DISSERTATION

EXPLORING THE *LENSES*© FRAMEWORK: REGENERATIVE DESIGN FOR THE BUILT ENVIRONMENT

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ABSTRACT

EXPLORING THE *LENSES*© FRAMEWORK: REGENERATIVE DESIGN FOR THE BUILT ENVIRONMENT

The Living Environment Natural, Social, and Economic Systems (LENSES©) Framework is a process-based decision support tool promoting regenerative built environment design, surpassing current sustainability tools. Regenerative design is important because it restores ecosystems to pre-built environment levels. A constant comparative analysis reduced obscurity for regenerative criteria on eleven content specific Flow--Land Use, Transportation, Money, Energy, Water, Materials, Education, Ecosystems, Well-Being, Culture, and Beauty--producing more concrete realities. A 2013 pilot study better informed the method of inquiry and coding scheme, after it was found that criteria were too broad, and findings could not be replicated using three-step coding without first delineating criteria into subjective or prescriptive topics. In this analysis, the first coding step delineated criteria into major topics, which were then refined into respective industry roles and tangible, usable design realities.

Findings yielded two types of realities, subjective (i.e., Education, Money, Well-Being, Culture, and Beauty) and prescriptive (i.e., Land Use, Transportation, Energy, Water, Materials, and Ecosystems). Lessening obscurity of criteria reduced the need for facilitators to implement and use the tool, permitting stakeholders to self-guide regenerative design. Limitations of realities prevented the presentation of precision standards. Parameters for subjective realities should be established, as should standards for prescriptive realities. Designs can be regenerative

following yielded realities presuming local building codes allow them and stakeholders desire to do so.

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CHAPTER ONE: INTRODUCTION

The planet Earth functions using inherent genetic programming. This naturally evolved programming drives the systematic chemical and physical processes that carry out and synchronize functionalities like axis and orbit, seasonal microclimates, and macroclimate changes (Craft et al., 2018; Freidman, 2007; Gao, Xuegong, & Yinghua, 2013; Gregorieva & De Freitas, 2013). Changes to any one function can alter interdependent functions in unknown ways. Like the human body, the planet has inherent limitations. A healthy planetary life consists of maintaining the appropriate balances among its inherent limitations and the environmental vulnerabilities imposed onto it. Where vulnerabilities exceed natural defenses, secondary functionalities are sacrificed.

Excessive or indifferent exploitations of planetary ecosystems for purposes of human consumption (e.g., mining; fossil fuel extraction and refinement) have affected the planet's inherent functionality and altered its intended outcomes. These exploitations have influenced secondary and unintended processes. In turn, the planet has witnessed variability in climate, temperature, precipitation, and in other unpredicted anomalies (Delju, Ceylan, Piguet, & Rebetez, 2012; Lacombe, Smakhtin, & Hoanh, 2012; Schmidt, 2010).

One example of unintended effects on one ecosystem due to its interdependency on another ecosystem is shown through mining. Subsurface material extraction, such as for coal, deposits onto the Earth's surface unearthed byproducts (i.e., mine tailings), which are then exposed to natural precipitation. Tailings saturated by rain biologically disintegrate and are broken down, and leach byproducts into and across surface topography (*BacTech*, n.d.). Human need for fossil fuel produces immediate primary and secondary environmental effects. Mining for coal and precious metals and drilling for fossil fuels has transformed the planet's natural ecosystems and their inherent programming into environmental vulnerabilities. As a result, the natural balance is altered and unsustainable environmental functionalities become manifest (Delju et al., 2012; Schmidt, 2010). For example, once coal has been excavated, its previously encapsulated surface tailings are no longer contained within their host's anatomy (i.e., rock strata below ground). Tailings affect surface and subsurface interdependency because they are no longer located where they once originated.

The natural world is not constant or stable, irrespective of human beings. Whether or not a function was intended to be chaotic or harmonious, the planet existed in a manner and as a cohesive entity in and of itself, prior to the arrival of humans. If an overgrown forest burned, it would soon give way to new growth. During an ice age, some species would become extinct giving rise to new ones. The planet was resilient and able to regulate its own interdependency for ensuring survival as its own entity and under its own evolutionary control. Then came humankind, a new evolution of species.

Gao et al. (2013) and Lacombe et al. (2012) found that to satisfy needs, human civilizations altered primary ecosystems without fully understanding their interdependencies and subsequent effects. Humankind's alteration of the planet's natural life cycle is a primary assumption guiding this research. Understanding how and to what degree civilizations have negatively, altered inherent programming is key to regenerative relationships with humankind and its built environments (Butera, 2010; Mang & Reed, 2015; Younger, Morrow, Vindigni & Danneberg, 2008).

Every human process has the potential to influence the natural world and how it interacts with itself. Human civilization is the critical variable connecting artificial built environments and the planet Earth. Human consumption determines the type and level of secondary impacts to natural interdependencies and holds the key to extending or prematurely ending the planet's life cycle (Younger et al., 2008).

Setting, Background, and Overview

Humankind is one of several species in a larger system alongside plants, rocks, and soils (Sayer & Campbell, 2004). Humans have long been the technologically dominant species on Earth (Mang & Reed, 2015; Thomson & Newman, 2017; Younger et al., 2008). During their quest for survival (e.g., agriculture & shelter), human civilizations have exponentially increased, migrated and emigrated at rates not known in the natural world, and exerted noticeable influence over otherwise geologically and geographically isolated ecosystems (Butera, 2010; Sayer & Campbell, 2004; Thomson & Newman, 2017).

Global scientists and policy makers continue to debate how and where human civilizations have impacted planetary health. Human civilizations will continue to rely on the natural world and its resources to supply food, water, and shelter in the future (Gao et al., 2013; Lacombe et al., 2012; Younger et al., 2008). Methods to attain subsistence food, water, and shelter create unknown challenges and potential effects to natural ecosystems. While these may not always be negative, a better regenerative balance among humankind and the natural world is needed to restore their relationships and ensure a future together.

Humankind is one species that shares limited space and finite resources (Friedman, 2007). Land and water, animal species, vegetation, and other non-carbon objects reside in sustained natural areas, regulating their respective populations according to the availability of local resources (Butera, 2010; Thomson & Newman, 2017). Conversely, human societies do not necessarily restrict their population numbers, population expansions, and/or consumptions based solely on the local ecosystem (Butera, 2010; Friedman, 2007). Historically, humans have exploited distant and previously untouched ecosystems to attain elements for extracting, manufacturing, and otherwise meeting their comfort and amenity needs and in the process have permanently altered them (Sayer & Campbell, 2004). At times, the exploitation of distant ecological systems surpasses the basic requirements for subsistence food, water, and shelter (Butera, 2010; Preservation Green Lab, 2008). The most extensive impacts to secondary ecosystems are seen through the creation of artificial shelters for human habitation, in the refinements of products and amenities to place within these shelters, and in the production of infrastructure and fuels to operate and maintain these shelters (Preservation Green Lab, 2008; Sayer & Campbell, 2004).

Throughout history, humans have designed and constructed artificial shelters using domestic and imported materials from local or imported social (i.e., cultural), economic (i.e., trade), and environmental (i.e., location) sources (Keeler & Burke, 2009). Examples are seen in the eighteenth century stone houses of Scandinavia, mud huts of precolonial America, and the pre-Christian pyramids of Egypt (Butera, 2010; Keeler & Burke, 2009). While some civilizations used simpler or localized methods of design, they were consistent in their need to provide shelter for human comfort and the storage of food. Earlier structures altered the ecosystems where they were located, but likely did not create a separate ecological interdependency half a world away (Preservation Green Lab, 2008).

A precolonial mud hut in North America was less impactful on subsidiary ecosystems than was an Egyptian pyramid in the African desert. This is evidenced by the continued presence of pyramidal ruins and the absence of precolonial mud huts, the mud huts were made of local materials and labor, and have decomposed back into the ecosystem. The Egyptian pyramids are made of rock not sand and continue to bear a presence today. Regardless, construction of either disrupted their native ecosystems with artificially built environments, and to some degree disrupted secondary processes dependent on the primary ecosystem (Sayer & Campbell, 2004; Younger et al., 2008).

It is not clear to what degree current built environment design realities have contributed to planetary destabilizations. However, humankind, through its built environments, has contributed to alternating the planet's inherent functions (Swiatek; 2017). This has produced immeasurable and sometimes unknown outcomes (Beatrice & Mang, 2017; Craft, Ding, Prasad, Partridge, & Else, 2018; Gao et al., 2013; Gregorieva & De Freitas, 2013; Lacombe et al., 2012).

Built environments serve a human need for shelter. The artificiality of a built environment determines the impacts it has on the ecosystem where it resides. Ancient Scandinavian structures were assembled using rocks, fallen logs and tree boughs, and native grasses harvested within the local geographic area. While Scandinavians likely designed this way because materials were readily available, doing so lowered environmental impacts to interdependent ecosystems by not having to transport remote products and materials (Keeler & Burke, 2009; Swiatek, 2017).

Removal of timber from one ecosystem in South America, then milling that timber using fossil fuel energy extracted from a second ecosystem in the Arctic Ocean, for use in constructing walls for a built environment designed in a third ecosystem in the United States exponentially quantifies detriments across all three ecosystems and their dependent ecosystems. Instead of capitalizing on localized resources for all portions of a built environment, technological innovations have allowed the design of built environments to occur using world markets (Butera; 2010). This is most evident in affluent regions like the United States and Europe.

The last century (1900s) in the United States has significantly redefined the relationship that human civilization has with its local ecology and that local ecology has with global climatology. Population growth and the requirements with which to sustain such have increased the demand for a continuous and increasing supply of resources, energy, food, land, and housing (Butera, 2010; McLamb, 2011; Sayer & Campbell, 2004). The industrial revolution and urbanization movements of the early nineteenth century left permanent environmental scars illustrating the scale and magnitude of unsustainable growth, which was accomplished through the destruction of local ecosystems.

During this period, resources were haphazardly extracted and refined using the most convenient methods available, leaving behind water, soil, air, noise, and light pollution (Younger et al., 2008). Although current built environments are less degenerative than traditional ones (i.e., with the advent of building codes), ecological damages remain steadfast from historical denigrations and the lack of regenerative design in previous built environments and infrastructures. The artificiality of hydroelectric dams removed entire mountainsides and affected natural watersheds. Waterway bridges displaced ocean floor habitats through placement of underwater piers (Freidman, 2007; Preservation Green Lab, 2008). To address the unsustainable nature and challenges of built environments both past and present, the design industry developed sustainable accountability tools.

By 2014, several environmentally enriched design tools had emerged. These included the United States Green Building Council's Leadership in Energy and Environmental Design (LEED) and the International Living Future Institute's Living Building Challenge Standard (LBCS) (International Living Future Institute, n.d.; Leadership in Energy and Environmental Design, n.d.; United States Green Building Council, n.d.). Formal sustainability accounting tools like LEED and LBCS provided guidance for the sustainable design of built environments, high performance attributes and construction methods usable in several applications from urban multitenant development to research laboratory construction (Butera, 2010; Keeler & Burke, 2009; McGown, 2011; Preservation Green Lab, 2008). Sustainability accounting tools were effective for early adopters and promoters of advancing technology and construction methods. Design innovations were diffused into built environments using high performance lighting and water attributes meant to be ecologically friendly and cost efficient (Boubekri & Boyer, 1992; Kua & Lee, 2002; Moffatt & Kohler, 2008).

According to McGown (2011), the LEED model decreased the “artificiality” of built environments in the natural world by decreasing resource intensive attributes and implementing efficient operations and maintenance processes (i.e., reductions in carbon footprints) (United States Green Building Council, n.d.). Designing a built environment under the guidance of a sustainability accounting tool was considered by the industry to be efficient over traditional methods, because doing so was an improvement over the previous method. Realistically, designing a built environment to be sustainable meant decreasing harm over time (Butera, 2010; Essa & Fortune, 2008; Hardie & Newell, 2011).

Current sustainability accounting tools are progressive in assessing overall design sustainability, but several challenges remain. One such challenge is to think regeneratively, by replacing materials and resources used for creating built environments and using the built environment to do so in lieu of merely sustaining the rate in which finite materials resources are depleted or destroyed.

Topic, Objectives, and Purpose

The topic of this study is regenerative design for built environments. This study examines the regenerative design capacity of built environments using LENSES©. LENSES© was created to surpass sustainable accounting tools and responded to an industry call for regenerative design decision support (Institute for the Built Environment, n.d.; see Figure 1). A comprehensive review of current sustainability accounting tools was performed in Chapter Two. This review illustrated gaps among current sustainability accounting tools and the need to restore natural environments and introduced the regenerative design concept for built environments.

LENSES© is a regenerative design framework for built environments designed to be implemented in modern societies. The framework consists of three smaller, content-oriented lenses, which are circular in logic and visually promote the interconnectedness among philosophical, theoretical, and technical aspects of a built environment's function.

The Foundations Lens is the outermost lens and used for guiding project stakeholders in understanding the overarching social, environmental, and economic principles of regeneration. The Flows Lens provides a conceptual understanding of regenerative abilities using processes and design implementations. Working together with the Flows lens, the Vitality Lens is a measurement lens that defines a level of desired achievement for the Flows concepts, (Center for Living Environments, n.d.; Institute for the Built Environment, n.d.). LENSES© is structured to be used for any type of project, whether it be new building design, construction or renovation, a parking garage, or a natural area.

The main objective of this study is to refine the current regenerative criteria for eleven Flows concepts comprising the LENSES© Framework, into tangible design realities usable by industry stakeholders. For example, LEED requires that a project team design a built

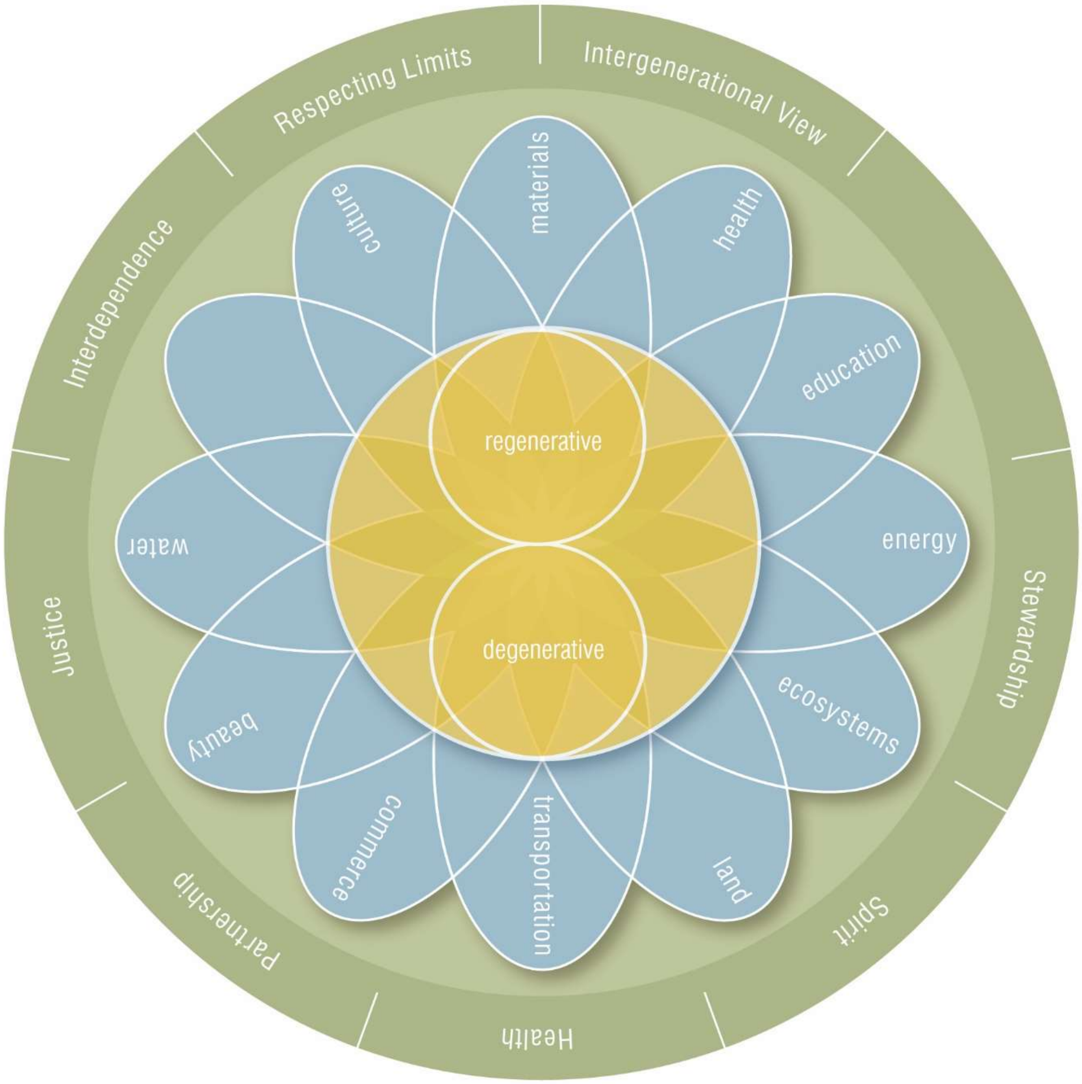

Figure 1. Illustration of the LENSES© Framework. Reproduced with permission from the Institute for the Built Environment, Colorado State University (2015).

environment using a renewable energy resource (e.g., wind or solar), but it does not require regeneration of ecosystems from which materials used were derived or where such materials were processed or transported (Leadership in Energy and Environmental Design, n.d.). The Energy Flow's regenerative criteria integrates language for renewable resources for reducing the carbon footprint used in creating them and producing additional carbon offsets.

The Flows Lens eleven concepts and criteria illustrate distinctions among sustainable and regenerative design. For example, the integration of renewable resource attributes is not a truly regenerative ideology because they deplete resources in one ecosystem to construct in another, merely exchanging one source of environmental destruction for another. Using a regenerative presumption, built environments integrating sustainable attributes are net zero and are catalysts of continual degradation through the lack of restoring affected ecosystems using net positive carbon offsets (Keeler & Burke, 2009; McLamb, 2011).

The purveyors of the LENSES© Framework offer trained facilitators to assist design teams in the comprehension of regenerative design, both in the appropriate context and when identifying and achieving net positive realities. With help from these facilitators, the Foundation Lens is introduced to transition the design teams' state of mind from sustainable to regenerative thinking. Regenerative criteria on the Flows Lens are used to guide design decisions for tangible levels of regenerative action (i.e., vitality) for "living" built environments.

Criteria on the Flows Lenses are not all regenerative. Criteria of the eleven Flows borrow content from current sustainability accounting tools. This makes the delineation among sustainability and regeneration difficult for project teams to implement, thus requiring a trained facilitator. Also, the Flows regenerative criteria are difficult to comprehend and translate into practice by designers, as they are theoretical and process oriented as opposed to more attribute oriented.

Designing a built environment to be regenerative requires a better understanding of the LENSES© Framework or a simplified version of the Flows criteria. Simplifying criteria will reduce the need for trained facilitation and assist in the uptake of LENSES© into the design industry (Rogers, 2005). This requires transforming obscure Flows criteria into tangible design realities that better illustrate regenerative realities. The purpose of this study was to produce a regenerative design portfolio for the eleven Flows of the LENSES© Framework. The researcher reviewed the criteria for regenerative themes and discusses and compares refined criteria within a built environment design context. This research is significant for two reasons: it differentiates LENSES© from other sustainability design tools; and it contextualizes obscure regenerative criteria that are currently limited in usability and applicability (Institute for the Built Environment, n.d.). An exploration into regenerative criteria will better contextualize the meaning of the Flows Lens.

Research Questions. Two research questions are asked: 1) What are the design realities discovered from each regenerative analysis; and 2) Is an inductive themes analysis suitable in exploring eleven Flow concepts using regenerative criteria and if not, why?

Definition of Terms

Design Realities – Built environment or site design actions or attributes. Usable during the design phase and in decision support by industry stakeholders. Several design realities compose a design portfolio.

Inductive Review – An intrinsic review of regenerative criteria, previously successfully in reducing obscurity for subjective and prescriptive criteria (Bond et al., 2012; Poston et al., 2010).

Regenerative Built Environment – A building that completely sustains its own environmental, social, and economic footprints. Also, one that contributes to regenerating the social, economic, and environmental denigrations caused by the footprints of other built environments (Center for Living Environments, n.d.; Plaut, Dunbar, Wackerman, & Hodgin, 2012).

Sustainable Ecosystem – An ecosystem that functions using inherent planetary programming, a system of ebbs and flows, delivering, and receiving), and component relationships, (i.e., resources and burdens) (Brauman, Seibert, & Foley, 2013; Gilbert, Thornley, & Riche, 2011).

Delimitations

This section describes study boundaries. The purpose of this research was to explore regenerative criteria of the eleven Flows concepts: Land Use; Transportation; Money; Energy; Water; Materials; Education; Ecosystems; Well-Being; Culture; and Beauty Flows, for concrete design realities, thus lessening their obscurity. No information, data, or concepts on the adjacent Foundations or Vitality Lenses were explored. Reducing obscurity for the criteria helps in determining their levels of design vitality but does not necessarily rank or organize them on the Vitality Lens. There is no analysis of additional meanings, foundations, or principles accomplished as part of this study, as doing so would add infinite amounts of complexity.

The topics of sustainability, sustainable design, and attribute and component performance and efficiency literature that date back more than 25 years were not reviewed or incorporated. Literature produced more than 25 years ago, was considered by the researcher to be redundant, insignificant, or foundational to current ideologies and accounting tools already deployed in the industry. Likewise, sustainability accounting tools that are unpopular and inappropriate for content review were not included. The top five most influential sustainability accounting tools are discussed for review and comparison.

The researcher narrowed the scope of review concerning academic literature and sustainability accounting tools, to produce simpler transitions in design "nomenclature" and to better comprehend the definitions for sustainability and regeneration. This was considered without first transitioning from traditional to sustainable nomenclature and again from sustainable to regenerative nomenclature.

The Flows were reviewed through their associated regenerative criteria, each consisting of known industry phrases. These are diverse but dissimilar in usage, frequency, and pattern. The coding scheme employed contextualized each Flow while capturing and organizing its regenerative criteria using a four-step coding process, which did not rely on technical content but rather general indications of subjective or prescriptive tendencies.

Procedures for analysis and expected outcomes were forecasted as descriptive. Findings and the researcher's interpretations of the findings exemplified design realities as subjective and central to the researcher's perspective and comprehension. Because there are no fully developed industry design tools for modelling regenerative criteria, inductive analyses using a constant comparative coding method were optimal for producing relevant findings.

Researcher Perspectives

The researcher is a design professional with experience and education in traditional, sustainable, and regenerative design and built environments. Because of the nature of its content, this research was exploratory and inherently subjective upon comprehending the original criteria, interpreting the findings, and relating to underlying Flows meanings. A subject matter expert from the design industry was required to explore the criteria and their conceptual and phenomenological natures to dissect and reframe incremental criteria into digestible realities for tangible action and attribute development. Without conducting this research, underlying meanings and an understanding of regenerative design remain elusive to industry professionals.

The researcher inquired into a conceptual "next level" of green building evolution. Specifically, regenerative ideologies surpassing current built environment sustainability. Regenerative criteria were explored and refined using the perspective of a design professional who viewed them as built environment acts and attributes.

The research examined obscure criteria that have been predefined with data collected and stored during an academic process. While not strictly interpretivist, the researcher translated and contextualized subjective findings previously gained from industry experts (e.g., trade crafts, engineers and architects, academics). Following refinement, examples in the design and building industry can be demonstrated. Design realities and discussions as to how and why these are relevant were central to the researcher's interpretations.

Assumptions

The refinement of regenerative criteria and continual development of associated design realities are limited in usability to a select group of industry professionals and clientele. This research provided clearer realities for industry uptake and usability by willing professionals and clientele. The findings were based on the researcher's interpretation of regenerative meanings and applications using focused and directed criteria, as they apply to the design environment. Each example was rationally based and formatted in a manner transferrable to any type of project worldwide requiring decision support for regenerative design.

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Not all regenerative criteria become better defined through comparative analysis. However, clarifying them into categories with less obscurity or types and placing them within a known industry context and format (i.e., like the LEED tool) may greatly influence the willingness of industry stakeholders' to use them.

Initially, the Institute for the Built Environment conducted focus groups to collect regenerative criteria. It is assumed that during these focus groups, highly technical and specific criteria were decontextualized into broad and obscure content. Because the research process was well documented and published, existing criteria were considered high quality (Plaut et al., 2012).

Regenerative realities are necessary for continually housing and sheltering humankind while balancing planetary resources (Du Plessis, 2012; Svec, Berkebile, & Todd, 2012). To ensure this study answered the research questions it presented, a narrative of the pilot study is explained with specific emphasis on coding and on subjective and prescriptive content criteria. This research design was created to produce concrete design actions and attributes for regenerative built environments.

CHAPTER TWO: LITERATURE REVIEW

This section summarized the sustainable built environment movement and evolution for the most recent 25 years. It reviewed relevant academic research, development of sustainability accounting tools and their built environment diffusions. Lastly, this review introduced the concept of regenerative design. Criteria for reducing the scope of literature reviewed pertain to sustainable engineering technologies and efficiencies, design, and built environment accounting tools. Groundbreaking regenerative design concepts and frameworks were reviewed.

Because sustainable built environment concepts, products, and ideologies have developed in different parts of the world at different times and in different ways, this review was not presented in chronological order. It is presented by order of relevance. Presenting sustainability by order of relevance better illustrated the development and evolution of sustainable design as emergent from traditional design. Mainly in terms of product and procedural functionality, efficiency, and product diffusions including accountability tools, this review was structured to present built environment design sustainability and to transition from sustainability to regeneration.

Current tools like the Leadership in Energy and Environmental Design (LEED) tool were based on engineered incremental attribute performance (e.g., component effectiveness in lighting and machines), but not focused on sustainable methods and procedures during built environment design and construction (Leadership in Energy and Environmental Design, n.d.; United States Green Building Council, n.d.). The LENSES© Framework is a regenerative framework created to enhance built environment design to go beyond sustainability, making spaces capable of restoring themselves and their surrounding ecosystems (Center for Living Environments, n.d.;

Institute for the Built Environment, n.d.). To illustrate the design industry's evolution of sustainability, including the identified need to surpass it, this chapter is divided into eight relevant sections.

The introduction examined the sustainable built environment design evolution from a macro perspective discussing planetary balances, ecological dependencies and interdependencies, human impacts to natural ecosystems and consequent global climatic changes. Also, humankinds' continual need for natural resources and built environments for serving those needs are discussed. Current design projects face multiple pressures, from increasing levels of efficiency to reducing environmental impacts. The introduction presented the LENSES© Framework in detail, as a decision support tool for optimizing sustainability and entering regenerative design.

This chapter discussed sustainable design diffusions; adopters of sustainable technologies; traditions of built environment phase and function; dimensions of sustainability in incremental and systems wide diffusions; gaps in sustainability accounting tools; and the LENSES© regenerative framework.

Diffusion of Innovations in Built Environments

The sustainability movement did not begin based solely on the betterment of our world, especially in the context of built environments. It began with the concept of improved efficiency and production while decreasing risk (Rogers, 2003). The most influential diffusion of innovation study was conducted by Ryan and Gross (1943), who analyzed a hybrid strain of corn introduced in 1928, as a developed augmentation to traditional corn cultivation (Rogers, 2003). The Iowa Agricultural Extension Service promoted use of the hybrid by local farmers, as it increased crop yield, increased drought resistance, and could be harvested using machinery.

Ryan and Gross (1943) were interested in the social relationships' farmers had with their neighbors and the impact this played in the adoption of the hybrid corn. As a result, Ryan and Gross (1943) established key foundations comprising a classical diffusion paradigm for innovations: "1) an innovation; 2) communicated through certain channels; 3) over time; and, 4) among members of a social system" (Rogers, 2003, p. 35).

The four elements of diffusion identified above are applicable in this discussion concerning the design industry's uptake of sustainability and to a later extent regenerative design. Technological innovations and the industry's drive for accountability in design are both factors in the uptake and usability of any new built environment product by design professionals. Sustainable design innovations have not been limited to incremental innovations in technology, hardware, or components, but in social philosophies like human caused climate change, in the inverse relationship of efficiencies and costs, in continual manufacturing alterations, and of the individual beliefs of project stakeholders (Rogers, 2003, p. 13).

Attributes of Adoption

Rogers (1995) identified five attributes of innovations that influence the sustainable design industry's rate of adoption: relative advantage, compatibility, complexity, trialability, and observability. Each of five attributes are relevant to increasing the uptake of sustainable design over the last 25 years and remain as an emerging need for regenerative design to be adopted.

Relative advantage. This attribute debates whether stakeholders view a sustainable or regenerative design innovation as advantage or hindrance. For example, clients' opinions drive non-prescriptive (i.e., technical) integrations like reduction in carbon outputs, mostly because of their lack in professional design education (Chiazor et al., 2009; Moffat & Kohler, 2008; Vischer, 2008). On the other hand, industry experts motivate the technological and performance-based integrations using their professional opinions of respective innovations (Chiazor et al., 2009; Moffat & Kohler, 2008; Vischer, 2008).

Compatibility. Compatibility and relative advantage are intertwined concerning design of built environments. A relationship exists between a client and a designer (i.e., architect) from the outset of the design process. However, project budgets sometimes remove a client's consideration of sustainable innovations, regardless of the user's choices (Moffatt & Kohler, 2008).

Complexity. Complexity and compatibility are best illustrated using a holistic, interoperability lens concerning sustainable space design. For example, innovations in lighting fixture technology must also meet carbon reduction requirements, primarily through a reduction in wiring needed if traditional lighting. A designer must integrate minimum lumens levels according to building codes, doing so by using additional windows. In the end, the integration of additional daylighting through windows must outweigh the reductions in traditional fixture wiring to satisfy the carbon reduction desires of clients (Boubekri & Boyer, 1992).

Trialability. The design, testing, and reporting of sustainably designed built environments are widely available using accounting tools like the LEED template and BREEAM tool (Building Research Establishment Environmental Assessment Method, n.d.; Cartes, 1998). Presently, there has been ample time for an entire generation of technologically advanced built environments to have been designed, constructed, critiqued, and improved for second generation design improvements. Most first generation sustainably designed built environments are private. However, in the 2010s public spaces provided a significant increase in prevalence of sustainable architecture and some technological integrations (Keeler & Burke, 2009).

Observability. Sustainable design of public spaces was a key enrichment tool for other industries and clientele for the last several years. Visibility is a primary teaching tool for others when deciding to mimic, uptake, or further a design's sustainability or its innovations (Rogers, 2003, p. 258; Timpson, 2017). In this study, observability was applied to facets of sustainable architecture like beauty, not necessarily for energy or water savings.

Adopters of Sustainable Innovations in Built Environment Design

In response to increasing pressure on production efficiency concerning fossil fuel refinement, innovators of sustainability first focused on increasing the compatibility between fuel production and facility limitations (Duffuaa, Sguaib, Raouf, & Budair, 1992). Early simulations proposed by Duffaa et al. (1992) increased production by decreasing operations and maintenance downtimes. This eventually branched into sophisticated layouts of fuel refinery attributes and equipment. Following fossil fuel production increases, the early innovators of sustainable practices or early implementers of sustainable design sought to maximize operational outcomes. This largely focused on the reduction in facility overhead.

Businesses proposed to increase function in relation to their built environments, by reducing overhead expenses caused by machinery downtimes. This type of sustainability reorganized materials and resources into convenient spaces thus reducing downtimes and increasing efficiency (Cartes, 1998; Chiazor et al., 2009). Early adaptations of sustainability concerning business eventually branched into early innovations of performance-based attributes and technological improvements to physical components (Boubekri & Boyer, 1992). Advancements in component technologies were a great leap forward to reorganizing operations or reducing maintenance downtimes (Boubekri & Boyer, 1992; Duffuaa et al., 1992).

Advancements in technology and integration into designs were high-performance attributes that signified the beginning of built environment sustainability accounting tools.

The majority of early adopters of sustainability were stakeholders pushing the integration of physical attributes into their built environments. A paradigm for the creation of sustainability using a built environment's attributes emerged, evolved into, and encouraged sustainability accounting tools like BREEAM and later the LEED tool. Sustainable activities and systems, and industry responses to this stage, spurred creation of several resource efficient methods, technologically advanced components, and improved procedures to create built environments that could sustain themselves (Building Research Establishment Environmental Assessment Method, n.d.; Leadership in Energy and Environmental Design, n.d.).

