Beyond Sustainability: Architecture for the Future

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ABSTRACT

The future is hopeful, optimistic, courageous, and home to unbound possibilities. From this overly bright perspective, this paper describes the exploration of the uncertain future of sustainable architecture in the context of complex-adaptive systems. Applying the main currents of thought around foresight, systems-thinking and sustainability, the paper contemplates how futures-thinking might describe the future of sustainable architecture and recommends strategies and tactics. This design research highlights some critical uncertainties that could define the future of sustainable architecture. The paper explores these questions and describes *six Key Design Tensions* affecting the future of architecture. Afterwards, the paper offers innovation *Strategies to Navigate Sustainable Architecture*, these strategies fit well regardless of how the *Key Design Tensions* unfold.

KEY TERMS

Sustainable architecture, literacy, sustainability, complex architecture, systems-thinking, strategic foresight

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A number of other individuals and organisations contributed to my thinking around these interesting topics, including: **Carl Hastrich** (Designer, Biomimicry), **Suzanne Stein** (Associate Professor), **Jeremy Bowes** (Professor), **Peter Jones** (Associate Professor), **Autodesk,** the **Strategic Innovation Lab**, and the students of **Biomimicry 2 Applications**.

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[If we wish to innovate in ways which have positive impacts… we must have innovation with anticipation – a forward view. Innovation must be sensible, realistic, and positive in its engagement with sensitive, complex and adaptive life systems.] [[i]]

[i] Adapted from Fry T. *A New Design Philosophy: And Introduction to Defuturing*. New South Wales: UNSW Press, 1999

PART I: INTRODUCTION

Architecture's relationship with the surrounding context has always attracted the attention of designers as well as users of architecture. The need for attention to geography, sunlight, wind, temperature, climate, ecology, humidity and precipitation all inform the technical design of architecture. Perhaps the Inuit igloo is the most elegant example of extreme context considerate architecture with the technical conditions of each site regulating construction. Of course most modern architecture is highly concerned with the subtle values presented as well. A peruse of local developments[ii] shows a "glass vision in the sky" in downtown Toronto. From the seventieth floor, life "between the lake and the stars" feels "chic, timeless, sophisticated", albeit in defiance of the natural context. Here the seductive qualities interact with our sensibilities straddling identity and culture and the hierarchies in between. Not surprisingly, sensibilities supportive of consumptive architecture – enlarged living areas, oversized graded lots, car-oriented design, etc. – manifest intensively on energy, water, and land resources. Moreover, the user's sensory experience of modern architecture relies entirely on the assumption that sufficient resources can be imported to maintain a comfortable environment. Resource scarcity, environmental degradation,

[ii] Retrieved from: http://www.10yorkstreet.info/about/on December 28, 2012.

population growth, and climate change cast suspiciously over this assumption for obvious reasons.

Problematic System

From this vantage, architectural designers encounter, as Rittel and Webber describe, a *wicked problem* – an ill-defined, evolving, multi-factored situation [[1]] which Buchanan agrees concerns the *design* of complex systems or environments over a space [[iii]], demanding design for social and systems transformations [[2]]. The practices of architecture and urban design are well placed to think about and intervene in wicked or otherwise complex social system-level problems. Our design values of practicality, ingenuity, empathy and a concern for appropriateness [[3]] promote for pragmatic interventions, integrative or systems-thinking and an anticipatory view towards the future [[iv]].

[iii] Buchanan argues that the “fourth area” of design concerns “complex systems or environments for living, working, playing, and learning”. Here, this is taken to mean whole systems design over space and concerning social and systems transformation.

[iv] Frequently described as *design-thinking, systems-thinking* and *strategic foresight*. Here the terms are avoided in favour of presenting the *thinking* that each expresses rather than the *methodologies* that are often implied. After all, this research articulates thinking from all three.

The *problematic situation* [v], as Folke et al present, is that our "...anthropogenic disturbances on the biosphere are diminishing the resilience of earth's eco-systems and this may cause unfavourable regime shifts towards less productive conditions for [human]kind" [4]. While contemporary architecture is part of the problem, it holds remarkable promise. After all, architectural spaces account for a great deal of our anthropogenic impact on the landscape either through resource, energy or spatial consumption.

The field of architecture offers a rich discourse about how we might begin to address this complex situation. Sustainable, green, low-impact and intelligent architecture discussions differ but offer alternatives to anthropocentric views. Cole's recent reflections on how the built environment might enhance eco-systems resilience through *regenerative design* adds that architectural design has a role in "...supporting the co-evolution of natural systems in a partnered relationship..." where the outputs of architecture "...are collectively focused on enhancing life" [5].

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[v] I prefer to describe this as the 'architecture of the problem'; however, 'problematic situation' is common in this discourse and connotes systems-thinking. The idea of the architecture of the problem is not mine, I first heard Dan Hill of Sitra (the Finnish Innovation Fund) describe this at Aalto University in Helsinki.

This kind of *eco-centric* [[vi]] future destination for architecture, which emphasises a systems approach, is at odds with the present-day anthropocentric view. This does not surprise, but it heralds the need for further thinking about the *critical uncertainties* – those highly impactful but also highly uncertain conditions – impacting sustainable architecture now and how these could unfold in the future. These conditions could point to possibilities for further design research or identify the many places of intervention.

Within the OCAD University's Environmental Design Program, Associate Professor Bruce Hinds and then Assistant Professor Carl Hastrich led research into Intelligent Building Design. As a Graduate Research Assistant, I supported the "Phase 1: Research Audit" for the "Sensing for Building Performance" project [[vii]] by undertaking the initial literature scan of the emerging signals and trends around environmental performance in architecture and generally about building sustainability. This contextual research was then presented in January 2012 to Autodesk, the project sponsor. The research project sought to understand

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[vi] Eco-centric is how we summarise Cole's view in contrast to alternative paradigms. Others, use the term symbiotic. Eco-centric refers to architecture that is regenerative in achieving sustainability.

