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EXAMINING THE ECONOMIC, PSYCHOLOGICAL AND PHYSIOLOGICAL BENEFITS OF RETROFITTING HOLISTIC SUSTAINABLE AND BIOPHILIC DESIGN STRATEGIES, FOR THE INDOOR ENVIRONMENT

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INTRODUCTION

A recent report from the United Nations estimates that by 2030 more than 60% of the World's population of 8.5 billion will live in cities, and by 2050 it will rise to 70% and 9.7 billion[1]. The task of surviving this dystopic future appears almost insurmountable, as poor living conditions, airborne contamination and energy consumption, continue to rise and threaten civilisation. It therefore seems obvious, that in future our buildings must support our health and wellbeing.

The Biophilia hypothesis[2], proposes that humans share a deep-seated propensity to be surrounded by nature, and that exposure to the natural world is therefore important for human wellbeing. It is becoming increasingly clear that Biophilia has a real and measurable impact on human performance metrics such as productivity, emotional wellbeing, stress reduction, learning and healing according to Kellert et al[3].

Up to now there has been limited research that examines the benefits that the combined retrofitting of Biophilic design and sustainable nanotechnology could have, on enhancing the outcomes of commercial interior design practice. The need therefore, to understand more about the specific contribution of this holistic design strategy to the design process, is now paramount. Not only in terms of wellbeing but also in terms of sustainability, and a better understanding of what these combined strategies could provide, to optimise building performance.

Therefore, could the retrofitting of a combined, Biophilic design and sustainable nanotechnology strategy provide an effective solution to help built environment professionals combat some of these problems? This paper therefore questions whether it's possible to yield a greater understanding of the mechanisms and potential for retrofitting holistic Biophilic design and sustainable nanotechnology strategies, to provide the greatest benefits to building occupants.

Rationale

Biophilia and Nanotechnology are terms that are not normally associated with one another, or even used together to tackle the same problem. However, adopting different tactical combinations like this, to help address some of the major environmental issues of our age, will hopefully become the norm, as we progress through the 21st century. The paper focuses on some of the seminal issues surrounding population growth, pollution of cities and the ensuing housing problem. It forms part of a wider research interest of the author, in fostering collaboration between local industry and academe for real world sustainable applications.

The drivers for change

In 2013 the Department of Energy and Climate Change[4] stated that the UK had an increasingly serious housing problem, as we had some of the oldest and most energy inefficient housing in Europe. With over 50% of our 24.4m homes being built, even before a basic level of thermal insulation was introduced into the Building Regulations in 1965. In response, the UK building industry embarked on a retrofitting campaign, to help improve the energy efficiency of our ailing housing stock.
If we have already started a retrofitting campaign, then why do we need Biophilic Design Strategies as well?

> 'Each year in the UK, around 40,000 deaths are attributable to exposure to outdoor air pollution which plays a role in many of the major health challenges of our day. It has been linked to cancer, asthma, stroke and heart disease, diabetes, obesity, and changes linked to dementia. The health problems resulting from exposure to air pollution have a high cost to people who suffer from illness and premature death, to our health services and to business. In the UK, these costs add up to more than £20 billion every year'.
> The Royal College of Physicians, 2016.

Energy retrofitting is only one solution for a healthier future, as the Royal College of Physicians[5] (RCP) know only too well. They have recently appointed UK architects AHR[6] to design a new Biophilic HQ for them in Liverpool, to ensure that their staff are kept in the best possible health. This is to be a new build, not a retrofit of an existing building; but with architect Sir Denys Lasdun's 1964 current RCP HQ in London as the standard to follow, and now Grade 1 Listed, Liverpool and AHR have a big task on their hands.

What are Biophilic Cities?

Biophilic Cities[7] are biodiverse cities where residents always feel close to the natural world.
Our desire to be close to nature for our health and wellbeing is not an entirely new phenomenon. Biophilic Cities are reminiscent of William Hogarth's Pleasure Gardens[8] of London in the 17th to 18th Century, and echo Ebenezer Howards' Garden City Movement[9], first established in 1898.
Although for a while in the UK we seemed to forget our heritage when developing urban areas, but now Birmingham is the first city in the UK to have been awarded the Biophilic City status. Setting it alongside San Francisco, Singapore, and Oslo. It has more parks, than any other city in Europe, and the number is increasing. Birmingham City Council sees the value of open and green spaces as 'Natural Capital' and a positive way of bolstering its working population.

Singapore, which is often celebrated as one of the leading Biophilic Cities, and it has had a continuous biophilic retrofitting policy for creating a Garden City for over 50 years. More recently Singapore's policy has moved it more towards becoming a 'City in a Garden', with its Green Plan[10]. A recent example of their determination to achieve this is Supertree Grove 2012 in 'Gardens by the Bay', see Figure 1.

Figure 1. Supertree Grove, Gardens by the Bay, Singapore 2012

Complementary solutions

So, what are our other options for reducing the pressure on what Bauman[11] in 1999 called the 'unholy trinity, of uncertainty, insecurity and unsafety'?
One of the other options to complement Biophilia is nanotechnology, which is science, engineering and technology conducted at the nanoscale. If introducing Biophilia isn't feasible, then nanotech coatings could provide direct solutions to many urban, interior and architectural problems by simplifying quite complex engineering issues. Nanotech coatings have broad reaching compositions, with uses from keeping buildings clean on the outside/inside façade, to reductions in damp and condensation, energy efficiency and other properties that absorb air pollutants and expels them as clean air over a 12-hour period.

USA company Dry Wired's product LumActiv[12] is particularly successful at disabling pathogens in airborne pollutants; it can be sprayed onto the interior as well as the exterior of a building and is considered a sustainable alternative. Its' titanium dioxide component is triggered by light energy, and works towards decomposing organic compounds at a molecular level breaking down VOCs and NOx in the air see Figure 2. It can also be applied towards LEED and WELL credits for improving air quality.

