100: BUILDING

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First approach to a 100 inhabitants community.

How do the distributed systems that are characteristic of the Internet affect the design and construction of buildings? How can buildings be designed to act as active organisms within urban ecosystems? Can buildings be self-sufficient?

Human beings wouldn't need houses or cities if they were interested in living naked out in the middle of nature.

Our ancestors did it.

A building is a habitable structure, the fundamental mission of which is to create stable boundary conditions for human activities. Buildings emerged as a part of the logic of setting up stable settlements in the territory, associated with the production of food, goods and energy, and with community living.

The history of civilizations is manifested through the history of their buildings. Each civilization is associated with a different degree of knowledge in the manipulation of natural resources to produce materials for their construction. Buildings are designed and constructed using each society's own technology and culture. Greek temples, the domes of Persian markets or Renaissance churches in Rome are all manifestations of the depth of the human spirit, which comes to life, timelessly, in certain places on Earth, at certain moments in history, as the expression of a civilization.

Buildings are the basic unit of an architectural project. Architecture is the art of dwelling.

Buildings are part of the material cycle of the world. Their materials come from nature and will return to nature as debris. Where industrialization allow for the development of manufactured materials, like steel or concrete, and later plastic petroleum-based products, now we are working toward the development of materials that do not contain chemical elements which, when they return to nature, are sources of pollution.

Buildings, as functional nodes in the multiscalar habitat in which we live, must be transformed into producers of resources, as opposed to mere consumers. They need to incorporate new systems and technologies, which will change them into active entities in the interchange of the city's energy and information.

Whereas, in the 20th century, the physical structure of buildings was transformed, moving from

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load-bearing walls to reticulated structures, in the 21st century buildings will incorporate a metabolism of their own, which will change the way buildings relate to the environment in which they are built.

Buildings, like organisms in urban ecosystems, form an organized and complex material structure, participated in by information systems, and which establishes a relationship with the environment through the exchange of material and energy in an orderly fashion, and which has the ability to perform the basic functions of dwelling. Architecture, according to the biologist Ramon Folch, is a particular case of ecology, in the same way that medicine relates to zoology.

Self-sufficient buildings

In the year 2005, we looked on, with astonishment, as housing prices continued to soar while the objective value failed to increase. The value of nearly any good does down over time and with use: a vehicle, a computer... And yet, the prices of office buildings and apartments kept getting higher. Logically, the illusion blew up, because it was “the market”, through multiple agents, that was causing the increase.

In any case, in 2005, we launched an Internet competition at the IAAC, called Self-Sufficient Housing, coordinated by the architect Lucas Cappelli. The goal was to create self-sufficient buildings by defining new technological paradigms and integrating them through design. If a building is going to be more expensive, it should do a lot more. And the local generation of energy seemed like a new requirement for buildings.

The result of the initiative was that we received more than fifteen hundred entries from students and architects from a hundred different countries, who sent in different proposals that negotiated with the technological and the formal, the organic and the natural. This initiative gave way to other competitions, like Self-Fab House or Self-Sufficient City, which helped us discover new talents and develop a framework for debate and international research on self- sufficient habitats.

Buildings consume a third of the energy that is consumed worldwide, and of that percentage, 10% corresponds to urban, non- industrial buildings.

In the nineteen twenties, a large number of paradigms were defined for new buildings. There was a moment during the 20th century when the fascination for mechanization and artificial control served

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to define a model in which buildings were net consumers of resources, especially energy and water, and generators of urban waste material. It was a race to improve people's quality of life, also rooted in the advance of democracy, and there was a tendency toward improving living conditions for the majority of citizens in Europe and America.

Metropolises were structured toward the external production of the energy that was to be consumed internally, and used to centralize and sterilize the management of the waste materials and grey water generated there. It worked up to a certain magnitude, both in physical terms and human terms. Today, in the West, cities are butting up against their neighbors, and many of the elements that were once external have been absorbed into the continuous built magma that surrounds cities.

We are now experiencing an internalization process with respect to cities' infrastructures. Buildings, as physical and legal entities, need to recognize the productive elements that they can take on.

If in the 20th century, the regulations required that all buildings include lighting infrastructures and running water, in the 21st century, the regulations will require that all buildings produce as much energy as they consume.

If we study natural patterns, we see that trees produce the energy they need to live, and they function because they are physically connected to the ground that lets them carry out the biochemical exchanges necessary for their survival.