[vii] Following up on earlier studio-based design research at the *Ontario College of Art and Design University, Faculty of Design, Department of Environmental Design. Initial survey results provided by* Hinds, Bruce, Carl Hastrich and Jonathan Veale (January, 2012) in *Sensing for Building Performance*.

how sensory information might be used to improve environmental performance of buildings and apply these learnings towards biomimetic solutions in the built environment. This is indeed a broad space with critics arguing for and against contrasting paradigms extending from the common anthropocentric, a developers dream, to the emerging user-centric, a democratized view of built space. And, of course, Cole's eco-centric future where architectural interventions actually ameliorate the ecological challenges of our time.

Thesis Statement

This paper argues that the future of architectural innovation can be found in eco-centric design, characterised by ecological and social regenerative-sustainability, and that new methods of architectural creation and production are needed to advance sustainability.

Framing Questions

[1] How do recent discursive insights in systems-thinking around sustainability unfold in the context of architecture?

[2] How would architecture differ by shifting towards a complex-adaptive systems view?

[3] What tensions persist within the current discursive body?

[4] What strategies might designers consider to achieve greater sustainability?

[5] How might these strategies be implemented?

Purpose

The *purpose* of this paper is to outline the findings of this explorative design-research [[viii]], which are summarized with six *Key Design Tensions*. This paper supports that these Key Design Tensions and related definitions help to frame the discourse around the future of sustainable architectural performance in relation to the complex environment that buildings inhabit. Of course, this is merely a departure point for an examination of the possibilities for the outputs of architecture, as alluded, to spaces beyond our anthropocentric paradigm. With an anticipatory gaze towards the future, I hope this paper illuminates some strategic choices that architectural designers may think about now to design for the future we dream of.

Last, this approach towards anticipating the future or at least the challenges of the future has critical implications for architectural design

[viii] Ibid.

practice. New methods of creation and production will be needed if we are to begin to think about built design in complex-adaptive systems. For this, I will discuss *Strategies for Sustainable Architecture*.

Methodology

The *methodology* of this research was concerned with a literature review of the body of knowledge around sustainable architecture and building and environmental performance. The findings are articulated through the lenses of systems-thinking, design-thinking, and strategic foresight. For example, the literature scan was approached using horizon scanning techniques and systems mapping about the critical uncertainties that may shape the future. Also, the language and some of the tools of strategic foresight are used deliberately to describe the inherent design tensions of the present to inform the possibilities of the future.

Figure 1: Process

Above, Figure 1 describes the overall research process and the "rough" structure of the paper. The findings of this paper draw upon the work of Hinds, Hastrich, and my own research (2012) in “Sensing for Building Performance”. Where shared ownership of the intellectual property occurs, I have been explicit about it in this paper. For the purposes of this Graduate Major Research Project, Figures 1 and 2 delineate shared ownership from independent research with part of the collection phase (literature review) being drawn from the 2012 project and the remainder being new research.

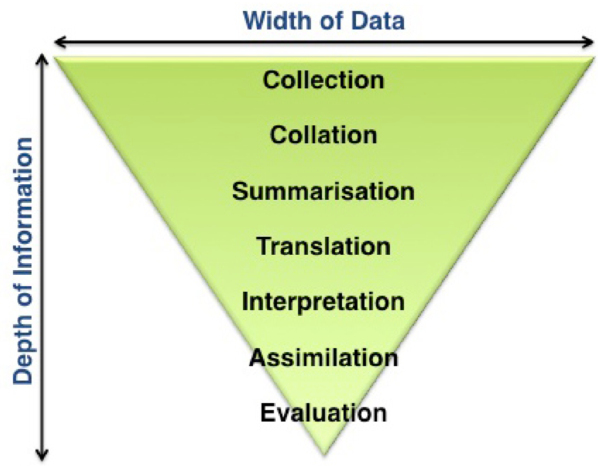

Figure 2: Strategic Information "Distillation"[ix]

While this paper relies on some of the same "collected" data, the independent research extends this with further collection (adding systems-thinking and foresight) and also "collates" (Literature Review Findings), "summarises" (Key Design Tensions), "translates" (new definitions) and "interprets" (Sustainable Architecture Challenges) this into novel and architecturally useful models. Some elements of "assimilation" and "evaluation" have been purposefully reduced in this paper. These steps require greater stakeholder research and participatory approaches that cannot be completed within the short (16 week) period of time provided for the MRP. For example, assimilating this information into a stakeholder's strategy and then making evaluated decisions about design would be

[ix] Adapted from text provided in Kuosa, Tuomo (2011). *Practising Strategic Foresight in Government*. The Cases of Finland, Singapore and the European Union. RSIS Monograph No. 19. S Rajaratnam School of International Studies.

impossible in the twelve-week project. This stated, the intention of this research is to provide an anticipatory view of architecture for community planners, designers, developers and investors. It still remains, that this paper describes a new approach to architecture that has not been interpreted until now and thus constitutes original research.

PART II: LITERATURE REVIEW FINDINGS

The "Sensing for Building Performance" research began with collection of the literature around sustainable architecture and eventually included a review of over 100 publications [[x]]. The literature scan collected the key definitions, stakeholders and main currents of thought found in this research. For that project, my involvement in that research ended at data collection. I have further extended this by way of review, collation and summarisation of these into themes, which are relevant to the question of sustainable architecture (i.e converting this into a literature review). This discussion provides the key concepts and definitions useful for the remainder of the paper.

