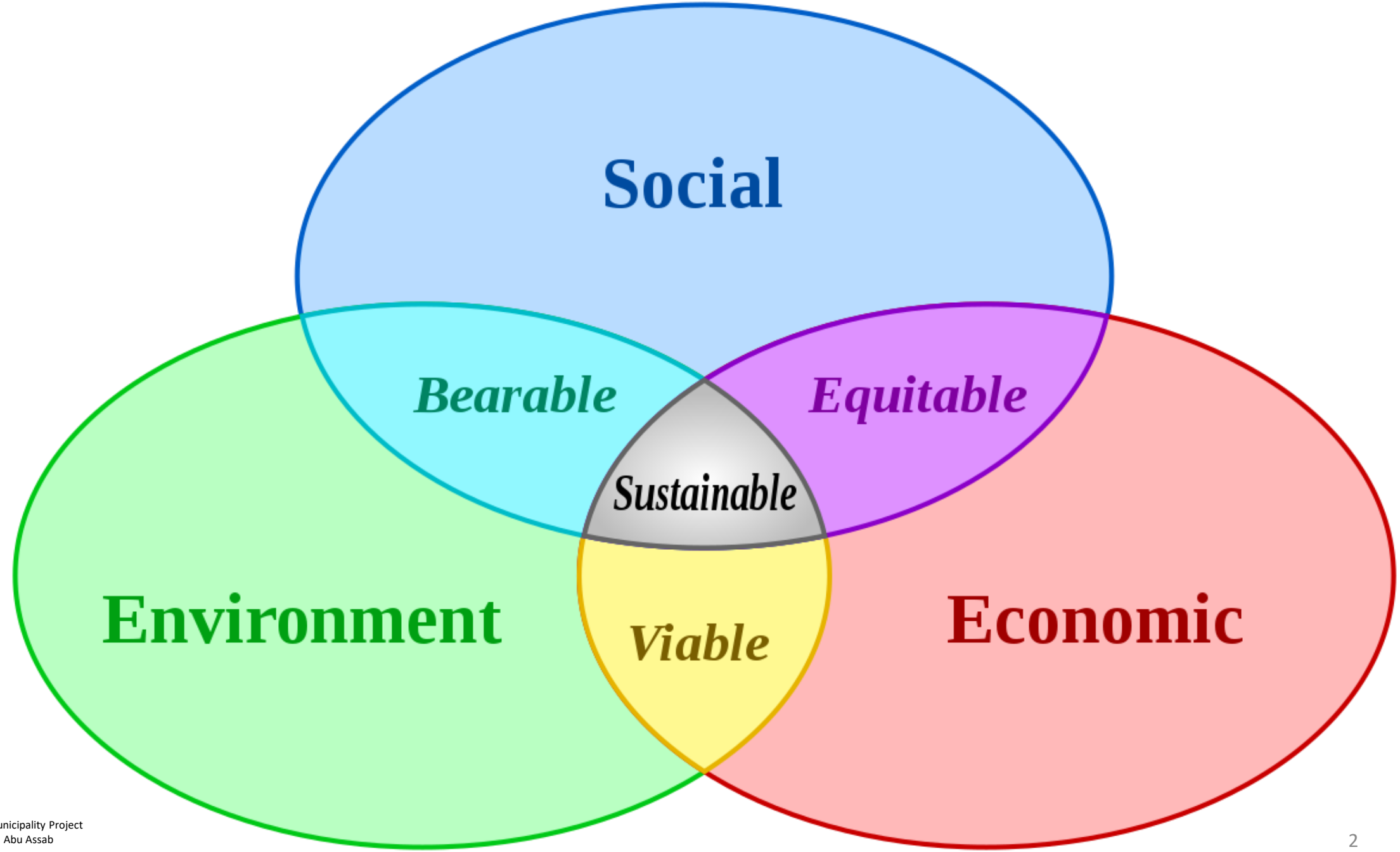
Sustainability


Social
Bearable
Equitable
Sustainable
Environment
Viable
Economic


SUSTAINABLE DEVELOPMENT GOALS
1 NO POVERTY
2 ZERO HUNGER
3 GOOD HEALTH AND WELL-BEING
4 QUALITY EDUCATION
5 GENDER EQUALITY
6 CLEAN WATER AND SANITATION
7 AFFORDABLE AND CLEAN ENERGY
8 DECENT WORK AND ECONOMIC GROWTH
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE
10 REDUCED INEQUALITIES
11 SUSTAINABLE CITIES AND COMMUNITIES
12 RESPONSIBLE CONSUMPTION AND PRODUCTION
13 CLIMATE ACTION
14 LIFE BELOW WATER
15 LIFE ON LAND
16 PEACE, JUSTICE AND STRONG INSTITUTIONS
17 PARTNERSHIPS FOR THE GOALS
SUSTAINABLE DEVELOPMENT GOALS

