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Sustainable Architecture: Meditations on New Repertoires of Forms

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Introduction

In recent years a debate has arisen amongst architects and theorists on architecture that concerns the extent to which sustainable architecture could be the foundation and imperative for a new repertoire of forms. The current ecological crisis not only raises questions about how to design the built environment in such ways that it demands less use of natural resources and energy; it also raises questions about the degree to which this can and should be expressed in form. To what extent and in what ways is it possible to exploit the design of a building so as to make the viewer aware of the building's sensible use of natural resources and thereby raise awareness about the human impact on the ecological environment? A negative answer would be that sustainability is mainly an economic and ecological imperative and as such is not applicable to form-related considerations. From this perspective it is irrelevant whether a sustainable building looks sustainable, as long as the building *is* sustainable. It can even be argued that the demand for sustainability in fact gets in the way of formal considerations. The counterargument would be that being part of the environment by definition, architecture thus by definition also relates to environmental issues. As such, the architectural form implicitly expresses how this relation is understood by the architect, how it is made explicit through its architectural form and subsequently how it is approached and contemplated by the beholder.
In this chapter I will discuss different arguments from the debate on the feasibility of sustainable architecture and will relate them to a number of examples from contemporary architecture. I will argue that there are indeed repertoires of forms that are fuelled by modern technology and that appear to be particularly connected to sustainable architecture. These repertoires of forms elicit aesthetical experiences that can also signify rational and moral concerns for the environment. However, it is not possible to state definitively that such an experience is also and always a necessity in the light of sustainability as a functional and moral imperative.

On sustainable architecture

From the perspective of the ›ecological‹ crisis, sustainability is often defined as the (moral) imperative that we are responsible for making sure that the needs of the present day do not harm the ability of future generations to ensure their needs.[1] The issue of sustainability therefore always relates to how we imagine possible futures.[2] Used as an adjective, sustainable in relation to architecture is then defined as architecture that does minimal harm to the environment and whose material and energy sources have a low impact on the environment, leaving future generations to make

1 Lane, Melissa: »A New Professional Ethics for Sustainable Prosperity«, CUSP Essay Series on the Morality of Sustainable Prosperity, 1, 5. See also Abreu, Pedro Marques de: »Sustainable Aesthetic in Architecture«, in: W. Leal Filho et al. (eds.), Handbook of Lifelong Learning for Sustainable Development: Springer 2018, 323–324.

2 Guy, Simon/ Farmer, Graham: »Reinterpreting Sustainable Architecture: The Place of Technology«, in: *Journal of Architectural Education* 54, 3 (2001), 142.

their mark on a future built environment as well.[3] The question is if sustainability can also be a formal imperative and thereby give it aesthetical relevance.[4] This question reverts to the 20th-century debate on the relation between form and function. Many of the functional aspects of modernist buildings resulted from new technology and the new or different use of materials.[5] As such, new technology and materials have expanded existing repertoires of form.[6] This also came with certain values and ethical concerns.[7] In the modernist debate it was often held that standardised production reduced costs and prevented the waste of material resources and labour, and was therefore more ethical.[8] Besides this, it would result in new forms of beauty and therefore raised aesthetic concerns.[9] These ideas were expressed in the form of manifestos that pervaded the progressive nature of their advocates, who derived a certain authority from being ahead of their times. Although in the Bauhaus manifesto Walter Gropius initially referred to past practices, in his later writings, new ideas about architecture and its social and cultural significance come to the fore.[10]
Manifestos still appear today, such as for instance the sustainist manifesto by Michiel Schwarz and Joost Elffers. It is too early to judge what the impact of these texts will be on the future and thus indirectly also on the history of the arts, architecture and design, but as in the 20th-century manifestos they express a concern for the relationship between form and function and its ethical implications framed in terms of sustainability and ecological awareness.[11]

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3 »sustainable, adj.«, in: *OED Online*, Oxford University Press, June 2019, www.oed.com/view/Entry/195210 [21 June 2019].

4 Baumberger, Christoph: »The Ethical Criticism of Architecture: In Defense of Moderate Moralism«, in: *Architecture Philosophy* 1, 2 (2015), 179.

5 Keeney, Gavin (ed.): »Chapter 3. Façades after the facade«, in: Rem Koolhaas (ed.), *Elements of Architecture*, Cologne: Taschen 2018.

6 As the ›usual‹ term ›formal language‹ comes with linguistic connotations, I want to avoid that term for now, although I do not deny that forms in architecture are related to language, for instance, as stylistic devices comparable to means of style in language, or in the sense of being able to index semantic content. My primary concern, however, is how to denote the possibility of a (more or less coherent) set of new forms that has the potential to constitute a distinguishable visual style in architecture for which I find ›repertoire of forms‹ more appropriate.

7 Raizman, David Seth: *History of modern design*, London: Laurence King Publishing 2010, 240–242; Heskett, John: *Industrial Design*, London: Thames & Hudson 1980, 21–26.

8 Gropius, Walter: *The New Architecture and the Bauhaus*, Cambridge (MA): The MIT Press 1965, 37–38.

9 Ibid., 43–44.

10 Gropius, Walter: *Programm des Staatlichen Bauhauses in Weimar*, Weimar: Staatliches Bauhaus 1919. See further, Curtis, Louise: »Architecture«, in: Olivier Gabet/Anne Monier (eds.), *The spirit of the Bauhaus*, London: Thames & Hudson 2018, 158–164; Wilhelm, Karin: »Die drei Direktoren am Bauhaus«, in: Jeanine Fiedler/Peter Feierabend (eds.), *Bauhaus*, Cologne: Könemann 1999; Gropius: *The New Architecture and the Bauhaus*, 19–29.