1. Buildings are Ecosystems

The idea that buildings are part of human and non-human ecosystems remains an important discussion found in the literature about sustainable architecture. While this view does not surprise, the implications are remarkable as an eco-centric view – architecture founded in ecology – radically changes how we think about designing and building. The

[x] For further discussion see Hinds, Bruce, Carl Hastrich, Jonathan Veale, and Julie Forand (2012) *Sensing for Building Performance*. Ontario College of Art and Design University, Faculty of Design, Department of Environmental Design. A studio exploration of sustainable architecture. September, 2012.

important concepts of *ecosystems, resilience, and adaptive capacity* significantly inform the discussion about sustainability found later on in this paper.

In ecology, ***an ecosystem*** refers to the system of dynamic interactions between plants, animals and microorganisms and their environment, including the abiotic elements (architecture), which work together as a functional and interconnected system of feedbacks (complex system) [6]. Ecosystems remain in a balanced, sometimes precarious, state of equilibrium, until the complex system of feedbacks is disturbed and the ecosystem changes states to a different level of productivity. This phenomenon is known as succession. Many factors impact ecosystem succession, but the system of feedbacks, if sufficient perturbations remain, is a determinant factor.

The capacity of an ecosystem to respond to perturbation or disturbance by resisting damage and recovering quickly is referred to as **resilience** [7]. Human influences that adversely affect ecosystem resilience such as a reduction in bio- or genetic diversity, natural resource consumption, pollution, land-use, and anthropogenic climate change are causal in promoting regime shifts in ecosystems, often to less productive and degraded conditions [8]. As the earth's systems face further anthropocentric-induced disturbances, architectural resilience will be influential in resisting damage and recovering quickly to change. Anthropocentric architecture contributes to ecosystem decline through natural resource consumption, land-use, materials waste and energy-related emissions.

Adaptive Capacity is the capacity of a system to adapt to a changing environment [9]. Adaptive capacity differs from resilience, where resilience is the ability to withstand disturbances. The term differs in usage between ecological systems and human social systems. In ecosystems, genetic diversity, biodiversity, and landscape and regional diversity is determinant [10]. While in human social systems, adaptive capacity is determined by the ability of institutions and networks to learn and store knowledge, creative flexibility in decision-making and problem solving, and the responsiveness of power structures to consider the needs of stakeholders [11]. Here, this paper extends stakeholders to the 'non-human' to include flora and fauna found in the air, water, and on land. Adaptive capacity remains an important determinant in shaping the future of sustainable architecture.

2. Sustainability must be Restorative

Sustainable development is most commonly referred to by the Bruntland Commission definition, as "…development that meets the needs of the present without compromising the ability of future generations to meet their own needs." [12]. Others have expanded this to include the three pillars of sustainability, where the economy, society, and the environment coexist in a balanced arrangement. For the purposes of this paper, these types of early definitions will be referred to as the **balanced-sustainability** approach. These definitions differ in that they do not acknowledge the complex and dynamic nature of living systems and the symbiotic and regenerative relationship between human society and the social-ecological systems within which it is embedded [13].

Regenerative-sustainability definitions extend into systems thinking where sustainability is the characteristic state of a socio-technical system based upon resilience and adaptive capacity and a co-evolutionary partnership between humans and the natural environment of which they form part that is aimed at regeneration of socio-ecological systems. [14]. The definitions differ by their view of the role humans play in their environment, with the later definition advocating for socio-ecological restoration rather than the earlier definition of 'do less harm'. In this paper, eco-centric is the term often interchanged with regenerative-sustainability to describe architecture that actual restores socio-ecological systems. Again, as a social, economic, cultural and built innovation with considerable ecosystems interactions, architectural form greatly influences sustainability.

In approaching regenerative sustainability, **regenerative design** is needed [15]. Regenerative design relates to approaches that support the co-evolution of human and natural systems in a *partnered* relationship. It is not the building that is 'regenerated' in the same sense as the self-healing and self-organizing attributes of a living system, but by the ways that the act of building can be a catalyst for positive change within the unique 'place' in which it is situated [16]. Within regenerative [design], built projects, stakeholder processes and inhabitation are collectively focused on enhancing life in all its manifestations, human, other species, ecological systems, through an enduring responsibility of stewardship [17]. Regenerative design is associated with whole systems approaches and improving environmental performance through improved adaptive capacity and resilience.

3. "Intelligent" Architecture deals with Control

Intelligent Architecture refers to the automation of technical systems within the built environment usually with the use of computers and sensors. Intelligent buildings are invested with technologies and *control* strategies designed to perform tasks more reliably and effectively than people and free occupants from these tasks enabling them to pursue other activities [18]. Intelligence based technologies rely on predictable and repeatable understanding found in computer models. Intelligent buildings have been evidenced to improve efficiency of resources and improve environmental performance. Emerging theory suggests that intelligent buildings are responsive to the comfort and well being of the user and designers should consider the social-technical systems that predate intelligent building control strategies. [[19]]. Naturally, as humans we are all too aware of the low level of control that we sway over ecosystems. The promise of intelligence afforded to sustainability needs to be considered in light of our low level of control within complex systems.

4. The Case for Eco-centric Architecture can be found in Natural Models

In thinking about the future of sustainable architecture vis-à-vis ecological models this paper draws on concepts from biology and biomimicry. This differs from the platitude discussions on ecosystems (point 1) and sustainability (point 2) as biology deals specifically with organisms and their habitat. This is later related to humans and our habitat (architecture and other built space). The important concepts of *biomimicry, ecosystem engineer, niche construction, additive construction, homeostasis,* and *agents of adaption* significantly inform the discussion about sustainable architecture found later on in this paper.

Biomimicry concerns the examination of natural, organic and evolved, models and approaches to design. Biomimicry seeks to mimic natural systems, models, and elements towards inspiring solutions to human problems. [20]. Biomimicry is relevant to an examination of sustainable architecture as natural models could inspire an integrated design perspective.

