Journal of Applied Arts & Sciences
مجلة الفنون والعلوم التطبيقية
كلية الفنون التطبيقية
جامعة دمياط Damietta University

The strategies of sustainable design for a better product design future.

استراتيجيات التصميم المستدام لمستقبل تصميم منتجات أفضل

Aziza Maher Abouelsoud

Lecturer at Product Design Department

College of Applied Arts October 6 University

Abstract :

The demand for a responsible design, is increasing rapidly, and it's becoming the face of future designs, known as Sustainable Design.

Sustainable Product Design aims to reach the goal of more environmentally conscious products and processes. Practicing SPD should involve a particular framework for considering environmental issues.

(SPD) has received growing attention on various levels, among stakeholders of industry and design. The challenges that the designers must face are increasing as sustainable Designers have to stand for the notion of "meet the needs of the present without compromising the ability of future generations to meet their own needs". Thus, they have to be aware of the elements related to SP starting from pollution to material awareness, production techniques, and the product life cycle.

In order to understand how to practice (SPD), there should be a deep understanding of the different strategies followed by different practitioners in the field.

Sitting these clearly and analyzing the circumstances related to applying them will make it easier for strategies PD to practice SPD.

Practicing SD is a big issue and, the PD needs to decide what kind of strategy, he should follow, and to understand what to target in the product life cycle in order to reach his goals.

The research aims to study& analyze some of the SPD strategies and prepare them as a reference for other product designers, through analyzing facts related to each strategy and the circumstances related to applying them then preparing a list of SPD strategies, sitting best goals achieved by using each strategy and excluding strategies that are not directly related to PD.

Keywords: eco-design; Design for Sustainability; Product life cycle; sustainable Design Strategies; SPD.

(ISSN 2537-1061) (Print)

(ISSN 2537-107X) (Online)

INTRODUCTION

Sustainable development is the process by which we pursue sustainability. Sustainability is about taking a system-level perspective when solving problems. From a system view looking at our planet, if we don't provide adequately for the basic needs of people around the world, we create imbalance, and with it an inability to address the mounting pressures upon natural systems. When we take more out of the earth than naturally goes back into it, we create problems. And when we introduce more man-made substances into the ecosphere than are naturally removed from it, we create problems. When we degrade biological systems, like forests and oceans, we create problems by decreasing their ability to give us the things we need, such as clean air, clean water, biodiversity, and so on.

For both designers and manufacturers sustainability has a lot to do with "doing better with less, not just for the sake of today but for tomorrow as well" and this, requires a deep full look into the lifecycle of the product and the impact that its design, manufacture, use, and retirement can have across a triple bottom line which includes its impact on business, on the environment and society, as well.

Which clearly means that sustainability isn't just about "doing the right thing" for, the environment or for society. It's also about doing the right thing, financially, in order to make a balanced case..

Sustainable Product Design, is intended to develop more environmentally conscious products and processes. The application of sustainable product design involves a- particular framework for considering environmental issues and a challenge to traditional procedures for design and manufacturing. Unfortunately, in many past situations, environmental effects were ignored during the design stage for new products and processes. The challenge of sustainable design is to alter conventional design and manufacturing procedures to incorporate environmental considerations effectively. So, this requires change in these existing procedures. However, change for any existing products and process is difficult. Consequently, we can advance general goals for a sustainable future:

- reduce or minimize the use of non-renewable resources
- manage renewable resources to insure sustainability;
- reduce, with the ultimate goal of eliminating, toxic and otherwise harmful emissions to the environment, including emissions contributing to global warming.

"SPD considers collectively some of the harder questions, such as need, ,profit, equity, ethics, social impact and total resource efficiency When a designer is immersed in the design process, trying to meet a client's expectations and to satisfy consumer desires, terminology can become peripheral."(4, Page 10)

Simply that's why PDs need to have a clear map about how to make their designs stand out for all these challenges, and that where sustainable Design strategies" SDS" can make a difference.

Abbreviations:

SPD: Sustainable Product design- **PPS**: Product service systems-

EIM: Environnemental Impact Matrix-

Problem, Aims& Methodology

THE PROBLEM

A product designer is a part of a team required to come out with products that can satisfy people's needs financially, socially

(ISSN 2537-1061) (Print)

(ISSN 2537-107X) (Online)

and environmentally. Achieving that need lots of knowledge and data he can use for help, there are so many strategies that are created to help with that topic, but which is better and when, that could be difficult to figure out so, having them collected in one place in a clear and a simplified way would make things a lot easier.

- **AIMS**

The aim of the research is to

a- collect the different strategies created for SPD and reflect the best use for each.
b- Connect the different strategies with the PLC (Product Life Cycle).
c- Suggest a plan for using the strategies during the PLC.

METHODOLOGY

Collecting data& analysis.

1- **The Concept of Sustainability**

There is no consensus on the origin of the term sustainable development, but some researchers believe that it may have originated in the World Watch Institute 1981 book Building a Sustainable Society by Lester Brown. The term Eco-development was also a common term used in the early and mid-1980s. However, in 1987 the United Nations World Commission on Environment and Development report entitled Our Common Future formalized the use of sustainable development by providing the first definition. In that report, sustainable development was defined as "meeting the needs of the present without compromising the ability of future generations to meet their own needs." More recently, Volume 2 of the Dictionary of Development defines sustainable development as "development that can be kept up over time because it does not erode its natural resource base and the natural environment in which it must take place." Each definition implies that sustainability includes a perpetual use of resources with no negative impact to natural ecosystems and when possible, achieving a net enhancement.

When designers are commissioned by an employer or a customer to create a new product or service, they are required to consider a number of variables including aesthetics, availability, durability, maintenance, materials, processing technology, cost, customer needs, and performance specifications. In the past, it has been difficult to include environmental considerations because of a lack of a generic systems approach to compare material specification options. As a result, design professionals have had little opportunity to document environmental sustainability improvements.

2-1 what is *sustainable design*?

This concept was largely advocated by William McDonough, an American designer, architect, author, and thought leader, who espouses a message that we can design materials, systems, companies, products, buildings, and communities that can continuously improve over time.

"If design is the first signal of human intention, our intention today can be to love all ten billion people who *will live on our planet by 2050. We can do this. If we imagine and embrace our cities as part of the same organism as the countryside, the rivers and the oceans, then we can celebrate ourselves, all species and the natural systems we support and that support us.*[(Website 2)] *This is our design assignment. If we are principled and have positive goals, we can rise to this occasion. It will take us all; it will take forever—that is the point."*[13: page 11)]

2-2 Sustainable Design Principles

McDonough crafted sustainable design principles for Expo 2000, The World's Fair,

(ISSN 2537-1061) (Print)

(ISSN 2537-107X) (Online)

which became known as "The Hannover Principles: Design for Sustainability." This document has wide philosophical and ethical dimensions and should be seen as a living document committed to the transformation and growth in the understanding of our interdependence with nature and future generations.

The Hannover principles (website 2)

- **"Insist on rights of humanity and nature to coexist** in a healthy, supportive, diverse and sustainable condition.
- **Recognize interdependence.** The elements of human design interact with and depend upon the natural world, with broad and diverse implications at every scale. Expand design considerations to recognizing even distant effects.
- **Respect relationships between spirit and matter.** Consider all aspects of human settlement including community, dwelling, industry and trade in terms of existing and evolving connections between spiritual and material consciousness.
- **Accept responsibility for the consequences of design** decisions upon human well-being, the viability of natural systems and their right to coexist.
- **Create safe objects of long-term value.** Do not burden future generations with requirements for maintenance or vigilant administration of potential danger due to the careless creation of products, processes or standards.
- **Eliminate the concept of waste.** Evaluate and optimize the full lifecycle of products and processes, to approach the state of natural systems, in which there is no waste.
- **Rely on natural energy flows.** Human designs should, like the living world, derive their creative forces from perpetual solar income. Incorporate this energy efficiently and safely for responsible use.
- **Understand the limitations of design.** No human creation lasts forever and design does not solve all problems. Those who create and plan should practice humility in the face of nature. Treat nature as a model and mentor, not as an inconvenience to be evaded or controlled.
- **Seek constant improvement by the sharing of knowledge.** Encourage direct and open communication between colleagues, patrons, manufacturers and users to link long term sustainable considerations with ethical responsibility and reestablish the integral relationship between natural processes and human activity."

2-3 Questions Before Designing

There are very important questions each product designer should ask befor deciding to go for SPD

• Does the consumer really need it?

- Before making a purchasing decision, the first question should be: do I really need it?

Have I been persuaded to buy it because it offers some real advantages over what I use now?

- Can the consumer borrow it?

- If the object you need will only be used infrequently, or just once or twice, can it be

borrowed? If it is possible, there is no need to buy.

• Can the consumers own it as a group?

