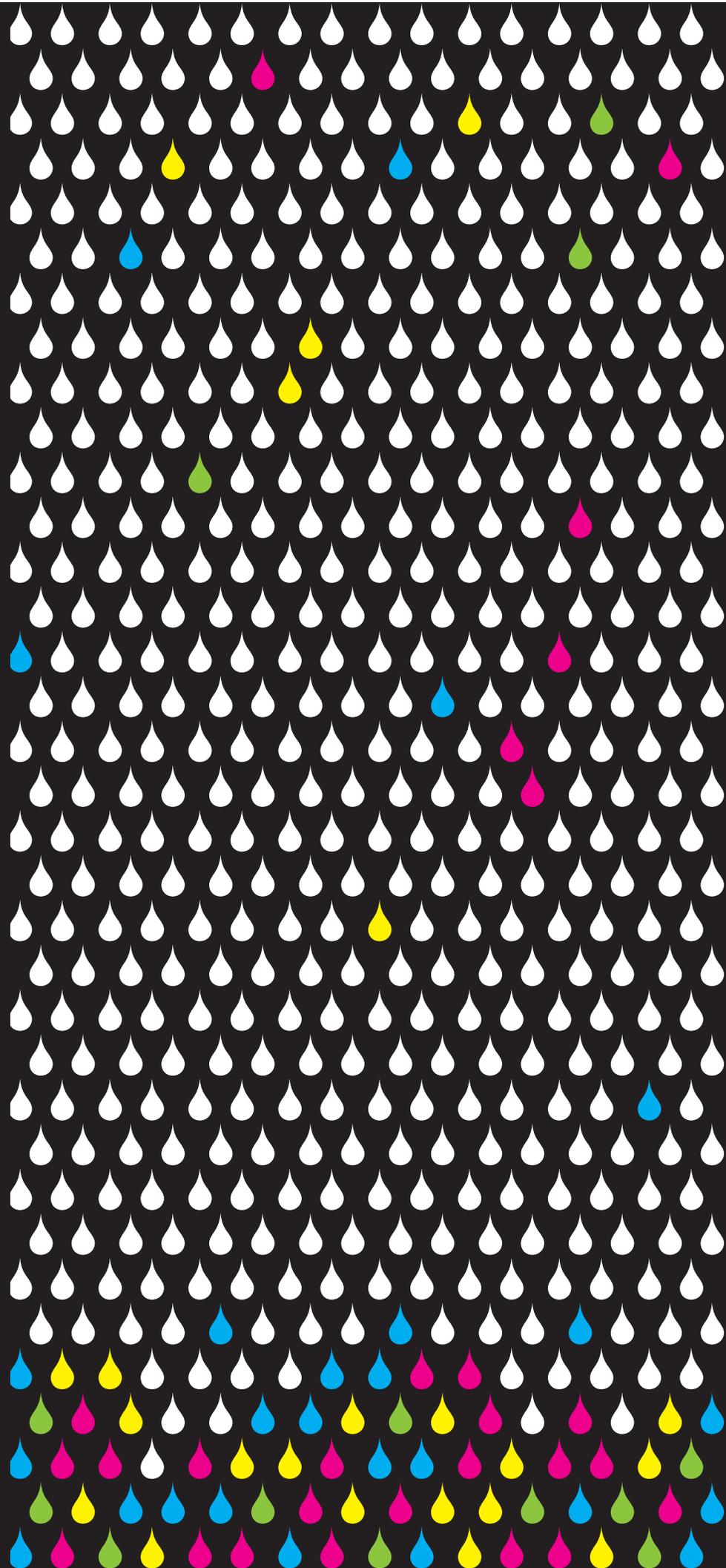


SMALL SCALE ENERGY HARVESTING

FRANCESCO ZORZI



This project analyses the possibility of collecting energy from simple everyday actions using developed alternative technologies applied in uncommon rhetorical ways. The aim of the project is to give people the chance to gather energy from their normal life for practical purposes, using new technologies embedded into familiar objects that will increase their sensibility towards energy and environmental issues.

A Changing world

The world is changing, becoming increasingly dynamic, diverse and complex. In the future, civilization will be forced to research and develop alternative energy sources: many changes are going to affect our lives and habits with the incoming need to look forward and redraw our attitudes to the world, the whole energy system and the environment.

”The world is on a growth kick that is unsustainable.

It is based on intense exploitation of natural resources and increasing production of material goods”

(Ayres, 1998). (industrial ecology 1)

Our current rate of fossil fuel usage will lead to an energy crisis this century. In order to survive the energy crisis many companies in the energy industry are inventing new ways to extract energy from renewable sources. New amazing possibilities are to be offered by alternative energy products together with the newest technologies; some of them are already on the market ready to be discovered by us, others are still being further developed.

Technology is becoming smaller, less tangible, and it will continue to evolve like this with the possibility to be integrated all around us without being visible.

The most important thing to understand is that the future is not about technology, it's about people, and how they feel about technology.

If we want to look into the future, we need to get close to how people think and feel and understand their future behaviours in a world where we have many new toys to play with. Furthermore the world we will be living in will be more populated and polluted. Today most of the energy production is based on fossil fuels, and this production is going to become less in the coming years, while its' price (and the cost of energy itself) is going to rise.

I started wondering if it would be possible to design something that would merge all these issues in one concept, reducing on the small scale the amount of energy used by the people, but being at the same time the first step to a more responsible and sustainable energy approach on the private level.

How would I go about designing something good for people and for the environment at the same time?

Forecasts

I studied future forecasts for technology, energy fields etc according to the environment and technology predictions:

8 billion of people will be living on the planet within 2030, and more than 5 billion of them will be living in urban areas;

Within 2030 the number of cars will increase by 30%. The price of fossil fuel will be 32% higher - turning fossil fuel based energy into a very expensive choice. Co2 emissions will shift from the value of 24GT in 2003 to 37GT .

In spite of this, even with a slow rate of development, mainstream awareness of these issues and pressure on governments to deal with environmental topics are growing: However supply of renewable energy will rise by 20% in the attempt to reduce Co2 emissions within 2030. Non-Hydro renewables will increase from 10% in the year 1990 to 30% in 2030.

Furthermore, power plants are getting older and need to be upgraded: surveys say that 55% of the European ones will be non-operative. The rest of world will increase spending by 60% between 2004 to 2030 on upgrading power plants to more renewable energy sources.

As we go further into the future, the energy used per capita will continue to increase. More than \$40 trillion will be spent over the next 30 years, as nations adapt to climate change and other environmental concerns.

