

Five Steps to Eco Design



**Improving the Environmental
Performance of Products through Design**

GRANTA

FIVE STEPS TO ECO DESIGN

Improving the Environmental Performance of Products through Design

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Introduction

Considering the environmental impacts of a product as part of the design process is a relatively new concept for many companies. Getting to grips with this topic can seem like a daunting challenge if you start to explore the complexities of Life Cycle Assessment (LCA) and carbon footprinting, the bewildering array of eco labels and standards currently in use, and the huge variety of environmental issues that you could choose to address.

This *Guide* aims to provide a simple introduction to the topic of eco design. We start with some of the drivers for eco design: these will help you evaluate the business case for investing in this area if you are undecided, or could help you gain wider support within your organization for eco design initiatives. In Section 2, drawing on our practical experience of helping companies to implement eco design activities and tools, we present some of the challenges organizations often face when starting out in this area. In Section 3, we share five simple and practical tips that can help you and your organization to implement eco design, whether you are a designer, engineer, environmental specialist, or someone involved in the management of product design or development. We then introduce the Granta technology that can be used to support your eco design activities (in Section 4), before summarizing the key points for incorporating environmental sustainability into product design in Section 5.

1. Business Drivers for Eco Design

Whatever stage you and your company are at in considering sustainable design, it is important to be clear on two things: the business drivers for eco design; and the potential value to the company of investing in eco design. The specifics and the overall strength of the business case for eco design will vary from market to market and from company to company so, as you read through the following list of commonly cited drivers for eco design, try to consider whether any are relevant to your company. If so, *which are the most important?*

Table 1: Summary of business drivers for eco design

A	• Product marketing, brand value, and Corporate Social Responsibility
B	• Legislation on energy and hazardous substances
C	• Cost & supply-chain management
D	• Stimulus for innovation

A. Product marketing, brand value, and Corporate Social Responsibility

Making claims about the environmental performance of operations or products is a double-edged sword for many companies. Such claims may help to increase sales, share prices, and brand value if they address environmental issues that are: of concern to customers, analysts or Non-Governmental Organizations (NGOs); are based on solid scientific evidence; and can be independently verified by interested third parties. However, if environmental claims fail to meet any of these criteria, then companies risk being accused of 'green washing'—making unsubstantiated environmental claims or using environmental marketing on certain topics to gloss over less flattering environmental issues for the company. The simplest answer would appear to be to make no environmental claims at all. However, this in itself can damage a company's brand or share value due to the rising expectations of investors and other stakeholders in relation to Corporate Social Responsibility (CSR) reporting, increasing scrutiny from NGOs, and pressure from competitors.

If you do choose to report on the environmental performance of your product, there are number of well-respected eco labels against which you can report (Figure 1). Some, such as the Carbon Trust's product carbon footprint label (1) (measured according to PAS 2050 (2)), require you to calculate and report on the environmental impacts of your product, but do not set any minimum performance requirements. (However,

applying the Carbon Trust label does at least commit you to reducing that footprint over the next two years). Other standards, such as EPEAT for IT equipment (3) or the EU Blue Angel mark (4), do set minimum performance targets that must be satisfied and verified before you can apply the label. For further guidance on making environmental claims see the recently revised guidance notes by the US Federal Trade Commission (5).



Figure 1: Just some of the eco labels available.

B. Legislation on energy and hazardous substances

The introduction of environmental legislation is probably the most common driver for companies to initiate eco design activities. The Integrated Product Policy (6), adopted by the European Union in 2003, has given rise to a number of significant pieces of product-focused environmental legislation that affect many types of product sold within the EU. Table 2 gives other examples from across the US, Asia, and Europe. As well as government laws and regulations, industry associations and NGOs are introducing standards, policies, and substance watch lists in an effort either to influence the regulatory framework, or to help companies keep track of a complex, globalized picture. Moreover, the challenge is not just one of geographical range—these legislations, regulations, and standards now cover the entire lifecycle of the product, from the substances that go into its manufacture through to the way that it is managed at the end of its useful life.

Table 2: Examples of issues now affected by legislation

Lifecycle energy consumption of the product	EU Energy-related Products (ErP) Directive
	Forthcoming Grenelle 2 regulations in France
Use of hazardous substances	EU Registration Evaluation & Authorisation of Chemicals (REACH) Directive
	California Green Chemistry Initiative
	EU Restriction of Hazardous Substances (RoHS) Directive
	'China RoHS'
	Norwegian PoHS
Use of batteries	US Toxic Substances Control Act (TSCA)
End-of-Life strategy for the product	EU Batteries Directive
	EU Waste Electrical and Electronic Equipment (WEEE) Directive
	Japanese Household Appliance Recycling Law (HARL)
	EU End of Life Vehicles (ELV) Directive

C. Cost & supply-chain management

Legislation may be forcing you to consider eco design, but there can also be clear cost benefits. By taking an eco design perspective *during the design of a product*, companies often find that they are able to reduce the manufacturing costs of a product because they reduce materials and energy usage, as well as eliminating waste.