In conjunction with early adoption, regulations for built environment design and construction were formed using energy codes and other municipal requirements that established certain performance criteria (Butera, 2010). Meanwhile, increasing global supply and demand conversations were beginning, and climate change entered the social conversation (Gao et al., 2013; Lacombe et al., 2012). Late adopters were the first to impose regulatory requirements for sustainable practices in the private sector, but were one of the last parties to comply due to budgetary limitations (i.e., government and municipal regulators) (Younger & Morrow et al., 2008). Municipal, state, and federal buildings in the United States were late in adopting sustainability standards, tools, and other requirements for publicly owned built environments. This was mostly due to budgetary constraints (McGown, 2011).

Once social influences were exerted and a natural progression of sustainable innovations become cost effective over traditional design, elected and employed officials eventually sought to join the sustainability movement. The concept of regenerative design was known but not debated or considered a real option by late adopters (Butera, 2010; McGown, 2011).

Equally, laggards in sustainability are mostly those who physically construct built environments. Effectively, general contractors, subcontractors, material vendors, and others who physically dispense work, materials, or commodities debated the effectiveness of long-term sustainability ideologies (McGown, 2011). This was because the construction industry, which follows the design industry, does so through outcome-based performance contracts. The more work, labor, or costly a material, the less profit and increased risks a contractor or vendor incurs using this platform.

While considered laggards of sustainable innovation, point-of-construction stakeholders have the right to speculate the true effectiveness of sustainable design and its standards. Architects do not physically construct a built environment but contractually specify performance-based outcomes; the final product used is chosen by the contractors.

Traditions of the Built Environment: Defining Phases and Functionalities

Functional and environmental built environments could be considered effective in several ways. Some employed standards of durability as a metric of being sustainable (e.g., remain standing for longer than 100 years) while others were judged by the successful integration of high-performance fixtures and occupant satisfaction (Ellis, 2011; Lewis, 2010). Regardless, a functional and effective, yet durable built environment was not always perceived as one that integrated sustainable features (Keeler & Burke, 2009).

Historically, effective spaces were those that met the design needs of the stakeholders, and functioned as designed, without excessive life cycle costs (Keeler & Burke, 2009; Li et al., 2002). Historically, designers have been more concerned with long-term return on investment than with sustainable integrations (Li et al., 2002). There are recent and significant changes in this regard. A newly defined relationship among built environments and their social, economic, and environmental stakeholders emerged (Lewis & Elmualim, 2011). Currently, stakeholders become obliged to shift their philosophies concerning traditional durability and ecological sensitivity, to link building function with occupant satisfaction and sustainable performance of design innovations (Lewis, 2010, Lewis & Elmualim, 2011; Rogers, 2003).

Singh, Berghorn, Joshi, and Syal (2011) analyzed occupant satisfaction data concerning performance of sustainable attributes in a traditionally constructed built environment. They argued the most effective spaces (i.e., in which occupants were most satisfied) existed where sustainable attributes (e.g., physical components) connected to the larger system of other activities occurring inside a space (Singh et al., 2011). Simply put, technologically advanced and highly performing attributes worked together within the core and shell of a traditional design to satisfy occupants (Lewis, 2010; McGown, 2011; Singh et al., 2011).

There was significant discussion among project designers over acceptable levels of sustainable attribute performance and synergy when comparing innovations against those of traditional design (Keller & Burke, 2009; Li et al., 2002). These discussions raised more questions than answers. Framing an appropriate design solution to achieve as close to one hundred percent sustainability is not accomplished as easily as forecasted (e.g., sustainable integrations emerge during the planning phase and will not function until the building is constructed; an incremental component integration will not function the same within a larger system of other, unsustainable components until it is programmed to do so) (Gylling, Knudstrup, Per, & Hansen, 2011; Lewis, 2010; Poston, Emmanuel & Thomson, 2010).

Lewis (2010), Ellis (2011), and Nergard, Sandberg, and Larsson (2009) quantitatively linked high levels of sustainable built environment functionality to intensive stakeholders' participation and decision making, beginning in the design phase and lasting well into the operations and maintenance phases (Lewis & Elmualim, 2011). Singh et al. (2011) linked the optimization of sustainable measures to high-performance attributes and disregarded operations and maintenance attributes, thus taking a rigid and engineered approach to judging sustainable achievement. Lewis and Elmualim (2011) supported Lewis (2010), Ellis (2011), and Nergard et al. (2009) by concluding that highly effective sustainable design integrations are related to participation. However, Gylling et al. (2011) proposed that a blend of quantitative performance measures combined with stakeholders' participation during the operations and maintenance phases, not the design phase, were the optimal method to measure true sustainable design success.

In 2008, Vischer concluded that stakeholders' experiences during the design phase were central to a built environment's effectiveness (i.e., high occupant satisfaction during high functionality of sustainable attributes). Moffat and Kohler (2008) determined that a client driven design process contributed to a high rate of sustainable effectiveness when combining traditional space functionality with integrations of sustainable attributes. The client centered concepts of Vischer (2008) and Moffat and Kohler (2008) were supported by Chiazor, Maxwell, Robison, and Charters (2009), who partnered stakeholder participation during design with definitive increases into sustainability effectiveness of occupant satisfaction. These combined to form a basis for Singh et al.'s work (2011), analyses of incremental attributes (e.g., component interoperability within a larger system of combined mechanics) and operational protocols during operations and maintenance phases (Beatrice & Mang; 2017; Ellis, 2011; Lewis, 2010; Lewis & Elmualim, 2011).

Agreement among a built environment's life cycle phases (i.e., design and construction, operations and maintenance) and the participation of project stakeholders (i.e., clients, users) quickly became recognized as key to the effective function and optimization of design sustainability. This illustrated the requirement for a client or user-based model of sustainable design and marked the beginning of a holistic process for effective and sustainable built environment modeling (Chiazor et al., 2009; Moffat & Kohler, 2008; Vischer, 2008). Sustainable integrations could not be effectively implemented without a user-based system of participatory processes by stakeholders, alongside high-performance attributes (Lewis, 2010; Moffat & Kohler, 2008).

The idea of an ecologically sensitive built environment contrasted with traditional and degenerative design ideologies. Traditional design gave little attention to differences among attribute and component performances and efficiencies or their related interdependencies. Traditional design makes little, if any efforts to restore environmental denigrations and ensure economic equality or prevent social impoverishment. Traditional design actively degraded primary, secondary, and tertiary ecosystems in their quest for materials, labor, and fossil fuel commodities (Li et al., 2002; Loftness et al., 2006).

Moffat and Kohler (2009) and Loftness et al. (2006) indicated a sharp nineteenth and twentieth century shift away from traditional design, specifically in enhanced stakeholder awareness. Although the design industry did not abandon all traditional design activities, efficient and environmentally sensitive activities emerged. The difficulty was in determining where and how to apply effectively these design activities to a variety of potential applications.

Architects, engineers, constructors, operators, and other built environment stakeholders serve the design industry. These individuals drive the prescriptive requirements of sustainable design developments and product integrations (e.g., standards for mechanical, electrical, and plumbing systems and subsystems) (Keeler & Burke, 2009; Moffatt & Kohler, 2009; Vischer, 2008). However, the actual use of sustainability integrations is dependent on project occupants, clientele, and associated budgets (Moffatt & Kohler, 2009; Vischer, 2008). Though sustainable and efficient design integrations may be apparent, they do not always integrate cohesively into holistic, systemwide applications. All too often, stakeholders integrated one side of sustainability, like that of high-performance attributes without ensuring their interoperability within a larger system of interrelated components (Beatrice & Mang, 2017; McCown, 2011). Ultimately, failing to apply a holistic approach complicated built environment functionality throughout its life cycle and detracted from overall levels of sustainable effectiveness (Chiazor et al., 2009; Moffat & Kohler, 2009).

For example, consider a high-performance furnace as a sustainable attribute, integrated into a traditionally designed building shell. Eliminating the traditional ‘lead lag’ redundancy (i.e., two furnaces taking turns firing at different times) was a design concept for saving resources and resulting in reducing capital expenditures. The most important long-term requirement is that a single source, high performance furnace must be operated and maintained as it is designed. A sustainable design that eliminates furnace redundancy (i.e., uses one instead of two) requires a reliable system of interoperability with the entire built environment to be effective. This is because there is no longer furnace redundancy to compensate for operational shortfalls. An appropriately designed single source furnace system will be functional, sustainable, and highly effective. However, an inappropriately designed or maintained single source furnace will require additional and immediate resources to satisfy the heating or servicing needs should it fail (Hardie & Newell, 2010; Kua & Lee, 2002; Lewis, 2010; Lewis & Elmualim, 2011; Li et al., 2002).

Creating a social, economic, and environmentally balanced tool for enhancing built environment sustainability parallels actualities found in other industries (e.g., farming, manufacturing). The basic principles of efficiency, resource optimization, input and output balancing and synergy are all components of sustainability (Brauman et al., 2013; Friedman, 2007). For example, farm scientists maximize sustainable crop production using average precipitation, natural soil, and sunlight hours each year. Effective resources management of natural conditions determines the efficiency of crop yields year after year. As part of being sustainable, crop production must be repeatable without augmentation or amendments to resources. Simply put, that crop production will sustain a certain yield per acre. If augmentation like soil amendments are added to increase production, yields can be increased but the production may no longer be sustainable (Gilbert et al., 2011). This same concept applies to sustainable design of built environments.

Foremost, a built environment design should satisfy user requirements (Chiazor et al., 2009; Vischer, 2008). Design requirements should develop in synchronicity with the rationale for which a respective built environment is created and directly impact a group of users (e.g., commercial power plant that generates electricity; a commercial office facility designed to be easily reconfigured for revolving tenants; a highly efficient public office building producing a low carbon footprint for low supported life cycle costs) (Hardie & Newell, 2010; Kua & Lee, 2002; Li et al., 2002; Vanegas, 2003).

Creating sustainable built environments and ensuring optimization of sustainable processes rest on intentions of the project stakeholders (Ellis, 2011; Lewis, 2010; Lewis &

Elmualim, 2011; Nergard et al., 2009; Singh et al., 2011). Because built environments require large amounts of diverse resources to construct, an office building in New York City may, without purposeful avoidance, directly affect a South American ecosystem (e.g., harvesting of raw materials; fossil fuel extracting and refining; carbon dioxide emissions). This has the potential to cause social or environmental byproducts in regional ecosystems (Keeler & Burke, 2009). The challenge begins with designing traditional durability integrated with socially, economically, and environmentally responsible actions (Kelly, 2014; Vanegas, 2003).

Traditional design is considered degenerative by current sustainability standards (Preservation Green Lab, 2008). Historically, built environments and supporting infrastructures were viewed as feats of engineering, acts of economic prosperity, and conquests of the natural world (Freidman, 2007). Actions that defined traditional design were based on the reliance of technological innovations, both were time tested and proven methods and those that were new and efficient, adaptable, or compatible (Moffat & Kohler, 2009; Vischer, 2008). Although the design industry has shifted away from strictly traditional integrations, sustainability has not completely replaced stakeholders' perceptions of traditional expectations (Li et al., 2002; Vanegas, 2003). Sustainable design for built environments began by analyzing relationships among manufacturing capabilities and the operations and maintenance of associated components, respectively (Kelly, 2014).

Dimensions of Sustainability. Prior to 1990, published sustainability assessment tools were informal and infrequent. In 1992, sustainable effectiveness emerged with innovations that streamlined operations and maintenance infrastructures to improve efficiencies within built environments, using inter-prospection (Boubekri & Boyer, 1992; Duffuaa et al., 1992). These types of analyses were the beginning of the sustainable built environment concepts. Indirect analysis of interconnecting components and their level of interoperability in a built environment spurred efficient and eventually sustainable design concepts. This was significant because it illustrated how sustainability first emerged in traditional built environments.

Production and Performance. The first significant sustainability research concerning an artificial space consisted of a simulation integrating operations and maintenance downtime in a fossil fuel production facility (Duffuaa et al., 1992). This work was significant because it represented analysis of process improvements between a built environment and its users, using decreased resources and the same or better standards concerning machine technologies. The better the management of machine operations and maintenance was accomplished using scheduling tools, the higher the rate of agreement among production and resource burden (Duffuaa et al; 1992).

Boubekri and Boyer (1992) performed a similar analysis of window size and sunlight presence on glare. This work encompassed a qualitative, human element, focusing on occupant cubicle configurations in relation to daylighting and energy consumption using artificial lighting. According to Boubekri and Boyer (1992), occupants reported lower rates of satisfaction when facing exterior windows. Despite an abundance of daylighting, employee dissatisfaction contradicted any energy savings gained (i.e., excessive glare despite statistical significance of actual glare) (Boubekri & Boyer, 1992). This concluded that one sustainable design innovation did not necessarily improve built environment effectiveness overall.

Ironically, traditionally designed residential, commercial, and industrial structures remain standing, effective, and functional currently. Some have rates of production as strong as when they were first designed (Duffuaa et al., 1992; Ellis, 2011; Lewis & Elmualim, 2011). Yet this does not change using new design and construction to serve the same outcome. Origins of materials used to design and construct traditional spaces that damage the ecology through a continual need to service traditional operations and maintenance protocols are high in number when compared to sustainable life cycle spaces (Lewis, 2010; Lewis & Elmualim, 2011). A good example of this is the sewer infrastructure in any major metropolitan area (New York City's Waste Treatment, n.d.).

A sewer system captures waste water and storm water and diverts them away from urban centers. A sewer system services several types of structures and replaces natural earth systems, with rigid, steel walled conveyances to a water treatment plant. While necessary, sewer systems are designed without analysis concerning holistic impact on local ecologies or on their interdependencies. Because of the importance in removing wastewater, sewer systems are commonly designed and constructed in the easiest and most cost-efficient locations. Removing top soil for installation of these systems disrupts the local landscape's inherent functionality, like stopping production while servicing facility integrated machinery (Duffuaa et al., 1992; Larson, Casagrande, Harlan, & Yabiku, 2009; Pearce & Vanegas, 2002). Instead of losing production increments, a sewer system causes loss in habitat and the natural characteristics of evapotranspiration from the landscape. For this reason, sustainable environmental ideologies began to surface.

According to Vanegas (2003) and Poston et al. (2010), the beginning of the twenty first century witnessed an increasing trend for integration of sustainable design concepts into built environments, a step beyond simplistic analysis of the relationships among built environments and their users. These first appeared in attribute integrations and in analyses of carbon footprints (Li et al., 2002; Pearce & Vanegas, 2002). Holistic built environment assessment tools and systemwide sustainable design were at the forefront of design innovations (Giama &

Papadopoulos, 2012; Haddad, Alkass, & Haghighat, 2003; Paranagamage, Primali & Khandokar, 2010).

Sustainable Design Integrations. Over the last 25 years, the natural sciences served as a formative basis for understanding and integrating sustainability into built environment design (Paranagamage et al., 2010). In its purest form, sustainable design is the diverse and productive endurance of ecological systems and processes transposed onto a built environment (Keeler & Burke, 2009; Preservation Green Lab, 2008). A sustainable ecosystem (e.g., a habitable space) demonstrated its interconnecting social, economic, and environmental inputs while producing predetermined and inherent outputs at a rate of net zero impact (Poston et al., 2010; Vanegas, 2003). A sustainable ecosystem used inherent and interdependent natural systems of ebbs and flows and optimizes component relationships by balancing resources consumed and outputs attained (Brauman et al., 2013; Gilbert et al., 2011).

Design sustainability is compromised when excessive burdens create an adverse balance and overwhelm limited resources (Kelly, 2014). Effective sustainable design means integrating features with interdependencies to align and function within a holistically driven ecology. Successful design integration ensures the continuous performance of high-performance attributes systemwide with other sustainable actions (Delju et al., 2012; Lacombe et al., 2012). An example of design interdependency is illustrated using structural piers. Piers are structural to hold up the foundation of a built environment. A foundation supports the load walls, and the load walls support the roof. A failure of any of these interrelated dependencies results in the failure of the entire system. Each character in the design sustains itself and the whole built environment through reliance and interdependency of one another.

Tools for integrating sustainable design comprise more than high-performance attributes. To varying degrees, these involve stakeholders' collaboration, both pre and post design (Haddad et al., 2003; Paranagamage et al., 2010). Mutual coexistence is imperative during the design phase for establishing a level of preferred sustainability and its technologies, differentiating those from traditional design actions. A sustainable design incorporates some degree of high-performance attributes, intrinsically and extrinsically (Haddad et al., 2003; Vanegas, 2003). However, cost and resource burdens may restrict the number and type of attributes selected. Decisions made piecemeal, rather than as a completely sustainable system, will affect the whole design in different ways (Essa & Fortune, 2008; Kua & Lee, 2002; Vanegas, 2003; Vischer, 2008).

Sustainable design (i.e., net zero) can transition a built environment from a degenerative space into one of ecologic prosperity (Moffatt & Kohler, 2008). To do so, design must exemplify, replicate, and integrate its local ecology and function in the same manner (e.g., precipitation is conditioned by climatic conditions) (Gao et al., 2013; Gregorieva & De Freitas, 2013; Moffatt & Kohler, 2008; Younger et al., 2008).

Two dimensions of sustainability that of incremental attributes and of systemwide sustainability need to be considered. Incremental measures are considered individual high-performance attributes like component advancements, engineering innovations, and other technologies (e.g., energy efficient fixtures, reflective and absorbent surfaces, windows that increase thermal value) (Li et al., 2002; Tian, Chen, Yang, & Chung, 2010; Tripanagnostpoulas, Souliotis, & Nousia, 2000). Sustainable advancements concern design integrations that increase holistic effectiveness using the synchronization of increments interdependent upon one another.

For example, a built environment's electrical power plan shows the design for artificial lighting needs, as interdependent with natural light from windows in terms of overall lighting levels (Haddad et al., 2003). A review of the relationship among sustainable increments and the holistic systems were needed to comprehend systemwide sustainability effectiveness (Craft, Ding, Prasad, Partridge, & Else, 2018; Gao et al., 2013; Gregorieva & De Freitas, 2013; Poston et al., 2010; Vanegas, 2003; Younger et al., 2008).

Incremental Integrations. Although design and construction and operations and maintenance phases are collectively intertwined, they as separate pieces of a built environment's life cycle. Construction is a physical process. Review and approval of conceptual design are sought along with permitting and bonding. Financing is secured and procurement of materials and labor occurs. The design phase clarifies the stakeholders' needs and produces conceptual drawings, which bring the construction phase to life (Haddad et al., 2003).

A designer (i.e., architect, engineer) may specify the installation of a high efficiency faucet (e.g., sustainable increment or fixture according to the LEED tool or BREEAM), a general contractor may later discover that a municipality mandates a different type of fixture from that currently specified, long after the engineer has done his/her work (International Building Code, 2014). Stakeholders are normally unaware of different requirements or any decreased interoperability of remaining dependencies until a construction document is approved by the municipality (Essa & Fortune, 2008). Often, this is where incremental innovations interfere with overall effectiveness of a sustainable built environment.

The design and construction phases are pre-occupancy phases. After a built environment is completed, inspected, and occupied, the operations and maintenance phases begin. Operations and maintenance phases consist of daily adjustments to temperatures, traffic patterns, occupant flows, and other alterations to attributes and components to gain performance as designed (Ellis, 2011; Lewis, 2010). Stakeholders', occupants', and clients' communications are crucial before and after a commissioning period in determining how effective incremental components are in the post design and construction phases (Haddad et al., 2003; Lewis, 2010). This is primarily because occupants have qualitative opinions for determining sustainable performance and effectiveness as opposed to engineers or architects using objective standards.

Design integration of sustainable "increments", better known as "attributes", did not begin by implementation of high-performance technologies (Brauman et al., 2013). Sustainable attribute assessment started because of a lack in design standards (Keeler & Burke, 2009; Preservation Green Lab, 2008). Prior to high performance attributes, evaluation and assessment of sustainable design were graded by use of locally sourced materials and labor during the construction phase (e.g., the local trade union) (Kua & Lee, 2002). Even then, the most cost-effective methods of construction and of the operations and maintenance phases were chosen over expensive methods. Recently, technology has provided the desired performances for substituting a traditional component for a sustainable incremental attribute (Vanegas, 2003; Ziger & Snead, n.d.).

During the 1990s, increased focus was placed on the relationship between the design intentions of a sustainable attribute and the actual performance during the operations and maintenance phases (Boubekri & Boyer, 1992; Duffuaa et al., 1992). During a production efficiency simulation, Duffuaa et al. (1992) produced an operations and maintenance model that concluded the need for a coordinated, managed system of interdependencies of design attributes functioning in smaller increments affecting the overall system within a space.

Boubekri and Boyer produced similar work illustrating the relationships between sustainable attributes and their corresponding effects on holistic operations (1992). Simultaneous advancements were occurring in component technologies and attribute innovations, mostly through energy and water. Methods for waste water reduction, integration of renewable energies, and solar energy attributes began appearing in built environment design plans (Mahant & Hussein, 1994; Otterpohl, Grottket, & Lange, 1997). During the 1990s, industry design rationale transformed to match a burgeoning movement in sustainability, through the first accounting tools (e.g., Building Research Establishment Environmental Assessment Method, n.d.; Cartes, 1998; Kelly, 2014; Li et al., 2002; Preservation Green Lab, 2008; Tian et al., 2010).

In 1994, Mahant and Hussein produced a Green Industrial Analysis Retrofit Program in Ontario, Canada, for operationally reducing industrial energy consumption and water waste. Through better production organization and attribute upgrades, this industrial project slowed the production of solid, liquid, and gaseous releases removing carbon overall. Existing operational processes were made efficient using coordinated attribute upgrades. Using incremental technological upgrades, Mahant and Hussein (1994) focused on the holistic environmental impact through carbon reduction,

Prasad (1994) identified sustainability benefits from incremental design attributes though analysis of photovoltaic solar panels. According to Prasad, one challenge to integrating solar energy into design was that little data were available proving energy savings at the time. This claim was soon addressed by Pitts (1996) identifying the need for an environmentally diverse (i.e., sustainable) and holistically encompassing (i.e., systemwide) design tool for assessing sustainability effectiveness.

Pitts (1996) is the most significant academic work since 1990 to suggest creation of a national sustainability standard (i.e., U.K.'s Sustainable Building Network). Pitts suggested forming a standard required by designers and industry partners by bringing together several dimensions concerning sustainable effectiveness, both within a design and throughout a building's life cycles. These converged around the optimization of sustainability through three ideologies: designing attributes for renewable energy production; designing and operating and maintaining other attributes to conserve resources; and, continually educating and informing stakeholders about energy and environment and the multidisciplinary nature of design and built environments. The Sustainable Building Network was established to coordinate a range of activities and educational curriculum concerning carbon reduction and design (Pitts, 1996).

Yohanis and Norton (1999) presented their incremental innovation for sustainability in the form of a design factor. This design factor created a solar heat gain equation for factoring into design loads, simplifying the design of supplemental heating, ventilation, and air conditioning systems. This work signified a shift in sustainable design rationale, from incremental attribute innovations to a cooperative system of sustainable attributes. This was done through the consideration of several attributes simultaneously while designing the building as a holistically functioning entity.

In the following years works by Tripanagnostpoulas et al. (2000) (i.e., analysis of solar thermal collectors against overall heating and cooling needs) and Li et al. (2002) assessed incremental attribute efficiencies across the four phases of a built environment's life cycle. Research of singular attributes remained ongoing as technology continued to advance; however, singular attribute innovations were considered a part of the larger system of sustainability design effectiveness (Haddad et al., 2003; Tian et al., 2010).

In 1993, the United States Green Building Council was founded by the American Institute of Architect's (AIA), early adopters of the sustainability movement. Within five years, under increasingly stringent regulations for reducing carbon outputs, and with the monetary assistance of the Federal Energy Management Program, an aggressive and environmentally friendly design tool was introduced (Leadership in Energy and Environmental Design, n.d.). The Leadership in Energy and Environmental Design (1998) sustainability accounting tool was representative of the era and location, capitalizing on United States (US) pressure over several years of heightened pollution awareness, energy crises, and debate over the reliance on fossil fuels (e.g., hole in the ozone; acid rain). Following federal rule making regulating private sector outputs, a method of carbon reduction took hold as the built environment sustainability movement.

Industry uptake of LEED was high in the United States. Technology had advanced in ideology and component performances. Traditional attributes could be substituted with a suitable counterpart that was cost effective and ecologically sensitive. Early adopters were architects, the very professionals consulted when beginning design for a built environment. The same group of early adopters formed the United States Green Building Council and structured the LEED format. These adopters promoted advancing technologies and high-performance attributes to their clientele according to government rule making (Rogers, 2003). Capitalizing on the social awareness of environmental sensitivities, architects became the primary drivers of sustainable design diffusions both incremental and systemwide (Leadership in Energy and Environmental Design, n.d.). Although the LEED tool was not the first of its kind, it was the most significant the industry witnessed.

The LEED sustainability accounting tool signified a beginning of design movement in the United States, it was a duplicate of BREEAM in the UK. These tools established minimum performance baselines for technologically enhanced attributes and created procedural templates for integrating a design as one piece of the larger systemwide collection, comprising a sustainable built environment. The LEED tool was a point system employing a template for first specifying and then accounting for certain high-performance attributes. These are then certified by a third party (see Figure 2) (Leadership in Energy and Environmental Design, n.d.; Kua & Lee, 2002; Preservation Green Lab, 2008; Vanegas, 2003).

Leadership in Energy and Environmental Design did not intend to provide qualitative metrics like environmental justice or economic equality when determining design sustainability. Instead, it evaluated stakeholder adherences to prescriptive design standards. Design standards were based on engineered technologies and industry research and developments.

Currently, LEED may be applied in a variety of built environment types and applications (i.e., building design & construction; interior design & construction, existing building operations & maintenance, neighborhood development; and homes) by scoring sustainability using prerequisite point categories of prescriptive attribute integrations (Leadership in Energy and Environmental Design, n.d.; McGown, 2011; United States Green Building Council, n.d.).

Systemwide Integrations. From 2000 to 2014, industry rationale concerning sustainable design evolved, from incremental attribute improvements and design integration to systemwide sustainability effectiveness of built environments. Gylling et al. (2011) reported a growing interest in mixed methods research, through descriptive and prescriptive design metrics (e.g., high efficiency attributes; occupant satisfaction) with which to design and later assess systemwide sustainability effectiveness (Poston et al., 2010). According to Gylling et al.

Figure 2. Leadership in Energy and Environmental Design. Leadership in Energy and Environmental Design Snapshot Card.

(2011), a symbiotic approach to quantifying design success was beneficial to surrounding ecosystems in the reduction of carbon emissions and effective in improving occupants' satisfaction. Gylling et al. (2011) was preceded by other innovators of mixed methods design metrics in that, multifactor analyses of systemwide sustainability both in forecasting attributes and in evaluating them (e.g., efficient components and human satisfaction) formed a holistic vision of sustainable effectiveness (Poston et al., 2010; Tian et al., 2010).

Haddad et al. (2003) indicated approaches to measuring sustainability effectiveness using building characteristics (Giama & Papadopolous; 2012). Since the origin of sustainable attributes is embedded within the design process, attributes are effectively determined by an accurate review of the type, site, location, and climatic conditions of a proposed space (Haddad et al., 2003). Haddad et al. (2003) concluded evaluation tools measuring technologically enhanced attribute performance against systematic functional cohesion were necessary to determine overall effectiveness of design sustainability (Giama & Papadopolous, 2012; Kua & Lee, 2002; Preservation Green Lab, 2008; Tian et al., 2010).

Design integrations of high-performance attributes and their interoperability with one another are one dimension. Project stakeholders, with their cultural, economic, and environmental characteristics, are another dimension. Combined considerations and requirements for sustainable design are represented in a mixed methods context (Gylling et al., 2011; Poston et al., 2010; Vanegas, 2003). Mixed methods contexts spurred development of several industry-borne sustainability accounting tools (e.g., LEED, LBCS, Green Globes), (Poston et al., 2010).

The last ten years (2009-2019) have been alive with conceptual debate, discussion, and experimentation on how to further design sustainability and optimize the total holistic effect of built environments. Complete design sustainability would regenerate natural ecosystems throughout all four phases of a built environment. However, recent research struggled on how to assemble flexible, location- and condition-specific, multifactor and multidimensional frameworks for maximizing levels of sustainability effectiveness of built environments (Bissolotti, Aoki, Alina, & De Oliveira, 2006; Kyrkou, Taylor, Pelsmakers, & Karthaus, 2011). Specific code standards for accomplishing optimal levels of sustainability or regenerative effectiveness remain elusive (Delju et al., 2012; Lacombe et al., 2012).

Current sustainability accounting tools lack enough prescriptive or descriptive guidance for achieving fully sustainable or regenerative design and lack true alignment with the definitions and functionality of ecological sustainability (Brauman et al., 2013; Clegg, 2012; Gilbert et al., 2011; Plaut et al., 2012). Because of this, built environments continue to do harm, albeit decreasing harm to the ecosystems from which they are derived, using current sustainability accounting tools.

Sustainable Design Accounting Tools

In this section, current industry tools for sustainable design are identified and reviewed. Analyses of sustainability accounting tools are relevant because this study reviews and refines the LENSES© Framework. This framework incorporated facets from most current sustainability accounting tools while seeking optimal sustainability effectiveness through regenerative design. Further, LENSES© incorporated the fundamental ecological principles, elements, and practical definitions of industry tools as a precursor to regenerative design (Plaut et al., 2012; Preservation Green Lab, 2008).

Early sustainability accounting tools were prescriptive and quantitative. These tools mandated the design and performance of component attributes like efficient lighting or water savings devices. Metrics for determining sustainability were usually evaluated against baseline performances in simulated conditions (e.g., energy consumption from old lighting fixtures) (Preservation Green Lab, 2008). These requirements were among the first formalized sustainable design accounting tools (Mahant & Hussein, 1994; Otterpohl et al., 1997).

Each emerging accounting tool evaluated sustainability in a different way and not always concerning actual performance or adherence to prescriptive standards. Prescriptive accounting tools were criticized for placing too much emphasis on quantitative design and evaluation as sole metrics for determining sustainable effectiveness for design and not paying enough attention to qualitative or holistic interactions and interconnections among attributes and occupant and component interoperability (Beatrice & Mang, 2017; Craft et al., 2018; Kua & Lee, 2002; Li et al., 2002).

The numerical structure of accounting tools (i.e., categorical ranking system for successive estimation and for achieving a score) constructed a useful precedence for determining categories of sustainability and organizational formats. The ease of integration and implementation into differing types of design (i.e., scoring templates for components or attributes used in one built environment tool) may be used in another (Building Research Establishment Environmental Assessment Method, n.d.; Leadership in Energy and Environmental Design, n.d.).

Early sustainability tools were quantitative because they evolved corresponding to industry technologies and innovations (Keeler & Burke, 2009). Product performance simulation and testing preset baseline efficiencies could be measured and compared with improved engineering technologies, thus determining which components could be applied in sustainable design. A similar theory applied to efforts of coordination concerning multiple sustainable components working in unison (Kua & Lee, 2002; Li et al., 2002; Mahant & Hussein, 1994; Otterpohl et al., 1997).

Heavily quantitative, early tools permitted design to become an indirect venue for social, economic, and environmental conservation. As the movement for design sustainability progressed, optimizing sustainability became a mixed methods priority with integrations in ecological stewardship and reformation intermingled with performance (e.g., LBCS) (Boubekri & Boyer, 1992; Duffuaa et al., 1992; Kua & Lee, 2002; Moffatt & Kohler, 2008). Culmination of this mixed methods resulted in tools and thinking that enhanced sustainability using design processes, stakeholder involvement, and collaborations rather than through strict product and component efficiencies. Here, a subtle and indirect regenerative ideology emerged through the creation of effective quantitative and qualitative designs. A mixed methods design approach created and optimized effectiveness.

In part, ecological scars created using traditional design are reflected in sustainability tools. Although newer tools for sustainable design permitted flexible interpretations, component prerequisites and quantitative performance are still heavily relied upon (i.e., as is traditional). This makes reviewing current sustainability accounting tools straightforward. Overwhelmingly, current sustainability accounting tools lack significant qualitative integrations (Giama & Papadopolous, 2012; Kua & Lee, 2002); Lacombe et al., 2012; Poston et al., 2010).

