Our Buildings Have Credentials…Now What?

A Design-Based Analysis Framework for Reconciling Green Buildings with the Sustainable Development Goals

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ABSTRACT

Our Buildings Have Credentials…Now What?
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Today's definition of sustainable buildings is primarily linked to their environmental performance and hedged on context-free and efficiency-driven standards, certifications, and recognitions. On the other hand, sustainable development requires simultaneous consideration of human and natural systems' needs. Beyond environmental credentials, the study aims to correct this epistemological contradiction by reintegrating sustainable building practices within the broader scope of sustainable development. The study adopts the UN 2030 Agenda as a comprehensive and unifying framework for sustainable development, presenting an opportunity for systemic change towards a sustainable future. The thesis examines the current sustainable real estate and building design approaches and academic debates, analyzing how the prevailing design analysis and assessment frameworks address the Sustainable Development Goals (SDGs). It exposes that the existing body of work is fragmented across different paradigms, showing that the prevailing approaches fail to account for the topic's pluralistic nature and exposing the misalignment between the current building practices and tools and the SDGs' transformative vision on the practical and theoretical levels. Furthermore, the current trends in sustainable real estate point to the broadening of concerns - making our current understanding and practice of sustainability in buildings practically ineffective. Alternatively, and to move beyond the current impasse, the research proposes adopting more complex and value-added analytical instruments that could maintain plurarily and accept opposites' co-existence. The research produces a theoretical framework for distinguishing between the critical and status-quo sustainable design approaches in buildings. The thesis also generates and tests mapping tools and frameworks for critically integrating the SDGs in building projects and analyzing their design approaches. Finally, the thesis examines the coverage, integration and design vision of Canada's most awarded green buildings to the SDGs' topics. While some examples of sustainability innovations emerge, the analysis reveals several gaps and limitations. This thesis contributes to the theory and practice of environmental design within the meta-field of architecture. It expands sustainable building approaches and redefines them as a critical practice for development. The findings and tools can enable the building industry and governmental bodies to accelerate the uptake and implementation of the 2030 Agenda in the built environment.

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“Nous arrivons dans un monde qui nous précède et qui nous survivra. [...]

La terre ne va pas disparaître. La terre n'a pas besoin d'être sauvée. Ce sont les rapports entre les vivants sur la terre que nous devons sauver.”

(Jean Pichette, in Gomez, 2020)

STATEMENT OF CONTRIBUTION

This thesis consists of material, all of which I (the thesis author – Sherif Goubran) authored or co-authored.

Sherif Goubran is the sole author for the Introduction and the conclusion of the document, which were written under the supervision of the thesis director, Dr. Carmela Cucuzzella, and were not written for publication. Beyond those two chapters, this thesis will consist in part of six (6) manuscripts written for publication. These include two (2) single authored manuscripts, from which one (1) manuscript has already been published, and one (1) to be published with in the near future. The thesis includes four (4) co-authored manuscripts; from which two (2) manuscripts have already been published, one (1) under submission in a journal, and another one (1) are to be published with co-authors in the near future. A detailed description of these publications, including the nature and extent of the thesis author's (Sherif Goubran) contribution and each listed author for every manuscript, is presented in Appendix (C).

In all the manuscripts included in this thesis, I (Sherif Goubran) was a lead author, the first author (or co-first author), or main contributor. This designation entails that I was the principal researcher responsible for conceptualizing the design of the study, studying and analyzing the research making up the review of literature, developing theoretical and methodological frameworks, carrying out data collection and analysis, and drafting, submitting and reviewing manuscripts. My committee members, be them co-authors and co-first authors, provided guidance during each step of the research and provided feedback on manuscript drafts. Other co-authors listed on the manuscripts provided varying levels of input, as described in Appendix (C) and summarized below.

Below is a brief summary of chapter-based contributions, for all materials with co-authors (organized based on the order of appearance and collaborators):

- For Chapter 3 and Chapter 4: This research was conducted at Concordia's John Molson School of Business under the supervision of Dr. Thomas Walker, within the Sam and Diane Scalia

Sustainable Built Environment Program. For Chapter 3, T Walker was invited by the book/book-series editors to contribute to this collection, which part of a book series titled *Business and Society 360*. We acted as co-first authors for the contribution. Chapter 4 is being finalized for submission. Tyler Schwartz worked on co-developing the analysis tool and completed the coding required for the content analysis. Dr. Carmela Cucuzzella assisted in developing and conducting the qualitative analysis. Dr. Thomas Walker supervised and funded the project and validated the manuscript and its findings. The citations for the published chapters are as follows:

Walker, T., & Goubran, S. (2020). Sustainable real estate: Transitioning beyond cost savings. In D. M. Wasieleski & J. Weber (Eds.), *Sustainability* (Vol. 4, pp. 141–161). Emerald Publishing Limited. https://doi.org/10.1108/s2514-175920200000004008

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- Chapter 7 remains an unpublished manuscript (ready for submission with minor edits), with the final authorship undecided yet. This research was completed under the supervision of Dr. Carmela Cucuzzella and Dr. Jean-Pierre Chupin, the Canada Research Chair in Architecture, Competitions and Mediations of Excellence (CRC-ACME). For Chapter 7, the thesis author collected all data pertaining to the buildings (design, descriptive and judgment documents). However, it is important to note that the data collection for the awards of excellence was paid for by a contract from CRC-ACME.

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PREAMBLE[1]

In the last few decades, governments, policymakers, designers, engineers, and even building tenants (including owners, developers, or investors) focused a great deal of their attention on buildings' energy consumption and environmental impacts.

This focus is well justified.

Commercial and residential buildings are responsible for close to 17 percent of Canada's greenhouse gas emissions (GHGe) ¬ making them the third-highest sector in Canada after oil and gas and transportation. Governments have invested considerable effort, research, and resources toward reducing buildings' energy use and their corresponding GHGe[2]. The good news is that, in comparison to the 1990s, the energy use per square foot in Canada has decreased significantly. Additionally, we also moved away from using high GHGe energy sources for heating (such as heating oil or wood) to using cleaner sources (such as electricity).

But the story does not end here.

To catch up with a rapidly growing population, we are now constructing more buildings at faster rates. In a report published in November 2018, the Standing Senate Committee on Energy, the Environment and Natural Recourses indicated that, despite the substantial efficiency gains achieved since the early 2000s, the sector's overall GHG emissions have only decreased by 3 percent. In fact, the building sector's overall energy consumption is increasing and is expected to keep that upward trend for a few more years. (The Senate Standing Committee - Energy the Environment and Natural Resources, 2018)

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1 Based on an op-ed I published in the Montreal Gazette (cross published in the Ottawa Citizen), and a number of my blog posts published by Concordia University's Public Scholars program (Goubran, 2019d, 2019c, 2019e, 2019f, 2019h)

2 Similar contributions from the building sector to GHGe and environmental degradation are reported in other countries and regions (World Economic Forum, 2016a).

Energy and emissions reduction goals are not new; they were first propagated during the 1973 oil crisis (Peffer et al., 2011), and they continued to be a cornerstone in the technical advancement of buildings ever since. In more recent years, energy infrastructure and grid limitation pushed researchers towards examining tactics to control energy demand – especially during peak hours (Zehir et al., 2019). In many cases, it is the technology that is driving innovation in the built environment (de Dear, 2011). While technology does offer gains (in efficiency, economy and jobs, for example), it does not hold the solution to our sustainability challenges – especially those that fall beyond the environmental realm (Berardi, 2012; Magee et al., 2015). In the next few sections, I will attempt to highlight how the problematic and approach of this thesis developed, through my experiences, learning and reflections on the topic of sustainability in the built environment[3].

Dilemmas in the building-related disciplines

> During my masters, my research focused on how technology can help reduce the energy consumption in commercial buildings: specifically, energy used to heat or cool air that is introduced through entrance doors. This was a real-life problem that we all experience when going through the entrances of buildings in Montreal's frigid winter months. In some cases, air infiltration through highly used entrance doors is responsible for up to 40% of buildings' total heating loads (Emmerich & Persily, 1998). The research outcomes I generated showed that improvements in the entrance door air sealing technology could help mitigate this problem. *My study reported an average of less than 3% building energy savings compared to current solutions, which can be considered a good incremental improvement.*
>
> *Although I obtained these results through a mix of laboratory testing, computational fluid dynamics and energy simulations, they didn't reflect the actual performance of a building (only of a model building that never and will never exist). They also didn't consider the broader environmental impacts (energy, GHGe and materials) of these savings, nor the spatial and cultural effects of the technology they advocated.*

3 Indentations indicate more of personal reflections on the topic (written in first person).

> My engineering degree taught me a lot about energy modelling, indoor air quality, optimization of design parameters, wall compositions, and technology's role in efficiency gains. While I gained a significant amount of new knowledge and technical skills, I came out with one key question unanswered*: is incremental technological improvement enough to solve our sustainability challenges?*
>
> I realized that incremental improvements are a good first step, but they can only go so far. In fact, gains in efficiency – in energy, water, or material use – do not always directly result in overall consumption reductions. Actually, efficiency gains might result in increased demand – a sort of rebound effect commonly known as Jevon's Paradox. Building "green" is a prerequisite for mitigating climate change. But this approach misses a key point.

In many cases, technological fixes come with some *terms and conditions*: the results obtained in a laboratory setting or through simulations are a good indicator of potential, but they don't necessarily translate directly into performance – simply because many interlinked factors affect the performance of buildings. In many cases, technological fixes have other broader social, cultural, environmental and economic consequences that are not readily studied in the field of building engineering.

You can find yourself comparing a multi-storey parking garage with an elementary school or a suburban strip-mall with a library building in a purely efficiency-focused approach. In such comparisons, you can even find the parking garage to be more energy-efficient than the school.

But in the big picture, what impact do energy-efficient parking garages have on climate change, our cities and even our health? Is it meaningful to consider buildings simply as electric consumption and emissions statistics?

Moving beyond energy efficiency in buildings

While our kitchen appliances come with an environmental rating sticker proclaiming their virtues, a building is more complex than a refrigerator. The buildings we construct serve many complex social, cultural and economic purposes. We live, work and learn in them. They shape our identity and culture. They sustain human progress. We must be more critical and consider, not only how much energy a building consumes, but what this energy is used for. *A consideration that differentiates between "green" and sustainable.*

We have to move beyond the narrow focus on efficiency to consider the broader effects and benefits buildings present us. This involves adopting a systemic view and understanding the scale of focus – since sustainability could have different manifestations, constituents and meanings at global, national, or local levels (Goubran, Emond, et al., 2020; Goubran, Masson, et al., 2019).

In fact, building *sustainably* requires dedicating equal attention to a structure's environmental, social, cultural and economic impacts. This means moving beyond simple harm-reduction towards protecting the environment, promoting cultural development, encouraging local economic development, and addressing social challenges in our communities. Sustainable buildings go beyond the materials and energy they use to contribute to society proactively.

While some critics could argue that sustainability, if not defined by quantitative measures of performance, is just a *buzzword* with little practical meaning, the United Nations' (2015) Sustainable Development Goals (SDGs) provide us with 17 clear objectives accompanied by clear targets that reach much further than the energy-carbon nexus [4] (Appendix (A)). Even if Goal 11 "Make cities and human settlements inclusive, safe, resilient and sustainable," is the most cited in discussions around the built environment, buildings can significantly contribute to other goals of the Agenda by tackling complex challenges such as access to food, education or biodiversity protection (Goubran, 2019a).

Buildings, especially those that are publicly funded, should address our long-term social, economic, environmental and cultural challenges.

Critically approaching sustainability in building

While certifications, assessment tools and standards played a vital role in popularizing green building principles (Díaz-López et al., 2019b; Riascos et al., 2015), their normalized and fragmented design approach show some major weaknesses. Additionally, the slow and

4 Canada, along with another 192 member states of the UN are committed to the 2030 Agenda

accumulative nature of codes and standards might not be aligned with the complexity of the challenges we are facing (Goubran, Masson, et al., 2020). Thus, it is essential for designers and project teams to continuously complement the existing standards and tools to help fuel critical and reflective decision-making around sustainability– especially at the early project phases. After all, Kuhn tells us in *The Structure of Scientific Revolutions* (1970) that significant developments in science do not come from accumulation or incrementalism but rather from paradigms shifts: revolutions in thinking and radical changes of world-views.

Researchers and designers' role should not be limited to supporting current building practices by proposing incremental improvements to the status quo, nor criticizing them by emphasizing their failures. They have to work towards changing the course of the future of our cities: to make our buildings not just consume less, but also put their energy, both primary and embodied, to good use. Also, they should help shift the focus on the active roles buildings can play in our society – such as giving access people access to where they can engage and learn, create new work opportunities, or raise awareness and encourage positive environmental behaviours (Cucuzzella, 2019b; "Du Didact. En Archit. / Didact. Archit.," 2019). Our role is to develop ideas that tap into the opportunities that sustainable development can offer to our buildings, cities, and our environment.

To achieve those bold objectives, researchers and designers have to either investigate and present: 1) practical approaches that can support critical decision-making or fuel innovations in building projects or 2) theoretical explorations that can help broaden the working definition of sustainability in building projects beyond its current eco-efficiency driven environmental focus.

While the benefits of the first line of research are self-evident, the theoretical explorations are key in shaping the future of sustainable building design. These studies, which could be less concerned with the technical applicability, could in fact put in question the meta-theoretical assumptions that guide the field (questioning what constitutes sustainability in building design and the process by which it could be attained), and thus have the potential to redefine sustainable building design.

The meaning of sustainable building design and how to attain it

While the definition of sustainable building design is a moving target, there is certainly a disconnect between how we define and practice sustainability in buildings and the larger scope of sustainable development.

Today, we depend on 3rd party certifications, standards and quantitative metrics to define a project's sustainability, building or structure. But we rarely ask questions that go beyond the requirements of such credentials.

In turn, this marginalizes critical design approaches – that reflect and adapt to the local and regional realities, that aims to innovate and experiment to discover new possibilities, and that see to achieve quality and leadership in design through reflective practice.

This research tries to reunite how sustainable design is practiced with the current guiding principles for sustainable development. It takes a critical stance against certifications, to investigate the potentials buildings hold, and what they could achieve beyond their credentials.

Thinking of a comparable analogy, getting a degree does not represent ones' major achievement, it just means that you were able to meet some program's requirements. However, it is the learnings, failures, successes, risks and relationships within your program that are significant. And most importantly, it is what you achieve and what you are able to accomplish with your degree that counts the most. In fact, the way I see it is that studying for a degree is just like designing for a credential: it takes the fun away, and it corrupts its purpose.

INTRODUCTION

CHAPTER 1. INTRODUCTION

1.1. Overview

Understanding, measuring, or attaining sustainability in buildings and the built environment are complex problems. They involve untangling interlinked elements that are scattered between the environmental, social and economic dimensions. This requires mediating between different geographic scales and temporal dimensions. And, they necessitate navigating between many different academic and professional fields - such as design, architecture, engineering, finance and environmental sciences. (Cucuzzella, 2015a; James, 2015; Sterman, 2015)

The notion of *sustainability* in the built environment[5] has passed through numerous phases: including the biological, the vernacular, the industrial and the modern (McLennan, 2004). Following the environmental awakening of the 1970s, sustainability in buildings was formalized in the 1990s through the establishment of international and national governing organizations and bodies as well as the emergence of the sustainability rating systems (McLennan, 2004; Tabb & Deviren, 2014).

On the other hand, the term *sustainable development* was first coined during the early 1980s in the *World Conservation Strategy: Living Resource Conservation for Sustainable Development* report prepared by the International Union for the Conservation of Nature (IUCN) (1980). This report was a result of several influential publications that came before it, including *Limits to Growth* published by the Club of Rome (Meadows et al., 1972). It was also followed by other prominent reports, including *Our Common Future* (commonly known as the Brundtland Report), where the term was popularly defined as "[…] development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987).

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5 The term sustainability hasn't been used explicitly: the type of practice that considers the ecological, environmental and human and non-human elements in the surroundings of project has been described by various adjectives (Cucuzzella, 2015a; James, 2015; McLennan, 2004; Sterman, 2015; Tabb & Deviren, 2014).

While the first movements of ecological and environmental design strived to adopt and operate these early holistic and comprehensive definition (Dewberry & Goggin, 1996; Fisher, 2008; Yudelson, 2008b), various political, economic and even technological forces have significantly diverged these efforts and have resulted in multiple, often competing, definitions, methods, methodologies, epistemologies and even ontologies around sustainability in the built environment (Cucuzzella, 2011a, 2016; Hajer, 1995). Today, as it was true almost 30 years ago, one cannot disconnect the discourse on the topic from the political forces surrounding it:

> *"In this light the present hegemony of the idea of sustainable development in environmental discourse should not be seen as the product of a linear, progressive, and value-free process of convincing actors of the importance of the Green case. It is much more a struggle between various unconventional political coalitions, each made up of such actors as scientists, politicians, activists, or organizations representing such actors, but also having links with specific television channels, journals and newspapers, or even celebrities."* (Hajer, 1995 - p12-13)

Thus, the continuously ongoing debates and tensions around the topic of sustainability, both in theory and practice, have resulted in a multitude of (A) definitions, (B) approaches, and (C) motives for sustainability in the built environment. Zuo & Zhao (2014) propose to organize these debates around questions that tackle these three central themes: 1) what is a green/sustainable building? 2) how to achieve green/sustainable buildings?, and 3) why green/sustainable buildings?

As it will emerge in this thesis, the answers to these three questions are indicative of the ongoing tensions between the *universal & the specific*, *the subjective & the objective*, t*he holistic & the targeted*, *the human & the industrial or technological*, *the fluid & the stable*, *the emergent & the predetermined*, and the list goes on.

Sustainability is often represented as the outcome of the intersection of the economic, social and environmental pillars. Even this definition, which is considered stable, has been challenged by scholars who propose adding more pillars – such as culture, ethics, and politics (Doan et al., 2017; Ehrenfeld, 2009; James, 2014). In building design, the current definitions result from the continuously contested definition of sustainability since the emergence of the environmental design in the 1960s (Tabb & Deviren, 2014). However, after the 1990s, and in synchronization with the institutionalization of the topic, sustainability in buildings has been popularly equated to "doing less damage" or "being more efficient' (Cucuzzella, 2015a; Tabb & Deviren, 2014). Even though there are more than 100 definitions for sustainable design available in the literature today, they distort the original definition of sustainable development proposed by the Brundtland Commission (Doan et al., 2017). Environmental design has shifted from searching for holistic ecological solutions to technologically driven, and arguably more shallow, approaches: methods that are focused on eco-efficiency or optimization of performance, and that are based on highly structured principles (Fletcher & Goggin, 2001; Jonas, 1979; Madge, 1997; Naess, 1973). Sustainability has been reduced to measurable indicators or multi-parameter optimization problems (Boyko et al., 2012; Rashid & Yusoff, 2015; World Commission on Environment and Development, 1987).

Similarly, the question relating to sustainable design approaches presents competing and inconsistent answers. With more than 600 environmental assessment and rating tools available globally (Doan et al., 2017), building designers are overwhelmed with criteria, checklists and procedures. Scholars argue that tools, such as environmental rating schemes, reduce the concept of sustainability to the quantifiable and objective environmental performance measures while failing to be comprehensive (*ex.* giving much less focus to the contextual, social and economic debates) (Bernardi et al., 2017; Brandon & Lombardi, 2011; Cucuzzella, 2019a; Doan et al., 2017). However, improved or even new tools[6], methods and frameworks (ex. WELL, or the living building challenge[7]) that promise to move beyond the traditional technical definitions of

6 A standard focused on occupants wellbeing (International WELL Building Institute (IWBI), 2017, 2018), a dimension of sustainable development. The standard indicates that it intersects with almost all of SDGs, with a large focus on health (SDG 3):

"By mapping WELL v2 features to the 17 SDGs, we sought to highlight the multi-faceted impact of WELL in a global context while identifying further opportunities to evolve WELL into an even more comprehensive framework. The results of our mapping exercise, shared below, reveal that WELL spaces are not just healthy spaces - they are also inclusive, resilient, sustainable, inspirational spaces with impacts reaching far beyond the scale of a single building. Above all, WELL's alignment with the SDGs reinforces the powerful opportunity we all have as global caretakers to catalyze our built spaces as mechanisms to deliver health and wellness benefits to the individuals within them, the wider community, and our surrounding environment." - https://www.wellcertified.com/sdgs

7 https://living-future.org/lbc/

sustainability to be more comprehensive, more accurate, or more contextual (Brandon & Lombardi, 2011; Gibberd, 2015; Markovich et al., 2018; Rashid & Yusoff, 2015; S. Walker, 2006).

Finally, the debates regarding the motives behind designing and constructing sustainable buildings remain politically charged and economically driven. Mostly, designers still have to respond to the market need for "benefits" – whether political, social or economic - to appeal to the investors, governments or even end-users (Allen et al., 2018b; Brouwer et al., 2012; Raymond J. Cole & Lorch, 2003; DeKay, 2011; Government of Canada, 2018; Gupta & Vegelin, 2016; Hosey, 2012).

Pyla's (2008) and Vandevyvere & Heynen's (2014) proposition that sustainability in the built environment – just like modernism – "is constantly running the danger of turning into a totalizing doctrine that subsumes critical thinking" is both true and alarming. For Vandevyvere & Heynen's (2014), the fact that sustainability does not have a stable and fixed definition was perceived as a positive characteristic– since it can keep the debates going.

However, their intent in this ambiguity was to avoid reducing design to a series of process-based decisions – a form of managerial science – focused on materials, energy, feasibility and political correctness (Pyla, 2008; Vandevyvere & Heynen, 2014). In fact, Pyla proposes that sustainability should not subsume "crucial design questions[8] about the social, the cultural, the political, the aesthetic and the physical, which, incidentally [which] are not unambiguous categories" (Pyla, 2008). But, unfortunately, it can be argued that we have already arrived at a point where sustainability "criteria" have overshadowed these critical design questions (Cucuzzella, 2009, 2015c; Pyla, 2008; Vandevyvere & Heynen, 2014). Thus, needing corrective and reflective action from designers – as well as researchers.

Certainly, a research thesis proposing to un-politicize sustainability would only be a manifesto with no practical application. Consequently, this research aims to argue that if sustainability in buildings has to be political and economically driven, it would be advantageous to ensure its

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8 Design questions have multiple correct solutions depending on how the problem is set and organized (Coyne, 2005; Cucuzzella, 2016; Frame & Brown, 2008; Rittel & Webber, 1973)

alignment with the current discourses and agendas. Especially if such an alignment could diversify and expand sustainable design's (A) scope, (B) methods, and (C) benefits (Pedersen, 2018).

The UN 2030 Agenda and the Sustainable Development Goals (SDGs) were developed through an inclusive, participatory process before being approved by the heads of 193 countries (Gusmão Caiado et al., 2018). The Agenda presents sustainable development as a network of targets and goals, in contrast to fragmented definitions found in various economic sectors – such as the building sector. Today, the UN 2030 Agenda, where the 17 SDGs (and their 169 targets are detailed) defines the global approach for at least the next ten years (United Nations, 2015). The Agenda has received wide acceptance and is today broadly considered as a suitable tool for mobilizing collective action around a set of common goals (GRI et al., 2015; Jiménez-Aceituno et al., 2019; Le Blanc, 2015; Türkeli, 2020). This presents an opportunity for the building sector to expand its focus beyond energy performance, capitalize on synergistic opportunities, and reconcile sustainable design requirements with broader sustainability goals (Allen et al., 2018a; Bernardi et al., 2017; Diaz-Sarachaga et al., 2018; Doan et al., 2017; Eizenberg & Jabareen, 2017; Gibberd, 2015; Lafortune et al., 2018; Le Blanc, 2015; Lior et al., 2018; Nilsson et al., 2018). Although the SDGs are global in scope, they require actions to be scaled to local settings, meaning that the role of buildings in sustainable development should be that of providing an "urban opportunity" (Sustainable Development Solutions Network Thematic Group on Sustainable Cities, 2015). In this context, buildings can be understood as , directly and indirectly, related to the concept of sustainability and to the SDGs (Goubran, 2019a). The list of the 17 goals is presented in Appendix (A).

As it will be clear from this thesis, the scale and breadth of proposing an alignment between the sustainability goals in buildings and the targets of the SDGs are rather complex: non-linear, multi-levelled, and varying in theoretical depth. The upcoming sections of the Introduction will present the overarching research problematic, the overall theoretical framework, and the general organization of how the thesis tackles this challenge.

1.2. Research problematic and overarching theoretical framework

Contextual and critical design practice is advocated as the appropriate means for approaching sustainability in the built environment. Yet, building designers are becoming ever more dependent on quantitative, context-free and efficiency-driven standards to define the quality of sustainable buildings (Cucuzzella, 2016). This presents an epistemological crisis in how both quality and context are understood in relation to sustainable building practices today.

The dominant incremental and efficiency-driven approaches to sustainable building design pose limitations due to their normative nature, their fragmented analysis processes, their technological determinism, their ignorance of contextual questions, and, most importantly, their disconnect from global sustainable development goals (Boschmann & Gabriel, 2013; Brandon & Lombardi, 2011; Doan et al., 2017).

The definition of sustainable "quality" in buildings, as outlined by current quantitative and checklist-based methods, continues to undermine the *context* of projects and puts the theory of qualitative judgment at risk (Ellul, 1964; Roetzel et al., 2015, 2017, 2016). Scholars have suggested assessing sustainability as an emergent property of design thinking through reflection-in-action (Bovati, 2017; Boyko et al., 2012; Cucuzzella, 2015b; A. D. Schön, 1983). From an anthropological lens, the latter is in line with design "futuring" and design projects' anticipatory nature (Boutinet, 1993, 2005; Fry, 2009, 2014; S. Walker, 2015). Although some contextual approaches to design are available, the absence of frameworks for the meaningful application of these approaches makes their use in building design difficult and augments the tensions between the global and local[9] (Guy & Farmer, 2000; Hunter, 2009; Lefaivre & Tzonis, 2003, 2012; Tsiambaos, 2014).

To move beyond this crisis and to re-align sustainable design with the goals of sustainable development, "context" in the built environment has to be reinterpreted as an expansive, dynamic, social and cultural phenomenon, which weaves together evolving and interconnected realities that exist at multiple levels – keeping with our modernity that is always in fluid and motion (Bauman, 2000; Bovati, 2017; Ingold, 2015; Moe, 2007; Pollock, 2007; Powell, 2007). In line with recent literature, this research uses the 17 UN Sustainable Development Goals (SDGs) as its organizing

9 As well as the other debates cantered around the tensions between: the subjective & the objective, the holistic & the targeted, the human & the industrial/technological, the fluid & the stable, the emergent & the predetermined

principle; since they articulate a comprehensive framework and a transformative vision for addressing systemic challenges: such as equality, health and wellbeing, economic sustainability, biodiversity, and social and cultural practices (United Nations, 2015; Wysokińska, 2017).

Beyond environmental credentials, certifications and other forms of recognition (such as prizes, awards and merits), the research aims to actively and systemically reintegrate sustainable building practices within the larger scope of sustainable development (Le Moigne, 1999; Morin, 2005). The research approaches sustainability as an emergent quality of critical design practice (Coleman, 2012; Frame & Brown, 2008; Le Moigne, 2013; D. A. Schön, 1984) and seeks to reconcile both quality and context in the built environment in the paradigm of sustainable development through a theoretical model rooted in the UN's SDGs.

To address its problematic, the thesis adopts an additive theoretical framework, where theories and concepts presented in the earlier chapters are built upon to arrive at the more complex and theoretically dense investigations attempted in the final chapter. This deepening theoretical approach is further explained in the upcoming sub-sections of the introduction. The next sub-section will further clarify the research structure. The overarching research question of the thesis and its key subsections are as follows:

How can the theory and practice of sustainable building design be reconciled with the broader and more comprehensive goal of sustainable development?

a. *What are the key underpinnings of sustainable building design theory and practice – that structured the field's development and current applications and that define the present critiques and possible future directions?*
b. *How are the external forces (such as political, economic and technological forces) pushing building designers to consider broader sustainable development objectives?*
c. *How can sustainable development function as a means for re-instilling critical approaches to the design of buildings?*
d. *How do contemporary buildings, which are considered exemplary in their sustainability today, stand-up against the holistic sustainability goals as defined by the UN?*

1.3. Research structure and directions

The thesis includes six main chapters, excluding the Introduction and conclusion. Each chapter is composed of one manuscript[10]: To ensure the coherence of the document, forewords and postscripts have been added for each chapter. While none of the manuscripts are organized explicitly as review articles, Chapter 2 presents a broad overview of the topic accompanied by a critical assessment of the current landscape. It also analyzes the current academic debates around the topic, and investigate the possible future direction for sustainable building design and evaluation. Chapter 3 points to the market's transition beyond quantitative environmental performance metrics. It underscores the increasing acceptability of sustainable development as a guiding framework for the building industry. As a result, several different strategies and trends that tackle some of our social, economic, and cultural challenges are emerging and gaining ground. Chapter 3 uses the case of carbon taxation schemes and high-rise timber construction (as a market and technology force) to illustrate this transition. Chapter 4 investigates the potential of currently available sustainable building standards and tools in meeting the transformative changes required for attaining the SDGs' objectives. Chapter 5 develops and tests novel frameworks for critically integrating the SDGs in the initial design phases of building projects and understanding designers' vision around the SDG topics. Chapter 6 investigates how to differentiate, based on the semiotics of C.S. Peirce, between different modes of sustainable design reasoning in architecture design projects. It specifically distinguishes between *deductive* and *abductive* sustainable design reasoning. – which can be considered analogues to the *critical* and *status-quo* approaches described earlier. The chapter uses documents extracted from the international competition for the new Montreal Planetarium[11] to create triads of sustainable design signs – where meanings emerge through both text and design-objects. The chapter also explores other important conceptual ideas relating to projects and their realization phases, the functions of sustainability and its features in projects, and the judgment of sustainability in architecture. In Chapter 7, some of Canada's most awarded green buildings are analyzed and compared. The chapter specifically focuses on public, institutional and education building that were an outcome of competitions or public tenders while

10 No partial exclusions have been made from any of the manuscripts.

11 "Le Projet du Nouveau Planétarium de Montréal", launched in 2008 and concluded in mid-2009

also considering their geographic distribution. Chapter 7 investigates the sustainable design visions (SDVs) pertaining to the 17 SDGs that are manifested in those buildings. This analysis draws on the theoretical and analytical framework established throughout the thesis. This overall thesis organization is illustrated in Figure 1.1.

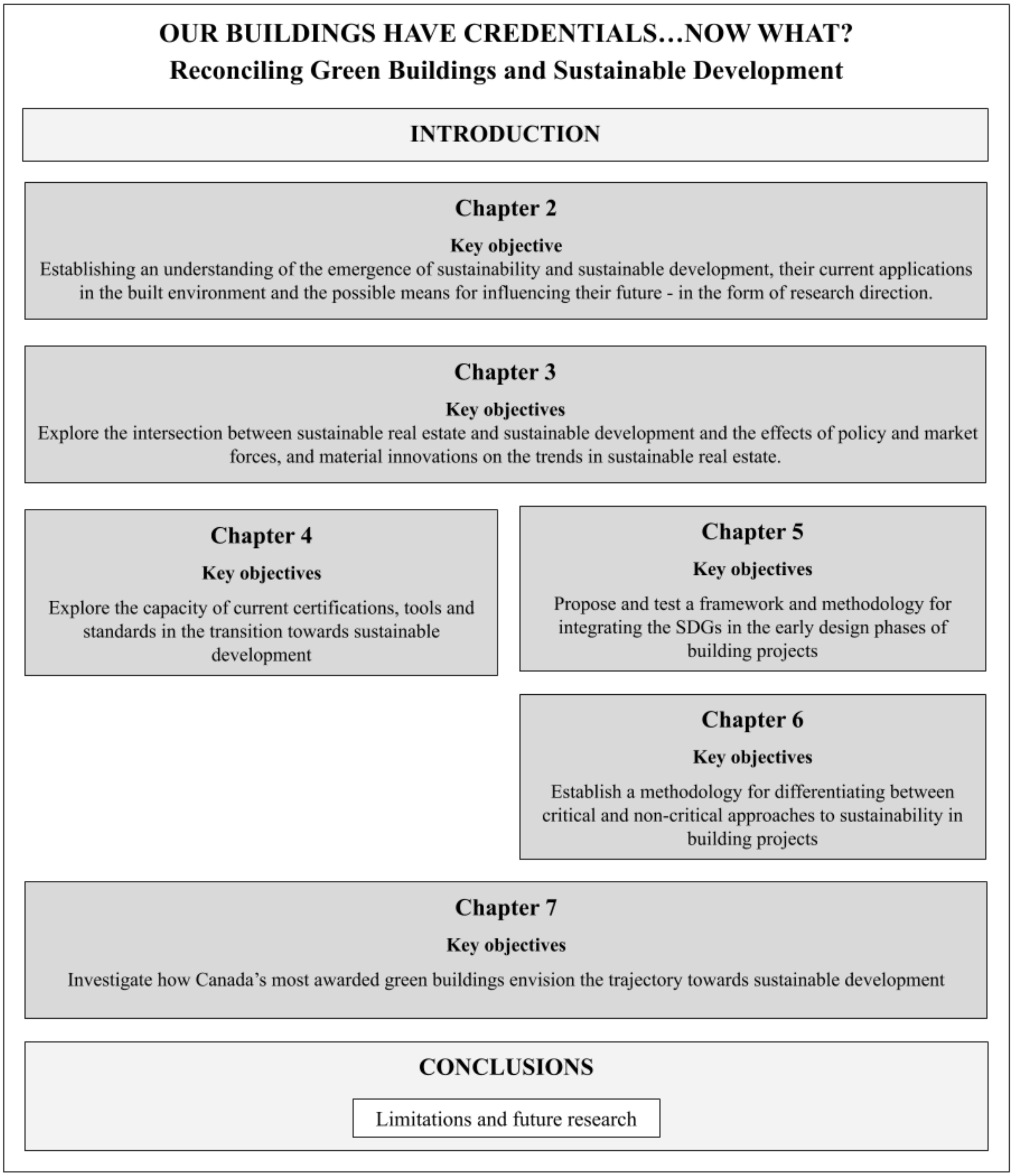

Figure 1.1. The overall organization of the thesis

Chapter 2 also established the research directions that will be followed in the remainder of the thesis, where sustainability in buildings could be understood as:

(A) an outcome of the external market, policy and technological forces: approaches sustainable buildings as real assets, akin to a financial and economic approach, and is focused on studying the effects of external forces (such as policies, markets and technological developments) on the future of the sustainable real estate sector.

(B) an outcome of the design process: explores the relationship between sustainable design approaches, tools and practices and the SDGs and the means for integrating the goals in building design.