- Sharing to cut down on waste, to make things more affordable or just to reduce the

amount of raw materials locked up in goods can operate on many different levels.

For example; sharing the expensive international professional magazines, more

(ISSN 2537-1061) (Print)

(ISSN 2537-107X) (Online)

than one person can use (profit) it, and so it cuts down on the wastefulness of paper and printing inks as well as transport.

• Can the consumer built it himself/ herself ?

-The average person, anywhere in the world, is better informed and more aware of his or her needs than any designer. It is therefore plain that the design needs of most people can best be served by the users themselves working in close collaboration with a designer. The next step is to suggest that people should be empowered to design their own solutions to their own specific requirements. Having considered all these possibilities, we must now ask the vital questions:

• Will it harm the environment?

• Does it use composite materials?

• Does it waste energy?

• Is it recyclable or reusable ?

-The materials chosen by designer and manufacturer are crucial. For example: the designer's decision to use foam plastic to make cheap, throw-away food containers damages the ozone layer. This is not a prescription for doing nothing at all, but an attempt to make designers aware that every choice in their work can have far-reaching and long-term ecological consequences. These are the crucial questions that we have to consider, before we decided to purchase. Considering these questions, it is certainly possible to make intelligent choices as to whether to buy or not to buy.

2- Product life cycle and sustainability

A product life-cycle considers the sustainability of a product across all stages of production and consumption from its origins to its end as an essential issue. point of origin is product development, where initial marketing and product planning take place. The action starts with material production phase, in which resources for making products are harvested then, material processing, which converts resources into feedstocks. The product manufacturing phase then turns these input materials into finished goods. From there products enter distribution networks that support customer transactions, after which the usage phase begins. The product stays in use as long as it is working well, or until the user decides it's time to end its life by throwing it away due to any reason and moves to get rid of it. At this point, end-of-life disposition determines whether a product is reused, recycled or dissipated. In a continuous, cradle-to-cradle cycle, end-of-life processes feed into another cycle of development. (14: Page 33-35)

(ISSN 2537-1061) (Print)

(ISSN 2537-107X) (Online)

Figure (1) product life cycle

3- **Strategies of sustainable Design**

These strategies synergies the evolving changes within product design in response to sustainable development by providing frameworks that could support the integration of sustainable design concepts early in the product design process where the most economical and sustainable outcomes can be achieved. The research aims to convey those strategies in basic concepts in order to help designers adapt what suits them according to their clients' financial and production abilities

4-1 Providing Product as Service

Product-service-systems (PSS) and service Design.Focus on meeting needs while minimizing the physical product component Service Design can manifest in many ways: (1: page 4-6)

- Product cooperatives that share products.

- Ownership models (like leasing) that insure system repair and upgrading.

- Systems that reward environmentally attuned behavior.

- Support extended producer responsibility for used products.

- New business models with ecological advantages.

Service design requires that perceived hurdles to the service system are overcome. For instance, in car-share or bike share programs, design can address the potential perceived inconveniences. The service of car-share programs can immediately allow vehicle reservation changes. Multiple drop-off locations for borrowed bicycles relieve the user of returning the bike to the rental origin. A working PSS system requires considerable design effort, including detailing the points of interaction (touchpoints) and rethinking how then service is sold.

(ISSN 2537-1061) (Print)

(ISSN 2537-107X) (Online)

Figure (2) Bike share program users purchase bike access, thus intensifying bike usage.

4-1 Mimic Biological Systems

Janine Benyus is a leader in researching biomimicry. She suggests that designers ask these questions about biologically inspired design concepts: (2: page 3-5)

Does it run on sunlight? Does it use only the energy that it needs?

Does it fit form to function?

Does it recycle its materials?

Does it sometimes reward cooperation?

Does it rely on biodiversity?

Does it demand local expertise?

Does it curb excesses from within?

Does it respect limits?

Biomimicry is the application of functional, organizational and chemical phenomena from

organisms in manufactured products. Victor Papanek referred to this approach as bionics

.

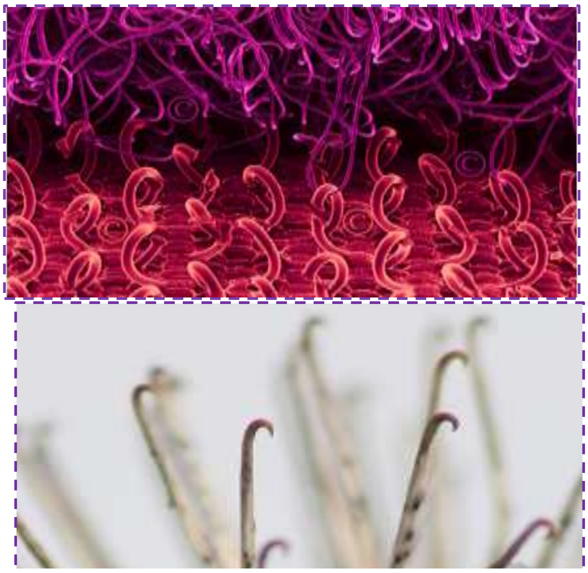

Figure (3) Hooked seed structures inspired Velcro

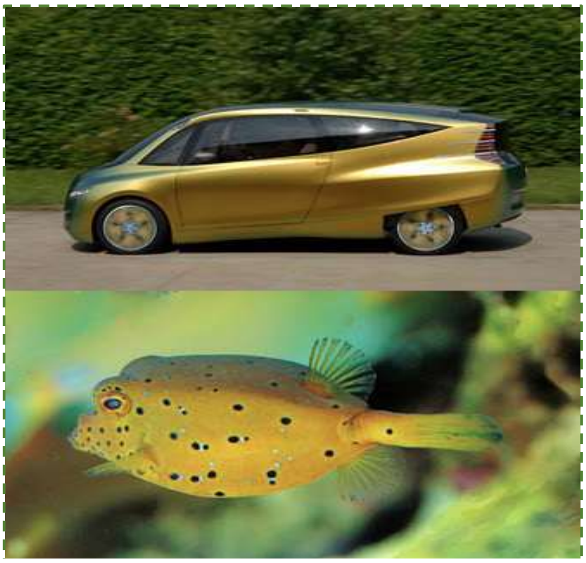

Figure (4) The low surface drag of boxfish inspire an efficient automobile Design

(ISSN 2537-1061) (Print)

(ISSN 2537-107X) (Online)

The complex process of applying biomimicry requires highly specialized knowledge about biology. It demands that designers either invest Considerable time studying biotic processes, work with biologists, or both. Designers can visit the website, asknature: hBp://asknature.org/

4-2 Design for Carbon Neutral Energy Designers can reduce global warming gases in three primary ways:

- Actively develop and use climate-neutral energy sources. Low- carbon energy technologies (typically also renewable energy sources): wind energy, photovoltaics, solar thermal, geothermal energy, nuclear fission electricity (nuclear energy has other ecological and social risks) (website 3)

Not climate neutral:

Fossil fuels (petroleum, natural gas, coal), hydrogen from Fossil fuels, ethanol from corn or sugarcane.

Yet to be fully developed (with other pollution types):

- Design products and systems for minimal energy demands.

- Design products, systems and services that encourage low energy- consumption

Behavior.

Design products and systems for minimal energy demands:

Methanol from non-irrigated grass, wood, or other plant cellulose.

Design products and systems for minimal energy demands: Automatically shut off products when not in use, use components with the most energy efficient available technologies.

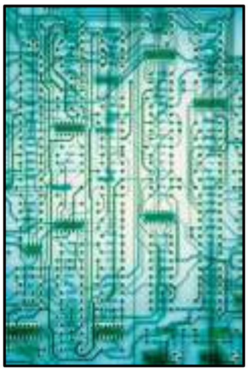

Figure (5) High efficiency circuits

Figure (6) Automatic shut off switches

Figure (7) LED lamps

- Drive cars with more than 40 mpg
- Avoid unnecessary plane flights
- Buy energy-star appliances
- Use led lamps

Design products, systems and services that encourage low energy-consumption behavior:

Designers can support users to take a range of actions that do not reduce convenience, <u>including:</u>

(ISSN 2537-1061) (Print)

(ISSN 2537-107X) (Online)

Is often only part of the reason for product disposal.(16: page 25-30)

- **Durable material quality encourages people to connect to a product**.
  Products made from materials that age gracefully (such as wood, stone or some metals) are more likely to be appreciated and kept than products made from materials that Age quickly (such plastics that are easily scratched and nearly impossible to restore).

- **Layered product functions can increase how long people keep a product.**
  Layered functions can increase the user's memories and attachment to the object, with several incarnations over a period of years.

- **Sales and service support product longevity.**
  Shifting emphasis from just selling products to maintaining products through the customer relationship also changes the way we think about design.