Buildings should be like trees: self-sufficient organisms rooted in a particular reality.

If in the 20th century there was a change in building paradigms as a result of new physical structures made of steel and concrete, in the 21st century there will be a paradigm shift as a result of new logical and energetic structures.

Housing is no longer a dwelling machine. Buildings are dwelling organisms.

Buildings can be self-sufficient and they can be connected to other buildings and other networks to define the processes of exchange between production and consumption.

In order for that to be possible, intelligent networks need to be developed to manage buildings generation and consumption processes. We dedicated our efforts toward that end in the Energrid project.

A house is like a tree: its roof produces energy, which is sent to batteries where it is stored. Its fruits

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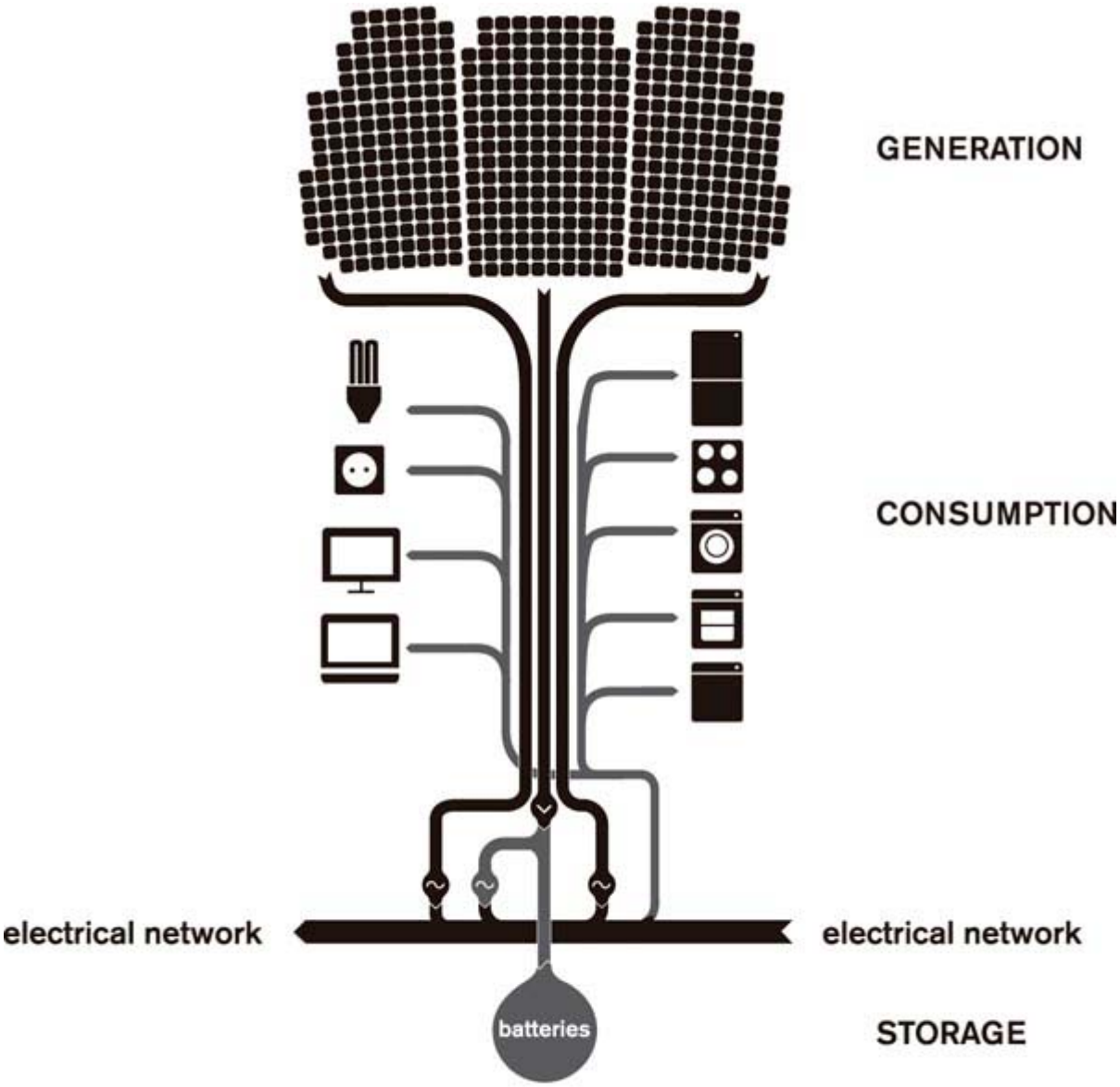
are light and energy.



