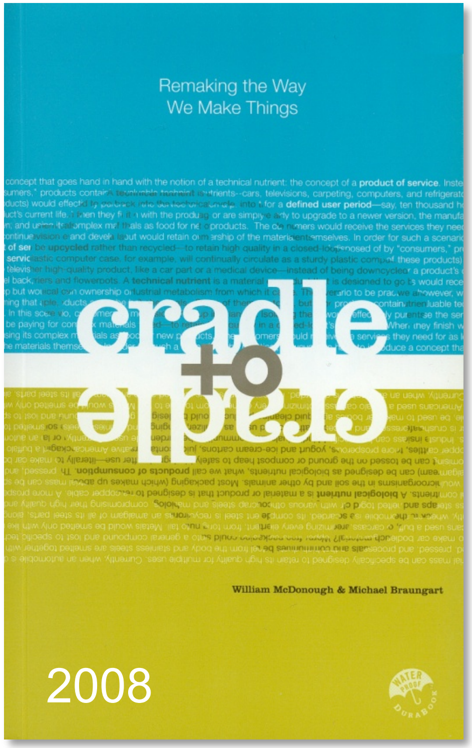
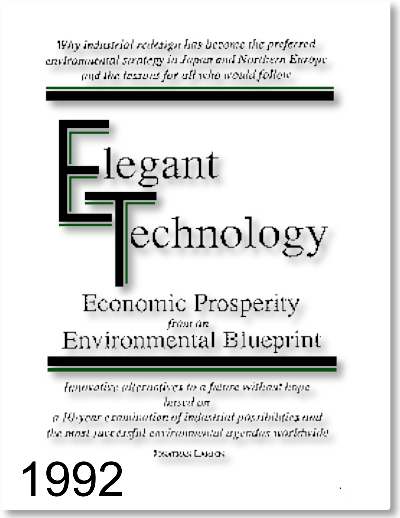
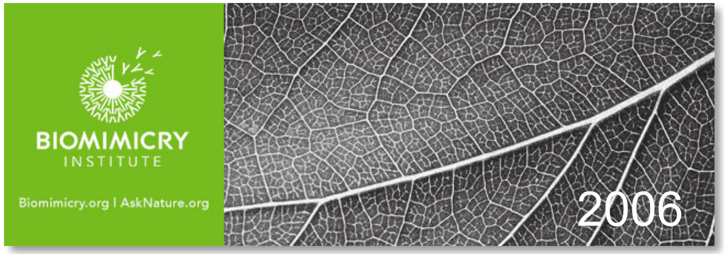
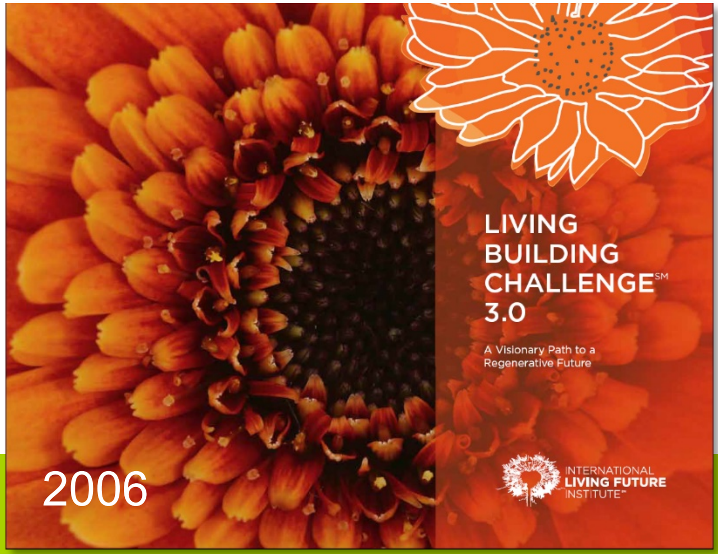
Philosophies of Sustainable Design









“The world will not evolve past its current state of crisis by using the same thinking that created the situation.”

– Albert Einstein

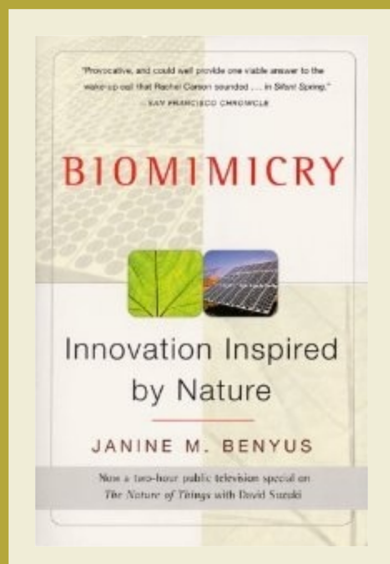
What is Biomimicry?

A design discipline that seeks sustainable solutions by emulating nature's time-tested patterns and strategies.

Core Idea: Nature has already solved many of the problems we are grappling with: energy, food production, climate control, non-toxic chemistry, transportation, packaging, and more.

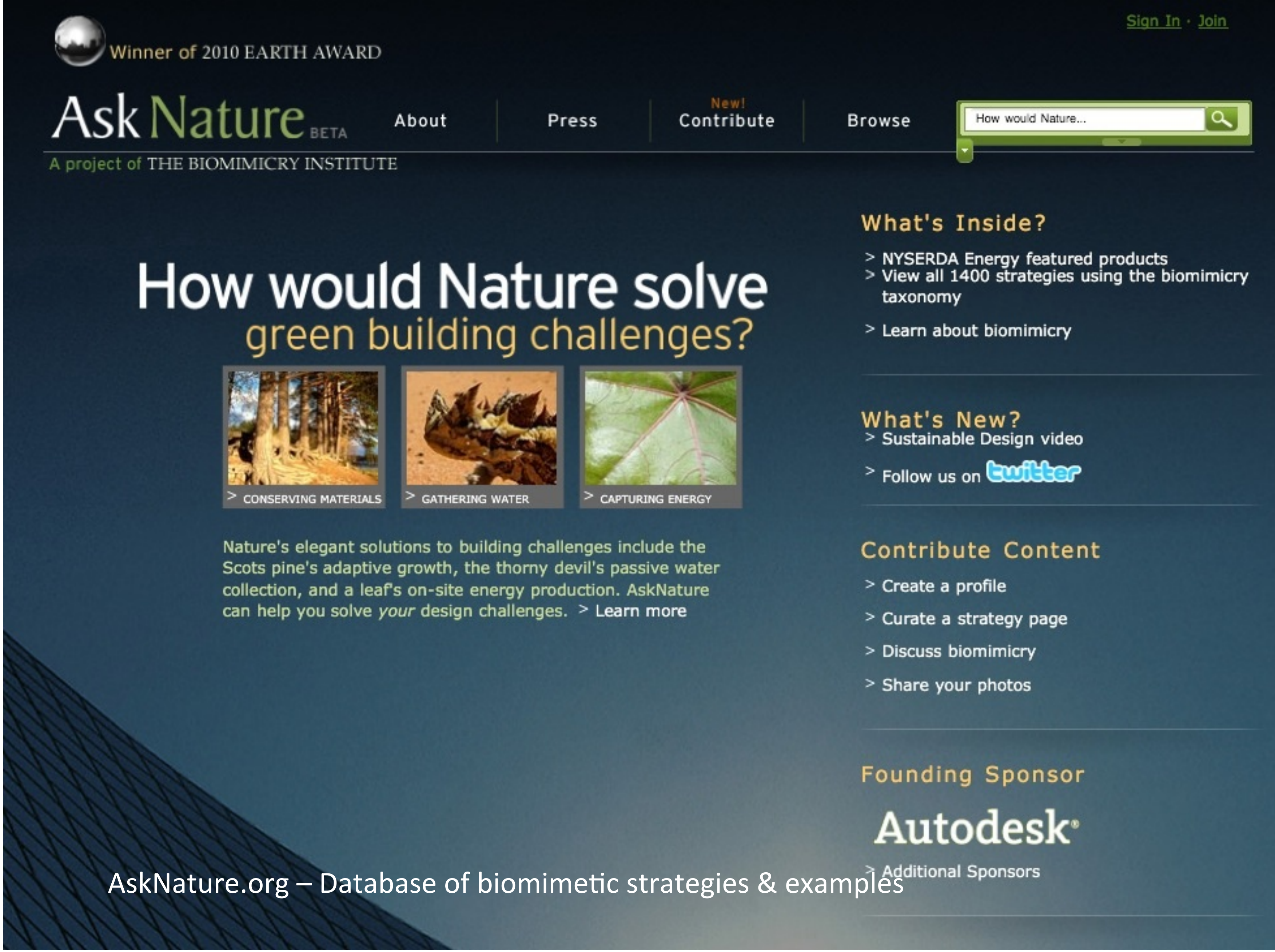
Brings disciplines together who historically don't interact (e.g., biologists, engineers, designers, economists)

"The biomimics are discovering what works in the natural world and more important, what lasts. After 3.8 billion years of research and development, failures are fossils, and what surrounds us is the secret to survival."



Janine Benyus
Biomimicry: Innovation Inspired by Nature

Several excellent videos of her talks on TED and YouTube web sites



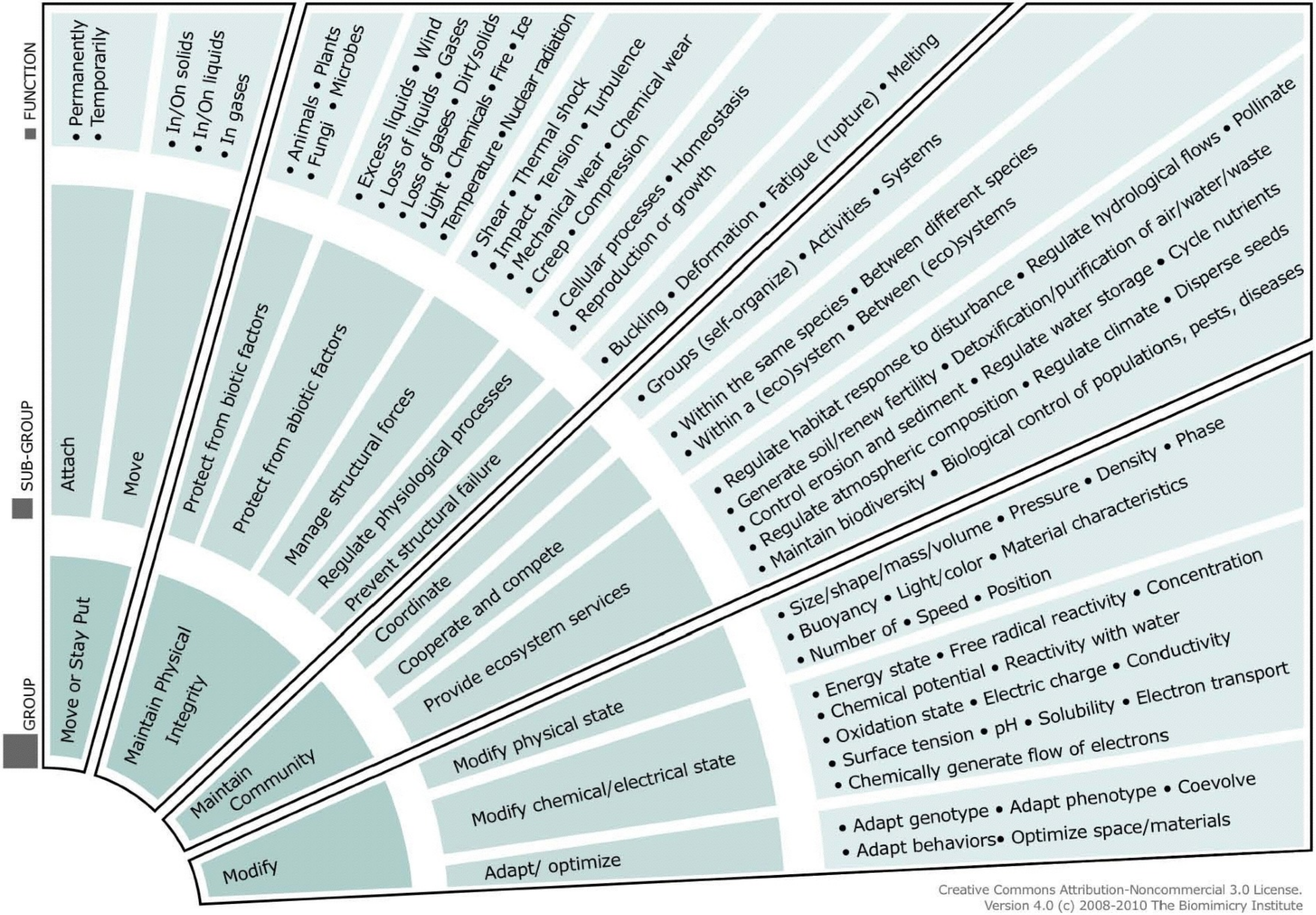
AskNature.org – Database of biomimetic strategies & examples

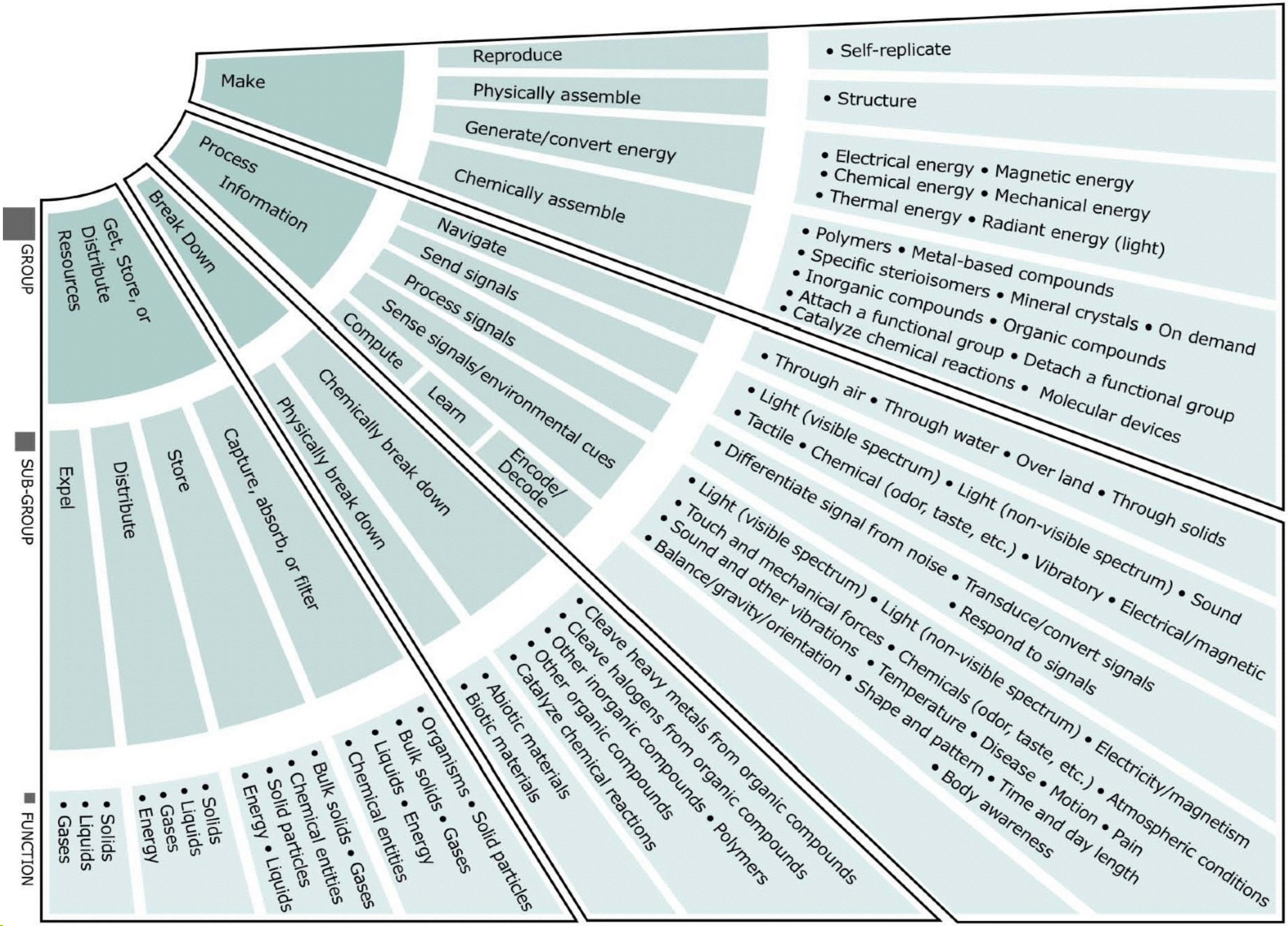
Biomimicry Taxonomy

What is the biomimicry taxonomy?

- Break down (87)
- Get, store, or distribute resources (412)
- Maintain community (306)
- Maintain physical integrity (923)
  - Manage structural forces (232)
    - Chemical wear (2)
    - Compression (55)
      - Bones self-heal: vertebrates
      - Hole structure strengthens bone: horse
      - Lightweighting: Scots pine
      - Fibers keep tall spikes upright: titan arum
      - Leaves given structural support: giant water-lily
      - Nest cells support heavy weights: bees and wasps
      - Structural composition provides strength in changing conditions: plants
      - Rod-like reinforcements provide strength: plants
      - Reinforced fibers provide strength: plants
      - Lignified parenchyma cells provide strength: plants
      - Sclereid cells prevent soft tissue collapse: plants
      - Collenchyma cells provide strength, flexibility: plants
      - Thickness stabilizes tall trees: baobob
      - Fluid protects eggs: birds
      - Intricate silica architecture survives forces: diatoms

Biomimicry Taxonomy




GROUP
SUB-GROUP
FUNCTION
Make
Reproduce
• Self-replicate
Physically assemble
• Structure
Generate/convert energy
• Electrical energy • Magnetic energy
• Chemical energy • Mechanical energy
• Thermal energy • Radiant energy (light)
Chemically assemble
• Polymers • Metal-based compounds
• Specific sterioisomers • Mineral crystals • On demand
• Inorganic compounds • Organic compounds
• Attach a functional group • Detach a functional group
• Catalyze chemical reactions • Molecular devices
Process Information
Navigate
• Through air • Through water • Over land • Through solids
Send signals
• Light (visible spectrum) • Light (non-visible spectrum) • Sound
Process signals
• Tactile • Chemical (odor, taste, etc.) • Vibratory • Electrical/magnetic
• Differentiate signal from noise • Transduce/convert signals
• Respond to signals
Sense signals/environmental cues
• Light (visible spectrum) • Light (non-visible spectrum) • Electricity/magnetism
• Touch and mechanical forces • Chemicals (odor, taste, etc.) • Atmospheric conditions
• Sound and other vibrations • Temperature • Disease • Motion • Pain
• Balance/gravity/orientation • Shape and pattern • Time and day length
• Body awareness
Compute
Learn
Encode/Decode
Break Down
Chemically break down
• Cleave heavy metals from organic compounds
• Cleave halogens from organic compounds
• Other inorganic compounds • Polymers
• Other organic compounds
• Catalyze chemical reactions
Physically break down
• Abiotic materials
• Biotic materials
Get, Store, or Distribute Resources
Capture, absorb, or filter
• Organisms • Solid particles
• Bulk solids • Gases
• Liquids • Energy
• Chemical entities
• Bulk solids • Gases
• Chemical entities
• Chemical particles
• Solid particles
• Energy • Liquids
Store
• Solids
• Liquids
• Gases
• Energy
Distribute
• Solids
• Liquids
• Gases
Expel

Biomimicry Taxonomy

1. Find the verb:

   Move away from any predetermined ideas of what you want to design, and *think more about what you want your design to do*. Try to pull out single functional words in the form of verbs. The questions you might pose through the Search or Browse options might be:

   How would Nature…

   Capture rainwater?
   Store water?

2. Try a different angle.

Some organisms live in areas that don't experience any rain, yet they still get all of the water they need. So other questions to pose might be:

How would Nature…

Capture water?
Capture fog?
Absorb water?
Manage humidity?
Move water?

