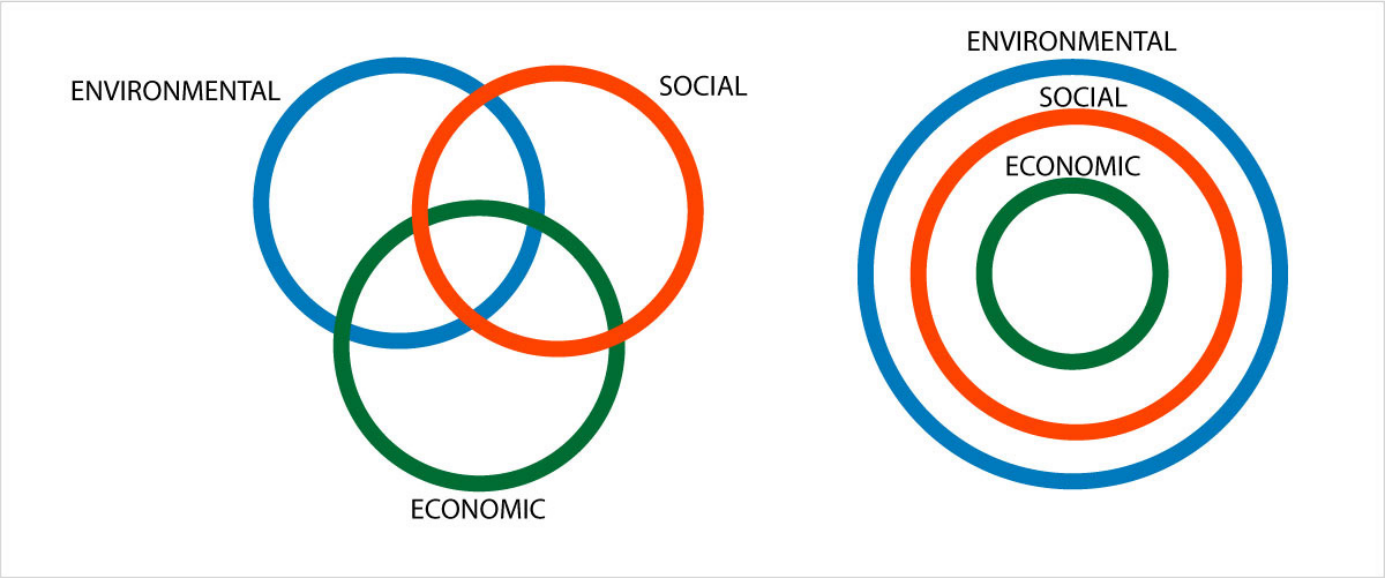
Design Course

Systems Design for Sustainability

From Product to System-Service Design and Innovation

by
Prof. Ravi Mokashi Punekar and Ms. Shruti Hemani
DoD, IIT Guwahati



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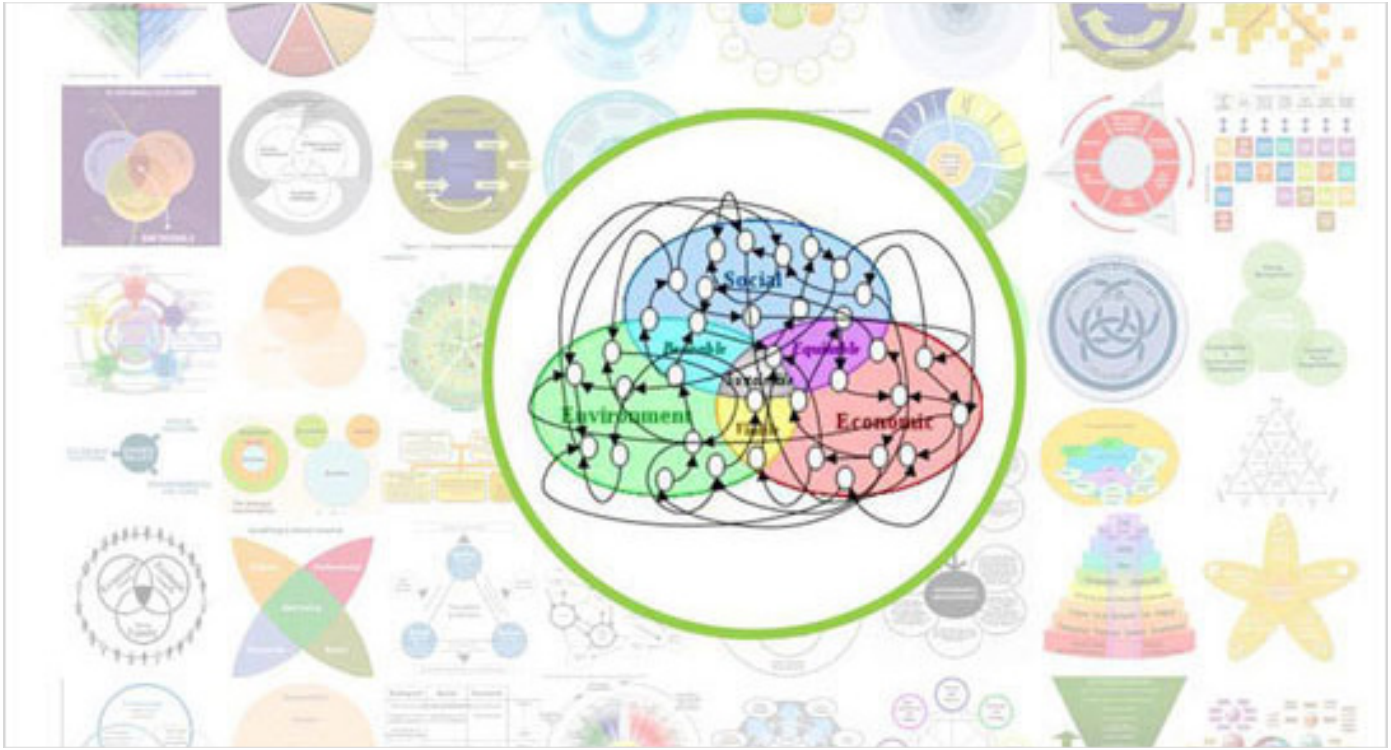
https://dsource.in/course/systems-design-sustainability/subject-summary

Subject Summary

This course introduces the principle of Sustainability in the design of products and product systems. It will introduce the issues, methods and tools used for the analysis and measurement of sustainability as applied to a system. Topics covered include:

- An introduction to the theory and practice of System Design for Sustainability.
- Product Service System (PSS) design for Sustainability.
- Evolution of sustainability within design.
- Life Cycle Design: methods, tools, strategies, guidelines
- System (PSS) design for eco-efficiency: criteria, guidelines
- System design for socio-ethical sustainability (emerging context): criteria, guidelines
- System design in emerging contexts
- Evolutionary transition path; methods and tools for system design (system map, interaction story board etc.)
- Methods and tools for system design for sustainability.



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Introduction

The concepts of Sustainability and Sustainable Design are a growing part of today's product design discourses and gaining importance within the policy context worldwide.

But, why is it important?

(Image source)

The quest for a comfortable life has led humankind to create a society based on convenience. However, environmental and social problems such as climate change, ecosystem destruction, energy crises, water scarcity, food and materials shortages have surfaced. In today's world as these issues continue to pose challenges that individuals and manufacturers will need to recognize and adapt to, if they are to survive and prosper in the future. At present opportunities for technological and product-service innovation are carving out space in the market. But the question is: how do we shape those opportunities to support the development and commercialization of more sustainable solutions? We now need to design and implement new systems to bring low-carbon, resource-efficient technologies, products and services that are also economically viable as well as socially inclusive

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to the mainstream market.

The United Nations Environment Programme Medium-Term Strategy 2010-2013 adopted by the Global Ministerial Environment Forum in February 2008, underlines that current economic growth and development patterns cannot be sustained without a significant shift in global production and consumption trends. Decoupling economic growth from negative environmental and social impacts will require producers to rethink design, production and marketing paradigms. Consumers will need to consider real environmental and social concerns along a product's life cycle – in addition to price, convenience and quality, in their purchasing decisions. While these drastic changes face formidable challenges, there are encouraging developments contributing to an expanding knowledge base in the product development field. There is now a strong feeling that the discussion has now moved from sustainable 'product' innovation to sustainable 'product-system-service' innovation and how to make it happen both at a design and policy level.

So, why is it necessary?

1. Personal interest and stewardship,
   Because we want to make the world a better place for everyone!

2. Professional expertise and growth area,
   Because Sustainable Design is gaining importance!

3. Company initiatives and Industry regulations

Because Sustainable Design is becoming integral to companies' intent and government policies!

Most people who work with product innovation, both product designers and business managers, are in the dominant paradigm that puts short-term profit forward as the primary goal. However, these people are also quickly awakening to the need to more directly include both environmental and social issues in their daily decisions. This is happening for many reasons: customer demand, an expanding regulatory environment, global resource constraints, and perceived opportunities for cost savings to name just a few.

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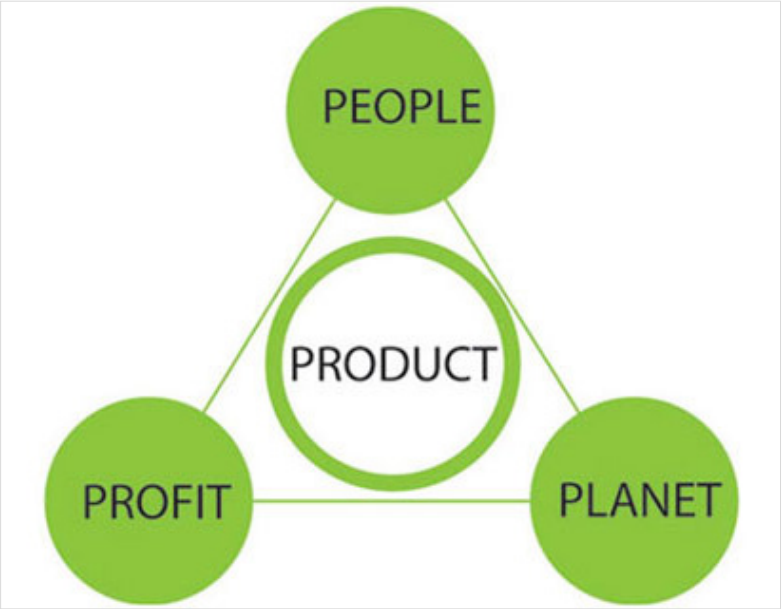

Sustainability Triangle:
The 3 key elements of sustainability – social, environmental, and economic – are also referred to as people, planet, and profit, and are the fundamental components of product innovation.

• http://www.unep.fr/shared/publications/pdf/WEBx0155xPA-DesignforSustainability.pdf

• DesignforSustainability.pdfPorter, M.E. and van der Linde, C., (1995): Toward a new conception of the environment-competitiveness relationship, The Journal of Economic Perspectives, Vol. 9(4), pp 97.

• Thompson, A. Larsson, T. Broman, G. (2011) Towards Sustainability-driven Innovation through Product-Service Systems, Proceedings of 3rd CIRP International Conference on Industrial Product Service Systems, Braunschweig.

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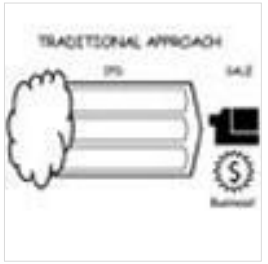
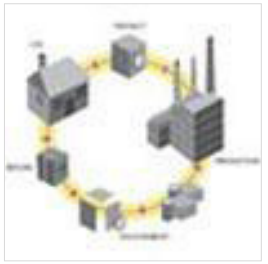
Sustainable Design

Introducing Sustainability



History of Sustainability Design

Current Scenario



Design Faces

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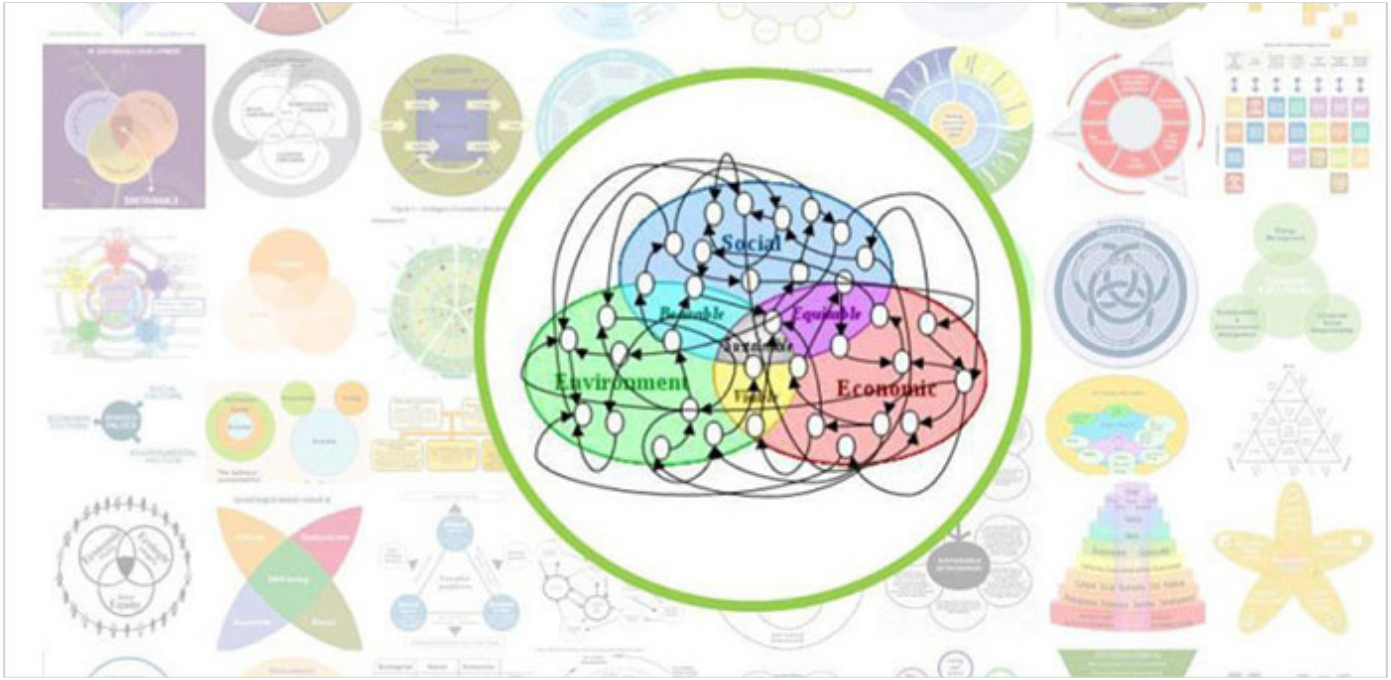
Introducing Sustainability

• **Scope & Contextual Relevance:**
We live in a global system in which our most critical problems go well beyond regional and national borders. When past civilizations were challenged, or even collapsed, they were relatively isolated from other parts of the world. Today, in our highly interconnected global system, massive social or environmental failure in one region threatens the entire system. Perhaps the overarching question for the 21st century is the following: can the current global system adapt and survive the accumulating, highly interconnected problems it now faces?

Increasingly, the global environmental change and social injustice, people are realizing that answers to this question require a new, more integrated, transdisciplinary understanding of the concept of Sustainability and Sustainable Development.

The Brundtland definition of sustainable development put forth an attractive vision, but left a significant gap for the business needs to be operational. This has led to many attempts to clarify the concept of sustainability leading to a variety of interpretations from various disciplines. One reason product developers have left sustainability essentially outside of their focus is that there is general confusion in the world around the topic of sustainability.



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• **Terminologies & Definitions:**
The terms 'sustainable development SD' and 'sustainability' are often used interchangeably. However we understand SD to refer to a process of change towards achieving sustainability goals, whereas sustainability, or the 'ability to sustain', refers to an (often ideal) end-state that can be sustained over time. Defining and discussing what sustainability is, will help us understand how the process of sustainable development should be shaped.

• **Sustainability:**
Sustainability is the capacity to endure. For humans, sustainability is the long-term maintenance of responsibility, which has environmental, economic, and social dimensions, and encompasses the concept of stewardship, the responsible management of resource use. In ecology, sustainability describes how biological systems remain diverse and productive over time, a necessary precondition for the well-being of humans and other organisms. Long-lived and healthy wetlands and forests are examples of sustainable biological systems.

• **Sustainable Development:**
In 1987, the United Nations released the Brundtland Report, which included what is now one of the most widely recognised definitions: "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

According to the same report, the above definition contains within it two key concepts:
1. the concept of 'needs', in particular the essential needs of the world's poor, to which overriding priority should be given;
2. and the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs. From *Our Common Future* (London: Oxford University Press, 1987)

Although the original definition by the Brundtland Commission does not make such a distinction, sustainable development has later become perceived as a combination of three dimensions or 'pillars', namely, the environmental (ecological), economic, and social dimensions. Since the Rio conference in 1992, this tripartite description has constituted the basis for most of the generally accepted definitions of sustainable development in international organisations called 'triple bottom line' in the business circles. The 'capitals approach'—(manufactured, natural, and social)—has its origins in economics, but has been much more widely accepted as a 'common sense approach' by the academic community more generally. However, much less consensus reigns over the relations among the dimensions.

The relationship between different dimensions of sustainable development is often represented as either a Venn diagram, with sustainability at the intersection, or as concentric circles, reflecting a layering of domains. This second case reflects the more realistic perspective that a healthy economy depends on a healthy society, both of which rely on a healthy environment. Sustainability occurs when all three are thriving. However, each of the three

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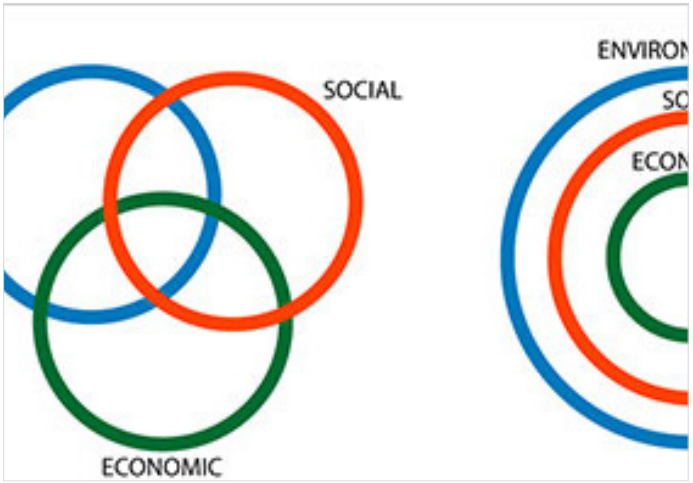
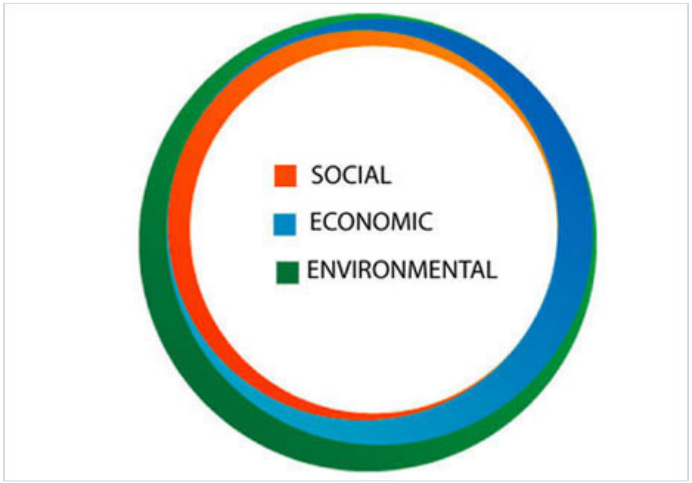
'pillars' has its own characteristics and logic, which are likely to conflict with each other. The sustainability models do not give any guidance on how to arbitrate between the unavoidably conflicting objectives of economic rationality (profitability), social justice and ecological equilibrium. For instance, the objectives of improving of material well-being and conserving natural ecosystems often conflict with each other. Finally, there are good reasons to believe that the three 'dimensions' of sustainable development are not qualitatively equal, but occupy different positions in a hierarchy. While the importance of each pillar may vary from one situation to another, the model as such does not attribute priority to any of the dimensions. Moreover, the model gives the impression of pillars as independent elements that can be treated, at least analytically, separately from each other. These disagreements over the proper hierarchy have probably prevented such models from becoming widely adopted in international policy circles.



Sustainable Development Intersections and Venn Diagram



Tripple Bottom Line

Since the Brundtland Commission (WCED 1987), the conceptualization and theorization of what sustainable development means is abundant in the literature. Some argue that the over-utilization but simultaneous under-theorization of 'sustainable development' as a concept means that it can lend itself to a range of very divergent goals others consider that its strength lies precisely in the fact that there is no centrally determined blueprint for sustainable development, and thus its meaning will have to emerge out of an interactive process of dialogue and reflection. Many agree that a universal and context-independent definition for 'sustainable development' may not be possible and as Haughton and Counsell put it, "rather than focus on searching for a definitive meaning of 'sustainable development' ... it is necessary to recognize the multiplicities of sustainabilities and to analyse the ways in which these are shaped".

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• **Sustainable Design:**
Sustainable Design can therefore be defined as:
"THE DESIGN OF SYSTEMS THAT CAN BE SUSTAINED INDEFINITELY"

and

Sustainable Product Design is defined as:
"THE DESIGN OF OBJECTS THAT AID THE SUSTAINABILITY OF THE SYSTEMS IN WHICH THEY OPERATE"

These definitions highlight the fact that sustainability is about systems. This is because nothing exists in isolation; everything is part of a system. The result is that in many cases the job of a Sustainable Product Designer will reach beyond designing physical objects and into designing other aspects of the system in which the objects operate.

• **Approaches to Sustainability in Design:**

- Sustainable Urban Design can be implemented only if an appropriate understanding of unsustainability. 'HOW YOU DEFINE IS HOW YOU DESIGN' (Clune, 2009).

- New kinds of innovation, changes in systems of production and consumption and even social transformations are needed.

- The scale of changes in urbanisation, necessitates PROACTIVE than the present day REACTIVE advancement (UNFPA, 2007).

- Dealing with this kind of system complexity in design requires COLLABORATIVE approach with many experts and stakeholders participating and collaboration brings with it its own challenges.

- What is at work for designers is TRANSDISCIPLINARY context along with 'COMMUNICATIVE RATIONALITY' rather than simply 'COGNITIVE RATIONALITY'.

