Using the environment as a creative generator for design has prompted new aesthetic models. This paper examines these cultural constructs, reflecting on principles, objectives and design techniques.

The naturalisation of architecture

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Introduction: aesthetics and sustainability

Contemporary debates on the aesthetics of sustainable architecture[1] recognise different positions. For example, some architects claim that there is very little relationship between the notion of sustainability and the interests of contemporary architecture. Others use the term sustainability in an ambiguous way. Even clear advocates of sustainable architecture rarely talk in terms of the 'style' or 'aesthetics' of their buildings. Some controversial statements about how sustainability is all about ethics and not aesthetics have recently nurtured substantial discussions in the media. Cesar Pelli alleged: 'most architects will keep giving the highest value to the looks of the building – that's how we know most buildings – and the sustainability doesn't necessarily photograph'.[2] Wolf Prix, co-founder of Coop Himmelb(l)au, declared: 'sustainability belies signification –and it is therefore not possible to generate "aesthetics" from the term sustainability'.[3] Lastly, Peter Eisenman asserted: '"Green" and sustainability have nothing to do with architecture. Some of the worst buildings I have seen are done by sustainable architects. They may optimise ecological constraints today but they don't do anything for the culture in terms of the excess required for architecture'.[4]

While sustainable architecture calls for austerity in the use of resources and the greatest possible reduction of any waste, aesthetics seems linked to the sensuality, enjoyment and luxury experienced in a space with certain proportions, materials and ornamental style. The truth is that for a large sector of the profession sustainability, by definition, cannot be framed within an aesthetic proposal. Aesthetics is regarded as the antithesis of any value close to the extreme functionality and efficiency demanded by energy savings.

However, based strictly on biological evidence, some theoretical positions welcome that 'excess' of energy that Eisenman mentioned as an indispensable contribution to cultural values. Some scholars postulate that it is precisely in energy's nature that it be expended; that waste is a fundamental

part of the natural process. As Henri Lefevbre argued in *L'Architectonique Spatiale*: 'the idea that the principle of economy is biologically inadequate goes back to Spinoza and can be traced through Schiller, Goethe, Marx and Nietzsche'.[5] Living organisms capture energy from their vicinity, use part of it for their basic needs (nutrition, respiration, heat…), and stock a surplus. This surplus is what distinguishes life from survival; what allows the organism to take initiatives. That stocked energy must find opportunities to be expended, otherwise the organism degenerates, and as in any release of energy, when expended it will have an impact on the environment: as Lefevbre says, 'waste, play, struggle, art, festival –in short Eros- are themselves a necessity'.[6]

We are trying to learn how to control energy by observing and emulating natural phenomena and processes, but are we approaching energy's dynamic condition correctly? It is in energy's nature to be ephemeral, vibrant, mutant, boundless, and ungraspable, but we are trying to contain, define, and stock it at our discretion. If architecture is considered a 'living organism' in constant exchange of energy with its surroundings, we not only need to manage energy as to achieve balance, but also as to use this excess in favour of that leeway for creativity.

The aesthetics of sustainable technology has been ruled mostly by the maxim of invisibility, trying to make the technical 'prosthesis' as much unnoticed as possible. If sustainability is the framework from which a future architecture must germinate, we should determinedly question if we must keep making its components invisible, or if architectural sensuality and beauty can be truly sustainable.

For some theorists and architects this is not only so but it comes as absolutely essential. Architecture always materialises somehow and, consequently, the architecture of sustainability is to be characterized by a convincing conceptual expression: it must develop its own formal vocabulary with which to build its own aesthetic semantic field. In 1994 Ezio Manzini drew our attention to this issue: not only is there no contradiction between ethics and aesthetics, but also that aesthetics should be taken seriously and not as a 'secondary' dimension, since aesthetics represents 'the way a historical period and the values it contains take shape', 'a way of expressing a synthetic, and therefore intelligible form, the complexity of a proposal'.[7]

For architects to be engaged and recognise their role, it is critical to regard the notion of sustainability as a form of aesthetic thinking that is fundamentally implicit to the discipline. For that to happen, architects should operate ontologically from within both sustainability and technology to develop their own practices, as opposed to leaving their application to the new class of experts, who will tackle it as an addition to whatever the architect is designing.

The end of the 1990s brought a new paradigm to approach this issue. During the design process of the London City Hall (1997-2002), Fosters +

Partners and Arup jointly produced a new strategic framework in which they reversed their traditional modus operandi, strongly supported by technical solutions. They proposed a triangular diagram where architectural form, passive systems and active systems were ordered in ascending progression[8] *[1]*. This inverted hierarchical approach committed them to an environmental strategy firmly supported by design-oriented operations. In the same years, three other leaders of high-tech also proposed a new relationship with technology: Helmut Jahn, Werner Sobek, and Matthias Schuler coined the term *Archi-neering*, following the same inclination towards producing a common discourse for low-tech and high-tech responses to sustainability.

Figure 1: *What makes a building green* diagram. Produced by the Author based on Torsten Schroeder's collage from Fosters + Partners.

However, how can this unified design method be put into operation? The image of sustainability is still mostly regarded as either one of the two extremes: as technological add-ons implemented in existing aesthetic trends (high-tech, sophisticated and expensive, active design), or as new versions of the North American counterculture environmentalism of the 1960s and 1970s (back-to-land, low-tech, social, inexpensive, passive design).

Recent approaches address this problem by focusing on the dialogue between natural and artificial environments, displacing the typical discourses between passive versus active design and moving towards a deeper interrelation between these two concepts, which now are envisioned as part of the same complex ecosystem: the *super-ecological*[9]. The distance between outside and inside, between the objective and the subjective is challenged[10]. This idea is not new. The influence of biological analogies on architecture can be traced to about 1750, and the meaning of 'organic' that we use in architecture today, was established at the beginning of the nineteenth century[11]. The findings from studies on form growth, the relationship between form and function or the effect of the environment and climate on the natural elements, was soon extrapolated to design, which became more evident at the

start of the twentieth century. From the 1920s' theories on natural formative processes (R. H. Francé, F. J. Kiesler, and S. Ebeling), to the sensorised and intelligent skins of the 1980s and 1990s (M. Davies)[12], design has attempted to emulate different aspects of the natural environment which, in Detlef Mertins' words, showed our continuous 'aspirations for ecologically benign technologies that enable buildings to perform as if they were alive'.[13]

This paper identifies and speculates on some of the latest trends which, continuing this same way of thinking, are trying to erase the boundary between culture and nature. In the production of this common ground, what are the aesthetic implications of a naturalisation of architecture?

Respect for nature

The subtlest propositions pursue an architecture that is receptive to the heterogeneous sensory qualities of the natural context. This feature is present, to a greater or lesser extent, in any vernacular architecture, and particularly present in Japan. Kengo Kuma explains that it is through the careful incorporation of colour, light, smell, sound, seasonal dynamics, and variations in the natural landscape that nature is manifested in Japanese architecture[14]. It is about starting the house from the garden following the gardener's practice: absorbing the rhythms of nature, instead of creating a limit, a shield with which to block it or a shelter from it. Junichiro Tanizaki's *In Praise of Shadows*, explained that the Japanese house essentially starts its planning by establishing a clear position regarding sunlight:

> *'In making for ourselves a place to live, we first spread a parasol to throw a shadow on the earth, and in the pale light of the shadow we put together a house. (…) Out beyond the sitting room, which the rays of sun can at best but barely reach, we extend the eaves or build on a veranda, putting the sunlight at still greater a remove.'*[15]

It is infinitely preferable to suggest than to show, veiling all the space with diffuse shadows, just letting the house limit to be hardly discerned from the inside, generating the internal spaces from a matrix of elements that screen the external light. Every point in the sequential structure of the Japanese house always allows a diagonal view to the garden's natural landscape, as one of the levels in the gradation of environments.

