business-ecodesign tools

ECODESIGN METHODS FOR INDUSTRIAL DESIGNERS

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industrial designers society of america
environmental responsibility section

IDSA

integrating ecodesign in business

Product designers advise business managers how to best develop new products and services. Our intensive knowledge of the product development process gives us considerable leverage in influencing decisions that can significantly reduce the ecological impacts of our creations.

Achieving significant impact reductions challenges us on several levels. Identifying and prioritizing the diverse ecological impacts of a single product can seem a daunting task. Additionally, finding product managers and clients who welcome integrating ecodesign in their process can push some designers beyond our zones of comfort. Hurdles can be overcome by the promise of improving the competitive advantage of products, a promise realized by reducing environmental impacts and reducing short and long-term costs. On a deeper level, helping to protect the quality of life on our biosphere is profoundly satisfying.

Hurdles can be overcome by reducing environmental impacts + reducing product life-cycle costs.

Design competitions give us additional incentives to improve the environmental design quality. The prestigious IDEA awards, which become more competitive each year, weigh ecological issues on equal footing with other design qualities, while European competitions place yet a higher value on eco-optimization.

Before discussing ways to assess and reduce the ecological impacts, we briefly review how designers can pave the path towards integrating ecodesign in the product development process, for those of us in corporate settings and those in design consultancies.

Finding a sympathetic champion in upper management (the higher the better) is a wise approach, analogous to finding a patron to support a superior design concept. Marketing managers are prime candidates for recognizing the market pull that ecologically superior products create. Communicating genuine ecological benefits (as opposed to hype) in packaging and sales media is a key to connecting ecologically superior products with the market.

Marketing research should pose relevant ecological impact questions (energy use, battery alternatives, product life, etc.) to identify market opportunities. Positive market feedback is pivotal in motivating management to ask for and accept ecodesign advice.

You can propose the evaluation of a successful standard product to understand its environmental impacts. Eco-evaluations educate all members of the product development process about the impacts and opportunities of their products. Managers are often unaware of what an eco-evaluation is until someone hands one over in full detail.

Larger companies can enable designers to specialize in environmental issues, and participate in eco-design organizations or implement baseline environmental standards such as ISO 14000 norms (see ***references***, backcover).

Ecodesign within the structure of a corporation can be delicate and frustrating work, but small changes in business practice can yield tremendous reductions in ecological impact. Working within the organization, you can make the best of its tremendous power.

ecodesign in a corporation

Inform yourself about environmental policies if you work within a corporation. Larger companies typically employ environmental managers at each factory and often employ public relations specialists to communicate about issues ecological. Ask for the corporate mission statement and environmental policy relating to the design of new products and services.

Don't lose heart if policies are limited, in practice, to minimal legal requirements. Unless you have direct and influential contact with the people in the company who define such policies, it is probably more efficient to work with the positive parts of the policy than to apply pressure to change the policy.

ecodesign in consultancies

Consulting designers serve clients on a more independent basis than designers working within companies. This independence allows us to more freely discuss ecological impacts and market opportunities. Clients come to us for fresh ideas, and their ears are often open for suggestion.

Client relationships are like gardens; they demand time and cultivation. So if the client is initially cool to your proposals for ecologically superior products, discreetly propose a few eco-solutions anyway, and next year he may return asking for more 'green' ideas. Consulting eco-designers use our perceived naiveté about company policy to open doors that designers in the corporation often can not. Plant the seed in your clients mind and be patient. If only a few come around, they can still build the momentum for future projects.

Consultancies can propose ecological impact evaluations and reductions in new projects. Clients may shy away from acknowledging that their products have negative environmental impacts, and hence shy away from commitments to improve those impacts. It is essential to separate the eco-evaluation and creative solution process from the commitment to implement any given solution. This approach educates the client about their product and clarifies questions relating to usability, manufacturability, cost and market pull. Examples where products have benefited from the eco-evaluation assist immensely in assuaging these anxieties.

Ecological benefits will be most successful when integrated with excellent usability, visual appeal, reduced production cost and overall product innovation. Let the client make the decisions about which direction to take, and propose additional market research if major questions still loom about market receptivity.