(C) an artifact that can communicate the visions for attaining sustainable development: studies the expression and realization of sustainability in buildings and the built environment, focusing specifically on recognized Canadian building

Figure 1.2 illustrates these three research directions, their focus and their theoretical frameworks, which will be elaborated upon in the postscripts of Chapter 2,Chapter 3 and Chapter 5.

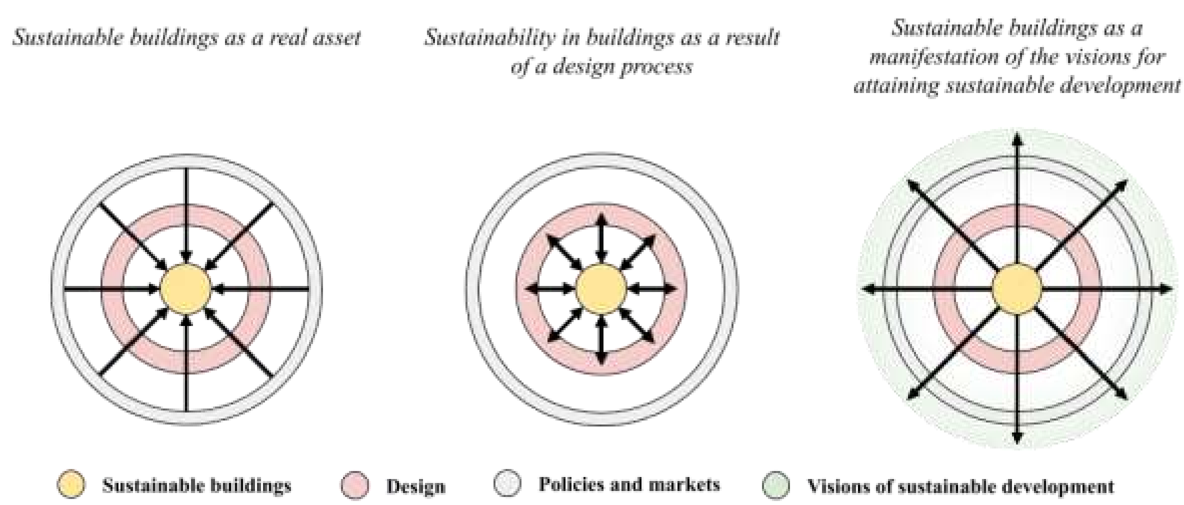

Figure 1.2. Illustration of the research directions of the thesis.

Note: arrows indicate the area focus of each direction

CHAPTER 2.
NAVIGATING SUSTAINABLE BUILDING DESIGN: A CRITICAL REVIEW AND FUTURING

2.1. Foreword

This chapter aims to establish the entry point to sustainability in the built environment and sustainable buildings. The chapter presents an extensive review of the literature covering close to 235 sources. The chapter starts by tracing the definition and the evolution of ecological, environmental and sustainable design principles. Divergent paths emerge: On the one hand, the global sustainable development definition has continued to grow in breadth and depth, while infiltrating further the public and private realms (Fuso Nerini et al., 2018; Maes et al., 2019; Nilsson et al., 2018; Scharlemann et al., 2020). On the other hand, the definition of sustainability in buildings became governed by short-term market dynamics and further limited to certification schemes; in what can be understood as a self-reinforcing cycle (Bernstein et al., 2013; DLA Piper, 2014; S. A. Jones & Laquidara-Carr, 2018; Zuo & Zhao, 2014).

This highlights how sustainable building design shifted from searching for holistic ecological solutions to technologically driven approaches guided by eco-efficiency and optimization of performance and are based on highly structured principles (Fletcher & Goggin, 2001; Jonas, 1979; Madge, 1997; Naess, 1973). This shift was accompanied by the rise of checklist-based assessment and certification tools – which are generally unable to capture the complexity of sustainability in the built space both technically and socially (Cucuzzella, 2015a, 2015b, 2015c; El-Shenawy & Zmeureanu, 2013; Gibberd, 2015; Newsham et al., 2009; Rashid & Yusoff, 2015; Sterman, 2015; S. Walker, 2006).

This gives rise to a few themes that are used to structure the review, namely:

- A revisit of the real-estate sector's adoption of sustainability principles – and some of the future directions pushing the market beyond the current environmental and resource optimization focus
- An overview of the most widely used assessment methods, their critiques and developments

- An exploration of alternative and less mainstream approaches to analyzing sustainable building design

Gidden's structuration theory is used to explain how the available tools (for sustainability assessment, measurement and design) have impacted our beliefs, understanding and visions of sustainable buildings and shaped design outcomes (Ehrenfeld, 2009; Giddens, 1984). Previous general and critical reviews of the topic, such as Al-Tamimi, 2017; Zuo & Zhao, 2014, have focused on the technical literature. There is a limited number of recent assessments of the design literature on sustainable buildings. Instead, most of the available work in the design field was focused on providing a critical lens and critiques, such as the work of Moe (2007) or Bonenberg & Kapliński (2018), or on presenting frameworks for analyzing sustainable design approaches, such as the work of Guy, Farmer and Moore (Farmer & Guy, 2004; Guy, 2010; Guy & Farmer, 2000; Guy & Moore, 2004, 2007).

After exposing the competing definitions, means and end-goals of sustainable building design, the chapter attempts to make sense of these contradictions by utilizing Burrell & Morgan's (2004) paradigms map. The map clarifies that the tensions around the topic of sustainable design are not merely methodological but deeply ontological and epistemological in nature (as suggested by Cucuzzella (2016) and others). In fact, dualities of truths and different levels of realities co-exist around the topic (Burrell & Morgan, 2004; Díaz-López et al., 2019b; Le Moigne, 1999; Max-Neef, 2005; Morin, 2008; Scofield, 2013).

The chapter then concludes by attempting to imagine a new paradigm for sustainable building design – one that approaches Max-Neef's (2005) definition of strong transdisciplinarity. Beyond the review of the available work, the chapter juxtaposes theoretical texts relating to complexity and system thinking, history of science, design, social sciences and sustainability research to address three key questions:

1. What types of tools and frameworks are available for analyzing the sustainability of building projects?
2. How can the current academic debates regarding sustainability in buildings be studied and categorized?

3. How can sustainable building design be reconciled with the paradigm of sustainable development? How can analysis tools and frameworks assist in such a move?

This chapter is based on the comprehensive examination completed in Fall 2018. Thus, the chapter has been prepared as a draft for a future manuscript, for which the thesis author is the main contributor. The chapter-specific status is detailed in Appendix (C). The keywords for this chapter are listed in Appendix (B).

This chapter builds on previous work published by the thesis author. Including:

Goubran, S., Emond, G., & Cucuzzella, C. (2020). Understanding Regional Sustainability in the Built Environment. In K.-P. Schulz & K. Mnisri (Eds.), *Pathways to Connect Creativity and Sustainable Development* (pp. 337–358). Presses universitaires de Nancy - Editions Universitaires de Lorraine. https://www.lcdpu.fr/livre/?GCOI=27000100602910&fa=description

It also helped formulate work beyond this thesis, such as:

Cucuzzella, C., & Goubran, S. (2020). Caught between measurement and meaning. In C. Cucuzzella & S. Goubran (Eds.), *Sustainable Architecture – Between Measurement and Meaning* (pp. 1–13). Vernon Press.

2.2. Introduction

Since the term "sustainable development" was coined in 1992, sustainability has been understood as the outcome of the equal consideration of the economic, environmental and social dimensions (McLennan, 2004). The formulation of the concept was a response to the Brundtland Commission report published in 1987 (World Commission on Environment and Development, 1987). With the development of the sustainability paradigm, ethical, cultural and institutional dimensions were added, augmenting the topic's complexity (Ehrenfeld, 2009; McMinn & Polo, 2005; Pawłowski, 2008; United Nations, 2015; Wysokińska, 2017). In the built environment, designers, engineers, developers, and users are now pursuing sustainability, with different underlying motives. In the literature, we find many tools and methods at our disposal to integrate, approach, apply or assess sustainability in building projects. However, and despite the field's development, many scholars have questioned the validity of the existing schemes (Cucuzzella, 2015a, 2015c; Newsham et al., 2009; Sterman, 2015).

In the last decade, sustainable building design has moved from a niche market to a mainstream trend (S. A. Jones & Laquidara-Carr, 2018). Today, the market pull is essentially powering the sustainable building market (Goubran, Masson, et al., 2019), which is driven primarily by business factors including lower operating costs and an increase in asset value (Acuff et al., 2005; Bernstein et al., 2013; DLA Piper, 2014; S. A. Jones & Laquidara-Carr, 2018; Sandström et al., 2017; World Economic Forum, 2016a). Within these dynamics, building researchers and architects are increasingly expected to integrate, develop, and communicate buildings' sustainability (L. Cole et al., 2018; Cranz et al., 2014). This design integration is based on the intent to realize the commercial benefits investors expect from sustainable buildings. In parallel, we witnessed an exponential growth in academic literature regarding sustainability in buildings – ranging from practical case studies, new technologies and developments to realize eco-efficiencies, and sustainability analysis tools and frameworks[12]. Despite sustainability being a well-established term in the industry, most reviews on the topic have cited its expansive, vague and uncertain definition (Bernardi et al., 2017; Doan et al., 2017; Roostaie et al., 2019).

In research, sustainability in buildings is often thought to be synonyms with: green, high-performance, efficient or even certified (Bernardi et al., 2017; Doan et al., 2017; Roostaie et al., 2019). Researchers have resorted to ground the definition of sustainable buildings in standards, certification and assessment frameworks – in what can be seen as an imposed practical (*i.e.* deductive from a semiotic perspective (Boudon, 2000)) institution of its meaning. Zuo & Zhao (2014) go as far as proposing that the answer to "what is a green building?" and "how to achieve green building? "are both grounded in a project's ability to meet the requirements of certification and standards. In turn, a large portion of the sustainable building is focused on studying *which one, or combination, of the available tools or standards is the most suited for capturing and attaining sustainability?* In this line of work, we are presented with sustainable building design as an exact science – whereby abiding by specific technical criteria can concretely lead to sustainability.

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12 An automated bibliometric analysis highlights a growth of 26,000% in yearly publications related to green building from 2000 (56 publications) to 2020 (1567 publications) - https://www.wizdom.ai/topic/green_building/1344439

On the other hand, other influential work is grounded in architecture and design (such as the work of Farmer & Guy, 2005; Guy & Farmer, 2000, 2001; Guy & Moore, 2007) proposes that sustainability in buildings is pluralistic with no single way and no-predefined outcome (Cucuzzella, 2020a). They suggest that different types of sustainable architecture(s) exist, and embedded within them are different concerns and priorities, leading to different design outcomes. This view implies that no-static tools, references, or set of indicators can function as a means for reaching sustainability in all project situations. Instead, that sustainable building design becomes a process of "problem setting" – where the designer works on envisioning what the world ought to be (Nelson & Stolterman, 2012), through an anticipatory (Boutinet, 2005) system thinking process (Checkland, 1993; Morin, 2008), to cater to the needs of real people and to solve the problems people have in meeting real needs. (Fisher, 2008). Here we are presented with sustainable building design as a pluralistic science that is social in its concern and sometimes technical in its outcomes.

Darko et al. (2019), in their recent scientometric analysis of global green building research from 1974 to 2018, concluded that "the environmental aspect of sustainability of [green building] has received special attention, whereas the social and economic aspects have been largely ignored, in the existing [global green building research]." The technical advancement of buildings and the close to 600 global sustainability assessment schemes available (Bernardi et al., 2017; Doan et al., 2017) have caused a gap between the practice of sustainability in buildings and the concept's three intersecting-circles framework, which incorporate the economic, social and environmental concerns (Cucuzzella, 2009).

This sheds light on a critical ethical and ideological paradox (Guy & Moore, 2004). Namely, if research has determined that the social and economic dimensions are being generally neglected in research and standard practice, *how can the term "sustainability" be associated with building projects that have been designed using today's best practices to meet existing standards?*

This study hypothesizes that sustainability in the built environment is settling within the realm of "organized complexity": a domain that we argue falls beyond the boundaries of exact science (Morin, 2008; Peterson, 2013; Weaver, 1948). It proposes to explore the theoretical grounds and some research directions that can enable moving sustainable building design beyond the environmental concerns to contribute to society proactively. This approach builds on Nigel Thrift's argument that buildings are "simultaneously made and are capable of making" (Thrift, 1983) and that buildings can be seen as both an outcome of what people do with them (following Gidden's theoretical stance as expressed in (Gregory, 1984)) and as autonomous forces that structure social practice (following Bourdieu's theoretical stance (Bourdieu, 1989, 1993)) [13].

The study starts by revisiting sustainability assessment and analysis schemes from this lens. This focus is in line with the approach taken with most available literature. The focus on tools is also justified by the structuration theory, as proposed first by Giddens (1984) and applied to sustainability by Ehrenfeld (2009); where *tools* are seen as a cornerstone in the structuration process, defining outcomes, and beliefs. The paper sets out to answer three research questions:

1. How has the definitions of sustainability and its integration in the building industry developed? Where are we today?
2. What types of tools and frameworks are available for analyzing the sustainability of building projects? Why are they important in the context of the topic?
3. How can the current approaches to sustainable building design be categorized and studied? What can be learned from this process?
4. How can sustainable building design be reconciled with the paradigm of sustainable development? How can analysis methods assist in such a move?

The paper starts by providing an extensive review of the current state of sustainable building design, focused on the definitions and evolutions of the topic and the adoption of sustainable and green principles in the building industry. By highlighting the role of assessment in defining sustainable building design today, the available assessment methods, evaluation and analysis are reviewed, compared and critiqued. The paper then adopts an analytical social-theory lens to categorize the topic's debates, further underscoring the fragmented and competing directions. Finally, an outlook for the sustainable building design paradigm’s future, which is rooted in sustainable development, is presented and supported by concrete adjustments needed to analyze sustainability in buildings.

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13 For more information on the distinction between the two stances refer to (Gieryn, 2002)

2.3. An understanding of the current state of sustainable building design

2.3.1. Definitions, evolutions and contradictions

Various authors have attempted to trace the evolution of the sustainability movement in building design (such as Cucuzzella (2020); Cucuzzella & Goubran (2020); McLennan (2004); Roostaie et al. (2019). The evolutionary timeline sustainability in the built environment could be traced back to the 1960s until today:

- Pre-1970s: Understanding the consequences of modernization on the environment (Carson, 2015) has led various radical thinkers to envision inter-disciplinary holistic approaches – forming what is commonly known as environmental design, challenging over-consumption in the developed world, and imagining new utopias. Within this era, the Environmental Design Research Association (EDRA) was formed, and radical projects (such as Buckminister's domes - (Fuller, 1968)) were realized.
- The early 1970s witnessed the rise of regional approaches supported by precedents from the vernacular. Designers started to rethink the passive and the natural, and they began to be more selective about the technologies they adopted. This was fueled by the limits to growth hypothesis, which was published during that time (Meadows et al., 1972). The oil crisis shifted the focus towards an ecological ideology, which was more focused on technology and reduction in energy and resource consumption—forming what we know as eco-efficiency (Naess, 1973).
- The 1980s saw the formalization of the approaches to eco-design, and designers started to resort to generalized and global and universal solutions to sustainability and environmental challenges. While efficiency became the driving entrepreneurial approach to the environmental crisis (including in buildings), the global community started to realize new forms of development are needed to tackle some of the planet's most critical human challenges. At that time., the term sustainable development was coined (to describe the harmonious relationship between human development and the biosphere's integrity), and its definition (Development that meets the needs of the present without compromising the ability of future generations to meet their own needs) was formalized (World Commission on Environment and Development, 1987).

- In the 1990s, the establishment of many national and international organizations and the emergence of several sustainability rating systems (such as LEED -1998, HQE-1996, BREEAM-1990) institutionalized the sustainable and green building movement. At that time, these tools were highly focused on attaining reductions in consumption of energy and other resources. Adversely, the international community has quickly realized that addressing sustainability challenges requires collective work – with the Rio Earth summit in 1992 (United Nations Conference on Environment and Development (UNCED), 1992).
- Finally, in the 2000s, the sustainable building movement moved into the mainstream. For environmental and economic reasons, both designers and developers were persuaded to adopt sustainable design philosophies in projects. Yet, the gap between sustainable buildings and sustainable development grew wider when the Millennium Development Goals (MDGs) were proposed as a unifying pathway for development (Wysokińska, 2017) – which were hardly integrated into the building industry's practices. (Ade & Rehm, 2019).

Further into the 21st century, environmental certifications and standards have become a standard in practice (Bernardi et al., 2017) – with more systems and tools launched and adopted (from 20 in early 2000 to close to 80 in 2014 as reported by Bernardi et al. in 2017). Each new or re-developed tool and scheme promises improvements and more comprehensiveness and vows excellence in sustainable design (Cucuzzella, 2020 - p.43). Yet, their assessment categories and their reliance on quasi-quantitative methods have marginally changed (Illankoon et al., 2017). This consistency was to ensure their continuity and applicability. For the industry, sustainable building design is hinged on using these schemes since they provide a publicly accepted and organized way to communicate their commitment to sustainable building activities (Bernstein et al., 2013; DLA Piper, 2014; S. A. Jones & Laquidara-Carr, 2018). While savings (in energy or other resources) might be a positive outcome, the market has allowed premiums in green real estate asset value overshadow their operational improvements– making the critiques of the performance gap in certified buildings limited in influence, as seen in Amiri et al., 2019; Newsham et al., 2009; Scofield, 2013; Yudelson & Meyer, 2013.

Other authors have heavily criticized today's market-driven sustainability trends, which are superficial in their concern to communicate their green properties, are short-lived due to their dependence on technologies, and lack of design substance due to the focus on efficiency (McDonough & Braungart, 2002; S. Walker, 2006). Fry (2009) sees that the current design practice is "de-futuring" humanity. Where it is proposed that design is the profession that provides the objects to consume, and that it has been intertwined with the current deteriorated state of the world. Of course, these critiques echoed the seminal work that explores sustainable design (Fiksel et al., 1998; Naess, 1973). In fact, Walker (2006, 2015) proposes that challenging precedents and rethinking standards might be the first step towards sustainability. McDonough & Braungart (2002) propose that being "less bad" is a failure for the imagination and that efficiency approaches can only be effective through the shrinking of efforts, activity and, most importantly, population. Instead, they propose a nature-inspired approach focused on local eco-effectiveness, which allows for local energy, material, and technical flows (McDonough & Braungart, 2002).

On a parallel global path beyond the built environment, sustainable development agendas have grown in complexity and comprehensiveness. With the approval of the 2030 Agenda (United Nations, 2015), world leaders charted a more clear definition of the multitude of challenges ahead – encompassing 17 transformative goals (SDGs) and 169 targets, which are interconnected and covering 5Ps (people, planet, prosperity, peace and partnership) (Fuso Nerini et al., 2018; Maes et al., 2019; Nilsson et al., 2018; Scharlemann et al., 2020). This was also expanded the theoretical scope of sustainability to include institutions, collaboration and partnership. While some green building proponents have proposed that certifications, eco-efficiency, and standard driven approaches can help achieve the SDGs (such as the work of Alawneh et al., 2019; Caiado et al., 2017; Omer & Noguchi, 2020), others have affirmed an epistemological contradiction between what is considered "incremental" and "transformational" approaches to sustainable development (Baue, 2019; Cucuzzella, 2011b).

The overview of this 50 years of development in sustainable development and sustainable building design demonstrates that Hajer's (1995 - pp. 12-13) proposition is as true today as it was more than 20 years ago:

"Environmental discourse should not be seen as the product of a linear, progressive, and value-free process [...]. It is much more a struggle between various unconventional political coalitions, each made up of such actors as scientists, politicians, activists, or organizations representing such actors [...]. These so-called discourse coalitions somehow develop and sustain a [...] particular way of talking and thinking about environmental politics."

It also highlights how in building design, when driven by markets and industry, "sustainability is constantly running the danger of turning into a totalizing doctrine that subsumes critical thinking" (Pyla, 2008).

2.3.2. The adoption of sustainable and green principles in the building industry

Construction and building projects are complicated endeavours. The traditional challenges in all projects (such as the unique site and context restrictions, as well as the financial, time and multi-stakeholder management pressures) are considered, until today, as major hurdles to the mitigation of unsustainable trends in the building industry (Teo & Loosemore, 2001). Additionally, the industry's negative environmental externalities have resulted in a relatively slow adoption of sustainability principles (Matisoff et al., 2016).

Buildings are estimated to consume more than 40% of the world's yearly energy supply, 30% of raw materials and 12% of freshwater (Willmott Dixon, 2010; World Economic Forum, 2016b). Most alarming is that the real estate sector is considered the single most significant industry in CO_2 contribution with more than 8.1 Gt of annual emissions (Rashid & Yusoff, 2015; Willmott Dixon, 2010). The increasing urban nature of the world population will result in exponential growth in demand for living and working space by 2030, further increasing the Building's CO_2 emissions by 56% (World Economic Forum, 2016a). These statistics have put pressure on the industry, especially developers, to adopt sustainability in projects. While the rising potential financial risks of pollution (including taxes, for example - as proposed by Murray & Rivers, 2015) can help accelerate this adoption, the main driver for increased sustainable building activity remains *market demand*.

While the most significant investment incentive was still perceived cost savings, the sustainable real estate market is essentially still client and market-demand-driven (Acuff et al., 2005; DLA Piper, 2014; S. A. Jones & Laquidara-Carr, 2018). Commercial factors mainly drive the uptake of ecological building activities: buildings with better environmental certification have higher market values and lower operating costs, which strongly influences the investment decisions (Bernstein et al., 2013; World Economic Forum, 2016a). This trend has been exposed in the seminal paper by Eichholtz et al. (Eichholtz et al., 2010), which indicated that certified and labelled buildings offer higher market value and rent premiums just based on the label – *without the need for energy savings per se*. Today, the building industry is gradually taking a more favourable view of ecological and sustainable buildings due to the decreasing cost of technologies, increasing demand, and more generous incentives for sustainable development (Acuff et al., 2005; Beland Lindahl et al., 2017; S. A. Jones & Laquidara-Carr, 2016).

An alternative way for justifying adoption is through the use of future scenarios, as presented by Henderson (2015). Henderson proposes four possible future scenarios for sustainable business: a) business as usual, b) demand-driven opportunities, c) supply-driven opportunities, and d) green as mainstream. From the examples provided by Henderson (2015) and the probabilities of each of the scenarios, we can see that the real estate businesses would be losing on opportunities if they do not address all the possible alternative future scenarios. Market reports indicate that today, real estate investors and businesses are more at risk by not adopting sustainability principles due to changing and ever-more stringent environmental regulations placed by governments (S. A. Jones & Laquidara-Carr, 2016, 2018). Currently, the most critical metric used to measure green buildings' benefits remains the lower operating costs they offer (S. A. Jones & Laquidara-Carr, 2016, 2018). However, this focus will need to be expanded further to capture the added value obtained through labels and certification and other financial incentives (such as incentives, and access to land or resources). An understanding of regional and local needs and aspirations, supported by incentive programs, might aid investors, developers and designers in adopting contextual and adapted solutions that feed into the immediate needs and expectations of communities (Rübbelke, 2011; Stern, 2008).

On the other hand, recent studies propose that, from a financial standpoint, sustainable investment results in more than cost-savings. Net income of responsible investors increase due to lower expenses, higher valuations and lower risk premiums (Deloitte, 2014). Environmentally speaking, the widespread application of sustainability principles in the construction industry could save a significant portion of energy and decrease GHGEs by 6% by 2030 and 11% by 2050 without affecting profit levels, and while simultaneously providing gains in productivity due to improved indoor environment quality (S. A. Jones & Laquidara-Carr, 2016; World Economic Forum, 2016b). From a social lens, the physical aspects of human spaces can reduce environmental risks and improve human welfare (Eizenberg & Jabareen, 2017). The social, environmental, economic, financial, and even health benefits of sustainable construction are becoming more apparent and are less debated – sustainability is no longer a niche in the industry (Deloitte, 2014; S. A. Jones & Laquidara-Carr, 2016).

Recent literature highlights a shift in the perception of "sustainable" real estate: more people realize that ecological buildings and sustainable projects are a product of a well-integrated design process. They do not need to be visibly different from traditional buildings (Acuff et al., 2005). These changes are helping investors rethink some of the challenges related to sustainability in buildings, such as the perceived higher initial costs, the lack of political support, and the perceived unaffordability of sustainable technologies (S. A. Jones & Laquidara-Carr, 2016, 2018). As proposed by Qian, Chan, Visscher, & Lehmann (2015) and clear in the UNDP report (United Nations Environment Programme, 2017), incentive programs and the constant higher values and returns for green building investors have helped create a stable demand and lower transaction costs

However, by comparing data from 2012, 2015, and 2017, we can see several key trends: 1) that the perception of higher initial costs has decreased significantly, 2) the importance of environmental regulations as a reason for adopting sustainability principles in buildings has increased substantially, and 3) the selection of the certification program has become more dependent on governmental and local incentives. The first trend is considered positive since it points to a more mature and stable sustainable real estate market predicted by different authors and institutions (Deloitte, 2014; S. A. Jones & Laquidara-Carr, 2016, 2018; World Economic Forum, 2016a). However, the last two recent trends presented might be pointing to increased risks in the sustainable real estate market, including a) political risks: by depending on and responding to regulations as a driver for sustainable building adoption, the businesses will be more vulnerable to changes in rules and 2) external dependencies risk: by selecting certifications based on the available incentives, businesses are exposed to risks relating to the stability and continuity of these programs – considering that it has been reported that many sustainability programs are short-lived (Lynch & Mosbah, 2017).

The market's maturity is a good sign of its readiness to tackle more complex challenges and adopt more complex assessment tools. These more complex tools would move beyond environmental issues to consider occupants' productivity, health, and well-being, as well as social and cultural issues (Markovich et al., 2018; Wichaisri & Sopadang, 2018). Additionally, markets around the world are changing quickly and will require investors and developers to incorporate new strategies such as 1) moving away from new construction to renovating or retrofitting buildings, 2) progressing towards smaller infill constructions or mixed-use projects which respond to social and cultural needs of communities (with a more vital collaboration with local governments), 3) new opportunities to consider wellbeing in projects (such as catering to the ageing population needs) (Hardy, 2016). Additionally, the introduction of new regulations and codes (such as the Zero Carbon Building Standard in 2017 by the Canada Green Building Council) will directly affect the adoption of sustainability in buildings (United Nations Environment Programme, 2017).

For the market actors (especially investors), communicating and proving their commitment to sustainable building aims to ensure that they realize the financial benefits reported and access the available local, national and international incentives for green buildings. Although many tools are already available to assess and analyze the sustainability of buildings and the built environment, new tools, methods and frameworks that to be more comprehensive, more accurate, or more contextual are still being developed (Brandon & Lombardi, 2011; El-Shenawy & Zmeureanu, 2013; Gibberd, 2015; Rashid & Yusoff, 2015; S. Walker, 2006).

2.3.3. Methods for assessing and analyzing sustainable building design

Tools (what could be considered *allocative resources*) constitute one of the main categories of structure in society (along with beliefs, norms, and power orders) – as proposed by (Giddens, 1984). In sustainability, systems, standards and tools are important elements in the structuration process, as elaborated by Ehrenfeld (2009). They can alter and shape outcomes (as presented by Cucuzzella, 2015a) and create changes in the real world and beliefs. In architecture and design, the development of sustainable building design towards a prescriptive and managerial science

(Cucuzzella & Goubran, 2020a) has already resulted in a "normative-turn" in sustainable architecture both in discourse and expression (Cucuzzella, 2019a).

Despite the large number of tools available, many authors argue that we can still not capture the complexity of sustainability in the built environment (Bernardi et al., 2017; Cucuzzella, 2015a, 2015b; Newsham et al., 2009; Sterman, 2015). Some researchers suggest that the technical nature of mainstream (or most widely adopted as proposed by Bernardi et al. 2017) assessment tools is creating perceivable changes in the sustainability narratives, presentations, and strategies in buildings, which have shaped the collective understanding of sustainable buildings (Fisher, 2008; Fletcher & Goggin, 2001; Fry, 2014; McLennan, 2004). Some have suggested that the constant changes and flux in the rating and assessment landscape indicate that it has not yet reached maturity (Díaz-López et al., 2019b).

Today, *two main categories* of approaches are available for understanding sustainability in buildings: 1) *environmental or sustainability assessment systems, standards and tools*, which are readily discussed in the literature and are the most prominently used in the industry (Bernardi et al., 2017; Brandon & Lombardi, 2011), and 2) *sustainability design analysis frameworks*, which adopt a complex system view to the problem and consists of frameworks that aim to move beyond reductionist approaches to design assessment and present a space where sustainability can be understood pluralistically (Guy & Moore, 2007). Other emerging tools, which move beyond the traditional concerns of sustainability, are focused on specialized areas – such as wellbeing and community welfare – and are considered to be beyond these categories (Markovich et al., 2018). It is also important to note that quality and excellence issues fall beyond the scope of most methods, even if researchers and practitioners attribute excellence to buildings that have received certifications and credentials. A short discussion on the quantification of quality in buildings is presented in Appendix (D).

2.3.3.1. Assessment systems, standards, and tools[14]

Studying assessment systems, standards and tools, even questioning their intents and focus, has been a tradition in academic research since their emergence (Raymond J. Cole, 2005; Raymond J Cole, 1999; Cooper, 1999). Today, with more than 600 methods available, these assessment schemes have received much attention in the academic literature. A large number of review and critical examinations are available, and they document, compare and build on existing tools – as seen in (Bernardi et al., 2017; Bragança et al., 2010; Díaz-López et al., 2019a; Doan et al., 2017; Illankoon et al., 2017, 2019; Liu et al., 2019; Luangcharoenrat & Intrachooto, 2018; Mattoni et al., 2018; Roostaie et al., 2019). Both Bernardi et al. (2017) and Doan et al. (2017) reported that a systematic comparison of the tools is difficult, if not prohibitive, due to language limitations for local schemes, the substantial variation in the assessment and weighting criteria, as well as differences in the motives or goals based on which each tool was developed. Most of the studies arrive at similar conclusions: LEED, BREEAM and CASBEE are considered the most widely used, studied and referenced in the literature (Bernardi et al., 2017; Doan et al., 2017). Some reviews present more concrete and rigorous methods (such as (Bernardi et al., 2017; Bragança et al., 2010; Díaz-López et al., 2019a, 2019b; Doan et al., 2017), and can be used as the authoritative references on the topic. This paper presents an overview and comparison between the key assessment methods.

Díaz López et al. (2019a) and Bragança et al. (2010) categorize the many methods available by their end purpose; namely, methods resulting in certification and scores (what they call Systems such as LEED), attaining minimum standards (what they call Standards such as Passivhaus) or assistive to the design process (what they call Tools such as ATHENA for LCA). The first two methods use performance-based indicators, whereby a specific set of criteria are selected based on the desired outcomes, and the building's performance, characteristics or design elements are assessed against them (Brandon & Lombardi, 2011). While both usually require minimum performance, or what is known as prerequisites in the LEED system, for example (The U.S. Green Building Council, 2020), scoring and certification systems are usually broader in their coverage of

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14 This review uses the word “method” to be encompass systems, standards and tools.

issues and follow a tiered scoring based on incremental improvements, as opposed to standards which usually contain only one-tier. The building rating and certification systems, which represent today's mainstream tools, were able to strike a balance by providing a defined pre-set of assessment criteria that can be used for rating and benchmarching, while providing a tiered approach to differentiate and prize buildings incrementally (Bernardi et al., 2017).

LEED (Leadership in Energy and Environmental Design) is one of most widely used in the industry, one of the most referenced tools in the academic literature (with more than 250 citations in Scopus) and one with the largest international application (Bernardi et al., 2017; Bragança et al., 2010; Díaz-López et al., 2019a, 2019b; Doan et al., 2017). LEED V4 is in use since 2016, with different schemes designed to rate new and existing buildings as well as neighbourhoods (Doan et al., 2017). LEED has been widely commercialized throughout the last decade (Yudelson, 2008b). BREEAM (Building Research Establishment Assessment Method) is the oldest rating tool available (launched in 1990) and has been updated continuously till its latest version in 2016 (Doan et al., 2017). It is used in more than 70 countries with more than half a million projects certified. It also has schemes that could be used for rating infrastructures and communities (Bernardi et al., 2017). LEED and BREEAM are both based on predefined credit categories, which are mainly divided into 1) global issues, 2) local issues, and 3) indoor issues (Brandon & Lombardi, 2011; Doan et al., 2017). These tools' simplicity enabled them to popularize the "green" mainstream in the real estate market: they permit the rating to be done rapidly while enabling comparisons between projects (Brandon et al., 2017; Brandon & Lombardi, 2011). Doan et al. (2017) note that these tools are mainly focused on the "green" portion of sustainability with about 80% of the credits available for environmental categories (mainly energy and water efficiency). On the other hand, these tools have a limited consideration for social aspects (around 10% of the credits) and no consideration for the economic aspects (Bernardi et al., 2017; Brandon et al., 2017; Brandon & Lombardi, 2011; Doan et al., 2017). CASBEE (Comprehensive Assessment System for Building Environmental Efficiency) is another widely used rating system. Although it has some of the same weaknesses presented for the previous two tools, its Built Environment Efficiency (BEE) ranking offers a unique assessment approach. The BEE is based on the ratio between Built Environment Quality (internal scope) and Built Environment Load (external scope) (Bernardi et al., 2017; Doan et al., 2017). Although the tool currently doesn't go beyond environmental considerations, the BEE provides a positive step towards more complex modes of ratings that will be explored in the next section.

Díaz-López et al. (2019a) note that, when compared to specific standards (such as Passivhause) or ASHRAE standards, the scale of the focus of rating systems (such as LEED, BREEAM or others) is the widest. In contrast to most other conclusions, such as those presented in (Bernardi et al., 2017; Doan et al., 2017; Schweber, 2017), Díaz-López et al. (2019a) propose that the existing systems adequately cover the social, economic and cultural dimension – through their focus on building materials and ensuring the commercial viability of designs. This view has been strongly criticized previously by designers (Berardi, 2012; Cucuzzella, 2009; Jefferies & Coucill, 2020), and even the founding members of the schemes (Ade & Rehm, 2019; Raymond J Cole, 1999)

Today, and within the definition of sustainable development, which expanded beyond the triple bottom line to include governance, culture, ethics and institutional issues (Doan et al., 2017; Ehrenfeld, 2009; Hossain et al., 2018) – the environmental efficiency focus and incremental approach to improvement of these tools can be considered their biggest weakness. Additionally, and due to the tools' tendency to fragment design projects, the sustainability crisis has been reduced to a score optimization scheme, and their criteria became themselves defining aspects in the design process. Here, the assessment and analysis tools become "design leading" rather than a supporter for "design-led" sustainability solutions (Berardi, 2012; Boschmann & Gabriel, 2013; Cucuzzella, 2009, 2015c, 2015a; Cucuzzella & Goubran, 2020b; Ding, 2008; Jefferies & Coucill, 2020).

