Architecting for CE;
Need for a holistic approach

Aly Syed, Sharina Ligtelijn
Philips
18-06-2024

innovation + you

Goal of the session

Introduction

Current process in product design
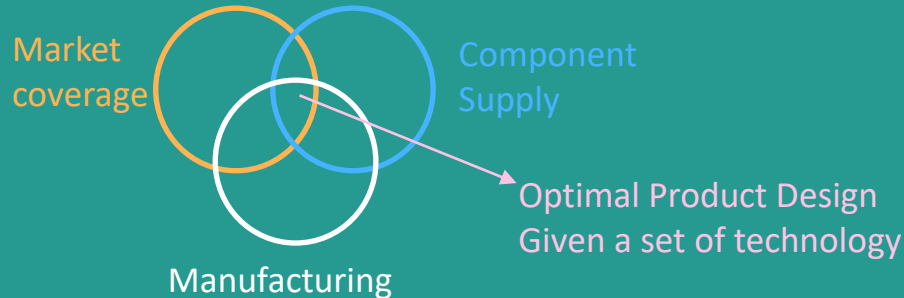
Effect on E2E Architecture

Discussion

Aly Syed
Systems Architect

Sharina Ligtelijn
Circular Product Designer

Sustainability is quality like security and is not bolt on

- Sustainability is a quality of a system
- We know that a quality should be designed into a system architecture
- Sustainability appears in the different phases of product definition and development

| 1 Value Proposition | 2 Architecture | 3 Product Implementation | 4 Product Deployment | 5 Product Maintenance |

Market coverage

Component Supply

Optimal Product Design
Given a set of technology

Manufacturing

Sustainability needs a holistic approach

Currently **CE integration** is still too much in **silos**

- An example is CE integration in the product implementation

| 1 Value Proposition | 2 Architecture | **3 Product Implementation** | 4 Product Deployment | 5 Product Maintenance |

- Let's have a look at the product development
  - Learn current generic circular product design process
  - Get inspiration how to implement in architecting
  - Get inspiration how to improve to take a holistic approach