According to Poston et al. (2010) and Kyrkou et al. (2011), the most heavily utilized sustainability accounting tool was created in the early 1990s in the United Kingdom, called the Building Research Establishment Environmental Assessment Method (BREEAM). It was launched by the Building Research Establishment, (see Table 1) (Kua & Lee, 2002; Preservation Green Lab, 2008; Vanegas, 2003). BREEAM's basic philosophies combined ease of sustainable design and efficiency of measurement based on known data.

BREEAM was intended to be flexible, offering nontraditional guidance concerning sustainable components concurrent with innovations and technological efficiencies. Primarily, BREEAM focused on reducing energy burdens caused by built environments and reciprocally reduced carbon dioxide emissions produced through the consumption of resources for creating energy (Keeler & Burke, 2009; Kua & Lee, 2002; Vanegas, 2003).

A quantitative, multi-attribute tool, BREEAM ranked incremental attribute performances using larger categories (e.g., transportation, water and energy efficiency, internal health and well-being, materials and waste management) (Giama & Papadopolous, 2012; Kyrkou et al., 2011). It successively estimated sustainability using points achieved in each attribute and in each category. Each category was then added for a total score to determine an overall sustainability design score among categories (i.e., actual score is weighed against manufacturers reported performances). Each categorical score consisted of how well an attribute functions compared to a simulated baseline resulting in an overall score for how effective it is (Building Research Establishment Environmental Assessment Method, n.d.). These categorical basics of BREEAM made its template an easy and usable launch pad for similar sustainability tools (Building Research Establishment Environmental Assessment Method, n.d.; Giama & Papadopolous, 2012; Kyrkou et al., 2011; Poston et al., 2010).

Almost every multiple attribute, multiple category (i.e., subject categories like energy, water) and sustainable accounting tool incorporated some form of prescriptive, performance-based organization (e.g., UK's BREEAM's main categories of Management, Water, Energy, Health, Materials, Waste, Land Use and Ecology, Pollution, Innovation) (Giama & Papadopolous, 2012; Kyrkou et al., 2011). Each primary category consisted of smaller subcategories or levels of accounting that described the metrics and actual performance of a sustainable attribute.

For example, when evaluating the energy category, lighting, daylighting, and task lighting were respective subcategories of performance assessed. The water category included bath and break room fixtures as categorical attributes (Giama & Papadopolous, 2012; Poston et al., 2012). Incremental component performances (e.g., lighting fixtures, plumbing fixtures) determined a sub-category score within each primary category (i.e., energy, water), and primary categories were ranked overall for effectiveness using a comprehensive score of sustainability effectiveness (Leadership in Energy and Environmental Design, n.d.; McGown, 2011; Poston et al., 2010).

Green Globes is a Canadian green building design tool, rating system, and assessment protocol (Green Building Initiative, n.d.). The primary category of Green Globes' is project management consisting of five subcategories: integrated design process, meetings, performance goals, environmental management, and commissioning (Green Building Initiative, n.d.). Each subcategory contained prescriptive, performance-based attributes or process guidance on optimization of sustainability design. Stakeholders accrue up to 50 sustainability points for managing a project using client-driven collaborations, like integrated design and meetings, and through performance goals strategies, environmental management processes, and commissioning processes (Green Building Initiative, n.d.). Sustainability scores are subtotaled in primary categories and then added into a total sustainability effectiveness score.

In the 25 years since formal quantitative assessment was introduced, spin off accounting tools have evolved in nearly every region of the world, including Brazil and Mexico, Canada and the United States, Australia and New Zealand, China and India, Jordan and Saudi Arabia, Europe, and South Africa (Kelly, 2014; Preservation Green Lab, 2008). No accounting tool is more universally recognized than the United States Green Building Council's LEED tool (Giama & Papadopolous, 2012; Kyrkou et al., 2011; Poston et al., 2010; United States Green Building Council, n.d.).

The LEED tool was launched in 1998 and is the Americanized version of BREEAM (Leadership in Energy and Environmental Design, n.d.). LEED employed a quantitative format like BREEAM and successively estimated a level to which a built environment is sustainably effective through its design (Giama & Papadopolous, 2012; McGown, 2011). LEED measured sustainability using prescriptive standards of major attribute categories, each assigned a point value. Stakeholder adherence to attribute standards is mandatory and a total number of points for doing so is successively estimated and awarded a basic sustainability certification, Gold, Silver, or Platinum (Leadership in Energy and Environmental Design, n.d.; McGown, 2011; United States Green Building Council, n.d.).

Both BREEAM and the LEED tools evaluated the level of sustainability of a built environment by rating stakeholders' adherence to prescriptive design standards specified by LEED standards. These standards were based on technological component innovations and other engineered industry research and developments. Neither BREEAM nor the LEED tool directly incorporated qualitative categories like social justice or economic equality.

Although largely quantitative, LEED indirectly provided avenues for attaining points relevant to social sustainability using occupant satisfaction criteria (Leadership in Energy and Environmental Design, n.d.). This was accomplished by mandating outcomes for indoor environmental quality using data from previous sustainability tools and engineering assumptions. This cannot be accomplished by collecting and analyzing actual data.

Though rigidly quantitative, BREEAM and the LEED tool are responsible for significant increases in built environment efficiency and for transitioning the design process from traditional to sustainable. These types of rigid accounting tools are currently challenged by flexible and socially sensitive ideologies, specifically those contemplating incremental attribute effectiveness, holistic sustainability effectiveness, and the regenerative design concept.

Ecologically considerate and qualitatively centered tools included the LBCS launched by the International Living Future Institute in 2006 (International Living Future Institute, n.d.). The International Living Future Institute was a spin off venture from the Cascadia Green Building Council, a jointly operated Chapter of the United States Green Building Council. Through creation of the International Living Future Institute, the United States Green Building Council uniquely positioned itself on both sides of an evolving need for qualitative and quantitative, prescriptive and descriptive design tools, and for socially just, culturally rich, and ecologically restorative living spaces (Cole, 2005; Plaut et al., 2012). However, a tool incorporating all aspects is currently lacking. The International Living Future Institute's LBCS tool consisted of seven core categories, known as Petals (i.e., Site, Water, Health, Materials, Energy, Beauty, Equity) for determining sustainable performance. Twenty subcategories called Imperatives composed each core category, performance area, or Petal (e.g., Petal: Water; Imperative: design strategy for achieving net zero usage) (International Living Future Institute, n.d.).

The LBCS intended design to be flexible, conceptual, and dependent on client driven input. Cumulatively, this is a process for surpassing technological sustainability and moving into natural, ecologically regenerative sustainability. The LBCS encouraged stakeholders to design living spaces capable of optimizing the natural definition of sustainability using design, sustaining both the built environment and the ecology from which it is derived (International Living Future Institute, n.d.). This tool promoted advocacy as opposed to a direct method for accountability and balanced human perspectives between the natural world and an artificial environment (Chiazor et al. 2009; Vischner, 2008).

Although the LBCS system incorporated high efficiency attributes, it went beyond incremental performances. Points for sustainability were achieved over the entirety of a built environment's life cycles in addition to qualitative processes diminishing the division among a built environment and its occupants. The tracking of actual component performances following post-occupancy adjustments (instead of through simulation) earn points. Just as BREEAM applied innovations in performance standards and simulations, the LBCS is a landmark development for measuring sustainability in qualitative performances and satisfactions. As the most prominent, loosely structured, humanistic form of sustainable design, this standard represented the first current accounting system promoting carbon neutral or net zero approaches for designing built environments (International Living Future Institute, n.d.; Keeler & Burke, 2009; Preservation Green Lab, 2008).

The Comprehensive Assessment Scheme for Building Environmental Efficiency (CASBEE) and the Natural Step's Sustainability Life Cycle Assessment (SLCA) tools are unique design tools unto themselves. CASBEE is a Japanese system focused on the hypothetical boundary between internal and external dimensions (i.e., spaces) of a built environment. Under CASBEE, Load (L) criteria evaluated negative environmental impacts going beyond the interior of the space and affecting the exterior. Quality (Q) evaluated the improvements to living amenities for building occupants (Comprehensive Assessment Scheme for Building Environmental Efficiency, n.d.). This scheme integrated four assessment fields that are like other sustainability accounting tools. These are energy efficiency, resource efficiency, local environment, and indoor environment (Kyrkou et al., 2011). CASBEE is unique because it incorporated quantitative and qualitative concept categories and can be unilaterally applied to different types of designs across all four built environment life cycle phases (i.e., design, construction, operations, maintenance).

The SLCA tool is a life cycle design process that employs a ten step, qualitative procedure for identifying negative impacts of built environments. The SCLA tool encouraged cross-disciplinary stakeholders' participation using four principles across five life cycle stages (Natural Step, n.d.).

Similarities and Differences in Tools. Each of the CASBEE and the SCLA tools differentiated approaches from BREEAM, the LEED tool, and LBCS concerning design processes (Preservation Green Lab, 2008). While CASBEE compared quantitative design guidelines with qualitative indoor occupant satisfaction for determining optimal standards, the SCLA tool encouraged incorporation of sustainable components throughout a built environment's life cycle. CASBEE is comprehensive and capable of evaluating pre and post design effectiveness. However, the SCLA tool qualitatively defined sustainable design (Natural Step, n.d.).

Current sustainability accounting tools have several similarities. They included categorical structure, performance guidance, and methods of calculating effectiveness (Building Research Establishment Environmental Assessment Method, n.d.; Green Building Initiative, n.d.; Gylling et al., 2011; Kyrkou et al., 2011). While BREEAM and the LEED tools relied on quantitative prescriptive mandates developed and tested through industry labs (i.e., high efficiency components), LBCS and CASBEE are flexible but complex (i.e., qualitative, requiring additional detail to evaluate) (Comprehensive Assessment Scheme for Building Environmental Efficiency, n.d.; International Living Future Institute, n.d.). Uniquely, the SCLA tool differs from BREEAM, LEED, LBCS, and CASBEE through the option to self-select, incorporate, and assess sustainable processes through the eyes of the stakeholders (Natural Step, n.d.; Poston et al., 2010).

The LEED tool represented a rigid and quantitatively prescriptive system and is the direct descendent of BREEAM. Like BREEAM's performance and baseline analytical comparison, LEED incorporated a successful adaptation of accounting for sustainable points (Leadership in Energy and Environmental Design, n.d.; Poston, et al., 2010; Preservation Green Lab, 2008; United States Green Building Council, n.d.). The tool's popularity can be attributed to its simplistic accountability structure and number of applications (e.g., Core and Shell, Hospitality, Data Centers, Warehouse & Distribution Facilities), each type mandating performance-based integrations for each primary category of sustainability (e.g., energy, water), and prescriptive requirements for each sub categorical attribute (Leadership in Energy and Environmental Design, n.d.). Undertaking a LEED project meant designing to prescriptive standards and methodically recording and tracking them, then applying for sustainable certification (Leadership in Energy and Environmental Design, n.d.; McGown, 2011; United States Green Building Council, n.d.).

Tools like BREEAM, LEED, and Canada's Green Globes dominated the quantitative spectrum. These systems existed amid strong criticisms (Lewis & Elmualim, 2011). Industry, academic, and research professionals debated whether value exists in the design integration of prescriptive attributes or in the holistic functioning of systems and other qualitative methodologies (Ellis, 2011; Lewis, 2010). Because quantitative systems mandated prescriptive design, they did not allow flexibility for new integrations (Kyrkou et al., 2011; McGown, 2011). Flexible and qualitative tools developed that rejected strictly prescriptive design standards (International Living Future Institute, n.d., Gylling et al., 2011; Poston et al., 2010; Preservation Green Lab, 2008). A matrix displays similarities and differences among popular tools (see Table 1).

By design industry standards, what was considered unsustainable is now sustainable. The LBCS system promoted prescriptive design and user defined regenerative integrations (International Living Future Institute, n.d.). Because of the complexity of qualitative integrations, use of this standard is limited in its number and types of applications. While established quantitative tools like BREEAM, Green Globes, and LEED rank sustainability using prescriptive attribute performance, the LBCS and SCLA utilizes loosely define qualitative metrics attained using descriptive categories like environmental justice. CASBEE and the SCLA tool mandate quantitative considerations during the design phase and switch to qualitative metrics to assess operations and maintenance effectiveness. CASBEE and the SCLA tools comprise a blending of quantitative and qualitative which capture a holistic version of sustainable design effectiveness.

Blending quantitative and qualitative facets illustrates holistic, optimal design effectiveness for achieving ecological sustainability. This is theoretical and uses the coordination of components and design actions. Current accounting tools do not accomplish a holistic built environment picture using a sum of quantitative and qualitative parts or achieve sustainable ecosystem balances and regeneration. Because of this, a new design tool has been developed to maximize sustainability by surpassing it.

The concept of a living, regenerative space cannot be outpaced by advances in technology, concept, or theory. Regenerative design realities developed conceptually with informal tools and frameworks. However, industry diffusions struggled to make inroads. Recent research exposed the ineffectiveness of prescriptive attributes as single methods to achieve overall environmental stewardship, given the complexity of natural ecosystems. Also, prescriptive accounting tools for optimal sustainability undermined actual performance as opposed to prescriptive and practical performance concerning occupant satisfaction.

Table 1. Comparison of six sustainability tools characteristics

Assessment Tool	Evaluates	Prescriptive/ Quantitative	Descriptive/ Qualitative	Method of Scoring	Primary Focus	Structure	Origin
BREEAM	Design & construction	Component efficiency & performance-based	None	Multi-attribute	Energy & carbon reductions	Sustainable	UK
GREEN GLOBES	Design & construction commissioning	Component efficiency & performance-based	None	Multi-attribute	Project management	Sustainable	Canada
LEED	Design & construction and operations & maintenance	Component efficiency & performance-based	Employs specified metrics from previous simulation	Multi-attribute	Energy, water, waste	Sustainable	USA
CASBEE	Design & construction and operations & maintenance	Construction efficiency & occupant satisfaction	Uniquely applied to differing applications	Multi-dimensional	Energy & resource efficiency	Sustainable	Japan
NATURAL STEP	Operations & maintenance life cycle	None	Five life cycle stages	Uniquely applied to differing applications	Waste	Sustainable	USA
LENSES©	Operations & maintenance life cycle	Primarily performance-based	Uniquely applied to differing applications	Pre/post evaluation by project stakeholders	Planning & logistics worksheets	Regenerative	USA

A Regenerative Built Environment Framework

The concept of maximizing sustainability in design effectiveness already exists in nature and ecology. Organic organisms exist with inherent features and in natural conditions that optimize their interaction with the natural world, balancing inputs and outputs, benefits and limitations, and rewards and liabilities (Brauman et al., 2013). Human beings and the structures we use for shelter, congregating, and food storage are the intervening variables upsetting the optimal ecological balancing act.

The design industry developed concepts of sustainability as tools to limit damage to the environment. Sustainability accounting tools quantified how efficient an attribute may be and how much it may reduce environmental impacts. Determinations of reductions in impacts are contemplated using design presumptions that are different from biological definitions of sustainability. This research intertwined design sustainability with biological sustainability and linked both to the complete optimization of biological sustainability in a design, also seen as regenerative. In this research, optimizing sustainability to 100% completely removed the carbon footprint and any ecological damage created by design of a built environment. Optimizing sustainability in a built environment includes a regenerative component, as in the biological definition.

The LENSES© Framework was developed by the Institute for the Built Environment at Colorado State University in response to industry's call for a regenerative support tool (Institute for the Built Environment, n.d.; Plaut et al., 2012). Drawing from several sustainability accounting tools and thinking in terms of natural and living organisms, "a group of faculty, staff, students, and professionals endeavored to create LENSES© (J. Plaut, personal communication, October 01, 2014; Plaut et al., 2012, p. 120). According to Svec et al. (2012), LENSES© is a tool useful in promoting a built environment's web of repetitious interconnections, sociocultural structures, physical content, and bases for ecological achievement in which to thrive in the natural world. The LENSES© Framework:

- guides stakeholder dialogue and shifts mindsets into regenerative thought;
- applies across cultures and regions;
- redefines built environment design across the spectrum of regenerative design processes;
- recognizes that qualitative and quantitative metrics add value;
- promotes that built environments become alive using the elements that flow through them (Institute for the Built Environment, n.d.; Plaut et al., 2012).

In 2007, The Institute for the Built Environment discussions concerning biological regeneration, built environment decision making paradoxes, and ecological impacts the world over compelled the creation of LENSES© (Center for Living Environments, n.d.). The Framework was developed as an illustrated graphic and included conceptual bases for design, and incorporation of prescriptive and descriptive standards using mixed metrics as presented in other popular sustainability accounting tools (Institute for the Built Environment, n.d.; Plaut et al., 2012).

In 2008, the United States Green Building Council provided the Institute with funding for additional development. The Institute for the Built Environment conducted the first of two workshops that included industry professionals and academic and research staff (i.e., from natural and social sciences, economics, architecture, engineering and construction, land management, health, education). A structured outline of LENSES© Foundations and Flows Lenses was created.

Colorado State University School of Global and Environmental Sustainability funded the Institute for the Built Environment in 2009 to conduct focus group research (i.e., spring, 2010) (Plaut et al., 2012). These focus groups identified and defined LENSES© Flows known as regenerative concepts and included degenerative, sustainable, and regenerative criteria (Center for Living Environments, n.d.; Plaut et al., 2012). One-day workshops were conducted on three consecutive occasions. Each workshop focused on developing four of eleven Flows using groups of eight to ten people. Three to five individuals were subject matter experts, two to four were non subject matter experts (i.e., community members, students), and one member was a facilitator (Plaut et al., 2012, p. 120).

LENSES© is seen in its current form in Figure 1. Currently, LENSES© consists of three supporting, content-oriented lenses:

- Foundations Lens – "Intended to guide teams in the common understanding of regeneration and systems thinking and guiding principles, facilitates discussions concerning the project's impact on the integrated bottom line (natural, social, & economic systems)";
- Flows Lens – "comprised of eleven concepts that define context, facilitate assessment of past and current state of Flows, and discovery of intersections and relationships amongst Flows";
- Vitality Lens – "intended to understand what characteristics and qualities comprise a regenerative state for each Flow. In concert with the Flows Lens, this lens guides teams in setting a project's regenerative goals and identifying strategies for achieving these goals. Its criteria provide qualitative metrics for identifying where decisions fall on a

scale from degenerative to regenerative" (Center for Living Environments, n.d.; LENSES© Application Guide, 2014).

Following structuring of the LENSES© Framework, an industry launch date was set. For rapid and efficient propagation into the marketplace, the Institute for the Built Environment transferred LENSES© to its profit arm, the Center for Living Environments and Regeneration. LENSES© was hereafter transformed from a theoretical design innovation to a decision support tool for creating regenerative built environments (Center for Living Environments, n.d.).

LENSES© was intended to be a decision support tool for creating continuous connections between design and the natural ecology encompassing it by using a built environment (Center for Living Environments, n.d.). LENSES© is a balance positive tool (Plaut et al., 2012) meaning it produces more than it detracts. It guides and informs users on how to capitalize on the vast amount of interwoven, interconnecting, and pressing social, economic, and environmental factors of design that form the restorative symbiosis between a built environment and the natural world enveloping it (Clegg, 2012; Plaut et al., 2012). Like the natural world, regenerative spaces should productively and sustainably balance their ebbs and flows of structure, functions and resources, and burdens placed upon and around them (Brauman et al., 2013; Gilbert et al., 2011; Kelly, 2014; Lacombe et al., 2012).

Although LENSES© fits the design industry's need for a subjective and prescriptive, mixed methods symbiosis of regenerative design concepts, it was unveiled as a highly obscure and complex framework to apply. This slowed the diffusion of LENSES©. The combination of three lenses added three potential dimensions to project complexity (e.g., guiding principles for attaining regeneration coupled with natural, social, & economic design bases). Determining how one Flow may interact with a Foundation was an arduous task yet undefined.

In response, the Center for Living Environments and Regeneration created a structured three-day Facilitator Training Program (2014) to train teams to practice regenerative design. With the goal for participants to understand and identify opportunities through hypothetical design creations and post design evaluations, they used LENSES© context appropriate regenerative criteria (Center for Living Environments, n.d.). The training program provided stakeholders a physical handbook for reference, but no additional follow-up resources were available. To prepare for the program launch, the center created a five-part, classroom ready Application Guidebook:

- User and Participant Overview Guide – provides context and meaning to the users;
- Process Guide – defines ways that teams collaborate when discussing regenerative processes;
- Metrics Guide – illustrates design integrations, achievements, and implementations through graphic representations;
- Activities Workbook – assists stakeholders in simulating real life solutions;
- Planning and Logistics Workbook (i.e., design realities templates) – provides regenerative criteria directly onto Flows templates for guiding built environment design realities.

The Application Guidebook recommended inclusion of a trained facilitator with project teams. This is significant because LENSES© has already collected regenerative criteria for surpassing sustainability. Without a trained facilitator, LENSES© remains too obscure to be comprehended by designers and is conceptually unrecognizable for intended users. Also, the framework's criteria relied heavily on design processes as opposed to specific actions. This compounds difficulty with diffusion (Rogers, 2003).

The Flows Lens is the transitional link for stakeholders between a project's foundations (i.e., process guide & activities workbook) and materialized design realities defining regenerative integrations (i.e., level of Vitality). The Flows Lens has eleven identified concepts for project teams to identify with using the LENSES© visual illustration (see Figure 3). The eleven Flows concepts are analyzed coincidentally with the corresponding regenerative criteria that defines them. All eleven Flows are supported by developed but highly obscure regenerative design criteria.

Regenerative Flows criteria are well intending but difficult to comprehend and complex in application to real scenarios even when using trained facilitators. Although LENSES© is a regenerative design innovation, its obscurity has slowed early adoption and overall industry diffusion to stakeholders. Even though the application guidebook presents an interactive platform among facilitators and designers, it does not assist in further refining regenerative criteria into usable design constructs or realities. A need to refine the regenerative criteria supporting each Flow into design realities that specify regenerative actions and attributes is required.

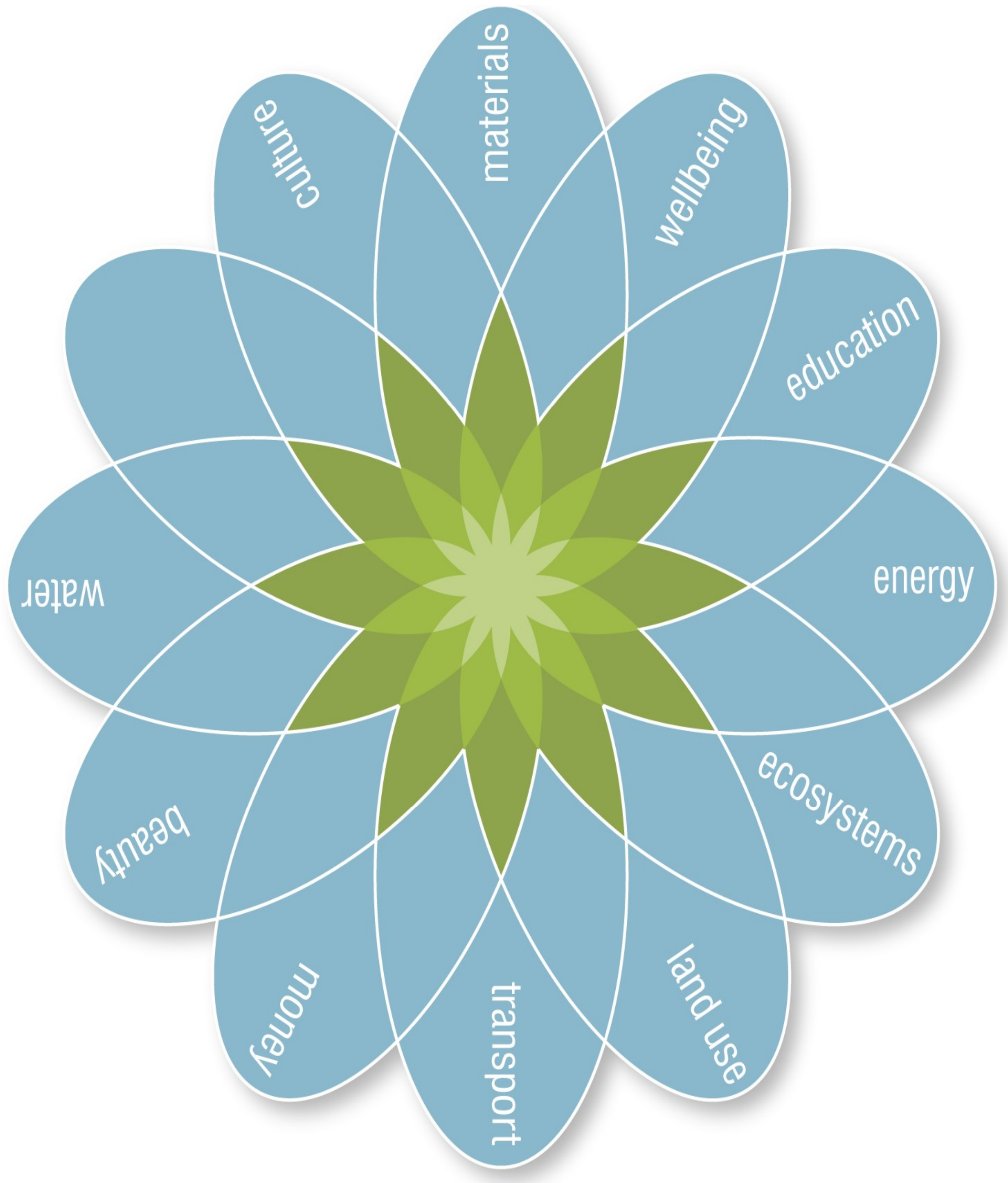

Figure 3. Illustration of the Flows Lens. Reproduced with permission from the Institute for the Built Environment, Colorado State University, (2015).

CHAPTER THREE: METHODS AND METHODOLOGY

This chapter identifies procedures used. The LENSES© Facilitator Training Program (2014) was developed to assist project teams in identifying regenerative processes during the design phase. The program includes an Application Guidebook and a Planning and Logistics Workbook. The Planning and Logistics Workbook incorporated eleven template packets, each packet representing one regenerative process for one of eleven Flows. Each packet identified a Flow's concept and regenerative criteria that guide design processes and responsible parties for implementing and evaluating them (Center for Living Environments, n.d.).

Currently, the intent of the Planning and Logistics Workbook is to actualize regenerative design processes into a built environment according to the intentions of project stakeholders. The Land Use, Transportation, Money, Energy, Water, Materials, Education, Ecosystems, Well-Being, Culture, and Beauty Flow templates (see Appendix C – Beauty: Why Consider Beauty) are provided to stakeholders along with:

- Opening statements about each Flow's concept, rhetorical questions to ponder when designing for it;
- Regenerative criteria for each respective Flow;
- Planning worksheet for tracking responsible design parties concerning project implementations, the appropriate resources needed, and prospective achievement strategies targeted for each Flow; and
- Methods for evaluating and ranking the achievements of any or all regenerative processes initially surmised during the design phase (Center for Living Environments, n.d.; J. Plaut, personal communication, October 01, 2014).

Flow packets use decontextualized criteria gathered during the Institute for the Built Environment's 2009 focus groups. To improve upon the criteria obscurity and overall quality of these packets, this research analyzed regenerative criteria for each of eleven Flows, as refining the criteria to aid design clarity and usability. Performing this analysis was transform process driven criteria into concrete design realities.

Refinement of obscure criteria was useful in developing historical sustainability actions, using metric centered assessment early on and client-based assessment later (e.g., BREEAM, LEED, & LBCS). LENSES© focuses on concept-centered design strategies, instead of metrics-centered or client-centered. Actions taken using the LENSES© tool are based on stakeholders' willingness to excel at regenerative design, and not on prescriptive product or component outputs as predetermined by equipment manufacturers.

Using LENSES©, design teams choose whether to alter the scope of their regenerative integrations by widening or narrowing their interpretations and applications concerning each Flow-associated interconnection with the social, economic, and environmental conditions. By using the Planning and Logistics Workbook templates, design teams customize built environment design using several circumstantial factors, encouraging regenerative realities, when and where important.

LENSES© regenerative criteria lack specific context, outcomes, and definitions. Although the creators of LENSES© created an intuitive ranking scale (i.e., 1-5 indicating a natural progression from degenerative to sustainable to regenerative design) for purposes of supporting decisions made with a regenerative mindset. Criteria gathered during the focus groups were decontextualized and inherently difficult to apply.

The illustration of LENSES© mimics other sustainability design tools, however, its regenerative applications are unique (Center for Living Environments, n.d.; Poston et al., 2010). LENSES© incorporated elements of several sustainability tools along with exploratory technologies and research and developments (Gylling et al., 2011; Robinson, Burch, Tallwar, O'Shea, & Walsh, 2011). These factors complicated a straightforward application using the Flows (Clegg, 2012; Cole, 2012). Without the analysis here, LENSES© will continue to require trained facilitators for its implementation (Du Plessis, 2012; Svec et al., 2012).

Data Selection

The Flows Lens encompassed regenerative concepts with criteria supporting each through qualitative descriptions (i.e., a level of Vitality). A design team dissected and assessed each Flow according to its regenerative aspirations. Each designer implements regenerative aspirations according to the design characteristics described by and extracted from the Flows' criteria. The outcomes of LENSES© are a collaborative and process-driven attempt at regenerative design, not necessarily identification of regenerative actions or attributes (Clegg, 2012; Cole, 2012; Mang & Reed, 2012; Svec et al., 2012).

The LENSES© Framework focused on stakeholder intentions. It did not incorporate prescriptive metrics describing how to become regenerative or the level of regeneration attained per a given Flow or through its criteria. Descriptive criteria are stored on eleven dedicated spreadsheets, one for each developed Flow (see Appendix C – Beauty: Why Consider Beauty). Flows spreadsheets arranged left to right contain five categories: degenerative; degenerative to partially sustainable; sustainable; sustainable to partially regenerative; and, regenerative criteria. Degenerative is on the far left and regenerative on the far right (see Appendix C). Criteria are structured so teams may easily locate and identify a desired level of guidance.

During the research process, more precise Flows criteria were decontextualized from design realities into much broader process criteria. As a result, regenerative criteria were rendered obscure and unusable. Reducing the levels of obscurity will produce illustrations unique to the intentions of each Flow. To better contextualize Flows meaning, this study refined regenerative criteria supporting each Flow, as stored on respective data spreadsheets (Colantonio, 2010; Gylling et al., 2011; Umakoshi & Goncalves, 2011). This method of refinement is consistent with the development of previous sustainability tools.

Colantonio (2010) recorded, coded, and refined themes from focus group data concerning the sustainable design of a publicly funded Canadian built environment. Umakoshi and Goncalves (2011) and Gylling et al. (2011) assessed post design and construction effectiveness for sustainable attributes on built environments in Japan and Norway (i.e., using occupant questionnaire data and performance metrics). Researchers consolidated and refined sustainability criteria to achieve relevant action themes. Umakoshi and Goncalves (2011) and Gylling et al. (2011) produced a template-ready portfolio of design realities guiding sustainable design (Colantonio, 2010; Gylling et al., 2011; Umakoshi & Goncalves, 2011).

Through its Flows concepts and supporting criteria, the LENSES© Framework was structured similarly to work conducted by Colantonio (2010), Umakoshi and Goncalves (2011), as well as Gylling et al. (2011) with limited exceptions: LENSES© highest achievement focuses on regenerative design. The Institute for the Built Environment research and creation processes for developing the LENSES© Framework were reliable and valid. Because the collection and recording of Flows criteria were legitimate, a document analysis of regenerative criteria was best suited for reducing obscurity (Colantonio, 2010; Plaut et al., 2012; Umakoshi & Goncalves, 2011).

Research Design

This research is qualitative and non-experimental. It is exploratory and developed eleven Flow concepts into regenerative constructs through analysis of supporting regenerative criteria (Bond, Morrison, & Pope, 2012; Colantonio, 2010; Rosas, Garcia, & Rodriguez, 2002). Regenerative criteria are separate from degenerative and sustainable criteria and maintained on the same spreadsheet. Intuitively, this suggests to users there are significant differences in the intentions of the criteria.

Degenerative criteria refer to design processes that teams should not integrate if they desire a regenerative built environment. Sustainable Flows criteria equally replicated sustainability accounting tools like the LEED tool and BREEAM. Regenerative Flows criteria are phrased in ideological terms as some are new design concepts (Center for Living Environments, n.d.).

In this analysis, focus is on subcategories for each Flow, which were refined separately. However, all focus points comprising each Flow are summarized and discussed under the holistic Flows concept to form a collective representation or regenerative construct relative to each Flow.