When the major environmental impacts of a product are related to a sub-system or component that is designed and manufactured by a supplier, eco design can provide a good opportunity to engage with these suppliers. This may result in a leaner, more cost-effective supply chain. This is certainly an ambition of companies such as Wal-Mart and Procter & Gamble who have begun extensive supply-chain reporting initiatives (7). These companies are asking suppliers to report on environmental issues such as energy usage, water usage, and CO₂ emissions. These data are then used to benchmark supplier performance and identify the environmental hotspots in their supply chain. Thus their eco design actions are reducing costs.

D. Stimulus for innovation

Companies can also discover opportunities for innovation when they consider the environmental impact of their products. For instance, Lightweight Medical (8) developed the award-winning LINT transport incubator: the use of carbon-fibres makes it >50% lighter than existing models, enabling easier movement and reductions in associated transport emissions. The Dyson 'Airblade' hand dryer uses high-efficiency electric pumps to force air through specially designed apertures that 'cut' water off the hands of the user as they slowly lift their hands out of the drying chamber. By blowing the water off the hands rather than trying to evaporate the water off as conventional hand-dryers do, Dyson claims that the Airblade requires ~77% less time and uses up to 80% less energy to dry hands (9). So designers and producers can deliver both functional benefits *and* environmental benefits. A simple analysis tool that can help you to identify this type of win-win innovation is the BEC Diagram (10).

2. The Challenge of Implementing Eco Design

How companies have typically responded to eco design drivers

If your company has decided that the business case for eco design is sufficiently strong to merit action, the first task is to establish what type of response is appropriate. To date, many companies have focused on reporting environmental performance and assessing the compliance of products against environmental regulations or standards. Initially, many of the environmental marketing claims made about products were based on limited evidence, or in some cases were misleading. This resulted in a backlash from environmental NGOs and consumer groups, who demanded greater transparency in these environmental claims.

Guidance is now available on how to conduct a Life Cycle Assessment (LCA) and how to communicate the results: standards such as the ISO 1404X (11) and ISO 1402X (12) series have helped to improve significantly the quality and transparency of environmental marketing claims. Conventional LCA methods and technology, with their focus on very detailed analysis of environmental impacts of existing products, are by far the best-known class of tools for analyzing environmental impacts. Similarly, the focus in considering the impact of regulations such as REACH has been on reporting the compliance of finished products. The downside of these approaches is that they are aimed at use late-on or after the design process, and are too data- or effort-intensive to be adapted for use in an iterative manner early in design. They are thus of limited use in making practical improvements to environmental performance for the current generation of a product.

Currently, the idea of addressing environmental impacts during design is in its infancy. It is seen as the preserve of dedicated eco specialists or consultants alone: they often find it hard to engage engineers and designer across the company in improving product sustainably. This Guide is based on the belief that to improve the environmental performance of products we need to embed practical eco design tools and approaches early in the regular design process.



"To improve the environmental performance of products we must embed practical eco design tools and approaches early in the regular design process."

The challenges

Before considering how to achieve this goal, it is worth asking why eco design is not already integral to the routine design process.

Limited time

Environmental impacts are just one of many constraints a designer must consider during product development. Designers are constantly battling to balance often conflicting project requirements such as functional performance, cost, aesthetics, regulatory compliance, and lead-time. Eco design adds yet another issue to consider and so, generally, only a very limited amount of time and effort can be spent on it.

Poor integration with design activity

When eco design activities are treated as a separate stream, distinct from mainstream product development activities, they struggle to gain acceptance and quickly become marginalized. This is compounded by the fact that companies often employ environmental experts, either as consultants or as part of an Environment, Health & Safety (or similar) team, to consider environmental performance and undertake environmental assessments. If the environmental expert is not in regular contact with the design team the results of their analysis can often be ignored, either because the analysis is not presented in a way that is accessible and useful for designers, or because there is little follow-up to ensure that the analysis leads to design improvements.