Generic process of Circular Product Design

Ecosystem research

1 Ecosystem Research **2** Circular aim
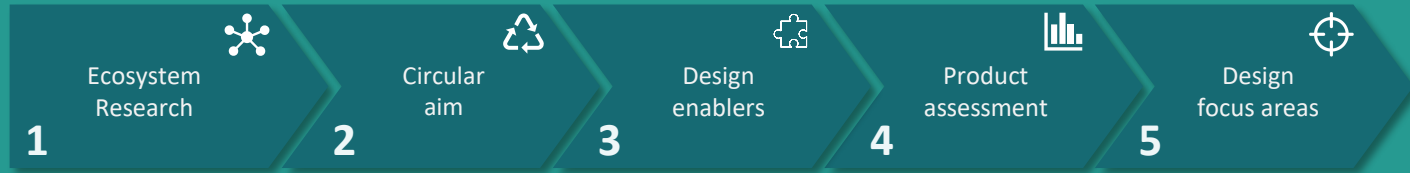
A Project background knowledge

Lots of design freedom → renting model
Little design freedom → recycling

High financial value → refurbishment
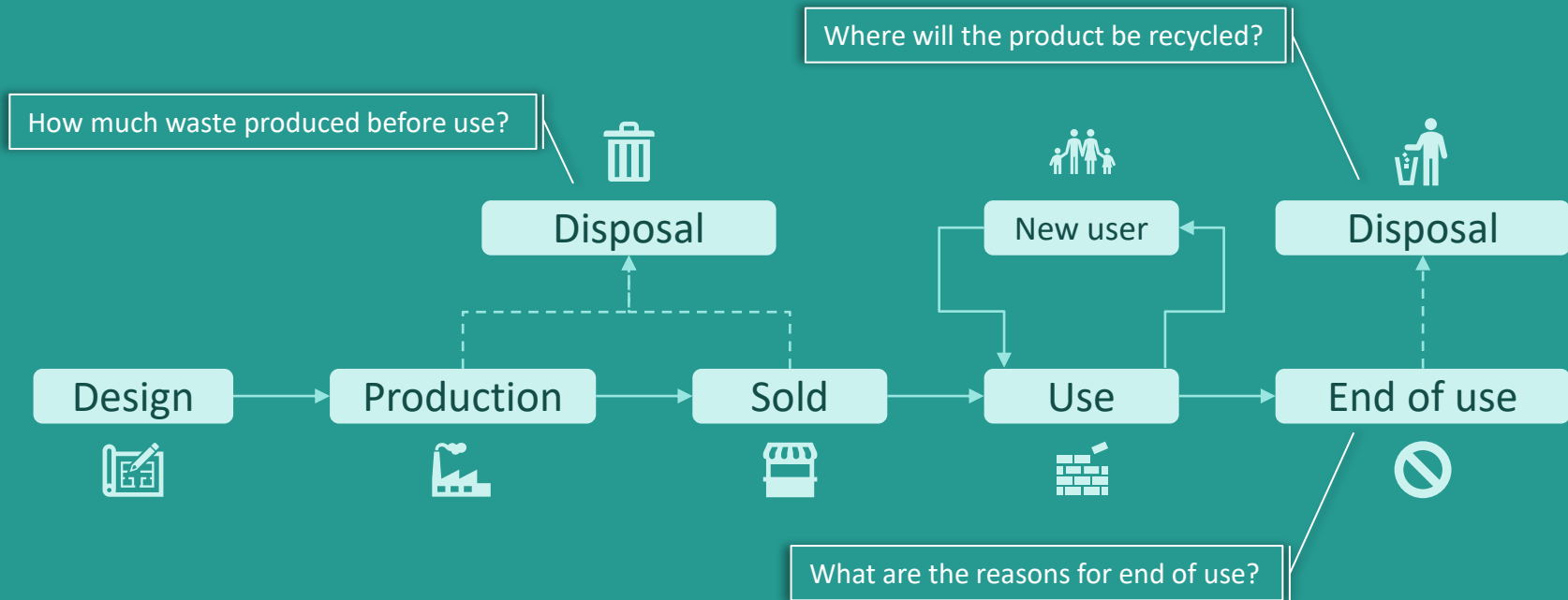Low financial value → recycling

B Product lifecycle

Reason for End-of-Use:
Technical malfunction → repair
Trend sensitivity → upgrade

**C** Current status

Predecessor already repairable → refurbishment

D Drivers and boundaries

Driver: Right to repair movement → repair
Boundary: Illegal to resell → don't focus on refurbishment

The simplified Life cycle

How much waste produced before use?

Where will the product be recycled?

Disposal

New user

Disposal

Design → **Production** → **Sold** → **Use** → **End of use**
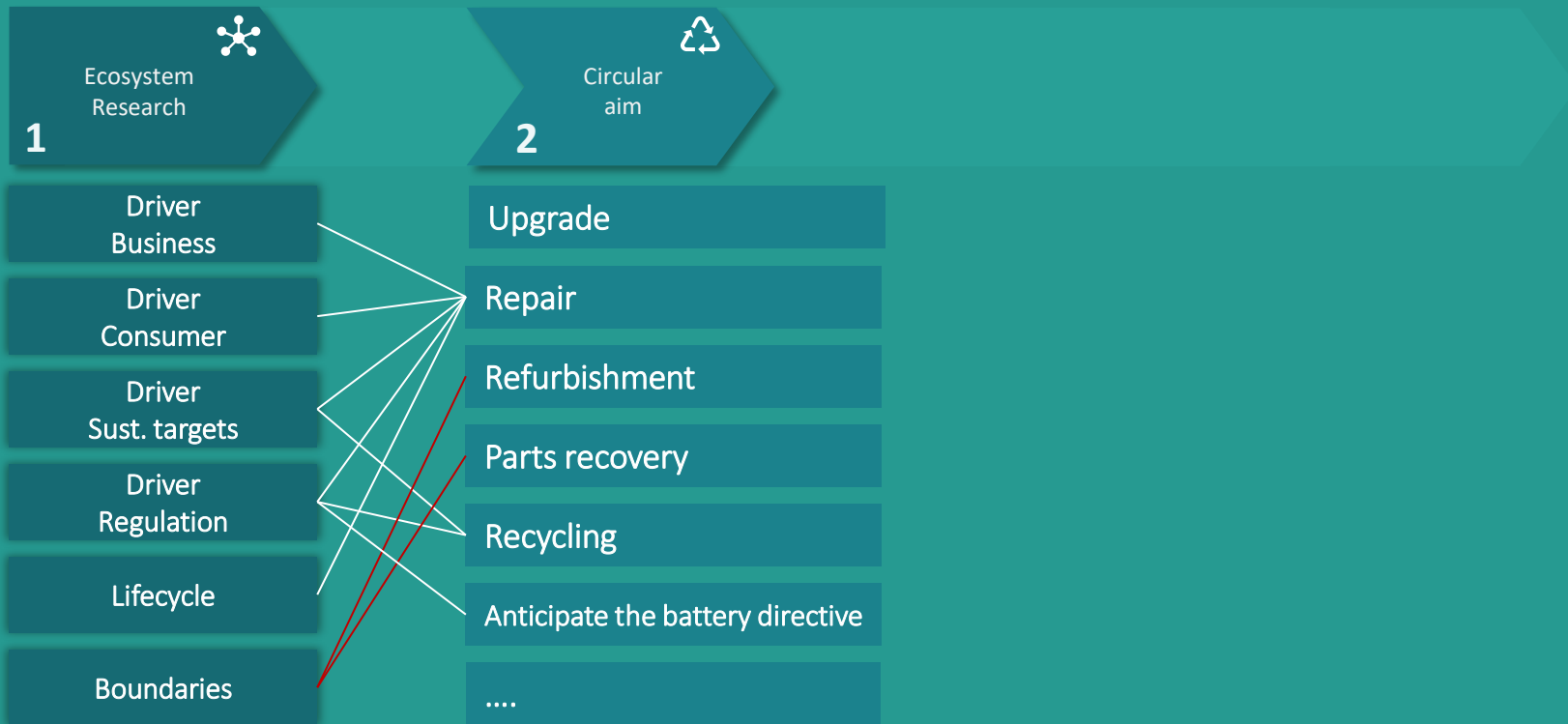
What are the reasons for end of use?