Ecosystem engineers are organisms that directly or indirectly modulate the availability of resources to other species, by causing physical state changes in biotic or aviotic materials. In so doing they modify, maintain, and create habitats [21]. Two kinds of ecosystems engineers are described in the literature. **Autogenic engineers** change the environment using their own structures, for example by using their living and dead tissues. **Allogenic engineers** change the environment by transforming living or non-living materials from one physical state to another by mechanical means or otherwise [22]. Spiders might be observed as autogenic engineers with the construction of their webs using their own tissues. Humans are allogenic engineers with our use of mechanical tools to construct the built environment. Organisms regularly modify local resource distributions, influencing both their ecosystems and the evolution of traits whose fitness depends on such alterable sources of natural selection in environments, this process is referred to as **niche construction** [23]. Niche construction is the process whereby organisms modify selective environments, thereby affecting evolution [24]. As allogenic ecosystem engineers, humans engage in niche construction activities, which have both the effect of directing our evolution of traits and also reorganisation of our ecosystems thus causing significant disturbance. This is relevant to the field of sustainable architecture as innovation should be considerate of the biological processes impacting our interactions with built space.

The property of a closed or open system that regulates its internal environment and tends to maintain a stable, constant condition of properties like temperature is referred to as **homeostasis**. Homeostasis "…is a process that counteracts out-of-balance fluxes of energy and matter so that a variety or conditions can be maintained" [25]. In buildings, mechanical assistance counteracts out of balance fluxes to achieve maximum comfort [26]. Homeostatic system parameters can be maintained as conformers or regulators. **Regulators** seek to maintain the subject parameter at a constant level or within a range (i.e. mammal body temperature) while **conformers** allow the environment to determine the parameters (i.e. reptilian body temperature). The term originates in 18th century systems ecology, and biology and now includes building science. Interestingly, in some systems, such as termite mounds, homeostasis is maintained through the use of two concepts. First, mounds are constructed using **Additive Construction**, which is incremental or modular construction of the structure. This additive method of construction minimizes the materials required, limits the energy consumed in construction, and enables the structure to be modified easily [[27]]. Second, ventilation and temperature are maintained as **Agents of Adaption** (i.e. delegated termites) modifies the configuration of the additive structure towards a homeostatic state and in response to environmental cues [[28]]

Summary

In reviewing the literature, these four themes directly inform the future of sustainable architecture:

- Buildings are ecosystems
- Sustainability must be restorative
- Intelligent architecture deals with control; and,
- The case for sustainable architecture can be found in natural models.

As ecosystems engineers, through niche construction we have the ability to radically alter the ecosystems that we inhabit towards more or less productive states. Modern city building, neighbourhood and site development exemplify architecture that manifests intensely on energy, resource and spatial consumption. Our sustainable engineering choices, or lack thereof, are prescribed by our paradigm towards sustainability. Contemporary practice suggests an anthropocentric view and thus the current state of ecosystem decline. The idea of balanced-sustainability suggests a user-centric or less impact view. Meanwhile the idea of regenerative sustainability – one that promotes systems resilience and adaptive capacity – reflects an eco-centric view.

PART III: THINKING ABOUT ARCHITECTURE AS COMPLEX

Defining Complexity in Architecture

Until this point, I have defined how the literature views complex systems and introduced Cole's idea that architecture's legacy could be regenerative. *Architecture* is the practice of and the physical expressions of the built environment that are situated in the landscape and network to varying degrees on social, economic and eco-systems. At a basic level, whether from insects, predators, heat, cold, rain, or enemy forces, architecture provides humans with protection from disturbances in these systems. Naturally, we are also drawn towards architecture for the aesthetic qualities, again, the relationship between the user and the expressed values. In these ways, architecture creates a good deal of economic and social value. Cole's vision, and the idea of sustainable architecture, extends this into ecological value. From this view, we observe a system of interactions centred on our design choices.

We live in an interconnected world where material design choices in one part may have ruinous implications for others elsewhere. To illustrate, Canada's export of white asbestos to the developing world stands out as an example. The mining of the crystalline material creates important jobs and a linked ecological and public health legacy in Quebec. The material is then exported to India where unprotected workers – the dust form should not be inhaled due to known carcinogens – install the material as insulation in buildings. Here a complex system of politics, culture, and economics reinforces a problematic situation. At what point shall we intervene? Stopping the extraction would cause disastrous unemployment in parts of Quebec and serious political perils, not to mention that Indian importers could just purchase from Russia instead. Perhaps we might improve the literacy of Indian labours so that they might demand improved working conditions. This might improve the health of the workers and perhaps another form of insulation, say wood fibre, from Indonesia might be selected. Indonesian wood fibre may be a better choice for Indian workers but it might reinforce deforestation and illegal logging in Indonesia.

What we see here is obvious, but in practice we do not often think about the complex systems peripheral to our design choices. In the reductionist tradition, we refer to these as ‘out of scope’ factors, which are interesting but difficult to isolate and understand so we decide not to consider these – these are for others to think about. In fact, we live in a world of systems and systems within systems. We must be holistic and consider the wider ecosystem or face productivity limiting perils for humankind. These systems are *complex* because we cannot predict how the aggregate of individual choices [29] will affect the social, technological, economic, ecological, and political conditions of this system [30]. Moreover, complex systems must be considered in light of the dynamic interdependencies within the environment and across various scales [[31]]. The system of building construction in India is *adaptive* [[32]] because it may change states and become more or less productive depending on the system of energy, matter, and information between the system and the environment [[33]]. As we see, changing a condition of the system may produce unintended consequences.

Modern architecture remains removed from but not entirely disconnected from eco-systems. Certainly, most urban buildings still rely on energy, resources and information produced elsewhere, but far from a partnership, this estranged relationship remains one sided. Simply put, sustainable architecture seeks to address this conflict by improving environmental performance.

