X- RAIL: A sustainable exhibition system for design schools -

part of the TANGO EU funded project

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ABSTRACT

The thesis is part of the TANGO / AH-Design project funded by the Culture Programme of the European Union-Education and Culture DG, aiming to explore the issue of social inclusion and in particular the intergenerational dialogue, proposing innovative solutions. The project partners are the Aalto University, Helsinki (Finland), the Ecole de Design Nantes Atlantique, Nantes (France) and the Politecnico di Milano, Milan (Italy).
An additional goal of the TANGO project is to design a travelling exhibition, which have to be an environmental sustainable and accessible one, in an open source and copyleft logic.

Just in relation of this last aim, the thesis purpose is to contribute to the design of the display system which will be used to expose the contents related to the TANGO project, during an event which will take place in Milano in April 2013 during the Salone del mobile.

The brief of the thesis and of the TANGO related project evolved during the design research was defined at last as it follows:
"design an highly flexible and durable exhibition display system which will be used first for the TANGO event, then to substitute those less sustainable exhibition display systems, used by the three involved universities".

The design process, coordinated by the unit DIS (Design and Innovation for Sustainability) of the INDACO research department of Politecnico di Milano has activated a collaboration with the set-up workshop of Politecnico di Milano.
The process was developed following the MPDS method (Method for Product Design and Sustainability) evaluating, in a first stage of strategic analysis, the environmental impact of the exhibition system currently used by the Politecnico di Milano (using LCA tools). In a next stage of exploring opportunities were involved the students of the course "Design per la sostenibilità ambientale" taught by prof. Carlo Vezzoli and part of the undergraduate degree "Industrial design" program of Politecnico di Milano. The obtained results consisted in

some tentative concepts which were then evaluated in environmental terms by the participating students.

The results of this first stages were the starting point for the proper concept design phase.
Starting just from the most promising tentative concepts, it started the design of the new exhibition system, thus featured:
X-RAIL is eternally durable and adaptable to the different kind of students' project presentations, from poster to movies and mock ups.
Its structure is essential and wire shaped and results flexible to answer to venues with different features.
It is made with locally based elements, simplifying its production and assembly.

In this way the TANGO exhibition will be structured avoiding completely the on road transportation, making the contents travel digitally and using the display exhibition system locally produced.
The components are made of easily recyclable materials towards a zero waste exhibition.

The further developments will consist in a final engineering and the exhibition system following production. It will be tested for the first time during the TANGO event in Milano.

ABSTRACT

La tesi fa parte del progetto TANGO / AH-Design finanziato dal Culture Programme of European Union-Education and Culture DG, volto ad esplorare il problema dell'inclusione sociale ed in particolare del dialogo intergenerazionale, proponendo soluzioni innovative. I partner del progetto sono Aalto University Helsinki (Finlandia), L'ècole de Design Nantes Atlantique Nantes (Francia) e Politecnico di Milano Milano (Italia).

Altro obiettivo del progetto TANGO è quello di progettare una esposizione itinerante a basso impatto ambientale e accessibile, in una logica open source e copyleft.

Proprio in relazione a quest'ultimo obiettivo la tesi intende offrire un contributo progettuale per il sistema di allestimenti con il quale verranno esposti i contenuti oggetto della mostra che si terrà a Milano nell'aprile 2013, durante il Salone del mobile.

Il brief della tesi e del progetto Tango si è evoluto durante la ricerca progettuale definendosi infine come segue:
"progettare un sistema espositivo altamente flessibile e durevole, che venga inizialmente utilizzato per la mostra TANGO e che poi vada a sostituire quei sistemi espositivi ambientalmente meno sostenibili utilizzati dalle tre università coinvolte".

Il processo progettuale coordinato dall'unità DIS (Design and Innovation for Sustainability) del dipartimento di ricerca INDACO Politecnico di Milano ha attivato la collaborazione con il laboratorio allestimenti..
Il processo progettuale è stato sviluppato seguendo il metodo MPDS (Method for Product Design and Sustainability) valutando in una prima fase di analisi strategica, l'impatto ambientale del sistema espositivo attualmente in uso dal Politecnico di Milano (usando strumenti di LCA).
In una fase di esplorazione delle opportunità sono stati coinvolti gli studenti del corso "Design per la sostenibilità ambientale" tenuto dal prof. Carlo Vezzoli, parte della laurea triennale in Design del prodotto industriale del Politecnico di Milano. I risultati ottenuti sono stato dei

tentative concept che sono stati valutati in termini ambientali dagli studenti del corso.

I risultati di questa prima fase sono stati il punto di partenza per la fase di progettazione del concept vero e proprio. Partendo dai tentative concepts più promettenti, è iniziata la progettazione del nuovo sistema espositivo, così caratterizzato:
X-RAIL è eternamente durevole e adattabile alle diverse tipologie di contenuti esposti, dai poster, alle proiezioni video fino ai modelli di studio. La sua struttura, essenziale e filiforme, risulta adattabile a spazi espositivi con caratteristiche differenti.
E' realizzata con componenti prodotti prevalentemente in loco, facilitandone la produzione e l'assemblaggio.

In questo modo la mostra TANGO verrà strutturata evitando completamente il trasporto su strada, facendo viaggiare i contenuti in forma digitale ed utilizzando i sistemi espositivi prodotti localmente.
I componenti utilizzati inoltre hanno caratteristiche di elevata riciclabilità evitando gli scarti e rifiuti.

Le prospettive per questo progetto consistono in una sua finale ingegnerizzazione e una successiva produzione. Il sistema espositivo verrà testato per la prima volta nella mostra TANGO a Milano.

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DESIGN AND SUSTAINABILITY

In this first chapter are dealt the themes and the results of the continuos research of the Unit Design and Innovation for Sustainability (DIS), of the laboratory of environmental requirements of industrial products (RAPI.labo) of the research department INDACO of Politecnico di Milano and the international network LeNS (Learning Network on Sustainability) financed from the european community for the diffusion of the principles of Design for sustainability in the Universities, Companies and studios which deal in design.

For further deepening in sustainability applied to industrial design are recommended the publications of Prof. Carlo Vezzoli and Prof. Ezio Manzini since 1995 to present. Among these, the most current and complete reference, which are recorded some content to the writing of this chapter, it is certainly Carlo Vezzoli, Fabrizio Ceschin, Sara Cortesi; Metodi e Strumenti per il Life Cycle Design; 2009, Maggioli Editore.

SUSTAINABLE DEVELOPMENT

We often hear about how much the planet on which we live is no longer willing to accept in our ongoing abuse and about the inability of the biosphere and geosphere to continue to absorb the effects of the system of production of goods and services without irreparable damage.

Over the years various institutions have first introduced the concept of sustainable development - in the '80s with the title Our Common Future World Commission for Environment and Development - which formed the basis for the United Nations Conferences on Environment and Development (United Nations Conference on Environment and Development) held in Rio de Janeiro in 1992 and Johannesburg in 2002.

As described by Carlo Vezzoli, Fabrizio Cortesi Ceschin and Sara in their publication,"With the expression sustainable development we refer to the systemic conditions for which, at the global level and at regional level, the human activities do not exceed the limits of resilience of the geosphere and the biosphere, which exceeded, they involve a irreversible degradation and, at the same time, not to impoverish the natural capital that will be transmitted to future generations, meant as the set of nonrenewable resources and the systemic ability of the environment to reproduce renewable resources."[1]

Considering the expected population growth and a growing demand for well-being in the countries where this is not present, the system of production could be considered sustainable in the case of a reduction of at least 90% of environmental resources used per unit of service provided, in societies industrial mature.[2]

Even approximately, this assessment provides an idea of the proportion of the change must be put in place to achieve the goal of a sustainable production system.

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1 Carlo Vezzoli, Fabrizio Ceschin, Sara Cortesi; Metodi e Strumenti per il Life Cycle Design; 2009, Maggioli Editore
2 Friends of Earth; Wuppertal Institute, Toward a sustainable Europe; Amsterdam, 1995

"In the coming years we will in fact be able to go from a society in which the welfare and economic health is measured by the growth of production and consumption materials, in a society in which we live better consuming (much) less"[3].

3 Carlo Vezzoli, Fabrizio Ceschin, Sara Cortesi; Metodi e Strumenti per il Life Cycle Design; 2009, Maggioli Editore

DESIGN FOR SUSTAINABILITY

What was reported in the previous paragraph should be one of the key points of the main design criteria observed by designers and especially organizations, companies and institutions operating in the world of industrial production.
However, realising the reasons of sustainability and sustainable development is not an easy task and requires continuous research in the optimization of production processes.
Basically the integration of the environmental requirements into the design process means to manage a greater complexity, in terms of information and relations, with stakeholders from different disciplines.

Over the years, during which the sensibility and the interest of organizations, companies and institutions to sustainability issues has grown, it was created a systemic design approach that aims to consider all stages of the life cycle of the product The Life Cycle Design (LCD).
The attention to the several phases of the life cycle of the product begins from the extraction of resources, which then have to be reprocessed to compose those materials used to produce the product parts, to the disposal of these materials.
The steps which describe the life cycle of a product are, in order, the following:

- Pre-production, which includes both the acquisition of resources (raw materials) and their reprocessing to produce the materials to be used for the product;

- Production, which includes the processes to make the product parts, the assembly and finishing;

- Distribution, which considers the transportation, storage, but also the packaging which have to be considered in its whole life cycle.

- Use of the product, which includes both the possible consumption of resources necessary for its functioning and the processes

connected to it (for example, the maintenance).
- Disposal, which considers that the product after harvest may follow different paths: landfill disposal, incineration, composting, recycling or "remanufacturing" and re-use (of the whole product or any of its components)[4].

The life cycle of the product can be described environmental terms considering and evaluating the environmental effects which the input and output of the various processes, related to each of the steps listed above, determine to the geosphere and biosphere.
Here are some of the most incisive and disturbing environmental effects:

- The exhaustion of resources;
- The greenhouse effect;
- The thinning of the ozone layer;
- Eutrophication;
- The smog production;
- Acidification;
- The toxins in the air, water and soil;
- The waste.

Today it is possible to measure these environmental effects in relation to a single product.
Indeed these are the parameters by which it is carried out the method called Life Cycle Assessment (LCA), which specifically tries to assess the impact of the life cycle of a product, allowing the comparison of the impacts of the life cycles of different products.
There are several tools which can be used to make an LCA of a product and which can support the design processes, in order to determine the environmental priorities to design and compare the results, at the end of the design, in terms of reduction of environmental impact, with the existing product. "The goal of the Environmental Life Cycle Design is

4 Carlo Vezzoli, Fabrizio Ceschin, Sara Cortesi; Metodi e Strumenti per il Life Cycle Design; 2009, Maggioli Editore

LIFE CYCLE DESIGN (LCD)

The goal of the Environmental Life Cycle Design is to reduce materials and energy inputs as well as the impact of all emissions and waste, in both quantity and quality terms, assessing the harmfulness of the effects (with the LCA or other tools) of the processes of all the stages of the life cycle of the products.[5]

The introduction of the idea of a functional unit is crucial:
In fact this defines the reference for the function offered by a particular product. The design must consider the "satisfaction" which is carried out by a product, a service or a set of products and services. This criteria allows to compare different products in environmental terms.
The Economic / Environmental premise of Life Cycle Design is in the prevention of environmental damage in the design phase, rather than remedy when a product is already on the market.

Some of the strategies that can address the development of products towards lower environmental impact, are listed below:

- the minimization of energy consumption;
- the minimization of the use of materials;
- the choice of renewable / conservative resources;
- the choice of non-toxic / harmful resources;
- the optimization of product life span;
- the extension of the life of the materials.[6]

Minimising the resources used means to reduce the use of materials and energy that determine a service offered by a product: they are used during the whole life cycle of a product so, for this reason, the design approach should aim to their reduction in all stages, including business planning and management.
Containing the use of resources produces not only the reduction of environmental impacts related to the production of the material of the

5, 6 Carlo Vezzoli, Fabrizio Ceschin, Sara Cortesi; Metodi e Strumenti per il Life Cycle Design; 2009, Maggioli Editore product, but also those related to the processing, transportation and disposal. Likewise as less energy is used, the more the impact of its production and transport is reduced.

Resources with low environmental impact are those materials and energy sources, which have a better environmental quality. As already pointed out above, the environmental quality have to be measured within all stages of the life cycle, in order to obtain an efficient and correct result.
For the choice of low impacting resources it should be considered:

- the several material processing technologies, as some can cause toxic and harmful emissions;
- the distribution systems which are less harmful to the environment;
- the use of resources with the lowest impact in the design of new products;
- the minimization of hazardous emissions in the treatments of disposal in relation to the choice of materials;
- the level of renewability of the considered resources: the least exhaustion of a resource determines its higher level of renewability.

Optimise the product life span means designing their longevity. A product that lasts more than another determines generally less environmental impact. In fact, a product that lasts less, generates early wastes and will result in an indirect impact, due to the necessity of replacing it.
The production, distribution and disposal of a new product will require the consumption of new resources and will result in the generation of new emissions.

In general, however, regarding the use stage, the extension of the life span of a product does not determine a reduction of the impact, but instead it can increase it; the technological innovation of a new product in fact, can justify its whole life cycle due to its higher efficiency in the use phase (regarding consumption and emissions) compared to an obsolete product.

Summing up, the economic and environmental condition of a life cycle design approach is to act upstream to prevent the amount of emissions and to reduce the consumption of resources: it is in fact more effective and less expensive to prevent the environmental damage in the design phase, instead than remedy to it once the product is already on the market.

In the following paragraph is described the method MPDS (Method for Product Design for Sustainability environmental) for sustainable design.

MPDS METHOD

The MPDS method has been developed from the Design and system Innovation for Sustainability (DIS) research unit of Politecnico di Milano – INDACO department (head: Prof. Carlo Vezzoli) and aims to integrate and support a product design process for the development of environmentally sustainable solutions. The designer who decides to design using the MPDS can integrate the indications provided at different levels, and decide which tools to use depending on the specific task he/she is facing and on the context in which he/she operates. The method is modular, flexible and organized into processes and sub-processes, so that they can be easily adapted to the specific needs of each designer and company, facilitating its application in various contexts and design conditions.

In the following table is presented the integration between the MPDS with the typical phases of the NPD (New Product Development process, or else:

- strategic product analysis (brief);
- concept design;
- product design;
- product engineering.

design stages	MPDS integration	
	Goals (for environmental sustainable design)	Processes (for environmental sustainable design)
Strategic analysis (Brief)	Assess the critic areas and the one with a higher improvement potential of the environmental sustainability of the product; define the final goal of the design (its function, their use contexts, the use interaction, ...); the main environmental impact reduction strategies which are going to be followed in the design phase	LCA of an existing product type to approach a sustainable design
		Definition of environmental design priorities
		Syntethic visualization of the environmental design priorities
Concept design	Definition of the main features of the final product which allows an environmental impact reduction compared to the existing alternatives	Focused generation of sustainable ideas
		Concept sustainability checks: new definition of environmental priorities and choise of the most promising concept
Product design (and engineering)	Product details definition which will take the product towards a high environmental quality	Choice of the less impacting processes and product details
Communication	Communicate the product features, showing the aspects related to environmental sustainability	LCA to evaluate the comparison with the considered product type
		Drafting of the document for the communication of the product environmental qualities

FIG.1
stages of the MPDS method

In the following lines are described in detail the processes and subprocesses which compose the MPDS, introducing those tools which have to be used to achieve each phase and explaining the results which are obtained.

MDPS in product strategic analysis (brief definition) and tools

In the early design stages, the MPDS considers the following processes and subprocesses:

- definition of the environmental design priorities:
  Life Cycle Assessment of an exhisting product, for a sustainable design orientation;
  definition of the environmental strategic priorities;
  synthetic visualization of environmental strategic design priorities.

Definition of the environmental design priorities

Life Cycle Assessment of an exhisting product, for a sustainable design orientation

Given the brief of the project is important to make an LCA of an existing product type (or a set of existing products type) whose function is the one defined by the product to design. It is good that the existing product chosen is as representative as possible of market trends. To make the LCA is useful at this stage to use a software or undertake a simplified assessment using LCA quick tools. It is also possible to use the tables that report the values of the indicators of environmental impact of the aggregates processes.

The goal of this early stage is to obtain the results the of a LCA - at an evaluation level -, functional to the definition of the potential for improvement. Actions to be taken are, first, to define aims and objectives of the analysis, pointing out that the assessment is made to help in the definition of the design priorities, and to define the function of the product or from the selected service.
As seen describing the basic steps of the LCA, this means defining the functional unit, that represents the reference to collect data and evaluate all the processes of the product life cycle.
Completed these first two steps it would be necessary to build the

inventory process, which collect data on processes of the various stages of the life cycle of the product (pre-production, production, distribution, use, disposal).
Afterwards, keeping in mind that the goal is to obtain the data needed to calculate the Indicators of Evnironmental Strategic Priorities (IPSA), one proceed to the assessment itself.
The main result of this subprocess is therefore a LCA report that contains, in addition to the definition of goals and objectives (as why is done by the study, which are the boundaries of the system under analysis, what is the functional unit, considerations on the quality of the data used) and the inventory processes (which were considered step by step and how they were eventually aggregated), the results of evaluation, a series of environmental indicators and their interpretation in terms of their subsequent use to define priorities for a design planning.

In this subprocess it may be used an LCA tool (as a software that allows you to make a rigorous LCA, or a simplified version, even paper).

Definition of the environmental strategic priorities

With the results obtained from the LCA it can be compiled the evaluation board of IPSA, one of the tools in ICS (Sustainable Design Concept) toolkit.[7] With IPSA is possible to put in priority order the main strategies of the Life Cycle Design for the product concerned, namely:

- reduction in energy consumption;
- reduction of materials;
- extension / intensification of use;
- resources conservation;
- toxicity reduction;
- materials life extension.

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7 See: Carlo Vezzoli, Fabrizio Ceschin, Sara Cortesi; Metodi e Strumenti per il Life Cycle Design; 2009, Maggioli Editore, pp.105-128.

Considering the LCA results, for each strategy it can then be defined the most impacting processes from which to point the action priorities.

Synthetic visualization of environmental strategic design priorities

At this point it is useful to render clearly the project priorities identified as the most promising design strategies.
This synthetic visualization may be achieved putting the information priority obtained in the IPSA on the multi-strategy radar (also present in ICS toolkit) and to produce histograms priorities for each strategy.
As a result it is shown a display of the priority level of each strategy, specifying which are the components, materials, processes, steps, to which pay more attention.

	process	sub-processr	esults	tools
strategic analysis (brief)	Definition of environment al design priorities	LCA of an exhisting product for sustainable design orientation	Environmental indicators useful to determine design priorities	LCA tools
				processes eco-indicators tables
		Definition of the environmental strategic priorities	environmental priorities indicators, expressed as value from 0 to 1	IPSA board (ICS toolkit)
			Istograms which render the design priorities about the processes for each strategy	
		syntethic visualization of of environmental strategic design priorities	Radar with indications about relative priorities in LCD strategies	Multi-strategy radar (ICS toolkit)

FIG.2
MPDS, strategic analysis stage

MDPS in concept design and tools

During the design concept, the MPDS considers the processes and sub-processes described below:

- focused generation of sustainable ideas:
  Workshops focused on generation of sustainable ideas;
  Reprocessing of sustainable ideas;

- Sustainability check of the concepts and new definition of the concept environmental priorities:
    - Representation of the environmental features of the concept;
    - Check of the concept environmental improvements;
    - Display of the potential of the environmental strategic improvements.

Focused generation of sustainable ideas

In this phase of ideas generation it might be useful to use the provided eco-ideas boards (contained in the ICS toolkit), one for each of the strategies considered into IPSA, where are listed some design guidelines, in order to stimulate and orient the brainstorming activity.

Workshops focused on the generation of sustainable ideas

Before the definition of a concept is useful to organize a workshop focused on the generation of sustainable ideas.
Once defined and clearly communicated to the entire team which are the design priorities (or redesign) from the environmental point of view, is necessary to proceed with a brainstorming session, facilitating designers in the generation of sustainable concepts to be later used to define the concept.
It is useful to organize a workshop for the working group involved, making the participants focus on strategies that have been previously identified as priorities.

The result is, therefore, a collection of ideas that emerged during the workshop grouped into six eco-ideas boards, one for each LCD strategy.

Reprocessing of sustainable ideas

The environmentally sustainable ideas produced might be clustered to be used effectively in the later stages of the design process, in

particular to encourage and stimulate the generation of one or more concepts.
The goal of this sub-process is then to review the ideas generated during the workshop, building an effective summary of the results which can be used as support for the later stages of product development.

It is produced as a result, a document that contains ideas, presented singularly or in clusters according to the possible sustainable concepts.

Sustainability check of the concepts / redefinition of the concept and environmental priorities

The ideas generated in the previous phases, then selected and reprocessed, have been used as input to develop one or more product concept. The concepts have to be checked and assessed in order to understand the improvements in terms of environmental sustainability, compared to the existing product.

In case of having several developed concept is also possible to assess which of these represents the most significant in terms of environmental impact reduction. Tests can be done with a simplified LCA or evaluating qualitatively the potential reduction of environmental impact, by using the checklist contained in ICS toolkit (which analyze the pursuit of the LCD guidelines), with the aim to refine and improve the concept.

Representation of the environmental features of the concept

To consider the product in relation with environmental sustainability it have to be estimated the main processes which will be carried out in each product life cycle phase, from manufacturing to distribution, use and disposal. Thus the designer might understand which alternatives can give more opportunity for improvements (considering the whole life

cycle) or, on the contrary, constitute major problems.
The goal of this process is to describe the concept, according to its environmental features, considering the processes that characterize it throughout all the phases of its life cycle.

The result will be the definition of the concept in detail and the layout of its life cycle, in which are displayed, component by component, the main processes involved.

Check of the concept environmental improvements

The goal is to make an assessment of the environmental features of the concept considering the LCD improvement strategies, in particular those with higher priority.
Considering the information listed in the layout of the life cycle of the concept, is possible to achieve, even if approximate, a new simplified LCA.
Through the results of the LCA of the concept and the calculation of the new IPSA, are obtained the improvement or worsening environmental assessments of the concept, compared to the existing product.

Display of the potential of the environmental strategic improvements

It is useful to use again the multi-strategy radar (ICS toolkit), to allow the designer to quantify the size of the environmental improvement or worsening of the concept, compared to the existing product.
On the multi-strategy radar is shown a hexagon whose vertex are the values of the factors contributing to the environmental improvements of the LCD six strategies. The area of the polygon represents the size of the improvement.
In short, the goal of this process is to let the designer get an idea of the potential improvements that can be obtained from the concept, especially in relation to strategic priorities.

concept design	Focused generation of sustainable ideas	Workshop focused on generation of sustainable ideas	sustainable ideas for the 6 LCD strategies with a first selection of most promising ones	Eco-ideas Boards (ICS toolkit)
				Multi-strategy radar (ICS toolkit)
		reprocessing of sustainable ideas	document which reorganizes the worksho produced results for the generation of sustainable ideas, useful for the generation of low environmental impact concepts	
	sustainable check of the concepts and new definition of the concept environmental priorities	Representation of the environmental features of the concept	definition and render of the outstanding feautures of the product concept life cycle	3D modeling software
				concept life cycle exploded view
		check of the concept environmental improvements (compared to the assessed product)	concepts environemntal impact assessment; indicators of environmental improvement in relation to the 6 LCD strategies	LCA tool
				environmental improvement checklist
				IPSA board (ICS toolkit)
		render of the potential of the strategic environmental improvements	multi-strategy radar with the improvement potentials for each LCD strategy	Multi-strategy radar (ICS toolkit)

FIG.3
MPDS in concept design stage

MPDS in product design and engineering and tools

In the later stages of the design process, when it comes to consider executive and engineering details of the project, the method requires a single MPDS process which can be repeated several times:

- Choice of project processes and details with a lower environmental impact.

Choice of project processes and details with a lower environmental impact

As the project takes shape is possible to achieve accurate environmental impact assessments of the possible options, in terms of materials, material processing, finishing, disposal treatments, etc..

The goal of this process is therefore to improve the level of sustainability of the project, especially in in the choice of detail.

	process	sub processr	esults	tools
product design (and engineering)	Choice of project processes and details with a lower environmental impact.		less environmental impacting design features and details	specific orientating tools (choice of materials, design for disassembly)
				LCA (more or less simplified)

FIG.4
MPDS in product design stage

The result are the technical solutions chosen accordingly to the results of LCA of alternative solutions, at various levels of detail.

MPDS in communication and tools

Once the design process is completed and before the launch of the product, the method MPDS considers the following processes:

- Comparison of the LCA of the new product with the existing one, for communication;
- Drafting of the communication of the environmental quality of the product.

Comparison of the LCA of the new product with the existing one, for communication

LCA is designed to obtain results useful to the communication of the environmental quality of the new product.
The goal is to have quantitative data, reliable and scientific, that describe the environmental improvement of the product designed, which can be used in communication issues, at various levels.

The results that are obtained are the complete LCA of the final product and its comparison with the LCA of existing product (or a set of products) functionally comparable.
Drafting of the communication of the environmental quality of the product
The goal is to communicate efficiently and with suggestions the features of the new product in relation to environmental qualities.
The result of this activity is a document that indicates: the priority level identified; the main results that could be obtained in the evaluation phase; the guidelines that have been adopted; the solutions details; the specifications developed shown by renderings and illustration, highlighting the features which reduce the environmental impact.

	process	sub processr	esults	tools
Communication	Comparison of the LCA of the new product with the existing one, for communication		Evaluation of the environmental impact of several design choices	LCA tools (more or less simplified)
	Drafting of the communication of the environmental quality of the product		Document containing the defined environ-mental design priorities, the main LCA results, le followed guidelines and the details of the adopted solutions	

FIG.5
MPDS in communication stage

TANGO EUROPEAN PROJECT

INTRODUCTION TO TANGO

TANGO (Toward A New inter Generational Openness) / AH-Design project is an European Community(Culture Programme of European Union-Education and Culture DG) financed project which has, as main issue, to explore the issue of social inclusion and in particular the inter generational dialogue.
The project started in September 2011 and will last for two years until August 2013.
Partners of the project are Aalto University (coordinator - Finland), Politecnico di Milano (the Design and Innovation for Sustainability (DIS) research unit of the INDACO dept., Italy) and L' École de design Nantes Atlantique (France).

The general objective of the Tango project is to promote social inclusion directly as a part of the design process of the project, involving external participants from the very beginning of the process to plan and develop together the path to design innovative solutions.
In other terms the three partners are caring out the Tango project as co-design process involving local actors, with a key requirement of activating elderly and youngsters, and communities as well as companies, associations and administrations as active parts of the design phases. They will be co-designers, final users or possible partners of the innovations to set the stage for future implementations.
In particular, every partner has been planned didactic courses as well as workshops and meetings to understand the local point of view and to add more trust to the projects.

The main outcomes of the process and contents of the Tango project, are the results of 6 university courses, as well as workshops and/or degree thesis activated by the three partner universities in the respective cities between 2011 and 2013.

Activities

The three partner universities activated 6 university courses, as well as workshops and/or degree thesis in the respective cities between 2011 and 2013:

The Aalto university in Helsinki has activated the course Repicturing Suburban Neighbourhood (May 2012). The objective of the course has been to define the identity of Kannelmäki area (a suburban area in the north of Helsinki) to address ways for increasing its potential and profile in relation to inter generational dialogue. During the course the students has started to design meeting places for intergenerational and multi-cultural inhabitants. Local culture and the arts have been utilized as mediums for delivering beneficial inter generational interactions and revitalization models in the everyday life of suburban neighbourhoods.
The assignments of the course consist of individual and group work, lectures, workshops, field study and an activist/interventionist approach to design. During the course students evaluated their ideas with the locals in real context situations through design interventions. The process and results of the course are now published in Aalto University and World Design Capital 2012 web site. Furthermore, Aalto activated the workshop Inter generational Accessibility in a Sustainable Exhibition (October-December 2012). The focus of the workshop is on pedagogical models where people of different ages would meet each other and create new understanding of design and inter generational exhibition pedagogy. The students are able to respond creatively to the exhibition context and exhibits, and gain knowledge on different age groups, gallery education in the field of design, and reflect upon the notion of a good life. Through the workshop, e-learning and tutoring students will learn and find ways of how the different groups of people can encounter interactively during the organized activities in a museum, in public spaces or/and in a design fair. The issues of intellectual accessibility are also emphasized.

L'École de Design Nantes Atlantique in Nantes has activated the workshop Prototyping empathy -Design and prospective project (May 2012). The focus of the workshop is to explore inter generational empathy exploiting developing and prototyping an 'Empathy methodology' related to seven different themes:

Impacts of physical ageing, Memory, Health, Sexuality, Autonomy - socialization, isolation, Youth in the world of Adults, Older generations empathizing with digital natives and broader challenges of generation. Working in small groups of local and international students each thematic group have been responsible for identifying a design opportunity (problem), developing and prototyping an 'Empathy methodology' – an experience that illustrates enhances our understanding of the problem (empathy), and creatively ideate and communicate a TANGO scenario. While the processes of analysis and creation constantly alternate and overlap, the project is punctuated by intermediary presentations defining 2 phases: context analysis and preliminary designs, proposals; prototyped empathy expressed through innovative methodologies and illustrative design concepts.
Furthermore, L'École de Design activated the course Designing a sustainable catalogue (November 2012-January 2013). The focus of the course will be related to the design of the layout for Tango Exhibition Catalogue and Tango End Publication and the Exhibition communication elements i.e. panels, postcards, flyers to sponsor the Exhibition event in the Tango partner cities.

The Politecnico di Milano in Milan has integrated the master course System design for sustainability (March-June 2012) hold by prof. Carlo Vezzoli as part of the Tango project. The course introduces to the theory and practice of Product-Service System (PSS) design for Sustainability. A first theoretical part presents the following topics: sustainable development and designer's role; evolution of sustainability within design; Life Cycle Design: methods, tools, strategies, guidelines and examples; system (PSS) design for eco-efficiency: criteria, guidelines and examples; system design for socio-ethical sustainability: criteria, guidelines and examples; designing transition paths for the introduction and diffusion of sustainable PSSs; methods and tools for system design and system design for sustainability. The

second part of the course is a design exercise in which the students are asked to design new sustainable PSSs to promote social inclusion and inter generational dialogue in 4 districts of Milan (Baggio, Barona, Giambellino and Gratosoglio).
Four master degree thesis projects have been activated in parallel with the above course aiming at the co- coordinating the co-design process towards the detailed design and incubation of 4 projects of Sustainable Product-Service System, promoting social inclusion and intergenerational dialogue in four districts of Milan. The design process coordinated by Prof. Carlo Vezzoli has involved four degree thesis students: Elisa Bacchetti, Alberto Fossati, Sara Hatef, Claudio Sarcì (January-December 2012).
These being the core interest for this paper, will be described through their co-design processes in the following paragraph.

Furthermore, the Politecnico di Milano has integrated the undergraduate courses Design for environmental sustainability hold by prof. Carlo Vezzoli (October 2011-January 2012 and October 2012-January 2013) part of the Tango project. The course presents an approach to design environmentally sustainable products.
The first part of the course includes a series of lectures and particular attention will be paid to the design of sustainable exhibitions and to relevant case studies in that sector. The second part of the course is dedicated to a design exercise aiming at designing environmental sustainable concepts using tools to orientate the design towards environmentally sustainable solutions (e.g. Life Cycle Assessment, indicators of strategic environmental priorities, eco-idea tables, environmental multi-criteria radar diagram, etc.).

The project which is object of this MA thesis, has been activated in parallel with the above course aiming at the detailed design and production of an environmentally sustainable exhibition system, that will be used for the Tango exhibition and as the new exhibition system of the involved universities (substituting existing unsustainable ones).
The sustainable exhibition system has been carried out with the

coordination by prof. Carlo Vezzoli, in a collaboration with the exhibition Lab of INDACO dept. of Politecnico di Milano.

TANGO EXHIBITION AS AN AGENT OF CHANGE

An important and specific feature of what is the co-design process related to the actors involvement will be the Tango interactive travelling exhibition. It is going to be the final event, also designed as an experience, the main outcomes of the whole Tango project and its process, in which there will be shown all the projects carried out by the students and the professors of the three universities involved in the project research. As said it is going to be a travelling exhibition, moving around europe and it will be held in Nantes in March 2012, in Milan between the 9-14 of April during the Furniture Fair (Salone del Mobile) within a Cultural Partner's space within the well known trademark "Zona Tortona" area, and in Helsinki in June 2013.

The exhibition is still in progress of design in order to act as a lab and a window, involving the visitors into different levels of interactions: to be an agent of change. With this we mean that we are trying to design an intrinsic experience toward the exhibition's visitors, both random people and direct stakeholders, which somehow stimulate the user to get in touch with the innovation, make the live an experience and energize new views of what's offered for them and what they can do.

The main aim of the exhibition is to create a fertile field-base to get promising opportunities to implement the pilot projects and to scale up the PSSs in similar context and other areas. This will be possible setting-up an interactive experience oriented to attract some target-figures among the crowd, which are important for the system, explain in an easy but communicative way what has been thought and done (for them), trying to make them feel instantly reflected within the system and let them the opportunity to leave a sign, such as ideas, comments or any other kind of feedback. As well as the design of a specific workshop with the direct stakeholders in which the touched points will be more real functional elements.

Projects as content to explain and drive the change

These kind of events represent a strategic opportunity to develop and implement radical innovations, such as sustainable PSS. Design socio-technical experiments, in our case focused on the exhibition, starts with the generation of ideas: guidelines are important to direct and orient the design process in a way that the experiment is able to act as an "Agent of Change". In this sense we want to raise the interest of the direct and indirect stakeholders on the innovations introduced through the "experiment" and attract new potential users and actors to be involved in the project.

More in general the exhibition is in course of design also in order to stimulate changes in users' and actors' behaviour, habits and mind set, and create favourable conditions for the introduction and the implementation of the innovation into the society.

As said the event will take place at the "Design Library" in Zona Tortona and is addressed not only to the important key actors invited, such as the Municipality of Milan, the main associations and the sponsors, but also to the community, to induce them to get the motivation to look forward the innovations and change their habits, since they could feel the support of the key actors.

As explained in the previous chapters we could in fact state that the exhibition in this project has to be seen as a "tool" of the design process, aimed to:

- launch events and the activities for a real implementation of the sustainable social innovations purposely designed.
(to be presented as concrete innovations that already 'tomorrow may become a reality')

- perform an event to involve specific target-actors related to the sustainable social innovations.

(the actors are already involved in the co-design process and in the exhibition design, wishing, though, that during the design week they will make a commitment for the implementations of the projects, deepening the definition of roles and modalities)

- attract youngster and retirees through an interactive presentation of the concept for the development of the sustainable social innovation models in different contexts.

(in order to gather feedback about: the appeal of the models, the necessary conditions and characteristics to replicate the models in other contexts)

The exhibition's contents experience

The contents of the Tango Milan exhibition will be a presentation of the three partners' experience into the European project with a focus on the Italian context. Relevant space will be given to the role of the Milan district within the project and to the ideas, concepts and services carried out by the Milan's designers team in order to highlight the process and the results: starting from the projects briefs definition, through to the co-design process and activities linked to it, getting to the state of the art and feasibility of each proposed sustainable PSS. These material will be shown using two different media: posters on hanging panels to show the process and projected audio-visual, always on hanging panels, to show the results.

It is very important indeed to understand which are the kind of person is wanted to communicate and why. The idea of the Tango in-Milan exhibition is to combine into the same event two different experiences: an interactive exhibition where to show the proposals (and the international contents); and a workshop space where to co-design with some key stakeholders. As interactive "tool" of the co-design process, therefore, it will have two main targets which will be involved (plus the general public passing by the fair's spaces), acting in the Milan contexts with dedicated interactions: young and retired people and stakeholders.

Let see all of them more in detail:

- general public: visitors passing by the exhibition being interested in inter generational dialogue and design for sustainability. They will approach the 4 sustainable social innovations proposals for milan in the form of 4 short videos in loop with a incisive narration of the proposals. Visitors can select italian or english language for the audio and the subtitles.

- young and retired: involved as final users of the sustainable PSS they could interact with the audiovisual files about the sustainable PSSs to (phase still in phase of design):

    - have the chance to deepen some technical aspects and therefore watch a set of sub-video giving more detailed informations about how the proposal works;

    - have the chance to give some feedbacks about the quality and replicability of the project in different contexts, about some lacking aspects or anything they may believe important (web or paper-based storage is possible);

    - have the chance to download the prepared and/or collected documents available to keep the interaction alive even after the exhibition or to re-use them in an open source and copy left logic

    (will be possible to choose all the contents' language in both italian or english).

- stakeholders: involved as potential concrete partners of the sustainable pss projects shown during the exhibition, they will take part of dedicated workshops (one per each proposal) based on the following stages and co-design tools:

- visual presentation of the sustainable pss using a set of sub-video which give a deeper and more detailed narration about the operation of the projects and a set of technical visualization tools: i.e. offering diagram, system map, interaction table-storyboard. Tools that are providing more informations about the interactions and the backstage workflow occurring during the performance of the proposal;

- open discussion in order to gather feedbacks on feasibility/opportunity for proposal improvements (paper-based database is foreseen) and incubation/effective start-up.

(the workshops will be held in Italian).

Exhibition set up

The values of sustainability, environmental, economic and social terms, have to be reflected in the staging of the exhibition in the three venues. The shown contents will be shown using two different media: posters on hanging panels to show the process and projected audio-visual, always on hanging panels.

The exhibition set up have to consider sustainability issues, mainly in these areas:

- use of the exhibition structures which will be used to expose the contents, hanging panels and showing projected audio/visual;

- use of the devices used for the exhibition of audio/visual expositions.

THE DESIGN PROCESS

STAGES OF THE DESIGN PROCESS

In this paragraph are resumed those phases which composed the whole design process, which are going to be deepen in next pages, in order to give a wide understanding of it.

Strategic Analysis

The strategic analysis moved towards several directions in order to have, as much as possible, a complete view of what does it means to design a sustainable exhibition system.
In particular, the research has been divided mainly in two parts:

- a theoretical one, were have been analysed existing exhibition systems which were considered as best practices towards sustainability;

- a practical one, were have been first analysed the exhibition system used from the Politecnico di Milano (and in particular the Set-up workshop') with environmental sustainable criteria and in particular with some LCA's, in order to have as a results some guidelines to move towards a sustainable redesign of it.

For this practical part it was initially involved the Set-up workshop of the Politecnico di Milano in order to analyse the exhibition system used during most of the events organized by the university, mainly to display content related to the students projects, for events organized by the university and in some cases used for external events, to host externals in the venues of the Politecnico di Milano.

The exhibition system has been the subject of a deep analysis, firstly analysing its several parts (to understand materials and processes composition), then understanding its functionality, flexibility and modularity.
The exhibition system fo the Politecnico di Milano has been object of an LCA analysis in order to understand its environmental sustainable critical and trying to define guidelines to redesign it in a more

sustainable way.

Once clearly apprehended the exhibition system, it was made a first LCA, starting from considering the kind of exhibition we are considering (through Milano, Nantes and Helsinki), giving three kind of compositions hypothesis for three different kinds of exhibition options (a paper based one, a projection based one and a half paper/half projection based one).

From this first step, and comparing the three exhibition options, were obtained some consideration about the environmental impact of the different kind of exposure.

Afterwards the students of the course "Design for Environmental Sustainability" were involved to make a further LCA as well as to make a design exercise based on the MPDS method[8].

Exploring opportunities: Course 'Design for environmental sustainability'

The students of the course "Design for Environmental Sustainability", held by Professor Carlo Vezzoli, were involved in order to verify the sustainability characteristics with LCA tools, to identify the critical and draw guidelines for its sustainable redesign, through the first phases of strategic analysis of the method MPDS.
The students were then asked to design some concepts which were following the guidelines identified as priorities for an environmental sustainable design, to display content related to the context of exhibitions university.
The results of this course are deepen explained in the next paragraph, where are also shown the most interesting concepts made by the students, which have been useful to give suggestions to move towards the design of the TANGO exhibition.

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8 see chapter 1

Concept design

From the results of the course 'Design for environmental sustainability' and the parallel theoretical research it was then defined the design brief for the sustainable TANGO exhibition and thus started concept design phase.
The development of the project of the structure for the exhibition moved throughout a continuos parallel research on structures which could give an inspiration and fit with the design brief. In particular it were analysed camping facilities, exhibitions facilities in shops and fairs, considering:

- de materialized structures;
- foldable/easily transportable structures;
- flexible/adaptable structures.

Product design

After the definition of the product concept, and of its the main aspects, it started the deepen of the technical aspects of it in all its parts and compositions, in order to make the design answering to the exhibition needs and the exhibition main issues.

STRATEGIC ANALYSIS

Main issues in exhibition design

As the opportunities and demand for exhibitions have increased, so too has the need for a broader understanding of where exhibitions ideas come from; how exhibitions are developed; what the choices are with regard to approach; who makes those choices; what exhibition cost; and what benefits can reasonably be expected from exhibitions in terms of engaging the public, creating new knowledge, and the impact on venues finances.

The understanding is recorded in the exhibition brief. Many venues, hosting exhibitions fail to develop a robust brief for an exhibition with potentially disastrous results that are laid at the feet of designers, or marketing or development. In fact the problems were likely to be divided museum staff, lack of clarity of purpose and insufficient research into the subject, the audience or both.

The design of the exhibition can be divided in three main stages:

- Development phase
    - Concept
    - Interpretative planning
    - Research
    - Exhibition brief/programme with preliminary budget and schedule
    - Sourcing

- Design phase
    - Schematic design
    - Design development
    - Detailed design and specifications
    - Detailed budget and schedule
    - Detailed content research, sourcing and text

- Implementation phase

Of course functions like budget, cost control and evaluation are ongoing throughout the whole process. And curators, designers and conservators will be quick to point out that their work does not end until opening day or later.
The purpose of an exhibition is to transform some aspect of the visitor's interests, attitudes or values effectively, due to the visitor's discovery of some level of meaning in the objects on display - a discovery that is stimulated and sustained by the visitor's confidence in the perceived authenticity of those objects.

Mainly, an exhibition is not essentially a problem of design, but a challenge in planning for effective communication with the intended groups of visitors. The essential questions are:

- What meanings do we wish to communicate?
- To whom do we intend to communicate these meanings?
- What are the most appropriate means of communicating these meanings?

The design of an exhibition follows on the answer of these questions, but cannot in itself solve them.

Functional design criteria

An essential component to the design process for new or renovated display spaces is a set of functional design criteria, which guide the architects, engineers, building contractors and exhibit designers working on the project.
One of the most important considerations for display facilities is the relative degree of flexibility of use that needs to be designed into the space. Whereas in the past museum exhibition halls were designed into as more or less permanent architectural entities with a strong character of their own, in the 20th century the trend has been towards spaces that are more neutral, easier to transform into new environments as the occasion demands, and able to accomodate widely

varying exhibition material with differing climate control, lightning, and other technological requirements.
Deciding what level of flexibility and modern technology will be demanded of a new display facility is a high-level decision early in the planning process that in itself may require extensive exploration of options and costs. Preliminary objective design criteria begin to emerge in the early stages of planning for a new facility.[9]

The exhibition system may be considered as the necessary connections between the space context, the set-up and the content exposed.
When the exhibition designer deals with the issue of using an existing architecture structure to stage an exhibition, the issues move around the definition of the relationship between content and container. The exhibition system has his own aesthetic presence and have to deal with the content exposed.
The designer sometimes overlaps its own aesthetic to what have to been exposed, but if this choice is coherent with the content of the exhibition, this may result emphasized.
Sometimes instead the designer tries to carry out the most neutral conditions to make the visitor able to see and be focused on the content exposed.[10]

Below are listed some design premises about the exhibition "l'altra metà dell'avanguardia", hosted in Palazzo Reale in Milan in 1980, wrote by Achille Castiglioni.

visitors path which allow a simple interpretation of the content exposed;
enlightening of the contents exposed with a diffused light and with a correct intensity;
need of support the content exposed with documentations about each

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9 Barry Lord, Gail Dexter Lord; The Manual of Museum Exhibitions, AltaMira Press; 2001
10 Sergio Polano, Mostrare, l'allestimento in Italia dagli anni '20 agli anni '80; Edizioni Lybra Immagine; 1988, contribution by Luciano Celli, "L'architettura del mostrare"

author;
Features of design:
unique path for visitors;
entering environment with a reception desk;
introducing hall with a continuous projection of a picture representing the exhibition content and a large planimetry of the exhibition space;[11]

Exhibition set-up general guidelines

Besides these issues which have been discussed in the previous chapter in general way, is now intended to be more specific on what concerns the planning of exhibition events.
The main aspects which have to be taken into account are represented in the scheme below.

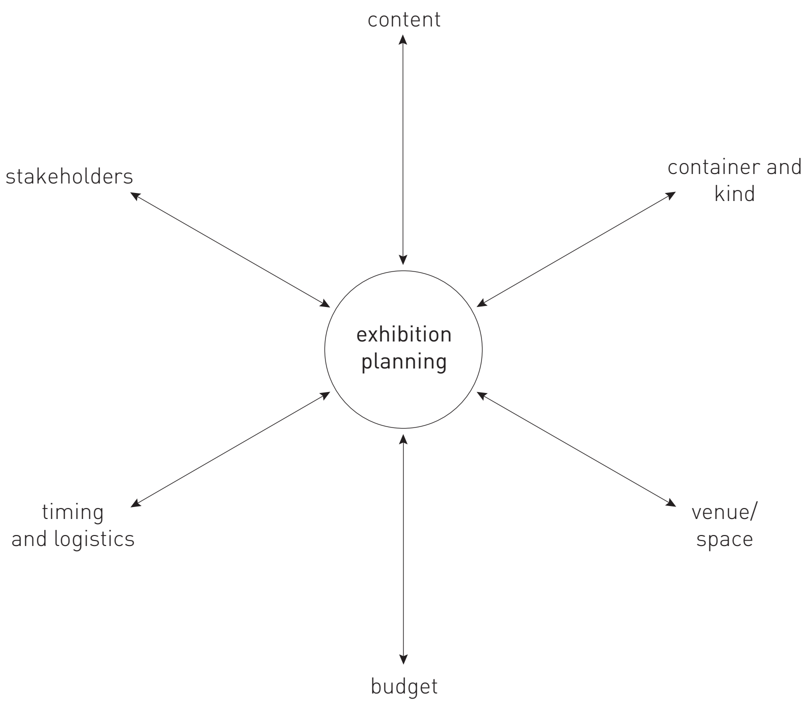


FIG.6
main issues in exhibition planning

11 Sergio Polano, Mostrare, l'allestimento in Italia dagli anni '20 agli anni '80; Edizioni Lybra Immagine; 1988, contribution by Achille Castiglioni, "L'altra met' dell'avanguardia"

Considering events connected to Universities exhibitions is possible to identify the content category in three different kinds:

- 2D contents; such as text, panels, drawings, pictures, advertising, general information;
- 3D contents; such as objects, mock-ups, prototypes, products;
- de materialized contents; such as movies, audio.

About the container have to be considered many variables which the designer may consider in relation of the kind of event which have to be carried out. These are mainly the kind of path in which the visitor may be guided into and the location/timing of the event.
The options related to these two variables are:

- a unique/free path;
- an itinerant/permanent/unique exhibition.