As with designers in corporations, consulting designers should include relevant environmentally related questions in user research. Consultancies who conduct the research themselves can control the questions and search for solutions that fulfill the needs of both user and client. As always, making the connection with marketing about the ecological benefits is essential.

impact evaluation + reduction

Most product designers are all too familiar with meeting deadlines–*time* is something that we often wish for more of. Before reviewing ecodesign methods that strive for accuracy, we review approaches for designers who lack the luxury of time.

swift approaches

The following methods make no pretenses about accuracy, although their resulting solutions may, by chance, yield results similar to results of more comprehensive methods.

All ecodesign approaches require a reference product–the closest product to the one which you are designing–be it the major competitor in the market or an existing design that you are giving a face lift. Obtain a sample of the reference product and any available information about it from the manufacturer.

increase energy efficiency

The principal ecological impact of electricity production is global warming caused by CO_2 production; energy efficiency is important to any product that plugs into a wall socket, uses batteries, or burns fossil fuel. Determine how many hours per year that the product uses energy in its various modes, and how may watts it uses in those modes. For you non-electrical engineers, Amps x Volts = Watts, and Watts x (hrs/yr) = Watt-hrs/yr.

Consider ways that the electricity use could be reduced, such as a more efficient motor, insulation, automatic shut-off mode, etc. Ask the assistance of engineers if necessary. Recalculate the energy use with the improvement. A 20% reduction is excellent, and more is better. For contacts about the EPA Energy Star program, see the Energy Star web-site.

use recycled materials + design for recyclability

Recyclability is defined by materials and constructions that are technically possible to recycle, and that have an infrastructure to process and resell the used materials. Consider which materials can be readily recycled in your target markets. Steel, aluminum, glass and paper are often readily recycled, depending on the purity, quantity and ease of separation of these materials from the product. In some areas thermoplastic housings can be recycled as well. European Union laws are gradually requiring the collection of used electronics for disassembly, recycling and waste management.

Inspect your reference product for large, easily removed components made from recyclable single materials. How much work is it to separate the parts? Are the parts large enough (>2 ounces) to justify the cost of disassembly? Propose designs that make the large recyclable single material segments faster to disassemble. Additionally, specify high-recycled content and label material types in the new product components.

reduce toxic materials

Toxicology combines knowledge of chemical composition, dosage, background levels, and their multilevel effects on animals (including humans) and other biotic systems. It is beyond the realm of most industrial designers; however, we can follow a few basic guidelines.

Does the reference product create large quantities of chemical waste over its lifetime (disposable batteries, film waste, water emissions from metal plating, exhaust from fuel combustion, ozone layer destroying chemicals, etc.)? How can the same quality of product be delivered, that eliminates or significantly reduces these emissions? What market opportunities does this create?

extend product life

Estimate the period of time that the product is typically used before it is thrown away.

Can the reference product be redesigned to be more durable, upgradable or repairable? Find market feedback indicating whether or not a longer lasting, and possibly more expensive, product is desired. Dedication to quality and service can create a competitive advantage that allows the company to gain market share.

provide the service in an innovative way

Reflect on the primary service that your product delivers, and conceptualize possible ways that this service can be delivered with lower ecological impact. For instance, alternatives to automobiles include public transpor-tation and bicycles. The service of a television with a 30-inch cathode ray tube can also be had with a more energy efficient projection TV or LCD display. An alternative to the wasteful daily half-pound newspaper is accessing your most wanted news via the WWW.

Open minded product managers listen to fresh ideas, but don't expect them to transform their expectations, production systems and marketing inertia overnight. This conceptual approach demands solutions that intelligently address the many needs of the market and the product manager/client.

more accurate approaches

Ask an industrial designer about the ecological impact of that product she just finished contouring, and you may hear about the recyclability of the polymer, but not about the energy consuming electronics within. Ask the average guy in the check out line about the environmental impacts of food shopping, and he may offer the pro's and con's of paper verses plastic bags, avoiding mention of the impacts of food production and driving his car to and from the grocer. The examples reveal a core problem: the risks of subjectivity when assessing ecological impact. ***More accurate eco-analyses require more time than swift approaches but their results are significantly more useful.***

The most complete method of quantifying the inputs, outputs and environmental impacts of a product or service is a Life Cycle Assessment (LCA). An LCA is a standard process that evaluates material flow, to and from air, soil and water, throughout the product's life cycle. It includes the following phases:

We urgently need standardized international indicator factors.