3. Turn the question around.

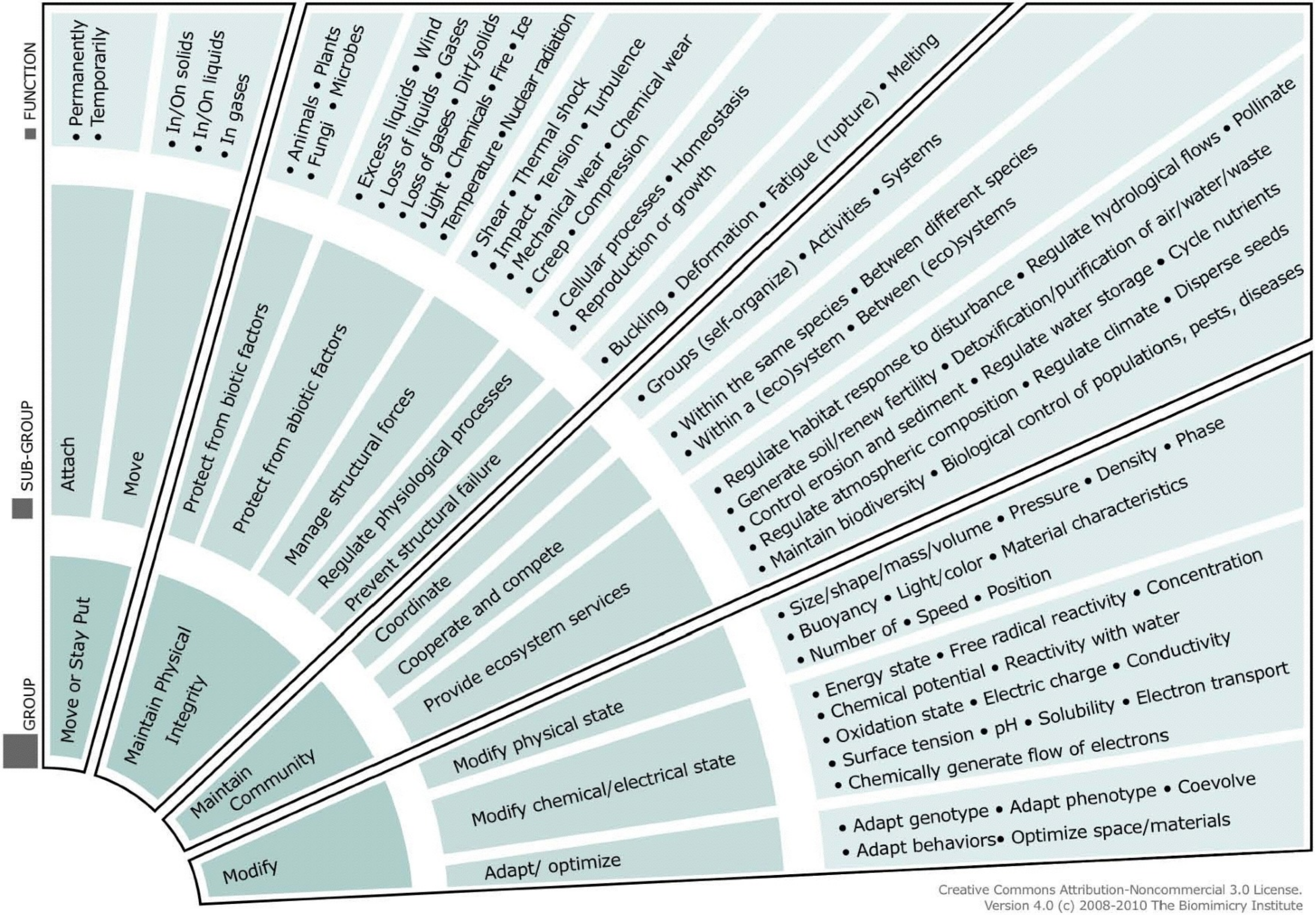
Instead of asking how Nature stores water, you might think about how Nature protects against excess water or keeps water out:

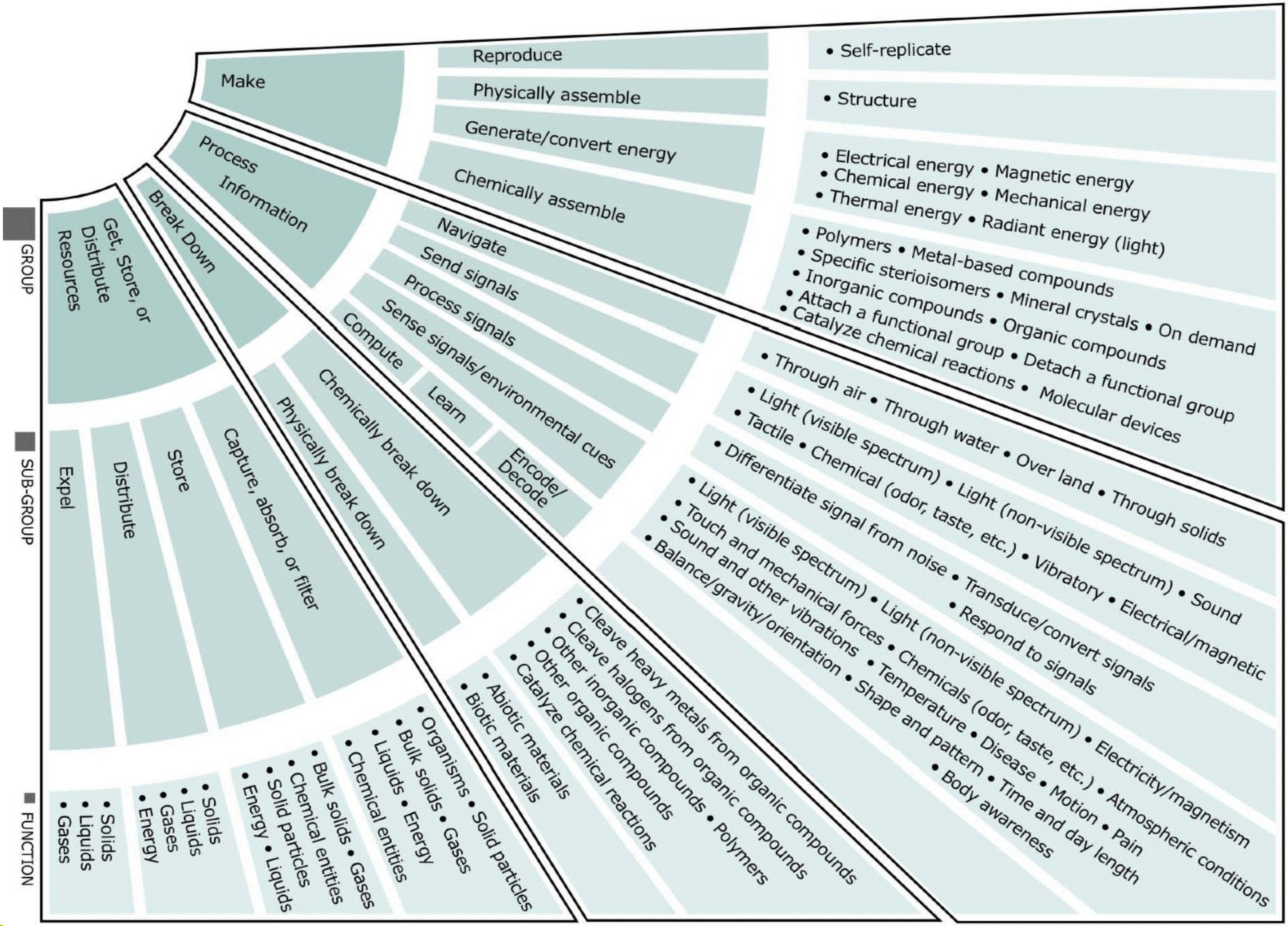
How would Nature…

Remove water?

Stay dry?

Biomimicry Taxonomy




GROUP
SUB-GROUP
FUNCTION
Make
Reproduce
• Self-replicate
Physically assemble
• Structure
Generate/convert energy
• Electrical energy • Magnetic energy
• Chemical energy • Mechanical energy
• Thermal energy • Radiant energy (light)
Chemically assemble
• Polymers • Metal-based compounds
• Specific sterioisomers • Mineral crystals • On demand
• Inorganic compounds • Organic compounds
• Attach a functional group • Detach a functional group
• Catalyze chemical reactions • Molecular devices
Process Information
Navigate
• Through air • Through water • Over land • Through solids
Send signals
• Light (visible spectrum) • Light (non-visible spectrum) • Sound
• Tactile • Chemical (odor, taste, etc.) • Vibratory • Electrical/magnetic
Process signals
• Differentiate signal from noise • Transduce/convert signals
• Respond to signals
Sense signals/environmental cues
• Light (visible spectrum) • Light (non-visible spectrum) • Electricity/magnetism
• Touch and mechanical forces • Chemicals (odor, taste, etc.) • Atmospheric conditions
• Sound and other vibrations • Temperature • Disease • Motion • Pain
• Balance/gravity/orientation • Shape and pattern • Time and day length
• Body awareness
Compute
Learn
Encode/ Decode
Break Down
Chemically break down
• Cleave heavy metals from organic compounds
• Cleave halogens from organic compounds
• Other inorganic compounds • Polymers
• Other organic compounds
• Catalyze chemical reactions
Physically break down
• Abiotic materials
• Biotic materials
Get, Store, or Distribute Resources
Capture, absorb, or filter
• Organisms • Solid particles
• Bulk solids • Gases
• Liquids • Energy
• Chemical entities
Store
• Bulk solids • Gases
• Chemical entities
• Solid particles • Liquids
• Energy
Distribute
• Solids
• Liquids
• Gases
• Energy
Expel
• Solids
• Liquids
• Gases

Leaves given structural support: giant water-lily

1 of 2 Underside of a giant water lily / Peter McKier.. / License BY-NC-ND

The leaves of the Amazon water lily gain structural support via girder-like support ribs.

Biomimicry Taxonomy

- Maintain physical integrity >
  - Manage structural forces >
    - Compression

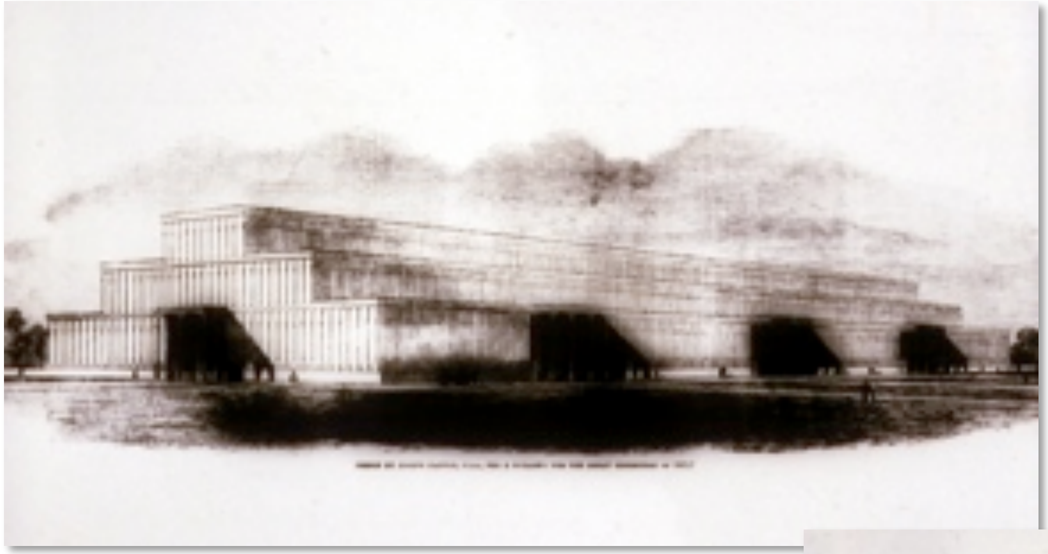
Biomimetic Application Ideas

Light-weight structurally strong panels for buildings or vehicles.

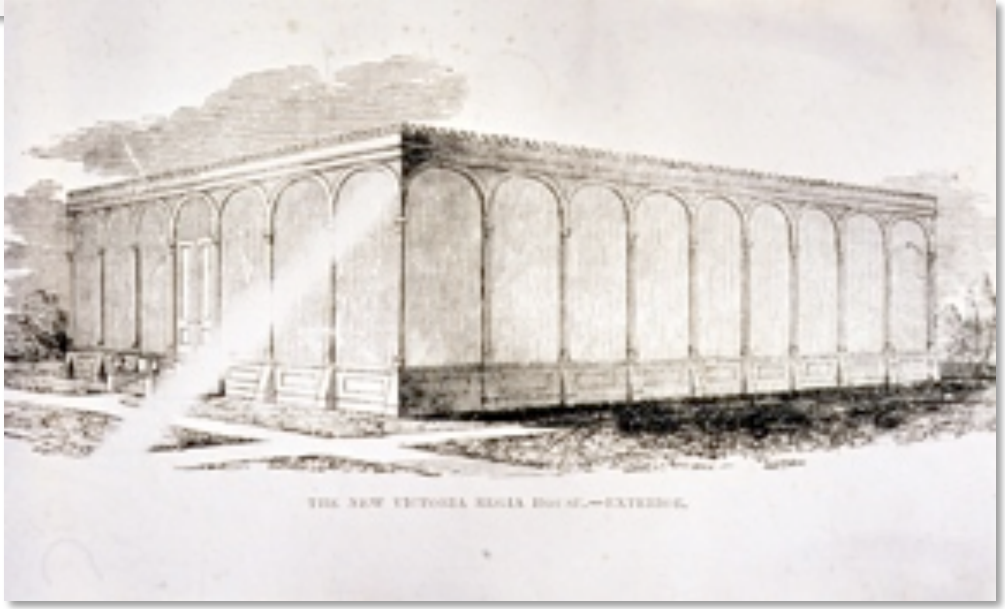
> Visit strategy page

SUMMARY [Collapse all sections]

"In still or slowly-moving waters there is one easy way to collect [light]: a plant can float its leaves upon the surface. No plant does this on a more spectacular scale or more aggressively than the giant



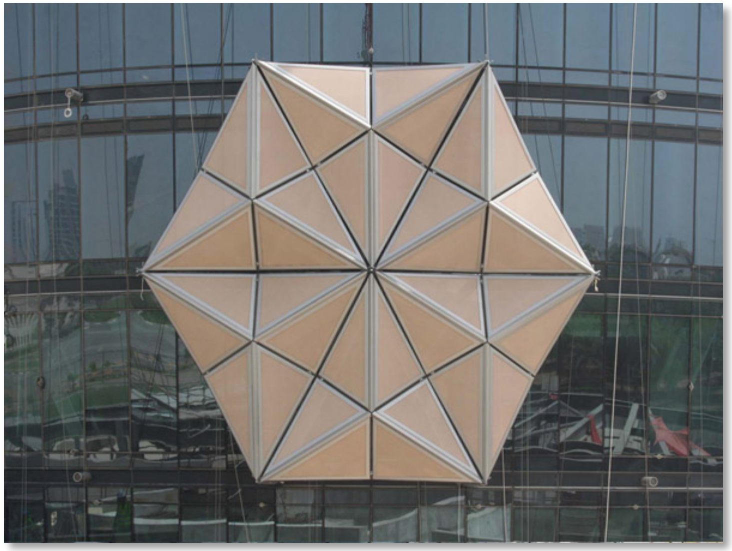
Paxton’s design for the Crystal Palace is a very early reflection of this sort of biomimicry type thinking.



Biomimicry in Architecture

Singapore Arts Center

Shading screen over glass roof whose angles are fine tuned to the solar path as inspired by polar bear fur.



Al Bahar Towers in Abu Dhabi, by Aedas – façade opens and closes as timed to the sun.

BIOMIMICRY
GUILD

THE INNOVATION CONSULTANCY FOR BIO-INSPIRED DESIGN

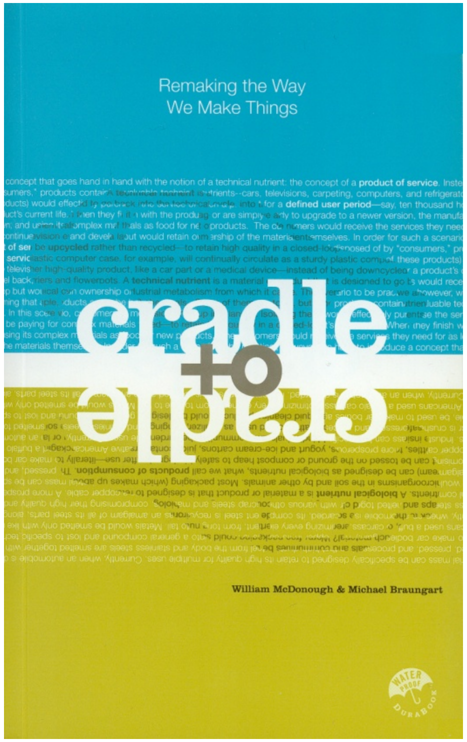
The Biomimicry Guild is the only innovation company in the world to use a deep knowledge of biological adaptations to help designers, engineers, architects, and business leaders solve design and engineering challenges sustainably.

ENTER THE SITE

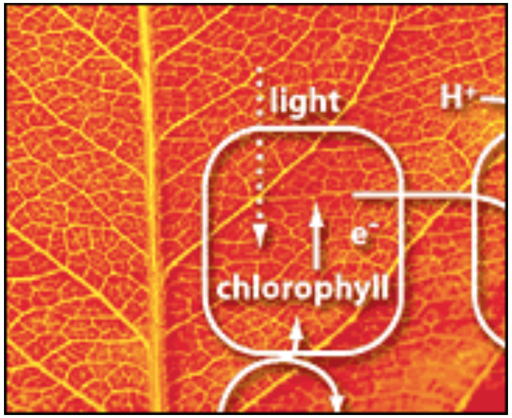
CRADLE TO CRADLE

remaking the way we make things

cradle 2 cradle



MBDC *(McDonough Braungart Design Chemistry)* is articulating and putting into practice a new design paradigm; what *Time* calls "a unified philosophy that—in demonstrable and practical ways—is changing the design of the world."



"Eco-effectiveness seeks to design industrial systems that emulate the healthy abundance of nature."

“A walking college lecture--he is also dean of the University of Virginia school of architecture--McDonough is a compendium of similar maxims, phrases and rules: "Honor commerce as the engine of change"; "respect diversity"; "build for abundance"; "eco-efficiency should be replaced by eco-effectiveness"; "design is the first signal of human intention"; "all sustainability, like politics, is local"; "I want to do architecture that is timeless and mindful.“

All this and much more come from a 48-year-old *innocent anarchist*; his language has the touch of the poet and of the bomb thrower; he looks like actor James Woods in a bow tie. He thinks abstractly, making it equally fascinating and difficult to talk to him, since he turns nearly every contribution one makes to the conversation into a refinement of his theories.” Time Magazine

William McDonough and Michael Braungart

"The growth/no-growth argument is specious," he said last week. "Growth is good. The question is, how do you want to grow?"

McDonough's guiding principle seems simple enough: the source of our environmental woes is waste. There is nothing wrong with cars, TV sets, and running shoes.

What's wrong is the waste—chemicals, heavy metals, CO_2—that's produced when we make them, use them, and, eventually, throw them away.

Eliminate that waste, and you eliminate the problem.

We don't necessarily need to make less stuff.

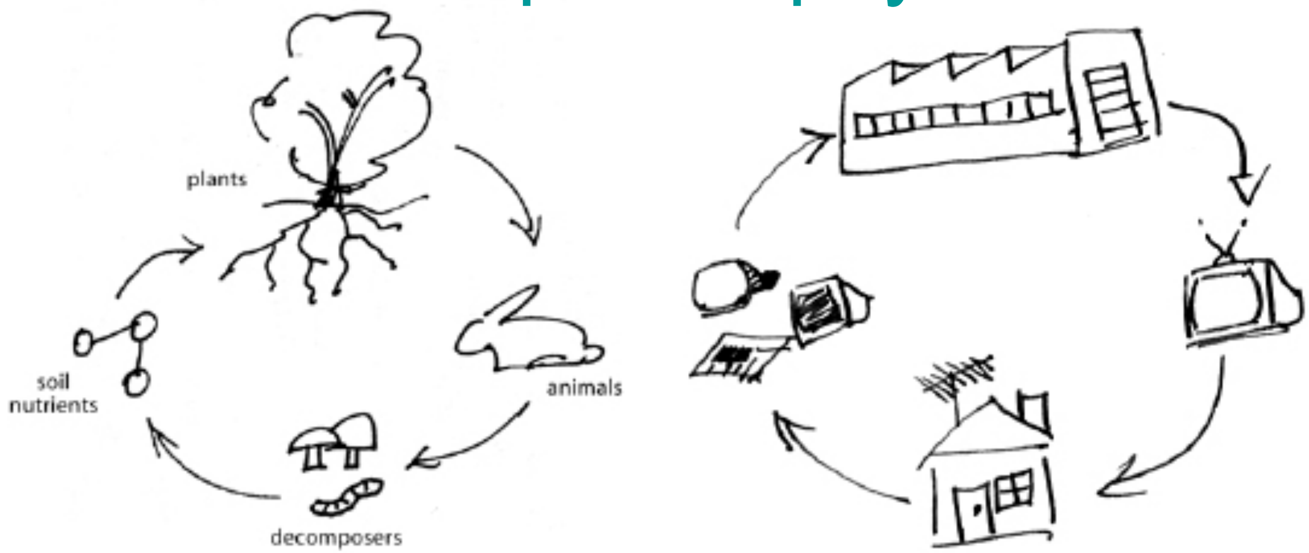
We only need to make stuff differently.

In McDonough's future, there would be only two kinds of products. The first would be made of natural substances—he calls them "biological nutrients"—and they'd be perfectly biodegradable. Had enough of those pants? Just toss them out the window, like an apple core.

The second would be made of "technical nutrients"—steel, plastics, polymers, silicon, glass—and would be endlessly reusable; old shoes would become new shoes, old cars would be turned into new cars.

Everything would be raw material for something else.

c2c philosophy



Cradle to Cradle Design™ is based on the living model for sustainability – nature. The flow and cycling of matter in nature does not lead to waste and pollution, but to a dynamic balance of growth and change within ecological systems. The fundamental elements of Cradle to Cradle Design™ are based on the principles that drive these systems in nature:

- Waste = Food
- Use current solar income
- Celebrate Diversity

biological nutrient vs technical nutrient

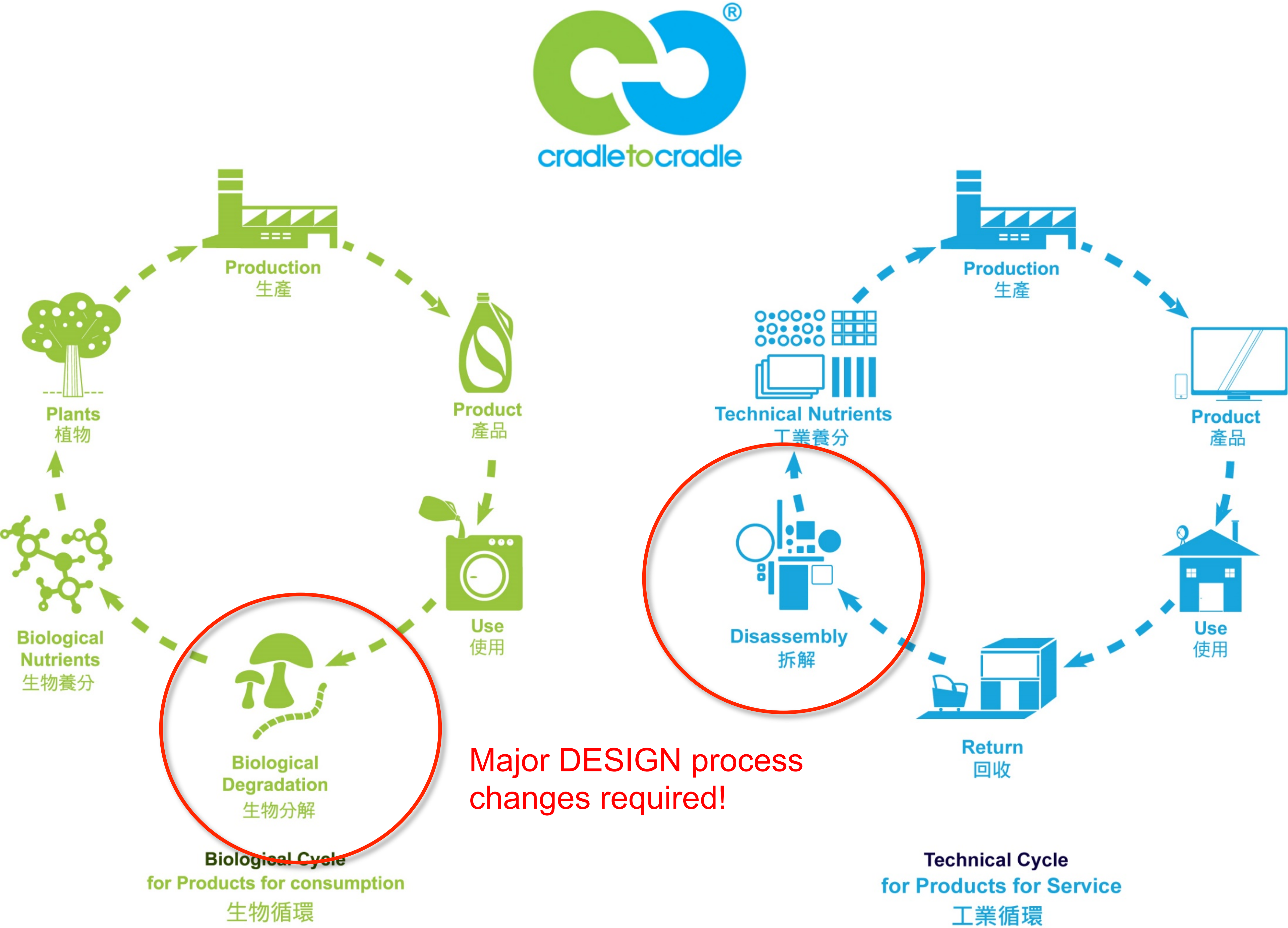
Utilizing *biological nutrient* and *technical nutrient* definition allows a company to virtually eliminate the concept of waste and recover value, rather than creating a future of solid waste liability and relinquishing material assets by simply delivering a physical product to a customer without a coherent relationship to the potential inherent in the product itself as a potential long term asset for the customer, nature, industry or the company itself. Cradle to Cradle Design™ turns contingent liabilities into assets.

