Ecodesign framework and principles for the UK bed sector

Written by: Nia Bell and Weijia (Vivian) Shi

Final check by: Melissa Myers

Approved by: David Fitzsimons

Date: 26/02/2020

Contact: Vivian.shi@oakdenehollins.com

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10 Principles of Ecodesign

1. Cultivate ecodesign motivations and capabilities in the sector
2. Maximise reach and impact of ecodesign through leveraging the whole supply chain
3. Ecodesign initiatives should not compromise the product’s fitness for purpose
4. Chemical use in products, and the supply chain, needs to be understood and rationalised
5. Lower-impact materials, including renewable and recycled materials, can be used to reduce a product’s environmental impact
6. Material resource efficiency (through appropriate levels of material use in products and waste prevention) needs to be explored
7. Support improved collection and increased material and component recovery from EoL products
8. Ecodesign requires multiple product environmental impacts to be minimised
9. Ecodesign must create long-term value for businesses
10. Long-term implementation of ecodesign depends on operational-level integration as well as managerial-level processes

How do these principles relate to the ecodesign process and the product life cycle?
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1 Overview

This document aims to distil the large, often academic, field of ecodesign into a framework that is directly applicable to the bed sector. We thank members of the National Bed Federation (NBF’s) Circular Economy Committee for their insights and feedback, and Professor Martin Charter for his contribution in this process.

This framework is meant as a guide, which individual companies can interpret depending on their respective business models and customer base. Wherever possible we have linked the principles to practices and learnings from the bed or closely related sectors.

An equally important purpose of this framework is to present some guidance as to how to identify products, services and practices that constitute good ecodesign. As discussions about potential extended producer responsibility (EPR) schemes are underway for the bed sector, this framework could also be referenced to stimulate a race to the top in terms of environmental outcomes. An award could be considered to recognise good practice and verified progress – with a focus on demonstrating learning that could benefit the sector as a whole.

Accompanying the framework are some example metrics and guidelines of ecodesign. Companies may use them to initiate, measure, monitor and benchmark progress. Given the diverse range of bedding products and commercial contexts, we acknowledge that there is no one-size-fits-all solution. Companies of different sizes and business areas are encouraged to interpret and integrate the framework based on their own contexts, capacities and resources.

We appreciate the multi-faceted nature of ecodesign, and recognise that it is an optimisation of many, sometimes conflicting, environmental and commercial impacts. It is not the minimisation of one of these impacts at the potential expense of others, and any methodology for comparing differently ecodesigned products should reflect these nuances. While this is highlighted in the framework, a separate project will address this challenge.

2 How to use this document

This document opens with a short background on what ecodesign is (and isn’t), why it is relevant to the National Bed Federation (NBF) and its members, and how the process works. Descriptions of the 10 ecodesign principles are covered on Pages 5 through 10. The principles are organised in three categories: People and Relationships, Products and Services and Processes. Some explanation and example metrics to support stakeholder interpretation of the principles has been provided in-situ. Page 11 presents four case studies of different ecodesign approaches in the bed sector.

Appendix A on Page 13 presents a Red List which categorically states what practices need to be avoided when applying an ecodesign approach. This list covers compliance requirements and recommended practices for ecodesigned bedding products.

Lastly, Appendix B on Pages 16 through 17 contains more details on common tools for quantifying the environmental impact of products.
3 Background: the what, why, and hows of ecodesign

Ecodesign is about maximising economic value while minimising environmental impact.

Since the 1980s, design professionals have been working on definitions for and approaches to environmentally sensitive product design. Though literature refers to these interventions inconsistently, this brief is specific to ecodesign, defined as:

“The integration of environmental aspects into product design and development with the aim of reducing adverse environmental impacts throughout a product’s life cycle”

Businesses interest in ecodesign is often driven by legislative, social, market/customer and organisational considerations, as opposed to purely environmental grounds. NBF members are facing a similar situation with the growing consumer awareness of environmental considerations as well as a potential EPR scheme and other regulatory changes.

An ecodesigned bed or mattress is one that achieves lower environmental impacts throughout its life cycle, (Figure 1) without compromising fitness for purpose. Considering impacts related to only a single life cycle stage could risk unexpected consequences up and down-stream of the intervention. Prioritisation can be supported by qualitative and quantitative methods (see page 11).