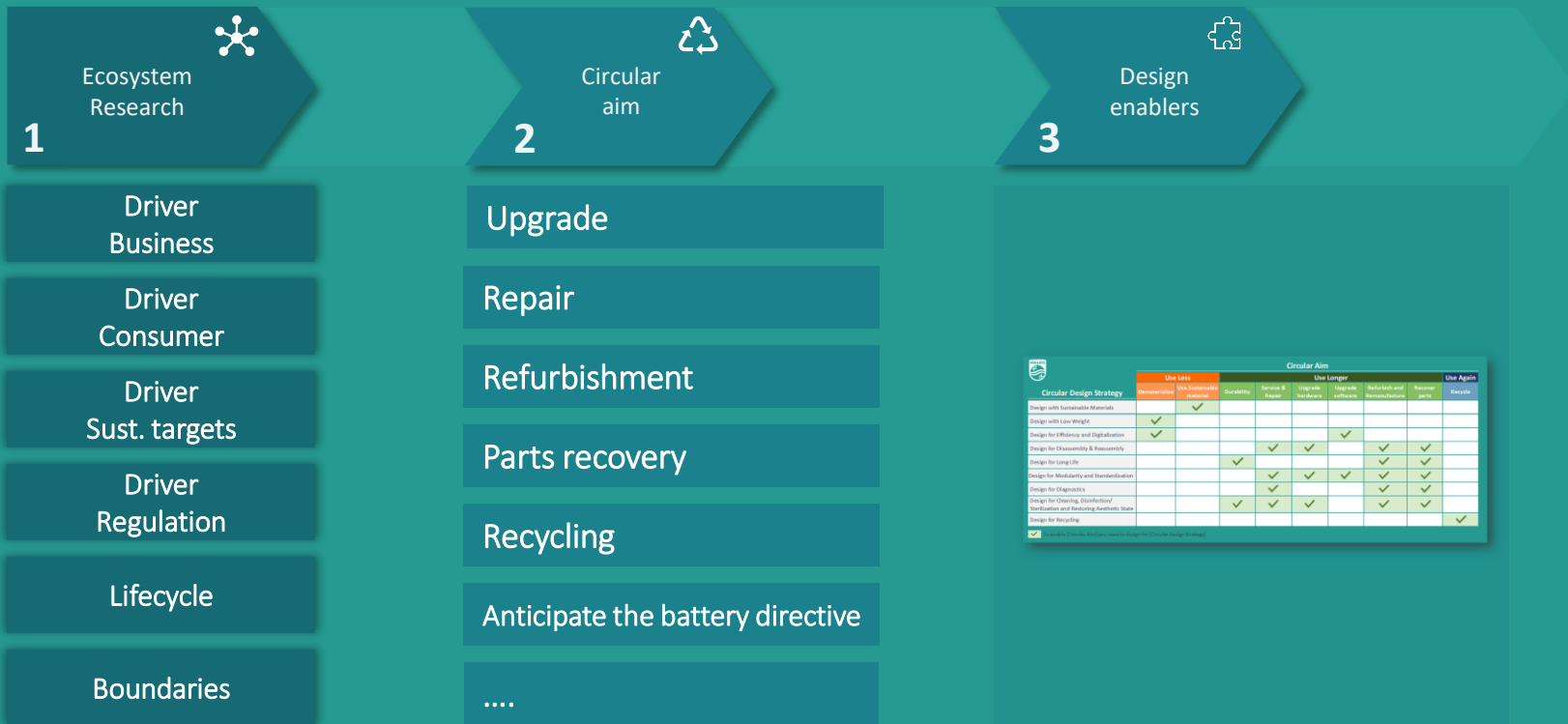# Life Cycle Assessment is a good tool to identify hotspots