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History of Sustainability Design

The sustainability idea is both very ancient and quite recent. Before consumerist modern era, most cultures lived in harmony with nature, their lifestyles, rituals and behaviour aimed for stability and continuity. However, the inevitable change happened in the rising global economy – it led to an industrial consumerist mono-culture that resulted in persistence of desperate poverty along with deep disparities as well as proliferation of risky technologies and degradation of essential ecosystems. However, realizing the environmental threats, real or potential, to the quality of life, environmental movements have begun in virtually all sectors of industrialized countries, including business, manufacturing, transportation, agriculture, and architecture. The critics pointed out to the fact that economic growth is not open-ended and that it has failed to deliver benefits where they were most needed. In last few decades, numerous reports, studies, theses, articles and books have been published documenting impacts and opportunities, e.g., species loss, resource constraints, and business opportunities for those aware of sustainability issues. There was general agreement in the scientific community that things need to change, and this is often discussed under the term "sustainability."

From Product to System and Services:
Pursuit of sustainable development requires a systems approach to the design of industrial product and service systems. Although many business enterprises have adopted sustainability goals, the actual development of sustainable systems remains challenging because of the broad range of economic, environmental and social factors that need to be considered across the system life cycle. Previous work on sustainable design has focused largely upon ecological efficiency improvements. For example, companies have found that reducing material and energy intensity and converting wastes into valuable secondary products creates value for shareholders as well as for society at large. To encourage broader systems thinking, the new design protocol involves the following steps: identifying system function and boundaries, establishing requirements, selecting appropriate technologies, developing a system design, evaluating anticipated performance, and devising a practical means for system deployment. The approach encourages explicit consideration of resilience in both engineered systems and the larger systems in which they are embedded. Sustainability is often misinterpreted as a goal to which we should collectively aspire. In fact, sustainability is not an end state that we can reach; rather, it is a characteristic of a dynamic, evolving system. And system thinking offers a potential means to overcome the above barriers.

A product, process, or service contributes to sustainability if it constrains environmental resource consumption and waste generation to an acceptable level, supports the satisfaction of important human needs, and provides enduring economic value to the business enterprise. Note that a product cannot be sustainable in an absolute sense; rather, it must and the natural environment. Therefore, the key practical challenge of sustainable design is to understand how products, processes, and services interact with these broader systems.

Product Service Systems, put simply, are when a firm offers a mix of both products and services, in comparison to

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the traditional focus on products. As defined by (van Halen, te Riele, Goedkoop) "a marketable set of products and services capable of jointly fulfilling a user's needs". PSSes can be realized by smart products.

The initial move to PSS was largely motivated by the need on the part of traditionally oriented manufacturing firms to cope with changing market forces and the recognition that services in combination with products could provide higher profits than products alone. Faced with shrinking markets and increased commoditization of their products, these firms saw service provision as a new path towards profits and growth. While not all product service systems result in the reduction of material consumption, they are more widely being recognized as an important part of a firm's environmental strategy. In fact, some researchers have redefined PSS as necessarily including improved environmental improvement. For example, PSS can be defined as "a system of products, services, supporting networks, and infrastructure that is designed to be competitive, satisfy customers' needs, and have a lower environmental impact than traditional business models".

Types of PSS:
There are various issues in the nomenclature of the discussion of PSS, not least that services are products, and need material products in order to support delivery however, it has been a major focus of research for several years. The research has focussed on a PSS as system comprising tangibles (the products) and intangibles (the services) in combination for fulfilling specific customer needs. The research has shown that manufacturing firms are more amenable to producing "results", rather than solely products as specific artefacts and that consumers are more amenable to consuming such results.

This research has identified three classes of PSS:

- **Product Oriented PSS:**
This is a PSS where ownership of the tangible product is transferred to the consumer, but additional services, such as maintenance contracts, are provided.

- **Use Oriented PSS:**
This is a PSS where ownership of the tangible product is retained by the service provider, who sells the functions of the product, via modified distribution and payment systems, such as sharing, pooling, and leasing.

- **Result Oriented PSS:**
This is a PSS where products are replaced by services, such as, for example, voicemail replacing answering machines.

'Product Service Systems (PSS) are not a new idea but if used intelligently can offer significant benefits to all parties. For example, the manufacturer might manufacture photocopiers and loan them to businesses that then

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pay for the service of photocopying. The customer gets good value for money by only paying for the service that they want, and need not worry about maintenance of the copier, which is taken care of by the manufacturer. The manufacturer never loses ownership of the copier and the business is no longer tied to manufacturing and selling photocopiers. They have an incentive to maximise the life of their products and re-manufacture/recycle old or broken models'.
www.espdesign.org

Eco Design, D4S [design for sustainability], LCM [life cycle management]:
As a brief history, in the 1990s, concepts such as Ecodesign and green product design were introduced as strategies companies could employ to reduce the environmental impacts associated with their production processes. These strategies also served to bolster a company's position and competitive edge in a market where more and more emphasis was being placed on environmental stewardship. In 1997, UNEP published "Ecodesign: A Promising Approach to Sustainable Production and Consumption" which was one of the first manuals of its kind and helped lay the foundation for widespread adoption of Ecodesign concepts. This publication introduced the fundamental concepts of Ecodesign to policy makers, programme officers, and project specialists. Like many other environmental concepts, Ecodesign has evolved to include both the social and profit elements of production and is now referred to as sustainable product design.

The concept of 'Design for Sustainability' (D4S) requires that the design process and resulting product take into account not only environmental concerns but social and economic concerns as well. The D4S criteria are referred to as the three pillars of sustainability - people, profit and planet. D4S goes beyond how to make a 'green' product and embraces how to meet consumer needs in a more sustainable way. Companies incorporating D4S in their long-term product innovation strategies strive to alleviate the negative environmental, social, and economic impacts on the product's supply chain and throughout its life-cycle.

Mere a 'Greenwash'?
Though sustainability is slowing building up as a new culture, there are several attempts to mere greenwash the whole ideology. Greenwash is a term used to describe the perception of consumers that they are being misled by a company regarding the environmental practices of the company or the environmental benefits of a product or service. It is a deceptive use of green marketing. A 2010 study by Terrachoice, an independent testing and certification organisation revealed: out of 5296 products only 265 were really as green as they claimed – 95% of the 'green' products are being greenwashed.

In December 2007, US environmental marketing firm TerraChoice gained national press coverage for releasing a study called "The Six Sins of Greenwashing," which found that more than 99% of 1,018 common consumer products randomly surveyed for the study were guilty of greenwashing.
The 6 Sins of Greenwashing (PDF)

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According to the study, the six sins of greenwashing are:

• **Sin of the Hidden Trade-Off:**
E.g. "Energy-efficient" electronics that contain hazardous materials. 998 products and 57% of all environmental claims committed this Sin.

• **Sin of No Proof:**
E.g. Shampoos claiming to be "certified organic," but with no verifiable certification. 454 products and 26% of environmental claims committed this Sin.

• **Sin of Vagueness:**
E.g. Products claiming to be 100% natural when many naturally-occurring substances are hazardous, like arsenic and formaldehyde (see appeal to nature). Seen in 196 products or 11% of environmental claims.

• **Sin of Irrelevance:**
E.g. Products claiming to be CFC-free, even though CFCs were banned 20 years ago. This Sin was seen in 78 products and 4% of environmental claims.

• **Sin of Fibbing:**
E.g. Products falsely claiming to be certified by an internationally recognized environmental standard like EcoLogo, Energy Star or Green Seal. Found in 10 products or less than 1% of environmental claims.

• **Sin of Lesser of Two Evils:**
E.g. Organic cigarettes or "environmentally friendly" pesticides. This occurred in 17 products or 1% of environmental claims.

The 2007 list had only six sins. Things, it seems, have gotten worse and a seventh sin, the Sin of Worshipping False Labels, emerged in the 2009 survey.

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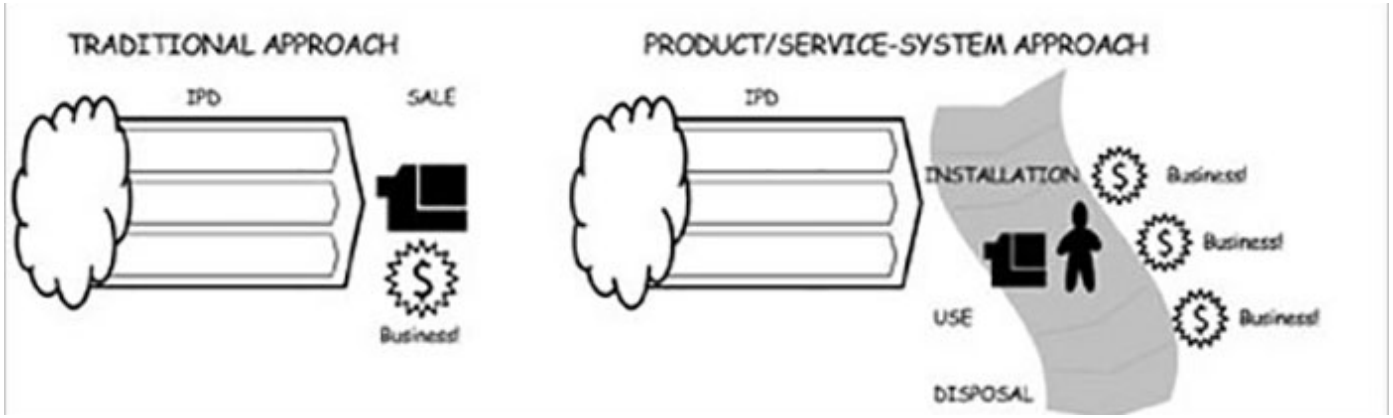

The figure shows the traditional approach, where the value creation process ends with the sale of the product, and the PSS approach, where the value creation process continues throughout the product's life.

Source:
Tan, A. R., McAloone, T.C., Gall, C. (August, 2007) Product/Service-System Development – An Explorative Case Study In A Manufacturing Company International Conference On Engineering Design, Iced'07, Cite Des Sciences Et De L'industrie, PARIS, FRANCE Figure-1.
Available at:
http://www.producao.ufrgs.br/arquivos/disciplinas/508_pss2p_334.pdf

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Current Scenario

The transition from the unhealthy consumptive patterns of modern technological life to a more sustainable mode of societal living has now begun. There is a clear need to re-address the manner, in which we develop and provide products to users and consumers, in order to be able to make leap-changes to the environmental profile of the products, rather than merely small incremental improvements. Or in other words, we need to move from focusing on the design and development of the simple artifact to the innovation of a whole product service system (PSS), including its socio-technical utility and behaviour problematic, in which the traditional producer-consumer relationship is rearranged, in order to deliver environmental and economical benefits for both customer and company alike. PSS development should result in enhanced consideration of utility, sustainability and societal values.

As market drivers shift from product-service to use-service, to result-service, the design emphasis shifts from first-cost to life-cycle-cost, to maximum-benefit. This evolution of sustainable service systems demands an increasingly holistic approach to the design process that requires the original definition of 'the system' to be extended to include a super-system. The development of Sustainable Service Systems requires innovative ideas, the involvement of new stakeholders and changes to innovation processes. Traditionally, innovation has been equated to 'high risk', and many organisations have been reluctant to devote precious resources to developing innovative new products, processes or services. Innovation projects with a 'sustainability' element are still treated with particular caution. Sustainable product innovation is a new field and a business model that integrates economic, environmental, social and ethical issues is still to be developed (Charter and Tischner, 2001).

Source: http://www.mspi.se/

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Design Faces

Design for Disassembly:
Sometimes shortened to DfD, this is a design approach that enables the easy recovery of parts, components, and materials from products at the end of their life. Recycling and reuse are noble intentions, but if a product cannot be disassembled cleanly and effectively they are impossible, or at least cost prohibitive to achieve.

(Image source)

Shoes With Soul:
Because the Earthkeepers 2.0 collection was engineered with disassembly in mind, approximately 70 to 90 percent of the materials that make up each shoe can be reused or recycled, including the detachable metal hardware.

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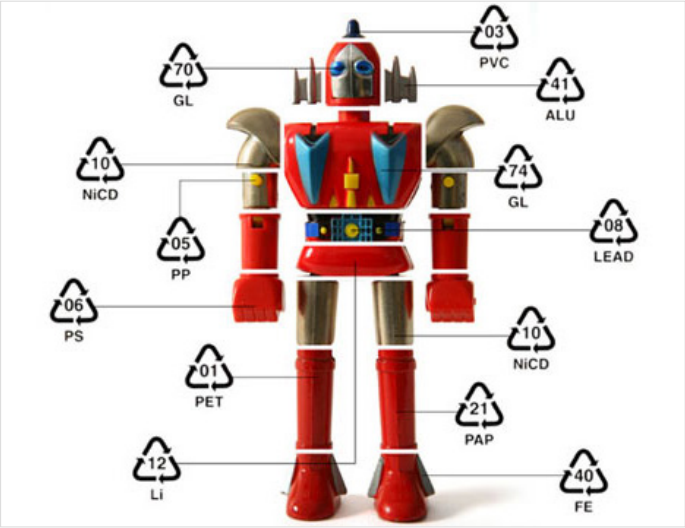

(Image source)

Recycling is an important tenant of sustainability, but in order to be effective, products need to be easily disassembled into component parts and separated by material. If this is difficult, these products simply end up in the landfill instead.

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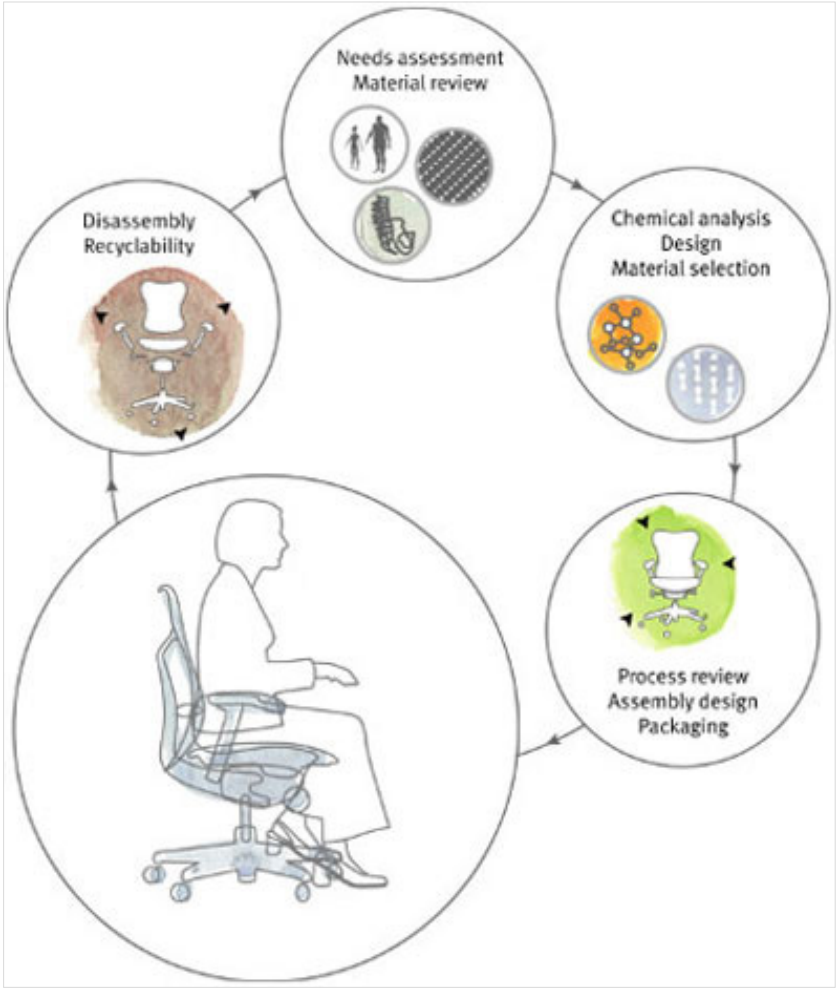
DoD, IIT Guwahati

Source:
https://dsource.in/course/systems-design-sustainability/sustainable-design/design-faces

Design for the Environment:
The consumer and the industrial & institutional products should be safer for the environment.



(Image source)

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Design for the Equity:
The Sustainable designs should also look at the often ignored third pillar of sustainability – Social justice and Equity.

(Image source)

Improving Competitiveness:
An artisan making incense sticks from bamboo with his indigenously manufactured bamboo splinter machine. Micro, small and medium enterprises (MSMEs), apart from playing a significant role in meeting national objectives of balanced growth, poverty alleviation and equity promotion, serve as nurseries for corporate enterprises of future. Thus, MSME financing is the latest buzzword in the financial sector in India.

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Product Stewardship:
Also known as extended product responsibility (EPR), this approach is based on the principle that all those involved in the lifecycle of a product should share responsibility for reducing its environmental impact. It often results in voluntary partnerships among manufacturers, retailers, government, and non-government organizations to set up effective waste-reduction systems and practices.

Players of product stewardship: All those involved in producing, selling, and using products should be responsible for the full environmental impact of the product. This includes manufacturers, retailers, consumers, and government.

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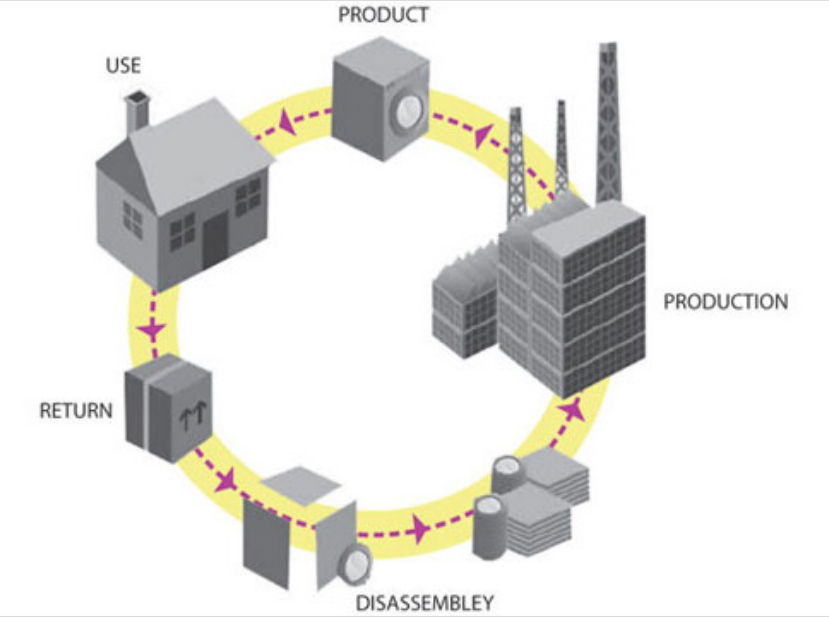
Cradle to Cradle:
William McDonough and Michael Braungart popularized the notion that product lifecycles should be considered not as cradle to grave, but as cradle to cradle. The key idea here is that there is no such thing as a "grave" at the end of use, since everything goes somewhere. As they say, there is no such thing as "away." Given that, in order to be sustainable all of the elements of a product that has reached the end of its useful life should be designed to go somewhere where it can serve as the input to another system, a concept often characterized as "waste = food." While product development processes may focus on cradle to gate, cradle to grave, or even gate to gate plans, effective lifecycle planning needs to find ways to close all possible loops.



Technical Nutrients:
Materials that can be used in continuous metabolisms without losing their integrity or quality. In this manner these materials can be used over and over again instead of being "downcycled" into undefined products, ultimately becoming waste.
Source: CATALYST Strategic Design Review
http://catalystreview.net/blog/wp-content/uploads/2010/02/cradle-to-cradle-illustration.jpg

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Biomimicry:
Nature has spent millions of years developing some very interesting and effective solutions to a wide range of design challenges. Biomimicry is "the practice of designing materials, processes, or products that are inspired by living organisms or by the relationships and systems formed by living organisms." Such inspiration comes in two forms, as either "challenge to biology" or "biology to challenge." In the first case, a design challenge exists and designers search nature for potential solutions. The second case entails starting with an interesting biological property that researchers or scientists attempt to apply more broadly or commercialize. Note that just because a solution is based on nature doesn't mean that it's inherently healthy or sustainable.

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Solar Biomimicry:
The flexible photovoltaics below not only capture the sun's energy, but the flexibility of these photovoltaics permits energy to be collected from motion. The idea is taken from leaves moving in the wind.
From the Copenhagen Institute of Interaction Design:

Turning whale power into wind power:
The "tubercles on the leading edge of humpback whale flippers" help humpbacks glide through the ocean with greater ease. This idea has been applied to wind power in order to increase efficiency.
From NextEnergyNews.com:
Source: http://conservationreport.com/

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Green Chemistry:
Green chemistry focuses on reducing the generation and use of hazardous chemicals, decreasing pollution at its source. Paul Anastas and John Warner published the 12 Principles of Green Chemistry in 1998 and set out the following design goal.

Chemical products and processes should be designed to the highest level of this hierarchy and be cost-competitive in the market.

1. Source Reduction/Prevention of Chemical Hazards
2. Reuse or Recycle Chemicals
3. Treat Chemicals to Render Them Less Hazardous
4. Dispose of Chemicals Properly

(Image source)

Design for the Environment assures that the EPA's Design for the Environment (DfE) scientific review team has screened each ingredient for potential human health and environmental effects, and contains ingredients that pose the least concern among chemicals in their class.

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Green Marketing:
Many companies find that promoting the environmental responsibility, or even just the benefits, of their products can be a powerful marketing angle. Touting the "green" aspects of existing products, processes, or systems has become almost the standard in many industries.

• http://allenpress.com/pdf/ambi/AMBI_Sustainability.pdf

• http://en.wikipedia.org/wiki/Sustainability

• http://en.wikipedia.org/wiki/Product_service_system

• http://www.unep.fr/shared/publications/pdf/WEBx0155xPA-DesignforSustainability.pdf

• http://www.ecoelves.com/

• http://www.solidworks.com/sustainability/

• Report on Design for Sustainability- a Step-by-step approach UNEP, TUDelft, United Nations Environment Programme, 2009.
[www.unep.fr/shared/.../WEBx0155xPA-DesignforSustainability.pdf]

• Johnston, P., Everard, M., Santillo, D., and Robert, K.H., (2007):
Reclaiming the definition of sustainability, Enviro. Science and Pollution Research, Vol. 14(1), pp 60-66.