As architects and community designers we regularly interact with complex-adaptive systems. In fact, the primary *places of intervention* for architecture entirely deal with systems. Architecture (a built system) is a design intervention to protect communities of people (social) from the harsh environment (ecological). Alternatively, we could think about architecture in place-making (cultural), public safety, social mixing, accessibility, public health (social), or economic development. For the purpose of this paper I will concentrate our thinking about how built form and function can contribute to improved environmental performance. In fact, we will extend our thinking as to view sustainable architecture as adding to the resilience and adaptive capacity of the eco-systems that life depends upon.

Systems-thinking: A Paradigm Shift

Systems-thinking encompasses the mindset and tools needed to make sense of complex future-oriented problems. This represents a paradigmatic move away from reductionism – the idea that objects, phenomena, explanations, and theories can be reduced to their individual parts to understand the wider system.

Systems-thinking relies on two fundamental observations about complex systems:

- Complex systems cannot be observed in their entirety; and,
- Complex systems cannot be completely understood.

Systems-thinking contrasts by offering a holistic paradigm for viewing complexity using cognitive tools supportive of sensemaking, including, systems-mapping, mental models, systems dynamics, iterative process of inquiry and other intuitive approaches. Systems-thinking helps designers find the places of intervention in *wicked problems*. “Wicked Problems are ill-defined, evolving, multi-factored situations" [34] possessing at least ten (10) identified properties [35], eight (8) presented by Jones, among them:

1. There is **no definite formulation** of a wicked problem;
2. Wicked problems have **no stopping rules**;
3. Solutions are not true or false but **good or bad**;
4. There is **no ultimate or immediate test of a solution** to a wicked problem;
5. Every attempt to solve counts;
6. Wicked problems **do not have an enumerable set of potential solutions**;
7. Every wicked problem is **essentially unique**; and,
8. Every wicked problem can be considered a **symptom of another wicked problem**.

PART IV: KEY DESIGN TENSIONS

The research involved extending the literature review using systems-thinking to identify critical uncertainties. These differ from the main currents of thought or concepts identified during the literature review. The term ‘tension’ is deliberately used as it describes uncertain but equally plausible directionality. Critical uncertainties are tension-filled, highly impactful and highly uncertain conditions, which, depending on their outcome, may define the future of sustainable architecture. This research extends the thinking of the initial project into original research by collating and summarizing the information collected in Phase 1 “Sensing for Building Performance” using systems-thinking and elements of strategic foresight.

The Key Design Tensions have been organised from most to least critically uncertain conditions (See Critical Uncertainties chart below).

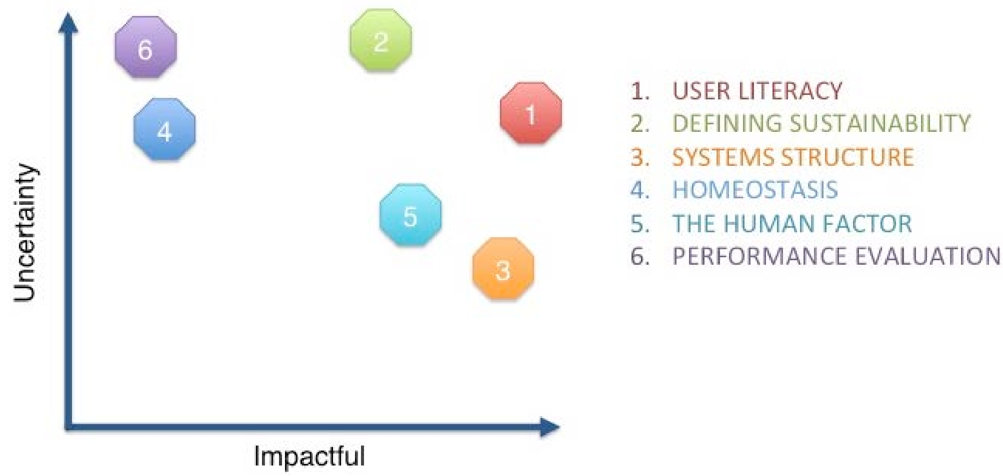

Figure 3: Critical Uncertainties (Key Design Tensions)

Below, a title and framing question are provided for each. Combinations of these tensions might be used to describe future design practice possibilities [xi]. More importantly, as designers, through practice, we have the ability to influence these critical uncertainties towards the emergence of desirable futures [36].

The literature review uncovered a discourse around sustainable buildings that remains a tension filled space. Tensions persist around literacy, sustainability, biomimetic architecture and environmental performance. Figure 2 and the associated text describes how these tensions were prioritised. As identified by system-mapping of the main currents of thought uncovered during the literature review, these six Key Design

[xi] We are referring to scenarios; however, scenarios as narratives were not part of this research.

Tensions articulate the challenges for the future of sustainable architecture:

1. User Literacy.

What is the degree of user literacy about energy and environmental choices within buildings?

> The degree that users can understand and act upon energy and environmental information will define their participation and motivate sustainable choices. Literacy *is* a state where occupants confidently engage in the architectural landscape and participate consciously and deliberately as informed actors. Literacy is demonstrated when occupants have a high degree of knowledge about the elements, flows and stakeholders involved in the built system and the implications of energy, resource, and spatial choices. Literacy is defined by our relationship with data and information and our response to it. The *objective* of user literacy in buildings is to inform individual and collective decision-making about environmental choices. This has implications for improved

energy efficiency and conservation, productivity and environmental performance.

The level of literacy will make sustainable and systems considerate choices less impactful and infrequent. Social engagement, democratisation, conceptualisation and educational tools about energy and environmental systems will be highly impactful towards achieving improved literacy. Moreover, sustainable architecture of the future could integrate energy and environmental literacy into the design and operation of buildings.

2. Defining Sustainability.

How is sustainability defined vis-à-vis building performance?