Increasingly complex and rapidly developing legislation

As we saw in Section 1B, product-focused legislation, regulations, and standards are becoming increasingly complex and demanding. Simply keeping track of their potential implications is a major information technology challenge that most companies have not begun to address. Take two examples:

- The Energy-related Products Directive, which provides a framework for setting eco design targets for products such as high definition televisions, is a requirement for CE-marking in the EU. But the range of products affected is expanding and the 'implementing measures' set targets that become more stringent over time – how do product development projects keep up-to-date?
- The REACH Directive's list of Substances of Very High Concern (SVHC) currently contains 44 substances. But this list will be updated roughly every six months, with approximately 25 substances being added every year. These substances may be present, or used in the processing of, thousands of material grades and coatings. As the list develops, how does a company gather substance declarations from suppliers and continually assess the risk across its product portfolio?

Designers' requirements not considered

To improve the environmental performance of a product you first need to understand when and where the environmental impacts occur across the product lifecycle. The primary tool for building this understanding is Life Cycle Assessment (LCA). Unfortunately, many of the commercially available software packages that enable LCA studies have been developed with LCA practitioners in mind, requiring an expert knowledge of the LCA methodology to conduct the analysis and interpret the results. Most designers and engineers do not possess this knowledge, which creates a major barrier to implementing eco design. Furthermore, LCA software is unsuitable for use during the early stages of the design process because it often requires detailed information about how the product is manufactured and used, and the input of data that is unfamiliar or unavailable to designers.

Lack of commitment / fear of cost

Design teams are sometimes reluctant to begin eco design activities because of concerns about the true level of commitment behind their company's rhetoric about wanting to improve a product's environmental performance. This may be because, until recently, companies have perceived eco design as a 'nice to have' capability. As they begin to investigate the manner in which eco design is typically implemented in today's manufacturing organizations, they are overwhelmed and quick to dismiss it as being an unnecessary and costly activity.

3. Five steps to get you started

In the remainder of this *Guide*, we provide five simple tips that aim to help you to overcome these challenges and enable you to introduce eco design activities within your existing design process in a cost-effective and manageable manner. These are drawn from our experiences (13) and from study of other publications offering advice on how to implement eco design activities (see, for example (14), (15), and (16)).

The top tip for *everyone* involved in eco design

Tip 1

Consider environmental impact early in the design process

It is widely claimed that 80% of a product's overall environmental impact has been 'built in' by the end of the conceptual design phase (Figure 2). At this point, the designer has typically selected materials and manufacturing processes, and defined the product lifecycle: these constrain not just the final economic cost but also fix many of the environmental costs.

By evaluating environmental performance during this early stage, the relative environmental costs of different options can be considered, in much the same way as economic costs or material suitability would be evaluated. This enables changes to the design before significant project costs have been incurred, and avoids costly and time-consuming redesign.

Committed Environmental Impact

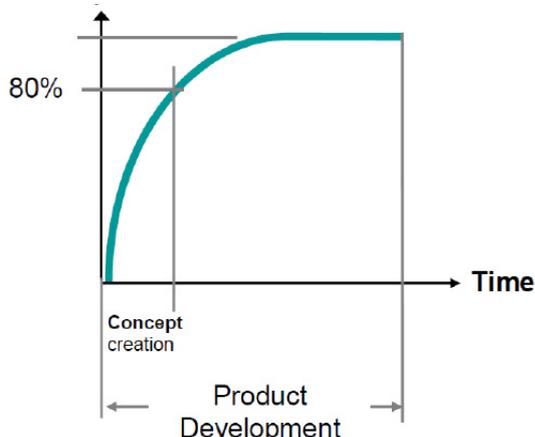


Figure 2: Illustration of design process against percentage of environmental impact fixed

Three tips for designers, engineers, and materials engineers

Tip 2

Imprecise data can guide good decisions

Engineers and designers, used to the precision with which physical properties are measured, can be disconcerted by the imprecision of eco-data where values are, at best, known to within 10%, and often with less certainty (20). However, it is important to realise that this does not prevent good decision-making, especially when the environmental impact of a particular life-phase dominates.

For example, when selecting materials, the difference between those with really large and really small values of embodied energy or CO₂ footprint can often be a factor of 1000 or more, so the imprecision still allows firm distinctions to be drawn (Figure 3). When the material-phase differences are small, other factors such as the recycle content of the material, its durability (and thus life-time), and the ability to recover and recycle scrap at end of life are more significant in making the selection.

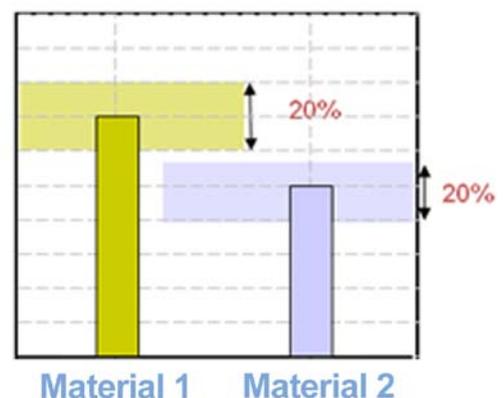


Figure 3: Firm conclusions can be drawn about the environmental impact of a material, even with imprecise data

Tip 3

Consider the entire product system

Environmental performance is often significantly affected by how the user interacts with a product, how it is maintained, the operating environment, and whether it is indeed the correct product for the user's needs. Creativity methods such as the 9-Windows diagram (10) can help to promote thinking about the wider system in which a product will be used, optimizing the eco design for the product's final use.