The venue where the event may be set-up may be indoors or outdoors. For this reason it have to be considered that it can be necessary to use self-standing structures (in case of outdoors events and indoors without the possibility to use the venue facilities such as walls, ceiling and other supporting structures).
The timing and logistics are strictly connected with the available event budget and stakeholders. It is extremely important to set a timetable not to go beyond the deadlines, considering all the stages of the exhibition:

- concept;
- executive project;
- set-up construction;
- exhibition set-up;
- exhibition;
- set-up disassembly;
- exhibition reuse;

- disposal.[12]

12 from the lecture 'Come progettare un allestimento e non morire nell'intento, taught by Prof. Mariano Chernicoff (Head of the Set-up workshop of the Politecnico di Milano); November 2011.

Best practices on sustainable exhibitions

In this paragraph are discussed those exhibitions which have sustainable features, so that can be considered as the best sustainable exhibition examples. These projects can be used to better understand how the market already answered to sustainability requests, and mainly can be considered as inspirations to move the design process towards sustainability.

To categorize the matching designs it were defined some design criteria, in order to simplify the interpretation of the results of this research.
These criteria are:

- minimization of resources;
- choice of low environmental impacting resources;
- optimization of the life of products;
- material life extension and design for disassembly.

For the first criteria are intended all those designs which are going towards a minimization of resources, in all the phases of their life cycle. This includes these exhibitions which are realized using structures realized with few materials, de materializing the contents towards a totally digital exhibition, reducing the energy consumption in the use phase and reducing the transportation.
Some examples are listed below.

The Koala exhibition system by CAIMI brevetti is highly flexible; the

FIG.7
Caimi Brevetti -
Koala

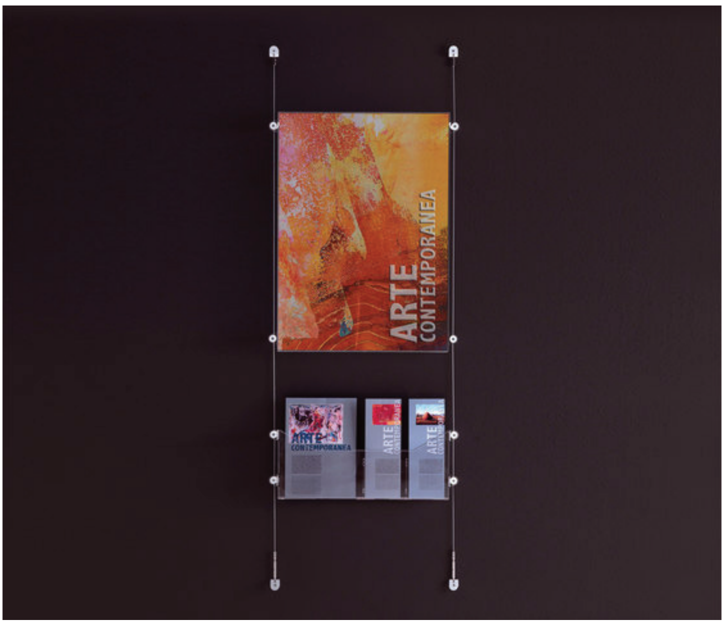


FIG.8
Caimi Brevetti -
Koala

contents are hanged on iron wires, using screw able fixings. The system can be used for rigid panels, and need a support as wall or ceiling.

FIG.9
Lightning
tension banner
stand - Epic
display

Lightning by Epic displays is a lightweight tensioned banner. The structure is self standing, for this reason it doesn't need to be fixed to surrounding supports. It can be used to expose just a certain dimension contents and is not adaptable for different In addition is easily transportable, as the structure is completely foldable and packable in small dimensions.

FIG.10
BYOB (bring your own beamer) exhibition

FIG.11
BYOB (bring your own beamer) exhibition

BYOB (Bring Your Own Beamer) is a series of one-night-exhibitions hosting artists and their projectors. This exhibition solution is interesting as the contents are completely de materialized and it uses the venues' walls for projecting. However the projecting systems requires a lot of electricity to keep working. This case does not represents an effective sustainable best practice but somehow it gives some suggestions for a further development and a new design. The environmental sustainability of the system depends in fact on the kind of sources and technologies which are used to project. Using best available technologies, such as LED projectors, or integrating the system with presence sensors to switch on the devices just once the visitors are passing through the exposing areas may represent a good strategy to move towards the design of a sustainable exhibition.

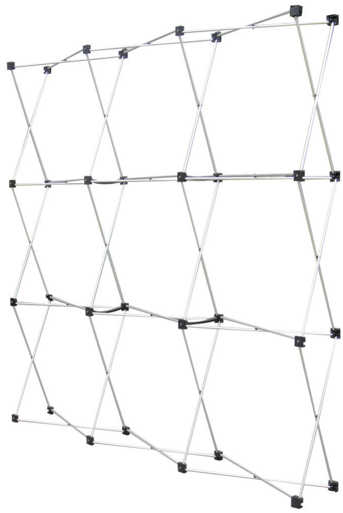


FIG.12, FIG.13
Suzhou Jiehui Exhibition Equipment Co.

FIG.14
Airwall - dryspace

The pop-up exhibition stand (FIG.13,14) are an example of foldable structure which, reducing their dimensions when are unmounted, can reduce consistently the transportation phase environmental costs as it is packed in a small dimension. In the same way, inflatable structures such as Airwall, designed by Dryspace structures LTD (FIG.15) may go towards the same environmental results, even if may be necessary to do some considerations about the durability of the inflatable materials.

Ready made: the exhibition system of the Politecnico di Milano

The way in which the Set-up workshop of the Politecnico di Milano has developed and enhanced its range of tools and equipment following rational and targeted logics.
The exhibition system has been designed focusing to answer to the exposition needs typical of Universities. In most of the cases, the exhibition needs are the one listed below:

- exposition of text and images, on posters and panels;
- exposition of mock-ups;
- exposition of movies;

The components used to build the structures used to achieve these functions are the following:

- structural cardboard (240x100cm, 240x150cm, 300x100cm);
- Aluminium tubes (Ø46 to 50mm, length 50-600cm);
- tube/tube joints (90° o variable angle);
- tube/panel joints (Super clamp[13]);
- telescopic tubes, for temporary fixings (Autopole[14]);
- support bases (New Jersey, which can host Ø50mm tubes; recycled plastic ones, commonly used as fences of construction sites);
- electric supply system with double protection and isolation;
- en lighting system with high level performances (halogen spots from 300W to 650W).

These components are easily available in the market and are the core of the exhibition system. Due to new exposing needs, this base has been enhanced with other standard components and with the design of new specific parts. Below are listed some of the most interesting elements which have been developed over time.

13, 14 produced by Manfrotto

The Padova expansion multifunction joint is the result of a deep research of the production system 'laser tube'. The flexibility of the component allows several different applications and has a low cost production. The design, approved as a high strategic level, has been patented by the Politecnico di Milano.

FIG.15
Giunto Padova, patented by Politecnico di Milano

Among the other elements designed by the technician of the Set-up workshop there are:

- support bases in OSB (Oriented Strand Board), which are the development of commercial basements and are featured with a high flexibility;

- alluminium rails, which allows a typical vertical exposing panel, without the need of tools or other equiments. This solution is

commonly used to set-up exhibitions for educational exhibitions.
Is assumed that about the 85% of the exhibitions organized from Politecnico di Milano are set-up using these exhibition system, combining the components listed above.

The set of the elements which are part of the exhibition system 'Ready made' answers to a certain kind of work style and "philosophy".
The aspect which mainly stand out this working approach are:

- low cost of exhibition parts;
- reuse of elements;
- flexibility of configuration options;
- simplicity and fast assembly;
- use of recyclable elements.

Comparison of environmental impact of three options for the whole exhibition

To start an evaluation in terms of environmental impact of exhibitions, it were considered three options for the TANGO exhibition, designed using the exhibition system of the Politecnico di Milano, as of those components the system is made of were knew the features about their whole life cycle, so was possible to make a deep LCA.

Taking in consideration the need to exhibit the same contents with different media, three possible configurations have been imagined, the results of the combination of different elements made from the components listed in the previous pages:

- a poster based exhibition, where all the contents are presented in a printed form;
- a video based exhibition, where the contents are presented in a digital form with little use of printed material, e.g. only as introduction to the project and the contents;
- an ½ video – ½ poster based exhibition, where a mixed use of printed and digital supports is made.

When more than one module was available to satisfy the same function, the one with the lowest environmental impact, but at the same time granting reliability and flexibility, was preferred[15].
Also in this case, in order to have comparable results, the same functional unit was considered and it is defined as:

- exhibition of twenty concepts (through A1 posters with two posters per concept, or four movies projected at the same time with five concepts per each movie);
- exhibition of five vertical info signs (800 x 2250 mm), properly illuminated;

15 the deepen LCA analysis on the singular elements considered is explained in the next chapter Exploring opportunities: Course 'Design for environmental impact'

- information and welcome with a reception desk and a rack with information brochures, properly illuminated.

The exhibition will last for the three stages:

- Milano (7 days, opened 10 hours/day);
- Helsinki (21 days, opened 10 hours/day);
- Nantes (7 days, opened 10 hours(day).

In addition, in order to have a deeper view of the possible impact of the exhibition configured with the three different modes, are shown the results of a further LCA, made considering just the TANGO exhibition in Milano, thus not considering the whole travelling exhibition.

Poster based exhibition

Composition:
- 5x Info modules with New Jersey base;
- 10x Poster display stands with Lycra backdrop;
- 1x Reception system.

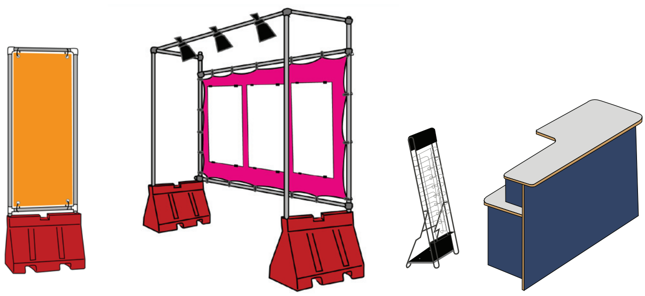


FIG.16
poster based
exhibition
configuration

The poster based configuration provides the printed exposition of all the twenty system concepts. Each concept is displayed in two A1 posters.
In addition, the use of five info spots is considered, where information about the exhibition in general and about the orientation order inside the exhibition venue is presented.

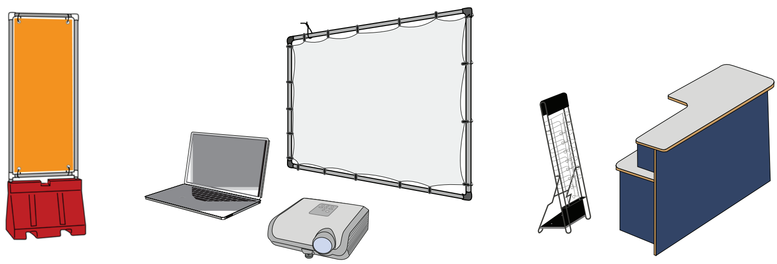
For the interaction with the visitors a reception system (desk + rack) is also provided, where brochures about the TANGO project, its development, the event setting and so on can be distributed.
On the overall, the lighting of this configuration is provided by twenty-six 120W incandescent bulbs.

The exhibition is fully transported on road through all the stages scheduled for the exhibition (from Milano to Helsinki, then to Nantes and back to Milano).

Video based exhibition

Composition:
- 11x Info modules with New Jersey base;
- 10x Projecting systems;
- 1x Reception systems.

FIG.17
video based
exhibition
configuration



The video based exhibition provides the exhibition of all the contents through the use of digital projecting systems. As for the first configuration, twenty concepts are exhibited using ten digital exhibition units with two concepts in loop on each system.
In addition, the use of eleven info spots is also considered, one per each projecting system (in order to introduce the contents on the videos) and the remaining one to give general information about the exhibition structure and orientation.

As for the poster based configuration it is also used a reception desk, in order to distribute brochures and additional information to the visitors. The reception desk, the projecting sheets and the info spots are transported on road through each exhibition stage. The electronic components are hired in the place where the exhibition is taking place. The lightning system is composed of twelve 120W incandescent light bulbs, one per each info spot and one for the reception desk.

½ video – ½ poster based exhibition

Composition:
- 8x Info modules with New Jersey base;
- 5x Poster display stands with Lycra backdrop;
- 5x Projecting systems;
- 1x Reception system.

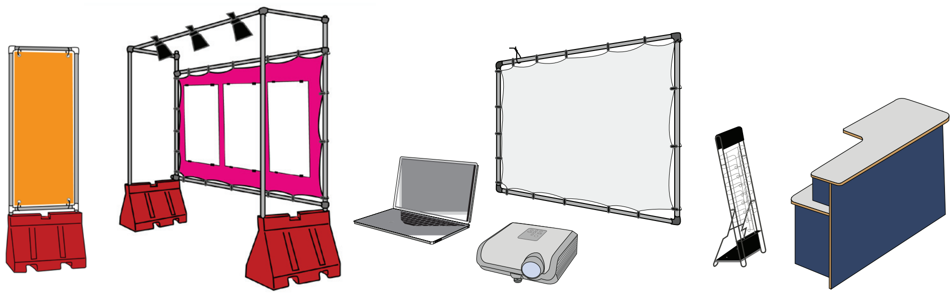


FIG.18
½ video – ½ poster based configuration

The ½ poster – ½ video configuration provides the exhibition of the contents with a mix of printed posters and projected of videos and pictures. In this case each one of the twenty concept ideas is described in one A1 paper and a video. On the overall five exhibition units (with fours concepts each) and five digital exhibition units (with four videos each) are used.

In addition, eight info spots (one per each digital system and three to give information about the orientation order) and a reception desk are also considered. As for the other two configurations, all the non-digital elements are transported on road through all the exhibition stages.
On the other hand, the electronics are hired in the place where the exhibition is taking place.
The lightning system is composed of nineteen 120W incandescent light bulbs, one per each info spot, two per each exhibition unit and the remaining one for the reception.

Comparison of the environmental impacts of the three options

In this section are returned the results of the comparison of the life cycle environmental impacts of the three configurations, inclusing a first interpretation of the results.

Considering the overall impact of the three configurations, it emerges that the one with the lower global environmental impact is the poster based one.

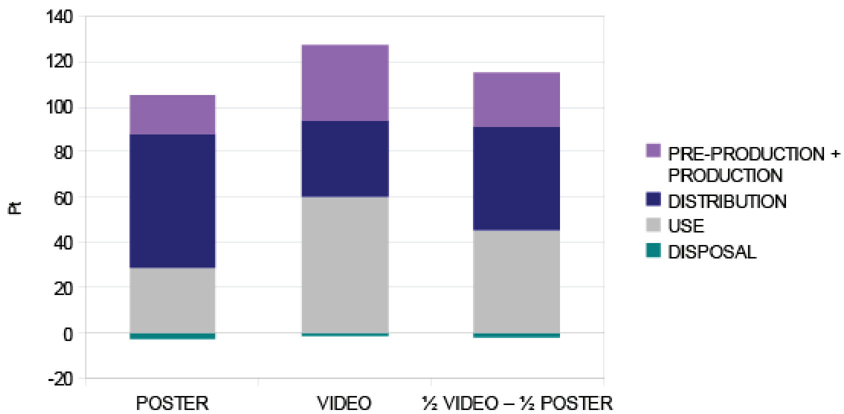


FIG.19
comparison of
the envornmental
impacts of the
three options

The three configurations impact as follows:

- Poster based – 104,91 Pt
- Video based – 127,12 Pt
- ½ video – ½ poster based – 115,1 Pt

In Fig. 19 it can be seen also how the single life cycle phases contribute to the overall impact of each configuration:

- for the poster based configuration the main impact is given by the distribution phase, which determines 55% of the overall impact;
- for the video based configuration the main impact is given by the use phase, which determines about 47% of the overall impact;
- for the ½ video – ½ poster based configuration use and distribution

equally contribute to the overall impact, determining 40% of the impact each.

In Fig. 20 the life cycle phases for the three configurations are directly compared.

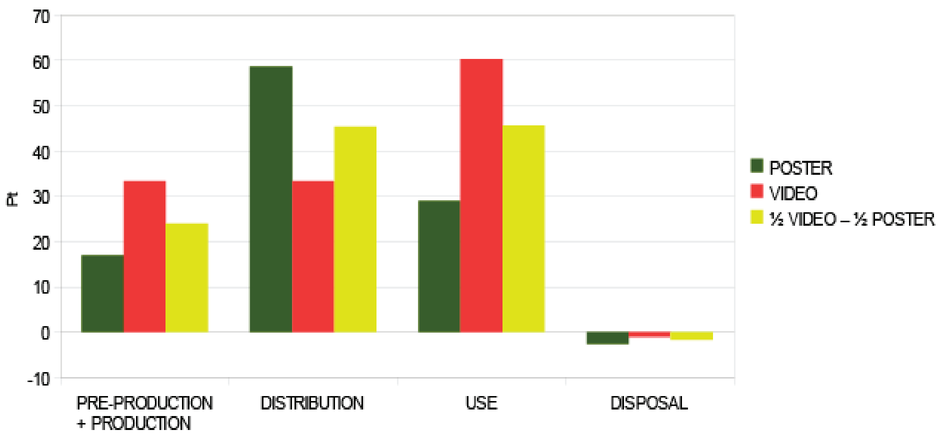


FIG.20 comparison of the envornmental impacts of the Life Cycle phases of the three options

The impact of the pre-production and production phases changes in relation to the quantity (weight) and the type (material and manufacturing) of components used. The video based mounting has the highest impact compared to the others due to the materials used for the electronic elements (laptop and projector).

The impact of the distribution phase changes in relation to the variation of the transported global weight. The poster based configuration is the heaviest one and for this reason the distribution phase of this configuration is the one with the highest impact. The impact of the use phase is mainly determined by the electricity consumption. The significant use of electronic systems for the projections of the concepts of the video based exhibition determines a substantial rise in the impact of the use phase of this configuration.

For all the three configurations the processes[16] which impact more to the overall impact are related to the distribution and the use phase. In particular they are:

- on road transportation;
- electricity consumption in Finland;
- electricity consumption in Italy.

From a design point of view, few considerations based on these Life Cycle Assessment results can already be made.

To reduce the impact of the use phase, that's one of the most relevant for all the configurations, different design guidelines could be evaluated, such as to design for the use of more energy efficient electronic and lighting equipment.
For example, replacing the 120W incandescent bulbs with 15W LED spots (which have an equivalent quantity of emitted light), it's possible to obtain a significant impact reduction for the use phase of the three configurations: about 90% for the poster based;
about 20% for the video based and about 40% for the ½ poster – ½ video based (Fig. 21);

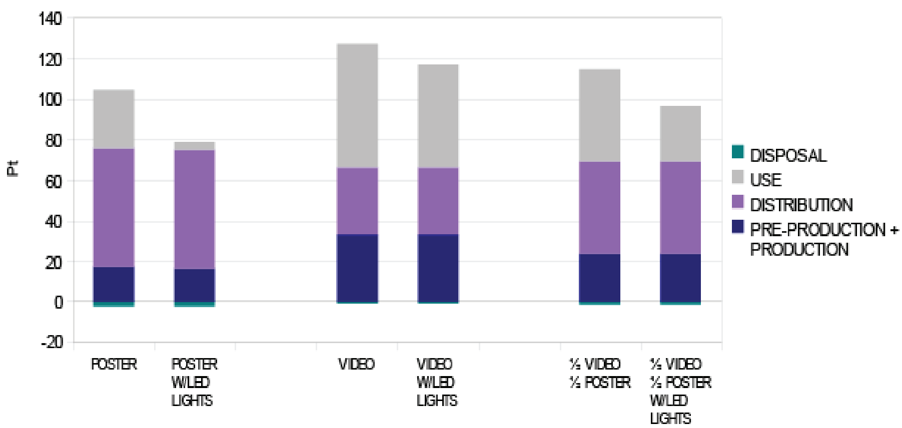


FIG.21
reduction of the evnironmtal impact considering LED lightning

16 The electronic components are considered at a system level, not splitting the process further, since the objective of the TANGO project is not the redesign of those components or to work on the processes used to produce them.

To reduce the energy consumption in the video based and ½ poster – ½ video based configurations, also more efficient projectors can be considered. For example, by replacing the 470W UHB projectors with 90W LED ones (which have comparable functional results), it's possible to obtain a significant impact reduction for the use phase: about 55% for the video based configuration and about 40% for the ½ video – ½ poster based one (Fig.22)

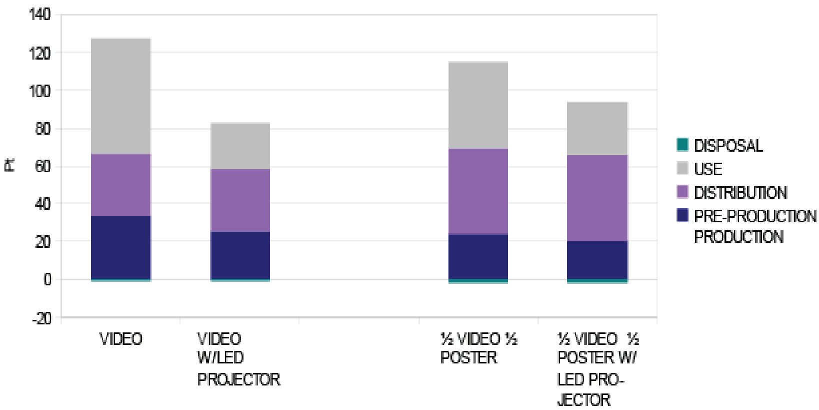


FIG.22 reduction of the evnironmtal impact considering LED projectors

Another guideline to reduce energy consumption could be to design the exhibition system in order to better adapt the switching on/off of electronic and lighting equipment to actual audience needs (e.g. at the moment they are turned on 10 hrs/day, not considering if someone is really visiting the exhibition or not).

Also to reduce the impact of the distribution phase, the other relevant one for every configuration, different design guidelines can be taken in consideration, such as to reduce the weight of the equipment to be transported or the need of transportation tout court, by providing the exhibition elements in each venue, not having the same equipment travelling across Europe (cf. what it's already been considered for the video configuration).

Another guideline to reduce the impact of the distribution phase could be use to design in order to favour the use of transportation means with a reduced environmental impact. A reduction of about 75% in the impact of the distribution phase can be obtained for each configuration, as shown in Fig.23.

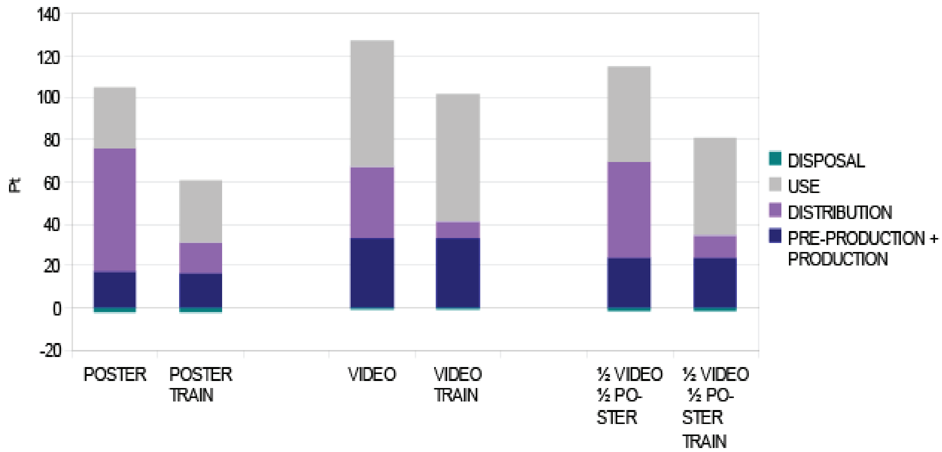


FIG.23
reduction of the evnironmtal impact considering train transportation

In the following pages the LCA results of each considered exhibition configuration are returned, in order to give detailed information about the impact of the single phases, processes and effects.

Poster based exhibition

Overall impact

The evaluation results show that the contribution of the different life cycle phases is, in descending order:

1. Distribution: 58,68 Pt
2. Use: 29,13 Pt
3. Pre-Production + Production: 17,1 Pt
4. Disposal: -2,36 Pt

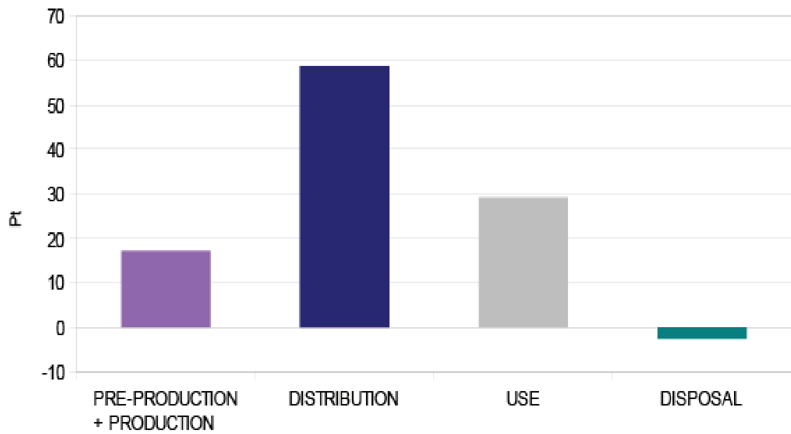


FIG.24
environmental impact of the poster based exhibition

Processes
The three processes which contribute more to the overall life cycle impact are, in descending order:

1. On road transportation: 58,7 Pt
2. Electricity consumption in Finland: 17,6 Pt
3. Electricity consumption in Italy: 8,88 Pt
4. Aluminium for the exhibition structure: 5,6 Pt
5. Lycra for sheets: 3,07 Pt
6. HDPE for New Jersey bases: 1,72 Pt
7. Aluminium for the exhibition modules joints: 1,43 Pt

Video based exhibition

Overall impact
The evaluation results show that the contribution of the different life cycle phases is, in descending order:

1. Use: 60,32 Pt
2. Pre-Production + Production: 33,5 Pt
3. Distribution: 33,3 Pt
4. Disposal: -1,03Pt

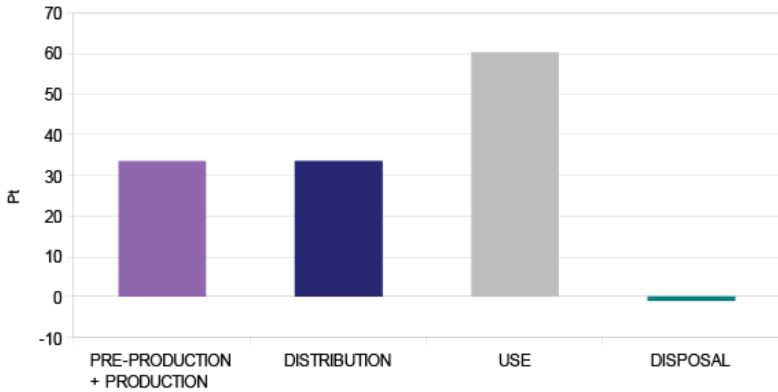


FIG.25
environmental
impact of the video
based exhibition

Processes

The three processes which contribute more to the overall life cycle impact are, in descending order:

1. Electricity consumption in Finland: 35,6 Pt
2. On road transportation: 33,3 Pt
3. Electricity consumption in Italy: 19 Pt
4. Aluminium for screen structure tubes: 4 Pt
5. Lycra for sheets: 3,38 Pt
6. Weaving process to produce Lycra sheets: 1,41 Pt
7. Nylon for clamps: 1,3 Pt

The contribution of the pre-production and production of the electronic components to the overall life cycle impact is:

- Laptop computer: 12,2 Pt
- Projector: 8,67 Pt

½ video – ½ poster based exhibition

Overall impact
The evaluation results show that the contribution of the different life cycle phases is, in descending order:

1. Distribution: 45,5 Pt
2. Use: 45,7 Pt
3. Pre-Production + Production: 23,9 Pt
4. Disposal: -1,67 Pt

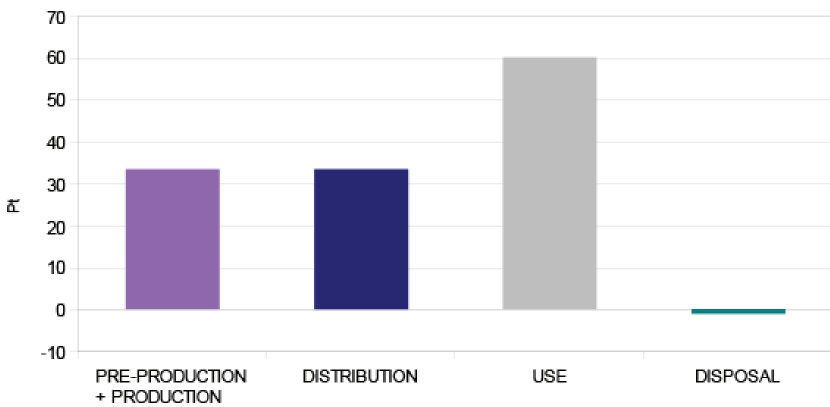


FIG.26 environmental impact of the ½ video – ½ poster exhibition

Processes
The three processes which contribute more to the overall life cycle impact are, in descending order:

1. On road transportation: 45,5 Pt
2. Electricity consumption in Finland: 27,6 Pt
3. Electricity consumption in Italy: 13,9 Pt
4. Aluminium for modules structure: 4,7 Pt
5. Lycra for sheets: 3,07 Pt
6. Weaving process to produce Lycra sheets: 1,28 Pt
7. HDPE for New Jersey bases: 1,24 Pt

The contribution of the pre-production and production of the electronic components to the overall life cycle impact is:

Laptop computer: 5,55 Pt
Projector: 3,94 Pt[17]

17 All the LCA analysis was carried out with the software Simapro, after a deep research on the components' life cycles; with the help and support of the members of the DIS (Design and Innovation for Sustainability) research unit of the Politecnico di Milano: Carlo Vezzoli (Head), Sara Cortesi, Fabrizio Ceschin.

Comparison of the environmental impact of three options for the tango exhibition in milano

In this section are returned the results of the comparison of the life cycle environmental impacts of the three configurations, including a first interpretation of the results.

In relation with the previous LCA made considering the whole travelling exhibition, in this section is considered just the Milano stage of the exhibition, which will last for 7 days, and will be opened 10 hours per day and will be exposed in the Design Library venue in zona Tortona for the Salone del Mobile event.

Even fo this case are considered the three possible configurations (video based, 1/2 video 1/2 poster based and poster based) deeply explained in the previous paragraph, to arrange the TANGO exhibition in Milano.

Considering the overall impact of the three configurations, it emerges that the one with the lower global environmental impact is the poster based one.

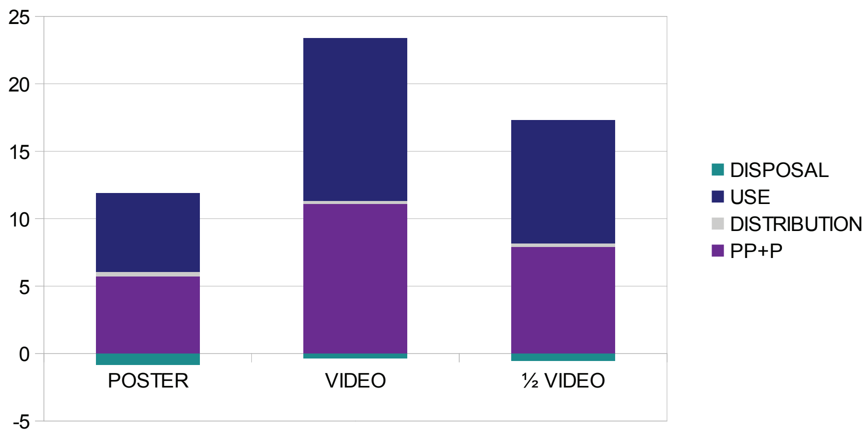


FIG.27 comparison of the environmental impact of the three options for the TANGO exhibition in Milano

The three configurations impact as follows:

- Poster based – 11,07 Pt

- Video based – 23,03 Pt
- ½ video – ½ poster based – 16,77 Pt

In Fig. 29 it can be seen also how the single life cycle phases contribute to the overall impact of each configuration:

- for all the three configurations, the main impact is given by the use phase, which determines mainly the 55% of the overall impact;
- for all the three configurations, the pre production and production phases has a significance of about the 45% on the overall impact.

In Fig. 28 the life cycle phases for the three configurations are directly compared.

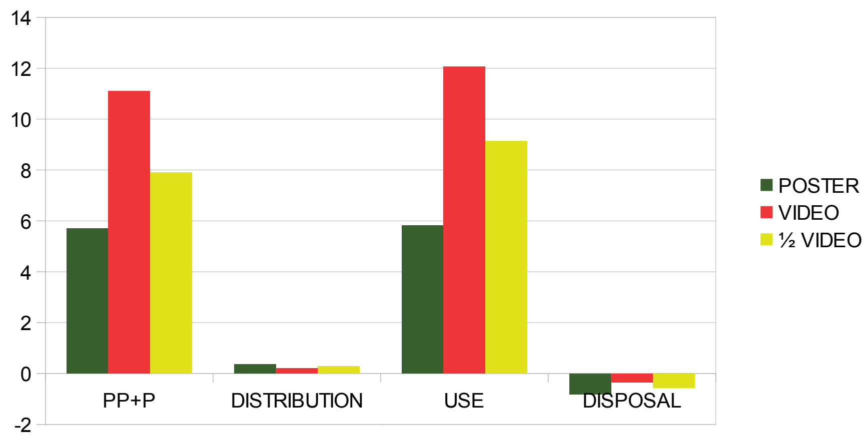


FIG.28
comparison of the environmental impact of the Life Cycle phases of the three options for the TANGO exhibition in Milano

The impact of the pre-production and production phases changes in relation to the quantity (weight) and the type (material and manufacturing) of components used. The video based mounting has the highest impact compared to the others due to the materials used for the electronic elements (laptop and projector).

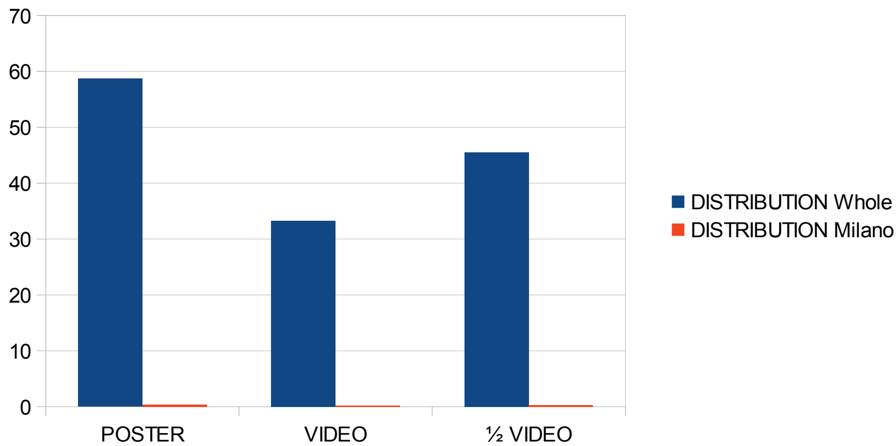
As is evident from the graph in fig.29, the distribution phase impact is almost irrelevant related to the overall impact.

The significance of the impact of distribution phase, compared to the overall one, for each of the three configurations is:

- poster based - 3,5%
- video based - 1%;
- 1/2 video, 1/2 poster based - 2%

If we compare this result with the one of the whole exhibition (related in particular to transportations), as shown in fig. 30, is clear how much the distribution phase changes its relevance in comparison with the whole exhibition impact.

FIG.29 comparison of the environmental impact of the distribution phases of the three options for the TANGO exhibition in Milano and the whole exhibition



In particular, comparing the result concerning the distribution phase of the TANGO exhibition in Milano and the travelling TANGO exhibition, we deduce that the distribution phase impact is lower of about the 99%.

These comparison are useful to define the redesign strategies of the exhibition system and above all, for the planning of the TANGO exhibition.
These considerations will result in the most promising strategies definition and in the exhibition design brief.

EXPLORING OPPORTUNITIES: COURSE 'DESIGN FOR ENVIRONMENTAL SUSTAINABILITY'

Course Framework and main results

The educational goal of the course Design for environmental sustainability is to provide students with knowledge, sensibility, tools and methods to integrate environmental requirements in the design of industrial products.
The first part of the course includes a series of ex-cathedra lectures. The themes of the lectures are:

- sustainable development and the evolution of sustainability in design;
- Life Cycle Design concepts and practice;
- strategies for the development of low impact products: resources minimization, low impact resources selection, product life optimization, material life extension, design for disassembly;
- method and tools to support design for environmental sustainability.

All the lectures of this part have been recorded. The recordings and the slide shows used during the lectures are available at www.lens.polimi.it.
Anyone can join the network and login to view and download for free learning resources and tools[18]. The second part of the course is dedicated to a design exercise that aims at presenting how and when tools to orientate the design towards environmentally sustainable solutions are used: Life Cycle Assessment (LCA) of an existing product; IPSA (Indicatori di Priorità Strategica Ambientale – translation: Indicators of Environmental Strategic Priority) evaluation; use of idea boards to generate low environmental impact ideas;
representation of the concept as an exploded diagram at the life cycle level; evaluation of the environmental improvement of the concept in relation to the existing product (LCA and IPSA).
As a result of this exercise the students design environmental

18 For more information, go to www.lens.polimi.it and click on Join network.

sustainable concepts of different standard elements for a sustainable travelling exhibition.

Design method and tools

The design method used during the design exercise is MPDS - Method for Product Design for environmental Sustainability.
The MPDS method has been developed from the Design and system Innovation for Sustainability (DIS) research unit of Politecnico di Milano – INDACO department (head: Prof. Carlo Vezzoli) and aims to integrate and support a product design process for the development of environmentally sustainable solutions.
The designer who decides to design using the MPDS can integrate the indications provided at different levels, and decide which tools to use depending on the specific task he/she is facing and on the context in which he/she operates. The method is modular, flexible and organized into processes and sub-processes, so that they can be easily adapted to the specific needs of each designer and company, facilitating its application in various contexts and design conditions.
During the design exercise, the students, working in group of six, go through the first two phases of a typical design process, i.e. strategic analysis (brief) and concept design. The integration of the MPDS with these two phases is detailed in the following table.
As shown in figure 17, different tools are integrated in different moments during these two design phases. In the next pages, when summarising the results of the design exercise, the outcome of only three tools is presented. They are:

- a life cycle assessment tool (in the specific instance, the students used SimaPro), to analyse both the environmental impacts of the existing exhibition elements and the ones of the designed concepts;
- the multi- strategy radar (included in the ICS toolkit), to visualise at a glance the
- priority (high, medium, low, none) of each design criteria in relation to the existing element and the related improvements of the

	process	sub-process	results	tools
strategic analysis (brief)	Definition of environment al design priorities	LCA of an exhisting product for sustainable design orientation	Environmental indicators useful to determine design priorities	LCA tools
				processes eco-indicators tables
		Definition of the environmental strategic priorities	environmental priorities indicators, expressed as value from 0 to 1	IPSA board (ICS toolkit)
			Istograms which render the design priorities about the processes for each strategy	
		syntethic render of design/strategic environmental priorities	Radar with indications about relative priorities in LCD strategies	Multi-strategy radar (ICS toolkit)
concept design	Focused generation of sustainable ideas	Workshop focused on generation of sustainable ideas	sustainable ideas for the 6 LCD strategies with a first selection of most promising ones	Eco-ideas Boards (ICS toolkit)
				Multi-strategy radar (ICS toolkit)
		reprocessing of sustainable ideas	document which reorganizes the worksho produced results for the generation of sustainable ideas, useful for the generation of low environmental impact concepts	
	sustainable check of the concepts and redefinition of the environment al priorities	render of the environmental features of the concepts	definition and render of the outstanding feautures of the product concept life cycle	3D modeling software
				concept life cycle exploded view
		check of the concept improvements (compared to the assessed product)	concepts environemntal impact assessment; indicators of environmental improvement in relation to the 6 LCD strategies	LCA tool
				environmental improvement checklist
				IPSA board (ICS toolkit)
		render of the potential strategic environmental improvements	multi-strategy radar with the improvement potentials for each LCD strategy	Multi-strategy radar (ICS toolkit)

FIG.30
stages of the MPDS method concerned in the course 'Design per la sostenibilità ambientale'

designed;
- the exploded view of the life cycle of the concepts, showing all the processes related to each component of the designed elements.

Design brief

The brief given to the students is to design different sustainable

elements for an itinerant exhibition that presents concepts of social inclusion and inter-generational dialogue, developed by design students in the three partner universities.
It's been considered that the exhibition[19] will be traveling in all the partners' cities, and in particular:

- in Milan (April 2013, during the FuoriSalone 2013, in collaboration with Associazione Tortona Area Lab, open 10 hours/day for 7 days);
- in Helsinki (May 2013, at the Helsinki Design Museum, open 10 hours/day for 21 days);
- in Nantes (March 2013, during Nantes European Green Capital, open 10 hours/day for 7 days).

Each group of students has to design for one specific function among those to be provided for the whole exhibition (the three locations), i.e.:

- exhibition of twenty concepts (through A1 posters with two posters per concept, or four movies projected at the same time with five concepts per each movie);

- exhibition of six polyurethane foam small scale models (300x300x150 mm), properly illuminated and protected;

- exhibition of five vertical info signs (800 x 2250 mm), properly illuminated;

- information and welcome with a reception desk and a rack with information brochures, properly illuminated.

The assigned function is also the functional unit to be considered when assessing the environmental impacts of the existing element and those

19 The ICS (Ideazione Concept Sostenibili) toolkit is available for free download from www.lens.polimi.it in the Tools section.

of the designed concept, thus making the fulfilment of a need the object of design and comparison and not the products themselves[20].

Description of existing exhibition elements

Each group should start the design exercise with the analysis of the environmental impacts of an existing exhibition element having the assigned function/functional unit described in the previous paragraph (cf. the sub-process of the MPDS method, i.e. Life Cycle Assessment of an existing product).

Therefore, working in close collaboration with the set-up workshop, for each function one or more representative/standard exhibition elements have been identified, among those use by the set-up workshop for its works:

- for the exhibition of twenty concepts on A1 posters (two posters per concept), three possible alternatives are considered:
    - poster display stands with suspended posters, with two concepts each;
    - poster display stands with Lycra backdrop, with two concepts each;
    - poster display stands made of cardboard, with one concept each.

- for the exhibition of twenty concepts through four movies projection at the same time (five concepts per each movie):
    - projecting systems;

- for the exhibition of six polyurethane foam small scale models (300x300x150 mm), properly illuminated and protected:
    - model showcases, with two models each;

20 Set in a minimum space of 75 m2.

- for the exhibition of five vertical info signs (800 x 2250 mm), properly illuminated, three possible alternatives are considered:
    - info modules with rubber feet;
    - info modules with recycled plastic bases;
    - info modules with New Jersey base.

- for the information and welcome with a reception desk and a rack with information brochures, properly illuminated:
    - reception system.

Data about each step of the life cycle of the selected elements, collected and provided to the students, are presented in the following pages. In particular:

- for the PRE-PRODUCTION (PP) stage: weight and material of each component and its standard life span (in terms of number of times the component can be used/reused);

- for the PRODUCTION (P) stage: manufacturing process/es of each component;

- for the DISTRIBUTION (DT) stage: estimated distance travelled by each component[21];

- for the USE (U) stage: electric energy consumed during the exhibition (for lighting and electronic equipment);

- for the DISPOSAL (DP) stage: type of disposal[22] (i.e. % of recycling, incineration and landfill for each material/material category).

---

21 Some components are provided on site, thus they do not travel, others are transported from Milan to Helsinki, then Nantes and back to Milan, collecting thousands of travelled kilometres.

22 It's been considered that the exhibition starts from Milan and that the exhibition modules, owned by the Laboratorio Allestimenti – Politecnico di Milano, should come back to Milan and there be disposed.

Poster display stand with suspended posters

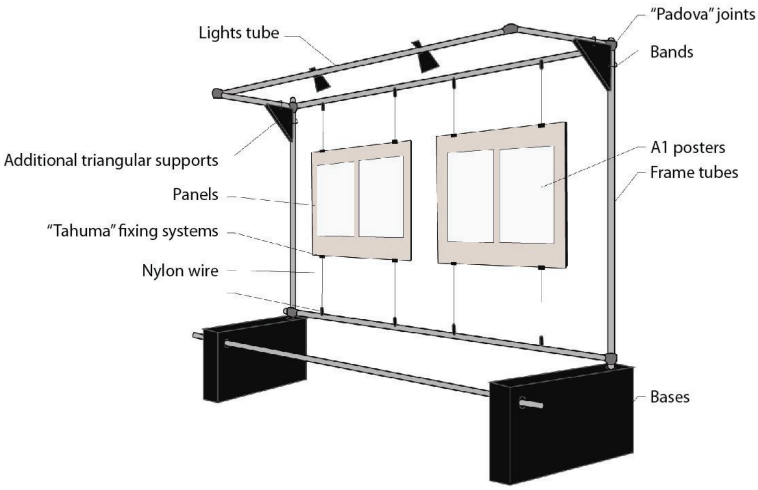


FIG.31
display stand with
suspended posters

Tubes, joints, bolts and the bases are used for 90 exhibitions before being disposed.
The Oriented Strand Board (OSB) platform is used for 48 exhibitions before being disposed.
The triangular reinforcements are used for 39 exhibitions before being disposed.
The support boards made of Forex are used for 12 exhibitions before being disposed.
A1 posters are used for 3 exhibitions before being disposed.
Nylon wires and clamps are disposed and substituted after each stage of the exhibition.

In the following table, data about the life cycle of one module are presented.

	COMPONENT	MATERIAL
PP	7x frame tubes	Aluminium
	1x light tube	Aluminium
	6x “Padova” joints	Reinforcing steel
	2x bases	OSB
	4x bands	Nylon
	Nylon wire	Nylon
	2x panels	Forex
	8x “Tahuma” fixing systems	Reinforcing steel
	2x additional triangular supports	Varnished OSB
	4x A1 posters	Paper
	COMPONENT	**MANUFACTURING**
P	7x frame tubes	Extrusion
	1x light tube	Extrusion
	6x “Padova” joints	Extrusion
	2x OSB bases	[included in the material]
	4x bands	Extrusion
	Nylon wire	[included in the material]
	2x panels	[included in the material]
	8x “Tahuma” fixing joints	Mechanical manufacturing
	2x additional triangular supports	[included in the material]
	4x A1 posters	[included in the material]
	MEANS OF TRANSPORT	**DISTANCE**
DT	Heavy lorry	Milano – Helsinki – Nantes - Milano = 6384 km
	FUNCTION	**PROCESS**
U	Module lighting in Milan	Electricity (grid) for two 120W light bulb switched on 10hrs/day, 7 days
	Module lighting in Helsinki	Electricity (grid) for two 120W light bulb switched on 10hrs/day, 21 days
	Module lighting in Nantes	Electricity (grid) for two 120W light bulb switched on 10hrs/day, 7 days
	TREATMENTS	
DP	Mix of recycle, incineration and landfill	

FIG.32 Life Cycle inventory of the module ‘display stand with suspended posters’

Poster display stand with lycra backdrop

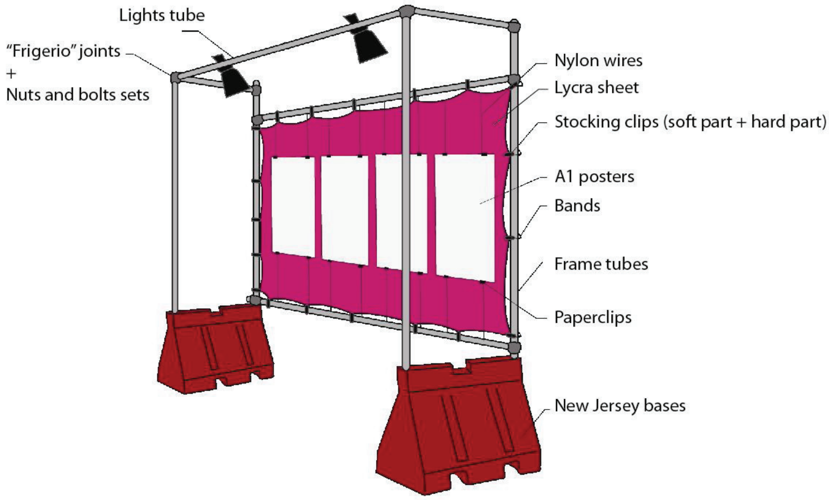


FIG.33
display stand with
Lycra backdrop

Tubes, joints, bolts and the bases are used for 90 exhibitions before being disposed.
The Lycra sheet and the paperclips are used for 9 exhibitions before being disposed.
The stocking clips are used for 6 exhibition before being disposed sheets are used for 3 exhibitions before being disposed.
Clamps and nylon wires are disposed and substituted after each stage of the exhibition.