- Find knobs to turn
- Select the most relevant knobs (impact & design-freedom)
- Investigate the effect of turning them
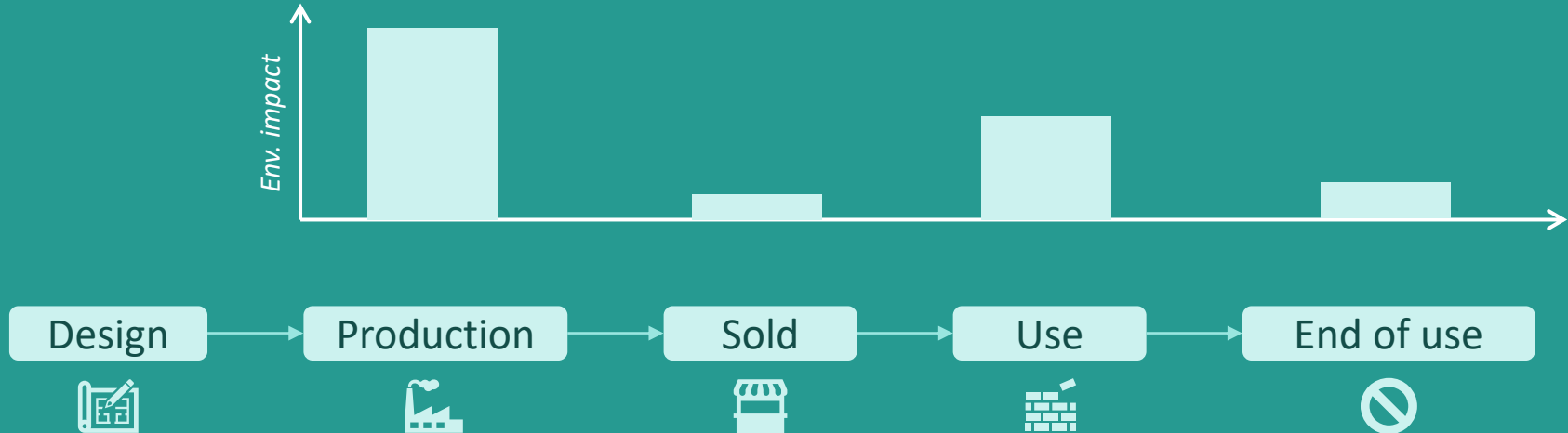
The Ecosystem Research results are used as input to define the Circular Aim(s)

1 Ecosystem Research

2 Circular aim

Ecosystem Research	Circular aim
Driver Business	Upgrade
Driver Consumer	Repair
Driver Sust. targets	Refurbishment
Driver Regulation	Parts recovery
Lifecycle	Recycling
Boundaries	Anticipate the battery directive
	....

A tool was developed to go from Aim to Design Enablers

1 Ecosystem Research

- Driver Business
- Driver Consumer
- Driver Sust. targets
- Driver Regulation
- Lifecycle
- Boundaries

2 Circular aim

- Upgrade
- Repair
- Refurbishment
- Parts recovery
- Recycling
- Anticipate the battery directive
- ....

3 Design enablers

The Circular Product Design Matrix

Circular Design Strategy	Circular Aim								
	Use Less		**Use Longer**						**Use Again**
	Dematerialize	Use Sustainable material	Durability	Service & Repair	Upgrade hardware	Upgrade software	Refurbish and Remanufacture	Recover parts	Recycle
Design with Sustainable Materials		✔							
Design with Low Weight	✔								
Design for Efficiency and Digitalization	✔					✔			
Design for Disassembly & Reassembly				✔	✔		✔	✔	
Design for Long Life			✔				✔	✔	
Design for Modularity and Standardization				✔	✔	✔	✔	✔	
Design for Diagnostics				✔			✔	✔	
Design for Cleaning, Disinfection/ Sterilization and Restoring Aesthetic State			✔	✔	✔		✔	✔	
Design for Recycling									✔