As aforementioned, the problems of pollution however affect not only the exterior, but most importantly the interior as well; as we spend approximately two thirds of our lives inside buildings. Another way to control this in the future, can be measured by the impact that the materials and finishes specified by the designer, have on the Indoor Air Quality (IAQ)). Therefore, as well as nanotech coatings and Biophilia, if we use Winchip's[13] 2007 theory for guidance, by considering the Whole Life-Cycle (WLC) of the materials and products, we create a 'cradle to cradle' system that closes the loop. Ensuring that the materials used in the interior, can be recycled, reused or safely decompose in landfill, at the end of their usefulness. However, some of the smaller design practices may struggle to convince their clients of the economics of this method so, unless its statutory and regulated unfortunately it won't happen.

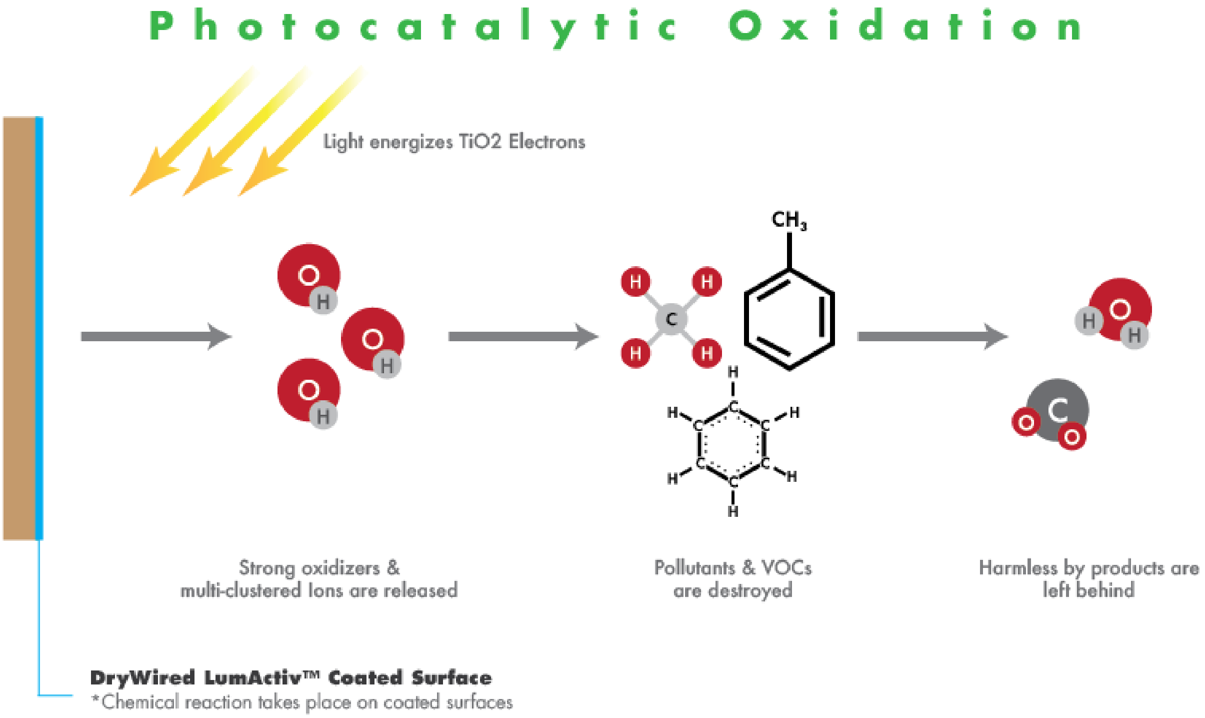

Figure 2. Chemical reaction diagram of nanotechnology coating LumActiv, by Dry Wired

OPPORTUNITIES

Therefore, apart from retrofitting existing building stock for improving energy efficiency, it seems obvious that we could easily consider nanotechnology and Biophilia as well, for improving the health and Well-Being of our citizens.
In Biophilia's case Kellert[14] *et al* in 2008 defined the three pillar concepts that serve as the tenets of Biophilic Design, as follows: 'nature in the space', 'natural analogs'; and the 'nature of the space'.

1) 'Nature in space' refers to the incorporation of plants, water (and animals) into the built environment to provide a direct connection to these elements;

2) 'Natural analogs' are described as one degree away from 'true' nature and refer to materials and patterns that evoke nature (e.g. representational art work, ornamentation, biomorphic forms natural materials); and

3) 'Nature of the space' is based on the idea that humankind developed in the Savannas of Africa, resulting in an unconscious infinity for similar environments (Kellert *et al.*, 2008).

Kellert and Calabrese[15] in 2015 also outlined 24 attributes of Biophilic Design, which pertain to the three experiences outlined above, see Table 1.

Table 1: Experiences and Attributes of Biophilic Design (after Kellert and Calabrese, 2015)

Pillars of Biophilic Design	Design Attributes
Direct Experience of Nature	Light
	Air
	Water
	Plants
	Animals
	Weather
	Natural landscapes and ecosystems
	Fire
Indirect experience of nature	Images of nature
	Natural materials
	Natural colours
	Simulating natural light and air
	Naturalistic shapes and forms
	Evoking nature
	Information richness
	Age, change and the patina of time
	Natural geometries
	Biomimicry
Experience of space and place	Prospect and refuge
	Organised complexity
	Integration of parts to wholes
	Transitional spaces
	Mobility and way finding
	Cultural and ecological attachment to place

Meanwhile, leading proponents of Biophilic Design, Terrapin Bright Green (environmental consultants), have identified 14 design elements or special patterns, which they clustered, in line with Kellert's three pillars, Browning[16] *et al.*, 2014. These are not new inventions, but rather codify the science behind why human's respond to certain traditional design elements, see Table 2.

Table 2: 14 patterns of Biophilic Design: improving health and wellbeing in the built environment, after Browning et al., 2014.