Regenerative criteria provide the prescriptive foundations for Flows conceptual meanings. Although vague, the criteria underpinned the "essential elements" of regenerative design for each Flow relative to design and a built environment. Flows are the LENSES© Frameworks' representational linkage to a holistic design philosophy surpassing sustainability. Contextualizing the regenerative underpinnings through analysis of supporting criteria required an inductive approach. The same approach has been used in the refinement of sustainable criteria (Bond, Morrison, & Pope, 2012; Colantonio, 2010; Rosas, Garcia, & Rodriguez, 2002; Umakoshi & Goncalves, 2011).

Previous works employed inductive, qualitative document analysis to produce prescriptive and descriptive criteria. Inductive inquiry into the Flows regenerative criteria uncovered embedded themes that may transition obscure design processes into tangible realities. Using a detailed coding process, both the meaning and practical applications of themes were refined and labeled, producing realities relevant to the intentions of the Flows (Gylling et al., 2011; Kyrkou et al., 2011; Umakoshi & Goncalves, 2010).

Procedures for Analysis

This section describes procedures for analyzing regenerative criteria using similar methods from previous works (Gylling et al., 2011; Kyrkou et al., 2011). The procedures used in previous works alongside lessons learned from a 2013 Pilot Study assisted in developing a structured coding process to test Flows criteria.

Rosas, Garcia, and Rodriguez (2002), Poston et al. (2010), and Umakoshi and Goncalves (2011) analyzed questionnaire data for recurrent sustainability themes, recursively contextualizing discoveries against the holistic effects of prescriptive sustainability integrations (e.g., LEED & BREEAM) (Gylling et al., 2011). Bond et al. (2012) concluded that sustainable design effectiveness is better accomplished through attention given to local site conditions and by considering social and environmental characteristics. Combined, these works provided a road map for the refinement of sustainable criteria concerning social and environmental design realities. As LENSES© regenerative criteria were structured like previous research on sustainable criteria, inductive themes analysis was optimal for refining sustainable criteria and for refining regenerative criteria.

Conversely, Gylling et al. (2011), Kyrkou et al. (2011), and Umakoshi and Goncalves (2011) conducted mixed methods research by reviewing occupant data and comparing it to prescriptive attribute performance data. These works compared occupant-based satisfaction themes to high tech attributes as required by one of several sustainability accounting tools. This type of research was valuable because it captured a holistic view of sustainability effectiveness, compared prescriptive attribute performances, and perceived effectiveness satisfaction. These studies were significant because they illustrated a major shift from the measurement of attributes to an interdependent matrix measuring sustainability effectiveness using mixed methods (Bond et al., 2012; Colantonio; 2010; Kyrkou et al., 2011; Poston et al., 2010). Mixed method holistic design and assessment of design performance was a cornerstone for the LENSES© Framework (Clegg, 2012; Plaut et al., 2012; Poston et al., 2010).

Poston et al. (2010) and Kyrkou et al. (2011) compared several prescriptive design tools, finding overlaps among them as "value added". They furthered the concept of "value added" by promoting flexibility of the mixed method approach and incorporating best practices for sustainable design. This research is important because it is predicated on the blending of subjective and prescriptive sustainability concepts similar to the Flows, which were predicated on regenerative concepts.

Colantonio (2010) employed methods like Poston et al. (2010), Gylling et al. (2011), Kyrkou et al. (2011), and Umakoshi and Goncalves (2011) by capturing qualitative sustainability and inductively analyzing it for themes. Colantonio (2010) structured raw or obscure sustainability criteria into discipline-specific subject matter "hard"/prescriptive themes (i.e., performance-based components), and "soft"/subjective themes (i.e., social or cultural nature). This research yielded criteria that were based on prescriptive attributes and subjective, occupant driven actions. This technique is important as it related to the Flows subjective and prescriptive nature.

Techniques for the refinement of regenerative criteria represented the nature of the concepts reviewed. Final themes are well understood as regenerative design realities, through consideration of their corresponding concepts and linkages presented (Colantonio, 2010; Kyrkou et al., 2011; Poston et al., 2010; Umakoshi & Goncalves, 2011).

Methodology developed for the refinement of Flows criteria has been better informed through previous research that presented: structured coding processes for producing sustainable criteria; inductive themes analyses based on sustainable design data; and analysis of combined subjective and prescriptive concepts (Colantonio, 2010; Kyrkou et al., 2011; Poston et al., 2010; Umakoshi & Goncalves, 2011). Thus, mixed methods design captures value added best practices by blending subjective and prescriptive criteria.

Pilot Test. In 2009, focus groups for The Institute for the Built Environment successfully gathered criteria, which were confounded. In 2013, the researchers conducted a pilot study on regenerative criteria for each of the Energy and Beauty Flows. The Energy Flow was selected because it contained prescriptive criteria, and the Beauty Flow was selected because it contained subjective criteria. Criteria found on the Energy and Beauty Flows required refinement into design realities.

The pilot employed three-step coding to refine regenerative criteria on the Energy and Beauty Flows. Development of the coding process was formulated using similar research concerning the development of sustainable design realities. A primary motivation for conducting the pilot was to develop coding guidelines usable for refining each of the eleven flows, whether they are subjective or prescriptive. (Bond et al., 2012; Colantonio, 2010; Gylling et al., 2011; Kyrkou et al., 2011; Poston et al., 2010).

The pilot did not develop a clear and consistent coding process for use on all eleven Flows. This was because there was no delineation of the type of criteria under review, whether subjective or prescriptive prior to refining the physical realities. While the pilot succeeded in reducing obscurity of criteria on the Beauty and Energy Flows, a coding step was added for this design, ensuring delineation of criteria into subjective or prescriptive categories. The additional step became the first coding step (A) and identified whether a Flow contained subjective or prescriptive criteria. Understanding major topics as being subjective or prescriptive better directed refinement in Step B, C, and D. Cumulatively, this design utilized a four-step constant comparative coding process.

Codes from previous sustainability research were not utilized in the pilot. The presented coding process incorporated detailed, four-step instructions for contextualizing regenerative concepts in relation to their supporting criteria. Yielded criteria were the units of analysis produced. Step D refinements were presented as design realities in the Findings.

This research is inductive and recursive. Criteria spreadsheets were reviewed to an exhaustive degree, allowing the researcher to transform obscure concepts into regenerative constructs. This analysis deconstructed obscure meaning and reconstructed it into design realities, in the manner of how previous sustainability works were developed (Colantonio, 2010; David, Coyle, DeVriese, & Schneider, 2008; Don, McKee, & Mak, 2011; Umakoshi & Goncalves, 2011).

Based on previous and relevant literature reviewed and a 2013 pilot test, the best approach for reducing criteria obscurity was determined through inductive review (Colantonio, 2010; Poston et al., 2010; Umakoshi & Goncalves, 2011). Because regenerative criteria are words and phrases located within text boxes and because each spreadsheet is specific to each

Flow (see Appendix C), a constant comparative approach was optimal. Constantly comparing yielded criteria in relation to each Flows and consistently applying this method across all Flows increased the value of regenerative design realities. Each Flow spreadsheet was identically formatted so reformatting content was not required (Gylling et al., 2011; Krank & Wallbaum, 2011; Robinson et al., 2011).

Coding Process of Regenerative Flows Criteria. Regenerative criteria for the Land Use, Transportation, Money, Energy, Water, Materials, Education, Ecosystems, Well-Being, Culture, and Beauty Flows were reviewed. Coding used a four-step process.

Step A Criteria - Identifying Major Topics. This step was added following the pilot study. An initial read through was conducted to better understand how each Flows concept was represented by its criteria (i.e., regenerative criteria support focus points; focus points support each Flow concept). In this step, regenerative criteria were reviewed and compared to the holistic regenerative concept of each Flow.

For example, the Beauty Flow has three individual focus points, each with regenerative criteria constituting meaning for the overall Flow. Regenerative criteria for each focus point was refined separately to code major topics, and then combined (see Table 2).

Major topics were considered content laden words or phrases encompassing a guiding meaning inherent to each represented focus point and regenerative concept, and indicative of content-specific information (e.g., guiding nouns representing content-specific intentions of the regenerative criteria like prescriptive or subjective; implying content and connotations that follow). Major topics yielded criteria from Step A.

For example, the Beauty Flow's Ecology focus point criteria contained the word "biophilia". Biophilia is a major topic and implies the content and connotations that will follow (i.e., "intentionally incorporated throughout"). Biophilia denotes plant life. "Plant life" is Step A's yielded criterion for the Beauty Flow (see Table 2).

Step B Criteria – Refinement and Application. Moving from Step A to Step B involved bringing forth major topics while contextualizing each focus point as interdependent segments considering the underlying meaning to each Flow. In Step B, words that "energize" codes into industry-specific major topics refined during Step A were developed. Step B added energy to major topics using a context of built environment design realities and refines major topics into practical design fragments or linkages while remaining in sync with the underlying meaning of the Flow. Step B coding illustrated design directions for major Flows topics and began to map out perceived themes for Step C refinements (see Table 2).

Step C Criteria – Theme Creation and Definition. Moving from Step B to Step C involved bringing forth applied industry-specific major topics while considering the underlying meaning for each Flow. Applied industry topics were put into an "action" context by moving Step B criteria from being theoretical into an active tense and providing meaning to them per the Flows concept to transform them into real time design realities, by category or similarity. Step C similarities placed industry topics into categories of design reality.

During Step C, loose themes were formed and defined. Structuring the yielded criteria in relation to similarity and the applied design realities by topic was accomplished. Step C remained flexible to add new major topics or criteria that were previously external to those constructed in Steps A and B. The coding process through Step C followed the natural pattern of criteria.

During the pilot (2013), the Beauty Flow Ecology focus point criteria stated the word "Biophilia". Biophilia is not an action word or verb in the Beauty regenerative criteria. However, this word stood out because it denoted a major topic, which became active thereby becoming something conceptually broadly based. Using subject matter logic, biophilia was transformed as plant life and integrated into built environment design, purposefully integrating natural ecology into part of a regenerative design. Analysis of focus points as interdependent from others illustrated an important Step C characteristic: Different actions and/or content laden words sometimes arose from different focus points and on different Flows.

Step D Criteria - Examine Relevance of Themes Against Original Text. In Step C, yielded criteria and definitions were examined against their original criteria in relation to the regenerative intentions of the Flows concept. To this point, yielded criteria were constantly compared against Flows concepts. Step C, themes and definitions were produced based on major topics from Step A and regenerative direction from Step B.

In Step D, loose themes were checked for comprehension and clarity. Step D examined refined themes and definitions for additional indicators relating to how each evolved and transformed from a theme into a regenerative design reality (see Table 2).

Codebook

The Flows' regenerative criteria were initially perceived as abstract rather than obscure. Coding abstract criteria involved changing the conceptual meaning of each Flow in relation to its criteria (i.e., as in the pilot study, 2013). There was little space in the regenerative criteria to infer prescriptive action. This was a limitation of the data. To seek actions and technological advantages from the existing criteria would have confounded each Flow's conceptual underpinning and would not meet reliability or validity standards. Since the coding process was partially developed and rationalized using the relationship among each Flow's conceptual meaning and its regenerative criteria, coding focused on reducing obscurity instead of interpreting abstractness.

For codebook development, Step A coding procedures were conducted on the three Flows (i.e., Land Use, Transportation, & Money) and major topics were identified. Following Step A, linkages were detected among Land Use, Transportation, and Money making their conceptual meaning and their corresponding criteria very clear. Step A coding was continued for the remaining eight Flows.

Step B was conducted on Flows in the same manner as Step A. The first three Flows were coded. A review of Step B yielded criteria for Land Use, Transportation, and Money in relation to their conceptual meanings, both closely and individually aligned. Step B continued in coding each of the remaining eight Flows.

Identifying major topics was conducted in Step A of the coding process. Identifying major topics as a first step provided valuable meaning and direction with respect to Step B. Step A delineated prescriptive topics from subjective ones. Step B built upon major topics refined through Step A. Without identifying major topics into prescriptive or subjective categories, assigning energy to them would have been difficult to do accurately in Step B and would obscure the results. Identifying whether a Flow contained predominantly prescriptive or subjective criteria needed to occur first, as it directly influenced the rest of the coding. This was a direct result of the pilot.

Step A refined a noun or "noun-like" major topic in each Flow's regenerative criteria. During Step B, "energy" was combined with major industry topics from Step A. This was different from the coding scheme for the pilot test (2013). During the pilot, no effort was made to delineate major topics as being prescriptive or subjective prior to energizing yielded criteria. This lack created a confounding effect on the pilot's subsequent coding or its using Step A to identify major topics with presumed energy through their content-carrying nouns. In the pilot, content-carrying nouns confused Step A yielded criteria because subjective Flows had many adjectives supporting each focus point where prescriptive Flows did not. Thus, several unfounded criteria were yielded from the Beauty Flow and these were not reproducible. It became difficult to understand which adjectives were meant to add energy and which simply described a Flow's major topics.

Step B yielded criteria aligning with each Flow's conceptual definition. Linkages among individual focus points found on each Flow and the concept of the Flow itself became evident during Step B. In Step B, linkages among Flows were detected and began to reflect early stages of themes as design realities. The definitions provided for each focus point, on each Flow, were helpful in comparing yielded criteria from the previous step against the overall Flow concept.

Step B yielded refined, but fragmented subject matter criteria using "energizing" words and phrases to boost major topics. Step B yielded straightforward criteria on prescriptive Flows, which remained obscure on subjective Flows because most of their criteria contained several adjectives describing the same major topic.

When performing Step B coding, some Step A yielded criteria were augmented or altered using constant comparative reflection. Separating the "nouns that guided meanings to follow" (i.e., Step A) from "energizing words" (i.e., Step B) was difficult on subjective Flows (i.e., like Beauty, Culture). Step B refined criteria used in Step C, which provided a valuable review on Step A-yielded criteria.

Yielded criteria following Step B reinforced the appropriateness of the research methodology. Some Flows yielded criteria like the previous obscure form. Most yielded criteria revealed more specific information. Subjective Flows yielded criteria that were less structured than prescriptive ones, using adjectives for major topics as opposed to being in support of major topics. As coding of subjective Flows proceeded, yielded criteria congested and produced fewer overall themes, where prescriptive Flows yielded detailed networks, themes, and design realities.

For most Flows, yielded criteria were somewhat redundant among focus points but differed enough for the development of additional criteria. Step C was difficult to code for this reason. There were fewer original criteria remaining to sift through at Step C, but plenty of refined criteria from Steps A and B to group together and apply.

Thus, during Step C, Step B codes were first reviewed and compared against original criteria for appropriateness and accuracy prior to grouping and applying them in Step C as design realities.

During the first full coding process, Step A was completed on all Flows, then Step B on all Flows, and so forth with Steps C and D separately. During a second full review of coding, yielded criteria proved insightful by reviewing Steps C and Step D together on each Flow. This differed from the first coding review, where Step C yielded criteria were considered a culmination of Steps A and B, and Step D was the culmination of yielded criteria from Steps A through C. During the second coding review, Steps A and B were again accomplished independently across all eleven Flows, with Steps C and D done collectively on each Flow.

Table 2. Beauty Flow coding for ecology focus point. Example of coding processes.

Ecology Focus Point: Regenerative Criterion	Coding	Rationalization	Yielded Criteria
Biophilia is intentionally incorporated throughout design	Step A – Identify Major Topics	Ecological focus point guides intentions Biophilia is the subject matter	From the local ecosystem Biophilia or plant life
	Step B – Refinement & Application	Plant is organic life Intentionally incorporated	Plant life Representing the web of life among all living things
	Step C – Theme Creation & Definition	Organic life Biophilia	Plant life established on the interior and exterior Visual expression of living things
	Step D – Examine Themes Relevance Against Original Text	Examined as to how it evolved against original text	Design realities create interior plant life as a visual expression of all living things

Ultimately, performing Steps C and D together assisted in developing a cohesive set of themes and definitions placing them into regenerative design realities.

During Step C, yielded criteria were taken from a passive to active tense, by consolidating key similarities of yielded criteria. It was clear in Step C that regenerative criteria could not be refined into actions. Rather, Step C illustrated tangible regenerative similarities and definitions, leading the way to design realities. Realities were categorized in Step D, but not necessarily converted into prescriptive innovations. Step D refined a moderately coherent grouping of similarities from Step C as design realties were formed. Step D yielded criteria had to fit within the definition and usability of a "design reality" for a regenerative design and are presented as such.

Most design realities did not cite regenerative actions or attributes usable in engineered technologies. But, clearer regenerative themes emerged from the coding process. Relating regenerative design realities is accomplished in the Discussions and Conclusions.

Reliability

This study explored regenerative criteria for the Land Use, Transportation, Money, Energy, Water, Materials, Education, Ecosystems, Well-Being, Culture, and Beauty Flows. Revealed design realities are reported and discussed as guidance for regenerative design actions and attributes in Chapter Four.

Reliability was assured using four internal mechanisms and one external check. Internally, this study incorporated methods from previous works for developing sustainability accounting tools; integrated lessons learned from a pilot to better inform coding processes in this research; provided a detailed explanation of coding processes evolution including a codebook;

and utilized researcher cross-checking for intracoder agreement. This study employed cross-checking for intercoder agreement by industry experts.

Regenerative criteria were similar in concept and potential application as were sustainable criteria. Previous works legitimized inductive analysis for refining mixed methods criteria into relevant and tangible statements. Lessons learned from a pilot study concerning criteria from one prescriptive and one subjective Flow illustrated a need to refine coding processes for this study by adding an initial step for clarifying which Flows are inherently prescriptive or subjective. The addition of this step detailed explanation of processes and greatly enhanced the likelihood of replication. The researcher reviewed Flows criteria in two distinct ways to remove potential intracoder bias.

Externally, difference measures for intercoder agreement ensured the appropriate criteria were yielded at each coding step and matched the underlying meaning of each respective Flow. Criteria yielded in Steps A-D were cross checked on the first focus point of two Flows (i.e., Energy, Beauty) using a rate of agreement of 80% (i.e., one subjective Flow, one prescriptive Flow), by peer reviewers (see Appendix E). Reconciliations for differences in consistency by external reviewers resulted in rates of agreement below 80% were merged into the researchers yielded criteria.

Full instructions and a cross checking template are found in Appendix E – Inter Coder Agreement Template, which summarized reviewer agreements, additions, or deletions, if any. Agreements, additions, or deletions from reviewers were scored on a “one word for one word” basis. For example, if the researcher coded “plant life” from the term “biophilia” and a reviewer coded plant life as “natural life” then a score of one disagreement against two overall words existed. Disagreements are summed for Steps A-D for each reviewer, for their review of two

Flows, across the first focus points. Additions or deletions considered were disagreements in the researcher's coding were divided by the total number of yielded criteria in each coding step, expressing any changes. If, the level of change at any step reached .20 (i.e., 80% agreement), then reliability was sacrificed for a reviewer. A target of three reviewers was accomplished. No reviewers were familiar with LENSES©; all were familiar with regenerative conceptual design.

Overall interrater reliability was high, with all changes equating to 80% or higher. Interrater agreement is the strongest measure of consistency, replicability, and reliability. There was no need to reconcile any changes, as additions and deletions were lower than 20% across the tested Flows. Reviewers may have reacted differently if reliability measures were administered verbally to the full group at one time. The format of Appendix E allowed for the addition, deletion, or agreement of yielded criteria and used a fixed format. This isolated cross checking to individual templates used by individual reviewers. Presenting and discussing yielded criteria with other peers, recording differences, and reconciling them by adding new language and discussion may have provided robust, beneficial, or additional results through group synergy.

Validity

Four quality criteria were contemplated in establishing trustworthiness: credibility, transferability, dependability, and confirmability (Korstjens & Moser, 2018). Evaluating study quality is relative to use of the appropriate methods and methodologies concerning concepts studied, for example, replicating the methods for refining sustainability criteria concerning regenerative criteria (Bond et al., 2012; Colantonio, 2010; Gylling et al., 2011; Kyrkou et al., 2011; Poston et al., 2010; Rosas, Garcia, & Rodriguez, 2002; Umakoshi & Goncalves, 2010).

Credibility was established through persistent observation, linking criteria from the original focus groups to the findings of this study, including using examples. Several academic and industry professionals participated in creating regenerative criteria inclusive of design actions and attributes for the built environment in 2009 focus groups. Subject matter participants included architects, engineers, vendors, and trade crafts persons. This study recontextualized those criteria to align with participants' input and interpreted recontextualized criteria into realities that appropriately illustrated design action and attribute guidance. The researcher's interpretation drew from the experiences, professions, and comments originally recorded by focus group participants.

The potential to which the findings can be transferred to stakeholders, building types, or locations of other scenarios is vast and high. This study presented reliable findings concerning regenerative design guidance, without specifically stating design acts or attribute standards (Gylling et al., 2011; Robinson et al., 2011). Design realities provided regenerative direction for stakeholders to self-interpret or to continue discussions and work with other decision-making tools. Design realities ultimately related to the researcher's interpretations and to each Flow's sphere of influence as it pertains to built environments (Colantonio, 2010; Kyrkou et al., 2011; Poston et al., 2010).

Dependability relied on the existence of industry pathways for architectural and engineering diffusions using templates created in previous sustainability accounting tools. Industry stakeholders, some of whom assisted in creating original Flows criteria, are currently implementing a number of the findings. However, industry professionals unfamiliar with Flows criteria may consider yielded realities from this study since they overlap with existing sustainability tools, for they cannot be disqualified due to a lack of standing, and, because they match the current format and levels of comprehension provided in sustainable design acts and attributes.

Findings present yielded realities in an informal template as concrete guidance on how design can achieve an advanced state of regeneration. Each Flow is structured identically and reflected in its realities, which are visually and verbally explained and exemplified. Using real-time examples allows stakeholders a more basic comprehension of realities that is general enough to reach many members in the value chain of design and construction (e.g., architect to materials supplier).

Findings were confirmed using extensive detailing of study procedures so other concepts and tools may incorporate, develop, and enhance regenerative design using these procedures. A codebook explained how the process evolved, starting with the initial concepts and continuing throughout the analyses. Each reality was related to a practical and usable strategy and with an example of a design act or attribute to coincide with it.

CHAPTER FOUR: FINDINGS

The purpose of this study was to explore Flow regenerative criteria for design realities on Land Use, Transportation, Energy, Water, Materials, Ecosystems, Education, Well-Being, Money, Culture, and Beauty. Yielded realities fell into prescriptive or subjective categories and are presented as concrete statements and discussed as regenerative design guidance for built environments.

Each Flow's yielded criteria are illustrated in a word cloud for increasing comprehension. The shape of each word cloud is defined through criteria yielded and the subject of each Flow (e.g. yielded water realities are shown in a photo of water). Full length yielded realities are compressed into succinct statements for display in the word clouds (See Figures 4, 8, 13, 18, 22, 26, 30, 34, 36, 39, & 41). Realities are presented in long form, organized by predominant criteria with relevant supporting realities listed underneath. Similar realities using multiple adjectives, applied when changing the meaning of a criterion, have been merged into a singular reality for clarity. Word Art software was used to illustrate yielded criteria for each Flow. Word Art removes common words and numbers not already manually sorted by the researcher (Word it Out, n.d.).

Findings shed light on the research questions by illustrating regenerative design realities from eleven Flows. They also illustrate the need for additional development and research endeavors by showing related, but not coded realities. The Findings are formatted within the original structure of each Flow. In the Discussion and Implications, two research questions are discussed in relation to yielded criteria presented in this chapter.

The Land Use, Transportation, Energy, Water, Materials, and Ecosystems Flows produced prescriptive over subjective realities and considered regeneratively prescriptive Flows. The Education, Money, Well-Being, Culture, and Beauty Flows produced subjective over prescriptive realities and considered regeneratively subjective Flows.

Land Use Design Realities

Analysis of Land Use realities concerning farming and development of land for built environments encouraged proactive management through a balance-positive philosophy, involving consistent stakeholder participation in land use, land use planning, and design. Collectively, yielded realities ensured a continued functionality of pre-farmed or built land using natural landscapes and environmental services that land originally offered (see Figure 4).

Figure 4. Land Use word cloud.

1. Proactive site management ensures continued functionality of natural land.
    a. Ensures protection and preservation of ecosystems.
    b. Is balance-positive through a built environment.
2. Natural light harnessed from a site protects and preserves native habitats and species.
    a. Creates an ecosystem where native conditions thrive.
    b. Shall not be obstructed.
3. Natural land resources offset by built environments.
4. Land uses are to be balance-positive relative to a development site.
    a. Preserve and protect against human consumptions and their overall value chain.
5. A project's return on investment should be dependent on the monetary value a stakeholder assigns to the inherent and intrinsic environmental services provided by developed land.
    a. Intensive valuations should be undertaken.
6. A site balances farming practices and productivity using resources available.
    a. Cultivate and produce forest or agricultural or fishing products equal to the amount of naturally occurring resources within the environmental capacity on the land.
    b. Produces diverse varieties of products.
7. A site development is actively productive in eliminating construction waste both on and off developed sites.
    a. Eliminates pollution.

   b. Balances quality and quantity of resources.
   c. Draws resources through the carrying capacity of the land in a method and manner that further enhances natural resources harvested.
8. A productive site ensures ecological diversity.
   a. Supports and sustains native, organic species.
   b. Cultivates learning.
   c. Learning is interdependent on the link between land and humans.
   d. Accumulates soil.
   e. Creates native microbial communities using natural biophilia.
9. No facilities or infrastructure waste produced on or off sites.
10. A regenerative site maximizes reuse concerning buildable land.
    a. Uses existing facilities and infrastructure.
    b. Uses existing taps.
11. Smart growth evaluates and discusses existing and new development of facilities and infrastructures.
12. Built environments mimic nature and enhance native climatology.
    a. Enhance native temperature.
    b. Showcase history of the land using aspects of a built environment.
13. Local input dictates decision making.
    a. Inputs are diverse.

Forested land is designed to blend with its surrounding trees, landscapes, and other natural features. A built environment must be compatible with existing land use or in this case, forestry. This reality encourages the survival and survivability of existing resources provided to the natural ecosystem by the forest (Sayer & Campbell, 2004). Yielded realities dictate that regenerative architecture or design biomimetics be used for built environments to physically mimic and function as a forest.

Tree houses are examples of regenerative land use employing biomimetic design, like those found at the Kabania Eco Resort in Quebec, Canada (Kabania, n.d.). Overnight bungalows are designed as habitable indoor environments and constructed using a “tree house” concept, to blend into the setting of a natural forest and not disrupt happenings on the ground (see Figure 5).

Figure 5. Kabania Eco Resort. Photo of stilt huts representing biomimetic design.

Through design immersion into natural surroundings of the land on which it resides, yielded realities surpassing sustainable design by removing all traces of a construction footprint. Inversely, this permits an ecosystem to continue to function uninterrupted and without further augmentation or mitigation. In a forested environment, regenerative designs can include operations and maintenance procedures for ongoing seeding, care of undergrowth, and planting of trees near to where a built environment was erected. Doing so protects against past, current, and future carbon degradations in the same area caused by the existence of an artificial footprint.

Realities require that designs not obstruct forest life or natural lighting pathways, and preserve native habitats and species located there. The requirement not to obstruct existing pathways or flows within an ecosystem drives innovations in design and physical attributes like those of building contours, orientations, angles, and window lines. Any regenerative attributes used are designed as balance-positive, including offsets for their own production and usage and in augmenting impacted ecosystem elements like shrubs, plants, and trees.

The integration of living indoor walls, gardens, water fountain attributes, and transparent windows and clerestory glass ensures natural lighting and unobstructed views from one side of a design to the other. An example of a transparent exterior curtain wall using integrated biophilia is found at the College Central Building at the Institute of Technical Education at Singapore (see Figure 6).

Yielded realities place emphasis on stakeholders conducting extensive return on investment (ROI) analysis for incremental and holistic decision-making support. An ROI analysis must include monetary value for each design change, attribute integration, etc. ROIs represent environmental equity for losses of natural features within a developed ecosystem and losses to inherent environmental services offered by ecosystems, for example, removal of site trees to build a structure. Trees offer shade, oxygen, and fauna habitats to the supporting ecosystem (Lewis & Elmualim, 2011; Li et al., 2002). An ROI analysis determines some or all regenerative mitigations or augmentations provided to the land to make up for the removal of trees. Mitigation strategies include the replacement of displaced trees, shrubs, or insect colonies, plus one.

Figure 6. Greenroofs.com. Photo of interior biophilia at the College Central building at the Institute of Technical Education at Singapore. Connecting the planet + living architecture.

Realities require that built environments design themselves as isolated from natural ecosystems, existing as artificial indoor environments within the hypothetical dimension of a larger ecosystem. Designs must exist independently of the site occupied and do so without disturbing a site. Designs are integrated into the supporting ecology that existed prior to development using coordination and functionality of the attributes and features of a built environment. Effectively, this makes a built environment a singular component that cooperates within a larger interwoven system of ecological components.

Like the design of built environments, land use for crop production is restricted to the resources that are naturally available and contained within the land. Further cultivation or production of crops beyond that supported through its natural capacity is degenerative and unsustainable. Following regenerative criteria, a dryland pasture should not be seeded, fertilized, or watered as doing so exceeds its capacity to naturally produce dryland grasses, causing alternation and ultimate decline without continual artificial augmentations (Butera, 2010; Mang & Reed, 2015; Younger et al., 2008). Realities regulate crop production on existing land to intermingle with the local ecology, consistently and independently (Gao et al., 2013; Lacombe et al., 2012).

Yielded realities mandate that design for built environments or crop production consume site amenities and materials for everything inclusive to production or construction. For example, a one-acre pasture for cattle permits a basic stock barn for sheltering cattle. The number of cattle grazed on land must match available feed supported through natural, unadulterated grasses, and annual precipitation. Cattle must be rotated throughout the pasture to consume grasses in a manner that enhances the quality and quantity of next season's crop. If the site naturally supports three cows and one stock barn without augmenting food or water, then grazing three cows is a regenerative use of the land. Three cattle must consume the available grasses using a fixed rotation pattern, thus naturally amending the soil through natural fertilization with biological droppings. A productive pasture that grazes an appropriate number of cattle ensures environmental support for other native species of the same land (i.e., sustainable grazing plus natural fertilization for enhancing ecological diversity). Grazing the correct number of cattle or rotating pastures is sustainable, physically fertilizing it through animal droppings allowing native microbials to thrive. In turn, new biophilia are used to feed the same cattle again while keeping pace with the environmental services that currently exist.

Yielded realities dissuade new designs on or on top of new lands (i.e., removing and leveling forests and watersheds). Rather, realities specify that reclamation of existing land and facilities and infrastructures should be considered first. Reclamation of existing support facilities and infrastructure is a primary driver for reducing pollution and construction waste of new construction. Consider again a basic stock barn for supporting cattle.

Instead of abandoning the stock barn and building a new home on the same land, regenerative design could instead convert the stock barn into a building standing on the same footprint. Conversion and remodeling strategies optimize the existing footprint of buildable land and make use of existing water, natural gas, and electrical taps without further impacts where possible. Any excess usable materials from the stock barn are repurposed into fencing around the pasture, lessening pollution or waste from new development.

Site reuse and redevelopment, or new development, are intertwined. Yielded criteria advocates “smart growth” through extensive stakeholder planning, reuse, and redevelopment. While smart growth is not always possible, stakeholders should entertain expansive discussions and evaluations around the reuse of facilities and infrastructure.

An early regenerative example of land use design and housing development is the Cliff Palace located in Mesa Verde National Park, Colorado (see Figure 7). The Cliff Palace was home to an ancient civilization of Native Americans. It exemplifies design features mimicking natural land and materials while minimizing disturbances to environmental services. The Cliff Palace integrated multiple social, administrative, and ceremonial suites carved into the rocks within the ecosystem. Design shape and orientation are fully immersed into existing material contours and match the solar and wind patterns unique to the area.