✔ To enable [Circular Aim] you need to design for [Circular Design Strategy]

The Circular Product Design Matrix

Circular Design Strategy	Use Less		Use Longer						Use Again
	Dematerialize	Use Sustainable material	Durability	Service & Repair	Upgrade hardware	Upgrade software	Refurbish and Remanufacture	Recover parts	Recycle
Design with Sustainable Materials		✓							
Design with Low Weight	✓								
Design for Efficiency and Digitalization	✓					✓			
Design for Disassembly & Reassembly				✓	✓		✓	✓	
Design for Long Life			✓					✓	
Design for Modularity and Standardization				✓	✓	✓	✓	✓	
Design for Diagnostics				✓			✓	✓	
Design for Cleaning, Disinfection/ Sterilization and Restoring Aesthetic State			✓	✓	✓		✓	✓	
Design for Recycling									✓

✓ To enable [Circular Aim] you need to design for [Circular Design Strategy]

The Circular Product Design Matrix

Circular Design Strategy	Use Less		Use Longer						Use Again
	Dematerialize	Use Sustainable material	Durability	Service & Repair	Upgrade hardware	Upgrade software	Refurbish and Remanufacture	Recover parts	Recycle
Design with Sustainable Materials		✓							
Design with Low Weight	✓								
Design for Efficiency and Digitalization	✓					✓			
Design for Disassembly & Reassembly				✓	✓		✓	✓	
Design for Long Life			✓				✓	✓	
Design for Modularity and Standardization				✓	✓	✓	✓	✓	
Design for Diagnostics				✓			✓	✓	
Design for Cleaning, Disinfection/ Sterilization and Restoring Aesthetic State			✓	✓	✓		✓	✓	
Design for Recycling									✓

✓ To enable [Circular Aim] you need to design for [Circular Design Strategy]

Generic **Implementation**

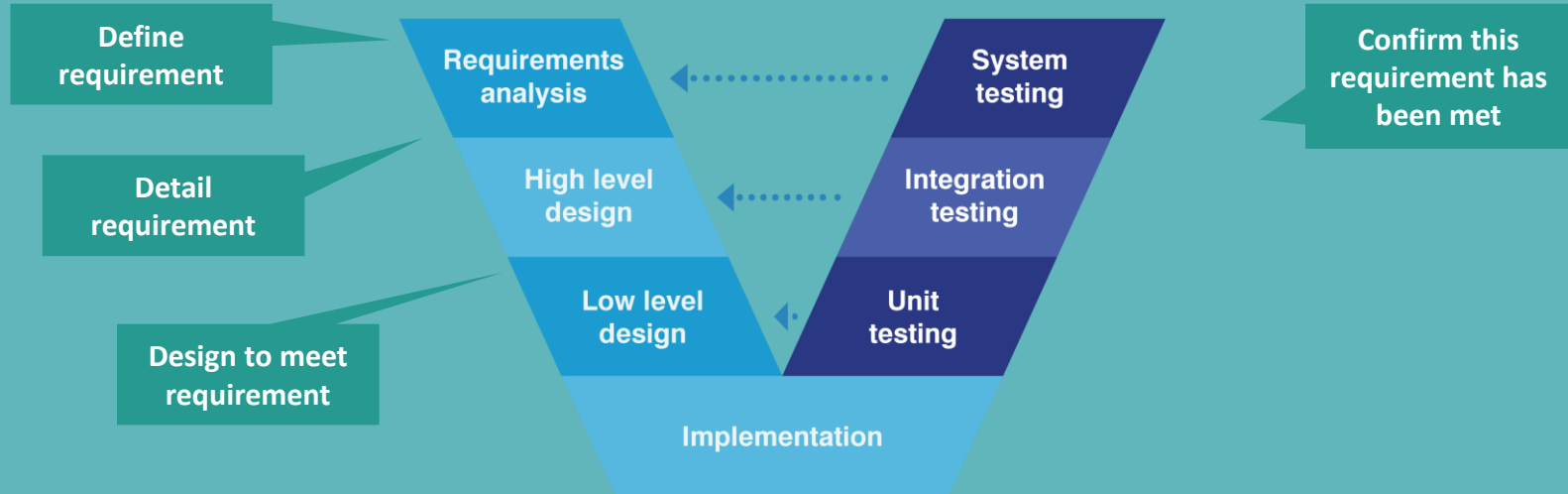**Tools**

| **VPC**, LCA, business model, regulations | CPD **Matrix** | Pre-decessor **Assessment** | Design **Guidelines** | **Assessment** tool |