Figure 1: Ecodesign emphasises impact minimisation through the entire product life cycle

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1 Envisioning Ecodesign: Definitions, Case Studies and Best Practice, European Network of Ecodesign Centres
2 ISO 14006:2011
3 Longitudinal Analysis of the Ecodesign Management Standardization Process in Furniture Companies, Landeta-Manzano et al., 2017
4 https://www.lifecycleinitiative.org/starting-life-cycle-thinking/what-is-life-cycle-thinking/
In practice, ecodesign is used at an operational level for both improving existing designs and generating new product concepts. Although specific practices are case-dependent, the ecodesign methodology can be divided into six general steps as described in Table 1.

Table 1 Steps of ecodesign and example questions to consider in each step

<table>
<thead>
<tr>
<th>Step</th>
<th>Example questions</th>
</tr>
</thead>
</table>
| 1. Define goals and scope | • What are the company’s environmental and commercial goals in the short, medium and long-term?  
• What kinds of benefits and/or risks could ecodesign bring to the company? |
| 2. Product selection and evaluation | • What product is to be redesigned?  
• What features (e.g. function, aesthetics, quality, price) are expected from the product?  
• What capabilities (e.g. environmental knowledge), resources (e.g. time and investment), and business processes (e.g. collaboration) are required to implement ecodesign on the selected product?  
• What are the significant environmental impacts throughout the life cycle of the product? |
| 3. Definition and analysis of design alternatives | • Which ecodesign principles are targeted? Do they contribute to or conflict with other principles?  
• How does meeting the ecodesign principles contribute to desired product features? |
| 4. Selection of design alternatives | • What is the potential impact of design alternatives on key performance indicators (KPIs) for internal stakeholders?  
• What are the reasons for choosing one design over another? |
| 5. Concept development and validation | • What does the improved product look like? How will it work?  
• How will retailers and consumers respond to them? |
| 6. Implementation and follow up | • How to roll out the improved product?  
• How to communicate the environmental improvements of the product to the market? |

Step 1 is to define the company specific goals of pursuing ecodesign. The goals should strike a balance between environmental and commercial values. In Step 2, products are selected based on their potential to fulfil the defined goals. The products baseline functional and environmental performances should be evaluated to identify significant life cycle stages.

**Example of finding the hotspots for reducing product carbon footprint:**
The carbon footprint benchmarking study by FIRA\(^7\) found that nearly 90% of a mattress’s carbon footprint is attributable to the materials they are made from. This suggests that design improvements aimed at carbon footprint reduction should focus on the type and quantity of materials.

In Step 3, the hotspots identified in Step 2 inform the development of alternative design strategies. Trade-offs need to be systematically weighed-up by relevant stakeholders and the most promising solutions selected, for further development and environmental validation through Steps 4 and 5. In the final step, production and

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\(^5\) Partially adapted from: Integrating Backcasting and Ecodesign for the Circular Economy: The BECE Framework, Mendoza et al., 2017


\(^7\) A study into the feasibility of benchmarking carbon footprints of furniture products, FIRA International Ltd, 2011
marketing plans are developed for commercialisation. Throughout the process, regular feedback is necessary for assessing the impact of ecodesign and aligning it with higher level goals.

In summary, ecodesign is an approach that focuses on product-level environmental and economic performance. Furthermore, ecodesign is evolving, most recently to include design for emotional durability and business model innovations. Social considerations, however, are not in scope of ecodesign and would need to be addressed and managed separately.

4 Ecodesign principles

People and relationships

1. Cultivate ecodesign motivations and capabilities in the sector.

*Why is this important?*
Adoption of ecodesign involves organisational change management. Human resources such as motivation and capabilities are the foundation and enabler of that change.

*What could businesses do?*
- Internally communicate the reasons for ecodesign and explain how it contributes to environmental and business goals.
- Involve and value the inputs of operational-level staff across departments when devising the action plan.
- Support development of appropriate skills and knowledge through formal and informal training.

2. Maximise reach and impact of ecodesign by leveraging the whole supply chain.

*Why is this important?*
Lack of external collaboration is a key barrier to successful adoption of ecodesign. Information sharing and collaboration with both upstream and downstream stakeholders is essential.