“A lot of the information I needed to develop my concepts were not data and numbers: the important thing is to pay attention to what is important, not just what is quantifiable.

A good research approach should deal with both quantitative and qualitative information, what is granted and what are assumptions.”

Sevaldson, B. (2008). *Rich Research Space. FORM akademisk, 1(1)*

My context

So following this research, I arrived at two solutions to the energy problem for the future:

1. “improve efficiency”
2. “don't waste energy”

I decided to focus on the second point. “ Don't waste energy”, at the same time I was constantly aware that both are irrevocably linked.- They will happen at the same time in different ways and different contexts. The future will experience diverse energy production spread on different scales and with different efficiencies.

We are moving towards a future in which the society we will be living in will be self sufficient and energy will be collected all around us and we will participate ourselves producing the energy we will need too.

By the way, my intervention is not “that far” in the future;

It represents a step in between that future scenario and the today scenario, to prepare people for the forecasted scenario in which we will be forced to be more eco-friendly and to change our energy habits, while all objects around us will be self sufficient and self powering.

The context I designed my collection for is a future that deals with different ways of producing energy, evolving the present situation spreading the power harvesting among the whole society, from the very powerful and efficient power plant for public energy production to less efficient devices that people use on a personal level.

I want to work on this level, working together with people and technology.

The future will be driven not only by technology or innovation but also by small choices of ordinary men and women on a large scale and the passion they feel about these things.

That's the reason why I wanted my project had a small pedagogic meaning: green can also be easygoing and funny, it can be even less efficient but on the large scale effective as well.

New people and new attitudes can influence companies and governments, that have the power to change the context with a boosted speed.

“Turn Green to Gold: new partnerships, industry alliances and radical rethink about how we make produce, transport and use things. Together we can green the world – often at almost zero cost, financed by reduced fuel bills.”

An alternative to today's alternative products

Working with environmental issues is complex, since they often deal with uncertainty and ignorance, possible resistance to change in social settings; influenced by different visions, world views, ideologies, politic issues (...)

Plenty of products and ideas have been developed through the years and are today available on the market as alternative products that only a small niche buys: Why? People lack information about the alternative choices they can make and the power of those choices; they don't trust the alternative way, I guess, because it is still “not popular”, not spread enough among normal lifestyle, not yet.

Already we have the portable electro-magnetic generator Potenco, which you can charge your car battery with; the portable wind generator that you fasten to your bike collecting energy for charging your electronic devices, the portable solar powered charger etc.

The idea of a portable alternative power generator is not a brand new one.

It exists from the '80s, developed in different ways according to different types of energy: kinetic, thermal, electromagnetical, solar, wind energy (...)

Usually most of them tend to be very efficient but intrusive due to their dimensions or their usage modes that narrow down the situations they can be used in.

People often choose to use products that are less efficient but easier to use in normal situations using normal actions.

Instead of focusing on the existing huge field of practical and efficient active power supply, I looked at the opportunity to show people that energy is all around us, we just need something capable of catch this energy and convert it into something useful.

This is a completely new concept and I see a lot of potential in it, because I think it can help to open people's minds and force them to rethink the way they live.

System thinking

The process has been System thinking related;

- Holistic;
- Intuitive;
- Imaginative;
- Real world oriented;

I have undertaken a large amount of research trying to understand the energy field: how it is produced according to different technologies, what has been done and in which directions we are going; where the technology is taking us and what kind of boundaries is it going to redraw?

Energy is definitely one of those.

I drew a large diagram, probably the core of my project, that evolved along the process helping me from its very beginning linking elements, putting together ideas, generating rough concepts I developed later on.

Collecting and using very large amount of information, simplified of course but not too much, I tried to keep large amounts of information alive: for instance, diagrams were stick on my studio desk;

digital libraries have been created with lots of files, images, inspirations (...); annotations and post it were stick on top of the diagram completing the information increasing its complexity of relations (Rich Design Space, for System Thinking).

I find System Thinking Approach useful because I think it helps to understand the context through the interaction between their parts, more than understanding each part by itself: interaction between living organisms, natural context, chemical processes, artefacts (...)

The diagram starts with the energy production line:

Input, *Conversion*, *Output* are the four main areas, each one follows the other in order to produce energy. *Storage* dialogues with the other areas and can be placed before of after the energy conversion (according to the conversion features).

Input is the starting point of the process, it is where the energy comes from ready to be transformed and converted into electrical energy afterwards: we can divide energy into sub-categories, electric, electro-magnetical, magnetical, kinetic, thermic, nuclear, chemical, solar energy, wind energy.

Conversion is the middle step, where the transformation of energy takes place: the main subdivision is between electro-magnetical conversion (the traditional one based on mechanical devices that convert kinetic energy into electric power), piezo-electric conversion (using piezoelectric properties of piezoelectric materials*) and the out coming brand new nanotechnologies (that will increase the possibilities of energy harvesting reducing the dimensions of the devices we are used to today).

The energy *storage* is crucial element for the production of energy: there is no energy to be used further if none has been stored.

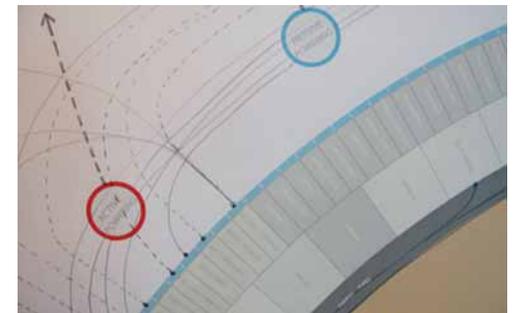
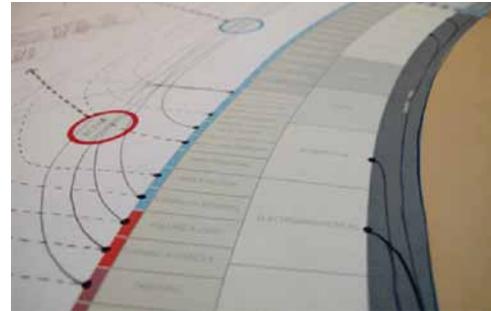
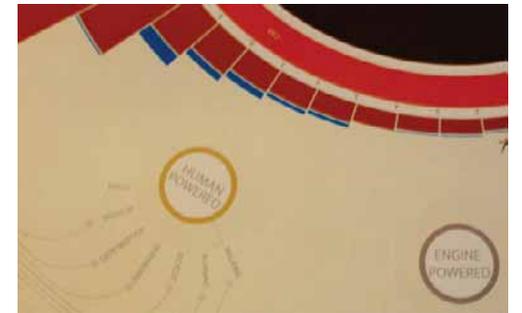
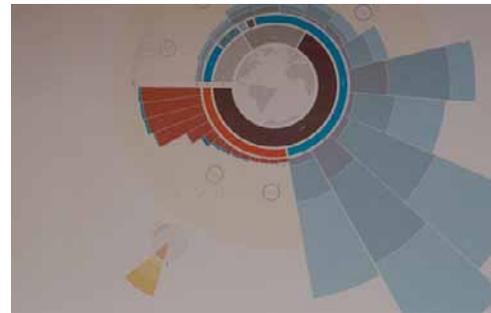
Pre-conversion storage can be mechanical, using devices (such as the flywheel, the spring..) that store inside themselves the incoming input energy, waiting for the moment in which the energy will be released and then converted into electrical power.