In the following table, data about the life cycle of one module are presented.

	COMPONENT	MATERIAL
PP	8x frame tubes	Aluminium
	1x light tube	Aluminium
	10x “Frigerio” joints	Aluminium
	10x nuts and bolts sets	Reinforcing steel
	2x New Jersey bases	HDPE
	1x Lycra sheet	Lycra
	20x stocking clips (soft part)	Rubber
	20x stocking clips (hard part)	Reinforcing steel
	20x bands	Nylon
	11x Nylon wires	Nylon
	16x paperclips	Reinforcing steel
	4x A1 posters	Paper
	COMPONENT	MANUFACTURING
P	8x frame tubes	Extrusion
	1x light tube	Extrusion
	10x “Frigerio” joints	Dye casting
	10x nuts and bolts sets	Mechanical manufacturing
	2x New Jersey bases	Injection moulding
	1x Lycra sheet	Weaving
	20x stocking clips (soft part)	Injection moulding
	20x stocking clips (hard part)	Mechanical manufacturing
	20x bands	Injection moulding
	11x nylon wires	[included in the material]
	16x paperclips	Mechanical manufacturing
	4x A1 posters	[included in the material]
	MEANS OF TRANSPORT	DISTANCE
DT	Heavy lorry	Milano – Helsinki – Nantes - Milano = 6384 km
	FUNCTION	PROCESS
U	Module lighting in Milan	Electricity (grid) for two 120W light bulb switched on 10hrs/day, 7 days
	Module lighting in Helsinki	Electricity (grid) for two 120W light bulb switched on 10hrs/day, 21 days
	Module lighting in Nantes	Electricity (grid) for two 120W light bulb switched on 10hrs/day, 7 days
	TREATMENTS	
DP	Mix of recycle, incineration and landfill	

FIG.34
Life Cycle inventory of the module ‘display stand with suspended posters’

Poster display stand made of cardboard

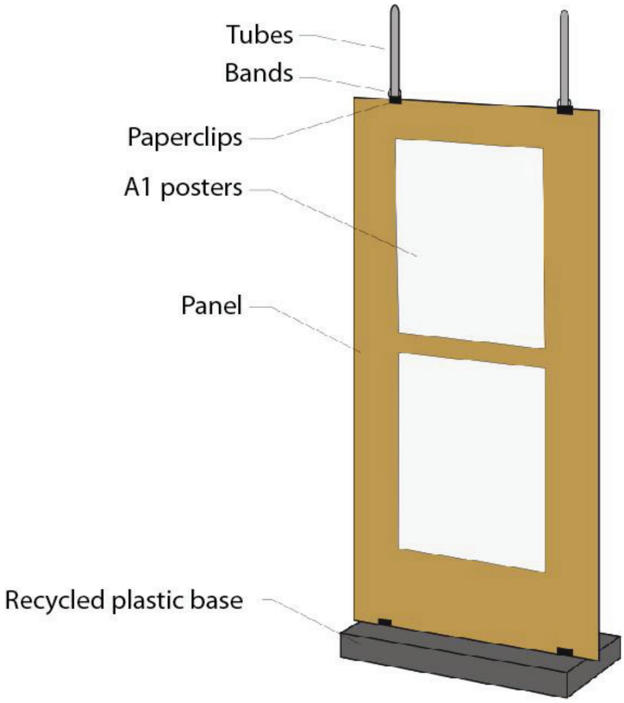


FIG.35
display stand made of cardboard

Tubes and bases are used for 90 exhibitions before being disposed.
The cardboard is used for 48 exhibitions before being disposed.
The paperclips are used for 9 exhibitions before being disposed.
A1 posters are used for 3 exhibitions before being disposed.
Clamps are disposed and substituted after each stage of the exhibition.

In the following table, data about the life cycle of one module are presented.

	COMPONENT	MATERIAL
PP	2x tubes	Aluminium
	1x recycled plastic base	Aluminium
	1x panel	Reinforcing steel
	4x bands	Nylon
	4x paperclips	Steel
	2x A1 posters	Paper
	COMPONENT	MANUFACTURING
P	2x tubes	Extrusion
	1x recycled plastic base	Injection moulding
	1x panel	[included in the material]
	4x bands	Injection moulding
	4x paperclips	Mechanical manufacturing
	2x A1 posters	[included in the material]
	MEANS OF TRANSPORT	DISTANCE
DT	Heavy lorry	Milano – Helsinki – Nantes - Milano = 6384 km
	FUNCTION	PROCESS
U	Module lighting in Milan	Electricity (grid) for one 120W light bulb switched on 10hrs/day, 7 days
	Module lighting in Helsinki	Electricity (grid) for one 120W light bulb switched on 10hrs/day, 21 days
	Module lighting in Nantes	Electricity (grid) for one 120W light bulb switched on 10hrs/day, 7 days
	TREATMENTS	
DP	Mix of recycle, incineration and landfill	

FIG.36
Life Cycle inventory of the module 'display stand made of cardboard'

Projecting system

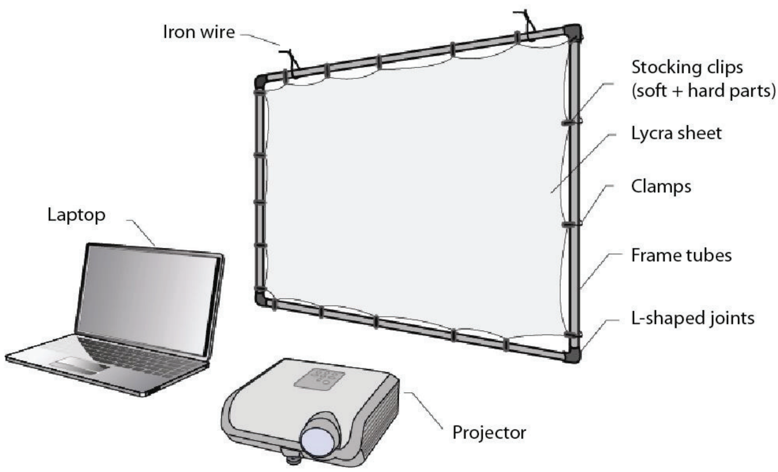


FIG.37
projecting system

Tubes and joints are used for 90 exhibitions before being disposed.
The sheet is used for 9 exhibitions before being disposed.
The stocking clips are used for 6 exhibitions before being disposed.
A1 posters are used for 3 exhibitions before being disposed.
Clamps and iron wires are disposed and substituted after each stage of the exhibition.
The laptop computer life span is about 10950 hours.
The projector life span is about 6000 hours.

In the following table, data about the life cycle of one module are presented.

	COMPONENT	MATERIAL
PP	4x frame tubes	Aluminium
	4x L-shaped joints	PVC
	1x Lycra sheet	Lycra
	20x stocking clips (soft part)	Rubber
	20x stocking clips (hard part)	Reinforcing steel
	2m iron wire	Iron
	34x clamps	Nylon
	1x projector	Various
	1x laptop	Various
	COMPONENT	MANUFACTURING
P	4x frame tubes	Extrusion
	4x L-shaped joints	Injection moulding
	1x Lycra sheet	Weaving
	20x stocking clips (soft part)	Injection moulding
	20x stocking clips (hard part)	Mechanical manufacturing
	2m iron wire	Wire drawing
	34x clamps	Injection moulding
	1x projector	[included in the material]
	1x laptop	[included in the material]
	MEANS OF TRANSPORT	DISTANCE
DT	Heavy lorry	Milano – Helsinki – Nantes - Milano = 6384 km
	FUNCTION	PROCESS
U	Projection in Milano	Electricity (grid) for one 470W projector switched on 10hrs/day, 7 days
	Projection in Helsinki	Electricity (grid) for one 470W projector switched on 10hrs/day, 21 days
	Projection in Nantes	Electricity (grid) for one 470W projector switched on 10hrs/day, 7 days
	Laptop use in Milano	Electricity (grid) for one 50W laptop switched on 10hrs/day, 7 days
	Laptop use in Helsinki	Electricity (grid) for one 50W laptop switched on 10hrs/day, 21 days
	Laptop use in Nantes	Electricity (grid) for one 50W laptop switched on 10hrs/day, 7 days
	TREATMENTS	
DP	Mix of recycle, incineration and landfill	

FIG.38
Life Cycle inventory of the module 'projecting system'

Mock up showcase

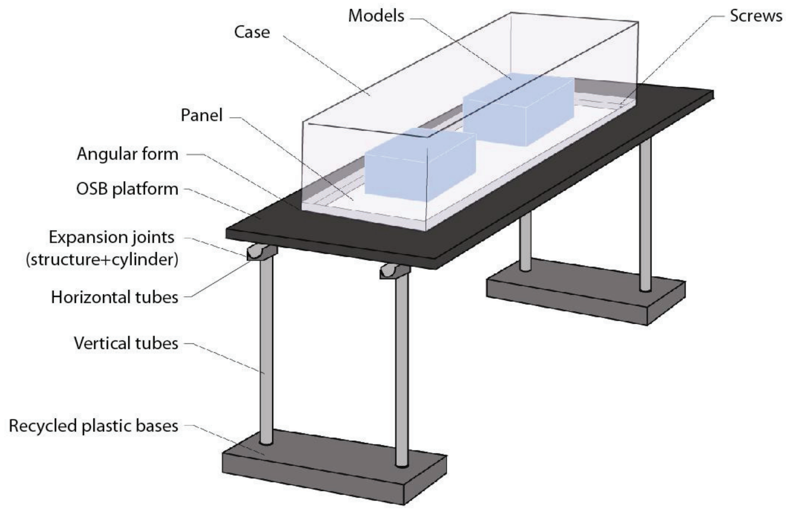


FIG.39
mock-up showcase

Tubes, base, panel, angular outline joints and screws are used for 90 exhibitions before being disposed.
The Oriented Strand Board (OSB) platform is used for 48 exhibitions before being disposed.
The PMMA showcase is used for 12 exhibitions before being disposed.
Models are used for 3 exhibitions before being disposed.

In the following table, data about the life cycle of one module are presented.

	COMPONENT	MATERIAL
PP	1x OSB platform	Varnished OSB
	4x vertical tubes	Aluminium
	4x horizontal tubes	Aluminium
	2x recycled plastic bases	Recycled PE
	1x panel	Dbond (Aluminium 70%, PE 30%)
	1x angular form	Aluminium
	1x case	PMMA
	14x screws	Reinforcing steel
	2x expansion joints (structure)	Low-alloyed steel
	2x expansion joints (cylinder)	Tetrafluoroethylene
	2x models	Polyurethane foam
	COMPONENT	MANUFACTURING
P	1x OSB platform	[included in the material]
	4x vertical tubes	Extrusion
	4x horizontal tubes	Extrusion
	2x recycled plastic bases	Injection moulding
	1x panel	[included in the material]
	1x angular form	Extrusion
	1x case	[included in the material]
	14x screws	Mechanical manufacturing
	2x expansion joints (structure)	Extrusion
	2x expansion joints (cylinder)	Injection moulding
	2x models	[included in the material]
	MEANS OF TRANSPORT	DISTANCE
DT	Heavy lorry	Milano – Helsinki – Nantes - Milano = 6384 km
	FUNCTION	PROCESS
U	Module lighting in Milan	Electricity (grid) for one 120W light bulb switched on 10hrs/day, 7 days
	Module lighting in Helsinki	Electricity (grid) for one 120W light bulb switched on 10hrs/day, 21 days
	Module lighting in Nantes	Electricity (grid) for one 120W light bulb switched on 10hrs/day, 7 days
	TREATMENTS	
DP	Mix of recycle, incineration and landfill	

FIG.40
Life Cycle inventory of the module 'mock-up showcase'

Info module with rubber feet

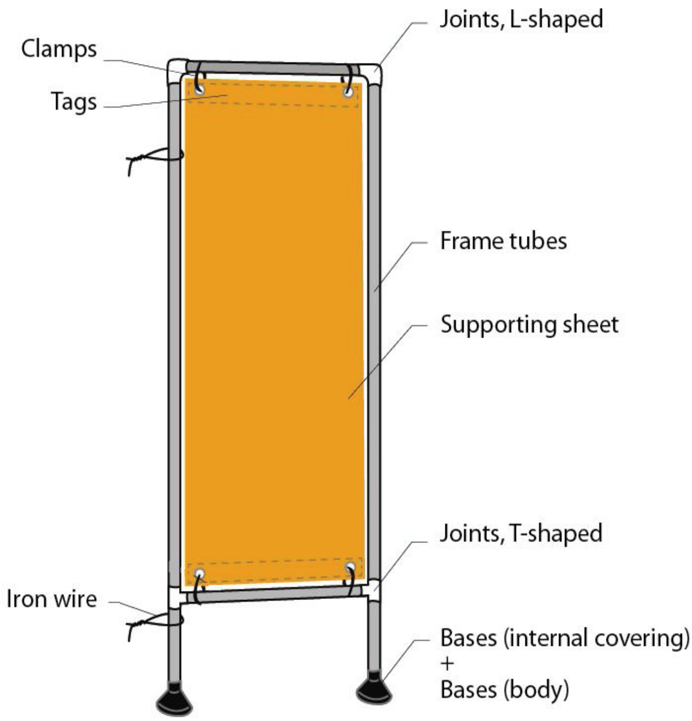


FIG.41
info module with
rubber feet

Tubes, joints, tags and bases are used for 90 exhibitions before being disposed.
The PVC sheet is used for 18 exhibitions before being disposed.
Clamps and the iron wire are disposed and substituted after each stage of the exhibition.

In the following table, are presented the data about the life cycle of one module.

	COMPONENT	MATERIAL
PP	4x frame tubes	Aluminium
	2x joints, L-shaped	PVC
	2x joints, T-shaped	PVC
	1x supporting sheet	PVC
	2x tags	Dbond (Aluminium 70%, PE 30%)
	4x clamps	Nylon
	2x bases (internal covering)	PVC
	2x bases (body)	Rubber
	2m iron wire	Steel
	COMPONENT	MANUFACTURING
P	4x frame tubes	Extrusion
	2x joints, L-shaped	Injection moulding
	2x joints, T-shaped	Injection moulding
	1x supporting sheet	Extrusion
	2x tags	[included in the material]
	2x bands	Injection moulding
	2x bases (internal covering)	Injection moulding
	2x bases (body)	Injection moulding
	2m iron wire	Wire drawing
	MEANS OF TRANSPORT	DISTANCE
DT	Heavy lorry	Milano – Helsinki – Nantes - Milano = 6384 km
	FUNCTION	PROCESS
U	Module lighting in Milan	Electricity (grid) for one 120W light bulb switched on 10hrs/day, 7 days
	Module lighting in Helsinki	Electricity (grid) for one 120W light bulb switched on 10hrs/day, 21 days
	Module lighting in Nantes	Electricity (grid) for one 120W light bulb switched on 10hrs/day, 7 days
	TREATMENTS	
DP	Mix of recycle, incineration and landfill	

FIG.42
Life Cycle inventory of the module 'info module with rubber feet'

Info module with recycled plastic bases

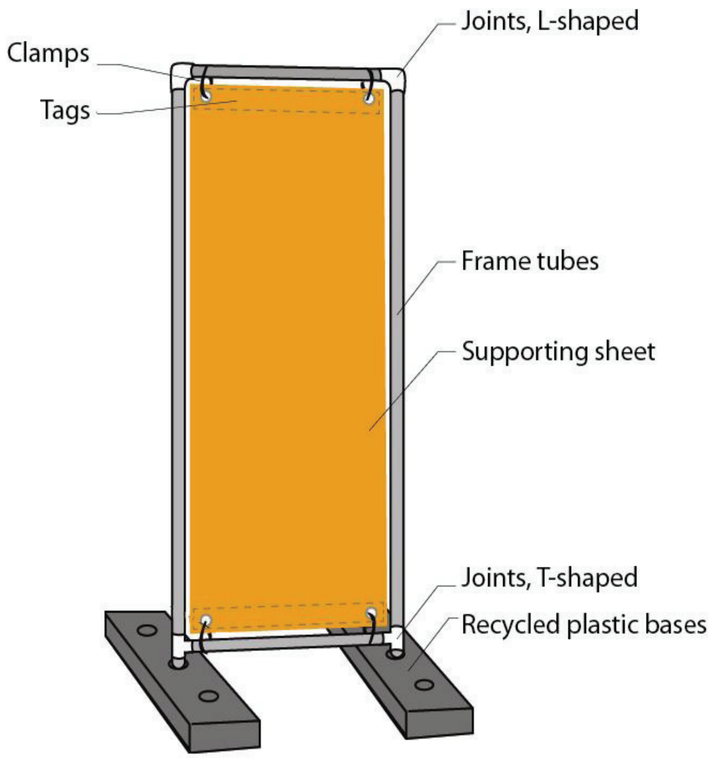


FIG.43
info module with
recycled plastic
bases

Tubes, joints, tags and bases are used for 90 exhibitions before being
The PVC sheet is used for 18 exhibitions before being disposed.
Clamps and the iron wire are disposed and substituted after each stage of the exhibition.
In the following table, data about the life cycle of one module are presented.

	COMPONENT	MATERIAL
PP	4x frame tubes	Aluminium
	2x joints, L-shaped	PVC
	2x joints, T-shaped	PVC
	1x supporting sheet	PVC
	2x tags	Dbond (Aluminium 70%, PE 30%)
	4x clamps	Nylon
	2x recycled plastic bases	Recycled PE
	COMPONENT	MANUFACTURING
P	4x frame tubes	Extrusion
	2x joints, L-shaped	Injection moulding
	2x joints, T-shaped	Injection moulding
	1x supporting sheet	Extrusion
	2x tags	[included in the material]
	2x bands	Injection moulding
	2x recycled plastic bases	Injection moulding
	MEANS OF TRANSPORT	DISTANCE
DT	Heavy lorry	Milano – Helsinki – Nantes - Milano = 6384 km
	FUNCTION	PROCESS
U	Module lighting in Milan	Electricity (grid) for one 120W light bulb switched on 10hrs/day, 7 days
	Module lighting in Helsinki	Electricity (grid) for one 120W light bulb switched on 10hrs/day, 21 days
	Module lighting in Nantes	Electricity (grid) for one 120W light bulb switched on 10hrs/day, 7 days
	TREATMENTS	
DP	Mix of recycle, incineration and landfill	

FIG.44
Life Cycle inventory of the module 'info module with recycled plastic bases'

Info module with new jersey base

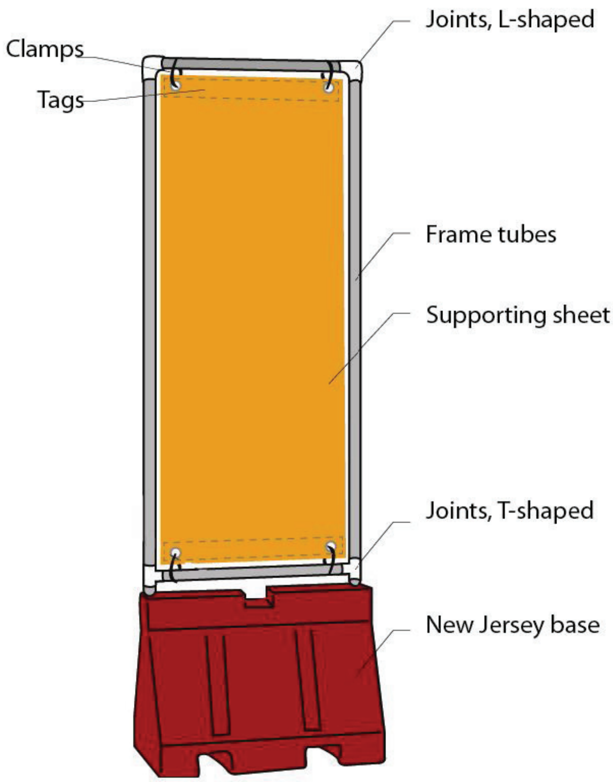


FIG.45
info module with
new jersey bases

Tubes, joints, tags and base are used for 90 exhibition before being disposed.
The PVC sheet is used for 18 exhibitions before being disposed.
Clamps are disposed and substituted after each stage of the exhibition.

In the following table, data about the life cycle of one module are presented.

	COMPONENT	MATERIAL
PP	4x frame tubes	Aluminium
	2x joints, L-shaped	PVC
	2x joints, T-shaped	PVC
	1x supporting sheet	PVC
	2x tags	Dbond (Aluminium 70%, PE 30%)
	4x clamps	Nylon
	1x New Jersey base	HDPE
	COMPONENT	**MANUFACTURING**
P	4x frame tubes	Extrusion
	2x joints, L-shaped	Injection moulding
	2x joints, T-shaped	Injection moulding
	1x supporting sheet	Extrusion
	2x tags	[included in the material]
	4x bands	Injection moulding
	1x New Jersey base	Injection moulding
	MEANS OF TRANSPORT	**DISTANCE**
DT	Heavy lorry	Milano – Helsinki – Nantes - Milano = 6384 km
	FUNCTION	**PROCESS**
U	Module lighting in Milan	Electricity (grid) for one 120W light bulb switched on 10hrs/day, 7 days
	Module lighting in Helsinki	Electricity (grid) for one 120W light bulb switched on 10hrs/day, 21 days
	Module lighting in Nantes	Electricity (grid) for one 120W light bulb switched on 10hrs/day, 7 days
	TREATMENTS	
DP	Mix of recycle, incineration and landfill	

FIG.46
Life Cycle inventory of the module 'info module with new jersey bases'

Reception system

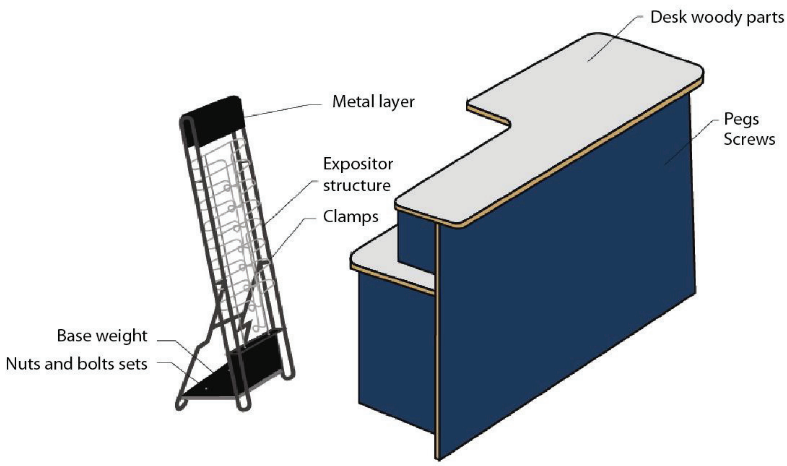


FIG.47
reception system

The desk is used for 99 exhibitions before being disposed.
The display rack is used for 90 exhibition before being disposed.
Clamps are disposed and substituted after each stage of the exhibition.

In the following table, data about the life cycle of one module are presented.

	COMPONENT	MATERIAL
PP	Desk woody parts	Plywood
	4x hinges	Reinforcing steel
	16x screws	Reinforcing steel
	8x pegs	Beech
	1x expositor structure	Reinforcing steel
	1x metal layer	Reinforcing steel
	1x base weight	Reinforcing steel
	2x nuts and bolts sets	Reinforcing steel
	2x clamps	Nylon
	COMPONENT	**MANUFACTURING**
P	Desk woody parts	[included in the material]
	4x hinges	Mechanical manufacturing
	16x screws	Mechanical manufacturing
	8x pegs	[included in the material]
	1x expositor structure	Mechanical manufacturing
	1x metal layer	Rolling
	1x base weight	Mechanical manufacturing
	2x nuts and bolts sets	Mechanical manufacturing
	2x clamps	Injection moulding
	MEANS OF TRANSPORT	**DISTANCE**
DT	Heavy lorry	Milano - Helsinki - Nantes - Milano = 6384 km
	FUNCTION	**PROCESS**
U	Module lighting in Milan	Electricity (grid) for one 100W light bulb switched on 10hrs/day, 7 days
	Module lighting in Helsinki	Electricity (grid) for one 100W light bulb switched on 10hrs/day, 21 days
	Module lighting in Nantes	Electricity (grid) for one 100W light bulb switched on 10hrs/day, 7 days
	TREATMENTS	
DP	Mix of recycle, incineration and landfill	

FIG.48
Life Cycle inventory of the module 'reception system'

Environmental impacts and design priorities of the existing elements

Following the MPDS method, using the SimaPro software the students started their design exercise with the Life Cycle Assessment (LCA) of an existing exhibition element, based on the information presented in the previous chapter.
In the following paragraphs, the main LCA results for each element are presented, i.e.:

- the impact[23] of each phase in the life cycle[24] of the products[25];
- the environmental effects that give a higher contribution to the overall impact of the products;
- the processes[26] that give a higher contribution to the overall impact of the products.

Then, the students used the results from the LCAs to define the environmental strategic design priorities of the assessed element and visualize them, using, respectively the IPSA table and the Multi-strategy radar, both part of the ICS toolkit (see the second and third sub-processes of MPDS).

In the following paragraphs, the strategic environmental priorities are shown through the Multi strategy radar.

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23 The environmental impacts are expressed in Pt that is the unit of measurement used by Eco-indicator 99, the assessment method selected for these LCAs.
24 In many of the following cases, the impact of the disposal phase is negative since the avoided impacts of recycling (i.e. considering the "savings" obtained by not having to produce new virgin material) are taken into account.
25 disposal. Due to the specific organization of the software used for the analysis, the results related to the first two phase are aggregated.
26 Following what happens in the software Simapro, here the expression "process" can refer to different phenomena and performances such as materials, production processes, energy consumptions, distribution tasks, ...

Poster display stand with suspended posters

Overall impact

The evaluation results show that the contribution of the different life cycle phases is, in descending order:

1. Distribution: 57,02 Pt
2. Use: 33,85 Pt
3. Pre-Production + Production: 12,97 Pt
4. Disposal: 0,08 Pt

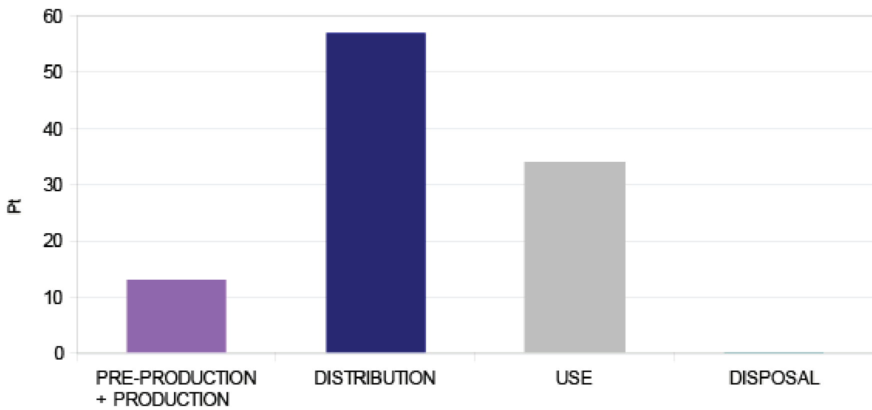


FIG.49 Environmental impact of the Life cycle phases of the Poster display stand with suspended posters

Environmental effects

The three environmental effects which contribute more to generate the overall impact are, in descending order:

1. Fossil fuels: 49,39 Pt
2. Resp. Inorganics: 20,41 Pt
3. Carcinogens: 7,16 Pt

Processes

The three processes which contribute more to the overall life cycle impact are, in descending order:

1. On road transportation: 25,26 Pt
2. Electricity consumption in Finland: 3,4 Pt
3. Electricity consumption in Italy: 1,71 Pt

Design priorities
On the base of the LCA results, the environmental strategic design priority of each Life Cycle Design strategy have been calculated and are presented in Figure 50.

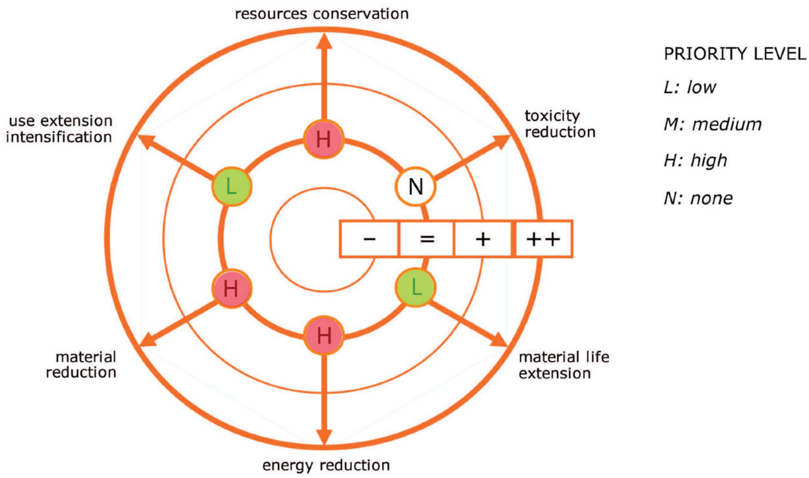


FIG.50
IPSA priorities for the redesign of the module

Poster display stand with lycra backdrop

Overall impact

The evaluation results show that the contribution of the different life cycle phases is, in descending order:

1. Distribution: 45,3 Pt
2. Use: 22,57 Pt
3. Pre-Production + Production: 15 Pt
4. Disposal: -2,06 Pt

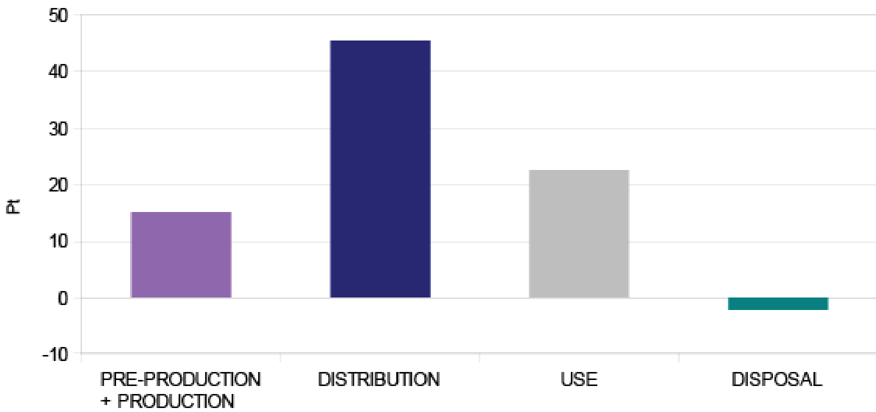


FIG.51 Environmental impact of the Life cycle phases of the Poster display stand with Lycra backdrop

Environmental effects

The three environmental effects which contribute more to generate the overall impact are, in descending order:

1. Fossil fuels: 40,89 Pt
2. Resp. Inorganics: 18,83 Pt
3. Carcinogens: 7,19 Pt

Processes

The three processes which contribute more to the overall life cycle impact are, in descending order:

1. On road transportation: 45,34 Pt
2. Electricity consumption in Finland: 13,6 Pt
3. Electricity consumption in Italy: 6,88 Pt

Design priorities
On the base of the LCA results, the environmental strategic design priority of each Life Cycle Design strategy have been calculated and are presented in Fig. 52.

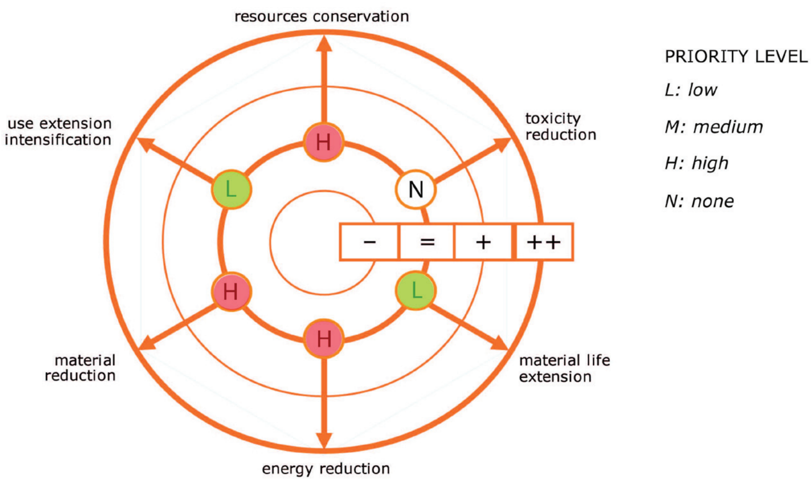


FIG.52
IPSA priorities for the redesign of the module

Poster display stand made of cardboard

Overall impact

The evaluation results show that the contribution of the different life cycle phases is, in descending order:

1. Distribution: 62,78 Pt
2. Use: 22,57 Pt
3. Pre-Production + Production: 7,66 Pt
4. Disposal: -0,24 Pt

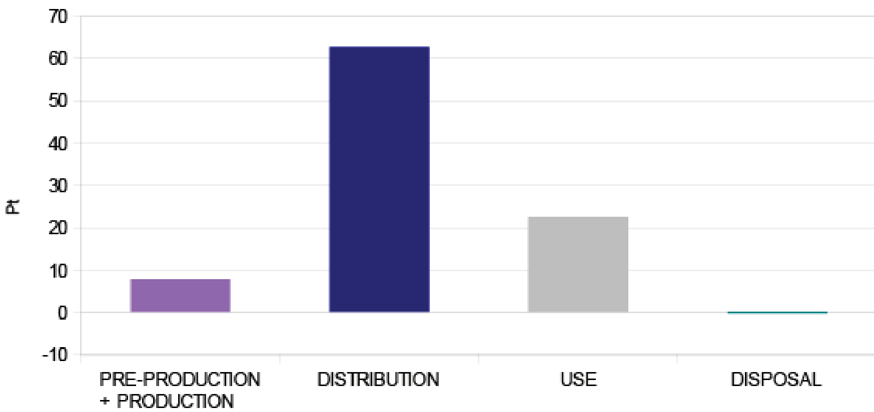


FIG.53 Environmental impact of the Life cycle phases of the Poster display stand with Lycra backdrop

Environmental effects

The three environmental effects which contribute more to generate the overall impact are, in descending order:

1. Fossil fuels: 50,5 Pt
2. Resp. Inorganics: 20,1 Pt
3. Climate change: 7,17 Pt

Processes

The three processes which contribute more to the overall life cycle impact are, in descending order:

1. On road transportation: 62,78 Pt
2. Electricity consumption in Finland: 13,62 Pt
3. Electricity consumption in Italy: 6,88 Pt

Design priorities
On the base of the LCA results, the environmental strategic design priority of each Life Cycle Design strategy have been calculated and are presented in fig.54.

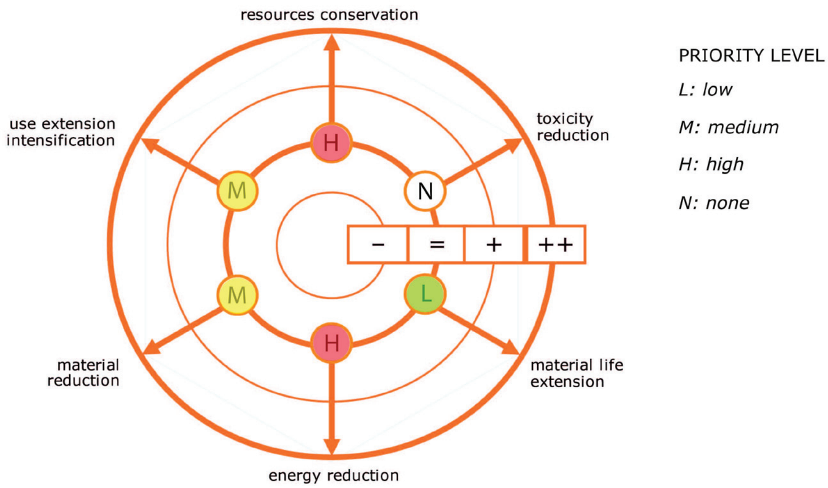


FIG.54
IPSA priorities for the redesign of the module

Projecting system

Overall impact

The evaluation results show that the contribution of the different life cycle phases is, in descending order:

1. Use: 19,56 Pt
2. Pre-Production + Production: 10,81 Pt
3. Distribution: 3,63 Pt
4. Disposal: -0,14 Pt

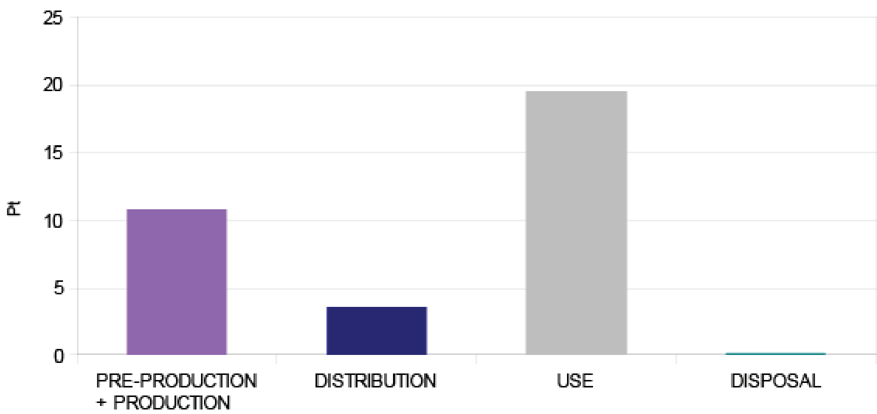


FIG.55 Environmental impact of the Life cycle phases of the Projecting system

Environmental effects

The three environmental effects which contribute more to generate the overall impact are, in descending order:

1. Fossil fuels: 11,03 Pt
2. Carcinogens: 8,51 Pt
3. Resp. Inorganics: 8,08 Pt

Processes

The three processes which contribute more to the overall life cycle impact are, in descending order:

1. Electricity consumption in Finland: 11,8 Pt
2. Electricity consumption in Italy: 5,96 Pt
3. Production of the laptop computer components: 4,44 Pt

Design priorities

On the base of the LCA results, the environmental strategic design priority of each Life Cycle Design strategy have been calculated and are presented in Figure 56.

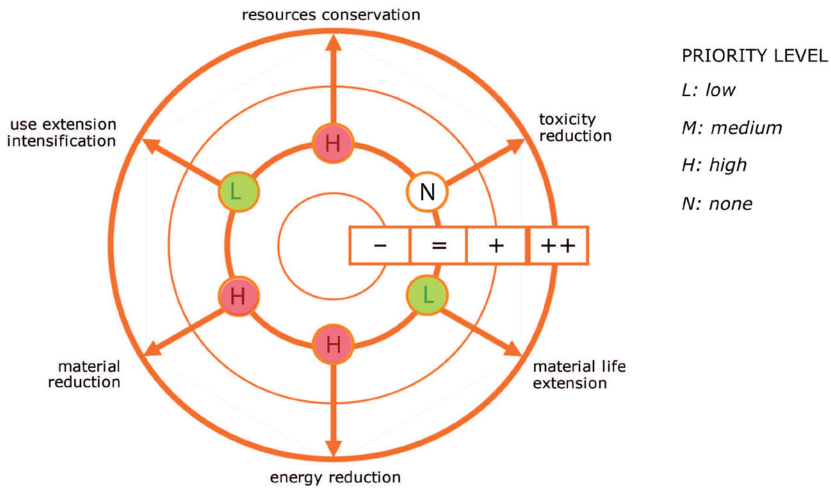


FIG.56
IPSA priorities for the redesign of the module

Mock-up showcase

Overall impact

The evaluation results show that the contribution of the different life cycle phases is, in descending order:

1. Distribution: 25,40 Pt
2. Pre-Production + Production: 11,27 Pt
3. Use: 3,39 Pt
4. Disposal: 0,60 Pt

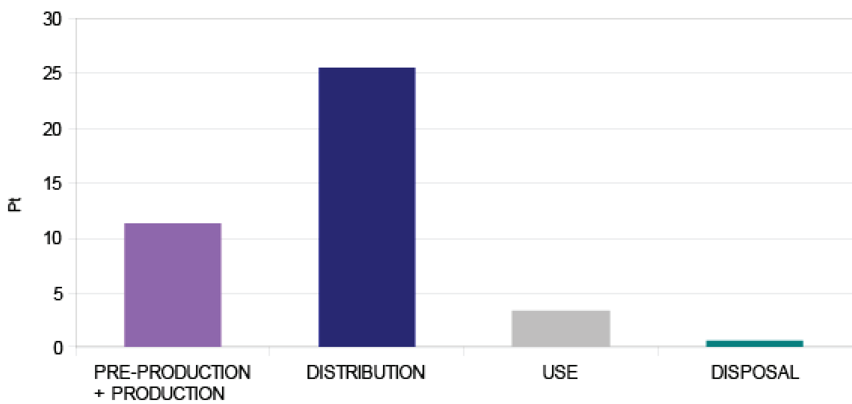


FIG.57 Environmental impact of the Life cycle phases of the mock-up showcase

Environmental effects

The three environmental effects which contribute more to generate the overall impact are, in descending order:

1. Fossil fuels: 24,57 Pt
2. Resp. Inorganics: 8,04 Pt
3. Climate change: 3,22 Pt

Processes

The three processes which contribute more to the overall life cycle impact are, in descending order:

1. On road transportation: 25,40 Pt
2. PMMA for the case: 8,08 Pt
3. Electricity consumption in Finland: 2,04 Pt

Design priorities

On the base of the LCA results, the environmental strategic design priority of each Life Cycle Design strategy have been calculated and are presented in Figure 58.

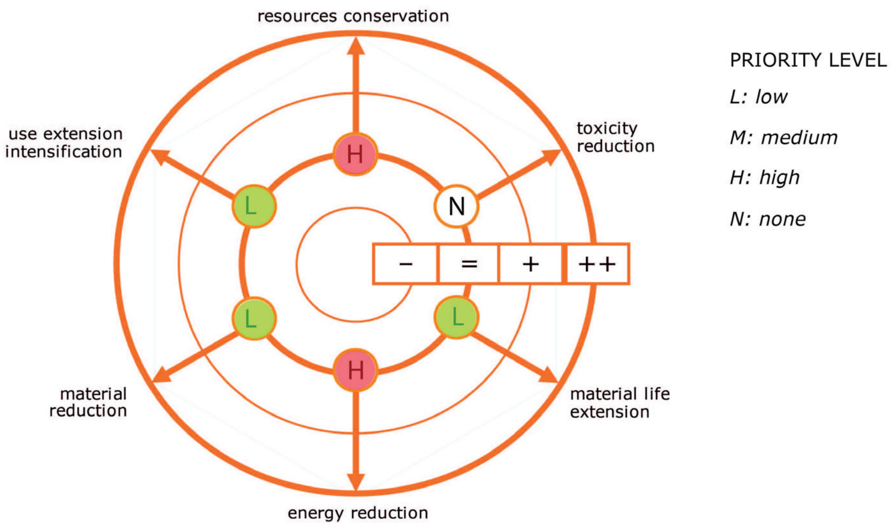


FIG.58
IPSA priorities for the redesign of the module

Info module with rubber feet

Overall impact

The evaluation results show that the contribution of the different life cycle phases is, in descending order:

1. Use: 5,64 Pt
2. Distribution: 4,40 Pt
3. Pre-Production + Production: 1,24 Pt
4. Disposal: -0,28 Pt

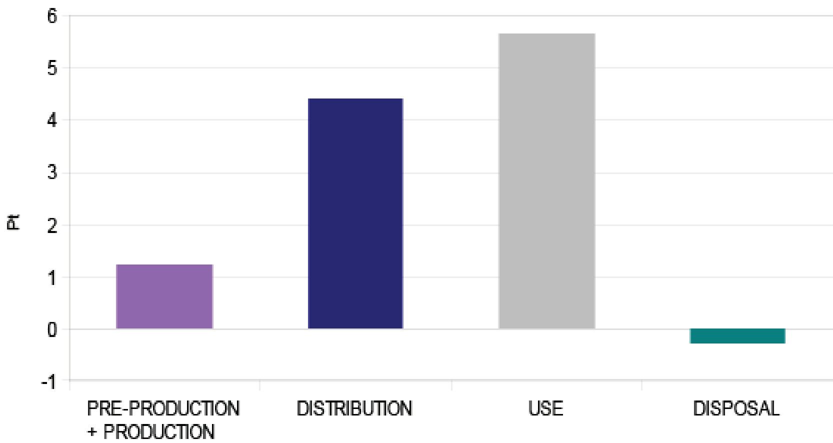


FIG.59 Environmental impact of the Life cycle phases of the Info module with rubber feet

Environmental effects

The three environmental effects which contribute more to generate the overall impact are, in descending order:

1. Fossil fuels: 4,99 Pt
2. Resp. Inorganics: 2,69 Pt
3. Carcinogens: 1,3 Pt

Processes

The three processes which contribute more to the overall life cycle impact are, in descending order:

1. On road transportation – 4,4 Pt
2. Electricity consumption in Finland - 3,4 Pt
3. Electricity consumption in Italy - 1,72 Pt

Design priorities
On the base of the LCA results, the environmental strategic design priority of each Life Cycle Design strategy have been calculated and are presented in Figure 60.

