



Pro EnviRo

Learner Management System



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CLEANER PRODUCT DESIGN FOR THE ENVIRONMENT

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CLEANER PRODUCT DESIGN FOR THE ENVIRONMENT

Course Overview

Cleaner product design for the environment is the design of a product to minimise its environmental impacts over its entire lifetime while maintaining other aspects of cost and functional performance. This approach commonly minimises waste and reduces costs with the potential for increased market competitiveness.

This course aims to introduce cleaner design, also known as Design for the Environment or Ecodesign, particularly with manufacturing SMEs in mind.

It outlines the benefits, the basic process & methods and gives case studies to illustrate potential results. Concluding with a checklist, the course is a primer enabling further steps to be prioritised.

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CLEANER PRODUCT DESIGN FOR THE ENVIRONMENT

Module 1 - Benefits

1.1 | Context

Pollution and waste from both consumer and industrial products are a major concern. Cleaner design is the design of a product to minimise environmental impacts over its entire lifetime while meeting customer requirements.

The drivers to improve the environmental performance of products are increasing:

- European & UK Government policy; stricter product-related environmental legislation
- Changing customer & supply chain demands and enhancing market appreciation
- Good business practice – fulfilling part of an environmental policy
- Savings from waste minimisation / resource efficiency

Like product costs, a product's overall environmental impacts are largely determined by design. Integrating cleaner design for the environment into design thinking enables environmental performance to complement functional and economic performance.

There are examples of proactive companies in many sectors who have successfully undertaken cleaner design and reduced production costs while maintaining competitiveness and future proofing against legislation. Some have found new business opportunities.

1.2 | Complying with Legislation

Design for compliance with current legislation is a first step. Legislation affecting design should be identified within a review of all environmental legislation relevant to business operations. Maintaining a register of legislation is part of an environmental management system.

In the UK, the [NetRegs](#) service helps those without in-house legislation monitoring to identify relevant legal requirements specific to their business operations. Simplified guidance to legislation applicable to many industrial sectors, sub-sectors and processes is available, identifying any variations between England, Scotland and Wales. The associated pointers to good practice may also be helpful, although specialist advice may be considered necessary to address the risk of non-compliance.

Examples of product-related legislation and some product design implications include those below. The Directives amongst these implement European policy to reduce product-related environmental impacts ensure a common standard across the EU. Those such as the Waste Electrical and Electronic Equipment (WEEE) & End-of-Life Vehicles (ELV) Directive are early implementations of the European Commission's **Integrated Product Policy** towards sustainable development, pursuing principles such as life cycle thinking and producer responsibility, e.g. by 'take-back'.

- **Waste Electrical and Electronic Equipment Directive** reducing waste in manufacturing, selling, distributing, recycling or treating EEE.



- Achieve a series of demanding recycling and recovery targets for different categories of appliance.
- **Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment Directive (ROHS) from 2006**
 - Design out lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBB) and polybrominated diphenyl ethers (PBDE).
- **End-of-Life Vehicles Directive** to reduce, or prevent, waste from ELVs and increase the recovery and recycling of ELVs and their components
 - Limit the use of hazardous substances; notably heavy metals.
 - Increase the quantity of recycled material.
 - Design vehicles for easy recycling, to meet recovery & recycling targets.
- **Energy Efficiency in Products** applying to white goods and electrical lamps
 - Meet minimum standards for energy efficiency.
 - Provide information on energy consumption.
- **Packaging** applying to large packaging producers
 - Minimise material used in packaging, while maintaining function
 - Reuse 'waste' materials for packaging e.g. shredded waste paper
 - Design packaging for reuse, recycling or recovery where possible
 - Remove hazardous substances such as heavy metals
- **Hazardous Waste** such as heavy metals, polychlorinated biphenyl (PCBs), oils, solvents, process chemicals – refer to European Waste Catalogue, also for allowable thresholds.
 - Design out materials or processes from the total life-cycle of the product, waste which is categorised; explosive, infectious, oxidising, flammable and highly flammable, irritant, toxic/ecotoxic, harmful, carcinogenic or corrosive.
- **Ozone-Depleting Substances Regulations** covering refrigeration, air conditioning or dry cleaning equipment, insulating foam, industrial solvents or halon fire-extinguishing systems
 - Design out banned hydrochlorofluorocarbons (HCFCs), anticipating an end to temporary exemptions.