Post-conversion storage waits the input energy to be converted into electricity, making use of chemical batteries (based on chemical reactions) or electronic devices (using difference of potential) to store the incoming energy before the moment of its actual use.

The *output* is the electricity we normally use, with all its related problems: the electric wave shape, the voltage, the intensity etc.

These features are small very important aspects that will allow us or not us to use the energy we stored to power our small electrical devices (the target of our charge). In short the output energy we stored we need to have the with a compatible characteristics of signal that our device will recognize and understand.

producing energy
without thinking



First diagrams

*It shows the energy production line,
the relations between alternative energy
production products and data taken
from world's surveys and forecasts.*

energy from renewable energy



Experts and upgrading

Why am I focusing so much on technology? Is this project about technologic devices? Not actually. It's more the concept of a new energy production scenario spread among society on a totally different scale.

I wanted to design something based on actual already existing technologies that was conceptual but that could have been developed tomorrow, not in the next five years. I wanted it to be something real even if not designed till the smallest detail, instead that just a futuristic wandering for the future energy production.

Research modes, exploration, reflection, generative work, description were the steps I went through during all my project.

That's the reason why I read a lot of articles, interviewed technology experts trying to understand as much as I could the technological aspects that must be taken in account before and during the design process.

I drew the first rough concepts, I went to the Oslo Institutt for energiteknikk (IFE), where I spoke about my ideas with Geir Helgesen (IFE Nanoparticles and Complex Materials Senior Scientist) and Arve Holt (IFE Solar Energy department head); I was in contact with Torben Damgaard Nielsen, innovation pilot researcher at Risø DTU (Danish center for sustainable innovation) and Barbara Bentzen, Danish Industrial designer MDD.

Taking in account their comments and criticisms, I tried to do an evaluation of each concept, doing some more research System Thinking related filling in the holes that I discovered to have. My old concepts were too much single product / technology oriented.

I upgraded my diagrams adding the data I took from statistics and forecasts for the future of technologies, transportations, environment, pollution, energy production (...) increasing the amount of information in my Rich Design Space, that turned to be a useful "tool" or a meta-tool for research-by-design.

Small scale energy harvesting and the concept of the piggybank

I ended up with a new concept that has parts of the initial concept framework, but developed in the direction of "practical use and conceptual rhetoric", embedding the newest technologies or the more traditional ones with brand new applications or some new special features;

The concept analyses the "small scale energy harvesting" theme showing a small collection of objects developed in order to seem not just a concept but actual and real products: in this way people are encouraged to think they can really be small scale energy producer and not nly mainstreamed energy consumers, inducing them to get informed about alternative energies, how they work and can be used to improve their lives.

I wanted my designs spoke somehow a rhetorical language, being challenging and provocative: the small collection is not made up with typical energy production related products, even if they collect energy anyway. How do they do it?

They underline that harvesting energy could be possible everywhere, if only we started getting used to alternative technologies and were ready to look forward to new ways of collecting power, understanding that very efficient way of doing it is not the only possible one. Energy is all around us.

As I said the project is not about technology but energy harvesting done in the easiest, most rhetorical and un intrusive way.

Un intrusiveness related with energy production is a concept that a lot of company are developing, in many different fields; in this case speaking about the energy one, energy producing systems are embedded directly into clothing, fabrics, buildings etc.

Energy production is loosing its engineering appeal becoming more charming, easy-going, closer to people's lives and lifestyles. Being something fascinating and beautiful. That is the way I wanted to take.

If someone loves the objects he owe, he is more willing to believe in it.

Here the power – and the responsibility – of communicating something good.

The concept of "small scale" harvesting is pretty new instead, at least if it is related like here to the idea of the "piggybank":

It is the traditional name of a coin accumulation and storage receptacle; piggy banks are typically made ceramic or porcelain, and serve as a pedagogical device to teach the rudiments of thrift and savings to children; money can be easily inserted, it will be stored there increasing more and more every coin we are adding till, in the traditional type of bank the pig must be broken open for it to be retrieved. The traditional symbol of money savings is used here to show that small savings could represent a practical and pedagogical way of relating to the energy issue.

Something going in this direction seems to be starting now:

from the last few years some projects around the world that use low efficient technologies have been developed (the Tokyo subway stations powered by the East Japan Railway Company installing a revolutionary piezoelectric Energy generating floor; the same happens in London with the eco-nightclub then in Rotterdam with Club Watt) even though this "low efficiency" is quite "efficient" and the amount of power harvested is quite decent due to the particular public context they are put into.

The most of the alternative energy power supply that I found are swinging between "power source + function" or "just a power source". In short are devices to be used merely to have a decent amount of power in a short time, for emergency situations. Most of them use kinetic energy converted into power, active work has to be done by the user in order to collect energy.

So then I thought, *wouldn't it be possible to harvest energy from normal actions and situations so that the needed work to be converted into energy is something we would do anyway?* The work needed would turn to be passive even it would be an active one.

This would turns a product like that into something less efficient compared to active powered power source, but it would be something completely different.

If these objects were not just power sources but simple normal objects, something useful and desirable that people like and use everyday, with the only difference that they harvest a certain amount of energy every time we use them collecting it on and on like the coins in the piggybank, the result would be at the same time practical, rhetorical and pedagogical.

Why energy has to be collected only for fast uses?

Why power sources can't be simple and charming, good looking as normal objects instead of just devices-to-accumulate-energy?

Until a few years ago it was hard to find something considered good being not efficient, performances first of all; now things are changing a little discovering, at least on a private scale, that it doesn't matter having the most efficient object if it doesn't have any link with our lives. Objects that we feel ours are the ones we use the most.

First diagrams

It shows the energy production line, the relations between alternative energy production products and data taken from world's surveys and forecasts.