• Marcuse P. 1998. Sustainability is not enough. *Environment and Urbanization*, 10(2): 103-111.

• Weingaertner, C. & Moberg, A. Exploring Social Sustainability:
Learning from perspectives on Urban Development and Companies and Products. kth.diva-portal.org/smash/get/diva2:378611/FULLTEXT02

• Lehtonen, M. The environmental-social interface of sustainable development:
capabilities, social capital, institutions Ecological Economics 49 (2004) 199– 214

• Haughton G, Counsell D. 2004.
Regions, Spatial Strategies and Sustainable Development. London, Routledge.

• espdesign.org

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Source:
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Sustainable Design Strategies

Production-Consumption system is a complex social and technological system in which socio-culturally and economically available natural resources are transformed into a supply of products, services and public goods that responds (or atleast is supposed to respond) to a demand of well-beginning the given society. It is all a great interactive network among people (consumers), organisations (public, private) and territorial resources (natural and social capital).

There are various ways in which the effects based on an impact of exchanging substances between nature and this production-consumption system can be measured or reduced. With regard to products, there are two obvious things that can be changed. First, the physical artefacts themselves can be changed, and second, the way that products are managed (including how they are used) over their life cycles can be changed. For the former, more efficiency can be pursued, e.g. material reduction and energy optimization. The movement in industry is now toward the design of artefacts and services together – often referred to as product-service systems (PSS) – and presents an opportunity for these two to be considered and improved in tandem.

Sustainable Design Strategies with respect to PSS involves either of the following two interventions:

1. Products and Systems Re-design: Altering existing products and systems to improve global efficiency.
2. Products and Systems Innovation: Designing new products and services or substituting old systems with more sustainable ones.

Companies operate in a rapidly changing world in which customer needs and wants are not fixed and industry faces increasing competition due to open markets and globalisation. Companies that effectively integrate innovation into their product development process can gain a significant competitive advantage.

For example, Henkel researchers claim to have developed a new generation of automatic dishwashing tablets that deliver full cleaning power even in short and low-temperature dishwasher cycles. The high-performance Somat 10 dishwashing tablets are an example of a product innovation that couples better performance with a smaller ecological footprint. Since dishwashers consume a great deal of energy, it makes ecological sense to use short and low-temperature programs. "By making the Somat 10 tablets dissolve more easily, we succeeded in getting them to release the ingredients faster so that they have more time to act on food residues and do a better job," explains Dr. Thomas Eiting, a chemist in the household cleaners' research department at Henkel.

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Products-Systems Redesign

Products-Systems Innovation

Sustainable Life Style

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Products-Systems Redesign

Designers and businesses who want to raise design standards to a respectable level are increasingly talking about designing sustainable products, but what is often overlooked is the fact that products do not exist in isolation, and so a product designed in isolation is unlikely to ever be sustainable. If sustainable product design is going to have maximum impact, then the process should begin with developing a sustainable business system.

Another better example is DANONE who understands that "we sell because of design, because our products are cool, because of price, because of service, but also because of sustainability." In other words, sustainability is an integral part of the product attributes which increase the value of the products and services offered. DANONE is working on "making five of our most popular products CO2 neutral by 2012". This process at DANONE also means taking risks, for example "eliminating the cardboard packaging of our yoghurts, which we have started to do already in some places in France and we will continue to do despite the fact that our estimates show that we will lose money, but we'll do it anyway because it is time and it is right." DANONE carried out a pilot project in some French supermarkets, and the response from consumers was quite negative, as they did not perceive it as a sustainability policy, but rather felt that "that DANONE is reducing the quality of the product". Despite these negative estimates, DANONE has decided to proceed with the progressive elimination of this packaging.

Image Source:
www.danone.com
www.yakult.co.in

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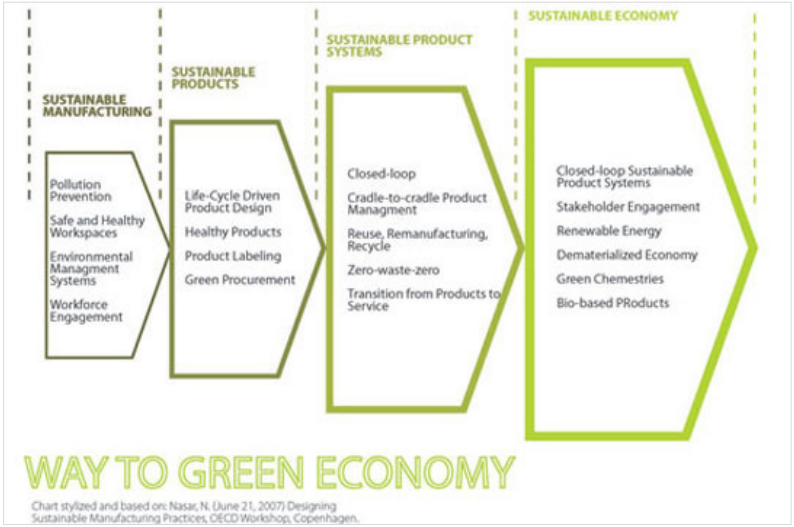
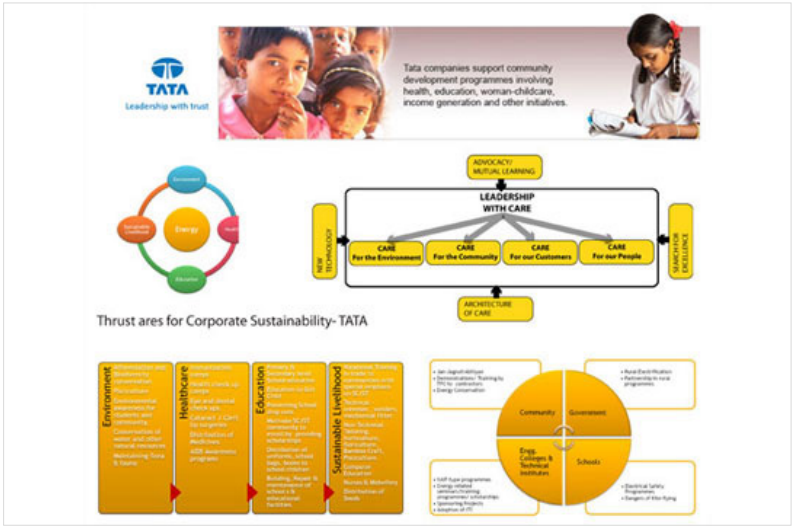


Image Source:
Chart stylized and based on: Nasar, N. (June 21, 2007) Designing Sustainable Manufacturing Practices, OECD Workshop, Copenhagen.



TATA Group is another leading group of companies that has sustainability policies well integrated with the business plans. The panoply of community development endeavours undertaken by Tata companies — embracing everything from health and education to art, sport and more — has touched, and changed, many lives.

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• Workplace
With a work culture that embraces ethics, value systems, comfortable and safe environments and learning opportunities, the Tata group encourages holistic growth amongst its most valuable asset — its people

• Community
In India and overseas, Tata companies are intensively involved in a wide variety of community development projects covering social needs that range from health and education to livelihoods, women-children welfare and more

• Environment
The Tata group's beliefs on sustainability have led to a corporate policy that emphasises environment preservation. Tata companies work on projects that include repairing green cover, reducing effluents and emissions, maintaining local ecologies and improving long term corporate sustainability.

At Tata Power, the Sustainability Policy integrates economic progress, social responsibility and environmental concerns with the objective of improving quality of life. The intent of their Sustainability model is 'Leadership with Care' with four key elements–
Care for the Environment;
Care for the Community;
Care for our Customers / Partners
Care for our People.

Tata has also developed an Index for Sustainability.
The Tata index for sustainable human development is a pioneering effort aimed at directing, measuring and enhancing the community work that Tata group enterprises undertake. The index provides guidelines for Tata companies looking to fulfil their social responsibilities, and is built around the Tata Business Excellence Model, an open-ended framework that drives business excellence in Tata companies.

Image Source:
• http://www.tata.com

• http://www.tatainternational.com/html/corporate_sustainability_initiatives.html

• http://www.tatapower.com/sustainability/sustainability-tata-power.aspx

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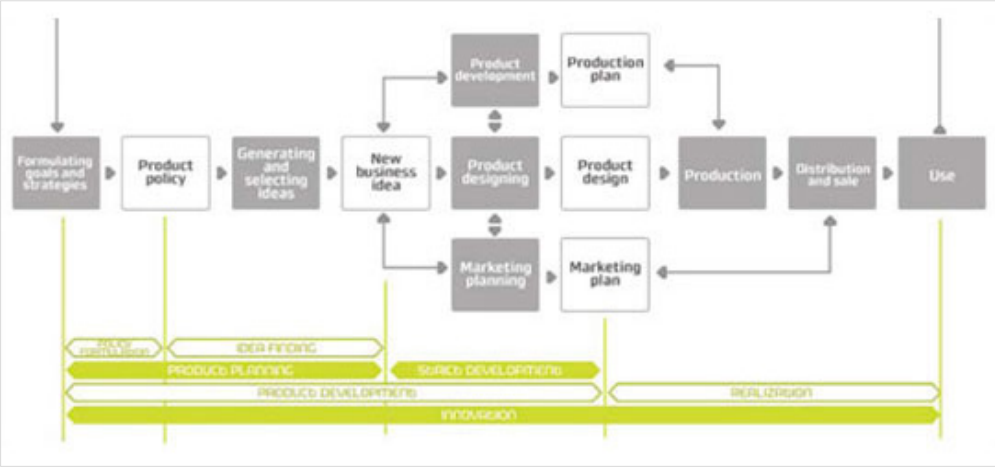
Products-Systems Innovation

Innovation is a broad concept that is used in many different contexts. As a result, there are many definitions of innovation. One useful definition is: "the commercial or industrial application of something new – a new product, process or method of production; a new market or source of supply; a new form of commercial, business, or financial organisation". Most definitions of innovation emphasize 'newness' and 'successfulness'. There are distinctions made between product versus process innovations and sometimes amongst market, business, and management innovations.

Product innovation is the introduction of new products that have characteristics and/or use applications that differ from existing products on the market.

Product Innovation = Product Development + Realization

The product development process is a disciplined and defined set of tasks, steps, and phases that describe how a company repetitively converts ideas into salable products and/ or services. The product development process itself can be split up into three phases: policy formulation, idea finding and strict development. Product development is not a stand-alone process. Parallel to the product development process the production development and marketing planning take place.



Product development process as part of the innovation process
Image Source: http://www.d4s-de.org/manual/d4sChapter03.pdf

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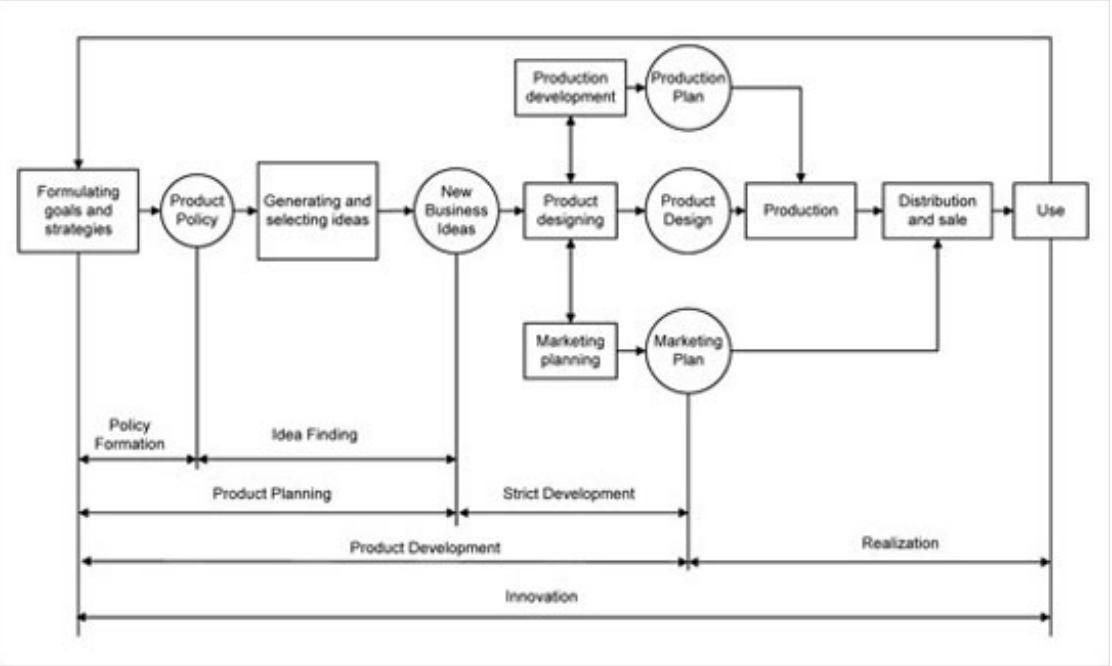
• **Process innovation**
Is the introduction of a new method of production that has not previously been used,or a new way of handling a commodity commercially, to make production more efficient or to produce new or improved products.

• **Market innovation**
Involves entering new markets, expanding existing markets, and/or developing new ways of serving customers.

• **Business and management innovation**
Involves developing new reward systems, organisational structures, and ways of handling responsibilities and human resources etc. that positively affect product sales.



Product Innovation Process. Recreated from (Roozenburg and Eekels 1995).

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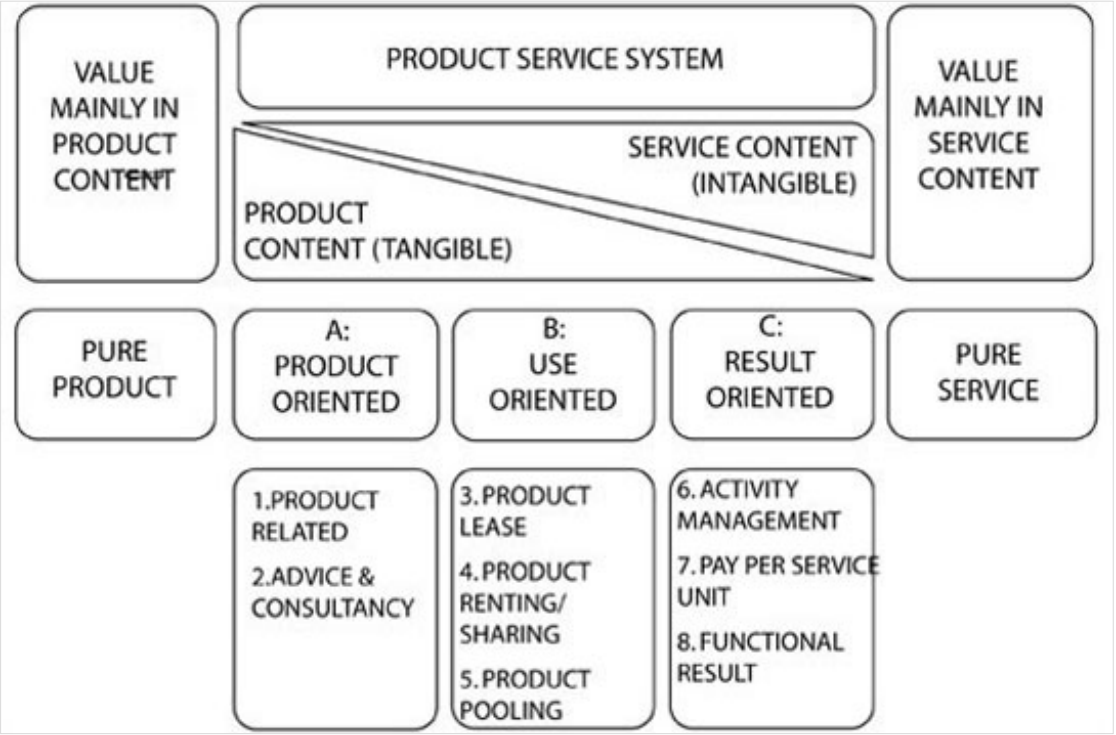

Towards Sustainability-driven Innovation through Product-Service Systems
Image Source: Thompson, A. W., (2010)

Innovation levels:
Innovation can be categorised into three levels: incremental, radical, and fundamental. Each category is progressively more significant and far-reaching.

- **Incremental Innovation:**
Entails step-by-step improvements of existing products.

- **Radical Innovation:**
Drastically changes existing products or processes.

- **Fundamental Innovation:**
Depends on new scientific knowledge and opens up new industries, causing a paradigm shift.

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CONSUMER LIFE

Innovation inspired by user needs can be a powerful transformational experience – making the world a better place to live

SHANTANU KHOSLA

Innovations

Economic Times
Date: 8 December 2009

Sustainable Product Innovations in India- P&G

"We innovate to incorporate sustainability criteria into our products in a number of ways - from formulation to packaging. In doing so, we find ways to deliver significant sustainability improvement without asking the consumer to make trade-offs in performance or value".

P&G is the largest consumer packaged goods company in the world today. This very fact coupled with our Purpose-inspired Growth Strategy—improving the lives of more consumers, in more parts of the world, more completely—requires us to continue to grow responsibly. And it also requires us to accelerate our commitment to helping solve some of the world's sustainability challenges. We have an obligation to help solve some of the world's sustainability challenges, and we believe we can do this through innovation.
http://www.pg.com

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Sustainability is about ensuring a better quality of life today, for people and our planet. P&G claims to contribute towards sustainability through the products and services they offer, making their products in an environmentally responsible manner, and through their social responsibility programs that improve lives for those in need around the world.

"We define sustainability broadly at P&G to include both environmental sustainability and social responsibility."

Environmental Sustainability:
As part of their strategy to grow responsibly, they claim to work towards a long-term environmental sustainability vision that includes:
- Powering our plants with 100% renewable energy
- Using 100% renewable or recycled materials for all products and packaging
- Having zero consumer and manufacturing waste go to landfills
- Designing products that delight consumers while maximizing our conservation of resources

In order to deliver their environmental vision they focus on two strategies:

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• Products
• Operations

Products:
"We will deliver products with an improved environmental profile.
To reduce the environmental impact of our products we use life cycle analysis to understand where the biggest impact exists, so we know where to focus our innovation. Our deep understanding of the consumer enables us to develop sustainable products that will delight her, without tradeoffs in price or performance."

Eg:
Products with Purpose: Gillette ProGlide
P&G partnered with Be Green® Packaging, a molded fiber supplier, to develop a breakthrough package for Fusion ProGlide, Gillette's newest high-performance razor. The new package launched in Western Europe with a 57% reduction in plastic compared to the originally launched Fusion outer pack and razor tray and a 20% reduction in gross weight compared to the Fusion launch package. To minimize plastic, the design uses fibre material made from bamboo, sugarcane, and bulrush.

Operations:
"We will improve the environmental profile of our own operations. We are focused on the environmental performance of our entire supply chain, including our own manufacturing facilities, our suppliers, and the logistics of our finished products. We are focused on creating efficiencies in energy, water, waste, and emissions."

Social Responsibility:

• Live, Learn and Thrive is P&G's corporate cause, focusing on helping children in need around the world. The programs enable children to get off to a healthy start, receive access to education and build skills for life. Since 2007, P&G has improved the lives of over 315 million children.

• India has the world's largest population of uneducated children, with nearly half of all children there not attending school. The Shiksha program (Shiksha - Hindu for "Education") is dedicated to fighting that trend, helping to provide access to education for more children. P&G India's flagship Corporate Social Responsibility Program, Shiksha, is an integral part of P&G's global corporate cause—Live, Learn and Thrive, which currently reaches out to over 50 million children annually. The program funds NGO efforts to address the underlying causes of poor access to education, such as poverty, health issues, and access to immunization. In cases where schools don't exist, the program also funds their construction. Now in its 7th year, Shiksha has enabled over 280,000 lesser-privileged children to access good, quality education by supporting the sustainable and tangible assets of schools. Shiksha has supported over 140 schools by interventions such as reactivating defunct government schools,

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building new schools or enhancing education infrastructure at existing schools.

• Almost one billion people in the developing world do not have access to clean drinking water. As a result, thousands of children die every day. The P&G Children's Safe Drinking Water (CSDW) Program reaches these people through P&G packets, a water purifying technology developed by P&G and the U.S. Centers for Disease Control and Prevention (CDC). One small P&G packet quickly turns 10 liters of dirty, potentially deadly water into clean, drinkable water. The packets can be used anywhere in the world, including areas affected by natural disasters. This Live, Learn and Thrive program provides water purification packets on a not-for-profit basis. Since the program began, more than 3.8 billion liters of purified drinking water in more than 65 countries have prevented an estimated 150 million days of diarrheal illness and helped save more than 20,000 lives.

• Every year, 59,000 people die from maternal and neonatal tetanus—a completely preventable disease. So for the fourth year running, Pampers is teaming up with UNICEF to deliver the vaccines that vulnerable women and their children need. The effort gets our consumers involved. With the purchase of one pack of Pampers, one dose of the vaccine is donated.
Image Source: http://www.pg.com

Many girls miss school, and gradually drop out as they enter adolescence, primarily due to lack of knowledge and access to amenities to ensure proper health and hygiene!

Johnson & Johnson Limited, India and UNICEF have partnered to raise funds to promote health and hygiene practices amongst adolescent girls in India.

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Source:
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Only 12 percent of women in India use sanitary napkins! Many girls miss school, and gradually drop out as they enter adolescence, primarily due to lack of knowledge and access to amenities to ensure proper health and hygiene. Similarly, many women suffer from infections due to lack of proper menstrual hygiene, resulting in poor health, adding to their healthcare burden and resulting in loss of wages as they have to remain absent from work.
Johnson & Johnson Limited, India and UNICEF have entered into a partnership to raise funds to promote health and hygiene practices amongst adolescent girls in India, benefitting more than five lakh girls over the next three years. From every Stayfree sanitary napkin sold, a part of the proceeds will go to UNICEF for a period of six months starting April 2012. This will support a pilot program, focusing on creating awareness and empowering adolescent girls for personal hygiene, in Bihar and in Jharkhand.

Image Source:
• http://www.unicef.org/india/media_7582.htm,

• http://www.stayfreewomenforchange.com

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Source:
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Sustainable Life Style

Create new scenarios for sustainable life style:
This involves socio-cultural innovation and alteration.

In many cases, a large proportion of products environmental impact is caused by its use by the consumer. Strategies such as reducing energy consumption can help, but often it is the behaviour, rather than the product itself that is inherently unsustainable. Designers should therefore think about how they can design products to encourage not only more sustainable use of the products themselves, but also more sustainable lifestyles in a broader sense. In this case the focus is not as much on the introduction of recent technology or production solutions, but on promoting new qualitative criteria that at the same time are environmentally sustainable, socially acceptable and culturally attractive.