The Japanese house is not insulated, so it relies on material use, passive energy strategies and user habits to minimise its ecological impact. Nature is not only visually present: the house uses natural, light, permeating, low processed or completely untreated materials - wood, bamboo, straw, willow, paper, rope-, which age, breathe, and expel their scent according to each season. This is clearly found in traditional examples, like in the Yoshijima Heritage House in Takayama (1890s) *[2]*, and contemporary projects, such as the Suntory Museum of Art in Tokyo (2007).

Figure 2: Yoshijima Heritage House, Takayama, Japan. Photograph by ©Larry Speck.

Kuma identifies environmental design with this sensitive and emotional design that permits the house to be adaptable and permeable to the outside, and not with the artificial climate of the environmental engineers[16]. His discourse does not find poetical or architectural value in the building services, but nevertheless contemporary Japanese architectural practice is making good use of artificial environmental systems and, in well known cases, it does not even disdain the use of high-performance, sophisticated technology in combination with the poetic dialogue with the exterior environment[17].

More committed positions try to find an appropriate role for technology in contemporary design, without losing sight of simple, traditional methods. Iñaki Abalos, in his analysis of this question, suggested that sustainable architecture will probably come up with a 'technical and aesthetic hybrid model' where both approaches are combined — 'addition sustainability (more layers more complex) and subtraction sustainability, useful in the first and third world' — but that undoubtedly must give primacy to the architectural form[18,19]. He refers to these forms as 'massive

systems, almost archaic', 'a vision yet to come'[20], but that in a way would have some connections with proposals taking landscape as the project's driver.

Adaptation, integration, imitation of nature

Organisational landscapes: Mega-forms

In this endeavour to create a dialogue with the natural context, many architects try to find a basis for action in the 'methods and tectonics of landscape'. In this approach the building's envelope is no longer just that sensitive mediator that exchanges inputs/outputs with the exterior world, but rather the building is designed as an extension of the natural landscape, using landscape design techniques to arrange the spatial configuration of architecture. It is therefore important to understand what these techniques are, which are the elements that make up landscapes, and what implicit and explicit qualities they bring to the new architectural space. The dialogue that a building establishes physically with its site depends on a number of factors: passively, with its topography, geometry and space; actively, with its ecological, climatological and functional processes. The concept of *megaform*[21] proposes an aesthetic sustainable model in this direction: as a structure capable of modulating the landscape, establishing itself as a *continuum* with the surrounding topology.

Kenneth Frampton discusses the megaform model as a very pertinent vehicle towards 'sustainable and environmentally responsible design that is both culturally stimulating and aesthetically expressive'.[22] In his discourse, sustainability should be defined by the durability and adaptability of buildings, where the topographic dimension must take precedence as the factor that links the architectural intervention to a specific context, emphasising its 'locality' as opposed to a sculptural and universal character. This design practice focuses on 'folding' the architectural components to be incorporated into the landscape's tectonics, rather than on using technology. However, although visually there is a unification of language, the mere topological adaptation presupposes no efficiency in the use of natural resources. Despite topography taking a prominent role for form generation and the spatial relationships that should articulate the building use between inside and outside, Frampton is aware of the need for a symbiotic conception at all levels: the built environment should participate in the ecological, geological and hydrological processes; that is, it should interact with the dynamic forces present in any environmental context.

Most of the referenced examples of megaforms, while clearly acknowledged as interventions highly sensitive to their terrain, fail to engage with this dynamic side of nature. The pleated architecture of the Yokohama Ferry Terminal designed by FOA (2002), the Rolex Learning Centre designed by SANAA (2010), or the City of Culture of Galicia designed by Eisenman (2011), despite generating an artificial landscape in synergy with the existing

topography, do not participate in the energy exchange processes of the ecosystems in which they are inserted *[3] [4]*. This design methodology shares with vernacular architecture the skilful integration in the landscape, but still does not embrace important sustainable indicators, such as the provision of materials in a way in which their renewal and constant supply is guaranteed, or the creation of an architecture that is not only sensitive to climate, but also effective in regulating phenomena and energy exchange in a passive way. Although claiming a deep relationship between architecture and landscape in all its layers, this mimicry is only visual and does not constitute integration in the energy balance. At the least, it seems too naive to assert that the Rolex Learning Centre is a sustainable building, however topographical this intervention may be. Let the overheating suffered by the occupants serve as an example, due to the fact that the design team did not consider the wind in the area when they designed the external blinds to protect the glass envelope (which were persistently retracted, otherwise they would blow away, break or produce noise incompatible with the educational activities taking place inside the building)[23].

Figure 3: Yokohama Ferry Terminal by FOA, Yokohama, Japan. Photograph by ©Neil Jackson

Figure 4: Rolex Learning Center by SANAA, Lausanne, Switzerland. Photo: Iwan Baan.

Patterns of nature

The building should reflect the immediate landscape, but it must also consider the forces that natural phenomena exert on form. Natural forces shape natural landscapes, and the reproduction of the local topography per se addresses this issue only superficially. Some architects are studying these phenomena to propose architectures that reveal the conditions of their environment, just as these forces are reflected in the growth and patterns of nature: the adaptation patterns of life. Landscape differentiation and diversification is related to how the different organisms have adapted to resist strong winds, extreme temperatures and solar radiation, or particular water conditions.

Buildings are subjected to the same natural forces that have caused differentiation in nature, thus their built form should evidence these influences. This theory, headed by Ralph Knowles since 1962[24], finds an advocate in the work of Norman Foster. Knowles mostly considered two natural phenomena as form-shaping forces, sunlight and gravity. Foster, in his project for the City of London (2002), investigated a combination of natural conditions with the assistance of the advanced simulation programs (i.e. optimising the building shape, openings arrangement and materiality regarding wind, sunlight, and gravity)[25]. This new aesthetic, according to Knowles, fails to be legible as a common form of expression, but constitutes all the varied patterns and rhythms that make clear the diversity and richness of forms that exist in nature. Form is not determined *a priori*; instead the design process generates adaptable forms to each natural phenomenon. For

instance, in maximising light distribution, form will emerge from the adaptation of the building to the solar path. Optimising the use of solar light will affect the form of the building's mass, the relationship between the building and its surroundings (i.e. avoiding obstacles), the type and size of openings, the inclination of walls, and the creation of light wells, courtyards, galleries, atria, conservatories, cornices, overhangs or shading devices *[5]*.