The small scale harvesting collection

Once focused on the theme “small scale harvesting”, I started developing a series of objects that could be at the same time actual tools to harvest energy and rhetorical instruments to make people think about the problem of energy savings and energy production, improving their alternative and green attitude to life.

The project is part of a discursive design, as it refers to the creation of utilitarian objects whose primary purpose is to communicate ideas—they engage in discourse. They are tools for thinking;

they raise awareness and perhaps understanding of substantive and often debatable issues of psychological, sociological, and ideological consequence in order to be considered design rather than art, they function in the everyday world, but their discursive voice is what is most important and ultimately their reason for being.

The products shown in the small collection are important but they are not the most important thing in the project: each one of them is based on a working developed technology and has its own meaning by itself, but the real meaning is understood

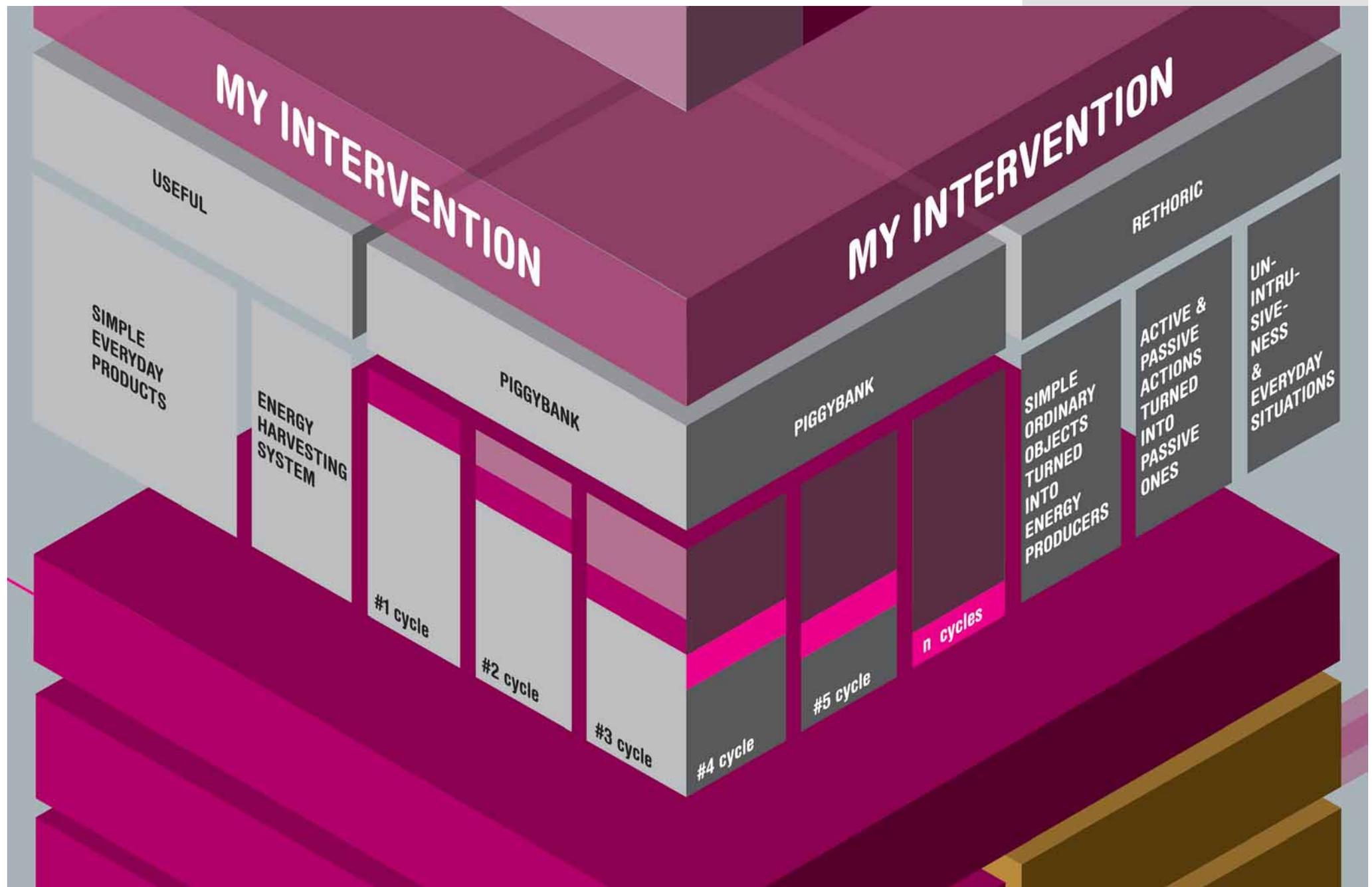
looking at the whole collection, considering them as a proposal among thousands possible of what this idea of small scale energy harvesting could be developed.