Encouraging more sustainable behaviour can have far greater benefits than any incremental improvements in product efficiency. However, changing behaviour requires different thinking, and a successful design positively influences people's lives. Think carefully as people don't always act as you'd expect, and a poorly conceived design could make things worse. Any attempt to change user behaviour should also involve careful risk calculation for the company.

As consumer products become increasingly efficient technologically, human behaviour is often the weak link, at a societal level but also at the scale of interaction with individual products and services. We buy 'energy-saving' lights and then leave them on all night and stick with the default setting on the washing machine, afraid of investigating the others. Individual behavioural decisions are responsible for a significant proportion of household energy use. This issue goes beyond simply the "removal of barriers to behavioural change" identified by Stern [8]: while tax incentives and social marketing campaigns have a large part to play, in many ways, encouraging more sustainable behaviour can be seen as a design problem, concerned with how and why people interact with the products and systems around them, and how the interaction that contributes to the use phase might be influenced. While there is growing recognition that "designers are in the behaviour business", there is little general guidance available for design teams briefed with influencing user behaviour.

The Design with Intent (DwI) method aims to complement and support these approaches, addressing the deficiency outlined above, by suggesting relevant design techniques for influencing types of behaviour, and providing examples of how similar problems have been tackled elsewhere. The starting point of the DwI Method is the existence of a product, service or environment—a system —where users' behaviour is important to its operation, or where it would be strategically desirable to alter the way it is used.

There are two 'modes' in which the method can be used, inspiration and prescription, depending on how the

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Source:
https://dsource.in/course/systems-design-sustainability/sustainable-design-strategies/sustainable-life-style

designer or design team prefers to make use of it. In inspiration mode a subset of the most important patterns is presented as a 'toolkit' or 'idea space'), also made available online as a reference for designers (www.designwith-intent.co.uk). In prescription mode, the designer expresses the brief in terms of one of a set of 'target behaviours', each of which has particular design patterns associated with it.

Architectural patterns Positioning & layout, Material properties, Segmentation & spacing, Orientation, Removal, Movement & oscillation.	The Architectural Lens draws on techniques used to influence user behaviour in architecture, urban planning and related disciplines such as traffic management and crime prevention through environmental design (Crowe 2000; Katyal 2002; see also the Security lens). While the techniques have been developed in the built environment (e.g. Alexander et al. 1977), many ideas can also be applied in interaction and product design, even in software or services, which are effectively about using the structure of systems to influence behaviour.
Error proofing patterns Defaults, Interlock, Lock-in & Lock-out, Extra step, Specialised affordable, Partial self-correction, Portions, Conditional warnings.	The Errorproofing Lens treats deviations from a target behaviour as 'errors' which design can help avoid, either by making it easier for users to work without making errors, or by making errors impossible in the first place (Shingo 1986; Chase & Stewert 2002; Grout 2007). This view on influencing behaviour is often found in health & safety-related design, medical device design and manufacturing engineering.
Persuasive patterns Self-monitoring, Kairos, Reduction, Tailoring, Tunnerlling, Feedback through form, Simulation & feedforward, Operant conditioning, Respondent conditioning, Computers as social actors.	The Persuasive Lens represents the emerging field of persuasive technology (Fogg 2003), where computers, mobile phones and systems with interfaces are used to persuade users: changing attitudes and so changing behaviour through contextual information, advice and guidance.

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Visual patterns Prominence & visibility, Metaphors, Perceived affordances, Implied sequences, Possibility trees, Watermarking, Proximity & similarity, Color & contrast.	The Visual Lens combines ideas from product semantics, semiotics, ecological psychology and Gestalt psychology about how users perceive patterns and meanings as they interact with the systems around them, and the use of metaphors (e.g. Saffer 2005; Barr et al.2002).
Cognitive patterns Social proof, Framing, Reciprocation, Commitment & consistency, Affective engagement, Authority, Scarcity.	The Cognitive Lens draws on research in behavioural economics looking at how people make decisions, choice architecture (Lockton et al 2009c) and how this is affected by heuristics and biases (Kahneman et al. 1982). If designers understand how users make interaction decisions, that knowledge can be used to influence interaction behaviour. Where users often make poor decisions, design can help counter this.
Security patterns Surveillance, Atmospherics, Threat of damage, What you have, What you know or can do, Who you are, What you've done, Where you are.	The Security Lens represents a 'security' worldview, i.e. that undesired user behaviour is something to deter and/or prevent though 'countermeasures' (Schneier 2003) designed into products, systems and environments, both physically and online, with examples such as digital rights management. From a designer's point of view, this can be an 'unfriendly' and, in some circumstances unethical view to take, effectively treating users as 'guilty until proven innocent'.

Design Course

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• http://www.henkel.com/press/product-innovations-34955.htm

• http://www.espdesign.org

• http://itemsweb.esade.es/wi/research/iis/publicacions/2011-03_SustainableInnovationStrategies.pdf

• http://www.d4s-de.org/manual/d4sChapter03.pdf

• Vezzoli, C., Manzini, E., (2008) Design for Environmental Sustainability, Springer LONDON.

• Dan Lockton, D. and Harrison, D., Design for Sustainable Behaviour: investigating design methods for influencing user behaviour. The Centre for Sustainable Design, http://www.cfsd.org.uk

• Thompson, A. W., (2010) Towards Sustainability-driven Innovation through Product-Service Systems. Thesis, Dept. of Mechanical Engineering, Blekinge Institute of Technology, SWEDEN.

• Crul, M.R.M. and Diehl, J.C. (eds) (2009) Design for Sustainability: a step-by-step approach, United Nations Environment Programme, Delft University of Technology, The Netherlands.

• Stern, N 2007, Stern Review: The Economics of Climate Change, Cambridge University Press, Cambridge.

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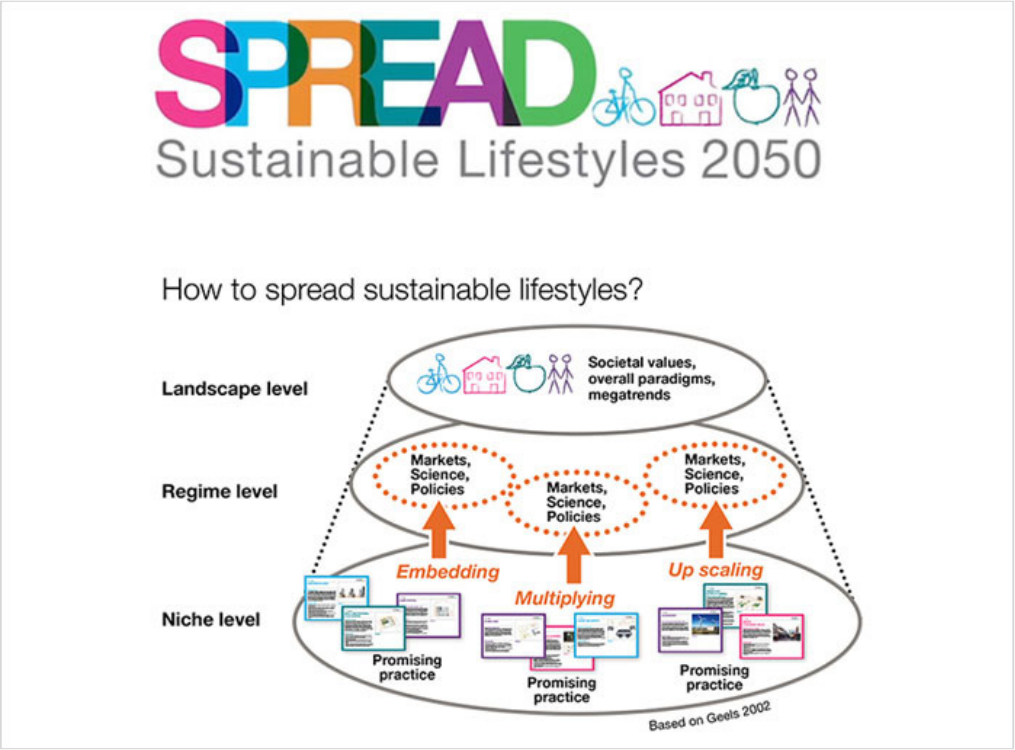

SPREAD Sustainable Lifestyles 2050 is a European social platform project running from January 2011 to December 2012. Different societal stakeholders – from business, research, policy and civil society – have been invited to participate in the development of a vision for sustainable lifestyles in 2050. This process will result in a roadmap for strategic action that will identify opportunity spaces for policy, business, research and civil society to take action to enable more sustainable lifestyles across Europe.

In recent years, we have witnessed the emergence of more sustainable products, services and experimental bottom-up initiatives. They have signalled new hope that more sustainable ways of living are achievable for all while celebrating diversity, in post-industrial societies. Despite these developments, existing promising sustainable living practices are not enough. They remain dwarfed by the unsustainable impacts of the average European's current lifestyles. To overcome the current challenges of our unsustainable lifestyles, the SPREAD project has developed future scenarios of possible societies that support more sustainable ways of living.

Source:
http://www.sustainable-lifestyles.eu/fileadmin/images/content/D4.1_FourFutureScenarios.pdf

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Systems Design for Sustainability

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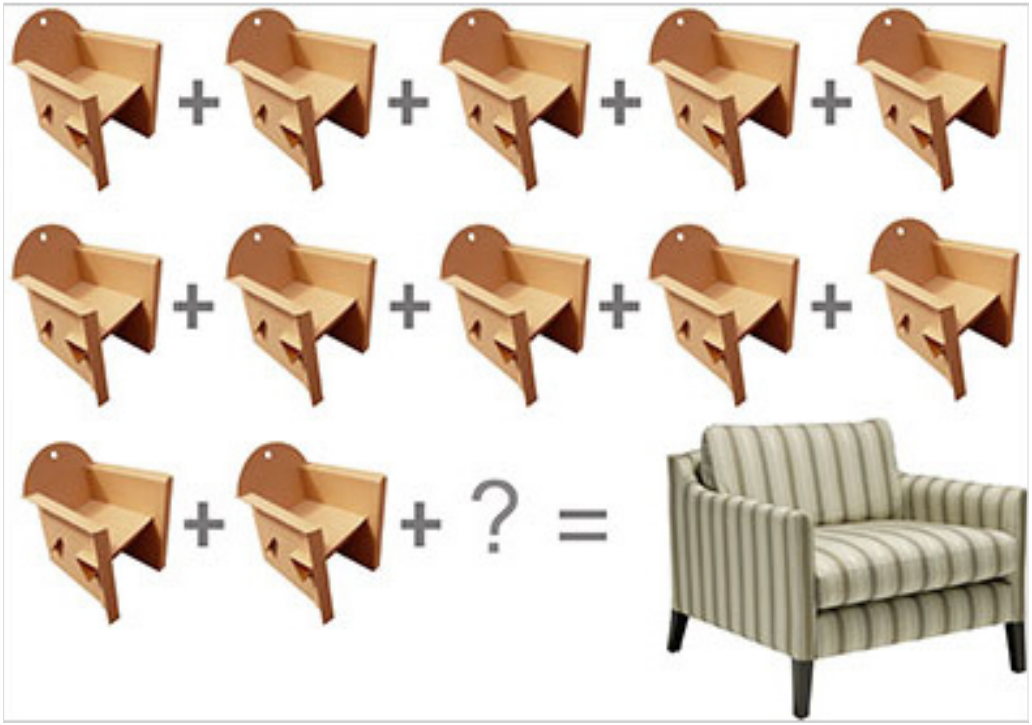
Life Cycle Design

Introduction:
The Life Cycle Design is closely related to eco-design or design for environment but LCD is more appropriate within the design discipline that deals with the sustainability requirements of industrial products.

Here, the goods have to be designed with all their life cycle stages. All activities needed for manufacturing its materials and then the product itself, its distribution, use and finally disposal are all considered to be one totality. Thus it takes from product design and goes to product system design, all the events that determine and accompany a product during its lifespan.

This process is very useful as it does not consider design where environmental impacts are reduced at one stage. For example, cardboard furniture, where the pre-production and production is less demanding than the furniture made from traditional durable materials, runs out of use very fast and has to be substituted again and again. Hence, the overall impact of cardboard furniture is much higher than one that is made up of traditional durable materials.



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The LCD approach, which takes into account all stages of the function, has an advantage in identifying the priorities of the product design concerned. The disadvantage remains in more complex designs where the information about the input-output of processes and about their impact on nature is limited. Another reason is the unpredictable operational and disposal techno-economical evolution. Not everything is known during the design process.

Currently, many organizational and operational factors limit the applicability of life cycle design and other design approaches to sustainable development. For example, lack of environmental data and simple, effective evaluation tools are major barriers. Despite these problems, companies are beginning to pursue aspects of life cycle design. The future of life cycle design and sustainable development depends on education, government policy and regulations, and industry leadership but fundamental changes in societal values and behaviour will ultimately determine the fate of the planet's life support system.

Strategies:
Strategies for Life Cycle Design are:

- Minimising Resource Consumption
- Selecting Low impact Resources and processes
- Product Lifetime Optimisation
- Extending Lifespan of Materials
- Facilitating Disassembly
- System Design for Eco-efficiency

The relative importance of various factors under life cycle design stratifies and their orientation will vary from industry to industry and product to product. However, there are general design principles for these life cycle requirements that will be generally applicable to many items

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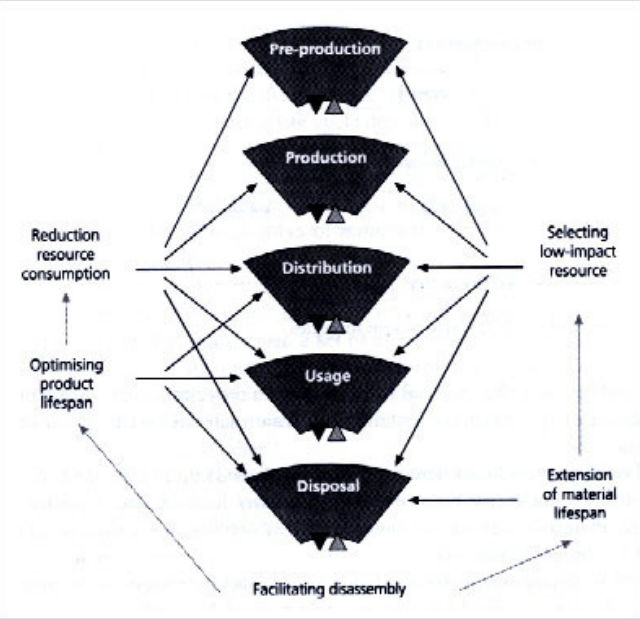

Life Cycle Design strategies and their influence on the stages of life cycle
Source: Vezzoli, C., Manzini, E., (2008) pp-65

Introduction

Phases

Design Guidelines

Design Tools

Design Course

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by
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Source:
https://dsource.in/course/systems-design-sustainability/life-cycle-design/introduction

Introduction

The environmental profile of goods and services that satisfy our individual and societal needs is shaped by design activities. Substantial evidence suggests that current patterns of human activity on a global scale are not following a sustainable path. Necessary changes to achieve a more sustainable system will require that environmental issues be more effectively addressed in design. But at present much confusion surrounds the incorporation of environmental objectives into the design process. Although not yet fully embraced by industry, the product life cycle system is becoming widely recognized as a useful design framework for understanding the links between societal needs, economic systems and their environmental consequences. The product life cycle encompasses all activities from raw material extraction, manufacturing, and use to final disposal of all residuals.

The entire life of a product can be described as one set of activities and processes, while every one of them consumes a certain amount of resources and energy, goes through a series of transformations and triggers emissions of various kinds. The product life cycle is another way in which the environmental and social effects during the life-time of a product can be studied, assessed and intervened for more sustainable outcomes.

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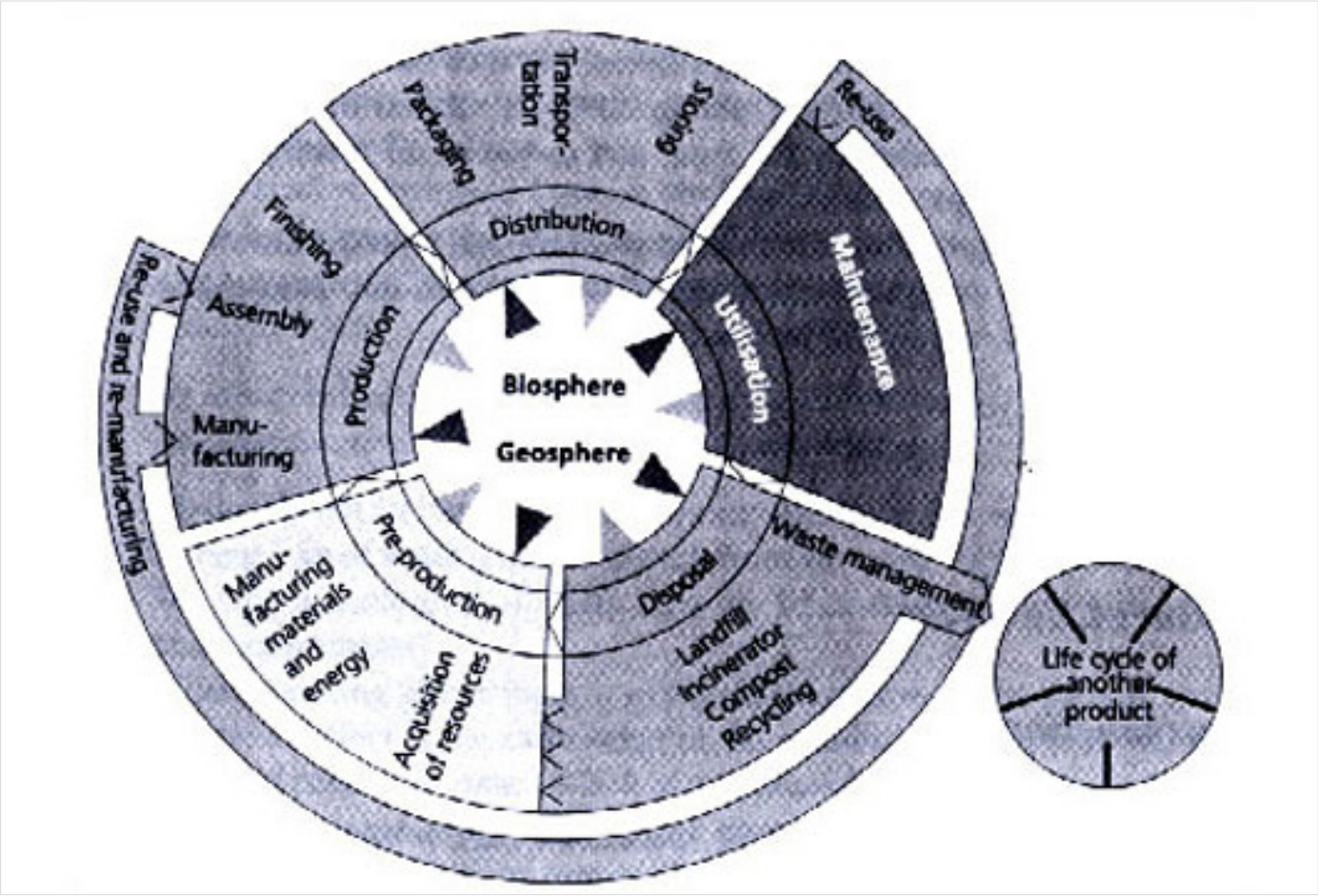
Phases

Product–system life-cycle:



Wheel showing phases from Prof. Ravi Mokashi's presentation)
Source: Vezzoli, C., Manzini, E., (2008)

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Source:
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Product Life Cycle can usually be divided into the following phases:
• Pre-Production
• Production
• Distribution
• Use/Customer Interface

Pre-Production:
In the preproduction stage, necessary resources and semi-finished products are prepared as components of the manufacturing of the final product.

The sub-stages are:
• Identifying sources and acquisition of resources
• Delivery of resources to the production area
• Transformation of resources into raw materials or energy

The sources could be primary (primary resources) or secondary (recycled resources). Criteria for selection of low-impact materials are:
• Cleaner
• Renewable
• Have lower energy content
• Recycled
• Recyclable
• Have a positive social impact, (e.g., generate local income)

Production:
The three key stages of production are:
• Processing of materials
• Assembly
• Completion

The raw materials need to be conveyed to the machinery and processed into components after which they are assembled for the completion of the final product.

Characteristic for the optimisation of production techniques:
• Alternative techniques
• Fewer steps
• Lower and cleaner energy use

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- Less waste
- Fewer and cleaner materials are used to support the production process
- Safety and cleanliness of workplace

Distribution:
Three fundamental stages that characterise distribution are:
- Packaging
- Transportation
- Storing

The final product is packaged in order to reach the end-user intact and functional; shipping is carried out by different means of transport either to an intermediate station or directly to the sphere of application. This stage entails not only energy consumption for transportation but also resource consumption to produce the means of transport as well as storage facilities.

Characteristics for the optimisation of distribution system:
- Less, cleaner, and reusable packaging
- Energy efficient transport mode
- Energy efficient logistics
- Involve local suppliers

Use/Customer interface:
Two fundamental stages that characterise utilisation are:
- Consumption
- Service

The utilisation or consumption of goods in most cases consumes resources and energy and leaves behind refuse and waste. Besides, they may require maintenance and servicing during its period of use.

Characteristics for reduction of impact during use:
- Lower energy use
- Cleaner energy source
- Fewer consumables required
- Cleaner consumables
- Health supporting and/or added social value

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Source:
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Characteristics for the optimisation of product lifetime
- Reliability and durability
- Easier maintenance and repair
- Modular product structure
- Classic design
- Strong product-user relationship
- Involve local maintenance and service systems

Product-System Life Extension Product System Life Extension strategies as described in the Life Cycle Design Guidance Manual: Environmental Requirements and the Product System (1993, January) US Environmental Protection Agency, Washington DC are as follows:

Appropriately Durable:
Durable items can withstand wear, stress and environmental degradation over long useful life.
A durable product continues to satisfy customer needs over an extended life. Impacts caused by products should be divided by estimated useful life. Such normalized figures allow designers to properly compare competing products.

Adaptable:
Adaptable designs either allow continual updating or they perform several different functions. Modular components allow single-function products to evolve and improve as needed.
Adaptability can extend the useful life of products that quickly become obsolete. to reduce overall environmental impacts, a sufficient portion of the existing product must usually remain after obsolete parts are replaced.