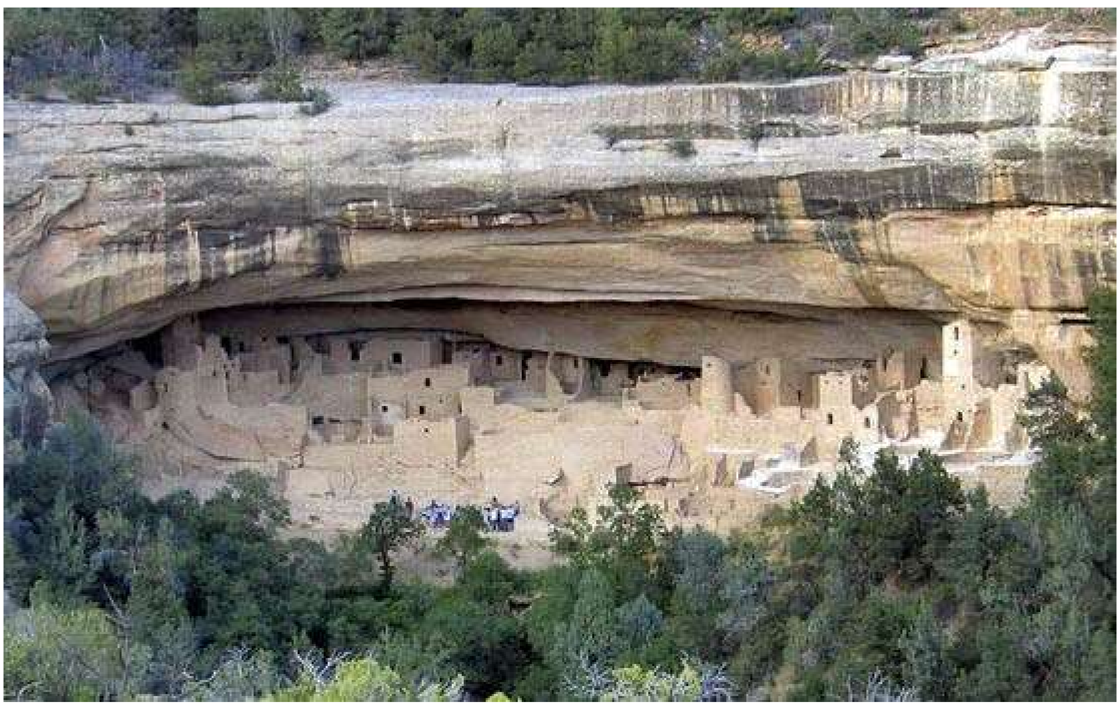

Figure 7. National Park Service. Photo showing regenerative land use through housing design at Mesa Verde National Park. Cliff Palace: Mesa Verde.

While the Cliff Palaces are not fully regenerative because they occupy what was once a natural feature with some of its inherent function, the ecosystem can be augmented through additional design to produce a balance-positive outlook. Examples of these may include creating rock dens to increase nesting habitats for birds; composting food to increase biological diversity in plant life; and utilizing the native geology by installing conductive attributes to capture the natural heating and cooling properties of the surrounding rock.

Transportation Design Realities

Yielded prescriptive realities for the Transportation Flow request multiple options of transport. These should be designed to be as equitable as possible to the natural environment and local wildlife. Transportation development requires the undertaking of extensive analysis of the life cycle impacts of differing options accounting for all byproducts, so that mitigation measures are accurately developed and implemented (Li et al., 2002; see Figure 8).

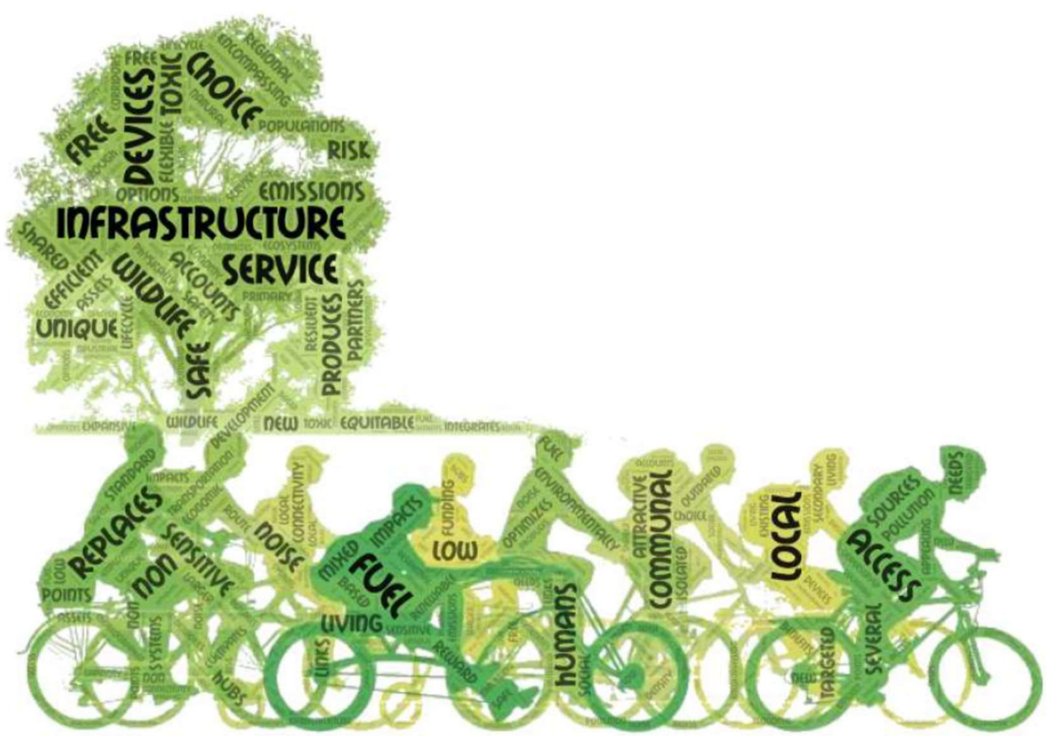

Figure 8. Transportation word cloud.

Transport realities surpass measures of sustainability because they require consideration of each separate impact. This construct restricts exponential growth of additional byproducts or environmental impacts through deployment of mitigation measures.

1. Transportation development is environmentally equitable to wildlife.
    a. Accounts for all impacts from fuel choice and emissions.
    b. Considers noise.
    c. Establishes a pollution-free standard for humans and wildlife.
    d. Uses renewable, clean fuel sources with low emissions.
2. Developments are several and are accessible and safe.
    a. Offers several attractive choices.
    b. Provides safe and accessible options for targeted populations.
    c. Optimizes mixed-use services.
    d. Shares risk and reward through connectivity with regional partners.
3. Transportation is flexible and resilient from conception.
    a. Replaces outdated systems and infrastructure.
    b. Produces economic security through assets and infrastructure.
    c. Integrates a life cycle-funding method for replacement and new devices.
4. Transportation includes coordinated accessibility to and from employment for isolated areas and those traditionally underserved.
    a. Physically links communities through unique corridors, and primary and secondary hubs.
    b. Access points are unique to the areas they service and include local devices that are efficient and appealing.

5. Developments are based on the needs of an area.
    a. Larger capacity in industrial areas and less dense in residential areas.
6. Benefits existing natural conditions of communal ecosystems by mimicking their environmental services and amenities.
7. Transportation infrastructure is sensitive to local economy and existing infrastructure, and expansive to social networks.
8. Transportation devices efficiently and consistently route to area sub communities.

Mitigation is the direct result of regenerative impact analysis concerning transport lines, routes, and supporting sites. Realities are based on and intended to offset damages to animal migrations, feeding areas, watering holes, and reproductive patterns, etc. For mitigation to be regeneratively holistic and not just incremental, an overall analysis must factor in secondary impacts caused by fuel emissions, noise, and reductions in open space.

Realities require transport options to utilize clean, renewable fuels for all modes and devices. This restricts fuel options to electric, hydrogen, or manually powered devices. Following primary reductions of environmental impacts, an equal amount of undeveloped land and re-created animal habitat must be set aside for ecological preservation above and beyond mitigation measures.

Realities call for options that are low or no noise to prevent disruption to the ecosystems in which they transverse. One reality indicates that transport pathways be designed to flow, twist, and follow the natural contours of the land, inherently minimizing noise effects to extrinsic animals, plants, and humans. For example, an electric commuter train track laid directly atop existing land, whether natural contours are hilly or swampy, is kept streamlined and directly adjacent to the topography to show how the ecosystem originally developed and should be maintained.

Most transport realities show that human-powered travel should be used as much as possible. Providing abundant walkways and/or human-powered driving lanes, is one example of a regenerative campus. A “foot traffic” college campus designating different lanes for bicycles and/or pedestrians is a regenerative reality of transportation. Several low noise, battery assisted technologies like electric bicycles, scooters, and mobility devices for travel currently exist that are low emission and accommodative (see Figure 9).

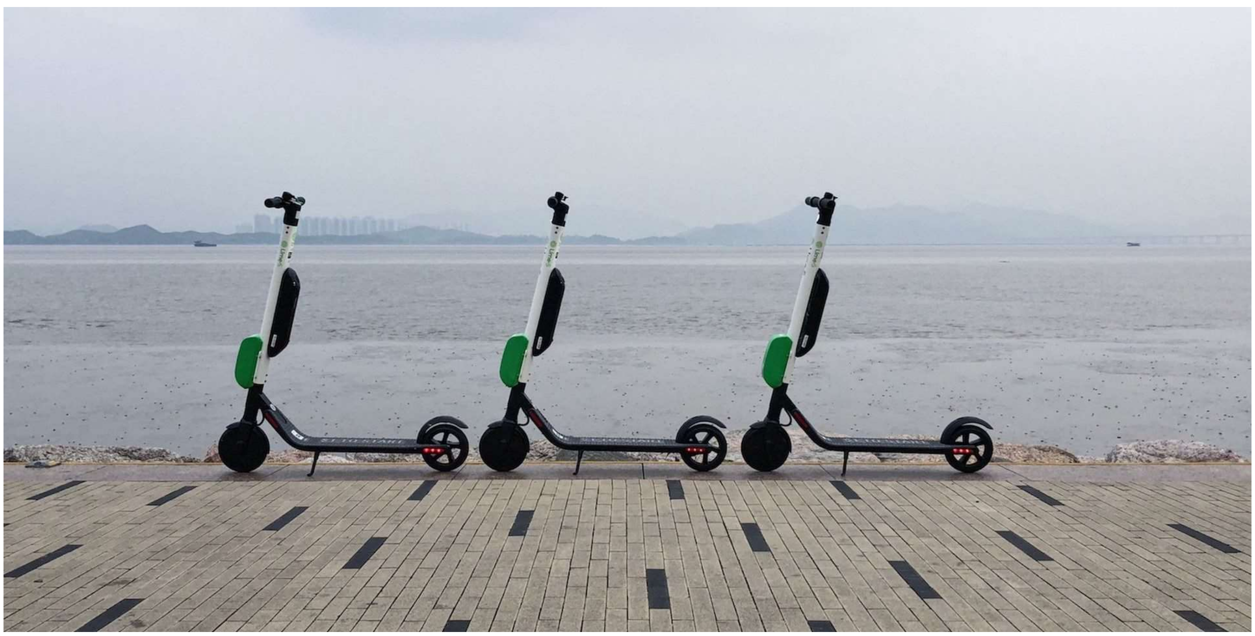

Figure 9. Electrek. Photo representing an example of a low emission method for personal transportation. Personal urban transportation.

An electric bicycle-sharing program and electrical wiring available at parking spots for use in recharging electric cars or bicycles constitutes regenerative methods of transportation. Moving larger groups of people requires a larger source of energy and a larger vehicle, for example, a bus or trolley, or a trolley bus system (see Figures 10-11).

Figure 10. Lausanne-Echallens-Bercher Railway. Photo of the Lausanne-Echallens-Bercher railway: A trolley bus system. Vaud: Lake Geneva Region.

Realities require accessible and safe options for targeted genders, minorities, and the elderly and disabled. For example, an “all female” bus operating after dark in high crime areas, a publicly shared wheelchair system for the mobility impaired, or a municipally sponsored taxi program operating 24 hours daily and 365 days yearly. Modes of transport must remain diverse and attractive, yet accessible and safe.

Regenerative modes of transport should be accessible for entire regions, splitting risk and spreading rewards (e.g., as a commuter train or trolley) to all. The same mixed-use, clean, and safe services should be offered across subdivisions and neighborhoods as well as towns and municipalities. Regenerative methods for ensuring the sustainment of mass transportation should include charging the same price to ride for all passengers (e.g., annual pass, monthly pass) and/or onboard employees and support personnel ensuring order and cleanliness. Also, posting a code of conduct fosters a sense of etiquette for passengers.

Realities are resilient but flexible in means of transportation and in their life cycles. Resiliency begins with extensive design planning and remains throughout a robust operation and maintenance program of transportation hubs, supporting sites, and other facilities. This includes the actual transport device, for example, an overhead powered electric commuter train.

Figure 11. Alamy. Photo of an electric car charging station. Electric car charging station with a Tesla sedan plugged in.

This type of train must be used in a tunnel with significant grade to operate efficiently and with low-use power requirements. Periodic operations and maintenance of brake systems must be factored into the design so that it is adaptable to retrofitting or repair during the operations and maintenance phases. Devising a plan for brake maintenance during the design phase is a regenerative procedure.

New modes of transportation, replacement and maintenance to support systems are “design inclusive”. Consider a central city trolley system. Historically, trolleys were the most efficient mode of rapid transportation in major cities. A trolley is now considered a tourist attraction. Using regenerative realities, the trolley's infrastructure and track system, or pathways, are redeveloped to fit a faster and more efficient trolley, train, or bus line operating along the same route.

Realities ensure that social and economic safety is widespread and comprehensive throughout new assets and infrastructures. An economic safety net is developed through ownership collaborations that support hub services, operations and maintenance service agreements, and value the sharing of partnerships at departure and arrival stations (e.g., ski resorts, airlines, coffee shops). A new sector of the economy is created from transport developments through collection of municipal taxes. A regenerative transport system has the integrated life cycle cost embedded within its costs, so replacements are forward-funded (Li et al., 2002).

Regenerative social design requires efficient routes for all patrons needing transportation, for travel to and from sources of employment, and for historically isolated and underserved areas. Serving traditionally underserved areas integrates a social safety net for blending impoverished areas with prosperous ones. Dense transport capacities should stay within areas appropriately zoned and remain outside of areas with high residential populations.

An example of a planned, expanded outlook for a regenerative transport system includes the Hyperloop concept. The Hyperloop is a revolutionary innovation for a moderate range passenger and freight transport consisting of a sealed chamber resting on air bearings, propelled using fluid suction inside a vacuum tube. This concept optimizes basic principles of physics through resistance-free travel at high efficiencies and speeds with low costs to operate. It is burgeoning regenerative technology and currently in its testing phases (see Figure 12).

Supporting infrastructures will have to be constructed for the Hyperloop that accurately match routes, speeds and costs, along with commuter migrations to make it efficient. However,

Figure 12. Dezeen. Photo of the hyperloop passenger pod and track system. Hyperloop passenger pods.

because it reduces cumulative and embodied amounts of resources (i.e., including time) required by moderate range commuters, the Hyperloop promises to be a sound regenerative design for mitigating negative impacts of emissions, noise, traffic, and habitat disruption.

Energy Design Realities

The Energy Flow yielded realities concerning the holistic cooperation of design attributes and the creation of energy for use by current and future generations. There are two significant dimensions to energy creation: the physical generation of energy and the transfer of energy into storage for later use (see Figure 13).

1. Invests in projects that support energy for future generations.
    a. Utilizes less energy than solar equity or endowment available for it.

b. Creates energy above that which is spent using it.

c. Produces long term and infinite global supplies.

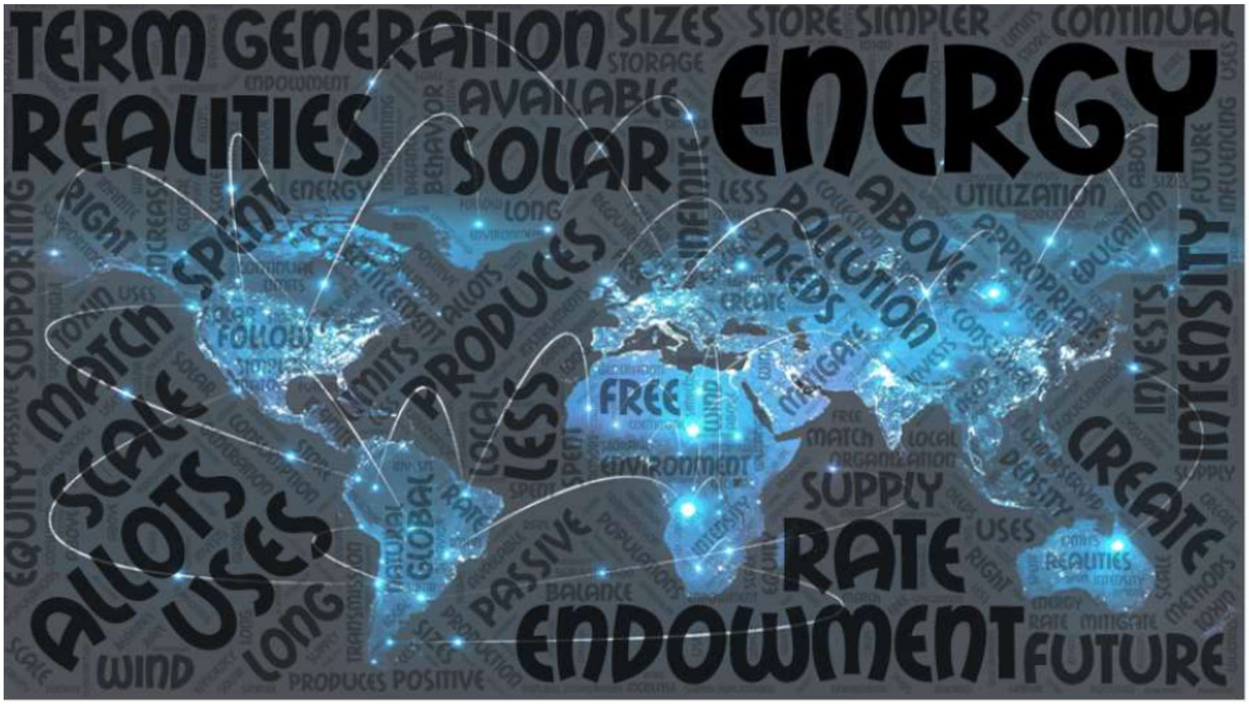

Figure 13. Energy word cloud.

2. Incorporates design realities at an appropriate scale and intensity for project needs.
    a. Matches allotment with entitlement.
    b. Right-sizes project needs with consumption.
    c. Allots energy to underserved populations first.
3. Incorporates continual education for influencing consumer behavior.
4. Matches the allotment of energy to the scale of design.
5. Limits intensity requirements to produce a simpler utilization rate.
6. Realities mitigate pollution caused by energy production.
    a. Generates on-site energy using passive realities of solar and wind.

    b. Stores energy in a passive environment.

7. Energy transmission and storage are pollutant and toxin free.

    a. Follow local, natural methods of transmission where energy is produced and used.

    b. Increases density through efficiency of collection and storage instruments.

8. Increases organization upon transmission.

9. Produces a balance-positive sequestration rate.

The sustainable design industry has developed several technological attributes and renewable energy integrations for use in built environments. These attributes reduce byproducts caused by fossil fuels because they are efficient. In some cases, renewable attributes produce energy surpluses and outpace their overall carbon footprint. Examples of direct source and active energy generating attributes are solar electric photovoltaic (PV) panels (i.e., convert sunlight into electricity using battery storage; see Figure 14), solar thermal heating panels (i.e., converts sunlight into heat using steam), and wind turbines (convert wind speed and force into electricity and storage through an electrical grid; see Figure 15).

Unfortunately, energy generating attributes began their life cycles by harvesting, processing, and refining materials from tertiary ecosystems (Keeler & Burke, 2009). On average, it takes 30 years to regain the economic costs of construction for a solar electric PV panel, not to mention the social or ecological byproducts that factor in the overall rate of return (Giama & Papadopoulos, 2012; Poston et al., 2012). Creation of surpluses can contribute to the replenishment of an electrical grid and an ecosystem. It is impossible to create energy without material consumption, thus regenerative attribute engineering and technology are restricted to the following paradigms: conservation through efficiency (i.e., cogenerating; and replenishment through surplus (Poston et al., 2012).

Figure 14. Alliance for Wise Energy Decisions. Integration of rooftop solar photovoltaic panels for energy creation. Solar.

Energy creation using attributes boils down to basic physics. Energy occurs within natural ecosystems and without consumption of fossil fuels. The earth and its ecological subsystems have catalytic processes for chemical, mechanical, and environmental reactions. These processes manifest as ocean tides and lunar gravity, air currents and carbon exchanges, and sunlight intensity and ecological decompositions (Mang & Reed, 2015; Thomson & Newman, 2017). Harnessing and storing this energy or recreating it without fossil fuel consumptions, in long term and accessible ways, are challenging (Kua & Lee, 2002; Moffatt & Kohler, 2008).

Figure 15. How do Turbines Work? Example of a rooftop and commercial wind turbine for energy creation. Energy.gov: office of energy efficiency and renewable energy.

Realities specify that built environments "design for decreased energy usage" matching the endowment of solar energy available. Normally, energy requirements are calculated from an electrical plan that specified the amount of energy intensity delivered to the front door. Yielded criteria limit that intensity to the available solar resources in the area while eliminating redundancy. For example, built environments designed to face south will optimize solar heat gain using sunlight, thereby decreasing energy used for heating and cooling (Essa & Fortune, 2008; Hardie & Newell, 2011).

Realities require that design of appropriate scale per intended use removes footprint redundancies like those found with "peace of mind" attributes (e.g., running one boiler instead of two boilers for fear that one boiler fails). Designs requiring high intensity or high need electrical design, like manufacturing mills, would be placed in areas of high solar irradiance. The same energy construct applies to proportionally reducing consumption, like placing high-use residential consumers in sunny areas and low-use consumers in cloudy areas. Realities specify the installation of high-performance lighting, efficient water heating attributes and hot air recirculation systems, and point-of-use components.

A holistic design aligns stakeholders' perceptions with available energy and with what is needed. Realities allot inexpensive, improved, and cleaner energy to underserved populations first. Underserved populations get priority access to energy as opposed to manufacturers that mass purchase energy. This reality is in direct opposition to the current merchandising of kilowatt hours where mass purchasing increases demand and the price per unit, thus favoring those who will buy more. Realities reallocate energy equity to those who cannot pay a high price but have a right to energy equality (e.g., schools, remote villages, or mission-critical systems). This can be accomplished using municipal regulations, utility shares, and/or fixed credit donations.

Designs are regenerative through reductions in consumption and by generating energy independently. Active and passive solar and wind attributes, or other building features, have the capacity to contribute to electrical surpluses. Designs that generate surpluses are used to offset the overall carbon footprint of the built environment and all facets within it. Surpluses are nearly impossible to use within the same footprint because of current inefficiencies of storage and transfer.

Renewable energy can be passively designed but must be free from toxins and generated without pollution. Passive solar and wind integrations are specified in the yielded criteria. Designing a passive built environment requires advanced analysis of an ecosystem to mimic its features. For example, animals dig burrows for shelter in cold climates. Applied through a regenerative design reality, this manifests as a solid core rammed earth wall, dug into a hill or mountainside. A rammed earth wall is a passive solar thermal reality mimicking the local ecosystem's animal life.

Passive solar design has made considerable inroads in sustainability and requires no direct interactions with other components. The problem is passive design simply absorbs and disperses. Yielded criteria surpass sustainability inroads by specifying that designs physically generate energy and store it for later release, using passive architectural mechanisms.

An example of a renewable architectural mechanism is the Eastgate Center in Harare, Zimbabwe. The Eastgate Center incorporated rooftop pinnacles, modeled after nature for heating and cooling using the stack effect (see Figure 16). The Eastgate Center's ventilation system was modeled following analysis of termite mounds in the local ecology (Gao et al., 2013; Gregorieva & De Freitas, 2013; Moffatt & Kohler, 2008; Younger et al., 2008). The concept consists of passive intake and exhaust ducts for conducting air currents using a thermosiphon, which created indoor cooling without significant energy consumption. This is accomplished using a series of cross-drafts and cooler, low-lying layers of air that, with horizontal vents combine to be cooler. Air is returned to the outside with no added adverse effects. This system is designed to be transient and uses available air flow relative to the ambient conditions. It does not store energy or energy potential for later release but does absorb and create air movement using conductive circulation.

To create and store energy using passive design, it must be done using a fluid (e.g., air, water, vapor) or a direct exchange with an associated mechanical, electrical, or plumbing attribute (e.g., solar panel, wind turbine; heat exchange through concrete walls and/or geothermal efficiencies). The physics of energy make its creation without consumption very difficult to accomplish. Passive and indirect solar homes are closer than ever to creating energy through static design.

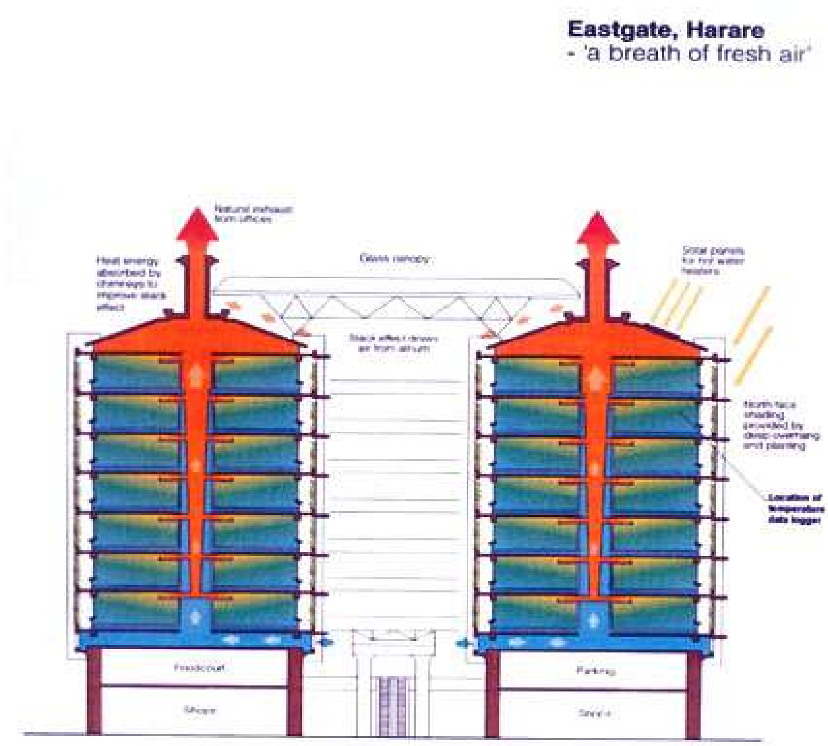

Figure 16. Biomimetic Architecture. Biomimicry’s cool alternative: Eastgate Centre in Zimbabwe.

Integrated earth homes (i.e., sometimes referred to as “bag homes”) use the ecosystem to stabilize the energy flowing through a built environment, primarily in the form of retaining or releasing heating and cooling. An adobe house built one story below grade in a hot climate allows for passive, pollutant-free reductions in thermal cooling in the summer and the opposite in the winter. Stability in temperatures occurs by thermal conduction through walls, roofs, and floors. Regenerative design can improve this natural efficiency using thermal massing. Hydronic hot and cold water piping can be added for domestic use to capitalize on existing solar thermal gains and losses. Solar PV panels mounted on roofs will power point-of-use storage for immediate electricity while also shading a rooftop garden.

Yielded realities for the energy construct specified that energy storage and transmission follow natural methods in the ecology, both where it is produced and used. Adobe houses nestled into the landscape create energy in the form of heat during the day, which is then stored in the surrounding earth using thermal conduction and accepted back at night through the same system. The installation of thermal bridging attributes, like those found in exterior cladding materials or steel structural beams, assist areas of sensitive temperature needs by increasing a structure's capacity to heat and cool more rapidly than its surrounding walls. Using ground pumps to draw water from the earth, circulate it through a cooling coil that traverses steel support beams, then return it to the ground, will super-cool a beam faster and function as a regenerative air conditioning system. When the earth's properties are harnessed to pre-cool a hydronic cooling system, a toxin- and pollutant-free reality is created.

By following the natural methods of energy generation from the ecosystem, a design reciprocally increases energy density. Designs in accordance with the natural principles of physics upon which the local ecosystem is based include: thermosiphons, fluid circulations (e.g., thermodynamics of air movement), convection and conduction (e.g., through thickness of walls; heating and cooling sinks), as well as condensation and gravity for improving efficiency and assisting in storing surpluses by decreasing overall resistance.

Realities specified the need to educate energy consumers. This is important for reducing overall consumption and correcting perceptions of energy entitlement. This reality presumed that stakeholders' behaviors are directly affected when the utility bill arrives and is expensive. Cost sharing among occupants and owners or builders and designers is a reality for continually educating energy stakeholders in reducing consumption.

For example, an expanded regenerative reality for powering residential developments is achieved by designing localized generators instead of relying on the traditional power grids (Tian et al., 2010). Most residential developments utilize power taps that split off from the main and provide electrical service to each residence. Because electricity is kinetic, it is inefficient when transmitted over long distances. It is generated at a central location and transmitted via direct current (DC) through high voltage lines into substations where the same electricity is converted and delivered as alternating current (AC) (Li et al., 2002; Preservation Green Lab, 2008).

Installing localized electrical generation for serving five-house clusters removes large amounts of kinetic loss from that of traditional delivery (i.e., losses due to DC/AC conversion; see Figure 17). Regenerative realities for local utility systems include integrating shared solar fields into common spaces or rooftop mirrors on each residence that align with a steam generator on a central water tower. Each residence has a main service line traveling directly to it from the local generator.

Water Design Realities

The Water Flow yielded realities in relation to the enhancement of water quality, designing according to the availability of water, and reducing consumption using low-use irrigation controls, faucets, showerheads, pre-rinse spray valves, and toilet fixtures (WaterSense; n.d.). The cumulative goal of this construct is to reduce overall impacts to ground water resources (see Figure 18).

Figure 17. Hys.org. Photo of large-scale reflective mirrors for redirecting sunlight to shaded communities. Giant mirrors bring winter sun to Norwegian village.

Figure 18. Water word cloud.

1. Design realities reduce ground water consumed.
   a. Replace ground source water mined.

    b. Decisions on design account for all aspects of water production and consumption during attribute life cycle.
    c. Design decisions are made using the total calculation of embodied water impact.
2. Realities include an interactive visual system showing the amount of water consumed for educating and predicting and trending water consumption.
3. Realities ensure equality in amounts used.
    a. Share the penalties and benefits among stakeholders for use.
    b. Limit stakeholder consumption (i.e., assigning a value to pristine, untapped water sources) so that water has "a right to exist".
4. Ground water consumption.
    a. Use is variable.
    b. Balances the amount consumed to the season and its natural availability.
5. Use of ground water improves potable water quality before returning it to the environment.
    a. Despite its previous toxicity.
6. Realities cultivates an integrated water system to be in harmony with nature.
    a. Scales realities to natural ecosystem parameters.
    b. Water relationship is cooperative and fits into the ecological cycle of climatology.
    c. Designs appropriately scaled systems.
7. Decisions follow guidance of interdisciplinary perspectives and metrics.

   a. Displays the essentials of water in associated realities through connections with people.
   b. Education is displayed across boundaries and aquatic areas.
8. Realities ensure security and accessibility of water for all living things.
   a. Measures secure storages of water and treatment.
   b. Calculates repetitive quantities from consumption and usability.
   c. Restores ecological balances using storage methods.
   d. Storages of water to ensure its own security and future availability.

Realities generate and capture water using the features of a built environment. Practical examples include large-scale attributes like common area dehumidification processes, thermal traps in building drains, waste heat and cold sink condensation and their associated tanks and catchment ponds, as well as rooftop drains for diverting rainwater. If a pipe directly returning water to an aquifer cannot be designed or municipally permitted, then captured water can be stored in intermediate tanks or ponds and diverted onto interior plants and flower beds or exterior grasses. Regenerative examples of water filtration attributes that improve water quality include intensive green roofs and rooftop gardens (see Figure 19).

Realities require a comprehensive life cycle analysis for all water-reducing attributes and fixtures, both holistically and as individual increments or components of a larger subsystem, like a drainage system (Giama & Papadopoulos, 2012; Haddad et al., 2003). Holistic analysis of these attributes creates an embodied value for water per unit of delivery. The unit value encompasses all aspects of the water life cycle, from manufacturing of devices to the supply and return of water transportation, including its mining and sanitation efforts (Keeler & Burke, 2009; Li et al., 2002). This value establishes a metric for stakeholders to use for decision support.