BIOLOGICAL NUTRIENT

A *biodegradable material* posing no immediate or eventual hazard to living systems that can be used for human purposes and can safely return to the environment to feed environmental processes.

TECHNICAL NUTRIENT

A material that remains in a closed-loop system of manufacture, reuse, and recovery (the technical metabolism), maintaining its value through many product life cycles.


cradletocradle
Production
生產
Product
產品
Use
使用
Biological Degradation
生物分解
Biological Nutrients
生物養分
Plants
植物
Biological Cycle
for Products for consumption
生物循環
Production
生產
Product
產品
Use
使用
Return
回收
Disassembly
拆解
Technical Nutrients
工業養分
Technical Cycle
for Products for Service
工業循環
Major DESIGN process changes required!

waste equals food

Philosophical Paradigm Shift

Waste equals food:

- Design materials and products that are **food** for other systems. This means designing materials and products to be used over and over in either technical or biological systems.
- Design materials and products that are **safe**. Design materials and products whose life cycle leaves a beneficial legacy for human or ecological health.
- Create and participate in systems to **collect and recover** the value of these materials and products.

wool, for example…

Utilizing biological and technical nutrients allows a company to eliminate the concept of waste. Recapturing materials encourages a manufacturer to integrate higher quality materials and focus on the full product life cycle; materials are not fully relinquished to customers when products are sold if the materials and their value are recaptured following product use.

Product cycling among multiple life cycles also creates a mechanism for reconnecting with customers to market the next product generation and provides incentives for return sales.

compostable end product

compostable - yes

Biodegradable Store.com
Made from Nature...Returned to Nature

Vegware

Everything here is made from wheat, potato starch or corn, and can be composted. *It is not plastic…*

BUT if it is NOT composted, then a total WASTE of potential FOOD!

Biofuel: what are the global consequences??

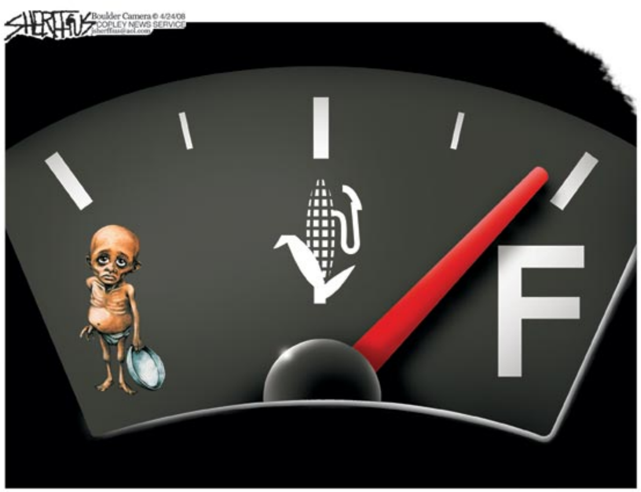
Biofuel is DIFFERENT! It is not composted and still contributes to CO_2 levels as you still BURN it.

When biofuels compete with food production, what happens?

Price of wheat goes up => bread and other basic food items increase in price

Price of corn goes up => processed food prices increase

Price of soybean goes up => beef becomes more expensive



use *current* solar income

Use current solar income:

- The quality of energy matters.
- Use renewable energy.
- But recognize that all renewable energy is not created equal (inferring issues in the manufacture of products like PV; and issues with some hydro generation sources)

celebrate diversity

Celebrate diversity:

- Water is vital for humans and all other organisms. Manage water use to maximize quality and promote healthy ecosystems while remaining respectful of the local impacts of water use.

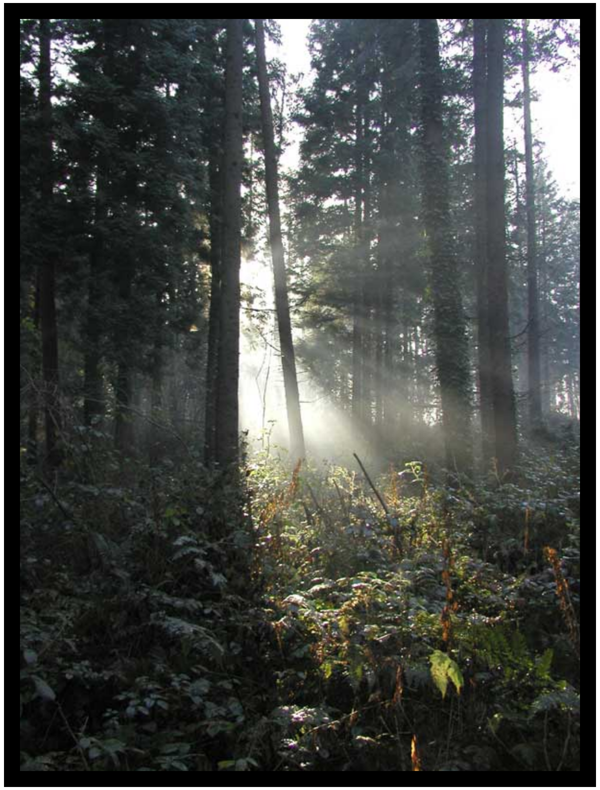
- Use *social responsibility* to guide a company's operations and stakeholder relationships.

c2c vs. cradle to grave

Instead of designing
cradle-to-grave
products, dumped in landfills at the end of their 'life,' need to transform industry by creating products for
cradle-to-cradle cycles, whose materials are
perpetually circulated in closed loops.

Maintaining materials in closed loops maximizes material value without damaging ecosystems.

c2c vs. cradle to grave



"the cradle"

One of the primary tenets of this philosophy is "grave avoidance".

But beyond that, REUSE OVER RECYCLING as reuse requires significantly less expenditure of additional energy and materials and often results in "downcycling" of valuable materials.

"the grave"

certification tracks

There are two tracks for certifying a product:

MATERIAL HEALTH CERTIFICATION (formerly: Cradle to Cradle™ Technical/Biological Nutrient Certification): a binary, pass-fail approach designed for those materials and simple products that are homogeneous in nature. This certification only encompasses the Material and Nutrient (Re)utilization criteria.

Cradle to Cradle™ Product Certification: a three-tiered approach consisting of Silver, Gold, and Platinum levels to reflect continuing improvement along the cradle-to-cradle trajectory. This certification contains the following five categories of metrics: Materials, Nutrient (Re)utilization, Energy, Water, and Social Responsibility.

Both certifications apply to materials, sub-assemblies and finished products.

cradle 2 cradle certification – the idea

Cradle to Cradle Certification provides a company with a means to tangibly, credibly measure achievement in environmentally-intelligent design and helps customers purchase and specify products that are pursuing a broader definition of quality.

Solutia Inc.'s Ultron® nylon 6,6 fiber has been certified as Cradle to Cradle™ Technical Nutrient.

PHOTO COURTESY OF SOLUTIA INC., KENNESAW, GA.

cradle 2 cradle product certification - requirements

This means using:

1. environmentally safe and healthy **materials**
2. design for **material reutilization**, such as recycling or composting;
3. the use of renewable **energy** and energy efficiency;
4. efficient use of **water**, and maximum water quality associated with production;
5. and instituting strategies for **social responsibility**.

CERTIFIED cradletocradle CM

BRONZE

CRADLE TO CRADLE CERTIFIED CM PRODUCT SCORECARD

QUALITY CATEGORY	BASIC	BRONZE	SILVER	GOLD	PLATINUM
MATERIAL HEALTH				✓	
MATERIAL REUTILIZATION			✓		
RENEWABLE ENERGY & CARBON MANAGEMENT		✓			
WATER STEWARDSHIP			✓		
SOCIAL FAIRNESS				✓	
OVERALL CERTIFICATION LEVEL		✓			

Since the introduction of the system the wording of energy has changed to include carbon management.

1.0 - Materials

MBDC

1.0 Materials

CRADLE TO CRADLE™ CERTIFICATION CRITERIA				
	TN or BN Certification	Silver	Gold	Platinum
1.0 Materials				
All material ingredients identified (down to the 100 ppm level)	●	●	●	●
Defined as biological or technical nutrient	●	●	●	●
All materials assessed based on their intended use and impact on Human/Environmental Health according to the following criteria: ***Human Health:*** Carcinogenicity, Endocrine Disruption, Mutagenicity, Reproductive Toxicity, Teratogenicity, Acute Toxicity, Chronic Toxicity, Irritation, Sensitization ***Environmental Health:*** Fish Toxicity, Algae Toxicity, Daphnia Toxicity, Persistence/Biodegradation, Bioaccumulation, Ozone Depletion/Climatic Relevance ***Material Class Criteria:*** Content of Organohalogens, Content of Heavy Metals	●	●	●	●
Strategy developed to optimize all remaining problematic ingredients/materials	●	●	●	●
Product formulation optimized (i.e., all problematic inputs replaced/phased out)	●		●	●
Meets Cradle to Cradle emission standards			●	●

1.2 Defined as a Biological or Technical Nutrient

The product is defined with respect to the appropriate cycle (i.e., technical or biological) and all components are defined as either biological or technical nutrients. If the product combines both technical and biological nutrients, they are clearly marked and easily separable. This is more of a strategic criterion and therefore there is no calculation or metric associated with it.

1.3 All ingredients characterized based on their impact on Human and Environmental Health.

Based on the interpretation of the data for all criteria, chemicals and materials are "scored" for their impact upon human and environmental health. A key factor in this evaluation is the risk presented by the component/chemical, which is a combined measure of identified hazards and routes of exposure for specific chemicals and materials, and their intended use in the finished product. The "score" is illustrated by the following color scheme:

GREEN (A-B)	Little to no risk associated with this substance. Preferred for use in its intended application.
YELLOW (C)	Low to moderate risk associated with this substance. Acceptable for continued use unless a GREEN alternative is available.
RED (X)	High hazard and risk associated with the use of this substance. Develop strategy for phase out.
GREY	Incomplete data. Cannot be characterized.

1.3.1 Human Health Criteria

The criteria are subdivided into Priority Criteria (most important from a toxicological and public perception perspective) and other Additional Criteria.

Criteria	Description
PRIORITY	
Carcinogenicity	Potential to cause cancer
Endocrine Disruption	Potential to negatively effect hormone function and impact development
Mutagenicity	Potential to damage DNA
Teratogenicity	Potential to harm fetus
Reproductive Toxicity	Potential to negatively impact reproductive system

ADDITIONAL	
Acute Toxicity	Potential to cause harm upon initial, short term exposure
Chronic Toxicity	Potential to cause harm upon repeated, long-term exposures
Irritation of Skin and Mucous Membranes	Potential to irritate eyes, skin, and respiratory system
Sensitization	Potential to cause allergic reaction upon exposure to skin or airways
Other	Any additional characteristic (e.g., flammability, skin penetration potential, etc.) relevant to the overall evaluation but not included in the previous criteria

Substances that do not pass the Priority criteria are automatically scored RED and recommended for phase-out/ replacement.

1.3.2 Environmental Health Criteria

Criteria	Description
Fish Toxicity	Measure of the acute toxicity to fish (both saltwater and freshwater)
Daphnia Toxicity	Measure of the acute toxicity to Daphnia (invertebrate aquatic organisms)
Algae Toxicity	Measure of the acute toxicity to aquatic plants
Persistence/ Biodegradation	Rate of degradation for a substance in the environment (air, soil, or water)
Bioaccumulation	Potential for a substance to accumulate in fatty tissue and magnify up the food chain
Climatic Relevance	Measure of the impact a substance has on the climate (e.g., ozone depletion, global warming, etc.)
Other	Any additional characteristic (e.g., soil organism toxicity, WGK water classification, etc.) relevant to the overall evaluation but not included in the previous criteria

1.3.3 Material Class Criteria

The following material classes are scored RED due to the concern that at some point in their life cycle they may have negative impacts on human and environmental health. In the case of organohalogens, they tend to be persistent, bio-accumulative, and toxic, or can form toxic by-products if incinerated.

Criteria	Description
Organohalogen Content	Presence of a carbon – halogen (i.e., chlorine, bromine, or fluorine) bond
Heavy Metal Content	Presence of a toxic heavy metal (e.g., Antimony, Arsenic, Beryllium, Cadmium, Chromium, Cobalt, Lead, Mercury, Nickel, etc.)

The complete phase-out of all RED components is necessary to achieve a Gold or Platinum product certification.

1.6 Meets Cradle to Cradle™ emission standards

For interior products to achieve Gold or Platinum certification, they must meet the Cradle to Cradle emission standards which are defined as the following:

- TVOC < 0.5 mg/m3 *(total volatile organic compounds)*
- Individual VOCs < 0.1 TLV or MAK values (whichever is lower)
- No detectable VOCs that are considered known or suspected carcinogens, endocrine disruptors, mutagens, reproductive toxins, or teratogens. Based on the lab chosen to do the work what is considered "non-detect" may vary. For the purposes of this certification, anything below 2μg/m3.

Labs approved for testing include Berkley Analytical, MAS, AQS, and Syracuse University. All testing is done according to ASTM D5116 for small chamber and ASTM D6670 for large chamber.

2.0 – Material Reutilization

MBDC

2.0 Material Reutilization/Design for Environment

CRADLE TO CRADLE™ CERTIFICATION CRITERIA	TN or BN Certification	Silver	Gold	Platinum
2.0 Material Reutilization/Design for Environment				
Defined the appropriate cycle (i.e., Technical or Biological) for the product and developing a plan for product recovery and reutilization	●	●	●	●
Well defined plan (including scope and budget) for developing the logistics and recovery systems for this class of product			●	●
Recovering, remanufacturing or recycling the product into new product of equal or higher value				●
Product has been designed/manufactured for the technical or biological cycle and has a nutrient (re)utilization score >= 50	●	●	●	●
Product has been designed/manufactured for the technical or biological cycle and has a nutrient (re)utilization score >= 70			●	●
Product has been designed/manufactured for the technical or biological cycle and has a nutrient (re)utilization score >= 85				●

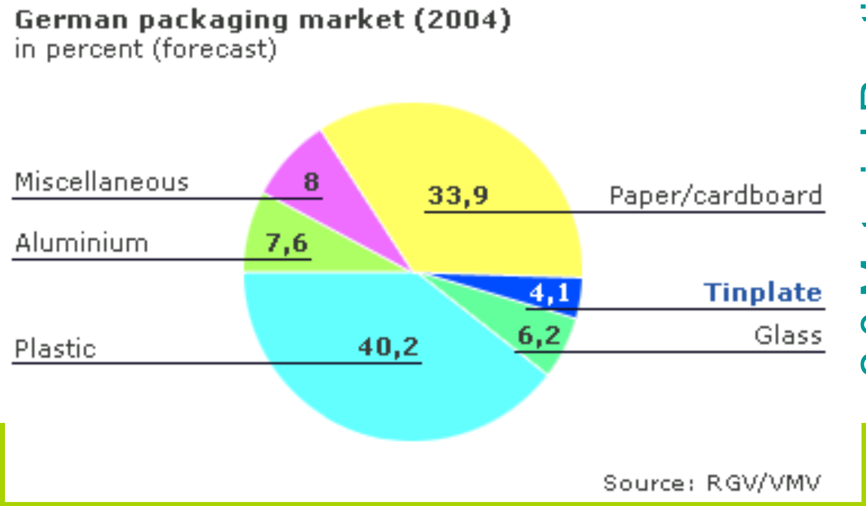
2.3 Recovering, remanufacturing or recycling the product into new product of ***equal or higher value***

For Platinum certification, the plan developed in 2.2 above has been implemented. As each manufacturing system varies, MBDC will judge the validity and efficacy of each applicants program on a case-by-case basis.

opposite of

DOWNCYCLING

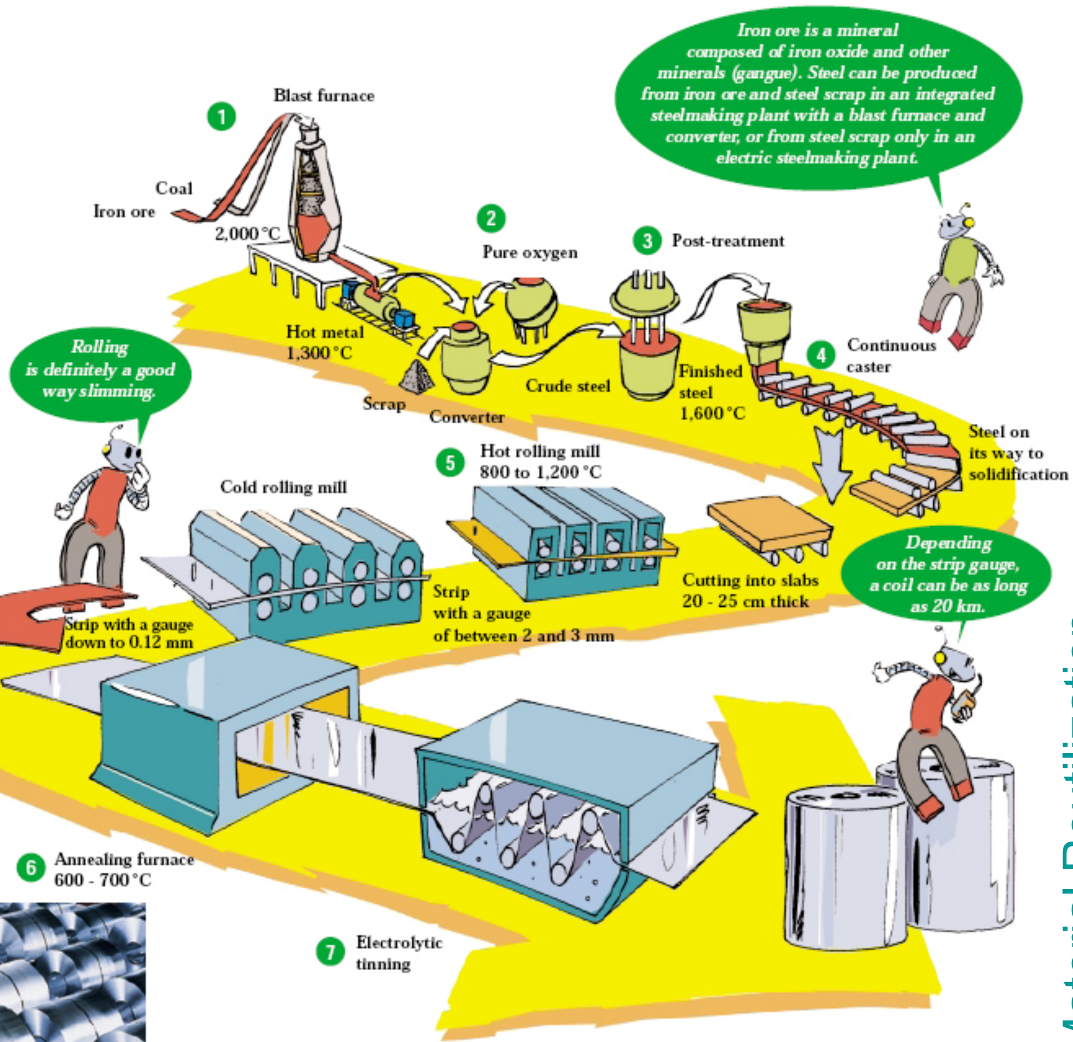
The practice of recycling a material in such a way that much of its inherent value is lost (for example, recycling plastic into park benches). This is true for the majority of major recycling efforts. Products can only be downcycled so many times before their usefulness is completely spent and they end up in landfills.

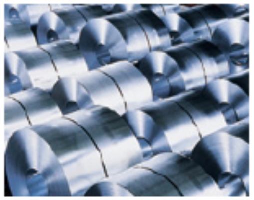


Downcycling does not occur with tinplate.

It is argued that the energy and material expenditure of transforming discarded plastic bottles into plastic wood is not worth the effort – therefore regarded as DOWNCYCLING the material.

Tinplate is steel with a very thin layer of tin to coat its surfaces so that it does not corrode.





Coils have a maximum width of 1,200 mm.

Source: http://www.izw.de/fileadmin/Download/Publikationen/verpackung_mit_pfiff_en.pdf

There are two main routes for recycling steel and tinplate

- collection of production waste
- collection of used tinplate

Steel recycling is environmentally friendly, as it reduces the consumption of iron ore. Every year, more than 500 million tons of iron ore are saved worldwide by the use of steel scrap. The steel industry uses about one million tons of scrap every day to make steel around the world. This corresponds to about 42,000 t per hour or 12 t per second.

3.0 - Energy

MBDC

3.0 Energy

CRADLE TO CRADLE™ CERTIFICATION CRITERIA	TN or BN Certification	Silver	Gold	Platinum
3.0 Energy				
Characterized energy use and source(s) for product manufacture/assembly		●	●	●
Developed strategy for using current solar income for product manufacture/assembly		●	●	●
Using 100% current solar income for product manufacture/assembly			●	●
Using 100% current solar income for entire product				●

4.0 - Water

MBDC

4.0 Water

CRADLE TO CRADLE™ CERTIFICATION CRITERIA				
	TN or BN Certification	Silver	Gold	Platinum
4.0 Water				
Created or adopted water stewardship principles/guidelines		●	●	●
Characterized water flows associated with product manufacture			●	●
Implemented water conservation measures				●
Implemented innovative measures to improve quality of water discharges				●

Controlling runoff into watershed areas

4.1 Create or adopt water stewardship principles/guidelines

For Silver, Gold, and Platinum certifications, create or adopt a set of principles or guidelines that will inform your facility's future strategies for protecting and preserving the quality and supply of water resources.