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The electrification of society

In fact, the electrification of society will allow for relating systems that are currently separate (housing, mobility, production) in the same way that digital systems have allowed for the interaction of different media.

A large part of the success of the information society has been due to the digitalization of a number of resources that used to be analog. We listened to music on records; television was broadcast through the air and telephone signals travelled via cable. Books were read, and are still read, on paper. Digital technology has allowed for the creation of new platforms where all of those media are interconnecting and they create synergies. Today, we use electricity for lighting, for home appliances, and in some cases, to heat buildings.

Cars are a separate question. When I was a child, there was an urban legend about an electric car that had been invented, but the inventor had "disappeared" as a result of the interests of oil-producing countries. It was a widely distributed myth. Ten years ago, I saw the first fuel cell car, powered by hydrogen, which seemed like it represented the future of energy sources for the automotive industry. However, ten years later it seems that the industry has developed lithium ion batteries that are more efficient and clean, which are the ones that have been used in the first electric cars that have been produced industrially.

High-speed trains are electric, in contrast to the coal-powered or gas-powered trains of the past. The electrification process seems unstoppable, and it could allow for the creation of synergies between the building industry and urban mobility. As such, buildings, as potential producers of energy, will be essential nodes for the generation of energy in cities, in close proximity to where that energy is consumed.

Automobiles will be the place where the energy produced in buildings can be stored. And the energy in an automobile will be able to power a washing machine or a computer. And a hundred automobiles parked and connected could recharge a city bus. Automobiles will be like the buildings' hard drive, used to store the energy that is produced, as opposed to information.

The automotive industry, which is multinational and global, will interact with the building industry, which is local in many cases, through the common language of energy.

Electrification will be to the physical world what digitalized has been to the information society.

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Adding value to the territory

Real-estate development is used, on a global scale, as a permanent platform for investment or, in most cases speculation.

In the traditional model for the urbanization of the territory, there are two moments in which value is added to a place.

The transformation of rural land into urban land, through urbanization, is the process through which the parameters for the transformation of the territory are defined. Definitions are provided for: density, uses, and the type of urbanization, facilities, general systems and other elements that will serve to constitute the city. Through this administrative process, the price of land increases, without necessarily increasing in value. Once land belongs to a new category, it has a different price.

Many large fortunes have been made through this process, in which there is no increase in the material value of a place. Having a purchase option on a plot of land, requalifying it and selling it without even having bought it is common practice in the western world, which is in keeping with the stock market speculation that has been seen in recent years. The territory is like a casino. Another moment that requires a greater effort is the construction of a building. The aim of anyone in business is to maximize profits. But, when the construction of a building implies a spatial, visual and urban impact for citizens, construction should be an activity tied in with excellence.

After decades of construction along the Mediterranean coastline, future generations will be condemned to suffer the consequences of this short-term economic development.

Whereas in the 19th century, value was added to the territory by transforming agricultural land into urban land, in the 21st century we can add more value to the territory by regenerating cities in order to make them self-sufficient. Making buildings self-sufficient means adding value to currently inert structures.
Building according to current techniques is relatively simple. All buildings have to guarantee structural security and a series of minimum networks. In Spain, when developers urbanize land, they are required to build infrastructures for water, electricity, communications and waste material, which are handed over to the city council to handle the connection of those buildings to the large-scale networks.

In Spain, at the present, all of those infrastructures are managed by private companies. Urbanization

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implies the transfer of a series of systems to companies, based on certain protocols that lead to a situation of near-monopoly.

This situation does not occur in any other sector. Except the urbanization of the territory. What is really relevant is that up to now, developers built as cheaply as possible, with as generic a design as possible, in order to encompass as broad a population as possible, and once the product resulting from the urbanization process was sold, they turned their backs on the place.

Build cheap, sell high, and hit the road.

Now, we know that the potential lies in sticking around. Securing a life-long client, who needs to be supplied with electricity, water, heating, telephone services and content, is what most companies that operate those infrastructures aspire to. Just like in the automobile sector, where automobile prices are set with a tight margin in order to allow for managing its maintenance, building maintenance and the provision of resources is a sector of the economy which will need to be promoted in coming years.