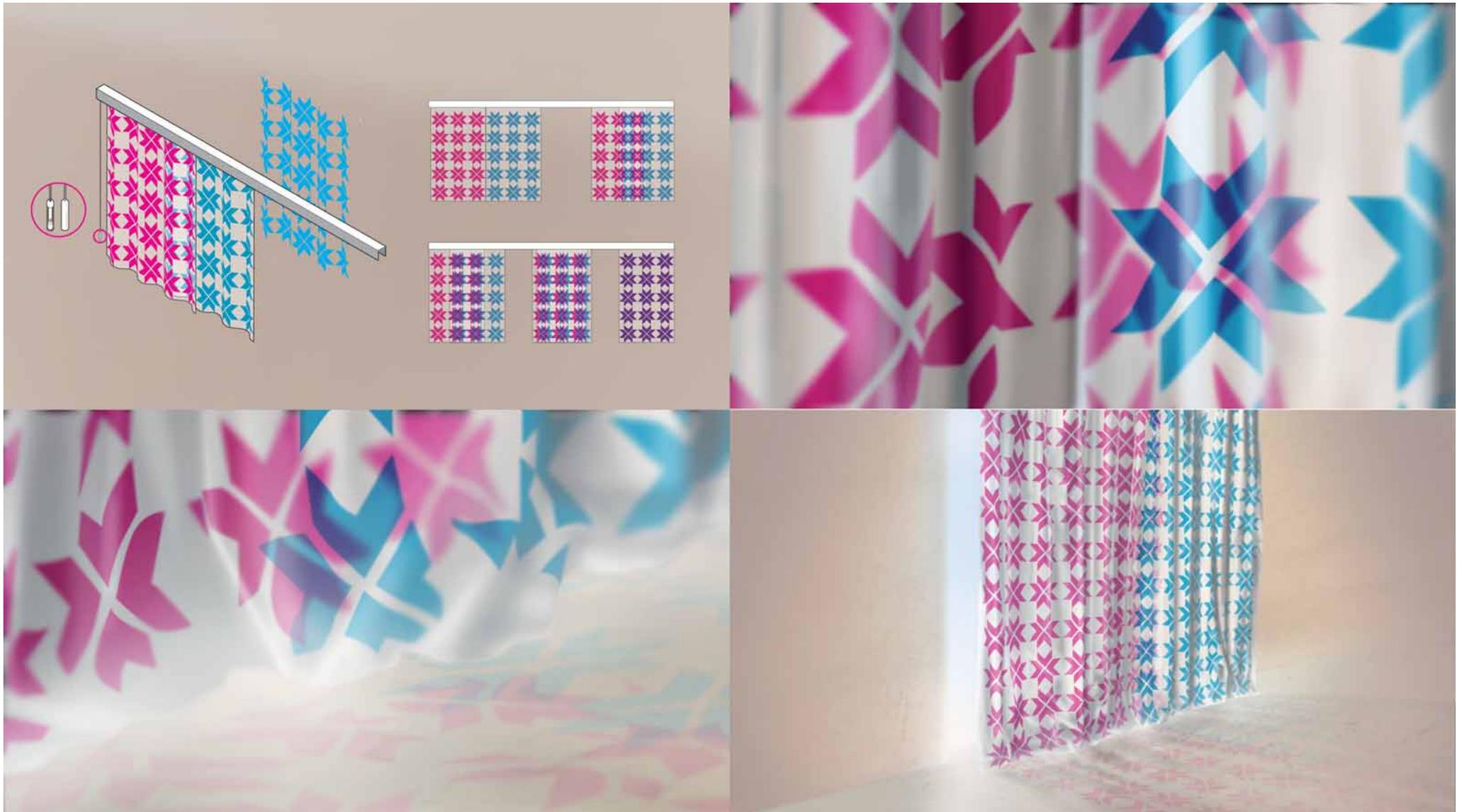
I chose simple object, the simplest I could.

I chose the most un intrusive technology developed today, without being too expensive or too much into future development and upgrading.

The small collection is made up of four products: Colourful energy, Enjoy the sofa, Energy from above, Cubes of light.

Final diagram: close up of the main features of the project with highlighted the central concept of the “piggybank”.

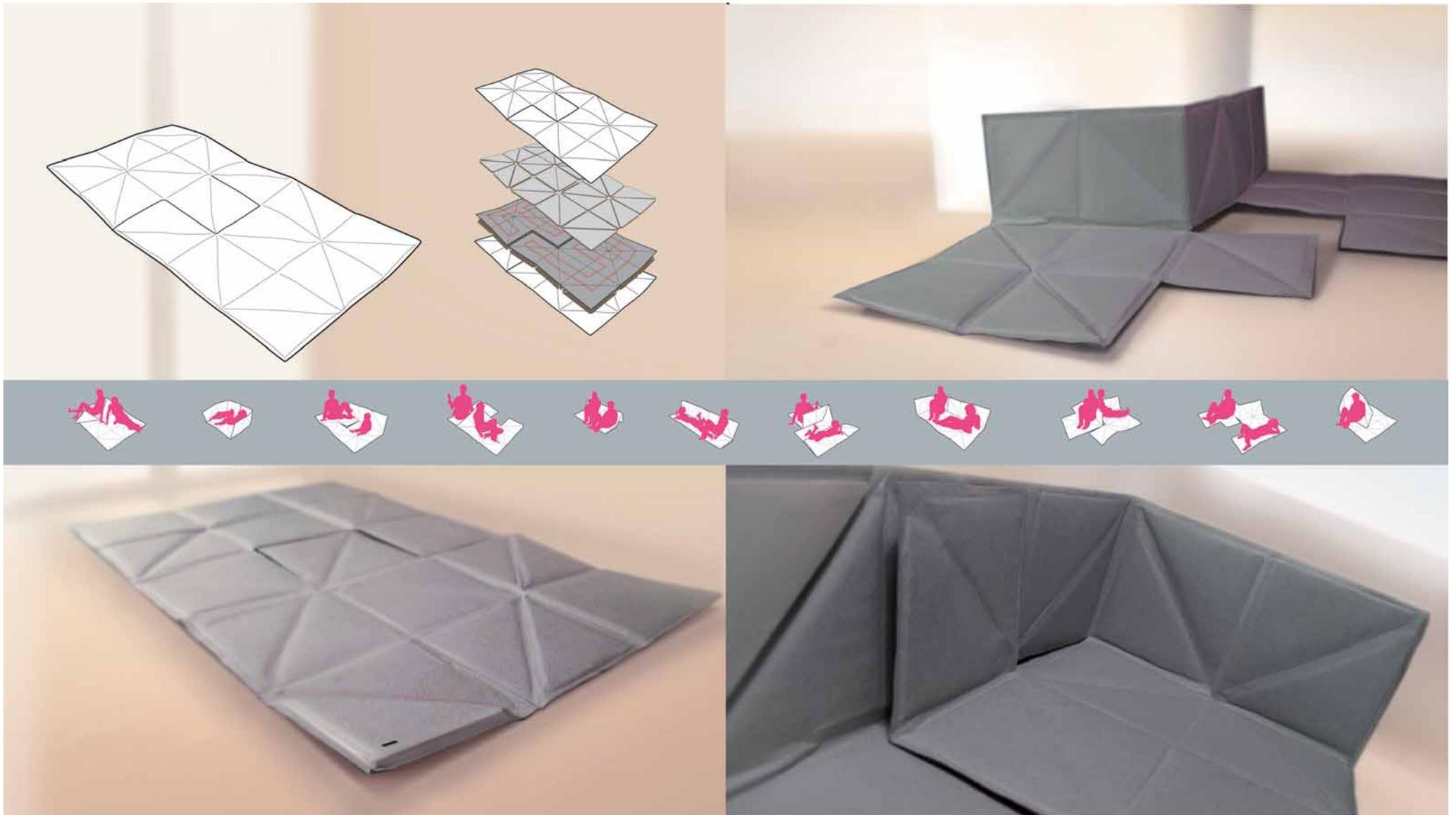




*From the top, clockwise:
main characteristics of the curtain, the
battery and the patterns overlapping;
close up of the patterns painted with
solar ink and connected to the storage
system;
the patterns overlapping each other
modulate the light coming in, drawing
on the floor colourful spots mixing together;*

Colourful energy:

The curtain project uses a brand new technology that turns solar panels into something beautiful and decorative, efficient and cheap at the same time. The base of the curtain is a recycled plastic sheet on which polymeric solar ink is printed through screen-printing: the polymer components are dissolved into a solution and then printable as normal ink with different shapes and different colours. Two or more separate transparent plastic sheets with different patterns and different colours printed on each one of them are mounted on the same frame. A rope with a plastic cylinder at the end of it hung from the frame; pulling the rope the two surfaces are moved modulating the amount of light coming through the curtain as the surfaces shift one close to the other and the patterns overlap more and more. The plastic element mounted at the end of the cord is a storage system (lithium battery) that collects the energy from the sun converted in electric power by the coloured textures of the plastic sheets, with a USB out to charge small electronic devices afterwards. The project shows the possibility to have a beautiful object you can interact with to change its behaviour and at the same time collect energy from the sun in a totally new way.