11 Schwarz, Michiel/ Elffers, Joost: *Sustainism is the new modernism: a cultural manifesto for the sustainist era*, n.p.: self-pub 2010. In these manifesto's, sustainability has a broader context and concerns not only the reduction of the use of energy or the most economical use of natural resources; it also relates to durability in a social sense. See also Meyer, Elizabeth K.: »Sustaining Beauty: The performance of appearance«, in: J*ournal of Landscape Architecture* 3 (2008) 1. Furthermore, see Guy, Simon/Farmer, Graham: Reinterpreting Sustainable Architecture, 143; Schwarz, Michiel/ Krabbendam, Diana (eds.), *Sustainist Design Guide: How sharing, localism, connectedness and proportionality are creating a new agenda for social design*, Amsterdam: BIS Publishers 2013, 12–13.

The possibility of sustainable aesthetics

The recent debate on sustainable architecture centres on whether and how the visual appearance of sustainable buildings can be endowed with specific formal properties, a repertoire of forms, that signify the specific sustainable nature of the built environment through an ›aesthetic‹ experience.

In defining aesthetics, architect Sang Lee departs from how Baumgarten denoted the term as a specific kind of knowledge not derived from reason but from sensual experience. The aesthetic quality of a building can thus be construed as the formal exterior quality that allows the subject to extract certain knowledge about the building in particular.[12] As the outer appearance of objects and bodies, and thus also of buildings, reveals information about the inner qualities of the object, the aesthetic experience allows the subject to also obtain knowledge about the interior qualities of the object as such, precisely through the perceptual properties of the object's surface.[13] With regard to architecture, this means that the aesthetic quality of a building relates to the way the building is perceived, comprehended and judged as a purposely designed and constructed form or assemblage of forms, designed and built from the context of a certain situation and a certain condition. According to Sang Lee, the built form articulates the fundamentals of its »programmatic, structural, material and spatial qualities.«[14] Lee argues that the aesthetic quality of a building arises from the order that connects these qualities to form a single whole. From this Lee draws the conclusion that, in the case of a sustainable building, the notion of its aesthetic quality thus concerns the way the built form is informative with regard to »how it was conceived and situated, and what makes it be so [sustainable] under what kind of conditions.«[15] He goes on to argue that as an aesthetic quality sustainability should be perceivable and comprehensible from the outer appearance of the building as the building's proper objective.[16] It can therefore be argued that the aesthetic quality of sustainable buildings resides, as with any architectural structure, in the expression of the qualities of the built form as a unified whole. It is through the building's distinctive visual appearance that these qualities find expression and allow the perceiving subject to acquire precise knowledge of the built form.[17]

In a paper from 2006 Tom Spector approaches the issue not by departing from a specific definition of aesthetics but by starting from the fundamental question of what constitutes architecture in the first place. To this end Spector refers to Vitruvius, who

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12 Baumgarten, Alexander Gottlieb: *Aesthetica*, 1750–1758, $ 1.

13 Lee, Sang: »Introduction«, in: Sang Lee (ed.), *Aesthetics of Sustainable Architecture,* Rotterdam: 010 Publishers 2011, 11.

14 Ibid.

15 Ibid.

16 Ibid.

17 Jauslin, Daniel: »Landscape Aesthetics for Sustainable Architecture«, in: Lee: *Aesthetics of Sustainable Architecture*, 109.

defined the constitutive values of architecture as structure, function and beauty of form.[18] Spector successively argues that sustainability is not such a constitutive value because a building that is not sustainable does not therefore cease to be architecture, whereas a construction lacking structure, function and form, does.[19] Furthermore, Spector argues that as a moral imperative, sustainability conceived in functional terms can easily turn into an economic motive to reduce ecological impact at the highest possible profit. Viewed from such practical considerations, Spector argues that form is likely not regarded as a necessary concern but probably as something that from the perspective of sustainability would rather be subject to limitations.[20] Pedro Marques de Abreu emphatically rejects the modernist imperative of novelty that according to him led to a succession of repertoires of forms which would indeed have proved to be unsustainable. The limited lifespan of such repertoires would become immanent from the deplorable situation of many of the post-World War II large-scale urban projects, some of which were already demolished shortly after their construction, such as Pruitt Igoe in Saint Louis.[21] De Abreu argues, therefore, in favour of a sustainable repertoire of forms based on what has proved to be successful in vernacular tradition or one that is inspired by organic forms in nature.[22] If such repertoires of forms are the outcome of a sustainable aesthetic, then it appears that De Abreu is arguing that the formal repertoire of forms of the sustainable architect should indeed be limited. After all, too many formalistic novelties would entail the danger of rapidly becoming outdated and obsolete, and therefore not being sustainable.

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18 Vitruvius: *De architectura*, Book I.2.