Another set of assessment tools that have been widely used and continuously developed are lifecycle-based approaches (LCA) – the most commonly known of them is the ATHENA tool (Díaz-López et al., 2019a). LCA is considered the most accurate, precise and systematic assessment tool; its rigorous methodology makes its use complicated for building projects in both the public and private sectors (Brandon & Lombardi, 2011). One of LCA approaches' main strengths is their comprehensive cradle-to-grave scope and the fact that they easily allow comparisons between design alternatives. However, their methodology is very rigorous and usually very costly and time-consuming, which resulted in some limitations in their wide applications (Brandon & Lombardi, 2011). This is clear in the slow linear development in their adoption trend presented by Bernardi et al. (2017). Despite their comprehensive nature, LCA tools still do not move beyond the eco-efficiency mindset - running the risk of encouraging decisions that are disconnected from the social, economic and political realities and the users' needs (Cucuzzella, 2009; Rashid & Yusoff, 2015).

LCA systems can be divided into three main categories: 1) the environmental LCA, 2) the life cycle costing (LCC), and 3) the social life cycle assessment (S-LCA) (Hossain et al., 2018). Although social life cycle assessment (S-LCA) considers the social costs of buildings, the method is generally quantitative and built on an optimization process of reducing damage (Han & Srebric, 2015; Stephan & Stephan, 2014, 2016). S-LCA, whose original guideline was proposed by the UNEP and SETAC, aim to add critical indicators relating to human well-being throughout the supply chain – dealing with issues such as worker's rights, community development, consumer protections, and societal benefits (Benoit-Norris et al., 2012). Most S-LCA approaches and case studies deal with specific materials or components of buildings rather than the building in its completeness due to the complexity of the process. In theory, by combining LCA with S-LCA and LCC you arrive at LCSA (life cycle sustainability assessment), which is believed to be the most holistic representation of the three pillars. As early as 2012, Benoit-Norris et al. (2012), had proposed a sustainability hotspot database to streamline the assessment process and minimize the data collection needed to create the assessment – similar in idea to the eco-indicator packages (Pré Consultants, 2000). The social hotspots' main components usually include risks of violations, labour rights and decent work, governance, women's rights, human rights, and community infrastructure. However, there have been many challenges in applying S-LCA due to the difficulties related to similarly quantifying the social impacts to the LCA or LCC approaches (Guinée, 2016).

Indices could be considered a "softer" approach to assessment. Indices are generated from the combination, either by addition or through mathematical formulas, of different measures or assessments. Some scholars have aimed to establish standardized certification-based indexes for the evaluation of buildings (Gibberd, 2015), and others have aimed to use specific indexes to measure cities' sustainability and urban growth (Mobaraki, 2016). An example of such index tools that can be found in literature is BEST (Built Environment Sustainability Tool), which combines the human development index and the ecological footprint index to measure the capacity for sustainability by tackling larger sustainable development topics such as food, shelter, mobility, health and employment (Gibberd, 2015). However, the availability of many developed indexes in the literature and the vast number of indicators is considered a hurdle to their wide use and creates significant limitations for comparative studies (Kylili et al., 2016). Most recently, the use of an SDG index has been proposed by the UN for addressing the Sustainable Development Goals (SDGs) (Diaz-Sarachaga et al., 2018; Lafortune et al., 2018; Sustainable Development Solutions Network (SDSN), 2018). The 2030 Agenda itself also includes 304 indicators used to assess the progress towards the 169 targets (GRI et al., 2015; United Nations, 2015).

Finally, other approaches aim to filter through extended indicator databases to select key ones that can simply measure performance (KPIs) – a concept that has been applied in renovation projects in the context of sustainable built environments (Kylili et al., 2016). It is important to note that most of the metrics require conducting pre and post-occupancy evaluation – with the latter being a commonly used method for assessing building quality (Bordass, 2003; Thatcher & Milner, 2016). Although a large portion of the research on indicators is focused on regional, national or urban scales (Boyko et al., 2012; Lynch & Mosbah, 2017), several examples aim to use indicators to assess the three pillars of sustainability in buildings (*i.e.* society, culture, regional priorities). These include the work of Rajagopalan & Kelley (2017) on the multi-attribute decision support system (MADSS) and Valdes-Vasquez & Klotz (2013) on tracking design and construction processes – which is rooted in the integrated design process (Hansen & Knudstrup, 2005). Although many sustainability indicators are available, beyond those in the commercially available tools, customizing performance-based assessment has gained little popularity due to the complexity of selecting indicators from the many hundreds available, the difficulty in choosing sustainability objectives in projects, as well as the complications that customization poses for benchmarking and comparisons (Brandon & Lombardi, 2011; Lynch & Mosbah, 2017).

2.3.3.1.1. Debates surrounding assessment methods

The academic debates regarding these methods are structured around four questions: *1) Are the ratings provided by the tools a good indicator of environmental performance? 2) How do the methods deal with regional issues?, 3) How do these methods integrate non-environmental dimensions (such as social, economic, and cultural concerns)? 4) what are the emerging new trends that are developing in parallel to environmental and ecological concerns?* The debates surrounding each of those questions will be overviewed in the next few paragraphs.

For the most-used certification systems, environmental issues constitute an average of 80% of their credits, with energy- and emissions usually receiving the most focus (Doan et al., 2017). Most of the certification systems available need performance improvements to be made in the design to reach energy credits. However, several published papers point to the gaps and discrepancies between the actual performance and the predicted performance (B. Lee & Hensen, 2015; Newsham et al., 2009; Scofield, 2013). Scofield (2013), in his study of NYC office buildings, reported that the LEED certification level does not correlate with specific energy performance and found that the Energy Performance Rating (*ENERGY STAR | The Simple Choice for Energy Efficiency*, n.d.) suggests energy efficiencies that are not confirmed by source energy utilization intensities. Scofield (2013) concluded that LEED resulted in a more efficient building that doesn't necessarily save energy nor reduce GHG emissions. In their study of 100 LEED-certified buildings, Newsham, Mancini, & Birt (2009) reported that, although on average the corpus of LEED buildings they studied saved energy compared to their counterparts, 28%-35% of LEED buildings consumed more energy. They attributed those discrepancies to several factors, including 1) occupancy hours deviating from the original assumptions, 2) new technologies not performing as expected, 3) gaps in transferring the knowledge needed to operate the building, 4) commissioning problems, and 5) plug loads deviating from design assumptions (Newsham et al., 2009). Yudelson & Meyer (2013) have explored this performance in-depth and concluded that post-occupancy evaluations, which are infrequently done, are needed to assess the efficacy of the different schemes in attaining their design performance (Newsham et al., 2009). Thatcher & Milner (2016), in their review of studies relating IEQ in buildings, presented a wide array of discrepancies in the effect of green buildings on the user's perception of indoor quality and reported no improvements in wellbeing from their statistical data analysis. This leaves the question of selecting the tools for building projects, specifically in public buildings, open to further research.

Based on the overview, existing systems, standards, and tools have focused on buildings' environmental assessment (rather than sustainability assessment). The available literature proposes to expand the scope of these tools to the other sustainability pillars, including social, economic, ethical, cultural and institutional dimensions (Bernardi et al., 2017; Bragança et al., 2010; Díaz-López et al., 2019a, 2019b; Doan et al., 2017; Hossain et al., 2018). Doan et al. (2017) propose to include economic and institutional factors to expand the sustainability definition they present in the introduction. Bernardi et al. (2017) point to the need for assessing the resiliency of the buildings to natural disasters and the need for more complete schemes. Other scholars propose incorporating risk indicators into existing energy performance evaluations to ensure the design's robustness (B. Lee & Hensen, 2015). Others have found that these system's approaches, which favours measurable improvements, come at the expense of more innovative and critical approaches (Brandon & Lombardi, 2011).

In response to the calls to accommodate the regional variations in green building rating systems, LEED incorporated regional priority or alternative compliance points in their credits (Wu et al., 2017). Wu et al. (2017), in their study of more than 4000 LEED-certified projects, identified that there are 21 region-specific credits available – named Regional Priorities (RP). The credits, which are made available based on the project's location, offer a wide array of options for better alignment between the project's regional and contextual needs and the assessment. However, Wu et al. (2017) indicate that certain credits are favoured without direct relation to the region, the projects' programs or specific site needs. Instead, RP credits are selected by the different Green Building Council's chapters (the authority that manages LEED certifications) if recognized as necessary (Susan Kaplan, 2018). To mitigate the fact the RP credits could only support existing criteria LEED, innovation credits were also introduced to allow project teams to move beyond the credit criteria. The USGBC recently introduced new pilot credits at the recommendations of the Social Equity Working Group, which address broader social issues such as social equity within the project team (assessed through documentation related to fair working and development condition in the project team), social equity within the community (through collaboration with local institutions or third-party assessments). These pilot credits could address other sustainability issues such as food, wellbeing, or biodiversity – in what can be perceived as a move to offering fewer credits to "light-green" strategies.

When non-measurable or quantifiable improvements are introduced in the current certification systems (such as LEED), three main modes are generally used, 1) using proxy indicators (ex. measuring worker's pay as a proxy for social equity for within the project team), 2) depending on third-party certification and collaborations with local organizations (such as FSC certificates for forest sustainability for example), or 3) by implicitly linking the criteria being assessed to the general context of the building (ex. if the building is an arid location, the credits for water efficiency would be highly weighted) (R. J. Cole, 2001; Susan Kaplan, 2018; Wu et al., 2017).

However, because this process creates added complexity to the assessment, designers may prioritize easier credits – “the low hanging fruits” (Cucuzzella, 2020a)

Other recent trends in the field are moving beyond the traditional sustainability definition to embrace questions of community wellbeing and health (Eizenberg & Jabareen, 2017). An example of this move can be seen through the WELL building standard, which focused on the occupants' wellbeing and health and that started to gain popularity (International WELL Building Institute (IWBI), 2018). Examples of the community wellbeing approach can be seen through the Community Wellbeing Framework (Markovich et al., 2018), which has been launched for Canada in July 2018 along with the WELL Community Standard pilot (International WELL Building Institute (IWBI), 2017). Although these examples do not refer directly to sustainability or sustainable development goals, their occupants or community well-being approach can be traced to earlier sustainability frameworks in the literature (James, 2014). The frameworks' main approaches are based on compiled metrics and indicators to assess the project's capacity to foster community well-being in topics such as health, social, environmental, economic, cultural and political domains. The standards developed by the International WELL Building Institute aim to certify and assess buildings and projects, while the Community Wellbeing Framework intends to facilitate decision making around design options (International WELL Building Institute (IWBI), 2018; Markovich et al., 2018). However, authors have already pointed out that the same market-demand and technology-push dynamics govern these newer concerns and systems (Tarkhan, 2020).

2.3.3.2. Sustainable building design analysis frameworks

Another approach to sustainability assessment aims to evaluate design outcomes through analytical frameworks that are embedded in qualitative mapping. Unlike the focus of certification, compliance-verification and performance optimization, these frameworks intend to categorize and compare the often-competing facets that make up sustainable building projects, their elements and the design decisions that resulted in their creation. These design analysis tools aim to focus on design projects as a whole and to highlight their sustainability intents and potentials – this is in contrast to the sustainability assessment methods, which fragment design projects to assess specific measures based on their criteria (Cucuzzella, 2011b). It is essential to point out how the design-oriented frameworks - although they might use metrics, surveys and data - do not intend to provide ranking or rating for projects or their elements. Instead, they are considered thinking or comparative tools for analysis (Roetzel, Fuller, & Rajagopalan, 2017; Ellul & Wilkinson, 1964). In general, the proponents of these methods hold that "critical thinking" rather than just technology can enable the development of many sustainable building forms (Guy & Moore, 2004). Thus, these approaches are firmly rooted in systems thinking and complexity theory since they recognize the sustainability imperative's competing logic (Guy & Farmer, 2000; Putnik, 2009; Vandevyvere & Heynen, 2014).

As part of the broader qualitative techniques of research, visual analysis methods have specific relevance to the art and creative fields – and have been gaining more grounds (Pauwels, 2009). In architecture and building projects, different media for communicating information are usually deployed, with images and visual elements, usually in the form of drawings, diagrams or charts, composing a cornerstone in the development of meaning (Andersson et al., 2013; Deledalle, 2000; Fisette, 1997; Goubran, 2019g). Mapping approaches are an important comparative tool since they propose to structure and categorize information and knowledge to expose contrasts, similarities and potentials (Conceição et al., 2017; Greckhamer et al., 2018; Lévy et al., 2015; Ragin et al., 2003; Stojiljković & Trajković, 2018). The mapping and explorations of the dynamics that link different elements of projects directly embed these frameworks in the systems thinking methodologies – especially those proposed by Checkland (1993) and Wilson (1984). Inspired by a structuralist tradition, the frameworks usually perceive that meaning comes into being from contradiction (Morin, 2008). In sustainability and sustainable building design, analytical frameworks have been proposed both as means to assist in the design process (*i.e.* Tools if we follow Díaz López et al.'s (2019a) definition) and as analysis approaches (falling beyond the three-categories proposed in the available reviews).

One example of these frameworks is the Integral Sustainable Design framework introduced by Dekay (2011) in response to the objective and quantitative tools dominating the design field. The work, which is mainly based on the integral theory first developed by Wilber (2000), aims to simultaneously map and consider different positions and approaches to the same topic. It can be understood as a form of mapping for the different sustainability paradigms (Andersen, 2013; Lakatos, 1978). This framework could be seen as a response to the ideas presented by Moore &

Engstrom (2004) that, even if we look at sustainability assessment tools, they represent conflicting social values (Putnik, 2009). The framework is a four-quadrants map that is created through the intersection of the individual, the collective, the objective and the subjective resulting in 4 distinct perspectives at the corners of the map: namely, the perspective of experiences (individual and subjective), the perspective of culture (collective and subjective), the perspective of performance (individual and objective), and the perspective of systems/context (collective and objective) (Roetzel et al., 2015, 2017) – seen in Figure 2.1.

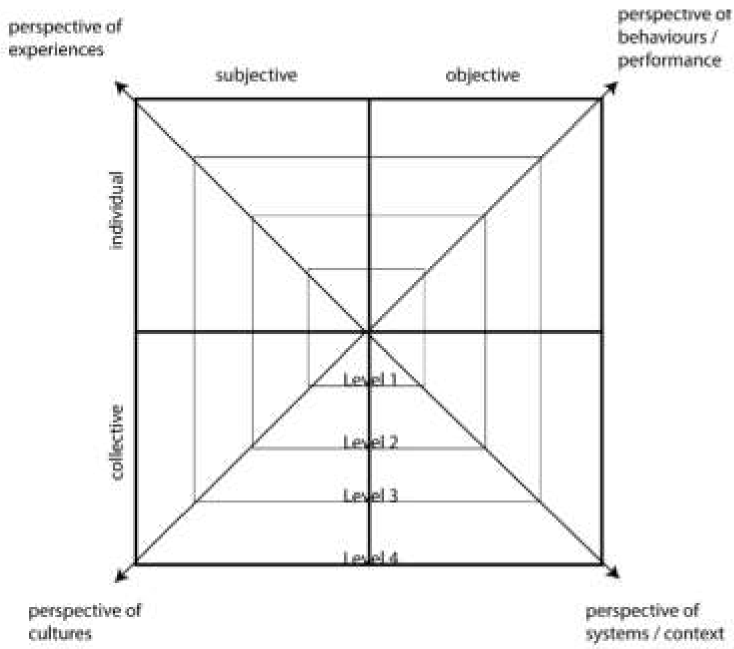

Fig. 2. The quadrants and levels of ISD.

Summary of the quadrants of IT.

Quadrant	Main question	Focus on
Upper Left (UL) – Experiences	How does an individual experience nature through the building?	Human senses, feelings, emotions, consciousness, experience (qualitative)
Lower Left (LL) – Cultures	What collective interpretation of nature does the building suggest??	Mutual understanding, worldviews, meaning, symbolism
Upper Right (UR) – Performance/Behaviours	How does the building perform?	Measurement, calculations (quantitative)
Lower Right (LR) – Context/Systems	What is the nature of the relationships of the building with nature?	Mapping, systems understanding

Four levels of Integral Sustainable Design.

Level	Scale at which nature is understood	Focus on
1. Traditional	Local forces	Protection
2. Modern	Resources	Optimisation
3. Post modern	Ecosystems	Interaction
4. Integral	Living systems	Dynamic patterns

Figure 2.1. Summary of the Integral Sustainable Design framework

As proposed by Dekay (2011)

Roetzel et al. (2015, 2017) presented a case study for assessing a building (through user responses and technical analysis). They utilized a mixed-methods approach to answer to each of the four quadrants of integral theory. Their analysis included structured interviews (for building users and visitors), energy performance metrics (resources use), comfort and lighting metrics as well as environmental analysis metrics (analysis of access to public transit climate and land use). This assessment aims not to evaluate the building but rather to simultaneously present the information gathered based on these different perspectives or world views. While they were able to connect further and qualitatively analyze the outcomes, they concluded that the framework might be easier to use in analyzing single elements (such as daylighting) as opposed to whole buildings and that the framework's strength lies in its ability to highlight the connections or contradictions in the different quadrants (Roetzel et al., 2017).

Another prominent example of this approach is Paul James' (2014) Circles of sustainability framework. Focused primarily on the urban level, the system uses a 9-point scale ranging from critical (here meaning problematic) to vibrant sustainability, and covers cultural, political, ecological and economic dimensions. The framework is developed around a series of paradoxes – similar to those explained previously – related to sustainability and aim to present a process to mediate between the contradictions and competing interests. The framework is presented in

Figure 2.2. Compound framework for mapping sustainable design

As presented by James (2014 - p.XIII)

Another example is the Compound framework for mapping sustainable design activities, proposed by Dusch et al. (2010) – seen in Figure 2.3. It aims to create a visualization tool for the relationship between sustainable design and sustainable development – through the mapping and classification of theories, tools, and strategies. The framework proposed to position two worldviews on the two axes of a map - namely the eco-centric and the techno-centric– to measure the departure of a specific element from the status quo towards creating new scenarios. This view echoes other approaches in the literature which use future scenarios and the interpretive nature of design (Boyko et al., 2012; Fisher, 2008; Fry, 2009; Kagan, 2019), and build on the work of Ceschin & Gaziulusoy (2016), Frame & Brown (2008) and Jabareen, (2008). It is also important to note that future scenario frameworks are increasingly utilized in business and investment to better position businesses for expected social, political and economic shifts (Henderson, 2015). Although the approach is simple, it can mainly be used in the design initiation and goal-setting phases of projects, and it falls short of providing a complete and comprehensive design assessment or analysis process due to its highly subjective nature.

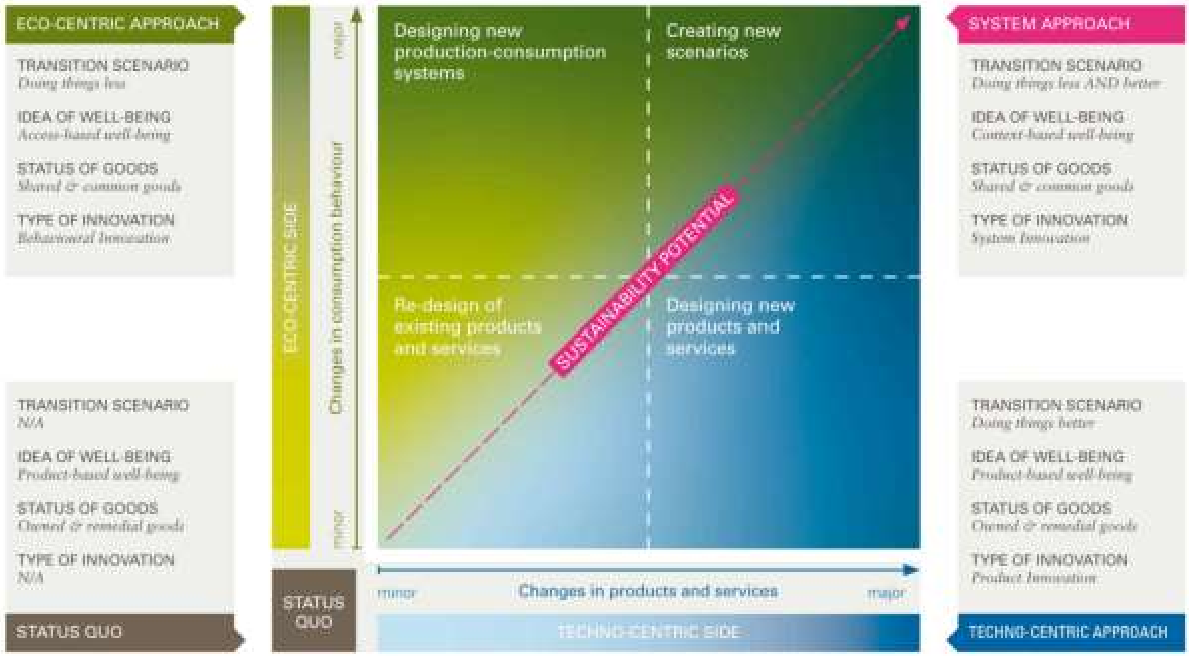

Figure 2.3. Compound framework for mapping sustainable design

As presented by Dusch et al. (2010)

Building onto the understanding of design projects and their trajectories (as presented in the work of Boutinet, 2005 and Nelson & Stolterman, 2012), Cucuzzella (2015a, 2020) developed a range of mapping tools, which aim to locate projects and their elements based on their *Rhetoric* and *Environmental expressiveness*. Cucuzzella utilizes these approaches to understand shifts in the visual expression in projects and study the variety and diversity of approaches in internationally recognized sustainable buildings. The sustainable design analysis and assessment literature present several other frameworks which aim to create a complex analysis for sustainability in the built environment through contrasting approaches and perceptions of users and experts. Other authors presented a proposal of such a framework which explores the sustainability priorities and perceptions of both experts and regional concurrently (Goubran, Emond, et al., 2020), understands the interplay between technological and cultural impetus in projects (Cucuzzella & Goubran, 2019), and maps the level of integration of sustainability issues in design (Goubran & Cucuzzella, 2019).

2.4. Making sense of the current landscape

Sustainability is one of the few endeavours where the human institutions (society, science, and economy), human consciousness (ethics) must be reconciled with the natural institution (environment – our planet)[15]. A level of integration that the industry failed to embody. This failure can be attributed to the fact that each of the building industry's fields[16] holds its independent view on the topic(McLennan, 2004).

Transdisciplinary approaches have been advocated as a valid means to tackle sustainability in the built environment (James, 2014; S. Walker, 2006). For Max-Neef, (2005), this type of transdisciplinarity requires a break out from the traditional paradigm of science and the exploration of new paradigms. Paradigms that are embedded in complexity (Le Moigne, 2013; Morin, 2008) that accept the duality of realities deal with the existence of multiple levels of reality and, most importantly, admit middles' logic. The drive of these approaches would be to explore and embrace the complexity of sustainable development issues, rather than reduce it or simplify it (Morin, 1977, 2008). This, of course, further calls into question the epistemological foundations of the scientific paradigm (Morin, 1977, 2008), and, in turn, its relevance to sustainability science.

The calls for a new paradigm for sustainability and sustainable design is nothing new – and was previously expressed in the work of Bonenberg & Kapliński (2018); Classen (2009); Ehrenfeld (2009); Fisher (2008); Fry (2009); S. Lee (2011); McLennan (2004); Perraudin (2016); S. Walker (2015)[17]. While these calls serve to imagine the future of sustainable building design, they result in new tensions and contradictions within sustainability science – such as the tensions between

15 Today, as identified by many authors, sustainability is perceived at the intersection of the environment, society and the economy (Brandon & Lombardi, 2011; James, 2015; S. Walker, 2015). For some authors, sustainability is made of the complex interaction of even more fields or topics (Ehrenfeld, 2009).

16 The building industry has been reduced today to three main fields: design (encompassing the inter-and intra- social issues of projects and experiential dimensions), engineering (encompassing the technical, technological and performance dimensions) and finance (encompassing issues related to affordability, market dynamics and viability) (Busby Perkins+Will & Stantec Consulting, 2007; Hansen & Knudstrup, 2005; Kanters & Horvat, 2012).

17 Kuhn (1970) can serve authoritative reference for issue of paradigms and scientific development.

disciplinary dependence and independence, as proposed by Andersen (2013). With this view of transdisciplinarity, a strong understanding of the paradigms guiding each of the disciplines can help researchers position themselves within the different world views related to the topic.

Burrell and Morgan's (2004) *"Sociological Paradigms and Organizational Analysis"* provides an essential tool for understanding the paradigms (Figure 2.4)[18]. Burrell and Morgan's (2004) map contains within it the fundamental tensions and debates that still shape the paradigms of social science, which are presented in Figure 2.4. Although the authors developed this tool for studying social theory, it was previously used to explore the theoretical and practical foundations of information system development and data modelling (as seen in the work of Goles & Hirschheim (2000) and Hirschheim et al. (2008)), to study building procurement (Green, 1994), to explore the possible socio-technical transitions towards sustainability (Geels, 2010), and as means for organizing the environmental discourse (Dryzek, 2013, p.16). Hirschheim et al. (2008) provide an overview of the four paradigms, a summary of which is shown in Table 2.1. Using this theoretical tool as a lens for understanding the current landscape of sustainable building design highlights that the research field's contradictions are deeply ontological and epistemological (*i.e.* relating to the world's reality and the nature of knowledge). This view is supported by research that examined the assessment of sustainable architecture – such as the work of Cucuzzella (2019) and Cucuzzella & Chupin (2013) which explore these tensions in the context of design competitions.

18 Numerous authors have criticized this map – proposing it oversimplifies the social sciences and creates artificial tensions. However, the map is used here as a tool for making sense of the current landscape of sustainable building design. Additionally, the work of (Reason & Rowan, 1981), who propose an alternative mapping, is also consulted and used in the upcoming section.

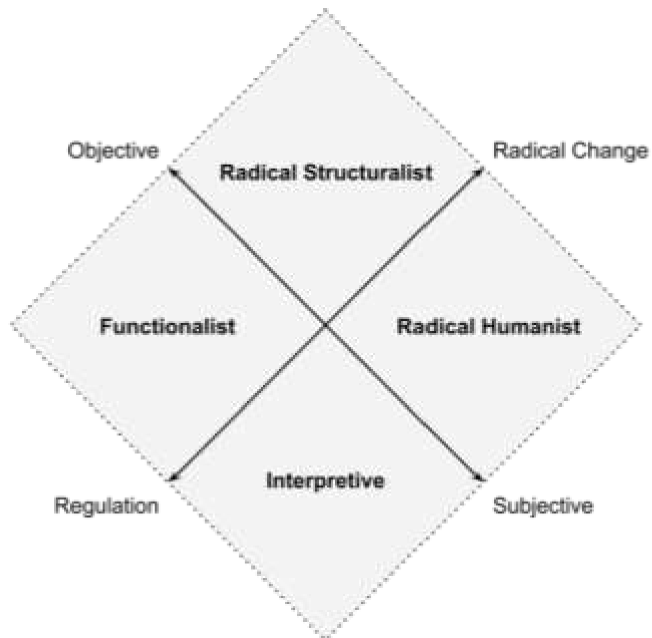

Figure 2.4. The four paradigms

Adopted from Burrell and Morgan (2004)

Using Burrell & Morgan’s (2004) paradigms map, we find that parts of the sustainable building design debate fall in each of its quadrants – examples of sustainable building approaches presented in Table 2.1 - adapted from (Hirschheim et al., 1995 - pp. 46-53). It is also clear that the designers' role moves between these quadrants depending on the coalition one is part of (if we use Hajer’s (1995) terms). However, we can propose that the two most prominent positions are at the ***1) functionalist*** (highly objective and embedded in the sociology of regulation) and ***2) radical humanist*** (highly subjective and embedded in the sociology of radical change) of the map.

Burrell and Morgan (2004) argue that the most dominant approaches to a topic are within very close proximity in their ontological, epistemological, human nature and methodological nature assumptions; the approaches express the orthodoxy within a specific subject. Based on the review presented and the prominence of quantitative methods of goal setting, assessment and certification, the orthodoxy for sustainable building design falls in the functionalist paradigm (Wahyuni, 2012). While structured and organized in its approach, the paradigm falls to justify its design objectives, negotiate between competing goals, or realize the importance of connotative (from the perspective of Eco, 1981). or social meanings in building design (Wahyuni, 2012).

Table 2.1. Summary of paradigm assumptions and exemplary sustainability approach

Paradigm	Regulation and change	Ontological Assumptions	Epistemological Assumptions	Human nature assumptions	Methodological Assumptions	Leading objective of sustainable building design	Key Deficiencies	Role of sustainable building designer	Example of sustainability approach
Functionalist	Regulation: views reality as highly cohesive	Realism: assumes that the world is made of concrete and real artifacts and relationships that can be studied, measured and reproduced	Positivism: The world is made of an objective reality that can be observed to generate knowledge and based on which theories can be developed to make a prediction	Determination: there are no multiple means of action – all outcomes can be explained rationally.	Nomothetic: empirical and analytical methods are used to observe, measure and predict.	To arrive at optimal solutions and at pre-defined goals/targets by fitting technologies that correct deficiencies.	Fails to explain how goals are set or the origination of subjective meanings or contradictory objectives.	An *Expert* in helping others attain the end goal.	Environmental life cycle analysis (LCA) or other prescriptive assessment methods – such as BREEAM and LEED
Radical Structuralist	Radical change: focused on understand conflict and finding ways to overcome existing oppressive structures	Realism: an ideological superstructure, terminated by production's economic conditions and exists beyond perception or theories.	Positivism: views change as embedded within the social structure	Determination: the interest to hold status-quo or change it what determines what one sees as the truth.	Nomothetic: empirical and analytical methodologies are adopted to understand the social forces that explain the change.	To design solutions that help users overcome social contradictions and achieve the emancipation of under-powered individuals.	Cannot explain the origin of conflict and contradiction in society by means other than the economic status and postulates that access and equity will lead to emancipation.	A *Worrier* on the side of progress	Architects Advocate – Action on climate change or Earth watch Institute (similar activist organizations)
Radical Humanist	Radical Change: consciousness of man is dominated by ideological superstructures that people need to overcome.	Nominalist: differentiates between social and physical realities	Anti-Positivism: multiple epistemologies are needed to understand the world,	Voluntarism: views society as anti-human and is concerned with the release from constraints – with critical debates and critical thinking as key for moderating between the realities.	Both Ideographic and Nomothetic: views society as anti-human and are concerned with the release from constraints: two types of methods are needed – to deal with each level of reality. With dialectical methods key in the process.	To design solutions that provide options and enable free choice, by removing barriers (external powers and psychological hurdles) and eliminating bias or distortion.	Fails to differentiate between social consensus and authentic consensus – thus could result in further enforcing repressive conditions.	An *Emancipator* from social and psychological hurdles	(Ehrenfeld, 2009) Sustainability by Design: A Subversive Strategy for Transforming Our Consumer Culture or (Fry, 2009). Design futuring: sustainability, ethics, and new practice. Berg. (or similar approaches)
Interpretive	Regulation: Holds that individuals' reflections and experiences make up the broader reality, which are determined by social institutions and human existence.	Nominalist: no fixed realities - the world is seen as an emergent social process	Anti-Positivism: more spiritual approach, based on individual and collective experiences	Voluntarism: views humans as individual actors.	Ideographic: interpretive and interactive modes of knowledge acquisition are utilized.	To design solutions that can result in meaningful social actions and that can assist in the transition to a more sustainable condition.	Fails to differentiate between informed/justified actions and habits/stereotypes leading to relativism and/or anarchy.	A *Catalyst* that can smoothen the transition between evolutions.	(S. Walker, 2006) Sustainable by Design: Exploration in Theory and Practice (or similar approaches)

2.5. A new paradigm for sustainable building design

Although Burrell & Morgan (2004)'s map helps in comprehending the underlying ontological (realism – nominalism), epistemological (positivism – anti-positivism), human nature (determinism – voluntarism) and methodological (nomothetic theory – ideographic) assumptions of research and approaches to sustainable building design, adhering to a single paradigm contradicts the call for "strong transdisciplinarity" advocated by (Max-Neef, 2005). Guy's seminal work, which proposes pragmatic yet fluid ecologies[19], is well situated to trace the characteristics of the new paradigm of sustainable architecture. Guy (2010), building on their previous work reviewed in this study, proposed that a new form of fluid architecture hybrids, which

> *"[…] means looking beyond fixed definitions and dualistic typologies, while at the same time resisting the temptation to either abandon the environmental project or simply swimming along in an ocean of free- flowing design options with no fixed reference points. It also means neither accepting the status quo – familiar buildings symbolically retrofitted with wind turbines and solar collectors – nor exclusively searching for radically new typologies". Guy (2010)*

In their seminal article, Kiel Moe (2007), highlights that energy, resources, technology, and the vernacular are not answers to the sustainability problems. He claims that "without critical reflection, technology is as likely to engender, as it is to annihilate unintentionally, sustainable possibilities". He states that:

> *"The shift in approach suggested here is not more statistics, checklists, or technologies but the development of deeper knowledge with regard to the actual context and technics of any architectural project."*

Both Guy (2010) and Moe (2007) highlighted that the mainstream approaches to sustainable building design were critical in moving the industry forward. Yet, they acknowledge that the dominant incremental and efficiency-driven processes pose limitations due to their normative

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19 Here this fluidity can be linked to the new form of liquid modernity – see Bauman (2000)

nature, their fragmented analysis processes, their technological determinism (Ellul, 1964; Volti, 2014), their ignorance to contextual questions, and, most importantly, their disconnect from global sustainable development goals (Boschmann & Gabriel, 2013; Brandon & Lombardi, 2011; Doan et al., 2017). In fact, Moe (2007) concludes that:

> *"The most significant adjustments to the discourse and practice of sustainability will involve a shift to more literal and extensive conceptions of context and technics. [...] Our Architects need an operational understanding of the physical milieu of their work, expanded knowledge of material ecologies and effects, the capabilities and culpabilities of technology, the social basis of technology, the actual situation of architects in our industries, and a more vital conception of its time-imbued context. Only then will architecture practice what David Harvey*[20] *has described as the ''advancement of more socially just, politically emancipating and ecologically sane mix of spatiotemporal processes".*

Here, we evoke Fry's (2009) ideas for design futuring, which propose that designers place the "politico-ethical" impetus before the project's confined needs and requirements to give oneself a future. We emphasize the need to re-align design with traditional epistemologies and understanding of the *human/nature* and *nature/culture* relationships (as suggested by Fisher (2007, 2008), and reiterated by Guy (2010)), to re-formulate the values of the society to appreciate what is essential for their continuation, rather than what is not needed or excessive.