1.3

Meeting and Exceeding Customer & Supply Chain Demands and Enhancing Market Appreciation

Environmental performance is increasingly part of a selling proposition, particularly at the consumer end of the supply chain. Consumer testing may incorporate environmental criteria.

Larger companies are exerting pressure down the supply chain by:

- Dealing only with suppliers that have a certified Environmental Management System (EMS) such as ISO 14001.
- Asking suppliers to demonstrate environmental responsibility, for example in materials sourcing and any design discretion at the sub-system supply level



- Involving suppliers in their cleaner design activities.

Trade associations may also be encouraging cleaner design as part of a drive towards best practice.

Producers who can innovate to include environmental features in their product or supply proposition ahead of responding to demands are likely to be favoured.

Innovation can provide entry into new markets and eco-labelling can reinforce the advantage.

1.4 | Good Business Practice – Fulfilling Environmental Policy

A company's environmental policy promotes reductions in environmental impact and the overall environmental impacts of a product are largely determined by design.

Integrating cleaner design for the environment into product design practices enables enhanced environmental performance to complement functional and economic performance; delivering against company objectives.

Improving occupational health and safety through product design can help motivate employees.

Employees and other stakeholders in the business are able to appreciate a responsible approach evident through product design. Improved company image, staff morale and customer relations are seen in a number of case studies.

1.5 | Savings from Waste Minimisation / Resource Efficiency

Typically 90+% of production materials do not end up in saleable products.

Reducing resource inputs to production, product use and end-of-life processes through product design saves both material, energy, water and hence expense. For manufacturing companies, on-going savings can be significant, frequently with little or no capital investment. Experience in the UK suggests that a wide range of industries can save between 4 and 5% of turnover by employing waste minimisation techniques, some derived from product design changes.

Material wastes may be;

- prevented by product design,
- reused or recycled internally to displace material use, or,
- re-cycled externally, perhaps earning revenue.

Incorporating energy and water savings in product design targets can lead to changes which also save time and better satisfies internal and external customers.

Energy and waste savings will become increasingly valuable as taxes based on the 'polluter-pays' principle favour reduced waste disposal and energy efficiency.



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Module 2 - Process

Consider the opportunities to define, measure, analyse and, improve and control activities through the design process covering the following stages.

2.1 | Market Demand or Opportunity

The design process is initiated by the identification of demand for a new or modified product, perhaps through marketing or a design review. This is often informal and usually produces general concepts and the specification of key features.

There may be a recognition of some of the environmental impacts associated with the general concept, but the key point is to explore the potential market pull for enhanced environmental performance.

Talking to customers about the products' use may help. Would they value;

- reduced energy consumption,
- reduced direct or indirect wastes and pollution,
- longer service life – greater durability or potential for upgrading, or,
- reuse or recycling
- a service associated with the function of the product (enabling the manufacturer to better control the life-cycle)?

Even if there seems to be no market pull at present, there are compliance, cost saving and good practice benefits to adopting cleaner design practices from concept through production.

2.2 | Concept Development

Alternative approaches to meeting the market needs are assessed for commercial and technical benefits and feasibility. General environmental criteria can be incorporated according to customer or policy priorities from legal requirements, market knowledge or experience of similar products – environmental aspects identified as part of environmental management.

It is important to prompt life-cycle thinking from the concept stage, simply the consideration of all life-cycle stages and the key environmental considerations.

Life-cycle stage	Key environmental considerations
Material extraction & processing	<ul style="list-style-type: none">▪ Use less materials▪ Use materials with less environmental impact
Manufacture	<ul style="list-style-type: none">▪ Use fewer resources▪ Produce less pollution and waste
Distribution	<ul style="list-style-type: none">▪ Reduce impacts, for example through



	<ul style="list-style-type: none"> ○ packaging design, reuse, recycling ○ fuel & energy reduction
Use	<ul style="list-style-type: none"> ▪ Use fewer resources ▪ Cause less pollution and waste ▪ Improve functionality and service life
End of life	<ul style="list-style-type: none"> ▪ Make reuse, recycling or remanufacturing easier ▪ Reduce the environmental impact of disposal

Life-cycle thinking aims to ensure all environmental aspects are considered and ensure product design changes reduce overall impacts, since impacts may be displaced from one stage to another.