- ***extraction*** of raw materials in the natural world (minerals, petroleum, wood, food, etc)
- ***processing*** of raw materials into usable products (metal structures, circuitry, glass, cuisine, assembled products, etc.)
- ***purchase & use*** of the product including repair (packaging, energy use and needed materials)
- ***end of life*** of the product and its by-products (landfill, recycling or incineration)
- ***transportation*** between and in each of these phases

In a complete LCA, chemical inputs and outputs in each material/process are quantified at each phase. Complete collections of these emissions are referred to as **life cycle inventories.** Conversion of an inventory into useful design information requires two additional steps:

1 ***NORMALIZATION OF DATA*** refers to scaling the quantity of the given emission to the estimated emissions from an average individual in a region or continent.

2 ***EVALUATION OF DATA*** scales the figure by weighting factors acording to the relative seriousness of different ecological impacts. These impacts include ecosystem impairment (from water pollution, acid rain, global warming, pesticides and habitiat loss), and also include mammal health impairment or death (from ozone layer depletion, toxic metals, carcinogens, smog and resource depletion).

International LCA evaluation standards are urgently needed. Because international standards do not yet exist, a European method, known as the Eco-Indicator, is an alternative. It offers the most usable method of LCA approaches.

eco-indicators

Eco-Indicators provide a simple process for product developers to comprehensively calculate the ecological impacts of products and services. The process requires that the total energy and material use of the product be defined over its lifecycle. The product elements are each quantified in relevant units and multiplied by their respective eco-indicator factors. The resulting numbers are eco-indicators, revealing which elements of the product create the most significant impacts and hold the greatest potential for impact reduction. The table on **page 6** lists publicly available eco-indicator factor values.

EXAMPLE pencil sharpener

Analyzing an electric pencil sharpener may clarify how the eco-indicator process works. To begin the process, its components are disassembled, weighed and materials identified. Energy use is estimated in Watt-hours/year and its projected life in years is estimated (7 years). The end of life destination in this case will be in a landfill.

Product **elements** are listed in the *first* column and their respective **eco-indicator factors** are listed in the *second*, and the product of their multiplication is listed in the right **eco-indicator** column. Keep in mind that the accuracy of the method is limited to two significant digits. By rounding at each calculation step, we maintain a consistent level of accuracy. Numbers with more than two significant digits are rounded to two digits (0.0147 rounds to 0.015 and 2,723 rounds to 2,700).

ELEMENT	QUANTITY	X	ECO-INDICATOR FACTOR	ECO-INDICATORS
PRODUCTION PHASE				
Housings - polycarbonate (PC)	0.69 lb	x	0.23/lb	0.16
EPDM elastomer	0.13 lb	x	0.16/lb	0.021
Injection mold PC	0.69 lb	x	0.02/lb	0.014
Steel - motor and screws	2.90 lb	x	0.05/lb	0.15
Magnetic metals in motor	0.06 lb	x	0.41/lb	0.025
PVC cable	0.25 lb	x	0.11/lb	0.028
Copper wire	0.19 lb	x	0.64/lb	0.12
Cardboard package	0.12 lb	x	0.031/lb	0.0037
PRODUCTION SUBTOTAL				*0.5217*
USE PHASE				
Transport - frieght ship	6.4 ton-mi*	x	0.0012	0.0077
Electrical energy 120 V	12.6 kWatt-hrs**	x	0.026/ kWatt-hr	0.33
USE SUBTOTAL				*0.3377*
END OF LIFE PHASE				
Landfill - PC	0.69 lb	x	0.0018 (estimate)	0.0012
Landfill - EPDM	0.13 lb	x	0.0020 (estimate)	0.0002
Landfill - Steel	2.90 lb	x	0.00064	0.0019
Landfill - PVC	0.25 lb	x	0.0013	0.0003
Landfill - Copper Wire	0.19 lb	x	0.010 (estimate)	0.0019
Landfill - Cardboard	0.12 lb	x	0.002	0.0024
Transport - Truck, 28 ton	0.176 ton-mi†	x	0.032	0.0056
END OF LIFE SUBTOTAL				*0.0145*
TOTAL ECO-INDICATOR POINTS				*0.8739*