Examples include:

- World Business Council for Sustainable Development – Water Principles (http://www.wbcsd.ch/web/publications/sinkorswim.pdf) pg 11

- Hannover Principles: Design for Sustainability – Water (http://www.gemi.org/water/resources/hannover.htm)

- Water Management Principles of the Ministry of Water, Lan
Protection from the Government of British Columbia (http://wlapwww.gov.bc.ca/wat/wtr_cons_strategy/basics.html)

For Future's Sake

4.2 Characterize water flows associated with product manufacture

Water Source(s):

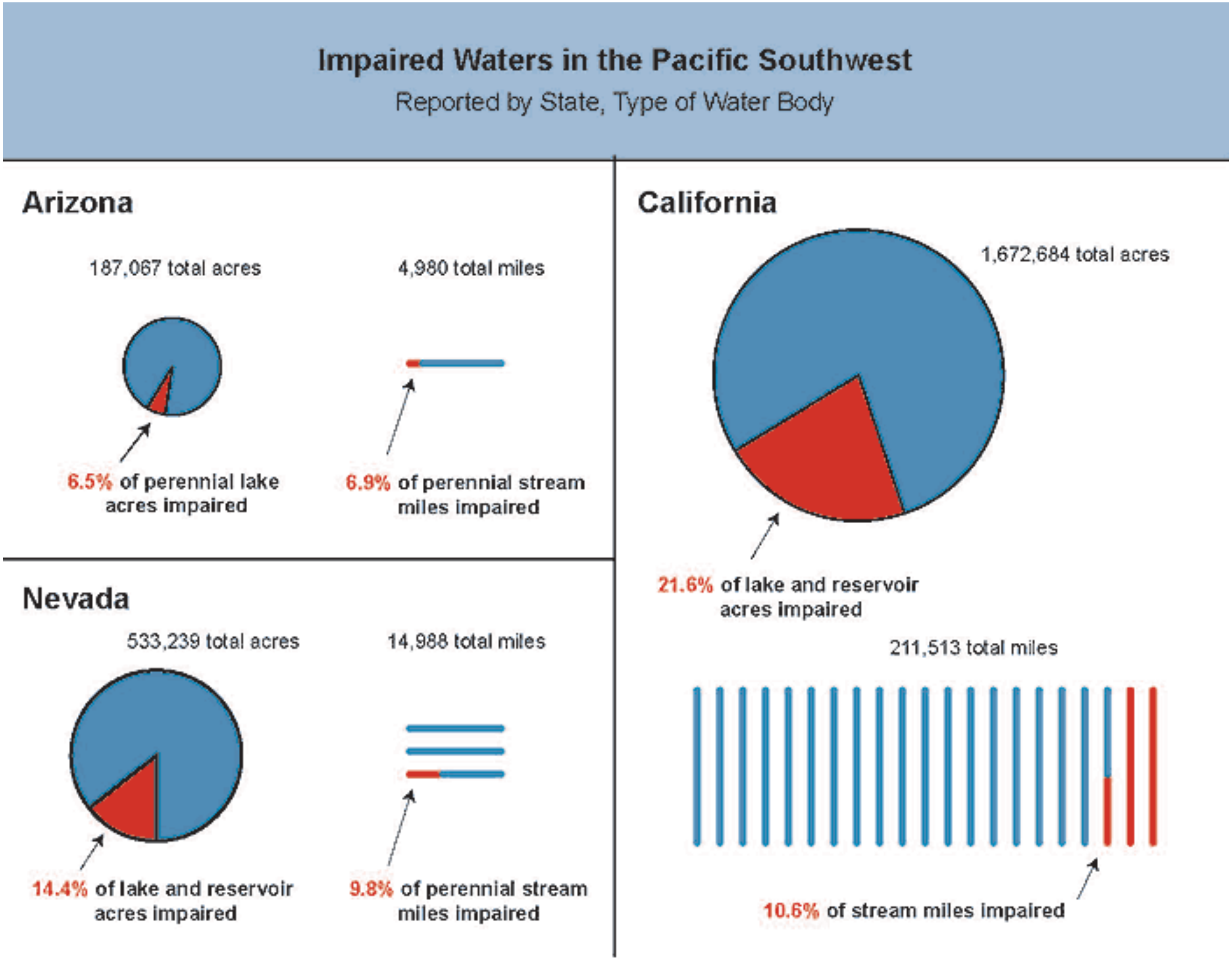
- Describe the types of water sources the facility(ies) relies upon.
- Determine whether or not the facility is located within or adjacent to a listed wetland
- Define the watershed. Document the following information:
  - Does the facility withdraw or discharge effluent to a water source that is listed as impaired by the EPA, state or local authorities? What are the water concerns for the area and how does the facility impact these concerns?
  - Ask the local or regional water authority whether the facility is considered a major or minor user of water relative to other users in the watershed region.

Water Usage:

- How much water is used per unit product produced?
- What measures have been taken to conserve water resources?

Water Discharges:

- Meets or exceeds EPA and state water quality regulations as required under EPA's National Pollution Discharge Elimination System (NPDES).

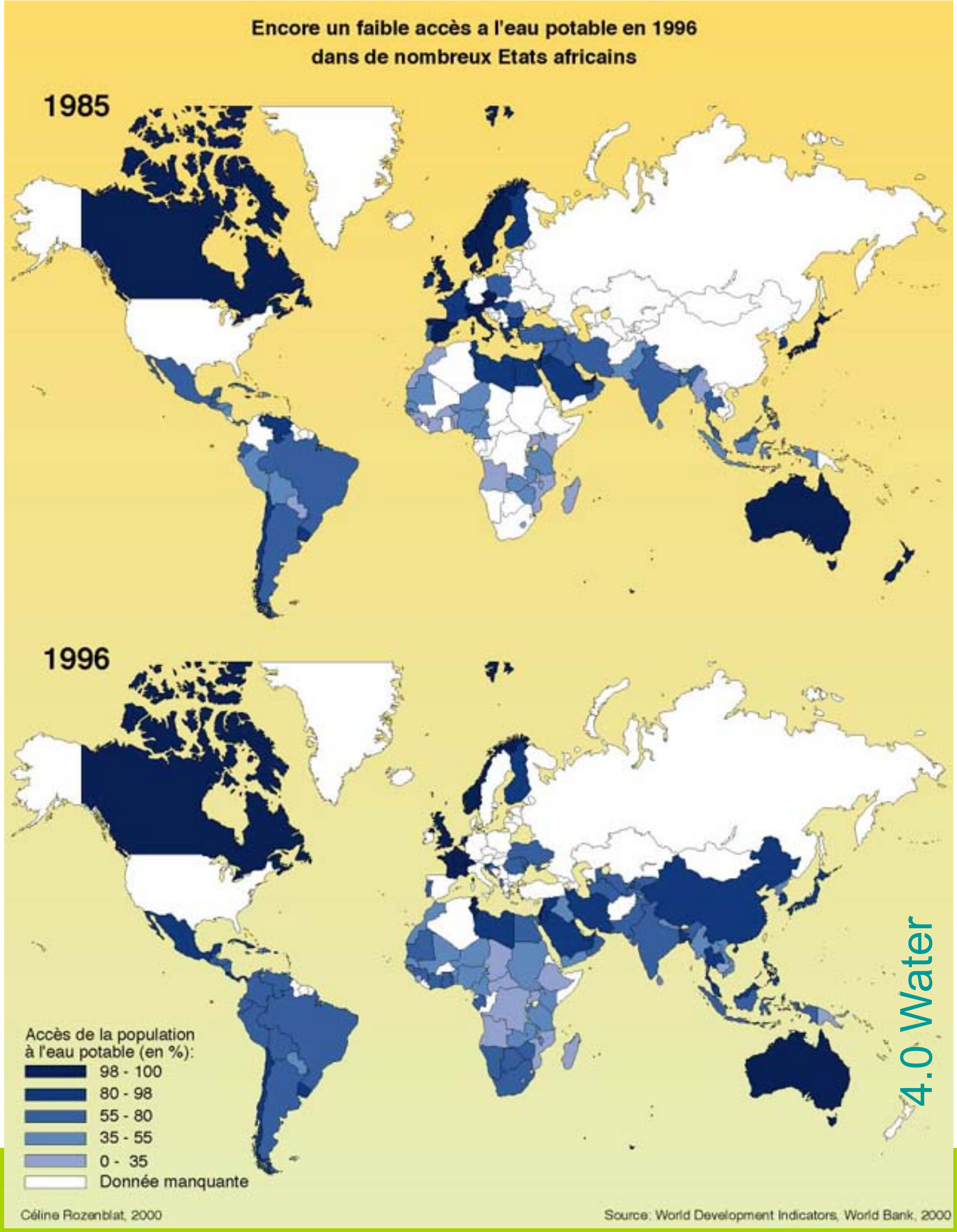

Impaired Waters in the Pacific Southwest
Reported by State, Type of Water Body
Arizona
187,067 total acres
4,980 total miles
6.5% of perennial lake acres impaired
6.9% of perennial stream miles impaired
Nevada
533,239 total acres
14,988 total miles
14.4% of lake and reservoir acres impaired
9.8% of perennial stream miles impaired
California
1,672,684 total acres
21.6% of lake and reservoir acres impaired
211,513 total miles
10.6% of stream miles impaired

4.0 Water

The idea behind “Water” is to promote clean water sources and to prevent the dumping of any chemicals whatsoever into any water source.

This applies not only to Industrialized Western countries, but developing countries as well.

Many Western companies have their products manufactured in the “Third World”, where/because standards are lower so profits can be higher.



5.0 – Social Responsibility

MBDC

5.0 Social Responsibility

CRADLE TO CRADLE™ CERTIFICATION CRITERIA				
	TN or BN Certification	Silver	Gold	Platinum
5.0 Social Responsibility				
Publicly available corporate ethics and fair labor statement(s), adopted across entire company		●	●	●
Identified third party assessment system and begun to collect data for that system			●	●
Acceptable third party social responsibility assessment, accreditation, or certification				●

cradle 2 cradle certification – "reward"

Steelcase Inc.'s Think™ chair has been certified Cradle to Cradle™ Silver.

PHOTO COURTESY OF STEELCASE INC., GRAND RAPIDS, MICH.

If a candidate product achieves the necessary criteria, it is certified as a Silver, Gold or Platinum product …

Haworth Inc.'s Zody™ office chair has been certified Cradle to Cradle™ Gold.

PHOTO COURTESY OF HAWORTH INC., HOLLAND, MICH.

Pendleton Woolen Mills Inc.'s Classic Wool Flannel has been certified Cradle to Cradle™ Biological Nutrient.

PHOTO COURTESY OF PENDLETON® WOOLEN MILLS INC., PORTLAND, ORE.

…or as a Technical/ Biological Nutrient (available for homogeneous materials or less complex products), and can be branded as Cradle to Cradle.

Victor Innovatex Inc.'s Eco Intelligent® Polyester fabric has been certified Cradle to Cradle™ Technical Nutrient.

PHOTO COURTESY OF VICTOR INNOVATEX INC., SAINT-GEORGES, QUEBEC, CANADA

Cradle to Cradle Certified Products Registry

CERTIFIED cradletocradle™ PRODUCTS PROGRAM

Stay informed about new certified products

Products listed according to the MasterFormat for specifications.

Search & Filters

Search by keywords

Categories MasterFormat

- All
- 03 00 00 - Concrete (3)
- 04 00 00 - Masonry (11)
- 05 00 00 - Metals (7)
- 06 00 00 - Wood, Plastics, and Composites (10)
- 07 00 00 - Thermal and Moisture Protection (17)
- 08 00 00 - Openings (12)
- 09 00 00 - Finishes (82)
- 10 00 00 - Specialties (31)
- 12 00 00 - Furnishings (59)
- 13 00 00 - Special Construction (1)
- 14 00 00 - Conveying Equipment (0)
- 22 00 00 - Plumbing (3)

254 certifications

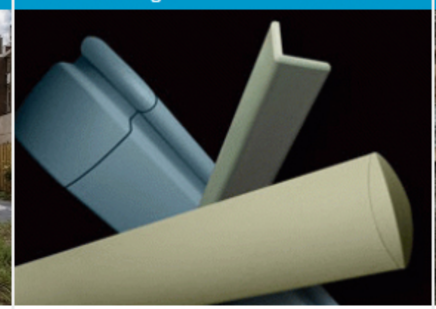
Structural Building Gold V3.0

Accoya® Wood (Radiata Pine & Alder)

ACCSYS TECHNOLOGIES

Accoya® wood is the result of decades of research and development that has brought...

Wall Coverings Gold V2.1.1



Acrovyn® 4000 Wall Protection - Profile and Sheet...

CONSTRUCTION SPECIALTIES, INC.

C/S Acrovyn® 4000 is a wall guard with a UL Class 1 fire rating that provides the...

Building Exteriors Gold V2.1.1

Barkhouse Brand Poplar Shingle Siding and Wall Covering...

HIGHLAND CRAFTSMEN

Barkhouse Brand Poplar Shingle Siding and Wall Covering Panel are made from...

Flooring Gold V3.1

Wall Coverings Gold V2.1.1

Carpeting Products Gold V3.1

Material Health Certificate Registry

Material Health

The Material Health Certificate uses the acclaimed material health assessment methodology of the *Cradle to Cradle Certified™ Product Standard* to provide manufacturers with a trusted way to communicate their work towards chemically optimized products.

The requirements that must be met in order to achieve a Material Health Certificate are identical to the requirements at each level of the Material Health section of the *Cradle to Cradle Certified™ Product Standard*, in addition to the Continuous Improvement/Optimization requirement. See the Material Health Certificate Standard for complete details.

Specialties and Platinum

BioBlend Enviromax 2.0 Biodegradable Elevator Hydraulic...

THYSSENKRUPP ELEVATOR AMERICAS

BioBlend Enviromax 2.0 Biodegradable Elevator Hydraulic Oil is formulated from...

more info »

Structural Platinum

Accoya® Wood (Radiata Pine & Alder)

ACCSYS TECHNOLOGIES

Accoya® wood is the result of decades of research and development that has brought...

more info »

Insulation Gold

EcoTouch® Insulation Products Unfaced

OWENS CORNING SALES, LLC

EcoTouch® Unfaced Insulation is flexible, light density insulation available in a...

more info »

Textiles for Platinum

Insulation Gold

Carpeting Gold

DfD

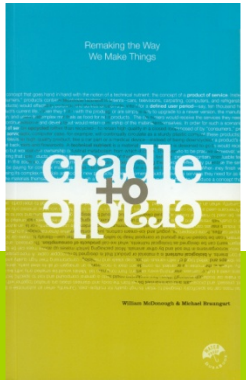
design for disassembly

DESIGN FOR DISASSEMBLY
Designing a product to be dismantled for easier maintenance, repair, recovery, and reuse of components and materials.

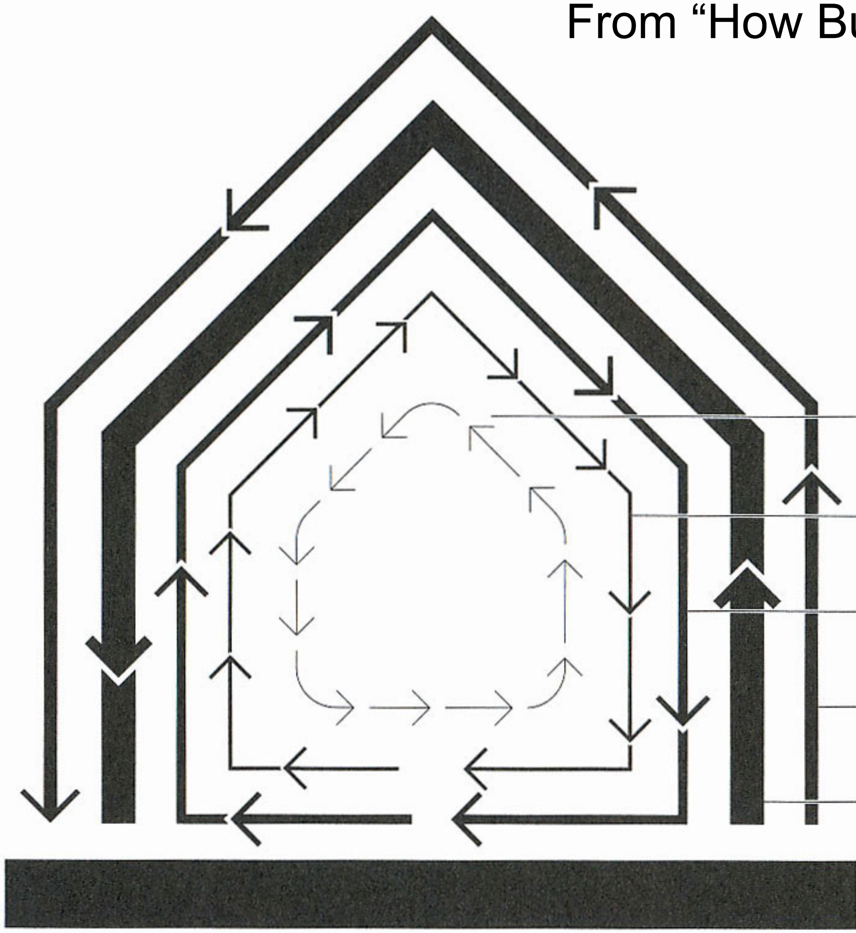
“Why take something as exquisite as a tree and knock it down? Trees make oxygen, sequester carbon, distill water, build soils, convert solar energy to fuel, change colors with the seasons, create microclimates and provide habitat.

My book "Cradle to Cradle," which I wrote with Michael Braungart, is printed on pages made of plastic resins and inorganic fillers that are infinitely recyclable. They're too heavy, but we're working with companies now to develop lightweight plastic papers. We have safe, lightweight inks designed to float off the paper in a bath of 180 degrees—hotter than you would encounter under normal circumstances. We can recapture the inks and reuse them without adding chlorine and dioxins to the environment. And the pages are clean, smooth and white.”

- William McDonough



From “How Buildings Learn” by Stewart Brand

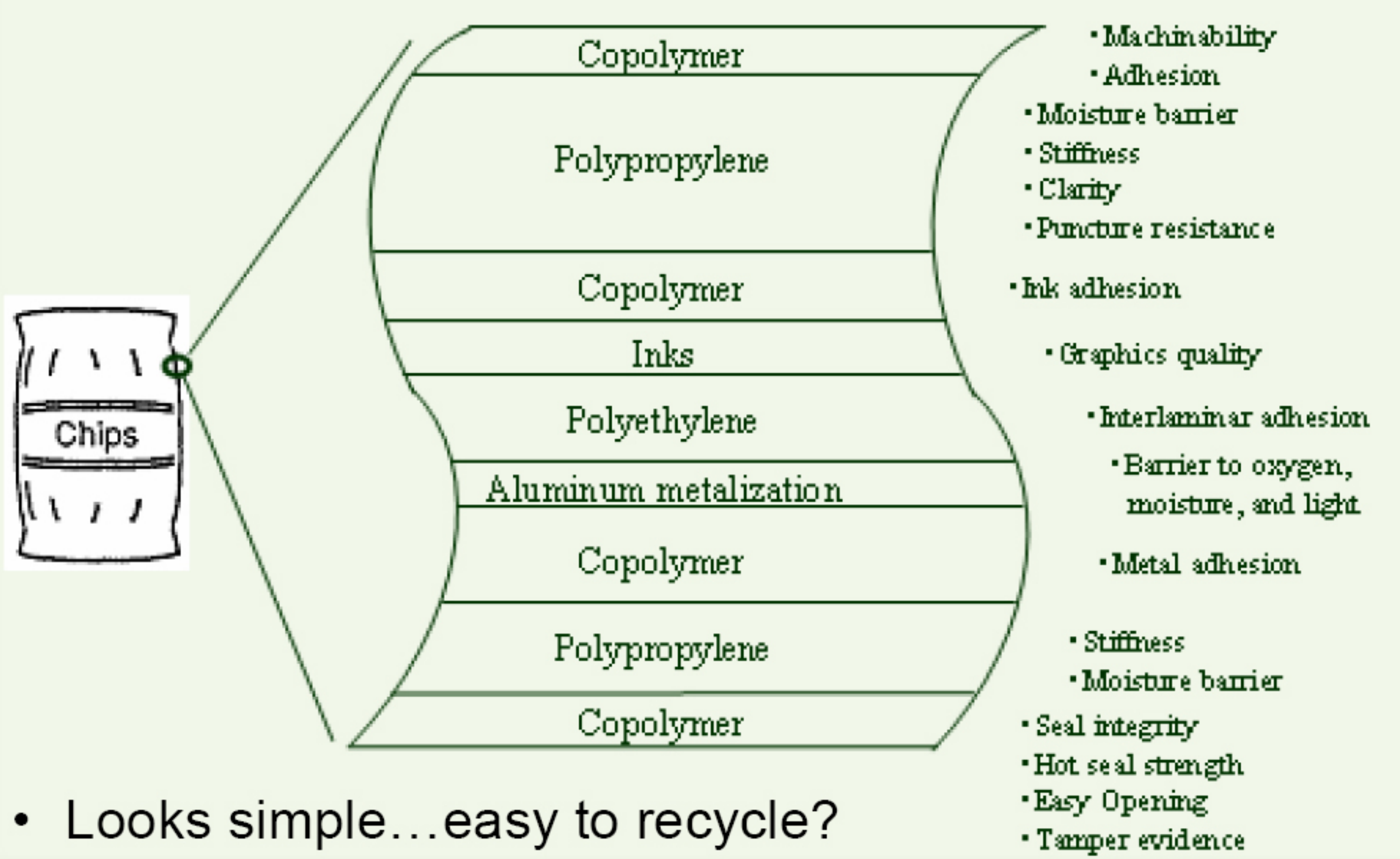


SHEARING LAYERS OF CHANGE. **Because of the different rates of change of its components, a building is always tearing itself apart.**

How do we take things apart?

- That were not intended to be taken apart
- Not designed to be taken apart
- Are glued or connected via means that make it next to impossible
- That are assembled in layers that degrade at different rates of speed
- That are highly complex
- That mix benign materials with toxic ones (paint, glue, coatings…)

Cross-section of a Snack Bag

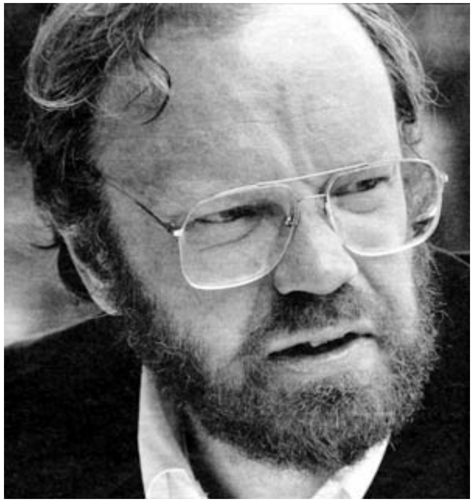


- Looks simple…easy to recycle?

Source: http://www.eng.uc.edu/~pbishop/69

This product is neither easy to recycle nor suitable for composting.

philosophy of design for disassembly (DfD)



Jonathan Larson

DFD is a subset of the emerging environmental redesign movement which assumes that:

a) humans cause pollution (apes and dolphins may be bright but they have never caused a toxic waste dump)
b) humans are conscious beings
c) pollution is caused by the conscious acts of these humans
d) the more difficult the act of humans, the more planning it takes
e) the truly difficult pollution problems are caused by acts of significant planning and design.

Therefore:

Pollution is a function of design!

source: http://www.elegant-technology.com/TVnewide.html

POLLUTION IS AN ACT OF DESIGN

Remember, EVERYTHING that is called 'disposable' was DESIGNED from day one to be garbage--as its PRIMARY and overriding design consideration."