A balanced and integrated evaluation of commercial, technical and environmental benefits, feasibility and risks with all interests represented enables;

- agreement on priorities,
- a full specification to be written, and,
- concept(s) to be chosen to take forward to detailed design or redesign.

2.3 | Detailed Design

Alongside an appreciation of the commercial and technical thinking embodied in the product specification, those responsible for detailed design need a sufficient level of understanding of;

- the key environmental considerations and priorities – representing internal & external customer needs and current & future legislation,
- both existing and potentially available materials & manufacturing processes and their environmental characteristics,
- environmental impacts during use and at end of life, and,
- the potential to extend product life and reuse, re-manufacture, repair, upgrade or recycle all or part of the product.

The checklist at the end of this course illustrates the scope of the questions that may need to be answered.

2.4 | Design Review

Once details of the design are sufficiently clear, an assessment against the product specification's expression of environmental performance may indicate whether iteration is needed to achieve further improvements.

Techniques such as Life Cycle Assessment, a practical disassembly exercise and a review against a checklist are available to support the design evaluation.

Life Cycle Assessment

Aspects of environmental performance may be evaluated using lifecycle assessment (LCA), a process for generating quantifiable data for each of the environmental impacts attributable to a product's life-cycle within a defined scope.



The LCA process comprises; goal and scope definition, inventory analysis of material energy and waste flows over the life-cycle, impact assessment and interpretation. It identifies significant environmental impacts and their sources at each life cycle stage, enabling improvements to be targeted and environmental claims to be substantiated. However, the method has been considered complex; requiring time, extensive data and dedicated resources, such as software requiring expertise or consultancy.

Generic data for many processes and some simplified approaches are now available, however basic expertise is needed to carry out LCA and gain the full benefits.

Practical disassembly exercise

Disassembling a product can be an individual exercise or focus discussion between designers, manufacturers and users. It is likely to reveal opportunities for redesign or development towards cleaner, cheaper and more effective products.

Following an examination of the total product including packaging to complement functional testing, a disassembly exercise;

- enables the range of materials, components and techniques to be better appreciated – demonstrating the number, amount and mix of materials,
- reveals joining methods, component interfaces and locations, and,
- shows the difficulty or potential for separating units and materials for reuse, repair, remanufacture, upgrading, recycling or energy recovery - informing the preparation of any instructions which may aid these processes.

The checklist at the end of this course may be used during a disassembly exercise to complement a focus on cost reduction, functions, appeal and design for manufacture & assembly.

If run as a demonstration, trial runs may help. In any case the health and safety of participants should be addressed for identifiable risks

Review against checklist

A review against the checklist such as that at the end of this course should reveal any items which are uncertain and need further work or which have scope for further improvement. As above, it can be an individual exercise or focus discussion between designers, manufacturers, users including those responsible for purchasing, quality, testing, and sales & marketing.

A simplified approach may be sufficient to identify, for example, that the majority of environmental impacts are caused by the consumption of resources in use. However, small items, such as traces of hazardous material or waste, may still cause unexpectedly significant impacts and the scope for improvements may be larger for aspects which are some way down the ranking.

A team approach and positive reinforcement for environmental improvement may be needed, especially if processes such as design reviews would otherwise treat environmental performance as a late addition to the design agenda. Celebrating even small successes will help people see that there is top-level commitment and they can make a worthwhile contribution.



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Module 3 - Case Studies

The following case studies from the Envirowise programme, show what steps were taken and what benefits were gained by small, medium and large companies from a range of sectors. Generic lessons may be drawn from each.

3.1 | **Small Electrical Manufacturer - Crawford Hansford & Kimber**

Crawford Hansford & Kimber Ltd (CHK) is a small company manufacturing a range of electronic sub-assemblies, containing printed circuit boards (PCBs), electrical components and associated housing.