*What could businesses do?*
- Articulate the internal strategy on ecodesign and communicate it with stakeholders along the supply chain (e.g. material and component suppliers, retail partners, recyclers).
- Develop more interactive and strategic relationships with suppliers to gain more knowledge on the composition and environmental impact of materials/components.
- Update internal ecodesign approaches with feedback from the supply chain (e.g. review construction techniques based on recyclers’ feedback).

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8 Defining the challenges for ecodesign implementation in companies: Development and consolidation of a framework, Dekoninck et al., 2016
Products and services

3. Ecodesign Initiatives should not compromise the product’s fitness for purpose.
   - Red list items; relevant legislation and standards for fitness for purpose (e.g. safety, durability).

   **Why is this important?**
   Ecodesign should serve to meet the needs of the customer. To ensure commercial success, product attributes related to fitness for purpose such as safety and durability should be prioritised over other environmental values if conflicts arise.

   While this may hinder sales in the short term, ensuring quality will likely increase consumers’ trust in the brand and reduce the cost for customer acquisition in the long run.

   **What could businesses do?**
   - Design for an appropriate level of durability, a recommended 10 years for household mattresses based on EU Ecolabel Criteria. This includes:
     - Appropriate mechanical durability.
     - Counteracting consumer cleanliness and hygiene concerns through design and communication (e.g. care instructions).
   - Ensure product performance (e.g. improve comfort by decreasing spinal muscle activity, improving spinal alignment and providing pressure relief 9)
   - Explore alternative revenue streams (e.g. expanded after-sales services) to counteract potential impact on sales.

   **Example metrics**
   - Inclusion of care instructions
   - Years of guarantee

4. Chemical use in products and the supply chain needs to be understood and rationalised.
   - Red List items; restricted and potentially hazardous chemicals in foams and textiles, and concerns with organic solvent-based adhesives.

   **Why is this important?**
   Avoiding (or limiting) the use of hazardous chemicals is a proactive approach a company can take to stay ahead of changes to legislation. It also supports better recycling and reuse of products.

   **What could businesses do?**
   - Identify potentially problematic chemicals (see those listed in the Red List) that are currently contained in the products and used during production.
   - Understand how chemicals impact production safety, consumer health and satisfaction (e.g. allergies), and end of life (EoL) considerations (e.g. some chemicals may be banned by the time a product reaches its EoL).
   - Seek more information about upstream processes; require suppliers to provide an appropriately detailed inventory of chemicals categorised as hazardous under REACH. Alternatively, require suppliers to demonstrate that their products contain less than the permitted levels of certain chemicals (approach taken in the OEKO-TEX 100 and Certipur certification schemes).

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5. Lower-impact materials, including renewable and recycled materials, can be used to reduce a product's environmental impact.

- Red list item; recommended practices on supply chain transparency.

**Why is this important?**

We recognise that there is currently insufficient evidence on the environmental impact of individual materials used by members of the NBF in beds and mattresses. This hinders systematic scoring and ranking of life cycle impacts of products.

In the meantime, this principle is meant to stimulate the market for renewable and recycled materials, through increasing their inclusion in beds and mattresses.

Renewable materials refer to materials that are composed of biomass (i.e. derived from plants and animals) and that can be continually replenished.\(^{10}\)

Incorporating more recycled materials typically lowers the carbon footprint of the product\(^ {11}\).

However, the environmental impact of recycled materials does vary depending on the recycling process. The use of recycled materials (e.g. recycled PET) in mattresses may also limit their future recyclability.

**What could businesses do?**

- Explore materials and construction techniques to increase the proportion of renewable and recycled content in beds and mattresses.
- Source materials produced to the highest possible sustainability standards, within budget, such as FSC certified wood and BCI cotton.
- Where feasible, verify the environmental claims of renewable and recycled materials. Pay special attention to recycled materials as they could introduce chemical contaminants.

**Example metrics**

- % Renewable/recycled material in products.
- Product carbon footprint: CO2 emissions embedded in the full or upstream supply chain.