One example of such thinking is to ensure that the design process considers the environmental impact of all phases of a product's life – material, manufacture, transport, use, and disposal (Figure 4). This encourages designers to invest greatest effort in improving the environmental sustainability of the phases that carry the highest demand for energy or generate the most CO₂. Doing this in the early stages of design will yield the maximum return on investment.

Tip 4

Materials and process decisions are critical to environmental impact and eco design

Material and process decisions play a very important role in determining the environmental impacts of a product across the lifecycle because:

- *Extraction & processing* of raw materials carries significant environmental impact
- *Materials choice* determines feasible manufacturing processes and associated energy and material efficiency
- *Material mass* can greatly influence energy consumption and CO₂ emissions in transport and use phases
- *The substances used in materials and their recyclability / reusability characteristics* determine toxicity, restricted substance impacts, and the impact of a product at the end of its life

Some key strategies for minimizing environmental impact of each life-stage are shown in Figure 4: many relate directly to materials characteristics. A critical point is that you cannot base "eco materials selection" simply on the "eco properties" of the constituent materials, such as embodied CO₂, recycled content, or toxicity. You need to assess these properties in combination with mechanical, physical, thermal, and electrical properties.

For example, when reducing CO₂ emissions, it may be better to make a vehicle body out of a lightweight material such as a carbon fiber composite *even if* this raises the CO₂ emissions associated with the material production and manufacturing phases: the lower mass is likely to lead to a large reduction in use phase CO₂ emissions and hence an overall improvement.

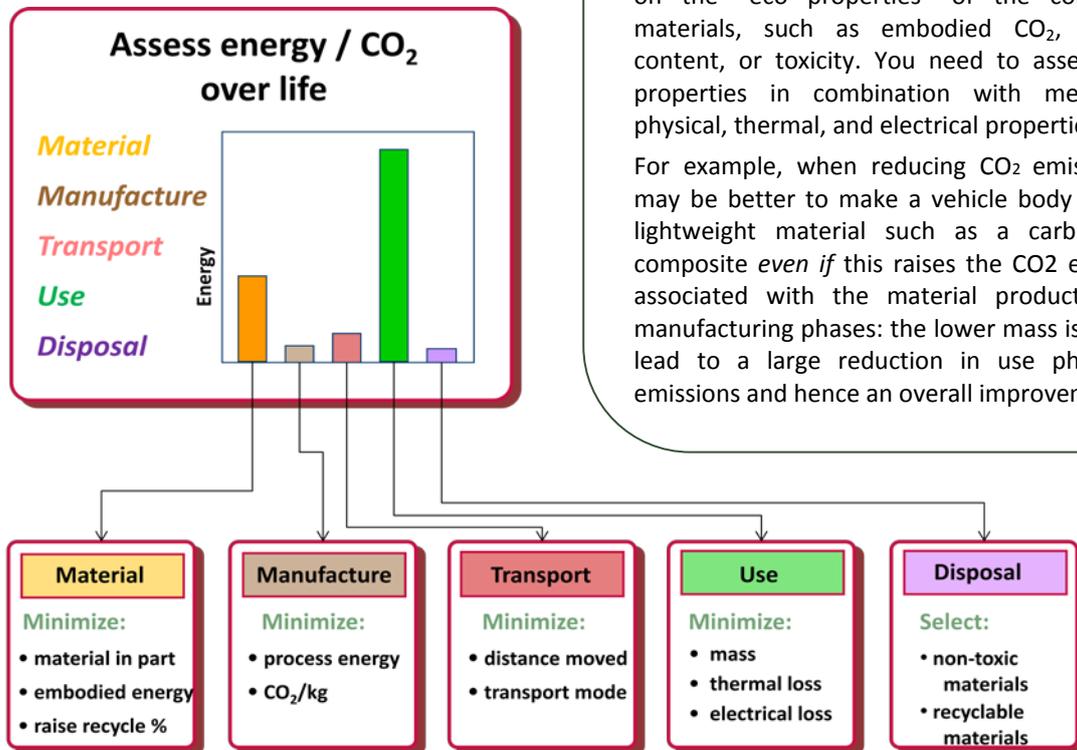


Figure 4: Environmental impact can be assessed for each life-stage of a product (Tip 3). Materials and process selection play an important role in determining environmental impacts and can be used in many eco design strategies (Tip 4.)