Enjoy the sofa:

The sofa is also based on the piezoelectric technology; It is a way in between a proper sofa and a mattress as it can be used both ways. It has a rectangular shape and it is made up of many soft triangular modules linked together that let people decide what shape give to the sofa, how to bend it, where to bend it and how many times. A zipper follows the modules allowing to break the shape of the mattress and to open it in order to have a more diverse and varied configuration.

The living-sofa has a cardboard core with printed foldings on it that define the modules shape; on top of the cardboard a long piezoelectric PVDF wire is put and is linked to a battery placed in one of the corners of the mattress. The piezo wire and the inner core are then covered both sides by as many triangular latex modules as the ones defined by the foldings on the cardboard, then everything is covered by textile.

The aim of the project is on one side to live the space in a different way having something adaptable, transformable, never the same and completely up to you; on the other side is designed to collect all the vibrations, all the impacts and the hits that people pass on the surface of the sofa through the PVDF wire using its piezoelectric properties to convert them into electrical power to power small electrical devices.

*Structure of the sofa with its elements
and the piezo wire n between
the core layers;
possible combinations for different
situations;*

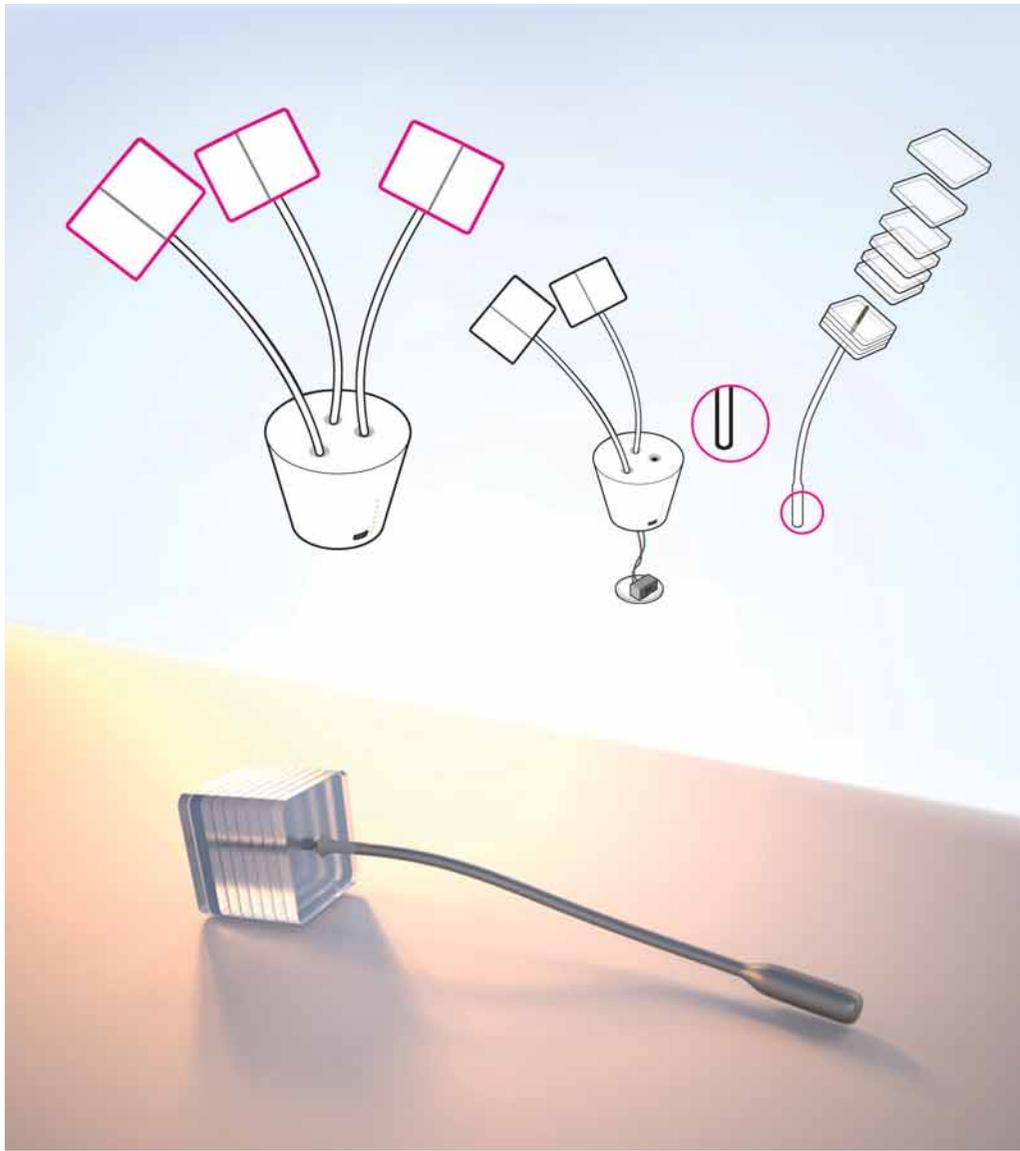


Structure of the umbrella with its elements and the piezo wire wounded on the plastic sheet and linked to the battery in the handle at the bottom of the stick

Energy from above:

The umbrella is made up of a thin plastic sheet on which a long piezoelectric rope is wound which covers the whole surface of the umbrella on it that covers the whole surface of the umbrella and it is linked to a battery placed at the bottom of the stick. ⇄

The project's aim is to collect energy from the raindrops bouncing again and again on the surface of the umbrella. It has its inspiration from the French research team directed by Jean-Jaques Chaillout that recently has discovered that each raindrop bouncing on a PVDF sheet collect until 15 m/W of power.