Throughout these emancipatory calls (as seen in Fry, 2009; Walker, 2006; McLennan, 2004 and McDonough & Braungart, 2002), we see a demand for focusing on quality and attending to "real" challenges[21]. As such, a return to the theoretical origins of design practice and project is needed: where 1) through design, designers can create a world that has more meaning, guided by judgement (as opposed to the sciences, which seek to create a more real-world, and directed by empirical

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20 David Harvey, ''The New Urbanism and the Communitarian Trap,'' Harvard Design Magazine: Changing Cities 1 (Winter/Spring 1997), pp. 68–69.

21 Yet, the definition of sustainable "quality" in buildings, as outlined by current quantitative and checklist-based methods, continues to undermine the *context* of projects and puts the theory of qualitative judgment at risk (Ellul, 1964; Giddens, 1990; Roetzel et al., 2015, 2017, 2016).

theories) (Nelson & Stolterman, 2012), and where 2) projects are seen as opportunities that allow people to realize the reasons for their wants, with partially determined outcomes (Boutinet, 2005).

At this point, we arrive at a possible new paradigm for sustainable building design: one that is expansive, dynamic, and considers the social and cultural phenomena, and that weaves together evolving and interconnected realities that exist at multiple levels – keeping with our modernity that is always in fluid and motion (Bauman, 2000; Bovati, 2017; Ingold, 2015; Moe, 2007; Pollock, 2007; Powell, 2007). A paradigm that considers sustainability in buildings as an emergent feature of critical design practice (Coleman, 2012; Frame & Brown, 2008; Le Moigne, 2013; D. A. Schön, 1984) and seeks to reconcile sustainability quality in the built environment in the paradigm of sustainable development. This new system would focus on linkages, relations, synergies, and self-organization, accept the continuous flow of information, and be less concerned with self-produced boundaries (Dempster, 1999). A paradigm that would have to accept the metaphysical assumptions of all four quadrants of Burrell & Morgan's map (2004), and would require a new type of scientist – who is closer to the conceptual humanist defined by Mitroff and Kilmann (1978) and Reason (1981)[22 & 23].

Yet, and as suggested by Guy (2010), a fixed frame of reference is needed to ground this paradigm and activate it. We propose that a sustainable development definition grounded in the 17 UN Sustainable Development Goals (SDGs) could serve this objective. The goals provide a clear outlook into the future through global commitments with direct national and local implications with a clear roadmap for the next decade (Allen et al., 2018b; Pedersen, 2018; United Nations, 2015, 2017). The choice of this definition is rooted in the goals' relative stability, their acceptability, determination to comprehensiveness, infiltration in all sectors at the different scales (inspired by the evolution of the topic and the future need, and the call for their application from the global to the local levels), and their integration in public and private sustainability reporting

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22 A conceptual theorist who views science as a group of interdependent fields, as not autonomous, and not value free; who is uncertain, value constituted, imaginative and holistic; who views science as a means for human development; who is a generalist, knows their biases, speculative and imaginative; and who is dialectic in their logic – as proposed by Mitroff and Kilmann (1978).

23 Similar ideas have been explored in a research note book publication on the notion on Didacticism in architecture (Goubran, 2019b)

(Allen et al., 2018a; Bernardi et al., 2017; Diaz-Sarachaga et al., 2018; Doan et al., 2017; Eizenberg & Jabareen, 2017; Gibberd, 2015; Lafortune et al., 2018; Le Blanc, 2015; Lior et al., 2018; Nilsson et al., 2018)

2.5.1. Value-added analysis of sustainability in building design within this new paradigm

Analysis methods have to accommodate this expanding and dynamic definition of sustainability and mediate between international and national objectives on the one hand and the local needs and priorities on the other. By compiling the different perspectives and critical views presented in the debates relating to the topic of sustainable building design and its analysis, six key characteristics for value-added analysis can be proposed:

1. Analysis frameworks are better suited to analyze design when there are able to incorporate and accept pluralistic views to sustainability (Guy & Moore, 2007). The design literature points us that there are many approaches and logic to sustainability (Guy & Farmer, 2000, 2001). Additionally, the definitions of sustainability range from technical to spiritual (McLennan, 2004; S. Walker, 2006). The mainstream assessment tools have been focused on creating value – in many cases, short-term economic value – through ratings and recognition (Fisher, 2008). Suppose we use Nelson & Stolterman's (2012) proposition that design needs to combine the real, ideal, and true balance. In that case, we realize the need for more expansive and complex tools to analyze and guide design decisions – to relocate the design field away from being a moderator to technical requirements or as an enabler to create economic value.
2. Design analysis frameworks have to deal with the complex anticipatory nature of design projects and consider future scenarios through the embodied and communicated vision of a sustainable future. Future-oriented perceptions of design projects have been highlighted in the literature. Fry (2009, 2014) points to how architects and designers are planning the future – a not yet existing and not fully defined state that is explored through the design process. Boutinet (2005) places projects in the "partially determined" mode of anticipation - where the project becomes an anticipation of the desired future.
3. New methods and frameworks have to mediate between the local realities and global benchmarks and sustainability agendas. This might require rethinking assessment processes

to map and mediate between the different design priorities simultaneously - for example, the users and expert domains (Goubran et al., 2017); since construction projects are inserted within complex social, environmental, economic and even political realities.

4. The new generation of methods must be practically and simultaneously used at multiple scales – from a single project component to complete buildings and globally to a local scale. Design projects are made of many elements and stakeholders that are interconnected. Additionally, buildings' context and users are intimately related to our modern world's dynamic social, political, and cultural reality (Bauman, 2000; Ingold, 2015; Moe, 2007; Söderberg & Netzén, 2010). New frameworks must move beyond project fragmentation approaches – where single building elements are analyzed in isolation from the building, context and use, and embrace sustainability's complexity.
5. The analysis frameworks must also consider the historicity of the present-day realities at the different temporal and physical scales. Scholars have suggested assessing sustainability as an emergent property of design thinking through reflection-in-action (Bovati, 2017; A. D. Schön, 1983) – in that sense; sustainability could even emerge as the product of the analysis process itself. The analysis frameworks must require critical design thinking and reflection for their use instead of simple data or documentation collection for completing checklists or measuring indicators.
6. The new generation of analysis methods has to shift the definition of sustainability in buildings towards the original path of sustainable development. The evolution of sustainable development and the integration of the topic in the building industry shows a disconnect between its holistic goals for synergistically improving human and planetary conditions on the one hand, and the incremental improvements and quantitative goal-setting approach currently implemented in the building industry on the other (Allen et al., 2018a; Bernardi et al., 2017; Diaz-Sarachaga et al., 2018; Doan et al., 2017; Eizenberg & Jabareen, 2017; Gibberd, 2015; Lafortune et al., 2018; Le Blanc, 2015; Lior et al., 2018; Nilsson et al., 2018). With the latter ignoring the connotational functions of building (Eco, 1981) and not utilizing the potential of buildings as catalysts for sustainable development (Sustainable Development Solutions Network Thematic Group on Sustainable Cities, 2015) As such, the new methods have to base themselves within the broader context of the topic. Yet, any subjective definition of sustainability risks not being recognized in the industry, a critical success factor

in today's demand-driven market. Thus, it is suggested that the tools utilize globally accepted frameworks to define "sustainability" – such as the UN 2030 Agenda which defines the global approach for at least the next ten years (GRI et al., 2015; Jiménez-Aceituno et al., 2019; Le Blanc, 2015; Türkeli, 2020; United Nations, 2015).

2.6. Conclusion

This research serves as a comprehensive critical review for the current state of sustainable building design and assessment. Beyond the review of available work, the study juxtaposes theoretical texts relating to complexity and system thinking, history of science, design, social sciences and sustainability research to analyze and map the tensions between the different approaches to the topic and to propose a path to reconcile the practice of sustainable building design with the fundamental objectives of sustainable development.

The first part of the study reviews the definition, evolutions and contradictions in the meaning and practice of sustainability in buildings. On the one hand, we find that the universal definition of sustainability, which was first formalized in the Brundtland Report (World Commission on Environment and Development, 1987), has continued to grow in breadth – further expanding the original 3-domain model (society, economy and environment) to include institutional, ethical and governance issue. Arriving at the 2030 Agenda, which was approved in 2015, the sustainability challenges are defined around 17 key goals encompassing five key domains (known as the agenda's 5Ps) (Wysokińska, 2017). Yet, on the other hand, the application of sustainability in building design has moved away from its initial objective of finding holistic solutions (Cucuzzella, 2020a; McLennan, 2004; Roostaie et al., 2019) and its critical drive for reconciling human and natural institutions (Naess, 1973). Instead, sustainable building design has taken a "normative" turn since the 1990s focused on attaining reductions in energy consumption and other resources, which was institutionalized by the available rating and assessment schemes (Cucuzzella, 2019a). Today, these tools have become the standard for practice, often providing the definition of sustainability in buildings and responding to the market needs for communicating greenness (Acuff et al., 2005; DLA Piper, 2014; S. A. Jones & Laquidara-Carr, 2018). These findings have grounded the review around three key themes: 1) providing an understanding of the adoption of sustainability principles in the real estate market and the forces that are guiding its current changes and transformations, 2) understanding the different approaches to sustainability assessment, their recent developments and critiques, and 3) exploring alternative ways for analyzing sustainability in buildings.

In the first theme, it was clear that resource efficiency and optimization were initial key drivers in adopting sustainability in the market (Acuff et al., 2005; DLA Piper, 2014; S. A. Jones & Laquidara-Carr, 2018). However, increased asset values, incentives, and future market opportunities position themselves as critical factors for the adoption today – signalling the market's maturity (Deloitte, 2014; S. A. Jones & Laquidara-Carr, 2016, 2018; World Economic Forum, 2016a). These changes are pushing the market to adopt and adapt to changing social, political and economic realities – including changes in the types of projects pursued, in how sustainability and environmental performance is analyzed, in types and locations of development activities, and in the project's end-users (Hardy, 2016; Markovich et al., 2018; Wichaisri & Sopadang, 2018). A key observation is that the communication and verification of projects' and assets' sustainability is critical for the continued adoption of sustainability in the real estate industry.

In the following section, it was clear that a significant portion of scholarly work has already studied in depth mainstream assessment tools, standards and systems. A short overview of three of the most widely used (LEED, BREEAM and CASBEE) reveals similarities in their areas of concern – which generally ignore projects' social, economic, cultural and even specific environmental context (Berardi, 2012; Bernardi et al., 2017; Cucuzzella, 2009; Doan et al., 2017; Jefferies & Coucill, 2020; Schweber, 2017). It is also clear from the literature that the criteria of these widely used standards have become defining to the definition of sustainability in buildings – and that in many cases, they become guiding to the design process itself (Berardi, 2012; Boschmann & Gabriel, 2013; Cucuzzella, 2009, 2015c, 2015a; Cucuzzella & Goubran, 2020b; Ding, 2008; Jefferies & Coucill, 2020). With multiple critiques and questions around the validity of the available assessment methods, both as representative of sustainability in building and as markers for performance (Bernardi et al., 2017; Bragança et al., 2010; Díaz-López et al., 2019a, 2019b; Doan et al., 2017; Hossain et al., 2018; Newsham et al., 2009; Scofield, 2013; Thatcher & Milner, 2016; Yudelson & Meyer, 2013), the study moved to review alternative ways of sustainability assessment.

The literature includes several frameworks that can be used to analyze buildings' sustainability (including the work of Dusch et al., 2010; Goubran et al., 2020; Goubran & Cucuzzella, 2019; Henderson, 2015; Roetzel et al., 2017). Rather than solely focusing on performance rating or compliance, these frameworks usually adopt more qualitative methods to understand the multiple layers and dimensions of sustainability that a specific project includes and use mapping and diagrams to attain this objective. Thus, these value-added approaches are firmly rooted in systems thinking and complexity theory (Checkland, 1993; Morin, 2008; B. Wilson, 1984), in the tradition of the social sciences of qualitative comparative analysis (Andersson et al., 2013; Conceição et al., 2017; Deledalle, 2000; Fisette, 1997; Goubran, 2019g; Greckhamer et al., 2018; Pauwels, 2009; Ragin et al., 2003; Stojiljković & Trajković, 2018), and they recognize the competing logics within sustainability (Guy & Farmer, 2000; Putnik, 2009; Vandevyvere & Heynen, 2014). However, it was clear that these frameworks lack a common frame of reference for the definition of sustainable design and its areas of concern.

The study then attempts to make sense of the extensive literature reviewed by adopting Burrell and Morgan's (2004) map of research paradigms. It becomes clear that the sustainability approaches are dispersed between the four quadrants – but concentrated in the functionalist position. This clarifies how the predominant approaches fail to justify their ultimate objectives, cannot mediate between competing definitions and goals, or consider design outcomes' social meanings. This, in turn, leads to a possibility of imagining a way forward beyond this impasse. The study proposed to root the design of sustainable buildings in a transdisciplinary approach, which bases its view of design projects on the work of Nelson & Stolterman (2012) and Boutinet (2005), and is inspired by the radical humanist approaches to sustainable design proposed by Fry (2009), Ehrenfeld (2009), Walker (2006) and others. To veer away from an interpretive approach, the SDGs are proposed as a fixed frame of reference to define sustainable development. The recent trends inspire this view in public and planning, assessment and academic research to connect sustainability efforts to this global agenda (Allen et al., 2018b; Pedersen, 2018; United Nations, 2015, 2017). Finally, the study compiles six key recommendations for developing sustainability analysis methods in buildings, which can help transition the industry towards meaningful reconciliation between buildings and the development goals. The six points can be summarized as follows:

1. Utilizing analysis frameworks that are inclusive of the varied and often competing logics of sustainable design
2. Focusing on identifying the sustainable design intent and visions of projects, and their realization in projects
3. Adopting approaches to design and analysis that consider the specific project's context and local realities.
4. Developing methods that do not mandate the fragmentation of projects and that would allow for whole projects or specific elements or features to be analyzed – focusing on the challenges and problems that are addressed rather than the outcomes
5. Moving sustainable design analysis towards a form of critical judgement and design thinking – where sustainability can emerge through time and as an outcome of the analysis itself.
6. Grounding the analysis frameworks in the current definition of sustainable development to provide a fixed frame of reference (such as global development agendas) – to assess how buildings are contributing to the global sustainable development endeavour

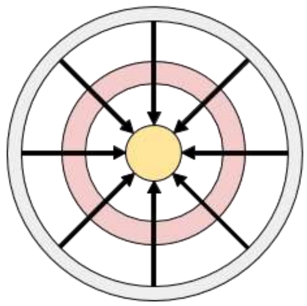
This research attempts to be a reliable reference on sustainable building design, which researchers and practitioners use an. It presents an overview of a large body of work on the topic . However, its structure was induced by the literature. Thus, future work might consider developing further on the review by presenting thematically structured studies that further explore each topic separately and deploy bibliometric or other quantitative methods to further understand the evolution and emerging trends. The study offers several critical areas for future exploration. It highlighted the need for further studying how the current social, economic and political trends are reforming the sustainable real estate market and possibly displacing the currently established definitions and design trends. Also, a need to explore the relevance of building activities to international development agendas, and how they can contribute to attaining the SDGs. The need to develop and test new frameworks for analyzing sustainability in buildings and studying how sustainability is being realized in buildings beyond its current normative definition.

2.7. Chapter Postscript

Chapter 2 reviewed, contrasted and compared a significantly large body of literature on the topic – spanning the fields of design and architecture, finance, development studies, the arts, policy, and different fields of engineering. It completed this review with critical historical documents and contrasted the findings to theoretical writing in the history of science, complexity theory, and sustainability theory. The chapter presents some of the most critical debates and tensions that surround the sustainable building design process. The chapter clarified the over-dependence on assessment methods (especially systems such as LEED, BREEAM and CASBEE) on establishing and communicating the "sustainability" of a given project and presented their misalignment, on the practical and theoretical levels, with the current market realities and global visions for sustainable development (Berardi, 2012; Boschmann & Gabriel, 2013; Cucuzzella, 2009, 2015c, 2015a; Cucuzzella & Goubran, 2020b; Ding, 2008; Zuo & Zhao, 2014).

Based on the call for a fixed frame of reference proposed by Guy (2010), the chapter put forward the theoretical foundation that justifies using the global sustainability agenda as a framework for approaching sustainability today, as represented by the SDGs detailed in United Nations (2015). . The chapter's conclusion argues that all the existing paradigms are intrinsically misaligned with the vision of building design as a transdisciplinary science. Instead, a new paradigm's foundations were imagined, whose ultimate aim would be realizing sustainable development. Finally, the chapter proposed six suggestions that could define how to approach and analyze sustainable building design within this new paradigm.

In this thesis, Chapter 2 acts as the literature review section. It helped formulate the thesis's directions, revealing that sustainable buildings can be studied as 1) products of external market and policy dimensions, 2) outcomes of the design process, and 3) as manifestations of designers' visions for attaining a more sustainable future. The details of these three directions' research focus and theoretical frameworks are presented in Figure 2.5.



Sustainable buildings as a real asset

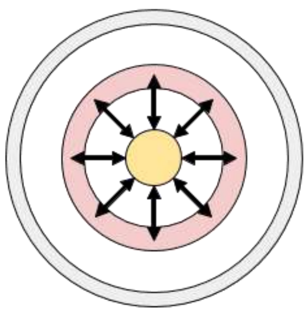
CHAPTER 3

Research Focus

Studying the implications of policies, markets, and technological development on sustainable buildings

Theoretical Framework

A simple and non-theoretically complex framework mainly composed a of sustainable development and sustainability theory and reinforced by building and real estate data and trends published by market and sector-based reports.



Sustainability in buildings as a result of a design process

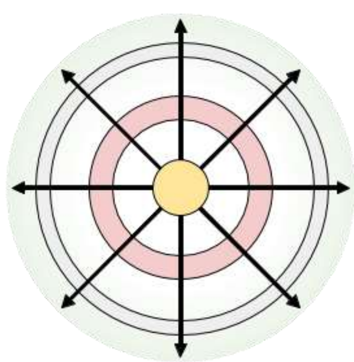
CHAPTERS 4 & 5

Research Focus

Exploring the relationship between the building sector, sustainability standards and sustainable development, and the implications of developmental approaches on building energy and emissions as well as new means for meaningfully integrating the SDGs in buildings

Theoretical Framework

Adding a significant layer of complexity by integrating design theory and practice, sustainable design theory, theory of projects and their trajectories, complexity and system theory, design futuring and theoretical work focused on the ethics of sustainable design.



Sustainable buildings as a manifestation of the visions for attaining sustainable development

CHAPTERS 6 & 7

Research Focus

Investigating the manifestation and realization of sustainability and sustainable development in architectural design project, with a focus on recognized green buildings

Theoretical Framework

Adds another layer of theoretical complexity by considering the meanings and its emergence in building projects through theories of semiotics and semiology. Also, architecture theory focused on the questions of quality, judgement, competitions and excellence.

Sustainable buildings **Design** **Policies and markets** **Visions of sustainable development**

Figure 2.5. Theoretical frameworks for the upcoming chapters

The upcoming chapter (Chapter 3) adopts a business perspective to sustainable real estate – by exploring buildings as outcomes of external market, policy and technological forces. It points to the transition of the real estate beyond quantitative environmental performance metrics and the increasing acceptability of sustainable development as a guiding framework for the building industry. As a result, several different strategies and trends, which tackle some of our social, economic, cultural challenges, are emerging and gaining ground. Chapter 3 uses the case of carbon taxation schemes and high-rise timber construction (as a market and technology force) to illustrate this transition.

Chapter 4 and Chapter 5 integrate design theory, sustainable design theory, theory of projects and their trajectories, complexity and system theory, design futuring and theoretical work focused on sustainable design ethics [24]. They take a slightly more theoretical approach that view sustainability in buildings as the outcome of the design process and its tools. Finally, Chapter 6 and Chapter 7 build onto this framework by adding theories of semiotics and semiology and architecture theory focused on the questions of quality, judgment, competitions, and excellence [25].

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24 Such as the work of (Berardi, 2012; Bhamra, 2004; Boutinet, 1993, 2005, 2014; Bovati, 2017; Boyko et al., 2012; H. Brezet, 1997; J. C. Brezet, 1997; Busby Perkins+Will & Stantec Consulting, 2007; Ceschin & Gaziulusoy, 2016; Chansomsak & Vale, 2008; Raymond J. Cole, 2005; Cucuzzella, 2009, 2011b, 2015b, 2016; Dewberry, 1995, 1996; Dewberry & Goggin, 1996; "Du Didact. En Archit. / Didact. Archit.," 2019; Feria & Amado, 2019; Fisher, 2008; Fletcher & Goggin, 2001; Fry, 2009; Goubran, Masson, et al., 2019; Guy & Farmer, 2001; Hajer, 1995; Hansen & Knudstrup, 2005; Kanters & Horvat, 2012; Lehni & World Business Council for Sustainable Development, 2000; Næss, 1994; Nelson & Stolterman, 2012; Orr, 2002; Prishtina, 2018; A. D. Schön, 1983; The Institute for Market Transformation to Sustainability (MTS), 2012)

25 Such as the work of (Andersson et al., 2013; Barley & Tolbert, 1997; Barthes, 1985; Baudrillard, 1995; Bonenberg & Kapliński, 2018; Boudon, 2000; Boutinet, 2005; Buchler, 1955; Chupin et al., 2015; Chupin, 2011; P. Collins, 1971; Cucuzzella, 2015b; Fisette, 1997; Fry, 2009; Giddens, 1984; Kaelin, 1983; Krampen, 2013; Yuan Li, 2017; Nelson & Stolterman, 2012; Oliveira & Sexton, 2016; Owen & Lorrimar-Shanks, 2015; Perkins-Buzo, 2017; Rönn et al., 2011; A. D. Schön, 1983; Simon, 1996; Strong, 1996; Turner et al., 2015; Zeisel, 2006)

CHAPTER 3.
SUSTAINABLE REAL ESTATE: TRANSITIONING BEYOND COST SAVINGS

3.1. Foreword

While the subject of sustainable buildings is typically and most commonly discussed from within the engineering[26] or the design[27] disciplines, the findings of Chapter 2 revealed that the uptake of sustainability in the building industry is heavily guided by environmental regulations (such as laws, bylaws and policies, and most importantly by its economic feasibility *i.e.* the bottom line). In fact, the increasing commitment to sustainability in the building sector can be directly traced to higher internal rates of return that can be realized when compared to traditional practices (Deloitte, 2014); a trend deeply rooted in the notion of *Doing Well by Doing Good* (Eichholtz et al., 2010).

Chapter 3 directly tackles the need for studying the implications of policies, markets, and materials on sustainable buildings. Specifically, it focuses on the implications of sustainability policies and technologies in the real estate sector. Thus, the area of real estate (and its intersection with the fields of finance and economics) constitutes a useful entry point to understanding the mainstream trends and emerging directions that are shaping sustainability in buildings.

The chapter starts by revisiting and critically reflecting on the role real estate can play in the international sustainable development agendas (specifically the SDGs) (United Nations, 2015, 2017). This analysis highlights that real estate, and its related industries, can have a strong influence and even be a leader in achieving goals related to renewable energy, resilience, knowledge dissemination, and others. By considering the development in the sustainable real estate sector, some trends point to the market's maturity. However, other developments highlight the political and external dependency risks of the sector. These uncertainties, which make the sector dependant on the policies, incentives, and credits, can also be seen as a driver for instituting,

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26 With a focus on the technical advancement enabling improvement in performance

27 With a focus on how sustainability can be a means or outcome of the design process.

through good policymaking, new strategies for tackling social, demographic, physical, cultural and environmental challenges.

Studying the case of carbon taxes in Canada, the chapter investigates the connection between taxation policies (cap and trade *vs.* carbon tax) and real estate. The economic and environmental consequences of these policies are also studied in details (based on the work of Beck et al., 2015, 2016; Dissou & Siddiqui, 2014; Gray & Metcalf, 2017; Lawley & Thivierge, 2018; Murray & Rivers, 2015; Zainol, 2017). Studying advanced and high-rise timber buildings technology, and its application in Canada, it is clear that technological developments can help the sector expand its focus beyond the prevailing site-specific eco-efficiency model, to provide economic, technical, policy and even socio-cultural benefits (Goubran, Masson, et al., 2020). The chapter concludes by highlighting some of the future research directions that can help strengthen the sector's alignment with the goals and topics of sustainable development, as presented in the 2030 Agenda (United Nations, 2015, 2017).

In this chapter, market reports, theoretical texts (from the fields of design, political science and development studies), review articles, and technical publications (journal articles and reports in engineering, planning and geography) are intertwined and put in conversation. Through this multidisciplinary review and analysis, the chapter addresses four key questions:

1. How do the changing political, social, economic, and environmental realities affect the real estate sector?
2. What are the intersections between sustainable real estate and the UN 2030 agenda and its SDGs?
3. How do carbon taxation schemes affect real estate and its future directions?
4. How could advances in building materials, such as EWPs, fuel the transition beyond eco-efficiency?

This is a co-authored chapter that is published in an edited book. The thesis author is a co-first author and main contributor. The chapter-specific publication details can be found in Appendix (C). The keywords for this chapter are listed in Appendix (B). The published chapter reference is:

Walker, T., & Goubran, S. (2020). Sustainable Real Estate: Transitioning Beyond Cost Savings. In D. M. Wasieleski & J. Weber (Eds.), *Sustainability* (Vol. 4, pp. 141–161). Emerald Publishing Limited. https://doi.org/10.1108/S2514-175920200000004008

This chapter builds on previous work published by the thesis author. Including:

Goubran, S., Masson, T., & Caycedo, M. (2019). Evolutions in Sustainability and Sustainable Real Estate. In T. Walker, C. Krosinsky, L. N. Hasan, & S. D. Kibsey (Eds.), *Sustainable Real Estate* (pp. 11–31). Palgrave Macmillan. https://doi.org/10.1007/978-3-319-94565-1_3

It also established the basis for detailed study that puts in question the potential of timber as a global substitute for un-sustainable building materials, which was previously published.

Goubran, S., Masson, T., & Walker, T. (2020). Diagnosing the local suitability of high-rise timber construction. *Building Research & Information*, *48*(1), 101–123. https://doi.org/10.1080/09613218.2019.1631700

3.2. Published Abstract

In recent years, sustainability considerations in the real estate sector have moved from being a niche market phenomenon to a mainstream trend. The movement has been accompanied by a shift in the industry's perception of sustainable buildings. Traditional cost-saving goals are now complemented by a growing interest in the potential for sustainable buildings to tackle broader economic and social sustainability challenges as well as issues related to health and well-being. The real estate industry is increasingly expected to adapt its strategies to incorporate new and more stringent environmental and urban development requirements, to cater to shifting demographics, and to utilize new advancements in construction processes and materials. This chapter explores recent research on sustainable real estate and highlights some of the newest trends in the market. The chapter then examines how policy and technological advancements can enable real estate developers to tackle environmental, social, and economic sustainability challenges. This will be exemplified through a focus on carbon taxation and timber construction. Based on these case studies, the chapter illustrates how today's sustainable real estate sector – marked by its move beyond a focus on cost savings – requires for building practices to be strongly rooted in global, sustainable development policies.

3.3. Introduction

Current projections indicate that the world's population could reach more than 11 billion inhabitants by the end of this century (Department of Economic and Social Affairs (Population Division), 2017 - p. 1). This sharp 3.5 billion increase from today's population is expected to be coupled with global urbanization: as more than two-thirds of the world population will be settled in urban areas by 2050 (Department of Economic and Social Affairs (Population Division), 2017 - p. 7). To meet the growing need for urban housing, the 750 largest cities in the world are expected to require 260 million new homes and 540 million m² of new office space by 2030 (World Economic Forum, 2016 - p. 6). These trends could add significant stresses on the natural environment. Today, the building sector is estimated to consume 40% of global final energy use, resulting in one-fifth of overall Greenhouse Gas Emissions (GHGEs) (World Economic Forum, 2016 - p. 6; Intergovernmental Panel on Climate Change, 2014 - p. 22). The GHGEs from the building sector are projected to increase by more than 50% by 2030 (World Economic Forum, 2016a) and by approximately 150% by 2050 (Intergovernmental Panel on Climate Change, 2014). In addition to emissions, 40% of raw material consumption, 40% of solid waste generation, 12% of potable water use, and 20% of water effluents are attributed to the building sector worldwide (World Economic Forum, 2016 - p. 6). These trends make urban centers and the building sector critical areas of focus in the path towards sustainable development.

With the current technologies and construction standards, the World Economic Forum estimates that emission reductions of more than 10% in the real estate sector are easily attainable without compromising profits (World Economic Forum, 2016 - p. 12). Commercial factors mainly drive the uptake of ecological building activities: buildings with environmental certifications have higher market values and lower operating costs, which strongly influence investment decisions (Oliver et al., 2014; World Economic Forum, 2016a; World Economic Forum & The Boston Consulting Group, 2018). Until recently, the most critical metric used to measure the benefits from green buildings was their lower operating costs when compared to traditional buildings (S. A. Jones & Laquidara-Carr, 2016, 2018). Market studies suggest that the real estate industry is gradually taking a more favorable view of ecological and sustainable buildings due to the decreasing cost of technologies, increasing demand, and greater incentives for sustainable development (Acuff et al., 2005; S. A. Jones & Laquidara-Carr, 2016, 2018; Sandström et al., 2017). Current reports are pointing to the fact that, by not adopting sustainability principles today, real estate investors and businesses will be more exposed to risks resulting from changing and evermore stringent environmental regulations (Henderson, 2015; S. A. Jones & Laquidara-Carr, 2016, 2018; Silvestri & Gulati, 2015).

Firms are increasingly adopting sustainability principles in the design, construction, operation and even demolition phases of real estate projects (S. A. Jones & Laquidara-Carr, 2016, 2018). As of recently, the traditional cost-saving goals are being complemented by a growing interest in the potential for sustainable buildings to tackle broader economic and social sustainability challenges as well as issues related to health and well-being (Deloitte, 2014; Eichholtz et al., 2010; International WELL Building Institute (IWBI), 2014; S. A. Jones & Laquidara-Carr, 2018; Roland Berger Strategy Consultants GmbH, 2010). The real estate industry is expected to adapt its strategies to incorporate new and more stringent environmental and urban development requirements to cater to shifting demographics and to utilize new advancements in construction processes and materials (Apanavičienė et al., 2015; M. Lawrence, 2015).

This chapter presents some of the development in sustainability and their implications on the built environment and the real estate sector. The chapter examines how the changing political, environmental, social, and economic realities of cities and urban areas are affecting and transforming the real estate sector. We shed new light on how policy developments (using the case of carbon taxation), as well as technical material advancements (using the case of advanced timber construction), can enable the real estate sector to transition beyond the eco-efficiency paradigm and move beyond cost savings. The examination presented highlights the requirements for building practices to be firmly rooted in global climate change goals and sustainable development policies.

3.4. The real estate sector and sustainable development

It was in 1972 that the international community gathered in Stockholm during the United Nations (UN) Conference on the Human Environment to reconcile human activities with the natural environment. This meeting was followed by a number of studies and reports, such as the Limit to Growth (Meadows et al., 1972), which detailed the approaching environmental and global economic challenges. The term sustainable development was first used in the early 1980s to express the harmonious relationship between human development and the biosphere's integrity. In

1987, it was formally defined as the "[...] development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987). It was not until the early 2000s that the holistic understanding of sustainable development, which integrates the economic, social, and environmental dimensions, was developed. In 2015, following the UN Sustainable Development summit in Rio de Janeiro (Rio 20+), a pivotal document titled *The future We Want* was published, setting the stage for what is today known as "The 2030 Agenda" (United Nations, 2012, 2015). The rise of sustainability as an organizing principle in development agendas worldwide has been accompanied by criticism. Sachs (2015) argues that governance, a dimension that is often overlooked, is a necessary complement to the three traditional dimensions of sustainability. Meanwhile, other authors argue that ethics should be an integral element within the quest towards sustainability Ehrenfeld (2009).

3.4.1. The role of real estate in international sustainable development agendas

The 2030 Agenda, which presents the Sustainable Development Goals (SDGs), offers a unique opportunity since it provides a clear road map for the commitments of governments for the next decade (United Nations, 2015, 2017). Real estate is both directly and indirectly related to the topics of the SDGs (Goubran, 2019a). The SDGs provide businesses with an international policy framework that has clear national and local implications, thus providing a strategic market outlook for investors and developers alike and enabling strategic long-term business planning (Pedersen, 2018). Pedersen (2018) further elaborates that companies who are likely to align their strategies and principles with the SDGs could potentially create new business opportunities.

Because cities lie at the intersection of today's major challenges, such as population growth and urbanization, real estate should be understood in the broader context of sustainable urban development (Christensen & Gabe, 2019). The real estate sector is well integrated into the SDGs through its active role in shaping the built environment (GRI et al., 2015; United Nations, 2017). Although the sustainability goals are global in scope, their implementation requires practical actions in local settings. Thus, the SDGs could further support the real estate industry's role in tackling more significant social, economic, and cultural elements of sustainability to capture the new opportunities that this global agenda provides (Pedersen, 2018; World Economic Forum &

The Boston Consulting Group, 2016). This opportunity would require the sustainable real estate industry to step up to the challenge of recognizing the global sustainability context and going beyond simply fulfilling current market or client demands for more efficient buildings or meeting the requirements of third-party certification systems (Bai et al., 2018; S. A. Jones & Laquidara-Carr, 2016, 2018).

The targets and indicators of the 17 SDGs (United Nations, 2015) demonstrate that the real estate sector can contribute to more than just the evident Goal 11: "Make cities and human settlements inclusive, safe, resilient and sustainable" (Christensen & Gabe, 2019). Figure 3.1 presents the connections between the sustainable real-estate industry and the SDGs. SDGs 7, 11, 12 and 13 are frequently cited as being relevant to real estate since they cover energy, cities, consumption and production patterns, and climate change (Goubran, Masson, et al., 2019). The sector can work on expanding into renewable energy sharing (addressing target 2 in SDG 7) and paving the way for new codes and standards for climate adaptation (addressing target 1 in SDG 13). Other scholars also point to the ability of the real-estate industry to reduce the exposure to climate-related events (such as floods and droughts), as addressed in SDG 1 (Lynch & Mosbah, 2017). In addition to achieving these targets directly, the attainment of various targets related to the 17 SDGs of the 2030 Agenda requires designing, constructing, and managing new facilities and infrastructure, as well as various renovations and urban regeneration projects (Goubran, 2019a).