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\(^{10}\) [https://www.ellenmacarthurfoundation.org/assets/galleries/ce100/CE100-Renewables_Co.Project_Report.pdf](https://www.ellenmacarthurfoundation.org/assets/galleries/ce100/CE100-Renewables_Co.Project_Report.pdf)

\(^{11}\) [https://ec.europa.eu/environment/integration/research/newsalert/pdf/331na5_en.pdf](https://ec.europa.eu/environment/integration/research/newsalert/pdf/331na5_en.pdf)
6. Material resource efficiency, achieved through appropriate levels of material use in products and waste prevention, needs to be explored.

**Why is this important?**

Using less materials, improving process efficiency and generating less waste typically reduces the environmental impact and could reduce operating costs.

At the product level, this means delivering the same (or even better) quality and performance with less material. At the supply chain level, this means preventing waste generated from procurement, production and consumer returns.

**What could businesses do?**

- Evaluate current volume of materials in product(s).
- Explore approaches to use fewer materials, reduce product weight and avoid over-engineering.
  
  (We recognise that product size and weight are not conclusive indicators of environmental impacts. Controversies around the life cycle impact of heavy versus light materials are well-acknowledged. Due to evidence gaps highlighted before, this recommendation encourages continuous improvement of existing products within companies and sectoral benchmarking of products under the same category).

- Validate material-efficient designs with standard quality testing procedures.
- Evaluate current levels of supply chain and production waste and diagnose main causes at each stage.
- Establish waste reduction goals and engage stakeholders to address identified causes.

**Example metrics**

**Technical metrics**

- Consumption of material: average product weight (kg)
- In-house material efficiency: 
  
  \[
  \text{yield (\%)} = \frac{\text{design weight of the component or product} \times \text{sales quantity}}{\text{total weight of material purchased}}
  \]

**Financial metrics**

- Procurement costs: related to material selection and consumption.
- Utility costs (energy, water, waste disposal): related to production and resource efficiency.
- Logistics costs (transport, inventory holding): related to service efficiency.
7. Support improved collection, increased material and component recovery from EoL products.
   - Red list items; recommended practices for product safety, health and environment standards and more efficient EoL management.

Why is this important?
The disposal and EoL management of mattresses is a highly visible issue for the public. Efforts in reducing the EoL impact will help mitigate reputational risks and reduce potential costs introduced by future EPR schemes.

What could businesses do?
- Where feasible, design for easy deconstruction and material separation.
- Help reduce barriers to future recycling processes (e.g. in 10 years’ time): Where possible, avoid use of chemical compounds that are currently under consideration for restriction. This is to mitigate the risks associated with legacy chemicals.
- Support EoL processors with the provision of relevant data (e.g. through tags or labels).
- Facilitate take-back schemes and support reuse (e.g. by partnering with charities).

Example metrics
- Number of types of materials and the weight split (from the bill of materials).
- Number of components (including staples, rings, threads and other small components).
- Number of EoL products recovered and the level of reuse/recycling facilitated by the company.

Processes

8. Ecodesign requires multiple product environmental impacts to be minimised.

Why is this important?
Improving one metric (e.g. carbon footprint) may cause unintended consequences in other areas of concern (e.g. water footprint). Designers need to assess the trade-offs and optimise the overall environmental and commercial impact.

What could businesses do?
- Strive to address multiple ecodesign principles (Number 3 through 7).
- Strive to address multiple items from the Red List (Page 12).
- Assign responsibility for systematically weighing-up the trade-offs inherent in ecodesign interventions to support business decisions.

9. Ecodesign must create long-term value for businesses.

Why is this important?
A lack of long-term strategy is a key barrier to successful adoption of ecodesign. Companies need to set objectives and action plans to ensure ecodesign is value-adding.
What could businesses do?

- Explore how ecodesign could contribute to at least one of the following for the business:
  1) Reduce cost.
  2) Increase revenue.
  3) Increase trust (from consumers and other stakeholders).
  4) Reduce risk (such as price volatility for certain materials and regulatory risks).
- Plan for investments and process change in the short to medium term, with the expectation that some benefits won’t be realised until the longer-term.
- In sales and marketing, develop long-term strategies and programmes to engage and educate consumers on the environmental benefits of ecodesigned products.

10. Long-term implementation of ecodesign depends on operational-level integration as well as managerial-level processes.

Why is this important?
Poor process integration is a key barrier to successful adoption of ecodesign. In the mid to long-term, ecodesign approaches should become a part of business-as-usual (BAU) practice across all levels of the company.