Reliable:
Reliability is a major aspect of quality. It measures the ability of a system to accomplish its design mission in the intended environment for a certain period of time. Unreliable products or processes, even if they are durable are often quickly retired.

Serviceable:
A serviceable system can be adjusted for optimum performance under controlled conditions. This capacity is retained over a specified life.
When designing serviceable products, the team should first determine who will provide service.

Maintainable:
The relative difficulty or time required to maintain a certain level of system performance determines whether that system can be practically maintained.

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by
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DoD, IIT Guwahati

Source:
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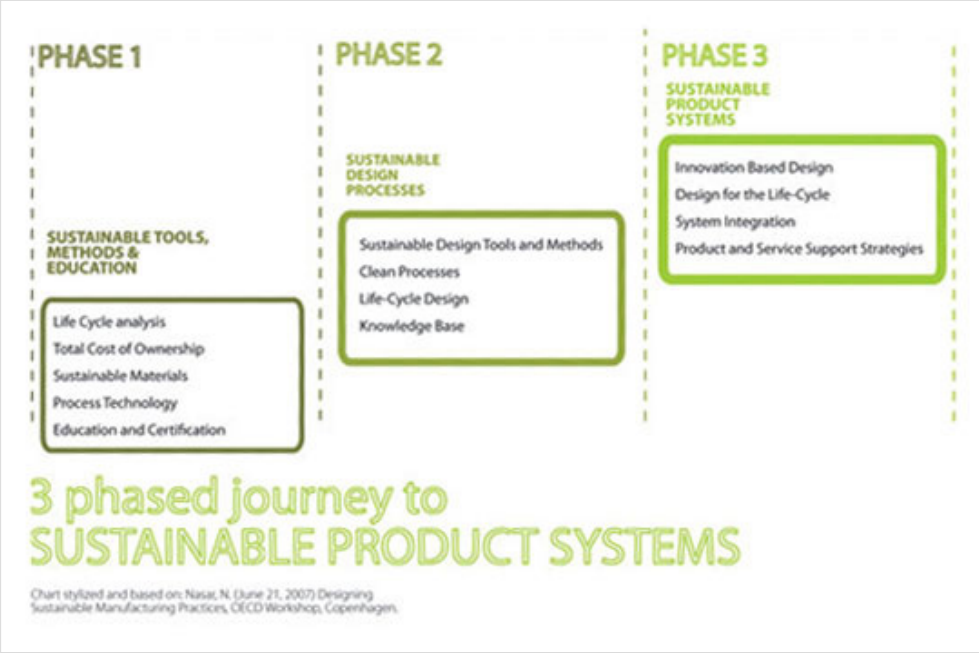
Repairable:
Repairability is determined by the feasibility of replacing dysfunctional parts and returning a system to operating condition.

Re-manufacturable:
Remanufacturing is an industrial process that restores worn products to lien-new condition. In a factory, a retired product is first completely disassembled. Its usable parts are then cleaned, refurbished, and put to inventory. Finally, a new product is reassembled from both old and new parts, creating a unit equal in performance and expected life to the original or a currently available alternative. In contrast, a repaired or rebuilt product usually retains its identity and only those parts that have failed or are badly worn are replaced.

Reusable:
Reuse is the additional use of an item after it is retired from a clearly defined duty. Reformulation is not reuse, however, repair, cleaning or refurbishing to maintain integrity may be done in transition from one use to the next. When applied to products, reuse is a purely comparative term. Products with no single use analogs are considered to be in service until discarded.



Three phased journey to Sustainable Product Systems.

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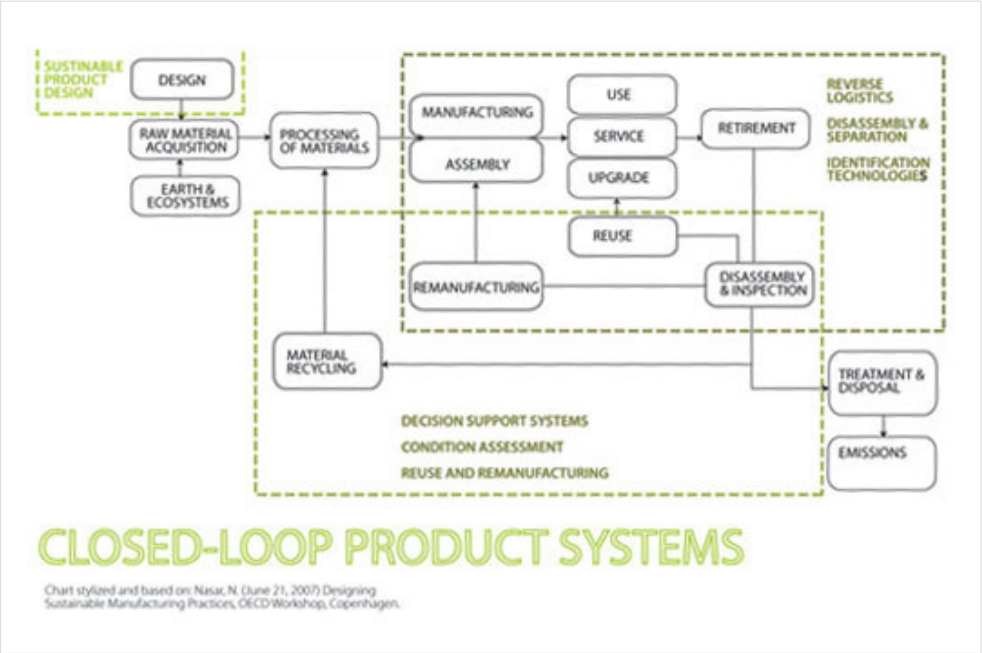

Closed loop Product Systems.
Image Source: Chart stylized and based on: Nasar, N. (June 21, 2007) Designing Sustainable Manufacturing Practices, OECD Workshop, Copenhagen.

Disposal:
At the time of disposal the product or its components can either be reused or recycled, composted or incinerated otherwise unused products are dumped into landfills or just dispersed into the environment.

Characteristics for the optimisation of end-of-life systems:
- Re-use of product
- Remanufacturing/refurbishing
- Recycling of materials
- Safer incineration
- Taking into consideration local (informal) collection/ recycling systems

The concept of life cycle is able to adapt a system vision over the products input-output during all phases, analyse and asses its environmental effect together with economic and social influences.

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Design Guidelines

Criteria and Guidelines: Minimising material consumption:

Minimise material content:
- Dematerialise the product or some of its components (eg. 01)
- Digitalise the product or some of its components (eg. 02)
- Miniaturise
- Avoid over sized dimensions
- Reduce thickness
- Apply ribbed structures to increase structural stiffness
- Avoid extra components with little functionality

Minimise scraps and discards:
- Select processes that reduce scraps and discarded materials during production.
- Engage simulation systems to optimise transformation processes.

Minimise or avoid packaging (eg. 03):
- Avoid packaging
- Apply materials only where absolutely necessary
- Design the package to be part of the product.

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Engage more consumption-efficient systems:
- Design for the more efficient supply of raw materials. (**eg.04** E-cloth system by Enviro Systems).
- Design for the more efficient use of maintenance materials
- Design systems for the consumption of passive materials
- Design for the cascading of recycling systems. (**eg.05** Integrated washbasin and flush toilet, Huib van Glabeek)
- Facilitate reducing materials consumption for the user (**eg.06** Dual control water tap, Grohe)
- Set the product's default state at minimum materials consumption

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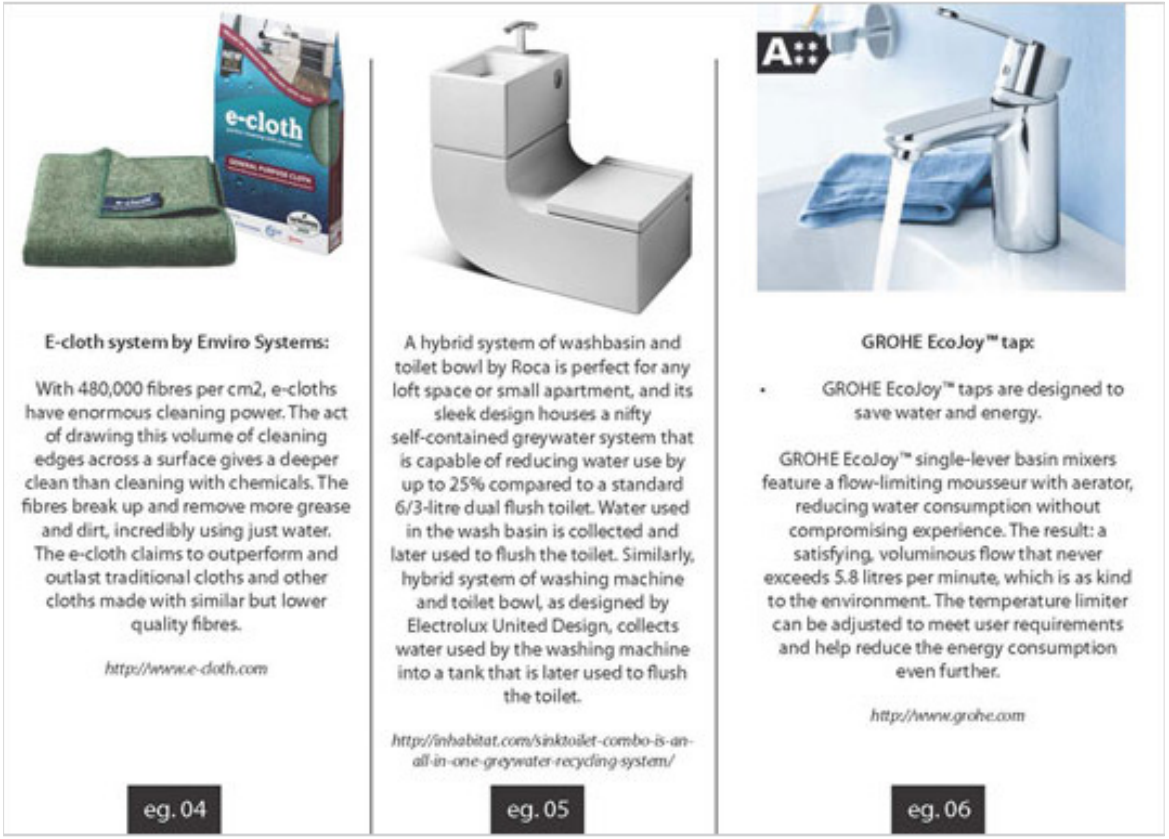

Engage Systems of flexible materials consumption:
• Engage digital support systems with dynamic configuration.
• Design for dynamic material consumption according to differentiated operational stages (**eg.07** Dual control flush toilet, Duetto Cesame).
• Engage sensors to adjust materials consumption according to differentiated operational stages (**eg.08** Fuzzy Logic Dishwasher, Rex Izzi).
• Reduce materials consumption in the product's default state.

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Minimise materials consumption during the product development phase:(**eg.09**)
- Minimising materials consumption of stationery goods and their packages
- Engage digital tools in designing, modelling and proto-type creating
- Engage digital tools for documentation, communication and presentation

Minimising Energy consumption:
Minimise energy consumption during pre-production and production

- Select materials with low energy intensity
- Select processing technologies with the lowest energy consumption possible
- Engage efficient machinery
- Use heat emitted in processes for per-heating other determined process flows
- Engage pump and motor speed regulators with dynamic configurations

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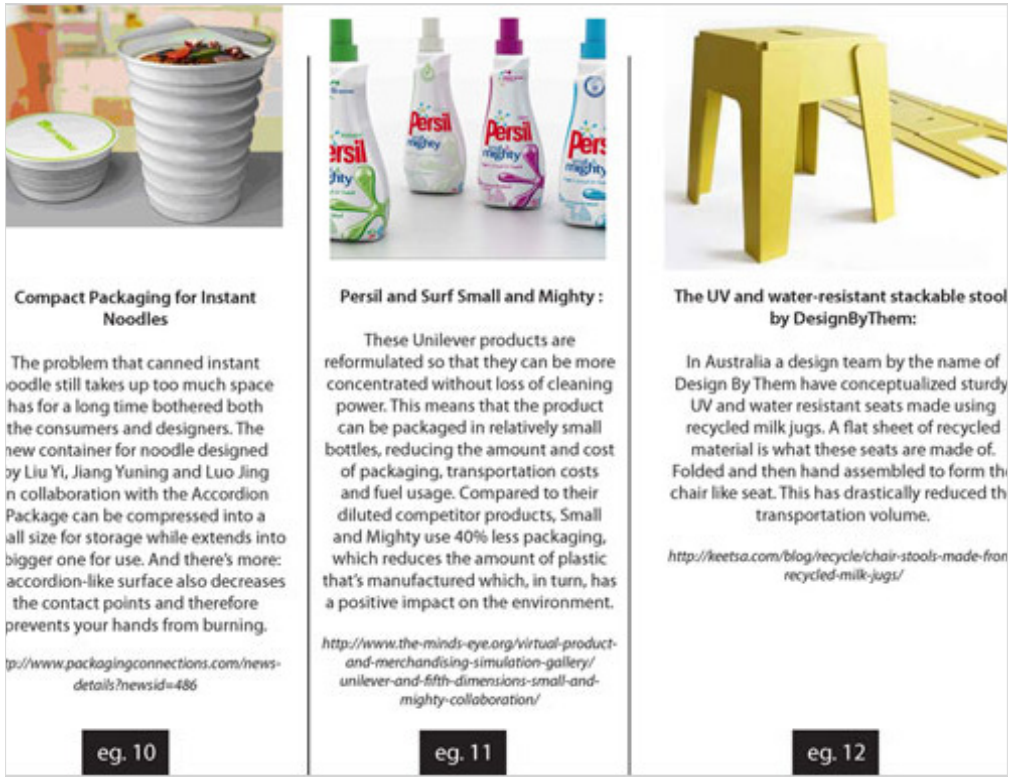
- Equip the machinery with intelligent power-off utilities
- Optimise the overall dimensions of engines
- Facilitate engine maintenance
- Define accurately the tolerance parameters
- Optimise transportation systems and scale down weight and volume of the materials and products
- Engage efficient general heating/cooling, lighting and ventilation in buildings.

Minimise energy consumption during transportation and storage

- Design compact products with high storage density (**eg.10**)
- Design concentrated products (**eg.11**)
- Equip products with on-site assembly (**eg.12**)
- Scale down the product weight
- Scale down the packaging weight (**eg.13**)
- Decentralise activities to reduce transportation volumes
- Select local materials and energy sources (**eg.14**)



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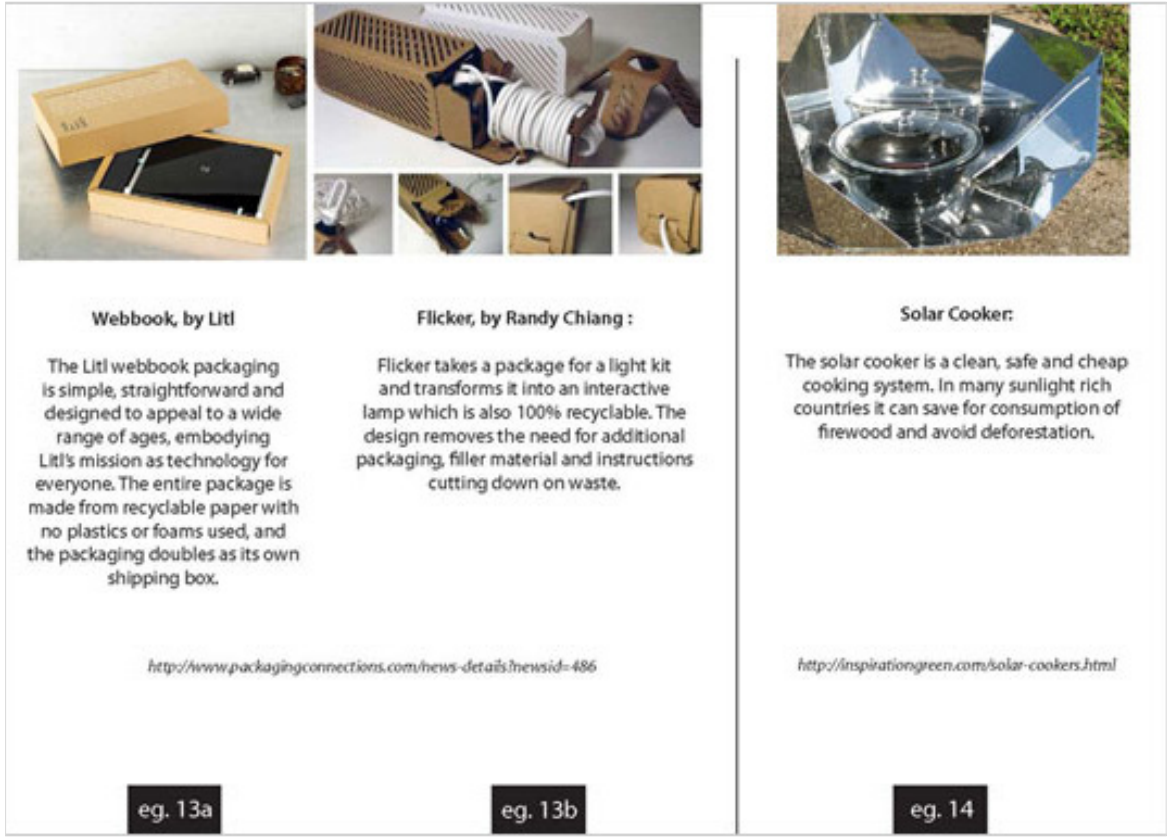

Select Systems with energy-efficient operation stage:

- Design attractive products for collective use
- Design for energy-efficient operational stages
- Design for energy-efficient maintenance (**eg.15**)
- Design systems for consumption of passive energy sources
- Engage highly efficient energy conservation systems
- Design/engage highly efficient engines and power transmissions (**eg.16**)
- Design for localised energy supply
- Scale down weight of transportable goods
- Design energy recovery systems (**eg.17**)
- Design energy saving systems

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Refrigerator FRIA, by Ursula Tichner

Tischner's FRIA reworks the basics of design, integrating the pre-designed cooling space with the natural ventilation of the relevant, usually northern, wall, which cooled the ergonomically spaced freezer, fridge and cool-storage compartments. In place of the CFC-heavy cooling of conventional refrigerators, the FRIA can use non-CFC materials: blown concrete, cork or recycled paper. As soon as the external temperature is low enough, this cold air cools the FRIA, so only requiring a small fan to draw air through the filtering system, rather than a complete cooling system. FRIA is also a long-term domestic appliance, since every part can be replaced or exchanged because of the fridge's modular design. All in all the energy pay off is potentially remarkable: the FRIA uses at most half the energy of a modern fridge; there is no CFC usage; and energy waste, up to 80% in a normal fridge, is removed through FRIA's integration into the building's fabric.

http://www.fourthdoor.org/pdfs/7.18.pdf

eg. 15

TATA aircars:

Tata motors and MDI technology have come to an agreement to use the air engine technology (that uses Compressed Air) of MDI on Tata Motors vehicle. According to Tata Motors the first phase to product these type of vehicles was a success.

http://openmarkets.in/2446/tata-mdi-air

eg. 16

i-Magic-Fortius bicycle:

i-Magic-Fortius bicycle releases muscular energy released during pedalling and transfers it to the network. It saves energy that could have been wasted otherwise.

http://www.wheelies.co.uk/p18756/Tacx-Fortius-i-Magic-VR-Trainer-with-Video-Reality-and-VR-Software.aspx

eg. 17

Engage dynamic consumption of energy:
- Engage digital dynamic support systems
- Design dynamic energy consumption systems for differentiated operational stages
- Equip machinery with intelligent power-off utilities
- Program products default state at minimal energy consumption

Minimise energy consumption during product development:
- Engage efficient workplace heating, illumination and ventilation
- Engage digital tools for communicating with remote work sites

Minimising Toxic Emissions:
Select non-toxic and harmless materials:
- Avoid toxic or harmful materials for product component

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Systems Design for Sustainability

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by
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DoD, IIT Guwahati

Source:
https://dsource.in/course/systems-design-sustainability/life-cycle-design/design-guidelines

- Minimise the hazard of toxic and harmful materials
- Avoid materials that emit toxic or harmful substances during preproduction
- Avoid additives that emit toxic or harmful substances
- Avoid technologies that process toxic and harmful materials
- Avoid materials that emit toxic or harmful substances during usage and disposal

Select non-toxic and harmless energy sources:
- Select energy resources that reduce dangerous emissions during preproduction, production, distribution and usage.
- Select energy resources that reduce dangerous residues and toxic and harmful wastes.