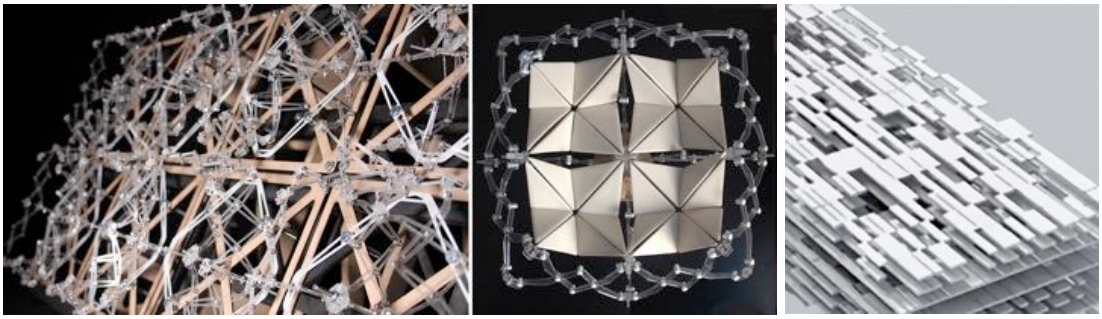

Figure 5: Kinetic solar façade designed by J. Fosbrook, A. John and O. O'Neil. Photographs by © Alex Kokai and the Author (left).
Figure 6: Layered surface generated from cellular automata rules, produced by the Author (right).

In a similar but more technical approach, some design propositions attempt to literally integrate natural adaptation patterns, in the majority of the cases through the reproduction of natural biological performances by mechanical means which are then applied to specific areas of the building. We can find a typical example of this strategy in the envelope designed by Nicholas Grinshaw's practice for the Las Palmas Water Theatre: by taking inspiration from the Namibian fog-basking beetle, the envelope generates fresh water for the building.

Whether shaping the building through topographical or environmental forces, both design approaches refer to a form-generating methodology that leads to a very diverse range of results. Yet the definition of aesthetics responds to a recognisable set of stylistic features. If there is no single image associated with a concept, but it rather refers to a process resulting in a variety of expressions, can we still recognise an aesthetic pattern of sustainability?

Actually, if we are to take nature as a reference, this problem reverts to a previous question: considering the vast diversity of elements, shapes and relationships that occur in natural ecosystems, what are the aesthetics of nature? What are the qualities that we automatically recognise in nature, that make us categorise items as belonging to the natural? And then, what is the level of subjectivity in our conception or perception of nature?

Appropriation of nature

The prominence that health as a global theme has recently taken in all research settings, along with a new understanding of comfort and well-being as part of the definition of sustainability, might have led to another negotiation with nature — through the appropriation of its natural elements. There is no doubt that our tendency towards a biophilic society[26] must have also contributed to this way of operating. Our society is increasingly aware of the benefits that result from human interaction with dynamic natural environments which are sensory stimulating, and how they help to promote our wellness in physical, psychological, and health terms.

Biomimetic Architecture

One line of action in this direction investigates biologically inspired designs. The biomimetic model is based on the processes of natural selection, evolution and optimisation, and therefore intends to generate design through working with the parameters which allows an organism to adapt its physiology over time. Using generative systems that meet parametric or environmental conditions, this design methodology pursues the generation of form as a direct translation of function[27] *[6]*. As opposed to the above-referred mimetic process that literally replicated a natural product, the new approach is based rather on understanding the intrinsic relationships with which natural phenomena are deployed, and how 'we position ourselves and establish an intimate relationship with the biological environment'.[28,29]

To put this into practice, it is not only necessary to identify the principles but also to set the metrics with which to assess ecosystems, so as to be able to make built habitats work in the same way that natural habitats do. The critical question of this procedure is to gauge whether natural factors can effectively be extrapolated to the artificial environment, and which are the factors that define ecological integrity in a natural ecosystem. According to the ecologists, the integrity of an ecosystem is defined as 'the ability to perform nature's services, evaluated in terms of biodiversity, stability, resilience, sustainability and naturalness'.[30] If we accept this definition, then the issue is how to transfer these five indicators into the 'built habitat'. As common denominators in all ecosystems, we can agree on the existence of: an organic dynamic condition of nature that includes the ability to adapt to change; fractal and complex geometries; energy balanced relationships; time and weather based cyclical processes; overall harmony; and synergetic and symbiotic relationships among their constituents.

Design methods derived from digital design using natural algorithms aim to recreate these parameters. However, we are still far from achieving the wealth present in nature due to our limitation to model the infinite possible occurrence of accidents and contingencies that lead to adaptation and diversity, and this takes us to simplistic geometrical configurations. To be

truly part of the ecosystem, a rather critical aspect is to allow the inert elements to interact with the natural ones, thus creating symbiotic relationships with the natural system, instead of subjugating it.

Living Architecture

Some proposals of artificial ecosystems have come up with the idea of putting natural processes and living things into play, integrating fauna and flora into the architectural components. The basis for this argument is to imagine that the non-natural environment will be less artificial if it is mixed, as much as possible, with life: moving the natural ecosystem to the actual building fabric, using living matter as a building material. If living natural elements were only the content in greenhouses, zoos or gardens, now these elements can come out of their enclosures and get interwoven with inert materials to become the container — the inclusion of the external context positions in the very tectonics and configuration of the architecture itself.

The sustainable architecture practiced by AMID.cero9 includes vital energy cycles as the driving and modelling force of architectural design. The ecosystem-envelope of their project for the refurbishment of the Ames Thermal Power Station in Iowa (2002), positioned within an important migratory route of birds, proposes to support a vital balance between these, and the local flowers and insects. The combined action of bacteria, algae and water provides the necessary physical and chemical reactions for the purification and replenishment of an aquifer in their project for Forms of Energy, in the Venice Laguna (2002), or the air in their design for the Blown Bottles pavilion in Pine Grove Park, Madrid (2008). In these man-made ecosystems, the mechanical and energy aspects of the tectonics of life intertwine with inert materials[31]. A built example of this approach is the prototype for a Garden Building with Host and Nectar Plants for Cali's Butterflies designed by Husos in Cali, Colombia, (2011) *[7]*, or the new initiatives to grow food vertically, like in the American pavilion at EXPO 2015 in Milan, designed by Biber Architects, where the crops are integrated in automated louvres which also control light and air ingress in the building *[8]*. In this mixed tectonics, plants and animals donate their image to the architectural object, and the technology which enables the reproduction of the energy processes is concealed within the living matter.

In these proposals, the delineation of the form and its limit still does not rely on clear determinants: the processes are consistent with the context, but the natural only wraps an architectural mass that is unrelated to the driving concept, which actually, in many cases, uses orthogonal boxes. We can find the same disconnect between envelope and building form in the new initiatives to incorporate photobioreactors or aquaponic systems, such as the microalgae façade developed for the BIQ building in Hamburg by Splitterwerk and Arup (2013) *[9]*, originally conceived as sun-tracking

louvres, or the prototype for a Vertical Farm developed at ENEA for EXPO 2015 *[10]*.

Figure 7: Garden Building with Host and Nectar Plants for Cali's Butterflies by Husos Architects (Diego Barajas, Camilo García), Cali, Colombia. Left: Photograph by ©Camilo García. Right: Photograph by ©Manuel Salinas.