Sustainable architecture is a promising practice that might be articulated by the axiom ‘do less harm’. Here we refer to the idea that architecture should reduce ecological impacts by considerate built form. The intensity of energy and water use of the building is reduced and, ideally, consideration for building materials that are renewable and non-toxic is made. The energy and water properties of the site are maximized to reduce imports. Energy and environmental sensory information that the building collects is intended for its own purposes and often remains centrally regulated. This characterises the most recent iteration of sustainable architecture where we view the building as an artefact of efficiency, analogous with social cooperation with nature. The term *cooperation* is used to describe the negotiation between nature and the built environment where architecture reconciles environmental impacts. The relationship is not partnered. Perhaps this might be considered as a starting point for an alternative paradigm where buildings are seen as part of the eco-system, not just the landscape.

In this future world, performance information, energy, and resources would be exchanged with the eco-system with a view to contribute to or restore the adjacent environment. The built form is constructed with a long-view in mind – not only would the materials be renewable but the waste flows would sustain other life processes, including the production and dissemination of energy, resources and information. The social analogy here is *collaboration* – collaboration portrays partnership, joint-organisation, self-governance and complexity not seen in current architectural models. Partnership involves the free exchange of information and given that nature's complexity is derived from distributed sensors this has implications for how architectural systems may be organised.

3. Systems Structure

How do systems structures exchange energy, resources, and information with the environment?

How systems organise and exchange energy, resources, and information with the environment will shape the sustainability of buildings. Options for highly centralised control of exchange remain more common in contemporary architecture; however, very little energy, resources and information is exchanged. **Centralised**: It is possible to conceive of highly centralised and high transaction architectural systems. Recent innovations in computing and networking make it possible for centralised information to be exchanged with the external environment (e.g. coloured-diode sensors embedded in surfaces indicating temperature, pressure and weather changes). At present, energy and resources are lost to but not deliberately exchanged with eco-systems. **Distributed**: biological sensors, such as those discussed in biomimicry, are generally distributed, responsive to environmental cues, and operate in partnership with the ecosystem. If the objective is to develop architecture that functions in partnership with nature, then distributed models are appealing because they interface with nature at the same scope and scale.

4. Homeostasis.

How are the levels of homeostasis achieved within the built environment?

Homeostasis is not a term commonly associated with architecture but rather with eco-systems and biology. Homeostasis "…is a process that counteracts out-of-balance fluxes of energy and matter so that a variety of conditions can be maintained…" [[37]]. In contemporary buildings, mechanical HVAC assistance counteracts out-of-balance fluxes to achieve a regulated and comfortable environment for the occupants. The tension here relates to the extent that the building should conform to the environmental context or regulate to occupant needs. Contemporary architecture is highly regulated; meanwhile, a high degree of conforming could result in improved environmental performance at the expense of occupant comfort. Navigating this tension will prove to be very challenging.

5. The Human Factor.

How is the user's relationship defined as part of building performance? What is the level of control made available to the user and its relationship to building performance?

The human factors affecting buildings relate directly to the discussion on occupant literacy. What are the consequences for providing users with a high degree of control when most users have a low level of literacy about the implications of choices? Moreover, even if users know the implication of choices, most building information is not collected or available to the user. From an occupant-centric perspective, providing users with a high degree of control is important to comfort, yet from an eco-centric view this remains at odds with improving environmental performance.

6. Performance Evaluation.

How is building performance evaluated?

In the reductionist tradition, building performance is measured in terms of resource and energy efficiency. Higher rated buildings rely on technology to reduce the intensity of resource and energy use per unit of floor space. The building's relationship with the external context is concerned with reducing the building footprint and perhaps the building materials used. A variety of methods are used but the post-occupancy evaluation (POE) – a "survey of the occupant's satisfaction of comfort and workplace experience including the acquisition of utility data and physical measurements" [[38]] is the most common method of feedback on performance. The POE captures a moment in the life of the building. In this conventional approach to the efficiency and effectiveness of buildings, occupants are seen to be "passive recipients of indoor conditions that are maintained within narrowly defined margins by automated, centralized systems" [[39]].

Alternatively, from a systems-thinking view, buildings are concerned with the complex and dynamic nature of living systems and the symbiotic and regenerative relationships [[40]] that interact with the built environment. Evaluating performance here concerns the efficiency and effectiveness that building systems collect, collate, interpret, translate and diffuse environmental information, energy and resources among the "building, occupant, and context" [[41]]. Idealized building systems could support life processes with the wasted energy and resources that are produced, while relying on the immediate context to sustain the needs of users.

PART V: STRATEGIES FOR SUSTAINABLE ARCHITECTURE

Given the Key Design Tensions the following strategies were generated, optimised, and then clustered into these five strategies. These categories overlap greatly but are intended to offer discrete approaches to improving the problematic nature of contemporary architecture towards greater sustainability. At the end of this section, Figure 3 shows a wind-tunnelling of the proposed strategies within the Key Design Tensions. The figure describes each strategy's effectiveness given the tensions. For this reason, all five strategies are intended to ameliorate the problematic nature of sustainable architecture. These strategies were developed to be considerate of the tensions regardless of the direction that each unfolds.

<u>Strategy 1</u>: Sustainable Energy Design of Architecture

Energy is the ability to perform work – to heat space, to construct, to provide services, and to create light – it enables a high quality and highly comfortable environment for the occupant. The use of non-renewable energy sources contributes to atmospheric pollutions, climate change, and extractive development on the land. Meanwhile, renewables appear to be a better option; however, excessive use of active renewables can manipulate energy in the biome and change the landscape (hydro reservoirs, wind and solar occupy more space). Also, energy is not something that we can see, we can certainly sense energy as radiation but only a small portion of the energy spectrum is observable without technology.