** 4.4 lbs X 2900 miles x ton/2000 lbs. = 6.4 ton-miles*
*** 3 min./day x 5days/week x x 50 week/year x hour/60 minutes = 12.5 hours/yr. and 12.5 hrs./yr. x 7 years x 120 Volts x 1.2 Amp = 12.6 kW-hours*
† 4.4 lbs. x 80 miles x ton/2000 lbs. = 0.176 ton-miles

round to **0.87**

analysis conclusions

Eco-indicators (in the right column) indicate which product elements create the greatest environmental impacts. The three most damaging elements are electricity use (0.33 points), polycarbonate production (0.16 points), and steel part production (0.15 points). Now we can begin the creative process of generating new proposals that attempt to reduce ecological impacts

impact reduction concepts

PROPOSAL 1

The first proposal is to specify recycled content in the manufacture of the product and to recycle the product at end of life instead of burying it in a landfill. If we can specify 80% recycled content in all production materials, the eco-indicators would be reduced accordingly:

ELEMENT	20% PRIMARY + 80% SECONDARY			ECO-INDICATORS
PC	(0.2 x 0.69 lb x 0.23/lb)	+	(0.8 x 0.69 lb x 0.08/lb(est.)) = 0.011 + 0.028 =	**0.039**
EPDM	(0.2 x 0.13 lb x 0.14/lb)	+	(0.8 x 0.13 lb x 0.05/lb(est.)) = 0.004 + 0.005 =	**0.009**
Steel	(0.2 x 2.9 lb x 0.05 /lb)	+	(0.8 x 2.9 lb x 0.011 /lb) = 0.029 + 0.008 =	**0.037**
PVC	(0.2 x 0.25 lb x 0.11/lb)	+	(0.8 x 0.25 lb x 0.006/lb) = 0.006 + 0.001 =	**0.007**
Copper	(0.2 x 0.19 lb x 0.64/lb)	+	(0.8 x 0.19 lb x 0.091/lb) = 0.025 + 0.014 =	**0.039**
Cardboard	(0.2 x 0.12 lb x 0.034/lb)	+	(0.2 x 0.12 lb x 0.086) = 0.001 + 0.001 =	**0.002**

TOTAL ECO-INDICATOR POINTS >>>>>>>>>>>> ***0.139 round to*** *0.14*

Recycled EPDM is not available on the chart, so an estimated eco-indicator value of one half of the virgin material is used. ***We see that using recycled materials reduces the material impact from 0.52 to 0.17 (0.14 plus magnetic metals and PC processing), a reduction of 0.35 points!*** The impact of landfilling the existing design is roughly 0.003 points, and recycling would eliminate those points completely. If we add 80% recycled content in production to recycling at the end of life we achieve ***a 40% reduction,*** which is great.