4-4 Environnemental Impact Matrix (EIM)

Strategy Rating System as a tool to evaluate progress toward achieving sustainability in new products and services. Building on the West Michigan Sustainable Business Forum's 1997 Concise Self-Assessment Guide to Environmentally Sustainable Commerce, the Design Work Group set out to develop a tool that would assist product developers in evaluating their progress toward sustainability. The specification of raw materials, energy inputs, purchasing specifications, hazardous materials generated, recycling of the product after consumer use, and worker health and safety are just a few of the potential impacts that are involved in the initial design. EIM is a tool for internal and confidential use on the part of a company

- We can also support laws and regulations, such as automobile CAF. standards, that require lower CO2 emitting technologies be developed and used. Guiding users to new, lower-impacting behaviors is a critical ecodesign skill. People make some decisions based on deliberate rational choices, however many decisions are based on quick instinctual cues. Increasingly, digital technology can give detailed feedback that supports more environmentally responsible decisions. For instance, online services inform a user how to most quickly connect public transportation systems to reach their destination. On-board car feedback can inform the driver when fuel is wasted. This teaches fuel-efficient driving behavior. For a target behavior to occur, B. Fogg suggests that a person must have "sufficient motivation, sufficient ability and an effective trigger". If the product offers a reward, the potential to change behavior increases significantly.

A reward can take many forms:

• earned app model points.

• sensory pleasure: Music or images.

• financial remuneration.

• the satisfaction of helping others

4-3 Design for System Longevity

The "Design for System Longevity" category encompasses a variety of strategies.

These strategies a help us design products that people want to keep much longer than products currently are kept. Several approaches can assist in this process.

Understanding why we throw things away is valuable. Loss of functionality

(ISSN 2537-1061) (Print)

(ISSN 2537-107X) (Online)

• It is easy to use, straightforward and logical.

• If used consistently, it will provide a measure of product to product

improvements.

• It is a self-analysis and enabling tool to help a company reduce its environmental

impact over time.

• The total score is useful as a comparative environmental impact measurement

between similar internal products.

Weaknesses of the Environmental Impact Matrix:

• It cannot be used as a complete Life Cycle Assessment. (see ISO 14040

Principles and Framework)

• Hard data may not be available to support each company's index values, in

which case experience and judgement should prevail.

Directions for using the EIM

Step One:

First, in the horizontal rows list all the various materials, sub-processes, etc. that go into a product or service. List one product or service per EIM, using multiple pages as necessary.

Step Two:

Assign a value range using internal company goals, objectives, or definitions to determine least impact and worst impact. The matrix user can use the 0 to 5 range or should feel free to adjust numeric values to better reflect company goals or priorities. If an environmental aspect is not relevant, a zero rating will not penalize the score. The whose focus is self-assessment and environmental improvement. [15: page 6-11]

Users of the matrix are required to allocate numeric values, by material type, for sustainable and environmental attributes for each product being evaluated. The ideal score is zero. This approach reflects the philosophy that less is better and least is best. Thus, the EIM is intended to reward product developers for creating resource efficient products.

The numeric values are subjective and company specific. The values used should

be consistent with each company's internal business, social, and environmental ethics and goals. The EIM is not intended to be used to compare a company's internal product to a competitor's products. Its primary goal is to compare internal products over the course of time to evaluate which changes will make a more sustainable product, or to compare alternative product options against each other. Expert decisions and weighting criteria should be based on internal policy issues, which should drive the subjective internal scoring system of the EIM.

The EIM allows a company to determine the most important environmental impacts of a product design in order to identify opportunities to improve the environmental performance and to lower the total score. It should be re-emphasized that the EIM is not intended to compare one company's products against another company's. The EIM is a tool used to document the environmental improvements of each company's own products.

Strengths and Weaknesses of the Matrix

Strengths of the Environmental Impact Matrix:

(ISSN 2537-1061) (Print)

(ISSN 2537-107X) (Online)

basis for the numeric value ratings can come from regulatory considerations, industry consensus, company preference, or a combination of influences relevant to the company’s corporate values.

Step Three:

The physical weight of each component should be recorded in the Physical Weight column. It may be beneficial to include all material needed, including waste, not just the material in the final product.

Step Four:

Go across the matrix for each line item component, add each impact value, and record the sum in the Subtotal Column.

Step Five:

Multiply the subtotal by the weight and record for each line item component.

Step Six:

Record the final score in the Final Score space.

(ISSN 2537-1061) (Print)

(ISSN 2537-107X) (Online)

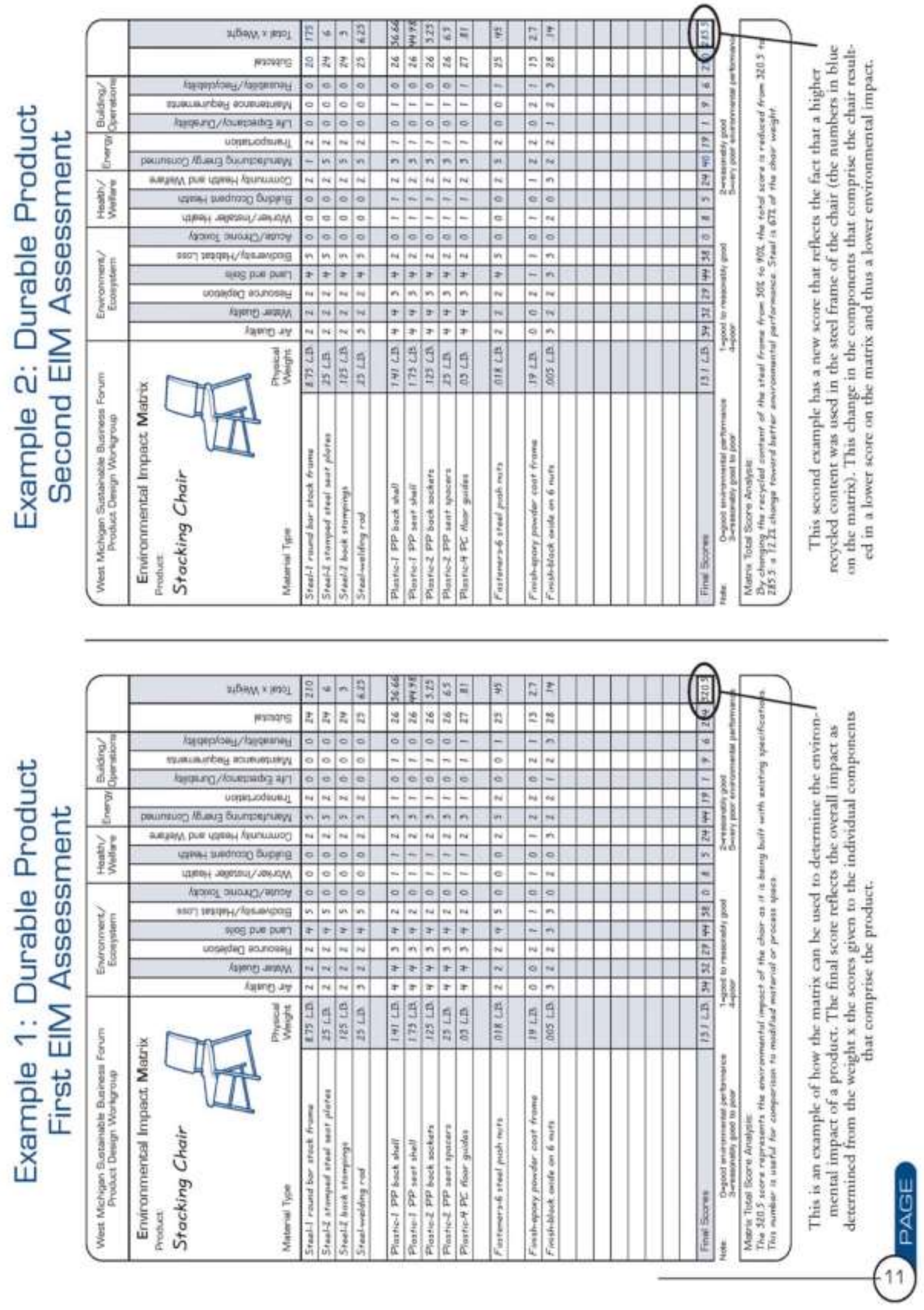

Figure (8) Durable products example1&2

(ISSN 2537-1061) (Print)

(ISSN 2537-107X) (Online)

4-5 Design for Product Lifetime (Sustainability workshop by Autodesk)

The strategy was produced for the first time during a workshop held by Autodesk under the title (Design for product life time) in June 2018. (website 4)

Access a product's components. Design for Disassembly:

Ensure products are easy to take apart quickly.

Parts

- Minimize the number of parts.

- Simplify structure and form.

- Use ferromagnetic materials to enable sorting and disassembly.

tools & Fasteners

Require only a few standard tools.