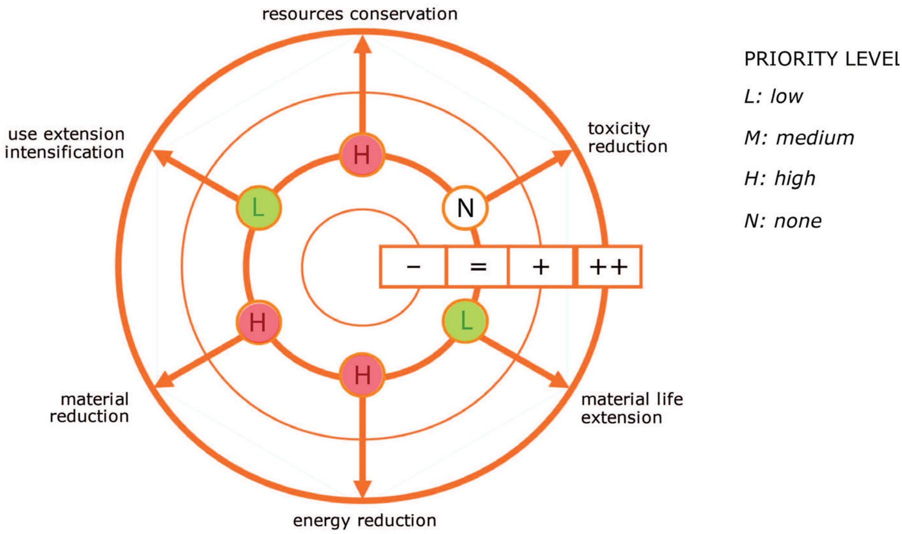


FIG.60
IPSA priorities for the redesign of the module

Info module with recycled plastic bases

Overall impact

The evaluation results show that the contribution of the different life cycle phases is, in descending order:

1. Distribution: 25,26 Pt
2. Use: 5,64 Pt
3. Pre-Production + Production: 2,81 Pt
4. Disposal: -0,1 Pt

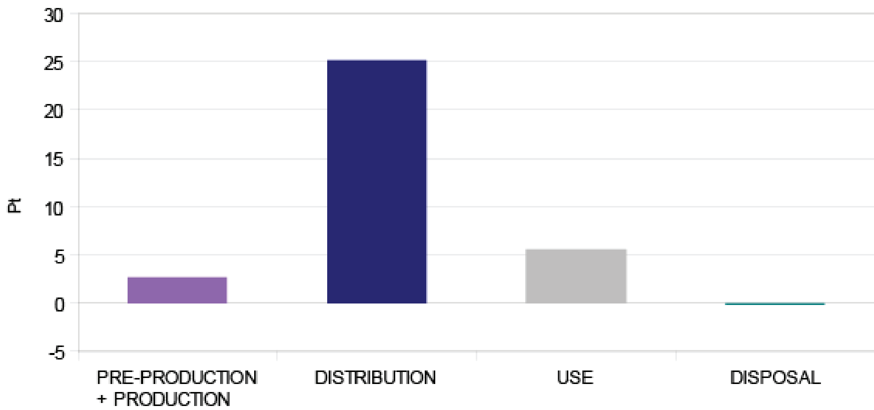


FIG.61 Environmental impact of the Life cycle phases of the Info module with recycled plastic bases

Environmental effects

The three environmental effects which contribute more to generate the overall impact are, in descending order:

1. Fossil fuels: 19,21 Pt
2. Resp. Inorganics: 6,99 Pt
3. Climate change: 2,57 Pt

Processes

The three processes which contribute more to the overall life cycle impact are, in descending order:

1. On road transportation: 25,26 Pt
2. Electricity consumption in Finland: 3,4 Pt
3. Electricity consumption in Italy: 1,71 Pt

Design priorities
On the base of the LCA results, the environmental strategic design priority of each Life Cycle Design strategy have been calculated and are presented in Figure 62.

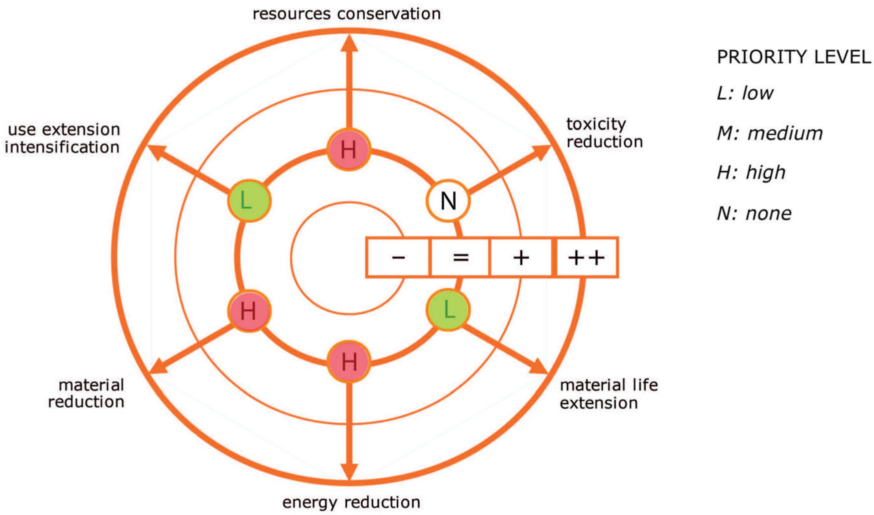


FIG.62
IPSA priorities for the redesign of the module

Info module with new jersey base

Overall impact
The evaluation results show that the contribution of the different life cycle phases is, in descending order:

1. Distribution: 8,19 Pt
2. Use: 5,64 Pt
3. Pre-Production + Production: 1,54 Pt
4. Disposal: -0,29 Pt

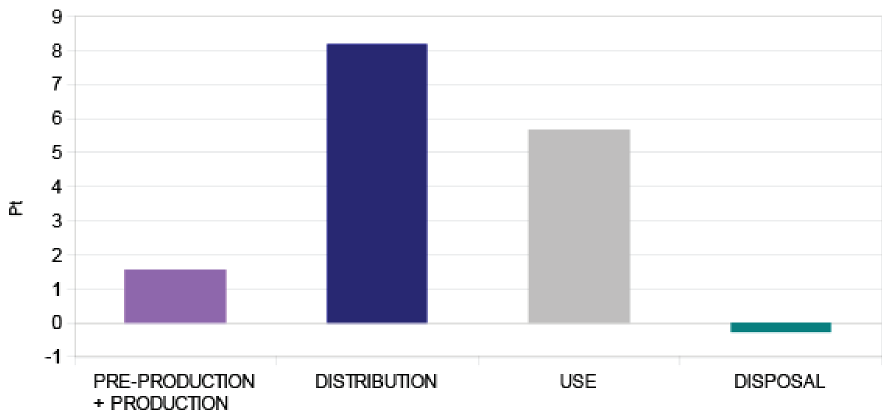


FIG.63 Environmental impact of the Life cycle phases of the Info module with new jersey base

Environmental effects
The three environmental effects which contribute more to generate the overall impact are, in descending order:

1. Fossil fuels: 7,56 Pt
2. Resp. Inorganics: 3,42 Pt
3. Climate change: 1,43 Pt

The three processes which contribute more to the overall life cycle impact are, in descending order:

1. On road transportation: 8,18 Pt
2. Electricity consumption in Finland: 3,4 Pt
3. Electricity consumption in Italy: 1,72 Pt

Design priorities
On the base of the LCA results, the environmental strategic design priority of each Life Cycle Design strategy have been calculated and are presented in Figure 64.

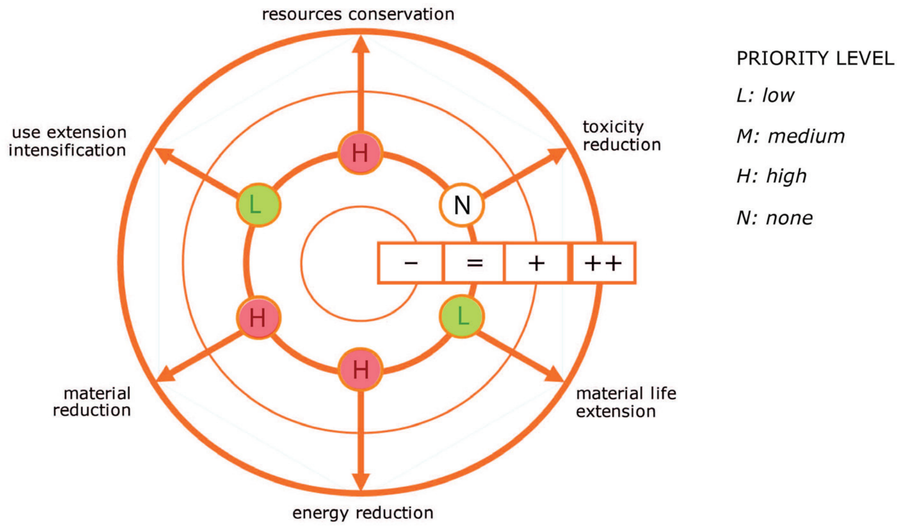


FIG.64
IPSA priorities for the redesign of the module

Reception system

Overall impact

The evaluation results show that the contribution of the different life cycle phases is, in descending order:

1. Distribution: 5,19 Pt
2. Use: 0,94 Pt
3. Pre-Production + Production: 0,1 Pt
4. Disposal: 0 Pt

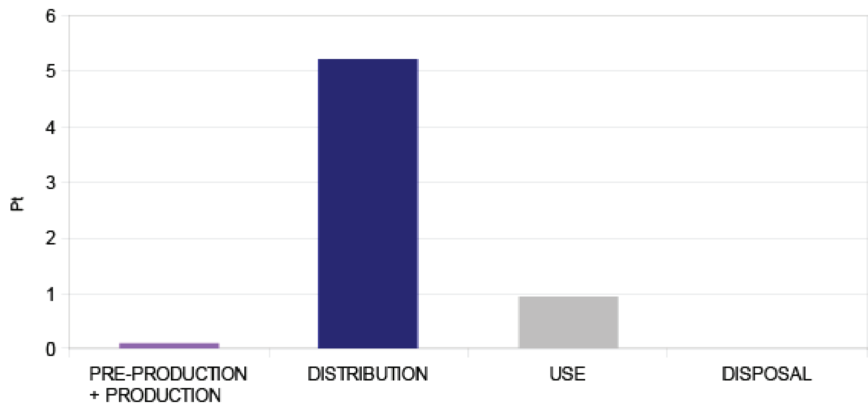


FIG.65 Environmental impact of the Life cycle phases of the reception system

Environmental effects

The three environmental effects which contribute more to generate the overall impact are, in descending order:

1. Fossil fuels: 3,63 Pt
2. Resp. Inorganics: 1,3 Pt
3. Climate change: 0,47 Pt

Processes

The three processes which contribute more to the overall life cycle impact are, in descending order:

1. On road transportation: 5,19 Pt
2. Electricity consumption in Finland: 0,57 Pt
3. Electricity consumption in Italy: 0,19 Pt

Design priorities
On the base of the LCA results, the environmental strategic design priority of each Life Cycle Design strategy have been calculated and are presented in Figure 66.

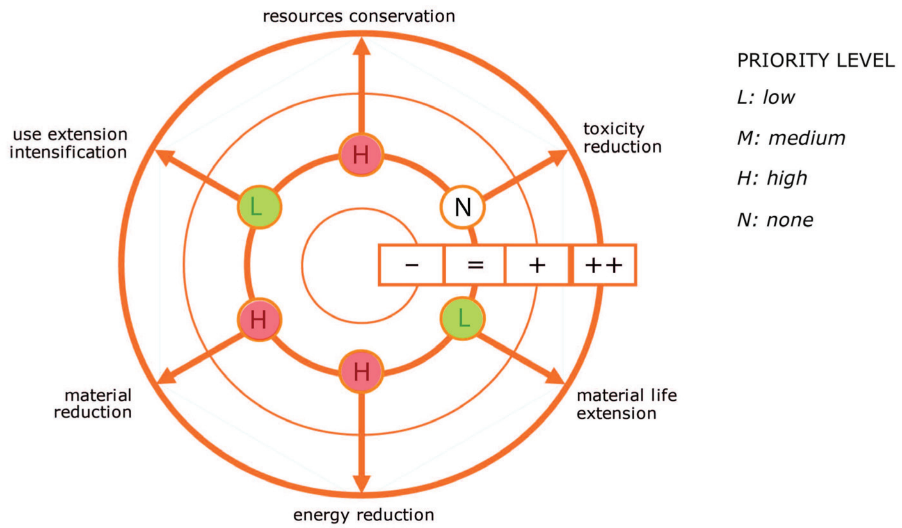


FIG.66
IPSA priorities for the redesign of the module

In the next pages are listed the concepts which have been designed by the students of the course 'Design per la sostenibilità ambientale', which tried to answer to the design brief defined after they made the LCAs of the assigned exposition modules.
The concepts are grouped by function and for each one are shown a general image and a detailed one (if available), with information about the whole life cycle of the components they are made of.
Furthermore are shown the comparison chart between the each new concept and the analyzed existing module.

Concepts for a poster exhibition

In this section are listed those concepts designed after the analysis of the modules:

- Poster display stand with suspended posters;
- Poster display stand with lycra backdrop;
- Poster display stand made of cardboard.

Snake

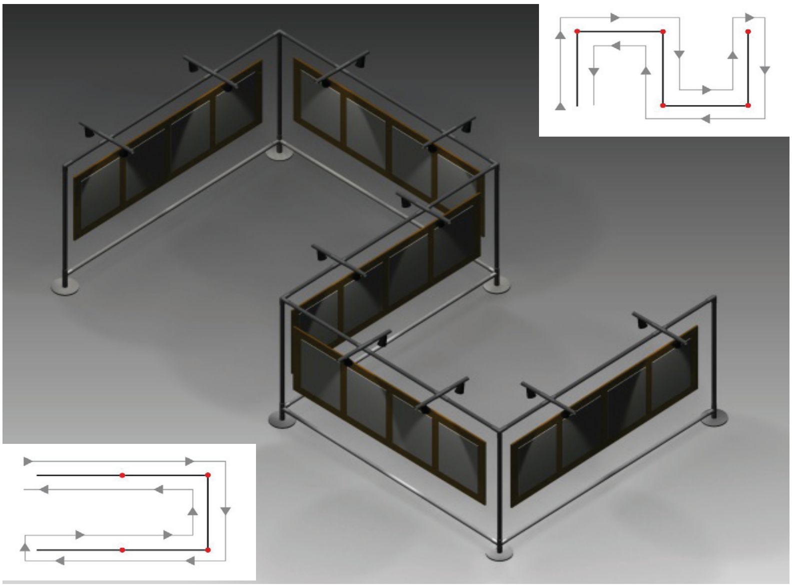


FIG.67
concept render

Snake is designed in such a way that allows the exposure of sheets on both sides of the structure. In this way it is halved the number of modules necessary for the exhibition.
In order to decrease the number of components necessary to realize the structure, it was decided to create a continuous structure with movable joints and with some vertical pipes in common.
The basement has been changed too: it will be composed by a pedestal in which the vertical pipe fits and is fixed.

In fig.69 are shown the comparison charts about the whole life cycle of the new concept (left bar) and the existing product (right bar).

The concepts reduces the environmental impact by more than the 70% compared to the existing system.

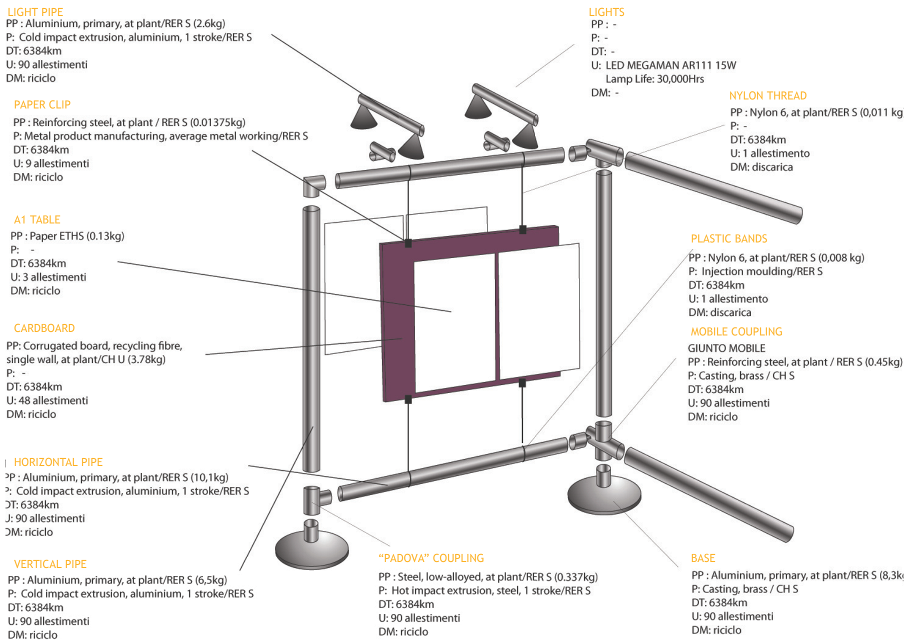


FIG.68
concept LCD
details

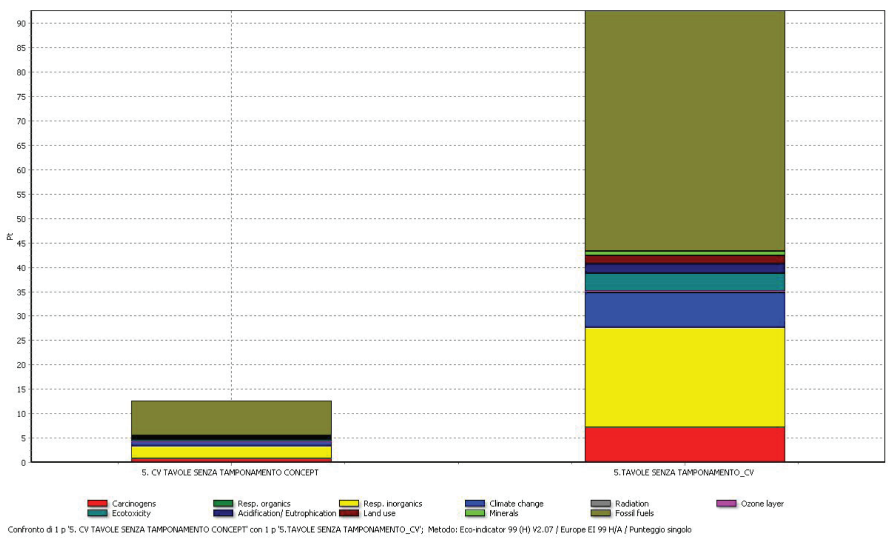


FIG.69
LCA comparison
between the
designed
concept and the
existing one

Piezoeletric walk

FIG.70
concept render

The piezoeletric tiles are a kind of hi-tech tiles (width- 90cm², thickness- 2.5 cm) which contains a piezoelectric layer on the inside able to catch the energy produced by the people walking on it. By walking two times on the tiles, a person of 60 kg is able to generate 0.5W. They can be easily installed in the exhibition's space.
To increase the production of energy we found interesting to study an interactive way in order to spur visitors to walk on ours piezoelectric carpets. By this way all the energy needed for the exhibition is produced by the same people going there to visit it.

In fig.72 are shown the comparison charts about the whole life cycle of the new concept (left bar) and the existing product (right bar).
The concepts reduces the environmental impact by more than the 50% compared to the existing system.

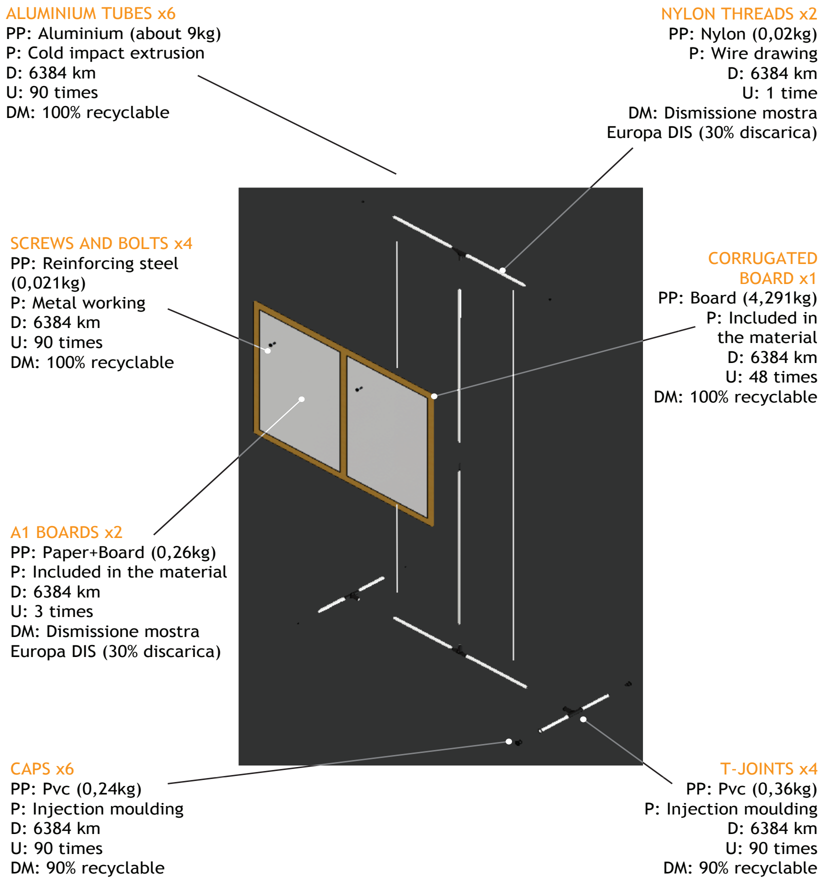


FIG.71
concept LCD
details

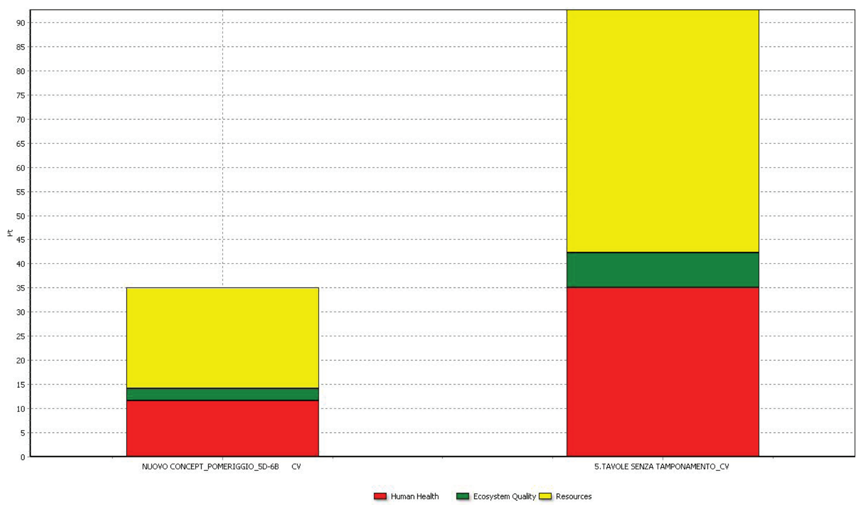


FIG.72
LCA comparison
between the
designed
concept and the
existing one

Stand-ino

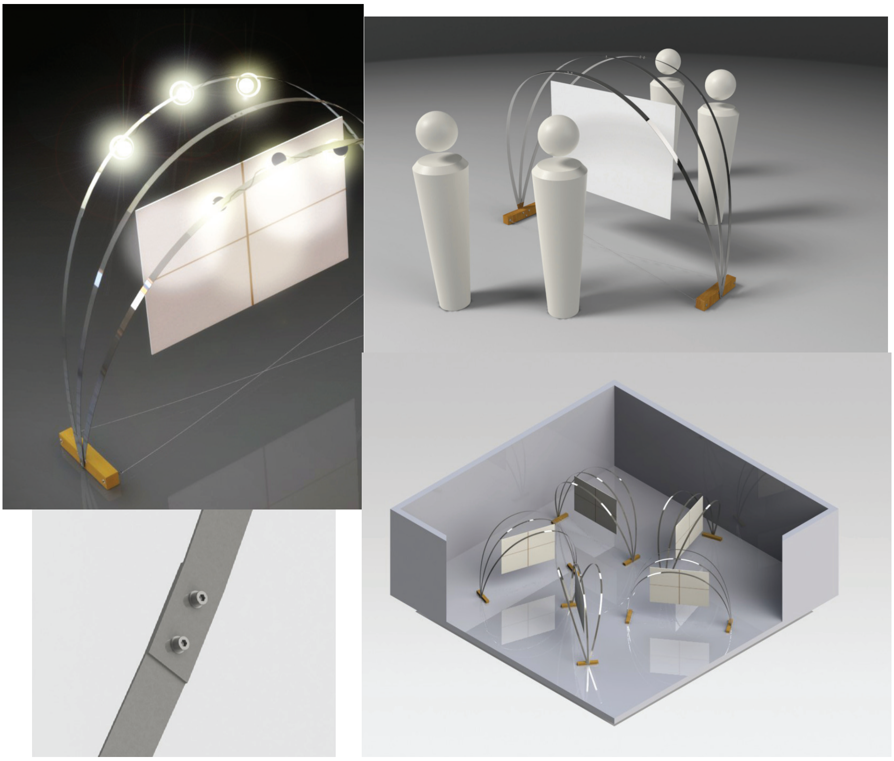


FIG.73
concept render

The module is mainly composed of three spring steel tapes that stand tighter because of two spruce bases. The entire structure is kept in tensions by two crossed steel cables connected with the bases and placed at the same level. The boards are printed on hard corrugated paper (1700x1200mm) and hanged on the central arch by a Nylon wire and Metal rings. The lighting system is composed by six high led technology spots (12W each.) which are located on the external arches and oriented to the central arch.

In fig.75 are shown the comparison charts about the whole life cycle of the new concept (right bar) and the existing product (left bar).
The concepts reduces the environmental impact by more than the 70% compared to the existing system.

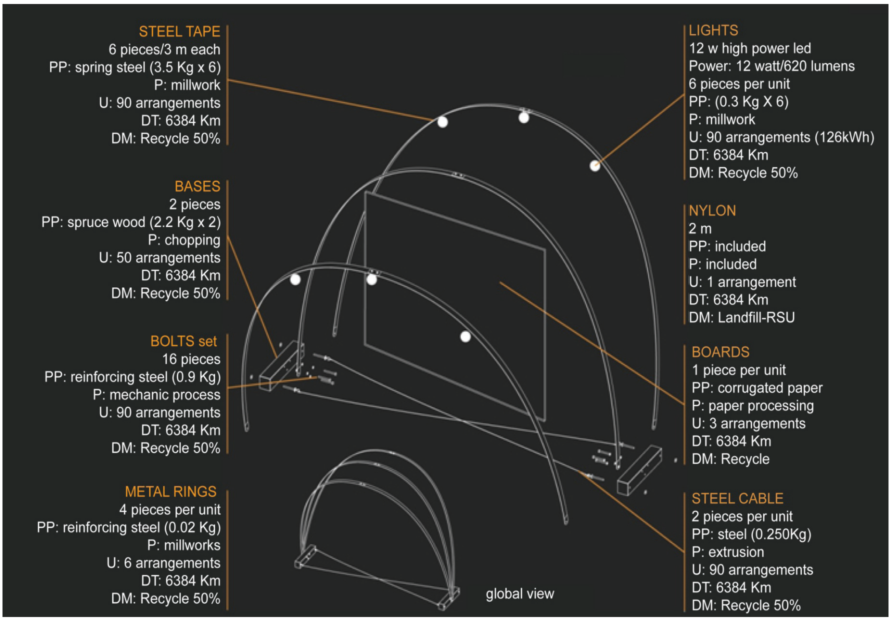


FIG.74
concept LCD
details

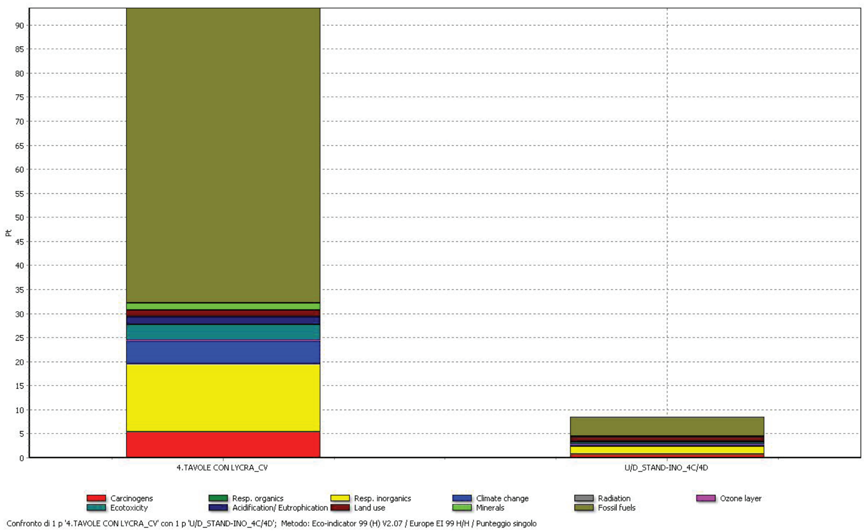


FIG.75
LCA comparison
between the
designed
concept and the
existing one

Show master

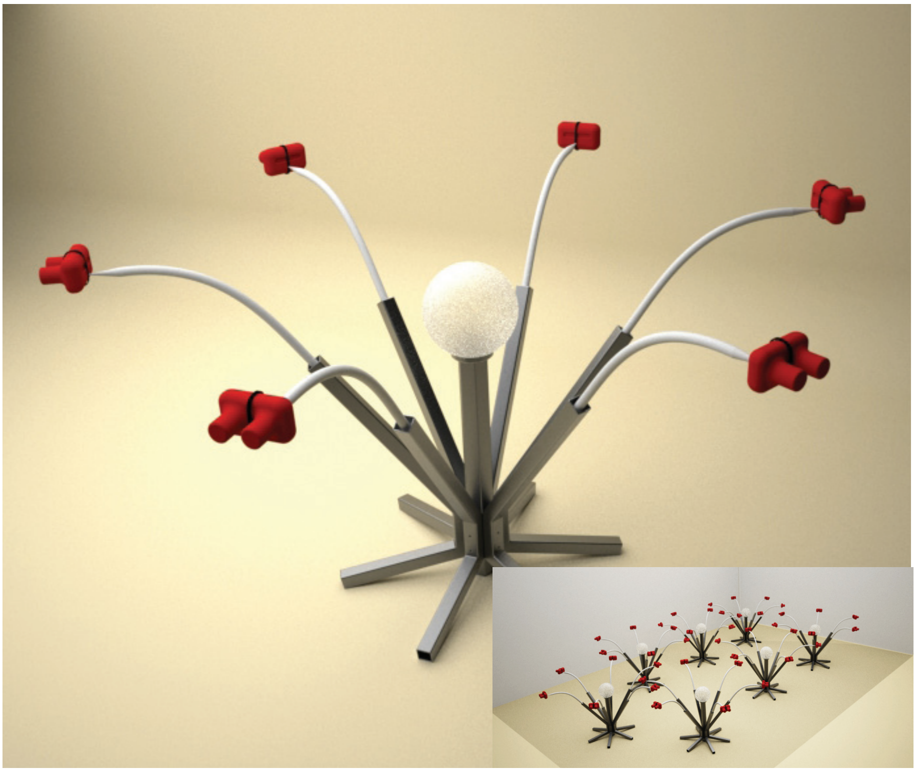


FIG.76
concept render

The showmaster tries out to reduce the environmental impact of the exhibition, where are exposed 40 artboards, size A1, using the View Master.
Main purpose: lower weights and sizes to reduce the high environmental impact of the transport of the old product.

In fig.78 are shown the comparison charts about the whole life cycle of the new concept (left bar) and the existing product (right bar).
In the central bar is shown the LCA result considering the transportation by rail instead than on road.
The concepts reduces the environmental impact by more than the 30% compared to the existing system.

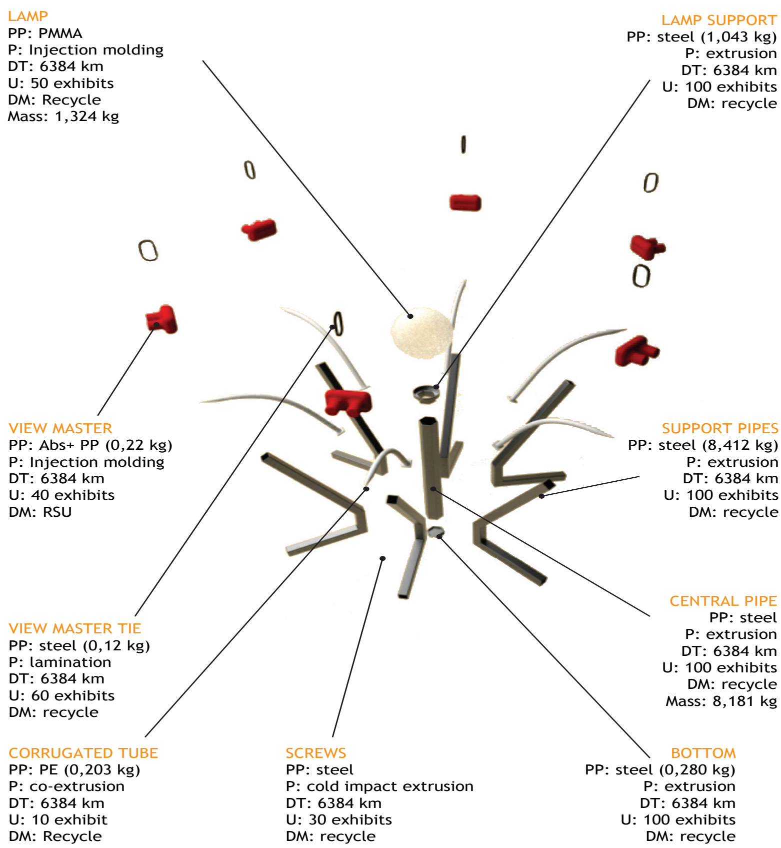


FIG.77
concept LCD
details

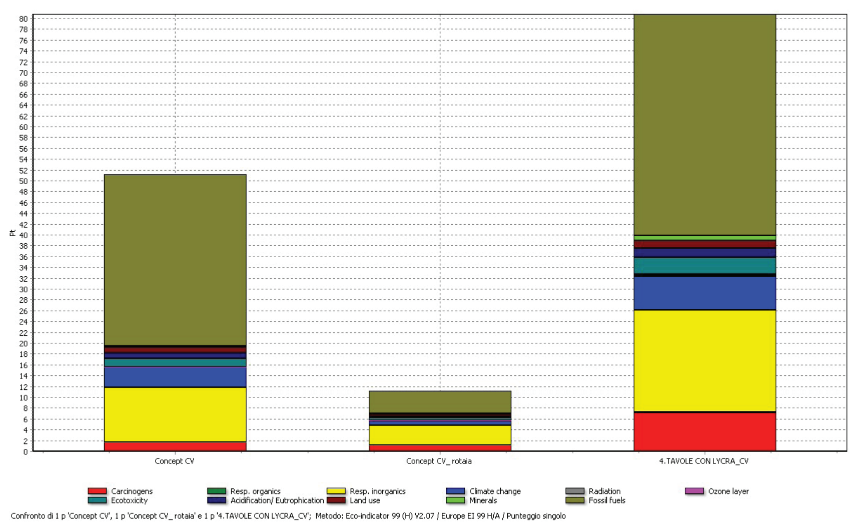


FIG.78
LCA comparison
between the
designed
concept and the
existing one

Fishing rod

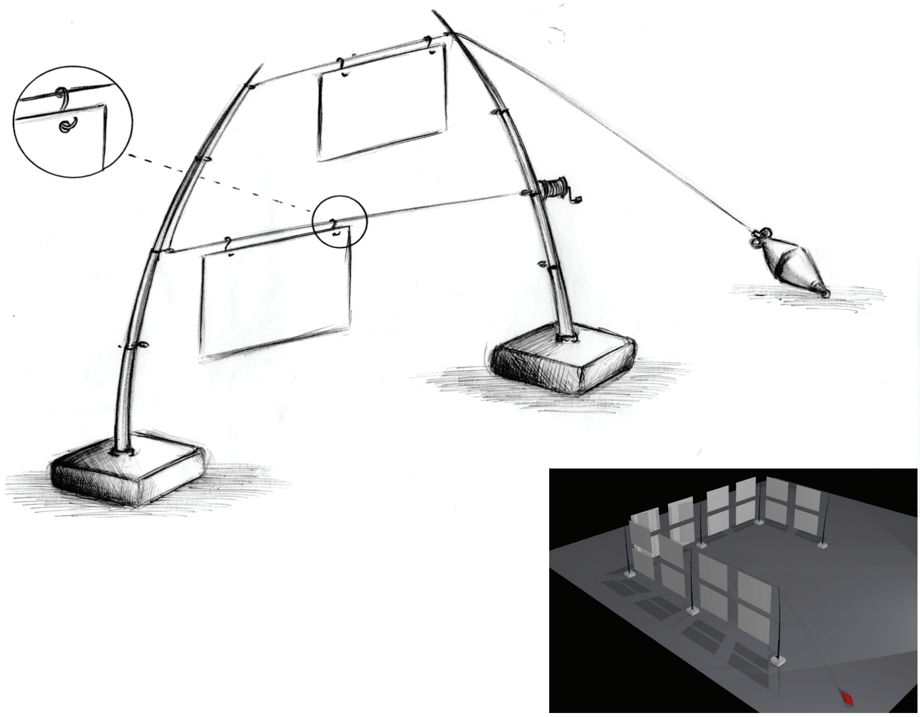


FIG.79
concept render

For the design of the concept it was decided to use elements from the world of fishing. In this regard, the aluminum tubes were substituted with real-bearing rods.
The structure is modular and adaptable to any type of arrangement.

In fig.81 are shown the comparison charts about the whole life cycle of the new concept (left bar) and the existing product (right bar).

The concepts reduces the environmental impact by more than the 40% compared to the existing system.

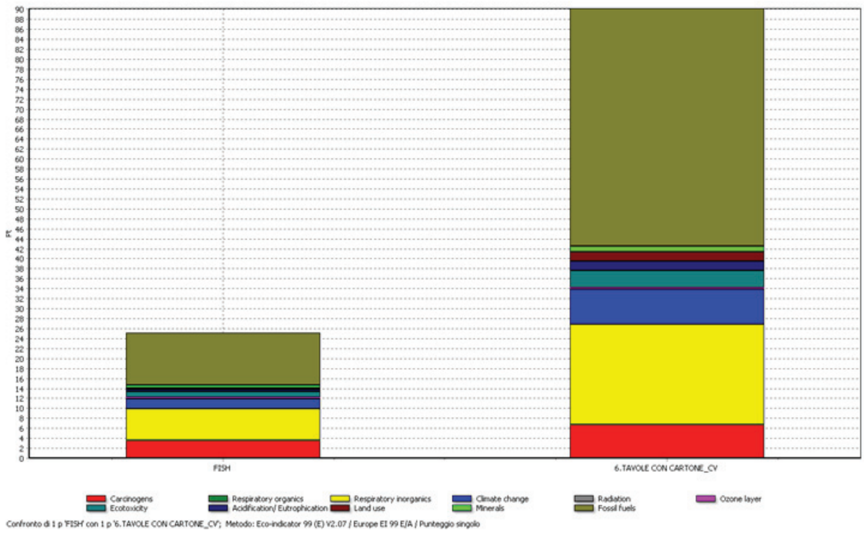


FIG.80
LCA comparison between the designed concept and the existing one

Bender

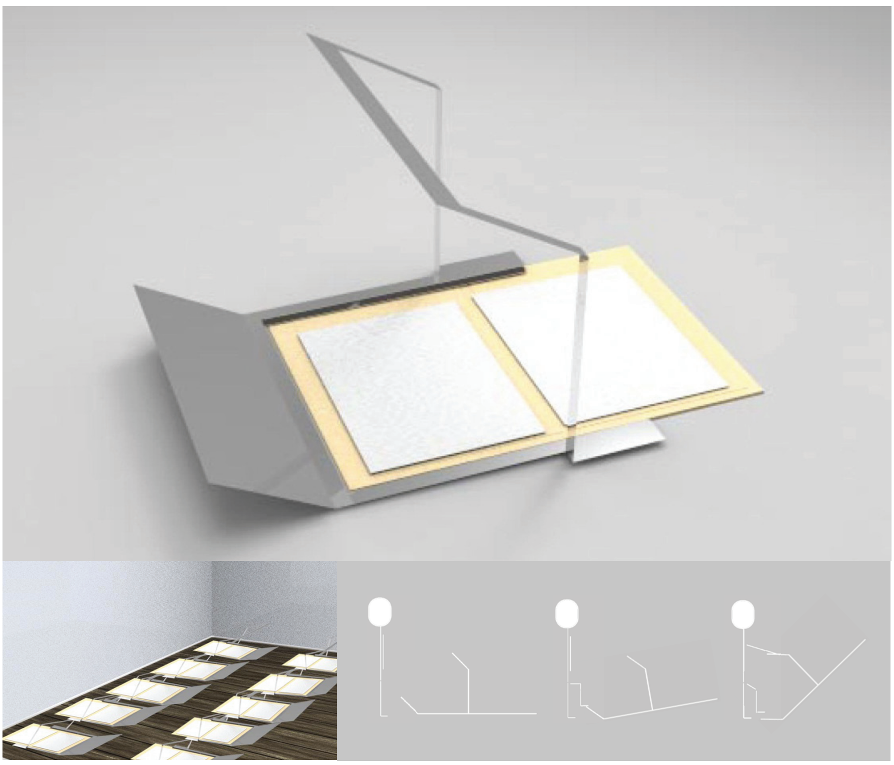


FIG.81
concept render

Bender is an aluminium sheet that visitors can lift with their hands and feet. Bender lies on the ground and it is bent so that visitors can lift it: they push a proper fold in the sheet with their feet and pull the display unit with their arms, in order to watch the tables which are stuck on the unit.
The concept therefore aims to reduce the use of materials and to allow the visitors interaction with the product.
Bender is made of a cut-and-bend sheet and is used as a lever.

In fig.83 are shown the comparison charts about the whole life cycle of the new concept (right bar) and the existing product (left bar).

The concepts reduces the environmental impact by more than the 40% compared to the existing system.

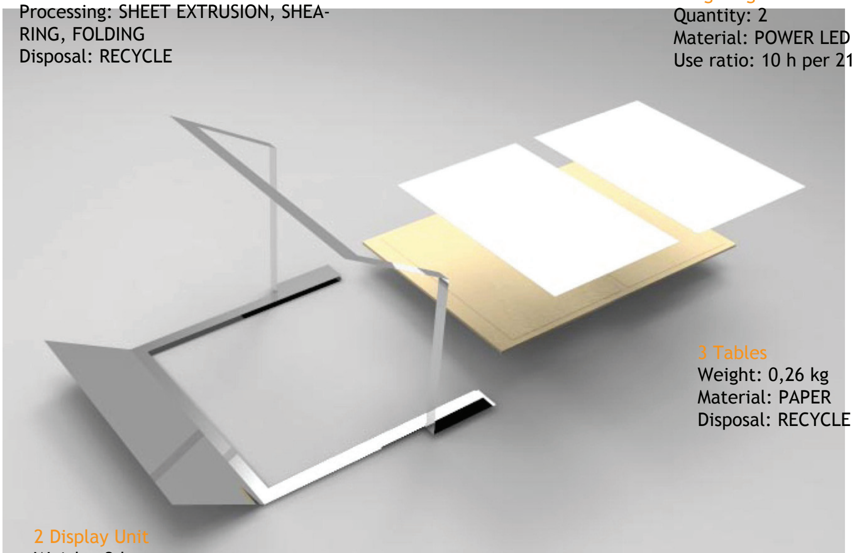


FIG.82
concept LCD
details

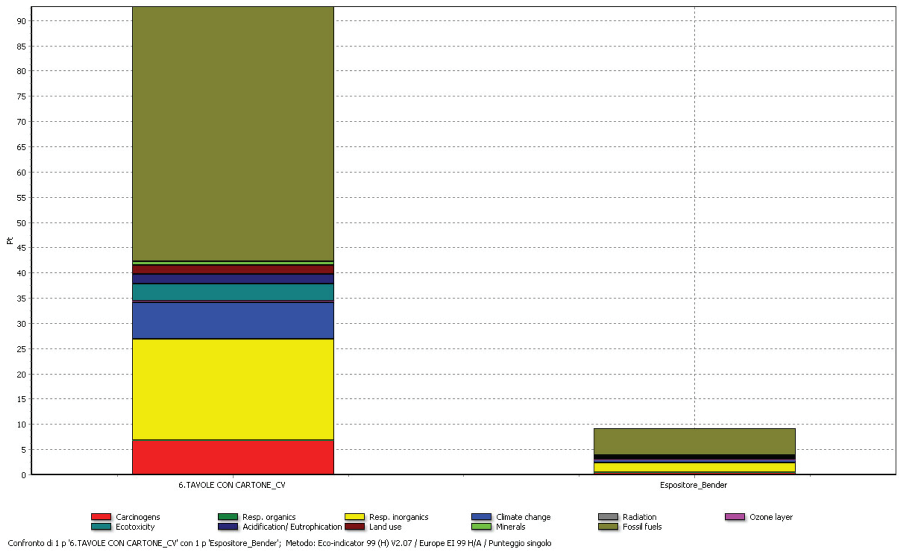


FIG.83
LCA comparison between the designed concept and the existing one

Concepts for a digital exhibition

In this section are listed those concepts designed after the analysis of the modules:

- Projecting system

Triangle

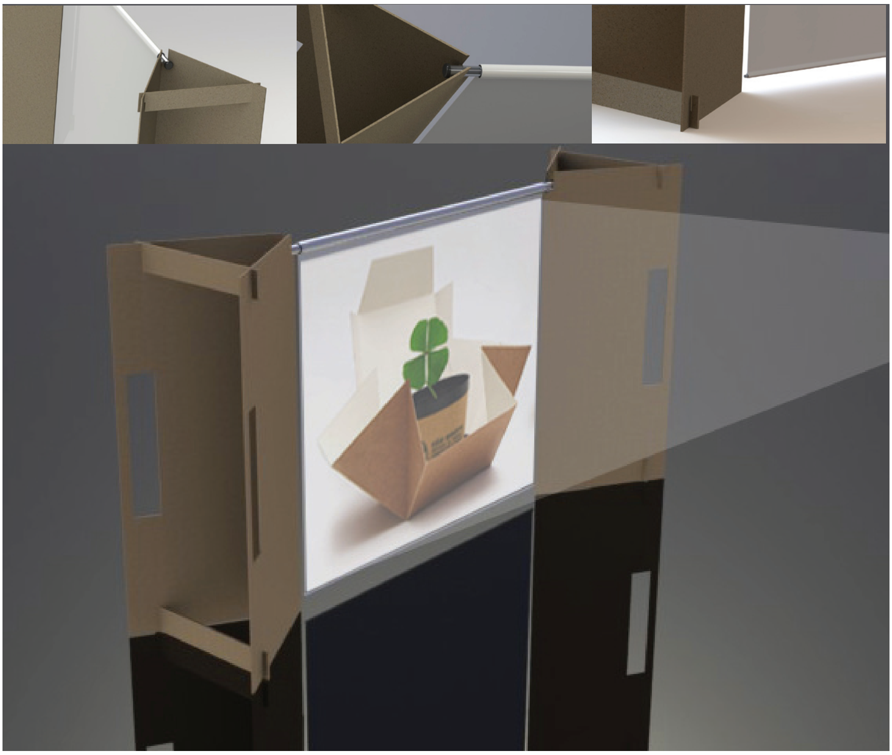


FIG.84
concept render

The structure is intended for bilateral projections on a unique support. the two “sides” of cardboard (1 m long each) are held in place by two strips of cardboard obtained from pre-cuts on the same sheet (the openings thus created can be used to easily move the structure), positioned into suitably threaded holes in the structure.