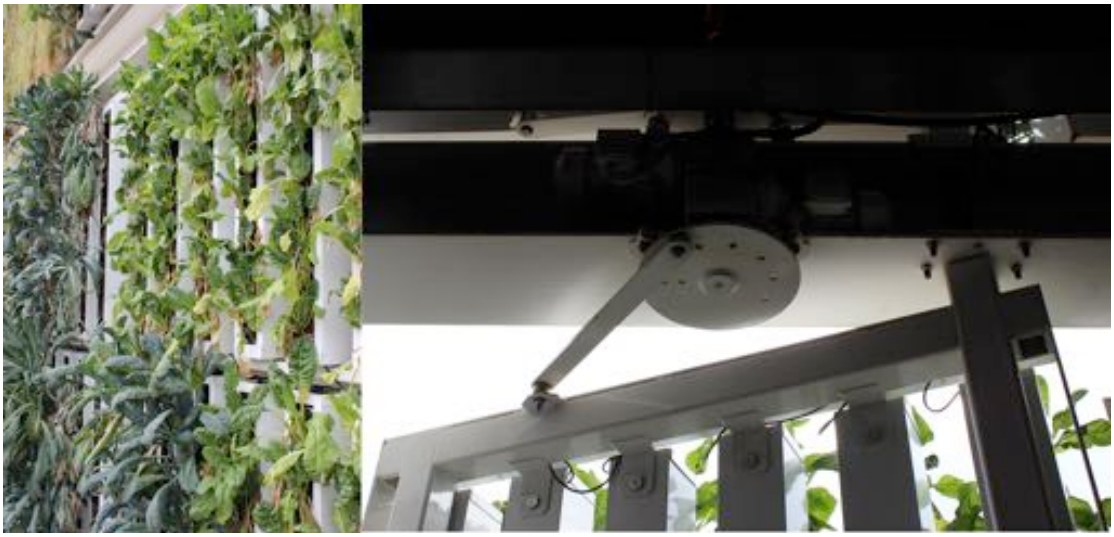

Figure 8: American Pavilion by Biber Architects, EXPO 2015, Milan, Italy. Photographs by the Author.

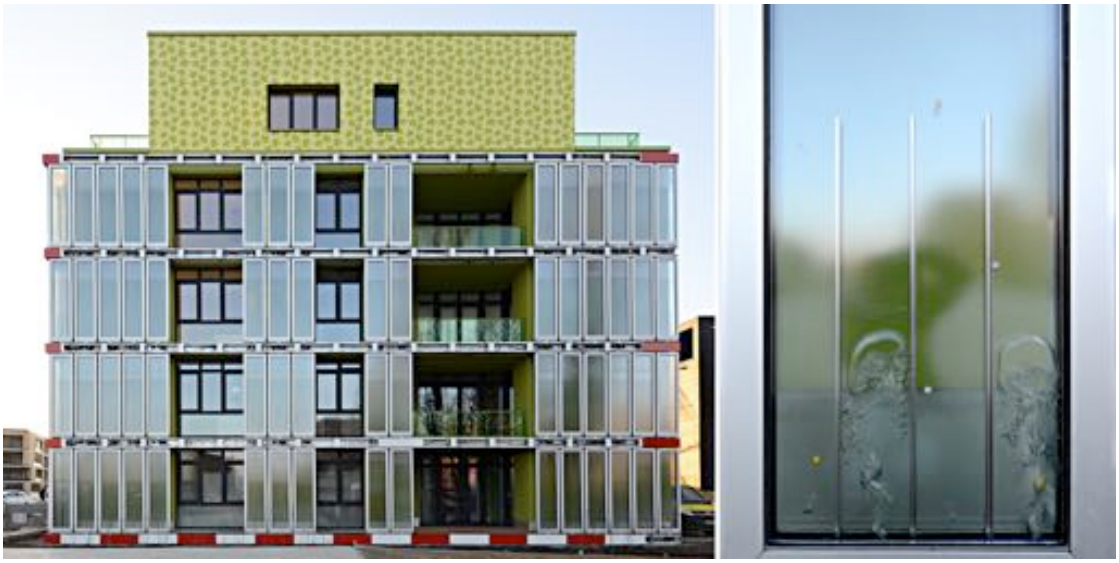

Figure 9: Photobioreactor façade by Splitterwerk and Arup, Hamburg, Germany. Images copyright Arup Deutschland GmbH, Colt International GmbH and SSC GmbH.

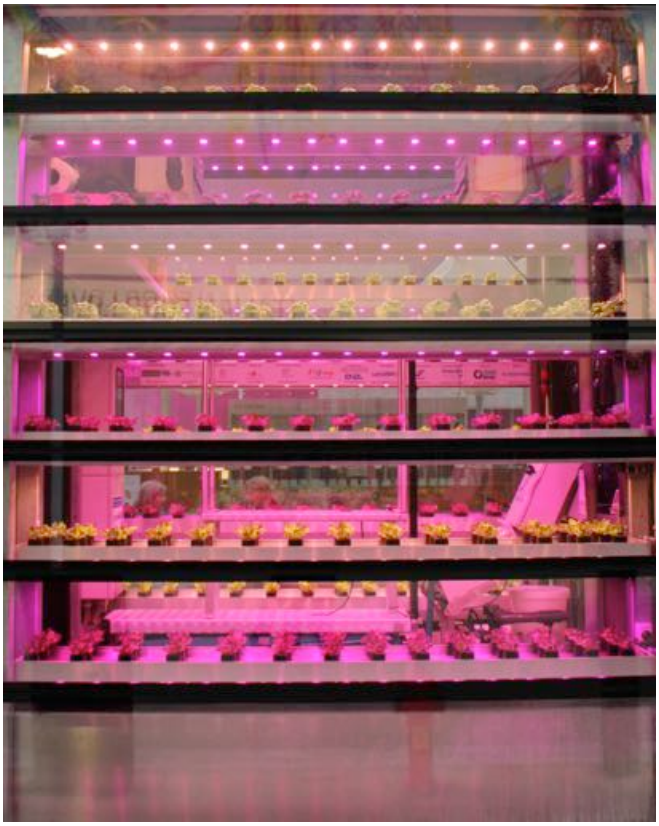

Figure 10: Vertical Farm by ENEA, EXPO 2015, Milan, Italy. Photograph by the Author.

On a theoretical level, concepts like *synthetic life-forms* and *vibrant matter* also investigate new kinds of living architectures. The former examines how emergent biological developments could be embedded in the building fabric at molecular scale to allow life-related performances: from stimulus-

responsive biomembranes (energy exchange interior-exterior) to the creation of synthetic metabolisms (provision of energy) and homeostatic processes (regulation of internal environment)[32]. The latter attempts to design alongside the 'many parallel realities that intersect with our architectural interventions at different scales': from molecular forces to grime, viruses or pigeons[33]. This expanded vision of matter as a non-inert element opens prospective new lines of design investigation, further discussed in the next section.

Energy as a design agent

Material energy manifestations

The building envelope has benefited from a status of sustainable responsibility that other areas have not enjoyed, being the place to exhibit technological sophistication. This is largely due to its strategic position between the inside and the outside, but also because of our need to link the performative to a material substrate accountable to generate morphology and tectonics.

We are used to conceiving architectural space as defined by material limits. But if that is not the case, if the building enclosure vanishes, what spectrum of materiality can be expected in a future architecture synergistic with energy phenomena? This was the critical question posited by the 2009 issue of AD titled *Energies. New Material Boundaries*[34]. What if energy takes a more 'solid' presence? What if the variations in temperature, air velocity, light spectra, or electricity solidify and become more visible? We are urged to reflect on the ability of energy-related phenomena to create spatial boundaries or distribute programmes.