19 Spector, Tom: »Does the sustainability movement sustain a sustainable design ethic for architecture?«, in: *Environmental Ethics* 28 (2006), 279. Vitruvius was nevertheless deeply concerned with the building's proper site and with how temples in particular are built in adaptation to nature and on sites with access to healthy water. But with regard to residential buildings, Vitruvius is concerned too with how, for instance, sleeping rooms and libraries are attuned to natural light sources. This shows that the relationship between the building and its environment was a concern for Vitruvius indeed and moreover a matter of ›decorum‹. Vitruvius: *De architectura*, Book I.2.7. See further Vitruvius: *De architectura*, Book I.4–7 about Vitruvius' concern for how the city as a whole is situated within the natural environment as well as the orientation of city walls, streets, and the fora and temples. See also Steiner, Frederick: »Toward an ecological aesthetic«, in: *Socio-Ecological Practice Research* 1 (2019) 34.

20 Spector: »Does the sustainability movement sustain a sustainable design ethic?«, 69.

21 Abreu: »Sustainable Aesthetic in Architecture«, 329–331. Many of these large-scale urban projects were founded on idealist visions of a new society inspired by, for instance, the ideas of the Bauhaus or those of Le Corbusier. However, their scale and formal characteristics were often experienced as monotonous and inhumane. As a result, many neighbourhoods were soon inhabited by socially vulnerable inhabitants with lower incomes who brought in social problems such as unemployment, criminality and drug abuse. This demonstrates how the repertoire of forms of the built environment affects communities; in essence it shows that aesthetic and ethical concerns are indeed closely related. See also Kirkpatrick, Sale: »There is a human scale at which everything works«, in: Schwarz, Michiel/Krabbendam, Diana (eds.): *Sustainist Design Guide: How sharing, localism, connectedness and proportionality are creating a new agenda for social design*, Amsterdam: BIS Publishers 2013, 46-47; Baumberger: »The Ethical Criticism of Architecture«, 184.

22 Ibid., 346-355. See also Guy/Farmer: »Reinterpreting Sustainable Architecture«, 144.

Spector argues that only a non-anthropocentric conception of sustainability could lead to a serious reduction in ecological impact and perhaps form the starting point for sustainability as a design philosophy underlying a specific architectural repertoire of forms.[23] However, he considers this impossible because he cannot see how a non-anthropocentric ethic would change from within what is essentially an anthropocentric activity, namely architecture.[24] Spector therefore concludes that sustainability does not offer a foundation for a new building philosophy.[25]

In a critical response to Spector's article, Roger Paden departs from the Kantian premise that the aesthetic experience is one of disinterested pleasure. When confronted with the form of an object, the aesthetic experience applies to the form of the very object and does not depend on any possible interest in the object.[26] We can find a painting ›beautiful‹ even though we do not own the painting and regardless of the painting's content, context or economic value.[27] Paden argues that nature evokes similar aesthetic experiences and therefore can urge humans to protect nature. Of course, we depend on nature and the natural environment because natural resources provide humans with food. Furthermore, natural resources can, for instance, be a source for medicines. Humans depend on the earth's atmosphere because it provides us with oxygen, and on trees because they filter out carbon dioxide. It therefore makes sense to protect nature from these very utilitarian objectives. However, by referring to the protection of nature arising from an aesthetical motive, Paden touches upon another attitude that humans develop towards nature, namely that we tend to imbue nature with an intrinsic value and it is this intrinsic value that is also aesthetically appealing. Paden thus basically argues that based on this value alone, the protection of nature is in itself already justifiable, irrespective of all our interests. Therefore, Paden assumes that what he refers to as 'environmental aesthetics' can also form the point of departure of a building philosophy. With regard to the environment, the subject is always part of that environment; the subject dwells in the environment and something similar applies to architecture in the sense that buildings are also always part of the environment; they are built precisely in the environment. From that perspective, sustainability could stimulate a building philosophy in which the emphasis is on the integration of architecture with its surroundings.[28]

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23 Spector: »Does the sustainability movement sustain a sustainable design ethic?«, 69. In explaining what he means by non-anthropocentric, Spector refers to Warwick Fox who argues that part of the ethical issue of sustainability concerns not departing solely from human interests but from those of the planet in its entirety, from a concept of humanity as unified with nature as opposed to conquering nature.

24 Ibid., 267–273.

25 Ibid., 283.

26 Paden, Roger: »Aesthetics and Sustainable Architecture«, in: *Environment, Space, Place*, Vol. 4, No. 1 (2012), 22–27.

27 Kant, Immanuel: *Kritiek der Urteilskraft*, Königlichen Preußischen Akedemie der Wissenschaften (red.), Akademieausgabe: Kants Gesammelte Schriften, Georg Reimer: Berlin 1910, 204–205.

28 Paden: »Aesthetics and Sustainable Architecture«, 22–27.

To understand how this could be achieved, it should first be clear in what ways buildings relate to the environment. Given that architecture comprises both the exterior form and the interior space of buildings, the exterior surface of the built form will at first sight appear to the viewer as the building's visual appearance. This exterior surface is in architectural terms traditionally referred to as the building's façade. This does not, of course, mean that the aesthetic experience of a building is limited to the formal qualities of its exterior. However, in the following sections I concentrate the discussion on the formal aspects of the exterior of buildings because the beholder's first confrontation with a building and her or his first response is with and to the exterior.[29] Therefore, if there is such a thing as a moral imperative underlying a sustainable aesthetic, then this should be expressed first and foremost in the building's façade – all the more so because the façade could be regarded as the very membrane between the built space and the environment in which the built object is situated and from which it draws its resources.[30]

The façade as the mediator between inner space and environment

There are two ways in which architecture can stress this relationship. First, architecture as a mediator between the interior and the exterior and second, architecture as a means to integrate the internal and external space. In both cases the façade plays a key role.