Select renewable and bio-compactable materials:
- Use renewable materials (**eg.18**)
- Avoid exhaustive materials
- Use residual materials from production processes (**eg.19**)
- Use retrieved components from disposed of products
- Use recycled materials, alone or combined with primary materials
- Use biodegradable materials (**eg.20a, 20b**)

Mitticool – A clay refrigerator

Conceptualized in 1997, Mitticool is developed by Gujarat based potter Manshuk Lal and the product works on the basic principle of evaporation. Mitti Cool Refrigerator weighs 20 kg (height:18.5" and width of 11") and the way it works is very simple – Water from the upper chambers drips down the side, taking heat from the inside gets evaporated, leaving the chambers cool..

www.mitticool.in
http://farmpottery.wordpress.com/2011/03/26/mitticool-a-clay-refrigerator/

eg. 18

Rothko chair, by Lievore :

The Argentinian architect Alberto Lievore developed the chair for the Rothko Bar in Barcelona, named after the American abstract expressionist painter Mark Rothko (1903-1970). The Rothko chair was designed at a time in the early 1990s when awareness of the ecological impact of making furniture was at its most pronounced. It is entirely made of a composite material called Maderón, a mixture of resin and ground almond shells developed by a chemical engineer, Silio Cardona, from 1980. The shells were a waste product of the Spanish almond industry.

http://collections.vam.ac.uk/item/O122406/rothko-chair-chair-lievore-alberto/

eg. 19

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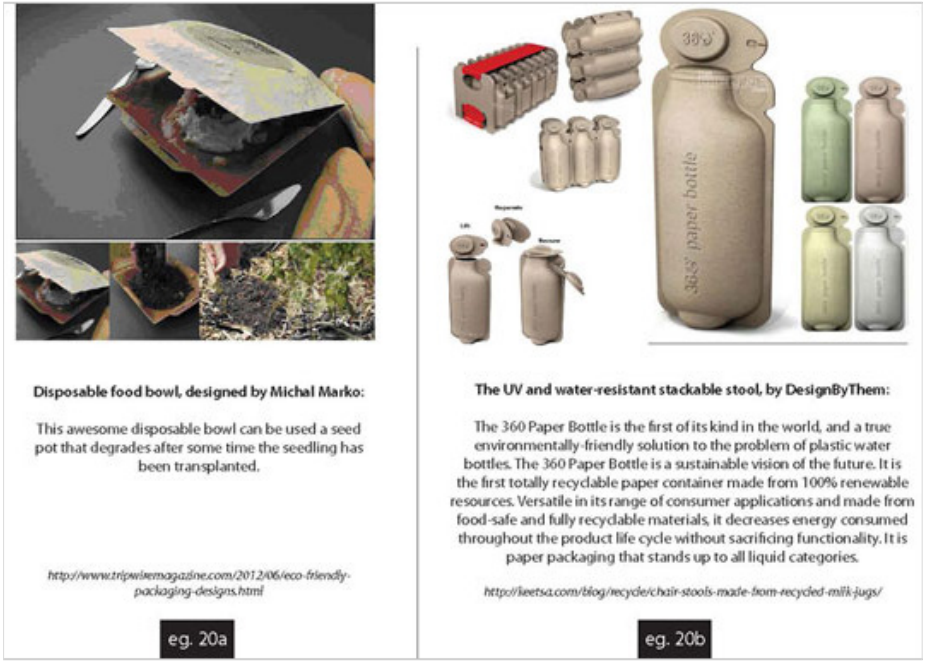

Select renewable and bio-compactable energy sources:
- Use renewable energy resources
- Engage a cascade approach
- Select energy resources with high second order efficiency

Product lifetime optimisation:
Design for appropriate lifespan:
- Design components with a coextensive lifespan (**eg. 21**).
- Design the lifespan of replaceable components according to scheduled durability.
- Enable and facilitate the separation of components that have different lifespans (**eg. 22**).
- Select durable materials according to the product's performance and lifespan.
- Avoid using durable materials for temporary products or components.

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Kyocera Mita printers with durable drums:

The company's main claim is the running costs of its machines. Nearly all of its printers use a unique photoconductor drum – the component on which the page image is built up during printing – with a secret coating which makes it a lifetime component. Under normal use, you should never need to replace the drum, meaning the only running cost is toner.

http://www.reghardware.com/2009/02/03/review_colour_laser_printer_kyocera_mita_fs_c5200dn/
http://www.kyoceradocumentsolutions.co.uk/index/products/sustainable_design.html

eg. 21

Canon inkjet printer cartridges:

Unlike traditional colour cartridges, which have one container for all colours the Canon printers started using different container for every colour. Though this solution used slightly larger materials, this innovation lengthened the average lifespan of a cartridge and reduced the wastage of ink colour as all the colours are never exhausted at the same time.

http://www.canon.co.in

eg. 22

Design for reliability:
- Reduce overall number of components.
- Simplify products.
- Eliminate weak links.

Facilitate upgrading and adaptability:
- Enable and facilitate software upgrading.
- Enable and facilitate hardware upgrading.
- Design modular and dynamically configured products to facilitate their adaptability for changing environments.
- Design multifunctional and dynamically configured products to facilitate their adaptability for changing cultural and physical individual backgrounds.
- Design onsite upgradable and adaptable products.
- Design complementary tools and documentation for product upgrading and adaptation.

Facilitate maintenance (**eg. 23, 24**):
- Simplify access and disassembly to components to be maintained.
- Avoid narrow slits and holes to facilitate access for cleaning.
- Prearrange and facilitate the substitution of short-lived components.

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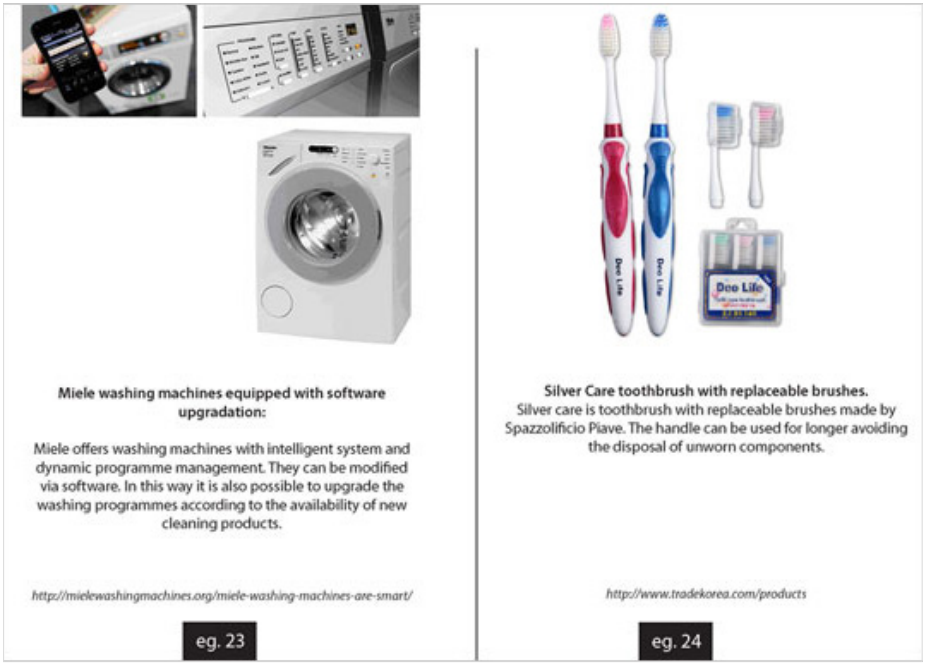
- Equip the product with easily usable tools for maintenance.
- Equip products with diagnostic and/or auto-diagnostic systems for maintainable components.
- Design products for easy on-site maintenance.
- Design complementary maintenance tools and documentation.
- Design products that need less maintenance.



Miele washing machines equipped with software upgradation:

Miele offers washing machines with intelligent system and dynamic programme management. They can be modified via software. In this way it is also possible to upgrade the washing programmes according to the availability of new cleaning products.

http://mielewashingmachines.org/miele-washing-machines-are-smart/

eg. 23

Silver Care toothbrush with replaceable brushes.
Silver care is toothbrush with replaceable brushes made by Spazzolificio Piave. The handle can be used for longer avoiding the disposal of unworn components.

http://www.tradekorea.com/products

eg. 24

Facilitate repairs:
- Arrange and facilitate disassembly and re-attachment of easily damageable components.
- Design components according to standards to facilitate substitution of damaged parts.
- Equip products with automatic damage diagnostics system.
- Design products for facilitated onsite repair.
- Design complementary repair tools, materials and documentation.

Facilitate re-use:
- Increase the resistance of easily damaged and expendable components
- Arrange and facilitate access and removal of retrievable components.
- Design modular and replaceable components
- Design components according to standards to facilitate replacement.

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- Design re-usable auxiliary parts.
- Design the re-filling and re-usable packaging.
- Design products for secondary use.

Facilitate re-manufacture:
- Design and facilitate removal and substitution of easily expendable components.
- Design structural parts that can be easily separated from external/visible ones.
- Provide easier access to components to be re-manufactured.
- Calculate accurate tolerance parameters for easily expendable connections.
- Design for excessive use of materials in places more subject to deterioration.
- Design for excessive use of material for easily deteriorating surfaces.

Intensify use:
- Design products and services for shared use.
- Design multifunctional products equipped with replaceable common components.
- Design products with integrated functions.
- Design products or components on demand.
- Design products or components on availability.

Improving lifespan of materials:
Adopt the cascade approach:
- Arrange and facilitate recycling of materials in components with lower mechanical requirements.
- Arrange and facilitate recycling of materials in components with lower aesthetical requirements.
- Arrange and facilitate energy recovery from materials throughout combustion.

Select materials with most recycling technologies:
- Select materials that easily recover after recycling the original performance characteristics.
- Avoid composite materials or when necessary, choose easily recyclable ones.
- Engage geometric solutions like ribbing to increase polymer stiffness instead of reinforcing fibres.
- Prefer thermoplastic polymers to thermosetting.
- Prefer heat-proof thermoplastic polymers to fireproof additives
- Design considering the secondary use of materials once recycled.

Facilitate end-of-life collection and transportation:
- Design in compliance with product retrieval system.
- Minimise overall weight.
- Minimising cluttering and improving stackability and compressibility of discarded products.

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• Provide the user with information about the disposing modalities of the product or its parts.

Material identification:
• Codify different materials to facilitate their identification
• Provide additional information about the material's age, number of times recycled in past and additive used.
• Indicate the existence of toxic or harmful materials.
• Use standardised materials identification systems.
• Arrange codification in easily visible places.
• Avoid codifying after component production stages.

Minimise the number of different incompatible materials:
• Integrate functions to reduce the overall number of materials and components.
• Mono material strategy- only one material per product or per sub-assembly.
• Use only one material, but processed in sandwich structures
• Use compatible materials that can be recycled together within the product or sub-assembly.
• For joining use the same or compatible materials as in components to be joined.

Facilitate cleaning:
• Avoid unnecessary coating procedures.
• Avoid irremovable coating materials.
• Facilitate removal of coating materials.
• Use coating procedures that comply with coated materials.
• Avoid adhesives or choose ones that comply with materials to be recycled.
• Prefer the dyeing of internal polymers, rather than surface painting.
• Avoid using additional materials for marking or codification.
• Mark or codify materials during moulding.
• Codify polymers using lasers.

Facilitate composting:
• Select materials that degrade in the expected end-of-life environment.
• Avoid combining non-degradable materials with products that are going to be composted.
• Facilitate the separation of non-degradable materials.

Facilitate composting:
• Select materials that degrade in the expected end-of-life environment.
• Avoid combining non-degradable materials with products that are going to be composted.
• Facilitate the separation of non-degradable materials.

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From Product to System-Service Design and Innovation

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Facilitate combustion:
- Select high energy materials for products that are going to be incinerated.
- Avoid materials and additives that emit dangerous substances during incineration.
- Facilitate the separation of materials that would compromise the efficiency of combustion with low energy value.

Design for Disassembly:
Reduce and facilitate operations of disassembly and separation:

Overall architecture:
- Prioritise the disassembly of toxic and dangerous components or materials.
- Prioritise the disassembly of components or materials with higher economic value.
- Prioritise the disassembly of more easily damageable components.
- Engage in modular structures.
- Divide the product into easily separable and manipulatable sub-assemblies.
- Minimise overall dimensions of the product.
- Minimise hierarchically dependent connections between components.
- Minimise different directions in the disassembly route of components and materials.
- Increase the linearity of the disassembly route.
- Engage a sandwich system of disassembly with central joining elements.

Shape of components and parts:
- Avoid difficult-to-handle components.
- Avoid asymmetrical components, unless required.
- Design leaning surfaces and grabbing features in compliance with standards.
- Avoid leaning surfaces around the product's centre of gravity.
- Design for easy centring on the component base.

Shape and accessibility of joints:
- Avoid joining systems that require simultaneous interventions for opening.
- Minimise the overall number of fasteners and fastener types.
- Avoid difficult-to-handle fasteners.
- Design accessible and recognisable entrances for dismantling.
- Design accessible and controllable dismantling points.

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Engage reversible joining systems:
- Employ two-way snap-fit.
- Employ joints that are opened with common tool. Use special tools when opening could be dangerous.
- Design joints are made of materials that become reversible only in determined conditions.
- Use screws with hexagonal heads.
- Prefer removable nuts and clips to self-tapping screws.
- Use screws made of materials compatible with joint components, to avoid their separation before recycling.
- Use self-tapping screws for polymers to avoid using metallic inserts.

Engage easily collapsible permanent joining systems:
- Avoid rivets on incompatible materials.
- Avoid staples on incompatible materials.
- Avoid additional materials while welding.
- Weld with compatible materials.
- Prefer ultrasonic and vibration welding with polymers.
- Avoid gluing with adhesives.
- Employ easily removable adhesives.

Co-design special technologies and features for crushing separation:
- Design thin areas to enable the taking off of incompatible inserts, by pressurised demolition.
- Co-design cutting or breaking paths with appropriate separation technologies for incompatible materials separation.
- Equip the product with a device to separate incompatible materials.
- Employ joining elements that allow their chemical or physical destruction.
- Make the breaking points easily accessible and recognisable.
- Provide the products with information for the user about the characteristics of crushing separation.

Use materials that are easily separable after being crushed.
Use additional parts that are easily separable after crushing of materials.

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Systems Design for Sustainability

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Design Tools

LeNS (2007-2010), the Learning Network on Sustainability, a project for curricula development and teaching diffusion on Design for Sustainability focused on product-service system innovation, has developed Product Life Cycle Design Tools.

LCA is a good tool to assess the environmental performance of a product. Although it is widely used by designers, LCA is often time consuming and costly. Different programme software providing LCA are:

Eco-Indicator 99:
The results of LCA are not so straightforward in favour of one product or material design over the alternative one, hence the results of LCA have to be interpreted or weighed. The eco-indicator 99 methodology is an LCA weighing method specially developed for product design. is the most recent version of the method, which uses a simple set of inventory tables and standard impact data for materials and processes, allows a basic assessment to be performed. Its main drawback is the limited number of impact indicators, but it is nevertheless an effective tool for those who do not wish to invest the money in a more accurate tool.

http://www.pre-sustainability.com/download/manuals/EI99_Manual.pdf
http://www.worldchanging.com/archives/002171.html

SIMAPRO:
SimaPro follows a similar system to the basic Eco-Indicator 99 method but as a software programme it is quick and easy to use, and has a far more comprehensive database of impact data. It also allows more experienced users to develop their own impact scores for materials and processes not included as standard.

http://www.pre-sustainability.com/download/Webdemo/SimaPro_7_Introduction.htm

SolidWorks SustainabilityXpress:
SolidWorks SustainabilityXpress enables you to perform screening-level life cycle assessment (LCA) directly on individual part designs to help you understand the environmental impacts of your design decisions. SustainabilityXpress is included with each of the SolidWorks 3D CAD design packages—SolidWorks Premium, Professional, and Standard.

You start by entering basic product parameters, such as manufacturing process and region, to calculate overall impacts of your part design on four key environmental indicators: carbon footprint, total energy demand, impacts to the air, and impacts to water. The initial analysis provides a baseline for direct comparison with any design changes.

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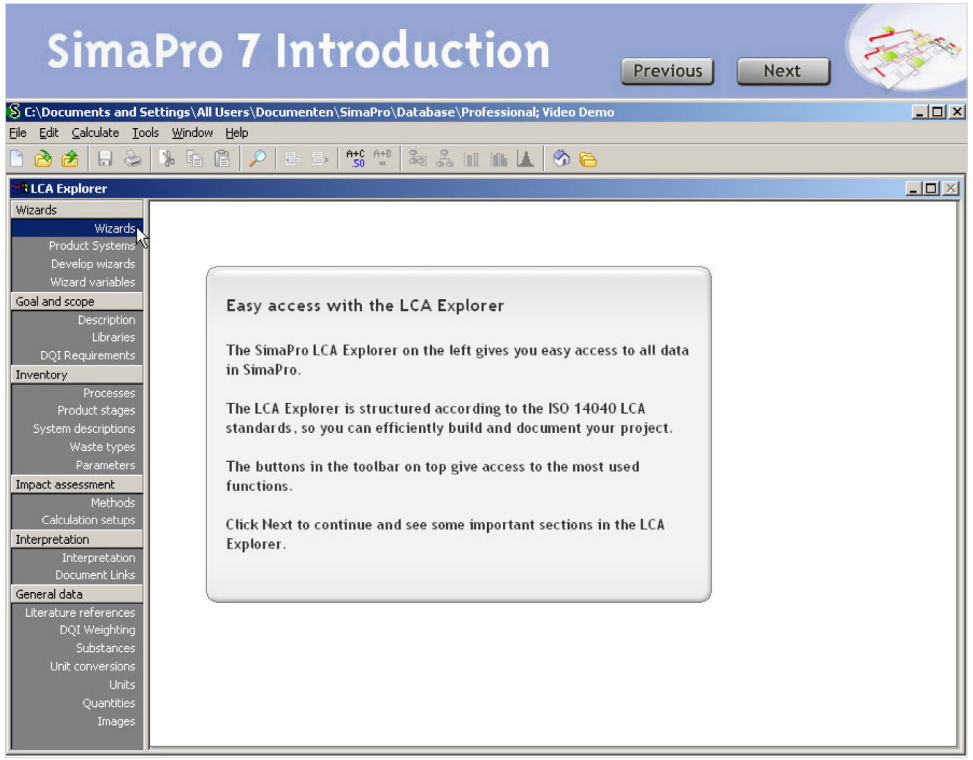
https://dsource.in/course/systems-design-sustainability/life-cycle-design/design-tools

http://www.solidworks.com/sw/products/10406_ENU_HTML.htm
http://www.solidworks.com/sustainability/

References:
1. Keoleian & Menerey. Sustainable Development by Design: Review of Life Cycle Design and Related Approaches.
http://css.snre.umich.edu/publication/
sustainable-development-design-review-life-cycle-design-and-related-approaches

Note:
This chapter is based on
Vezzoli, C., Manzini, E., (2008) Design for Environmental Sustainability, Springer, London.
and
Design for Sustainability manual at
http://www.d4s-de.org/



Source: http://www.pre-sustainability.com/download/Webdemo/SimaPro_7_Introduction.htm

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Source:
https://dsource.in/course/systems-design-sustainability/life-cycle-design/design-tools

Design for Sustainability manuals and tools
Source: http://www.d4s-de.org/

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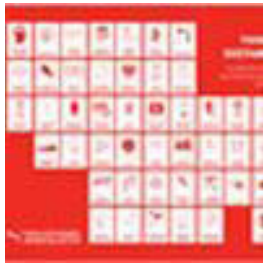
Methods and Tools



Introduction

Methodology for SDS

Design Tools for SDS

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Introduction

In order to comprehend how to use methods and tools to orient design towards sustainable solutions, it is useful to use as a benchmark, a simplified scheme of phases of development of products, services or systems that lead to sustainability oriented concepts, design and related engineering.

Series of tools have been developed that could be applied during different phases of development. It is rather obvious that integrating necessary requisites for sustainable outcomes, i.e. appropriate methods and tools, during the initial phases of development is rather efficient.

The tools and methods are meant to assist the designer in accomplishing three specific objectives according to Vezzoli, C. [2007]:

1. Setting sustainability priority (assessing existing system)
2. Generating sustainability-focused ideas (developing innovative systems)
3. Checking/visualizing sustainability improvement/worsening of the developed concepts (comparing the existing and innovative system)

New design capabilities are required by the designers to orient the system design practice towards innovative sustainable solutions, satisfaction, interactions and relationships between the stakeholders. Hence, it is clear that we need methods and tools to support system design for sustainability.

Various research projects have been funded in the European Union over past few years with the aim of developing and testing methods and tools for system design, the main ones being:

• SusHouse: Strategies Towards the Sustainable Household (1998-2000)

SusHouse (Strategies Towards the Sustainable Household) is an EU-funded research project concerned with developing and evaluating strategies for transitions to sustainable households. Three household functions are being studied in the SusHouse project: Clothing Care, Shelter, and Shopping, Cooking and Eating (previously known as Nutrition). With the help of stakeholders from industry, government, universities, and public interest groups, the project formulates normative scenarios of possible developments of these household functions for the year 2050 focusing on the necessary technological and cultural innovations that contribute to the sustainable household. The project was carried out by six research teams from five countries – Germany, Hungary, Italy, the Netherlands and the United Kingdom – from January 1998 to June 2000.
http://infohouse.p2ric.org/ref/26/25626.pdf

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• ProSecCo: Product Service Co-design (2002-2004)

PROSECCO intends to develop an integrated, modular innovation management system for product-service co-design (PSCD) projects in dynamic networking contexts. SMEs, Start-UPs and modular units of large companies are seen as end-user target groups whereas all other knowledge-workers and creatives constitute an intermediate group. Application areas for the PROSECCO results are management of a) PSCD innovation-related processes and; b) resources and competencies in innovation networks. With innovation as trigger for economic growth, the project will have an important impact on current as well as new employment by keeping European SMEs competitive in enhancing their innovative capacities and in supporting their networking flexibility as well as their capacities to respond proactively to market demands. The consortium includes partners with various profiles and from four European countries.
http://www.istworld.org/ProjectDetails.aspx?ProjectId=e2313e20098f4f8c8355841638612193&SourceDatabaseId=e4fcfde0182a45898e8741a1abae3984

• HiCS: Highly Customized Solutions (2001-2004)

Today's consumption patterns ask for HiCS, i.e. customised solutions for specific customers in specific contexts of use and
in specific socio-cultural and physical habitats.
www.istworld.org/ProjectDetails.aspx?ProjectId=96878f45e83f406abbf6e8627e43f672&SourceDatabaseId=9cd97ac2e51045e39c2ad6b86dce1ac2

• MEPSS: Methodology for Product Service System development (2002-2005)

The MEPSS project develops a methodology that helps the industry to set up and analyse newly developed product service systems. SERI is a member of the scientific peer review group.

The project focuses on the following aspects:

• Design and implementation aspects;
• Micro-, meso- and macro-economic impacts;
• Social and environmental impacts and issues related to consumer acceptance and culture and ethics.

The project offers a tool for companies for the implementation of new product service systems in line with their business goals, and their consumers' needs and with the aim to reduce negative environmental impacts.

The project has been built up around three main theoretical concepts: 'PSS design and implementation (system

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Systems Design for Sustainability

From Product to System-Service Design and Innovation

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DoD, IIT Guwahati

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innovation)', 'Assessment of impact' and 'Success and failure factors' addressing six major issues:

PSS Design and implementation

- Design of services
- Combining product and service

Assessment of impact

- Impact on macro level (system model)
- Impact on micro and meso level (LCA/LCC)

Success and failure factors

- Consumer acceptance
- Culture and ethics

http://seri.at/projects/completed-projects/mepps/

- SusProNet: Sustainable Product Service Co-design Network (2002-2005)

SusProNet is the first European Network on Sustainable Product-Service Development and plays a central role in the field of Product-Service-Systems (PSS) design and development. SusProNet is funded under the European Commission's Fifth Framework Programme. The Network's aims are to exchange, analyse, complete and make easily available information on best practices on Sustainable Product-Service Development, identify research needs to create excellence in Sustainable Product-Service Development in Europe, and, by this contribute considerably to various EU policy objectives, such as Integrated Product Policy, Sustainable Development, and competitive growth. The SusProNet Consortium consists of over 30 organizations.

