online]. Understanding REACH.
133.   European Chemicals Agency [online]. Former UK-based REACH registrant.
134.   Gov.uk [online]. Packaging waste: producer responsibilities.
135.   Gov.uk [online]. Regulations: waste electrical and electronic equipment (WEEE).
136.   Gov.uk [online]. Waste batteries: producer responsibility.
137.   Langley, J. (2020). Retailers prepare to take back WEEE instore. *Letsrecycle.com*.
138.   Circular Economy Task Force (2021). Personal communication.
139.   European Chemicals Agency [online]. SCIP.
140.   Croner-i [online]. SCIP Database: In-depth.
141.   Chemical Watch [online]. UK government discussing need for own substances of concern database.
142.   INTERACT.
143.   EURECA.
144.   Office for Product Safety & Standards (2021). Office for Product Safety & Standards Enforcement Policy.
145.   National Audit Office (2021). Environmental tax measures.
146.   Defra/Government Statistical Service (2021). Fly-tipping statistics for England, 2019-20.
147.   Environmental Services Association (2017). Rethinking waste crime.
148.   Defra (2018). Independent review into serious and organised crime in the waste sector.
149.   Basel Action Network (2018). Holes in the Circular Economy: WEEE Leakage from Europe.