- Avoid requiring tools for the most common actions.

- Minimize the number and variety of fasteners.

- Use intuitive snap-fits, clips, or sliding connections.

- Design connections that are visually and physically accessible.

- Access fasteners from the same axis.

- Hold multiple parts with one fastener.

- Use coarse threaded screws for speed; use nuts and bolts for strength.

- Use human-scale fasteners.

- Use hand-strength press-fits instead of tight press-fits.

- Avoid glues and use only glues that are easily soluble or heat reversible.

- Ensure fasteners are adequate for structural integrity.

- Use fasteners that will hold up over repeated use.

Documents

- Embed clear, graphical disassembly instructions onto the product.

- Document materials and methods for deconstruction for the user.

Keep it alive longer. Design for Repair

Ensure product repair is simple for everyone.

Product Architecture

- Use modular assemblies that enable the replacement of discrete components.
- Ensure easy access to parts likely to need maintenance.
- Use self-locating parts.
- Use robust connectors.
- Label and color-code parts to enable troubleshooting.
- Standardize between product lines and across generations.

Documents

- Make technical documentation freely available or open-sourced.
- Include parts list and part numbers.
- Create user interfaces and troubleshooting tools to diagnose problems.

Business

- Make repair and services options clear to customers.
- Consider repair-friendly warranty terms.
- Make replacement parts available and affordable.

Keep it alive longer. Design for Upgrade

- Keep products relevant and useful longer.

Product Architecture

- Use standard-size modular parts to enable
- interchangeability and customization.

(ISSN 2537-1061) (Print)

(ISSN 2537-107X) (Online)

- Design easy access to parts likely to become obsolete.
- Use standard, cross-platform connections (for example, USB).

Documents

Build diagnostic tools to help users understand the components that are limiting performance.

Enable a responsible end-of-life. Design for Recycling

Make it easy to properly dispose of the product.

Materials

- Choose materials that are recycled everywhere.
- Minimize the number of materials used. When possible, use only one.
- Label parts with recycling codes or other permanent ways to identify materials.
- Avoid paints, additives, and surface treatments.
- Use inherent color.
- Avoid combinations of materials that are difficult to separate.
- Make it easy to separate components that are
- hazardous, toxic, or not conventionally recyclable.

Business

- Specify the use of recycled materials in your products (this also helps stimulate demand for recycling).
- Create easy take-back programs to ensure proper
- disposal of complicated products.

Enable a responsible end-of-life. Design for Remanufacturing

Enable reuse of old components in new products.

Business

- Create product-as-service business model.
- Design smooth touchpoints between the company and users.

Design a quality-control system for testing returned components

(ISSN 2537-1061) (Print)

(ISSN 2537-107X) (Online)

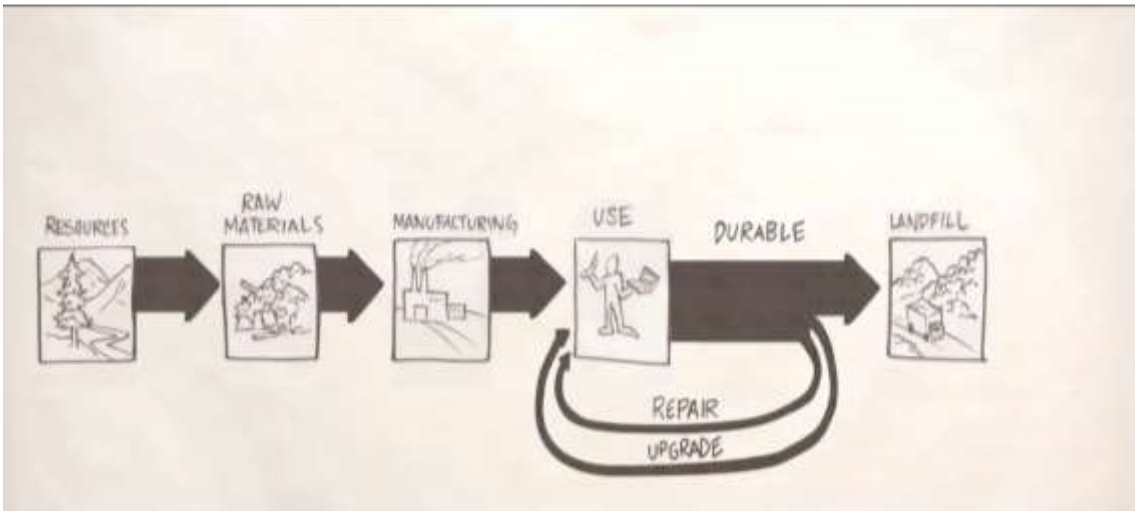

Figure (9) Understanding the life cycle of a product will help the designer pay more attention to all the factors that would affect the environment and avoid them or find creative solutions to reduce/diminish their effect.

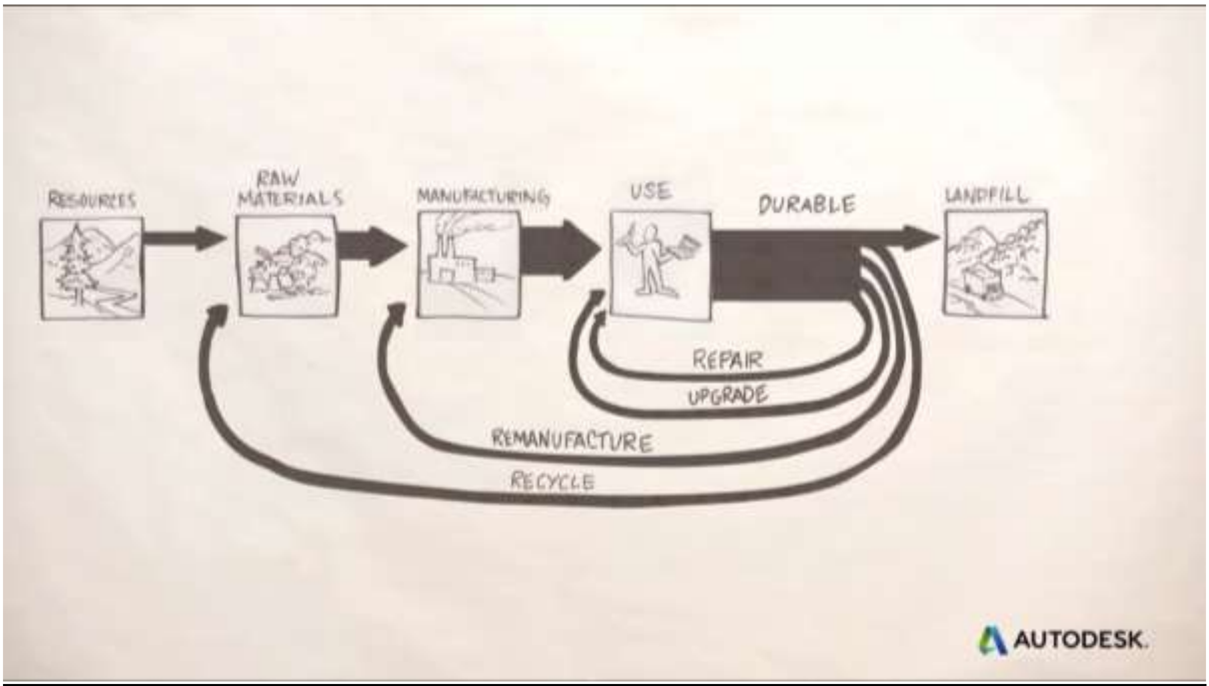

Figure (10) The strategy helps the designers to imagine the logical solutions and motivate their creativity skills by challenging their abilities to find them through a clear map of what to do with what and when

(ISSN 2537-1061) (Print)
(ISSN 2537-107X) (Online)