CHK implemented a cleaner design programme with the aim of reducing unit production costs and increasing the potential for recycling the product. The company believes that the WEEE Directive could have increased its costs as product design and processes are changed to comply with the legislation. Although this legislative driver was the main reason for implementing cleaner design, the company also identified a growing customer demand for cleaner products.

- The main benefits of the cleaner design programme at CHK were:
- Improved product development and production efficiency.
- A reduction of approximately 80% in the use of lead solder. Replacement of lead solder with a non-hazardous, tin-based alternative has significantly increased the potential for recycling of the company's products.
- A reduction in the number of metal fixings and moulded fixtures used to construct the PCB casings. This has significantly reduced the time taken to disassemble the product and increased its recycling potential.
- Improved competitiveness and relationships with suppliers.

The company has identified a potentially significant market for cleaner electrical goods and intends to increase production to accommodate this market.

CHK's move towards the use of lead-free solder in its products has encouraged its main supplier of PCBs to take a similar approach. Greater use of lead-free PCBs by its customers meant that the supplier could change its production process to a more cost-effective one based primarily on silver. This switch also allowed the supplier to recycle the silver and copper content of the process effluent in-house.

3.2 | **Power Tool Manufacturer - Black and Decker**

Black & Decker Corporation is a global manufacturer and distributor of power tools, hardware and home improvement products used for DIY and commercial applications. Black & Decker's interest in cleaner design stemmed from a growing awareness of the need to consider the environmental impacts of its products to maintain its market position.



Black & Decker's marketing analysis showed that its commercial customers consider energy consumption during use to be critical. The company was also under pressure (from customers, competitors and to comply with legislation) to integrate environmental aspects into product development processes.

The company had already developed tools for life-cycle assessment (LCA) and impact analysis. Use of these tools to prioritise cleaner design opportunities led to a DfE programme in three phases.

Initial efforts in Phase 1 focused on:

- preparation of a DfE checklist;
- elimination of ozone-depleting substances during manufacture;
- the use of leaded brass in faucets;
- minimising packaging use.

Initiatives were set up within Phase 2 to:

- develop awareness of the concept of DfE within the company as part of the progress towards an ISO 14001-accredited environmental management system at its Spennymoor site;
- carry out proactive programmes on energy issues throughout the company;
- participate in an internal discussion group on life-cycle issues.

In addition, two pilot projects were launched at the Spennymoor and Towson sites. These involved performing LCAs at Spennymoor on a battery-powered and a mains-powered tool. The results have contributed to development of a cleaner design training package by external consultants, focusing on the following priority aspects;

- ease of assembly and disassembly;
- co-moulding and serviceability;
- material selection and manufacturing safety;
- integrating cleaner design with a quality management tool already used to identify cost savings.

Phase 3 involved a number of elements:

- Developing internal DfE guidelines aimed particularly at designers and engineers.
- Integrating DfE with other relevant programmes, e.g. take-back initiatives.
- Answering specific questions such as whether there were any materials that the company should not use, and which materials should be preferred.
- Examining leasing programmes.

Benefits identified from introducing the DfE programme include:

- An insight into its environmental performance and a good information base for creating cleaner products.
- The necessary tools, organisational infrastructure and internal expertise for continual delivery of improved environmental performance.
- The ability to prepare for forthcoming legislation and ensure product compliance in many countries where products are marketed and distributed.

The essential elements of the company's DfE support system are:



- use of the DfE checklist;
- resources to collect information and participate in pilot studies to further test DfE value within power tool production;
- market analysis of environmental drivers by marketing groups;
- internal communication of DfE efforts and outcomes between product programmes.

3.3 | **Small Furniture Manufacturer – Avad**

Avad Contemporary Furniture is a small company set up to manufacture high-quality contemporary furniture.

The company pursues the efficient use of resources by sourcing sustainably managed hardwood and developing original construction methods, including joints that do not require adhesives or additional fixing materials.

This has resulted in;

- production savings,
- minimal use of non-sustainable materials,
- increased longevity, and,
- greater material reuse at end-of-life.

These cleaner design features have helped to develop Avad's market position due to increased consumer demand for contemporary, environmentally sustainable products.