What could businesses do?

- Set up technical methodologies and environmental management systems (e.g. by following ISO 14006 or IEC/ISO 62430:2019) to guide the integration of ecodesign into BAU practices.
- Examples of what environmental managers could do: 12
  1) Identify regulatory requirements, review and monitor environmental compliance; identify and quantify significant environmental impacts associated with current operations.
  2) Monitor, evaluate and engage with suppliers on environmental performance.
  3) Facilitate two-way communication between senior management and operational staff; facilitate cross-departmental communication to encourage internal collaboration.
- Examples of what designers could do:
  1) Consider the life cycle of the product and the questions posed in Table 1 Understand how decisions in each stage (e.g. material selection, incorporation of certain product features, production processes and likely EoL scenarios) relate to the range of environmental impacts described on Page 16.

12 https://apparelcoalition.org/higg-download/
5 Case studies from the bed sector

There is no one-size-fits-all for an ecodesign approach.

**Again® mattress: recycled content and 10-year guarantee**

Mattresses with a core made up of bonded polyurethane foam (presumably sourced from post-industrial off-cuts) sold with a 10-year guarantee. TENCEL, used in the ticking, has lower energy and water footprint than cotton.

Belgium/France-centric survey carried out by producer indicated 98% of the customers were willing to invest in a mattress containing recycled materials.

**BekaertDeslee prototypes for biodegradable and recyclable mattresses**

100% biodegradable mattress designed to demonstrate material and design principles to support EoL biodegradability using industrial composting. 100% recyclable mattress uses recyclable materials (mostly polyester and steel) and construction techniques supportive of deconstruction and material recovery. Value chain partnerships supportive of developing and commercialising these proof-of-concept products.

**Hypnos-Whitbread collaboration: Service based ecodesign intervention diverting EoL waste in the contract sector**

Long-term, mutually beneficial, arrangement between Hypnos and Whitbread whereby Hypnos recover and arrange the recycling of the EoL mattresses from Premier Inn hotels.

**Palatine beds - MoD contract: Component reuse in the contract sector**

Palatine beds has a contract to supply and take-back mattresses for MoD sites. Where possible, and with full disclosure to the MoD, they reuse spring-sets and insulator pads in the mattresses they supply. As well as keeping the price down, a major driver for the MoD, component reuse has a duel benefit of preventing waste and significantly reducing the carbon footprint of the products. Note that remanufacturing is BAU for the MoD when it comes to the military equipment they use and it has to last decades.

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14 https://again-mat.com/avis/
15 Page 21 of https://issuu.com/bekaertdeslee/docs/sustainability_report_-_23_5_x_21_-_
6 Conclusion and on-going work

It is our hope that this document will serve as a primer and guide for companies interested in embarking on the ecodesign journey. This document drew from a large body of relevant academic literature, business practices, and available industry standards. However, ecodesign is still an evolving field with new concepts, interpretations, methodologies, tools and standards being put forward. For example, the recently published ISO 14006 and IEC/ISO 62430:2019 will provide guidelines for incorporating ecodesign in environmental management systems. We are prepared to revise and update the processes and principles summarised in this document to be consistent with the latest standards. In the meantime, we welcome feedback on this work from NBF members, interested parties, and the general public.

The NBF is committed to further improving the sector’s sustainability performance through ecodesign. Efforts are underway to survey and benchmark members’ environmental performances. Development of a methodology and scoring tool for evaluating different ecodesign products is in progress. The methodology shall be consistent with the principles in this document and other scoring schemes in the broader furniture sector. Outcomes of these projects will be publicised during the NBF Earth Day Event on April 22nd 2020.
Appendix A: Red List for Ecodesigned Bedding Products – Chemical, Material, Construction and General Practice

Maintain good in-house knowledge of what is used in your products and why, regularly reviewing them to make sure they’re up to date with best practice.