The top tip for those involved in managing product design and development

Tip 5

Establish targets and the information systems to support them

Companies that have successfully implemented eco design often have long-term, corporate-level targets for improving environmental performance. For instance, in 2010, Philips (19) set a range of corporate-level, environmental goals to be achieved by 2015. These include:

- Improve energy efficiency of Philips products by 50% compared to 2009
- Double global collection, recycling, and recycled materials in products in the same period

Setting this type of target has two effects: it demonstrates the company's long-term commitment to environmental performance and it establishes a framework within which targets can be set at the project level. Some companies have found it effective to 'cascade' these targets to the project level by including environmental impact reduction targets within product requirements specifications. This is because designers use product requirements to focus their design effort and assign design time.

Defining targets helps to develop the right behavior in an organization. But delivering on those targets requires the right information. Consider the challenges of legislation raised in section 2. Meeting these requires an organization to track the effect of regulations, laws, and standards on its products. In the light of our Tip 4, this often means ensuring access to up-to-date information on the restricted substance or other environmental impacts of specific materials and process choices. Executives should not only set targets, but ask "what systems do we have in place to enable informed materials and process decisions?"

4. How Granta technology can support your eco design activities

Granta's core expertise in materials and process selection and materials information management, together with our understanding of the challenges of eco design (17), has allowed us to develop a range of practical eco design software tools complete with supporting materials and environmental data. They are designed to be used during the early stages of design—where changing the material and process choices costs least but matters most (Figure 5).

A	•Assessing environmental impacts
B	•Improving environmental performance
C	•Deploying and applying restricted substances information
D	•Materials and environmental data
E	•Integration with engineering and business software

Table 3: How Granta's software can support your eco design

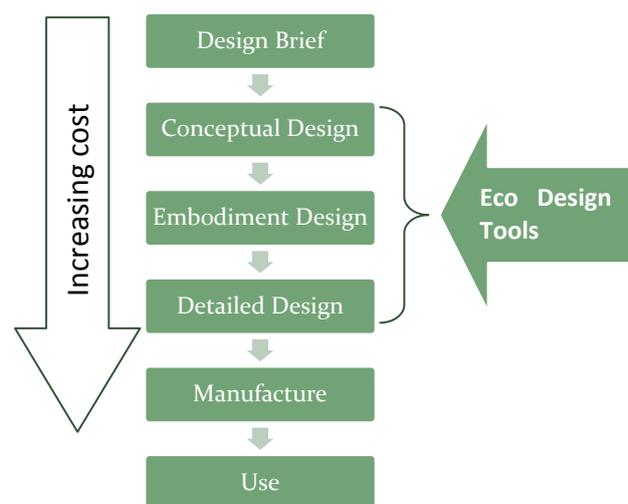


Figure 5: Granta's Eco Design tools meet the need for assessing environmental impact during design

A. Assessing environmental impacts

Granta's Eco Audit Tool provides a quick and interactive means to determine the factors that make the greatest contribution to a product's environmental impact, and to make materials and process choices that minimize this impact.

This rapid assessment helps engineers and designers to focus their efforts on the most significant life phases in the product lifecycle. They can experiment with 'what-if' scenarios during the early stages of design, before time has been spent and funds have been committed (see Tip 1).

A simple user interface enables quick input of key information about the product—the materials and processes used, its transport, and use. This helps consider the entire life cycle of the product (see Tip 3), as well as clearly see the effects of material and process decisions (Tip 4).

The tool produces graphs (Figure 6) and tabular data of energy usage and CO₂ footprint. The focus is on ease-of-use and speed. Accuracy is sufficient to drive key design decisions – e.g., substituting materials to reduce weight, or to cut embodied energy (see Tip 2).

The Eco Audit Tool can be delivered as standalone PC software or used via a web browser.

Eco audit technology can also be embedded within CAD and other engineering software systems (Figure 9), letting designers instantly see the relative merits of their material choices.