Major Challenges to Sustainability

	Pollution	Depletion	Poverty
Developed economies	–greenhouse gases –use of toxic materials –contaminated sites	–scarcity of materials –insufficient reuse and recycling	–urban and minority unemployment
Emerging economies	–industrial emissions –contaminated water –lack of sewage treatment	–overexploitation of renewable resources –overuse of water for irrigation	–migration to cities –lack of skilled workers –income inequality
Survival economies	–dung and wood burning –lack of sanitation –ecosystem destruction due to development	–deforestation –overgrazing –soil loss	–population growth –low status of women –dislocation

Design for Environment:
Environmental Sustainability through Better Product and Process Design

We start with a Video

- Wildfires, floods, and extreme weather

https://www.youtube.com/watch?v=pf4aOlE_3bc

- Fires in Turkey

https://www.youtube.com/watch?v=4SQNPsqwL3w

Introduction to DFE

essentially the world's got two environmental problems. We've got an **energy problem** and we've got a **materials problem**

Energy Problem

- The energy problem is a big deal
- global warming is created by the burning of fossil fuels primarily
- and the to solve that of course it is by reducing the amount of fossil fuel we use, eventually to eliminate it.
- From a design perspective, we have to design products and services to consume less energy and use cleaner energy.

Material Problem

- Not quite clear
- So the problem is digging up materials out of the earth,
- creating products with them,
- using those materials and then
- depositing them back onto the earth in a way that is polluting the world.
- Actually this is destroying the productivity of the earth;
- it's making it harder to live.
- And most of the waste that we create is not accessible to use in new products in the future.

We have to change the way we do things

DFE

- Design For Environment or DFE
- sometimes called green design or eco design

Essentially it's a method to minimize or eliminate the environmental impacts of a product over its life cycle

DFE Decisions

- life cycle thinking is the key
- the idea is to maintain product quality or/ and improve it and
- to have no negative cost impacts or possibly save money
- decisions would improve or maintain quality, improve or maintain **good DFE** costs, and at the same time reduce environmental impact.
- **bad DFE** decisions would hurt product quality while it improves the environmental impact.
- how do we get to making good DFE decisions?

What do you think?

- Identify a product or service that is more environmentally friendly than previous alternatives.

Examples

Dunlop Recycled Wellington Boots

Source: www.biothinking.com

Dunlop Wellington boots are made from polyurethane, PVC, and rubber.

Dunlop developed a line of recycled boots.

Dunlop takes back used Wellingtons from customers. Old boots are re-ground and re-manufactured into new boots.

This helps to reduce production of new PVC and keeps it out of the waste stream.

Downside: it takes energy to recycle those materials

Freitag Bags

Freitag reuses
- truck tarps
- inner tubes
- seat belts

Downside: how much transportation, energy does it take, how much water, waste to run the process

www.freitag.ch

Stokke Tripp Trapp Chair

Peter Opsvik (for Stokke, 1972) designed the award-winning Tripp Trapp chair to grow with the child, increasing the effective lifetime of the chair.

www.stokke.com

STOKKE


FREITAG

Environmental Impacts

Global Warming

www.buildbabybuild.com

Resource depletion

www.flickr.com Ben Rad

Solid waste

www.wonkroom.thinkprogress.org

Water pollution

www.co.rockingham.nc.us

Air pollution

commons.wikimedia.org

Land degradation

www.adb.org

Design for Environment (DFE)

Design for Environment (DFE) is a method to minimize or eliminate environmental impacts of a product over its life cycle.

Effective DFE practice maintains or improves product quality and cost while reducing environmental impacts.

DFE expands the traditional manufacturer's focus on the production and distribution of its products to a closed-loop life cycle.