Pillars of Biophilic Design	Design Elements
Nature in the space (direct experiences of nature)	**Visual Connection with Nature.** A view to elements of nature, living systems and natural processes.
	Non-Visual Connection with Nature. Auditory, haptic, olfactory, or gustatory stimuli that engender a deliberate and positive reference to nature, living systems or natural processes.
	Non-Rhythmic Sensory Stimuli. Stochastic and ephemeral connections with nature that may be analysed statistically but may not be predicted precisely.
	Thermal & Airflow Variability. Subtle changes in air temperature, relative humidity, airflow across the skin, and surface temperatures that mimic natural environments.
	Presence of Water. A condition that enhances the experience of a place through seeing, hearing or touching water.
	Dynamic & Diffuse Light. Leverages varying intensities of light and shadow that change over time to create conditions that occur in nature.
	Connection with Natural Systems. Awareness of natural processes, especially seasonal and temporal changes characteristic of a healthy ecosystem
Natural Analogues (representations of nature)	**Biomorphic Forms & Patterns.** Symbolic references to contoured, patterned, textured or numerical arrangements that persist in nature.
	Material Connection with Nature. Materials and elements from nature that, through minimal processing, reflect the local ecology or geology and create a distinct sense of place.
	Complexity & Order. Rich sensory information that adheres to a spatial hierarchy similar to those encountered in nature.

Nature of the Space (preferred spatial experiences found in natural settings)	**Prospect.** An unimpeded view over a distance, for surveillance and planning.
	Refuge. A place for withdrawal from environmental conditions or the main flow of activity, in which the individual is protected from behind and overhead.
	Mystery. The promise of more information, achieved through partially obscured views or other sensory devices that entice the individual to travel deeper into the environment.
	Risk/Peril. An identifiable threat coupled with a reliable safeguard.

In addition, Browning[17] *et al.* in 2014 identify seven key Biophilic Design patterns:

1. **Visual Connection with Nature.** A view to elements of nature, living systems and natural processes.
2. **Non-Visual Connection with Nature.** Auditory, haptic, olfactory, or gustatory stimuli that engender a deliberate and positive reference to nature, living systems or natural processes.
3. **Non-Rhythmic Sensory Stimuli.** Stochastic and ephemeral connections with nature that may be analysed statistically but may not be predicted precisely.
4. **Thermal & Airflow Variability.** Subtle changes in air temperature, relative humidity, airflow across the skin, and surface temperatures that mimic natural environments.
5. **Presence of Water.** A condition that enhances the experience of a place through seeing, hearing or touching water.
6. **Dynamic & Diffuse Light.** Leverages varying intensities of light and shadow that change over time to create conditions that occur in nature.
7. **Connection with Natural Systems.** Awareness of natural processes, especially seasonal and temporal changes characteristic of a healthy ecosystem.

Many of these principles are all now being adopted by some of the world's leading corporations Apple, Google and Amazon in their workplaces. Hopefully the rest of the world will soon follow.

Ratings tools

How do we know that it's working? Rightly or wrongly ratings tools have the ability, to shift the 'conversation' in the building industry as proven by the introduction of LEED and BREEAM to support sustainable decision-making. There are therefore benefits of incorporating Biophilic Design into rating systems to measure performance.

Biophilic Design was incorporated into the Living Building Challenge[18] from the International Living Future Institute, in 2016, which is perhaps the most progressive Green Building rating tool on the market. To achieve 'living' certification, a building must meet the requirement for each of the 20 imperatives, including Biophilic Environments. Design teams must look at the six Biophilic elements as proposed by Kellert[19] *et al*. (2008), and demonstrate how they have been incorporated into the design.

The WELL[20] Building Standard is a new rating system. Launched in 2014 by the International WELL Building Institute (IWBI), focuses on human health and wellbeing in the built environment. It has two areas dedicated to Biophilic Design, one of which is compulsory and modelled on the Living Building Challenge Biophilic imperatives. **NB** architects AHR are aiming to achieve a Platinum grade with their designs for the RCPs new Liverpool HQ.

Biophilic building strategies therefore, should not just aim to minimise adverse environmental impacts, but also maximise end user 'satisfaction' through improved health and wellbeing, and provide a sense of connectedness with the natural environment. Whether it's a vertical garden for a corporate HQ, a single domestic wall planter, or even an illusion it's all beneficial, see Figure 3.

Figure 3. 'Biophilic Illusions' from Sky Factory, installed in Vendome hospital, France

The efficacy of combined strategies

While many of the leading examples of Green Building design incorporate aspects of Biophilic Design, many do not. This is something that should be remedied as the Green Building movement continues to evolve. Biophilic Design should be incorporated for two primary reasons:

1. It is becoming increasingly clear that Biophilic Design elements have real, measurable benefits relative to such human performance metrics as emotional wellbeing, stress reduction, learning and healing; and

2. From an environmental standpoint, Biophilic Design features foster an appreciation of nature, which in turn, should lead to behaviours that support Climate Change amelioration, as well as efforts to eliminate pollution and other environmental concerns.

As aforementioned research indicates, Kellert[21] et al in 2008, that Biophilic buildings can influence human health and wellbeing at three critically important scales:

1. Directly at the individual level through providing 'optimised' indoor environments.
2. Directly with also economic improvements in productivity and reductions in absenteeism.
3. Indirectly through reduction in energy use and the reduction in air pollutants.

Biophilic Design strategies provide flexible solutions to improving the built environment. 'It's a 'Non-formulaic approach' says Irish Landscape Architect, Joe Clancy, co-author of Terrapin Bright Greens' '14 Biophilic Patterns'. 'We ensure each building is treated as being unique. It's a transdisciplinary effort depending on what's required i.e. reductions in stress levels, views out, improved indoor air quality, all decisions are made to suit the site'.