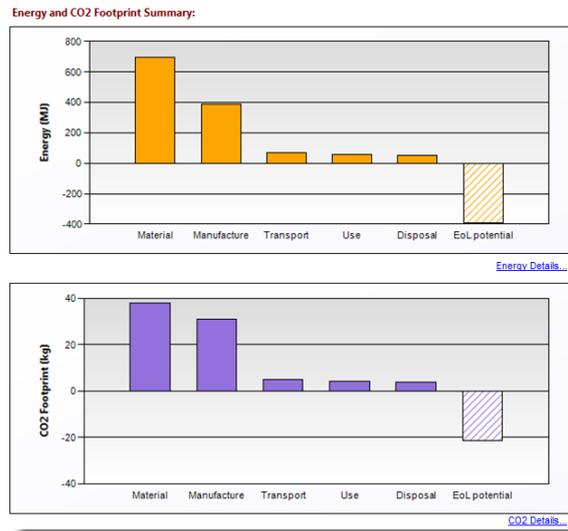


Figure 6: Sample Eco Audit output graph for embodied energy (top) and CO₂ emissions (bottom). In this case, showing materials production (first column) is the dominant lifecycle phase, followed by manufacturing (second column)

B. Improving environmental performance

Granta have long provided powerful selection and substitution tools through the PC-based CES Selector™ software and the enterprise-wide materials information management system, GRANTA MI™. During design (Tip 1) engineers and designers can search and browse materials data, including economic and environmental properties, and then combine and use that data in rational materials selection (Tip 4) through tools such as Ashby diagrams (Figure 7). Such tools ascertain which materials meet the constraints of your application, rank materials against design objectives, and investigate tradeoffs (18). If these tools suggest new material and process options, the Eco Audit Tool makes it easy to test the environmental impact of those changes.

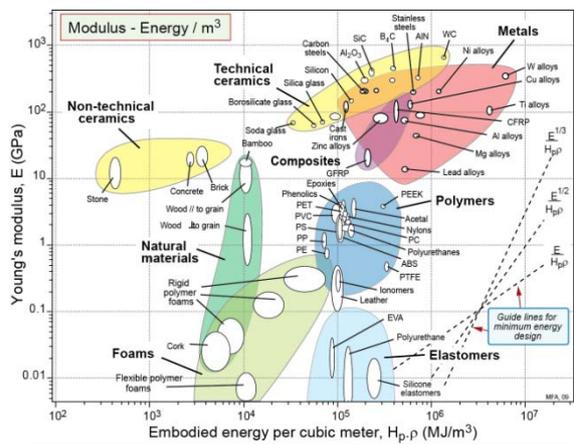


Figure 7: Ashby diagram showing embodied energy versus Young's modulus plotted using CES Selector

C. Deploying and applying restricted substances information

Granta’s restricted substances solution is a package of software and data that leverages the GRANTA MI materials information management system, enabling you to assess, manage, and ‘design-out’ risk due to restricted substance regulations. A regularly-maintained information resource tracks over sixty global legislations, regulations, and industry standards and their current or future impact on thousands of substances. Through the GRANTA MI system, a company can link this information to data on its own materials, processes, and coatings. Desktop tools allow designers, engineers, materials experts, and compliance staff to quickly answer questions such as “which at-risk substances are present in our products?”, “is this design at risk from materials obsolescence due to regulatory impacts?”, or “what material could I substitute here so that no restricted substances are involved in the manufacture of my product?” These tools can be delivered within routine engineering workflows via a web browser user interface (Figure 8) or from within engineering, PLM, or ERP software (Section 4D, below). Thus information is available when and where it is needed to support good decision-making.

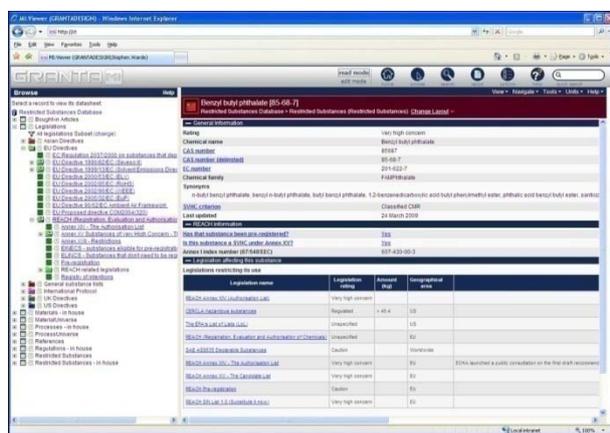


Figure 8: GRANTA MI web browser user interface – viewing information on which legislations impact a specific substance.

D. Materials and environmental data

The tools described above all require the right data. Granta not only embeds this data within its eco assessment, materials selection, and restricted substance software, it also provides it as a unique series of reference data modules (Table 4), enabling users to search and browse to find specific information. All data is compiled and reviewed by subject experts from some of the best sources available – details of data sources are provided within the data modules.