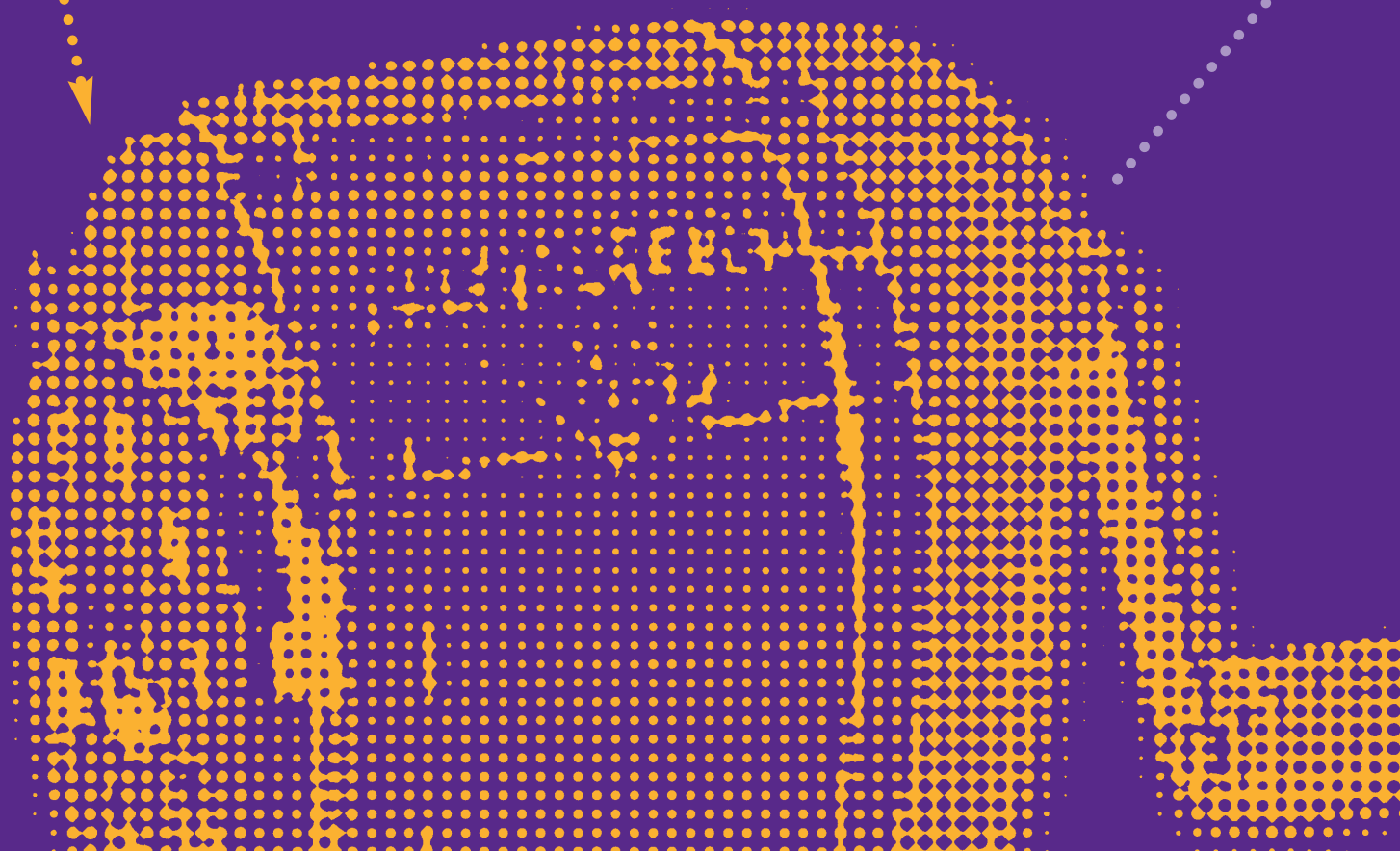
PROPOSAL 2

Another approach would be a non-electric pencil sharpener, with (for the sake of simplicity) the same quantity of plastic and metals as the original. It reduces the eco-indicator points by 0.33 points to 1.7 points, ***a 38% reduction.*** Most products use proportionately more electricity than this example and have greater potential for energy efficiency improvements. The superior environmental performance of such a sharpener can be highlighted in sales and promotional materials.

PROPOSAL 3

A more adventurous solution would be to use mechanical pencils that do not require sharpening, which would create ***a significant reduction*** in ecological impact. The reduction coul be calculated by modelling the mechanical pencils and packaging over the seven year period. The proposal could be a business strategy shifting towards production of mechanical pencils.