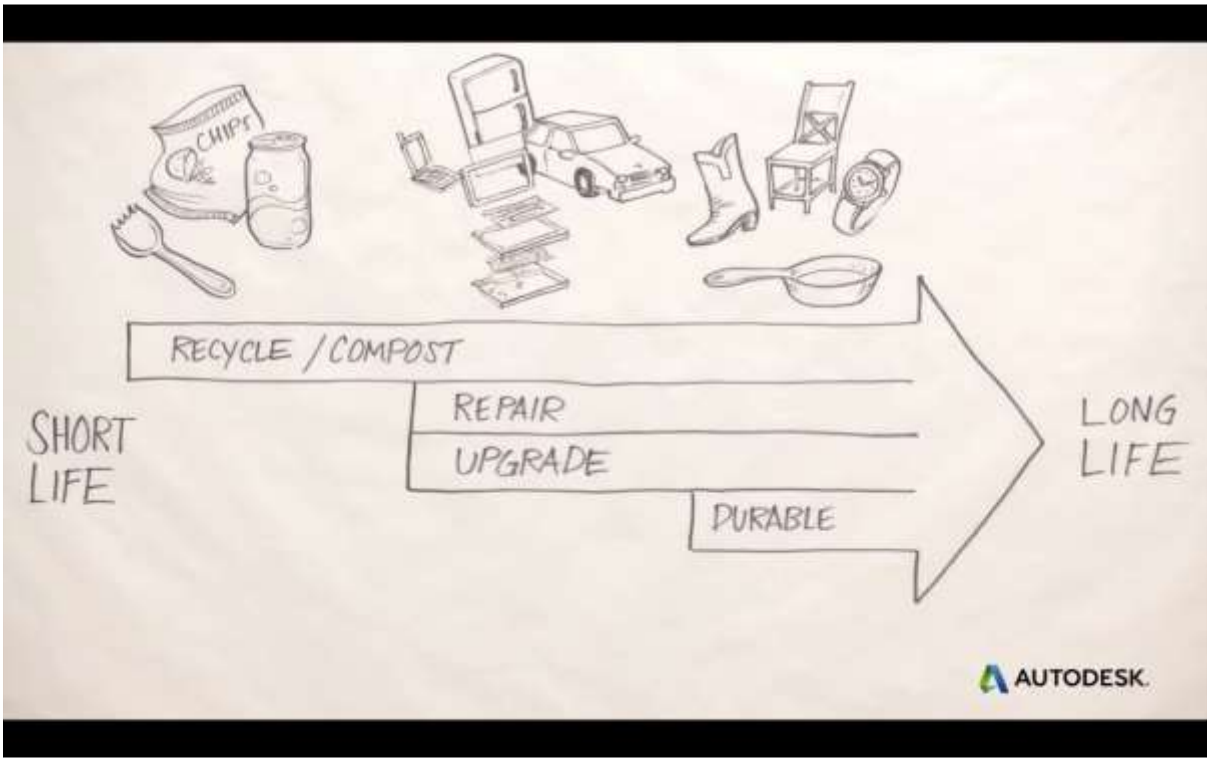

Figure (11) The strategy also makes it clear for the designer when to design for longevity as solution and when a short life is the best solution

4-7 Okala Eco Design Strategy wheel

Ecodesign strategies help designers and system developers imagine new opportuni8es. The Okala Ecodesign Strategy Wheel1 organizes the strategies According to the phases of the lifecycle. It serves as a powerful brainstorming. (7: Page30-40)

Tool to explore areas of product development that have not yet been considered.

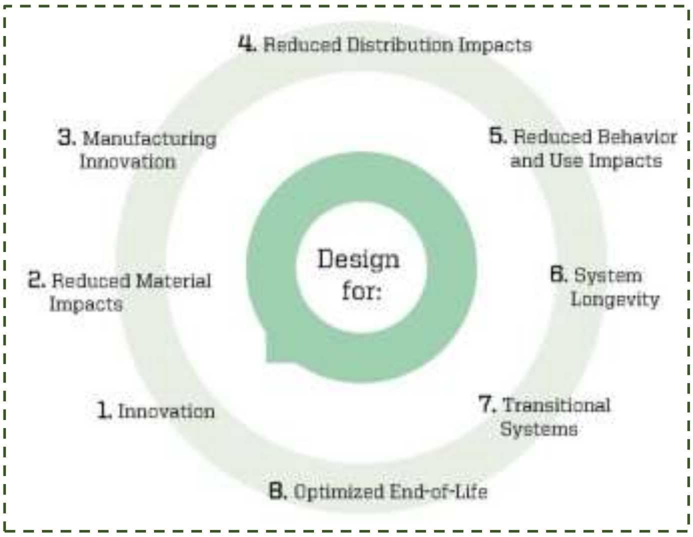

Figure (12) Okala strategy wheel

(ISSN 2537-1061) (Print)

(ISSN 2537-107X) (Online)

a.Design for Innovation

- Rethink how to provide the benefit
- Design flexibility for technological changes
- Provide product as service
- Serve needs provided by associated products
- Share among multiple users
- Design to mimic biological systems
- Use living organisms in product

Figure (13) Recycled Aluminum

b. 2. Design for Reduced Material Impacts

- Avoid materials that damage human or ecological health
- Avoid materials that deplete natural resources
- Minimize the quantity of materials
- Use recycled or reclaimed materials
- Use renewable resources
- Use materials from reliable certifiers
- Use waste byproducts

Figure (14) Lithium batteries Rechargeable Lithium batteries are much less toxic than Lead or Cadmium batteries.

(ISSN 2537-1061) (Print)

(ISSN 2537-107X) (Online)

c. 3. Manufacturing Innovation
- Minimize manufacturing waste
- Design for production quality control
- Minimize energy use in production
- Use carbon neutral energy sources
- Minimize number of production steps
- Minimize the number of parts /materials
- Seek to eliminate toxic emissions

d. 4. Reduced Distribution Impacts
- Reduce product and packaging weight
- Reduce product and packaging volume
- Develop reusable packaging systems
- Use lowest-impact transport system
- Source local materials and production

e. 5. Reduced Behavior and Use Impacts
- Design to encourage low-consump8on behavior
- Reduce energy during use
- Reduce material consumption during use
- Reduce water consumption during use
- Seek to eliminate toxic emissions during use
- Design for Carbon-neutral or renewable energy

f. 6. System Longevity
- Design for durability
- Foster emotional connection to product
    - Design for maintenance and easy repair
- Design for reuse and exchange of products
- Create timeless aesthetic appeal

g. 7. Transitional Systems
- Design upgradable products
- Design for second life with different function
- Provide for reuse of components

h. 8. Optimized End-of-Life
- Design for fast manual or automated disassembly
- Design recycling business model
- Use recyclable Non-toxic materials
- Provide ability to biodegrade
- Integrate methods for used product collection
- Design for safe disposal

4-8 Process Tree
The process tree helps designers strategically explore the transformation of resources and materials through the life of a product system. It triggers thoughtful reflection about ecological impacts and design priorities. (15: Page 32-33)

The process tree also assists in presentations and discussions because it visualizes the flow of materials through the manufacturing and use phases of a product system.

(ISSN 2537-1061) (Print)

(ISSN 2537-107X) (Online)

Example:

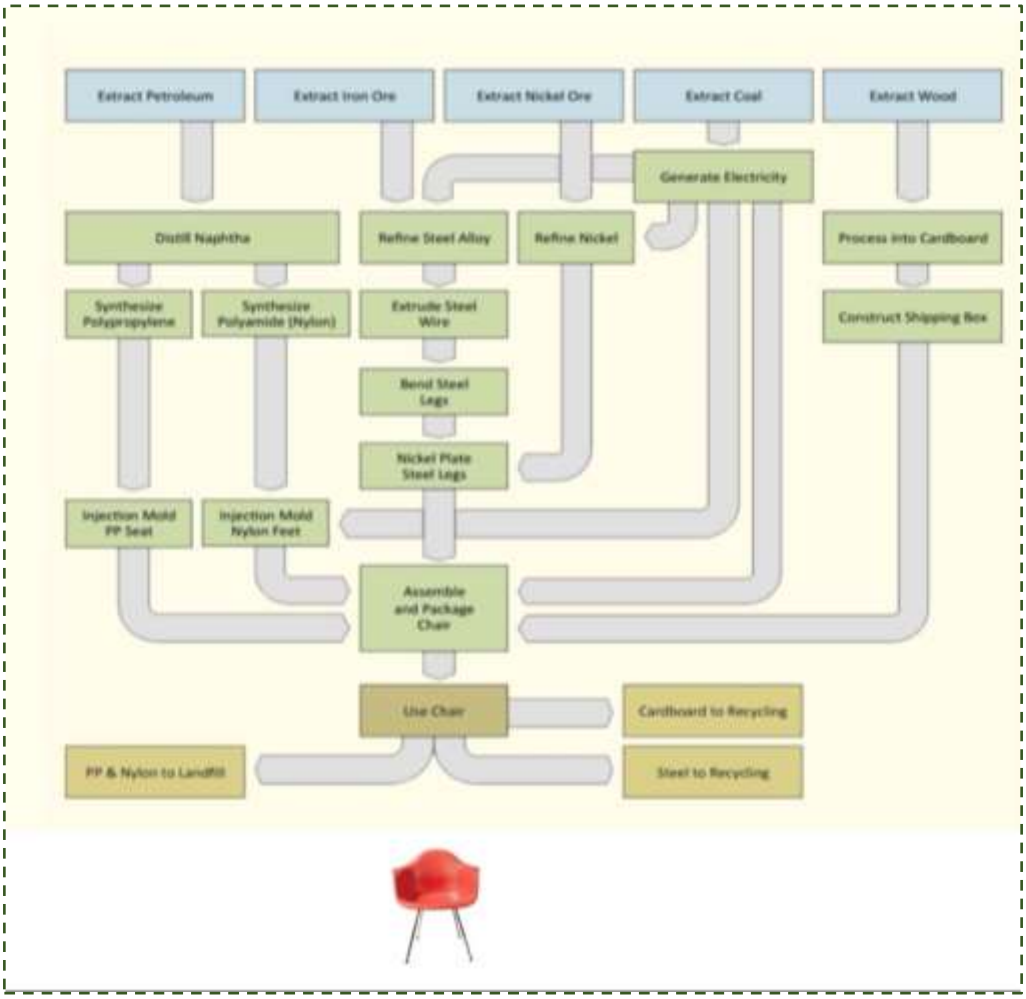

Figure (15) tree life applied on a chair production

4-9 Strategies by ESP DESIGN

ESP Design is a free online guide for design professionals and students to learn about Sustainable Product Design. It aims to provide practical advice and guidelines on how to design sustainable products. And on their website, they give a complete guide to all the strategies involved in SPD from their own perspective as follows. (website1)

a. Design the Business System First

Products cannot be designed in isolation if they are going to be truly sustainable. The typical product design and development process is fragmented and incoherent, and it is this lack of integration that has led to many of the poor standards of design that currently prevail. 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.