The mediation takes place in the form of the passing of light, heat and air and thereby in the possibility of the regulation of the internal climate by means of resources used from the external climate. The surface thus has a transgressive character. It functions as an interface between one realm and the other. However, being the visible divider between an inside and an outside space, the surface also has a potentially expressive quality and with that the ability to communicate, to be an agent of some kind.[31] As such, the surface is implicitly referential with regard to the notion of architectural space and its place in the world itself.[32]

In both cases, as an interface between two climates and as a signifying surface, the façade appeals to the human senses. It is this sensual aspect of the surface through which the subject acquires sensual knowledge about the building from which a sustainable aesthetic should be contemplated. Architects Matthias Sauerbruch and Louisa Hutton argue that this sensual aspect should not be limited to the visual but should include the whole range of bodily perception, including touch, hearing and smell.

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29 Ingold, Tim: »Surface visions«, in: *Theory, culture & society* 34 (2017) 7–8, 103.

30 Trüby, Stephan: »Chapter 2. Façade façades«, in: Rem Koolhaas (ed.), *Elements of Architecture*, Cologne: Taschen 2018, 896–905.

31 Lee, Sang/Holzheu, Stefanie: »Building Envelope as Surface«, in: Lee: *Aesthetics of Sustainable Architecture*, 127.

32 Zaera-Polo, Alejandro: »A material and environmental perspective«, in: Rem Koolhaas (ed.), *Elements of Architecture*, Cologne: Taschen 2018, 914.

They state that the objective of a building that stimulates bodily perception is to provide the subject with a sense of what a building after all still is: a construction which provides both shelter and security but which at the same time can evoke wonder and astonishment. Furthermore, the building should promote openness and should be comprehensible to such an extent that the subject is able to acquire knowledge about the building's underlying aesthetical and ecological concepts, as well as about its place within the immediate environment.[33]

Reasoning from the experience of beauty as we perceive it in response to a landscape, Elizabeth Meyer also argues that such an experience is multi-sensorial and involves the whole body. Moreover, she argues that the aesthetic experience can inform our rational and moral considerations in important ways.[34] The very fact that we can experience a sense of beauty in the first place, whether it relates to nature, artworks or buildings, and that we can consider this experience in relation to rational and moral concerns is a given that the architect can deliberately employ when designing the building's façade.

Sauerbruch and Hutton stress the importance of colour as a means to highlight the qualities of the façade's surface. It allows the architect to endow the surface of a building with optical effects, not only to emphasise the qualities of the surface as such but also to manipulate, as it were, the supposed flatness of the surface. They point to the fact that distance influences the ways in which a subject perceives a surface. From a distance, façades, even those that are curved and have depth, tend to appear flat. The architects argue that this also changes the bodily engagement with architecture. The more distant the view the more distant the engagement. As an example, Sauerbruch and Hutton refer to the façade of the building they designed for the Museum Brandhorst in Munich. The outer skin of this façade is a layer that consist of a series of coloured glazed vertical ceramic batons that are hung offset in front of a two-coloured horizontally folded metal wall. The architects explain that as a result the frontal view of the building generates a completely different bodily and visual experience as opposed to the oblique view. In the first case the layered façade is clearly recognisable, while in the second the two layers tend to merge together and almost become immaterial. Walking around the building, the spectator's experience would change from a concrete bodily experience of space and material to a more intangible, purely visual experience, and vice versa.[35] (Fig. 1)

Sauerbruch and Hutton explain that by treating the façade in such a way the architect is able to make the subject aware of the very act of perceiving itself. Moreover, it also makes the beholder aware of the effect of visual perception on how we as humans bodily engage with our surroundings. With regard to buildings the subject

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33 Sauerbruch, Matthias/Hutton, Louisa: »What Does Sustainability Look Like?«, in: Lee: *Aesthetics of Sustainable Architecture*, 46.

34 Meyer: »Sustaining Beauty«, 7–8.

35 Sauerbruch/Hutton: »What Does Sustainability Look Like?«, 48.

becomes aware of the surface's essential quality of being a mediation between an internal and external space, and of the surface being the separation between the internal and external space and thereby being the denominator of what defines the building as a form on its own.[36] While approaching the Museum Brandhorst the beholder becomes aware of the façade's layers because the patterns of both layers shift rhythmically with the changing position of the beholder. In using colour as an index for the layered patterns, the two architects aim to highlight how façades, and contemporary façades in particular, should no longer be perceived as single-layer separations between an inside and an outside. (Fig. 2) Rather, in mediating between the inner and the outer climate, façades are increasingly highly porous and indeed often multi-layered, as with the Museum Brandhorst. As such, the multi-layered façade questions the very idea of a clear separation between an inner and an outer realm. Furthermore, in its mediation between the inner climate and outer climate lies what both architects refer to as ›the performative aspect of the surface‹.[37]
This performative aspect refers back to the beholder. As the beholder moves towards the building, a dialogue, as it were, arises between building, beholder and environment. In her manifesto, Elizabeth Meyer also rightly points out how our experiences in the natural landscape, and this counts for the urban landscape as well, are performative in the sense that we move through space and we experience the objects and bodies that surround us as also moving in space. In short, our experience of the environment is dynamic and cannot be reduced to a specific moment or point of view. As beholders, we become aware of how the bodies and objects of both the natural as well as the built environment appeal to us perceptually while we are moving. Meyer argues that these experiences encourage us to think about our responsibility towards the environment and incite us to act and take care of this environment. On this point her manifesto seems to connect to Paden's argument that it is specifically the aesthetic experience of nature that inspires us to protect nature for the very sake of nature itself. What Meyer thus argues for with regard to sustainable design is to design experiences, which is exactly what Sauerbruch and Hutton appear to have done with regard to the architectural façade.[38]