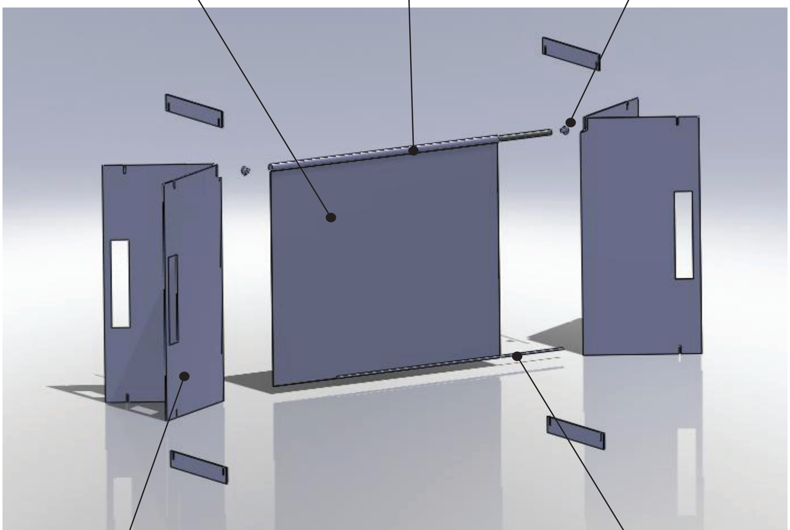
In fig.86 are shown the comparison charts about the whole life cycle of the new concept (left bar) and the existing product (right bar).

The concepts reduces the environmental impact by more than the 20% compared to the existing system.

PVC SHEET
PP: 3 layer PVC (5 Kg approx.)
P: Calendering
DT: 6384 Km
U: 200 times
DM: Recycle

ALUMINIUM TUBE
PP: Aluminium (2,8 Kg approx.)
P: Extrusion
DT: 6384 Km
U: 200 times
DM: Recycle

RUBBER TUBE ENDS
PP: rubber (100 g approx.)
P: Injection molding
DT: 6384 Km
U: 100 times
DM: Recycle



CARDBOARD SHEET
PP: Structural cardboard (10 Kg approx.)
P: Cut in form
DT: 6384 Km
U: 3 Exhibitions
DM: Recycle

ALLUMINIUM ROD
PP: Aluminium (1,8 Kg approx.)
P: Extrusion
DT: 6384 Km
U: 200 times
DM: Recycle

FIG.85
concept LCD details

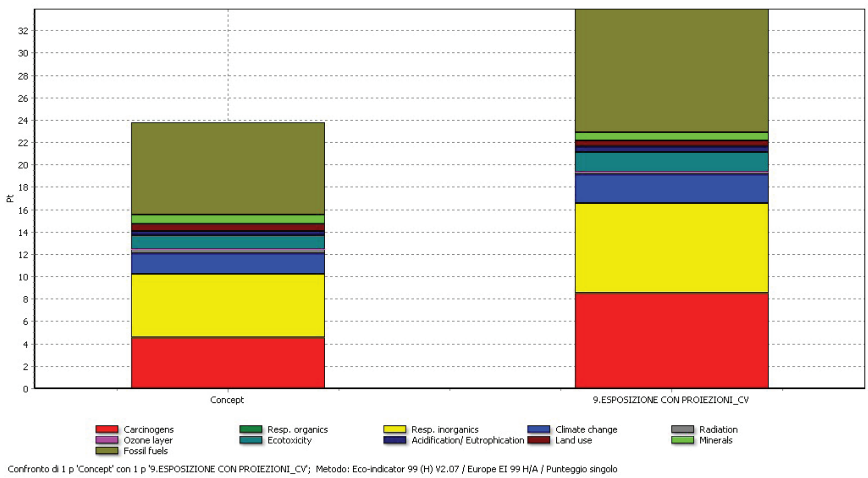


FIG.86
LCA comparison between the designed concept and the existing one

Cross cube

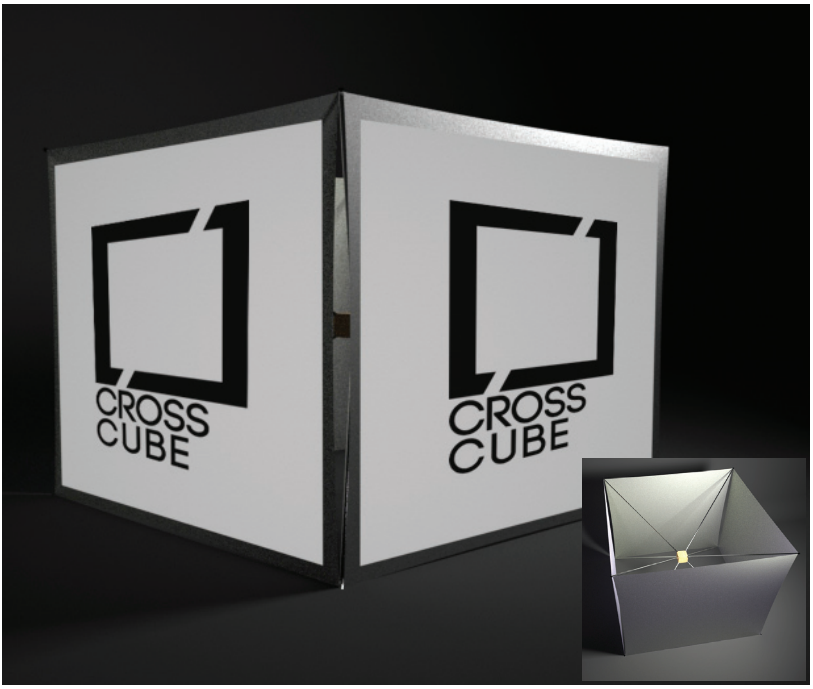


FIG.87
concept render

The structure is made of a poplar parallelepipedon working as structure to support eight aluminium tubes (200x2.5 cm) inserted by 10 cm in wood and extending along its diagonals, with four sheets in lycra fixed at its edges (250x200 cm) due to steel rings.
On each face of the parallelepipedon, the sheets create an "X" structure which turns out to be self-supporting due to the tension applied by the projection sheets.

In fig.89 are shown the comparison charts about the whole life cycle of the new concept (left bar) and the existing product (right bar).
The concepts reduces the environmental impact by more than the 20% compared to the existing system.

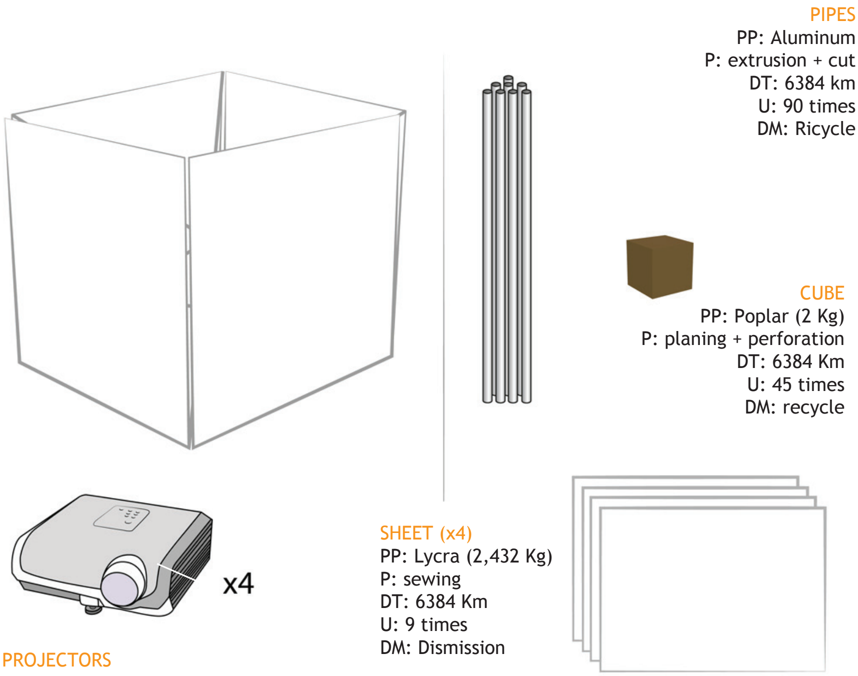


FIG.88
concept LCD
details

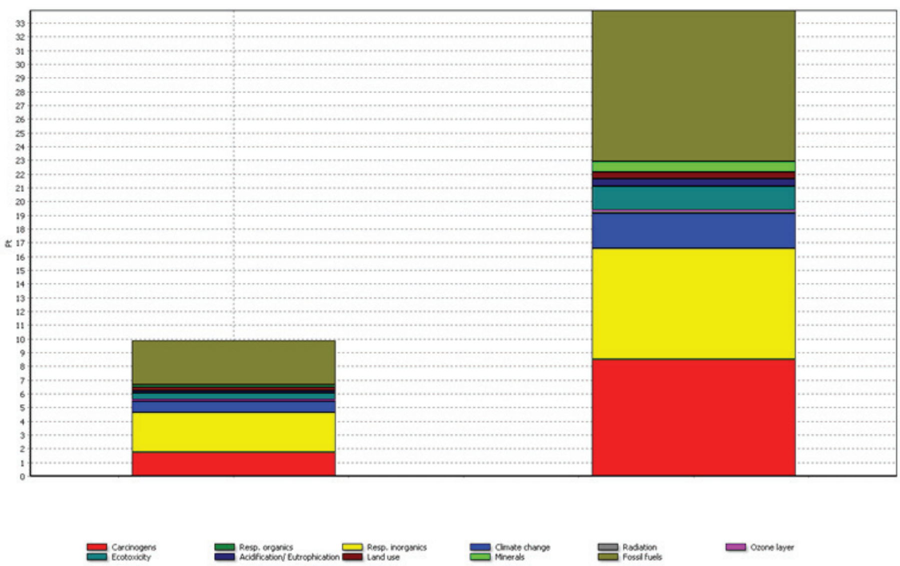


FIG.89
LCA comparison
between the
designed
concept and the
existing one

T-Eco

FIG.90
concept render

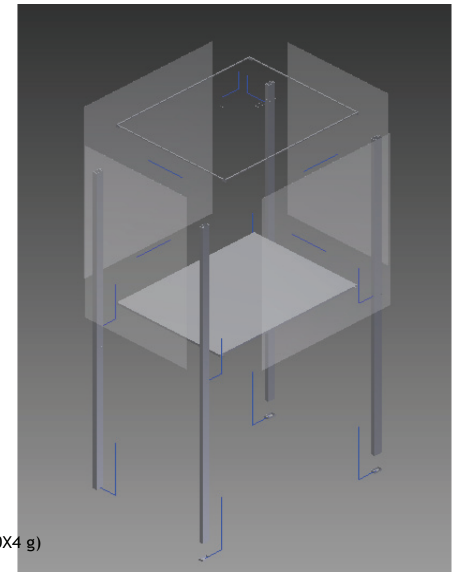
T-eco is a table display showing 3D models.
It is made of birch plywood plane whose held up on four supporting hollow bars in alluminium.
The structure stability is ensured by four bars fitted in the upper part. Four PLA sheet held up on bars and protect the models. T-eco has a low environment impact due to the simple components disassembly, the modularity and the recyclable materials used.

In fig.92 are shown the comparison charts about the whole life cycle of the new concept (right bar) and the existing product (left bar).
The concepts reduces the environmental impact by more than the 80% compared to the existing system.

SCREW HOOKS
PP:STEEL (~5X4 g)
P:EXTRUSION+
THREADING
DT:6384 km
U:200 times
DM:RECYCLE

STABILITY BARS
PP:ALUMINIUM (~50X4 g)
P:EXTRUSION+
BEND
DT:6384 km
U:200 times
DM:RECYCLE

PLAN
PP:PLYWOOD
DI BIRCH (~4000 g)
P:CUT
DT:6384 km
U:150 times
DM:RECYCLE



CARRIER BAR
PP:ALUMINIUM (~600X4 g)
P:EXTRUSION+
HOLING+WELDING
DT:6384 km
U:200 volte
DM:RECYCLE

FEET
PP:SILYCON (~20X4 g)
P:INJECTION MOLDING
DT:6384 km
U:100 volte
DM:RECYCLE

PROTECTION SHEETS
PP:PLA (~0,5X4 g)
P:ESTRUSIONE
DT:6384 km
U:3 volte
DM:RECYCLE + COMPO-STING

SPRING HOOKS
PP:ACCIAIO (~3X32 g)
P:ESTRUSIONE+
PIEGATURA
DT:6384 km
U:30 volte
DM:RECYCLE

FIG.91
concept LCD
details

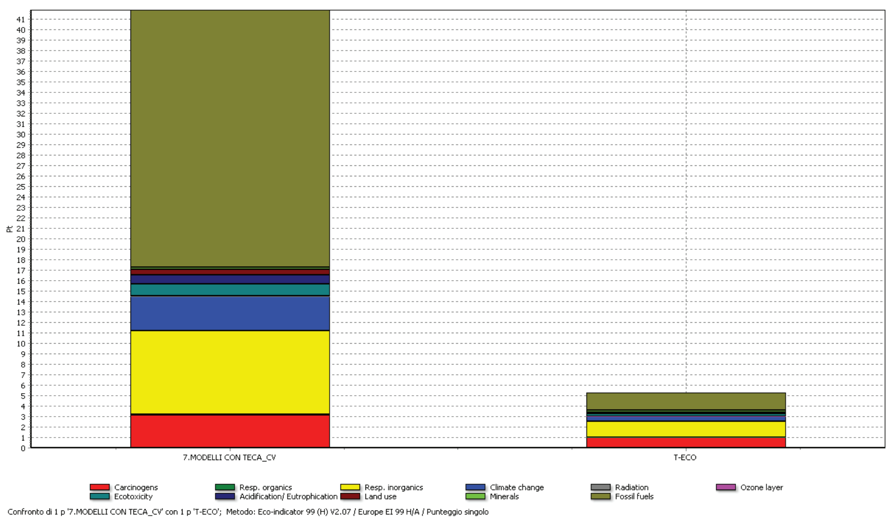


FIG.92
LCA comparison
between the
designed
concept and the
existing one

Sixty

FIG.93concept render

The showcase takes advantage of its special shape and aims to create a psychological barrier between the visitor and the exhibition showcase itself. This barrier is formed due to the lower body of the structure, being extended forward, which keeps the viewer at arm's lenght; to get it to take models the viewer should become unbalanced. The presence of other people at the exhibition joined to the distance imposed by the structure should notlead the visitor to touch the models.

In fig.95 are shown the comparison charts about the whole life cycle of the new concept (right bar) and the existing product (left bar).
The concepts reduces the environmental impact by more than the 50% compared to the existing system.

FIG.94
concept LCD
details

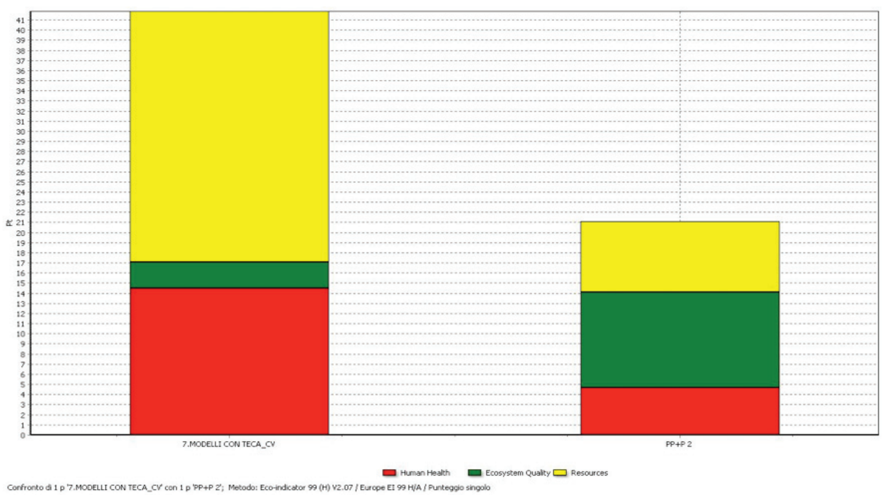


FIG.95
LCA comparison
between the
designed
concept and the
existing one

Tripla hoop

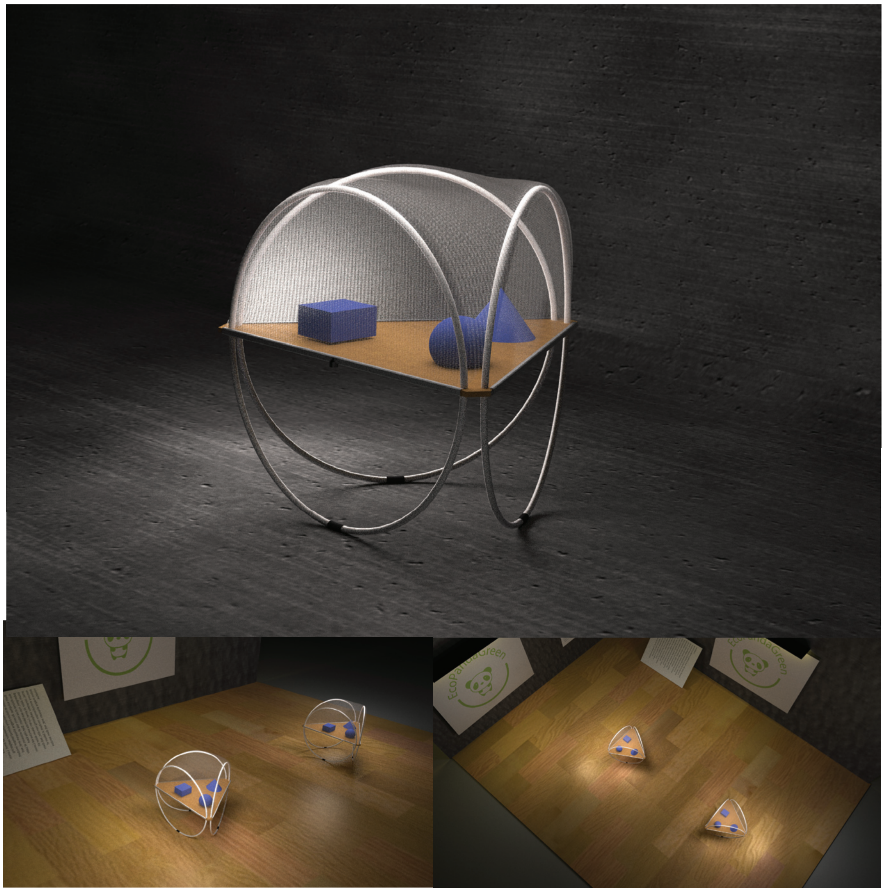


FIG.96
concept render

The counter top is made by a cardboard sheet of triangular shape (side= about 1 metre) with 2 holes next to each angle. These holes allows the intersection of the cardboard sheet with 3 tubes made in polyethylene.

In fig.95 are shown the comparison charts about the whole life cycle of the new concept (right bar) and the existing product (left bar).
The concepts reduces the environmental impact by more than the 90% compared to the existing system.

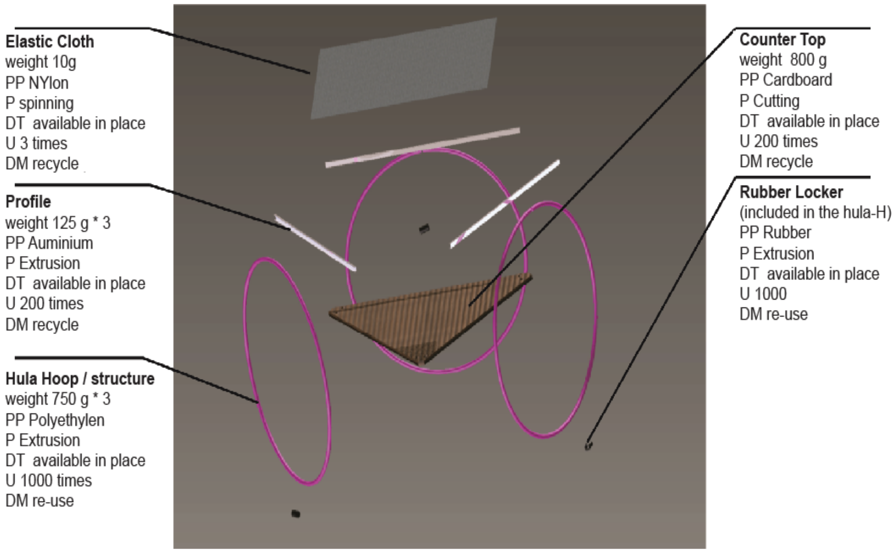


FIG.97
concept LCD
details

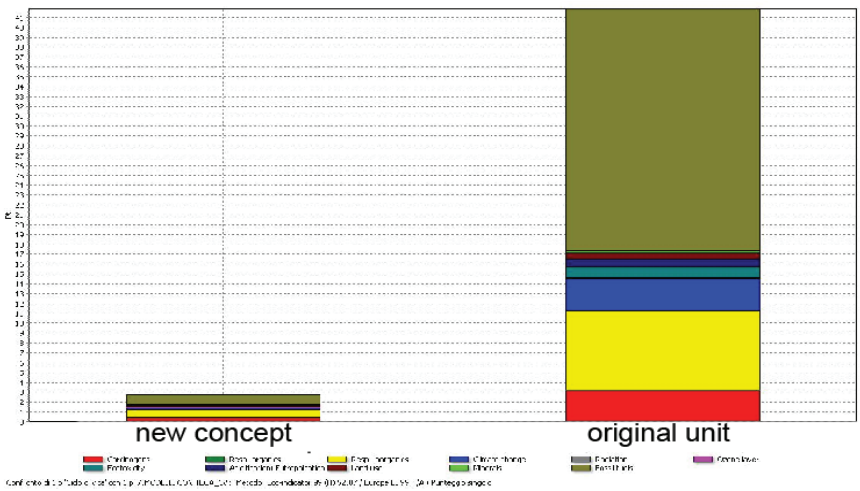


FIG.98
LCA comparison
between the
designed
concept and the
existing one

Concepts for an information facility

In this section are listed those concepts designed after the analysis of the modules:

- Info module with new jersey base;
- Info module with rubber feet;

- Info module with recycled bases.

Modul air

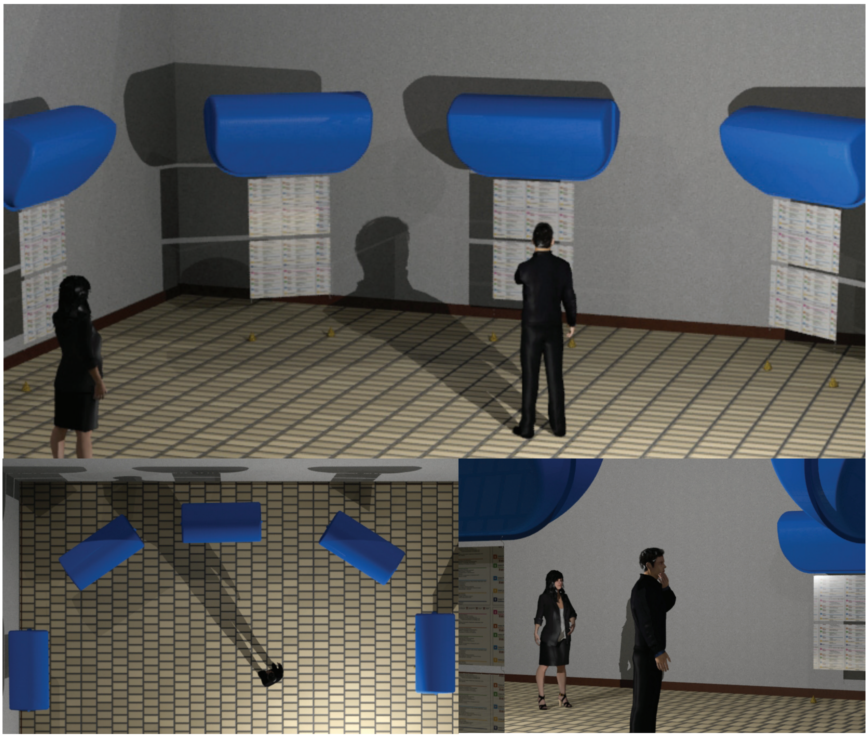


FIG.99
concept render

The basic idea was to dematerialize the «New Jersey» module, creating a super-light and small module, avoiding the use of transportation.

The components are:
-Aerostatic Support (baloon inflated with helium);
-Visual Support (cardboard sheets);

In fig.101 are shown the comparison charts about the whole life cycle of the new concept (right bar) and the existing product (left bar).
The concepts reduces the environmental impact by more than the 80% compared to the existing system.

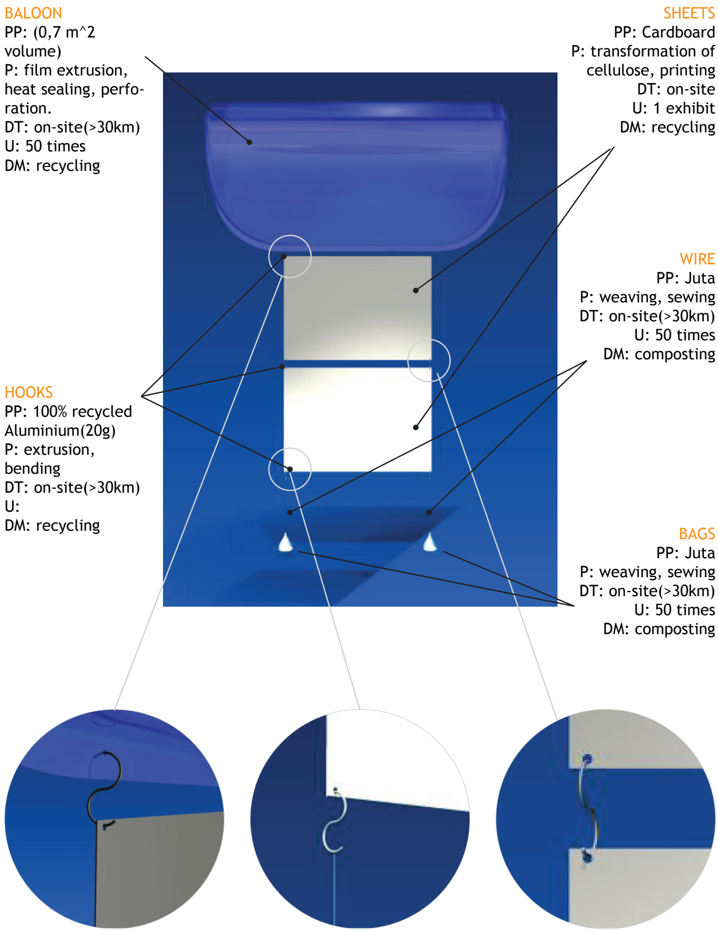


FIG.100
concept LCD
details

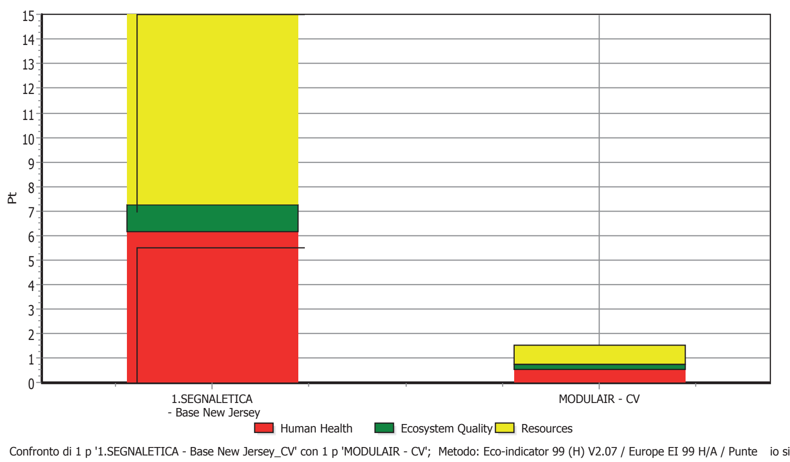


FIG.101
LCA comparison
between the
designed
concept and the
existing one

Spider

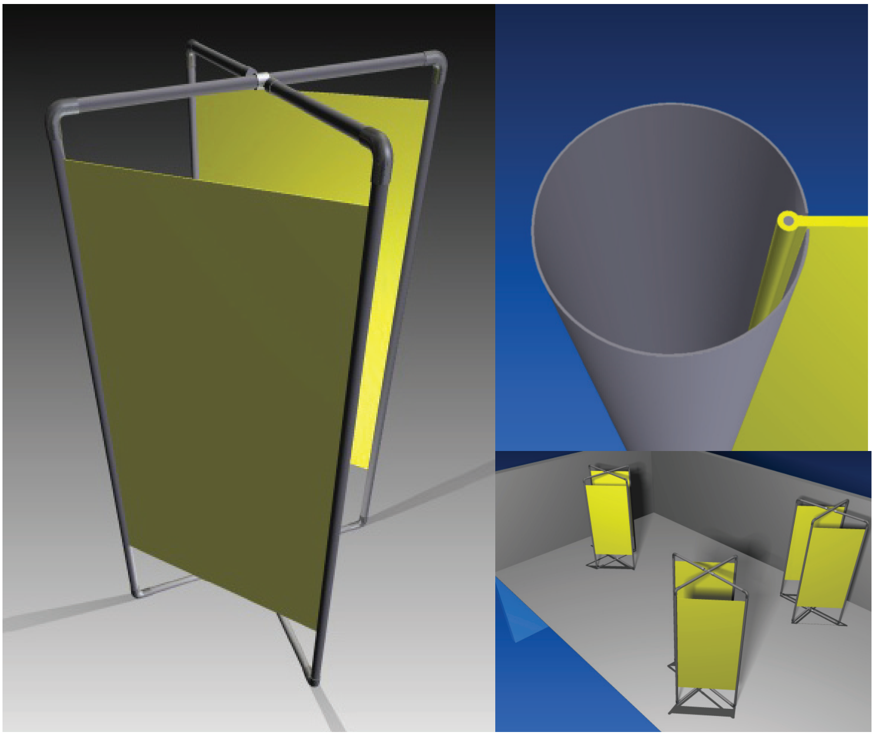


FIG.102
concept render

The concept reduces the number of materials used and a simplifying the transportation.
The New Jersey base has been removed and is now used an alluminium self-supporting framework. Each unit allows to display two sheets, making possible the use of three supports instead of five.
The simplyfied disassembly allows an easier transport.

In fig.104 are shown the comparison charts about the whole life cycle of the new concept (right bar) and the existing product (left bar).
The concepts reduces the environmental impact by more than the 25% compared to the existing system.

BARB
PP: PVC (~0,298 Kg)
P:Iniection moulding
DT: 6384 Km
U: 90 times
DM: recycling

COMBINED JOINT HINGE
DOUBLE IN LINE
PP: Galvanized malleable cast iron (~1,64 Kg)
P: die casting
DT: 6384 Km
U: 90 times
DM: recycling

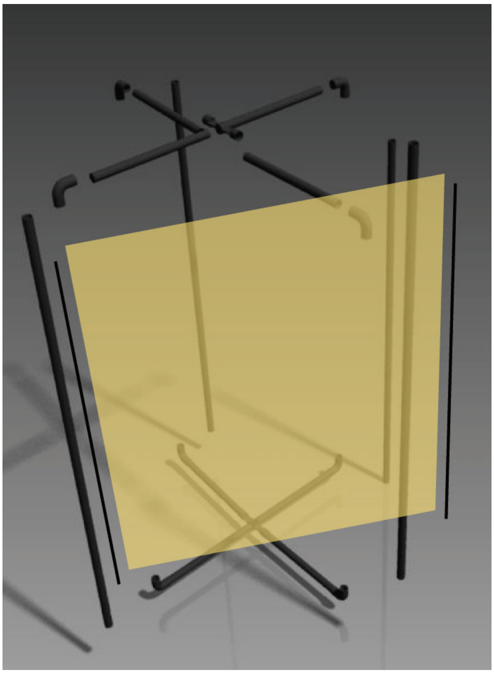


FIG.103
concept LCD details

PIPE1
PP: Aluminium (~1,6 Kg)
P: Extrusion
DT: 6384 Km
U: 90 volte
DM: Recycling

PIPE 2
PP: Aluminium (~0,9 Kg)
P: Extrusion
DT: 6384 Km
U: 90 volte
DM: Recycling

PIPE 3
P: Extrusion
DT: 6384 Km
U: 90 volte
DM: Recycling

SHEET
PP: PVC (~0,94 Kg)
P: Extrusion
DT: 6384 Km
U: 18 times
DM: Recycling

METAL CORE
PP: Iron (~0,0135 Kg)
P: Extrusion
DT: 6384 Km
U: 90 times
DM: Recycling

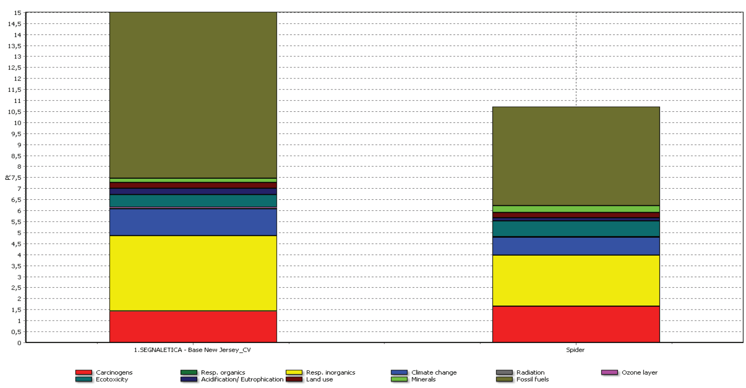


FIG.104
LCA comparison between the designed concept and the existing one

Baloon

FIG.105
concept render

A vertical signposting module that consists in a sheet made of a very light material (flag), printed and supported by a balloon filled with helium, through four nylon threads. The balloon has the same size of the sheet and is placed behind it; it is anchored to the ground with a recycled plastic base and it is connected to it through two of the four nylon threads.
The aim of the project was to lighten the parts and reduce the material needed to realize the object, in order to minimize the environmental impact of production and transport.

In fig.107 are shown the comparison charts about the whole life cycle of the new concept (right bar) and the existing product (left bar).
The concepts reduces the environmental impact by more than the 60% compared to the existing system.

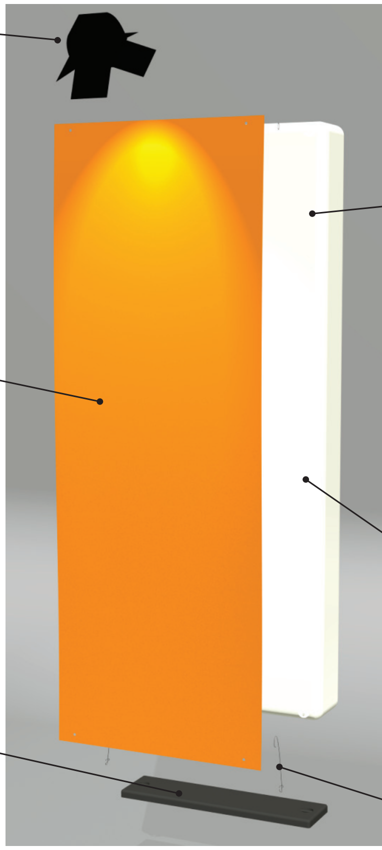


FIG.106
concept LCD
details

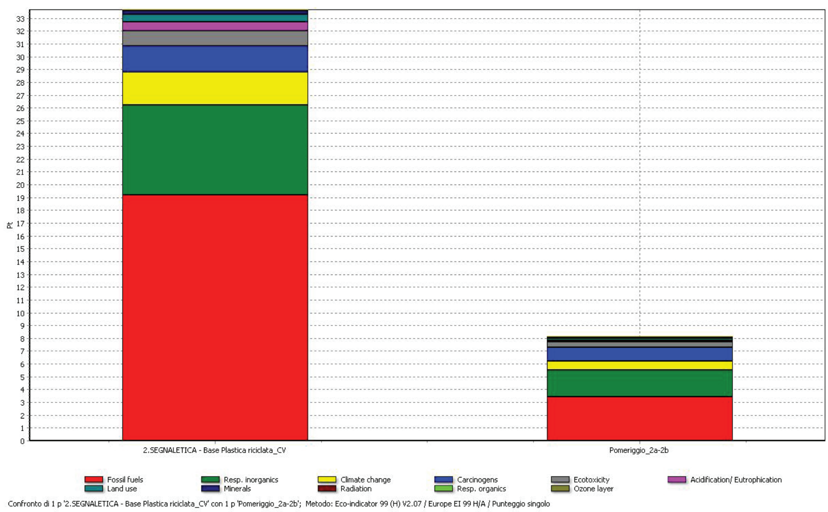


FIG.107
LCA comparison
between the
designed
concept and the
existing one

Monolith

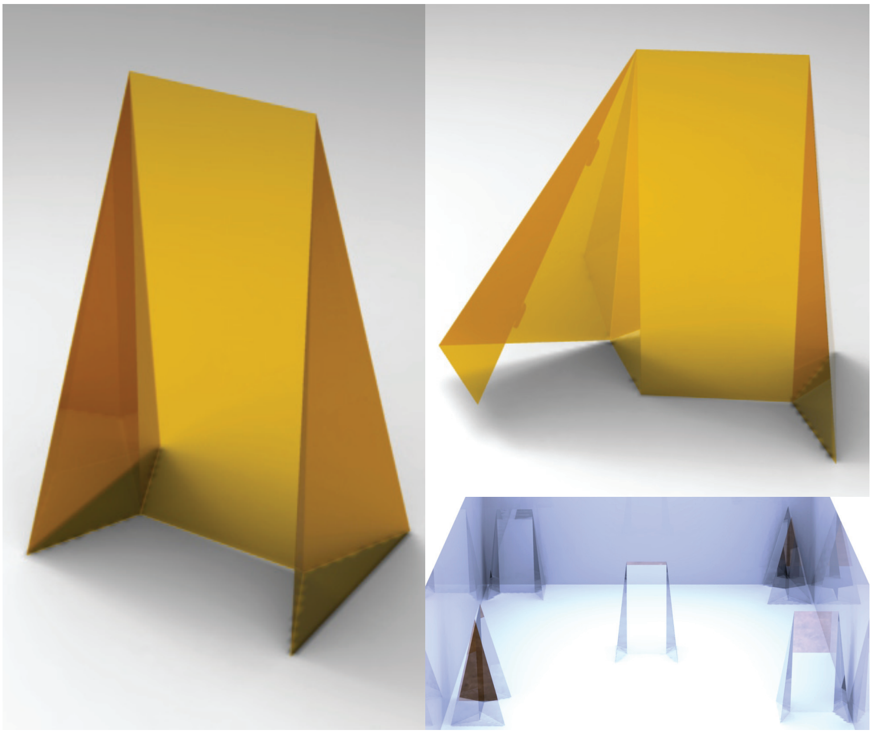
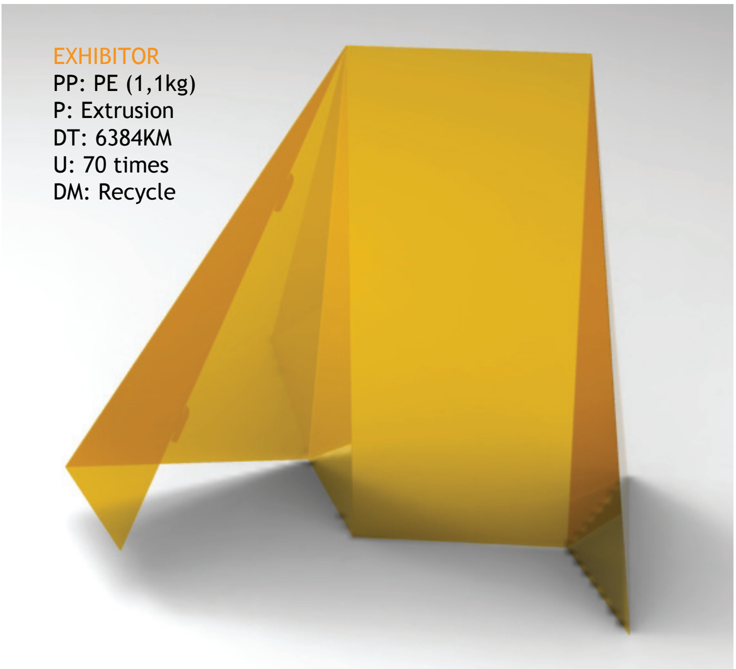


FIG.108
concept render

The joints are made of simple tabs, an easy way to join two different surfaces. The structure is furtherly stiffened by a rib at the top, which allows the display area to remain rigid.
The signal is fixed to the central panel with less complex tabs, which keeps the package "hung".

In fig.110 are shown the comparison charts about the whole life cycle of the new concept (left bar) and the existing product (right bar).
The concepts reduces the environmental impact by more than the 90% compared to the existing system.



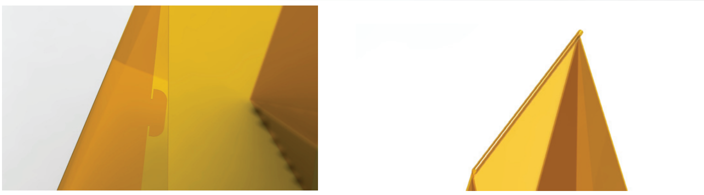


FIG.109
concept LCD
details

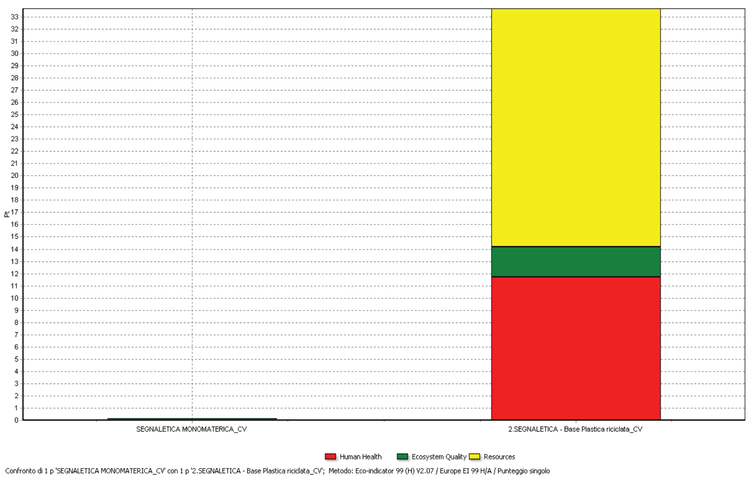


FIG.110
LCA comparison
between the
designed
concept and the
existing one

P-Prisma

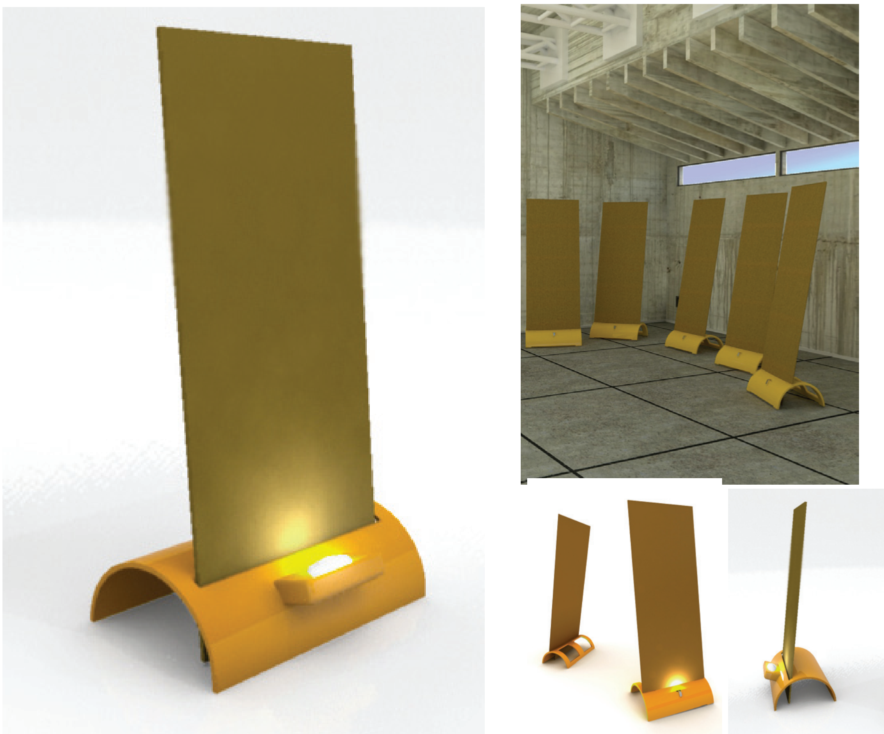


FIG.111
concept render

The module uses PVC pipes (for water supply) which could have different standard dimensions; the one used has the larger diameter of 500 mm and thickness of 9,8 mm.
I was designed a dent where it can be inserted the LED lamp.
The cartboard panel unifies the different parts of the object into a single minimal silhouette and to give more structural material to the PVC pipe avoiding the breaking of the orange pipe where the cardboard is insert.

In fig.113 are shown the comparison charts about the whole life cycle of the new concept (right bar) and the existing product (left bar).
The concepts reduces the environmental impact by more than the 50% compared to the existing system.

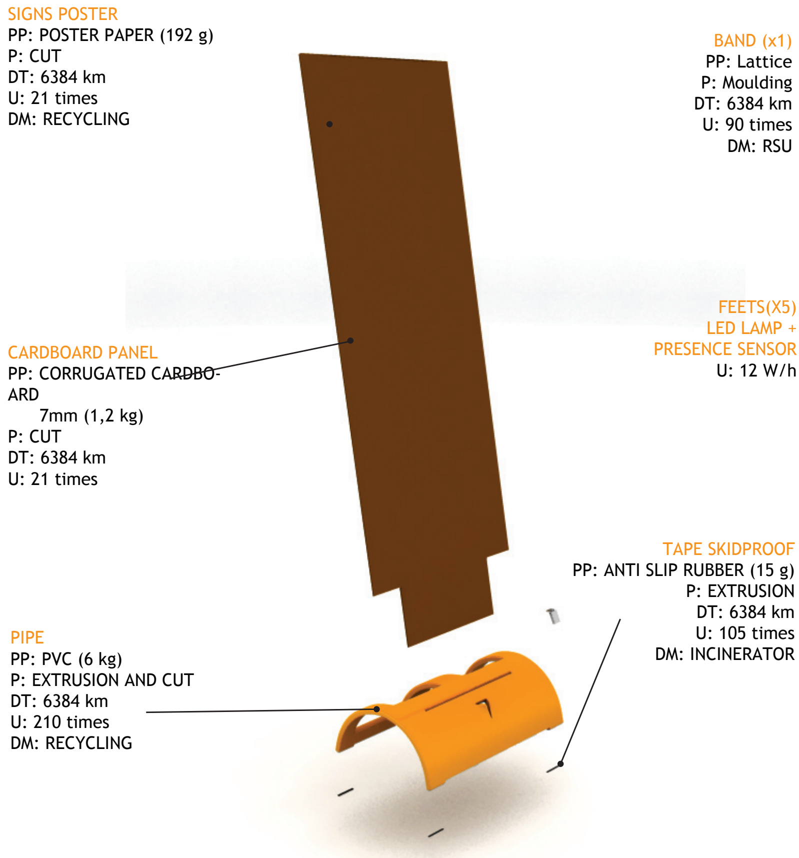


FIG.112
concept LCD
details

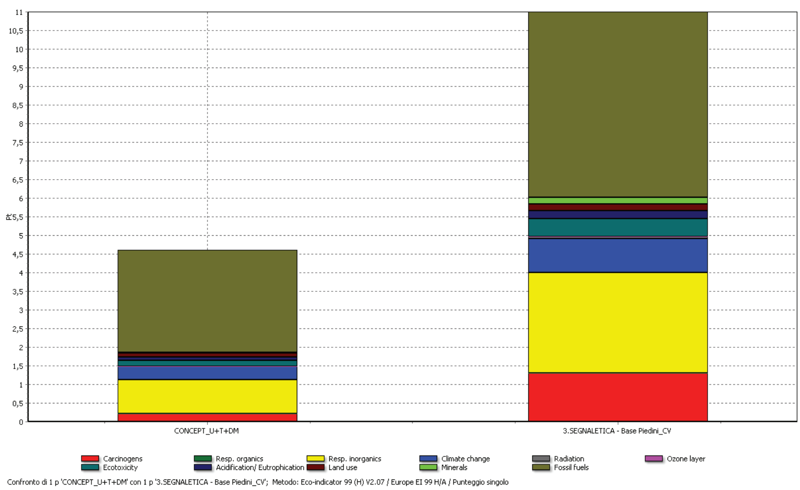


FIG.113
LCA comparison
between the
designed
concept and the
existing one

Bamboo

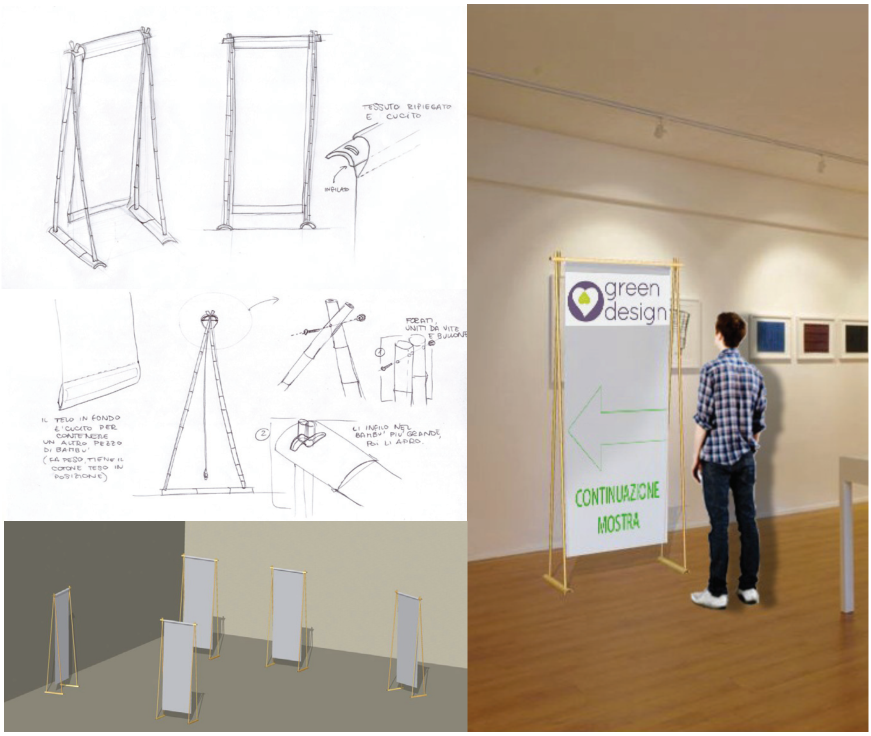


FIG.114
concept render

Bambò is a vertical made of natural materials, except screws and nuts. The structure is formed by two vertical poles wedged into a base for both sides, and fixed on top to an horizontal pole with screw.
A printed cotton sheet is hung on the horizontal pole and made stretched by a bamboo pole, placed inside.