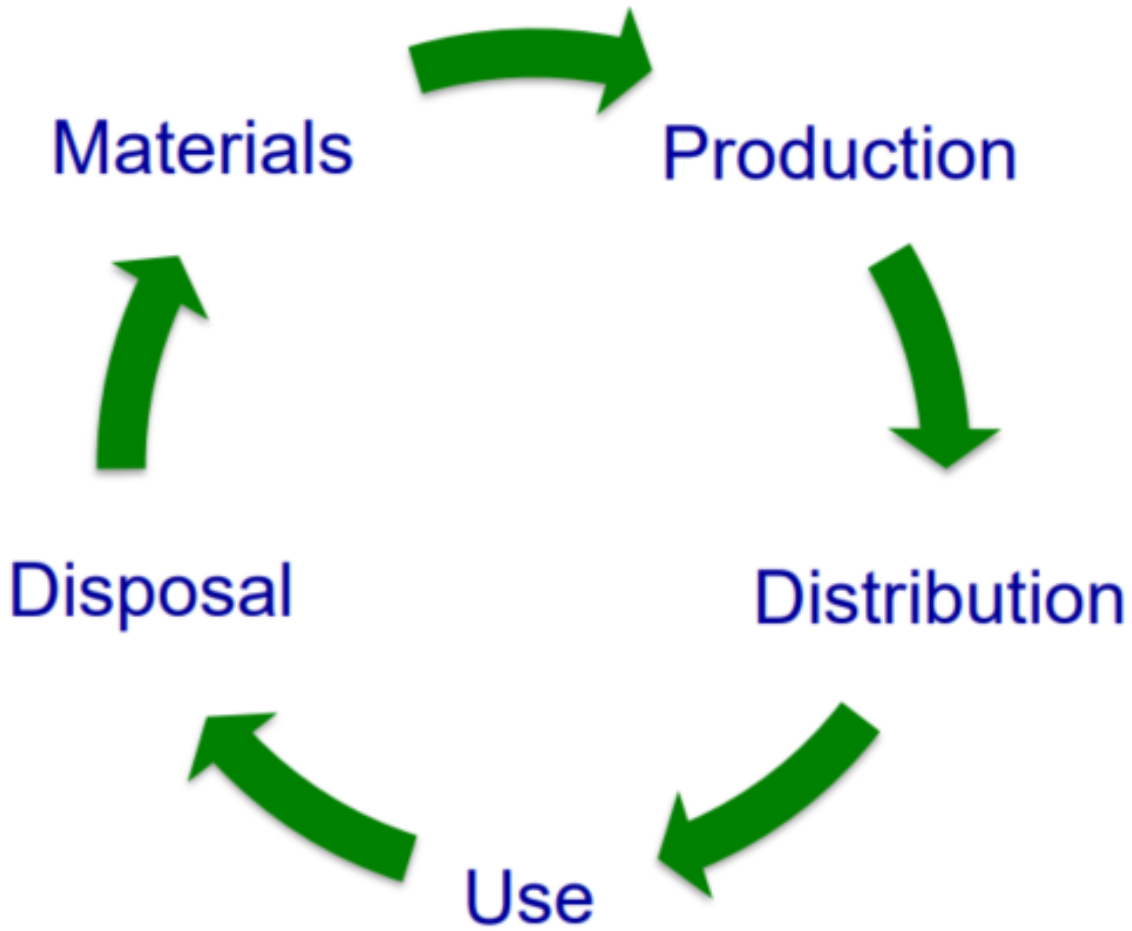
Product Development Process and DFE

the right way to do it is to embed DFE thinking into every stage of the process starting from the Concept Development Stage. For example, right up front, in the Planning stage, we would set goals, we set goals for the product, we can set environmental goals.

Product Development Process and DFE

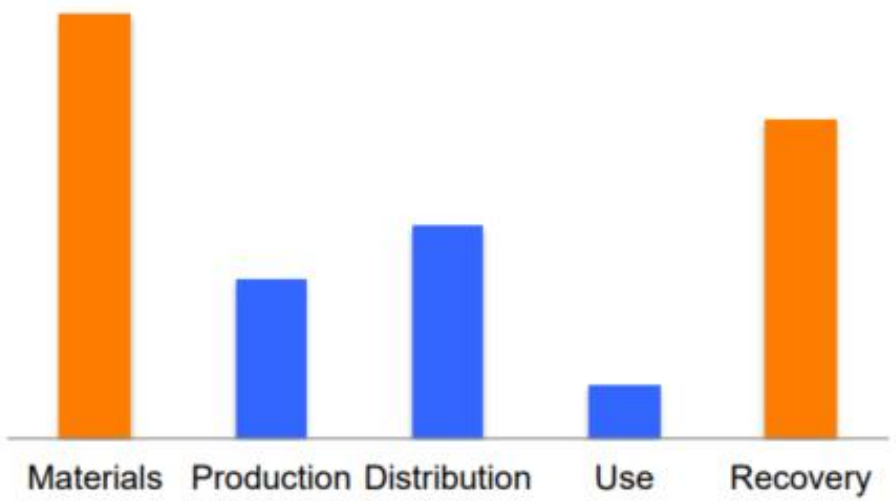
run the LCA, Life Cycle Assessment as early as possible