Developed countries and their real estate businesses, especially the ones who have advanced their sustainability agenda and technologies, have additional important roles in the 2030 Agenda by sharing knowledge and building expertise. For instance, Canada performed a voluntary review of its sustainability performance in 2018 (Government of Canada, 2018). Its report outlines several opportunities for Canadian sustainable real estate and construction businesses that also apply to the international level. These opportunities include participating in sustainability knowledge dissimilation in the private sector (addressing target 7 of SDG 12), as well as opportunities for collaboration and partnerships through SDGs, potentially leading to expansion in developed and developing nations (addressing several targets related to SDG 17) (Goubran, Cucuzzella, et al., 2019; Goubran & Cucuzzella, 2019).

Figure 3.1. The connections between the sustainable real-estate industry and the SDGs

<u>3.4.2. The relation between real estate and the pillars of sustainability</u>

The adverse effects of human development on the natural environment have been presented in numerous studies. Since the early 1990s, the effects that construction activities have on the environment were organized in the following categories: 1) resource deterioration, 2) physical disruption, 3) chemical pollution, 4) social disruption, 5) environmental loading, 6) visual impacts, and 7) health impacts (Ofori, 1992). Today, this classification has become the focus of sustainable real estate standards which have emerged and gained popularity in recent years (Bernardi et al., 2017; Brandon & Lombardi, 2011). The unique nature, site, and context of each project, as well as the large number of stakeholders involved in and implicated by the construction, and the intense financial and time pressures of construction projects are considered some of the biggest hurdles to the broad application of sustainable construction practices (Teo & Loosemore, 2001). Today, through codes, regulations, and voluntary programs, the industry has almost institutionalized the process of environmental assessment in building projects. However, the sociocultural and economic dimensions of sustainability have yet to receive the same attention.

The Intergovernmental Panel on Climate Change (IPCC) dedicates an entire chapter to buildings in its report on the challenges of climate change (Intergovernmental Panel on Climate Change, 2014). As the report details, sustainable buildings not only promise emission reductions through technology and changes in behaviours, but also provide benefits from a socioeconomic and health perspective, thus showing the important role the real estate sector plays in addressing social challenges. Sustainable urban living, which favors inclusive economic growth and innovation, has the potential to use resources more efficiently, protect the environment, create jobs, and construct better places for people and communities (Goubran, Masson, et al., 2019). Eizenberg and Jabareen (2017) suggest that physical aspects of human spaces are crucial for social sustainability since they contribute to reducing environmental risks and increasing human welfare. The private sector is also responding to the call for sustainable urban living, as some investors are financing real estate projects to support social housing, developments in deprived urban areas, or integrating community development functions within new developments. Additionally, sustainable urban forms can promote a sense of community, safety, and the development of economic activities in cities and local communities (Cucuzzella & Goubran, 2019). Eizenberg and Jabareen (2017) also provide a set of typologies to explain how sustainable urban forms can affect climate change risk management, which includes 1) compactness of cities, 2) integration of public transportation, 4) density, 5) mixed land uses, 6) diversity or inclusive urban landscapes, 7) optimization of energy production and consumption, 8) bringing nature into the city, 9) renewal and 10) utilization of urban spaces. Furthermore, the United Nations Environment Programme (UNEP) discusses the benefits in employee productivity and well-being derived from sustainable buildings because of reduced indoor air and noise pollution (UN Global Compact et al., 2011). Indeed, the U.S. Green Building Council (USGBC) and Booz Allen Hamilton (2015) indicate that, in the United States, the reduction in the cost of energy consumption and other climate advantages (e.g., water savings) may be outweighed by financial benefits produced by labor cost-savings and productivity gains. This has placed a significant focus on topics such as better indoor air quality, natural ventilation, local thermal control, daylighting, and rent premiums.

The Global Construction 2030 report forecasts that between now and 2030, the green building sector will grow by 85% (Global Construction Perspectives & Oxford Economics, 2015). Moreover, the sustainable building sector provides employment opportunities and better working conditions for people in developed and developing countries. As for the labor market, the move towards sustainable buildings is positively impacting job creation in 1) construction, 2) building materials manufacturing, 3) maintenance, 4) building management, and 5) appliances and components manufacturing (Global Construction Perspectives & Oxford Economics, 2015). The USGBC estimates that between 2011 and 2018 in the United States alone, the green construction market supported over 5 million jobs, generated more than $400 billion in GDP, and provided more than $350 billion in labor earnings. In developing countries, sustainable real estate could contribute to formalizing or creating decent jobs, providing better working conditions, and upgrading workers' skills. Decent jobs also have positive effects on the quality of life and poverty alleviation (UN Global Compact et al., 2011).

As noted earlier, the SDGs attribute a significant role to urbanization and cities, recognizing that cities are the platform where the economy, natural resources management, communities, and technology meet and connect (GRI et al., 2015; Shen et al., 2016). Moving forward, a major goal should be to make cities and human settlements more inclusive, safer, resilient, and sustainable. This goal could be achieved through different innovations in the sector, which could include adequate housing, effective and sustainable transport systems, sustainable urbanization, inclusive public spaces, the preservation and development of the natural and cultural heritage, the preparedness for disasters, and the monitoring of the cities' environmental impacts (Kauko, 2019).

3.5. Recent developments in sustainable real estate

The perception of "sustainable" real estate is shifting. Today, more investors, developers, businesses, and buyers realize that green buildings are a product of a well-integrated design process and that sustainable projects do not need to be visibly different from traditional buildings (Acuff et al., 2005). Some of the key reported challenges to wide applicability include the perceived higher initial costs, the lack of political support, and the perceived unaffordability of sustainable technologies (S. A. Jones & Laquidara-Carr, 2016, 2018). By comparing global data available from 2012 and 2017, several leading trends emerge: 1) the perception of higher initial costs has significantly decreased, 2) the importance of environmental regulations as a reason for adopting sustainability principles in buildings has increased considerably, and 3) the selection of the certification program has become more dependent on governmental and local incentives.

The first trend is considered positive since it points to a more mature and stable sustainable real estate market that different authors and institutions have foreseen (Deloitte, 2014; S. A. Jones & Laquidara-Carr, 2016, 2018; World Economic Forum, 2016a). The maturity of the market indicates its readiness for adopting more complex assessment tools that move beyond environmental issues, such as methods that take into account the economic and social factors as well as occupant productivity, health, and well-being (Markovich et al., 2018). As presented in the United Nations Environment Programme report (2017) and as proposed by Qian et al. (2015), the increased application of incentive programs by governments and the persistent higher values and returns for investors in green buildings have helped create a stable demand and low transaction costs.

Although the wide adoption of green real estate has been increasing steadily, the last two trends might be pointing to growing risks in the sustainable real estate markets. These risks can be divided into political and external dependency risks. A political risk exists when businesses become more vulnerable to changes in regulations because they rely on those regulations to adopt sustainable buildings. In terms of external dependency risks, the choice of certifications based on the available incentives might expose businesses to risks related to the stability and continuity of these programs. This is significant since many sustainability programs and certifications are short-lived (Lynch & Mosbah, 2017).

Tenants, investors, industry and governments all have different, important roles to play in sustainable real estate. Investors must commit to green and sustainable building practices, to integrate sustainability in all their decision levels, and to strive for sustainable investments (Goubran, Masson, et al., 2019). Tenants must keep away from "brown" properties (*i.e.*, buildings that are not green and have significantly lower market values) to maintain and increase the demand for sustainable urban planning, community development, and green building construction and operation (Bernstein et al., 2013; Deloitte, 2014; DLA Piper, 2014; S. A. Jones & Laquidara-Carr, 2018). Governments must ensure that the correct instruments (such as taxes) are in place to encourage investors and owners to increase their sustainable and environmental practices (Deloitte, 2014). The real estate sector's supporting industries, such as material and building components, or the design industry, also must ensure that continuous research and development lead the transition to sustainable real estate (Hein, 2014; Ramage et al., 2017)

Again using Canada as an example, several consulting and investment firms have explored recent trends in the real estate sector, which they summarize as follows: 1) Adjustments by real estate investment trusts (REITs) to generate returns and investment shifts to development and redevelopment opportunities rather than acquisitions, 2) changes in regulations and policies to limit foreign purchases in the residential sector while allowing local authorities to have a stronger voice in development decisions, 3) a rise in urban infill projects[28] , 4) a shift to a placemaking perspective[29] with more diverse mixed-use components, 5) a rise in the senior housing market, and 6) new incentives and programs for sustainable and local materials (Cucuzzella & Goubran, 2019; Hardy, 2016). What these trends signify for the sustainable real estate sector is a divergence in strategies, which include: 1) moving away from new construction to renovating or retrofitting buildings, 2) moving towards smaller infill constructions or mixed-use projects that respond to the social and cultural needs of communities with a stronger collaboration with local governments, and 3) considering well-being in emerging opportunities, such as catering to the needs of an aging population (International WELL Building Institute (IWBI), 2014, 2017). Additionally, incentives and programs for new sustainable materials, presented by both local governments and through pilot credits in certifications (The U.S. Green Building Council, 2020), have helped trigger the interest of local investors in wood and high-rise wood structures as well as other materials with low carbon footprints (Fallahi, 2017; Gouvernement du Québec, 2008b, 2008a; Teshnizi et al., 2018). The UNEP points to several Canadian initiatives that might directly affect the sustainable real estate market with stricter energy regulations and a new energy code by 2022, and the launch of the Zero Carbon Building Standard in 2017 by the Canada Green Building Council (CaGBC) . These trends offer guidance to investors on the opportunities and challenges ahead. The next two sections of this chapter focus on exploring how policy and technical developments are driving the sector towards sustainability and move it beyond the typical focus on cost savings.

3.6. Policy development and real estate: The case of carbon taxes in Canada

Canada has been implementing a carbon taxation scheme across all provinces, in the form of either a carbon tax or a cap-and-trade system (or other emission trading schemes). The introduction and application of either system serve as a clear greening signal for the Canadian real estate sector. Based on a number of recently published papers as well as government publications (Beck et al.,

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28 Infill projects aim to use land that was left vacant during previous developments or develop on land that is not on the urban margin (i.e. existing already-approved subdivision)

29 Placemaking approaches in development aim to focus on the cultural dimension and at creating dynamic experiences for the users – for more information, consult (Cucuzzella & Goubran, 2019)

2015, 2016; Dissou & Siddiqui, 2014; Gray & Metcalf, 2017; Lawley & Thivierge, 2018; Murray & Rivers, 2015; Zainol, 2017), there are divergent views and data supporting each system.

In a carbon tax system, the taxes are usually introduced directly to the entire market which could be a disadvantage for commercial real estate businesses because they might not have embraced green or sustainable principles and thus would incur a significant new tax burden with their "brown" building investment portfolio (Beck et al., 2016). For the residential sector, some risks have been reported in rental properties with leases, including the utility costs. The introduction of the tax would require the commercial real estate sector to quickly adapt and update properties (e.g., retrofitting or selling properties with high energy consumption) as well as to explore new green lease agreement for their business (Deloitte, 2014; DLA Piper, 2014; World Economic Forum, 2016a). Additionally, in the residential sector, depending on the types of credits a resident qualifies for, the tax burden might also be crippling. What is clear from British Columbia's experience, for example, is that the introduction of the carbon tax was accompanied by intense lobbying and political campaigns and resulted in the creation of a number of tax cut systems, such as revenue recycling schemes, for different sectors in the economy. Beck, Rivers and Yonezawa (2016) present one such case where the homeowner benefit program overcompensated Northern rural households creating significantly higher welfare for the respective parties than for people living in urban households. For the real estate sector, these events may signal significant changes in investment and development strategies, requiring investors and developers to explore new property types, including rural developments (which might be counterproductive from a broad sustainability perspective). By looking at global carbon tax revenues, Carl and Fedor (2016) indicate that the revenue spending decisions under the carbon tax system are inherently more political since the system is usually expected to generate higher tax revenues than the cap and trade system. Although the evidence indicates that the commodity price increase at a low tax rate would not necessarily create more inequality, the introduction of a carbon tax has a more apparent and measurable effect on the prices of properties (Dissou & Siddiqui, 2014).

Cap and trade systems and emission trading schemes are, in many cases, introduced incrementally. In Quebec, for example, only the industry and electricity sectors were targeted in the first years of compliance (Liang & Renneboog, 2017). The primary disadvantage relates to the instability and uncertainty of the price in the system. However, by allowing the market to decide the price of emissions (based on supply and demand), the price automatically adjusts with little or no political interference. This change requires investors in real estate to re-strategize their green investments in property and shift their metrics from cost savings to emission reductions, requiring more research in the real estate management and finance fields. When first applied, the cap & trade system also allocates allowances for polluters, which in effect give them the time needed for sustaining their business activities while adapting and upgrading to meet the GHGe reduction requirements. This shift may result in a more gradual adoption of green principles in the sector that could potentially generate higher tenant and homeowner acceptance, and easier adaptation than the carbon tax system (Murray & Rivers, 2015). Additionally, the cap and trade system also allows governments to create mechanisms to minimize or eliminate carbon leakage.

Each system adopts a different approach to the problem of emissions: where cap and trade creates uncertainty about the price of emission and certainty in emission reductions, carbon tax creates certainty about the price and uncertainty about the emission reductions. On one hand, since the governments cannot predict the specific revenues from a cap and trade system, they tend to be re-invested in green and sustainable development projects or initiatives. On the other hand, because the carbon tax system generates pre-determined revenues, the data indicates that a higher proportion of the revenue, if not all, is redistributed in the form of credits and benefits (Carl & Fedor, 2016). For the construction industry, the surveyed re-investment and redistribution strategies for cap-and-trade revenues might create new business opportunities. A summarized comparison between the two systems is presented in Table 3.1.

Table 3.1. Main advantages and disadvantages in the carbon tax and cap & trade schemes for the real estate sector

	Carbon Tax	Cap and trade
Advantages	Certainty about the price of the emissions over a medium/long term (enabling better planning).	The gradual implementation gives real-estate businesses and homeowners the time to adapt.
	Clear savings and a higher reduction in operating costs for green properties.	Control for carbon leakage could create competitive disadvantages for businesses.
	A higher demand for properties that provide emission reduction options for tenants (such as properties that are closer to public transit hubs).	A reduction in the political/governmental involvement in the operation of the system creates a system of fair competition for sectors and businesses.
Disadvantages	A sudden application of the tax may result in urgent and potentially hasty investments in green properties.	The uncertainty in emission prices could create clear risks in the commercial real-estate sector without green leases.
	The need for political "lobbying" to ensure the availability of tax credits for the sector.	The need for adapting and developing current sustainability metrics for the real estate sector.
	The need to create sudden investment shift strategies towards new construction and new markets that are less affected by carbon taxes (or benefit the most from credits or cuts).	A slower transition to sustainability could minimize the advantages for current and early adaptors of green real estate investments and homeowners that might have incorporated green features at higher prices.
		A need to develop new strategies and tools to ensure that price uncertainties are shared with tenants.

Although these two systems are among the most prominently discussed in the literature and in politics, Borck and Brueckner (2018) point to another taxation system for cities that might offer more advantages for the real-estate sector. They propose a combination of land, housing, and sales taxes that would parallel the adjustment in resource allocation while generating more compact cities and increasing building heights. These spatial characteristics, which are already being leveraged in dense urban settings, might be beneficial for the commercial real estate sector because it would allow commercial real estate businesses to develop the current knowledge and strategies without excessive and sudden investments in emission reductions; the compactness factor of the urban cities will naturally create the reduction in emissions. For the residential sector, this could allow investors to explore new types of mixed occupancy structures that create new business opportunities.

3.7. The case of advanced and high-rise timber buildings

Advancing sustainable real estate entails considering the effects of buildings throughout their lifecycle—from planning to demolition—as well as their relation to society and the economy. Public policy instruments, taxes, and standards have had their successes in helping to reduce the operational energy and emissions of buildings. As they become more energy efficient—with zero operational energy targets for building projects becoming increasingly common—the embodied energy of buildings is set to become a substantial, if not the major, source of emissions in the building sector (M. Lawrence, 2015; United Nations Environment Programme, 2017; Waugh et al., 2010). Timber construction offers new opportunities for the real estate sector to tackle GHGE challenges by reducing building emissions and sequestrating carbon in their materials (Fleming et al., 2014). Within the context of cities and high-density urban areas, timber has been re-explored in recent years (Fleming et al., 2014). For example, high-rise timber buildings are increasingly sprouting in places like the United Kingdom, Canada, Norway, and Austria[30]. Timber, especially in its new engineered form, is considered a rediscovered building material that could help the real estate sector tackle sustainability challenges beyond carbon emissions (Skullestad et al., 2016).

Today, sustainability within the construction industry generally involves managing resources and contemplating the social and economic context (Tam et al., 2018). The industry is moving beyond the optimization of the buildings' operational energy to consider sustainability at a more holistic level (Foo et al., 2012; Lynch & Mosbah, 2017; Skullestad et al., 2016). Many of the newly proposed approaches are rooted in the Life Cycle analysis (LCA) methods that consider the effect of buildings and its related processes throughout its life. When the life cycle cost of wood is

30 Examples include the 24-story Hoho tower in Austria (2017), the 18-story Brock Commons Tallwood House in Canada (2017), the 14-story Treet in Norway (2015), the 8-story Wood Innovation and Design Centre in Canada (2014), and the 9-story Murray Grove residential building in the United Kingdom (2009).

compared to other materials used in construction, such as concrete, many advantages appear across all the life cycle phases (Pajchrowski et al., 2014; Robertson et al., 2012). One of the main advantages that is widely cited is the ability of wood to store carbon throughout its life cycle (Skullestad et al., 2016). In a study employing LCA methods for different structural system alternatives, the climate change impact of timber structures was found to be 34% to 84% lower than that of reinforced concrete structures with a significantly higher increase in greenhouse gas savings in structures above 12 stories (*i.e.*, very tall timber buildings) (Skullestad et al., 2016). In another study that applied the concept of "urban equilibrium" in New Zealand, the authors discovered that up to 65% of carbon emissions could be saved in the manufacturing of building materials if low carbon footprint materials, such as timber, were used (Stocchero et al., 2016). Additionally, synergetic carbon savings, due to sequestration, storage maximizing, substitution, and avoidance, can be achieved across the life cycle of buildings and their constituent elements from the use of timber in all constructions (Skullestad et al., 2016); it was estimated that the use of timber across all constructions, including high rise timber structures, would help to reach emission-reduction targets 20% faster than initially forecasted (Skullestad et al., 2016). Moreover, at the end of their life, wood structures offer options that ensure the continuation of the carbon sequestration gains, by means of reusing certain wood elements or via recycling (Ramage et al., 2017). Thus, timber construction could potentially allow the real estate sector to significantly reduce the carbon footprint of buildings and become key in helping reach currently envisioned emission reduction targets on a local and global scale.

The broad adoption of timber in construction in high rise buildings will certainly result in higher demands for wood products and in timber extraction from forests. The Food and Agriculture Organization of the United Nations (FAO) indicates in their most recent State of the World's Forests report that forests and trees can significantly contribute to the SDGs (including SDG 3, 4, 9, 10, 14, 16 and 17[31]) (FAO, 2018). The FAO specifically highlights the critical role wood construction can play in building resilient infrastructure, promoting inclusive and sustainable

31 SDG 3: Good health and well-being; SDG 4: Quality education; SDG 9 Industry, innovation, and infrastructure; SDG 10: Reduced inequalities; SDG 14: Climate action; SDG 16: Peace, justice, and strong institutions; and SDG 17: Partnerships for the goals.

industrialization, and fostering innovation—specifically related to SDG 9. The FAO also highlights the importance of timber construction in the transition towards the bio-economy (FAO, 2018 - p. 5). Through correct forest management, significant amounts of timber can be extracted sustainably from forests. In fact, in developed countries where more than 30% of the world's timber products are extracted, governments have managed to sustain and increase their forest cover and quality since the 1990s (Fleming et al., 2014; Ramage et al., 2017). Additionally, the uptake of timber construction has been accompanied by a broad recognition from governments, institutions and industries of the value of healthy forests and their stewardship (Julin, 2010). The increased interest in timber buildings has led to developments in standards and programs that ensure sustainable forestry management and sustainable sourcing of wood products. Certification standards, such as the Forest Stewardship Council (FSC), have become widely adopted. Additionally, the use of certified wood became a requirement for green building credits (seen, e.g., in the Leadership in Energy and Environmental Design's (LEED) pilot credits for wood construction or the FSC Project Certification, which tracks all wood sourcing in projects).

Engineers and architects are collaborating to explore the possibilities of building taller timber buildings (Hein, 2014; mgb Architecture + Design et al., 2012). New methods for mitigating some of the concerns of wood construction are being developed, which include innovation in the construction process, in the structural connections, and even in the space configuration (K. Jones et al., 2016; Ramage et al., 2017; Weckendorf & Smith, 2012). Researchers are also focusing on increasing the safety of high-rise timber construction, the buildings' ability to respond to natural disasters, such as earthquakes, floods and water damages or to fires, their comfort, and their durability (Caniato et al., 2017; J. Li et al., 2019; Lukacs et al., 2019; Pei et al., 2016; Schmidt et al., 2019). Currently, one of the biggest hurdles to the wide adoption of timber in high-rise buildings is the lack of expertise in both their design and construction (mgb Architecture + Design et al., 2012). Today, design teams are exploring the role of structural timber in contemporary architecture beyond their environmental benefits (Fleming et al., 2014). Recent advancements in timber products, specifically in the area of engineered wood products (EWP), have opened the door for designers to investigate the limits of these structural systems and their possible innovative application, including tall and very tall timber building applications and hybrid structural systems (Hein, 2014; Teshnizi et al., 2018; Weckendorf & Smith, 2012).

These explorations require moving away from the current methods and processes to pave the way for the creation of new urban forms that could reconcile the urban, social, and natural environments. These trends highlight the ability of technical progress, such as developments in building materials, to push the boundaries of current standards, resulting in regulatory changes. In this context, the building industry and real estate sector are leading these transformations through experimentation, practice, and research (Goubran, Masson, et al., 2020). This progress is exemplified in the Province of British Columbia in Canada where the provincial government introduced a Woods First Initiative to support innovation in the forestry sector whose aim is "to facilitate a culture of wood by requiring the use of wood as the primary building material in all new provincially funded buildings" (*Wood First Act*, 2016). British Columbia's case is an example of how technology policies targeting building materials can move from merely correcting a market failure, as in the case of carbon taxation, to what can be called a "market creation" (Mazzucato, 2016).

The return to timber construction in urban centers promises the revival of locally appropriate urban forms that are culturally and historically relevant (Koo, 2013). This revival is again evident in the case of British Columbia where the cultural significance of timber dates to the confederation (Buggey, 1976). Furthermore, the EWP industry, which has seen significant growth since the adoption of advanced timber construction systems, is promising to revitalize the forestry sector and to create new jobs. In terms of Canada as a whole, the advanced wood manufacturing sector employs an estimated 88,000 workers with 7,900 more expected by 2020 (BC Wood, 2017). In addition, British Columbia employs an estimated 13,000 workers in the value-added wood manufacturing industry with industry sales of approximately $2.8 billion (BC Wood, 2017; Natural Resources Canada, 2017). The industry also aids rural communities in finding employment as it provides for 153 lumber mills located in 85 different communities with populations of less than 10,000 people (Natural Resources Canada, 2017). Furthermore, Vancouver Island in British Columbia has a value-added wood manufacturing industry that is responsible for an estimated 2,893 jobs, approximating a quarter of the forestry industry in the region, which corresponds to a GDP of about $212.7 million and government revenues of $50.1 million annually (MNP, 2017). Another example is the Province of Quebec where the pulp and paper industry has been facing many difficulties in recent times. These hardships have translated into the loss of jobs for many in the forestry sector. However, with the growth of value-added timber products in Quebec, including

EWP, new job opportunities could potentially arise for laid-off workers and other subsectors of the forestry industry (Gouvernement du Québec, 2008a). Timber construction, as a result, is helping support local networks and develop new sectors in the economy.

The case of timber buildings exemplifies a technical development that is helping the real estate sector to transition beyond the prevailing eco-efficiency paradigm. As seen in the literature and the cases in Canada, innovation in timber construction allows buildings to tackle sustainability challenges across environmental, economic, and socio-cultural dimensions. Additionally, high rise timber buildings promise significant technical, policy, and regulatory developments, which could significantly redefine cities and urban centers in the coming decade (Goubran, Masson, et al., 2020). Table 3.2 presents a summary of how modern timber construction is helping the real estate sector move beyond its aforementioned focus on cost savings.

Table 3.2. The benefits of timber buildings beyond eco-efficiency and cost savings

Environmental	• Moving beyond operational energy optimization to focus on the embodied energy component. • Increasing the focus on wood certification and equitable sourcing of timber products.
Sociocultural	• Helping maintain and support local networks whose livelihoods depend on forests through increased interest in sustainable forestry management. • Helping the revival of culturally and historically appropriate modes of construction and buildings styles.
Economic	• Helping create new jobs related to engineered wood products, which can replace jobs lost in other forestry sectors. • Presenting new business opportunities driven by growing demand for value-added wood products.
Technical	• Questioning some of the predominant and unsustainable methods and processes of construction and paving the way for new innovations. • Offering new possibilities for research collaborations between architects, engineers, and practitioners to deliver sustainable, safe, and healthy new buildings.
Policy and regulations	• Paving the way for new policies that are sustainability-focused. • Providing possibilities for changes in codes and regulations that could root the real estate sector in the bio-economy.

Notes: based on Goubran et al. (2020)

3.8. Conclusion

Considering the significant contribution of buildings and urban areas to the global environmental and sustainability crisis, the greening of the real estate sector has become an imperative for sustainably meeting the building demands projected for the near future. In recent years, the uptake of green building activities and the integration of sustainability principles in the real estate sector have been steadily growing (S. A. Jones & Laquidara-Carr, 2018; World Economic Forum, 2016a). While cost savings were the core motivation for real estate investors to adopt green building certification and standards, the market is now witnessing noteworthy transitions beyond this first stimulation (Sandström et al., 2017). There is a growing interest in the potential for sustainable buildings to tackle broader economic and social sustainability challenges as well as issues related to health and well-being (Eichholtz et al., 2010). The current sustainable development agendas, as represented by the United Nations' SDGs, place a heavy focus on cities and the built environment (United Nations, 2015). The overview of the 2030 Agenda reveals that real estate can directly and indirectly contribute to many of sustainable development goals and targets (United Nations, 2015). Although the agenda is considered by many as global in scope, achieving the goals requires action on the local level (Christensen & Gabe, 2019). This chapter aims to contextualize the real estate sector as a key player within the broader sustainable urban development agendas.

Although the negative environmental effects of buildings have received their fair share of attention, the same cannot be said for the social, cultural, and economic dimensions for moving towards a more sustainable real estate sector. The recent urban and demographic changes in cities, along with changing political, social, cultural, economic, and technical realities, are forcing the real estate sector to respond to the call for sustainable urban living and to move beyond cost savings (Eizenberg & Jabareen, 2017). By investigating the case of carbon taxation in Canada, it becomes clear how both the carbon tax and the cap & trade schemes offer opportunities and disadvantages for the real estate sector (Beck et al., 2016; Gray & Metcalf, 2017; Lawley & Thivierge, 2018; Zainol, 2017). What is definite in both schemes is the need for the real estate sector to shift its focus to analyze emissions and environmental effects rather than cost savings (Liang & Renneboog, 2017). Additionally, the literature points to the growing significance of socio-political dimensions in the real estate sector (Dissou & Siddiqui, 2014).

During the past decade, the industry has placed an emphasis on energy savings in buildings. Today, zero energy targets in building projects are becoming ever more common (Athienitis, 2015). This change has led the main sources of emissions in buildings to shift away from operational energy to other secondary causes. The embodied energy of buildings is set to become a substantial source of building emissions (Waugh et al., 2010). Additionally, the increasing adoption of LCA methods in the sustainability analysis of building projects are helping to further focus the attention on building materials (Skullestad et al., 2016). These changes have created new opportunities for low carbon materials, such as wood, to receive scrutiny (Skullestad et al., 2016). The rediscovery of timber, especially in its engineered form, is leading to various technical and regulatory changes that have the potential to deeply transform the real estate industry (mgb Architecture + Design et al., 2012; Ramage et al., 2017). The transition from traditional materials, such as steel and concrete, to timber also requires further analysis on the social, cultural, environmental, and economic benefits and effects of building projects (Goubran, Masson, et al., 2020; Natural Resources Canada, 2017).

This chapter attempts to reveal the broad adoption of sustainable development as a significant influence in the real estate sector. The developments and recent trends examined in the chapter are pointing to the need for the real estate sector to move beyond the common cost-savings approaches to sustainability by adopting new innovative methodologies. If properly implemented, this process could position the sector as a key player and leader in achieving the sustainable development goals. Based on the trends presented in this chapter, we propose some key future research directions.

3.8.1. Future research directions

3.8.1.1. Establishing standards for measuring real estate related co2 outputs

Researchers, practitioners, and policymakers must start exploring methods for meaningfully measuring the emissions of the real estate sector, including non-conventional carbon accounting methods such as per capita weighed CO2 emissions. Although the sector's complexity poses significant challenges, a well-designed standard could have the potential to globally overhaul the industry. Researchers must specifically focus on the applicability of emission accounting processes at the various geographic scales (*i.e.*, from local to global) and on ways to encourage investment in carbon reductions for existing "brown" properties.

3.8.1.2. Further research into policies and taxation schemes which can accelerate the transition towards sustainability

Based on the current evidence, emission trading schemes (such as the cap & trade system) provide significant benefits to the real estate industry (Murray & Rivers, 2015). Researchers and policymakers must explore how revenues from such schemes could be strategically reinvested into the real estate sector to 1) encourage (e.g., via sales and property tax cuts) investors, developers, and tenants to transition away from brown properties, 2) provide significant incentives to ensure the adoption of sustainability and green principles in new developments, and 3) ensure the viability of retrofitting projects for existing properties. The establishment of such policies would require the collaborative efforts of governments, research institutions, and the non-governmental sector, and extensive research efforts to model, plan, coordinate, and optimize these strategies.

3.8.1.3. Research into various means to reduce the cost of green buildings

Although the price of established sustainable and green technologies (for example, solar panels) has been steadily decreasing in the last decade, new green construction processes, technologies, and materials are still expensive, in some cases resulting in added costs of more than 15% to achieve high-performance standards (Kawar, 2019). New research must focus on exploring and optimizing construction and business strategies, which can significantly reduce the footprints of buildings while minimizing their costs. These strategies include exploring 1) means to accelerate expertise in sustainable and green construction, 2) effective scaling of emerging green technologies and materials (including mass manufacturing, optimized supply chains, as well as considering local and circular economy concepts), and 3) strategies to move the sector beyond the "pay more to do good" model, where green products and services are being priced based on expected premium returns or savings, the customers' willingness to pay more for green products, or on the current price of brown products.

3.9. Chapter Postscript

Real estate, including the design, construction, and management of built structures and land, is one of the sectors that have a decisive role in our fast-growing cities' future. Considering the already large and expanding footprint of buildings[32], aligning the sector with the sustainable development goals is crucial to the transition towards a more sustainable and inclusive urban future.

The commitment to environmental protection in the industry is growing – with green building activities estimated to represent as much as 38% of building activities globally in 2013 (Bernstein et al., 2013). Recent studies indicate that the current demand-driven actuality of sustainable real estate dictates important roles for all stakeholders – including tenants, governments and investors (Apanavičienė et al., 2015; World Economic Forum, 2016a). In response to changes in

32 Not only the environmental footprint of buildings but also impacts that are social (in the form of accessibility and affordability to safe, resilient and inclusive living and working spaces), cultural (in the form of the cultural, patrimonial and esthetic value of buildings and built spaces), economic (as a form of economic activity and real assets), political (as a form of structures that organizing social and economic activities)

demographics, climate and technology, the real estate industry is today increasingly expected to incorporate new, and more stringent, sustainability requirements (Apanavičienė et al., 2015; M. Lawrence, 2015). Similarly, sustainable building and real estate have an important role in economic and social developments – from job creations to creating safe and resilient settlements (Eizenberg & Jabareen, 2017; United Nations Environment Programme (UNEP), 2011). These findings are in line with the necessity to ground sustainability in what *needs to be developed* (individuals, the economy or society), with that which *needs to be sustained* (nature, life support systems or community) (Robert et al., 2005)

The concrete societal and environmental changes that mark our time are also pushing the real estate sector into new territories and are opening new opportunities that directly intersect key sustainability challenges that our cities face. These opportunities include shifting the focus towards redevelopment and retrofitting, infill and mixed-use projects, as well as catering to the needs of a more senior population (International WELL Building Institute (IWBI), 2014, 2017). By investigating technological and policy developments, this chapter emphasized that the sustainable real estate sector is moving beyond the environmental focus, the cost savings and the efficiency-driven approaches that have defined it during the past decades.

The different carbon taxation schemes are putting pressure on developers to explore new property types, incorporate new technologies for further GHGe reductions, and even develop new tools (such as leases and agreements) to share the risks with tenants, owners, and investors. The effort to reduce taxes and expenditures on carbon emissions could also encourage more compact, multi-use and efficient building forms to emerge. Also, the demographic changes taking place in many western societies could enable new types of partnerships to emerge between the government, not-for-profit and public sectors (Carl & Fedor, 2016; Murray & Rivers, 2015).

The uptake of new material and more sustainable technologies in the real estate sector is also signalling a shift from focusing on operational energy to the embodied energy portion in projects (M. Lawrence, 2015; United Nations Environment Programme, 2017; Waugh et al., 2010). Timber, especially in its new engineered form, is considered a rediscovered building material that could help the real estate sector tackle sustainability challenges beyond primary carbon emissions (Skullestad et al., 2016). The shift from the traditional concrete and steel structures to timber, a renewable and low carbon source of construction material, could drastically reduce the carbon footprint of high-rise structures, while also synergistically contributing to several sustainable development goals (FAO, 2018; Ramage et al., 2017). Additionally, the return to timber construction in urban centers could promise the revival of locally appropriate urban forms that are culturally and historically relevant (Koo, 2013). New timber materials promise significant technical, policy, and regulatory developments, which redefine cities and urban centers in the coming decade (Goubran, Masson, et al., 2020).