In contrast the model of building cheap, selling high and getting out, new developers will want to build well, sell or rent at a fair price, and stick around to manage the provision of services indefinitely.

If we understand the economy of the information society to be focused on producing and selling products, the information society is based on a service economy. Building as service hubs. Cities as centers for dwelling services.

Energy Services Companies

That is how energy services companies came about, called ESCo (Energy Service Company).

The business model for these companies is based on the idea of investing a certain amount in buildings so that they can produce energy (through photovoltaic systems, windmills or other) and so they are better isolated, and then creating a control system that allows for improving the buildings operations to make a return on their investment based on the savings that are generated. That could mean the creation of energy services companies for every building, city block or neighborhood.

One fundamental variable for evaluating possible investments and returns is the price of energy and

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the premiums (as the case may be) for the generation of energy using renewable systems.

However, Spanish law allows for the production of food and products to be sold to neighbors, but it does not permit the production and sale of electricity (or an Internet connection) for resale to neighbors. It is unbelievable that the two key aspects of our culture, energy and information, are regulated in such a way that citizens are not free to produce them and engage in trade with them, like with any other economic activity.

Traditional power is based on the control of a few key questions, like military force, finance, energy or information. The local production of energy and its direct trade and exchange in an unregulated manner would break with the logic of the control of habitats, production and mobility which energy implies.

It is also true that the emergence of systems for the micromanagement of energy requires a new energy culture, both among citizens and among energy companies and cities' own management, and in the infrastructures designed for that purpose. In the case of renewable energies, many countries decided initially that all of the energy produced had to be sold to the network, compensating for this micro-production with quantities far in excess of the price at which it could be repurchased later. If energy is sold, the premiums in existence up to the present make it more profitable to sell it to the network and repurchase it than to make direct use of the energy produced. This situation is sure to change. Eventually, citizens will pay the real price for energy; renewable energies will no longer be subsidized and the cost of production will be equivalent to other technologies.

When that happens, self-sufficient buildings will make all the energetic sense in the world.

In 2009, the City Council of Sant Cugat del Vallès, a town in Barcelona's metropolitan area, Acciona and the IAAC came to an agreement to evaluate the possible development of a self-sufficient building. The initial idea was to be able to literally disconnect from the electric grid, given the obstacles that electricity companies tend to put in the way of developing certain kinds of projects. It is technically possible, but it isn't legally possible yet.

In this project, a public company would finance the housing and the extra investment for the local production of energy would be financed by and energy services company. During fifteen years, then, the energy produced locally by that company would be sold, and then the infrastructure would be transferred to the City Council. In theory, the energy production would be carried out using a small biomass plant or through geothermal energy complemented by photovoltaic systems.

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Finally, instead of being off-grid, we proposed that it should be “zero emissions,” i.e., that the annual difference between production and consumption would be equal to zero. Sometimes, zero-emissions buildings are just a politically correct concept, but they imply a certain amount of euphemism. Some buildings claim to be zero-emissions, but they only generate locally 10% of the energy they need, and to compensate for the emissions of greenhouse gases, thousands of trees have to be planted in another location, while the buildings are under construction. Accounting maneuvers, once again.

In Gandia (Valencia), we built a building with the company Visoren (Social Housing for Rent) for young university students. In this case, the company builds and manages housing on public land in a concession for a period of forty year, and they have the possibility of offering other services associated with the rent. In the process, they reached an agreement with Endesa, the company that will provide the energy services by buying gas from a supplier, producing hot water locally to supply to users and producing electricity, the excess of which will be sold to the network.

The building produces a large portion of the energy it needs to operate, but it will obviously not be zero emissions, because its basic energy is derived from natural gas.

In both cases, the model works economically and, as such, could be extended to other locations.

The fact that buildings will produce energy will change the relationship between buildings and automobiles. If a building produces energy, the decision can be made as to whether to consume that energy locally, sell it to the network, store it in batteries in the building itself, or store it in automobiles.

An intelligent management system should be able to assess the price of energy at any moment and decide what each building should do (or each user within a building if the system is segregated) with the energy it produces.

In the case of Barcelona, the city blocks that make up the Eixample include buildings that can create energy production units based on the relationships between a number of owners-generators and consumers, in order to create a more dynamic system. It would be useful to analyze how to reward the communities that produce their own energy and which, as a result, will not depend on large-scale infrastructures outside of cities.