EVEN THIS BUILDING!
GATE 1

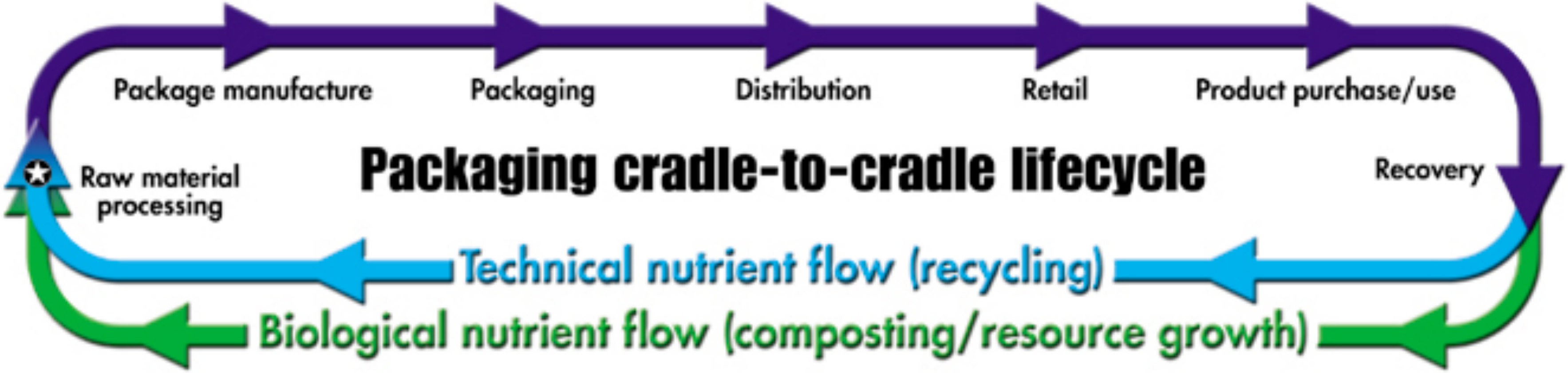
pollution is an act of design

"Nuclear power and the resulting waste problems were brought to us by the creative genius of scientists, inventors, and design engineers. Global warming is the product of planning by geologists, mining engineers, shippers, civil engineers, automotive designers, and the clever folks who solved the problems of mass production. The ozone hole is courtesy of organic chemists who were merely trying to give the world a safe way to preserve food and medical products with refrigeration. In fact, virtually every thing that can be considered pollution is the product of intense planning and design--down to the last bubble-pack and plastic milk carton clogging our waste dumps.

Remember, EVERYTHING that is called 'disposable' was DESIGNED from day one to be garbage--as its PRIMARY and overriding design consideration."

this was ALL designed

packaging



Packaging accounts for a significant amount of pure waste in the Modern World. The c2c philosophy agues for more/more durable packaging that can be reused.

Alternatively, manufacture packaging that does not contain toxic elements so that it can be cleanly burned as a fuel source.

c2c looks at traditional versus eco-effective packaging

…how would you design this differently to make it more eco-effective??

The traditional way: eco-efficient packaging	The cradle-to-cradle way: eco-effective packaging
Minimize the amount of packaging materials to reduce impact on environment.	Use as much packaging as is desired to protect and differentiate the product because that package will become a biological or technical nutrient after its first use.
Discourage littering because materials don't break down for decades; and, if they do, toxic additives can enter the environment.	Discarded biodegradable packaging that incorporates soil nutrients would actually benefit the environment, not harm it.
Consumer is left with the liability of package disposal after product is consumed.	Consumer no longer has disposal liability because package will become a technical or biological nutrient after its first use. Customer is left with a positive impression of the product and the manufacturer.
Recycled-content packaging can result in reduced performance and attractiveness.	By positively selecting the right additives and inks, packaging can be cheaper to recycle in a true, 100% closed-loop process with no loss in performance.
Recycling often requires consumers to distinguish among unfamiliar types of materials, such as various types of plastics.	Consumers pitch all recylables in a single bin and biodegradables in another, letting modern sortation technology do the work.
Deposits may be mandated by law.	Packagers can create their own deposit systems to recover expensive, desirable packages.
Packaging materials must be as cheap as possible, often leading to multilayer composites or laminates that are difficult or impossible to reuse or recycle.	Returnable packaging reduces or eliminates the need to create hybrids that don't readily disassemble into technical or biological nutrients.

…how would you design THIS to make it more eco-effective?

Recent enviro-packaging developments

Below is a partial list of recent commercial developments in environmental packaging, most of which happen to be plastic. Of course, environmental advantages have also been associated with paper, glass, and metal packaging.

Company	**Technology**
Amcor PET Packaging	SuperCycle™ recycling technology now handles multilayer PET
Cargill Dow	NatureWorks™ biodegradable resin from renewable resources
CCL Plastic Packaging	Plastic tubes with up to 35% post-consumer recycled (PCR) content
DuPont	Biomax® biodegradable polyester coatings and films
Earthshell	Biodegradable foodservice packaging
Eastman Chemical Co.	Eastar Bio® biodegradable resins
Shell Chemical	Biodegradable solvents for coatings and printing inks
UCB Films	NatureFlex™ biodegradable films
Zed Industries	Biodegradable skin packaging

Visit **packworld.com/go/w068** *for a more complete list, including Web links to the above items.*

Fact is…

It was successfully "designed for disassembly"

real men are environmentalists too

"It's Your Creation. The joy of inventing and building is clear to those who have done it--it makes a man feel like a god. The process of turning a synaptic flash of an idea into the products of industrialization defines much of male creativity. Because technology is almost exclusively the offspring of men, much of the demonization of technology is nothing more than male-bashing. Yet some criticism is legitimate for like irresponsible fathers, we have not nurtured our creations. Like sex, technological creation is more fun than maintenance of the offspring--for some reason, sex until dawn is more invigorating than caring for a sick child all night. Like with humans, technology is also more enjoyable when it is young than when it is old and dying."

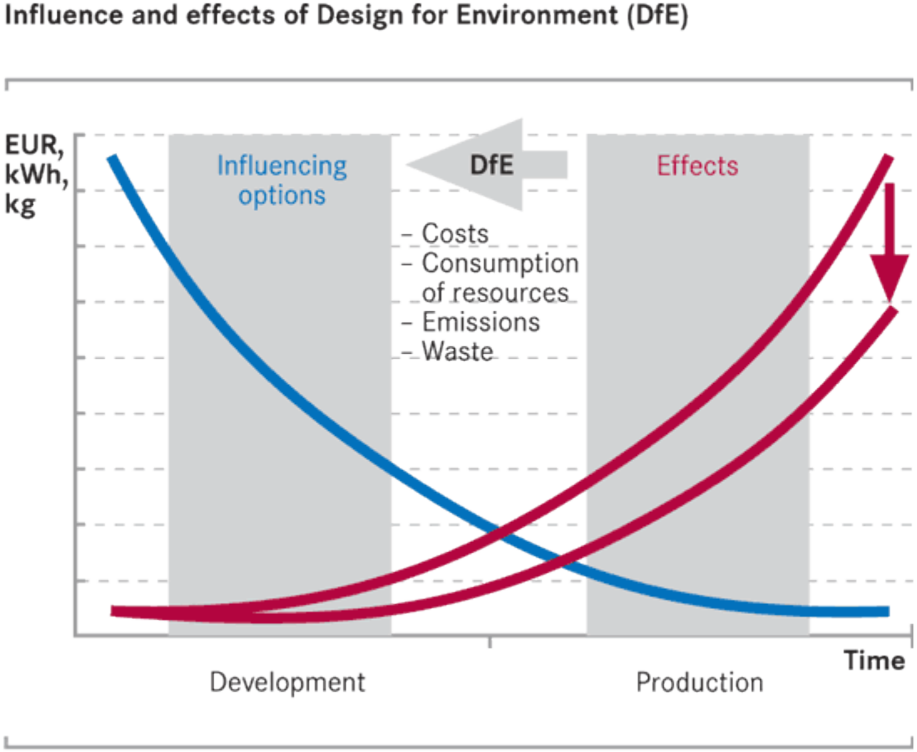
- *Jonathan Larson 1997*

the Germans have already done it

“The Germans, who are no slouches when it come to technological creativity, have passed what may be the world's most interesting environmental law. Because they are running out of places to hide their garbage, they now require manufacturers to take responsibility for recycling. The principle is: You made it--you figure out what to do with it when its useful life has ended. Three general strategies to cope with this legislation have emerged: Some products are designed for easy disassembly and resource recovery, others are being reformulated to biodegrade on their own, while other products and processes are designed out of the system altogether. By assigning total product life responsibilities on the original technological creators, the Germans are forcing into existence a whole new generation of industrial excellence.”

- *Jonathan Larson*

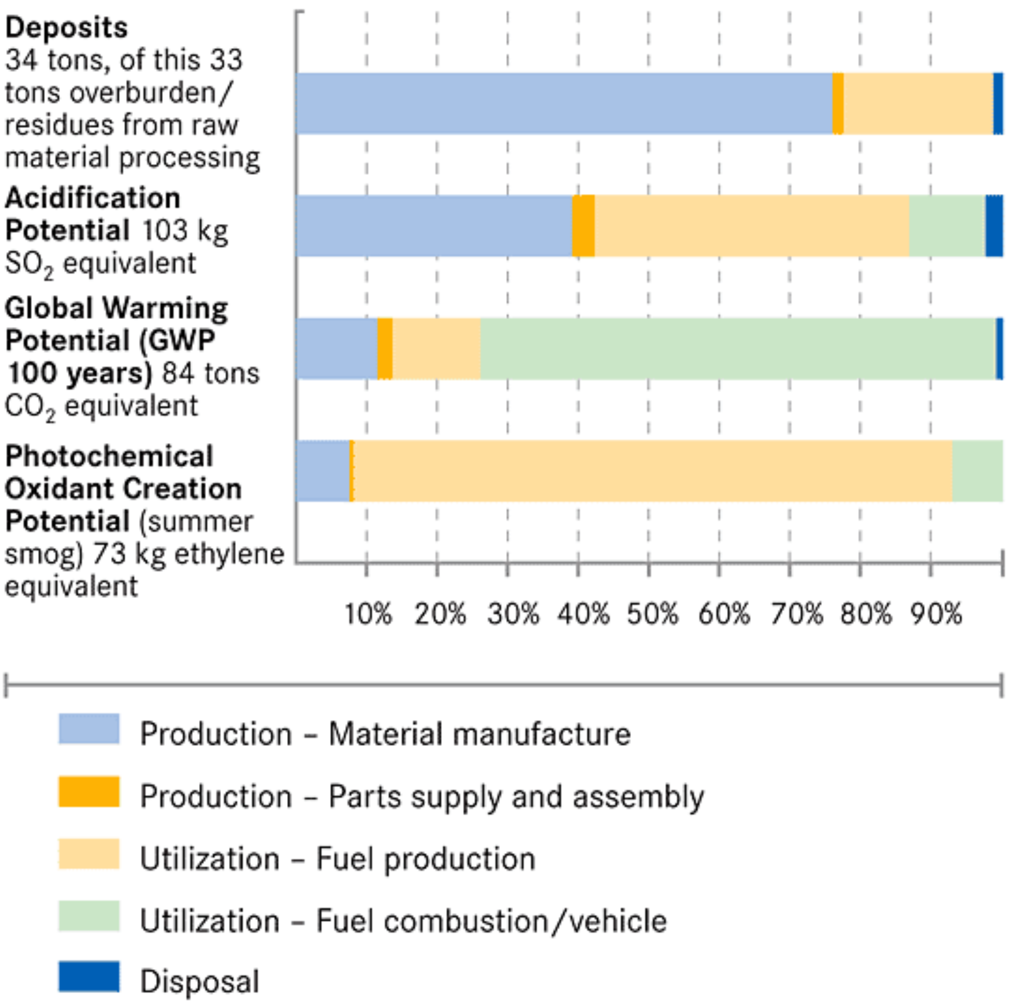
mercedes benz + DfE



DfE starts as early as the early development stages. This is because even minor measures taken at this early point in time can have significant effects at a later stage – and yield tangible reductions in the consumption of resources, in emissions, in waste volumes and in costs. By contrast, it is extremely difficult and costly to modify a vehicle component at an advanced stage of development or as late as the production stage.

DfE = Design for the Environment

Environmental impact on the lifecycle stages of a passenger car using the example of the Mercedes-Benz E-Class



Renewable materials in the new E-Class station wagon

Raw materials	Used in
Flax, sisal, hemp	Door trim, backrest cover driver's seat
Coconut fiber/latex compound	Seat backrests and upholstery
Wood veneer	Trim strips, panels
Wool, cotton	Seat and head restraint covers
Reprocessed cotton	Insulation, seat cushions, parcel shelf brackets in sisal/cotton compound with plastic matrix

Recycling applications in Chrysler Group vehicles

Component	Recycled material (100 %)
Spare tire protector	Crumb rubber
Transmission oil filter	Polyamides (PA66)
Headlamp bezels; I/P top cover; speaker grille	Polycarbonates (PC)
Lamp housing	PC/acrylonitrile-butadiene-styrene
Battery case; splash shields, wheel house	Polypropylene (PP)
Package shelf tray, door trim panel	PP with wood (fiber/flour)
Mirror bracket	Polyethylene terephthalate (PET)
Acoustic pad	Resinated cotton
Air dam	Thermoplastic olefin TPO

A house is likely not even as complex, when you really get right down to it…

“The Germans produced DFD regulations because they understood the importance of production issues and environmental issues coming together. It is the logical outcome of the Red (Social Democrat) Green coalition. The Social Democrats believe that for workers to prosper, industry must prosper. The Green Party believes that for industry to prosper, it must be environmentally sustainable. The combining strategy is industrial **redesign**.

In some ways, it is not surprising that the Germans would reach such a conclusion. For them, industrial design is a valued profession. Mies Van der Rohe said that "Form follows function" in the 1920s and they have believed him ever since. If Germans could be convinced that environmental sustainability is simply a design target, and they have been largely convinced, then industrial-environmental design is the necessary logical outcome. It is why 1992 German cars already conform to DFD regulations, and automakers have established sophisticated recycling facilities, while in the U.S., DFD is still an essentially unknown concept.”

- *Jonathan Larson*

“The European environmentalists I know consider the American infatuation with consumerist strategies to be utterly infantile. If the last twelve years have taught us anything, it is that peoples and nations who know how to successfully produce, eventually dominate those who merely know how to shop.”

-Jonathan Larson

DfD – the rules…

Design for the Environment encompasses many issues including Design for Disassembly and Design for Recycling. There are a number of benefits of achieving efficient disassembly of products as opposed to recycling a product by shredding, which include:

- Components which are of adequate quality can be refurbished or reused.
- Metallic parts can be separated easily into categories which increases their recycling value.
- Disassembled plastic parts can be easily removed and recycled.
- Parts made from other material such as glass or hazardous material can easily be separated and reprocessed.

Although most products can be disassembled eventually, lengthy disassembly does not make for economic recycling as the cost of disassembly is likely to be much larger than the revenue gained through recycling the parts and materials from the product. It is for this reason that designing products for easy disassembly has increased in popularity enabling more of the product to be recycled economically.

source: http://www.co-design.co.uk/design.htm

The most comprehensive work on Design for Disassembly has identified the more detailed areas associated with Design for Recycling, these are:

- Designing for ease of disassembly, to enable the removal of parts without damage.
- Designing for ease of purifying, to ensure that the purifying process does not damage the environment.
- Designing for ease of testing and classifying, to make it clear as to the condition of parts which can be reused and to enable easy classification of parts through proper markings.
- Designing for ease of reconditioning, this supports the reprocessing of parts by providing additional material as well as gripping and adjusting features.
- Designing for ease of re-assembly, to provide easy assembly for reconditioned and new parts.

Four categories which are related to the four important areas of disassembly and recycling, these are:

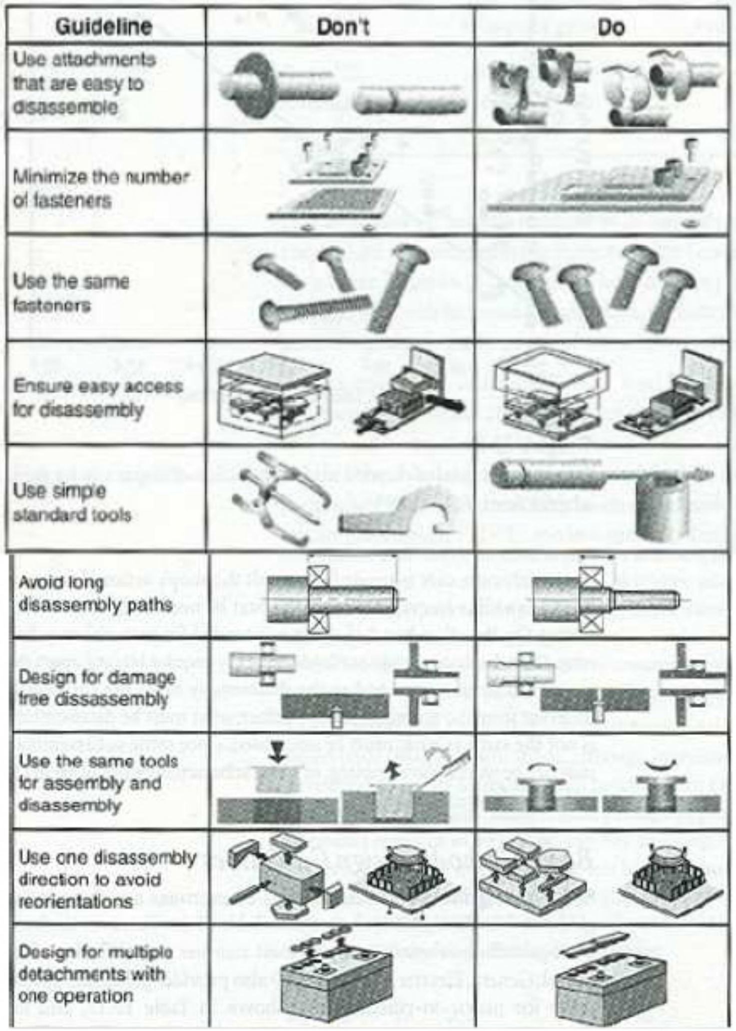
- Materials, enabling the disassembled materials to be easily recycled but the principles can apply equally to disassembled parts for Re-manufacture or reuse.
- Fasteners and Connections, enabling easy and quick disassembly.
- Product Structure, enabling rapid and economic disassembly.
- Avoidance of glues, adhesives and toxic coatings

as simple as

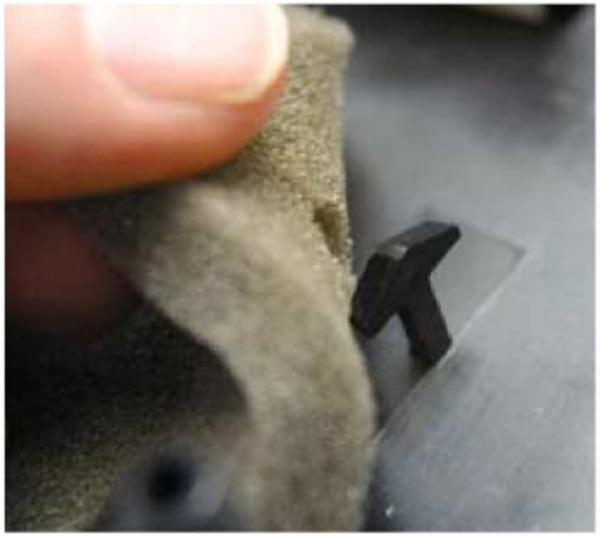
vs

?

Joints suitable for Disassembly



Guideline	Don't	Do
Use attachments that are easy to disassemble		
Minimize the number of fasteners		
Use the same fasteners		
Ensure easy access for disassembly		
Use simple standard tools		
Avoid long disassembly paths		
Design for damage free dissassembly		
Use the same tools for assembly and disassembly		
Use one disassembly direction to avoid reorientations		
Design for multiple detachments with one operation		



"Design for environment surprisingly coincides very well with design for manufacturability"

- Development engineer at IBM

Source: http://www.moea.state.mn.us/publications/betterbydesign.pdf

Material Flows

- Assuming disassembly is possible, material flows must be identified that acknowledge whether a material is:
  - RECYCLABLE
  - COMPOSTABLE
  - DISPOSED (no choice but to be waste)
  - TOXIC (avoid if possible)

Acknowledgement for the following content and diagrams to the thesis of Scott Proudfoot, 2017.

RECYCLABLE

- McDonough and Braungart’s concept of technical nutrients, man-made substances that can be renewed by industry, is here termed recyclable.
- Effective recycling depends on the strict meaning of re-cycling, returning materials back to their original use.

COMPOSTABLE

- Compostable materials emerge from the concept of biological nutrients. Plant matter is harvested, used, and left to decompose at end of life.
- Leveraging the environment for production and disposal creates a far smaller ecological footprint than mined materials.

DISPOSED

- Materials extracted for a single use encompass most of what we build with today. Many of these, like gravel, will not be exhausted any time soon. However they form the bulk of waste.
- Downcycled materials also appear here, as they are designed for only one use in their current form.

Gypsum, Concrete → Disposed → Waste

TOXIC

- A surprising number of building materials are toxic to their occupants or the environment.
- Removing these from use is a priority, as managing them in waste streams is a long term problem without immediately obvious or economically viable solutions.