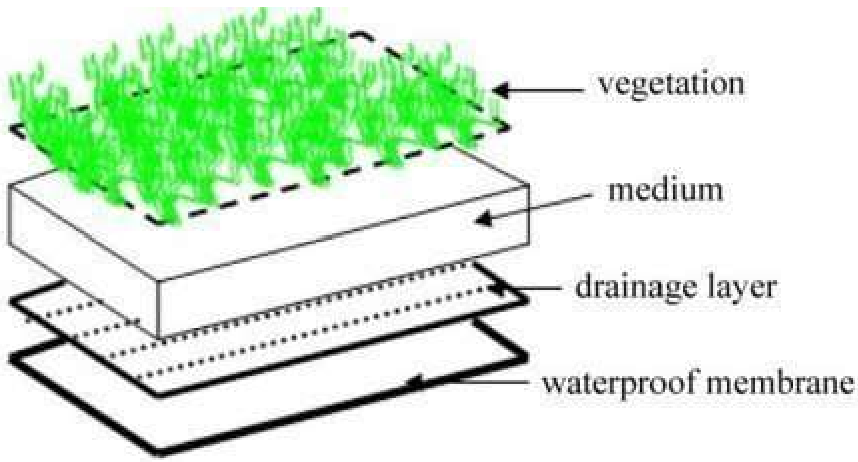

Figure 19. PennState Extension. A profile schematic for a green roof stormwater filtration system. Greenroofs for stormwater.

Realities require an interactive visual attribute for showing water consumption designed to educate occupants about water consumption and used for predicting future needs. A flat screen television mounted in a main lobby that uses commercial sub meters and accounting software to update displays regularly is a regenerative reality. Depending on the software, the value chain of water can be visually displayed using graphics or comparisons to the overall amount of carbon used. Operations- and maintenance-driven attributes for interactively displaying consumption are glass drainage pipes with inline meters and integrated waterfalls (see Figure 20). A visual display is the most effective method for educating occupants about consumption and capacity of the water construct. Visual displays inspire collaboration among owners and occupants reducing consumption. Like the energy construct, cost-sharing of water provisions among stakeholders will have the same effect.

Balancing the amount of water consumed with the appropriate climate and season for determinations of availability is a regenerative reality. Practical attributes consist of non-potable

Figure 20. Dezeen.com. Photo of a building integrated waterfall in China. Chinese skyscraper incorporates 108-metre high waterfall.

retention ponds, storage tanks, and graded exterior confluences for trapping or capturing water and delivering it for refinement or use at a fixed point. Potable but untreated importation is useful for interior biophilia and easily acquired using snow melt, condensation, or roof runoff (see Figure 21).

The water construct surpasses sustainability by requiring independent generation of water using an artificial space, for example, through the installation of indoor, intensive biophilia boxes. These types of boxes are placed into concrete subflooring and capitalize on the earth's temperature stability using the principles of conduction.

The biophilia bed uses rock or concrete as its base, which extends below the frost line. Extending a monolithic box below the frost line creates a temperature differential between the earth and the above-grade conditioned air inside a building that is insulated by the soil. Moisture develops through evapotranspiration and collects on leaves. This moisture is captured and reused on the same plants that helped to produce it (Brauman et al., 2013; Gilbert et al., 2011; Kelly, 2014; Lacombe et al., 2012).

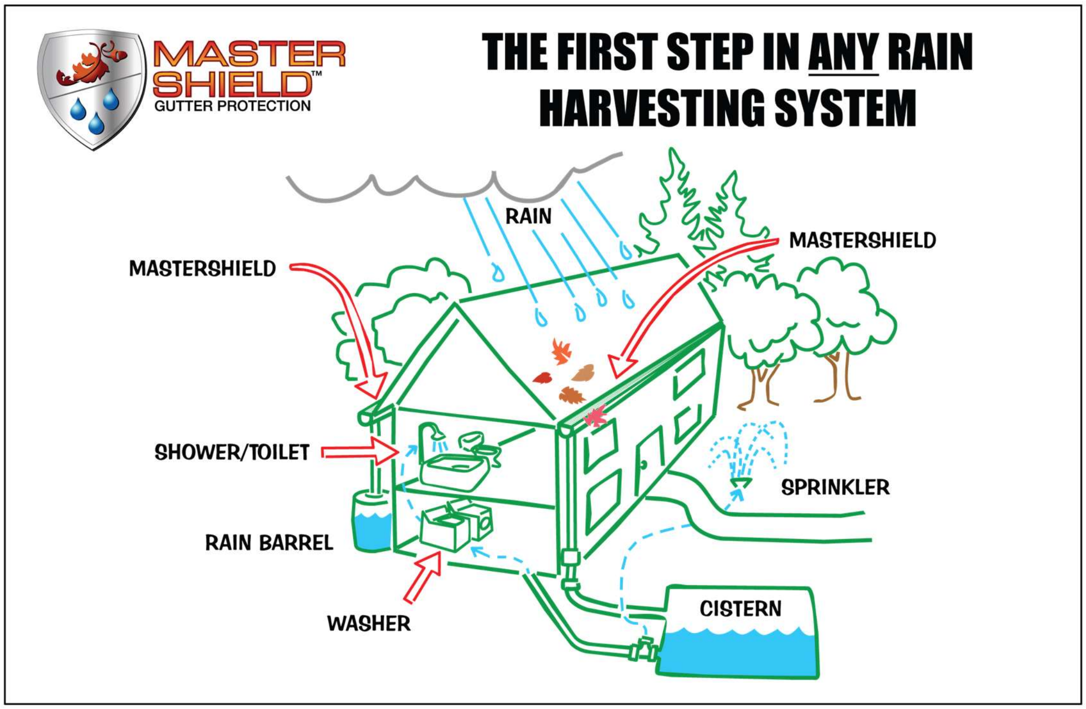

Figure 21. Mastershield. Design schematic for harvesting rainwater. Start rainwater harvesting with Mastershield.

Realities specify that water be improved before it is discharged. This is required regardless of its prior level of toxicity. According to building codes, potable water for human consumption must be supplied to all fixtures (International Building Code, 2018). Drinkable water is treated to a neutral ph at a district plant and delivered using a municipal grid and main tap. Once potable water is consumed, it is discharged in the same manner. For example, in toilet discharges, unsanitary water goes to a collective discharge using a series of pipes routed back to a treatment plant (International Building Code, 2018; Chapter 29). Recovering this water and restoring its quality prior to discharge is regenerative but requires pre-treatment attributes.

Diverting unsanitary wastewater requires capture at a centralized tank for pretreatment procedures. Regenerative attributes like composting or macerating toilets aid in pretreating wastewater using a tank. Chemical treatments are another viable pre-discharge option using acid neutralizers and automatic injection of bases or acids. Adding natural bacteria is a non-toxic method for breaking down wastewater prior to discharge. This is common practice in septic systems before leaching water into ground sources. Other pretreatment realities include evaporating non-potable water using redirected waste heat or through active solar energy systems. The use of worms to break down waste in vaults and leach fields and usage of expansive leach field piping are regenerative pretreatment realities.

Regenerative realities specify a "feeling of place" concerning water; one that cultivates and maintains the interface between interior systems and exterior landscapes. If pressured underground water is available, a design capitalizes on a natural spring to gravity fill an indoor pond for occupants' serenity and comfort. An overflow pipe is installed to allow drainage back into the aquifer. Likewise, sites with outdoor facilities (e.g., zoo) direct animals to drink directly from lakes and streams using unpressurized spouts, tanks, mix fixture and process filtration. Seasonal availability and the amount of water provided are exemplified through any attribute that reduces consumption.

Indoor realities design for low-, medium-, and high-use fixtures to accommodate the availability of water within the region. In times of low availability, ballast tanks or small stock reservoirs are used to maximize inside pressure, both for potable drinking water and non-potable irrigation water. Hot water loops are installed on domestic supply lines to deliver heated water to occupants more rapidly using a thermosiphon effect, thus saving overall carbon.

The water construct presumes that at some point in time, water will disappear or be disproportionately available. Some years receive more moisture than others resulting in floods and droughts. Regenerative realities require full integration of the built environments in concert with the average precipitation of local climatology. For example, a reuse structure placed on the same footprint as a former dryland barn will not appropriate large stocks of water, as it was previously dryland. Landscaping on dryland will consist of naturally occurring grasses and rock gardens instead of lush blue grass.

Water security and accessibility are regenerative realities. The ability to store water and have it available so that stakeholders can see, smell, and feel it solidifies its right to exist. Site attributes, like lined ponds and neighborhood allocated reservoirs, illustrate to stakeholders their reliance on water and aid in their understanding that water must exist for survival. Outdoor capture ponds, modified site gradients and confluences, and other methods that capture stray moisture and fill local reservoirs are regenerative. Sites that collect and store water using design features will integrate capture features that agree with the local ecology (i.e., biomimicry) (Gao et al., 2013). Capturing water in a natural depression using the same methods for which it can be accessed by local animals is a regenerative reality.

The measurement and maintenance of water supplies are essential, requiring extensive procedures for monitoring inventory (e.g., check sheets and review of utility bills for consumption). Operations and maintenance procedures specify augmentation planning as highly scrutinized calculations that include projections and consumption. Water is better tracked and understood using digitized flow devices to help plan for high- and low-use months.

An expanded example of regenerative design includes capture of storm water in a centralized, local site pond. Sized accordingly, a cluster of five residences can use a pond for irrigating purposes. A direct system of transmission and dispersion must be integrated. A large part of water's negative embodied value can be removed if natural rainfall is collected and used in natural landscapes.

Lawns act as a filtration device for water quality. A neighborhood pond designed to capture naturally occurring storm water may also accept raw or untreated water from households that use natural detergents in washing machines (i.e., a gray water). This is one method of enhancing the availability of water for a neighborhood pond. Water is then reused on lawns, which filter it and return it to ground sources.

Materials Design Realities

The Materials Flow yielded criteria relevant to the types and uses of materials in a design and in their range of applications (e.g., from furniture fabrics to structural wall studs). Presuming a design meets required structural building codes using certain materials, then, practical applications of regenerative material realities are best understood by discussing a basic wall system. Understanding a basic wall system limits the complexity of this example (see Figure 22).

1. Design realities use no more materials than needed.
    a. Creative mechanisms reduce consumption.
    b. Use that which is effective, simple, and uncomplicated.
2. Design implements extensive investigations into selections for water use.
    a. Investigates specific uses.
    b. Utilizes acts and attributes with properties that degrade completely into the appropriate mediums.
    c. Transfers into and rejuvenates ecosystems.
    d. Recycles, composts, or reuses within the local ecosystem.

Figure 22. Materials word cloud.

3. Design elements are based on a life cycle of well-being.
    a. Healthy, natural materials positively impact comfort and beauty and social responsibility.
    b. Inspire and celebrate natural materials.
4. Water acts and attributes are connected to nature through being created by nature.
5. Realities increase social equity and quality using fair and appropriate selection procedures.
    a. Holistic investigative and selection procedures.
6. Materials with low embodied values have lower impacts in production and delivery.
    a. Exclude infinite perceptions recognizing unlimited raw materials.

   b. Created to feed habitats through the habitats that created them.
   c. Net zero-waste facilities and site footprints or impacts.
   d. Nurture habitats by not harvesting or performing post-harvest augmentation.
7. Use systems from local or regional habitats.
   a. Supports local production, delivery, and installation.
   b. Prevents degradation to subsidiary ecosystems.
   c. Ensures self-sufficiency and long-term economic health.
   d. Encourages community partnerships.
   e. Excludes overpriced production and labor from external areas.
   f. Encourages regional inclusion in the appropriate context of culture propagating dignified selections.
   g. Represents the region and promotes a sense of place.

A basic wall system is made of wood or metal studs and a type of fasteners to bind the studs together. Structurally, a wall holds up the roof and provides support to the building, allowing it to stand. Walls have fenestrations (i.e., windows and doors) and electrical components embedded within them alongside heating and ventilation duct penetrations. Exterior walls are insulated. For this example, a typical structural wood stud wall is discussed as an attribute-based regenerative diffusion. No fenestrations or electrical or ducting penetrations are considered, no wall anchorage or component fasteners are considered.

An exterior wall is a rigid panel of specified height, width, and depth. Material properties for constructing a wall are often selected using the cheapest wood and sources satisfying an engineer's requirement according to building codes (International Building Code, 2018).

Wooden wall studs or two-by-four milled lumber are the most common application. Studs are produced by harvesting trees in one ecosystem; milling, drying, and planing them in another ecosystem; and, then shipping to a construction site in a third ecosystem for installation (Preservation Green Lab, 2008; Swiatek, 2017).

Realities consider wood studs connected to nature due to their creation in nature. This requires production of dimensional, structural lumber from trees already located on a project site. Consumption of site trees prevents harvesting of trees from other ecosystems and the potential for interruption to expanded planetary interdependencies (Gao et al., 2013; Lacombe et al.; 2012). To be regenerative, a tree must be milled to become dimensional lumber for construction, and used within the same ecosystem to be regenerative. Following the harvesting and full life cycle of this wood, which is considered a structural member, a tree's usefulness is complete when it has been deconstructed and mulched, shredded, or composted on site, going back into the soil from which it came (Keeler & Burke, 2009; Li et al., 2002; see Figure 23 for nature taking over a built environment).

Sustainability accounting tools do not encourage on-site harvesting or milling of structural grade lumber or the return of lumber to compost, chips, or shreds to native ecologies (IFLI, n.d.; Leadership in Energy and Environmental Design, n.d.). The materials construct surpasses systems like the Leadership in Energy and Environmental Design or LEED tool and the Living Building Challenges Standard by requiring a full-circle biological process and transfer medium for an end-of-life wood disposal.

Realities require that a fully embodied life cycle value be placed on materials from trees, for instance, which are used for wall studs. This value is established using an inclusive value for degradations caused by harvesting and producing studs on site. The result of any negative

Figure 23. Colour Box. Photo representing nature reclaiming a built environment. Norwegian country house.

impacts caused by harvesting local trees is offset through augmentation measures and replanting. For example, the front load wall in Figure 23 is comprised of approximately 15, eight-inch round logs stacked atop one another. Replanting that same number of trees within the local habitat ensures future forest health and reproduction.

Replacing trees consumed is a recognized procedure in sustainable building. Regenerative realities surpass sustainability by requiring replenishment of all values that are or were “potential” to a tree or known to be lost from its harvesting. This ideology calculates the value of trees for all their known benefits that, for some, will include the birds that nest in them and the value that those birds provide (Keeler & Burke, 2009; McLamb, 2011). For example, raptors prey on woodpeckers and woodpeckers bore holes in trees. An acceptable augmentation plan will replenish woodpeckers and raptors, and will ensure the appropriate growth and function of trees throughout their normal life cycles.

Harvesting local trees visibly alters a site's appearance and reinforces stakeholder perceptions that raw materials are a finite resource. Designers literally bear witness to impacts on native forests and vegetation that a built environment makes. This is unique to the regenerative materials construct. By impacting stakeholders' perceptions, an extensive investigation into the need for building size and the amount of materials required are triggered (Moffat & Kohler, 2008; Rogers, 2003).

The materials construct seeks to waken the consciousness of stakeholders, anticipating their aversion to the removal of site trees. In turn, stakeholders reduce their needs in order to save forests (Chiazor, 2009; Ellis, 2011; Lewis, 2011). Physically or visibly marking trees designated for "construction harvest" prior to construction alters mindsets that structural wood, and to a larger degree forests, are in ample supply. Using no more than is absolutely required for construction is the goal of this reality.

An understanding that wood is required for structural purposes and trees provide that wood, and that deforestation will occur without appropriate augmentation, makes the ultimate point for using materials constructed with wood. Reduction in the footprint of a built environment is a purposeful and intended reaction, ultimately driving creative diffusions in design shapes, angles, and orientations to reduce harvesting (see Figure 24).

Realities specify that designers employ creative mechanisms for reducing overall wood uses through uncomplicated, simple framing solutions. The mechanisms are monitored by project management. Examples of practical diffusions for these include low-edge rooflines (i.e., eliminating distances to ground, decreasing material); designing modular wall systems and prefabricated beams like microlams (i.e., replacing large structural members with smaller pieces); and reusing waste (i.e., creating particle board or plywood using scraps). In the case of plywood, processing facilities will need to be placed on-site so all unusable or smaller sections of wood including chips, shreds and knots, and other waste can be joined into usable pieces (see Figure 25).

Realities require regional vendors, mostly because local labor contributes economically to enhancing social equality in areas otherwise vulnerable to cheaper, imported labor or materials. The harvesting of wood and its processing and installation create opportunities within communities through use of local labor. Newly generated local businesses are ensured self-sufficiency and long-term economic health through a secondary economy.

Realities surpass sustainability through creation of a primary and secondary commodity-based social system for generating income. Initial income from wood production, is enhanced a second time by supporting local infrastructures such as grocery stores, housing, and health systems for laborers and their families. This application of primary and secondary social systems parallels "biological sustainability" as discussed by Brauman et al. (2013) and Gilbert et al. (2011), stating that an activity is sustainable if it has a reproductive element, such as secondary income. Criteria yielded exemplifies this through propagation of self-sustaining partnerships and collaborations through labor and adds a social element to the economic health of the local populace.

Materials realities are usable in evaluating all items in design and construction, but are strongly dependent on stakeholders' desires to do so. Analysis and application of all materials in a design can be simple or expansive depending on site factors, intertwined realities with other

Figure 24. Skydome. Rendering of innovative framing concepts due to available site lumber. House of the future.

constructs, and project factors. Material realities have illustrated how to convert site trees into wood studs for basic wall systems.

An expansive example of regenerative materials usage in built environment design is considered with hand soaps. Plant-based hand soap products are commercially available and simple in their applied uses. Plant life is natural and ecologically sound. Using the materials construct, plant-based soaps are usable in washrooms of commercial buildings. This removes toxins and lowers the amount of pretreatment to sanitary water, yet meeting the needs of clients (Preservation Green Lab, 2008).

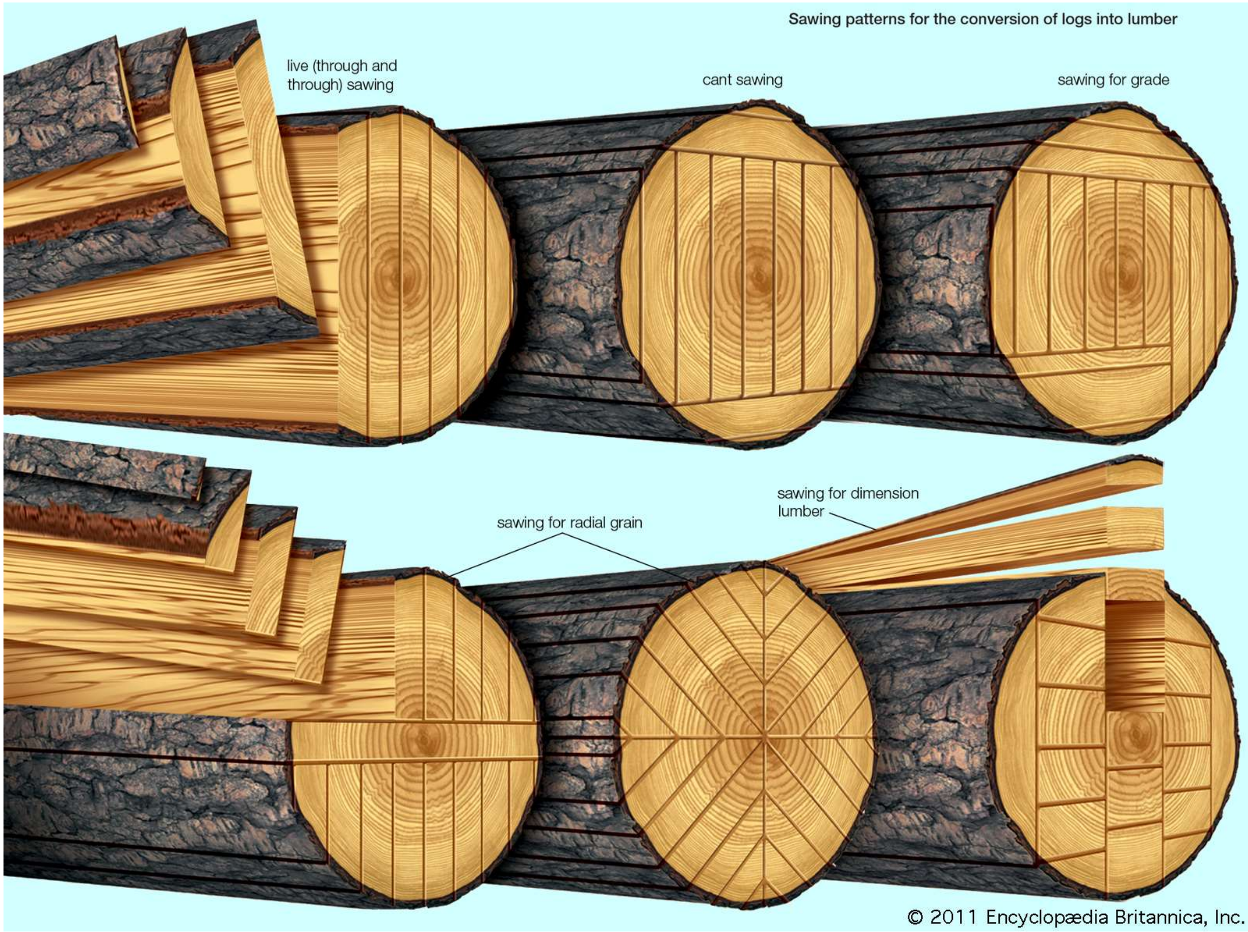

Figure 25. Encyclopedia Britannica: Wood Plant Tissue. Sawing patterns for the conversion of logs into lumber.

Plant-based fabrics also provide the fundamental elements in ecologically friendly furniture and wall coverings used to furnish built environments (Keeler & Burke, 2009). Burlap is one of these plant products. Although plant products must be farmed, cultivated, and manufactured – their life cycle can be easily and extensively evaluated by stakeholders for optimized regenerative benefit, during design and construction and operations and maintenance phases.

Ecosystems Design Realities

The Ecosystem Flow yielded realities concerning interconnections among the ideological and practical functioning of plant, animal, and human systems (Giama & Papadopoulos, 2012; Haddad et al., 2003). As design seeks to separate indoor stakeholders from outdoor plants and animals, the ecosystem construct intertwines all life forms as interdependent on one another through energy. Energy creation, sharing, and transfer among differing life forms regeneratively renews each species within an ecosystem while fostering communities. Therefore, improving integration between indoors and outdoors is regenerative (see Figure 26).

1. Design realities integrate all forms of life into an ecosystem for sustaining and renewing one another using energy.
    a. Integrates plant and animal and human populations to sustain themselves and one another through cogenerating energy.
    b. Integrates all forms of life into an interconnected community.
2. Artificial projects in natural ecosystems detract from natural services that ecosystems provide.
    a. Fosters natural capital by replacing capacities lost, through active management.
    b. Increases interior and exterior ecosystem capacities for production of additional natural services.
3. Ecosystem capital acts as a catalyst that drives increases in health and economy.
    a. Ensures that surpluses in capital are created.

Figure 26. Ecosystems word cloud.

b. Ensures that active management of surplus provisions provide security for the future.

4. Design realities integrate new forms of life into ecosystems thus ensuring diversity.

   a. Delivers diversity over the life cycle.

   b. Interrelates artificial environments with a natural ecosystem.

   c. Integrates interiors and exteriors to ecosystems using diverse webbing.

   d. Ensures strong genetic populations and communal life forms.

5. Design realities place ecosystem concepts at the center of artificial environments.

   a. Integrates artificial spaces through interior and exterior ecosystem realities using multiple methods of resiliency.

   b. Centralizes resiliency.

    c. Adjusts to thriving social and economic and natural systems.

6. Design realities perpetuate communal species population and resiliency.
    a. Integrates resistance to internal and external stresses.
    b. Becomes a regional reserve of ecological species and populations of community.
    c. Incorporates methods of transfer and balance to assist interdependent ecosystems.

An artificial environment (e.g., built environment) placed within a natural ecosystem detracts from the inherent environmental services the natural elements provide. These are quantified by losses in carbon dioxide capture and oxygen creation from plant life, insect infestation due to plant life, and predatory losses due to a lack of insects, etc. The length and breadth of interconnections cannot be overstated in any application using this construct.

It is unrealistic to envision a built environment where anteaters roam seeking insects for food. However, ecosystem realities seek regenerative design through practically applied actions and attributes that replicate interconnectedness between the inside and outside and/or among the natural and artificial ecosystems.

Realities specify the integration of indoor plants and other biophilic attributes (e.g. rocks, sand) replicating the exterior. Taken separately, plants are interconnected to several other constructs that further comprise microecosystems. In addition to this, regenerative ecosystem realities specify that animals coexist with humans. Designing interiors using animals is an uncommon reality in the sustainable design market or construction industry at large. The LENSES© Framework is an innovator in this respect.

Regenerative interior ecosystems surpass sustainable guidance primarily through the inclusion of reproductive elements—animals—in the interior of a built environment. Animals are the base unit for creating energy, which is necessary for cohabitation among humans, and they are contributors to the regeneration of the natural ecosystem. Take for example a parcel of land used for farming. Pasture grazing a fixed number of livestock is sustainable without augmentation and produces net zero carbon emissions (Poston et al., 2010; Vanegas, 2003). Adding natural compost from livestock droppings is fertilization, thus the same pasture becomes regenerative using a biological catalyst. This is expressed through a potentially higher grass yields and more diverse species of grasses, and through the number of insects and animals that naturally coexist with these grasses. The same theory applies within a built environment.

Regenerative realities ensure the security and survival of natural species in design. Using reproductive energy from an outdoor habitat on the inside of a built environment allows nature's "capital" to thrive through surpluses in energy storage in the form of animal and plant life—for example, an indoor fishpond. Designs that integrate water features for live fish and aquatic plants taken from naturally occurring habitats are regenerative. An indoor/outdoor pond traversing and connecting exterior habitats with interior ones enables the free flowing of water, bacteria, and fish. Designing and integrating a pond are actualized through a foundation confluence or a permanent structural penetration, which is poured during construction. The confluence is thermostatically sealed using an exterior glass curtain wall for viewing and educating occupants about shared ecosystems (see Figure 27).

Attributes of regenerative ecosystems manifest as food, fuel, or other catalysts for consumption by humans, animals, and plants. Energy is then transferred from outside to inside and the same in return. Just as increasing soil through biological composting replenishes the

Figure 27. Indoor/Outdoor Koi Pond. Photo showing a koi pond design feature that integrates nature.

diversity of grasses, insects, and microorganisms, life forms also share interrelated catalysts, transferring energy throughout their life cycles. For example, fish consume bacteria from indoor ponds and other potable waste systems and convert previously contaminated water into pretreated water for irrigating plants (Brauman et al., 2013; Lacombe et al., 2012).

Designing artificial environments with ample open space for an exterior habitat is a regenerative reality. Terrarium-filled lobbies with embedded plants and gardens, and floor level ponds are essential for replenishing the natural ecosystem. Aesthetically pleasing spaces for biophilia, water features, and contained beds or gardens illustrate effective ways to cohabit for fostering energy (see Figure 28). Overnighting livestock with human occupants is an old concept. Nineteenth century European and North American societies designed sleeping quarters directly above animal pens, known as housebarns, both for the safety and security of the animals

Figure 28. Sand Creek Post & Beam: Endless Possibilities. Photo of a mixed-use barn and household. WPE505 prairie carriage housebarn.

and for the capture of waste heat for human living quarters.

Intermingling an artificial environment with the exterior ecosystem requires that stakeholders isolate and replicate unique factors of a natural ecosystem and relate them to a built environment. Yielded realities encourage regenerative architecture. Design of a built environment's interior should mimic the exterior ecosystem in appearance and function. For example, if the exterior ecosystem fosters leafy plants, tropical fish and moderate climate, then interior design attributes replicate those same leafy plants fixtures using enhanced structural walls for supporting them. Not all living walls can accommodate the same leafy varieties because of practical considerations or sensitivities to occupants.

An expansive example of a regenerative ecosystem design is an Earth Sheltered Home (see Figure 29). These homes capitalize on naturally occurring contours, shapes, and climatology of an extrinsic ecosystem when developing an artificial environment for human habitation. Sheltered homes are dug into the earth to take advantage of the natural confluences and contours above them and then are covered by natural materials, thus benefitting from environmental services that nature already provides (e.g., animal cohabitations, heating and cooling, insulation). Communities of multiple houses, buildings, and even a transportation tunnel may be designed as an earth sheltered system, making this design cogenerating and available for use in several applications.

Figure 29. Earth Homes Now. A photo of a built environment sharing exterior walls with natural earth. Earth sheltered homes.

Education Design Realities

The Education Flow yielded subjective realities for ensuring access for all to unlimited educational content and materials using integrated physical and technological resources (see

Figure 30). Design is used as a teaching aid for consumers using regenerative actions of interconnectedness of regenerative constructs such as culture, well-being, and the like.

Figure 30. Education word cloud.

1. Realities integrate access for all through the unlimited amount of material and physical and technological resources at a site or built environment.
    a. Incorporates a healthy and engaging and inspiring built environment for learning.
    b. Technologically adept.
    c. Interactive through intermingling of materials and technological elements.
    d. Integrates adaptable and flexible learning spaces for future upgrades.
2. Spatial realities are adaptable through their flexibility of use, upgrades to infrastructure, as well as sizing and shape.
3. Interactive realities draw from several sets of educational sources and content.
    a. Interactive realities portray ideologies from multidisciplinary experts.
4. Independence and interconnectedness among design delivery and transfer.
5. Continuously explores progressive design ideologies.
6. Moderates transfer of information and skills using design.
    a. Engage in feedback loops for information and skills transfer.
7. Transfers new and challenging design ideologies through interaction.

8. Integrates design pathways for understanding challenging material.
9. Portrays accurate relational contexts among people, organizations, and communities.
    a. Stakeholders have confidence in this relationship.
    b. Realities represent stakeholder decisions, goals and accomplishments.
10. Incorporates realities for non-centralized ideas.
11. Distributes information to all stakeholders using design.
12. Reflective of collaborations among peers and students.
    a. Creates environments using mentoring.
    b. Reflects cultural education of people, organizations, and communities.
13. Realities for lifelong learning and retention.
    a. Promotes literacy.
    b. Promotes educational competence and actualization.
14. Gears design for self-discovery.
15. Leads to discovery of future achievements and learning methods.
16. Educational realities are abundant through design.
17. Permits stakeholders to influence educational outcomes.
    a. Stakeholders use homes and communities to directly affect their acquired achievements and actualizations.
    b. A back and forth educational paradigm are diverse.
18. Builds capacity to solve social problems in larger communities using individual problem solving.
19. Integrates meaningful methods of assessment.

The purpose of regenerative design is to create an adaptable and flexible platform for stakeholders, which is interactive for all audiences. For example, placing an energy-generating attribute in the front lobby of a children's center is a way to raise awareness of consumption and its corresponding effects on climate change (e.g., Fort Collins Discovery Center).

Yielded realities are regenerative using adaptability and interaction through everyday behaviors. For example, bathroom sinks fitted with hose spouts and indoor carpet mimicking real grass are design attributes that raise awareness through touch and sight—two highly adaptable senses inclusive to all demographics and age groups. The more adaptable the interactions among realities and stakeholders are, the greater chance to become regenerative education for the audience (see Figure 31).

Educational realities create opportunities for engagement and inspiration using differences in features like room shapes, angles, colors, and scales. Raising awareness for the quantity of source materials required in built environments using space and time comparisons is a cornerstone surpassing previous sustainable education. An example would be ceiling panels of glass that allow stakeholders to readily view the sky, birds, and other beautiful portraits of nature.

Transparent panels also allow the viewing of overhead power lines through spaces formerly belonging to nature. Viewable power lines educate stakeholders by raising awareness of the value a society places on aesthetics over energy. These realties aim to influence the cognitive state of users through enduring and limitless, thought-provoking impact (Rogers, 2003; see Figure 32).

Figure 31. Fort Collins Museum of Discovery. Photo showing hands-on education using practical applications in design. Shatz family exploration zone: exhibits.