1. Use of local and renewable materials make it possible for architects to understand the implications of design choices on social, economic and eco-systems.
2. Fulfill onsite energy demands with on or near site energy sources. Both passive and active energy sources should be used. This restricts the envelope of the building to locations where energy resources are sufficient.
3. Surplus energy should be exchanged with ecosystems for resources or services rather than lost to the atmosphere. For example surplus wastewater heat may be used for onsite food or air needs.
4. Intensified use of space. Onsite energy consumption should compliment onsite social and ecosystems.

<u>Possible Tactics may include</u>: encourage low impact development practices (LID) on vulnerable sites, community planning should consider energy planning in land development, encourage site-based energy generation (given the context) to off set or eliminate imported demand for energy.

<u>Strategy 2:</u> Design for Occupant Literacy

Information about energy and resource consumption and supply could factor heavily on decision-making within architecture. Unfortunately, users have both a low level of awareness about this and access to reliable information is scarce within architecture. These factors both influence occupant literacy. Given that occupant literacy has been identified as powerful force affecting the sustainability of buildings, architecture should enhance literacy.

1. Architecture must address literacy by conveying actionable information about energy, resources and the external context to occupants.
2. Information visualization and sensory cues about architecture should be embedded in the building and within surfaces so that users are more aware of energy and resources flows and real-time scarcity.
3. Identify and exchange actionable information about energy and resource flows with ecological and social systems.
4. Information transmission between the building, occupant and external context should be enabled.

<u>Possible Tactics may include</u>: encourage sensory (distributed and centralised) monitoring of institutional and residential buildings, publish

sensory results in ‘real-time’ or next to real-time for occupants, and support biomimetic-building research.

<u>Strategy 3:</u> Sustainable Physical Design of Architecture

The physical design of architecture has a major impact on spatial, energy, and resource consumption. Immense opportunities for both efficiency and effectiveness of energy and resource use is possible. We need should imagine architecture as a force upon the landscape. As we construct buildings we are laying the seeds of future communities and ought to be thinking about ecosystems succession, adaptive capacity and resilience in architecture. The future of sustainable architecture will likely include both highly durable buildings and easily constructible, perhaps modular, smaller buildings in temporary or non-permanent locations.

1. Build durable, high quality and variable scale architecture that may be adapted to different uses in mature and culturally important spaces.
2. Place modular and adaptive, easily constructible and, perhaps, recyclable architecture, in temporary or non-permanent spaces and as infill.
3. Architecture can be built to create habitat for other species in addition to human uses.

4. Further research around compostable or biodegradable architecture is needed. This is an interesting eco-centric opportunity for architecture to support ecosystem succession.

Possible tactics may include: design buildings for a variety of future uses including requiring mixed-use and densification ‘adaptability’ in building requirements, allow temporary structures (with life spans less than 5 years) in unstable neighbourhoods, including decommissioning mechanisms for government or communities.

Strategy 4: Design for Social and Systems Transformations[xii]

Leadership is needed to advance architectural social and systems transformations towards greater sustainability. This is not to say that leadership does not exist, it merely means that further leadership is needed. Leadership about how we design and build should address the new forms of social organisation that are needed. Examples of new social organisation might include: social enterprises, new forms of residential cooperatives or neighbourhood cooperatives. This poses critical implications for design practice and methods creation and production.

[xii] I first learned of this phrase from Jones, Peter (2011). *Methods Problematique: How do we locate the epicenter of global crises?* Systems-thinking lecture at OCAD University. March, 2011. Slide 4 of 26.

1. Work in interdisciplinary and integrated collaborative teams applying systems-thinking for innovation.
2. Define the architecture of the problem or the problematic systems requiring intervention and identify and act upon the many places of intervention.
3. Define and address leadership in the context of shifting social values and as new social relations emerge.
4. Apply participatory action research for social change in changing stakeholder behavior towards sustainability.
5. Foster and maintain resilient multi-stakeholder engagement networks to improve literacy, foster sustainable choices, and to collect important information useful to the design process.

Possible Tactics may include: establishing participatory forums for strategic engagement on sustainable buildings, do not view ‘design’ as primarily an expertise-based profession, and training designers in participatory and action research methods.

Strategy 5: Planning and Designing for Complex-Systems

The field of systems-thinking offers architectural design the opportunity to enable social and systemic change in the field of sustainable architecture. Given the complex environment that buildings inhabit, the field needs new tools for sustaining adaptive capacity both in ecosystems and social systems. Moreover, while the idea of resilience is new to the field, methods of stakeholder engagement are not. There is space for multi-stakeholder engagement around resilience to enable sustainable actions within existing and new architecture.

1. Architecture must be restorative towards sustainability and ameliorate degraded, damaged, or dysfunctional systems at the many places of intervention.
2. Anticipate the future. Interdisciplinary teams must think about architecture as a platform for the future and design for:
    a. Adaptive capacity
    b. Resilience;
    c. Succession;
    d. Reduced ecological brittleness; and,
    e. Built form integrated with the landscape.
3. We must consider the long-view. Designing for life cycles of 20 or 50 years is far too short for eco-system succession and social gentrification [[xiii]] in residential architecture. In some cases, durability and architectural longevity is needed. While

[xiii] Interestingly, eco-systems succession bears a resemblance to social gentrification. Each successive stage involves a greater system of energy and resources.

in other circumstances, recyclable or temporary structures are required.

4. Think about architecture as a techno-ecological system

Possible Tactics may include: use of durable building materials, training architects in the basics of ecology and biology, train designers in strategic foresight and systems-design methods and practice.

Wind-tunnelling

Each of these strategies interacts with the Key Design Tensions with varying degrees of effectiveness. Figure 4 describes how each strategy might meaningful interact with each tension. Figure 4 displays the results of applying the logic of each strategy with the logic of the respective Key Design Tension. Given the logic of both, the effectiveness of each strategy was rated from ineffective to effective.