Sustainable real estate can function as a catalyst for climate change risk management, economic development, and improvements in the quality of life. Beyond these direct impacts, the sector and its stakeholders in developed countries, should also contribute in the transfer of knowledge and expertise to developing countries – a key focus of the 2030 Agenda (Goubran, Cucuzzella, et al., 2019; Goubran, Masson, et al., 2019; Goubran & Cucuzzella, 2019). However, there is still today a disproportionate focus on eco-efficiency and incremental performance improvements (Fletcher & Goggin, 2001; Jonas, 1979; Madge, 1997; Naess, 1973). Green building certification schemes have widely popularized this approach, where most of the focus is on the technical and design characteristics of projects skews the focus towards the operational energy of buildings (Cucuzzella, 2015c, 2015a; Ding, 2008).

The findings of Chapter 3 revealed a two-way relationship between the real estate sector and policy, markets and technologies. Additionally, the real estate sector was shown to have an important role in meeting local sustainable development needs and challenges. Chapter 3 only briefly mentions the role design, designers and design tool play in this transition. As presented inChapter 2, Chapter 3 and Goubran et al. (2019), the uptake of sustainability in the construction and design industry generally responds and adapts to the real estate sector's demands. A simplified illustration of this relationship is presented in Figure 3.2, showing that buildings are both an outcome of the design process, and a real asset that is directly influenced by multiple external factors.

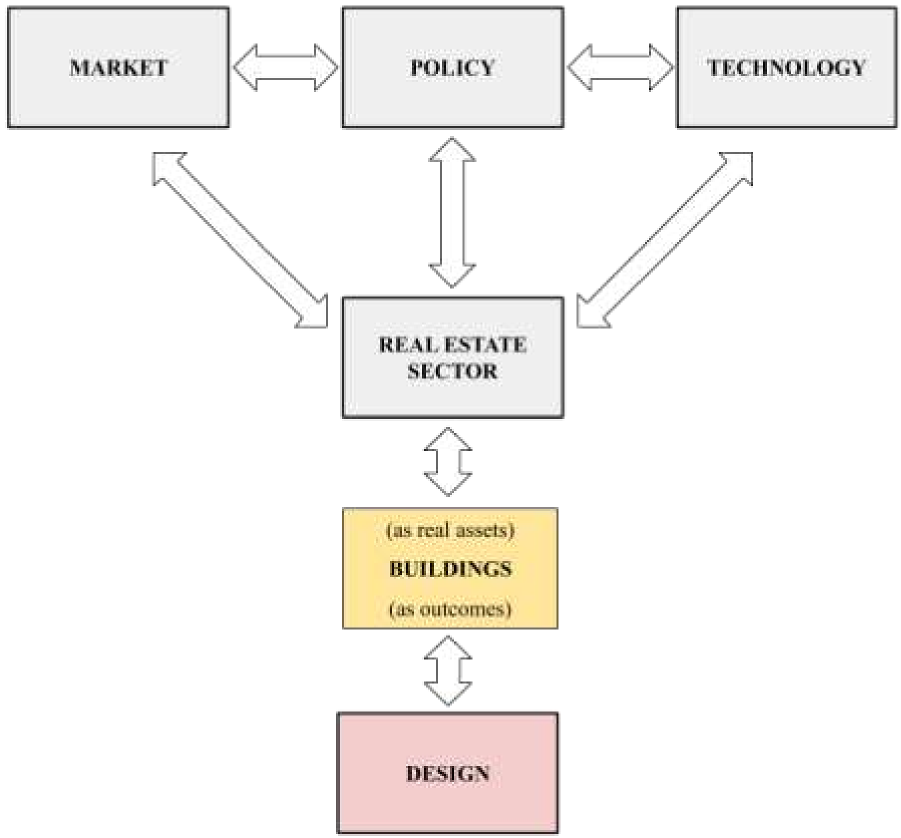


Figure 3.2. The relationship between design, buildings and the real estate sector

Chapter 4 and Chapter 5 look at buildings as the outcome of the design process, focusing on the design, construction, and operation phases of buildings. From a theoretical perspective, and by enabling human intentions to reshape the world, design enables the creation of objects which reflect the conditions in which the world "ought to be" (Nelson & Stolterman, 2012; Simon, 1996). On the other hand, the project can be understood as a tool for realizing a type of operational anticipation that is only partially determined (Boutinet, 2005). The 2030 Agenda, like building design projects, is also an outlook for the desired future that is only partially determined, with some of its elements only unfolding with time (Gusmão Caiado et al., 2018). Thus, relying on checklist based and standardized approaches predetermines the sustainability approach and its sustainability features of a building; a process that is misaligned with the nature of design, projects as well as the SDGs and their objectives.

Chapter 4 examines how the current sustainability building standards and certification system address the topics of the 2030 Agenda. Chapter 4 studies coverage and the sustainability approach of prominent building standards to the SDGs, in order to understand their potential for encouraging transformative sustainable development. This analysis aims at understanding if the currently available standards are assisting building professionals in addressing the sustainability challenges highlighted in the Agenda and instilling sustainable development as a paradigm in the industry. This analysis is crucial for identifying whether the mainstream tools could, in fact, serve in attaining sustainable development (as proposed by Alawneh et al., 2018; Alawneh, Ghazali, Ali, & Asif, 2019; Alawneh, Ghazali, Ali, & Sadullah, 2019; Czerwinska, 2017; Roostaie et al., 2019).

CHAPTER 4
GREEN BUILDING STANDARDS: REAL OR ILLUSIONARY CONTRIBUTIONS TO THE SUSTAINABLE DEVELOPMENT GOALS?

4.1. Foreword

Recent academic and industry publications (such as Alawneh et al., 2018; Alawneh, Ghazali, Ali, & Asif, 2019; Alawneh, Ghazali, Ali, & Sadullah, 2019; Czerwinska, 2017; Roostaie et al., 2019; Wen et al., 2020) have proposed that existing sustainable building assessment standards and certifications (what are called in this chapter green and sustainable building and real estate standards – or GSBRES) address and contribute to a large number of the SDGs. However, research that explores the overlaps and connections between the SDGs and GSBRES presents several fundamental methodological flaws. These include: 1) approaching the analysis with an a priori assumption that connections and overlaps must exist, 2) depending heavily on the subjective assessment of local experts, 3) not resorting or validating findings with empirical evidence or project precedents, and 4) focusing on the 17 SDGs and disregarding the specific targets of the Agenda.

Additionally, most of the industry-focused research, especially in the technical field, is fixated on calculating hypothetical contribution indexes (*i.e.* the contribution of GSBRES to achieving the SDGs)– where contributions are defined by overlaps between the standard broad topics and the general topics of the 2030 Agenda. None of the available studies consider the interlinkages, be them synergies or trade-offs, between the Agenda's goals and targets. In turn, this leads researchers to conclude that partial contribution to a select few of the SDGs can help achieve the Agenda in its entirety, a premise that was falsified by recent studies (Kroll et al., 2019; Scharlemann et al., 2020).

In the face of these gaps, and stemming from the critique of the available tools and standards presented in Chapter 2, this chapter aims to establish that the dependence on the existing standards cannot lead to the transformative changes required to meet the 2030 sustainable development objectives (Ade & Rehm, 2019; Baue, 2019; Burch et al., 2014). The chapter explores if the current GSBRES address the UN 2030 agenda: 1) uniformly (*i.e.* giving equal focus to the Agenda's 5Ps);

systematically (*i.e.* utilizing into the full potential buildings and construction for achieving the SDGs); and 3) adequately (*i.e.* whether the approach and intent of prominent GSBRES are aligned with the transformational strategy required for attaining the SDGs and impactful sustainable development (Baue, 2019; Cucuzzella, 2016; Dyllick & Muff, 2016; Utting, 2018; Vefago & Avellaneda, 2010)).

The chapter focuses specifically on the design, operation and maintenance, and building projects' investment phases. We specifically consider the widely used standards in the Canadian market: using LEED V4.1 BD+C for New Construction (The U.S. Green Building Council, 2020) for the design phase, BOMA BEST V3 for the Universal Category (The Building Owners and Managers Association, 2018) for operation, and GRESB 2020 Real-Estate for Performance (GRESB, 2020) for investment.

The chapter moves away from industry experts' qualitative assessment for defining overlaps and coverage unlike currently available publications. Instead, it utilizes the available and published keyword catalogues (Elsevier & SciDev.Net, 2015; Körfgen et al., 2018; Mori Junior et al., 2019; The UN Sustainable Development Solutions Network, 2017a, 2017b) and the SDG Data Structure Definition (United Nations, 2019a) and the official Agenda's document (United Nations, 2015) to find overlaps and similarities in topics. For this purpose, the chapter presents a comprehensive keyword catalogue for the 2030 Agenda and validates it in the context of sustainable design and construction. The chapter only uses qualitative analysis to analyze the sustainability approach of the standards – backed by a strong theoretical and methodological base (Baue, 2019; Ceschin & Gaziulusoy, 2016; Coyne, 2005; Cucuzzella, 2016; Dewey, 1929; Dyllick & Muff, 2016; Dyllick & Rost, 2017; Fletcher & Goggin, 2001; "Late Lessons from Early Warnings: The Precautionary Principle 1896–2000," 2001; Rittel & Webber, 1973; Utting, 2018).

Rather than celebrating expected coverage and overlaps, the chapter focuses on identifying gaps in the coverage and approach of the current GSBRES concerning the SDGs.

The chapter aims to address three key questions:

1. How do prominent sustainability assessment tools and standards across the building life cycle relate to the 2030 Agenda?

2. How do their scoring methodologies affect their focus on the 17 SDGs and their targets? What are the gaps that need to be addressed?
3. How do the objectives of these standards compare to the transformational vision of the 2030 Agenda?

This chapter presents important insights regarding the potential and limitations that current GSBRES offer for the transition of the building sector towards sustainable development within the thesis. The chapter aims to further justify the need for new frameworks and design tools that can enable building designers to critically integrate the SDGs in building projects.

This chapter is based on current ongoing research with Dr. Thomas Walker. The chapter-specific status is detailed in Appendix (C). The keywords for this chapter are listed in Appendix (B). At the time of the writing of the thesis, the chapter was under review for publication.

This chapter builds on previous work published by the thesis author. Including:

Goubran, S. (2019). On the Role of Construction in Achieving the SDGs. *Journal of Sustainability Research*, *1*(2). https://doi.org/10.20900/jsr20190020

4.2. Abstract

The building industry relies on and is influenced by green and sustainable building and real estate standards (GSBRES). Such reliance and influence calls for a detailed analysis of the GSBRES' relevance to the Sustainable Development Goals (SDGs). To this end, we propose a catalog of more than 1,500 keywords for the 2030 Agenda, as a tool to analyze the content of three GSBRES, respectively representing the design, operation, and investment phases of projects. We complement this formal content assessment with a qualitative analysis of the standards' transformational potential. Our analysis reveals a misalignment and a fundamental incompatibility between the three GSBRES and the SDGs, which should be working in concert towards the same objectives. Although new transformation-focused standards are recommended to address this gap, we conclude that the GSBRES' contribution to the SDGs requires further evidence-based inquiries, to avoid sustainable development greenwashing.

4.3. Introduction

Buildings are some of the largest consumers of energy, raw materials, and water, as well as significant contributors to global greenhouse gas (GHG) emissions, landfill waste, and water effluents (Brandon & Lombardi, 2011; Rashid & Yusoff, 2015; World Economic Forum, 2016a). With rapid population growth and global urbanization, construction activities in cities are only expected to expand in the future (United Nations - Department of Economic and Social Affairs Population Division, 2018). Against this backdrop, tackling challenges related to climate change requires that we work quickly and that we build *sustainably*, not only to reduce emissions and resource consumption (Bulkeley, 2013; Intergovernmental Panel on Climate Change, 2014; Sustainable Development Solutions Network Thematic Group on Sustainable Cities, 2015).

Since the adoption of the United Nations' 2030 Agenda (United Nations, 2015) and the dissemination of the global call for transformative sustainable development, organizations, businesses, and institutions have focused on aligning their activities with the Agenda's 17 Sustainable Development Goals (SDGs) (The World Business Council for Sustainable Development, 2018). Similarly, the research community has been proactive in studying the 2030 Agenda's goals and targets, their synergies and trade-offs, as well as the contribution of different sectors, tools, technologies, and policies to achieving the SDGs (Fuso Nerini et al., 2018; Kroll et al., 2019; Maes et al., 2019; Nilsson et al., 2016; Salvia et al., 2019; Tjoa & Tjoa, 2016; Yeeles, 2019).

Even though major transformations in cities and buildings have been underscored as a priority for attaining the SDGs (Sachs et al., 2019), the building sector has been inconsistent, and generally slower than other sectors, in its adoption of the Agenda. Instead of exploring the potential changes and improvements needed to align the construction and real estate sectors with the 2030 Agenda, the sustainable building field's attention remains concentrated on assessment and rating standards, tools and systems (Bernardi et al., 2017; Díaz-López et al., 2019a; Doan et al., 2017; Liu et al., 2019). Even though the GSBRES' issuers claim that they significantly and comprehensively contribute to attaining the SDGs beyond SDG11 (sustainable cities and communities) and SDG7 (energy) (Czerwinska, 2017; GRESB, 2019)., some researchers have questioned the standards' ability to work towards achieving sustainability (Amiri et al., 2019; Newsham et al., 2009; Scofield, 2013).

The alignment of the GSBRES with the SDGs is the topic of recent studies in the field of engineering. Published work is largely limited to hypothetical frameworks (Alawneh, Ghazali, Ali, & Sadullah, 2019; Roostaie et al., 2019; B. Wen et al., 2020), is focused on goal-level analysis, does not consider the Agenda's targets, is dependent on regional expertise, and rarely explores the issue of transformative change (Alawneh et al., 2018; Alawneh, Ghazali, Ali, & Asif, 2019). Additionally, such scholarship mostly approaches the topic with an *a priori* assumption that connections and overlaps must exist, and is therefore concerned with quantifying nominal "contributions" (where many of the GSBRES's contributions to the achievement of the SDGs are computed based on the qualitative assessment of experts, with little or no empirical evidence) (Alawneh et al., 2018; Alawneh, Ghazali, Ali, & Asif, 2019; Roostaie et al., 2019; B. Wen et al., 2020). Finally, the existing research rarely examines how these GSBRES relate to the published synergies and trade-offs of the Agenda. These gaps prompt us to query: *can the GSBRES meaningfully contribute to achieving the SDGs?*

Public agencies are increasingly institutionalizing the GSBRES as a means of demonstrating their commitment to sustainable development, and have been integrating them into their policy frameworks (Raymond J. Cole, 2005). Thus, our systematic study of overlaps between the GSBRES and the SDGs is crucial to avoid misleading project stakeholders into believing that the current GSBRES are amply addressing the Agenda's issues and to combat potential sustainable development greenwashing. Herein, we address three main questions related to this gap. First, how do the prominent GSBRES overlap with the 2030 Agenda in terms of their goals and targets? Second, how do their scoring methodologies affect their focus on the 17 SDGs and their targets? Third, how do the objectives of these standards compare to the transformational vision of the 2030 Agenda?

To answer these questions, we select three prominent and widely used GSBRES tackling the design (LEED V4.1 BD+C for New Construction (The U.S. Green Building Council, 2020) – shortened to LEED), operation (BOMA BEST V3 for the Universal Category (The Building Owners and Managers Association, 2018) – shortened to BOMA BEST), and investment (GRESB

2020 Real-Estate for Performance (GRESB, 2020) – shortened to GRESB) phases of building projects. We specifically focus on the intent, or objective description, of the standards' various attributes (see details in the Methods section). We use authoritative sources (The UN Sustainable Development Solutions Network, 2017a; United Nations, 2019b), published research (Körfgen et al., 2018; Mori Junior et al., 2019; Salvia et al., 2019), and reports (Elsevier & SciDev.Net, 2015; United Nations, 2019a) to compile a comprehensive repertoire of keywords and subjects for the 17 SDGs and their 169 targets, against which we evaluate the standards. We complement this formal content analysis by qualitatively evaluating the standards' call for system-level innovations, value creation, and transformation, all of which are required to meaningfully contribute to the 2030 Agenda.

4.4. Methods

Four steps for assessing the contribution of sustainability standards to the SDGs and their targets

4.4.1. Step 1: Building and validating a keyword catalog for the SDGs and their targets

To map the overlaps between sustainable building standards and the SDGs, we develop, using direct content analysis, a detailed keyword and subject catalog, a method recently employed in several studies to map the contribution of research to the SDGs (Körfgen et al., 2018; Mori Junior et al., 2019). Academic publishers and indexing providers also use this method to assess the contribution of research institutions and researchers to the topics addressed by the 2030 Agenda (Elsevier & SciDev.Net, 2015). We begin by merging the already-published catalogs on the topic (Elsevier & SciDev.Net, 2015; Körfgen et al., 2018; Mori Junior et al., 2019; The UN Sustainable Development Solutions Network, 2017a, 2017b). The combined list consists of 915 non-unique keywords, distributed across the 17 SDGs, plus an 18th category titled "Miscellaneous". To improve the catalog's accuracy and to ensure the comprehensive coverage of all 169 targets, we systematically examine the SDG Data Structure Definition (United Nations, 2019a) and the official Agenda's document (United Nations, 2015). This is to guarantee that we include target- and goal-specific keywords and subjects. We revise the keywords to ensure non-overlapping terms between goals. We achieve this by adding specificity to subjects across SDGs, or by placing keywords that appear repeatedly across the SDGs in the Miscellaneous category. In a next step, we workshop, develop, and improve the catalog based on "grey" sources and online tools (such as the linked SDG app: http://linkedsdg.apps.officialstatistics.org). Finally, we identify synonyms for basic words and terms, and mark these with asterisks (*) to signal variations, such as pluralization, alternate tenses, and differently-spelled words with identical meanings.

We develop a classification for the terms' specificity level:

1) *keywords in the miscellaneous* category are general terms that relate to sustainable development, but that are not specific to one SDG or specific target (e.g., *ecology*).

2) *keywords assigned to a specific SDG* are terms that relate exclusively to the SDG in question, but lack the specificity required to indicate an overlap with a specific target (e.g., *standard of living* for SDG1 or *inclusive growth* in SDG8).

3) *words assigned to targets* are terms that indicate an overlap with a specific target in the Agenda (e.g., *marine pollution* for SDG14.1 or energy efficiency for SDG7.3).

We employ the open-access R-Studio package to develop a code that uses the catalog to document and tally matches between the catalog and text-files.

We use two paths for validation. The first path compares the R-code analysis results to a qualitative assessment conducted on the texts. In this validation, we analyze a selection of textual content from five sustainability standards (some beyond those reported in this study – e.g., we also analyze LEED for Operation and Management, GRESB for Development and STARS (The Association for the Advancement of Sustainability in Higher Education, 2019)) and code them based on their overlaps with the goals and targets of the 2030 Agenda, independent of the keyword catalog. We then develop the catalog in order to ensure the consistency between the code output and the qualitative assessment. The second path compares the outcome of the code with previous studies and reports that describe or quantify overlaps between sustainability standards and the SDGs. This includes LEED (Alawneh et al., 2018; Alawneh, Ghazali, Ali, & Asif, 2019; Alawneh, Ghazali, Ali, & Sadullah, 2019), GRESB (GRESB, 2019), and STARS (The Association for the Advancement of Sustainability in Higher Education, 2019). The two validation paths help to optimize the catalog and to add industry specific synonyms.

The final catalog features 1,503 keywords, with 564 terms including asterisks (Appendix (H) and Table 4.1). Our analysis reveals significant correlations between the number of keywords per SDG, the word count of the goals and their targets in the original UN document (at a significance level of 0.1%, with an average of 0.176 keywords per word count and a standard deviation of 0.180 words), as well as between the number of keywords per SDG and its targets number (at a significance level of 0.1% with an average of 8.57 words per target and a standard deviation of 2.241 words).

Table 4.1. Summary of keyword catalog. Distribution of keywords across the 17 SDGs and the Miscellaneous category.

The table also presents the number of targets for each SDG.

SDG	Number of Targets	Distinct Keywords
1	7	43
2	8	73
3	13	126
4	10	84
5	9	65
6	8	81
7	5	61
8	12	104
9	8	59
10	10	65
11	10	116
12	11	116
13	5	62
14	10	65
15	12	90
16	12	93
17	19	76
Misc.	N/A	124
Total	169	1,503

4.4.2. Step 2: Analyzing the overall overlap between the standard and the 2030 Agenda

This next step constitutes the first level of quantitative assessment. From the selected official published industry standards (GRESB, 2020; The Building Owners and Managers Association, 2018; The U.S. Green Building Council, 2020) we extract the list of attributes or credits (*i.e.*, elements of assessment) and the description of their intents. In building standards, each attribute's intent presents its background, rationale, and/or importance in the context of the standard, in addition to its view of sustainability (The Association for the Advancement of Sustainability in Higher Education, 2019). Based on several iterations, other texts within the attribute description (such as the reporting standards, requirements, or implementation options) present an inconclusive understanding of the attribute, as they offer illustrations or specific solutions that might not be used by the team or institution using the document. The intents highlight the standards' approach and comprehension of sustainability issues as well as their idea of their contribution to sustainable development. From LEED V4.1 BD+C for New Construction, we extract information for 54 attributes distributed across nine categories (604 words). From BOMA BEST V3 – universal, we extract information for 19 attributes distributed across 16 BEST practices – which, in this case, are organized in the form of questions (64 words). From GRESB 2020 Real Estate for Performance, we extract 79 attributes distributed across 16 aspects within three categories (2,049 words). The total number of words reported is equal to the total words in each intent minus all "stop words" (common words with no individual significance, e.g., "the", "and", "or", "if") and numerical terms. The details of the intents analyzed are available in Appendix (G)

In this first-level analysis, we report the occurrence frequency of the catalog's terms in the extracted text. We measure this occurrence frequency by the number of keyword matches divided by the total number of words. We normalize the comparison between the three selected standards and illustrate it by using radial diagrams that present the overall frequency in percentage terms (as seen in Figure 4.1). In Supplementary Data File 3 [*file not added to appendix due to its extensive size],* we report the full list of matched keywords for each attribute across the three GSBRES. In this step, we do not consider the distribution of the keywords in the standards' attributes or categories, nor do we consider the standard's scoring methodology. However, we do explain if the standards' intents match with target-specific keywords or subjects that distinguish between outcome and means of implementation targets, as explained in the Agenda's original documents (United Nations, 2015). Thus, the resulting radial graphs (Figure 4.1) illustrate the overall overlap between the standard and the 2030 Agenda.

4.4.3. Step 3: Credit, score, and target-level analysis

In this step of the assessment, we focus on each standard, its attributes, its categories, as well as its scoring distribution. We extract from the analysis how each attribute's intent relates to the keyword catalog and establish a record of connections with distinct SDGs and targets for each. For example, the Advanced Energy Metering in LEED connects to SDG7, specifically addressing target 7.3, as well as SDG12. We intersect this analysis with the standard's scoring methodology in order to highlight the relative score given to each of the standard's attributes and consequently to the Agenda's topics. GRESB's score adds to 100%, LEED's score adds up to 110 credits and BOMA BEST adds up to 100%. It is important to note that we only analyze 78% of the 100%

possible score for BOMA BEST, because the remaining 22% of the score is based on compliance with (and the score of) other third party standards, which fall beyond the scope of this study. Details of the scoring mechanism are provided in our Appendix (G)

We illustrate the connections between the individual standard attributes and the SDGs as well as their targets using a Sankey diagram (Figure 4.2 and Appendix (F) . When multiple connections occur, the score for each attribute is equally distributed across the matching SDGs. Thus, the diagram shows the distribution of the scores across the Agenda, and does not aim to judge the strength of the presented connection. LEED is designed so that a project can only attain some credits after meeting certain prerequisites. Thus, the overlaps between the prerequisites' text and the catalog were added to the relevant credit (per Appendix (G)).

Our analysis dedicates special attention to studying how the standards move beyond referencing generic sustainable development issues (represented by the Miscellaneous category) to SDG-specific and target-specific topics. We assess this by measuring the number of connections and the relative scores attributed to each of those levels. Figure 4.3 presents the target-level overlaps. It is important to highlight that our analysis presents matches between the textual content of the standards and the topics of the SDGs. However, to assess the actual contribution of these standards to the 2030 Agenda may require analyzing realized projects and qualitatively measuring the actualization of the standards' intents. The results for steps 2 and 3 – based on R code – are available in supplementary data file 3 [*file not added to appendix due to its extensive size]*.

4.4.4. Step 4: Qualitative assessment of green and sustainable building and real estate standards' sustainability approaches

Design and organizational theory offer different frameworks for analyzing the typologies and levels of sustainability approaches. Due to the broad scope of the analyzed standards, we combine three major published frameworks: Fletcher & Goggin's (2001) three-step structure for eco-design (product, outcome, and need-focused design), Ceschin & Gaziulusoy's (2016) four-step evolution of design for sustainability (product, product-service system, spatio-social and socio-technical system innovation levels), and Dyllick et al.'s (2016; 2017) three-level frameworks for business and product sustainability (risk management and harm reduction with selective improvements, integrated and systemic management and design, and holistic improvements focused on overcoming critical challenges and creating value). We complement the design and organizational perspectives with risk management theory, specifically suggesting that more nuanced approaches to sustainability move from a preventative to a precautionary approach to risk (as proposed by Werner and Harremoës et al. ("Late Lessons from Early Warnings: The Precautionary Principle 1896–2000," 2001), and synthesized by Cucuzzella (Cucuzzella, 2016)). In this context, the principal dependence on technology (as theorized by Ellul (Ellul, 1964)) and the pursuit of certainty (as suggested by Dewey (Dewey, 1929) become key indicators for a preventative, if not reductionist, approach to our sustainability related "wicked problems" (Coyne, 2005; Rittel & Webber, 1973). By fusing these frameworks, we arrive at the three-level structure shown in Table 4.2 – with an added Level 0 to indicate a "business as usual" approach that does not lead to sustainability. Here, we propose that Level 3 is the most aligned with the "transformative vision" of the 2030 Agenda (United Nations, 2015). This position is clear in recent UN publications that seek to further define and institutionalize this concept of transformation (Baue, 2019; Utting, 2018).

Table 4.2. Four levels of sustainable design and management. Their definition, focus, approach to risk, and sample keywords.

	Definition	Focus	Approach to risk	Sample signaling keywords
Level 0	"Business as usual" and un-related to sustainability	-	-	-
Level 1	Creating better outcomes through incremental improvements in one dimension of sustainability (environmental, social, or economic*)	- Improvements in products/projects - Harm and impact reduction - Managing environmental and social footprint	Identification and management of a known risk (preventative)	Reduce; manage
Level 2	Creating better outcomes through integrated improvements across the dimensions of sustainability (environmental, social, and economic*)	- Integrated improvements in products/projects - Harm and impact reduction - Synergies between social, economic, and environmental dimensions - Managing for the triple bottom line	Integrated approach to the identification and management of known risks (preventative)	Promote; conserve
Level 3	Creating 'good' and positive outcomes and public benefits by holistically tackling critical challenges (environmental, social, economic*, and beyond)	- Holistic approach beyond the specific product/project - Problem and needs focused - Creating new value for people (while simultaneously reducing harm and managing known risks) - Transforming the collective vision or attitudes - Managing for positive value	Integrated approach to the identification and management of known risks (preventative) complemented with an exploratory approach based on scenario building focused on supporting new modes of action (precautionary)	Create; revitalize

* The definition of economy transcends the provision of cost savings or economic benefits to a specific project owner and/or business and instead focuses on the provision of economic benefits for a given locality or community

Based on the proposed framework, we conduct a qualitative assessment of the three standards' attributes using an expert-elicitation process (Morgan, 2014). Specifically, we use the standards' published guides (GRESB, 2020; The Building Owners and Managers Association, 2018; The U.S. Green Building Council, 2020) – looking beyond the intents analyzed in component 2 and 3 – in order to understand each attribute's focus/approach to risk. We classify each attribute (Level 0 to 3), rather than undertaking a systemic review of the published evidence for each attribute. We use the description, requirements, and validation proposed by each standard's guideline document. The results were discussed in various group meetings, and we reached consensus after two further assessments.

We design a radial graph that represents the relative overlaps between the standards and Levels 0 through 3. The total number of connections between the SDGs and the intents stemming from component 2 and 3 serve as the denominator. We identify the distribution of connections (measured by angle) for each SDG (excluding the Miscellaneous category) at each of the four levels of Table 4.2. These figures visually represent the levels at which each standard approaches the SDGs, with the highest level indicating a possible alignment with the transformative vision of the 2030 Agenda. The results of the qualitative assessment, comments on the assessment, as well as the total number of connections used to generate the figures can be found in Appendix (G) .

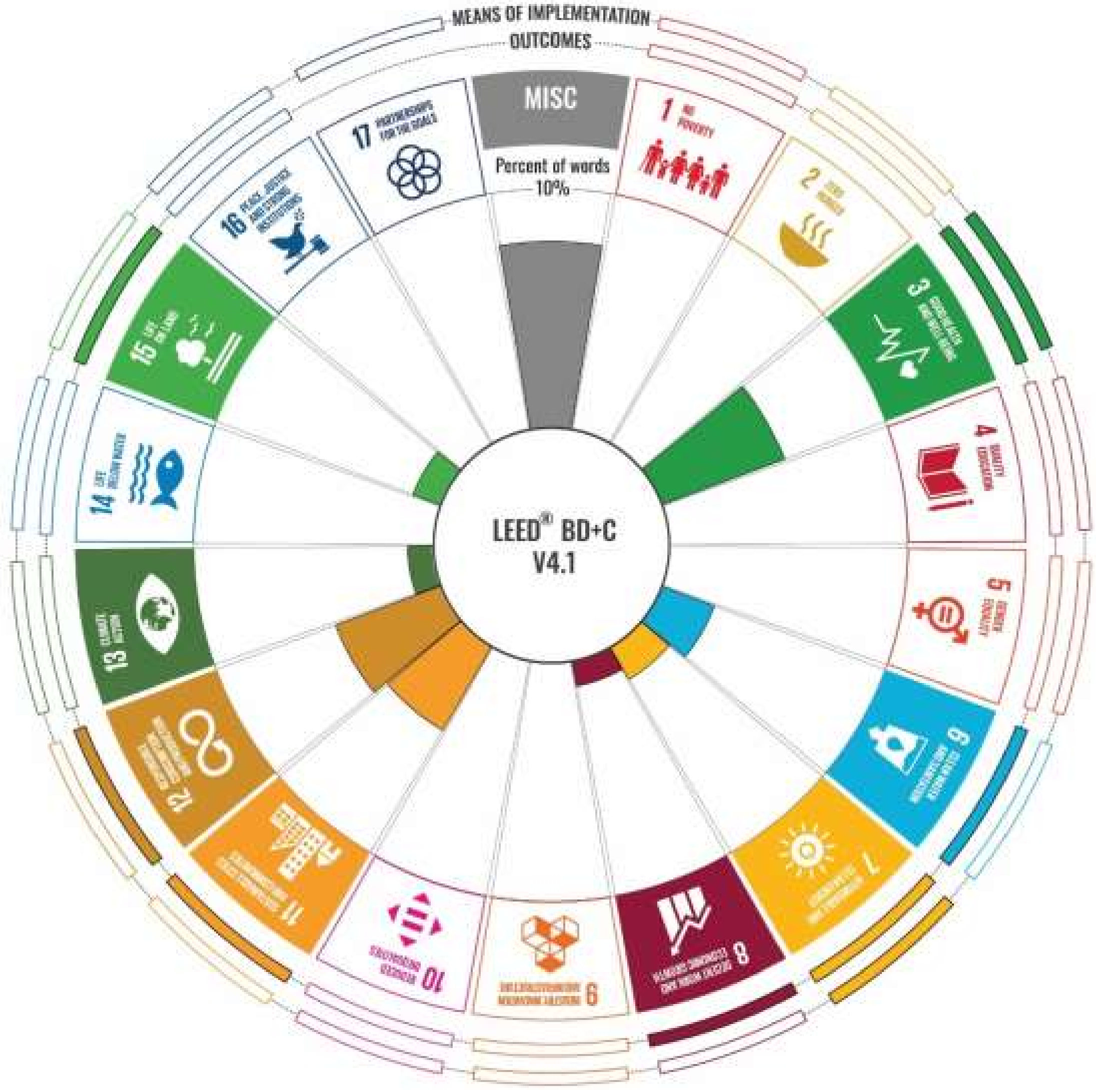
4.5. Results

Analyzing the attributes of each GSBRES reveals several key gaps in their coverage of the 2030 Agenda's topics. None of the analyzed text from the standards matches with keywords in SDG1, SDG2, SDG5, and SDG14. Based on the hierarchy of keywords developed, the miscellaneous category received a significant portion of matches, constituting the largest category for LEED and GRESB, and the second largest in BOMA BEST after SDG12. This suggests that these standards address several sustainability issues outside the direct scope of the Agenda's individual goals. Overall, 28.81% of LEED's text, 21.88% of BOMA BEST's text, and 13.18% of GRESB's text matches with the catalog (including the miscellaneous category). It is important to note that the lower matching percentage for GRESB may be attributable to the larger document size. In addition, LEED and GRESB both have a significant number of attributes with a larger number of words, as opposed to BOMA BEST that has both the smallest number of attributes and the lowest word count.