In fig.116 are shown the comparison charts about the whole life cycle of the new concept (right bar) and the existing product (left bar).
The concepts reduces the environmental impact by more than the 60% compared to the existing system.

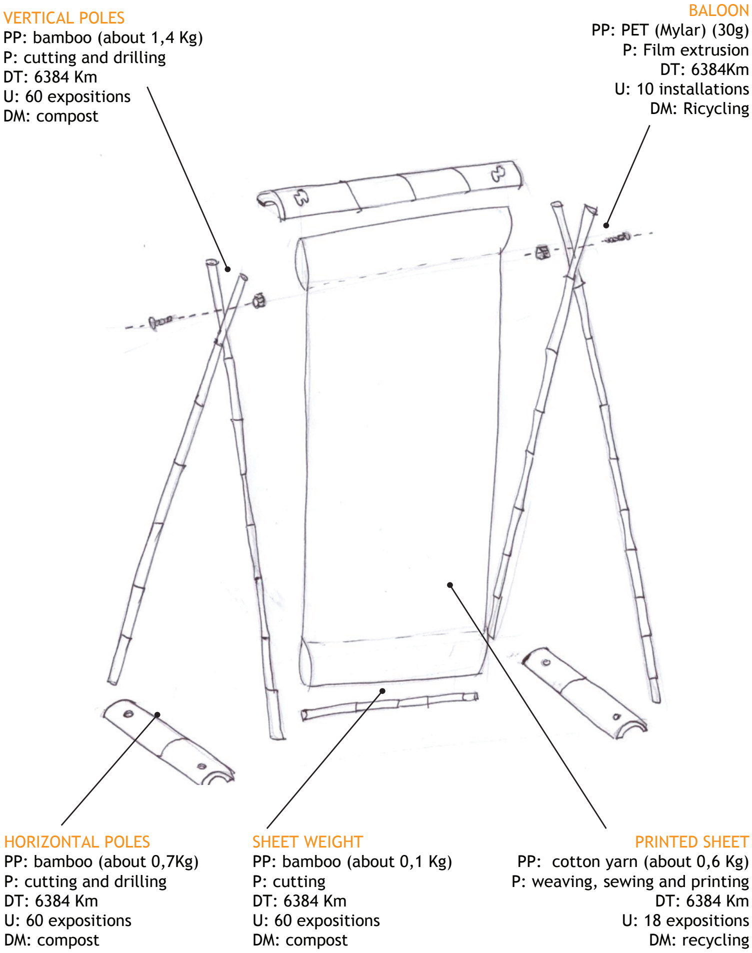


FIG.115
concept LCD
details

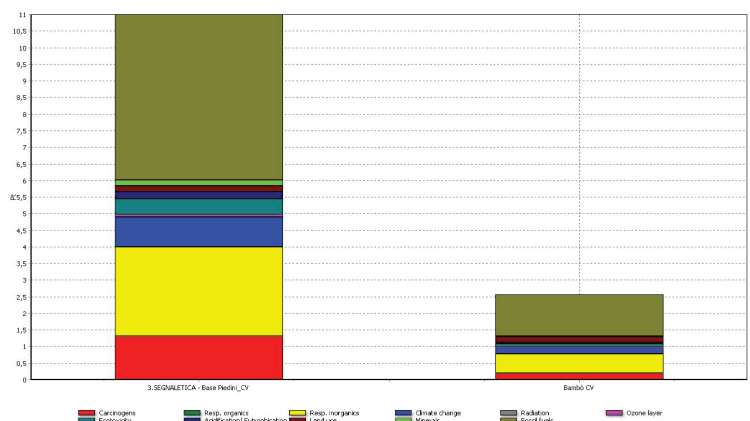


FIG.116
LCA comparison
between the
designed
concept and the
existing one

Bilbao

FIG.117
concept render

This design offers support to the exibition using less material possible.
It's composed by an hollow recycled plastic base and a panel.

In fig.119 are shown the comparison charts about the whole life cycle of the new concept (left bar) and the existing product (right bar).
The concepts reduces the environmental impact by more than the 70% compared to the existing system.

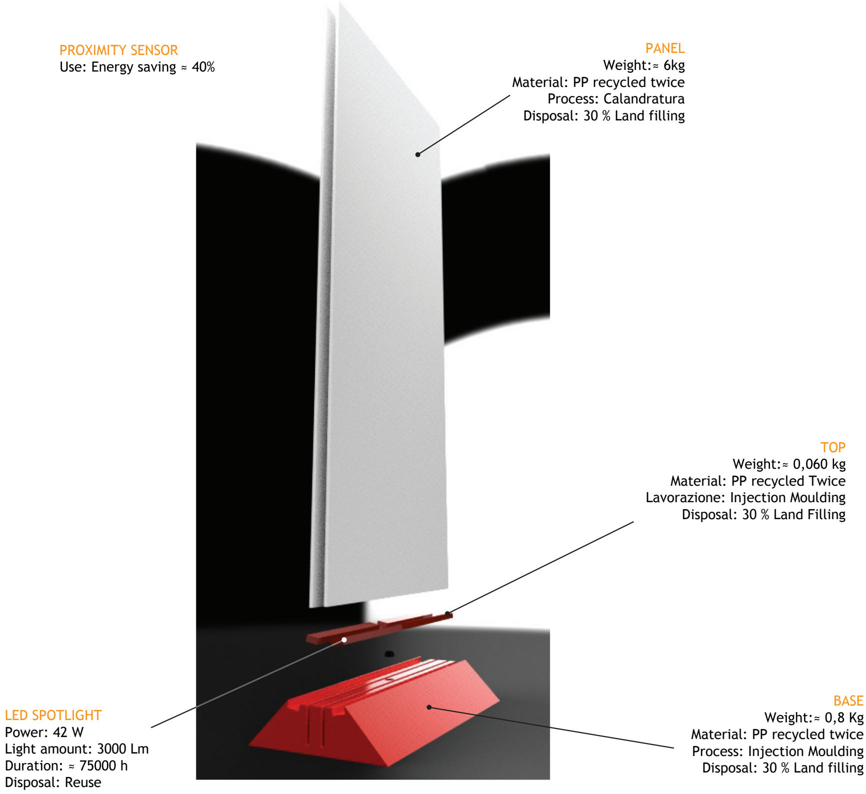


FIG.118
concept LCD
details

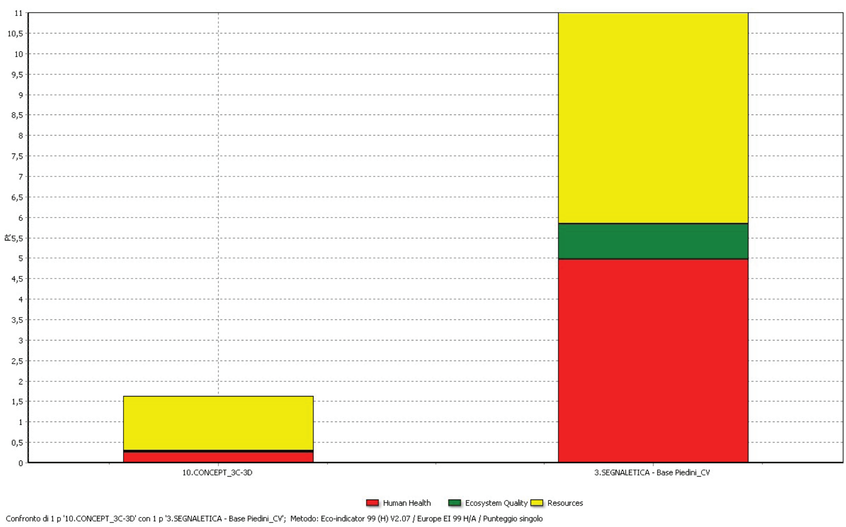


FIG.119
LCA comparison
between the
designed
concept and the
existing one

Concepts for a reception desk

In this section are listed those concepts designed after the analysis of the modules:

- reception desk

Woody

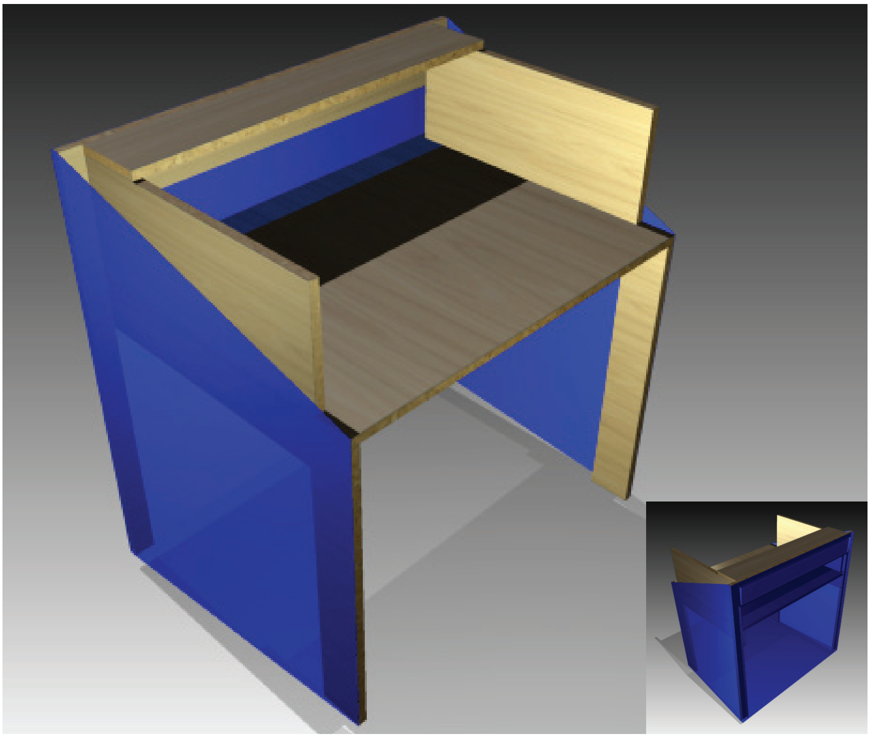


FIG.120
concept render

The production processes create as less swarfs as possible. The covering cloth is made of ecologic cotton and it can be filled with event's logo/info. The drawer is integrated on the reception, creating several needled nests in the upper side of the frontal part, in order to put brochures and flyers directly on the reception. Nontheless there will be a QR code beneath the pockets, to make smartphones able to download depliants and flyers in digital content.

In fig.122 are shown the comparison charts about the whole life cycle

of the new concept (left bar) and the existing product (right bar).
The concepts reduces the environmental impact by more than the 80% compared to the existing system.

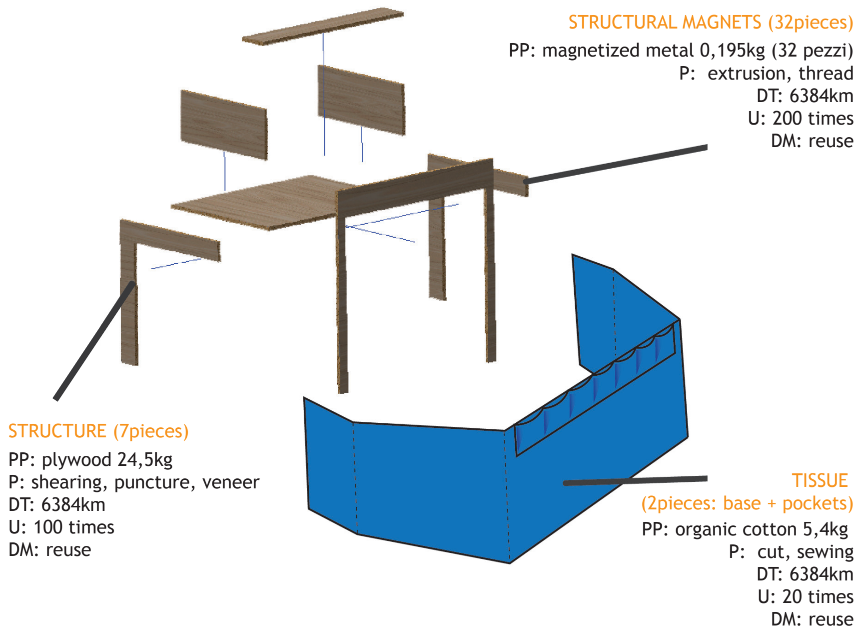


FIG.121
concept LCD details

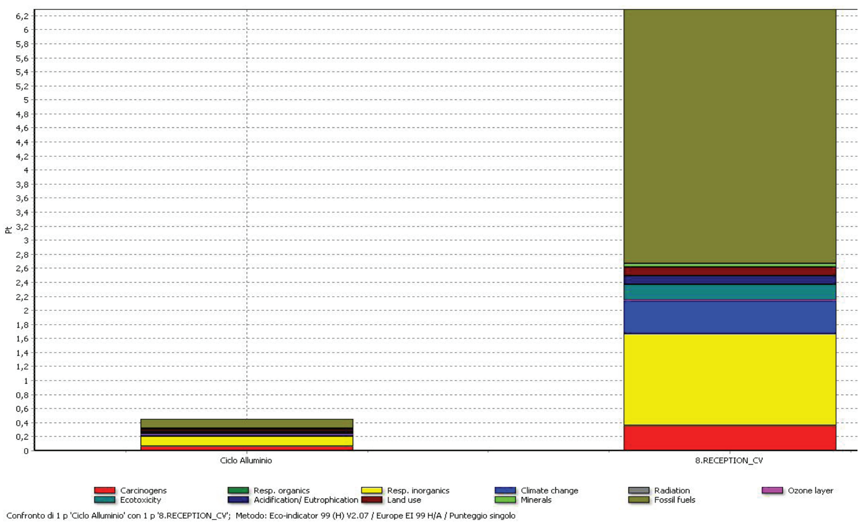


FIG.122
LCA comparison between the designed concept and the existing one

Desky

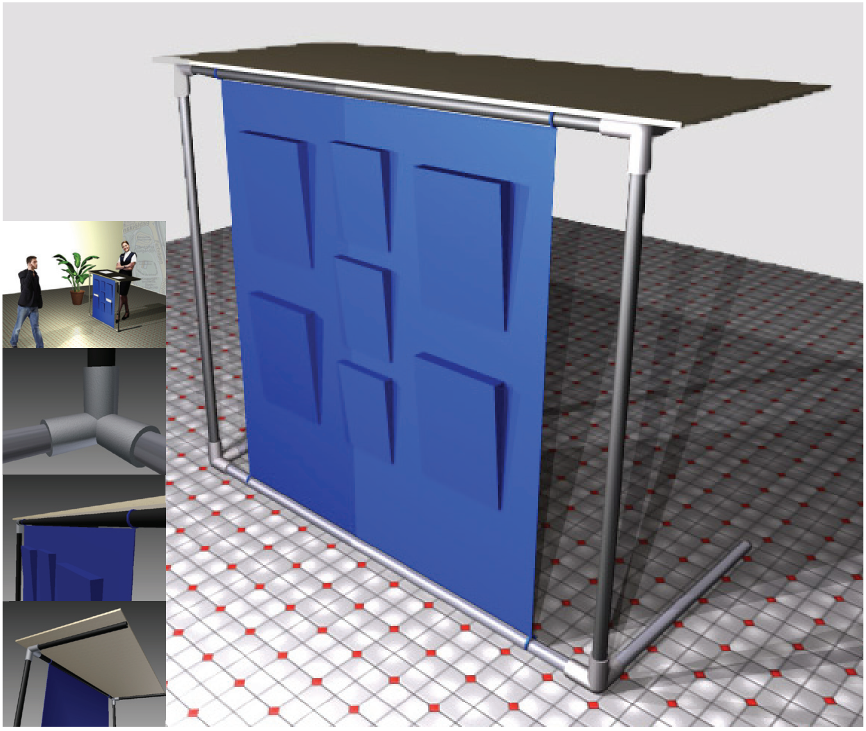


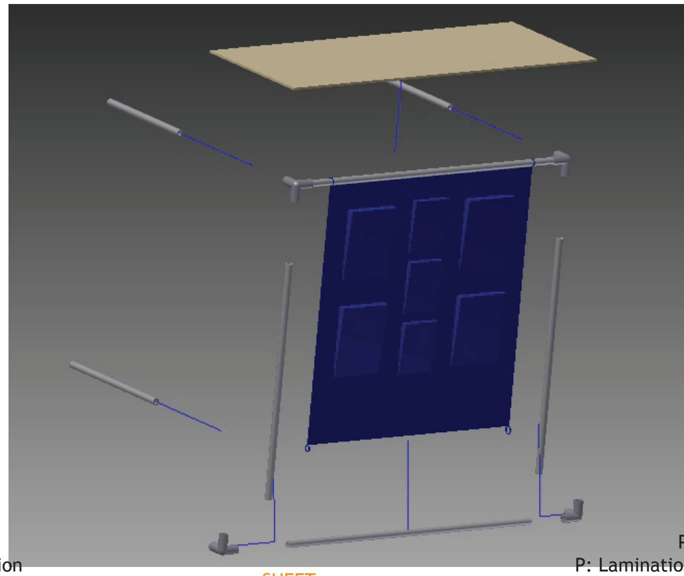
FIG.123
concept render

The concept aims to minimize the amount of materials used, reducing the total weight of the object resulting in a minor impact in transportation.
The table top consists in a plywood board which slides over the pipes to prevent its tilting.
Moreover, it was integrated the exhibitor into the desk due to a sheet of PE fabric which includes a number of pockets to display paper and brochures. This is fastened to the structure through bands which slides into the pipes.

In fig.125 are shown the comparison charts about the whole life cycle of the new concept (left bar) and the existing product (right bar).
The concepts reduces the environmental impact by more than the 80% compared to the existing system.

PIPES
PP: Aluminum
P: Extrusion
DT: 6384 km
U: 120 times
DM: Ricycle

SIDE OUTLET TEES
PP: Aluminum
P: Die Casting
DT: 6384 km
U: 120 times
DM: Ricycle



PIPES
PP: PVC
P: Extrusion
DT: 6384 km
U: 99 times
DM: Ricycle

SHEET
PP: PE
P: Weaving
DT: 6384 km
U: 50 times
DM: Ricycle

TABLE TOP
PP: Plywood
P: Lamination + Bonding
DT: 6384 km
U: 99 times
DM: Ricycle

FIG.124
concept LCD
details

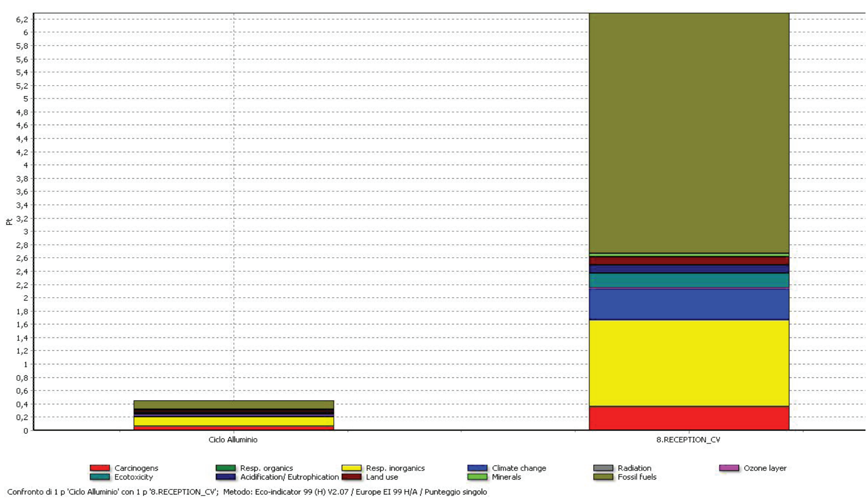


FIG.125
LCA comparison
between the
designed
concept and the
existing one

CONCEPT DESIGN

Selection of the most promising concepts

A selection of some interesting design ideas included in the concepts presented in the previous pages are highlighted here.
Even if not they are not yet completely feasible and in need of further development and refinement, they can be used as cues to stimulate the definition of the brief for the design of the sustainable travelling exhibition for the TANGO project, that will be presented in the next chapter.

The first two selected concepts go towards the reduction of materials in exhibition elements for posters or signals.
Stand-ino[27] takes advantage from the design of a bigger structure (with a reduced use of materials) where concepts can be exposed on both sides.

Likewise, the Fishing Rod[28] exhibition system reduces consistently the materials used for the structure, using both sides for exhibition.
The strings and the vertical poles of the Fishing Rod result as a minimalist functional structure where the contents to be exposed can be hanged on.
Interesting solutions are included in this stringy concept:

- the support structure just strains when the structure is assembled;
- the modules could be easily folded, so to take up a minimum space when not used;
- the overall structure weight is kept down.

In both cases the issues related to the structure reliability have to be further investigated, since at the moment they do not look really robust.

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27 see pages 120, 121
28 see pages 124, 125

The next two concepts present an interesting option to dematerialize the exhibition, with a lightweight structure made by few components. The ModulAir[29] and the Balloon concepts tend to dematerialize the module to hang info signals, using a balloon inflated with helium to build the element structure. Having helium inside the balloons, instead of simply air, allows the signals to stay suspended in the air.

Further in-depth examinations may be considered for the ModulAir concept in order to verify that the size of the balloon and the quantity of helium are enough to allow the weight of the cardboard sheets to stay suspended.
In the Balloon[30] concept, the upper structure is fixed to a plastic base, in this way the weight issues are partially cleared up.

The Monolith[31] concept consistently reduces the number of materials used. The mono-material module is easy to be produced, to be transported (flat), and to be assembled (there are no added joints such as screws).
Being made by only one material, the module does not have to be disassembled during the disposal phase to separate materials that have to join different waste flows.
This concept presents a really simplified product, which can be intuitively assembled from anyone, without the need of technical support.

However, the full plastic panel build a heavy structure, which can probably be lightened by designing it further. Other analysis may also be made in order to verify the actual resistance of the fixing folded parts.

The last selected concepts are about the reduction of the electricity

29 see pages 138, 139
30 see pages 142, 143
31 see pages 144, 145

consumption during the use phase, in particular the one related to lightning.

The Piezoelectric concept[32] uses the piezoelectric technology applied on floor tiles: while the guests are visiting the exhibition and stepping on these special tiles, they are giving energy to supply the lightning of the modules.

In this last case, the use of the piezoelectric technology must be examined in-depth in order to verify how the different components of the module could interact.

Most promising strategies

The most important outcomes of the various LCAs (both on a single module level and on a whole exhibition level) and the most promising developed concepts were used to define the requirements and the most promising strategies to design the environmentally sustainable TANGO travelling exhibition, i.e. to define the design brief from an environmental point of view as a contribution to the overall design brief of the TANGO exhibition.

For all of the three different types of exhibitions transportation is highly impacting, suggesting to design for locally-based exhibition kits.
In this framework a video based exhibition may represent a promising modality, enabling the digital transportation of the contents (the concepts).
Nevertheless the results emerging from the LCA comparison of three different types of exhibition (from mostly paper based to mostly video based) shows that the dematerialization throughout digitalization (i.e. presenting the concepts of sustainable social innovation with videos instead of printed paper posters) does not necessarily represent the most environmental sustainable solution per se, mainly as a

32 see pages 118, 119

consequence of the high consumption of electricity in use. That means that a digitally travelling
exhibition needs to be designed minimizing the energy consumption (per functional unit) and/or selecting low impact and renewable energy.

Durability is a key for the eco-efficiency (i.e. at the same time economic and environmental sustainability) of the exhibition system. It is in fact, to some extent, already pursued throughout adaptability of the different mounting systems; being a key strategy for both the environmental and economic sustainability, it need to be further and more deeply pursued. Within this framework material minimization (without compromising nor durability neither selecting materials with higher environmental impact per functional unit) is a strategy worth to be followed with high margin of improvement, till the limits to have a "wire-shaped" sort of structure.

Even if it is not a design priority to reduce the environmental impact, design for material life extension, throughout recycling, energy recovery or composting could be followed.
Finally, it is of key importance to see the design of the low impacting exhibition system for the TANGO project to be re-usable even after the three TANGO events (in Milano, Helsinki and Nantes). Better still, TANGO project could be seen as the right opportunity to come out with a new generation of highly eco-efficient exhibition systems within the three partner universities (Politecnico di Milano, Aalto university and L'École de design Nantes Atlantique). In fact, design universities are places where students' projects exhibitions always occur, and for this they usually have their own exhibition systems. These exhibition systems after the TANGO project could be the same that
TANGO project has designed with a very low environmental impact. Whatever other design requirements for the TANGO exhibitions are, all these considerations lead us to formulate the following design brief for what concern the environmental sustainability of the exhibition.

New design brief

Design a highly adaptable and long lasting exhibition system to be used at first by the TANGO exhibitions, and then to replace less environmentally sustainable exhibition systems used within the three universities.
The exhibition needs to be usable for a video based, paper based and/or model based students' projects presentations, and to be ecoefficient it needs to be designed in accordance with the following strategies:

- durable/adaptable for different types of students' projects presentations, from video-based, to paper-based and/or mock up based ones, towards an "eternal university-owned exhibition kit";
- digitally travelling exhibition, transporting only concepts and as digital files, towards a "zero road/rail use";
- minimal and locally-based exhibition elements, towards a "wired-shaped" exhibition;
- low energy consumption/impact for video installation and/or lightening systems, towards a "zero energy impact exhibition";
- though with a low priority, easily recyclable exhibition components, towards a "zero waste exhibition".

PRODUCT DESIGN

X-Rail: A sustainable exhibition system for universities

The product aims to answer to several exhibition needs for unviersities. The attention in the final process focused on the exposition of mock-up, posters and projected contents, in order to answer to the basic exhibition needs of universities.

The main goal was to design an 'open' exhibition system which can be used by several universities which have the same needs for content exposition. For rhis reason the design refers especially to architecture and design schools but can be suitable even for other kind of scopes.

The system was designed to simplify the assemblies and disassembly phases: as far as possible the components used are taken from the market, so they don't have to be "explained in use" and they are clear by itself.
Just a little part of the components used for the design have to be realized "ad hoc" for this exhibition system.
As the exhibition needs, exhibition forms and configurations may change during the times, the system wishes to be a base of components, which assembled are able to perform different exhibition and, at the same time, can be enhanced and developed over time, during a continuos use, practical issues and considerations.

The designer sometimes overlaps its own aesthetic to what have to been exposed, but if this choice is coherent with the content of the exhibition, this may result emphasized.
Sometimes instead the designer tries to carry out the most neutral conditions to make the visitor able to see and be focused on the content exposed.[33]

The aestethic features of the system try to follow this second belief,

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33 Sergio Polano, Mostrare, l'allestimento in Italia dagli anni '20 agli anni '80; Edizioni Lybra Immagine; 1988, contribution by Luciano Celli, "L'architettura del mostrare"

keeping it far from bulky components, which can divert the attention of the visitor of exhibition from the content exposed, going towards an essential functional shape, dematerializing as much as possible the structure, emphasizing in this way the real content exposed.

The exhibition system have to be adaptable and configurable in many ways in relation to the space features.

X-rail can be used both taking advantages from venues features such as existing supporting structure both using self standing structures.
To reach this goal it is used an extremely essential selfstanding structure tripod shaped, made of thin pipes which can support an orizontal rail between the two of them.
As an alternative, in case of suitable venue supports (located on the cielings or walls,) the orizontal bar can be used with a cable system, which allow the exposition in an extremely "matericless" configuration.

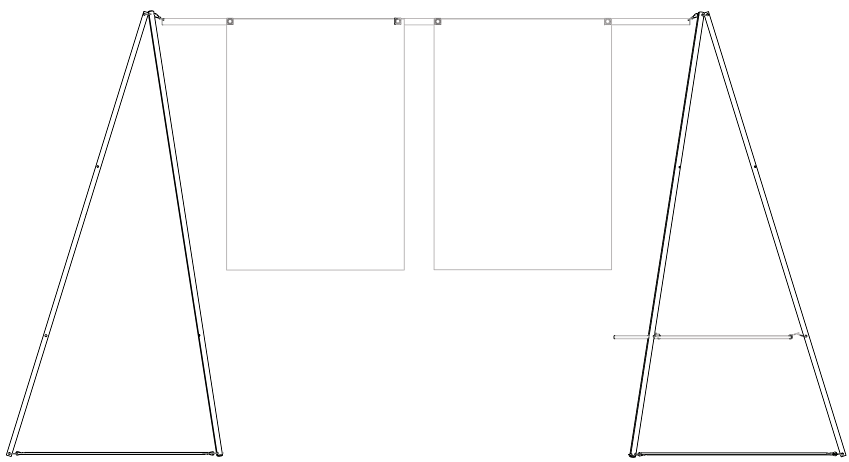


FIG.126
use of the
exhibition rail
with selfstanding
structures

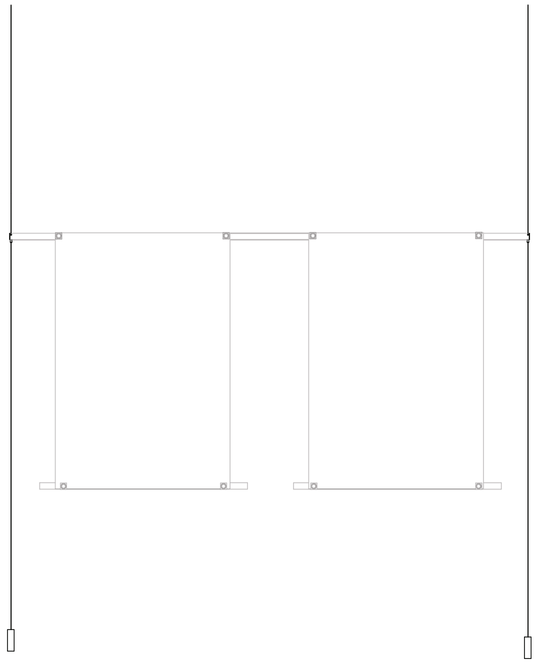


FIG.127
use of the exhibition rail with supports which take advantage from existing venues' structures

As shown in fig.126 and fig.127 , an orizontal rail (with a U shape section) is used as support to expose panels, printed boards and projecting sheets.

This items are fixed on the rail using a magnet clip system, which is deepen explained below.

Exhibition system features and assembly details

Magnetic clip system

The magnetic clip is composed of two simple parts:
- a bent steel sheet
- a threated magnet with a knob. The magnet choosed has an attraction force of about 18kg.

As shown in fig.130 , the magnet is attracted from the steel sheet and goes through the hole, fixing itself.

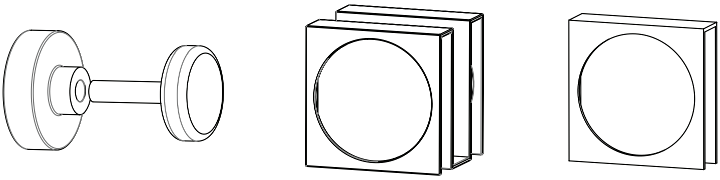


FIG.128
components of the
magnetic clip

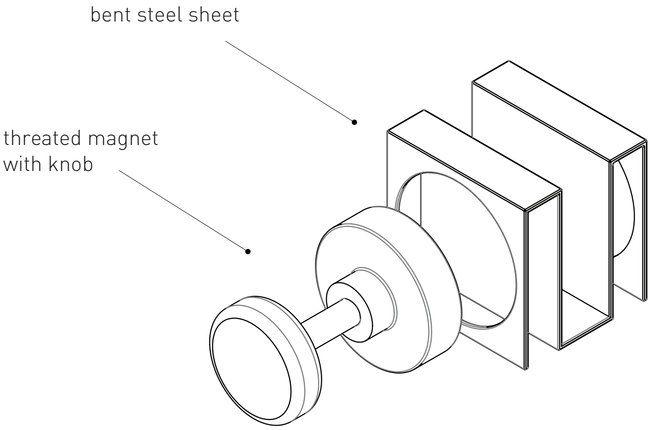


FIG.129
magnetic clip
assembly detail

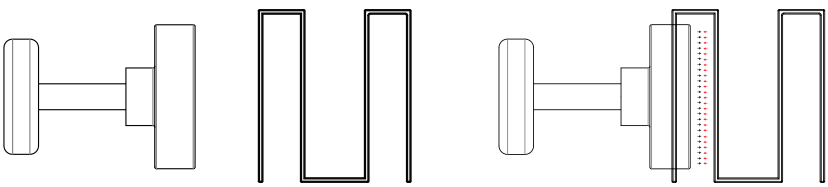


FIG.130
magnetic clip
functioning

The panels and the projecting sheets can be clipped to the orizontal bar, and easily removed and relocated, without using throwaway components. Moreover, neodymium magnets are eternally durable materials.

Use of the magnetic clip

The “M” shaped steel bent sheet and the magnet staple the exposing item (from 0 to 5mm) to the orizontal “U” shaped bar, as shown in fig.131 .

The “M” steel sheet fits in the “U” shaped rail, allowing a double side use. In this way it is possible to show contents in both sides of the rail, intensifying the use of the part.

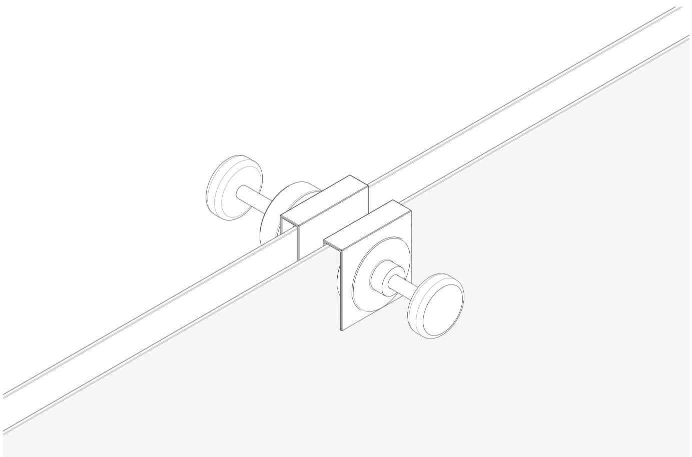


FIG.131
Use of the magnetic clip in both sides of the rail

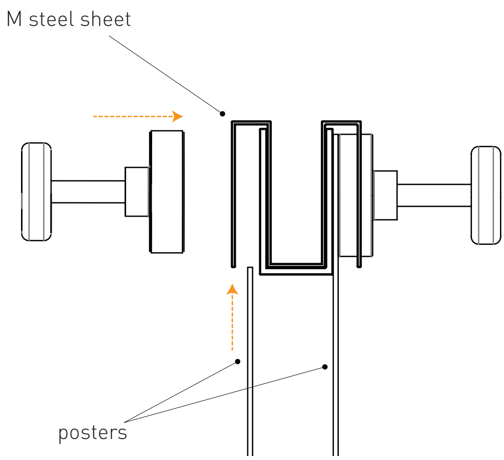


FIG.132
use scheme of the magnetic clip

The one-sided steel clip may be used to keep tighten the thin posters, in case of need, fixing the bottom part with an "I" section bar.

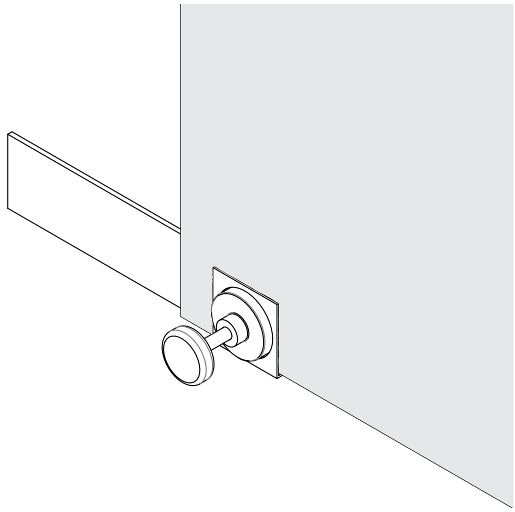


FIG.133
use of the single magnetic clip to keep a thin sheet tighten

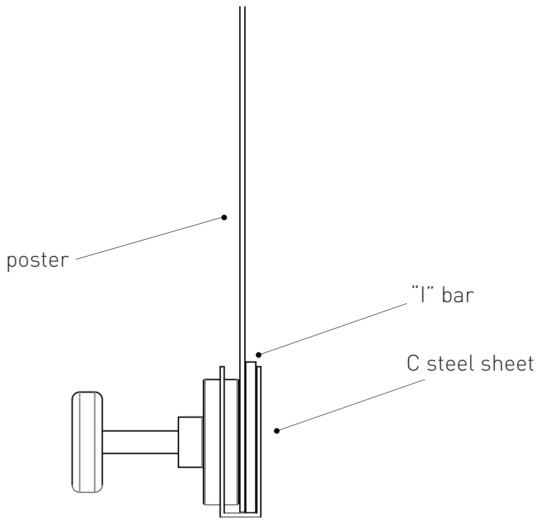


FIG.134
use scheme of the single magnetic clip

Orizontal rails

The orizontal rail, used as support to hang the contents exposed, semi-finshed aluminium bars, with "U" shape.
The system is designed to have different lenghts bar, due to the need of different of expose different dimension sheet.

The lenght of the “U” shaped rails is designed in three basic misures:
- 2,50m
- 1,80m
- 1,40m

FIG.136
on top the “U” section rail; below the “I” section bottom bar

The bars allow to expose different measures sheets and posters, as to configure the system answering to several exhibition needs.

Even the bottom “I” bars are designed in three different basic measures, to fit with most of the dimension of the sheets/posters:
- 1m
- 0,7m
- 0,5 m

Fixing of the orizontal rail

It were designer two different ways to fix the orizontal “U” bar to the selfstanding tripod structures and to the wires (in the case of opportunity to take advantage of the system to venues’ structures).

In fig.137 and fig.138 are shown the two arrangements to fix the rail to the two supporting structures.

To fix the rail to the top vertex of the selfstanding strucure is designed a simple system using a key ring and a carabineer.

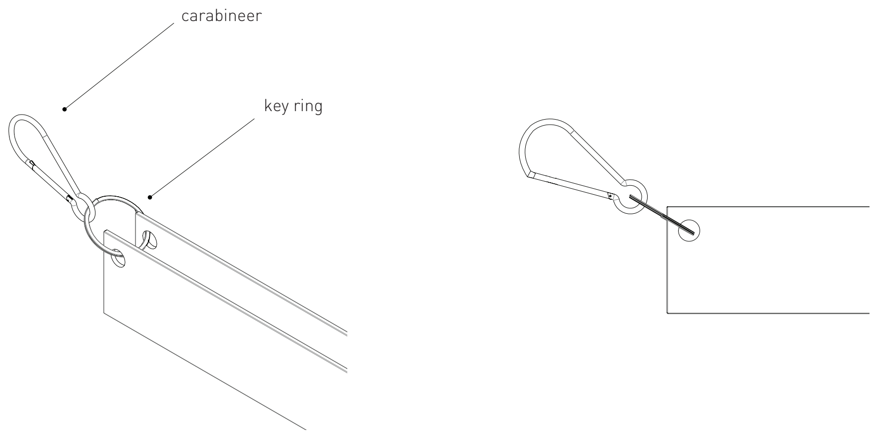


FIG.136
fixing assembly
details using self
standing structures

To fix the rail to the wire is used a finished component which allows to regulate the height of the rail, latching itself on the wire. Due to the shape of this component, and a hole in the bottom part of the rail, the gravity force pushes the rail down, automatically fixing it.
The cap is used to fix the the wire in two points, in order to give more stability to the structure.

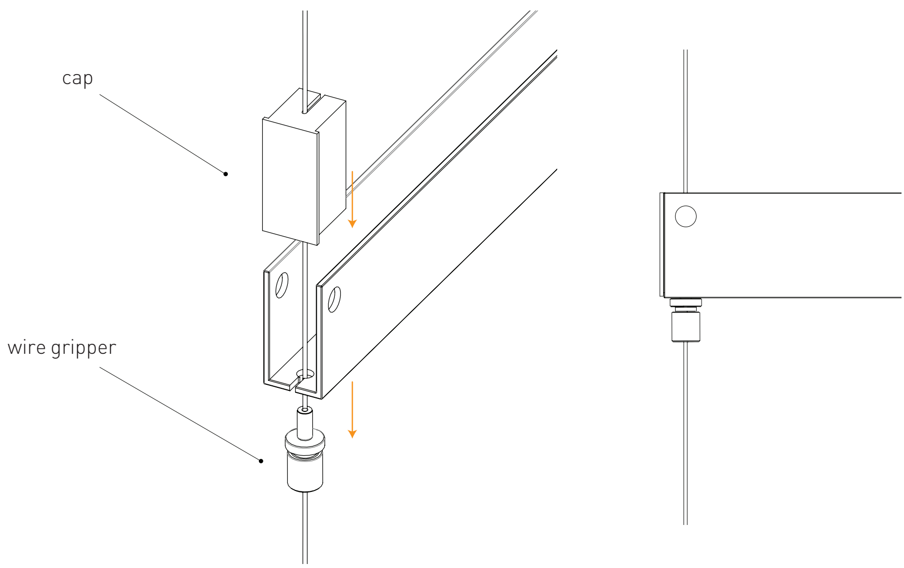
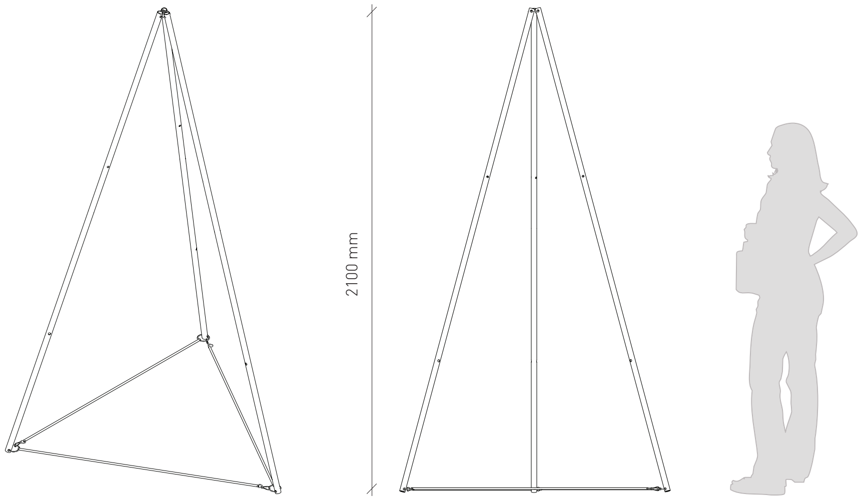


FIG.136
fixing assembly
details using
already existing
venues' structures

Tripod, self-standing structure

FIG.138
view of the tripod
self standing
structure



The tripod is made of 3 tube legs, long 2,20m each. As shown in FIG.139 the three legs are connected on the top vertex with a simple key ring.

In the bottom part three sticks connect the legs to make the structure stable (fig.140)

FIG.139
assembly detail
of the top vertex
of the tripod

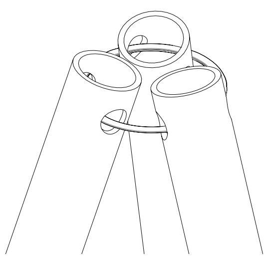
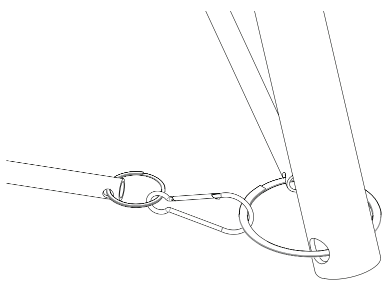


FIG.140
assembly detail
of the bottom
vertex of the
tripod



Tripod features

The designed self standing structures can be located indipendently in several venues, being arranged in several ways.
The system aims to be as much flexible as possible, allowing different configurations based on the different exposition needs.

It can be used simply to support the orizontal exposing rails (fig.141), using the carabineers and key rings as shown in fig. 142, and as show-case, with the addition of a plane between the three legs (fig.143) .

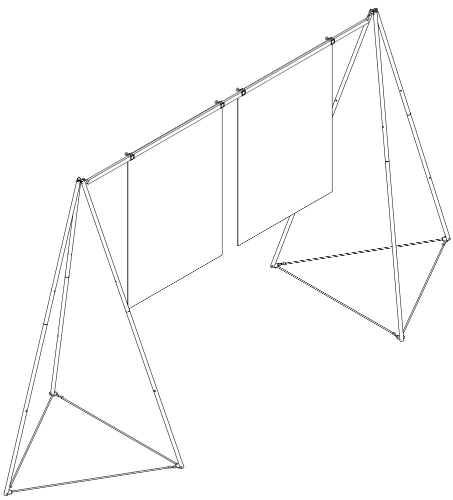


FIG.141
view of the self tripod as self-standing support

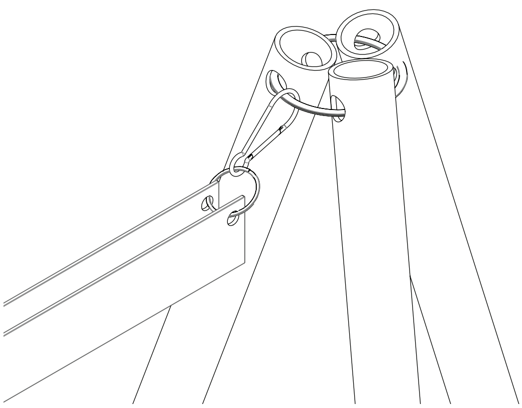


FIG.142
view of the fixings of the "U" rail with the tripod

The wood plane fixed to the tripod bars may be used to expose mock-ups, prototypes or simply to lay information brochures and flyers on it. The plane is fixed on the tripod structure due to the use of key rings and carabineers, as shown in the assembly detail in fig. 145.