The biggest challenge presented by these new principles that entail the local production of energy, its intelligent management and, optionally, waste material recycling and water treatment, is the

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development of new designs that integrate all of those aspects will city dwellers' living conditions.

Building parameters

Current buildings are defined according to their form and their function. They should also be given a metabolism.

If today buildings are defined using parameters that have to do with their height, building depth, their total floor area and the permitted uses, other parameters should be added to emphasize their efficiency.

We should be able to describe a building's anatomy, like an organism's, (its form and its parts), its physiology (its function) and its metabolism (energy flow and systems).

If a building generates all of the energy that is consumed within the building, should the taxes paid on it really be the same as for the surrounding buildings? Self-sufficient buildings reduce a country's energy dependence and eliminate the need for creating large-scale transmission infrastructures to ensure supply. Buildings should have an epsilon coefficient that reflects the relationship between the energy they generate and the energy they consume on an annual basis. A coefficient of one, or more than one, should be rewarded (at least initially) with lower taxes. Similarly, water consumption should be fixed using an alpha coefficient that defines the consumption of water per inhabitant, how much is recycled and the amount of rainwater that can be stored.

The word Barcelona contains the initials of the parameters that buildings should incorporate in order to evaluate their operation, linked to the different networks that run through buildings and cities:

B be good

A aqua

R recycling

C circulation

E energy

L logistics

O2 air quality

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N nature

@ Information

As such, buildings should set parameters concerning their metabolism, which should have the same importance as their physical and operational parameters.
The inclusion of values related to the building operations in the transformation of the city can help us leave behind “Barcelona posa’t guapa” for “Barcelona, regenerate”, where citizens will be active agents in the changes that are effected, not just on the surface, but in functional and energetic structures.

The Solar House

In summer of 2010, the IAAC participated in the Solar Decathlon competition, with the project Fab Lab House organized by the United States government’s Energy secretary, the Spanish Ministry of Housing and the Polytechnic University of Madrid. When the competition began in Washington in 2002, launched by Richard King, the idea was to promote the development of solar housing by universities and research centers, with the aim of demonstrating that it was technically possible, and to encourage the creation of consortiums and working groups that would be dedicated to the effort.

Many of the projects that had been presented in previous years were energy efficient, but they often employed solutions that were very elementary from a spatial and formal point of view. A solar house is more than just a house with solar panels on the roof.

We decided to put together an international team, made up of participants in the Self-Sufficient Housing competition and students in the Master’s program at the IAAC. Our design was based on the shape that would have the most interior volume and the least surface area: the sphere. From a natural perspective, it is the most efficient because it has the minimum exterior surface area that needs to be insulated.

When we transformed this primitive form to adapt to a specific location, with respect to the exposure to sunlight, it resulted in avoid. Then we lifted that surface off the ground to create a two-story building, one in the open air and one enclosed, without any significant increase in the budget. This solution generated a structure that captures sunlight with active systems and produces a large expanse of shade under the house to provide well-being through passive systems, common in

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Mediterranean architecture. If in the 20th century the saying was “form follows function,” now we can assert “form follows energy”.

Nature has always worked that way.

If, for years, software has helped us to draw more efficiently and, recently, to produce different-shaped pieces using numeric manufacturing, new programs allow for evaluating a proposed form with respect to its potential for energy production, and then modifying that form repeatedly until the best solution is found. Buildings should produce energy, but they also need to control energy consumption, both when they are being built and during their service lives.

We decided that the solar house should be produced using a material that had grown due to the effects of the sun: in this case, wood, which is a recyclable material, produced by nature, and which develops as a result of the effects of the atmosphere on the land.