Table 4: Granta’s Eco Data Series, providing up-to-date material, process, economic, and environmental reference data

Data module	Content summary	Attributes and properties
MaterialUniverse Eco Data	Generic property data on 3,500+ engineering materials and 240 processes – complete and normalized allowing comparison and selection for metals, ceramics, polymers, composites, and natural materials	For each material: sixty engineering properties, 25 eco properties (e.g., energies, emissions, end-of-life), plus cost data
Restricted Substances	Covers 6,000 substances and over 60 national and international regulations, legislation lists, and industry standards that impact those substances. Updated quarterly, ensuring the latest information.	Substance records provide property information and links to relevant regulations. Legislation record describes the regulation and links to records for affected substances.
Coatings	Describes 100+ coatings and surface treatments – helps decisions, particularly relating to restricted substances	Over sixty attributes per coating: e.g., mechanical properties, restricted substances, cost, substitution

E. Integration with engineering and business software

A key concept throughout this *Guide* has been embedding environmental considerations into the routine design process, as early as possible. One obvious way to do this is to provide practical eco design tools within routine engineering and business software—for example, within CAD systems. The GRANTA MI:Materials Gateway technology enables this. It allows Granta to integrate tools into third party software, with those tools able to connect to and use materials, process, and environmental data stored in a database hosted by the GRANTA MI system on a corporate network or the Internet. In principle, this allows all of the tools and data described in sections 4A-4D to be provided within the user’s favored design environment.

An example of this technology in action is the Eco Materials Adviser in the Autodesk® Inventor® CAD system. Announced in March 2011, Eco Materials Adviser is based on the Granta eco audit technology described above. The user can search and browse a database of materials and processes, apply these to parts within their model, and instantly generate an eco impact dashboard (Figure 9). The effect of changes to the model or materials assignments can be explored interactively. GRANTA MI offers integration with other CAD and PLM systems—contact Granta to discuss your preferences.

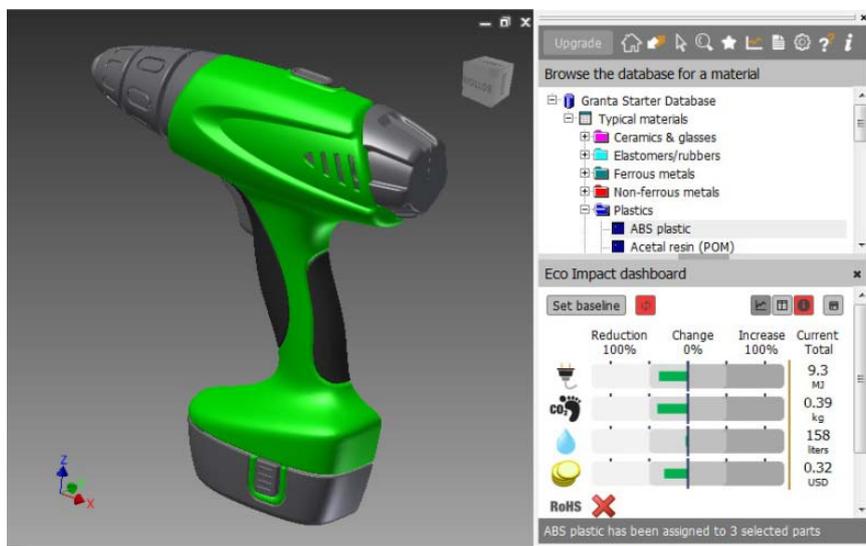


Figure 9: The Eco Materials Adviser tool delivers the Eco Audit technology within Autodesk software

5. Summary

This guide has provided an introduction to the topic of eco design. We began by discussing some of the commonly cited drivers for eco design: it is crucial to develop a sound business case by identifying which of these drivers are relevant for your company. Having acknowledged the challenges commonly encountered, we went on to offer five simple tips to help you achieve your eco design goals (Figure 10).

For everyone	For designers, engineers, materials engineers			For managers
Tip 1	Tip 2	Tip 3	Tip 4	Tip 5
<ul style="list-style-type: none"> Consider environmental performance early in the design process 	<ul style="list-style-type: none"> Imprecise data can guide good decisions 	<ul style="list-style-type: none"> Consider the entire product system 	<ul style="list-style-type: none"> Materials and process decisions are critical to environmental impact and eco design 	<ul style="list-style-type: none"> Establish targets at the information systems to support them

Figure 10: Granta’s tips giving you the Five Steps to Eco Design

Granta provides a series eco design tools help you to implement these tips. These tools are:

- Practical, simple, and quick to use
- Integrated into the environment of the people who need them (e.g., designers)
- Connected to and leveraging corporate materials, process, and substance information
- Able to help users optimize material and process selection
- Designed for rapid iteration and exploration of “what-if” scenarios
- A complement to full LCA approaches

Figure 11 summarizes how our tips and tools help to meet the challenges identified in Section 2:

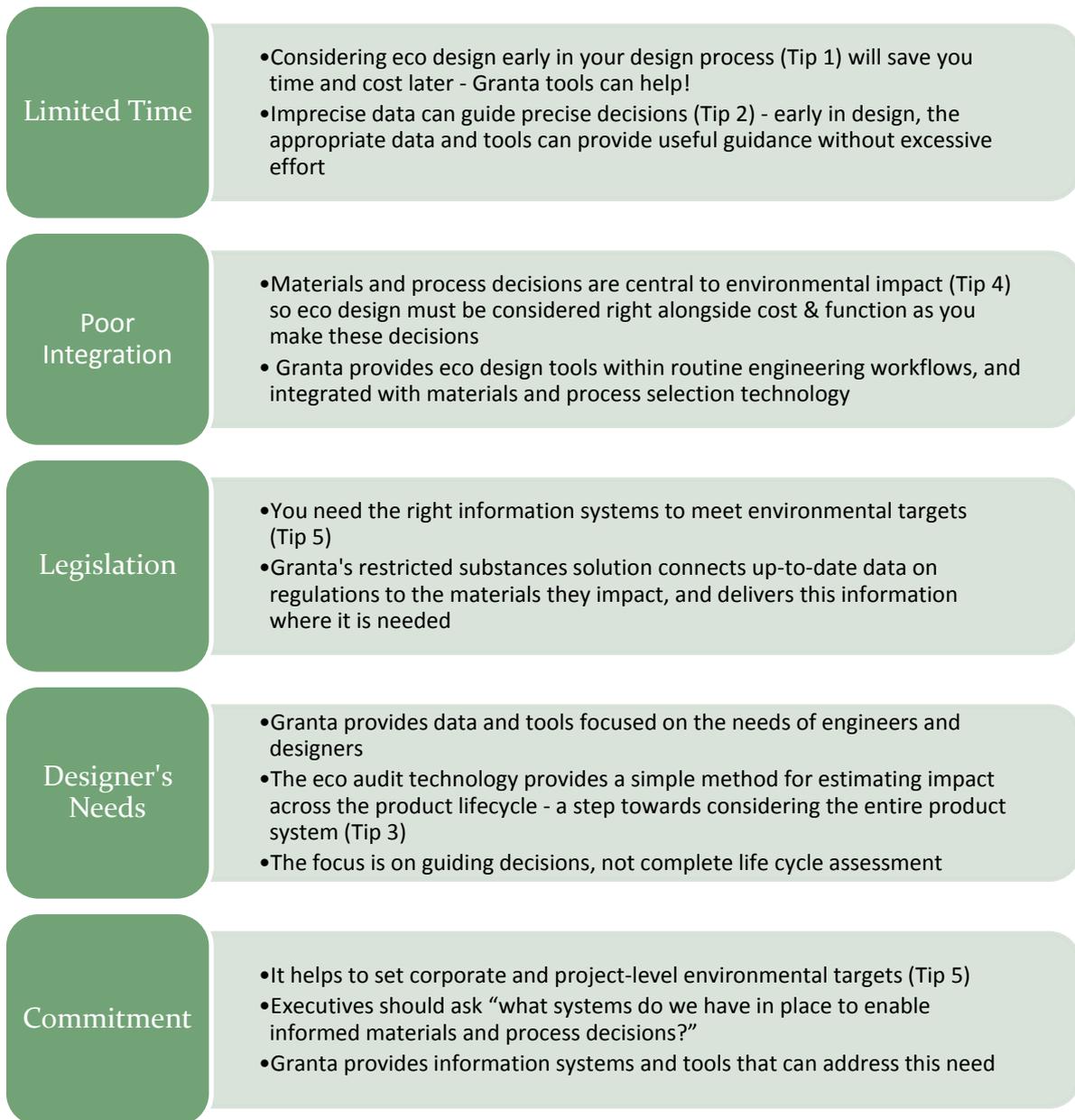


Figure 11: How our tips and tools can meet the challenges of eco design identified in Section 2.

With suitable processes and tools in place, you can not only begin to deliver on eco design, but can actually enhance innovation and reduce costs. If you would like further information on any of the eco design solutions discussed here, please contact us for more information:

info@grantadesign.com

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About Granta

Granta Design is a spin-off from the University of Cambridge. Founded in 1994, Granta has grown to be the world leader in materials information technology, with customers in hundreds of top engineering enterprises and universities. Granta co-founder Professor Mike Ashby is a world authority on eco design, following many years of active research in the area, including the recent publication of the book MATERIALS AND THE ENVIRONMENT - ECO-INFORMED MATERIALS CHOICE (17).

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