Façades, technology and new repertoires of forms: the solar, parametric and biomimetic

At this point I think it is possible to draw the preliminary conclusion that sustainable architecture is indeed about more than the functional and moral imperative of a sensible use of natural resources, minimum harm to the ecological environment, and the consideration of the imagined future of generations to come. The moral imperati-

36 Ingold: »Surface Visions«, 103.

37 Sauerbruch/Hutton: »What Does Sustainability Look Like?«, 48–49.

38 Meyer: »Sustaining Beauty«, 18–19.

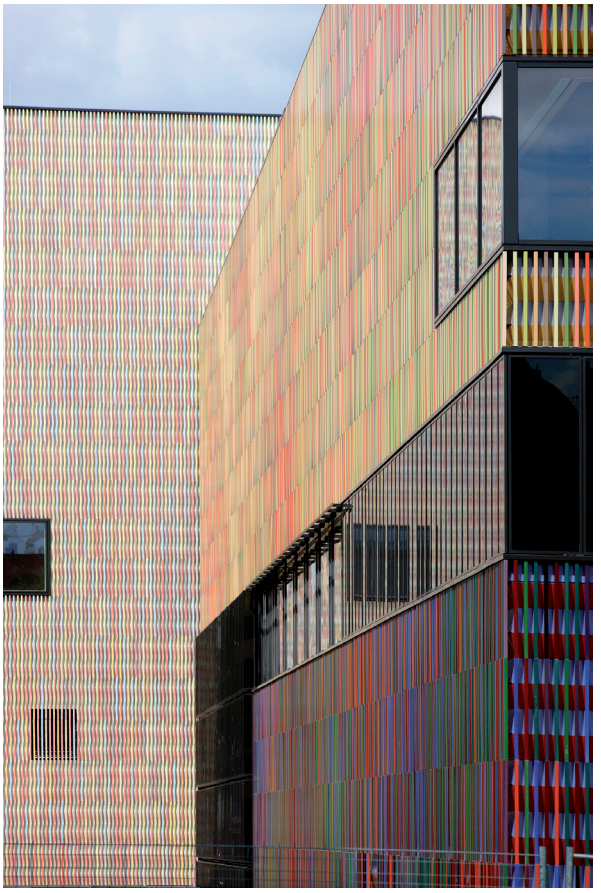

Fig. 1: Sauerbruch & Hutton, Museum Brandhorst, Munich, Türkenstraße 19, 2008, eastern and frontal Façade, viewed from northeast

Fig. 2: Sauerbruch & Hutton, Museum Brandhorst, Munich, Türkenstraße 19, 2008. Back front façade and western façade, viewed from inner court southwest

ve of sustainability can be the foundation of a sustainable design philosophy and an aesthetics as well, to the extent that within the context of a building as sustainable in terms of functionality and (social) meaning, ethical concerns are also relevant aesthetically.[39] This design philosophy should take the aesthetic experience of the building as situated within the spatial environment as the point of departure. It appears that the façade as the visually most prominent part of the building is the obvious architectural element to be endowed with the capacity to evoke such an experience. In this section it will be clear that whether or not the demand of sustainability limits the possibilities of the architect largely depends on the technological possibilities available to the architect. Many design solutions in contemporary architecture particularly affect the façade.[40] Most of these result from the increase in technological solutions to design problems as well as more advanced software used in design processes making possible repertoires of forms that go beyond more traditional and straightforward geometrical architectural forms and are more comparable to the organic and capricious forms found in nature, such as for instance those visible in parametric design.[41] Parametric design has contributed to a significant increase in possibilities that are both aesthetically challenging as well as technically realisable within a construction. Many of the parametric designs were inspired by forms in nature.[42] As such, parametric design could be used to design an architecture which in a more formal sense could integrate more closely with the natural surroundings. Parametric design not only makes possible new repertoires of forms but can also generate forms that minimise the resistance that natural forces such as wind impose upon the building's surface and maximise the benefits from natural conditions.[43]

Other repertoires of forms build on existing ones but their possibilities are extended due to new technology. The use of glass in curtain walls for high-rise buildings has since its advance been applied worldwide and has seen many adjustments and inventions. The latest is the use of ceramic printing on glass to equip buildings with more sustainable and aesthetically appealing façades. It is made by imprinting an ink made of a ceramic frit (the glass is therefore also called ›fritted glass‹) onto the glass. As opposed to earlier techniques such as UV printing, the ceramic is now fused with the glass and is therefore more durable. These partly translucent glass panels can be used, for instance, to regulate daylight and temperature and as such in a literal sense perform the mediation function of the façade. Above all, these panels are perfect for making highly decorative surfaces. Using this technique thus contributes to reducing

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39 Baumberger: »The Ethical Criticism of Architecture«, 187.

40 I want to thank Dr Juliette Roding from Leiden University for making me aware of some of the most notable examples of sustainable buildings.