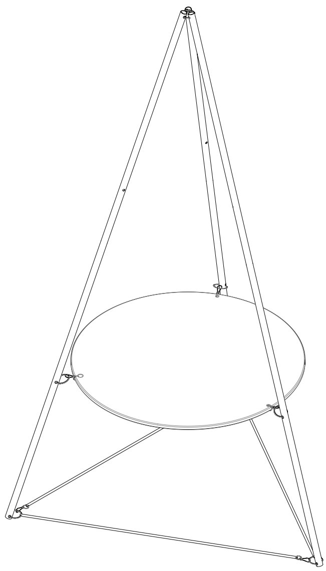


FIG.144
view of the tripod structure used as showcase

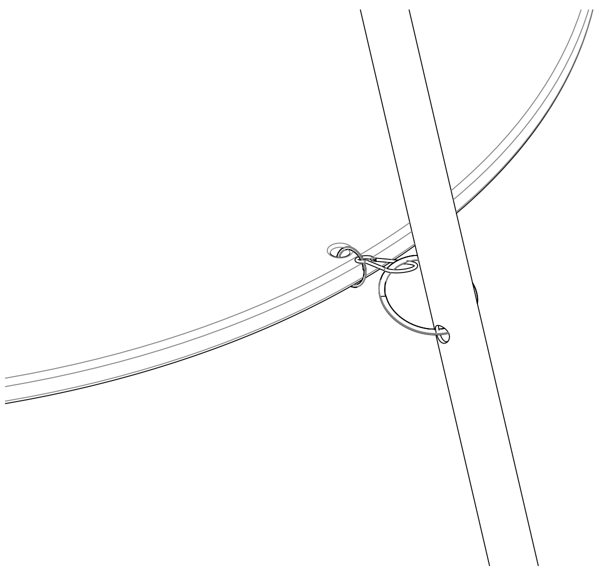


FIG.145
assembly detail of the plane fixing with the tripod structure

The wire shaped structure

This structure is developed in order to answer to different features of the possible exhibition venues.

During the design process, in relation to the TANGO project, it was observed that could be appropriate to develop this kind of solution in order to make the exhibition system even more flexible and adaptable, reducing the transportation of several components, if it is possible.

In particular, after the definition of the exhibition venue which will host the TANGO exhibition in Milano, it started the development of this part of the design, as in the venue there are existing supporting structures by which can be used themself to support the "U" rail.

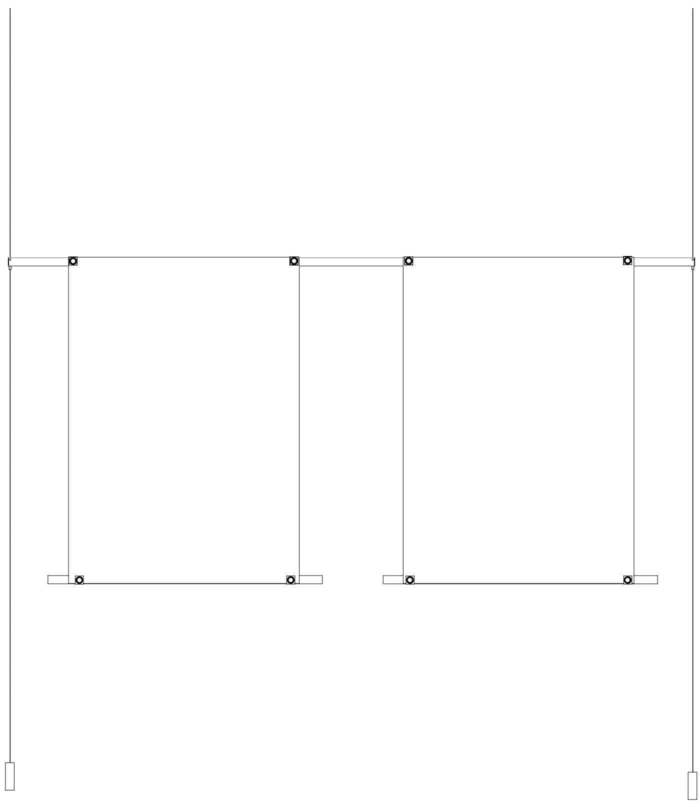


FIG.146
use of the hanging
system to hold the
"U" exposing rail

The components which compose this part of the design are basically:

- 4m iron wire, ending with a ring, to be coupled with hooks on cielings and walls;

- a Micro Cable gripper (Cable gripper Inc.) (fig.147);

- a ground weight, to keep the wire tensed, equipped with a reel, to store the wire and regulate its lenght once the system is used (fig.149, 150).

- a cap to cover the rail endings (fig.149).

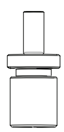


FIG.147
detail of the micro Cable gripper

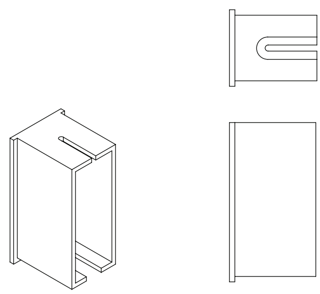


FIG.148
detail of the rail ending cap

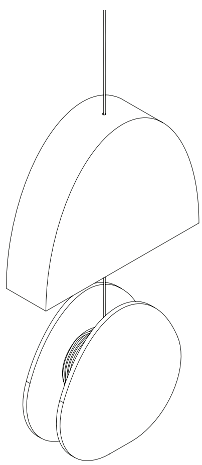


FIG.149
assembly of the ground weight

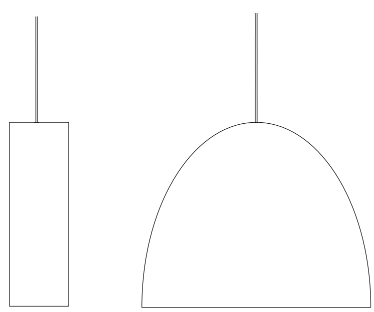


FIG.150
views of the ground weight

The wire shaped structure features

The wire shaped structure can be fixed to the existing vanue structures, such as wall or cieling hooks or other kind using the ring on the top of the wire (fig.152).

The weight on the bottom keeps the wire tensed, so that can be used to fix the orizontal rail at a certain height (fig.151).

The height can be regulated with a cable gripper. pushing and keeping pushed the top part of the gripper it can scroll up and down along the wire. once the top part is released, the gripper automatically fixes (fig.154).

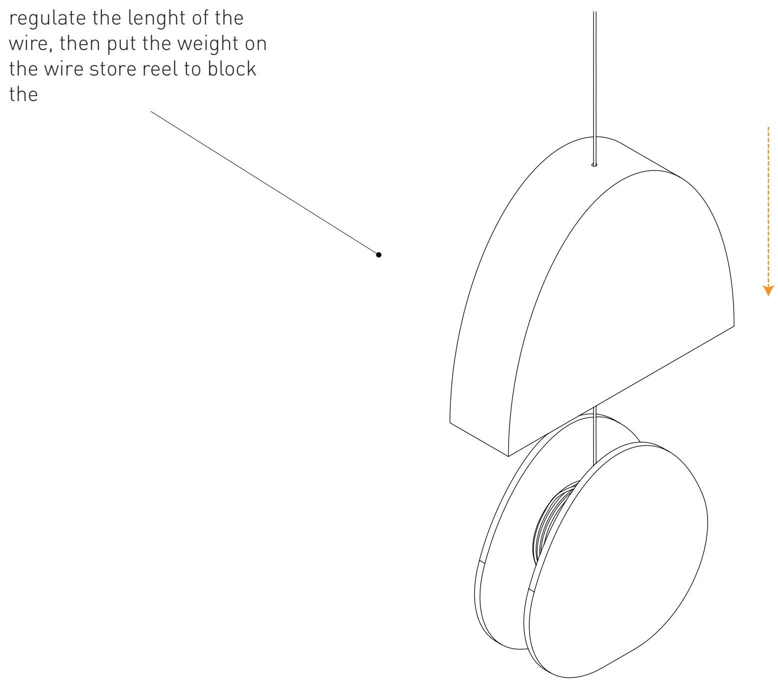
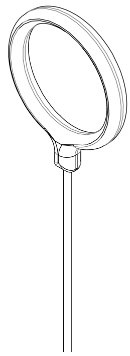


FIG.151
functioning detail of the the ground weight



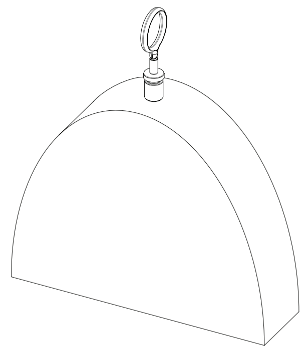


FIG.152
detail of the top ending of the wire

FIG.153
compact assembly of the weight ground

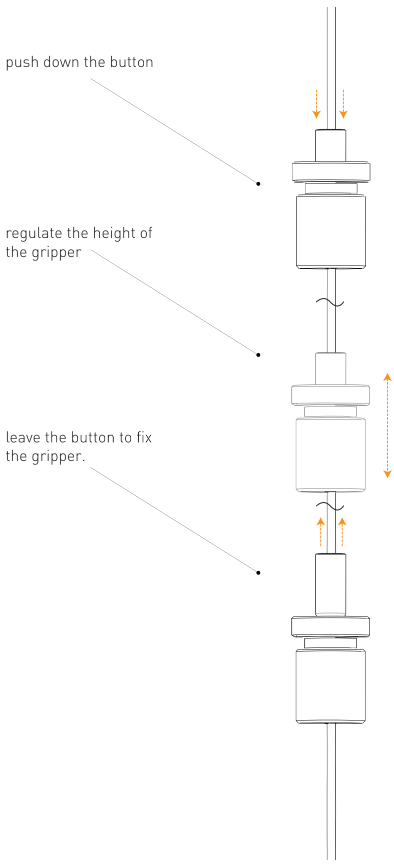


FIG.154
functioning of the micro cable gripper

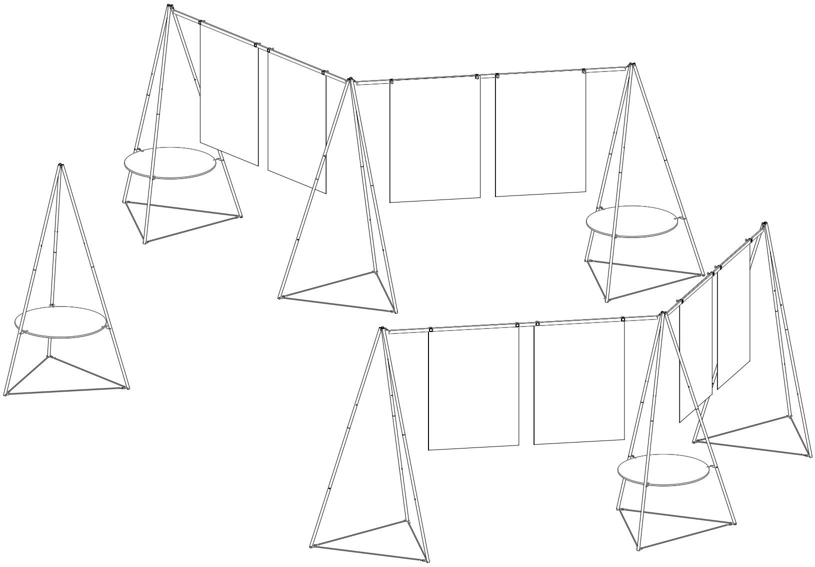


FIG.155
view of the
a possible
configuration with
the self standing
structure

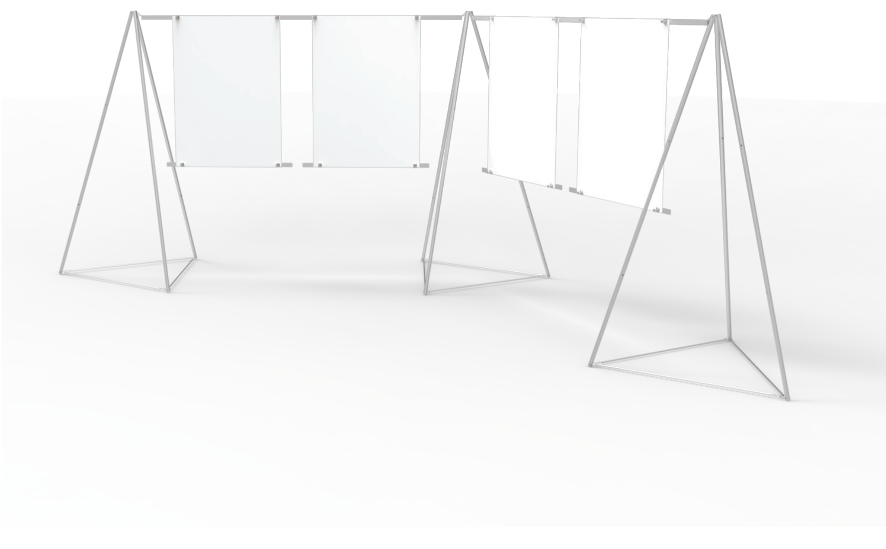


FIG.156
render of X-rail
structure used to
expose posters

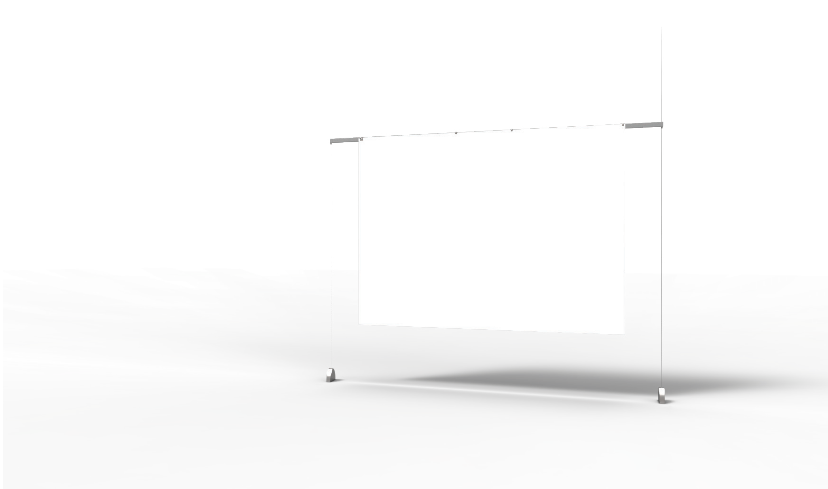


FIG.157
render of X-rail
structure used to
expose a projecting
sheet

Exhibition components and sustainability

The components used to design the system are mainly of metal materials, in particular aluminium and steel, which are long lasting materials.

Even the other components, not made of metal based materials, such as the wood planes and the magnets, are chosen for their durability.

As deeply explained in the previous sections, the designed exhibition system is the result of the combination of on market existing components and simple designed ones.

In particular the on market existing components are:

- carabineer (reference Cernitalia s.r.l product code P6413000);
- key ring (reference Cernitalia s.r.l. product code P632830, P632818);
- threated magnets (reference supermagnete.it product code Micro-GR
- cable gripper (reference cablegripper.com product code FTN-25;
- threated knob M4;

the other components which are designed expressly for the exhibition system are:

tripod structure
- 2,20m aluminium tubes;
- 1,20m aluminium tubes;
- wood panels;

wire shaped structure
- 4m steel wire;
- steel wire reel;
- steel weight base;

- aluminum cap;

exposition rail

- 2,50m “C” section aluminium rail;
- 1,80m “C” section aluminium rail;
- 1,40m “C” section aluminium rail;
- steel bent sheet (double);
- steel bent sheet (singular);

other materials

- 1m “I” section aluminum bar;
- 0,7m “I” section aluminium bar;
- 0,5m “I section aluminium bar;
- Lycra projecting sheet.

ASSESSMENT OF THE SUSTAINABLE EXHIBITION SYSTEM

In this paragraph are shown some evaluation about the designed sustainable exhibition system, in environmental and economic terms.

Environmental assessment

To make an evaluation of the system are shown the results of the LCA made with the software Simapro, comparing them with the one made about the existing system used by the Politecnico di Milano.

To achieve this goal are hypothesized two different exhibition arrangements, with the two different systems, in order to make them comparable in relation to their functional unit.
The two arrangements are thought in relation to the content exposed:

- a poster based exhibition;
- a digital based exhibition.

To make the configurations with the different system comparable it is defined this funtional unit for the two considered exhibition:

Poster based exhibition
- Exposition of 20 concepts through A1 posters (two posters per concept), properly illuminated;
- Exposition of five vertical info signs, properly illuminated.

Digital based exhibition
- Exposition of 20 concepts though 10 movies projected at the same time (five concepts for each movie);
- Exposition of five vertical info signs, properly illuminated.

In order to fulfill the defined functional unit are used the elements of the existing exhition system used by the Politecnico di Milano, deeply analyzed in the previously stages of the design process and some arrangements considered using the designed exhibition system.

For the new exhibition system are considered the the use of three configurations:

Poster based exhibtion configuration

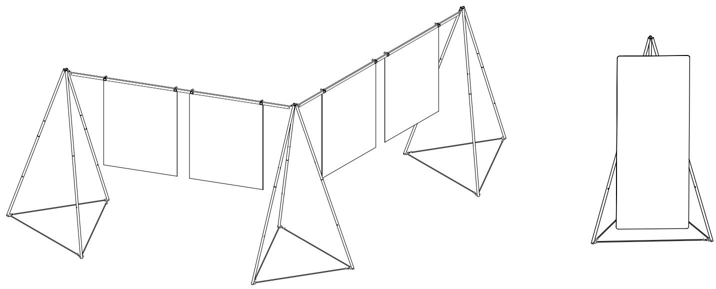


FIG.158 module configuration for the poster based exhibition with the X-rail system

- 10 exposition structures made of 15 tripods structures and 10 “U” rails
- 5 info spots with tripods

This arrangement is compared with a configuration realized with the exibition system components, chosed from the analysis deeply explained in previous paragraphs.

The chosed elements are those ones which risulted as less impacting among the one analyzed:

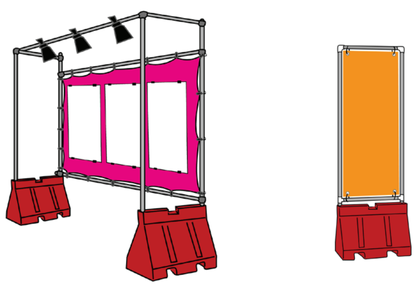


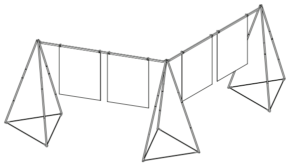
FIG.159 module configuration for the poster based exhibition with the existing system

- 10 exposition structures with lycra backdrop;
- 5 info spots with new jersey base

Both the configurations are provided with 26W LED spots.

Are now shown the features of the whole life cycle design of the elements assembled from the new exhibition system.

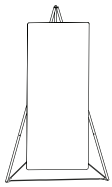
Panels and posters exhibition structure, life cyle inventory



component	material
2x "U" section rail	aluminium
4x "M" blocks	steel
16x "C" blocks	steel
32x knobs	steel
32x threated magnets	NdFeB
3x large key rings	steel (P6328, Cernitalia S.r.l)
4x carabineers	steel (P641300, Cernitalia S.r.l)
8 "I"section aluminium bars	aluminium
9x aluminium tubes	aluminum
12x large key rings	steel (P6328, Cernitalia S.r.l)
9x carabineers	steel (P641300, Cernitalia S.r.l)
9x small key rings	steel (P6328, Cernitalia S.r.l)
8 A1 panels	Paper
component	**manufacturing**
2x "U" section rail	extrusion
4x "M" blocks	mechanical manufacturing
8x "C" blocks	mechanical manufacturing
32x knobs	mechanical manufacturing
32x threated magnets	magnet manufacturing
3x large key rings	mechanical manufacturing
4x carabineers	mechanical manufacturing
8 "I"section aluminium bars	extrusion
9x aluminium tubes	extrusion
12x large key rings	mechanical manufacturing
9x carabineers	mechanical manufacturing
9x small key rings	mechanical manufacturing
8 A1 panels	-
means of transportation	**distance**
small truck	University – venue: 40km (A/R 2 times) x 3exhibitions
function	**process**
lightning of 1 module: 10h/d*7g	4x 15W LED bulb 10h/d*7g
lightning of 1 module: 10h/d*21g	4x 15W LED bulb 10h/d*7g
lightning of 1 module: 10h/d*7g	4x 15W LED bulb 10h/d*7g
treatments	
Mix of recycle, landfill and inceniration	

FIG.160
life cycle inventory of the poster exhibitor

Info spots structure, life cycle inventory



	component	material
PP	3x aluminium tubes	aluminum
	4x large key rings	steel (P6328, Cernitalia S.r.l)
	3x carabineers	steel (P641300, Cernitalia S.r.l)
	3x small key rings	steel (P6328, Cernitalia S.r.l)
	component	manufacturing
P	3x aluminium tubes	extrusion
	4x large key rings	mechanical manufacturing
	3x carabineers	mechanical manufacturing
	3x small key rings	mechanical manufacturing
	means of transportation	distance
DT	small truck	University – venue: 40km (A/R 2 times) x 3exhibitions
	function	process
U	lightning of 1 module: 10h/d*7g	1x 15W LED bulb 10h/d*7g
	lightning of 1 module: 10h/d*21g	1x 15W LED bulb 10h/d*7g
	lightning of 1 module: 10h/d*7g	1x 15W LED bulb 10h/d*7g
	treatments	
DM	Mix of inciniration, recycle and landfill	

FIG.161
life cycle inventory
of the info spot

Results of the poster based exhibition LCA

In this section are presented the results of the LCA[34] of the two configurations for the poster based exhibition;
Considering the overall impact of the two configurations, it emerges that the one with the lower global environmental impact is the poster based arranged with the new exhibition design.

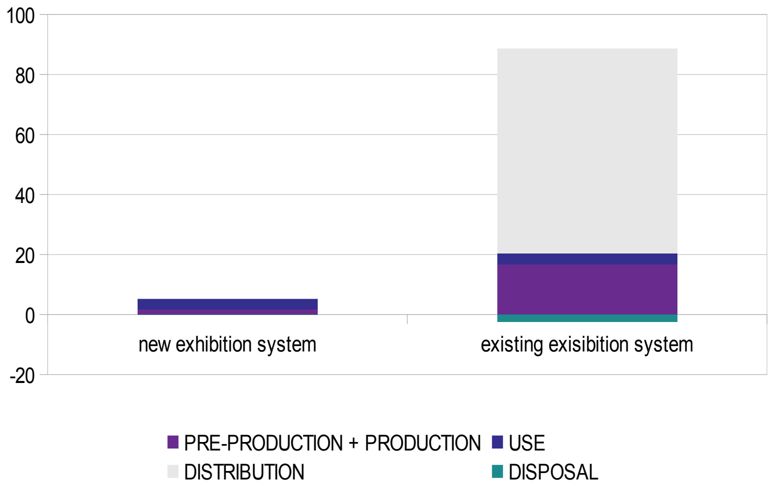


FIG.162
comparison of the environmental impact considering the two exhibition modes

The two configurations impact as follows:

- new exhibition system poster based exhibition - 5,26 Pt
- existing exhibition system poster base exhibition - 76,19 Pt

It can be also noticed how the single life cycle phases contribute to the overall impact of each configuration:

- for the new exhibition system, the main impact is given by the use phase, which determines the about the 60% of the overall impact;

- for the existing exhibition system, the main impact is given by the

34 the LCA was made using the software Simapro.

distribution phase, which determines more than the 75% of the overall impact.

In fig.163 are shown the life cycle phases for the two configurations, directly compared.

The main gain using the new exhibition system is given from avoiding the transportation phases in the life cycles. The strategy to design locally based exhibitions systems thus resulted efficient.

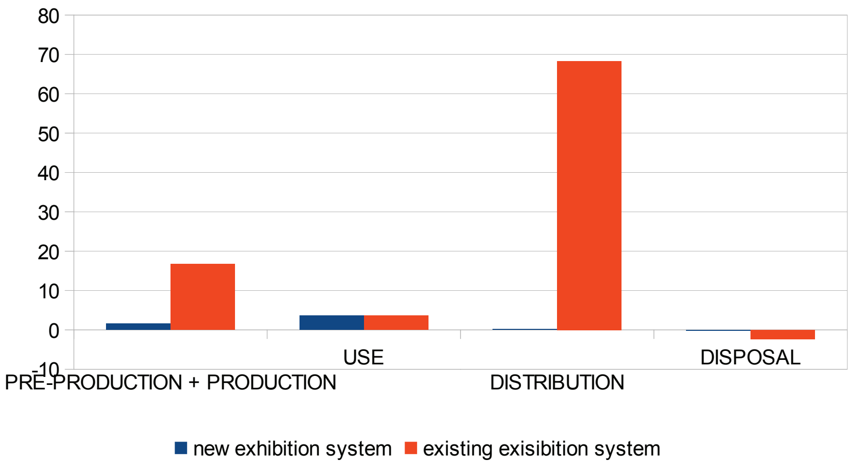


FIG.163 comparison of the environmental impact of each life cycle phase of the two exhibition modes *digital based exhibition configuration*

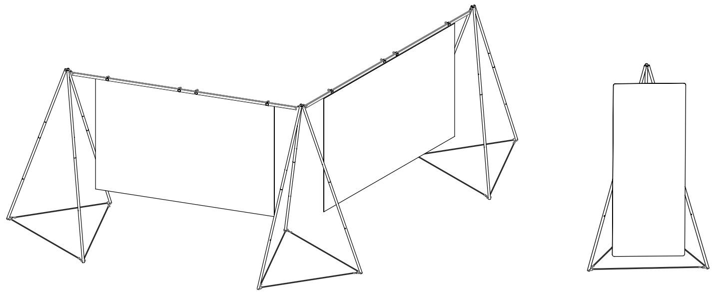


FIG.164
module
configuration for
the poster based
exhibition with the
X-rail system

- 10 exposition structures made of 15 tripods structures and 10 “U” rails
- 5 info spots with tripods

This arrangement is compared with a configuration realized with the exibition system components, chosed from the analysis deeply explained in previous paragraphs.

The chosed elements are those ones which risulted as less impacting among the one analyzed:

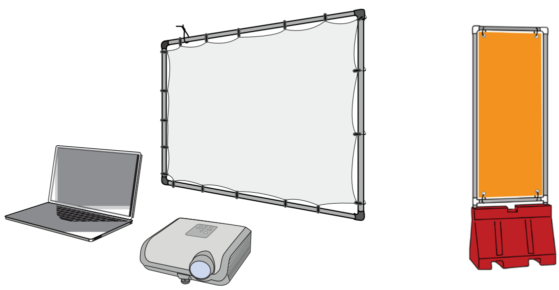
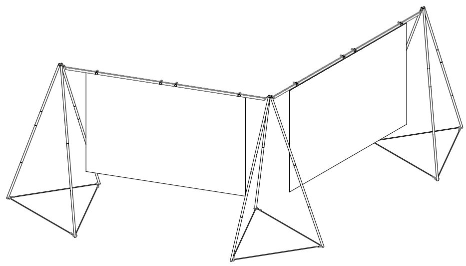


FIG.165
module
configuration for
the poster based
exhibition with the
existing system

- 10 projecting systems;
- 5 info spots with new jersey base.

Both the configurations are provided with 26W LED spots for the info elements and uses LED projectors, instead of traditional ones.

New projecting structure, life cyle inventory



	component	material
PP	2x “U” section rail	aluminium
	4x “M” blocks	steel
	4x “C” blocks	steel
	8x knobs	steel
	8x threated magnets	NdFeB
	3x large key rings	steel (P6328, Cernitalia S.r.l)
	4x carabineers	steel (P641300, Cernitalia S.r.l)
	2 “I”section aluminium bars	aluminium
	9x aluminium tubes	aluminum
	9x large key rings	steel (P6328, Cernitalia S.r.l)
	9x carabineers	steel (P641300, Cernitalia S.r.l)
	9x small key rings	steel (P6328, Cernitalia S.r.l)
	2 lycra sheet	Lycra
	2 laptop	several
	2 projectors	several
	component	manufacturing
P	2x “U” section rail	extrusion
	4x “M” blocks	mechanical manufacturing
	8x “C” blocks	mechanical manufacturing
	32x knobs	mechanical manufacturing
	32x threated magnets	magnet manufacturing
	3x large key rings	mechanical manufacturing
	4x carabineers	mechanical manufacturing
	8 “I”section aluminium bars	extrusion
	9x aluminium tubes	extrusion
	12x large key rings	mechanical manufacturing
	9x carabineers	mechanical manufacturing
	9x small key rings	mechanical manufacturing
	2 laptop	-
	2 projectors	-
	means of transportation	distance
DT	small truck	University – venue: 40km (A/R 2 times) x 3exhibitions
	function	process
U	projection in Milano: 10h/d*7g	2x 90W LED projection 10h/d*7g
	projection in Helsinki: 10h/d*21g	2x 90W LED projection 10h/d*21g
	projection in Nantes: 10h/d*7g	2x 90W LED projection 10h/d*7g
	laptop in Milano: 10h/d*7gg	2x 50W laptop 10h/d*7g
	laptop in Helsinki: 10h/d*21gg	2x 50W laptop 10h/d*21g
	laptop in Nantes: 10h/d*7gg	2x 50W laptop 10h/d*7g
	treatments	
DM	Mix of inciniration, recycle and landfill	

FIG.166
life cycle inventory
of the poster
exhibitor

Results of the digital based exhibition LCA

In this section are presented the results of the LCA of the two configurations for the digital based exhibition;
Considering the overall impact of the two configurations, it emerges that the one with the lower global environmental impact is the digital based arranged with the new exhibition design.

The two configurations impact as follows:
- new exhibition system poster based exhibition - 15,69 Pt
- existing exhibition system poster base exhibition - 55,34 Pt

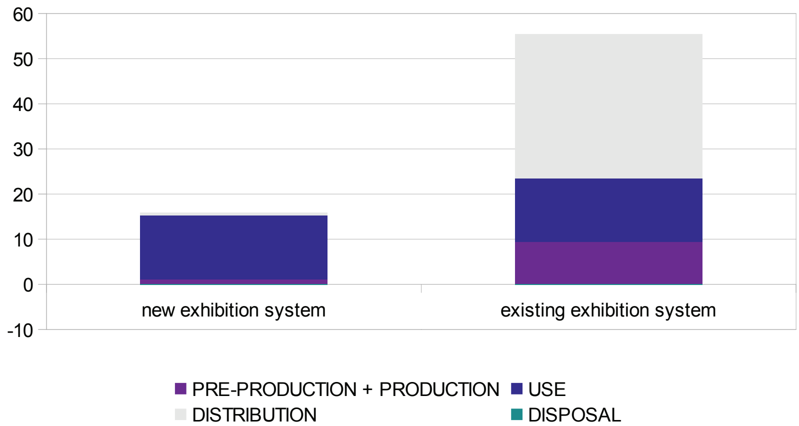


FIG.167
comparison of the environmental impact considering the two exhibition modes

It can be also noticed how the single life cycle phases contribute to the overall impact of each configuration:

- for the new exhibition system, the main impact is given by the use phase, which determines the about the 85% of the overall impact;

- for the existing exhibition system, the main impact is given by the distribution phase, which determines about the 60% of the overall impact.

In fig.168 are shown the life cycle phases for the two configurations, directly compared.

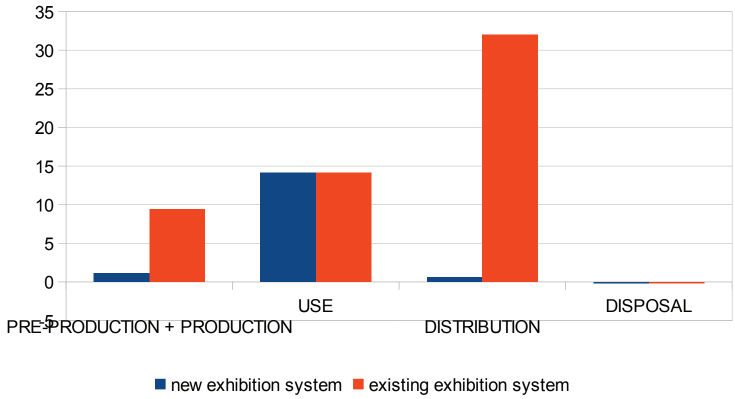


FIG.168
comparison of the environmental impact of each life cycle phase of the two exhibition modes

The main gain using the new exhibition system is given from avoiding the transportation phases in the life cycles. The strategy to design locally based exhibitions systems thus resulted efficient.

Even excluding this aspect, the preproduction and production phases of the two systems are considerably different.
The one related to the new exhibition system results reduced by about the 80% compared to the one of the existing system, making clear that the strategy to go towards dematerialization resulted effective.

To complete the environmental assessment of the new exhibition system compared to the existing one, are now shown the LCA results considering just the Milano stage of the exhibition, in order to have a direct comparison of the two systems related to the same exhibition option.

For this LCA were considered for both the exhibition configurations (video based and poster based) the transportation from the Politecnico di Milano to the exhibition venue (about 40km for the whole roundtrip) of the exposing modules. The data used to calculate this LCA are the one listed in the first section of this paragraph, when describing the Life cycle inventory of the exhibition options.

Results of the poster based exhibition in Milan LCA

The two configurations impact as follows:

- x-rail exhibition system poster based in Milano - 1,72 Pt
- existing exhibition system poster based in Milano - 6,91 Pt

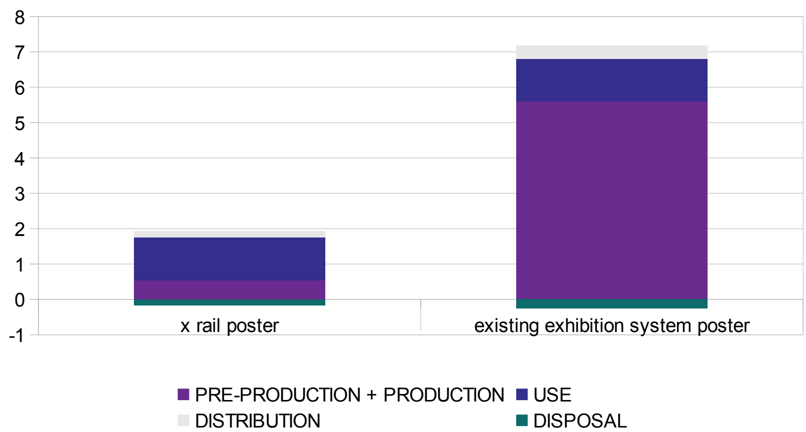


FIG.169
comparison of the environmental impact considering the two exhibition modes

It can be noticed how the single life cycle phases contribute to the overall impact of each configuration:

- for the existing exhibition system, the main impact is given by the pre-production and production phase, which determines the about the 70% of the overall impact;

- for the x-rail exhibition system, the main impact is given by the use phase, which determines about the 60% of the overall impact.

In fig.170 are shown the life cycle phases for the two configurations, directly compared.

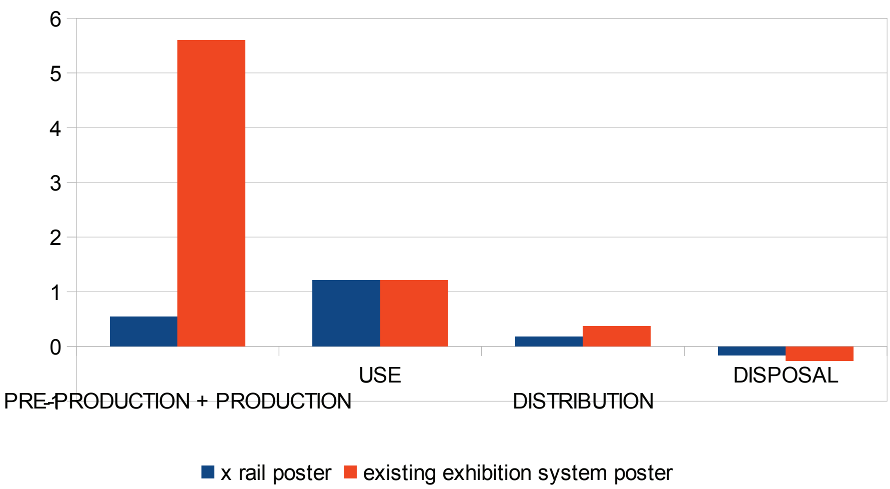


FIG.170
comparison of the environmental impact of each life cycle phase of the two exhibition modes

From this comparison it emerges that the desisgned exhibition system is less impacting in the preproduction and production phases. Comparing the PP+P datas of each of the two considered set-up, x-rail impacts about the 85% less than the existing exhibition system.

Results of the video based exhibition in Milan LCA

Considering and comparing the two video based configurations, for the Milano exhibition, the higher impact results using the existing system.

The two configurations impact as follows:

- x-rail exhibition system poster based in Milano - 5,2 Pt

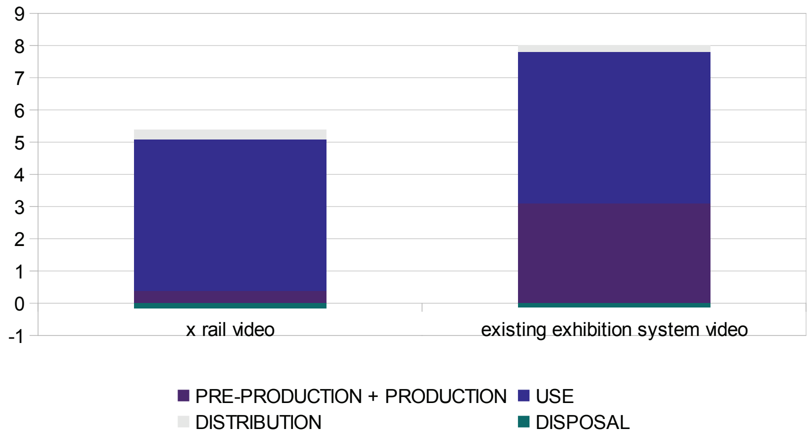


FIG.171
comparison of the environmental impact considering the two exhibition modes

Considering this kind of configuration the result is not changing, as the x rail configuration results again less impacting.

It can be noticed how the single life cycle phases contribute to the overall impact of each configuration:

- the USE phases impact the same and for both the configurations results as the highest contribution for the overall impact.

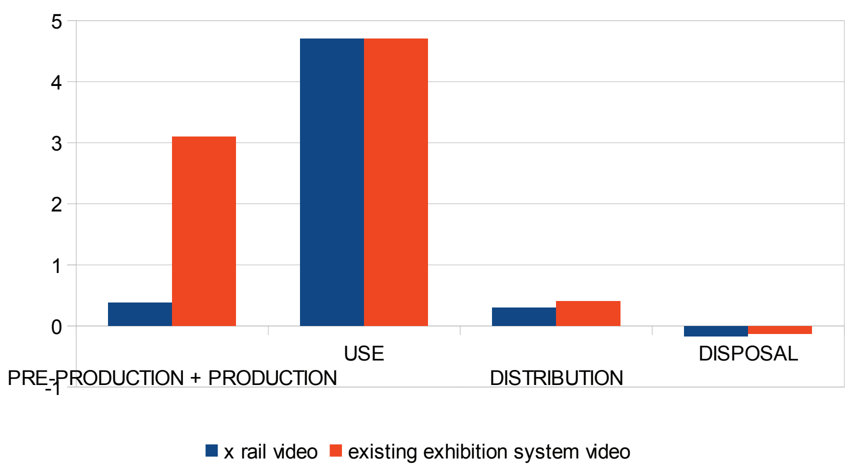


FIG.172
comparison of the environmental impact considering the two exhibition modes

However, the difference between the impact of the two options are less different as the USE phase as the highest influence for both the configurations and is not chaging its values in relation to the system used.

Using the x-rail system instead of the existing one, for the video exhibition, contribute to reduce the impact of about the 30% of the overall impact.

ECONOMIC ASSESSMENT

In this section are listed the results of a cost assessment, related to each component.
This evaluation aims to render an order of magnitude of what it could be the overall pricing of an exhibition kit.

To meet this goal it was defined a standard kit which can be used by Universities, considering average dimensions of the universities' exhibition.

The standard kit is composed to cover a exhibition space from 200mq to 500 mq (depending on the exhibition arrangements) considerding the people flows and the possible configurations of the systems.
This is made of:

- 15 tripods structures;
- 10 rail "U" structures, of several lenght;
- 40 "I" section bars, of several lenght;
- 10 exposing sheets
- 20 hanging kits (20x 4m wire, reel and weight, cable grippers);
- 80 magnets with knob;
- 80 "M" shaped iron clamps;
- 80 "C" shaped iron clamps;

In the next tables are listed in detail the pricing for each component of the exhibition kit, refering to online catalogues of manufactures and retailers[35].

For those components which have been designed has been considered the pricing of the raw material and giving rough pricing for their reprocessing considering handwork.

35 www.lamilanoalluminio.com, www.siderchiesa.com, www.cernitalia.it, www.brico.it, www.cablegrippers.com, www.alibaba.com. For further information about the singular components's pricing and features, contact the retailers.

TRIPOD STRUCURE		
3x2,20m aluminium tubes	aluminium	€ 7,80
7x large key rings	steel (P6328, Cernitalia S.r.l)	€ 4,20
6x carabineers	steel (P641300, Cernitalia S.r.l)	€ 4,50
6x small key rings	steel (P6328, Cernitalia S.r.l)	€ 1,30
1x90cm large wood panel	wood	5 €/mq
15x		€ 340,00
HANGING KITS		
2x weight steel base	steel	€ 3,50
2x wire steel reel	steel	€ 7,00
2x 4m steel wire	steel	€ 3,00
2x Steel cable gripper	nickel plated brass	€ 3,00
2x aluminium cap	aluminium	€ 0,50
20x		€ 340,00
MAGNETIC CLIPS SYSTEM		
8x “M” blocks	steel	€ 20,00
8x “C” blocks	steel	€ 10,00
8x knobs	steel	€ 2,50
8x threated magnets	NdFeB	€ 18,50
10X		€ 510,00
OTHER PARTS		
1x2,50m “U” section rail	aluminium	€ 7,00
10X		€ 70,00
4x1,50 “I” section rail	aluminium	€ 6,50
10X		€ 65,00
1x 1x2,50x1,50m lycra sheet	lycra	€ 10,00
10X		€ 100,00
TOT.		€ 1.366,50

FIG.173
cost resume table
for a standard kit

CONCLUSIONS

The results of the LCA analysis shows that X-Rail, reduces in any exhibition configuration the environmental impact, compared to the existing system of the Politecnico di Milano.
Whether the exhibition is a video based or poster based one, the high flexibility and adaptability of the new system, together with its high dematerialization reduces the global environmental impact.
For this reason it can be resumed that the designed product answered correctly to the requirements which have been defined in the brief, thus moving towards sustainability.

The LCA results underline, for istance, the reduction of the environmental impact reduction, related to the use of the designed exhibition system, as it were avoided the throwaway components and those parts overly bulky and in some cases unnecessary.

The project described in the previous paragraphs is mainly made of metallic parts, which increase the global durability of the whole system, avoiding the need of substituting parts and moving towards the achievement of a new eternally durable exhibition system.
The product has been designed consideratingα intense and frequent use, thus using extremely simple and durable fixings among parts and, as far as possibile made with standard components, which are direct to communicate their use and interaction.
The integration of this parts which some designed parts (as far as possibile made with some readily available materials, processed in simple way, even indipendently) define the core of the exhibition system.

Furthermore the structure with the existing exhibition system of the Politecnico di Milano this was reduced in terms of dimension and weight, going towards an essential and minimalist aesthetic, to keep it as much neutral as possible.The metallic parts in steel and aluminium are deliberately left without aesthetic finishing and colorings, in order to avoid a possible visual disturb during the carried out exhibition and to facilitate the focusing of the visitor on the contents exposed.

The system results configurable and adaptable to several exhibition contexts, using a double exposition options: a steel wire to be fixed on the cielings and walls (in the case of venues where are present those supports which permits this kind of use) or using selfstanding structures lightweights and simply assemblable and configurable. Some parts can be added or removed without compromising the stability of the structure, allowing the exposition of several kind of contents.
The involvment of the course "Design per la sostenibilità ambientale" was useful in the concept phase: some of the ideas by the students were effectively deepen in order to consider different options for the development of the product, verifying feasibility and functional criticals, contributing in this way to define the definitive prodcut concept.

The following design choices useful to improve the concept, which then brought to the definition of the several parts of the product, were the result of continuous discussions with the members of the set up workshop of the Politecnico di Milano, taking advantage from their competences and experiences in the field. In particular the results of these meetings where useful to understand some aspects of the organization of exhibition which are hard to be understanded immediately, as they are the result of a continuous use of this kind of exhibition systems; from these issues it were then defined some design guidelines as "semplifying" the assembly and disassembly processes, of the eventual needs for arrangements during the event carry out.

On this partecipated design logic, which move from the assumption that the exhibition may meet with different exposing needs, due to the evolution of contents and of the supports, to the different interaction needs and issues to this connected, the intentions is to consider the designed product as a structural base which can solve same basic exhibition requests, but which want to be enriched of new components and parts which can make it even more flexible, in order to develop during its use towards a continuous design process.

The same technicians of the set-up workshop of the Politecnico di Milano may have a relevant role in the evolution of the exhibition system, making consideration after the use and trying to remedy to eventual functional lacks and to answere to new exposing needs.

ESTRATTO DEL TESTO IN LINGUA ITALIANA

ABSTRACT

La tesi fa parte del progetto TANGO / AH-Design finanziato dal Culture Programme of European Union-Education and Culture DG, volto ad esplorare il problema dell'inclusione sociale ed in particolare del dialogo intergenerazionale, proponendo soluzioni innovative. I partner del progetto sono Aalto University Helsinki (Finlandia), L'ècole de Design Nantes Atlantique Nantes (Francia) e Politecnico di Milano Milano (Italia).

Altro obiettivo del progetto TANGO è quello di progettare una esposizione itinerante a basso impatto ambientale e accessibile, in una logica open source e copyleft.

Proprio in relazione a quest'ultimo obiettivo la tesi intende offrire un contributo progettuale per il sistema di allestimenti con il quale verranno esposti i contenuti oggetto della mostra che si terrà a Milano nell'aprile 2013, durante il Salone del mobile.

Il brief della tesi e del progetto Tango si è evoluto durante la ricerca progettuale definendosi infine come segue:
"progettare un sistema espositivo altamente flessibile e durevole, che venga inizialmente utilizzato per la mostra TANGO e che poi vada a sostituire quei sistemi espositivi ambientalmente meno sostenibili utilizzati dalle tre università coinvolte".