(ISSN 2537-1061) (Print)

(ISSN 2537-107X) (Online)

Products can then be designed as necessary to fit into this sustainable system.

b. Clarify Core Functions

The true purpose of a product must always be at the Centre of its design. Consumers may accept losing some secondary functionality in order to achieve other benefits but will not tolerate a product that does not meet its core functions. Consumers will not buy a product for reasons such as sustainability alone, and nor should they. Products must be good in their own right, with factors such as sustainability providing the "icing on the cake", not the cake itself.

c. Product Service Systems

Product designers typically design products for sale. Their aim is to provide high value goods at low production cost and maximize the customers rate of consumption in order to provide high profits. Inevitably this results in consumer's needs not being met, poor value for money and vast wasting of material resources. Product Service Systems (PSS) are not a new idea but if used intelligently can offer significant benefits to all parties. A typical PSS involves lending a product to a customer while selling them a service. For example, the manufacturer might manufacture photocopiers and loan them to businesses who then 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 maximize the life of their products and re-manufacture/recycle old or broken models.

d. Multi-functionalism

It is often possible to combine several products into one unit. For example, a mobile telephone can also be an alarm clock, personal organizer, camera, handheld gaming machine and more.

e. Modularization

Products can often be designed as a set of modules that can be fitted together to provide a combination of functions. It allows customized products to be created from a set of standard modules, products to be altered or upgraded to meet the users changing needs, and for products to be easily repaired.

f. Minimize Material Variety

Most products contain several different types of materials. This is not always necessary, and benefits can be achieved by standardizing the materials used, particularly at end of life.

g. Weight Reduction

It is often possible to reduce the weight of products through a variety of methods including reducing the quantity of material, using lighter weight materials and reducing the requirements of the product.

h. Recyclable Materials

If a product is to be recycled at the end of its life then it must be produced from materials that can be recycled. The designers must consider current technologies and infrastructures when deciding which materials are recyclable. Many materials claim to be recyclable but are not recyclable unless the systems exist to ensure that the materials will be recycled.

i. Recycled Materials

A large proportion of products are already produced from materials that are theoretically recyclable, but very few are actually recycled. This is partly due to a lack of infrastructure, but also due to the

(ISSN 2537-1061) (Print)

(ISSN 2537-107X) (Online)

lack of demand of recycled materials. Designers should investigate the availability of recycled materials and specify them in the design where possible. Ideally, a system will be designed to recycle the companies own products at end of life, for manufacture into new products, thus avoiding contamination with other products and saving the company waste disposal and material costs.

j. RENEWABLE MATERIALS

Increasingly it is possible to produce materials from renewable sources such as wood, starch and sugar cane. These materials are typically substitutes for plastics.

k. BIODEGRADABLE MATERIALS

Recycling is not always the most effective method of disposing of materials. It is possible for many renewable materials to be composted. However, the benefits of composting biodegradable materials are dependent on effective systems being in place to ensure that the materials are treated correctly. If these systems are not in place then biodegradable materials can have negative impacts such as contaminating plastics recycling.

l. Minimize Composites

Composites are materials that have been mixed together to achieve a particular blend of properties. This can be beneficial in certain applications such as weight saving in vehicles, but in many other applications are unnecessary and could be replaced by simpler materials.

m. Avoid Hazardous & Toxic Materials/Substances

Some substances are toxic to humans and/or the natural environment and should be avoided wherever possible. Examples include heavy metals and Volatile Organic Compounds (VOC's).

n. Low Embodied Energy Materials

All materials have energy consumption associated with their production. Some materials are far more energy intensive than others and for non-energy consuming products the embodied energy can make up the bulk of the products lifetime energy consumption.

o. Minimize Material Contamination

Most materials used in products are not in a pure state. They are contaminated with a range of other substances such as colorings, fillers, UV stabilizers, fire retardants, surface treatments, labels etc. These contaminants are often impossible to separate from the material during recycling and so become mixed with other materials and their contaminants. The result is that every time the material is recycled, its quality is reduced (downcycled) due to the unwanted mixing and increasing quantity of contaminants. Not all contaminants are necessary and so designers should aim to keep contaminants to a minimum.

p. Identify/Label Materials

Proper end of life treatment of materials relies on the users and waste disposal services knowing the type of material and preferred method of treatment. Many materials are difficult or impossible to distinguish from others without clear identification (usually in the form of labelling), and some such as home compostable materials need very clear labelling if the material is to be disposed of in the correct way.

q. Avoid Glass

Glass is often considered to be an "environmentally friendly" material because it is produced from an abundant resource, is non-toxic and easy to recycle. However, in many applications it is often

(ISSN 2537-1061) (Print)

(ISSN 2537-107X) (Online)

disposed of in consumer waste and causes damage to recycling facilities due to its hardness. It is also very heavy and so inefficient to transport. Glass can be highly effective in some applications such as UK milk delivery but must be considered carefully.

r. Look for Synergies

Many products are comprised of systems where a number of different components interact. As a result, changing the design of one component can in turn affect other components. Designers should look for areas where this knock-on effect can be used beneficially.

s. Aim for Maximum Efficiency

All resource-consuming systems have a maximum theoretical efficiency. Generally speaking this efficiency can never actually be achieved but using it as a benchmark allows the designer to more easily identify areas of inefficiency and so make continuous improvements. It is likely that more significant improvements will be achieved than if the target is set below the theoretical maximum.

t. Efficient Processes

Manufacturing processes should be considered throughout the design process and the product designed so that it can be manufactured using efficient methods.

u. Plan for Continual Improvement

Technology is constantly changing and improving, and so while extending product durability is theoretically a good thing, it can result in inefficient, outdated products continuing to operate for longer than is efficient to do so. Designers should therefore design energy consuming products to be upgradable to the latest technology. For example or might be possible to upgrade a fridge/freezer to use new refrigeration technology without replacing the body of the product.

v. Minimize Leaks

Energy is often consumed for no useful purpose because of leaks in the system. This is particularly applicable to heating and cooling systems, but also to others such as water and gas systems. Standby energy of energy consuming products may also be considered as leakage, and can consume more energy over the life of the product than is used in to operate the product. Large efficiency losses can result from apparently small leaks.

w. Minimize Cycling Losses

Cycling losses are the energy wasted by a system starting up or shutting down. For example, heating systems, engines, fluorescent lights. Efforts should be made to minimize these losses and the designers should establish whether shutting down the system when not in use is always the most efficient option, and whether partial shut-down may be possible.

x. Renewable Energy

Sources of renewable energy through the mains are highly limited in most countries and even where available, the designer usually has little or no control over whether it is used. Increasingly viable as an alternative is for products to be self-powered, either through a micro power generator such as a solar panel or kinetic generator, or by utilizing power provided by the user, for example wind up or dynamo powered products. These technologies are improving and can offer both environmental and functional benefits.

y. Rechargeable Batteries

Products that operate on battery power should be designed to use rechargeable

(ISSN 2537-1061) (Print)

(ISSN 2537-107X) (Online)

batteries, and where possible the batteries and a charger should be supplied with the product to discourage the use of disposal batteries.

z. Feedback Mechanisms

Consumers are often reluctant to take energy conservation seriously because they are not aware of the problems of energy use or of the amount of energy that they are using. Feedback mechanisms in buildings and products to alert and educate consumers about their own behavior can be affective in improving behavior. Could be extended to other aspects of behavior.