Realities design structures to have moderate or large scale theatres and open space auditoriums for recreation and social gatherings. The implementation of sound, music, and creativity labs usable as interactive mediums to transfer knowledge are regenerative methods of learning (e.g., Denver Center for Performing Arts). Music, social gatherings, and artistic expressions through elements like live performances act to encourage the acquisition of knowledge by fostering individual exploration. Yielded criteria provide a central point for interconnecting other constructs and their associated realities using educational exhibits (e.g., fuel and emissions samples; materials submittals like plumbing alloys, carpet swatches, LED

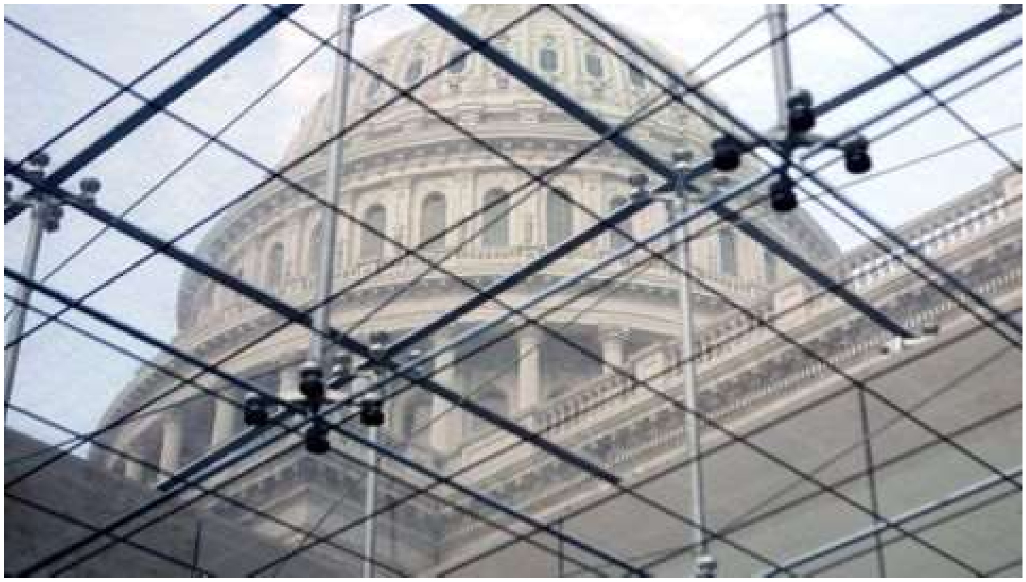

Figure 32. Why the US Keeps Having Debt Ceiling Debates: Quicktake. A glass integrated ceiling, to educate viewers of their natural environment. Washington post.

lighting fixtures). These may include degenerative design integrations like glass ceilings with opaque panes that represent carbon buildup or a “hot” room to represent differing levels of climate change. Regenerative realities surpass sustainable guidance through interactive features and aspects of design.

Accuracy of educational context and the appropriate representation of that context are important and relevant aspects in this construct. For example, in a United States museum a wall painting of the Pilgrims sharing a meal with Native American peoples does not accurately reflect the appropriate relational context of colonization. In an American West museum, regenerative artwork should purposefully illustrate early events of Native American tribes inclusive of diseases, treaties, and reservations. Most importantly, this type of educational attribute or feature does not have to be presented negatively.

Innovative features like structure, shape, or color can successfully transfer the same ideas. Constructing a building in an area it historically represents surpasses sustainable design and is regenerative. For example, the University of Wyoming Art Museum in Laramie, Wyoming is constructed to resemble a teepee in which Native Americans of the area once resided (see Figure 33).

Yielded realities found across the American West have been integrated and adopted into interactive educational themes for decades. For example, cross-country trains can be considered regenerative design realities because they represent the icon of western modernization in transport. Once the most efficient mode of passenger and cargo travel across the Great Plains, trains have now been replaced by cars and cars are not iconic or relevant to the settlement of the American West and are, thus, not educationally regenerative.

Figure 33. University of Wyoming: Art Museum. Photo representing a culturally integrated building envelope. University of Wyoming.

Money Design Realities

The Money Flow yielded realities in relation to project funding (see Figure 34). Project funding, financing, or cash investment is instrumental to stakeholder decisions for supporting traditional, sustainable, or regenerative realities. Regenerative design requires a collaboration of social resourcing for ascertaining design funding using multiple stakeholders and a client-driven process. Money is a socially responsible and restoratively driven construct for achieving a net zero return on investment and the same net zero ecological impact through regenerative design (Clegg, 2012; Cole, 2005; Poston et al., 2010).

Figure 34. Money word cloud.

1. Projects directly and indirectly benefit disadvantaged populations.
    a. Achieves collaborative and socially responsible funding through net zero resources.
    b. Reinvests profits for healthy communities.
2. Funding compounds the positive effects of development to local resources and partnerships.
    a. Disallows false capital.

   b. Bridges the divide between project needs and negative impacts to local areas.
   c. Benefits all stakeholders through equal access to opportunity and wealth.
3. Mitigates risk for current and future generations.
   a. Leverages risk against equality and inequality.
   b. Reduces risk secures intergenerational harmony and limits social, economic, and environmental damages.
   c. Appropriate distribution balances liabilities with rewards.
   d. Leveraging funding enhances equality and stakeholder rewards.
4. Funding sourced indiscriminately is beneficial and communal.
   a. Encourages new community partnerships.
   b. Benefits excluded populations.
   c. Creates a social welfare system.
   d. Realities help to restore ecosystems.

Regenerative monetary realities require solicitation of funding through socially responsible sources, that is, companies who build to LEED standards (e.g., like-minded companies; Sierra Club; Green Peace, [see Figure 35]). The goal of seeking diverse, socially responsible funding is to decentralize traditional financing models, where a single company dictates control over budgets and thus control over regenerative integrations. In this respect, return on investment is calculated based on benefits instead of just costs.

Realities reinvest profits from existing indoor spaces into production of regenerative spaces to create healthy, thriving, and reinvested socioeconomic communities. Taken in this context, the term “reinvestment” is a regenerative act. A regenerative built environment is inhabited by companies that reinvest profits, or a portion of their profits, into similar philosophical interests as promoted by LENSES©.

Figure 35. Sierra Club. Photo lobbying clean energy through project financing. Texas beyond coal campaign.

Realities discourage the inflation of equity or capital to drive others out of real estate markets. Regenerative designs should bridge divides in socioeconomic disparities; realities create ongoing measures for socioeconomic justice that are intergenerational and broad. For example, donating or dedicating "free space" in an office building for use by a non-profit as a job or community center. Realities enhance social equity by making access available to everyone using measures such as dedicating free space. Designating a proportion of rent-controlled spaces in urban condominium complexes is also a regenerative action.

Realities reduce monetary risks by using diverse and numerous investors, through long-term financing and fixed rates. Harmony should exist between project socioeconomics and environmental impacts, because both can be mitigated using socially responsible funding that supports regenerative design. For example, capital construction financing for a publicly held company removes weighted voting in a boardroom for design investments. Although this can obscure profits, realities enhance socioeconomic rewards using stockholder equality and unweighted voting on how and where to invest in capital designs.

Regeneratively, design develops through community collaborations and local companies, and by forming partnerships with contractors, designers, schools, and other vendors. Funding intentionally targets native and local contractors, designers, and vendors of small, family-owned businesses, removing extrinsic corporate bidding and their associated temporary socioeconomic effects. Investing locally creates self-sustaining social systems through employment and reproduces using secondary economic investments in housing, grocery stores, and municipal services.

Well-Being Design Realities

The Well-Being Flow yielded realities for heightening stakeholder senses through relaxing and rejuvenating indoor space attributes. Realities encourage physical, mental, and spiritual development in accessible spaces that are well connected to nature (see Figure 36). Cafeterias, conference rooms, and service areas cater to generational and cultural inclusiveness (see Figures 37–38).

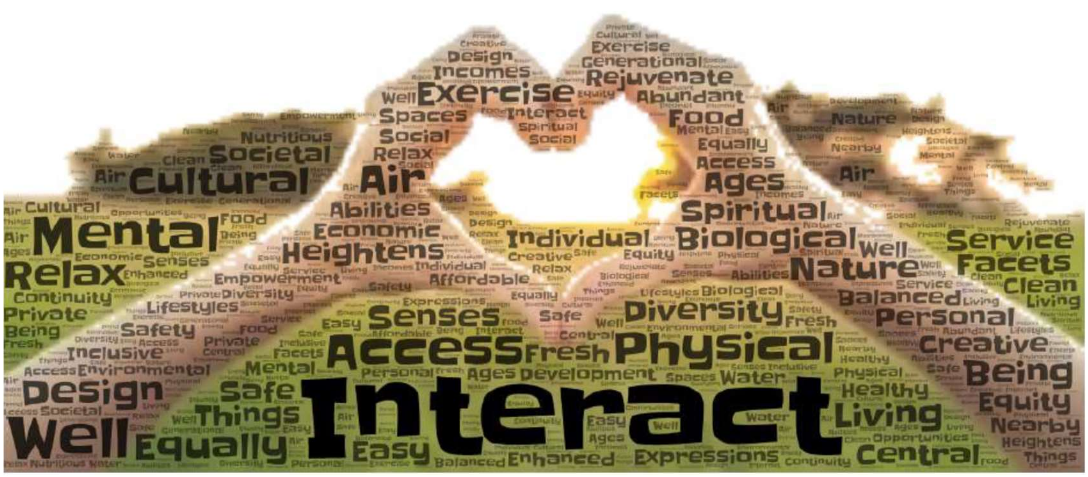

Figure 36. Well-being word cloud.

1. Design heightens senses through realities that relax and rejuvenate.
2. Creative, individual expression and interactions with nature through design.
   a. Personal development of the physical, mental, and spiritual.
   b. Central access for equality.
3. Service integrations are accessible, equally balanced through design and include well-being of all living things.
   a. Ensures well-being of societal, economic, and environmental facets.
   b. Well-being of living things enhanced through cultural empowerment, biological diversity, and generational continuity.
   c. Captures generational equity and inclusivity through abundant access.
   d. Biological and cultural diversity through ages, abilities, and incomes.
4. Realities ensure healthy lifestyles.
   a. Spaces are easy to access.
   b. Nearby physical exercise spaces and affordable nutritious food.
   c. Spaces are safe and have fresh air.
   d. Safety is defined through private physical and mental exercise spaces.
5. Ensures opportunities for social interactions through design.
6. Realities deliver clean water.
7. Stakeholders interact with nature through design.

For some, this means installation of an outdoor exercise area or yoga hut. For others, this may constitute a private reading room. Realities require that common libraries and individual offices have glass in their ceilings with clear views of the outside or clerestory panels on top of walls for abundant daylighting. Design of heating, ventilation, and air conditioning (HVAC) systems increase the amount of outside air pumped indoors, in addition to that required by building codes (International Building Code, 2018). Manually operable windows and air registers are required as regenerative attributes, further surpassing fresh air standards set by current sustainability accounting tools. Libraries and cafeterias are designed for stakeholders to intermingle across generations, abilities, and incomes. These spaces are centralized, highly visible, and easy to access from multiple places.

Realities design indoor spaces as physically interactive and representative of the stakeholders who occupy them. A cafeteria should serve food that enhances well-being, which is nutritious and fresh. Growing one's own vegetables using indoor, biophilic attributes (e.g., potted lettuce or peppers) is a reality that crosses educational, wellness, and ecosystem constructs. Because growing food can occur in a natural lighted atrium adjacent to a cafeteria, it is quickly available and affordable to stakeholders. Well-being realities specify attributes that purify or filter water at the point of use. Clean water is delivered to sinks and water fountains through charcoal or infrared filtration.

Figure 37. Portland Japanese Garden Cultural Village. Photo of an integrated garden encouraging occupant well-being. Architectural record.

Figure 38. Penketh Group. Photo of a socially designed lunchroom for occupant mixing and work collaboration. Social workspaces office design.

Culture Design Realities

The Culture Flow yielded realities concerning a community's holistic yet diverse views on natural, social, and economic systems, and an accurate representation of these foundations in design. Cultural characteristics are portrayed through a community's sociopolitical structure, including highlighting the correlation of inequalities among natural surroundings and economies (e.g., economically depressed areas). Realities place the most value on heirlooms and traditions unique to the characteristics of locals where a design will be placed (see Figure 39).

Figure 39. Culture word cloud.

1. Design realities reflect fair and accurate representation of the community by identifying diverse members.
    a. Accurate assessment of cultural impacts.
    b. Reflects cultural values of those prohibited from decision-making or the disenfranchised.
2. Provides environmental justice and compliance through cultural norms in design.
3. Reflects holistic cultural analyses in terms of relating realities to the natural, social, and economic systems of the community.

4. Representatives engage and represent cultural bases in design.
    a. Community participation and ownership constrained through culture in design realities.
    b. Design centralizes a collective sense of ownership by expanding and improving methods for engagement.
5. Design communicates using a cultural vocabulary.
    a. Centralizes a cultural language using languages for all demographic bases under a system of representation.
    b. Provides safe feedback loops for community involvement.
    c. Implements forums for cultural inputs and permits communities to actively engage issues.
6. Design decisions stem from local culture, cultural knowledge and characteristics.
    a. Encapsulates local resources.
    b. Continual and ever changing characteristics.
    c. Grass roots initiatives and decision of cultural values.
    d. Promotes a shared social contract using cultural ownership and pride, and responsibility and accountability.
7. Realities illuminate cultural appreciation.
    a. Includes a sense of membership.
    b. Includes a means of education and employment.

For example, in the United States, migrant farm labor presents several unique sociocultural inequalities common to seasonal employment. The agricultural sector employs thousands of migrant laborers annually for production of food (Butera, 2010; McLamb, 2011;

Sayer & Campbell, 2004). Social justice and respecting cultures of a migrant labor force involves designing work, living quarters, or production facilities around cultural facets that mimic the characteristics, mannerisms, and/or even meal times of laborers as if they were at home. Seasonal dormitories honoring cultural differences can be regenerative through attribute preferences in paint colors, laundry facilities, and locations and times for religious assembly.

Environmental justice and compliance for all cultures are a regenerative reality. Cultural realities integrate respectful design, placement, and function of built environments and supporting sites in cooperation with those who are disproportionately affected by products and toxic byproducts caused by development, low wages, or cultural assimilation. For example, the United States taking acquisition of Native American lands to site land grant universities. Land grant universities choose open space for the establishment of academic institutions of higher learning. Some of this land was formerly occupied by several Native American tribes and was subsequently resettled (Wolfe, 2006). Regenerative design actions incorporate social justice, respecting the past, present, and future of a site or facility, a reconciliation process accomplished using design attributes.

Regenerative realities include interpretative statues or murals and commemorations telling the full story of an area or location. Implementing attributes that honor the cultures including recognizing holidays that close facilities (e.g., Martin Luther King Day; Caesar Chavez Day). Yielded realities take regenerative design a step past the recognition of historical events by striving to recognize cultural differences, regardless of ethnicity, age, disability, or income. Examples of cultural regeneration focuses on disabilities and include proactively designing to the American for Disabilities Act (ADA) standards instead of a lower design denominator, conducting guided tours in wheel chairs, installing gender neutral bathrooms, and installing baby changing stations in all-gender bathrooms (International Building Code, 2018).

There are commonly project discussions concerning short-term costs and long term benefits for integrating design actions and attributes. However, fair and accurate assessments and integration of sociocultural norms are regenerative realities. The culture construct promotes a holistic assessment of impact against, and in concert with stakeholder norms and does not necessarily involve design actions. Instead, it allows consideration for, and representation of, those most affected and often disenfranchised. A soup kitchen is a representative example of sociocultural design.

Soup kitchens reflect a broad cross-section of sociocultural norms derived from diverse stakeholders. Realities state that soup kitchens will integrate neutral paint colors and formats, furniture settings and placements, and music for encouraging free expression of cultural values within a neutral and judgment-free space. This is particularly relevant to stakeholders and designers, because poverty does not have an ethnicity or preferences in paint colors or music. It has its own social stigma. Soup kitchen stakeholders are likely to be disproportionally afflicted with disabilities and mental illnesses. Realities must offer a safe and stress-free space to converse and spend time, with attributes of soft tone lighting and subtle paint sheens for calming the senses. Extra interior space provides decreased congestion for patrons and potential reactions toward one another—it becomes a place where everyone can dine. Large, ADA equipped bathrooms contain regenerative features permitting stakeholders to rest and refresh themselves while traveling with all of their possessions, and possibly pets, these facilities are also equipped for people with varying disabilities (see Figure 40).

Operators of a soup kitchen engage their sociocultural base of patrons using employees from the local area. Operators, who alongside patrons promote and participate in the personal ownership of life, contribute to the regenerative construct. Attributes centralize and bring to bear personal ownership through seating for staff, patrons, and volunteers, sometimes seating individuals face to face to encourage positive interactions. A dining table becomes a safe venue to engage with others, using feedback loops for gathering information. Ownership, pride, responsibility and accountability, when applied to an individual all inspire a sense of membership in this common sociocultural community.

Figure 40. No Time for Flash Cards. An example of multicultural classroom materials. Multicultural classroom materials.

Beauty Design Realities

The Beauty Flow yielded realities that subjectively define beauty and how to appropriately represent its subjectivity in physical attributes, etc. (see Figure 41). A regenerative design integrates interior plant life. The type of biophilia implemented will represent the local ecology and stakeholders' cultures (Gao et al., 2013; Moffatt & Kohler, 2008; Younger et al., 2008).

Figure 41. Beauty word cloud.

1. Realities create interior living walls as visual expressions of all living things within a local ecosystem.
    a. Ecological systems inside and outside.
    b. Scaled within capacity and function.
2. Realities characterize beauty using historical features of an era for which these were designed or modeled.
    a. Reflects timeless beauty.
    b. Shows respect to the era(s) using iconic features.
3. Realities heighten sensations to a level of serenity.
    a. Delight and happiness, inspiration and reflection of achievements and appreciations.
    b. Heal though self-actualization.
4. Have a beautiful spirit.
5. Incorporate beautiful realities celebrating cultural beauty by way of life, shared beliefs, and community values.
    a. Cultural beauty is appreciated by expression of its members.

b. Beauty expressed by minority cultures and celebrated through local vernaculars and traditions.
c. Meaning and significance through cultural beauty.

Take for example a jungle. If a stakeholder is designing a built environment for placement in a jungle, then biomimetic plant life will be wild, ungroomed, and creative or "natural" in appearance. The opposite is also true. Visual expression of living things better demonstrates their capacity and scale within a natural ecosystem, while positively interacting with stakeholder well-being (see Figure 42).

Realities mimic an era in time. Remodeling an opera house from circa 1800 relies on the preservation of articles and artifacts (i.e., velvet covered seating, open truss rafters) and applying required upgrades to several other facets (i.e., ADA, fire routes). Keeping with the tradition of a nineteenth century opera house, stakeholders feel regenerative with ushers for walking patrons down aisles instead of upgrading seat lighting.

Figure 42. IGrow News. Photo showing a beautiful indoor space. The Eden Project.

Realities become beautiful through designs that complement the landscapes and cultures they occupy, like arrival and departure stations that align with the direction of travel for incoming and outgoing trains, trams, or monorails. Regenerative design is revered through distinct building shapes and orientations. Using this example, a transport structure can be regenerative by including linear seating for express route patrons or conditioned spaces with Internet and café amenities for long-haul patrons.

Characterizing design around the locations and through the cultures in which beauty is defined reflects timelessness of icons and forms the social morality occurring within them (see Figure 43). Realities heighten stakeholders' sensations allowing them to experience serenity, delight and happiness, inspiration and reflection by means of attributes. Appreciation is achieved using interior décor such as tiles, wall murals, and artwork of historical eras featuring awe-inspiring icons, all of which are intended to uplift and evoke sensations regardless of generation.

Chapter Four presents and discusses yielded realities using built environment design examples. Of the eleven analyzed, Land Use, Transportation, Energy, Water, Materials, and Ecosystems Flows yielded prescriptive realities. These were exemplified using attributes of built environments and developed sites. The Education, Money, Culture, Well-Being, and Beauty Flows yielded subjective realities and are exemplified using design actions.

Figure 43. Tile Devil. Photo of the Azulejo train station in Portugal, integrating wall art. Beautiful decorative wall tiles.

CHAPTER FIVE: DISCUSSION AND IMPLICATIONS

The findings presented as concrete and content-specific actions and attributes from the eleven Flows. Stakeholders may use realities for decision support and to implement prescriptive and subjective design choices in regenerative built environments. Analysis yielded guidance for assisting stakeholders in understanding regenerative directions and underpinnings arising from each Flow but did not produce precise code standards for the integration of subjective actions or prescriptive attributes. Multiple redundancies were found within the content of each Flow and in the interdependencies among similar Flows. Redundancies mirror the complex interdependencies found within built environments. Design realities provide a recontextualization of the Flows per their original development and interconnect them to one another and the larger LENSES© Framework. Built environment design is exemplified using examples from the Flows through the same course of action.

Discussion

Eleven Flows are currently displayed on a two-dimensional lens. Their illustrated interconnections are derived through process-driven discussions among stakeholders and facilitators during the design phase. Two-dimensionality of the Flows lens suggests that each operates independently from the Foundations and Vitality Lenses and from the other Flows. A two-dimensional perspective compounds confusion when applying the Flows or their regenerative criteria (i.e., whether process-based or refined) and prohibits the full use of LENSES© as a holistic framework.

The Vitality Lens is intended to assess the strength of regenerative design actions and attributes, using criteria refined from each Flow. Vitality is an assessment of cooperation, interconnections, and interactions that design criteria on one Flow have with others, and within a holistic design (i.e., including other Flows). Optimizing interconnections is the overall intention of LENSES© (Du Plessis, 2012; Svec et al., 2012). Process-driven design discussions are inadequate for capturing relationships among all realities, including the regenerative integrations linking the eleven Flows together in a holistic design. Facilitation assists in contextualizing regenerative thinking behind the Flow concept but does not assist stakeholders when refining Flows guidance through a reduction in their obscurity and ambiguity. Chapter Four depicted recontextualized content-specific realities in a holistic-based frame without relying on process-driven facilitation.

The refinement of original criteria provided relevant design realities for achieving high levels of vitality in new built environments. Each reality considers its own contextualized intentions and those of interrelated and interdependent realities from other Flows, which are exemplified using practical design actions and attributes. A summary of refined yielded realities and practical examples of each provided insight into research question one; what are the design realities from each Flow?

Several meaningful realities are presented as usable, realistic design actions and attributes (see Chapter Four). However, these are somewhat flexible and not absolute. While flexibility is generally considered a negative aspect along the trajectory in developing building code standards, it is a positive aspect concerning overall workability with project stakeholders, including new regenerative training programs for architects and engineers as it increases chances of success when implementing emerging actions or technologies (Chiazor et al., 2009; Maxwell et al., 2009). Based on two decades of professional experience, the researcher concludes that regenerative realities are ripe for industry uptake and design diffusions in the field. Flexibility ultimately assists the uptake of realities through applied and continuous industry development. Yielded criteria put forth usable regenerative examples for guiding further development in design. Regeneration as a concept may now be understood by project stakeholders as represented in similar criteria and guidance, methods, and practices.

Research question two asks if an inductive themes analysis was optimal for extracting realities from regenerative criteria. The researcher believes that inductive review is optimal over other qualitative or quantitative methods or rationale (e.g., in-depth interviews, focus groups, word counts). This is for two basic reasons: previous design research was successful in reducing sustainability criteria into more concrete realities using inductive inquiry; and inductive review was previously used to refine both subjective and prescriptive sustainability criteria to be exemplified in a usable context (Bond et al., 2012; Poston et al., 2010). Regenerative criteria resembled previous sustainability criteria, as they contained multiple levels of cross-disciplinary content and utilized process-based discussion to reconcile prescriptive and subjective blending without absolute outcomes. Regenerative criteria were originally derived from focus groups but decontextualized. Inductively analyzing regenerative criteria refined content without reconvening original focus groups.

The largest challenge to the researcher was delineating major topics within the criteria when identifying whether a Flow was inherently prescriptive or subjective. This had to be done prior to additional coding (e.g., determining action codes, energizing codes). This challenge was overcome by thinking through the end-use applications of major topics (i.e., Step A codes) as they eventually transferred into design for built environments, while keeping in mind how each topic applied to an overall Flow. Separating new criteria into prescriptive or subjective categories will continue to constrain industry development of regenerative standards.

The intent of using an inductive approach was to yield realities from broader and blended criteria as it did in past applications concerning sustainable design. Coding for inductive analysis provided a deeper understanding of regenerative underpinnings unique to each Flow while yielding content-specific statements about the interconnections of each Flow, in the form of realities. Combined both the meanings and actualized realities represented a holistic design vision for each Flow and all other interconnected Flows combined.

Flows provided clarity to the extent the original criteria permitted, but more precise regenerative standards could not be contemplated. Analysis of one Flow at a time, as opposed to all Flows together, may have produced more precise realities and allowed for the establishment of standards instead of guidance. Yet from a holistic standpoint, doing so would have lost valuable insights on the interactions and interdependencies among all Flows. Integrating realities from one Flow would be infinitely complex and irrelevant because interactions from ten other Flows could not be captured as intended by the overall LENSES© Framework (Lacombe et al., 2012; Plaut et al., 2012).

Realities can be used for guidance and show a level of detail that provides better information for built environment design on which stakeholders can base their decisions to align with regenerative outcomes. Realities surpass sustainable design standards in most cases. Stakeholders are better equipped to understand and employ refined realities using a self-guided mode, without having to participate in facilitated, process-based discussions or expend additional costs for Planning and Logistics Workbooks.

Implications

Although obscurity has been reduced, the application of yielded realities becomes difficult as they do not reveal precise technical or subjective standards, but rather design guidance. Depending on the type of building design, insight or skill level of clientele, or municipal building department, differing levels of design action or attribute specificity may be required (e.g., commercial, residential, outbuilding). It is common practice for jurisdictions to require either engineered construction plans (i.e., design-bid-build) or submittal of a generalized design plan and schematic, in addition to a series of progressive permitting to take place alongside construction (i.e., design-build). In either case, a building department must review, approve, and inspect final construction according to code standards. This is a disadvantage for yielded criteria, through a lack in precision and formal adaptation into building codes.

For a construction permit to be issued in a regenerative design application, a jurisdictional agent must review the architectural and engineering specifications against local building codes (International Building Code, 2018). The International Building Code (2018) is one such technical document regulating the production, assembly, and installation of attributes in built environments (e.g., precision of specifications for new lavatories according to the Americans with Disabilities Act) (International Building Code, 2018).

Using this code standard, precise engineering specifications must be submitted to the municipality for review and approval of proposed design work. Construction documents are issued, the contractor builds the structure, then an inspector certifies construction in accordance with the design standards. For example, new commercial office buildings require lavatories to be assembled using regulatory standards in building code (International Building Code, 2018). The same is true for appurtenances of lavatories such as a sink for hand washing. An architect specifies room dimensions, paint color, and furniture colors, and may even perform a code analysis for a lavatory. A plumbing engineer will then draft code specifications (i.e., instructions) for the contractor to follow when installing an accessible lavatory (e.g., a sink must have a 1.5

inch drain line and a .25 inch supply line; two-quart basins made of porcelain; etc.). The extent to which construction outcomes pass municipal inspection largely depends on the engineer's specifications, the standards by which the specifications were created, and the platform for project delivery.

Yielded criteria may be used in several types of project delivery (e.g., integrated project delivery, construction manager at risk), using progressive design permitting. The design-build platform is optimal as an innovative and widely adopted method of new design, construction, and progressive permitting for regenerative criteria. The design-build platform was a response innovation from the industry to accommodate emerging sustainability guidance from a time when there were no precise standards available.

Design-builds have advantages over other platforms. Clients may participate in design conversations, avoid contract liability, and conduct progressive permitting. Simply, project architects and engineers draft "preliminary" specifications for the contractor to cost and construct per each phase of design. A design-build capitalizes on process-based stakeholder participation and discussion forming loosely based schematic criteria that adapt to follow regulatory building codes. This platform is optimal for encapsulating emerging guidance in areas of regeneration, where little or no code standards exist. Yielded realities depict regenerative guidance and more concrete statements about design than producing precise standards for engineered attributes or technologies. Without fully developed standards to permit regenerative attributes, realities are less usable with other platforms.

Using the design-build platform, a general contractor together with subcontractors work intensively through material and product submittals in conjunction with requirements from clientele, architects, and engineers. In this application, yielded realities provide a context and direction for actualizing regenerative built environment actions and attributes. If a holistically regenerative design is sought, stakeholders immerse themselves into design discussions to achieve the maximum amount of synergy with the restraints being that of regulatory codes.

Realities are currently structured in a manner that will accelerate adoption of LENSES© into the design industry for continual developments and innovations, diffusions of those innovations, and more refinements. Although the realities are straightforward and usable in an incremental form, the largest benefit of the Flows is by the collective advantages through eleven interacting Flows. Adoption of regenerative realities using a design-build platform increases the interconnections of Flows through increased coordination among respective stakeholders. Eventually, resulting in more common actions and attributes, and becoming more precise through use, consider on-site lumber production.

Materials realities specify the use of on-site lumber by harvesting local trees. This is an attribute-driven design reality. If used for structural columns, lumber must be selected and produced in consistent with structural requirements because differing sizes of lumber are a direct consequence of the availability of local trees. What is locally available affects structural properties of a building because of the trees, which can be harvested and utilized during construction. Yielded realities interconnect structural strength requirements with how a built environment is assembled, as both are being observed during the design phase. These two elements meet at this intersection (i.e., what is available and what the structural requirements are) to effectively determine what requirements can or cannot be reconciled. Materials realities state “what” is regenerative but not “how” to implement them into design, thus the need for cooperation among stakeholders using a design-build platform. Without a design-build platform, no coordination or on-site harvesting exists. Energy components are additional examples of incremental attribute-driven criteria for producing collective outputs.

Building heating and cooling attributes must be sized appropriately with exterior wall types, coverings, and windows because energy consumption depends on thermal conduction and leakage. Attributes for heating and cooling must coincide with internal temperature requirements per the desired number of exterior windows, as required by building code. Following regenerative guidance from the Ecosystem and Energy Flows, exterior wall systems and energy attributes are interdependent.

The design-build platform allows contractors to follow an architect's bare "sketch", meeting code requirements using coordination of exterior wall systems and energy components on site, thus being able to achieve regeneration. This platform works well during new construction projects. Because there are no fixed code standards, builders can achieve code compliance through a collaborative yet quasi approach to traditional specifications. But, a design-build is not without its problems. Vapor-free paint is a regenerative reality. A building department will not permit vapor-free paint application on a fire-rated wall, for purposes of chemical fire protection (International Building Code, 2018). Even with robust stakeholder collaboration, a lack in a regenerative standard makes implementing all realities difficult.

Most of what is yielded as prescriptive was borrowed from one of several sustainability accounting tools. Items previously tested in industry and code compliant, added to the Flows used a reproductive element within the sustainability standard. Prescriptive realities presented in a form applicable to sustainable engineering and construction over the last decade included high performance attributes. Prescriptive realities are essentially improved sustainability innovations following a decade of industry development. Subjective realities have some roots in sustainable design ideas, because they have defined parameters they are considered incremental.

The organization of realities in relation to their levels of function and interdependency is an implication of their usability. The two-dimensional display of eleven content-specific Flows implies a circular relationship among content categories and their subsequent realities. It does not illustrate the interconnections among all Flows as they are intended to apply in three-dimensions. More sophisticated graphics illustrating the flows in three-dimensions is beneficial. Realities are better contemplated using two smaller groups of Flows, a subjective and a prescriptive subgroup for better understanding and usability (Bond et al., 2012; Rosas et al., 2002). Currently, there is no advanced guidance other than yielded realities to guide early adopters.

Prescriptively, the Ecosystem Flow encompasses the concept of an “artificial shelter” (e.g., a built environment) within a natural ecosystem. The Ecosystem Flow incorporates overlapping interconnections with energy, water, transportation, land use, and materials realities. Because of this, the Ecosystem Flow is the best choice for a prescriptive subgroup. Subjectively, the Education Flow incorporates overlapping realities of beauty, well-being, culture, and money. The Education Flow is the best choice for a subjective subgroup. Altering the visual presentation of the Flows lens into these two subgroups assists in comprehending interconnecting realities without process-based alterations or confusions between them (Colantonio, 2010; Umakoshi & Goncalves, 2011). Envisioning Flows in this manner puts forth a better understanding of interconnections in planetary ecology, while considering artificial or built environments as singular components operating and interacting within a holistic system.

Limitations

Realities do not provide fully developed design actions or attributes. Specialized development must be thoughtfully conducted to create more precise standards inclusive to regenerative design and for use in code compliant construction. Realities cannot be used to address behavioral aspects of occupants following the construction phase of a built environment. Because successes of regenerative design are partially dependent on the operation of built environments coinciding with the satisfaction of the occupants, this is severely limiting.