Process

Define requirement

Detail requirement

Design to meet requirement

Confirm this requirement has been met

- Requirements analysis
- High level design
- Low level design
- Implementation
- System testing
- Integration testing
- Unit testing

14

Example **Implementation**

Tools

| **VPC**, LCA, business model, regulations | CPD **Matrix** | Pre-decessor disassembly **Assessment** | Disassembly design **Guidelines** | Disassembly **Assessment** tool |
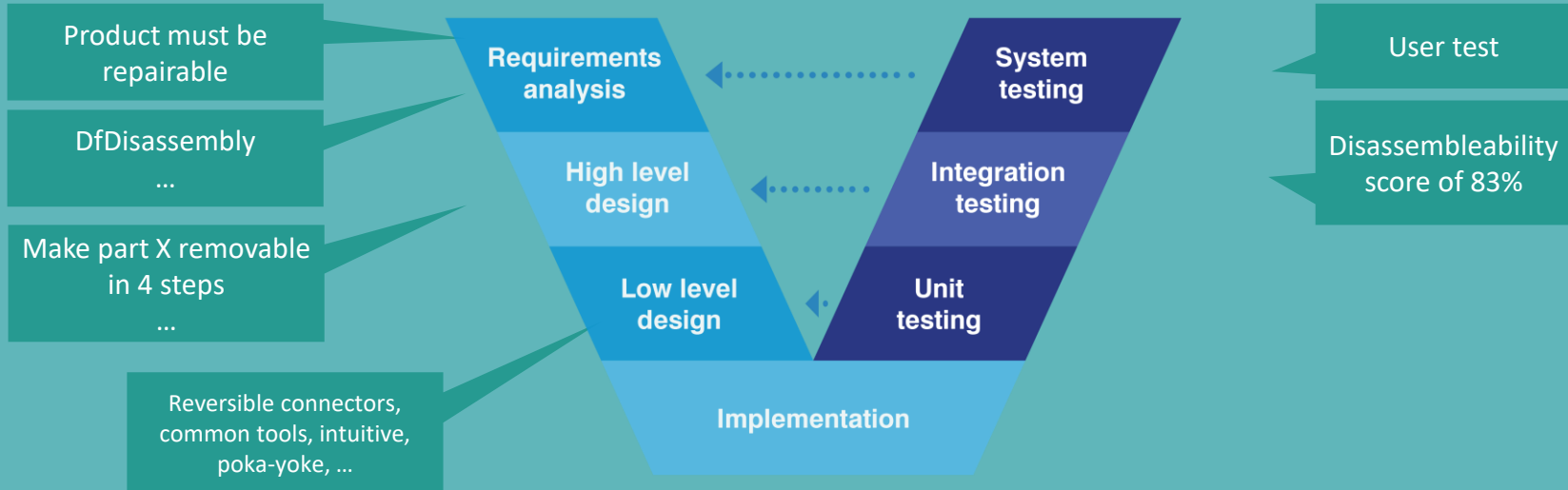
Process

Product must be repairable

DfDisassembly …

Make part X removable in 4 steps …

Reversible connectors, common tools, intuitive, poka-yoke, …

Requirements analysis

High level design

Low level design

Implementation

System testing

Integration testing

Unit testing

User test

Disassembleability score of 83%

Enormous improvements!

- Great steps have been made.
- CE integration has some links with for example VPC and supply chain

- But more is needed…

Enormous improvements!

- Great steps have been made.
- CE integration has some links with for example VPC and supply chain

- But more is needed…
  - All links in the chain need to be in place to make CE work
  - Lack of early integration strongly hinders implementation later on
  - Drastic changes such as other business models can only be implemented from the start
  - Platformisation cannot be done on single product level
 - …
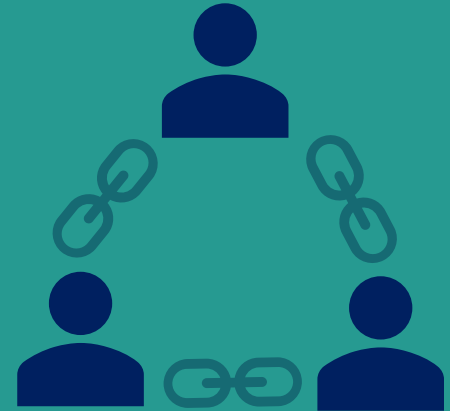
Sustainability needs a holistic approach

What is a holistic approach view?

What is a sustainable product?