Cubes of light

The lamp is made up of a vase in which three flower lights are placed; the head of each flower is made with several plexiglass squares forming a transparent cube with a LED light in the middle of it;

Each flower's stem is flexible and is completed at the bottom by a storage system (cylindrical lithium battery) and it contains the wires, the technical parts and a potentiometer that twisting the cube modulates the light intensity. Each plexiglass cube is painted with a transparent varnishing called Photon Inside, a new special paint, a solar panel liquid spread like a paint.

The painting is made of five layers, and the electric contacts are incorporated into the layers, in order to store the energy harvested from the sun into each flower's battery. Each flower's power is about 1W.

The flowers collect energy both when they are put alone under the sun rays and when they are in the vase.

The 'flower vase' has two different uses:

When the electricity goes off, the vase switches the lights inside the plexiglass on, that can be used as emergency light sources in the moments of complete darkness.

*from the top, clockwise:
structure of the vase lamp, with its parts
and the inside of the vase;
the flower used as emergency light;
the three flowers placed in the vase light
using the energy stored in each battery;
flower lamp laying on the sun harvesting
energy from the sun rays.*

The vase has also a USB out, so that when our small electronic devices run off energy, we can plug the adapter in the vase and a mobile, mp3, pda, iPod (and other small low voltage electronic devices) will be charged or partially charged "for free" sucking from the three flowers the overall energy collected in the batteries.

The aim of the project is to have something useful and beautiful at the same moment that could be used in different ways, on different levels making people think about the energy saving issue.

Collection completion:

They are thought to be easy to disassemble, making the recycling process easier and more effective. The chosen materials are supposed to be re-usable, recycling friendly: the sofa's cardboard inner-core, the curtain's recycled Plastic sheet on which the solar panels are screen printed, the LED lamp's plexiglass waste products, the recycled plastic surface of the umbrella.

To complement the small energy harvesting collection there are also some other support-products: a *web platform*, a *wrist watch* and a *mirror*.

Getting registered people can download an application to install in their mobiles, Pda, laptop (...) with built in bluetooth technology:

All the products of the small energy harvesting collection have built in bluetooth technology that communicates the amount of stored energy in each one of them via Bluetooth.

The *mirror* is also a sort of media between the energy harvesting collection and the user: on one hand it is a normal mirror reflecting the owner's image, on the other it becomes the reflection of the user's behaviour, showing him the harvested energy of all his products, suggesting what he can power at the moment, how long etc.

At the moment of the first purchase of one of the objects of the small harvesting collection, a *wrist watch* is given as a free loan to the buyer;

it's a simple normal watch with some special features: it has built in Bluetooth technology and has a screen under the watch hands that shows the owner the presence of other objects of the small harvesting collection in the nearby. It communicates the robustness of the project, showing that other people like the owner of the watch made the same alternative choices, that the products work like other people's ones, generating awareness in the mind of the people. It is a sort of subtle propaganda of the "harvesting project" main idea, but all happens in the mind of the people, without moralism or undue underscores. The watch has also an emergency button thought for those situations in which people are outside or far from home and the mobile (or whatever other small electronic device) all in a sudden run off battery: pushing the red button on the side of the watch, it sends an emergency signal to other (possible) small harvesting collection's owners, in order to ask for some energy loan, energy sharing.

The *web application* downloaded on mobiles (...) allows also to have access to the same information communicated by the watch, having the possibility as well both to see the harvesting fellows and to send the emergency signal in extreme situations.

The three media supporting the energy harvesting products: the wrist watch, the mirror and the website with the application downloadable on Pda, mobiles and laptops.



Possible future consequences

This project works around relations, between people and objects and between people; working with relations implies working with time, immediate and long term impacts:

the project on the long run might have also pedagogical outcomes.

As a matter of fact if people are shown that harvesting energy is possible and the technologies available today are developed enough to be used in our everyday life, this could help thinking that having electricity at home in the traditional way is good but it is not the only possible way.

If you are shown that saving energy from normal actions or situations on one hand is hard because the amount saved could be very little, but easy to harvest on the other hand because it requires no “more” energy by the people (since it uses energy they would have used anyway), it would be a good way to teach people how to save energy, keep on accumulating it waiting for a proper practical use.