Product Life Cycle

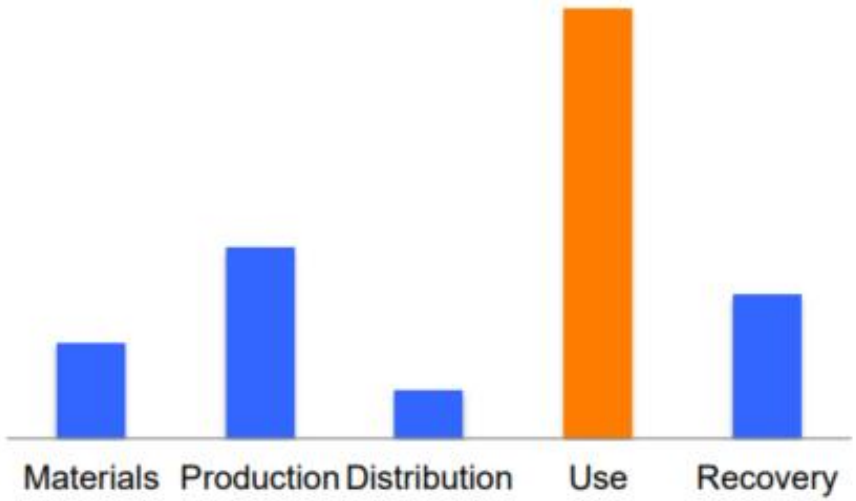


Life Cycle Impacts

Materials-Intensive Product Impact



Use-Intensive Product Impact



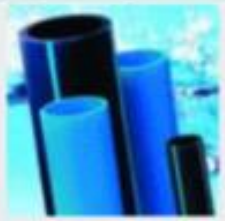
Life-Cycle Assessment (LCA)

- Quantifies environmental impact over product life cycle
- Steps in LCA analysis:
  1. Prepare proposed design options
  2. Identify life cycle, including recycling and disposal
  3. Identify all materials and energy sources used
  4. Identify outputs and waste streams
  5. Quantify impacts of each material, energy, waste
  6. Aggregate impact into categories for comparison
- Requires specialized LCA software and training
- Commercial LCA software growing in capability
  - SimaPro, GaBi, OpenLCA, Sustainable Minds, …

Sustainable Minds LCA Software

	2008 ToastMaster Reference	ToastMaster - disassembly
		
		61% impact reduction
Impacts per functional unit	**13** Okala mPts Per 1 Hour of Use	**5.2** Okala mPts Per 1 Hour of Use
Total amount of service delivered Impacts of total service delivered Assessment level	125 x 1 Hour of Use $1.7x10^{3}$ Estimate	125 x 1 Hour of Use 650 Estimate
Greatest impacts		
SBOM input Impact category Life cycle phase	steel, municipal incin. Ecotoxicity End of life	Electricity, 120 V, US Global Warming Manufacturing
Total impacts by impact category		

Impact category	%	Impact category	%
Ecological damage		**Ecological damage**	
Acidification	0.579	Acidification	1.48
Ecotoxicity	33.6	Ecotoxicity	14.5
Global Warming	25.3	Global Warming	56.0
Ozone Depletion	$1.02x10^{-4}$	Ozone Depletion	$2.58x10^{-4}$
Water Eutrophication	0.00512	Water Eutrophication	0.00718
Resource depletion		**Resource depletion**	
Fossil Fuel	0.00208	Fossil Fuel	0.00429
Human health damage		**Human health damage**	
Human Respiratory	0.0307	Human Respiratory	0.0772
Human Carcinogens	13.3	Human Carcinogens	18.2
Human Toxicity	27.1	Human Toxicity	9.78
Smog	0.0137	Smog	0.0346

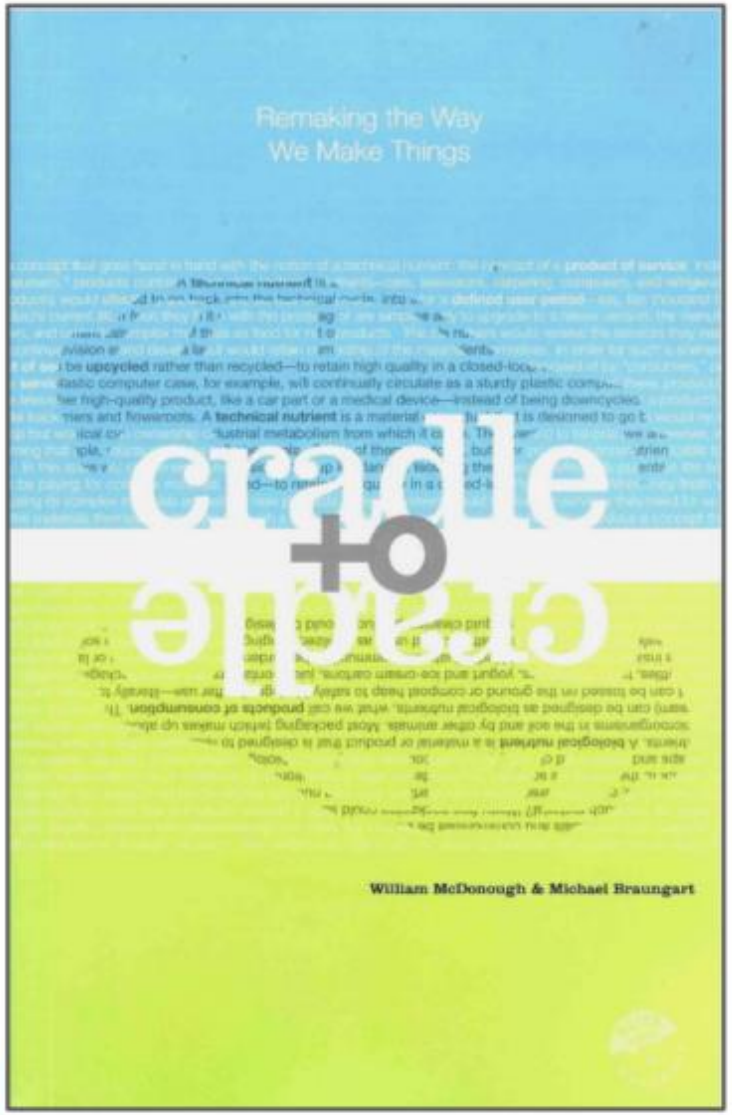
	Housing Only - 100% Virgin HDPE	Housing Only - 100% Recycled PET
		