Indeed, some design initiatives are looking at nature's modeller agent to effectively provide a methodology to aesthetically define our architecture: the quantitative and qualitative components of energy. Images as impressive as those of Nikola Tesla in his laboratory in Colorado Springs, with eighteen meters long electricity sparks crossing the space above his head, give an idea of how electricity, a form of energy normally invisible, can take other spatial corporeality that is in effect appreciable. Still we do not know much about the manifestations that energy can incarnate, but it is important to start considering the potential that these energy manifestations can offer beyond producing effects or providing a certain character to the environment. Since the Industrial Revolution, these potentials have been explored in association with a material surface, but they have been little explored in a state freed from the substrate material. Energy has been one of the protagonists that has influenced our architecture, but not yet determined its design. Architect Sean Lally argues in this respect: 'sustainability has kept us locked in talks on efficiency, preconceived notions of comfort levels, and the discourse on the "atmospheric". Instead, we should investigate the material energies as

something generative and exploratory beyond cosmetic effects: sound out how these materialities can take more responsibility in the architectural design, acting as organisational systems'.[35]

Some artists deal with this proposition in their installations, bringing the materiality of environmental phenomena to solid state. Laurie Anderson, in her piece *From the air*, intensified an area of the room thanks to a precise delimitation of light and sound. When the entrance to the space is crossed, deep darkness and silence is perceived, just disturbed by the only spatial reference, a circle of light on the floor. The island of light represents a unique spot, selected from the total space. First that differentiation is evident by the contrast of light but as we approach it another sense comes into play: the ear. Only between the limits of the circle of light can we hear the singing of some birds. Without positioning oneself at the edge of the circle of light, curious about its auditory limits (which ultimately is to test the accuracy and scope of the technology behind the directional speakers), there is no discourse. What qualifies that space is the individual wandering around the solid light. Other artists work on similar concepts. Anthony McCall's work also uses light and dark, time and space, and essentially the viewer to construct his narrative. McCall's investigation of solid light as sculptural forms requires the spectators to move inside and outside the light-form, not only to comprehend its changing geometry, but also to contribute to its infinite instantaneous materialisations by slicing the light projection with their passing bodies *[11]*. In all these cases, the surrounding darkness serves to focus attention on the illuminated area, but also avoids the need to define the container's form and limit.[36] James Turrell uses light to modify our perception of the space, challenging the spectator to experience disconcerting phenomena, such as loss of depth, and illusions of spatial components (walls, corners, veils). Swiss architect Philippe Rahm, apologist of the concept of atmospheric gradient as the articulator of architectural space, has analogously implemented his theories as art installations within galleries or museums (thus using existing structures), or as formalisations of modernist architectures[37]*[12]*. Similarly, the exploration of either deceptive or 'intensified' atmospheres tends to ignore the spatial confines.

Whether as a physical manifestation or as a comfort condition, it still seems very difficult to generate building form out of environmental gradients without using a delimiting mediating envelope. The latest façade environmental research appears to incline towards the revision of familiar themes, such as thermal insulation. Michelle Addington criticises the still present ghost of the need for the sealed envelope, 'the famous "Build Tight, Ventilate Right" as a paradigm of environmental control'.[38] Addington states that we have the necessary technology to provide the exchanges that the human body needs with the environment at a local level; therefore, the design of comfort can be resolved without having to entrust it to the building's

enclosure. From the open-air movement to contemporary approaches such as the urban development for Vatnsyri in Reykjavik (2007), or the project for the Estonian Art Academy in Tallinn (2008), by the architectural practice Weathers *[13]*, these proposals attempt to implement architectures that revolve around microclimates and are sculpted by natural agents such as geothermal sources.

Figure 11: Left: Anthony McCall. “You and I, Horizontal (III)” (2007). Installation view, Kunstmuseum St. Gallen, Lokremise, 2013. Photograph by Stefan Rohner. Right: Anthony McCall. "Between You and I" (2006). Installation view, Peer/The Round Chapel, London, 2006. Photograph by Hugo Glendinning.

Figure 12: Décosterd & Rahm, Hormonorium, 8e Architecture Biennale of Venice, 2002. Photo: Jean-Michel Landecy.

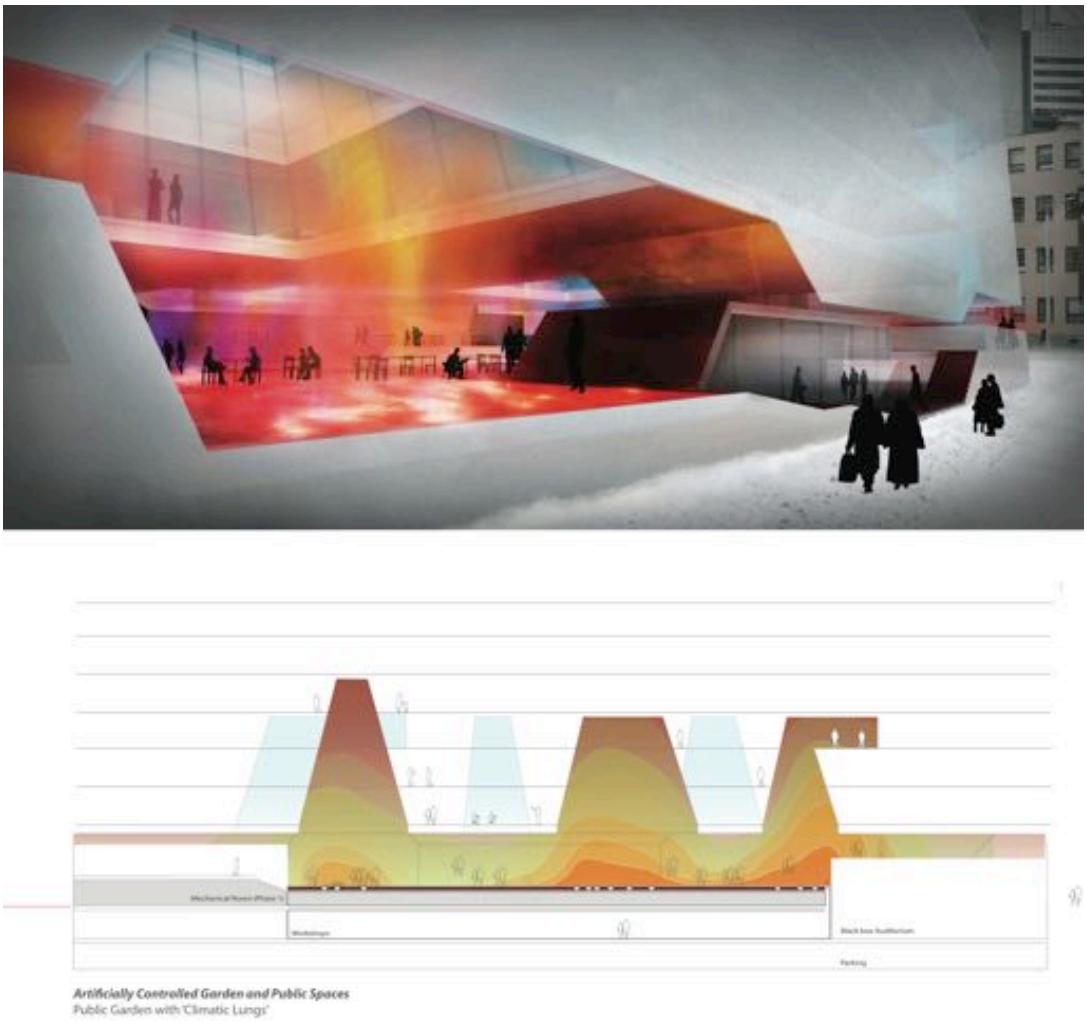

Figure 13: Estonian Academy of Arts Tallinn, Estonia, 2008 Sean Lally / WEATHERS Executive Architect: Morris Architects, Houston.