TOXIC RED LIST

Compiled by the Living Future Institute:

- Alkylphenols
- Asbestos
- Bisphenol A (BPA)
- Cadmium
- Chlorinated Polyethylene and Chlorosulfonated Polyethlene
- Chlorobenzenes
- Chlorofluorocarbons (CFCs) and Hydrochlorofluorocarbons (HCFCs)
- Chloroprene (Neopene)
- Chromium VI
- Chlorinated Polyvinyl Chloride (CPVC)
- Formaldehyde (added)
- Halogenated Flame Retardants (HFRs)
- Lead (added)
- Mercury
- Polychlorinated Biphenyls (PCBs) Perfluorinated Compounds (PFCs)
- Phthalates
- Polyvinyl Chloride (PVC)
- Polyvinylidene Chloride (PVDC)
- Short Chain Chlorinated Paraffin
- Wood treatments containing Creosote, Arsenic or Pentachlorophenol
- Volatile Organic Compounds (VOCs) in wet applied products

https://living-future.org/declare/about/red-list/

White List (Masterformat)

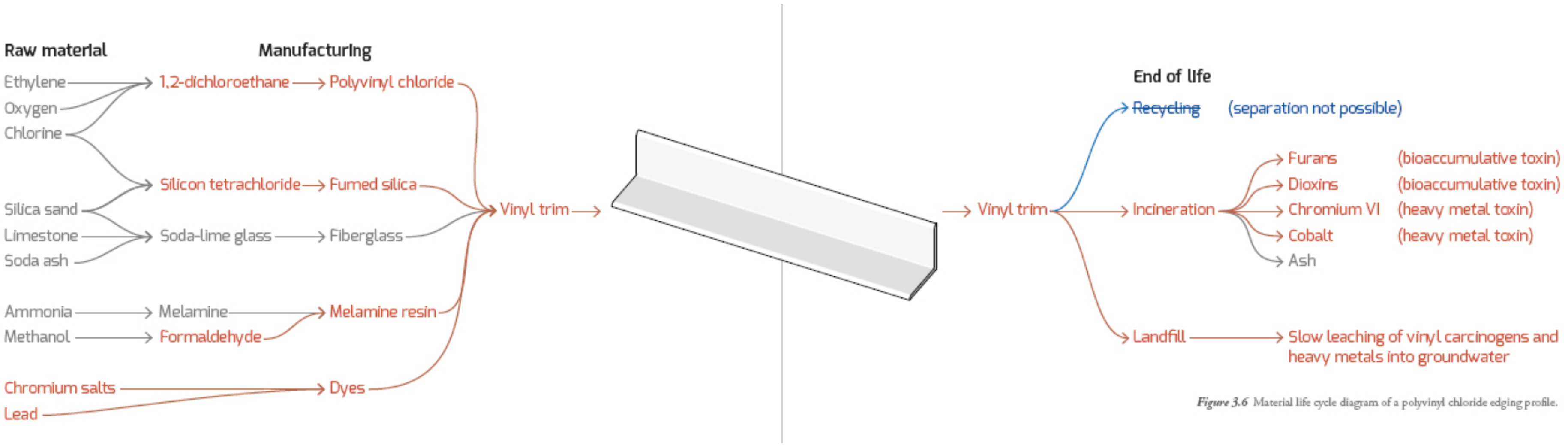
Div.	Material	End of life
03	~~Concrete~~	~~Downcycled~~
04	Mortared masonry	Reusable
	~~Glued masonry~~	~~Inseparable~~
	~~Toxic glazes, pigments~~	~~Toxic~~
05	Steel	Recyclable
	Aluminum	Recyclable
	Copper	Recyclable
	Stainless steel	Recyclable
	Galvanized steel	Recyclable
	~~Lead~~	~~Toxic heavy metal~~
	~~Mercury~~	~~Toxic heavy metal~~
06	Wood	Compostable
	Polyethylene	Recyclable
	~~Polyvinyl chloride~~	~~Toxic chlorine~~
	~~Pressure treated lumber~~	~~Toxic arsenic and creosote~~
	~~Neoprene~~	~~Toxic chlorine~~
	~~Chlorinated plastics~~	~~Toxic chlorine~~
	~~Epoxy~~	~~Toxic bisphenol-A~~
	~~Formaldehyde glues~~	~~Toxic~~
	~~Composites~~	~~Inseparable~~
07	Tyvek (spun polyethylene)	Recyclable
	Polyethylene film	Recyclable
	Cellulose fibres	Compostable
	Straw	Compostable
	Rockwool	Recyclable
	~~Polystyrene foam~~	~~Landfilled~~
	~~Flat roofing products~~	~~Toxic, inseparable~~
	~~Painted metal roofs~~	~~inseparable~~
	~~Caulking~~	~~Inseparable~~
08	Aluminum and steel frames	Recyclable
	~~Vinyl frames~~	~~Toxic chlorine~~
	Glass	Recyclable
	~~Coated glass~~	~~Inseparable~~
	~~Laminated glass~~	~~Inseparable~~
	~~Tinted glass~~	~~inseparable, possibly toxic~~
	~~"Smart windows"~~	~~Inseparable, possibly toxic~~
09	~~Plaster~~	~~Downcycled~~
	~~Gypsum board~~	~~Downcycled~~
	Fastened panelling	Recyclable or compostable
	~~Tile~~	~~Downcycled~~
	~~Concrete flooring~~	~~Downcycled~~
	Wood flooring	Sometimes recyclable
	~~Vinyl flooring~~	~~Toxic~~
	~~Fluid applied flooring~~	~~Inseparable~~
	Carpet	Some are recyclable

Sticky things…

The following finishes are only appropriate where the base material and finish can biodegrade together.

Most paints	~~Inseparable~~
Glued anything	~~Inseparable~~
Composites	~~Inseparable~~

Not so simple Vinyl Trim



An inherent issue with any building product manufactured from PVC:

- Window frames
- Roofing membranes
- Plumbing pipes
- Baseboards, trim, etc.

Not so innocent Wood??

Wood is naturally biodegradable so most wood exposed to the environment has been protected with toxic materials to slow degradation.

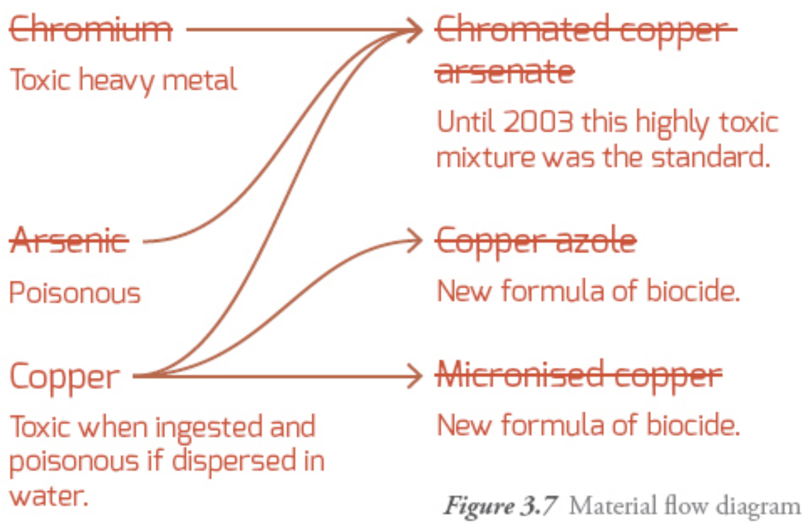
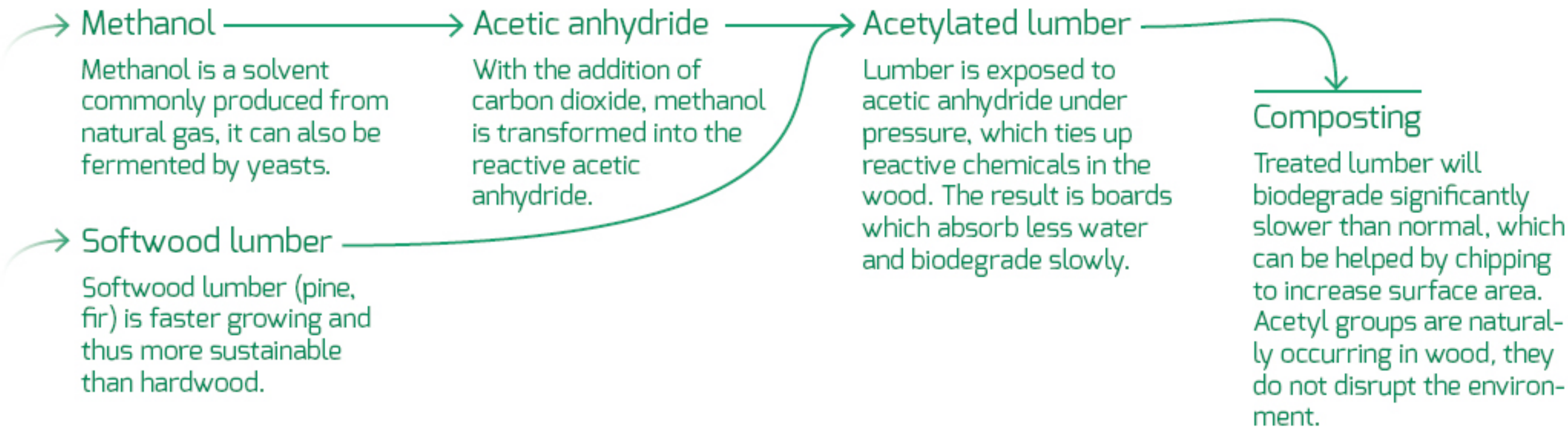


Figure 3.7 Material flow diagram for wood treatments

Changed Wood Treatment Required



Cellulose Insulation

Cellulose insulation has the lowest environmental footprint of all insulation types. To render the fluffy paper fibres fireproof however, boric acid (borax) and ammonium sulfate are added. Borax is an environmental toxin, which relegates the eminently compostable paper fibres to landfill. Ammonium sulfate, on the other hand, while not renewable is commonly used as fertilizer. Substituting a greater quantity of ammonium sulfate for boric acid will produce cellulose insulation that can be safely composted.

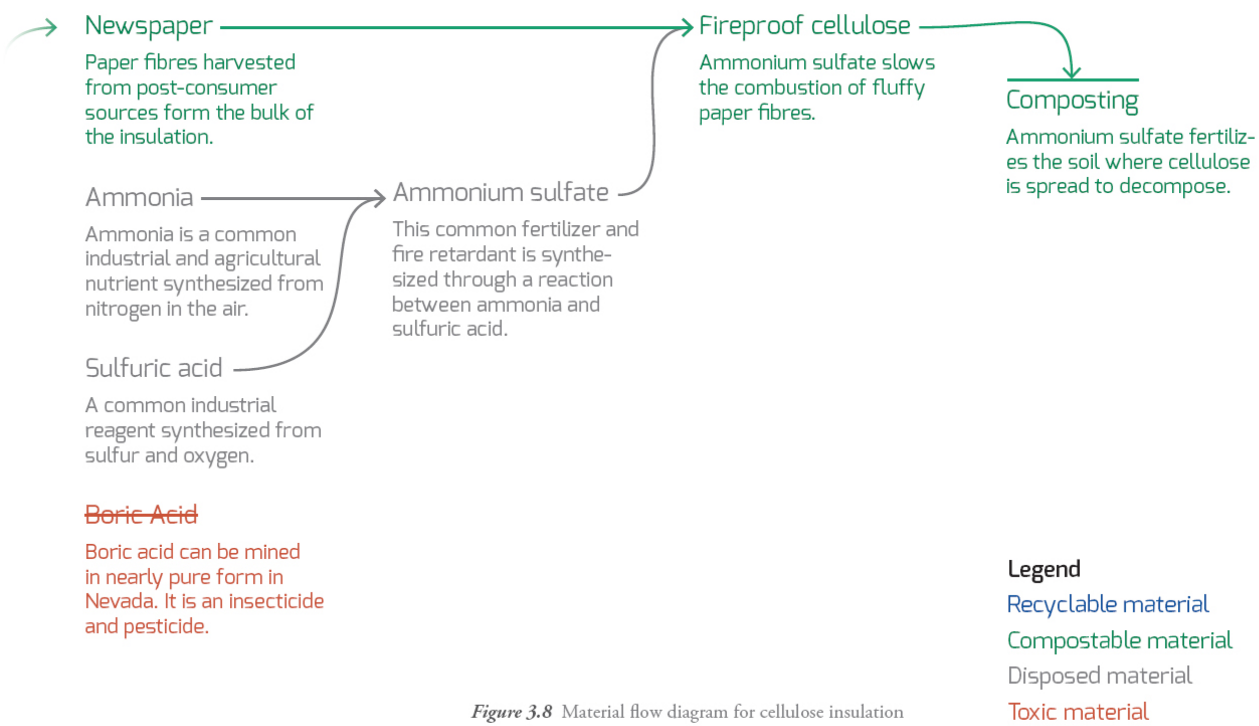


Figure 3.8 Material flow diagram for cellulose insulation

Rockwool Insulation

Rockwool is growing more and more popular for building insulation. Marketing materials often tout its environmental friendliness, however, the rock fibres are held together by a toxic thermo-set phenol formaldehyde adhesive. Post-industrial recycling of small quantities is practised, though there is no widespread collection system for post-consumer rock-wool. By replacing the formaldehyde adhesive with a thermoplastic polymer such as nylon, the materials can be separated at end of life. Nylon can be recovered by solvent dissolution, and cleaned rock fibres can then be remelted into fresh wool.

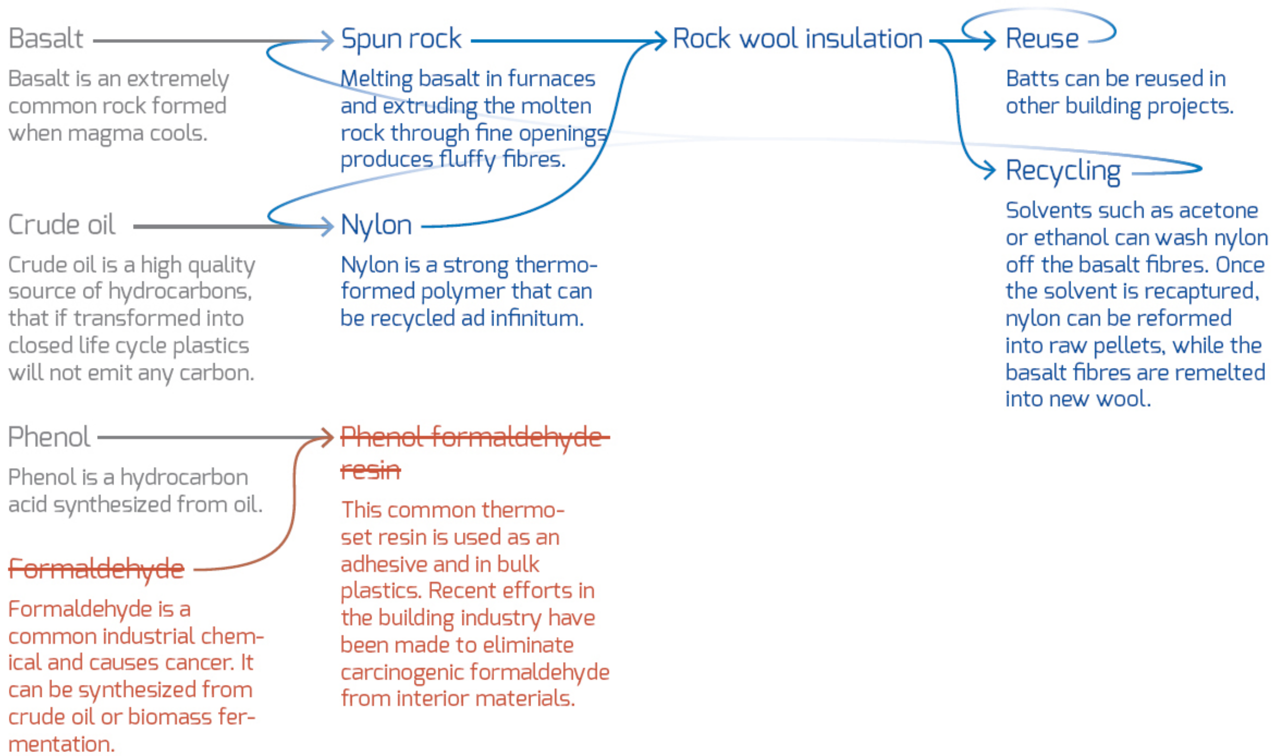


Figure 3.9 Material flow diagram for rock wool insulation

Wood Adhesive

Recent advances in soy glue promise to remove formaldehyde emissions from composite wood products. However, a deeper dive into the chemistry of soy flour adhesives reveals that the new ingredient is a curing polymer blend called Kymene. This chlorinated hydrocarbon does not emit formaldehyde but will produce the persistent toxins dioxin and furan when burned. Research into soy glue chemistries is ongoing, but there may be no good solution. Any biodegradable glue will fail to be waterproof enough for structural use.

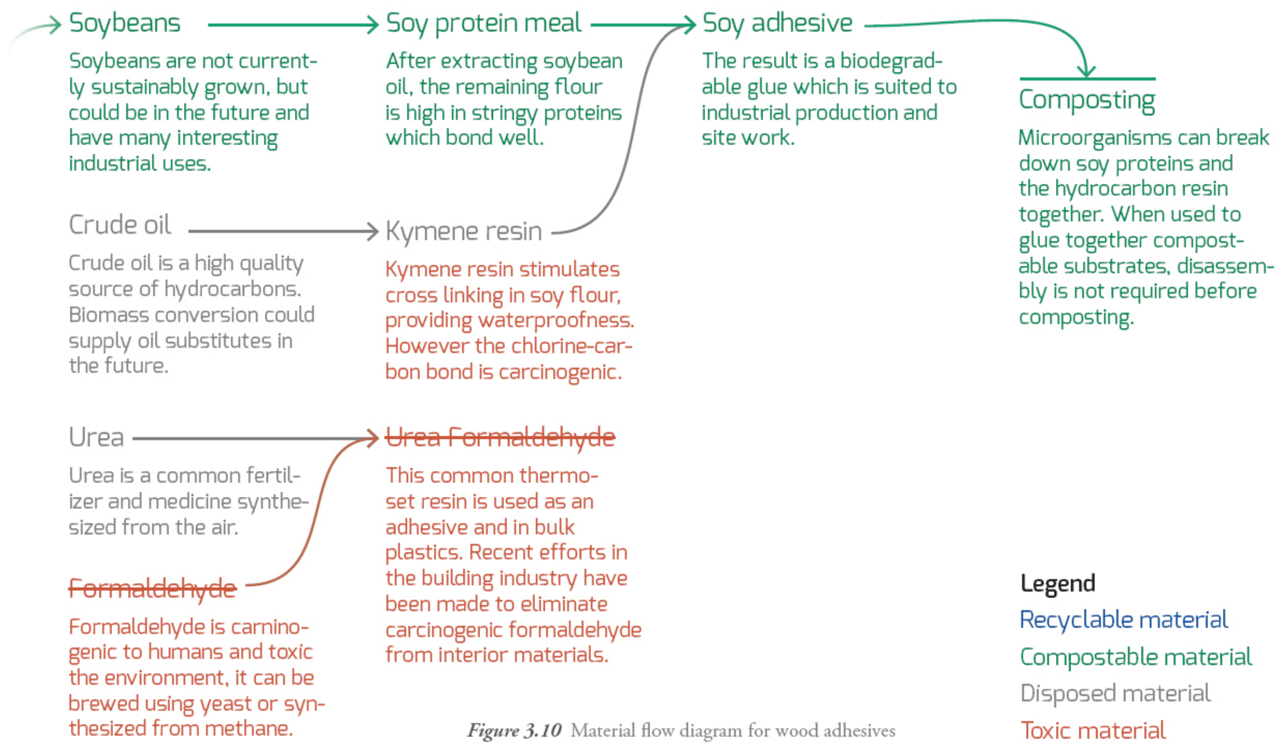


Figure 3.10 Material flow diagram for wood adhesives

Polyethylene

The challenge in designing the life cycle of plastic building components is selecting nontoxic chemistries that can be recycled. Polyethylene is the best construction plastic for closed life cycles. It is the world's most common polymer, synthesized from simple hydrocarbon precursors without toxic chlorine bonds. Polyethylene and PET in beverage bottles, are the only two commonly recycled plastics. When several cycles of use have weakened or contaminated polyethylene it can be chemically broken down the original monomers for feedstock recycling.

Crude oil → Ethylene → Polyethylene → Reuse / Recycling

Crude oil

Crude oil is a high quality source of hydrocarbons, that if transformed into closed life cycle plastics will not emit any carbon.

Biomass ethanol

A pilot plant in Brazil uses yeast to transform sugarcane into ethanol, then polyethylene. This pathway will be more useful when oil becomes expensive.

Ethylene

Ethylene is a short hydro-carbon produced by steam cracking of oil. Ethylene can also be produced by removing oxygen from bio-based ethanol.

~~Polyvynil Chloride~~

PVC or Vynil is toxic at all stages of manufacture, use, and disposal.

~~Polystyrene Foam~~

Polystyrene foam is common in rigid insula-tion and sandwich panels. However, styrene mono-mers are carcinogenic, and the bulky foam is not recycled.

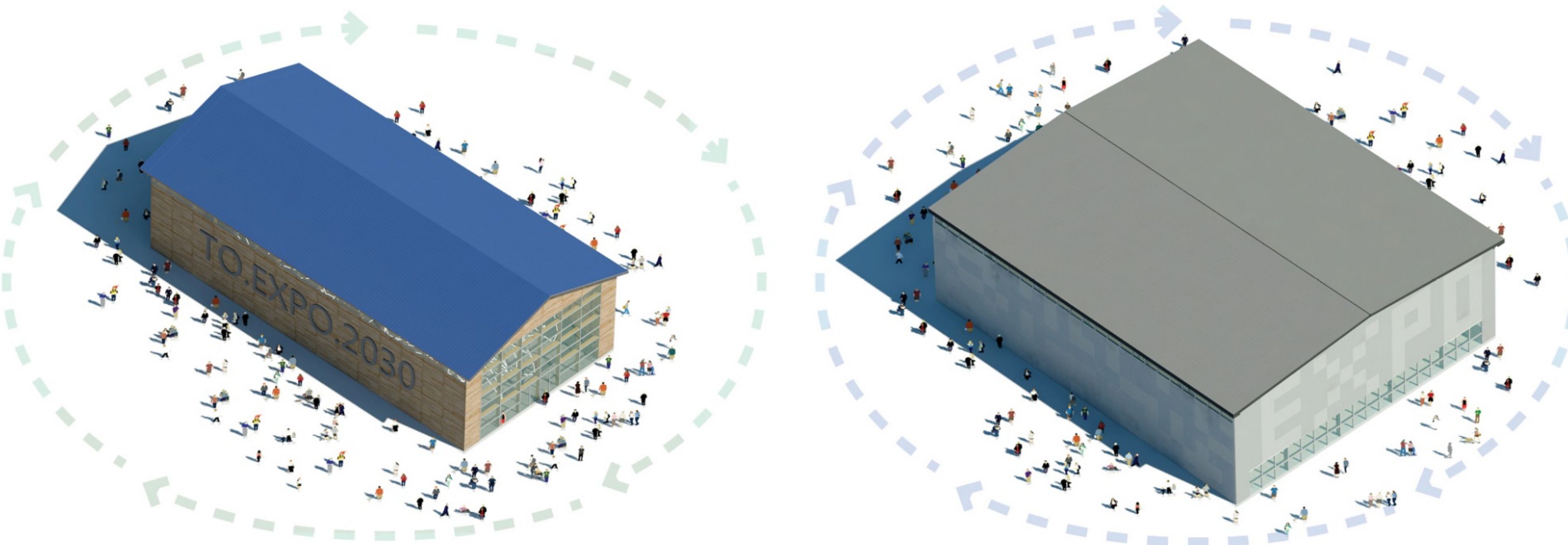
Polyethylene

Reuse

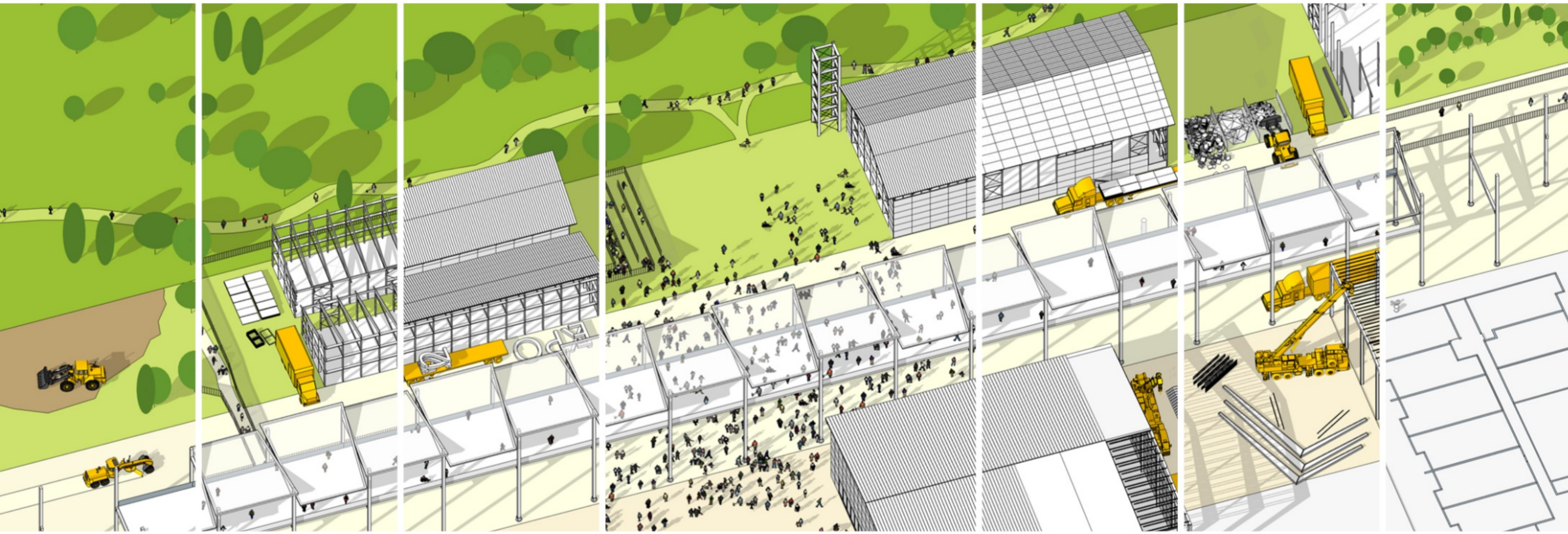
Panels can be reused in other building projects.