It is not known whether regenerative technologies can be developed or successfully integrated using the Flows lens. The ways in which prospective technological advancements or conceptual innovations are diffused and perceived by stakeholders is critical to success of the refined criteria. Regardless, development of attribute technologies will still be dependent on materials and commodities markets. Reducing resource consumption using high-efficiency components is immediately possible and balancing a building's consumption alongside equal outputs is possible using Flows criteria. Yielded regenerative criteria may over-replenish one area of an ecosystem in exchange for losses in another. However, this study and the Flows did not analyze proportional rejuvenation specific to affected ecosystems.

For example, installing solar panels as exterior cladding on a high-rise building may generate more electricity than is consumed by the built environment, but will not make up for the loss in precious metals in creating the solar panels. Additionally, if precious metals mined for solar panels came from China and were installed in Europe, excess electrical generation will rejuvenate a different continent. A specific method of carbon accounting and replenishment of affected ecosystems is required to directly balance what resources are needed with what is consumed. A method of overall carbon accounting is required to ensure appropriate coordination of ecosystems on the larger scale of planetary function.

This study encourages stakeholders to optimize an existing industry pathway for usability for a yet unknown state of regenerative design. Analysis has provided prescriptive design realities existing in current sustainability accounting tools. These include high-performance attributes like low electricity using lighting fixtures and faucets with aerators. Although these are incrementally regenerative, neither the refined realities nor this study orders, ranks, or sorts by magnitude a holistic plan for implementing regenerative realities incrementally.

Success of sustainability accounting tools is based on a whole system working in cooperation, using several incremental components in conjunction with their dependencies rated holistically. Without organizing regenerative priorities within the Flows, high-performance attribute realities will not mesh within a holistic design as they currently do in the sustainability accounting tool from which they were borrowed (Du Plessis, 2012; Poston et al., 2010; Svec et al., 2012). This research does not clarify an organizational structure or series of metrics for determining priorities to yielded realities. This compromises some attribute realities as they are ineffective when balancing resource consumption to attain a holistic design.

Realities strongly encourage a three-pronged theoretical basis for altering stakeholders' rationales relative to regenerative design: reduce consumption; balance consumption with outputs; and restore ecosystems. These three prongs represent the building blocks to rejuvenate ecosystems and restore natural conditions and functions of the planet's operations using built environments, and in turn, undoing disruptions in planetary balance.

This research did not consider regenerative achievements over a built environment's life cycle of operations and maintenance. This is because realities do not delineate new design and construction guidance from an operations and maintenance cycle, making the Flows less impactful in life cycle conversations. The realities require linkage, beginning with the regenerative action or attribute and spanning into holistic operations and maintenance cooperation. Increasing linkages among new design and the operations and maintenance phases, proportionally and exponentially, increase the effectiveness of integrated realities from new construction.

For example, realities specify composting as a regenerative design action. Composting is a subjective reality that takes place during the post-occupant phase (i.e., during the operations & maintenance phases). The concept of composting must begin as a prescriptive attribute included during the design phase to support compost accumulation and removal. Similarly, a "smart logic" electrical program is a design-driven innovation. Following construction, operational sequencing for consumptive electrical use is programmed according to weather, infrastructure needs, and work schedules.

A prominent limitation of this research, the Flows, and the LENSES© Framework is that reducing consumption cannot be the first in a set of building blocks represented in a three-pronged paradigm. The design phase is the foremost phase for determining core and shell requirements, (e.g., concrete, steel types, layout, electrical switchgear, etc.) and is heavily regulated according to building codes. Although reducing consumption (i.e., by decreasing concrete in a core and shell) is a regenerative reality, an adequate structural substitute must first be created in accordance with the International Building Code (2018), following formal industry diffusion and testing. Thus, a realistic criterion for reducing consumption for concrete in new construction is to change the method in which it is poured. Tenant remodels, inclusive of occupant space construction, are the first practical area where realities can be used for regenerative actions and attributes that reduce consumption, because the building code has already been satisfied.

Realities replenish ecosystems in unknown ways and amounts without regard to how much is too much or what proportions are too much, and whether these reimbursements themselves will damage an ecosystem more than the removal of the initial resource. Without advanced analysis of which inputs may be required and where they should be applied, supplementary givebacks are simply overloading one ecosystem instead of balancing another.

Presuming that stakeholders are supportive up surpassing sustainability in built environment design, systemic barriers in ascertaining project financing and restrictions in building code from local municipalities remain. Design requirements are dependent on location, application, and the general progressiveness of a municipal building department. Acceptance of regenerative substitutions for traditional standards can be difficult when presenting untested technologies and methods (Rogers, 2003). For example, consider structural grade wood production.

Structural lumber is load-bearing, and code regulations require that it be cut, planed, and kiln-dried to prevent warping, cracking, and other weaknesses in its bearing capacity (International Building Code, 2018). A process for certifying structural lumber using nontraditional methods (i.e., outside of an approved manufacturing facility specified for that purpose) under a design-build platform of delivery is required by building codes (International Building Code, 2018). Physically performing this certification increases project costs. If code standards for on-site processing were developed and incorporated into the building code then costs would not increase. In turn, stakeholders would be more likely to use on-site lumber for structural design. This is a best case scenario for regenerative adoption.

This study did not produce or identify existing procedures for continually updating regenerative design realities. LENSES© has no formal mechanisms to help it evolve and be current within the design and construction industry. Dissemination through publication of trade papers and technical journals, client briefings, technology groups, and learning labs from stakeholders using regenerative innovations could improve its adoption and evolution. Continual adoption of new products and/or methods is required to maintain competitiveness and the growth of regenerative design. Confounding cycles of natural disruptions like fire, wildlife, and air pollution can complicate continual innovations and interfere with applying currently yielded realities in future contexts, thus continuous improvement procedures are necessary to ensure LENSES© survival.

Future Research

The LENSES© Framework provided a robust base of regenerative design ideology. This research refined Flows content in producing less obtuse statements guiding regenerative design. Regenerative realities fall short of precise standards required for code compliant design and construction, requiring additional industry development of realities. Like the refinement of sustainability innovations, regenerative actions and attributes are honed through diffusion of the realities, where they can be implemented, tested and trialed, and refined using continuous improvement strategies. The professional design industry is an important proving ground for guiding the direction and evolution of regenerative actions and attributes.

Realities have an existing and reliable pathway available for increasing diffusion created by previous sustainability accounting tools. In a similar fashion, regenerative innovations must demonstrate improvement in overall design function to stakeholders while reducing long-term risks, just as sustainable attributes did. Progressive industry development and refinement of design realities will advance regenerative technological attributes (i.e., physical components), products (i.e., new materials), and specific standards (e.g., code criteria for manufacturing & engineering) in prescriptive and subjective actions and attributes.

Technical professionals, like architects and engineers, are optimal candidates for further refinement of regenerative attributes using the design-build project delivery platform. Using this platform, conceptual inspiration and promotion of regenerative realities can be transferred to other stakeholders participating in the design process during actual projects (Rogers, 2003). Five key factors affect the rate of adoption of regenerative realities into the design industry: relative advantage, compatibility, complexity, trialability, and observability (Rogers, 1995). Regenerative guidance has a relative advantage to be adopted, as it follows closely with the sustainable design movement, which is familiar to industry stakeholders. Producing an informal template of regenerative criteria for decision support is advantageous to current stakeholders.

For non-technical stakeholders (e.g., clients, financiers, furniture manufacturers) subjective realities offer advantages in new design because subjective criteria (e.g., paint color, interior biophilia) allow clients to define and create a prescriptive, code compliant parameter for a subjective reality. Architects and engineers are the primary drivers of technologies using performance analysis, testing, and evaluation of incremental and holistic performances.

Advantageous stakeholders' perceptions of regenerative realities are intertwined as they relate to components and their compatibilities or incremental and holistic interoperability. Prescriptive attributes must prove to be reliable to meet the basic needs of design function based on agreement among architects, engineers, and permit officials reviewing the building code (International Building Code, 2018). Beyond meeting basic functions, performance and cost efficiencies are the leading factors in including or excluding regenerative integrations.

As with many new technologies and industry tools, changes in commodity harvesting, manufacturing, and installation will increase costs by an order of magnitude. Where a group of stakeholders overcomes “sticker shock” and includes regenerative realities, remaining variables blocking successful diffusion of the Flows are the interconnection and arrangement of design components to be integrated. Depending on the rarity or need for a certain commodity in the production of a regenerative component (i.e., based on a regenerative reality), costs can be exorbitant, and a project’s budget will stall the diffusion of this innovation. Widespread adoption can be limited to increments deemed cost effective or by stakeholders who deem them effective at the time (Gladwell, 2000).

Although compatible, certain regenerative design actions and attributes are too cumbersome to integrate without significant changes in design, both conceptual and in the type of built environment. For example, integrating a new green roof on an existing concrete missile silo. The amount of carbon recovery from a small surface atop a concrete silo is not worth the security and chemical hygiene liabilities. Similarly, the number of windows, open-air plenum atriums, and central heating and cooling designs overall must relate well in a commercial high-rise building. Both examples illustrate how system functionality is more regenerative than the integration of one increment or component.

For example, light fixture innovations must meet carbon reduction requirements as stipulated in the Materials and Energy Flows. This can be done through a reduction in the amount of wiring required for traditional light ballasts. An engineer must design for a minimum number of lumens and make up for lost lighting using additional windows. Integration of additional regenerative daylighting (i.e., windows) must outweigh reductions in singular lighting fixtures to satisfy the carbon reduction target.

The design, testing, and reporting of realities in a structured format is a new area of research and development for regeneration. While an existing sustainability format may be used to organize regenerative realities, additional development from a framework to a formal scheme is needed. Expansive differentiation of what constitutes a subjective or prescriptive reality is useful but defining "what is regenerative success" must be witnessed and measured. Most physical attribute realities refined from the Flows have performance metrics attached to them, drawn from prior sustainability testing. In this case, the researcher expects that early regenerative diffusions will present indiscriminate carbon offset schemes using a variety of preconceived and sustainable attributes. While this is positive, it is not a focused solution propagated by LENSES©.

Observability of integrated regenerative realities is an integral part of measurement and assessment. Prescriptively, occupants living with solar heating and cooling integration on an exterior wall will positively or negatively confirm the success of the reality during the operations and maintenance phases, through their levels of satisfaction (Timpson, 2017).

Outside of performance, realities designed for public spaces are the best mechanism for influencing other industry stakeholders. Seeing, sitting on, and feeling a chair made from the fibers of natural shrubs grown in the local forest are both subjective and prescriptive educational tools for continuing regenerative diffusions (Rogers, 2003, p. 258). By far, subjective realities have the most potential for diffusion because they are less technical and influence laypersons the most. Every occupant will perceive an interaction among paint colors, pictures, draperies, and furniture differently, using their senses. The greater the number of differences and individuals, the greater influence on diffusion.

For example, interpreting a color of interior paint using a subjective reality for “beauty”, which is often defined individually, will denote differences in preference even though several individual preferences can be lumped together to form a general code standard. Research consolidating “what is a beautiful indoor color” can help create a more specific idea of what beauty is and be a prescriptive parameter through continuous use, tracking, and development. Diffusion of beauty migrates from a subjective perception for many to a prescriptive trial of durability and measure of relative advantage in achieving regenerative design. For subjective realities, applications control the developmental parameters while maintaining flexibility for encapsulating a range of beautiful colors, pictures, and coverings.

Regenerative realities represent the eleven Flows of LENSES©, surpassing sustainability accounting tools in action and attribute guidances. Sustainable design improves upon negative impacts of traditional design to local and distant ecosystems. Likewise, regenerative design performs an enhanced function. Following the saturation and optimal growth of sustainable design, stakeholders’ rationale evolved relevant to the needs of the industry. These needs are currently defined through enhanced desires to reduce overall carbon footprints and in reversing climate change by replenishing and restoring ecosystems using structures for human habitation.

Design realities produce clearer guidance for achieving regenerative design for built environments. This is significant because design stakeholders must have clarity and comprehension of regenerative concepts to successfully implement them. The transition from sustainable to regenerative design will need additional development, both during adaptations in the field and through analytical adaptations in testing labs, at building sites, and in differing technical professions. Additional development transforms a framework into a regenerative tool.

The decision to employ the realities, Flows, and the LENSES© Framework must occur at the onset of a project. A high level of resource interdependencies requires complete dedication and cooperation from stakeholders beginning with the design concept, continuing with the acquisition of financing, and culminating with the issuance of building plans. Specifically defining and physically applying location- and structure-specific regenerative design actions and attributes are the challenge. Organizing, even categorizing, regenerative realities into a type of accounting scheme or accountability model is much simpler.

The realities seek to develop a "next level" of green building design, surpassing sustainment of ecosystems and moving to offset environmental damages caused by human structures for habitation. Regenerative realities mitigate altered planetary functions using built environment design, through replenishment of affected ecosystems.

Maintaining its resiliency and interdependencies and surviving as its own entity using its own evolutionary control, the planet existed prior to the arrival of humans. Humans will continue to rely on the resources of the natural world to supply food, water, and shelter. Understanding how built environments will affect ecosystems is key to the continual existence of the planet. Regenerative realities help to guide the balance among humankind and the natural world ensuring a future together - a future where restored resiliency drives chemical and physical functionalities for planetary stability.

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APPENDICES

Appendix A – LENSES Copyright Release

Greenwell, Craig

From:	Plaut,Josie <Josie.Plaut@ColoState.EDU>
Sent:	Thursday, July 18, 2019 1:08 PM
To:	Greenwell, Craig
Subject:	RE: Letter of Copyright Release

Yes – you are more than welcome to use LENSES in your dissertation.

Hope you are well,

Josie

Josie Plaut LEED AP BD+C
Associate Director
Institute for the Built Environment
O: 970.491.5665 | C: 970.391.6080
ibe.colostate.edu

From: Greenwell, Craig <Greenwell.Craig@epa.gov>
Sent: Wednesday, July 17, 2019 2:58 PM
To: Plaut,Josie <Josie.Plaut@ColoState.EDU>
Subject: Letter of Copyright Release

Hi josie.

I hope you are well. I am hoping you can reply to this email approving/granting permission for me to use the LENSES Framework in my dissertation. I realize you have done this before and I am updating everything for a final revision.

Let me know. Thank you.

Craig Greenwell.

Appendix B – Chapter Two Literature Review Search Terms

This section summarizes literature review search terms.

- The term 'Green Building' was searched;
- The time span Green Building was searched was 25 years (1990 – 2015)
- Academic research and industry developments were searched, tracing the historical transitions from traditional and sustainable innovations and accounting tools and frameworks to regenerative processes;

Literature is gained through Colorado State University's digital library databases. Specifically: *Compendex; Business Source Complete*; *Academic Source Premier*.

- Search terms: included a combination of words and phrases grouped, both together and separately: built environment; and/with stakeholders, phases, functionality, and life cycle; and/with traditional, sustainable and sustainability, and regenerative and regeneration; and/with, integration and assessment, systems and frameworks, and tools;
- Approximately 100 peer reviewed articles were reviewed for content and specificity and 49 were used to complete Chapter two;
- Criteria used in reducing reviewed material consisted of those containing sustainable and regenerative engineering technologies and efficiencies, integrations and philosophies, and accounting systems, tools, and frameworks. These included industry publications and websites.

Appendix C – Beauty: Why Consider Beauty

beauty

why consider beauty?

Beauty inspires care, concern, and engagement. Beauty can be the difference between a user's experience being one of complacency, resignation and possibly discomfort or being one of enlightenment, joy and happiness. With beauty present, humans are more likely to be enthused. Edward O. Wilson popularized the biophilia hypothesis, one that emphasizes the connections that human beings subconsciously seek with the rest of life. Literally, the term means "the love of life or living systems." Opposed to phobias, philias are the attractions that people have toward certain habitats, activities and objects in their natural surroundings. Related to biophilia is pulchraphila: the innate need to be surrounded by beautiful and well-designed environments with a particular connection to nature. From the Latin "pulchra" for beautiful and "philia" for love. Humans crave beauty: it motivates them.

Despite it's subjective nature, there are some generally agreed upon elements to strive for when seeking beauty. There are three Focal Points for the Beauty Flow: Ecological Beauty, Era, and Emotion & Sensory. **Ecological Beauty:** Study, understand, and celebrate the natural surroundings as they can deeply inform an aesthetic expression. **Era:** Consider and provide enduring expressions of the era that are not simply trendy. **Emotion & Sensory:** Explore how the emotions and senses will be affected by the potential new place or project.

powerful questions

- How is beauty to be embodied into the project?
- Can waste be reused in this project and celebrated beautifully?
- How can this project create enduring beauty?
- Is nature present in a meaningful way?
- Does the design express the appropriate era and does this expression endure the test of time?
- Are the intended emotions and sensations evoked?

beauty

focal point	degenerate	–	sustain	+	regenerate
Ecological Beauty The aesthetic expression of the web of life between all living things.	Design obstructs biophilia; creates an entirely synthetic environment disconnected from ecological context; prohibits ability to appreciate local ecological system.	Design minimally considers biophilia; attempts to integrate ecological context or scale of place.	Design allows for biophilia; appropriately scaled for surrounding ecological system.	Biophilia is considered in most aspects of design; restores impacted or degraded ecological systems to their natural balance and beauty.	Biophilia is intentionally incorporated throughout design; explicitly or implicitly enhances appreciation of the local ecological systems; harmoniously scaled per immediate ecological system.
Era Distinctive period of history.	Ignores consideration of current era; blind to the concern of future generations; serves initial purpose only; generic solutions; premature replacement occurs.	Only attempts trendy and temporarily satisfying solutions; decisions made with only limited exploration falling back on status quo or habitual solutions; outdated quickly.	Aesthetic solutions are beyond simple decoration or fashion and are not simply nostalgic; enduring; recognizes the needs and limits of future society; promotes an investment in longevity.	Encourages adaptability to alternate uses; benefits future generations of use; solutions create authentic sentimentality; honors the spirit of the time.	Creates great meaning; instills a desire to promote the project's endurance; produces a timeless appreciation; encourages respect for the era of a project's birth as well as the project itself.
Emotion & Sensory Heighten feeling; relating to sensation.	Causes fear, repulsion or general discomfort; breaks down the spirit of the occupants; hopeless, dangerous and/or unappealing environments.	Evokes limited or undesirable emotions; causes boredom and complacency; limited sensorial displeasure.	Creates a state of contentment and peacefulness; evokes feelings of safety and satisfaction; responds to humans love for nature and order.	Encourages joy, energy, reflection, thought and productivity; enhances well-being.	Evokes delight, happiness, inspiration, deep reflection, great achievement, appreciation or serenity; generates healing and self-actualization; celebrates spirit.
Culture Way of life; shared beliefs and values of a group.	Prohibits, destroys, violates or disrespects culture; imposes inappropriate culture and practices; disharmonious with surrounding built and natural environment.	Neither excludes nor promotes local, cultural context; meaningless and/or generic; ignores and disregards cultural significance and meaning; does not create opportunities for cultural appreciation.	Maintains or perpetuates cultural standards; does not threaten culture; allows cultural appreciation; harmonious within the context of the surrounding built and natural environment.	To a limited extent, promotes understanding of local culture; encourages cultural appreciation and expression; challenges dominant culture or lack of culture; considers local cultural vernacular and traditions.	Respects and honors local culture; inspires cultural appreciation and expression; challenges dominant culture or lack of culture; celebrates local culture, vernacular and traditions; encourages and generates cultural significance and meaning.

beauty - planning worksheet

How to use this planning worksheet: The purpose of this worksheet is to identify project goals, specific achievement strategies, resources needed, responsible parties, and a realistic implementation timeline for relevant Focal Points. Begin by discussing the ideal beneficial state for the project or initiative using the descriptions and desired outcomes below each Focal Point as guidelines. The associated Rubrics may also be used for reference, as desired. Next, determine specific strategies that will help your team reach its ideal state, making notes directly in the worksheet below. **Identify the resources needed, individuals or groups that should be engaged for each achievement strategy, and a reasonable timeline for implementing each strategy. Use the outcomes of this worksheet to develop an implementation plan for your project or initiative.**

focal point	achievement strategies	resources needed	responsible parties	timeline
Ecological Beauty The aesthetic expression of the web of life between all living things *A desired outcome for ecological beauty:* • Biophilia is intentionally incorporated throughout design • explicitly or implicitly enhances appreciation of the local ecological systems • harmoniously scaled per immediate ecological system				
Era Distinctive period of history *A desired outcome for era within beauty:* • Creates great meaning • instills a desire to promote the project's endurance • produces a timeless appreciation • encourages respect for the era of a project's birth as well as the project itself				
Emotion & Sensory Heighten feeling; relating to sensation *A desired outcome for emotional and sensory beauty:* • Evokes delight, happiness, inspiration, deep reflection, great achievement, appreciation or serenity • generates healing and self-actualization • celebrates spirit				

beauty - evaluation worksheet

How to use this evaluation worksheet: The purpose of this worksheet is to evaluate a project or initiative's success in meeting its goals, as originally determined using the Planning Worksheet. Completing this worksheet is also intended to identify project achievements, challenges, and lessons learned to help inform continual improvement. Begin by assessing where the project or initiative currently falls on the scale of degenerative to regenerative for each relevant Focal Point. You may find that more than one classification is applicable, which can be noted by checking more than one box. Discuss why and/or how the project is meeting the selected classification(s), making notes directly within the worksheet below. The associated Rubric and Planning Worksheet may be used for reference, as desired. Use the process and outcomes of completing this worksheet to determine additional opportunities for improvement.

focal point	degenerative (-3)	degenerative-sustaining (-1)	sustaining (0)	sustaining-regenerative (+1)	regenerative (+3)	score
Ecological Beauty The aesthetic expression of the web of life between all living things *A desired outcome for ecological beauty:* • Biophilia is intentionally incorporated throughout design • explicitly or implicitly enhances appreciation of the local ecological systems • harmoniously scaled per immediate ecological system	☐ Why and/or how?	☐	☐	☐	☐	
Era Distinctive period of history *A desired outcome for era within beauty:* • Creates great meaning • instills a desire to promote the project's endurance • produces a timeless appreciation • encourages respect for the era of a project's birth as well as the project itself	☐ Why and/or how?	☐	☐	☐	☐	
Emotion & Sensory Heighten feeling; relating to sensation *A desired outcome for emotional and sensory beauty:* • Evokes delight, happiness, inspiration, deep reflection, great achievement, appreciation or serenity • generates healing and self-actualization • celebrates spirit	☐ Why and/or how?	☐	☐	☐	☐	
total beauty flow score						0

Appendix D – Human Research Board Release Letter

Colorado State University

Research Integrity & Compliance Review Office
Office of Vice President for Research
Fort Collins, CO 80523-2011
(970) 491-1553
FAX (970) 491-2293

Date: February 25, 2015

To: Carole Makela, Ph.D.
Professor, School of Education

Craig Greenwell
Doctoral Student, School of Education

From: Evelyn Swiss, CIP, IRB Coordinator

Re: *Exploring the LENSES Framework: Regenerative Processes for the Built Environment*

After review of information regarding the secondary anonymous data that you will analyze for the above-referenced project, it was determined that the data do not meet the requirements of the federal definition of human subject research. "Human subject means a living individual about whom an investigator conducting research obtains data through **intervention or interaction with the individual**, or **identifiable private information**" (45CFR46.102(f).

Living individual – Y
About Whom – Y/N
Intervention/Interaction – N
Identifiable Private Information – N

Thank you for submitting this information. If you have more projects that are similar, please contact us prior to submission. The IRB must determine whether a project needs to have IRB approval.

Animal Care & Use • Human Research • Institutional Biosafety
321 General Services Building http://web.research.colostate.edu/ricro/

Appendix E – Inter Coder Agreement Template

Peer review ensures a high level of intercoder agreement and is essential to establishing coding consistency and study reliability. Each reviewer will receive an individual coding sheet with four steps of yielded criteria from the Energy and Beauty Flows. Responses from all reviewers will be summarized and discussed in the Discussions and Conclusions.

Instructions:

1. Read and review the Coding Process of Regenerative Criteria for Flows, and review yielded criteria for Steps A-D.
    a. Review the Energy and Beauty Flows original regenerative criteria and begin coding them.
        i. Code the Energy and Beauty Flow using Step A, then code both Flows using Step B; the same with steps C and D (one step for both Flows at the same time, then the next step on both Flows, etc.).
        ii. At each step (i.e., A, B, C, or D) during the reviewing process, check your own yielded criteria against the researcher's findings in the respective step. Either 'Agree' with the researcher's findings, or 'Add' or 'Delete' additional words or phrases.
    b. Reread the Coding Process of Regenerative Criteria for Flows, Steps A-D, and the section called 'Codebook'.
    c. Review the Energy and Beauty Flows regenerative criteria for a second time and begin coding both Flows.
        i. Code the Energy and Beauty Flow using Step's A and B, then code both Flows using Step's C and D.
        ii. At Step A-B for both Flows, check your level of agreement against the researcher's findings and your initial Agreements, Additions or Deletions, if any. Reconcile these differences and state a final Agreement or Addition or Deletion in the space provided, if any.

	ENERGY FLOW				
	Focus Point #1. <u>Investment</u>: The idea that our energy endowment is equal to stored global solar energy and that we "spend" our energy.	**Step A: Identifying Major Topics**	**Step B: Refinement & Clustering**	**Step C: Theme Creation & Definition**	**Step D: Examine Themes' Against Original Text**
	<u>Abstract Criteria</u>	<u>Researchers Step A Yielded Criteria</u>	<u>Step B Yielded Criteria</u>	<u>Step C Yielded Criteria</u>	<u>Step D Yielded Criteria</u>
	Takes an intergenerational view about restoring energy endowment to support future generations.	Intergenerational energy investment (3)	Energy endowment, for multiple generations; global solar energy (8)	Use no more stored global energy than endowed for a project; investment in more energy for endowments (16)	Design invests in project realities that support energy endowments for future generations; design uses less than the endowment of solar equity available for it (25)
	<u>Responses</u>: 1) Agree with all; or, 2) Add or Delete Words or Phrases.	<u>Agreement Step A</u>	<u>Agreement Step B</u>	<u>Agreement Step C</u>	<u>Agreement Step D</u>
	REVIEWER #1	Agree (0)	Delete: Solar (1)	Agree (0)	Agree (0)
	Ratio	3/3 or 100%	8/1 or 87.5%	16/16 or 100%	25/25 or 100%
	REVIEWER #2	Agree (0)	Add: Intergenerational (1)	Add: Generating (1)	Add: Support (1)
	Ratio	3/3 or 100%	8/1 or 87.5%	16/1 or 94%	25/24 or 96%
	REVIEWER #3	Agree (0)	Agree (0)	Agree (0)	Delete: Support (1); Add: Create (1)
	Ratio	3/3 or 100%	8/8 or 100%	16/16 or 100%	25/23 or 92%
	Total Reviewer's Average Ratio	**100%**	**93%**	**98%**	**93%**
	<u>Abstract Criteria</u>	<u>Researchers Step A Yielded Criteria</u>	<u>Step B Yielded Criteria</u>	<u>Step C Yielded Criteria</u>	<u>Step D Yielded Criteria</u>
	Invests the energy spent on a project in long-term efforts to rebuild energy endowment.	Long term energy investment (4)	Increases solar endowments through long term efforts (7)	Project realities to create energy offsetting equity spent; permanent realities are an investment for fixed global supply (17)	Design realities create energy above that which is spent using project realities; design invests in realities producing a long term and infinite global supply of energy endowments (27)
	<u>Responses</u>: 1) Agree with all; or, 2) Add or	<u>Agreement Step A</u>	<u>Agreement Step B</u>	<u>Agreement Step C</u>	<u>Agreement Step D</u>

	Delete Words or Phrases.				
	REVIEWER #1	Agree	Add: Energy	Add: Ensure	Add: Built environment
	Ratio	4/4 or 100%	7/1 or 85.8%	17/1 or 94.1%	27/2 or 92.6%
	REVIEWER #2	Agree	Add: Energy	Add: Replacing; Energy	Delete: Endowments
	Ratio	4/4 or 100%	7/1 or 85.8%	17/2 or 88%	27/1 or 96.3%
	REVIEWER #3	Agree	Add: Energy	Agree	Delete: Infinite
	Ratio	4/4 or 100%	7/1 or 85.8%	17/17 or 100%	27/1 or 96.3%
	Total Reviewer's Average Ratio	**100%**	**86%**	**94%**	**95%**
	BEAUTY FLOW				
	Focus Point #1. <u>Ecological Beauty</u>: The aesthetic expression of the web of life among all living things.	**Step A: Identifying Major Topics**	**Step B: Refinement & Clustering**	**Step C: Theme Creation & Definition**	**Step D: Examine Themes' Against Original Text**
	<u>Abstract Criteria</u>	<u>Researchers Step A Yielded Criteria</u>	<u>Step B Yielded Criteria</u>	<u>Step C Yielded Criteria</u>	<u>Step D Yielded Criteria</u>
	Biophilia is intentionally incorporated throughout design.	Biophilia or plant life; from the local ecosystem (8)	Plant life; representing the web of life among all living things (11)	Plant life established on the interior and exterior; visual expression of living things (13)	Design realities create interior plant life as a visual expression of all living things (14)
	<u>Responses</u>: 1) Agree with all; or, 2) Add or Delete Words or Phrases.	<u>Agreement Step A</u>	<u>Agreement Step B</u>	<u>Agreement Step C</u>	<u>Agreement Step D</u>
	REVIEWER #1	Agree	Add: Inside ecosystem	Agree	Agree
	Ratio	8/8 or 100%	11/2 or 82%	13/13 or 100%	14/14 or 100%
	REVIEWER #2	Agree	Add: Indoors	Agree	Add: Exterior
	Ratio	8/8 or 100%	11/1 or 90.9%	13/13 or 100%	14/13 or 92.8%
	REVIEWER #3	Add: Design	Agree	Agree	Add: Biophilia
	Ratio	8/1 or 87.5%	11/11 or 100%	13/13 or 100%	14/13 or 92.8%
	Total Reviewer's Average Ratio	**96%**	**91%**	**100%**	**95%**
	<u>Abstract Criteria</u>	<u>Researchers Step A Yielded Criteria</u>	<u>Step B Yielded Criteria</u>	<u>Step C Yielded Criteria</u>	<u>Step D Yielded Criteria</u>

	Explicitly or implicitly enhances appreciation of the local ecological systems.	Design characteristic of the local ecosystems (6)	Ecological beauty (2)	Local systems represented interior and exterior and in all tenses; local ecology represents web of all living things (18)	Design realities integrate local ecology and ecological systems inside and outside; these realities visually represent the local ecosystem (18)
	Responses: 1) Agree with all; or, 2) Add or Delete Words or Phrases.	Agreement Step A	Agreement Step B	Agreement Step C	Agreement Step D
	REVIEWER #1	Add: Interior	Agree	Agree	Add: Functions
	Ratio	6/1 or 84%	2/2 or 100%	18/18 or 100%	18/1 or 95%
	REVIEWER #2	Add: Enhances	Agree	Delete: All	Agree
	Ratio	6/1 or 84%	2/2 or 100%	18/17 or 94.4%	18/18 or 100%
	REVIEWER #3	Add: Similar	Agree	Agree	Delete: Visually
	Ratio	6/1 or 84%	2/2 or 100%	18/18 or 100%	18/1 or 95%
	Total Reviewer's Average Ratio	**84%**	**100%**	**98%**	**97%**
	Abstract Criteria	Researchers Step A Yielded Criteria	Step B Yielded Criteria	Step C Yielded Criteria	Step D Yielded Criteria
	Harmoniously scaled per immediate ecological system.	Design realities are scaled representing all living things (8)	Modelled after the immediate ecosystem (5)	Local beauty is scaled per the immediate area (8)	Design realities scale themselves to agree with their own capacity and function (12)
	Responses: 1) Agree with all; or, 2) Add or Delete Words or Phrases.	Agreement Step A	Agreement Step B	Agreement Step C	Agreement Step D
	REVIEWER #1	Agree	Add: Local	Add: Represents	Agree
	Ratio	8/8 of 100%	5/1 or 80%	8/7 or 87.5%	12/12 or 100%
	REVIEWER #2	Agree: To	Agree	Add: Ecosystem	Add: Are scaled
	Ratio	8/7 or 87.5%	5/5 or 100%	8/7 or 87.5%	12/10 or 83.3%
	REVIEWER #3	Agree	Add: Local	Agree	Agree
	Ratio	8/8 or 100%	8/1 or 80%	8/8 or 100%	12/12 of 100%
	Total Reviewer's Average Ratio	**96%**	**87%**	**92%**	**94%**