As with ecosystems, we need a proper categorisation for the great diversity of expressions and the unpredictability with which environmental phenomena manifest in front of our senses (thermodynamic, atmospheric, acoustic, olfactory...). To understand these phenomena, we should describe them with rigour. In order to characterise architectural space through climatic modulation as a tactic to create new programmes for spatial distribution, we must first comprehend the climatic effects and their benefits on our health, emotional and psychological well-being.

The problem is to recognise the great variety and complexity of phenomena, and to discern individuality within the atmosphere. For this task we will need to borrow advanced pattern recognition techniques from other fields. In his seminal text *Air/Condition*, Peter Sloterdijk emphasises how very little we are aware of the manipulation of the air to which we are subjected, and suggests that we let the disciplines where atmospheric description is

more developed guide us, such as climatology and meteorology, in order to understand air and climate events that are important both culturally and for the welfare of people[39]. Firstly, we have to apprehend the different phenomena. Secondly, we need to get familiar with the categorisations and visualisations used by the experts on these fields. And lastly, we need to design space planning in synergy with them, to take advantage of the natural energy flows.

The active incorporation of these environmental references in our spatial cognition is becoming indispensable. Normally attached to land, these expanded references have long been obvious determinants when we move through other media such as air or water. The artist James Turrell, a supporter of this theory, describes the importance of incorporating, in his art, his experiences as a pilot — as a navigator in a medium that exerts its spatial impositions with a different perspective:

> *'[…] There are many moments in flying that are a world apart. Well, it's a world within our world, but it is something to pay attention to, just as in orienting to light. I use light by isolating it, and often not very much of it. I try to do something relevant to our perception and our relationship to this ocean of air. As you fly, you do see space that is determined not so much by physical confines, but by atmospheric and light phenomena within the space. I've seen sometimes a contrail that goes through the sky where you can see its shadow come down through the sky, the shadow of the contrail. This beautiful shadow actually divides the space in an amazing way. And so for me, sitting up there in this cockpit, I've seen so many things that reminded me of this other way of seeing, where light is the material and this makes the space.*[40]

There is clearly much to investigate in this direction. Indeed, it is only very recently that some aspects of the atmosphere are taught in architecture schools, or represented in our drawings. Not long ago, any sensuous effect was eliminated; representation was dominated, in Mark Wigley's words, by the 'authority, aseptic and accuracy of the ink line on white paper'.[41]

Active porous thresholds

At the moment, for most artistic and architectural production, environmental phenomenology still has a material substrate that should support the phenomenon's formation. However, Achim Menges and Michael Hensel offer with their concept of *morpho-ecologies* a particular point of view within this proposition, where two types of space coexist: one virtual and one material[42]. For instance, light forms an environment with its patterns of visual and thermal variations. That luminous environment can be considered a virtual space, which in turn is contained within a space of material limits. But the physical limit should not ignore the energy and the effects of environmental phenomena which develop within its boundaries. Material form and

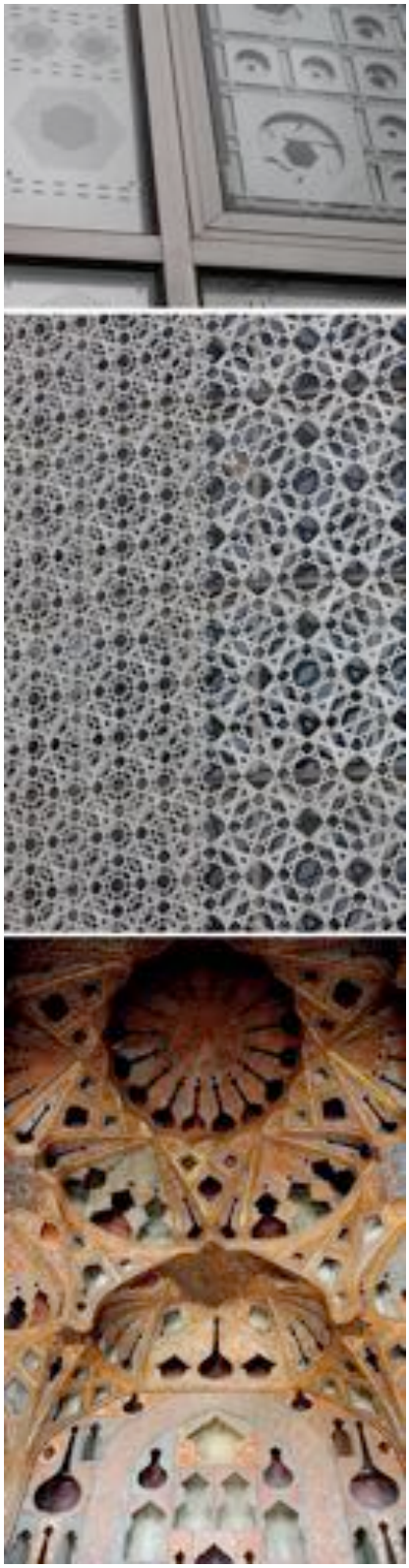

Figure 14: Environmental thresholds. Top: solar facade designed by Jean Nouvel for the WAI, Paris, France. Photograph by the Author. Centre: solar facade designed by Jean Nouvel for the Doha Office Tower, Doha, Qatar. Photograph by © NELSON GARRIDO/www.ngphoto.com.pt. Bottom: acoustic ceiling in the music chamber of the Ali Qapu Palace, Esfahan, Iran. Photograph by ©Azin Eslami, Isfahan Azad University.

environment must interact, and will do it in accordance with two different scales: at a matter's level (physical and chemical reactions), and at an architectural level, where the material's surfaces act as extensions of the agents that generated the phenomenon. In performance-oriented architecture, the design process is not driven by the architectural elements (defining form, function, etc. of that element), but architectural conditions: the relationships of the element with its ecosystem[43].

The increasing miniaturisation, fragmentation and complexity of contemporary envelopes at the material level coincide with a trend towards a heterogeneous conception of space at a comprehensive scale. With the new operations for the generation of algorithmic spaces, surfaces become deep, organic and full of cavities. This spatial complexity not only accommodates a new sense of ornament or the hardware required by active systems to control the environment, but also hosts and generates those virtual spaces *[14]*. In the geometrical investigations experienced by both surfaces and volumes, light patterns (being the most obvious), and other surrounding environmental parameters will arise accompanying these new spatial compositions.