aa. Reduce Transportation

The resources used in the production of a product often travel vast distances before reaching the consumer. Much of this transportation is often unnecessary and simply the result of inefficient planning. Designers should be aware of the potential travel patterns of resources over the lifecycle of their products and attempt where possible to select combinations of materials and processes that keep transportation distances to a minimum. The method of transport should also be taken into account, for example it may sometimes be beneficial to travel a longer distance by rail or sea than a short distance by air.

bb. Simplification

Many products are extremely and unnecessarily complex. Designers should seek to simplify the product from the outset of the design project. However, in some cases simplification could have a negative affect so designers should monitor the impact of any changes.

cc. Integrate Packaging Design

Packaging Design is often approached independently of product design, after the product design has been completed. Packaging design should be integrated into the product design process and considered from the beginning, so that products can be designed with minimal packaging requirements, and that the packaging can work effectively within the business system with minimal negative impacts.

dd. **Durability**

Planned obsolescence is often an element of product design. Designers should instead seek to eliminate the obsolescence of products by increasing durability. This includes physical toughness, but also design for repair and upgradability, and design for emotional attachment. It is important that energy consuming products are designed so that energy saving modifications can be made to the product over time.

ee. Re-Usability

Many products are designed to be disposable or have limited cycles of use. Sometimes these products are actually in excellent condition when they are discarded. Designers should seek ways of reusing these products and avoid their disposal until the time that they actually fail to function.

ff. Remanufacture

Most products are disposed of when they fail to function correctly, but the fault is usually only in one small part of the product. If carefully designed, it is often possible for products to be remanufactured so that faulty or worn parts are replaced or repaired, and the product can then be resold as a new product.

gg. Design for Disassembly

End of life treatment is becoming an in increasingly big issue in the life cycle of products. Products should be designed so that they can be easily disassembled into their constituent parts for appropriate treatment at end of life. It is also often the

(ISSN 2537-1061) (Print)

(ISSN 2537-107X) (Online)

case that products which are easy to disassemble, are also easy to assemble.

hh. Maintenance

Products should be designed to be maintained in good condition. Most products cannot be maintained and simply run until something goes wrong and are then discarded. Maintenance is vital in maintaining performance and increasing the lifespan of products. Designers should attempt to minimize the amount of maintenance required but make any maintenance that is required easy and cost effective to carry out. The product should also be designed in a way that encourages the user to keep the product properly maintained.

ii. Reduce Consumables

Many products consume materials during their lives, such as washing powder in washing machines and ink cartridges in pens and printers. Products should be designed in a way that minimizes the quantity of consumables used over the life time of the product.

jj. Integrate Disposal Instructions

If products are to be treated properly at end of life then the user must know what to do with it when it reaches the end of its life. This means designing products in a way that clearly indicate to the user, and the waste management workers, how the product should be treated. Any such instructions should be designed in a way that will last the lifetime of the product.

kk. Use Waste Products

Waste arises in the production of must products. Rather than writing this material off as waste, designers should seek to develop uses for this waste material and design products that can be produced form it. These products may be completely unrelated to the main product and the industry sector of the business.

ll. Closed Life Cycle Design

The majority of strategies presented here will improve the sustainability of a product over its lifetime, but even if they are all implemented effectively, it is possible that the product may not meet the sustainability criteria of being Cyclic. If products are to maintain their value indefinitely and be truly sustainable, they must be designed with this intention in mind. Designers should plan the potential uses of the products several life cycles into the future.

mm. Design Products to be Loveable

Many purchasing decisions are made for emotional rather than logical reasons. The same applies to the treatment of a product during its life, including the decision to dispose of the product, often prior to technical end of life. Sustainable products should be designed to be loveable. If people fall in love with the products they will want to buy them, want to care for them and want to keep them for as long as possible. In fact they may increase in value to the individual over time. Sustainability can help products to be loveable as it ensures that the products genuinely meet the needs of the user and do not have any dark secrets. In other words, they are trustworthy.

nn. Rewrite the Brief

Design is all about finding creative solutions to problems, but very often it is the problem itself that is wrong. However hard they try, designers cannot design to sustainability, if they are given a brief that is inherently unsustainable. Managers need to write breeds more carefully and designers need the confidence to challenge flawed briefs and suggest better alternatives.

oo. Change Consumer Behavior

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 behavior, 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.

pp. Design for Part Load Operation

Many systems are designed to run most efficiently when running at full capacity, but in reality may only occasionally operate under such conditions. The system should therefore be designed to run most efficiently under the conditions that it is to be used most often, and where appropriate should be designed to operate efficiently over a range of conditions.

qq. Select Responsible Suppliers

The integrity of a product is partly dependent on the integrity of the organizations that supply services and components for its manufacture. If designers and businesses wish to become sustainable then they must seek to work with organizations that share that vision and can be relied upon to provide clear and accurate information about their operations and not compromise the integrity of their clients.

rr. START WITH A BLANK SHEET OF PAPER

Most design projects begin with a great many preconceived ideas, and therefore resulting designs that are left are marginally better than whatever preceded them. Open your mind and think about the real problem from first principles, you are far more likely to find the big improvements that you're looking for.

4- Conclusions:

5-1 A table of comparison would help in understanding each strategy

Table (1) comparison between strategies

	strategy	Main content	Used by	Indicators
1	Provide Product as Service	Focus on meeting needs while minimizing the physical product component Service. Design can manifest in many ways: - Product cooperatives that share products. - Ownership models (like leasing) that insure system repair and upgrading. - Systems that reward	Producers Designers	With the spread of the concept on the long run the results will be obvious

		environmentally attuned behavior. - Support extended producer responsibility for used products. - New business models with ecological advantages.		
2	Mimic Biological Systems	Explanation of the concept with strong examples, web site named ask nature is an open source for those seeking to adapt the strategy in their work	Designers with the help of biologists	No indicators mentioned
3	Design for Carbon Neutral Energy	Suggestions to put the designers on the right tracks, through scientific factors supported with, examples and guide lines to help clarifying how to achieve each factor.	Engineers with Designers	No indicators mentioned
4	Design for System Longevity	encompasses a variety of strategies. These strategies help to design products that people want to keep much longer than products currently are kept. Several approaches can assist in this process. Understanding why we throw things away is valuable. Loss of functionality is often only part of the reason for product disposal.	Designers	No indicators mentioned
5	Environmental Impact Matrix (EIM)	assist product developers in evaluating their progress toward sustainability. The specification of raw materials, energy inputs, purchasing specifications, hazardous materials generated, recycling of the product after consumer use, and worker health and safety are just a few of the potential impacts that are involved in the initial design. EIM is a strategy for internal and confidential use on the part of a company whose focus is self-assessment and environmental improvement.	Producers and designers Assessing an old product or a new one before going further with the production process	Direct results well come out indicating the impact on the environment
6	Design for Product	The strategy leads the designer	Engineers&	Direct

(ISSN 2537-1061) (Print)

(ISSN 2537-107X) (Online)

	Lifetime	through the product life cycle inspiring solutions divided upon three elements: Access a product's components. (Design for Disassembly), Keep it alive longer. (Design for "Repair-upgrade"), Enable a responsible end-of-life. (Design for "Recycling, remanufacturing"), giving a direct brief under each element on how to handle.	Designers	results well come out indicating the impact on the environment
7	Okala Strategy wheel			
7-1	Design for Innovation	In each phase related to the product life cycle designers are given general directions how to be innovative in the way that would support a sustainable approach in that phase and all the data supported with applicable examples.	Designers Marketing	No indicators available
7-2	Design for Reduced Material Impacts			
7-3	Manufacturing Innovation			
7-4	Reduced Distribution Impacts			
7-5	Reduced Behavior and Use Impacts			
7-6	System Longevity			
7-7	Transitional Systems			
7-8	Optimized End-of-Life			
8	Process Tree	The process tree aims to help designers strategically explore the transformation of resources and materials through the life of a product system. It triggers thoughtful reflection about ecological impacts and design priorities.	Designers Engineers	Results will be noticeable once the tree chart is filled by the design team
9	Strategies by ESP DESIGN			
9-1	Design the Business System First	A group of strategies explained briefly as a general reference, then, it is the designer is turn to	Designers, Engineers & stakeholders	As these strategies are just guides no indications are expected
9-2	Clarify Core Functions			
9-3	Select Responsible			

(ISSN 2537-1061) (Print)

(ISSN 2537-107X) (Online)

	Suppliers	dig further for each strategy.		unless the designer decides to pick a group of them to work with
9-4	Product Service Systems			
9-5	Multi-functionalism			
9-6	Modularization			
9-7	Minimize Material Variety			
9-8	Weight Reduction			
9-9	Recyclable Materials			
9-10	Recycled Materials			
9-11	Biodegradable Materials			
9-12	Renewable Materials	A group of strategies explained briefly as a general reference, then, it is the designer is turn to dig further for each strategy.		
9-13	Minimize Composites			
9-14	Avoid Hazardous & Toxic Materials/Substances			
9-15	Low Embodied Energy Materials			
9-16	Minimize Material Contamination			
9-17	Identify/Label Materials			
9-18	Avoid Glass			
9-19	Look for Synergies			
9-20	Aim for Maximum Efficiency			
9-21	Design for Part Load Operation			
9-22	Efficient Processes			
9-23	Plan for Continual			