Concluding thoughts

The arguments for finding solutions to halt our inexorable slide, back into the 'pea soup' foggy days of the 1950s, are very encouraging. Architects and interior designers will soon be able to further convince their clients of the salutogenic[22] benefits of Biophilia on the interior as well as exterior environments; as the Building Research Establishment (BRE) and the IWBI are gathering evidence based design data in test spaces for The Biophilic Office Project [23]. Which they have constructed at the BRE HQ in Hertfordshire, UK.
Furthermore, the two institutions have combined their Credit Rating systems, Building Research Establishments Environmental Assessment Method (BREEAM) and WELL respectively. The economic benefits are therefore there for all to see, and can be measured in the reductions in absenteeism, increases in productivity and the lessoning of the burden on the National Health System (NHS).
However, what they haven't considered yet is the efficacious role that nanotechnology coatings, might contribute to the exercise. Whilst these costs may initially be expensive, what price should be levied against our children's right to breathe clean air, in the long term future?

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enclosure, is far from a straightforward matter[4]. This was also critical in the context of this project due to the privileged relationship of the site with the upper outfield commons, as well as its status of unplanned public property. The competition provided the opportunity to determine degrees of access and enclosure, but also rights of way and spatial continuities. In tune with this, the submitted proposal attempted to provide a basis for the practice of what Harvey denominates *commoning*: the establishment of a collective social relationship with a specific aspect of the environment –urban public space and landscape in this particular case-. Critically, such relationship was intended to be non-commodified, and therefore not governed through the logics of market exchange[5].

The competition context

The Nordic Built Cities Challenge[6] aimed to foster the development of innovative solutions for liveable, smart and sustainable cities. Within this programme, an open competition was run in collaboration with the Runavík municipality, with the goal of designing a new residential area in its lower outfield. The new development would function as a new boundary area between the outfield and the settlement. A critical requirement was achieving a higher population density, hence addressing two recurring issues in the Faroe Islands: Limited available land and the effort needed to mould the steep, rocky terrain. The competition brief explicitly mandated to address the latter by proposing alternative approaches to the established mode of preparation of construction sites, which relies on making very substantial incisions in the basalt soil. Further requirements included developing a broader range of dwelling options and sizes, as well as proposing a more efficient use of space, which superseded the prevalent urban model of private plots with detached single-family houses.

Figure 1. View of Runavik from towards the competition site (top): A nuanced urban image for Runavik and its adjoining region

THE DESIGN PROPOSAL

The proposed image for the Runavík site was based on the notion of sitting on the landscape rather than obstructing it. An overarching goal was knitting the new urban fabric into the outfield land, as a continuation of its natural pattern. Such an image summarised our position with regards, not only to the site, but also to the urban landscape of the conurbation of which Runavík is the largest town. In that sense, the competition proposal was developed in a holistic manner, so that its impact was reflected at the scale of the individual, at the scale of the municipality, and at the scale of the broader context of the Faroe Islands. We understood these three domains as being overlapped and intertwined with one another, and therefore our design process endeavoured to address all of them simultaneously.
The design proposition was grounded on a dual geometrical and typological approach, based on the use of a strip form factor that would allow for minimal excavation on site. Dwelling units were divided into separate modules, aligned into strips and oriented to follow existing lines of maximum slope in the terrain. This dramatically minimised the amount of basalt soil excavation.

Designing a community development tool

This basic approach was developed further to design modalities of collective input into the proposal. In doing so, the proposal was conceptualised as a community development tool, grounded on a modular construction system with opportunities for interactive mass customisation –which was considered as a fundamental enabler of choice in the context of housing provision[7]-. Potential residents would be prompted to pick a plot and choose within a range of modular spaces. Modules would then be aligned into strips and oriented to follow existing lines of maximum slope in the terrain. Each functional module required only one single, reduced area of contact with the ground. Therefore, each housing unit would be adapted to the sectional profile of its particular plot. Further mass customisation opportunities would be enabled by providing a choice of material finishes (Figure 2).