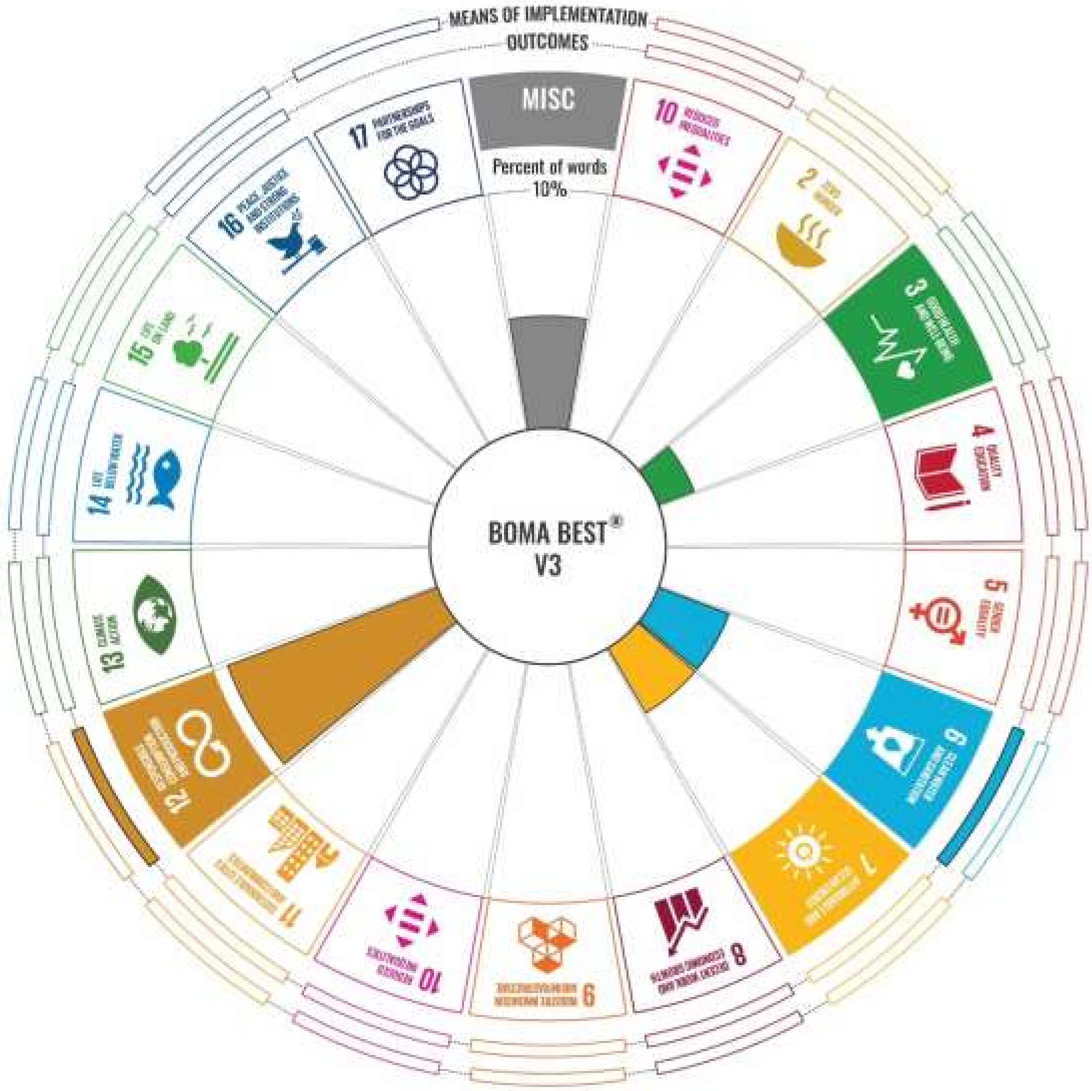
GRESB has the largest coverage in terms of the number of SDGs, with matches for keywords across 12 different SDGs. GRESB is also the only standard that matches with keywords from SDG16, SDG4, SDG10, and SDG17 (ordered by decreasing percentage of content matched – SDG10 and SDG17 both at 0.05%). The extracted text from BOMA BEST only matches with four SDGs, namely SDG12, SDG6, SDG7, and SDG3 (ordered by decreasing percentage of content matched – SDG6 and SDG7 both at 3.125%). The extracted text from LEED matches with eight SDGs. The LEED text matches most with keywords from SDG3 (5.46%), followed by SDG12 (4.64%), and SDG11 (3.97%). BOMA BEST matches most with keywords related to sustainable consumption and production (SDG12 – 9.38%). GRESB matches most closely with keywords from SDG16 and SDG12 (both at 1.51%). For the SDGs matched, the average overall word overlaps between the text of each GSBRES and the keyword catalog was below 4% for each SDG, representing an average of 2.63% across eight SDGs (with a standard deviation of 1.69%) for LEED, 3.52% across four SDGs (with a standard deviation of 3.56%) for BOMA BEST, and 0.61% across twelve SDGs (with a standard deviation of 0.48%) for GRESB.

The texts match most consistently with SDG12 (with 4.64%, 9.38%, and 1.51% for LEED, BOMA BEST, and GRESB, respectively). On the other hand, SDG11, which focuses on sustainable cities and communities, is only the third-highest match for LEED (preceded by SDG3 and SDG12, respectively) and GRESB (preceded equally by SDG16 and SDG12). The analyzed text from BOMA BEST does not match with any keywords for SDG11. These findings suggest that the GSBRES's attention is not primarily dedicated to issues related to sustainable cities and communities as framed in SDG11 (average for three standards 1.70%). Rather, they principally overlap with issues related to sustainable consumption and production (SDG12 – average for the three standards = 5.18%), health and wellbeing (SDG3 – average for the three standards = 2.47%), water (SDG6 – average for the three standards = 1.93%), and energy (SDG7 – average for the three standards = 1.75%).

Relative to the SDGs with which it matched, LEED's text pairs with the highest number of the targets' keywords (seven of the eight SDGs with which it matched), and is the only standard that overlaps with keywords for the means of implementation targets (for SDG3 and SDG7). GRESB's text matches with the largest number of target keywords (eight of the 12 SDGs with which it matched), but only matches with keywords for the outcome targets. BOMA BEST's text only overlaps with outcome target keywords for SDG6 and SDG12. These findings highlight the wide variances in coverage of SDG topics across the different standards, and the possible tensions that could arise between the different stakeholder groups working with these tools, as these groups might be operating with different understandings while moving from design to operation, and from operation to investment.



A) LEED Building Design and Construction V4.1 (New Construction)



B) BOMA BEST V3 (Universal)

C) GRESB 2020 Real Estate (Performance).

Figure 4.1. Overlaps between the green and sustainable building and real estate standards and the 2030 Agenda.

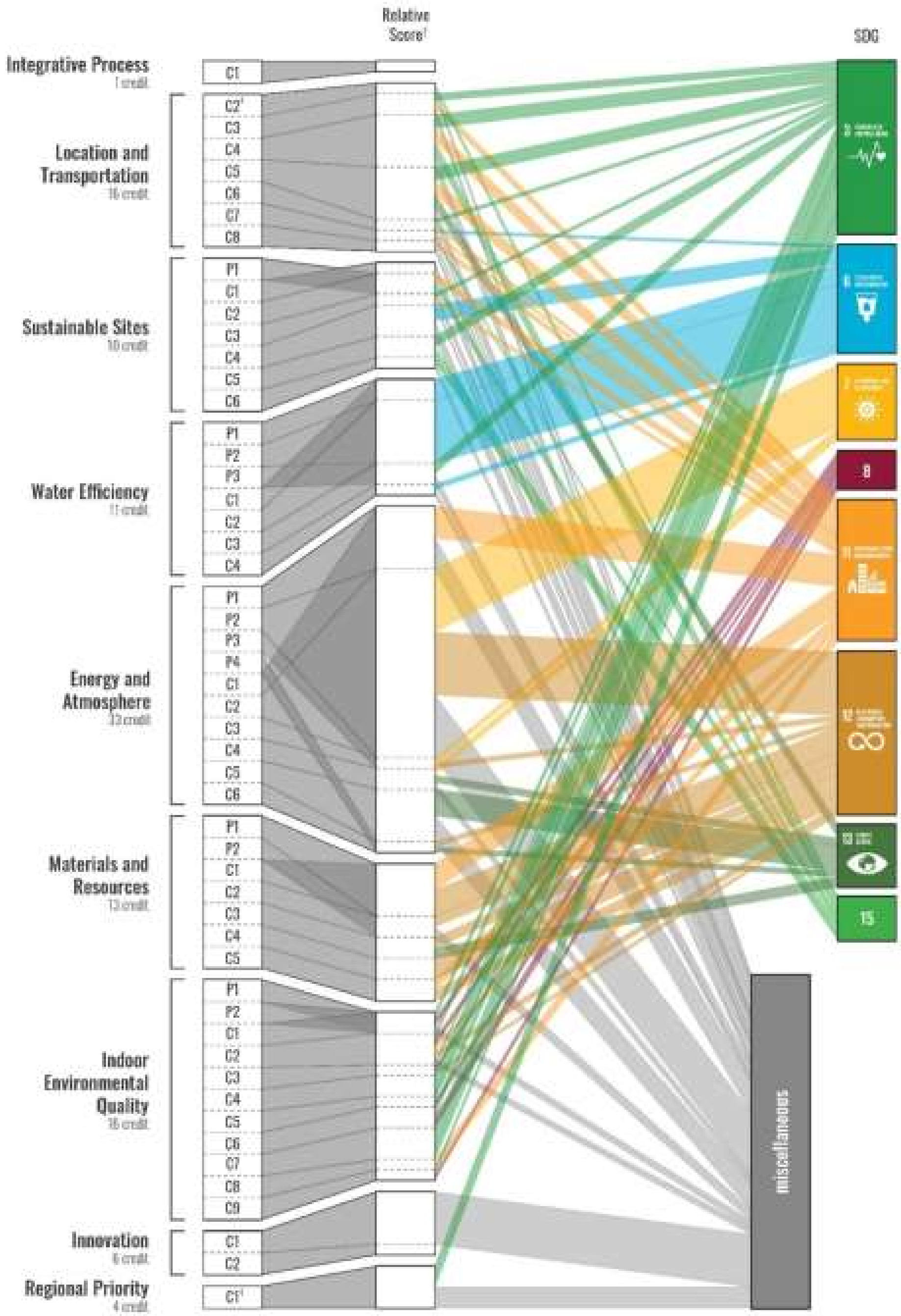
The maximum height of the bars (from the center to the inner circle for each SDG logo) represents a 10% match of words. Full-color SDGs logos are those with at least one keyword match. Highlighted first ring indicators signify a match with at least one outcome target keyword, and highlighted second ring indicators signify match with at least one means of implementation target keyword.

The attribute-level analysis reveals that not all attributes have connections to the SDGs. Specifically, only 38 of LEED's 54 attributes, 10 of BOMA BEST's 16 attributes, and 41 of GRESB's 79 attributes match with keywords related to the SDGs. In LEED, the largest number of matches (16 attributes) correspond to keywords from SDG3, further highlighting the permeation of health and wellbeing issues in the standard's text. In GRESB, the largest number of matches (16 attributes) pertain to keywords from SDG16 – pointing to a focus on standards related to strengthening institutions through transparency and the institutionalization of environmental, social, and governance (ESG) standards in the management and operation of buildings in an investment portfolio. While SDG12 has the most matches in BOMA BEST (five attributes), it is difficult to conclusively state that sustainable consumption and production permeate the standard, due to the small number of attributes and small text count.

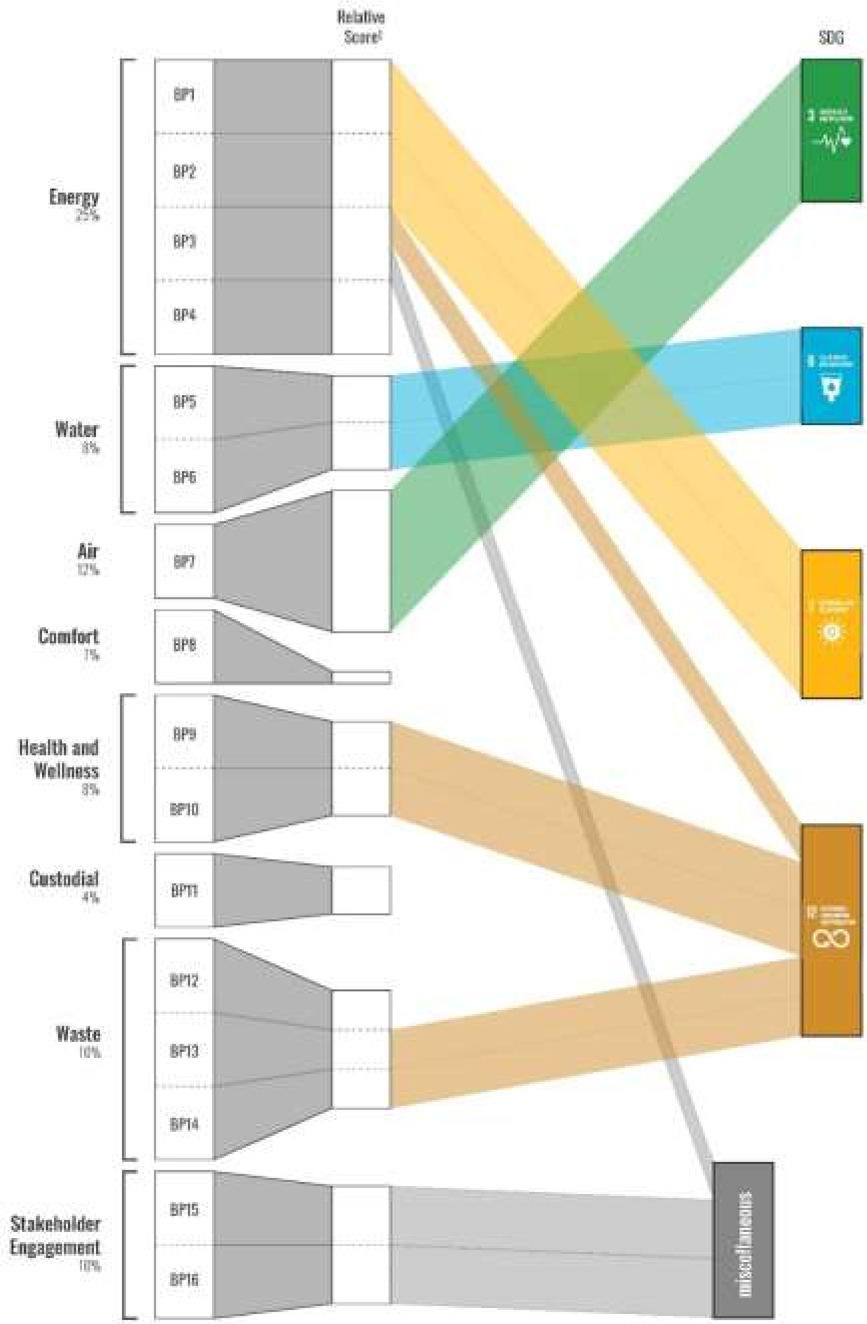
The application of the scoring methodology for each standard (details of the scoring methodology for each standard is available in Appendix (G)) significantly modifies its areas of focus. When compared to the normalized weight (moving from the first to the second row of Figure 4.2 and Figure 4.3), the scoring of all the three standards tends to reduce the median significance of each attribute and thus magnifies the focus on a small number of attributes. For LEED, 41 attributes reduce and 12 increase in relative significance. For BOMA BEST, 11 attributes reduce and 5 increase in relative significance. For GRESB, 50 attributes reduce and 16 increase in relative significance. For both LEED and GRESB, the scoring methodology magnifies attributes related to energy (optimization, reduction, and monitoring) more than nine-fold (in LEED the single attribute of energy performance optimization constitutes 16.36%, and in GRESB EN1-energy consumption for this property type constitutes 14.00% of the total possible score). In BOMA BEST, the single attribute related to indoor air quality is significantly magnified by the scoring methodology (constituting 12.00% of the total possible score).

In LEED and GRESB, the largest portion of the score (see score distribution in step 3 of the Methods section) relates to the miscellaneous category, comprising 28.64% of the score from 23 attributes, and 43.31% of the score from 24 attributes, respectively. In contrast, in BOMA BEST, only 13.13% of the score can be attributed to the miscellaneous category. In total, the 53 analyzed attributes of LEED have 65 connections to eight SDGs (representing 69.37% of the relative score), and 23 connections to the miscellaneous category (see Appendix (G) for the treatment of prerequisite credits). The 16 analyzed attributes of BOMA BEST have ten connections to four SDGs (representing 66.29% of the relative score) and three connections to the miscellaneous category. The 79 analyzed attributes of GRESB have 65 connections to 12 SDGs (representing 56.69% of the relative score) and 33 connections to the miscellaneous category. Appendix (F) presents the full range of connections on the SDG- and target- levels.

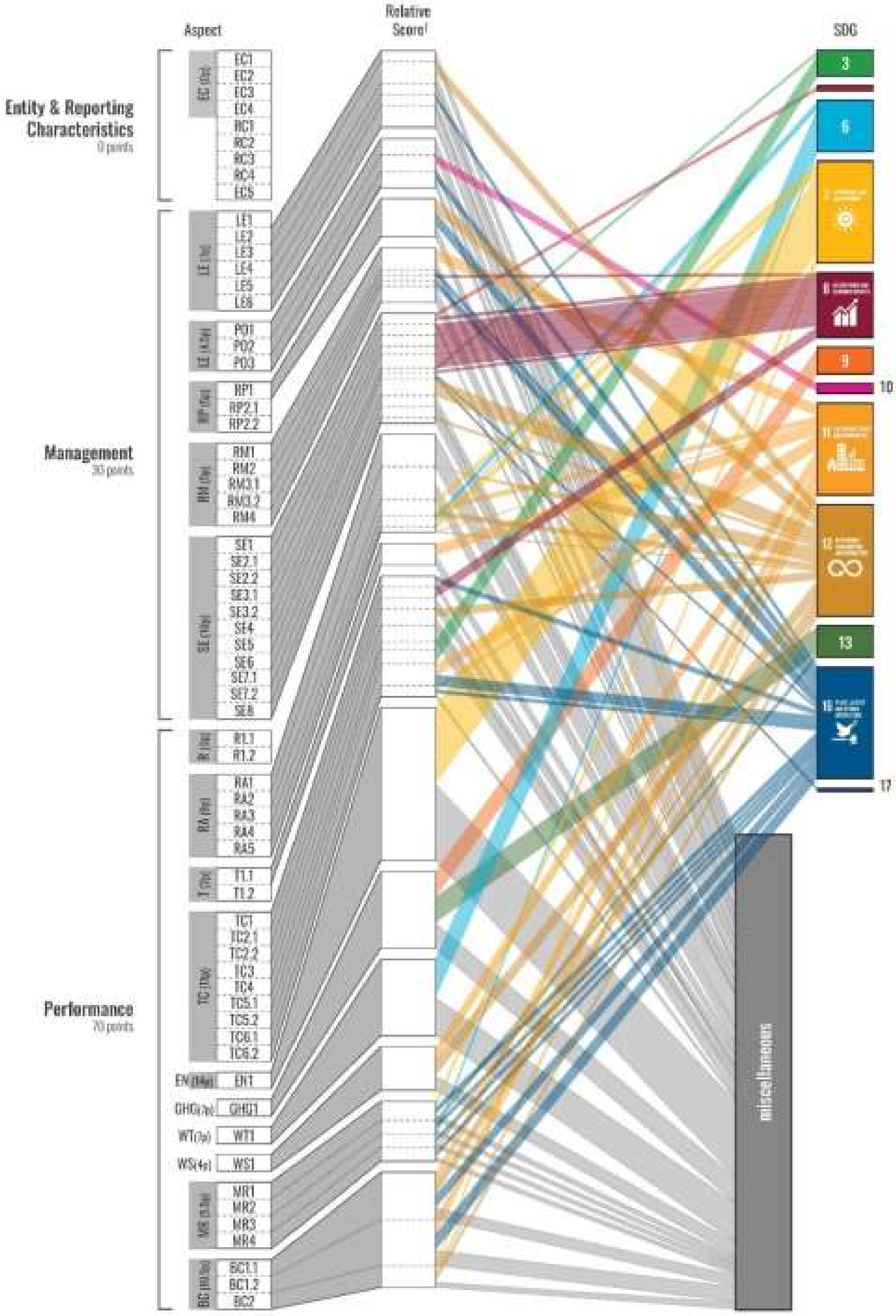
For each standard, the links between the attributes and the SDGs are unique, both in terms of distribution and focus. In LEED and GRESB, each attribute tends to match with a larger number of SDGs than in BOMA BEST, making their overlap with the 2030 Agenda more complex. However, in both LEED and GRESB, there are strong variations in these connections, where certain attributes match with keywords related to many SDGs and others only match with one SDG. This is could be due to the complexity and length of the texts, making the intent overlap with more concepts from the 2030 Agenda. Also, there is no relation between an attribute's score and its connections with the Agenda. For example, in LEED, the "Low Emitting Materials" credit matches with keywords from four SDGs and the miscellaneous category for only 2.73% of the score, while the "Indoor Water Use Reduction" matches only with SDG6 for 5.45% of the score. In contrast, BOMA BEST presents a more focused approach, where each best practice (BP) matches with one, or a maximum of two, SDGs.



A) LEED Building Design and Construction V4.1 (New Construction)



B) BOMA BEST V3 (Universal)



C) GRESB 2020 Real Estate (Performance)

Figure 4.2. Credit level assessment of green and sustainable building and real estate standards and the 2030 Agenda – SDG-level.

Each attribute's score is distributed equally across SDGs with keyword matches. The size of each SDG frame is thus indicative of its score weight within each standard.

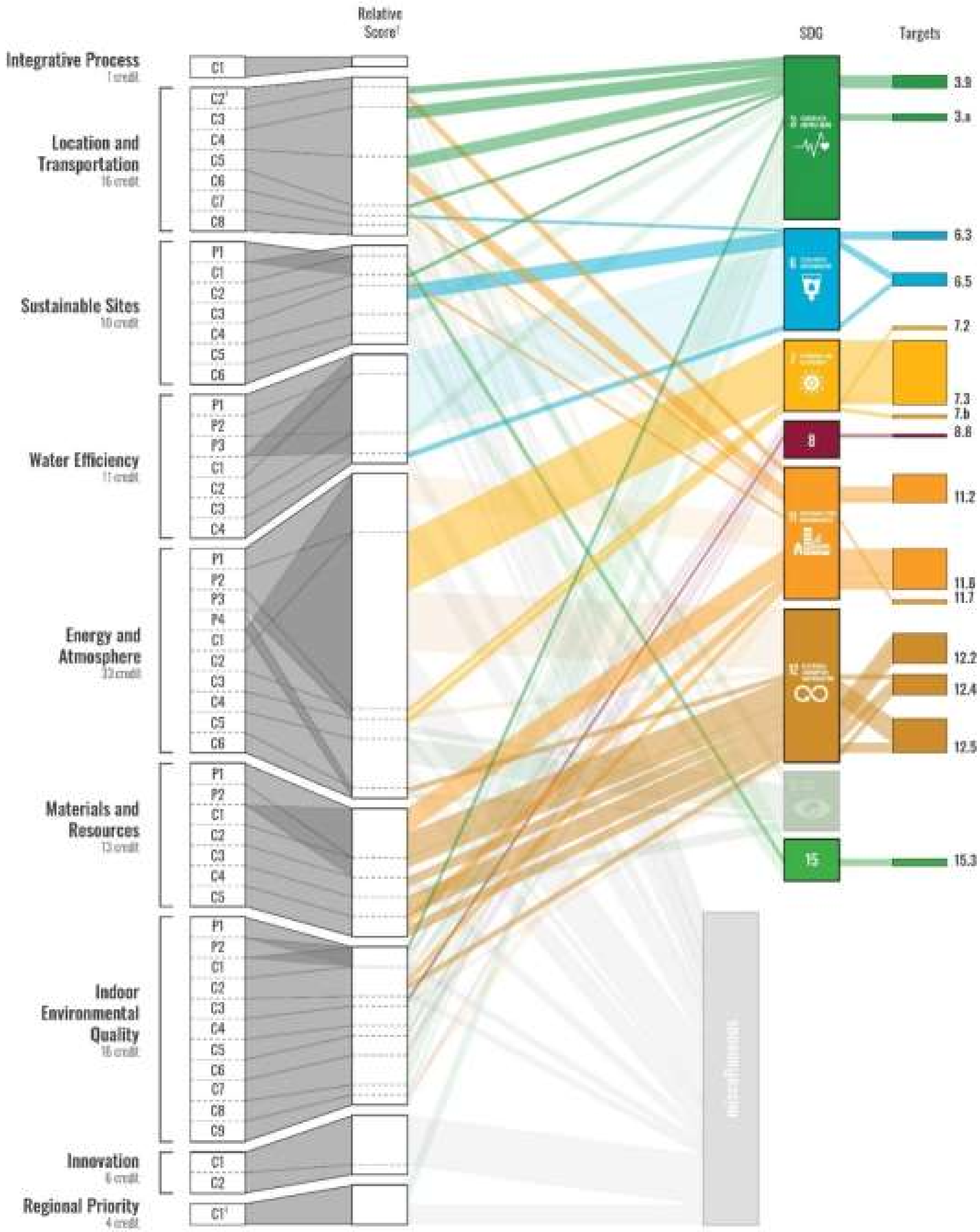
† Relative score: In the figures, LEED's score adds up to 100% credits, BOMA BEST adds up to 78%, and GRESB's score adds to 100%. It is important to note that we only analyze 78% of the 100% possible score for BOMA BEST, because the remaining 22% of the score is based on compliance with (and the score of) other third party standards, which fall beyond the scope of this study. See details Appendix (G) .

When we move from the SDG-level to the target-level, we observe a clear decline in the number of connections (as can be seen in the two right columns of Figure 4.3). In the case of LEED, only 27 of the original 65 connections link to specific target keywords (representing 25.39% of the relative score), while six of the original ten connections in BOMA BEST (representing 22.46% of the relative score) and 16 of the original 65 connections in GRESB (representing 17.54% of the relative score). This indicates that, while many of the standards' attributes relate to the SDGs' general topics, their overlaps are limited with respect to the 2030 Agenda's specific targets. For example, an attribute such as LEED's "High Priority Site" credit in the "Location and Transportation" category ("to build the economic and social vitality of communities, encourage project location in areas with development constraints and promote the ecological and community health of the surrounding area" (The U.S. Green Building Council, 2020)) addresses the topic of community health and wellbeing (SDG3), among others. However, its focus is not directly aligned with any of the individual targets proposed for SDG3.

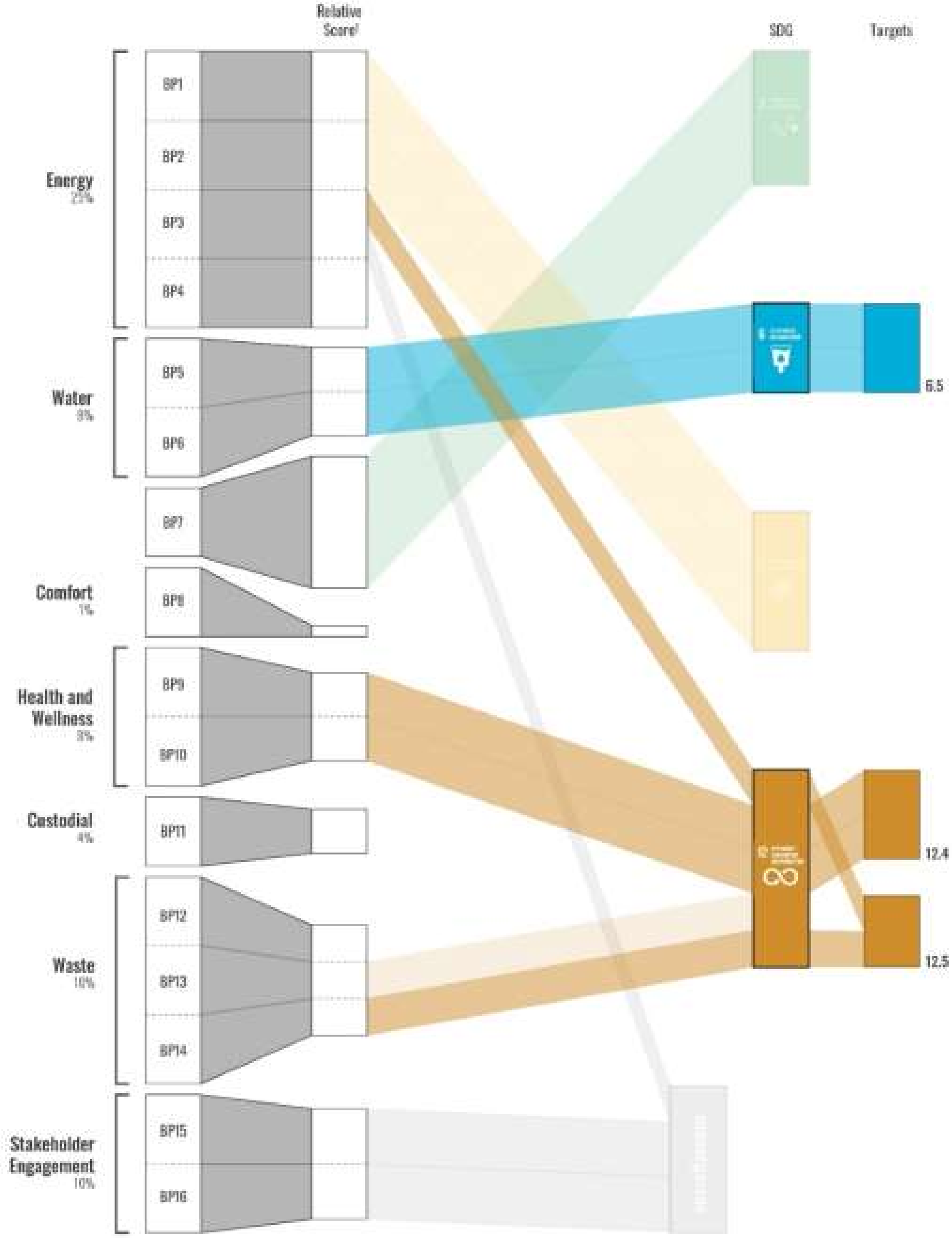
LEED boasts the most significant coverage of targets: 16 different targets across seven SDGs; addressing at least one target from its matched SDGs (except SDG13). LEED is the only standard that matches with the means of implementation targets (namely 3.a, concerning "Control of Tobacco Smoke", and 7.b, concerning the "Upgrade of Energy Infrastructures"). BOMA BEST connects with three targets from two of the original four SDGs (namely targets 6.5, 12.4, and 12.5), while GRESB contains connections for eight targets from seven of the original 12 SDGs. It is important to note that GRESB is the only standard that presents a match with target-specific keywords for SDG16, illustrating its focus on transparency and its call for stronger institutions.

Across the three standards, we observe high target-specific matches for SDG12, further highlighting the focus on sustainable production and consumption patterns. In the case of both LEED and GRESB, we note high target-specific matches for SDG7 and SDG11. In LEED, all attributes connected to SDG7 have target-specific keyword matches. This indicates that LEED's text overlaps with the target-specific areas of focus for energy proposed by the Agenda. While in GREBS only three of the total six attributes that connect to SDG7 have target-specific keyword matches, these attributes constitute 86.88% of the relative score for energy-related issues in the standard. In BOMA BEST, all the attributes related to water match with target specific keywords in SDG6, as opposed to a much smaller target-specific portion in both LEED and GRESB.

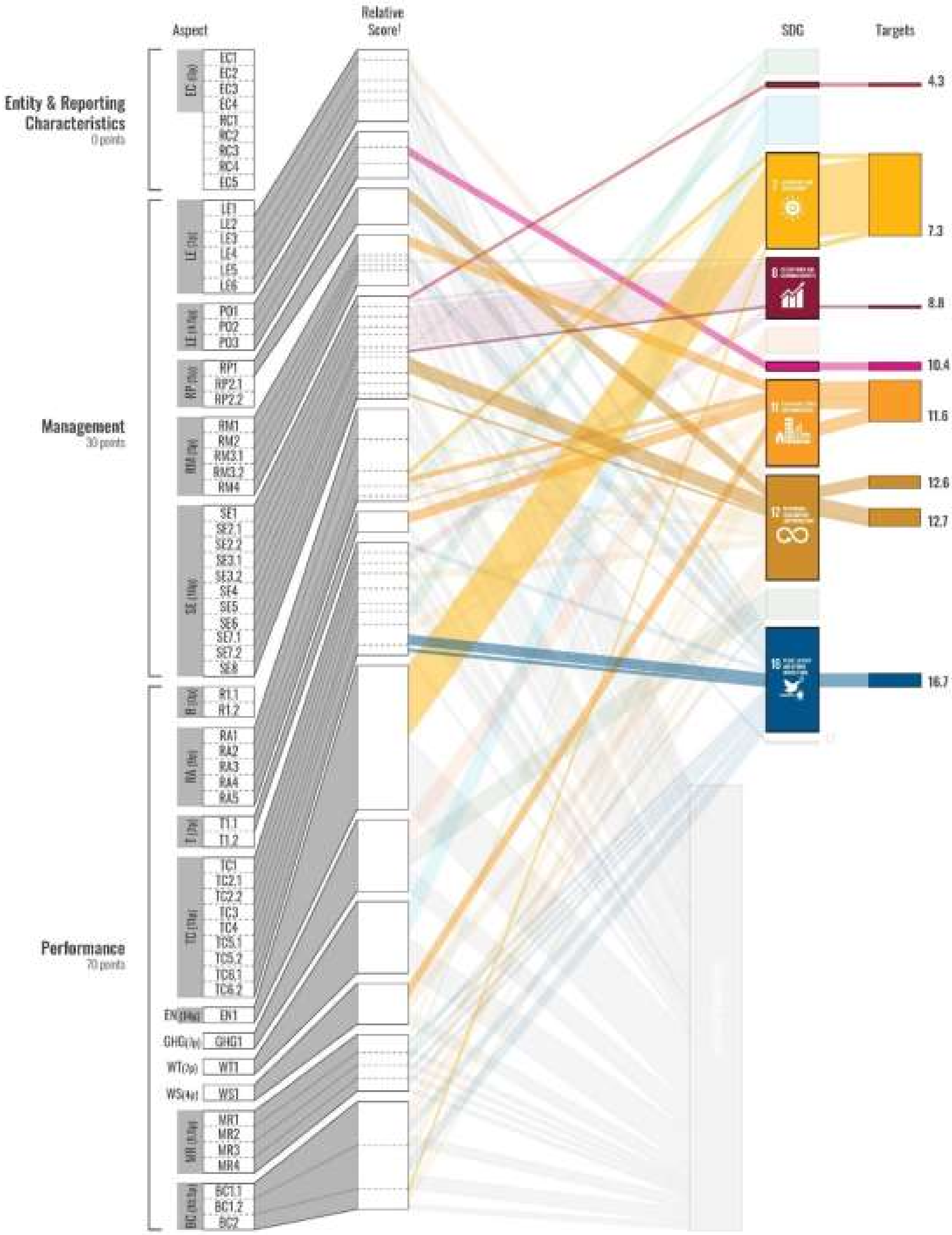
From the validation of the attribute-SDG-level analysis (especially for LEED or GRESB (Alawneh et al., 2018; Alawneh, Ghazali, Ali, & Asif, 2019; Alawneh, Ghazali, Ali, & Sadullah, 2019; GRESB, 2019; Roostaie et al., 2019) – details in the Methods section), we infer that the SDG overlaps identified by our content analysis match those proposed by published studies, suggesting a similarity in the standards' areas of interest and the general topics of the SDGs. However, the considerably smaller number of target-level overlaps indicate a possible misalignment between the three GSBRES' particular areas of focus and the specific targets of the 2030 Agenda.



A) LEED Building Design and Construction V4.1 (New Construction)



B) BOMA BEST V3 (Universal)



C) GRESB 2020 Real Estate (Performance)

Figure 4.3. Credit level assessment of green and sustainable building and real estate standards and the 2030 Agenda – Target-level.