Of especial interest in Menges and Hensel's article is the reference to the detail of the filigree carved inside the vaults of the Music Chamber in the Ali Qapu Palace in Isfahan. Through this geometric richness the vault becomes an acoustic agent. According to popular belief, one can still listen to the music in the room even after the musicians finish their performance, through sound reverberation. The chamber's spatial proportions together with its sculpted surfaces are finely calibrated to become an extension of the musical instruments. This relationship between matter, energy and form connects with recent discourses on *New Materialism*[44, 45]: moving away from 'an Aristotelian view on matter as an inert receptacle of form' to envision the generation of material form as 'driven from within by immanent patterns', 'by matter's own tendencies and capacities'.[46] It is this potential of architectural form as a generator of a stimulating and sustainable environment that is substantially attractive about this theory.

Conclusions

Traditionally, the aesthetic evaluation of architecture discusses the design values, concerns and interests originated within a period's technological, political, economic, ethical, and socio-cultural context. The origination of distinct aesthetic and stylistic expressions entails a physical formalisation, which is usually assessed upon inspection of compositional aspects, such as order, geometry, form, proportion, organisational axes, ornament, function, materiality, tectonics, construction, structure, context, etc. Compositions based on aesthetic styles or standards have been applied and practiced since ancient times to impart properties such as beauty, splendour, spirituality or power in buildings and cities.

Our contemporary context demands new negotiations between the aesthetics of architecture and the natural environment, generating an effective synergy between the use of technology, energy and environmental resources, and the production of space to develop our needs. A fundamental issue is to propose design methodologies that identify the crucial design parameters in order to achieve such a synergy. The design problem therefore revolves around a new approach to architectural composition, where dynamic processes like energy exchange, the optimisation of resources or biodiversity are critical design factors.

Among the aesthetic realities reviewed in this article, those that consider the constructed habitat as a natural one, present a more innovative and challenging approach to the fusing of ecology and design. On the other hand, the distinct biodiversity inherent in each ecosystem raises some questions as an aesthetic model. In aesthetic terms, biodiversity implies that the system's image is constructed from a set of different elements. Individually, the integration of the building in the system assumes its generation from a process of adaptation to it. As a methodology for sustainability, this procedure is consistent for all buildings, each in its own ecosystem. But when brought together it will lead to a series of aesthetically separate buildings, in the same way that ecosystems are formally independent from each other. Again we could ask how an aesthetic of sustainability is then generated? Does the set of rules for the adaptation to a particular microclimate and ecosystem generate recognisable aesthetic standards in all ecosystems? Can we find aesthetic connections between sustainable buildings set in very different climatic, cultural and economic regions?

In a similar way, research on environmental control and the creation of atmospheres seems to still have work ahead to identify, classify and assimilate the vast diversity of energy patterns within our design language. For now, what we mostly have at hand is the notion of the environmental gradients in combination with material thresholds. These porous boundaries have been explored more as acoustic and luminous experiences, historically exemplified in the ceilings developed by Alvar Aalto, Gustave Lyon, Jean Nouvel or Hans Scharoun for their auditoria; and of course, in the very diverse *brise–soleil* structures that gave character to the architecture of the fifties and sixties. This concept of selective barriers offers a very inspiring path to study other environmental parameters in combination with applied knowledge from other disciplines and computational tools.

Going back to our triangular diagram, this is, in my opinion, the most consistent way to design technological sustainability departing from architectural form: either there is no limit at all and architecture is configured as an open space in continuation with the natural context, as in the topographies proposed by Weathers or the open architecture proposed by Addington, or these thresholds are the most concrete points of departure for a

connection between form and energy. But once again, does this lead to a generation of aesthetics?

In natural ecosystems, there are a variety of forms among their components, and there is no unifying structure acting as a referential formal system. Except in specific examples, living beings do not adopt literal contextual forms to work in harmony with nature. Exchanges between components occur at different levels, some are very subtle, and many are invisible or not directly related to form at all. The consensus with the existing is established at an energy level regarding gravity, climate-seasons, life cycles, etc. That is what, in a variety of forms and programmes, all living beings have in common. There are many ways to serve in the chain of elements that build up the balance in an ecosystem, without defining a list of physical features that can be extrapolated as the determinants that characterise the aesthetics of nature[47].

Reflections on the design strategies presented reveal exploratory design trends where new aesthetic metrics have to be considered: those related to the integral principles of nature. Ultimately, this article has attempted to reveal that for now, our role on the aesthetics of sustainability is not about defining style and envisioning specific visualisations of a naturalised architecture, but about assimilating new operational methodologies that include techniques imported from scientific disciplines, like biology, biochemistry or climatology. None of the analysed lines of action on their own seem to provide a holistic approach, but represent a promising first step forward.

Notes

1. The terms 'sustainable' and 'green' architecture are often used interchangeably, although they have different denotations. Green refers to design that complies with minimum requirements for certification under one of the several available green building rating systems; sustainable has a broader scope, referring to environmentally responsive design that aims to achieve an ecological balance by avoiding depletion of natural resources.
   The term 'aesthetics' has several acceptations. In this discussion, aesthetics relates to the enjoyment of beauty, but most significantly, as derived from the Greek *aisthanesthai*, means 'perception by means of the senses' or 'our physical appreciation of' architecture. The term 'style' is used in its most common acceptation: 'a distinctive appearance, typically determined by the principles according to which architecture is designed', or 'a particular procedure by which architecture is done'.
2. Josh Stephens, 'Starchitecture and Sustainability: Hope, Creativity, and Futility Collide in Contemporary Architecture', *Planetizen* (1 November

2009) <http://www.planetizen.com/node/41489> [accessed 1st April 2016].
3. Daniel Jauslin, 'Landscape Aesthetics for Sustainable Architecture', in *Aesthetics of Sustainable Architecture*, ed. by Sang Lee (Rotterdam: 010 Publishers, 2011), pp. 109-119 (p.109).
4. Vladimir Belogolovsky, 'Interview with Peter Eisenman', *Intercontinental Curatorial Project Inc*. (October 2003) <http://curatorialproject.com/interviews/petereisenmanii.html> [accessed 1st April 2016].
5. Henri Lefebvre, *The Production of Space*, (London: Blackwell Publishing, 1991), p. 176.
6. *Ibid*.
7. Ezio Manzini, 'Design, Environment and Social Quality: From 'existenzminimum' to 'quality maximum'', *Design Issues* 10 (1) (spring 1994), pp. 37-43 (pp. 42-4).
8. The 'Triangular Approach' or 'What makes a building green' diagram, in Torsten Schroeder, *Translating the concept of sustainability into architectural design practices: London's City Hall as an exemplar*. PhD Thesis (London: London School of Economics, 2014), pp. 160-162. This diagram was also presented in a lecture delivered by Stefan Behling in April 2004 at the Illinois Institute of Technology, Chicago.
9. Term coined by Michael Speaks. See Marianne Krogh Jensen 'Remarks on nature, super-ecology, life, production, position and other negotiations', in *Olafur Eliasson: Chaque matin je me sens différent. Chaque soir je me sens le meme*, ed. by Joseph Jacquet (Paris: Musée d'Art Moderne de la Ville de Paris, 2002), pp. 57-61 (p. 58).
10. See Jane Jacobs, *The Nature of Economics*, (New York: Modern Library, 2000).
11. Peter Collins, 'The Biological Analogy', *The Architectural Review* 126 (December 1959), pp. 303-306 (p. 306).
12. Mike Davies, 'A wall for all seasons', *RIBA Journal* 88 (2) (February 1981), pp. 55-57.
13. Detlef Mertins, 'Bioconstructivisms', in *Engineered Transparency – The Technical, Visual and Spatial Effects of Glass*, ed. by Michael Bell and Jeannie Kim (New York: Princeton Architectural Press, 2009), pp. 33-38 (p. 38).
14. Kengo Kuma, 'Gardening versus Architecture', *Lotus International* 97 (June 1998), pp. 46-63 (pp. 46-49).
15. Junichiro Tanizaki, *In Praise of Shadows* (London: Vintage, 2001), pp. 28-30.
16. Kengo Kuma, *Small Architecture / Natural Architecture*, (London: AA Publications, 2014).