- LeNS: the Learning Network on Sustainability (2007-2010)

LeNS, the Learning Network on Sustainability, is an Asian-European multi-polar network for curricula development on Design for Sustainability focused on product-service system innovation. LeNs is a 3 years project (15/12/2007 - 15/12/2010) funded by the Asia Link Programme, EuropAid, European Commission, involving 7 design schools in Europe and Asia. LeNS aims at contributing to human resources and curriculum development, in a reciprocal understanding of cultures, by promoting a new generation of designers (and design educators) capable to effectively contributing to a transition towards a sustainable society. LeNS's ambition is to promote a new

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shared disciplinary ground on Design for Sustainability through a series of exchange activities among the partner institutions. LeNS consortium will jointly produce an open e-learning package. It will also promote a series of diffusion activities targeting the design community worldwide.
http://www.lens.polimi.it/index.php?M=0

50 'ways of working' by University of Brighton Faculty of Arts researcher Dr Jonathan Chapman for 'The Puma Sustainable Design Collective' (PSDC) enhances the ecological performance of their products, processes and thinking. These ranged from some fairly technical tools and methods such as 'zero waste pattern cutting' or designing for 'low chemical impacts', through to psychological tools such as 'object as educator' or 'emotional durability'. Represented by a series of icons, these '50-ways' live on today in the Puma studios.

Source:
http://arts.brighton.ac.uk/research/news/developing-sustainable-design-at-a-global-level

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Methodology for SDS

The following two sections of this chapter are based on the work of Vezzoli, C., (2007) [Chapter 5: Methods and tools for SDS. SYSTEM DESIGN FOR SUSTAINABILITY: Theory, methods and tools for a sustainable "satisfaction-system" design. Second Edition, Maggioli Editore. pp. 215-294].

Here the Methodology for System Design for Sustainability (MSDS) is described together with its tools. Both methodology and tools have been tested by the DIS Research Unit. The same method was also adopted in pilot courses within the research project LeNS.

MSDS was developed by the research unit System Design and Innovation for Sustainability (DIS) in the INDACO department of the Politecnico di Milano. This method aims to support and orient the entire process of system innovation development towards sustainability. It was conceived for designers and companies and special attention has been paid to co-designing procedures both within the company itself and outside, bringing different socio-economic actors and end-users into play.

This method is organised in stages, processes and sub-processes. The MDSS method is also characterised by a flexible modular structure that can be easily adapted to the specific needs of the designers or companies and to diverse design contexts and conditions.

It consists of four main stages:

1. strategic analysis
2. exploring opportunities
3. designing system concepts
4. designing and engineering a system

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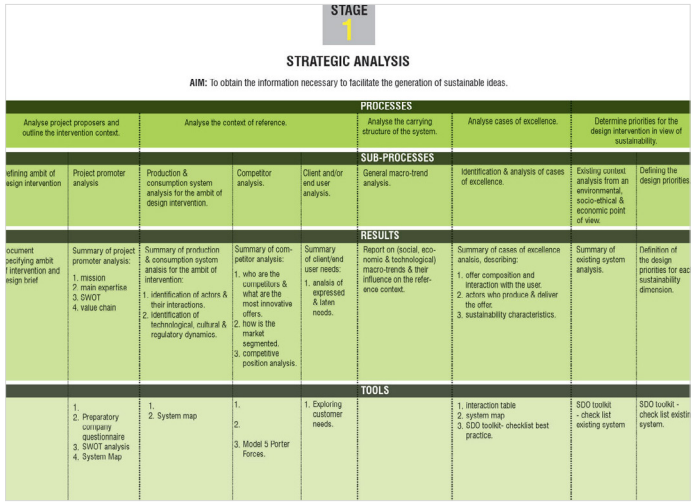
Source:
https://dsource.in/course/systems-design-sustainability/methods-and-tools/methodology-sds

The details of the various stages are shown in the images below:

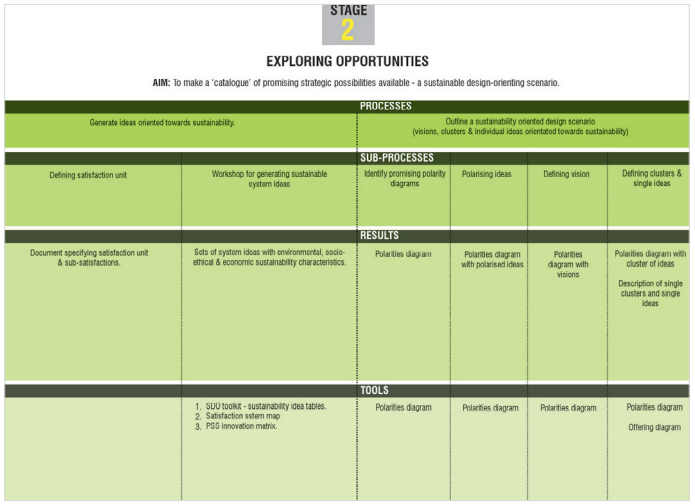


STAGE 1

STRATEGIC ANALYSIS

AIM: To obtain the information necessary to facilitate the generation of sustainable ideas.

PROCESSES							
Analyse project proposers and outline the intervention context.		Analyse the context of reference.			Analyse the carrying structure of the system.	Analyse cases of excellence.	Determine priorities for the design intervention in view of sustainability.
SUB-PROCESSES							
efining ambit of esign intervention	Project promoter analysis	Production & consumption system analysis for the ambit of design intervention.	Competitor analysis.	Client and/or end user analysis.	General macro-trend analysis.	Identification & analysis of cases of excellence.	Existing context analysis from an environmental, socio-ethical & economic point of view.	Defining the design priorities
RESULTS							
ocument pecifying ambit f intervention and esign brief	Summary of project promoter analysis: 1. mission 2. main expertise 3. SWOT 4. value chain	Summary of production & consumption system analsis for the ambit of intervention: 1. identification of actors & their interactions. 2. identification of technological, cultural & regulatory dynamics.	Summary of competitor analysis: 1. who are the competitors & what are the most innovative offers. 2. how is the market segmented. 3. competitive position analysis.	Summary of client/end user needs: 1. analsis of expressed & laten needs.	Report on (social, economic & technological) macro-trends & their influence on the reference context.	Summary of cases of excellence analsis, describing: 1. offer composition and interaction with the user. 2. actors who produce & deliver the offer. 3. sustainability characteristics.	Summary of existing system analysis.	Definition of the design priorities for eac sustainability dimension.
TOOLS							
	1. 2. Preparatory company questionnaire 3. SWOT analysis 4. System Map	1. 2. System map	1. 2. 3. Model 5 Porter Forces.	1. Exploring customer needs.		1. interaction table 2. system map 3. SDO toolkit- checklist best practice.	SDO toolkit - check list existing system	SDO toolkit - check list existi system.

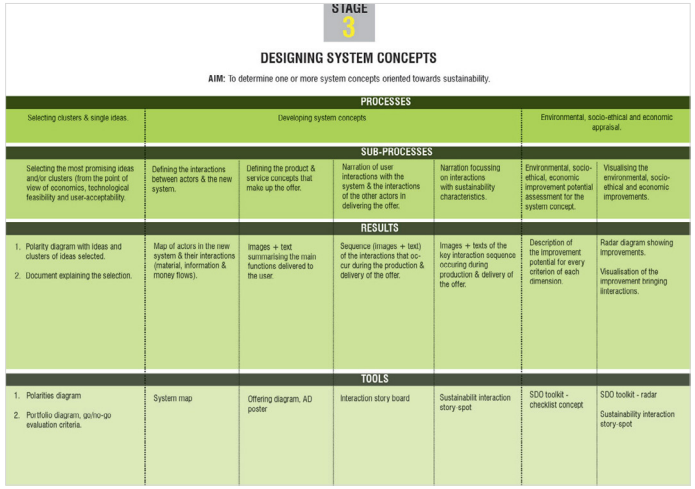


STAGE 2

EXPLORING OPPORTUNITIES

AIM: To make a 'catalogue' of promising strategic possibilities available - a sustainable design-orienting scenario.

PROCESSES					
Generate ideas oriented towards sustainability.		Outline a sustainability oriented design scenario (visions, clusters & individual ideas orientated towards sustainability)			
SUB-PROCESSES					
Defining satisfaction unit	Workshop for generating sustainable system ideas	Identify promising polarity diagrams	Polarising ideas	Defining vision	Defining clusters & single ideas
RESULTS					
Document specifying satisfaction unit & sub-satisfactions.	Sets of system ideas with environmental, socio-ethical & economic sustainability characteristics.	Polarities diagram	Polarities diagram with polarised ideas	Polarities diagram with visions	Polarities diagram with cluster of ideas Description of single clusters and single ideas
TOOLS					
	1. SUO toolkit - sustainability idea tables. 2. Satisfaction sstem map 3. PSS innovation matrix.	Polarities diagram	Polarities diagram	Polarities diagram	Polarities diagram Offering diagram

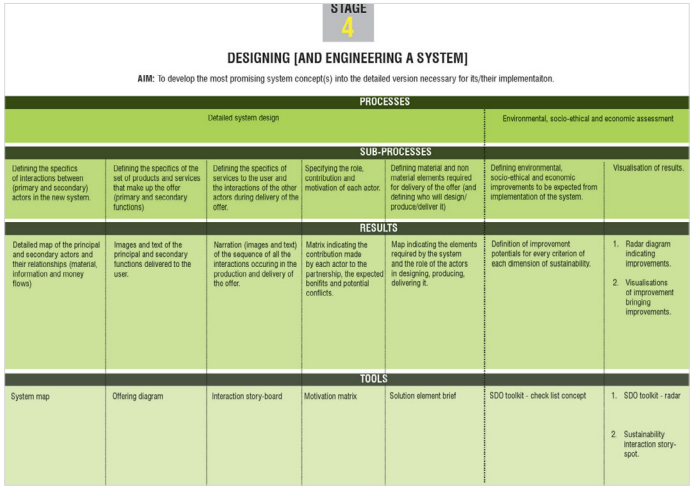


STAGE 3

DESIGNING SYSTEM CONCEPTS

AIM: To determine one or more system concepts oriented towards sustainability.

PROCESSES						
Selecting clusters & single ideas.	Developing system concepts				Environmental, socio-ethical and economic appraisal.	
SUB-PROCESSES						
Selecting the most promising ideas and/or clusters (from the point of view of economics, technological feasibility and user-acceptability.	Defining the interactions between actors & the new system.	Defining the product & service concepts that make up the offer.	Narration of user interactions with the system & the interactions of the other actors in delivering the offer.	Narration focussing on interactions with sustainability characteristics.	Environmental, socio-ethical, economic improvement potential assessment for the system concept.	Visualising the environmental, socio-ethical and economic improvements.
RESULTS						
1. Polarity diagram with ideas and clusters of ideas selected. 2. Document explaining the selection.	Map of actors in the new system & their interactions (material, information & money flows).	Images + text summarising the main functions delivered to the user.	Sequence (images + text) of the interactions that occur during the production & delivery of the offer.	Images + texts of the key interaction sequence occuring during production & delivery of the offer.	Description of the improvement potential for every criterion of each dimension.	Radar diagram showing improvements. Visualisation of the improvement bringing interactions.
TOOLS						
1. Polarities diagram 2. Portfolio diagram, go/no-go evaluation criteria.	System map	Offering diagram, AD poster	Interaction story board	Sustainabilit interaction story-spot	SDO toolkit - checklist concept	SDO toolkit - radar Sustainability interaction story-spot



STAGE 4

DESIGNING [AND ENGINEERING A SYSTEM]

AIM: To develop the most promising system concept(s) into the detailed version necessary for its/their implementaiton.

PROCESSES						
Detailed system design					Environmental, socio-ethical and economic assessment	
SUB-PROCESSES						
Defining the specifics of interactions between (primary and secondary) actors in the new system.	Defining the specifics of the set of products and services that make up the offer (primary and secondary functions)	Defining the specifics of services to the user and the interactions of the other actors during delivery of the offer.	Specifying the role, contribution and motivation of each actor.	Defining material and non material elements required for delivery of the offer (and defining who will design/ produce/deliver it)	Defining environmental, socio-ethical and economic improvements to be expected from implementation of the system.	Visualisation of results.
RESULTS						
Detailed map of the principal and secondary actors and their relationships (material, information and money flows)	Images and text of the principal and secondary functions delivered to the user.	Narration (images and text) of the sequence of all the interactions occuring in the production and delivery of the offer.	Matrix indicating the contribution made by each actor to the partnership, the expected bonifits and potential conflicts.	Map indicating the elements required by the system and the role of the actors in designing, producing, delivering it.	Definition of improvement potentials for every criterion of each dimension of sustainability.	1. Radar diagram indicating improvements. 2. Visualisations of improvement bringing improvements.
TOOLS						
System map	Offering diagram	Interaction story-board	Motivation matrix	Solution element brief	SDO toolkit - check list concept	1. SDO toolkit - radar 2. Sustainability interaction story-spot.

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STAGE 5

COMMUNICATION

AIM: To draw up reports to communicate the general, and above all sustainable characteristics of the system designed.

PROCESSES		
Drawing up documentation.		
SUB-PROCESSES		
Communicate design priorities for sustainable solutions.	Communicate the general characteristics of the product-service	Communicate sustainability characteristics of the product-service.
RESULTS		
A document indicating design priorities for each dimension of sustainability.	Document with the denral characteristics of the innovation: 1. Actors making up the system and their interactions. 2. Set of products and services making up the system. 3. Interactions between user and offer.	Document with the sustainability characteristics of the solution: 1. Environmental, socio-ethical and economic imporvements. 2. Elements of the system bringing improvements.
TOOLS		
SDO toolkit - radar	1. System map 2. Offering diagram 3. Interaction table	1. SDO toolkit - radar. 2. Sustainability interaction story-spot

Source: Vezzoli, C., (2007) Chapter 5: Methods and tools for SDS. SYSTEM DESIGN FOR SUSTAINABILITY: Theory, methods and tools for a sustainable "satisfaction-system" design . Second Edition, Maggioli Editore. pp. 215-294.

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Design Tools for SDS

Various tools may be used to support different stages of MSDS method. More tools are available on the LeNS website:
http://www.lens.polimi.it/index.php?M1=6&M=3&LR=1&P=tools_select.php

The sustainable system design support tools can be classified into two groups:
• Sustainable system design steering tools
• Stimulus and support tools for generation of ideas and strategies for system design

Sustainable system design steering tools:
These are tools that can aid in steering the system design process towards environmental, socio-ethically and economically sustainable systems. These tools are intended to:

• facilitate the identification of design priorities
• steer the generation of ideas towards sustainable solutions
• define the potential sustainable improvements brought by the solutions designed
• visualise the sustainability characteristics of the system innovation designed.

Examples of tools to orientate the design processes towards sustainable system innovation are:

• Sustainability Design-Orienting (SDO) toolkit:
The objective of this tool is to orientate the design process towards sustainable system solutions and has different functions like setting sustainability priorities, analysing best practices, using sustainable design orienting guidelines, checking and visualising the potential improvements in relation to an existing reference system. The SDO toolkit is open-source, copy-left software that can be used online (http://www.sdo-lens.polimi.it/ or downloaded from www.lens.polimi.it, "tools" section and installed for use on Local Area Network (LAN).

• Sustainability interaction story-spot:
It is a co-designing tool, above all for visualisation. Its purpose is to describe the salient elements of a product-service system in relation to given objectives. It is like an interaction table focussing only on specified interactions. The display, to be visualised on a screen/page, contains the following key elements:

• the key interactions of the client/end-user with the offer delivered by the system.
• the key interactions of the various actors during production and delivery of the offer.
• how the designed solution achieves given aims.

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The tool is also useful when it is necessary to visualise, and communicate several hypothesis of system concepts to the actors involved.

Stimulus and support tools for generation of ideas and strategy to system design:
These are tools that are aimed at supporting and stimulating idea generation at system level as well as facilitating their organisation and communication.

Examples:
• Polarities diagram:
The polarities diagram aims to explore the possible and promising directions in which current systems may evolve. It is a tool that supports the definition of how the existing system can be reshaped, starting with specified design choices.

• Satisfaction system map:
The satisfaction system map is a support tool for generation of system ideas. The purpose of this tool is to identify and visualise the potential socio-economic actors who could be involved in the satisfaction of a given demand for wellbeing. This visualisation is used during ideation process.

Strategic tools for system design have been thought up to facilitate the co-production and visualisation of the various elements in a product-service system innovation. These tools are aimed at designing and visualising.

Examples:
• Offering diagram:
The offerings diagram is a static representation of the system functions; it can be used both as a design and a visualisation tool. It shows the functions delivered by the set of products and services that make up the offer. The tool is useful to the design team for defining in ever increasing detail the functions that the system delivers to the user.

Result:
The result is a diagram that visualises the functions (core, basic and added value) and sub-functions offered by the systems.

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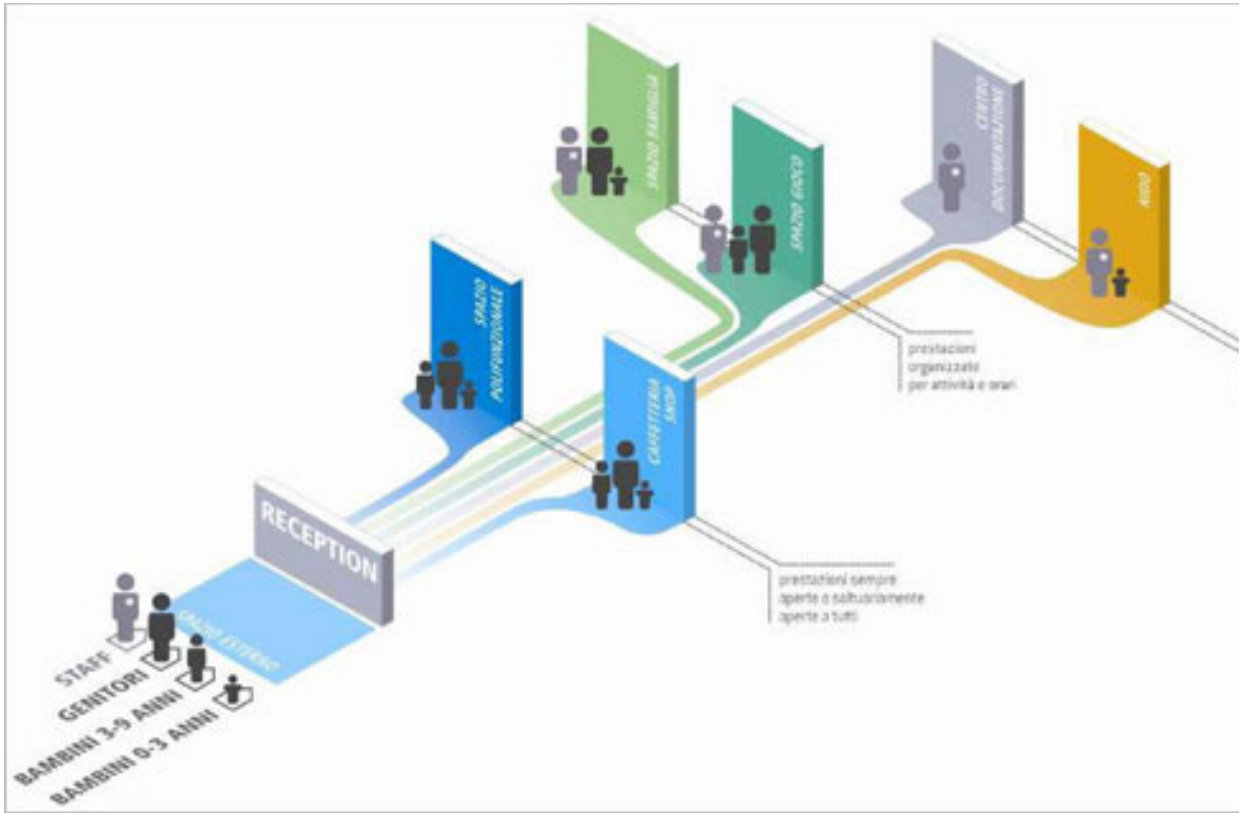

Lodi Children Centre

DARC, Domus Academy Research & Consulting:
"This representation is part of a project for a new children's centre in the Municipality of Lodi. The map represents what the centre will offer, locates the performances in different areas of the centre and describes the kind of users who will take advantage of those performances. The map was useful in identifying the performance issues and was useful during the designing of the space."

Source:
http://darc.domusacademy.it
http://www.servicedesigntools.org/tools/38
References: Morelli, N. (2007) New representation techniques for designing in a systemic perspective, paper presented at Design Inquires, Stokholm.

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• **Ecology map:**
The ecology map is a graph representing the system of actors with their mutual relations. It provides a systemic view of the service and of its context. The graph is built through the observation of the service from a specific point of view that becomes the centre of the whole representation; for example if the selected subject is the user, the graph will show all the actors starting from their relations with him.

Flat Multi + Actors

Live work:
Live Work uses this kind of representation in order to get a systemic view of the service and of the context it will operate in, a systemic view that helps them in finding opportunities, inspiring new ideas and establishing the overall service concept.

This map is also called ecology map because the idea of ecology implies the presence of a complex system but also has a connotation of sustainability, that means that all the actors exchange value in ways that are mutually beneficial over time.

Source:
http://www.livework.co.uk, interview with Chris Downs,
http://www.servicedesigntools.org/content/59
References: Morelli, N. (2007) New representation techniques for designing in a systemic perspective, paper presented at Design Inquires, Stokholm.