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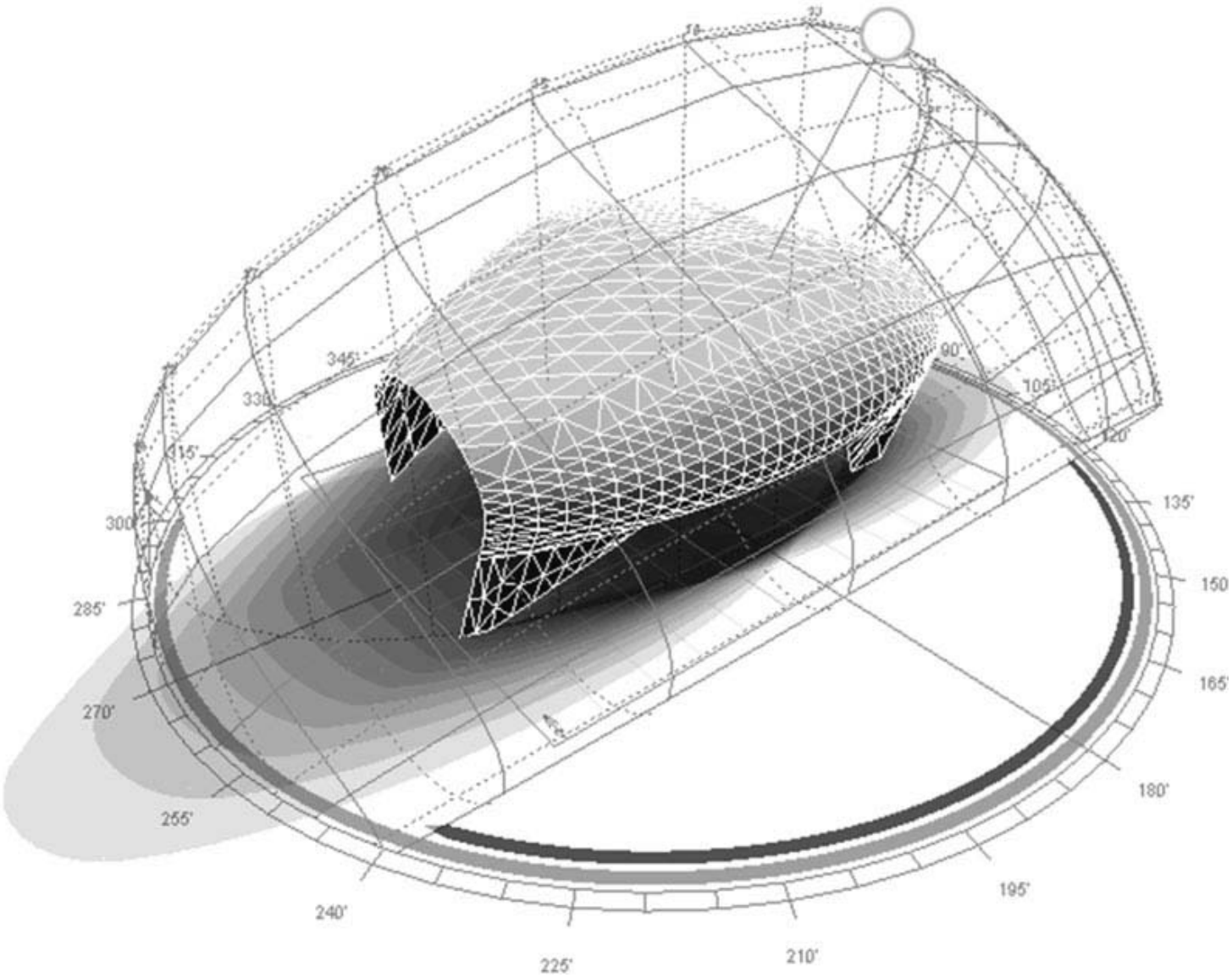

Our solar house also took on another challenge involving the inclusion of solar production in the building. We wanted to use a flexible photovoltaic material in order to produce a more naturally curved surface. We tried working with a new generation system based on technology like copper iridium gallium selenide (CIGS), but it wasn't available at the time, aside from the fact that its efficiency was only about 10%.

In the end, we improvised. We bought the most efficient solar cells in the world, produced by Sun

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Power, and with the help of engineer Oscar Aceves, one of the pioneers of photovoltaic systems in Spain, we encapsulated them between layers of Teflon, which is flexible. Thus, we produced what is probably the most efficient flexible solar panel in the world. It is also very light because it does not contain glass or aluminum, as opposed to traditional panels, and it can be attached to any surface using screws (piercing just the Teflon that sticks out beyond the panel). The result was a flexible photovoltaic surface that can be installed on curved surfaces. It doesn't shine like glass: the texture is similar to zinc, with a dark color similar to graphite.

The IAAC developed the project, installed it in Madrid, achieved widespread attention in the media and won the People's Choice Award. After that experience in Madrid, I had the opportunity to show our project in Shanghai, during the International Exposition, as a guest of the Barcelona Design Center. After that presentation, different Chinese groups showed interest in our houses.