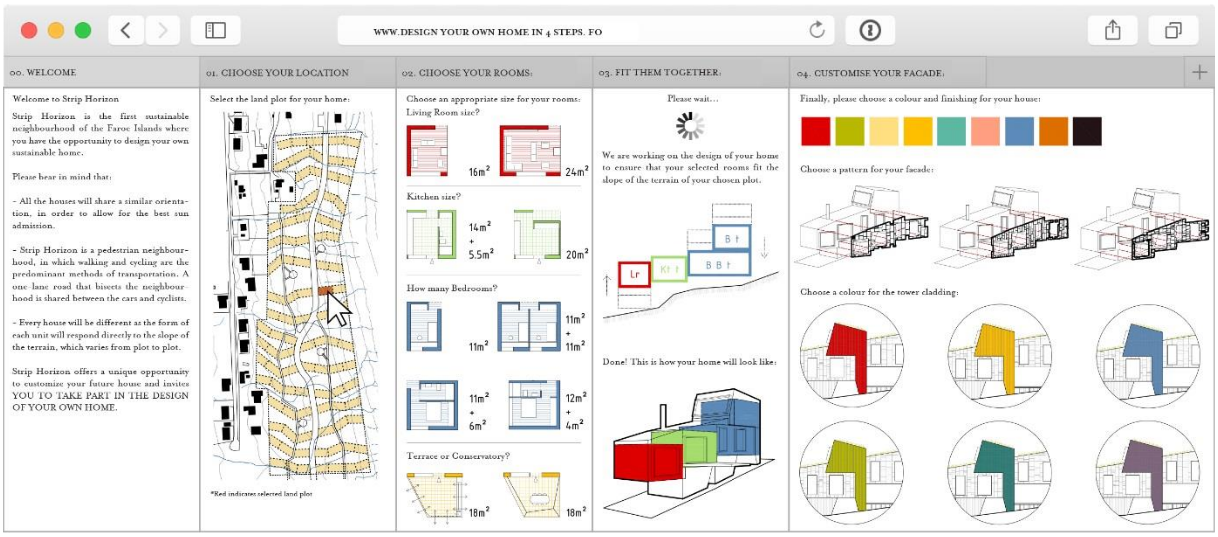

Figure 2. The proposal as a community development tool

With this in mind, nine base typologies were developed. However, a critical feature of the proposal was that variations of these typologies could yield a larger number of different dwellings. This provision of variety –facilitated by a collective platform for user choice- was considered critical in the development of the design proposal, insofar it was identified as an enabler of community identity[8]. Moreover, the establishment of an open design system via mass customisation attempted to address the contemporary criticism directed towards past excesses of mass production in the context of housing provision –particularly with regards to the use of prefabricated concrete structures-[9]. Individual houses were laid out together in lines of four to seven units, forming strips that follow lines of maximum slope in the site to facilitate minimal excavation, often running in parallel to existing water streams in order to minimise any disruptions to the natural profile of the terrain. The competition submission laid out a possible outcome for this system, considering how it could be deployed throughout the totality of the site by responding to conditions such as the local variations in slope or the location of the main road. This procedure enabled both diversity and individual customisation. Moreover, it helped construct a distinctive urban image, where strips provided a form of urbanity that combined continuity with porosity.

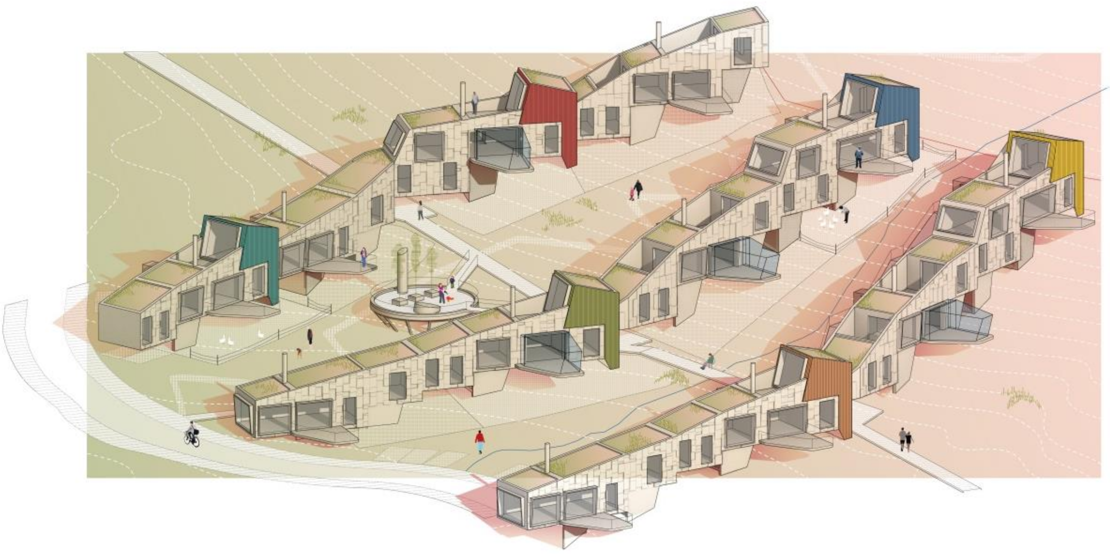

Figure 3. Adaptation to the natural profile of the terrain

The resulting urban image contrasted with the less structured landscape of detached houses and private plots that is prevalent in Runavík. This facilitated a gradation of public and private spaces while simultaneously fostering a sense of density, community and collective ownership. It should be noted that the proposal was strongly informed by Peter Marcuse's defence of non-commodified housing, particularly with regards to the development of housing initiatives with a prevalent public share[10]. In tune with this, our masterplan proposal attempted to maximise public land tenure. Marcuse's work explicitly acknowledged that people do not only occupy buildings, but also neighbourhoods and communities. All these locations constitute a web of relations within the social fabric, therefore linking housing to other public domains such as that of the urban commons[11].

Urban place making

The proposed Master Plan allowed for 95 dwellings of different sizes to be built on the site (see Figure 4). Compared to current averages, this layout provided a significant increase in built density. This was not only helpful from an environmental sustainability perspective, but also promoted interaction and encounters between people, hence facilitating increased social sustainability[12]. With regards to the latter, an explicit design goal was developing a walkable neighbourhood, where pedestrian priority would be encouraged[13]. Car access was intentionally minimized: One single-track road following the lines of minimum slope provided car access and parking places to the entire site, and connected to the existing road infrastructure. A number of linear pedestrian pathways defined fully accessible routes with minimum changes in slope to most houses. This additional network of stepped walkways provided quick connections to the main pedestrian flat paths. Such configuration promoted pedestrian priority within the whole neighbourhood while simultaneously minimising terrain excavation -as illustrated in Figure 4. Moreover, the network of shared pedestrian pathways facilitated casual encounters among neighbours, therefore fostering a sense of communality. This layout reflected an interest in developing yet another quality identified as an enabler of a sense of identity in urban housing: the permeability of public spaces –in the sense that they provide an abundance of potential linkages and thus facilitate public choice in terms of circulation-[14].