The wind-tunnelling highlights some interesting insights. First, the Sustainable Energy strategy is targeted directly at improving the sustainability of architecture, with some implications for occupant literacy and how we might evaluate performance. And second, Designing for Social and Systems Transformations is highly effective at addressing most (4 of 5) of the Key Design Tensions. Strategy 2 appears to be least effective in ameliorating architectural sustainability. Of course this is all theoretical evaluation that helps us understand; however, valuable outcomes are achieved during implementation.

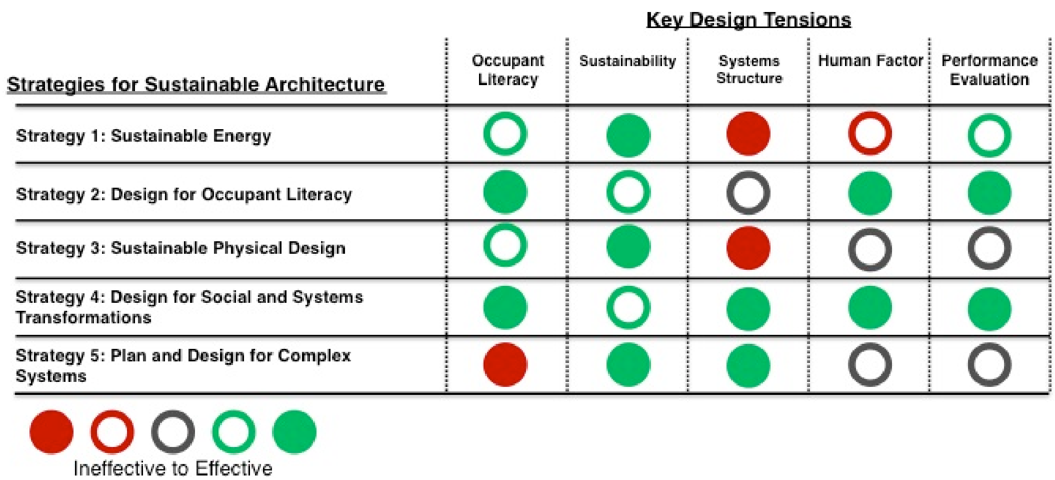

Figure 4: Strategic Wind-tunnelling

Implementation Plan

For the purposes of the MRP, this research seeks to highlight the actionable nature of *Strategy 2: Design for Occupant Literacy*. This strategy was selected because the desired outcome is the least tangible and thereby appears less actionable. Perhaps this is because literacy is difficult to measure and invisible to the senses. Occupant literacy relates to the relationship between the occupant and the building and this is the space where sustainability may affect change. The following is an exploration of implementation – if occupant literacy is about our relationship with actionable or useful information as defined here, then **Step 1** is to identify the dynamic flows of information found in buildings.

What prospective information is being emitted? Where is prospective information being released? Consideration for energy and environmental information flows and the form and structure of information should be made. **Step 2**, information useful to influence sustainability should be collected. Naturally, sensory technology and data storage will be needed to convert energy and environmental information into understandable formats. These technologies should be distributed, embedded in the architecture and powered using renewable or recycled energy sources. **Step 3**, concerns technological augmentation that will be needed to communicate actionable information to occupants, but not the actual conveyance of information. Technology should summarise useful information such that a relationship with users might be enabled. This technology should function as both receptor and transmitter such that a cooperative relationship may emerge between the technology and the occupant. **Step 4** concerns the actual conveyance of information to and from the occupant. The challenge here is to convey actionable information via various sensory mediums – auditory, visual, olfactory, tactical, social, etc. Occupants of architecture often encounter sensory impoverished spaces that do not convey useful information. Meanwhile, our information-saturated society lacks useful and actionable (summarized) information. **Step 5** involves the monitoring, evaluation and adaptation needed to develop a complex-adaptive system that positively influences occupant literacy towards greater and greater sustainability. Prototypes will need to be developed, tested and adapted to assure the objectives of the Occupant Literacy Strategy (e.g visualisations in surfaces, auditory cues for changes in environmental conditions, open information portals etc.).

Implementation Steps:

- Step 1 – Identify Dynamic Information Flows
- Step 2 – Collect Information to Influence Sustainability
- Step 3 – Augment Architecture with Technology
- Step 4 – Convey Actionable Information to Occupant Senses
- Step 5 – Monitor, Evaluate and Adapt as Needed

CONCLUSION

The challenges of the future for sustainable architecture rest with how designers navigate the multiple interfaces between nature, occupants and built form. If we can find joint-solutions, those that benefit both social systems and eco-systems, then we can improve the sustainability of architecture towards regenerative-sustainability. Restorative sustainability is needed to address the problematic nature of contemporary architecture. At least six critical uncertainties concern the future design of sustainable architecture:

1. **User Literacy.** *What is the degree of user literacy about energy and environmental choices within buildings?*
2. **Defining Sustainability.** *How is sustainability defined vis-à-vis building performance?*
3. **Systems Structure.** *How do systems structures exchange energy, resources, and information with the environment?*
4. **Homeostasis.** *How are the levels of homeostasis achieved within the built environment?*
5. **The Human Factor**. *How is the user's relationship defined as part of building performance? What is the level of control made available to the user and its relationship to building performance?*
6. **Performance Evaluation.** *How is building performance evaluated?*

As designers, through practice, we have the ability to influence these critical uncertainties towards the emergence of a more sustainable future. We should be thinking about interventions that improve occupant literacy, encourage regenerative forms of sustainability, and identify opportunities for energy, resources and information exchange among the building, user, and context. This paper describes five possible innovation strategies to achieve the aim of sustainable architecture. These strategies speak to the many places of intervention discussed above and the complex adaptive nature of architecture. By thinking about sustainability and architecture in this way, we can offer a hopeful vision of the future.

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