Leilei Chan and Pilar Clavo, who had spread the word about the activities at the Barcelona pavilion in Shanghai, introduced us to a group of Chinese investors. We began putting together master plan for an island near the city, where the idea was to build a self- sufficient environment that would include food production and solar houses. In a recent visit to China, we began to evaluate the use of bamboo in housing, because it is a rapid-growth material and it can be cut into thin sheets to create panels and sections similar to the ones we needed to build the homes we designed.

Through this project, we want to bring innovation in the design of self-sufficient buildings to society in the quickest way possible. In the digital world, innovation is transferred to society nearly automatically through information networks.

Why is innovation in architecture and in housing so slow? Google updates their algorithm at least once every few months. Apple updates their computer and iPhone models at least once a year. The automobile industry produces new versions of its models every five years. The construction industry changes how buildings are built every twenty-five years, and that's an optimistic estimation. We need to carry over the innovation from the information society into the construction industry.

Francis Ford Coppola says that he managed to buy his freedom to produce his own films, removed from the big movie studios that are directed by managers who evaluate a film's worth in terms of the increase their company's worth on the stock market. Money is cowardly. In cinema and in real estate development. It would be fitting to find the formula to connect directly with people, in order to be apprised of their desires and hopes for their homes and their living environment.

But now, given the brutal crisis of values concerning what we should do with the resources we have

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and how we should organize our habitat to live better, consuming less energy, there is no doubt that investments will need to be made in innovation with respect to the human habitat. It is the first step toward being more efficient in interacting with the world. Culture generates more culture. Innovation creates more innovation. Creating self-sufficient buildings, even if there is no demand in the market, because they are unfamiliar, is a way of opening up new economic territory.

Printing buildings

Creating objects using a digital printer is already a reality; and people are currently working on digitally printing buildings. Berok Khoshnevis, at the University of Southern California, has been working for years on the creation of building-scale plotters installed in cranes with the capability of literally building houses or blocks apartments. He studies pen points that release precise quantities of ink, in a controlled manner, in order to allow for writing on paper.

In the same way, the right printer head, with the ability to pour a material similar to concrete, with a precisely calculated thickness, would be able to print building-scale structures. A parallel printer head might even introduce the necessary cables or conduits for the building systems.

If architecture is a landscape, then buildings are mountains

But buildings are not architecture if they can establish a precise relationship with their location and the environment in which they are built. High-rise buildings are functional accumulators, such that cities can multiply their extension by a factor of n through the accumulation of one floor on top of another. However, buildings don't necessarily have to be parallelepipeds. Modern architecture exalted abstract, Euclidian geometry, moving beyond the classic styles of the past. The development of fractal geometry by Benoît Mandelbrot allowed for a numerical description of the structure of a tree, a cloud or a broken coastline. It also allowed for the design of complex surfaces in buildings, which have been produced using parametric design tools that admit the creation of a number of different elements with the same basic form, introducing slight "parametric" variations to make them distinct.

In recent years, aided by new geometries, architecture has sought out a new relationship with nature and the landscape around cities, building what have come to be known as "Landscrapers".

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As opposed to positioning itself on the landscape, architecture wants to become a landscape.

“If architecture is a landscape, then buildings are mountains,”20 we argued at the end of the nineties. In Dènia, a town located on the Mediterranean coast, there were plans to rebuild the volume of a mountain in an old quarry, in order to build a spa resort and create commercial activity, along with urban services in its interior. Based on that idea, I developed a project that proposed building a building-mountain where the access points were located along the exterior surface of the reconstructed volume, thereby also creating an urban park and a center for urban activity. I also designed a building-mountain in Wroclaw (Poland) that included a convention center and a hotel as part of the city’s candidacy for the Expo2012.

A number of cities have expanded until they have come up against quarries or geological structures that have been used in the past to obtain materials for the construction of the city. This interaction between the city and its environment should allow for new forms of construction, closer to the natural structures that fractal geometry has helped us discover.

Form follows energy

Living things are the product of natural evolution over thousands of years. They are specialized organisms that are adapted to their environment; their basic principle is fulfilling their basic functions (be born, grow, reproduce and die) with a minimum consumption of energy. Their shape responds to their adaptation to the environment to make them more efficient as a part of an ecosystem where there is mutual feedback from all of the parts.

Buildings have only been around for five thousand years.

For centuries, Man has built using the materials found near the most appropriate areas of the territory, with the aim of deriving a maximum of resources from his surroundings.