		62% performance improvement
Impacts per functional unit	**0.29** mPts per 2 years of use	**0.11** mPts per 2 years of use
Total amount of service delivered Impacts of total service delivered Assessment level	1 x 2 years of use 0.29 mPts Estimate	1 x 2 years of use 0.11 mPts Estimate
Greatest impacts		
SBOM input Impact category Life cycle stage	Stretch blow molding Ecotoxicity Manufacturing	Injection molding Ecotoxicity Manufacturing
Total impacts by impact category		

Cradle to Cradle

Cradle to Cradle (C2C) is a DFE method emphasizing renewable resources and sustainable life cycles.

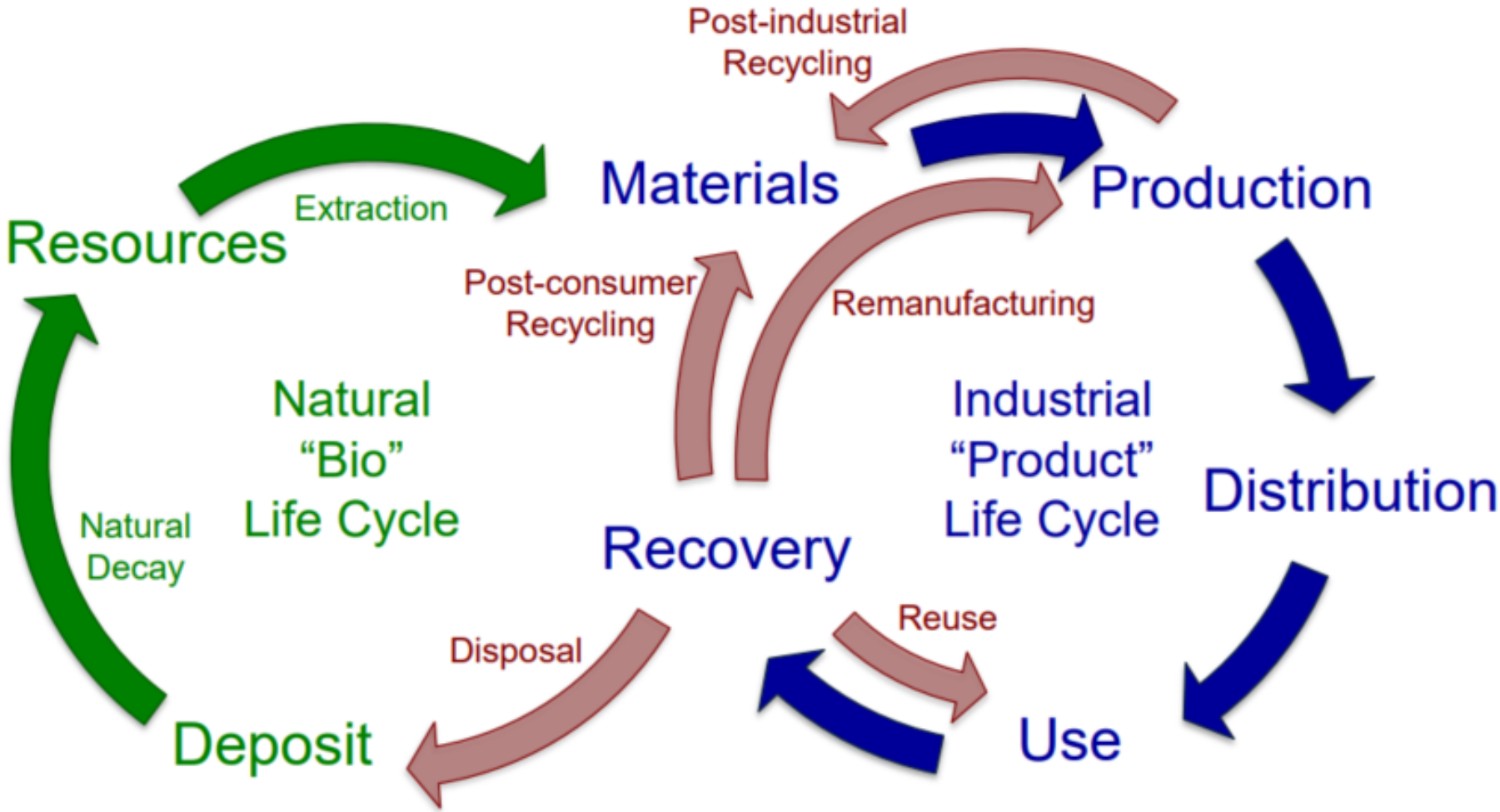
William McDonough and Michael Braungart, *Cradle to Cradle: Remaking the Way We Make Things*, 2002.