Compliance

a) Do not use brominated flame retardants (BFRs) that are restricted under REACH or the Stockholm Convention (targeting persistent organic pollutants, or POPs) and consider the best available scientific evidence when considering the appropriateness of other flame retardants. The following BFRs are restricted under REACH (noted that this is for general reference and some compounds listed here may not be commonly used in mattresses):17

- Polybrominated diphenyl ethers (PBDEs):
  - 2,4,4’-Tribromodiphenyl ether
  - 2,2′,4,4′-Tetra bromodiphenyl ether
  - 2,2’,4,4’,5-Pentabromodiphenyl ether
  - 2,2′,4,4’,6-Pentabromodiphenyl ether
  - 2,2′,4,4’,5,5’-Hexabromodiphenyl ether
  - 2,2′,4,4’,5,6′-Hexabromodiphenyl ether
  - 2,2′,3,3’,4,4’,5,5’,6,6′-Decabromodiphenyl ether

- Hexabromocyclododecane (HBCD or HBCDD)

b) Additional eco-chemical label requirements (to be updated in 2020)

c) Products must comply with all other essential legislation and standards as highlighted in the NBF’s code of practice (version 3 2018, links to online copies are available from the NBF’s guide to regulation and standards). To date, these include:

- Compliance with BS7177 for mattresses, mattress toppers, divans and bed bases.
- Compliance with the Furniture and Furnishings (Fire Safety) Regulations (as amended).
- Compliance with BS 1425: Part 1: 1991 – Cleanliness of fillings and stuffings for bedding, upholstery and other domestic articles. Specification for fillings and stuffings other than feather and/or down; or EN 12935:2001 – Feather and down – hygiene and cleanliness requirements.
- Compliance with NBF policy on the sale of used and reconditioned mattresses, used components and materials.
- Compliance with the Consumer Rights Act 2015, with particular regard to consumer protection from unfair trading terms.
- Compliance with the Textile products (Labelling and Composition) Regulations 2012.
- Compliance with the EU Timber Regulations 2013.
- Compliance with chemical legislation; Registration Evaluation, Authorisation & Restriction of Chemicals (REACH), Stockholm Convention (POPs) and the EU Biocides Regulation 528/2012.

- Awareness of Health & Safety compliance.
- Awareness of Process Controls/Procedures.
- Awareness of PAS 7100 product safety recall requirements.
- Awareness of Modern Slavery Act 2015.

**Recommended Practices**

**Supply chain impact**

d) If using natural fibres and the products derived from them, request/provide information as to their sourcing and supply chain impacts.

- Claims of environmental benefits from using supposedly low-impact materials need to be evidence-based, for example through LCA studies or certifications. Otherwise, it could cause unexpected technical challenges (e.g. management of unknown hazardous chemicals) and business risks (e.g. being challenged as greenwashing).

**Product safety, health and environment standards**

e) Flame retardants (FRs): without compromising the product’s fitness for purpose, avoid the use of synthetic organic flame retardants that have been proposed by ECHA for restriction where possible. More environmentally friendly alternatives and natural flame retardant materials such as wool/wool blends could be considered.

f) PU foams: avoid products without CertiPUR certification or demonstrated equivalence in terms of Safety, Health and Environment (SHE) standard.


h) Adhesives: avoid organic solvent-based adhesives where water-based ones can be used instead.

- Solvent-based adhesives release volatile organic compounds (VOCs), which pose health and safety concerns throughout the manufacturing and application process.
- And, as outlined in the diagram below, consider removing adhesives from products where possible (without affecting fitness for purpose).

*Figure 2 Bonding with levels of hazards* [http://arbejdskemi.dk/substitution.htm](http://arbejdskemi.dk/substitution.htm)

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18 Example LCA done on Austria, New Zealand, and UK sourced wool (open access): [https://link.springer.com/content/pdf/10.1007%2Fs11367-015-0849-z.pdf](https://link.springer.com/content/pdf/10.1007%2Fs11367-015-0849-z.pdf)


20 [http://arbejdskemi.dk/substitution.htm](http://arbejdskemi.dk/substitution.htm)
**EoL management**

i) Do not over-staple layers together (e.g. the spring insulator pad to the spring unit) while ensuring product fitness for purpose.
   - This may reduce the value of recovered materials because staples are a major contaminant in the foam and filling fractions recovered through manual disassembly.

j) Do not quilt foam layers into the ticking.
   - This makes material separation more difficult, which reduces the purity and hence value of recovered materials.
   - Reducing foam contamination in your textile production waste, by avoiding quilting, would also support the recyclability of both the textile and foams.

k) Do not make recyclability claims unless they are ‘widely’ (not just theoretically) recyclable.
   - Currently the recycling infrastructure isn’t there for polyester ticking and wadding, natural fibres or other ticking materials.

l) Where possible, avoid use of chemical compounds that are proposed by ECHA for restriction. This is to mitigate the risks associated with legacy chemicals in material recycling.
Appendix B: Tools for quantifying environmental impact

A standardised approach to quantifying environmental impact is necessary. However, cost and complexity need to be weighed up against accuracy and usability.