41 Guy/Farmer: »Reinterpreting Sustainable Architecture«, 144.

42 Phillips, Steven: »Parametric Design: A Brief History«, in: *arcCA* 10 (2012).

43 Lotfabadi, Pooya; Alibaba, Halil Zafer; Arfaei, Aref: »Sustainability; As a Combination of parametric patterns and bionic strategies«, in: *Renewable and Sustainable Energy Reviews* 57 (2016).

the building's energy consumption while at the same time the motifs on the panels create intricate decorative patterns to cover the building's surface.[44] In recent years fritted glass has been applied by architects such as Frank Gehry for the Interactive Corporation Building in New York and more recently by Norwegian architects Snøhetta for the Ryerson University Student Learning Centre in Toronto. (Fig. 3)
Ralph. L. Knowles highlights another way in which the façade is used to mediate between the inner climate of the building and that of the outside, namely by adjusting the form of the ›envelope‹ of the building to natural patterns such as the path of the sun. As a result, the form of the building will, for instance, not be the same on all sides. Knowles points to examples of terraces where houses are designed towards a slope in such a way that they all maximally benefit from the incoming solar energy. Singapore's Solaris building by T.R. Hamzay & Yang is an example of a building of which the envelope is designed such that different parts of the building continuously increase in height so that each part at specific moments benefits from the radiation of the sun according to the angle of radiation at certain times of the day.[45] (Fig. 4)
The Pearl River Tower by Skidmore, Owings&Merill in Guangzhou China contains many sustainable solutions. One of those which also affects the aesthetic appearance of the façade is the use of panels with photovoltaic cells on the western and eastern elevation of the building. These panels capture energy from the sun while at the same time they also form the shading system of the building.[46] (Fig. 5) These panels bring to mind the persienne, also known as the Venetian blind, but applied as an important and recursive functional element within the Pearl River's envelope these panels contribute to the form of the building as a whole and as such have the potential to elicit an aesthetic response.
The façade of Chicago's Acqua Tower is an example of a parametric surface founded on a concept of the façade which is at the same time ecological, environmental and social. (Fig. 6) At each different level of the tower the floor has bulges that function as the floor of balconies. These balconies are not only created to provide different views of the surroundings but, because each balcony is not in line with the other, it makes it possible for residents to see each other's balconies and therefore to communicate. This creates a different potential for social contact. (Fig. 7) Viewed from the front, the building's façade appears as a surging landscape of curved lines which according to the architects resemble the lines of natural valleys and hills.[47] In this example the façade has almost become a social landscape in itself.
The most obvious association between landscape and façade are the many green façades that have been erected in recent decades. Some of those are even literal extensions of parks such as is the case with Jean Nouvel's One Central Park building

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44 Keeney: »Facades after the facade«, 982.

45 Knowles, Ralph L: »Solar Aesthetic«, in: Lee: *Aesthetics of Sustainable Architecture*, 61–63.

46 https://www.som.com/projects/pearl_river_tower__sustainable_design (14 February 2019).

47 http://studiogang.com/researchproject/a-morphology-of-tower-research (14 February 2019).

Fig. 3: Snøhetta, Ryerson University Student Learning Centre, Toronto, 341 Yonge Street, 2014, facade, view from Gould Street

Fig. 4: T.R. Hamzay & Yeang, Solaris building, Singapore, 1 Fusionopolis walk, 2011, external façade, View from northeast

in Sydney.[48] (Fig. 8) Green façades obviously add aesthetic qualities to the surfaces of buildings but also pose the question of whether the natural forms of the plants and trees applied to those façades could be considered a new repertoire of forms. Perhaps, it problematises the notion of a repertoire of forms in the first place. Designing a green façade after all comes down to the use of an existing repertoire of forms in a radical new way. It is a product of technology in the sense technology allows the green façade to be maintained as such while the green of the façade also obscures the very same technology as it hides all the underlying draining and piping. Furthermore, plants, moss and trees have always ›colonised‹ human structures. The green façade is therefore an example of a very deliberate and organised exploitation of a natural principle. However, green façades use the literal stuff and this is relatively new while the mimicking of natural forms in design is an integral part of design's history.[49] Biomimetic architecture builds on this tradition and the repertoire of forms is obviously inspired by natural forms such as those of cells and crystals. The principle of growth in which cells regularly expand and form a coherent fabric is often expressed in the façades of biomimetic buildings and clearly inspired the Biosphere 2 and the Eden Project whose designs have almost become iconic for the genre. The surface of the domes in the Eden Project are made with an inflatable foil which is light in weight and therefore drastically limits the necessary bearing power of the structure.[50] (Fig. 9)

Façades integrating into the landscape

I stated earlier that besides stressing the relation between the inner space of the building and the outer space of the environment, the façade also plays a key role in buildings which have been built from the objective of integrating the built environment into the landscape. Being integrated in a designed landscape, the Eden Project could be considered as an example of how Paden envisages a possible environmental aesthetic in architecture. Paden argues that this should be accomplished in such a way that buildings take up a modest position.[51] According to Paden, sustainable buildings should not be self-referential objects but should express in a meaningful manner the different ways in which the relationship between humans and their environment can be conceived.[52] De Abreu argues that a sustainable design philosophy should be

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48 http://www.jeannouvel.com/en/projects/one-central-park/ (14 February 2019).