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Source:
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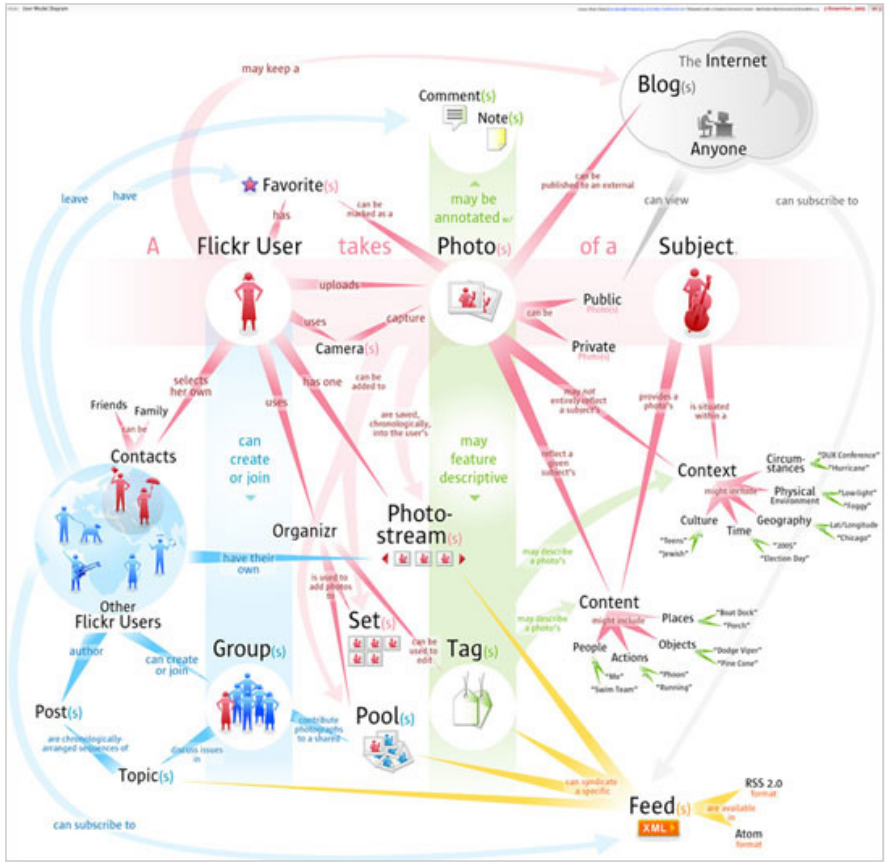
• **[Stakeholder] system map:**
The [stakeholder] system map's purpose is to support the co-designing and visualisation of the structure, indicating the actors involved in their interactions. It is basically a graphic representation showing:

• the socio-economic actors involved in the system
• the different interactions between the various actors



Flicker User Model Diagram

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Source:
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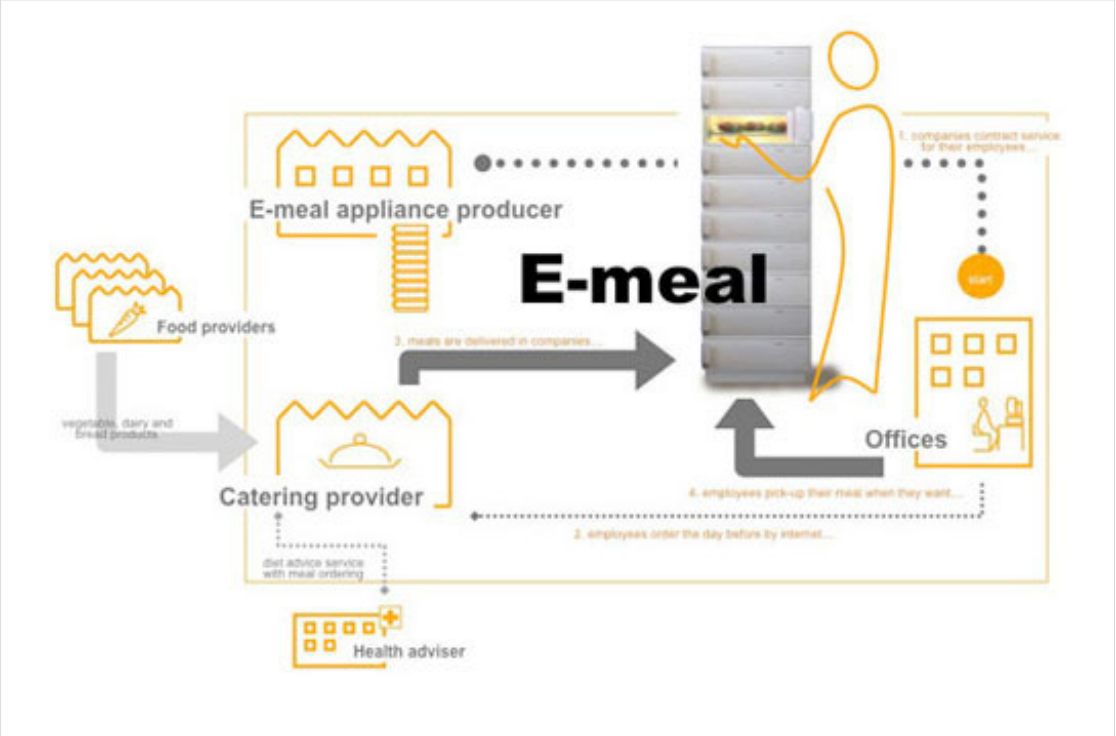
Bryce Glass:
"The Flickr model diagram proposed by Bryce Glass in 2005 describes the ecosystem and the full potential of the well-known photo-sharing service.

The map combines together text and pictograms in an effective visual representation: the use of colors, the different sizes of the objects and the way in which they are related inside the space of the visualization help reading the graph and understand the system."

Source:
http://soldierant.net/archives/2005/10/flickr_user_mod.html;
http://www.visualcomplexity.com/vc/project_details.cfm?id=336&index=336&domain=
http://www.servicedesigntools.org/tools/21
References: Morelli, N. (2007) New representation techniques for designing in a systemic perspective, paper presented at Design Inquires, Stokholm.



E-meal system map

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Source:
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Francois Jègou:
The "SystemMap" tool has been developed within the HiCS research project in order to support the representation of service solutions through the description of the system working. The tool is based on a given set of graphical elements -including objects, arrows and actions- that can be put together according to the specific service idea to visualize. The use of the same graphical set of elements allows a quick comparison between different concepts and the simplicity of the language ensures the comprehension also inside extended teams.

(2002) François Jégou, F. Manzini, E. Meroni, A. « Design plan, a tool for organising the design activities oriented to generate sustainable solutions » working paper, SusProNet conference, Amsterdam.

Source:
http://www.servicedesigntools.org/content/82;
http://www.servicedesigntools.org/tools/21
References: Morelli, N. (2007) New representation techniques for designing in a systemic perspective, paper presented at Design Inquires, Stokholm.

PPT-2
Source: http://www.lens.polimi.it/index.php?M1=6&M=3&LR=1&P=tools_select.php

• Interaction table (story-board):
The Interaction table (story-board) shows the interactions occurring between the client/end -user and the system during offer delivery, and those that occur between the various actors in the system during its production and delivery. The purpose of this tool is to support co-designing and visualisation of a sequence of interactions between user and the product-service system designed.

Result- The result is a visualisation, made up of images and text elements, that shows the interaction sequence, between the various actors who make up the system and the user during production and delivery of the offer.

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Source:
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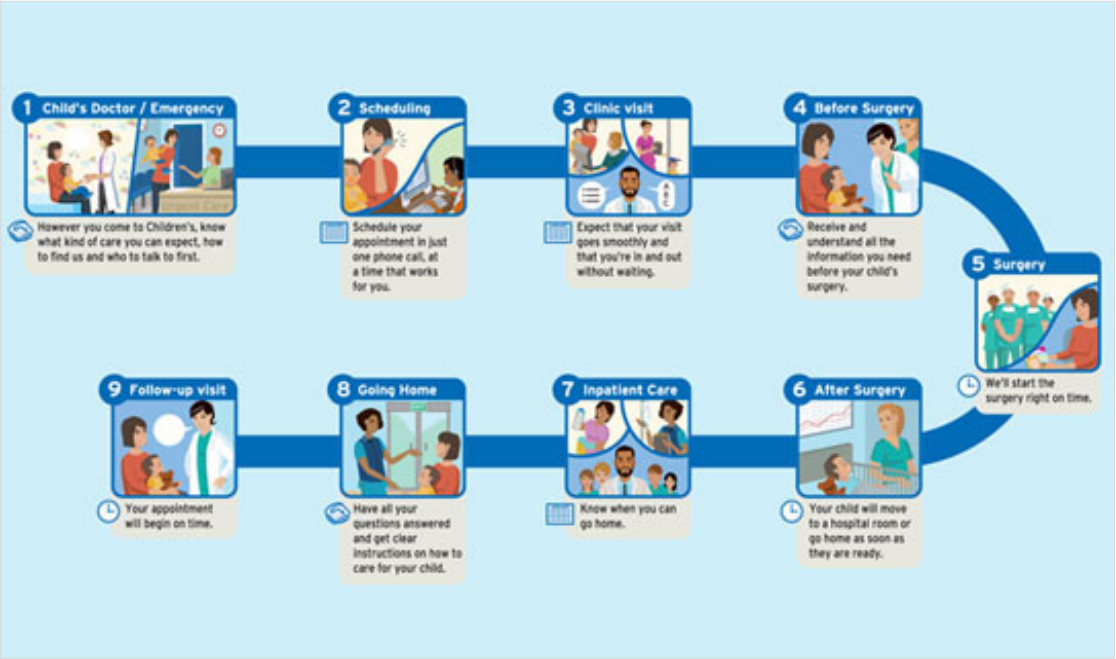
TABLE - 1
Source: http://www.lens.polimi.it/index.php?M1=6&M=3&LR=1&P=tools_select.php



Seattle Children's Hospital Process Map

Xplane:
This is an example of an illustrated storyboard used to support the explanation of the process during the staff internal meetings and to support the communication of the service to the final users, explaining how the hospital will take care of them. In particular this representation describes the complicated and frightening stages surrounding the children's surgery: what the family of a child who is being treated at the medical centre will experience. The representation shows the different steps of the storyboard taking into account their spatial position: we have four steps to arrive to the patient's surgery that is the central point of the experience and for steps after the surgery.

Each action is illustrated and supported by other two layers of information: one is given by the pictogram that indicates if it is a moment of wait, a moment of planning or a moment of interaction with the medical staff and the other is given by the text. "Going through the consulting session with XPLANE allowed us to hone in on the nine critical steps that we wanted to clearly communicate to families at the medical centre. We recognize that having a child undergo surgery is a life-altering experience for families and we want to do everything in our pow-

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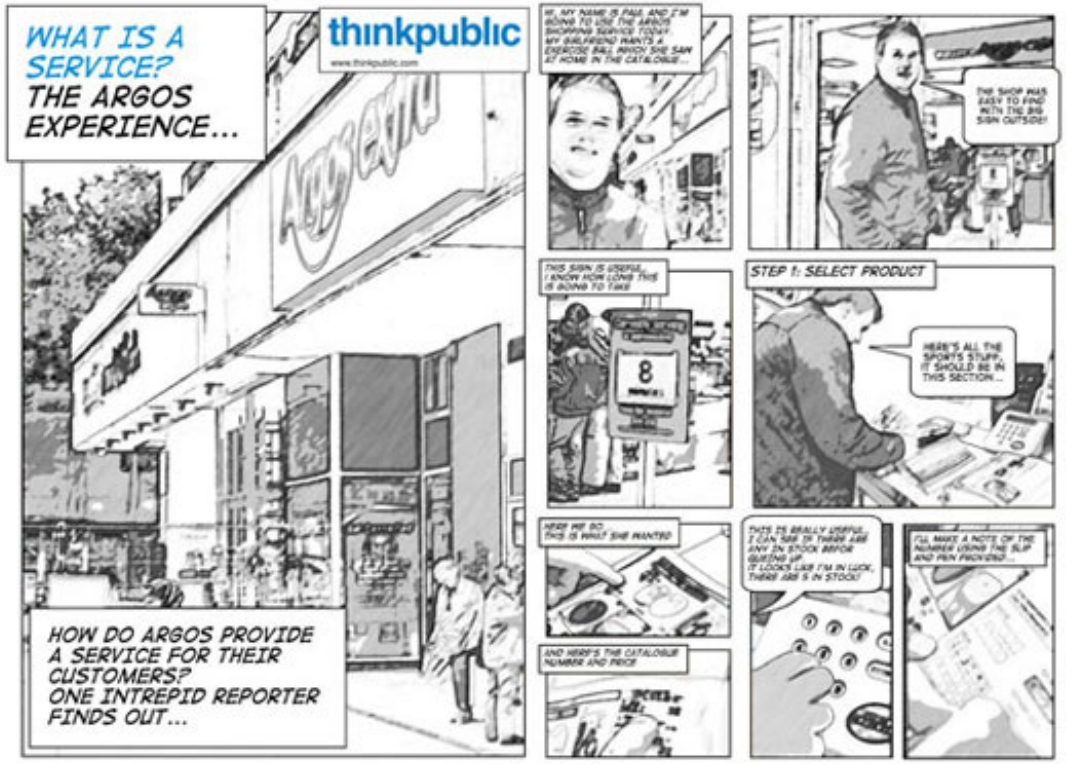
er to promote their peace of mind and understanding; we feel this map helps accomplish that goal."

David Perry, vice president of marketing, Children's Hospital
Source:
http://www.servicedesigntools.org/content/115;
http://www.xplane.com/;
http://www.servicedesigntools.org/tools/21
References: Morelli, N. (2007) New representation techniques for designing in a systemic perspective, paper presented at Design Inquires, Stokholm.



The Argo's Experience

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Source:
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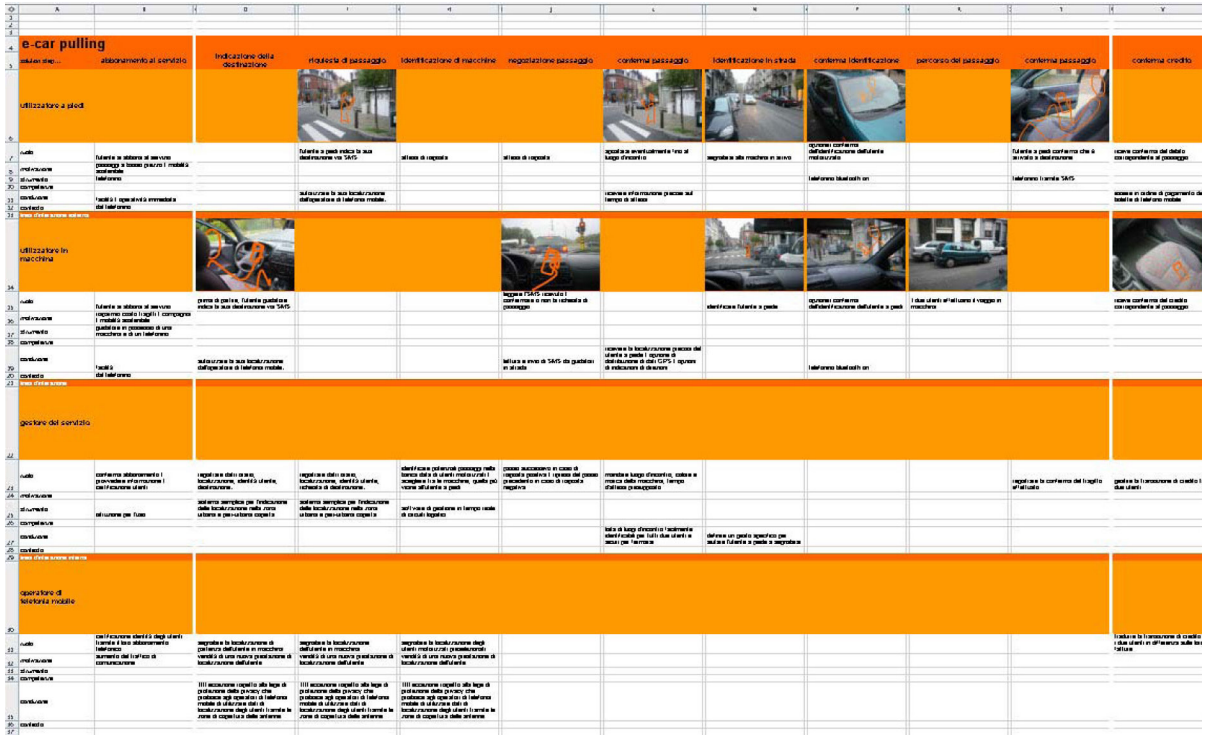
Thinkpublic:
Thinkpublic showed an entire service encounter at Argos through a three page comic. This kind of storyboard gives the opportunity to notice some questionable aspects. First of all, the visualization is totally centred on the customer perspective, without giving information about what happens in the back-office. Moreover, the use of this graphic language -similar to a photographic composition- gives such a uniform degree of detail throughout the image that it becomes difficult to focus on the storytelling.

Source:
http://www.servicedesigntools.org/content/98;
http://thinkpublic.com/news/;
http://designforservice.wordpress.com/2009/01/20/thinkpublic-comic/;
http://www.servicedesigntools.org/tools/21
References: Morelli, N. (2007) New representation techniques for designing in a systemic perspective, paper presented at Design Inquires, Stokholm



E-Car Pooling

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Source:
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François Jègou:
In the interaction table, the actors (both the users and the service staff) are located vertically and divided by the different lines of interaction: the external line of interaction separates the real users -taking advantages from the service- from the other users involved in the service experience, the central line of interaction separates the users from the figures that are part of the service organization and finally the internal line of interaction separates the front line staff from the back-office. Each actor is the protagonist of a storyboard that illustrates the process with the support of detailed specifications. The process can be read horizontally, actors by actors, in order to get a description of the role and the activities of each figure, but the process can also be read vertically in order to find the correspondences between the activities of the different subjects.

Source:
http://www.servicedesigntools.org/content/77;
http://www.servicedesigntools.org/tools/21
References: Morelli, N. (2007) New representation techniques for designing in a systemic perspective, paper presented at Design Inquires, Stokholm.

• Stakeholder motivation matrix:
The Stakeholder motivation matrix shows the relationship between the various actors in the system. It is a co-designing and visualisation tool. Its purpose is to represent the solution from the point of view of the motivations of the single actors for taking part in the system. it is basically a tool for defining the role and the contributions each actor can supply to the general partnership, and to each of the other actors.

Result- The result is a graphic visualisation structured as a two way table, where for each actor in the system, the motivations, contributions, expected benefits and potential conflicts and synergies deriving from being part of the system are described.

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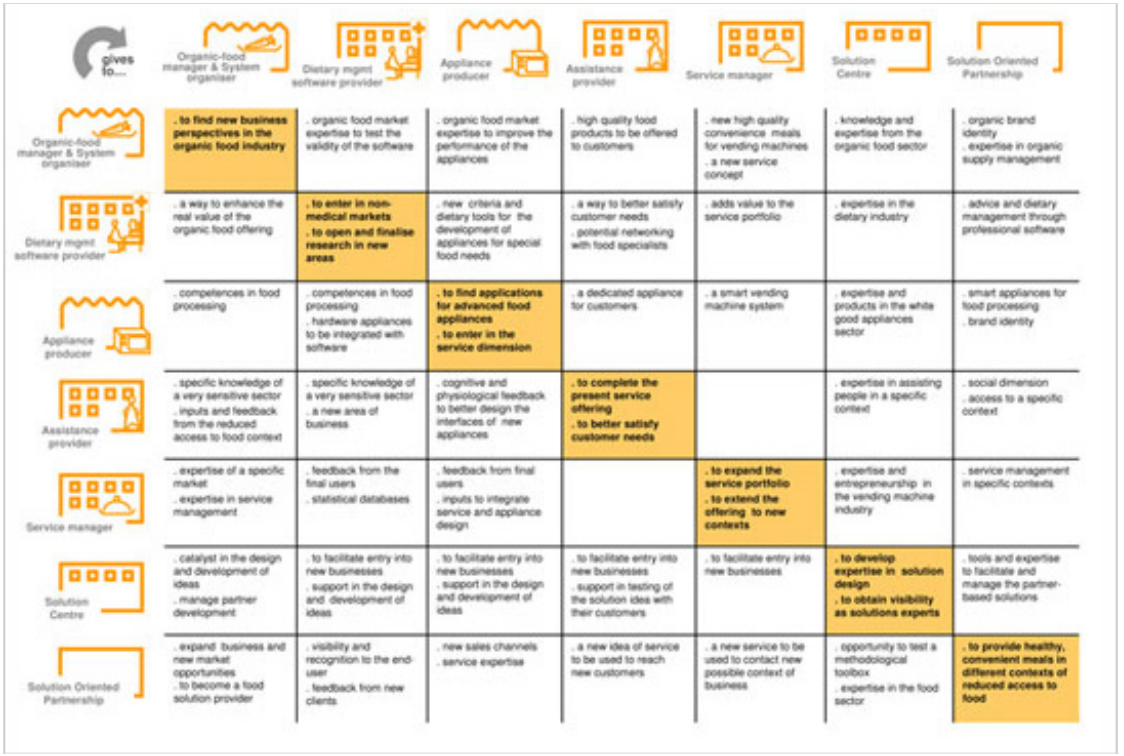

E-Meal Motivation Matrix

François Jégou, Ezio Manzini, Anna Meroni:
This sample is taken from the context of the HiCS (Highly Customized Solutions) EU Research, whose objective was to define methodological tools for supporting and guiding network of firms in the development of highly customized solutions. As this sample shows, the motivation matrix gathers the real partners involved in the solution and their expected benefits and makes the interactions between partners emerge in terms of synergies and potential conflicts that the designers have to investigate.

Source:
http://www.dsource.in/course/systems_design_for_sustainability/methods_and_tools/c/index.html
http://www.servicedesigntools.org/tools/21

References: Morelli, N. (2007) New representation techniques for designing in a systemic perspective, paper presented at Design Inquires, Stokholm.

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https://dsource.in/course/systems-design-sustainability/methods-and-tools/design-tools-sds

• Solution element brief:
The Solution Element Brief represents the role of the different actors in the design/production/delivery of the various (material and non-material) elements that make up the system. It is a co-designing and visualisation tool. Its purpose is to describe the elements required by the system, and which of the system actors must design/produce/deliver these elements. The tool basically helps define the roles of the individual actors in developing and delivering the solutions.

Result - The result is a graphic representation structured as a two way table showing the elements required for implementation of the system and the roles of the various actors in designing, producing and delivering each element.

Note:
This chapter is based on
Vezzoli, C., (2007) Chapter 5: Methods and tools for SDS. SYSTEM DESIGN FOR SUSTAINABILITY: Theory, methods and tools for a sustainable "satisfaction-system" design. Second Edition, Maggioli Editore. pp. 215-294.

Design Course

Systems Design for Sustainability

From Product to System-Service Design and Innovation

by
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Source:
https://dsource.in/course/systems-design-sustainability/contact-details

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