Quantitative

Full Life Cycle Assessment (LCA)
LCA is a systematic tool that enables quantitative analysis of the environmental impact of a product throughout its entire life cycle. Alternatively, just a section of the life cycle can be considered: 21

- Cradle-to-gate: From source (extraction) to factory gate.
- Cradle-to-grave: From source (extraction) to disposal (excluding recycling).
- Cradle-to-cradle: From source (extraction) to disposal (including recycling).

Both products and services can be evaluated. The most relevant impact categories include:

- Acidification: indicated by the increase of the acidity in water and soil systems, considering the acidifying potential of oxides of nitrogen and sulphur.
- Climate change: indicated by the disturbances in global temperature and climatic phenomenon, considering the greenhouse gases and their global warming potential.
- Depletion of abiotic resources: indicated by the decrease of resources, considering distinctions between renewable and non-renewable resources.
- Eco-toxicity: indicated by biodiversity loss and/or extinction of species.
- Eutrophication: indicated by the increase of nitrogen and phosphorous concentrations, or the formation of biomass.
- Human toxicity: indicated by cancer, respiratory diseases, other non-carcinogenic effects and effects to ionising radiation.
- Land use: indicated by species loss, soil loss, amount of organic dry matter content etc.
- Ozone layer depletion: indicated by the increase of ultraviolet UV-B radiation and number of cases of skin illness.
- Particulate matter: indicated by the increase in different sized particles suspended on air (PM10, PM2.5, PM0.1).
- Photochemical oxidation: indicated by the increase in the summer smog.

MET Points
The MET points method simplifies the LCA results. Impact categories listed above are aggregated into three groups as below. Each impact category is assigned a score; the scores are weighted to yield a value that represents the overall impact of each M/E/T group. 21

- Material cycles (M): covers resource consumption.
- Energy use (E): covers greenhouse effect, acidification, smog, and eutrophication.
- Toxic emissions (T): covers ozone layer depletion, human toxicity, and eco-toxicity.

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21 For detailed methodology, see ISO/TR 14062 (now covered by ISO:14006 and IEC/ISO 62430) and ISO14001:2015
Simplified/Software-based life cycle assessment
LCA can be simplified by leaning on assumptions and estimations to fill gaps in the data. Software-based assessments may lack data quality but do give some quantified results for the design process. These results can be verified with more detailed research if desired.

Common tools include LCA modelling software such as SimaPro, Gabi; design support software such as GRANTA Selector and sustainability modules in computer-aided design software such as AutoCAD or SolidWorks; and industry-developed tools such as the Material Sustainability Index developed by the Sustainable Apparel Coalition.

Product Carbon Footprint (PCF)
PCF reduces the number of impact categories of concern to one: the impact on climate change. PCF estimates the global greenhouse gas emissions related to the entire life cycle of a product, process or service. The carbon footprint of only part of a products life cycle can also be carried out, as demonstrated by FIRA when they attempted a benchmark of furniture carbon footprints only up to and including the manufacture of the product and delivery to the customer.\(^{22}\) The value can be obtained through an LCA analysis but requires far less data compared to a full LCA.

Comparison of quantification methods\(^{23}\)

<table>
<thead>
<tr>
<th></th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full LCA</td>
<td>High objectivity and accuracy</td>
<td>High cost and time-consuming; Poorer design applicability compared to other methods</td>
</tr>
<tr>
<td>MET Points</td>
<td>High objectivity and accuracy; better design applicability compared to full LCA</td>
<td>High cost and time-consuming</td>
</tr>
<tr>
<td>Simplified/Software-based LCA</td>
<td>Lower cost and time requirement; Better design applicability compared to full LCA</td>
<td>Reduced objectivity and accuracy compared to full LCA</td>
</tr>
<tr>
<td>PCF</td>
<td>Lower cost and time requirement than simplified LCA; Better design applicability compared to full LCA</td>
<td>Reduced objectivity and accuracy compared to simplified LCA</td>
</tr>
</tbody>
</table>

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\(^{22}\) A study into the feasibility of benchmarking carbon footprints of furniture products, FIRA International Ltd, 2011
\(^{23}\) ISO/TR 14062
Qualitative

Practitioners may use qualitative tools such as checklists and rules of thumb to guide the exploration and selection of ecodesign strategies.