Recycling

Polyethylene without dyes, fillers or reinforcing can be melted and re-extruded several times. When the polymer chains get too short, high temperature and pressure can break the plastic back down to ethylene.



Design of generic compostable and recyclable pavilions for Expo 2030



12 months before
Site preparation.

6 months before
Visitors can watch construction from elevated pathways.

1 month before
Preview of event and finishing touches.

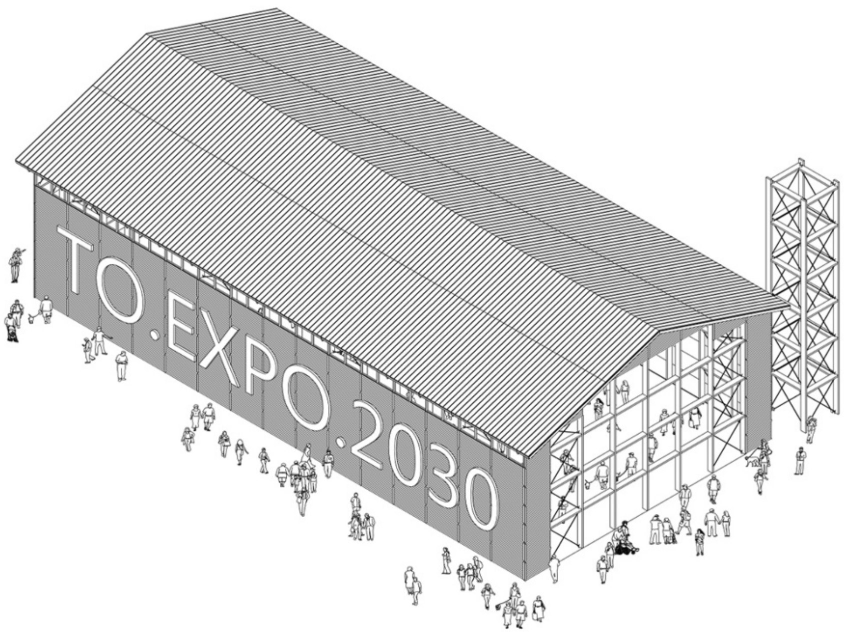
Expo opens
Construction hoarding reused as queueing fences.

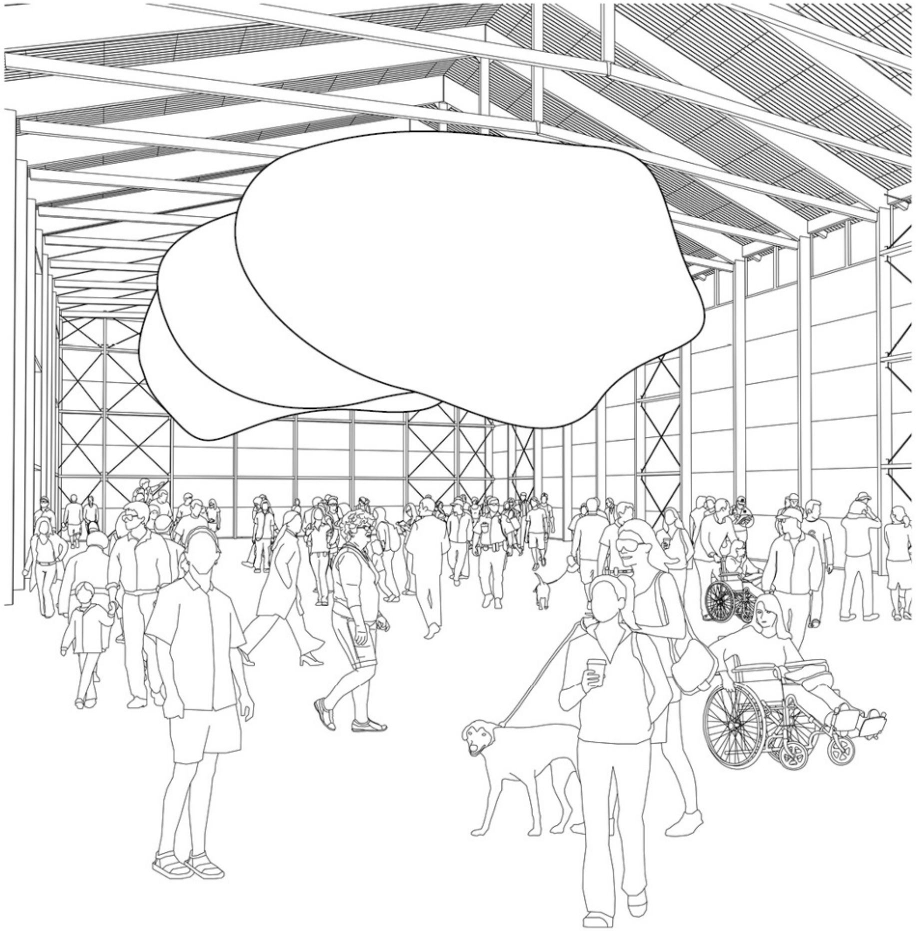
1 month after
Disassembly and shipping of pavilions.

6 months after
Sorting of recyclables can be observed by public.

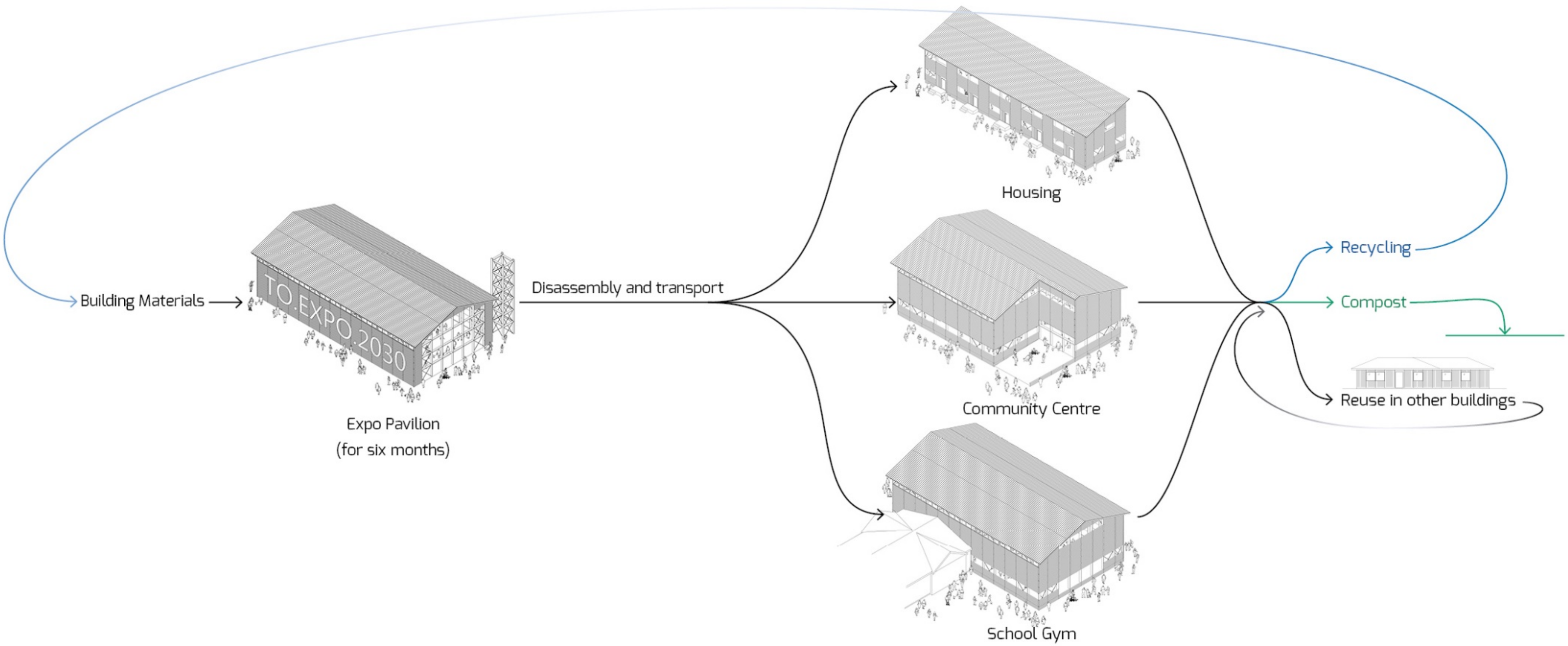
12 months after
Expo welcomes the public back to a landscape in regeneration

Time lapse of Expo site from construction through use and regeneration.



