Circular Product Design

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CML / 22-03-2016
Sustainable?

- **Energy:** 10-15 times more efficient
- **Lifetime:** 30000 iso 1500 h
- **Optimal recyclability**

**New technology**
Sustainable?

• Materials: recycled and recyclable

• Rapid disassembly

Sustainable?

• Business model: leasing

New business model
Circular product design

- Lifecycle Thinking
  
  - Energy efficiency / renewable energy
  - Design for Recycling
  - Design for Multiple Lifecycles

Product Life Cycle – Value Chain

- Packaging
- Sales
- Use
- Design & Production
- Raw materials
- Waste
- Recycling

Raw materials and waste are recycled back into the value chain.
Recycling

Connections limit separation

Recycling

[Image of recycling equipment and materials]
Circular Economy:

- **Materials**
- **Parts supply**
- **Manufacturing**
- **Distribution**
- **User**
- **Collection**
- **Waste**
- **Recycle**
- **Part harvesting**
- **Refurbish**
- **Service**
- **Enablers**

**Circular Product Design:**
- Enable multiple life-cycles with minimal loss of quality and value
- Maximize remaining value
- Minimize required energy input
- Modular design for easy disassembly
- Create re-usable platforms

**New Business Models:**
- Service/Solution Delivery vs. Asset Ownership
- Easy access and affordable prices
- From transactions to relationships

**Collaboration:**
- Cross value chains
- Cross business sectors
- Financial and Social Partners

**Reverse Logistics:**
- Enable efficient closed loops
- Collection of materials
- Legislation compliance

**Circular Economy: recycling**

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Standard MR16

MR16 low voltage lamp

random fracturing:
- PCB and heat sink remain connected

Design guidelines for recyclability

not compromising performance or increasing cost

- Only use materials that can be recycled
- Avoid the use of non-compliant coatings
- Limit the number of different materials
- Use preferred/pure materials
- Get PCB out in one piece (stripping)
- Enable easy test detection of materials
- Use ISO components
- Avoid fixed connections
- Break-down (by shredding/disassembly) to:
  - Pieces with uniform compaction
  - Pieces of relatively large size (>1 mm)

- Visual marks
- Extensive use of RFID
Redesign: MR16 with fracture lines

fracturing along fracture lines:
- screws released
- PCBs detached

Assist and guide fracture in the case of brittle housing

Impact assessment  MR16

Recycling percentages
(default shredding settings)

<table>
<thead>
<tr>
<th></th>
<th>Standard</th>
<th>Fracture Lines</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘Strict’ rec.%:</td>
<td>41%</td>
<td>67%</td>
</tr>
<tr>
<td>(materials actually recovered)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WEEE Dir. rec.%</td>
<td>82%</td>
<td>92%</td>
</tr>
<tr>
<td>(materials to recovery process)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>QWERTY</td>
<td>63%</td>
<td>80%</td>
</tr>
<tr>
<td>(environmentally weighted, incl. all impacts)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Impact assessment  MR16
Circular Product design: *multiple lifecycles*

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- **Collection**
- **Recycle**
- **Part harvesting**
- **Service**
- **Waste**

### Circular Product Design

- Durability
- Adaptability
- Attachment and Trust
- Ease of disassembly
- Standardization
- Lifetime prognostics
- Identification
- Communication
- Roadmap
MR16 redesign

- Heat sink top / fixation
- Collimators
- LED PCB
- Heat spreader LEDs
- Heat spreader driver
- Driver
- Contact pins
- Driver clamp
- Shell

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**Apple Watch**
Apple Watch Repairability Score: 5 out of 10
(10 is easiest to repair)

- While not an industry standard, the watch band is easily removed and swapped out for a replacement.

- Removing the screen is difficult, but not impossible—it’s the first component out, simplifying replacement.

- Once you’re inside, the battery is quite easy to remove—only mild adhesive holds it in place.

- While not proprietary, incredibly tiny triwing screws are a repair hindrance—especially when Torx or Phillips could have been used.

- Removing any other component is essentially impossible—all peripheral cables are soldered onto the back of the S1.

- The fully-encased S1 system makes board-level repairs impossible.

Fairphone
• Designed for serviceability
• Robust
• High residual value
• durable materials (e.g., aluminium),
• streamlining parts and integrating functions
• easy manual disassembly to facilitate efficient remanufacturing / limited fasteners
• upholstery and castors as well as the seat foam can be easily removed
• Joining methods
• Handling
• RFID tags, data logs, sensors
  • Tracking history
  • Bills of Materials
  • Known failure modes
  • Test data and
  • Original performance
  • Build specifications

Light as a Service (Philips)

• Concept carrier
  - Modular
  - Easy disassembly
  - Low impact materials
  - Accessibility of LEDs and electronic driver
  - New LED concept
  - Zigby connectivity
  - Easy recyclability
Our approach to circular product design

- Life cycle thinking is crucial
- Industrial design is driven by business objectives
- Circular economy is about closing economic loops as well as ecologic loops
- Recycling is the last resort, but recyclability is a prerequisite
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