In 2000, Avad commissioned a life-cycle assessment (LCA) to support its marketing claims of sustainability. The LCA found that there was a 45% lower environmental impact embodied in the company's product than in that of the nearest comparable products.

3.4 | **Medical Equipment Manufacturer - Varian Medical Systems**

Varian Medical Systems UK Ltd, a subsidiary of Varian Medical Systems Inc in the USA, manufactures sophisticated x-ray equipment for simulating radiotherapy treatment.

The main reasons that Varian adopted cleaner design were:

- to maintain a competitive advantage;
- forthcoming legislation - particularly the WEEE Directive;
- a corporate policy requirement for improved environmental performance – supporting the environmental responsibility demonstrated in a certified EMS.

A cleaner design approach was applied to the collimator unit of Varian's main product, a radiotherapy simulator for cancer treatment.

The main benefits of cleaner design for Varian included:

- cost savings of £162,000/year from changes in component numbers and materials;
- 65% reduction in the number of components used per collimator;
- 29% reduction in the number of fasteners used per collimator;



- 27% reduction in assembly time;
- elimination of the use of glass reinforced plastic (GRP) which prevented reuse;
- use of water-based paints instead of solvent-based paints to minimise solvent emissions to air;
- a more modular design, allowing easier upgrading to extend product life;
- improved customer relations.

Varian sees cleaner design as an integral part of its continuing design strategy and has developed procedures to integrate cleaner design into its EMS, which is certified to ISO 14001.



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Module 4 - Checklist

Generic questions such as those in the following checklist can be developed as a prompt to incorporate environmental considerations at product concept and detailed design stages, as well as during design reviews. Aspects may be rated to prioritise them and ideas for potential improvements captured and translated into an action plan.

Checklists are widely used both by individuals or in discussion between designers and manufacturers including those responsible for purchasing, quality, testing and sales & marketing. Involving suppliers or customers may yield further ideas for improvement.

LIFE-CYCLE STAGE	ASPECTS	QUESTIONS
Material extraction & processing	Amount of materials	Can less material be used in the finished product? Can fewer types of materials be used? Can recycled materials be used?
	Impact of materials	Do materials comply with legislation and customer restrictions? Can materials be substituted for alternatives with less environmental impact – through changes in design? Can materials be separated easily? Are materials marked, also with recycling information or a means of easily tracing recycling potential?
Manufacture	Resource use	Does production use energy in ways which can be reduced by product design changes? Can less material be used in production? Can production consumables be reduced by changes in design? Can components fixings, joints and fittings be reduced? Can the product components be re-manufactured?



LIFE-CYCLE STAGE	ASPECTS	QUESTIONS
	Pollution and waste	<p>Are any hazardous substances used in manufacture?</p> <p>Can production 'waste' be made recyclable by changes in design?</p>
Distribution	Resource use	<p>Can package size or packaging material be reduced?</p> <p>Can recycled packaging or recycled materials be used?</p> <p>Can the product be made closer to the point of use?</p> <p>Can the product be made in response to demand – with less stock & storage?</p>
	Pollution and waste	<p>Can packaging materials be substituted for materials with less environmental impact (e.g. less bleach, coating or biodegradable materials)?</p> <p>Can packaging be designed for recycling and marked as such?</p>
Use	Resource use	<p>Can any energy used by the product in use be reduced?</p> <p>Can any consumables used by the product in use be reduced?</p>
	Pollution and Waste	<p>Can any consumables used by the product in use be substituted by those with less impact?</p> <p>Can any waste produced by the product be reduced?</p>
	Functionality and Service Life	<p>Can the product's service life be extended?</p> <p>Can the product be repaired or upgraded?</p> <p>Could the product's function be sold as a service to retain control of the product by the manufacturer through use and at end of life?</p>
End of Life	Reuse, remanufacture and recycling	<p>Can the product be reused?</p> <p>Can parts/modules of the product be reused, remanufactured or recycled?</p>



LIFE-CYCLE STAGE	ASPECTS	QUESTIONS
	Disposal	Can parts of the product be made biodegradable? Are recommendations for disposal easily available to those disposing? Are substances identified, especially those comprising hazardous waste?