Il processo progettuale coordinato dall'unità DIS (Design and Innovation for Sustainability) del dipartimento di ricerca INDACO Politecnico di Milano ha attivato la collaborazione con il laboratorio allestimenti..
Il processo progettuale è stato sviluppato seguendo il metodo MPDS (Method for Product Design and Sustainability) valutando in una prima fase di analisi strategica, l'impatto ambientale del sistema espositivo attualmente in uso dal Politecnico di Milano (usando strumenti di LCA). In una fase di esplorazione delle opportunità sono stati coinvolti gli studenti del corso "Design per la sostenibilità ambientale" tenuto dal prof. Carlo Vezzoli, parte della laurea triennale in Design del prodotto industriale del Politecnico di Milano. I risultati ottenuti sono stato dei

tentative concept che sono stati valutati in termini ambientali dagli studenti del corso.

I risultati di questa prima fase sono stati il punto di partenza per la fase di progettazione del concept vero e proprio. Partendo dai tentative concepts più promettenti, è iniziata la progettazione del nuovo sistema espositivo, così caratterizzato:
X-RAIL è eternamente durevole e adattabile alle diverse tipologie di contenuti esposti, dai poster, alle proiezioni video fino ai modelli di studio. La sua struttura, essenziale e filiforme, risulta adattabile a spazi espositivi con caratteristiche differenti.
E' realizzata con componenti prodotti prevalentemente in loco, facilitandone la produzione e l'assemblaggio.

In questo modo la mostra TANGO verrà strutturata evitando completamente il trasporto su strada, facendo viaggiare i contenuti in forma digitale ed utilizzando i sistemi espositivi prodotti localmente.
I componenti utilizzati inoltre hanno caratteristiche di elevata riciclabilità evitando gli scarti e rifiuti.

Le prospettive per questo progetto consistono in una sua finale ingegnerizzazione e una successiva produzione. Il sistema espositivo verrà testato per la prima volta nella mostra TANGO a Milano.

LO SVILUPPO SOSTENIBILE

Si sente spesso parlare di quanto il pianeta su cui viviamo non sia più disposto ad accettare in nostri continui abusi, dell'impossibilità della biosfera e geosfera di continuare ad assorbire senza danni irrimediabili gli effetti del sistema di produzione di beni e servizi.

Col passare degli anni varie istituzioni hanno dapprima introdotto il concetto di sviluppo sostenibile - negli anni '80 con il documento Our Common Future della World Commission for Environment and Development – che ha costituito la base per le conferenze delle Nazioni Unite su Sviluppo e Ambiente (United Nations Conference on Environment and Development) tenutasi Rio de Janeiro nel 1992 e a Johannesburg nel 2002.

Come descrivono Carlo Vezzoli, Fabrizio Ceschin e Sara Cortesi "Con l'espressione sviluppo sostenibile ci si riferisce alle condizioni sistemiche per cui, a livello planetario e a livello regionale, le attività umane non superino i limiti di resilienza della geosfera e della biosfera, oltrepassati i quali iniziano degli irreversibili fenomeni di degrado e, allo stesso tempo, non impoveriscano il capitale naturale che verrà trasmesso alle generazioni future, inteso come l'insieme delle risorse non rinnovabili e delle capacità sistemiche dell'ambiente di riprodurre le risorse rinnovabili."

Mettendo in conto gli incrementi demografici previsti e una crescita della domanda di benessere nei paesi dove questo è meno presente, il sistema di produzione potrebbe essere considerato sostenibile nel caso di una riduzione di almeno il 90% delle risorse ambientali impiegate per unità di servizio reso, nelle società industriali mature. Per quanto approssimativa, questa valutazione fornisce l'idea della proporzione del cambiamento che dovrà essere messo in atto per raggiungere l'obiettivo di un sistema produttivo sostenibile.

"Nei prossimi anni dovremo, infatti, essere capaci di passare da una società in cui il benessere e la salute economica sono misurati dalla crescita della produzione e dei consumi materiali, a una società in cui si viva meglio consumando (molto) meno".

DESIGN PER LA SOSTENIBILITÀ AMBIENTALE

Quanto riportato nel paragrafo precedente dovrebbe costituire uno dei punti fermi tra i principali criteri progettazione osservati da designers e soprattutto enti, aziende ed istituzioni che operano nel mondo della produzione industriale e la normalizzano.
Concretizzare le ragioni della sostenibilità e dello sviluppo sostenibile non è tuttavia compito facile e richiede continua ricerca nell'ottimizzazione dei processi produttivi.
In sostanza integrare i requisiti ambientali nei processi di progettazione vuol dire gestire una maggiore complessità, in termini di informazioni e relazioni con interlocutori provenienti da discipline differenti.

Nel corso degli anni, durante i quali la sensibilità e l'interesse degli enti, aziende ed istituzioni ai temi di sostenibilità è cresciuta, si è venuto creando un approccio progettuale di tipo sistemico che mira a considerare tutte le fasi del ciclo di vita del prodotto, il Life Cycle Design (LCD).
L'attenzione alle varie fasi del ciclo di vita del prodotto cominciano dall'estrazione delle materie prime necessarie per la produzione dei materiali (del prodotto) e arrivano allo smaltimento di questi stessi materiali quando il prodotto viene dismesso.
Le fasi che descrivono il ciclo di vita di un prodotto sono, nell'ordine, le seguenti:

La pre-produzione, che include sia l'acquisizione delle risorse, cioè delle materie prime, sia dei processi per la successiva produzione dei materiali.
La produzione, che comprende i processi di lavorazione dei materiali (per farne componenti), l'assemblaggio e le finiture.
La distribuzione, cioè il trasporto e il magazzino, ma anche l'imballaggio, a sua volta da intendersi nel suo intero ciclo di vita.
L'uso del prodotto, che include sia gli eventuali consumi di risorse necessari per il suo funzionamento, sia i processi ad esso collegati (ad esempio la manutenzione).
La dismissione del prodotto che dopo la raccolta può seguire diversi percorsi: la discarica, l'incenerimento, il compostaggio, il riciclaggio

oppure la "rifabbricazione" e il riuso (dell'intero prodotto o di alcuni suoi componenti).

Prendendo in considerazione e valutando gli effetti ambientali degli input e output rispetto alla geosfera e biosfera dei vari processi relativi ad ognuna delle fasi elencate sopra, è possibile descrivere il ciclo di vita del prodotto in termini ambientali.
Di seguito vengono elencati alcuni degli effetti ambientali più incisivi e preoccupanti:

- L'esaurimento delle risorse;
- L'effetto serra;
- L'assottigliamento della fascia di ozono;
- L'eutrofizzazione;
- La formazione di smog;
- L'acidificazione;
- Le tossine in aria, nell'acqua e nel suolo;
- I rifiuti.

Oggi è possibile misurare questi effetti ambientali rispetto a un singolo prodotto.
Questi costituiscono infatti i parametri di valutazione attraverso i quali viene messo in pratica il metodo chiamato Life Cycle Assessment (LCA), che mira appunto a valutare l'impatto del ciclo di vita di un prodotto e consentendo il confronto degli impatti dei cicli di vita di diversi prodotti.

Per realizzare un LCA di un prodotto esistono diversi strumenti che possono e devono essere utilizzati come supporto alla progettazione per determinare le priorità ambientali di intervento e confrontare, al termine della progettazione, i risultati in termini di riduzione di impatto ambientale, rispetto ai prodotto esistenti.

"L'obiettivo ambientale del Life Cycle Design è quello di ridurre gli input e di materiali e di energia, nonchè l'impatto di tutte le emissioni

LIFE CYCLE DESIGN (LCD)

e i rifiuti, in termini sia quantitativi che qualitativi, valutando cioè la dannosità degli effetti (con la LCA o altri strumenti) per i processi di tutte le fasi del ciclo di vita dei prodotti."

Di fondamentale importanza è l'introduzione del concetto di unità funzionale, che definisce il riferimento relativo alla funzione offerta da un determinato prodotto. La progettazione deve considerare infatti la "soddisfazione" a cui portano un prodotto, un servizio o un insieme di prodotti e servizi. E' infatti questo criterio che ci consente poi di realizzare il confronto tra un prodotto e un altro in termini ambientali. Il presupposto economico/ambientale del Life Cycle Design sta nella prevenzione del danno ambientale in fase progettuale, piuttosto che nel rimediarvi quando un prodotto è già sul mercato.

Tra le strategie che possono indirizzare lo sviluppo dei prodotti verso risultati a minor impatto ambientali, ci sono le seguenti:

- la minimizzazione del consumo di energia;
- la minimizzazione del consumo di materiali;
- la scelta di risorse rinnovabili/conservative;
- la scelta di risorse non tossiche/nocive;
- l'ottimizzazione della vita dei prodotti;
- l'estensione della vita dei materiali.

Minimizzare le risorse impiegate significa ridurre l'uso dei materiali e di energia che determinano un servizio offerto da un certo prodotto: questi vengono usati durante l'intero ciclo di vita di un prodotto ed è per questo motivo che l'approccio progettuale deve mirare alla loro riduzione in tutte le fasi, includendo le attività progettuali e gestionali. Ridurre l'impiego di risorse comporta non solo l'abbassamento degli

impatti ambientali relativi alla produzione dei materiali

che compongono il prodotto, ma anche di quelli relativi alla loro trasformazione, trasporto e dismissione. Allo stesso modo quanto meno energia viene usata, tanto più l'impatto relativo alla sua produzione e trasporto risulta ridotto.

Per risorse a basso impatto ambientale si intendono qui materiali e fonti energetiche che abbiano una maggiore qualità ambientale. Come già sottolineato in precedenza questa va misurata all'interno di tutte le fasi del ciclo di vita, al fine di ottenere un efficace e corretto risultato. Nella dimensione della scelta delle risorse a basso impatto vanno considerate:

- le varie tecnologie di trasformazione e di trattamento dei materiali, in quanto alcuni possono determinare emissioni tossiche e nocive e altri no;
- i sistemi distributivi meno dannosi per l'ambiente;
- l'uso delle risorse a minor impatto nella progettazione di nuovi prodotti;
- la minimizzazione della pericolosità delle emissioni nei trattamenti di dismissione in relazione alla scelta dei materiali;
- il grado di rinnovabilità delle risorse considerate: la minor esauribilità di una risorsa determina il suo più elevato grado di rinnovabilità.

Ottimizzare la vita dei prodotti vuol dire progettare la loro longevità. Un prodotto che duri nel tempo più di un altro determina generalmente un impatto ambientale minore. Un prodotto che dura meno infatti, genera prematuramente rifiuti e non solo, ma determinerà soprattutto un altro impatto indiretto dovuto alla necessità di doverlo sostituire.
La produzione, distribuzione e la dismissione di un nuovo prodotto richiederà il consumo di nuove risorse e comporterà la generazione di nuove emissioni.

In generale tuttavia, per quanto riguarda la fase d'uso, l'estensione della vita di un prodotto non determina una riduzione dell'impatto, ma può al contrario aumentarlo; l'innovazione tecnologica infatti, può giustificare l'intero ciclo di vita di un nuovo prodotto che abbia un efficienza in fase d'uso nettamente maggiore (per quanto riguarda consumi ed emissioni) rispetto a un prodotto più vecchio.

Riassumendo, il presupposto economico-ambientale di un approccio di progettazione a ciclo vita è quello di intervenire a monte per prevenire la quantità di emissioni e ridurre il consumo di risorse: è infatti più efficace e meno costoso prevenire il danno ambientale in fase progettuale, invece che porvi rimedio una volta che il prodotto è già sul mercato.

Nel seguente paragrafo viene descritto il metodo MPDS (Method for Product Design for environmental Sustainability) per una progettazione sostenibile.

FASI DEL PROCESSO DI PROGETTAZIONE

In questo paragrafo sono riassunte le fasi di progettazione dell'intero processo che verranno approfondite nelle pagine succesive.

Analisi strategica

L'analisi strategica è stata svolta in diverse direzioni al fine di ottenere, per quanto possibile, una completa visione di cosa significhi progettare un sistema espositivo.
In particolare la ricerca è stata divisa in due parti:

- una parte teorica, durante la quale sono state analizzati i sistemi espositivi esistenti considerati come migliori esempi di sostenibilità;

- una parte teorica, durante la quale è stat inizialmente analizzato il sistema espositivo del Politecnico di Milano (e in particolare dal laboratorio allestimenti), attraverso dei criteri di sostenibilità e in particolare con alcune LCA, con lo scopo di avere come risultato alcune linee guida per muovere la progettazione verso la sostenibilità.

Per questa parte pratica è stato inizialmente coinvolo il laboratorio allestimenti del Politecnico di Milano, al fine di analizzare il sistema allestimenti utilizzato durante la maggio parte degli eventi organizzati dall'università, fondamentalmente per mostra contenuti relativi a progetti degli studenti, per eventi organizzati dall'università e, in alcuni casi, utiizzato per eventi esterni, per ospitare terze parti negli spazi del Politecnico di Milano.

Il sistema espositivo è stato oggetto di una profonda analisi, inizialmente analizzandone i diversi componenti (per comprendere i materiali e i processi produttivi con i quali sono realizzati), poi capendone la funzionalità, flessibilità e modularità.

Il sistema espositvo del Politecnico di Milano è stato inoltre oggetto di un'analisi di LCA al fine di comprendere i suoi aspetti più critici in termini di sostenibilità.

Una volta apprese le caratteristiche del sistema espositivo è stata realizzata una prima LCA, inizialmente consideando le tipologie di esposizione lagate al progetto TANGO (attraverso Milano, Nantes ed Helsinki), ipotizzando tre soluzioni per tre diversi tipologie di mostra (una mostra di poster, una mostra video e una mostra metà stampata e metà video)

Da questo primo passo, confrontando le tre diverse opzioni sono stati ottenute alcune considerazioni circa l'impatto ambientale delle diverse soluzioni espositive.

Dopodichè sono stati coinvolti gli studenti del corso "Design per la sostenibilità ambientale" del Politecnico di Milano per realizzare delle approfondite LCA come esercizio di messa in pratica del metodo MPDS.

Esplorando opportunità: il corso "Design per la sostenibilità del Politecnico di Milano"

Gli studenti del corso tenuto dal prof. Carlo Vezzoli, sono stati coinvolti al fine di verificare le caratteristiche ambientali di moduli realizzati con il sistema espositivo utilizzato dal Politecncio di Milano tramite degli strumenti di LCA, per identificarne le criticità e designare delle linee guida per una loro riprogettazione sostenibile, attraverso le prime fasi dell'analisi strategica del metodo MPDS.

Agli studenti è stato poi richiesto di progettare alcuni concept che seguissero le linee guida identificate come prioritare per una progettazione ambientalmente sostenibile, per esporre contenuti relativi a contesti di esposizioni universitarie.

I risultati del corso sono approfonditi nei seguenti paragrafi, dove sono inoltre mostrati i concept più interessanti sviluppati dagli studenti che sono stati utili a dare suggestioni per muoversi attraverso una progettazione sostenibile della mostra TANGO.

Concept design

Dai risultati del corso “Design per la sostenibilità ambientale” e della parallela ricerca teorica è stato così definito il brief di progetto per l’esposizione TANGO sostenibile e così è iniziata la vera e propria fase di ideazione del concept.
Lo sviluppo del progetto della struttura dell’esibizione si è mossa attraverso una continua ricerca parallela sulle strutture che potessero dare un ispirazione e conciliarsi con il brief di progetto.
In particolare sono state analizzate le strutture da campeggio, per esposizioni in negozi e fiere considerando:

- strutture dematerializzate;
- strutture facilmente trasportabili e pieghevoli;
- strutture flessibili e adattabili.

Product design

Dopo la definizione del concept di prodotto e dei suoi aspetti principali è iniziata poi la fase di approfondimento degli aspetti tecnici in tutte le sue parti, al fine di realizzare un progetto che rispondesse alle esigenze espositive.

Nuovo design brief

L'obiettivo è quello di realizzare un durevole sistema espositivo che possa essere utilizzato inizialmente per le esposizioni TANGO e che possa poi sostituire quei sistemi espositivi meno sostenibili all'interno delle tre università.

L'esposizione necessita di essere utilizzabile per esporre contenuti cartecei, digitali e modelli di studio e, per essere ecoefficiente deve seguire le seguenti linee guida:

- essere durevole/adattabile alle diverse esigenze espositive dei concept degli studenti (cartecee, digitali e modelli di studio);
- essere una mostra che si sposta digitalmente, trasportando i concepts come files digitali, verso l'annullamento dell'utilizzo di trasporto su strada e rotaia;
- essere minimale e localizzata nei contesti di esposizione, attraverso una struttura filiforme;
- avere un basso consumo energetico, soprattutto per le video installazioni e sistemi di illuminazione, verso la riduzione totale dell'impatto energetico;
- utilizzare componenti facilmente riciclabili, attraverso una esposizione che annulli i rifiuti.

LO SVILUPPO DEL PRODOTTO

X-Rail: A sustainable exhibition system for universities

Il prodotto mira a rispondere ai diversi bisogni espositivi delle università.
L'attenzione si è concentrata nell'esposizione di poster, mock up e contenuti digitali, al fine di rispondere all esigenze di esposizione indispensabili delle università.

Uno degli obiettivi perseguiti è stato quello di progettare un sistema espositivo "aperto"che potesse essere utilizzato da diverse università che avessero le stessi bisogni di esposizione dei contenuti. Per questa ragione il progetto si rivolge soprattutto alle università di architettura e di design ma può essere comunque utilizzato per altri scopi.

Il sistema è stato progettato per semplificare l'assemblaggio e lo smontaggio: per quanto possibile i componenti utilizzati sono componenti semplici e standard, così che non abbiano la necessità di essere compresi nel loro utlizzo e che siano comunicativi di per sè.

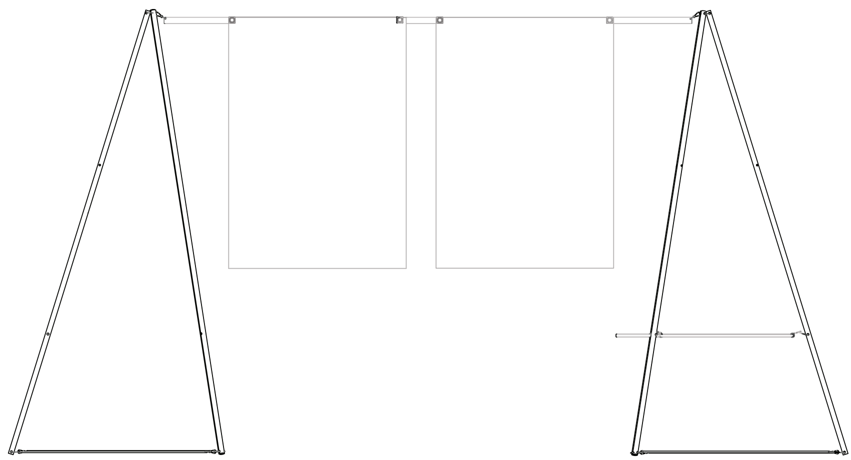
Solo una piccola parte delle componenti utilizzate utilizzate per il progetto devono essere prodotte ad hoc per questo sistema espositivo. Così come le necessità epositive, formali e le configurazioni possono cambiare nel tempo, il sistema vorrebbe costituire una base di componenti che possano essere implementati nel tempo, in seguito a un uso continuativo, a questioni pratiche e altre considerazion.

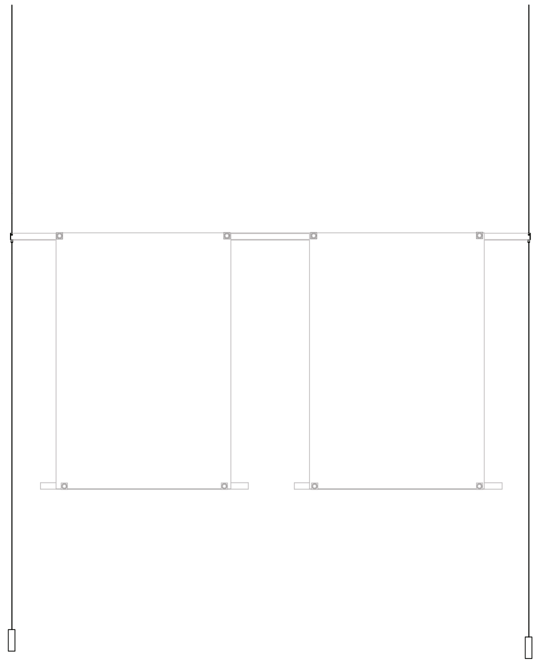
Il progettista alle volte sovrappone il suo gusto estetico a ciò che deve essere esposto, ma se la scelta fatta è coerente col contenuto dell'esposizione, questo può risultare enfatizzato.
Altre volte invece, il progettista cerca di raggiungere le condizioni di esposizione più neutrali possibili per far si che il visitatore sia concentrato sui contenuti della mostra.

Le caratteristiche estetiche del sistema cercano di seguire questa seconda linea guida, cercando di eliminare i componenti invasivi e poco coerenti, che possano distogliere l'attenzione del visitatore dai contenuti esposti, andando attraverso una forma essenziale e funzionale, dematerializzando per quando possibile la struttura ed enfatizzando in questo modo il reale contenuto esposto.

Il sistema espositivo è adattabile e configurabile in diversi modi in realzione alle caratteristiche dello spazio.

Le strutture possono essere utilizzate sia traendo vantaggio da supporti preesistenti presenti negli spazi espositivi, sia utilizzando strutture autoportanti. Per raggiungere questo obiettivo è stato utilizzata un'estremamente essenziale struttura a forma di tripode, realizzata con tubolari di alluminio che possano supportare un binario orizzontale posto tra le due strutture.
Come alternativa, nel caso in cui sia possibile fare uso di supporti presenti nel luogo della mostra, il binario orizzontale può essere utilizzato con un sistema a cavi, che permette all'esposizione di essere configurata in modo ancor più dematerializzata.





Come mostrato nelle immagini precedenti, una sbarra orizzontale (con sezione a U) è utilizzata come supporto per esporre pannelli, contenuti stampati e teli espositivi.
Questi elementi sono fissati sulla sbarra utilizzando una clip magnetica, che è descritta in dettaglio di seguito.

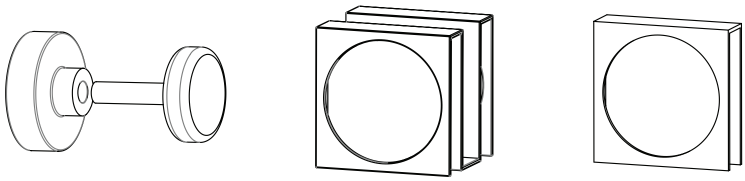
Caratteristiche del sistema espositivo e dettagli di assemblaggio

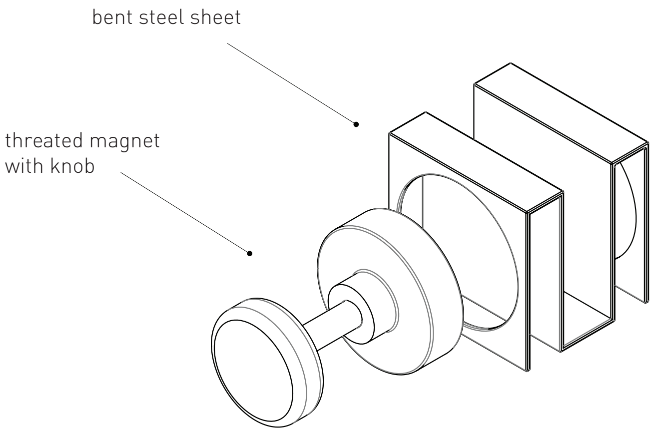
Clip Magnetica

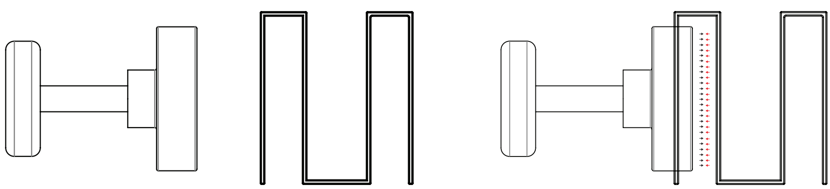
La clip magnetica è realizzata da due semplici parti:

- un lamierino metallico piegato
- un magnete filettato con un pomellino. Il magnete scelto ha una forza d'attrazione di circa 18 kg.

Come mostrato nell'immagine successiva, il magnete è attratto dalla parte retrostante del lamierino metallico, fissandosi passando attraverso il foro posto nella parte frontale.







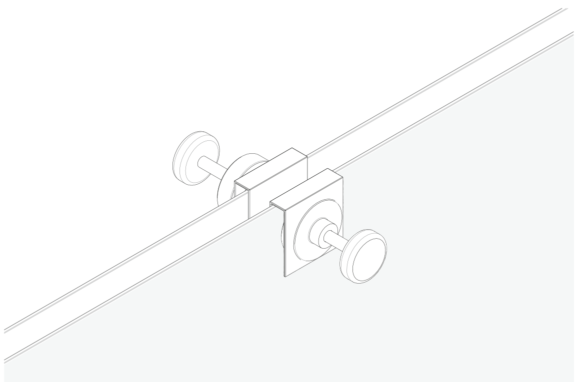
I pannelli e i teli per le proiezioni possono essere pinzati alla sbarra orizzontale ed essere facilmente rimuovibili e riposizionabili, senza utilizzare componenti usa e getta. In più, i magneti al Neodimio sono eternamente durevoli;

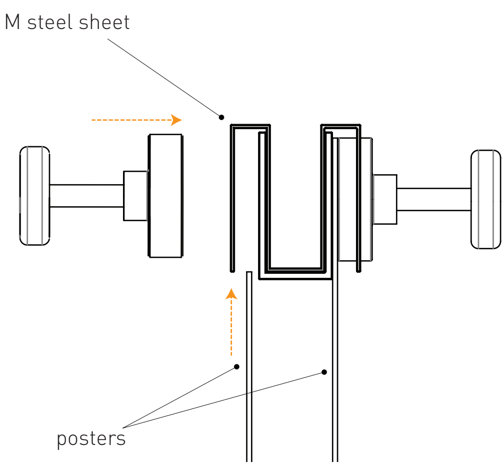
Uso delle clip magnetiche

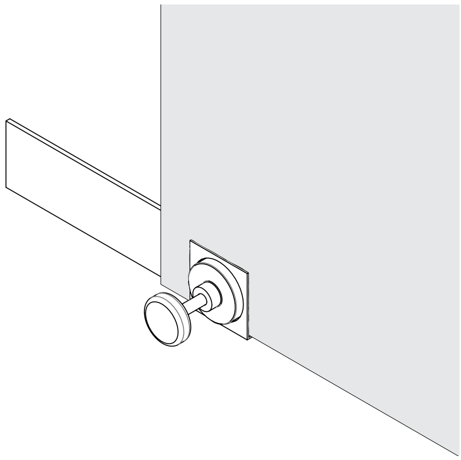
I lamierini piegati a “M” e il blocco magnetico pinzano il foglio o pannello (da 0 a 5 mm) alla sbarra orizzontale, come mostrato nella figura che segue

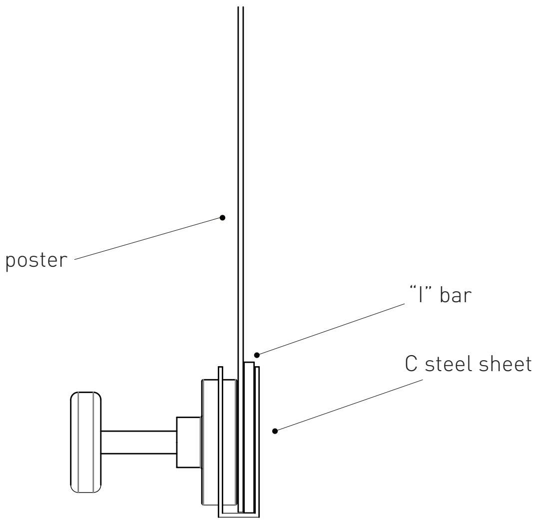
La “M” entra nel binario a “U” consentendo un utilizzo su entrambi i lati. In questo modo è possibile mostrare i contenuti su entrambi i lati del binario, intensificando l’utilizzo del binario.

La clip d’acciaio a “C” può essere utilizzata per tenere tesi i poster, in caso di necessità, fissando la parte inferiore con l’ausilio di una sbarra a sezione a “I”.









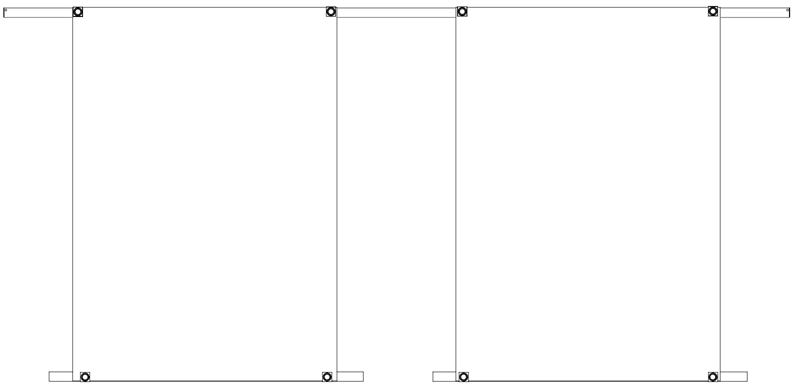
Binari orizontali

Le sbarre orizzontali, utilizzate come supporto per appendere i contenuti esposti, hanno una sezione a "U".

Il sistema è progettato per avere sbarre di diverse lunghezze, in modo da poter esporre diverse dimensioni di fogli e pannelli

La lunghezza delle sbarre a sezione a “U” è progettata in tre diverse misure:

- 2,50m
- 1,80m
- 1,40m



The sbarre fanno si che sia possibile esporre fogli di dimensioni diverse, e per configurare il sistema per rispondere alle diverse esigenze espositive.

Anche le sbarre nella parte inferiore (a sezione “I”) sono disponibili in diverse misure per supportare diverse misure di fogli:

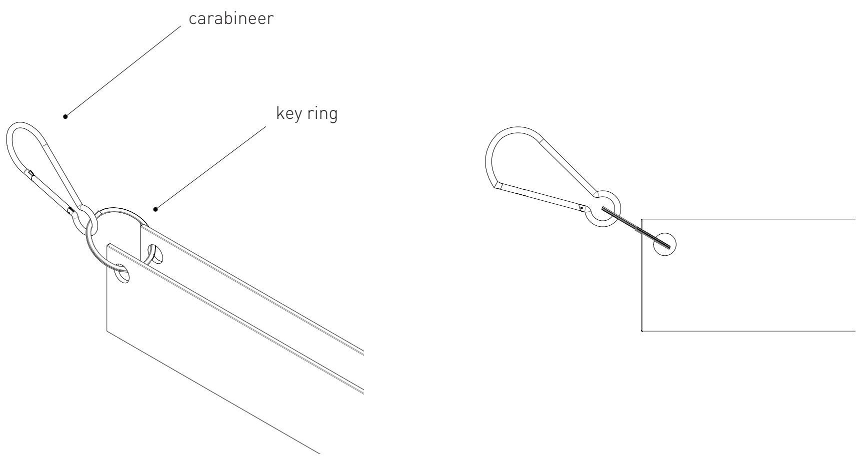
- 1m
- 0,7m
- 0,5 m

Fissaggio della sbarra orizzontale

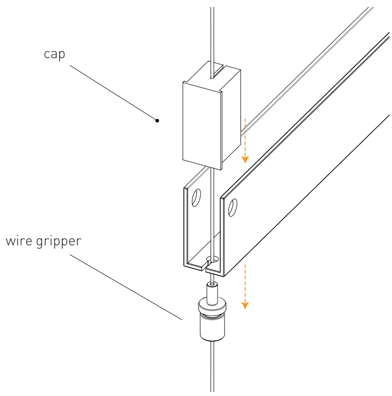
Sono state pensate due possibili soluzioni per fissare la sbarra orizzontale alle due diverse tipologie di struttura (tripode e a fili).

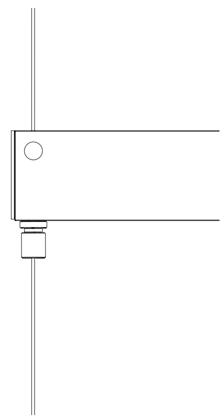
Nelle figure di seguito sono mostrati due possibili meccanismi per fissare la sbarra alle due strutture di supporto.

Per fissare la sbarra al vertice superiore della struttura a tripode è stato progettato un semplice sistema di bloccaggio, utilizzando un anellino portachiavi e un moschettone.



Per fissare la sbarra al filo sono utilizzati dei sistemi di bloccaggio esistenti sul mercato che permettono di regolare l'altezza della sbarra, bloccandosi sul filo. Grazie alla forma di questi componenti, e un foro posto nella parte inferiore della sezione del binario, questo si appoggia all'elemento di fissaggio rimanendo bloccato. Il tappo è pensato per tenere la struttura fissata in due punti del filo, così da renderla più rigida.

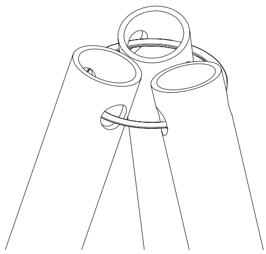


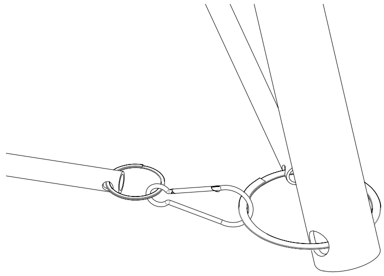


Tripod, struttura autoportante

Il tripode è costituito di tre tubolari, lunghi 2,20m ciascuno. Come mostrato nella figura di seguito le tre gambe sono collegate nel vertice superiore con un anello portachiavi.

Nella parte inferiore tre aste di alluminio sono fissate utilizzando dei moschettoni che si fissano a degli anelli portachiavi.

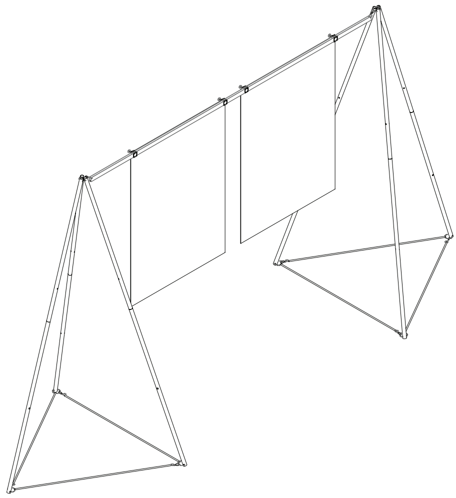


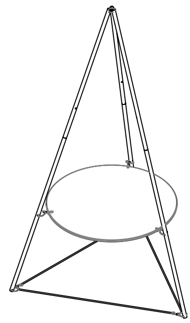


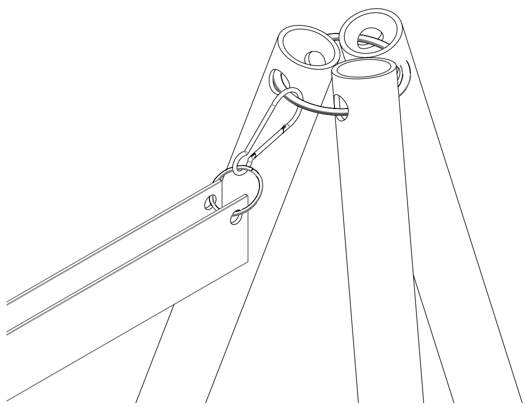
Caratteristiche del tripode

La struttura autoportante può essere collocata indipendentemente in diversi spazi espositivi, configurandosi in diversi modi.
Il sistema intende essere quanto più flessibile possibile, consentendo configurazioni differenti, basati su diverse esigenze espositive.

Può essere semplicemente utilizzato come supporto per i binari orizzontali (come mostrato nella figura successiva) utilizzando moschettoni e anelli portachiavi e come bacheca, aggiungendo un piano tra le tre gambe tubolari.







La struttura filiforme

Questa struttura è stata sviluppata al fine di rispondere alle diverse caratteristiche degli spazi espositivi.

Durante il processo di progettazione, in relatione al progetto TANGO è stato osservato che potrebbe essere interessante sviluppare questo tipo di soluzioni al fine di far si che il sistema espositivo sia ancora più flessibile e adattabile, riducendo i trasporti di diversi componenti, se possibile.

In particolare, dopo la definizione dello spazio espositivo che ospiterà la mostra TANGO a Milano è stata iniziato lo sviluppo di questa parte del progetto, in quanto nel luogo stabilito sono presenti alcuni supporti per le esposizioni.

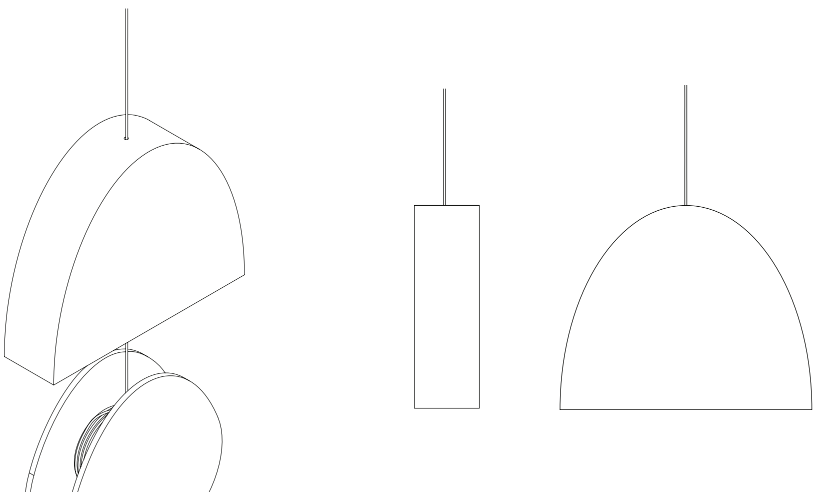
I componenti che compongono questa versione del progetto sono:

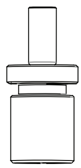
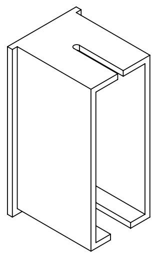
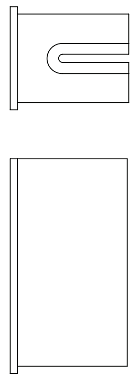
- filo d'acciaio, 4m, con una testa ad anello, che può essere accoppiata a ganci al soffitto o a muro;

- un Micro Cable gripper (Cable gripper Inc.);

- un peso a terra, per mantenere la struttura tesa, equipaggiato con un roccchetto per conservare il filo e renderlo regolabile una volta utilizzato

- un tappo per coprire le estremità del binario.



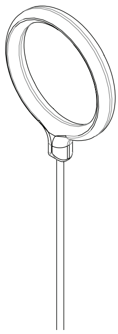
  

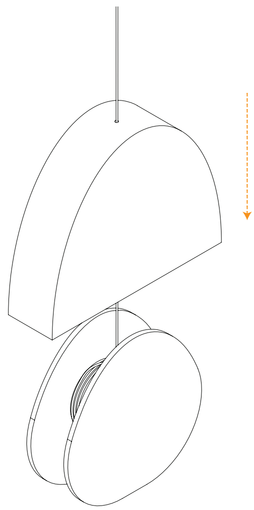
Caratteristiche della struttura filiforme

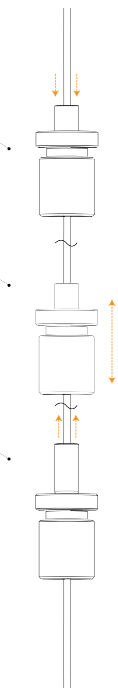
La struttura filiforme può essere fissata su supporti preesistenti negli spazi espositivi, come ganci a muro e soffitto, utilizzando l'anello posto su una estremità del cavo.

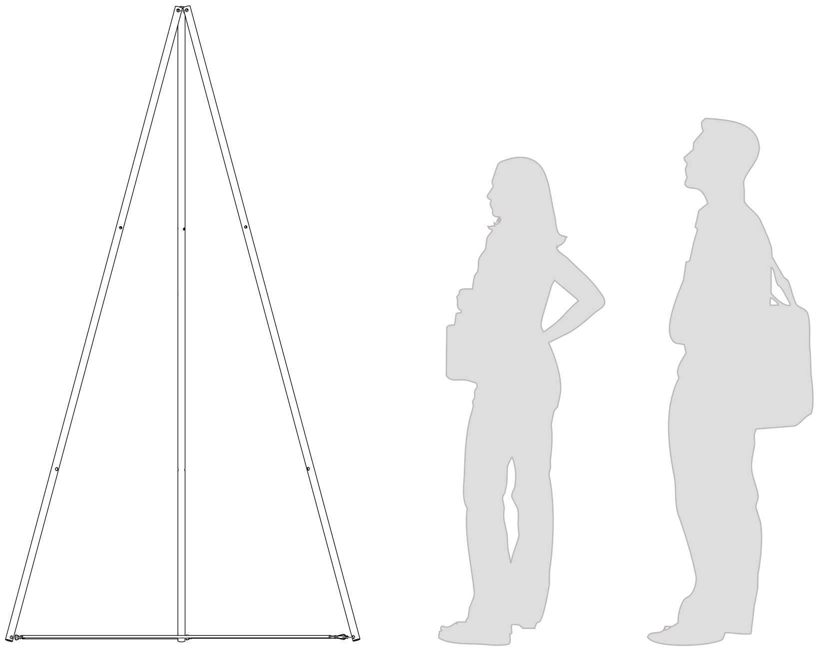
Il peso a pavimento tiene il cavo teso, così che possa essere utilizzato per fissare il binario a una determinata altezza.

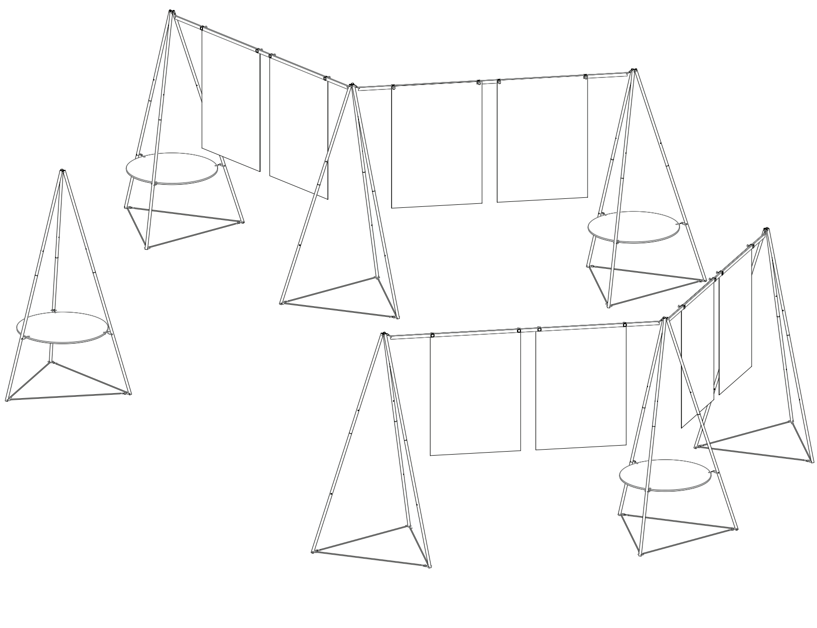
L'altezza può essere regolata con un sistema di bloccaggio per filo. Tenendo premuta la parte superiore del meccanismo questa può scorrere lungo la lunghezza del filo. Una volta rilasciata questa si blocca automaticamente.




regulate the lenght of the
wire, then put the weight on
the wire store reel to block
the


push down the button
regulate the height of
the gripper
leave the button to fix
the gripper.





CONCLUSIONI

Il risultato del processo progettuale è coerente con il brief definito nella fase conclusiva dell'analisi strategica. I risultati dell'LCA sottolineano quanto la riduzione d'impatto ambientale dovuta all'utilizzo del sistema espositivo progettato sia notevole, in quanto sono stati eliminati i componenti usa e getta e quelle parti eccessivamente ingombranti, in alcuni casi, superflue.

Il progetto descritto nei paragrafi precedenti è infatti costituito di una componentistica prevalentemente metallica che ne aumenta la durabilità complessiva, evitando la necessità sostituzione delle parti, muovendosi verso la realizzazione di un sistema espositivo "eternamente" durevole.

Il prodotto è stato progettato considerandone un utilizzo intenso e frequente, quindi adottando soluzioni per gli incastri delle varie parti estremamente semplici, duraturi e, per quanto possibili, realizzate con componenti standard e immediate nell'utilizzo. L'integrazione di queste parti con alcuni pezzi progettati ad hoc per il prodotto realizzato, di fattura estremamente semplice, realizzabili con pochi e semplici processi di produzione, realizzabili autonomamente, costituiscono la natura del sistema espositivo.
La struttura è stata complessivamente ridotta nelle dimensioni e negli ingombri, ottenendo un risultato estetico quanto più neutro possibile.
I componenti metallici in acciaio ed alluminio sono stati volutamente lasciati senza finiture o colorazioni, proprio per evitare un possibile disturbo visivo durante le esposizioni messe in scena e per facilitare la concentrazione del visitatore sui contenuti della mostra.

Il sistema è risulta inoltre configurabile e adattabile ai diversi contesti espositivi utilizzando una doppia possibilità di configurazione: attraverso un filo metallico per essere appeso a soffitto e a parete (nel caso nei luoghi delle esposizioni siano presenti supporti per questo tipo di fruizione), altrimenti utilizzando delle strutture autoportanti, leggere, facilmente assemblabili e componibili.
Alcuni componenti possono essere aggiunti o rimossi senza

compromettere la stabilità della struttura, consentendo l'esposizione di diversi tipi di contenuti.

Il coinvolgimento del corso "Design per la sostenibilità" è stato proficuo nella fase di concettualizzazione del prodotto; alcune idee degli studenti sono state approfondite al fine di considerare diverse opzioni di sviluppo del prodotto, verificandone fattibilità e criticità funzionali, contribuendo in questo modo alla definizione del concept definitivo.

Le successive scelte progettuali di perfezionamento del concept, che hanno poi portato alla definizione delle varie componenti del prodotto, sono state frutto di continui confronti con i membri del laboratorio allestimenti del Politecnico di Milano, traendo vantaggio dalla loro competenza dovuta alla loro continua esperienza nel campo. In particolare sono stati utili per comprendere a alcuni aspetti dell'organizzazione degli allestimenti difficili da cogliere intuitivamente in quanto derivate da un continuo utilizzo di questo tipo di sistemi; da queste sono poi state definite alcune priorità progettuali come la semplicità del montaggio, dello smontaggio, delle modifiche nella disposizione in corso d'opera, frutto di consapevolezze che sono immediate per chi si occupa quotidianamente di esposizioni ma che possono non risultare così chiari ai progettisti che non abbiano esperienza nel settore.

Su questa logica di progettazione partecipata e partendo dal presupposto che le esposizioni possono venire a incontrarsi con necessità diverse, dovute alle evoluzione dei contenuti e dei supporti, alle diverse necessità di interazione espositiva e questioni ad esse connesse, l'intenzione è quella di considerare il sistema progettato come una base strutturale, che possa venire arricchito di nuovi componenti in modo da evolversi progressivamente nel tempo attraverso una progettazione continua.

Gli stessi tecnici del laboratorio allestimenti potrebbero avere un ruolo sempre più presente e rilevante nell'evoluzione del sistema espositivo, facendo di volta in volta considerazioni sull'utilizzo e tentando di rimediare alle eventuali mancanze e per rispondere a nuove esigenze.

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