McDonough Braungart Design Chemistry (MBDC) works with companies to select the safest materials for product design.

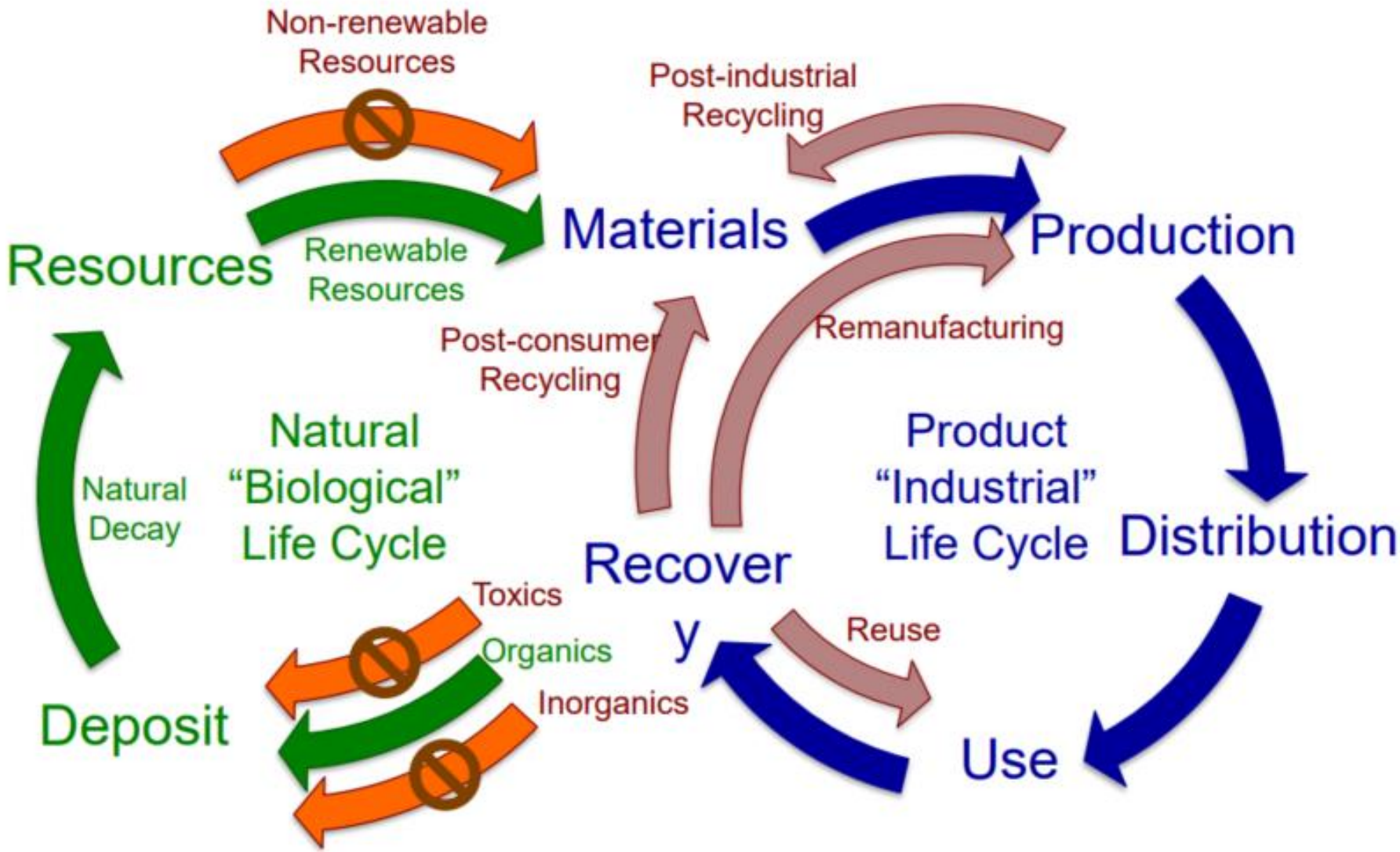


CERTIFIED CM
cradle to cradle

Two Life Cycles



Two Life Cycles

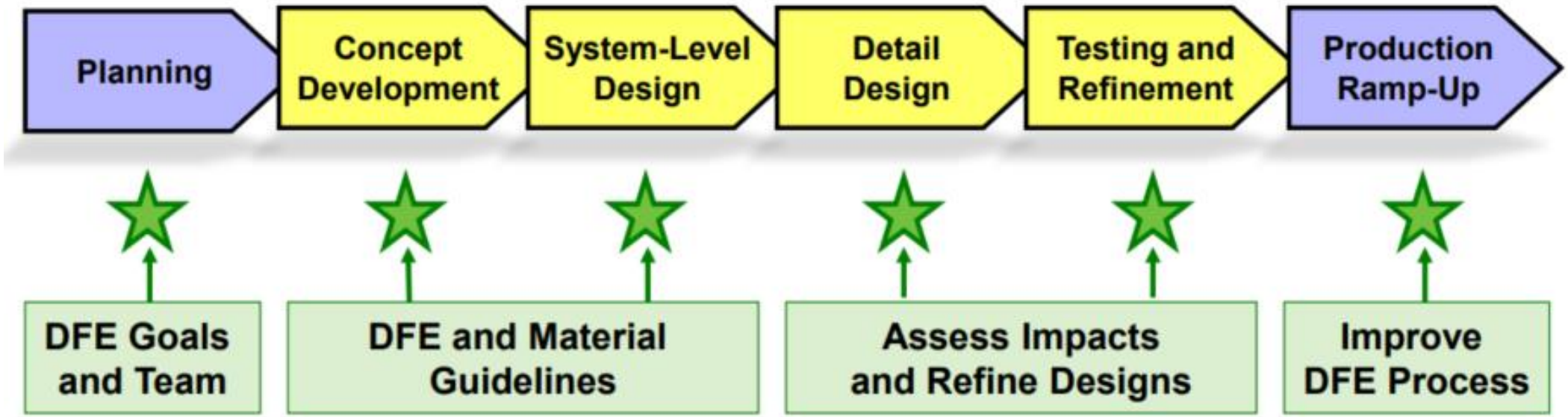


Think about it!

- List at least 10 types of environmental impacts over the life cycle of your personal computer or mobile phone.

- Below are environmental impacts over the life of my personal computer:
- (1) natural resource depletion
- (2) land degradation due to mining,
- (3) emissions and waste generation from mining,
- (4) Reduced biodiversity due to deforestation,
- (5) air pollution from factory emissions,
- (6) water pollution from factory discharge,
- (7) waste generation during production,
- (8) air pollution due to transportation emissions,
- (9) waste generation from packaging,
- (10) electricity consumed during operation,
- (11) heat generated during operation requires extra A/C in buildings,
- (12) maintenance and cleaning materials,
- (13) metals in landfill could leak toxins to water supply,
- (14) landfill leads to land degradation,
- (15) waste generation during recovery process
- (16) incineration generates air pollution and toxic ash.

Product Development Process



DFE can be integrated into the standard product development process.

DFE and Material Guidelines

Example DFE Guidelines

- Do not combine materials incompatible in recycling
- Label all component materials for recycling
- Enable easy disassembly into separate material recycling streams
- Use no surface treatments
- Eliminate packaging
- Reduce weight and size for shipping

Example Material Guidelines

- Use recycled and recyclable industrial materials
- Use natural materials which can be returned to biological decay cycles
- Use processes which do not release toxic materials
- Capture and reuse all hazardous materials