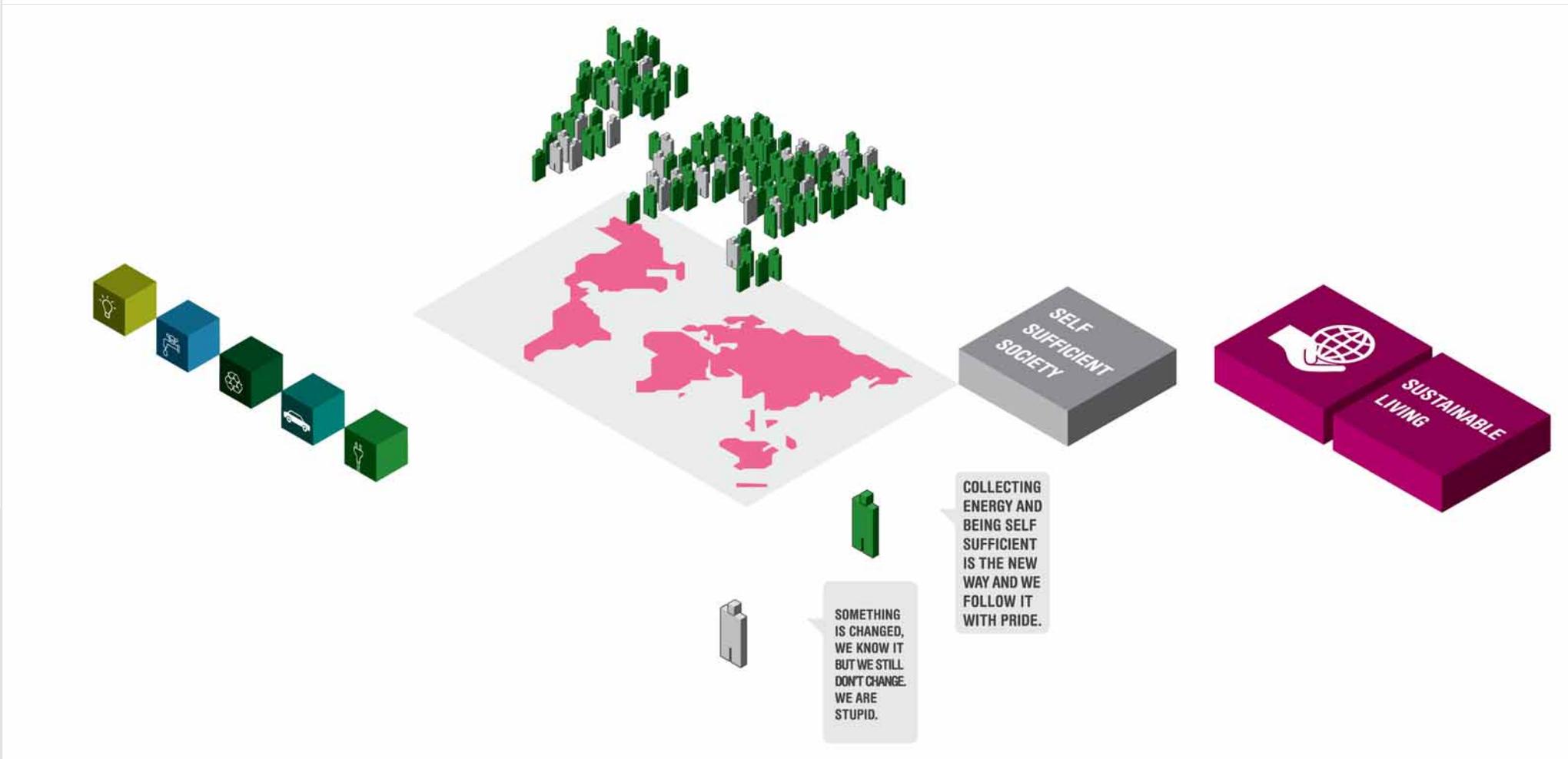
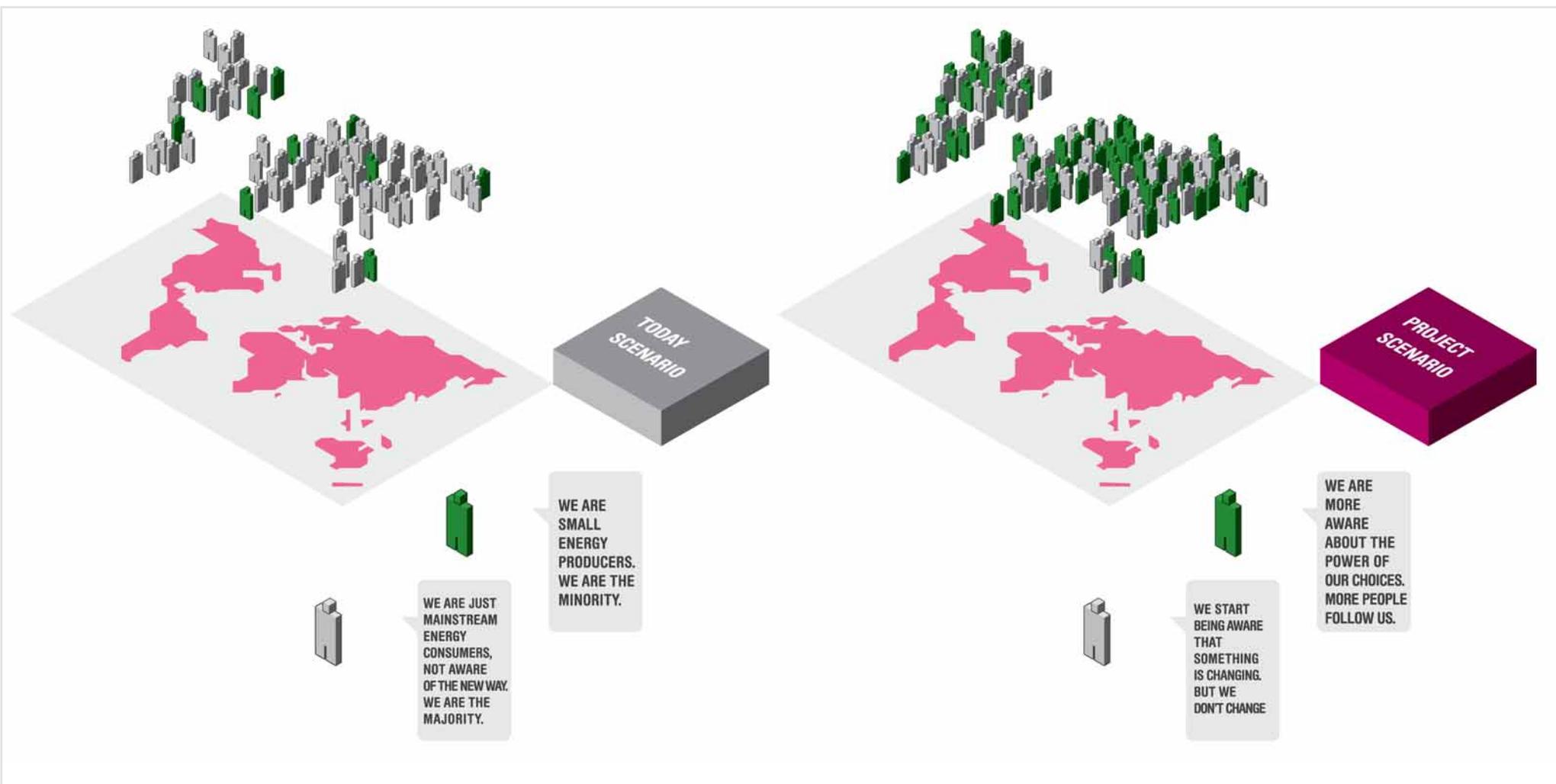
People could become small scale energy producer instead that just energy consumer, and for a greener and more sustainable future this is a better choice. If in the future scenario the objects around us collected some energy as the piggybank collects money, probably people would have a different attitude to the world, being more and more sensible towards environmental issues and probably more and more independent.

Saving energy means helping the planet to be less polluted than it is today; furthermore helping the planet means a lot of other things, from wastes recycling and re-using, to more radical little changes in people’s life that if followed by many people could really make the difference.

It’s a big step because today people don’t want to pay more money for no energy harvested.

But if the energy collected is pretty cheap and integrated into all normal objects around us designed as simple, beautiful and desirable, they can be an alternative choice to the non-objects that populate our houses, fellows of ours in our lives: their beauty would fascinate us, their special features would stimulate our minds going beyond their simple shape and uses, speaking instead about possible shared alternative lifestyles, alternative choices made about the same small energy harvesting collection.

World attitude towards environmental issues evolution from the nowadays situation to the future scenario.



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Discursive Design:

Beyond Purely Commercial Notions of Industrial/Product Design

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