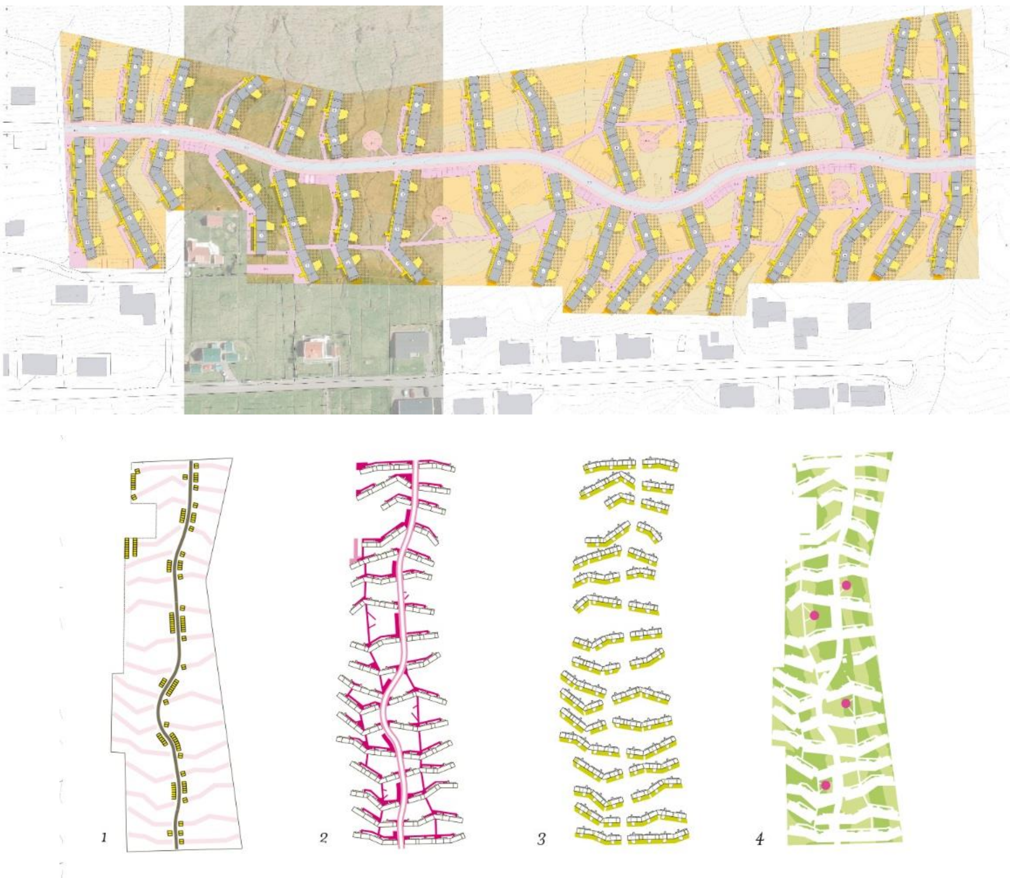

Figure 4. Masterplan configuration: Walkability and Commonality - 1. Main motor vehicle access road and parking spots; 2. Pedestrian access platforms; 3. Private plots and gardens; 4. Public space and common grounds

Individual access to each house was granted through its north facade, ensuring privacy in all the south aspects. Each dwelling included a private garden which ran alongside it south facade, providing access to tool and storage rooms at ground floor level. More importantly, each garden was open to the untouched landscape and water streams, which shaped the main public spaces of the submitted proposal. This general configuration attempted to facilitate Walkability and Commonality while also addressing some of the shortcomings identified in the design of modern social housing neighbourhoods, such as the excessive intricacy of layouts, the abrupt separation of vehicles and pedestrians –thus reducing visibility and therefore diminishing perceived safety-, the lack of allowances for public transportation links, and the failure to provide amenities within walking distance-[15].

The masterplan design maintained as much untouched landscape as possible while promoting uninterrupted connections between the municipality of Runavík and the open outfield uphill. In tune with the explicit ethos of fostering the public commons, unrestricted circulation through public grounds in the site was granted to the community of Runavik. Seizing this allowance of communal land, and tapping into the established link between the quantity and range of outdoor activities and the global quality of public space[16], a substantial provision of such activities was concentrated on the site. These included flat playgrounds -located on the sunnier central spots- and spaces allocated for collective gardening. Moreover, collective covered spaces –intended to perform as meeting places for nearby neighbours- were developed where pedestrian pathways crossed underneath housing strips, attempting to strike a design balance between facilitating access from individual units while avoiding being perceived as ‘divorced from the ground’[17]. The provision of opportunities for planned and unplanned encounters and social interaction was considered a key aspiration of the design. The encouragement of both walking and open space activity was instrumental to the development of a diverse, balanced community, with potential for mutual support, surveillance and learning from diverse people. It should be noted that the design of higher-density housing developments has often been criticised for including large amounts of communal -yet unformed- green space that lowers the overall density level below that of detached housing neighbourhoods[18]. In that sense, our design of open space attempted to find a balance between achieving a higher built density than the average in Runavík –thanks to the strip form factor- and providing a ratio of green space that is generous yet manageable while also facilitating various modes of ownership and appropriation.

Figure 5. Detail of housing strips, private plots and common grounds

Designing and building for environmental sustainability

As a fundamental environmental strategy, strips served as barriers from the prevailing northern winds[19], sheltering the southern facades of the dwellings. Furthermore, all 95 dwellings enjoyed a south-facing main aspect. Full direct sunlight penetration from south facade openings into all rooms was guaranteed, thanks to the narrow form factor of the strips. Finally, the general layout prevented strips from casting shadows over one another, even in the worst-case scenarios. The proposed strip layout provided permeable boundaries due to their low contact ratio with the terrain, avoiding disruptions to the development of local fauna and flora[20]. Voids underneath each house were envisioned as productive spaces that articulated an intermediate area between the inside and the outside. These voids could be used as sheltered play spaces, garden extensions, work spaces, connections with lower storage and tool rooms. Such configuration helped define the spatial domain of each dwelling without formally enclosing it or restricting access to and between common grounds. In doing so, the proposal attempted to find a suitable balance between collective and individual solicitations.