49 See, for instance, Pugin, A.W.N.: *Floriated ornament: a series of thirty-one designs*, London: H.G. Bohn 1849; Dresser, Christopher: *Art of decorative design*, London: Day & Son 1862.

50 Jodidio, Philip: »Nicholas Grimshaw: The Eden Project: St Austell«, in: Jodidio, Philip: *Green architecture*, Cologne: Taschen Biblioteca Universalis 2018. About the material see also Keeney: »Façades after the façade«, 1017.

51 Frank Lloyd Wright's Falling Water House could be considered as such an example. More recent examples include the Juvet Landscape Hotel in Norway from 2007–2009, and the Glass Wood House in New Canaan, Connecticut. Jodidio: *Green architecture,* 342–347; 398–401.

52 Paden: »Aesthetics and Sustainable Architecture«, 18–26.

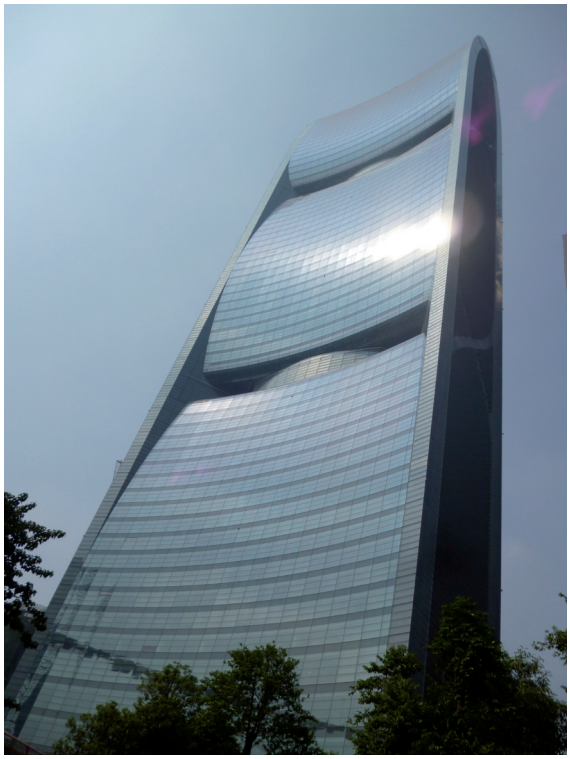

Fig. 5: Skidmore, Owings&Merill, Pearl Tower, Guangzhou, 15 Zhujiang W Road, façade, view from southeast

Fig. 6: Studio Gang, Acqua Tower, Chicago, IL, 225 N Columbus Drive, south and east façade, viewed from southeast, 2009

Fig. 7: Studio Gang, Acqua Tower, Chicago, IL, 225 N Columbus Drive, 2009. Balconies

Fig. 8: Jean Nouvel, One Central Park Building, Sydney, 28 Broadway, Chippendale, 2013. Hanging gardens, view from north

founded on what he refers to as a »dialectics between Nature and Culture« which should be expressed in a specifically organic repertoire of forms.[53]
The Nanyang Technological University School of Art, Design and Media in Singapore, designed by CPG Consultants, could be regarded as such a building as it is comprised of three interlocking curved wings covered with green roofs that integrate with the hilly and wooded surroundings. The wings of the building encircle a lower-lying inner courtyard with two ponds, trees and stairways that run between two of the wings and lead up to street level. The façades of the wings that face the courtyard are made of glass curtain walls allowing the space of the building to extend into the courtyard, which lies as a kind of micro environment protected by the wings of the buildings from the elements, although not isolated from the scenic architecture as a whole. Its openings allow the students, staff and visitors to move from the courtyard to the higher level of one of the green roofs on which a path in the form of a stairway lets the roof to function as an urban meadow.[54] (Fig. 10)
The buildings of the Chenshan Botanical Garden in Shanghai China are designed from the same principle of integrating buildings into the landscape. Here, one can also witness the repertoire of forms that is characteristic for many of the bio-mimetic designs.[55] (Fig. 11)
A sustainable and modest architecture does not necessarily mean a literal integration of the built environment with the natural surroundings. For architects Terunobi Fujimori and Keichi Kawakami it particularly revolves around the sustainable use or re-use of natural materials. The architects aim to take sustainability beyond the mere functional meaning and by using materials such as wood, stone, grass or sand want to promote sustainability with a unified architectural expression. The architects take into account the natural characteristics of the materials and try to exploit these characteristics in the design. The irregular surface of wood and stone therefore becomes part of the building's architectural expression. Their objective is furthermore to create a style not referring to national or historical styles but one which alludes to ecological concern as a universal given. They are therefore inspired by ancient cave dwellings such as Lascaux whose characteristics they are trying to emulate, for instance, in the Yakisugi house in Nagano City, Japan. The house looks from one side like a small church but on closer inspection it appears to unfold as a relatively long cave-like hall which recedes in height towards the rear. What appears as a tower is actually a small, square, free-hanging room topped with a gable roof that is connected to one corner of the structure and that rises significantly higher than the rest

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53 Abreu: *Sustainable Aesthetic in Architecture*, 355.

54 https://www.cpgcorp.com.sg/CPGC/Project/Project_Details?ProjectID=1022 [17 February 2019]. CPG consultants is a a subsidiary of CPG corporation.