- A sustainable product:
  - Fulfills the requirements of today and future
  - It preserves environment
  - Does social justice
  - Is economically feasible and remain feasible for a longer time

- According to the CE model from Ellen Macarthur foundation
  - Can be kept relevant with updates and repair
  - Can stay in service with a second life
  - Can give its parts when out of service for reuse
 - Its materials are easily recovered for recycling
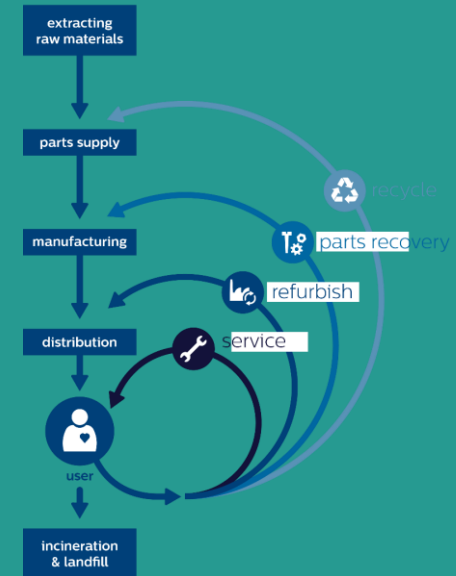
System Architecture: A balancing act between stakeholder concerns
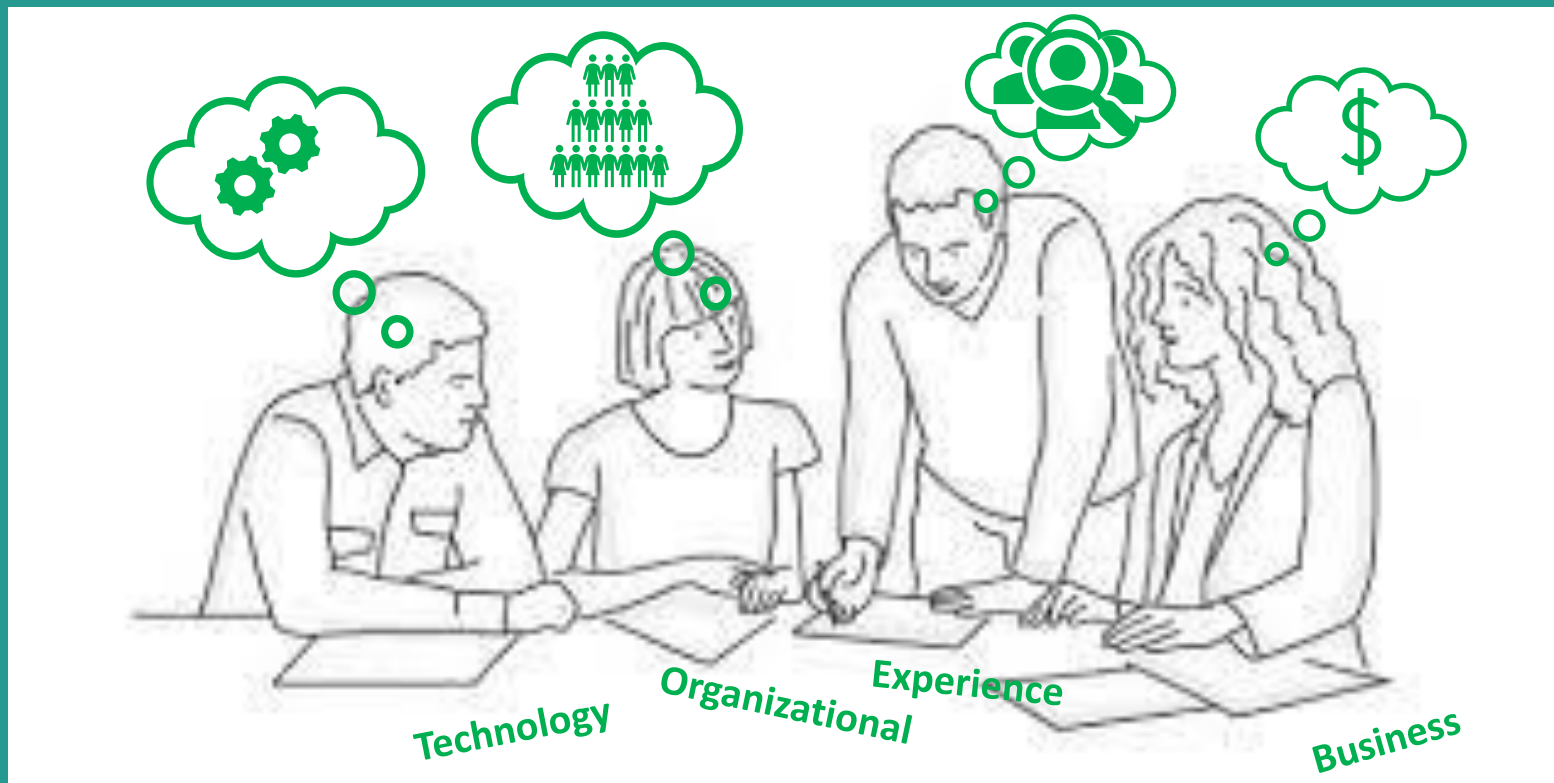
User Experience Architecture