(ISSN 2537-1061) (Print)

(ISSN 2537-107X) (Online)

	Improvement			
9-24	Minimize Leaks			
9-25	Minimize Cycling Losses			
9-26	Rechargeable Batteries			
9-27	Feedback Mechanisms			
9-28	Reduce Transportation			
9-29	Simplification			
9-30	Integrate Packaging Design			
9-31	Durability			
9-32	Re-Usability			
9-33	Remanufacture			
9-34	Design for Disassembly			
9-35	Maintenance			
9-36	Reduce Consumables			
9-37	Integrate Disposal Instructions			
9-38	Use Waste Products			
9-39	Closed Life Cycle Design			
9-40	Design Products to be Loveable			
9-41	Rewrite the Brief			
9-42	Start with a Blank Sheet of			

(ISSN 2537-1061) (Print)

(ISSN 2537-107X) (Online)

	Paper			
9-43	Change Consumer Behavior			

5-2

5-3 How Designers can benefit from all these strategies:

After studying these strategies, understanding the benefits of each and the circumstances related to using each a general plan could be built connecting the team work members with these Strategies, referring to more than one team or team member here reflects a need for joint sessions between those teams or team members

Product designers &Engineers

- Design for Carbon Neutral Energy
- Aim for Maximum Efficiency
- Design for Part Load Operation
- Efficient Processes
- Minimize Leaks
- Minimize Cycling Losses
- Rechargeable Batteries
- Feedback Mechanisms

Product Design

- Mimic Biological Systems
- Design for Product Lifetime
- Design for System Longevity
- System Longevity
- Design for Innovation
- Plan for Continual Improvement
- Simplification
- Durability
- Re-Usability
- Remanufacture
- Re-Usability
- Remanufacture
- Design for Disassembly
- Maintenance
- Reduce Consumables
- Closed Life Cycle Design
- Design Products to be Loveable
- Rewrite the Brief
- Start with a Blank Sheet of Paper
- Modularization
- Providing Product as Service
- Multi-functionalism
- Look for Synergies
- Clarify Core Functions

Engineers with Product Designers&Graphic Designers

- Environmental Impact Matrix (EIM)
- Process Tree
- Minimize Material Variety
- Weight Reduction
- Recyclable Materials
- Recycled Materials
- Biodegradable Materials
- Renewable Materials
- Minimize Composites
- Avoid Hazardous & Toxic Materials/Substances
- Minimize Material Contamination
- Low Embodied Energy Materials
- Design for Reduced Material Impacts
- Use waste products

Stake holders& Production team

- Manufacturing Innovation
- Design the Business System First
- Select Responsible Suppliers

Graphic Design

- Identify/Label Materials
- Avoid Glass
- Simplification
- Integrate Packaging Design
- Integrate Disposal Instructions

(Marketing)

- Reduced Distribution Impacts
- Reduce Transportation
- Change Consumer Behavior

(ISSN 2537-1061) (Print)

(ISSN 2537-107X) (Online)

5- **Recommendations**

This issue needs more care on governmental level and a database needs to be constructed, as a national opensource, country wise maybe, with the ability for interactive actions specially for the materials calculations and expected hazards info.

6- **References:**

1- B.Eng M.Sc.(Eng), PRODUCT LIFE CYCLE MANAGEMENT, Thessaloniki 2002, URENIO - Urban and Regional Innovation Research Unit.

2- Carlos Alberto Montana-Hoyos, Carlos Fiorentino, Biological Approaches to Design for sustainability, The International journal of Designed objects,2016

3- Chong-Wen Chen, Guidance on the Conceptual Design of Sustainable Product–Service Systems, Department of Information Communication,Yuan Ze University, 2018.

4- Christopher Sho Taylon Beard, Great Design comes with Great Responsibility, Exploration into responsible Industrial Design (RID).

5- David II. Gardner, Professor, Department of Business Administration, The Product Life Cycle a Critical Look at the Literature

6- Deniz Deniz, Sustainability and Environmental Issues in Industrial Product Design, MASTER OF INDUSTRIAL DESIGN, Izmir Institute of Technology Izmir, Turkey, September, 2002.

7- J. Brezet and C. Van Hemel, Ecodesign, a Promising approach to Sustainable Production and Consumption, UNEP, 1997

8- Fabio Giudice, Guido La Rosa, Antonino Risitano, Product Design for the Environment: A Life Cycle Approach, CRC press, 2006.

9- Jerrod Bradley Windham, Sustainable Design Methodology for Industrial Designers within an Organization with no environmental policy, A Thesis Submitted to the Graduate Faculty of Auburn University in Partial Fulfillment of the Requirements of the Degree of Master of Industrial Design.

10- J¨org Niemann, Serge Tichkiewitch, Engelbert Westk¨amper (Eds.), Design of Sustainable Product Life Cycles, Library of Congress.

11- Lewis et al, Design + Environment: A Global Guide to Designing Greener Goods, Greenleaf Publishing,2001

12- Lofthouse V, Ecodesign tools for designers: defining the requirements, Journal of Cleaner Production , (2006)

13- McDonough W& Braungart M .,Cradle to Cradle, North Point Press2002

14- Philip White, Okala Practitioner “Integrating Ecological Design”,2013

15- The Design Work Group, West Michigan Sustainable Business Forum, Designing products& Services with sustainable Attributes. West Michigan Environmental Action Council, First Edition - September 1999

16- Conny A. Bakker, Ruth Mugge, PLATE: Product Lifetimes and The Environment, research in design theories,2017

Websites:

1- http://www.espdesign.org/

2- https://www.e-education.psu.edu/eme807/node/687

3- http://www.tboake.com/carbon-aia/carbon_definition.html

(ISSN 2537-1061) (Print)

(ISSN 2537-107X) (Online)

4- https://knowledge.autodesk.com/support/inventor-products/learn-explore/caas/simplecontent/content/improving-product-lifetime.html

(ISSN 2537-1061) (Print)

(ISSN 2537-107X) (Online)

الملخص:

تزداد الحاجة إلى تصميم أكثر مسئولية بسرعة كبيرة، لكي تصبح الوجه الممثل للتصميم المستقبلي يوماً بعد يوم. ويهدف تصميم المنتج المستدام إلى تحقيق هدف التوصل إلى منتجات وعمليات تصميم أكثر وعياً من النواحي البيئية.
يجب أن تتضمن ممارسة التصميم المستدام إطار عمل محدد يتناول القضايا البيئية بما يتضمنه ذلك من تحديات في مواجهة إجراءات التصميم والتصنيع التقليدية

ازداد الاهتمام بالتصميم المستدام بدرجة كبيرة فيما بين القائمين على الصناعة والتصميم. وعلى المصممين الذين يمارسون التصميم المستدام أن يطبقوا مفهوم" تحقيق احتياجات الحاضر دون التنازل عن المحافظة على قدرة الأجيال المستقبلية على تحقيق احتياجاتهم. ولذا عليهم أن يكونوا على دراية بكل العناصر المتعلقة بالتصميم المستدام بداية من مسببات التلوث إلى الخامات وطرق الإنتاج وكذلك دورة حياة المنتج.

لفهم كيفية ممارسة التصميم المستدام بشكل صحيح على المصمم أن يكون ملماً بإستراتيجيات ذلك الاتجاه المختلفة

وتكمن مشكلة البحث في كون ممارسة التصميم المستدام أمراً لا يستهان به، ومصمم المنتجات بحاجة إلى أن يقرر الاستراتيجية التي يجب أن يتبعها وما يجب أن يركز عليه في دورة حياة المنتج لكي يحقق أهدافه وإلا قد يفشل.

ويهدف البحث إلى دراسة وتحليل بعض استراتيجيات تصميم المنتجات المستدام وإعدادهم بشكل يسهل على مصممي المنتجات الاستعانة به من خلال تدوين وتحليل الحقائق المتعلقة بكل استراتيجية، وكذلك الظروف المتعلقة بتطبيقها للاستفادة منها بالشكل الأمثل ثم إعداد قائمة لاستراتيجيات التصميم المستدام وتحديد أفضل النتائج المتعلقة بتطبيق كل استراتيجية واستبعاد الاستراتيجيات ضعيفة الصلة بتصميم المنتجات.

مفاتيح البحث: التصميم الإيكولوجي، التصميم للاستدامة، دورة حياة المنتج، استراتيجيات التصميم المستدام، التصميم الأخضر، المحاكاة.

(ISSN 2537-1061) (Print)

(ISSN 2537-107X) (Online)