55 These buildings are designed by Auer Weber, Munich, together with the Shanghai Institute of Architectural Design and Research, and Schlaich Bergermann + Partner, Beratende Ingenieure, Stuttgart. Jodidio, Philip: »Auer + Weber + Assozierte: Buildings in Chenshan Botanical Garden: Shanghai«, in: Jodidio, Philip: *Green architecture*, Cologne: Taschen Biblioteca Universalis 2018.

Fig. 9: Nicholas Grimshaw, The Eden Project, St. Austell, 1998-2005. View from southeast

Fig. 10: CPG Consultants, a subsidiary of CPG Corporation, The Nanyang Technological University School of Art, Design and Media, Singapore, 81 Nanyang Drive, view from east

of the structure. The façade of the house is made from an alternating arrangement of charcoaled cedar woods that increase the durability of the wood, and white strips of plaster, adding rhythm to the outer surface of the building. The surrounding garden is also designed as a kind of small landscape and contains several small hut-like structures.[56] (Fig. 13)

Discussion

The above examples make clear there are many innovative ways of producing architectural form with which new repertoires of forms are developed that could be considered to express an ecological concern and which could therefore be regarded as proof that there is indeed such a phenomenon as sustainable or environmental aesthetics. With the increase in technological possibilities, it is only to be expected that more and perhaps for us still inconceivable repertoires of forms will be designed by future architects, provided that we do indeed succeed in establishing a sustainable economy and allow future generations access to resources to fulfil their needs. In future, buildings might become expanded or merge with virtual spaces in ways that are currently still unimaginable. It may well be that humans will live in some kind of virtual Platonic caves. Perhaps the floating cities or extra-terrestrial colonies known from science fiction movies will one day be a reality.[57] But rather than speculating on the possible nature of future repertoires of forms, I want to finish this chapter with some thoughts on the sustainability of the aesthetic and ethical aspects underlying sustainable architecture. I think that the question is not only whether the moral imperative of sustainability *can* be the foundation for a design philosophy but also whether as a design philosophy it will be sustainable.

Let us therefore finally imagine a future in which every building - every man-made structure -is by definition sustainable. Sustainability as such will no longer be a distinctive feature but buildings and objects will still be admired or condemned in response to their formal properties. They will still be judged on the extent to which they are aesthetically pleasing whatever the design philosophy underlying their repertoire of forms. Considered from this perspective, Spector is right in arguing that sustainability is not a fundamental principle of architecture and is therefore also not an imperative for a new design philosophy. For the sake of form, architecture can do without sustainability.

In a future in which everything is sustainable, new design philosophies will still emerge and will be contemplated by the beholder. New technologies will also continue to emerge and will make possible what by then will be regarded as future repertoires of forms. Humans might still approach those new architectural forms from

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56 Feireiss, Kristin/Feireiss, Lukas: *Architecture of change 2: Sustainability and humanity in the built environment*, Berlin: Die Gestalten Verlag 2009, 100–105.

57 See, for instance: Callebaut, Vincent: »Lilypads«, in: Joachim Mitchell/Mike Silver (eds.), *XXL–XS: New directions in ecological design*, New York/ Barcelona: Actar Publishers 2016, 49.

Fig. 11: Auer Weber, Munich, with Shanghai Institute of Architectural Design and Research, Shanghai, and Schlaich Bergermann+Partner Beratende Ingenieure, Stuttgart, Shanghai Chenshan Botanical Garden

Fig. 12: Terunobi Fujimori and Keichi Kawakami, Yakisugi house, Nagano City, Nagano Prefecture, Japan.

a sustainable perspective; it is self-evident that in a future in which everything is sustainable, sustainability remains a functional imperative. However, if sustainability is no longer considered a distinctive feature of a building as opposed to non-sustainable buildings, simply because there will no longer be any non-sustainable buildings and buildings will be sustainable by definition, the need to express sustainability in visual form will either cease to exist or it will – in the form of a dominant repertoire of forms (bio-morphism may be a likely candidate) – dictate the visual appearance of any kind of built form. I would however like to advocate architectural variety and consider the possibility that sustainability should perhaps therefore be perceived as a temporal imperative, one that for the reasons sketched above will some day become obsolete.

Although I have discussed some enlightening examples of how sustainability can be expressed so as to evoke an aesthetic experience, it can still be maintained that there is no necessary relationship between sustainability as a functional property of a building (founded on the moral imperative to be sustainable) and a specific repertoire of forms, let alone aesthetic experience. It can be argued that it is preferable that a sustainable building should be aesthetically pleasing but it is not necessary for a building to be sustainable to be aesthetically pleasing as well or to be designed according to a specific repertoire of forms. A building which is not aesthetically pleasing can be sustainable, so one might wonder why we should then bother about a sustainable aesthetic in the first place. Perhaps because, as the examples discussed show, expressing sustainability through architectural form *can* contribute to increasing the awareness of the ecological crisis amongst the users of the building. The potential of what a building makes architecture is its ability to communicate or signify certain content. It does so through its form and, as Spector showed referring to Vitruvius, form *is* one of the foundations for a building to be architecture.

I therefore conclude by stating that a sustainable building should express its sustainability in form as well, at least in the times we are living in, because expressing sustainability in form is the appropriate and worthy thing to do for a building designed from the perspective of ecological concerns. In other words, from the perspective of the urgency of our environmental concerns this is simply a matter of ‘decorum’, especially in the light of those who will judge our merits from the functional, moral and aesthetic standards of a present yet to come.

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