Example Architecture drivers w.r.t user experience:

- *The architecture must provide capabilities to do partial upgrades of equipment HW and SW*
- *The architecture and material choices should enable cleaning of the equipment by creating easily reachable and cleanable surfaces that can be quickly cleaned many times*
- *The architecture must allow easy changes to the aesthetic elements so that the equipment remains attractive for users*
- *In addition to physical cleaning, the architecture must enable preservation of data security and privacy of the users of the equipment.*
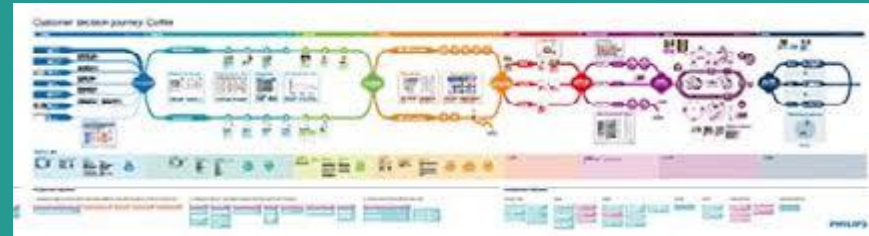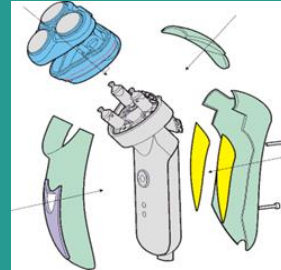
Eco system Architecture

Example Architecture drivers w.r.t user experience:

- *The supply chain architecture should ensure availability of parts for repairing equipment promptly*
- *A reverse supply chain is enabled by the architecture with relevant partners*

Device/Technology architecture

Example Architecture drivers w.r.t Device/Technology:

- *The equipment architecture should make appropriately durable material choices in line with the business model*
- *The architecture of an equipment must be able to count the usage of an equipment and parts of the equipment that need servicing based on usage. The usage data should be communicated to the service personnel remotely*
- *The architecture of the equipment must enable easy extraction of parts for reuse.*

Organizational Architecture

**Example Architecture drivers w.r.t Organization:**

- *The architecture must provide capabilities to do partial upgrades of equipment HW and SW*
- *A reverse supply chain with partners needs to be set up that can take back products for CE goals*
- *Capabilities in the organization should be enabled to do diagnostics and evaluation of the returned products*
- *Organization for prompt delivery of parts for repair*

Data Architecture

**Example Architecture drivers w.r.t Data:**

- *The architecture should identify the data items that indicate usage, extract, and report these data to allow a business to charge the customer for the supplied services*
- *The architecture must be able to measure system variables that can predict an imminent failure. The granularity of the equipment data should be chosen in such a manner that the relevant equipment or part for failure prediction can be identified*
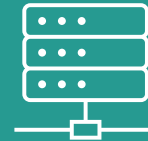
Sustainability affects a product design but also the infrastructure, organization, customer experience and Eco systems

Discussion points

Brown-Field

Innovation Green-Field
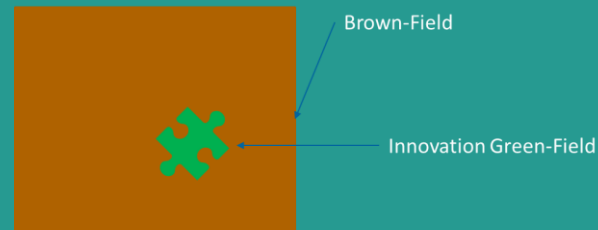
We are mostly in a Brown Field situation

Sustainability is not a bolt on -> refactoring the architecture:

- Where to start and how to transition the architecture into a sustainable/CE architecture?
  - How to evolve architecture?
  - Can we take a phased approach?