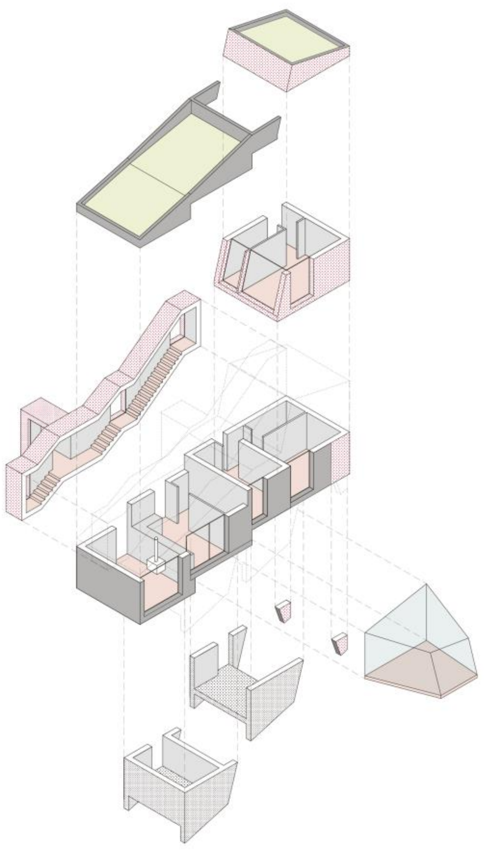

Figure 6. Assembly of modules

With regards to the development of the modular system, environmental sustainability was achieved by minimising its impact on the environment during its all life cycle. Therefore, we proposed using prefabricated timber room modules, dimensioned according to the restrictions of road transport, manufactured at local factories and assembled on site (see Figure 6). This contributed to minimise the impact of the construction works in the surrounding environment[21]. Due to the high load-bearing capabilities of the basalt bedrock and the need to keep excavations to a minimum, modules transmitted loads through direct supports into superficial foundations cast in situ. This simple system minimised not only terrain excavation, but also structural requirements.

The material palette used on the exterior of the houses fulfilled a dual function. On the one hand, it addressed the existing social and environmental landscape by using materials coming from (or produced at) the Faroe Islands. On the other hand, the material choice allowed for a high degree of customization in each house, therefore fostering a sense of individual identity within the broader community.

Further to this, global passive and active design strategies were implemented in order to minimise energy consumption. This was of particular importance, since the harsh climatic conditions of the Faroe Islands often pose energy demands that can hardly be met using renewable sources only. Therefore, design passive strategies were incorporated to make dwelling units self-sufficient in terms of both heating and electricity demands. These energy-saving measures were extracted from a number of studies carried out at those latitudes that demonstrated that it is possible to build typical single-family houses with a minimal energy consumption without problems concerning building technology or economy[22] and included extensive use of the southern orientation and its subsequent passive solar gains, a thermal bridge-free design using much higher levels of insulation and airtightness than normal to reduce heat loss, and green roofs[23]. Active Design strategies included fulfilling the energy needs of the new neighbourhood through a combination of geothermal heat and wind power via connection to the existing wind-powered grid, and developing an efficient system for both ventilation and heat energy recovery. Finally, modules were designed with disassembly and reutilisation at the end of their life cycle in mind[24].

THE AFFORDANCES AND LIMITATIONS OF SUSTAINABLE DESIGN ENDEAVOURS

Our competition proposal for Runavík provided a comprehensive set of rules that addressed Sustainability from Environmental, Economic and Social perspectives. Within this global set of aspirations, a number of sub-categories were identified: Green Design strategies, Walkability, Compactness, Connectivity, Resilience and Diversity. As shown in the Urban Strategies diagram (Figure 7), addressing each sub-category posed specific design goals and constrains.

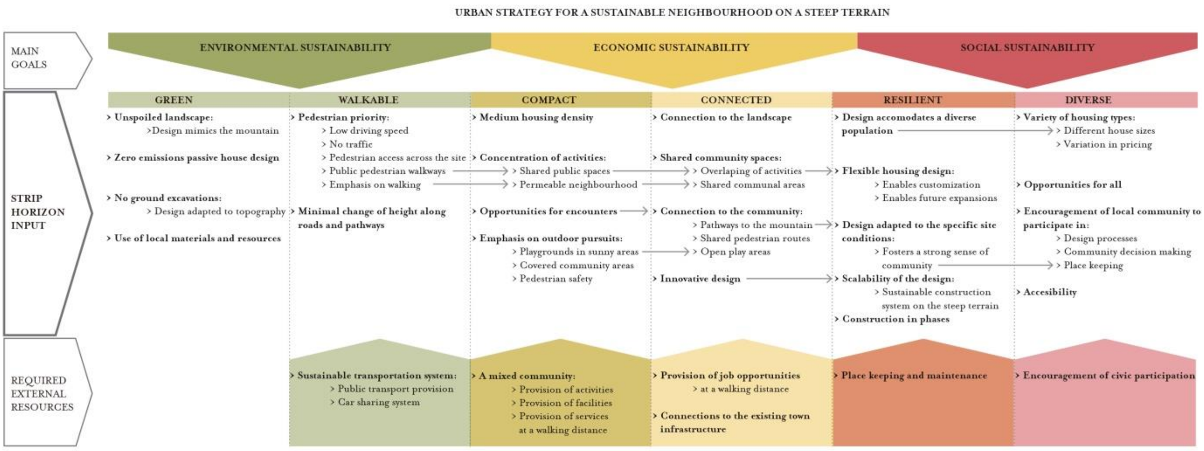

Figure 7. Urban Strategies diagram

In most cases, goals and constrains pertaining to one sub-category were also linked to other sub-categories. For example, and as shown in Figure 8, addressing Walkability through public pedestrian walkways also facilitated Compactness by creating shared public spaces were activities could be concentrated. This, in turn, leveraged Connectivity through the overlapping of those activities, ultimately leading to a flexible scheme where customisation and expansion were facilitated by the density and openness of the public space network. Such flexibility was also instrumental to the fulfilment of the Resilience goal. As this example illustrates, the submitted design proposal emerged out of a process of strategic negotiation, which attempted to articulate the most suitable balance between many different solicitations.