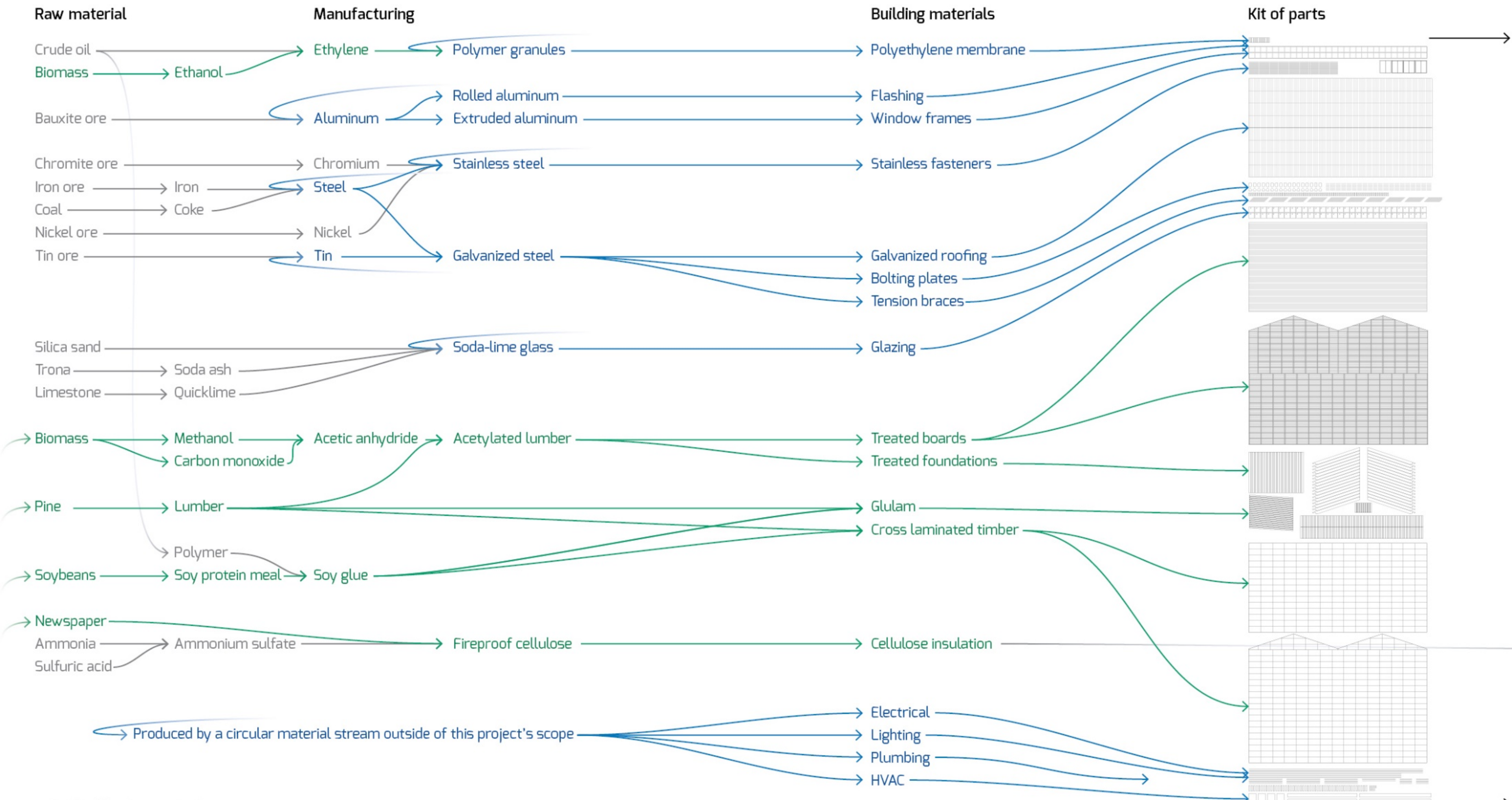


Compostable Pavilion



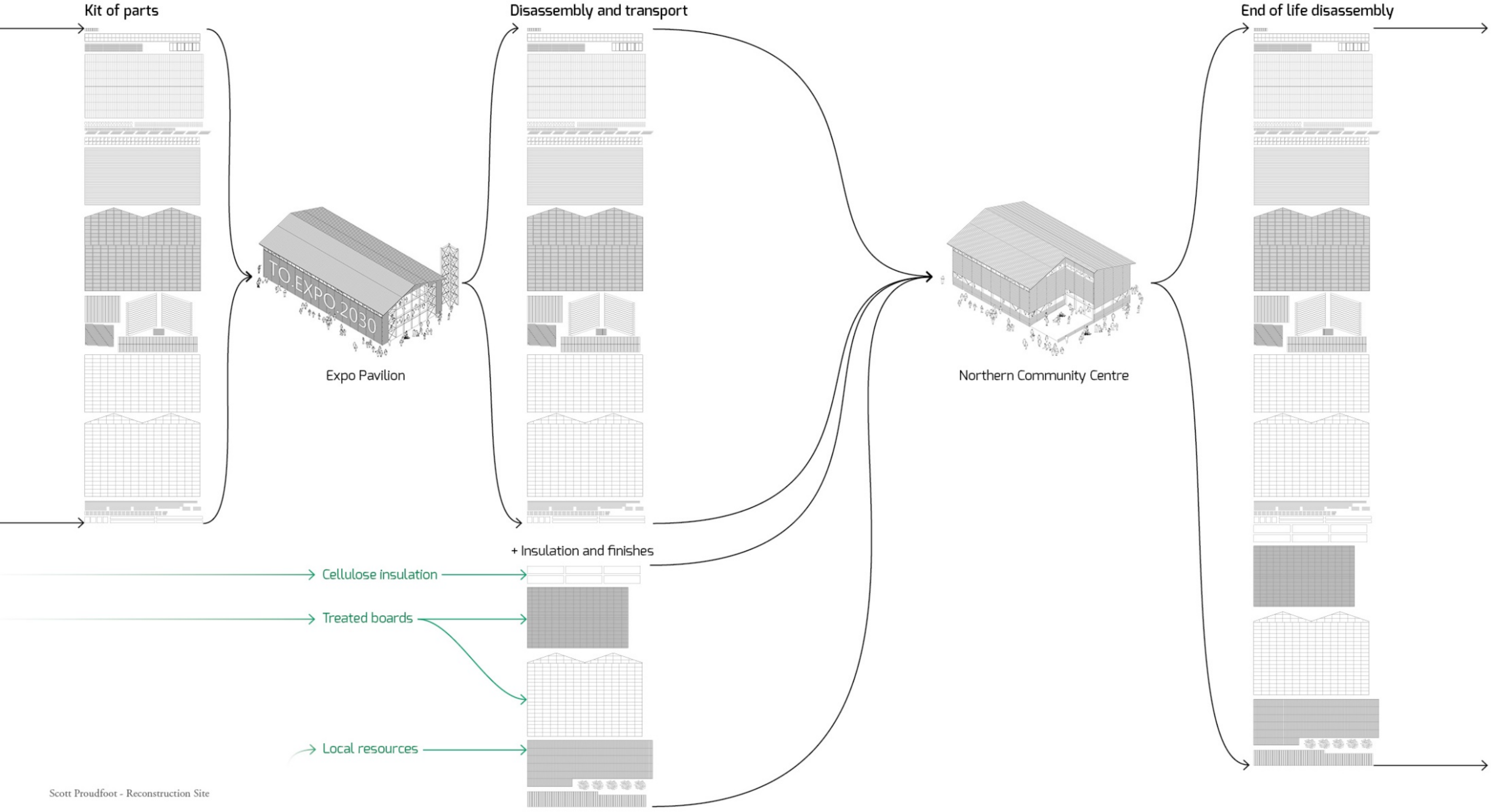
Pavilion life cycle diagram


ARCTIC WATERSHED
ELEV. 1660 FT.
FROM HERE
ALL STREAMS
FLOW NORTH
INTO THE
ARCTIC OCEAN

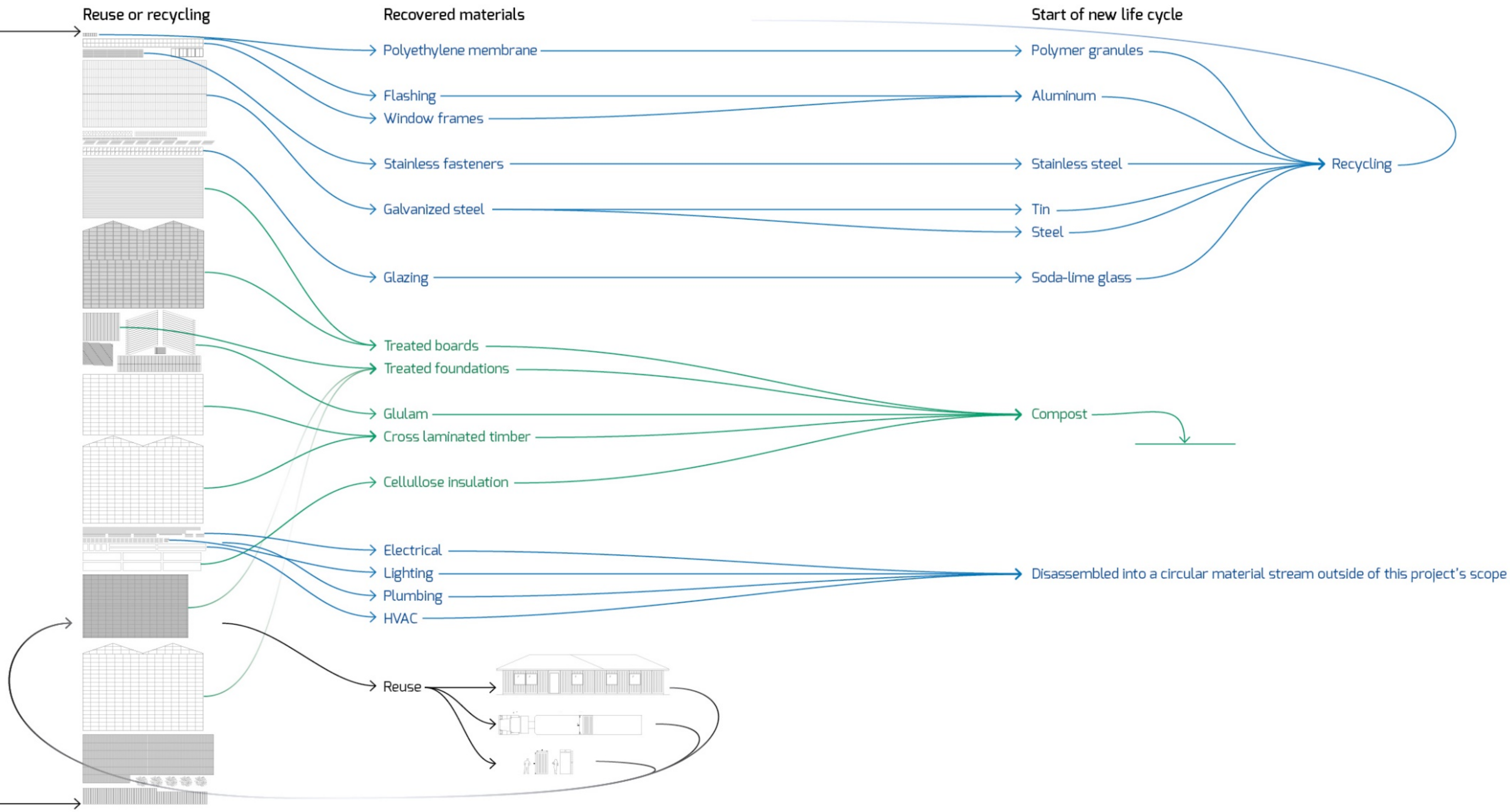


Scott Proudfoot - Reconstruction Site

Building material flow diagram

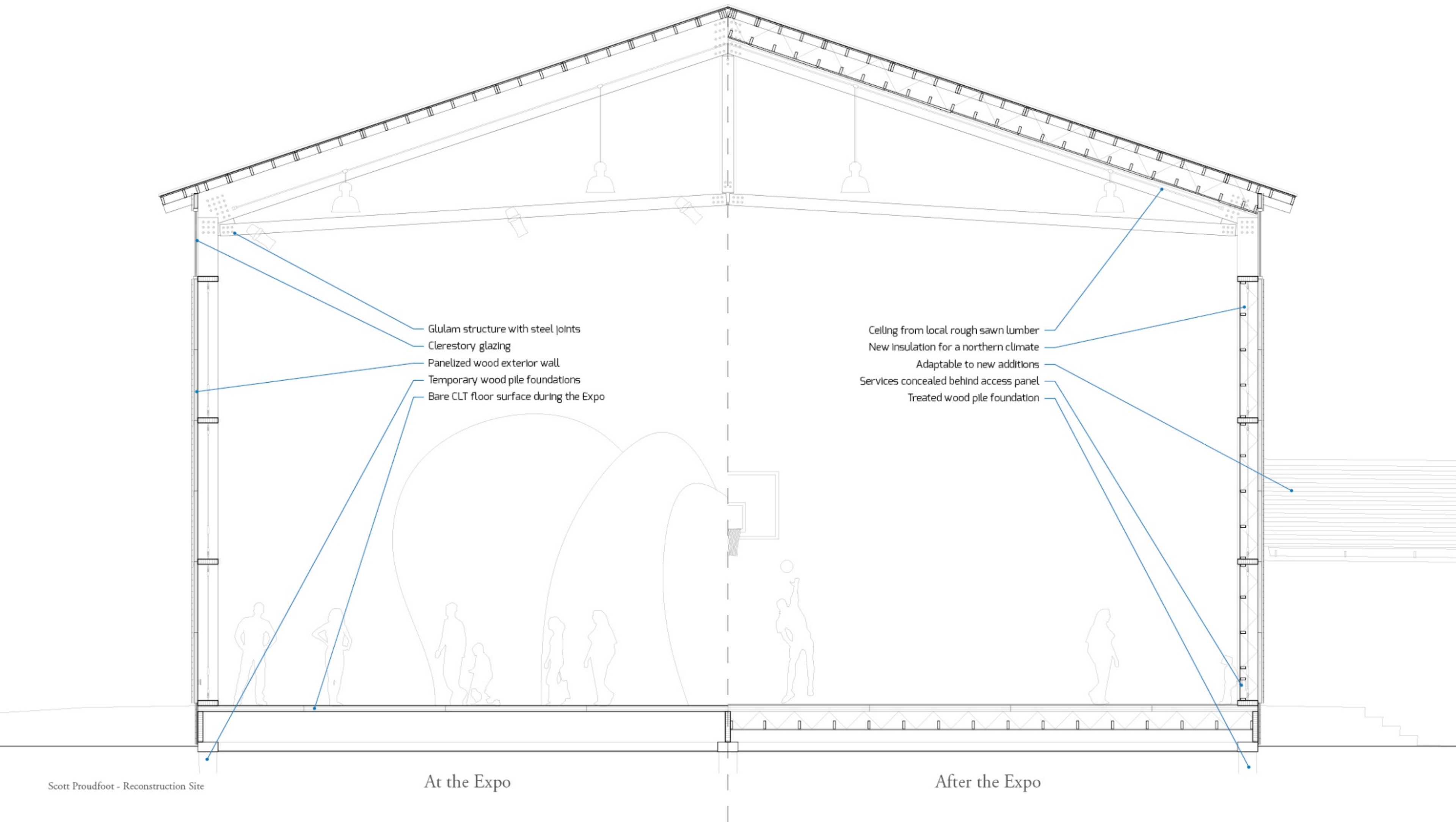


Scott Proudfoot - Reconstruction Site

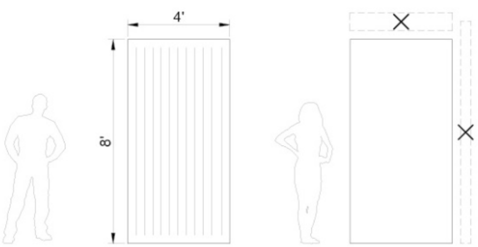


Scott Proudfoot - Reconstruction Site

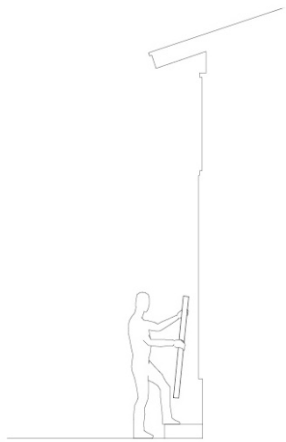
Building material flow diagram



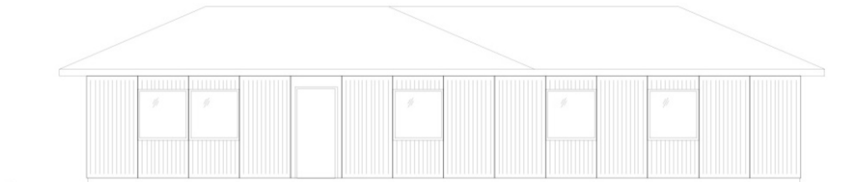
Scott Proudfoot - Reconstruction Site



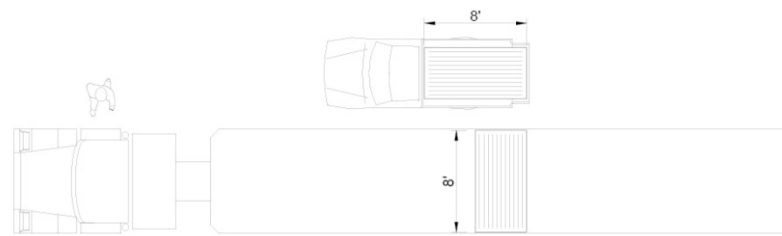
A standard sized module reduces offcuts.



Human liftable shape

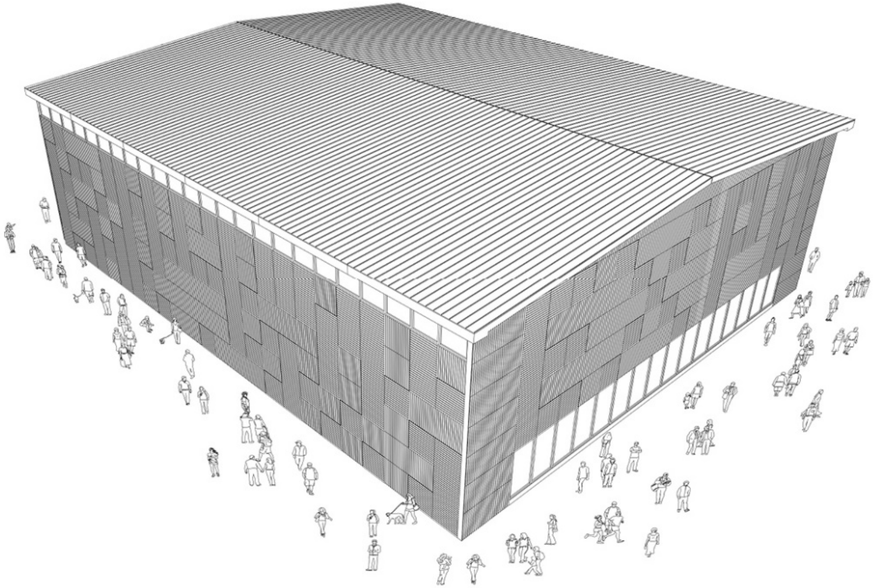


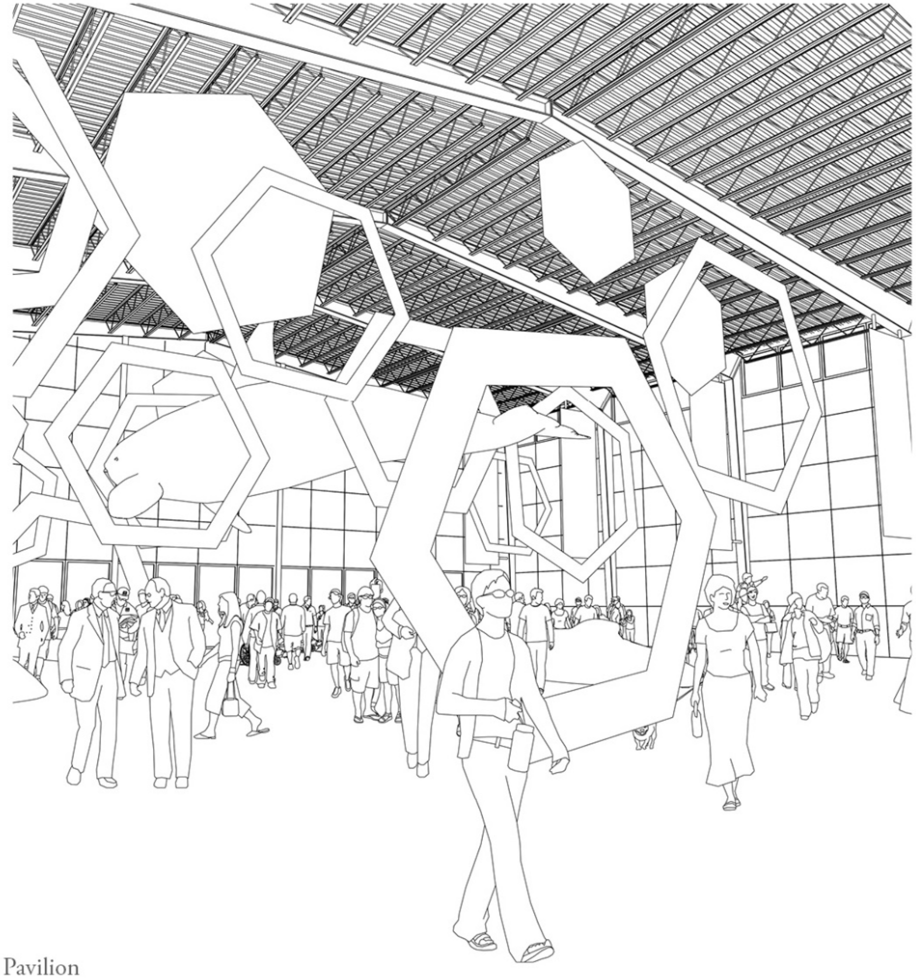
Reusable in other buildings



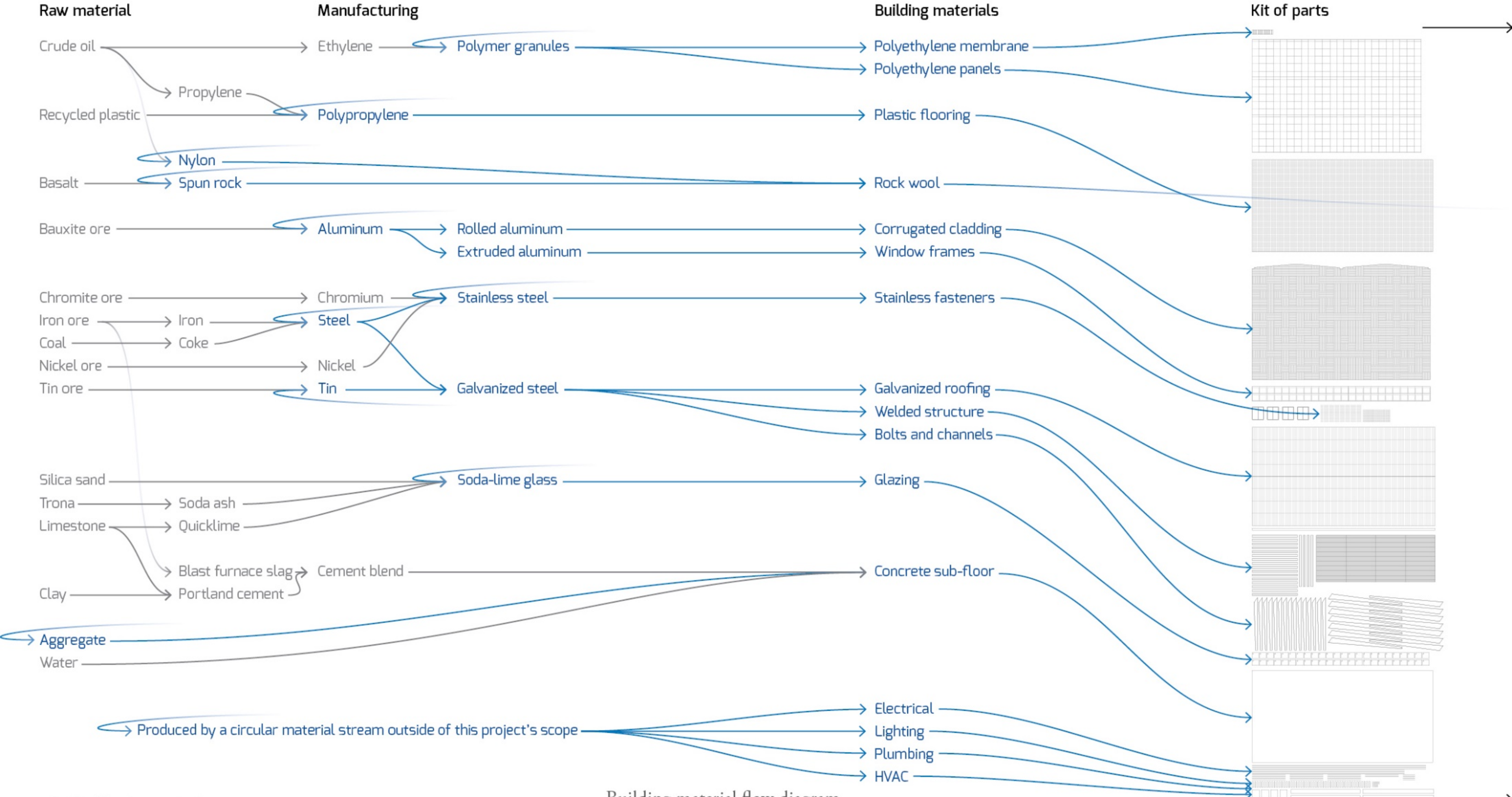
Standard size is easy to ship

Benefits of a generic module size



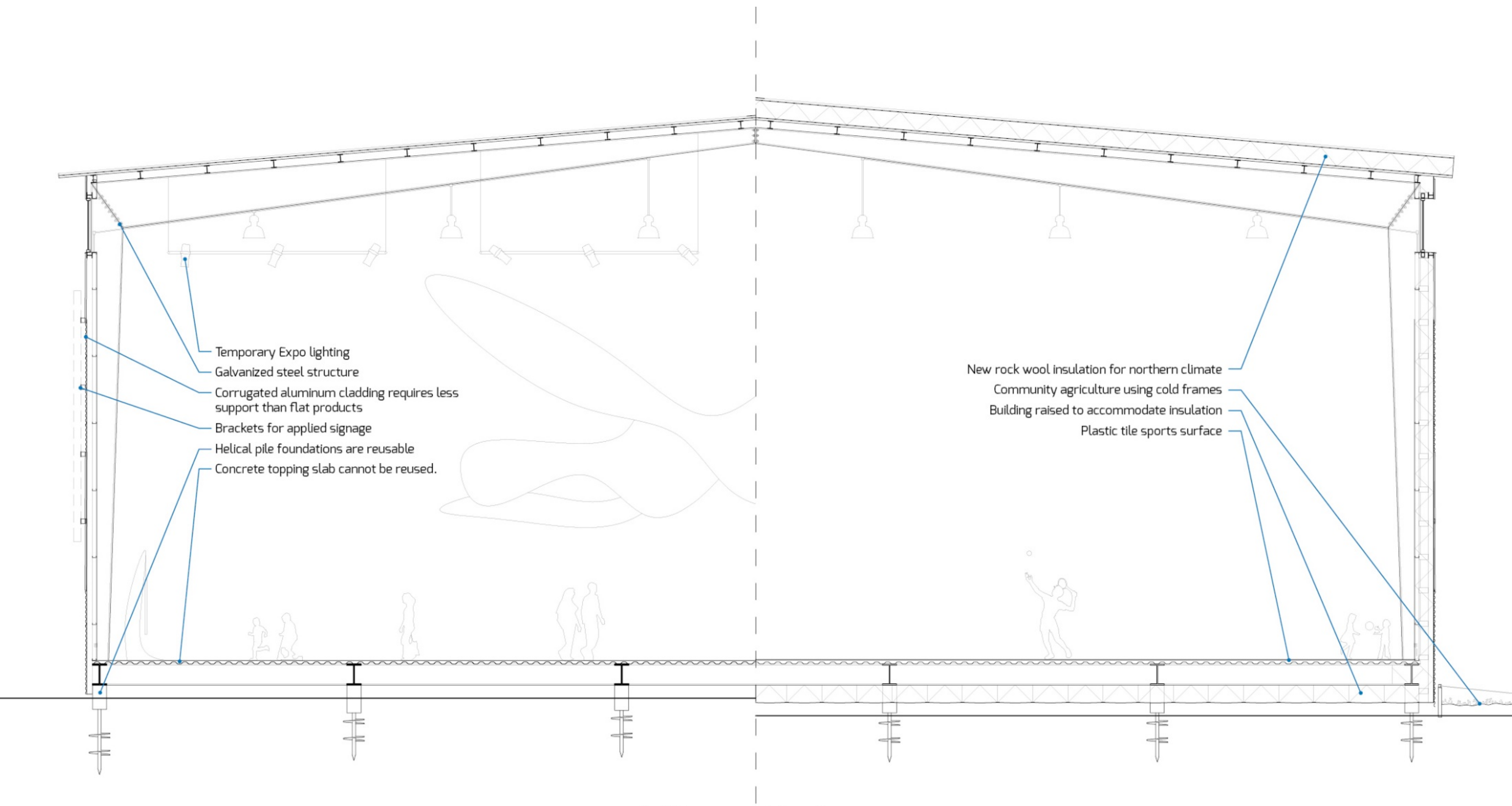


Recyclable Pavilion



Building material flow diagram

Scott Proudfoot - Reconstruction Site



Building material flow diagram

DfD - benefits

Designing for disassembly can have the following benefits:

- Facilitate maintenance and repair, thereby reducing costs.
- Facilitate part/component re-use, thereby recovering materials and reducing costs.
- Assist material recycling, thereby avoiding disposal and handling of waste.
- Assist product testing and failure-mode/end-of-life analysis.
- Facilitate product take-back and extended producer responsibility, thereby reducing liability and assisting in regulatory compliance.

source: http://dfe-sce.nrc-cnrc.gc.ca/dfestra/dfestra7/dfestra7_2_e.html

D f DISASSEMBLY – attempt to…

Factors, such as the life span of parts/components, their standardization, maintenance requirements, and instructions for servicing and re-assembly, play a major role in designing for disassembly. In general, designers should attempt to:

- Use detachable joints such as snap, screw or bayonet instead of welded, glued or soldered connections.
- Use standardized joints so that the product can be dismantled with a few universal tools, e.g., one type and size of screw.
- Position joints so that the product does not need to be turned or moved for dismantling.
- Indicate on the product how it should be opened non-destructively, e.g., where and how to apply leverage with a screwdriver to open snap connections.
- Put parts that are likely to wear out at the same time in close proximity so they can be easily replaced simultaneously.
- Indicate on the product which parts must be cleaned or maintained in a specific way, e.g., colour-coded lubricating points.

DfD- evaluate ease of disassembly

Evaluate the ease of disassembly. Consider assigning a weighting and scoring system to the list. *(based upon an industrial model – adapt to architecture…)*

What are the bonding and fastening methods of parts and components?

- insert moulding
- cohesion
- adhesion
- mechanical fastening
- friction fitting

What are the additional operations required for disassembly?

- fracturing
- drilling
- ungluing
- heating
- lubricating

What are the tools required for disassembly?

- special tool
- simple tool
- by hand

What is the tool motion required for disassembly?

- complex
- turning
- straight line

What is the level of difficulty for disassembly?

- technician needed
- assistant needed
- deformation required
- hold-down required
- heavy
- small
- resistant
- difficult access
- difficult to grasp
- difficult to view

What are the hazards during disassembly?

- chemical
- electrical
- sharp edges/corners

Where are the instructions for disassembly?

- provided integrally
- provided separately

Table I DFD design rules

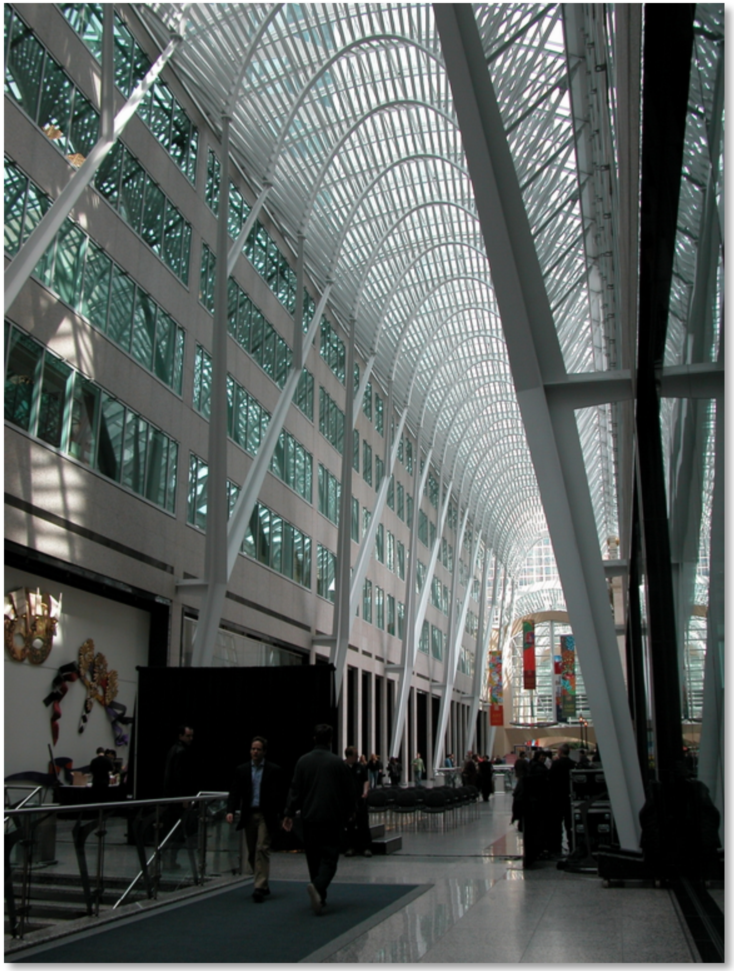
Factors affecting the disassembly process	Guides to improve disassembly
Product structure	Create a modular design
	Minimise the component count
	Optimise component standardisation
	Minimise product variants
Materials	Minimise the use of different materials
	Use recyclable materials
	Eliminate toxic or hazardous materials
Fasteners, joints and connections	Minimise the number of joints and connections
	Make joints visible and accessible, eliminate hidden joints
	Use joints that are easy to disassemble
	Mark non-obvious joints
	Use fasteners rather than adhesives
Characteristics of components for disassembly	Good accessibility
	Low weight
	Robust, minimise fragile parts
	Non hazardous
	Preferably unpainted
Disassembly conditions	Design for automated disassembly
	Eliminate the need for specialised disassembly procedures
	DFD with simple and standard tools

disassembling architecture

Utah School of Architecture – reinforced concrete

?

Is one of these inherently easier or better to disassemble?



BCE Place – structural steel