This example shows that the Eco-Indicator provides a way to compare the environmental impacts of various elements in a product. Although eco-indicator factors for many materials and processes need to be added to the list, and the values need to be calibrated to international norms, it is the most usable of available ecodesign methods.



eco-indicator factor table

PRODUCTION PHASE

POLYMERS

	eco-indicator point /unit
ABS	0.18/lb
HDPE	0.15
LDPE	0.16
PA	0.29
PC	0.23
PET - amorphous	0.17
PET - bottle	0.18
PP	0.15
PS (general)	0.17
PS - expandable foam	0.16
PS - high-impact HIPS	0.16
PUR - flexible foam or impact	0.22
PUR - rigid foam	0.19
PVC-high impact or rigid	0.12
PVC-flexible (without lead stabilizer)	0.11
PVDC teflon	0.20
PP - secondary	0.046
PS - secondary	0.012
PVC - secondary	0.006

ELASTOMER

EPDM, vulcanized	0.16

METALS

Steel	0.039/lb
Steel - low alloy	0.05
Steel - stainless	0.41
Aluminum	0.35
Copper	0.64
Lead	0.29
Nickel - enriched	2.4
Palladium - enriched	2,100
Platinum	3,200
Rhodium - enriched	5,400
Zinc	1.5
Steel - secondary	0.011
Aluminum - secondary	0.027
Copper - secondary	0.091

ASSORTED MATERIALS

Glass	0.025/lb
Ceramics - brick	0.013
Cement - not reinforced	0.025
Alkyd varnish	0.013
Mineral wool	0.025
Wood board - temperate	0.34
Wood - endangered tropical	AVOID
White Paper	0.044
Cardboard	0.031
White paper - secondary	0.029
Cardboard - secondary	0.0086

POLYMER PROCESSING

Injection mold PE, PP, PS, ABS	0.0095/lb
Injection Mold - PVC, PC	0.02
Reaction injection mold, PUR	0.0054
Extrusion blowing PE	0.00095
Ultrasonic Welding	0.00003ft
Vacuum Forming	0.0041/lb
Vacuum Pressure Forming	0.000003/lb

STEEL PROCESSING

	point /unit
Pressing, deep drawing	0.00001/lb
Rolling	0.000002/ft^2
brazing	0.0018/braze
Zinc coating	0.000005/yd^2-μm
Band zinc coating	0.0004/ft^2
Hot galvanizing	0.00031/ft^2
Electrolytic galvanizing	0.000012/ft^2
Electrolytic chrome plate	0.0009/yd^2-μm

ALUMINUM PROCESSING

Extrusion	0.032/lb
Spot Welding	0.0027/weld

USE PHASE

Electricity, 120 - 360V	26/kW-hr
Gas Heat	5.4/MJoul
Oil Heat	5.6/MJoul
Solar electricity, monochrystaline	7.2/kW-hr
Solar electricity, polychrystaline	10/kW-hr

END OF LIFE PHASE

LANDFILL

Glass	0.00064/lb
PE, PP, PS	0.0018
PVC, PVDC, PET	0.0012
EPS foam	0.0034
PUR foam	0.0044
Paper	0.002
Steel , aluminum	0.00064

INCINERATION

Glass	0.0023/lb
PE	- 0.0086
PP	- 0.0059
PET	- 0.0029
PS	- 0.0024
PUR foam	0.0013
PVC	0.017
PVDC	0.03
Paper, cardboard	- 0.0054

RECYCLING

All	0/lb

TRANSPORT (ANY PHASE)

Delivery van	0.20/English ton-mi
Truck - 16 ton	0.050/Eng.ton-mi
Truck - 28ton	0.032/Eng.ton-mi
Truck - 40 ton	0.001/Eng.ton-mi
Passenger car	0.058/Eng.ton-mi
Train	0.0057/Eng.ton-mi
Ship - frieght, oceanic	0.0016/Eng.ton-mi
Ship - liquid tanker, oceanic	0.17/Eng.ton-mi
Aircraft - 737 - continental	0.12/Eng.ton-mi
Aircraft - 747 - intercontinental	0.11/Eng.ton-mi

data source:

Eco-indicator '99
Manual for Designers
2nd edition 17 April 2000
Goedkoop, Effling & Collignon
Pre' Consultants, Amersfoort, NL

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If you would like to participate in the Environmental Responsibility Section or if you have questions about the application of Business-Ecodesign Tools, please contact the Section Chair, Philip White.

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