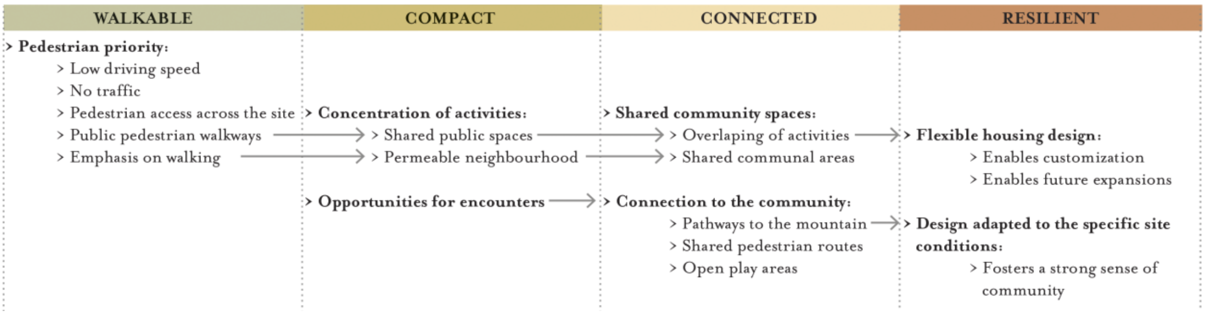

Figure 8. Detail of Urban Strategies Diagram, focusing on the design relationships between Walkability, Compactness, Connectedness and Resilience established by our proposal

In tune with the above goals and constrains, design development focused initially on the scale of the site and its immediate local context. However, and in keeping with the aspirations of comprehensiveness, innovation and exportability posed by the Nordic Built Cities Challenge, our proposal also attempted to identify a wider set of regional scale strategies that were of particular importance to its implementation. On the one hand, these strategies would allow for the new neighbourhood in Runavík to thrive and become a landmark of sustainable urbanisation at regional level. On the other hand, they would also allow us to successfully redeploy it as a repeatable urban scheme in other instances of steep terrain throughout the Faroe Islands.

In formulating these regional-scale strategies, some limitations of the competition brief and its overarching regulatory framework were highlighted: As shown in the bottom row of the Urban Strategies diagram (Figure 7) all strategies required external resources as a condition to facilitate the fulfilment of the environmental, economic and social sustainability goals. A critical example of this had to do with the enforcement of pedestrian priority criteria and the discouragement of car traffic to leverage Walkability. In order to fulfil this goal, additional public transport provision needs to be in place. Another example is that of the additional provision of public services like nurseries and primary schools, especially considering that young families are one of the most important target groups for the new housing development. The provision of such resources fell within the domain of municipal and regional bodies, requiring substantial mutual awareness and trans-scalar co-ordination among institutions. In practice, though, it has been noted that the relevant agents tend to lack an integrated approach, and may often enforce policies that actually 'pull in different directions'[25].

Our reflection –summarised in the Urban Strategies diagram (Figures 7 and 8)- suggested that such co-ordinated provision could not be developed on an ad hoc basis, but rather needed to be articulated as a comprehensive, trans-scalar policy. Whereas such policy should have the provision of alternative forms of housing at its core, it would also need to incorporate the regulatory and the infrastructural frameworks required to implement it within a more sustainable urban model. In doing so, the provision of housing would not become a burden for the existing urban setting, but rather constitute a transformative action towards a truly sustainable, context-sensitive built environment.

Further reflection on the regulatory framework surrounding the competition would lead us to interrogate its legal and economic development model, which was not fully defined at the time of the competition. In lieu of a specific development framework, the municipality of Runavík expected that private developers and the newly created Faroese Housing Association would be interested in undertaking all or part of the project. It must be noted that this was, historically, one of the very first attempts to build denser residential neighbourhoods using non-detached housing typologies in the Faroe Islands (one earlier, not very successful development had already been built in the fringes of Torshavn, the Faroese capital). As a result of this, the proposal submitted by our team was praised for its innovativeness, but also met with substantial reservations with regards to its marketability[26].

As a conclusion to this reflection, it could be argued that both the competition and the development of the four finalist proposals were a remarkably successful pilot initiative for sustainable design innovation. However, and considering the complexity of scalar, infrastructural and regulatory frameworks that is involved in the development of urban design processes[27], we should also acknowledge that, in spite of its transformative ambition and its aspirations of repeatability, this particular initiative operated within a comparatively restricted domain –more so considering that not all stakeholders had been identified at the time of launching the competition-. Because of this, further development of the project will necessarily have to take place on an ad hoc basis, therefore curtailing the potential of future schemes to articulate a truly sustainable urban model.

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[8] This is connected to the research on identity conducted by Watson and Bentley. See:

Georgia Butina. Watson and Ian. Bentley, *Identity by Design* (Elsevier, 2007). pp. 238-240

[9] Linsey Hanley, *Estates. An Intimate History* (London: Granta, 2007). pp. 105-106

[10] Peter Marcuse and David Madden, *In Defense of Housing* (London: Verso, 2016). pp 201-203

In Marcuse's case the strategies suggested to achieve this do not just focus on the modification of current financial and ownership regimes –which are beyond the already broadened scope of our proposed intervention- but also on the expansion of public housing initiatives. Whereas allocating quotas of public and private tenure was outside the framework of the competition, the planning stage was undertaken under public initiative, hence providing multiple opportunities for expanding the public commons.

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[15] Lisa McKenzie, *Getting By. Estates, Class and Culture in Austerity Britain* (Bristol: Policy Press, 2015). pp. 37-38

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[25] Barton. pp. 246-247

[26] A more conventional housing block proposal, developed by a large Danish office, ended up being chosen as the winning entry. Among other qualities, the winning proposal went through great effort to provide a reassuring typological image, which both developers and the public could recognise as a traditional block of flats distributed

around a central courtyard. This option was regarded by the jury as the most palatable from the point of view of both real estate development and public acceptance.

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