Herman Miller

Aeron, 1994

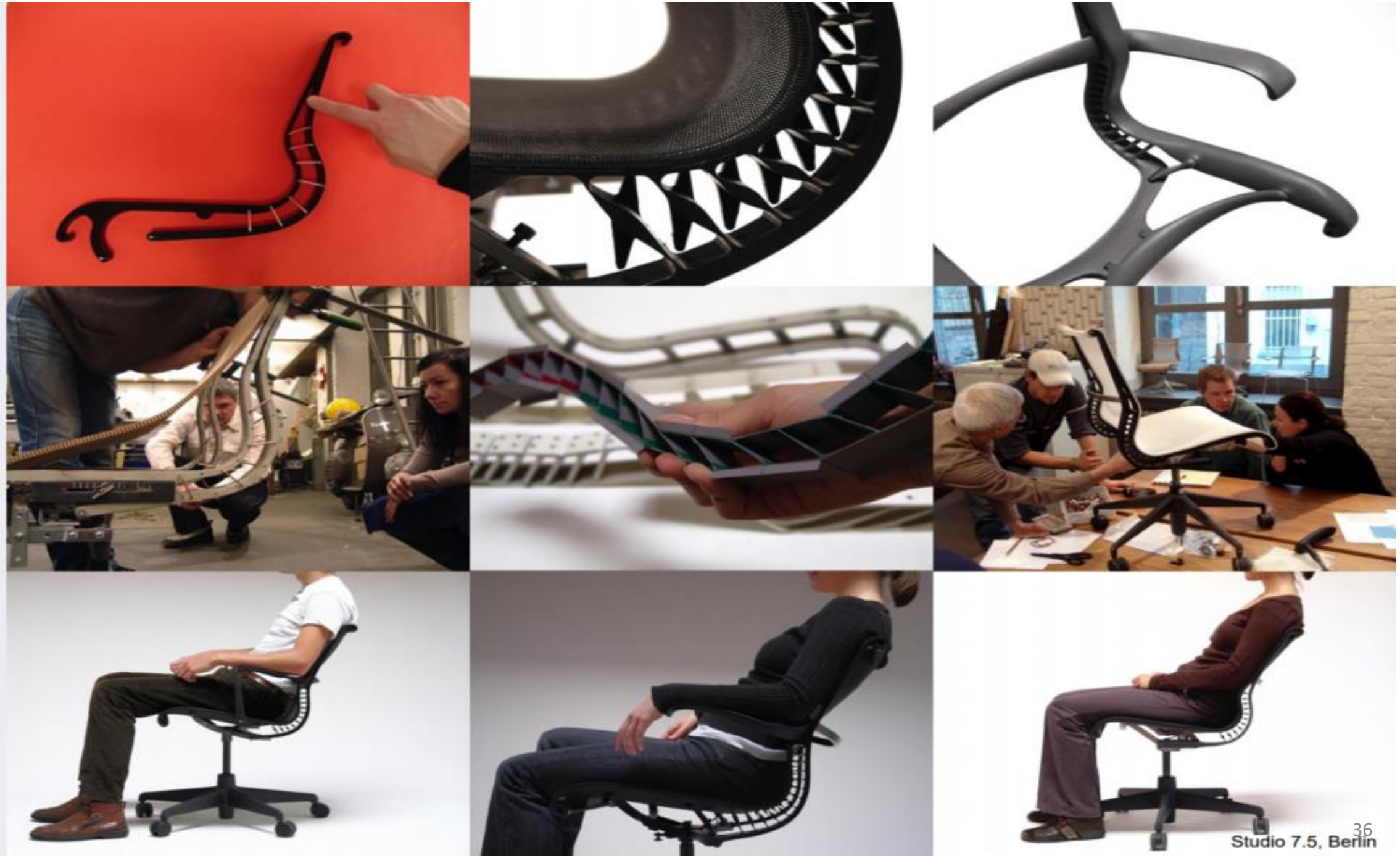
Mirra, 2004

Setu, 2009

Herman Miller's Environmental Goals

Perfect Vision 2020

- *Zero* landfill
- *Zero* hazardous waste generation
- *Zero* air emissions (VOC)
- *Zero* process water use
- *100%* green electrical energy use
- *100%* of sales from DfE products
- Company buildings constructed to a *minimum* LEED Silver certification


Studio 7.5, Berlin

Herman Miller
Setu Multipurpose Chair

- Environmentally friendly and non-toxic materials
  - 41% aluminum, 41% polypropylene, 18% steel, by weight
- Recycled materials
  - 44% by weight - 23% post-consumer, 21% post-industrial
- Less material content
  - 20 lbs lighter than most task chairs
- Easy to disassemble
  - 86% easily separable materials
- Recyclable
  - 92% by weight
- Production line uses 100% green power
- No air or water emissions released in production
- Returnable and recyclable packaging

Source: Herman Miller, Inc.

Herman Miller
DFE Assessment Method

Material Chemistry (33.3%)

Safest	Low Hazard	Uncertain	High Hazard

Recycled Content (8.4%)

Post-consumer 	Post-industrial 	Virgin Material 

Disassembly (33.3%)

Separation 	Time (30 sec) 	Tools (common) 	Labeling 

Recyclability (25.0%)

Up-cycle 	Down-cycle 	Not feasible 

Ref: Rossi, Charon, Wing, and Ewell, "Incorporating Cradle-to-Cradle Design into Herman Miller Products", *Journal of Industrial Ecology*, 2006.

Four Simple DFE Rules

1. Design products and processes with **industrial materials that can be recycled continually** with no loss in performance, thereby creating new industrial materials.
2. Design products and processes with **natural materials that can be fully returned to the earth's natural cycles**, thereby creating new natural materials.
3. Design products and processes that **do not produce unnatural, toxic materials** that cannot be safely processed by either natural or industrial cycles.
4. Design products and processes with **clean, renewable sources of energy**, rather than fossil fuels.

Final Message on Green Design

- This is hard.
- This is important.
- This is our responsibility.
- This is a great opportunity…
  - for businesses and entrepreneurs
  - for scientists, engineers, and designers
  - for researchers

Videos

Video 1: Design for Environment: Steelcase

(1178) Designing for the environment – YouTube

Video 2: Life Cycle Assessment as part of Strategic Sustainability for Product Design

(1178) Life Cycle Assessment as part of Strategic Sustainability for Product Design – YouTube

Video 3: The Five Principles of Sustainability- Design and Sustainability

(1178) The Five Principles of Sustainability - Design and Sustainability (3/7) - YouTube

It is your Responsibility, Take action!

Thank You :)