Up until the end of the 20th century, architecture fulfilled the function of representing the values of its promoters based on certain constructive codes based on the language of classical architecture, using capitals, friezes or arches, integrated through axes of symmetry, scale relationships, etc.

In classical architecture, form follows representation.

In the 20th Century, the development of new materials like concrete, steel and glass, allowed for

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changing the rules of construction. In contrast to the historical model based on load-bearing walls, where the form of a building was directly related to its structure, the free design of the ground plan allows for increased flexibility in terms of a building's use. And its representation as well.

The "machine age" allowed for imagining buildings that "breathed" artificially and were fed by electrical systems. A new physical structure and a mechanical system —the elevator, which definitively cemented the possibility of vertical growth in buildings— led to new architectural paradigms. "Form follows function," asserted the Bauhaus school. Glass and steel promoted a generic, international architecture, which had to resolve its relationship with its surroundings. Using mechanical systems, they produced more or less energy, and controlled their surroundings without a thought for the associated energetic costs. This model has obviously run its course. At present, we are faced with the challenge of putting up buildings that return to emerging naturally from the place where they are built. Buildings that use a maximum of resources in order to ensure their energetic self-sufficiency, to obtain water from the surroundings and to recycle their waste material. This has to be done based on two principles. On the one hand, a detailed analysis of the systems and resources available in a specific place. And on the other, using design as a mechanism to resolve the combination of all of the functions the building needs to provide and the mechanisms that need to be developed, with the aim of consuming as few resources as possible for the building's operation.

Likewise, technology allows for integrating new resource production systems (energy, food, goods) to make buildings productive. Buildings should be produced artificially and managed naturally. That is why they need to develop their own metabolisms, as a result of the combination of those two variables.

If in the 20th century architecture was altered due to a change in its structure, in the 21st century, architecture will be altered because of a change in its metabolism.

In order for buildings to become self-sufficient, they must first be intelligent. They need to develop intelligence systems, built in to their structure. The idea is not to design traditional buildings and equip them with control systems, or solar panels on the roof. It is a question of defining new paradigms that combine function, energy and information in a single habitable structure.

Buildings as organisms. Cities like natural systems.

Photosynthesis and energy

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In collaboration with Gerard Passola, known as Doctor Tree, we analyzed how to learn from the metabolisms of trees and other living things to structure the metabolism of buildings.

Trees are organisms that capture energy through their leaves by means of photosynthesis. The energy efficiency of a leaf is about 25%. In the case of real sunlight, where only 45% of the light is photo-synthetically active, the maximum theoretical efficiency for the conversion of solar energy is about 11%. At present, however, plants do not absorb all of the sunlight that come in (due to reflection, the requirements for the respiration of photosynthesis, and the need for optimum levels of solar radiation). In 2010, the most efficient solar cell had an efficiency of 23%. It is only a question of time, and of development in nanotechnology, until we reach the efficiency of natural systems, or even surpass them.

The leaves on a tree transform light energy into chemical energy in the form of raw sap in the roots. They use chemical energy to synthesize organic fuel molecules, which can be “stored” as carbohydrates. The physical structure of the branches and the trunk and the logical structure by way of which the information is sent through the woody conduits is the same. In architecture, there are examples that are oriented in the same way. The columns under the square in Barcelona’s Park Güell have a physical structure and serve as a water collection system. The structure of the Media House combined the physical structure with the electric structure and the data structure in the same section.

Modern architecture separated systems into differentiated layers, whereas nature generally tends to integrate systems, for increased efficiency. In the case of trees, the structural connection with the ground is carried out in the roots, which have a similar branching structure to the crown. On the surface of the root hairs, outgrowths at the tip of a plant’s roots, minerals are absorbed and water is taken in. The tree works like a pump, capable of sending the elaborated sap toward the crown and transforming its energy into fruit. All of that without being connected to far-off electricity network. Maximum local efficiency.

In years to come, buildings will work in a similar way. On the one hand, they will maximize their relationship with their surrounding in order to use passive resources in an active way.

The best energy is the kind that is not consumed. And on the other hand, technology will be used in a subtle way to manage the resources needed for a building to function, in an organic and efficient manner.

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Therefore, whereas in the past a building's form followed its representation, and in the 20th century form followed function, in the 21st century, form has to follow energy, using natural patterns for the design of buildings and cities, just like nature has always done.

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