Table 2 Checklist to design for circular economy; from Designing for Circular Economy by Martin Charter

<table>
<thead>
<tr>
<th>Design Focus Area</th>
<th>Options for Design Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour Code</td>
<td>General environmental improvement</td>
</tr>
<tr>
<td><strong>Design for Material Sourcing</strong></td>
<td>Reduce weight and volume of product</td>
</tr>
<tr>
<td></td>
<td>Increase use of recycled materials to replace virgin materials</td>
</tr>
<tr>
<td></td>
<td>Increase use of renewable materials</td>
</tr>
<tr>
<td></td>
<td>Increase incorporation of used components</td>
</tr>
<tr>
<td></td>
<td>Eliminate hazardous substances</td>
</tr>
<tr>
<td></td>
<td>Use materials with lower embodied energy and/or water</td>
</tr>
<tr>
<td><strong>Design for Manufacture</strong></td>
<td>Reduce energy consumption</td>
</tr>
<tr>
<td></td>
<td>Reduce water consumption</td>
</tr>
<tr>
<td></td>
<td>Reduce process waste</td>
</tr>
<tr>
<td></td>
<td>Use internally recovered or recycled materials from process waste</td>
</tr>
<tr>
<td></td>
<td>Reduce emissions to air, water and soil during manufacture</td>
</tr>
<tr>
<td></td>
<td>Reduce number of parts</td>
</tr>
<tr>
<td><strong>Design for Transport and Distribution</strong></td>
<td>Minimise product size and weight</td>
</tr>
<tr>
<td></td>
<td>Optimise shape and volume for maximum packaging density</td>
</tr>
<tr>
<td></td>
<td>Optimise transport and distribution in relation to fuel use and emissions</td>
</tr>
<tr>
<td></td>
<td>Optimise packaging to comply with regulation</td>
</tr>
<tr>
<td></td>
<td>Reduce embodied energy and water in packaging</td>
</tr>
<tr>
<td></td>
<td>Increase use of recycled materials in packaging</td>
</tr>
<tr>
<td></td>
<td>Eliminate hazardous substances in packaging</td>
</tr>
<tr>
<td><strong>Design for Use (Including installation, maintenance and repair)</strong></td>
<td>Reduce energy in use</td>
</tr>
<tr>
<td></td>
<td>Reduce water in use</td>
</tr>
<tr>
<td></td>
<td>Increase access to spare parts</td>
</tr>
<tr>
<td></td>
<td>Maximise ease of maintenance</td>
</tr>
<tr>
<td></td>
<td>Maximise ease of reuse and disassembly</td>
</tr>
<tr>
<td></td>
<td>Avoid design aspects detrimental to reuse</td>
</tr>
<tr>
<td></td>
<td>Reduce energy used in disassembly</td>
</tr>
<tr>
<td></td>
<td>Reduce water used in disassembly</td>
</tr>
<tr>
<td></td>
<td>Reduce emissions to air, water and soil</td>
</tr>
<tr>
<td></td>
<td>Eliminate potentially hazardous substances that can be released during use</td>
</tr>
<tr>
<td></td>
<td>Maximise ease of materials recycling</td>
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<tr>
<td><strong>Design for End of Life</strong></td>
<td>Avoid design aspects detrimental to materials recycling</td>
</tr>
<tr>
<td></td>
<td>Reduce amount of residual waste generated</td>
</tr>
<tr>
<td></td>
<td>Reduce energy used in materials recycling</td>
</tr>
<tr>
<td></td>
<td>Reduce water used in materials recycling</td>
</tr>
</tbody>
</table>
From its offices in Aylesbury and Brussels, Oakdene Hollins provides research and consulting services to clients under three main themes:
Circular Economy
Sustainable Products
Innovative Technologies & Materials

For more information visit oakdenehollins.com