17. For instance in the thermally active surfaces of the Zollverein Management School, designed by SANAA.
18. Iñaki Ábalos, 'La belleza termodinámica', *Circo* 157 (2008) <http://www.mansilla-tunon.com/circo/epoca7/pdf/2009_157.pdf> [accessed 1st April 2016]
19. Iñaki Ábalos, 'Aesthetics and Sustainability: Alternatives', *Abalos + Sentkiewicz* (2008) <http:// www. http://abalos-sentkiewicz.com/files/Aesthetics_and_Sustainability.pdf> [accessed 7th March 2016]
20. *Ibid*.
21. Kenneth Frampton 'Urbanization and Discontents: Megaform and Sustainability', in *Aesthetics of Sustainable Architecture*, ed. by Sang Lee, pp. 97-108 (pp.102):

    > *'The megaform may be defined as: 1 a large form that extends horizontally rather than vertically; 2 a complex form that is not articulated into a series of structural and mechanical subsets; 3 a form that is capable of inflecting the existing landscape in terms of its strong topographic character; 4 a form that is not freestanding but rather one that insinuates itself as a continuation of the surrounding topography; and last but not least, 5 a form that is oriented toward a densification of the urban fabric.'*

22. *Ibid*., pp. 98-108.
23. As experienced by the author during visits to the building.
24. Ralph L. Knowles, 'Solar Aesthetic', in *Aesthetics of Sustainable Architecture*, ed. by Sang Lee, pp. 50-65.
25. Hugh Whitehead, 'The Practice of Smartgeometry', in *Inside Smartgeometry. Expanding the Architectural Possibilities of Computational Design*, ed. by Braddy Peters and Terri Peters (Chichester, UK: Wiley, 2013), pp. 232-241 (p.241):

    > *'The Specialist Modelling Group computational investigations into designing design methods for architecture combine 'geometry, form finding, fabrication, building physics, fine arts, material science, environmental design, simulation, fluid dynamics and sustainability research. All are underpinned by a fluency in parametrics, scripting and computation. It is the combination of diverse skill sets which continues to push the boundaries, helping to deliver high-performance design based on radical new concepts'*.

26. Edward O. Wilson, *Biophilia* (Cambridge, MA: Harvard University Press, 1984).
27. Sang Lee and Stefanie Holzheu, 'Building Envelope as Surface', in *Aesthetics of Sustainable Architecture*, ed. by Sang Lee, pp. 120-133 (p. 120).
28. *Ibid*., p. 131.

29. Jacques Derrida, 'Economimesis', *Diacritics* 11 (2) (June 1981), pp. 3-25.
30. Giancarlo Mangone and Patrick Teuffel, 'Constructing Sensuous Ecologies: beyond the Energy Efficiency and Zero-Carbon Argument', in *Aesthetics of Sustainable Architecture*, ed. by Sang Lee, pp. 243-258 (p. 245).
31. Cristina Díaz and Efrén García, 'Atmosphere, Material for the Digital Gardener', in *Breathable*, ed. by Cristina Díaz, Efrén García, Uriel Fogué and Fermina Garrido, (Madrid: Universidad Europea de Madrid, 2009), pp. 26-27.
32. Michael Hensel, '(Synthetic) Life Architectures: Ramifications and Potentials of a Literal Biological Paradigm for Architectural Design', *AD* 76 (2) (March 2006), pp. 18–25.
33. Rachel Armstrong, *Vibrant Architecture: Matter as a CoDesigner of Living Structures* (Warsaw/Berlin: De Gruyter Open, 2015) (p. 280).
34. Sean Lally, 'Twelve Easy Pieces for the Piano', in *AD* 79 (3) (May 2009), pp. 6-11 (p. 8).
35. *Ibid*., p.8.
36. We can relate this back to the Japanese house, where the variation of shadows lends specific qualities to the space, blurring or even concealing the actual physical container. See for instance the description of the *toko no ma* room in Junichiro Tanizaki, *In Praise of Shadows*, pp. 29-32: '*Were the shadows to be banished from its corners, the alcove would in that instant revert to mere void.*'
37. Hans Ulrich Obrist, 'Interview with Philippe Rahm and Jean Dider Vincent', in *Breathable*, ed. by Cristina Díaz, Efrén García, Uriel Fogué and Fermina Garrido, pp. 292-303 (p.302): 'my architecture seeks to redefine modernist elements using the current understanding of the psychological and physiological needs of man'.
38. Michelle Addington, 'Contingent Behaviours', *AD*, 79 (3) (May 2009), pp. 12-17.
39. Peter Sloterdijk, 'Air/Condition', *Terror From Air* (Los Angeles: Semiotext(e), 2007), pp. 71-106.
40. Richard Whittaker, 'Greeting the Light: An Interview with James Turrell', *Works and Conversations* (13th February 1999) <http://www.conversations.org/story.php?sid=32> [accessed 1st April 2016].
41. Mark Wigley, 'The Architecture of Atmosphere', in *Breathable*, ed. by Cristina Díaz, Efrén García, Uriel Fogué and Fermina Garrido, pp.84-99 (pp.95-96).
42. Michael Hensel and Achim Menges, 'The Heterogeneous Space of Morpho-Ecologies', in *Space Reader. Heterogeneous Space in Architecture*, ed. by Michael Hensel, Christopher Hight and Achim Menges (London: John Willey and Sons, 2009), pp. 195-215.

43. *Ibid*., p. 212:

> *'A design approach based on programme strategies, which attempt to match spatial units or locations with unique ways of inhabiting, but to consider it an opportunity for human interaction with specific environments as processes instead of fixed conditions. Therefore, the spatial organisation responds to gradient conditions interacting with the material thresholds, and these material systems act as connecting filters between the macro and the micro: the external environment's energy flows and the internal micro–environment.'*

44. Rick Dolphijn and Iris van der Tuin, *New Materialism: Interviews & Cartographies*. (Ann Arbor, MI: Michigan Publishing/University of Michigan, 2012).
45. Manuel DeLanda, 'The New Materiality', *AD* 85 (5) (September 2015), pp. 16-21.
46. Achim Menges, 'Fusing the Computational and the Physical. Towards a Novel Material Culture', *AD* 85 (5) (September 2015), pp. 8-15 (pp. 11-12).
47. Malcolm Budd, *The Aesthetic Appreciation of Nature. Essays on the Aesthetic of Nature* (New York: Oxford University Press, 2002).

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