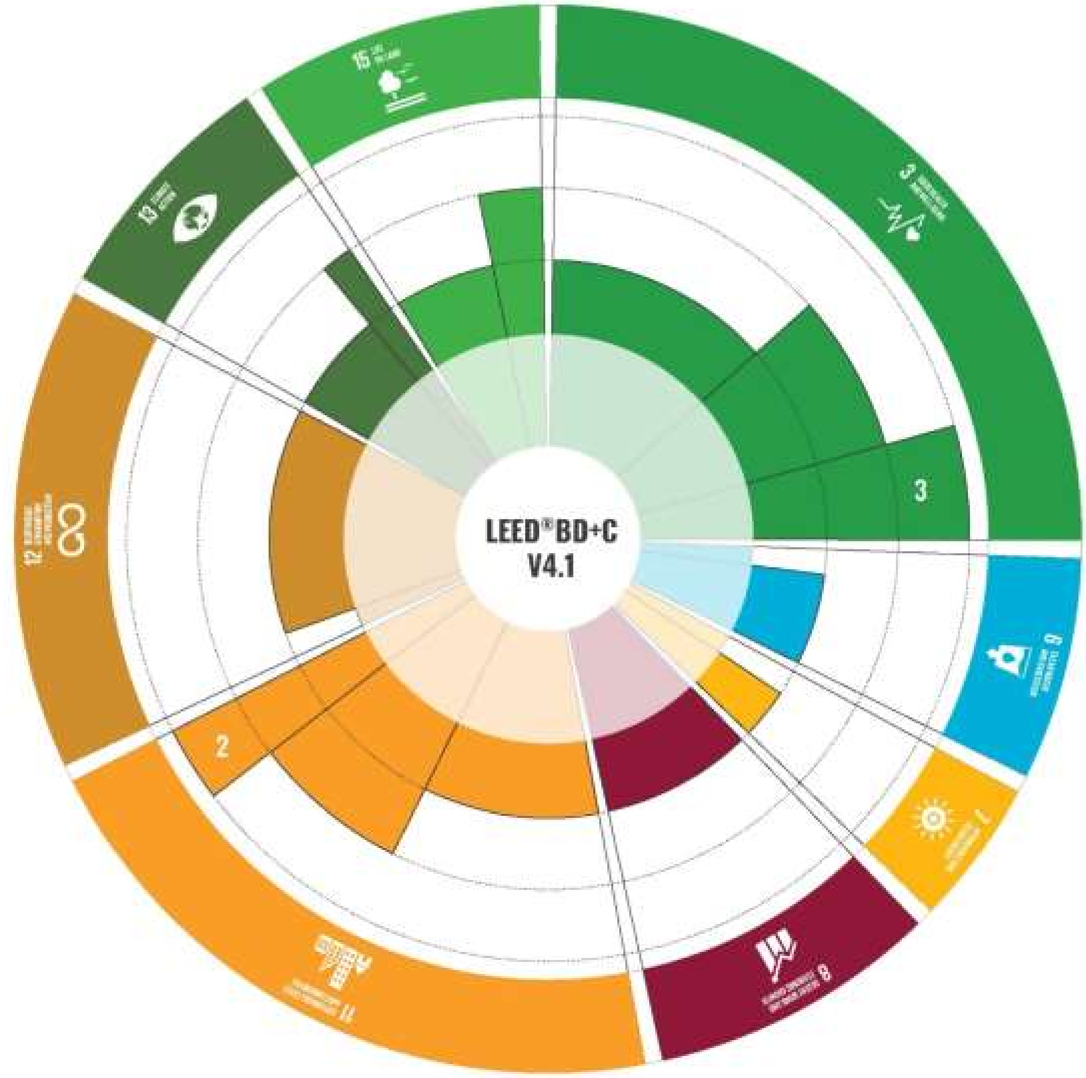
The figure presents the distribution of matches across the standards' intents. Each attribute's score is distributed equally across the SDGs with keyword matches, making the size of each SDG frame indicative of its possible score weight within each standard. The size of the SDG frame represents the overall connections presented in Figure 4.2, showing the difference in relative weights between SDG-level and target-level connections.

† Refer to Figure 4.2 for a note on relative scores.

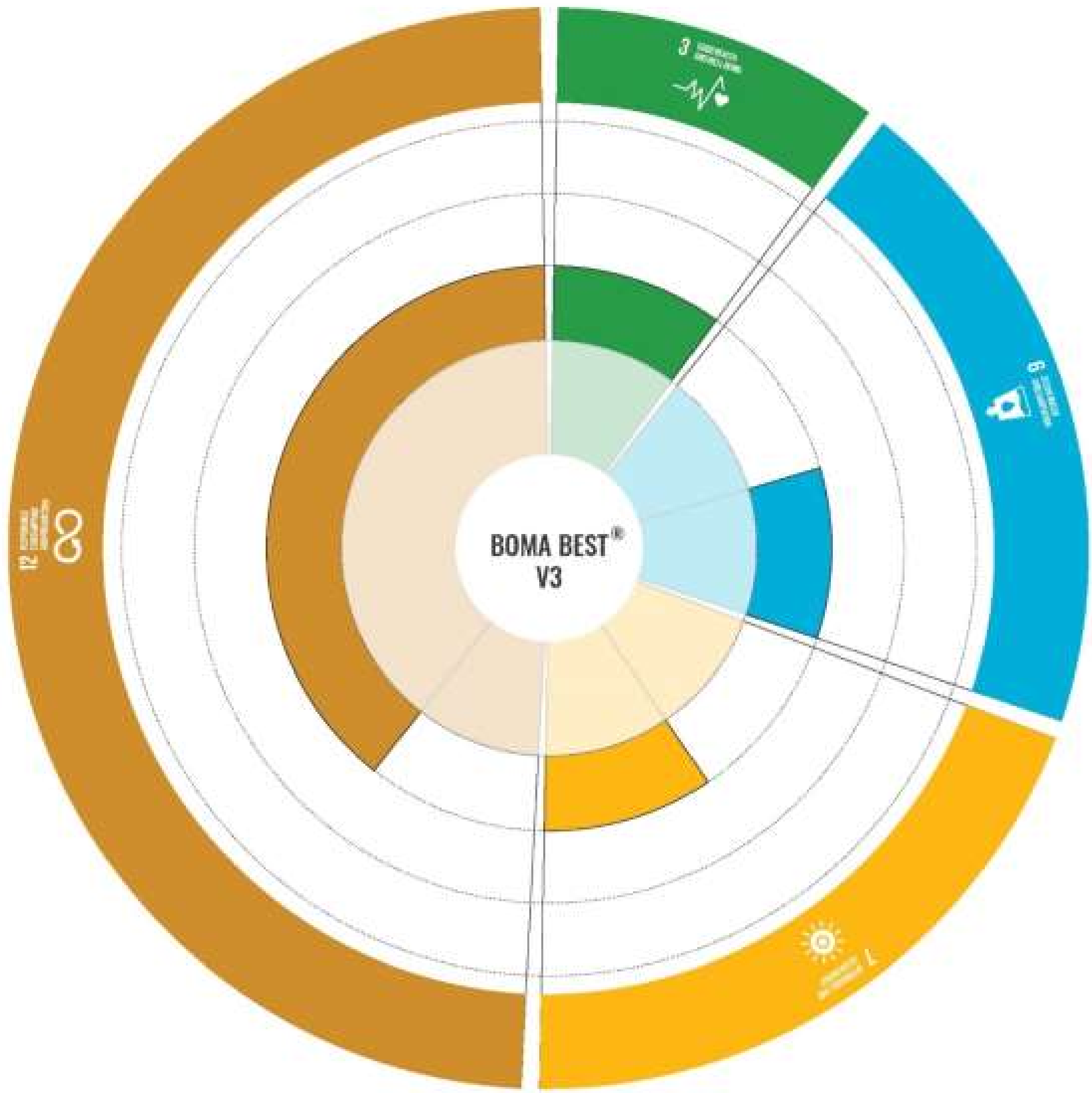
In addition to a shortage of target-specific overlaps, the qualitative analysis highlights a possible second gap with regards to the alignment of the analyzed GSBRES and the 2030 Agenda. Specifically, most of the standards present Level 1 approaches to sustainability, in which incremental improvements in one dimension of sustainability (specifically environmental performance) are sought: 36 of the 54 LEED attributes, 11 of the 16 BOMA BEST attributes, and 40 of the 79 GRESB attributes. GRESB exhibits an almost equal distribution between Level 0 (14 attributes), Level 2 (12 attributes), and Level 3 (14 attributes), where Level 3 suggests a call for transformative sustainable development – on a collective level. LEED displays more Level 0 (6 attributes) and Level 2 (7 attributes) connections than Level 3 (3 attributes), whereas BOMA BEST has the highest portion of "business as usual" attributes (for Level 0, 3 out of 16 attributes) and an equal distribution between Level 2 and Level 3 (1 attribute each). These findings indicate possible incongruence between the dominant approach of design (LEED) and operation (BOMA BEST) standards, and that of investment and real-estate portfolio performance management (GRESB). The latter is more holistic in its sustainability approach, a phenomenon that requires further investigation.

When analyzing the distribution of the connections between the attributes and the SDGs based on the qualitative assessment (see Figure 4.4), we find that three attributes assessed in Level 3 for LEED are connected to SDG3 and SDG11, and constitute only 7.58% of its connections to the SDGs. In the case of LEED, most connections to SDGs pertain to Level 1 attributes (68.18% of the connections), with a less significant number of connections to Level 2 attributes (19.70% of the connections). The single attribute ranked at Level 3 for BOMA BEST forms no connections to the SDGs, as is the case for the attribute at Level 2. The majority of BOMA BEST's connections

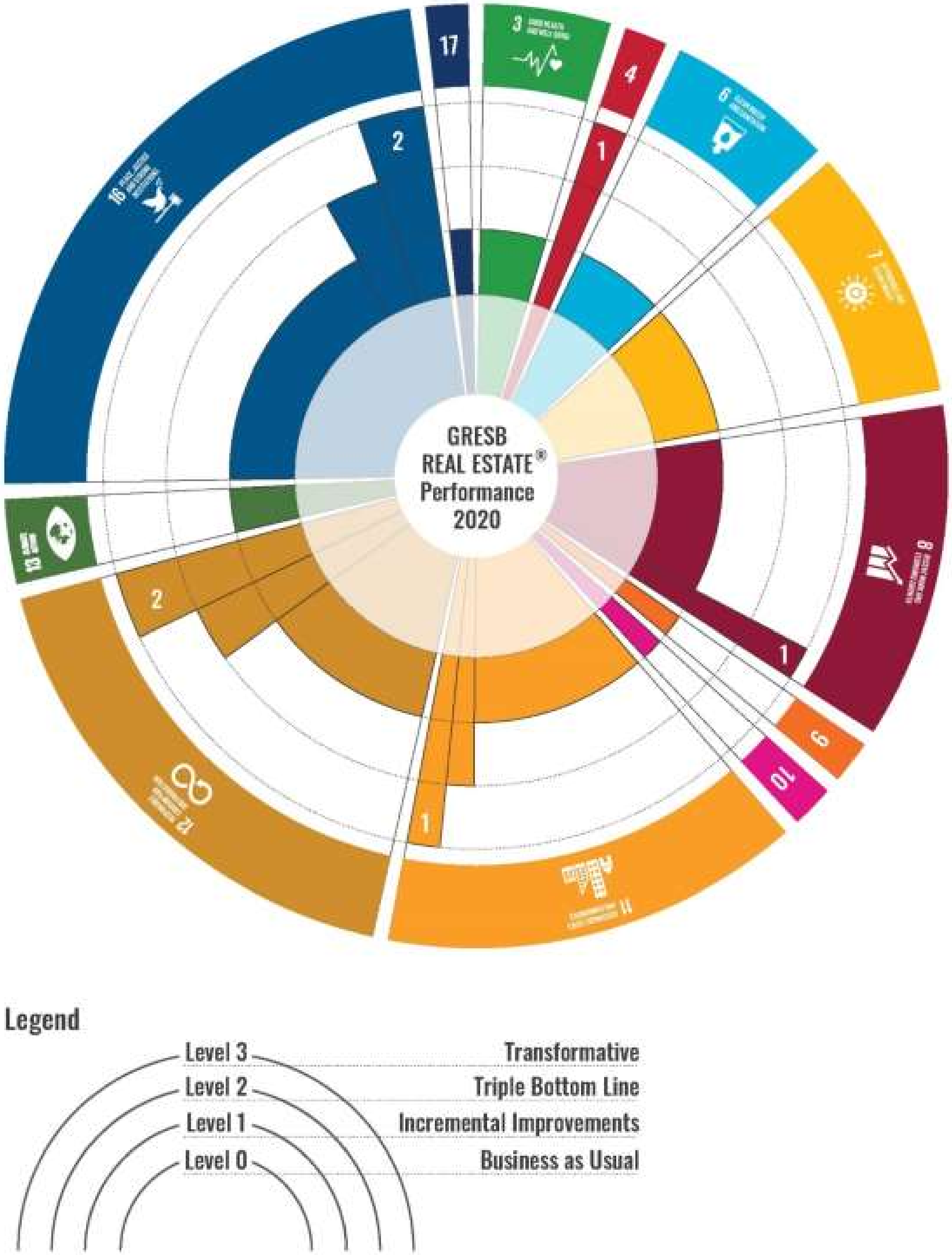
(70%) to the SDGs are Level 1, with the remaining 30% of connections representing what can be considered “business as usual” approaches. As for GRESB, the 13 attributes assessed at Level 3 form only seven connections (10.77% of the connections) with the SDGs, and are focused mainly on SDG4, SDG12, SDG8, SDG13, and SDG11. While GRESB has only about 50% of its attributes assessed at Level 1, these have the most connections with the SDGs (81.54% of connections), followed by Level 3, and then Level 2 (7.69% of connections). Interestingly, none of the attributes ranked as “business as usual” (Level 0) in GRESB have any connections with the SDGs. We calculate the relative scores allocated to transformational attributes to be 6.36% for LEED, 5% for BOMA BEST, and 10.5% for GRESB. These results indicate that while both LEED and GRESB attempt to include attributes focused on value creation and transformation, they remain mostly focused on incremental improvements concerning the 2030 Agenda’s topics. Such a focus brings into question these standards’ capacity to meaningfully contribute to achieving the SDGs (Alawneh et al., 2018).



A) LEED Building Design and Construction V4.1 (New Construction)



B) BOMA BEST V3 (Universal)



C) GRESB 2020 Real Estate (Performance).

Figure 4.4. Distribution of the connections between the standards' attributes and the SDGs based on a qualitative assessment.

The figure presents the number of connections for each goal, where each attribute may be connected to multiple SDGs. The figures are designed based on the total number of connections for each standard. Some attributes do not have any connections with the SDGs and are therefore not considered in this figure (see the 4.4. and Appendix (G)). The total number of connections between attributes assessed at Level 3 and each SDG is indicated in the figure. It is important to note that some attributes connect to more than one SDG. A legend explaining the distribution of the levels is included with Figure 4.4 - C.

4.6. Discussion

4.6.1. Synergies and trade-offs within the Agenda

An important factor to consider in the context of the SDGs is their interlinkages. The fact that most standards focus on sustainable consumption and production (SDG12), and economic growth (SDG8) can be problematic, as they represent the SDGs with some of the highest number of trade-offs with other goals, including social and economic progress-oriented SDGs (Kroll et al., 2019; Pradhan et al., 2017). Moreover, the focus on health and wellbeing (SDG3), especially in LEED's and BOMA BEST's scoring methodologies, may have adverse effects on energy-related targets (SDG7). In addition, the emphasis on air quality and emission reduction connects most standards to parts of both SDG3 and SDG11 (Nilsson et al., 2018). The focus on SDG6 and SDG7 presents some synergies between the two goals (Fader et al., 2018). However, the attention on SDG7 could result in trade-offs with most of SDG4's targets, and a significant portion of both SDG14's and SDG15's target (Fuso Nerini et al., 2018). This risk is amplified when one considers that the design standards do not address these goals. Also, the focus on target 7.b in LEED could limit the standard's ability to achieve food-related targets (such as 2.1, 2.2, 2.3) (Fader et al., 2018), a dimension that is not addressed whatsoever by the standard. Furthermore, the focus on water issues, without clear links to SDG2 and SDG13, presents a missed opportunity for potential synergy (Scharlemann et al., 2020). Finally, previous studies have suggested that the focus on SDG11 could create positive synergies with poverty-related issues (SDG1) and climate action (SDG13), but only if it is complemented by an emphasis on risk exposure reduction, topics addressed by targets 11.5 and 11.b (Pradhan et al., 2017). However, these synergies remain unrealized in the three standards analyzed, due to the absence of considerations for disaster and risk exposure management.

4.6.2. How the GSBRES overlap with the 2030 Agenda and contribute to the Agenda's 5Ps

In comparing the standards to the 5P framework proposed for the Agenda (people, planet, prosperity, peace and partnership) (United Nations, 2015), the standards are predominantly concerned with the "planet" dimension, with but few links to the prosperity dimension (specifically on economic progress). This misplaced focus presents a deviation from the suggested broader areas of concern recommended by the recent literature for the construction sector, which includes poverty, partnership, innovation and equality (Ghosh & Rajan, 2019). The target-level links uncovered further highlight this principal focus on the environmental dimension (which fall largely within the environmental outcome targets category) (Engberg-Pedersen, 2016; Engberg-Pedersen & Zwart, 2018). While previous publications have employed elaborative qualitative, accounting, and statistical methods to propose how the GSBRES contribute to achieving the SDGs (Alawneh et al., 2018; Alawneh, Ghazali, Ali, & Asif, 2019; Alawneh, Ghazali, Ali, & Sadullah, 2019; Czerwinska, 2017; GRESB, 2019; Roostaie et al., 2019; B. Wen et al., 2020), such analytical methods fail to account for several important concerns. First, primarily qualitative methods do not concretely show how such prospective contributions can be materialized in projects. Second, their outcomes remain focused on calculating hypothetical contribution indexes (using statistical methods) rather than demonstrating why and how the GSBRES overlap with the specific targets of the Agenda. Finally, their definition of contribution overlooks the vision of the 2030 Agenda for social, cultural, or economic changes, and equates incremental improvement to transformative change.

Our analysis suggests that, while there are overlaps between prominent GSBRES and sustainability or sustainable development, most of the overlaps are generic. In other words, they do not fit within the direct scope of the SDGs. Additionally, our qualitative assessment highlights the misalignment between the dominant sustainability approach of these standards, which remains incremental and focused primarily on the environment, and the value-driven approaches that are required to realize the broader transformative vision of the 2030 Agenda. Our analysis casts doubt on the findings of recent research that proposes that GSBRES can address systemic challenges such as equal access to services (by gender and socio-economic class) (Omer & Noguchi, 2020), reduce premature mortality from non-communicable diseases (B. Wen et al., 2020), make improvements in regional and transborder infrastructure (B. Wen et al., 2020), or even achieve the energy targets of SDG7 (Alawneh et al., 2018). An analysis of possible *relationships* – such as synergies and trade-offs (Fuso Nerini et al., 2018; Kroll et al., 2019) or direct or indirect relationships (Goubran, 2019a) – between different sectors, standards and the 2030 Agenda is needed to provide more clarity and better transparency, as current research trends that suggest *contributions* to achieving the SDGs through normative standards are misleading for communities, property owners, and governments.

4.7. Conclusion

To conclude, our content analysis shows that GRESB exemplifies a standard with wide coverage concerning the SDG topics, including institutional and partnership issues, but that it is limited in terms of its overlap with the specific targets of the Agenda. However, it aims to address broader sustainability issues, such as education, equality, innovation, peace, and partnership. These areas are of critical importance to sustainable building, as reflected by the sustainability reports of real estate companies (Ionașcu et al., 2020). LEED is successful in addressing topics specific to many of the Agenda's targets, but it has the highest ratio of attributes (more than 70%) that are incremental and not triple bottom-line focused and the smallest proportion of attributes with a potential for value creation. Finally, BOMA BEST remains fixated on operational issues that are generally not in line with the 2030 Agenda's focus, but when such overlaps do occur, they show the potential to address target-specific issues. These design and operation standards are primarily focused on content and scoring on issues related to sustainable production and consumption, energy, water, and economic development. Finally, the three standards' foci (specifically on SDG12, SDG3, SDG6, SDG7, and SDG11 as well as their targets) ignore potentially important synergies with human-focused goals, and may result in trade-offs.

We recommend that building and real estate researchers use evidence-based approaches, case studies and control trials to validate hypothetical contributions (*i.e.* those that fall beyond direct topic/subject matches) to better serve policymakers and practitioners. Because most projects (whether buildings, institutions, or investors) usually do not fully meet the requirements of all the standards' attributes, further research is needed to study the most implemented attributes and how they compare to the full standards in terms of overlap with the 2030 Agenda. Ultimately, we propose that more transformational, contextual, and comprehensive standards (Brandon et al., 2017) that are fundamentally designed around the SDGs are needed for the industry to contribute to the 2030 Agenda meaningfully.

4.8. Chapter Postscript

Chapter 4 approached Green and sustainable building and real estate standards (GSBRES) critically regarding their coverage and approach to the SDGs. The chapter argues that the prominent GSBRES are still designed on incremental improvement and are not fit for driving transformative change in the building industry. The chapter focused on three key standards across the life-cycle of the building, namely tackling the design (LEED V4.1 BD+C for New Construction (The U.S. Green Building Council, 2020) – shortened to LEED), operation (BOMA BEST V3 for the Universal Category (The Building Owners and Managers Association, 2018) – shortened to BOMA BEST), and investment (GRESB 2020 Real-Estate for Performance (GRESB, 2020) – shortened to GRESB) phases of building projects.

The chapter also considers the currently published interlinkage maps as well as synergy and trade-off analysis (Gusmão Caiado et al., 2018; Le Blanc, 2015; Stafford-Smith et al., 2017; Türkeli, 2020) to highlight the shortcomings of the fragmented approach of most prominent GSBRES. A four-step methodology was developed and validated to analyze these standards, including creating a topic suitable keyword-catalogue, analysis of overall overlaps, the effects of the schemes' scoring on the overlaps and qualitative analysis of their sustainability approaches.

The results of the analysis revealed several key insights:

- Most of the overlaps between the GSBRES and the SDGs were focused on the miscellaneous category, indicating general overlap with sustainable development topics that are not specific to one SDG.
- Some SDGs are solemnly addressed in the analyzed standards – such as SDG1, SDG2, SDG5, and SDG14.

- Only one standard, namely GRESB 2020 Real Estate (Performance), addresses issues related to institutions, transparency, governance and partnership – which are core to the 2030 Agenda's success.
- The GSBRES' most considerable attention is dedicated to sustainable consumption and production issues – rather than issues related to cities and communities.
- The scoring methodology of the standards appeared to skew their attention towards specific issues. For example, in LEED, the credit for one energy attribute appeared to constitute 16.36% of the total possible score. On the other hand, some other sustainability issues appeared to have less importance in scoring, such as climate change and economic development issues.
- The sustainability approach's analysis revealed that most of GSBRES' focus is dedicated to incremental improvements – with some efforts to propose triple bottom line approaches. Only three out of 54 attributes (i.e. credit categories) presented possible transformational approaches in LEED, and only 13 out of 79 attributes in GRESB. This highlights the fundamental mismatch between the Agenda's call for transformation and the current standards and tools used in the building industry.

When overlapping those results with the published synergy and trade-off data for the Agenda, we find those essential synergies are ignored, and potential trade-off tracks are augmented through the GSBRES' fragmented method. Most importantly, the chapter highlights that mainly the planet (*i.e.* the environmental) dimension of sustainability is addressed by the available standards – leaving the people, prosperity, peace and partnership dimensions unaddressed (United Nations, 2015). The findings presented exemplified that the analytical and statistical analysis published of the GSBRES' contributions to the SDGs miss the defining principles of the 2030 Agenda.

While some schemes present commendable approaches, the chapter concludes that the existing building industry sustainability standards still need a lot more development to be considered a means for attaining the SDGs' targets. Ultimately, the chapter proposes that more transformational, contextual, and comprehensive standards (Brandon et al., 2017) that are fundamentally designed around the SDGs are needed for the industry to contribute to the 2030 Agenda meaningfully.

The tension between innovative and status-quo approaches to the topic (which emerged in Chapter 2) becomes visible in this study's results – where innovation is associated with transformative approaches, and status-quo approaches are embedded in the incremental-improvement mindset[33]. While previous work has attempted to distinguish these two approaches theoretically (as seen in the work of Ceschin & Gaziulusoy, 2016; Cucuzzella, 2016a; Dyllick & Muff, 2016; Dyllick & Rost, 2017; Fletcher & Goggin, 2001; "Late Lessons from Early Warnings: The Precautionary Principle 1896–2000," 2001, none of these frameworks bridge the theoretical-methodological gap.

Combining the conclusions of Chapter 4 (regarding the limits of the current assessment approaches), with the characteristics of sustainable building analysis proposed in Chapter 2, Chapter 5 develops and tests two analytical maps that can be used in the integration of the SDGs in building projects. The tools propose qualitative approaches for integrating the SDGs and their analysis based on the comprehensive and nuanced understanding of the 2030 Agenda. Chapter 5 proposes this notion of future-outlook, or what it defines as sustainability design visions (SDVs), to understand designers' character and inspiration around the topics of the SDGs.

33 Cucuzzella (2016a) proposes to define those two approaches as the preventative (for the status-quo) and precautionary (for the innovative) risk management approaches.

CHAPTER 5.
INTEGRATING THE SUSTAINABLE DEVELOPMENT GOALS IN BUILDING PROJECTS

5.1. Foreword

Chapter 4 highlighted that, even though buildings have a significant potential to contribute to accomplishing the development goals, the current widely adopted sustainable building tools and standards and the predominant paradigm of eco-efficiency can be considered hurdles for the sector. Thus, and based on the context established in Chapter 2, new frameworks are urgently required to facilitate and evaluate the integration of the SDGs in construction projects.

Since the early 2000s, when environmental design imperatives have been institutionalized in the mainstream building practice (Yudelson, 2008b), design scholars and architects have been calling for more comprehensive and critical integration of sustainable design in buildings, as well as for new frameworks, tools and standards that encourage moving beyond the environmental and energy improvements (Alyami & Rezgui, 2012; Bernardi et al., 2017; Brandon & Lombardi, 2011; Raymond J. Cole, 2005; Raymond J Cole, 1999; Cucuzzella, 2011b; Díaz-López et al., 2019b; Doan et al., 2017; Eizenberg & Jabareen, 2017; Gibberd, 2015; Illankoon et al., 2017). The 2030 Agenda, which has gained significant attention from both public and private organizations, presents a new opportunity for the building sector to reconcile sustainable design requirements and with the broader sustainable development mission since it: 1) provides a clear and unified framework for development activities that are to be achieved by 2030, 2) presents sustainable development as a network of targets and goals, in contrast to fragmented definitions found in various economic sectors – such as the building sector, and 3) encourages unified action by being organized around stable and clear themes (Allen et al., 2018a; Bernardi et al., 2017; Diaz-Sarachaga et al., 2018; Doan et al., 2017; Eizenberg & Jabareen, 2017; Gibberd, 2015; Lafortune et al., 2018; Le Blanc, 2015; Lior et al., 2018; Nilsson et al., 2018).

While some published studies have proposed generic frameworks for implementing and attaining the targets of the SDGs, they remain abstract and unfit for the unique nature of building projects (Gusmão Caiado et al., 2018). This chapter aims to tackle this gap by developing a set of simple tools, consisting of analytical grids and maps, that can be used by building designers to 1) understand the agenda, its goals and targets, 2) localize the SDGs in building projects, 3) evaluate the level of integration of each goal in a given project, and 4) analyze the design approaches used in such integration.

Through an extensive literature review of more than 132 references, a composite theoretical framework that bridges concepts from the fields of design, engineering and development studies, and a practical methodology embedded in the integrated design process, this chapter aims to answer four key questions:

1. Why do practitioners need new tools and frameworks to deeply integrate the SDGs in building design?
2. How can the scope of the SDGs be scaled down to the building or building feature level?
3. How can the integration of the SDGs be analyzed and visualized?
4. How can such analysis illustrate the sustainable development visions of practitioners?

This is a co-authored chapter that is published in a journal. The thesis author is the first author and main contributor. The chapter specific publication details can be found in Appendix (C). The keywords for this chapter are listed in Appendix (B). The published chapter reference is:

Goubran, S., & Cucuzzella, C. (2019). Integrating the Sustainable Development Goals in Building Projects. *Journal of Sustainability Research*, *1*(2). https://doi.org/10.20900/jsr20190010

A simplified copy of this publication was presented in a conference and appeared in its proceedings:

Goubran, S., Cucuzzella, C., & Lee, B. (2019). Sustainable Development Goals to support the design of an energy positive interpretation center for UQROP in Quebec Canada. In A. Beth, R. Wener, B. Yoon, R. A. Rae, & J. Morris (Eds.), *Proceedings of the Environmental Design Research Association (EDRA) 50th Conference - Sustainable Urban Environments*. Environmental Design Research Association (EDRA). https://cuny.manifoldapp.org/read/untitled-0a85ebc9-1f00-4fd9-b7c3-e399e1a35136/section/48b9458f-a996-4fbe-b93b-452dd00a07f9

5.2. Published abstract and graphical abstract

Building designers are struggling to deeply integrate the 2030 Agenda and its Sustainable Development Goals (SDGs) in projects. The review of the literature revealed that the available research is focused on linking the current practices, including sustainable building practices, with the SDGs. This has, in turn, limited the development of novel approaches as well as new building design methodologies that specifically aim at attaining the agenda's targets. To help building design teams achieve the meaningful integration of the agenda's five Ps, this paper proposes two analytical mapping tools which can be used during the integrated design process to track the integration of SDGs in the building projects, and to analyze the building design approaches and visions in reference to the topics of the goals. The research uses a case study for an energy-positive building in Quebec to test the proposed tools. The analysis focuses on the integration of 8 of 17 SDGs, discusses the specific building features which were used to achieve this integration, and analyzes the team's design visions regarding the goals. The results reveal that in the case studied, the integration of the 8 SDGs moves beyond the current standards by mostly applying design approaches which are future-driven and focused on products and technologies. This research provides important practical tools that can inform building practices in the private and the public sector and contributes to the theory and practice of sustainable building design. It also supports the current effort towards the implementation and localization of the SDGs.

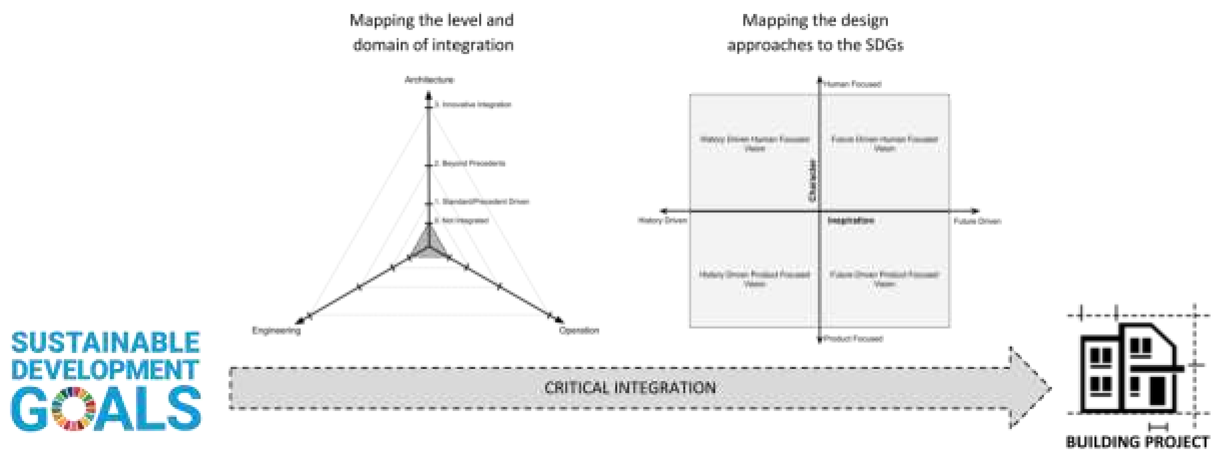


Figure 5.1. Graphical Abstract.

5.3. Introduction

With more than 100 definitions for sustainability and 600 assessment methods available in the literature, design teams are facing uncertainties regarding the criteria and definition to adopt in sustainable building projects (Bernardi et al., 2017; Doan et al., 2017). In the last 10 years, researchers focusing on sustainability in the built environment have consistently concluded that existing standards and tools are largely focused on the environmental dimension of sustainability (Alyami & Rezgui, 2012; Raymond J. Cole, 2005; Díaz-López et al., 2019b; Illankoon et al., 2017). Also, they highlighted that the available standards are commonly lacking indicators regarding the contextual, social, cultural and economic aspects of buildings (Bernardi et al., 2017; Brandon & Lombardi, 2011; Cucuzzella, 2011b; Doan et al., 2017). Although there have been many attempts to establish new frameworks that integrate sustainability more comprehensively in buildings and the built environment, their wide adoption has been rather limited (Bernardi et al., 2017; Eizenberg & Jabareen, 2017; Gibberd, 2015). Today, international sustainable development agendas are gaining more attention beyond the public sector and are being increasingly integrated into private organizations and local practices (Loh et al., 2017; Pedersen, 2018).

The approval of the 2030 Agenda in 2015 marked a global milestone in the field of sustainability and sustainable development (United Nations, 2012, 2015; Wysokińska, 2017). The agenda, including its Sustainable Development Goals (SDGs) and their targets, established a clear expansive framework for development which dedicates equal attention to the environmental, social and economic pillars of sustainability (Diaz-Sarachaga et al., 2018). Moreover, the agenda's targets were strategically structured around five key themes: people, planet, prosperity, peace and partnership—commonly known as the five Ps (Jayasooria, 2016). The 2030 Agenda offers a stable and global definition for sustainability over the next 10 years which is accompanied by global, national and local commitments (Allen et al., 2018b; Pedersen, 2018; United Nations, 2015, 2017). This stability could benefit the construction sector, especially building designers, in overcoming some of the current limitations and assist in the sector's transition beyond its current ecological and energy performance focus (Ni et al., 2015; Pedersen, 2018; Roetzel et al., 2017).

Achieving meaningful integration of the five Ps in building projects requires stepping back from the existing quantitative criteria for assessment, to consider the broader potential contribution of buildings to the SDGs and their targets. It also requires exploring the means to translate the global focus of the agenda to the local and project-specific level (Gusmão Caiado et al., 2018; Loh et al., 2017). Although there has been a number of frameworks proposed for achieving the SDGs, they remain mostly conceptual in nature and are not adapted to specific needs of construction and building projects (Gusmão Caiado et al., 2018). Available building-related research is aimed at intersecting individual credits or credit categories from dominant certification systems with the SDGs and estimating how they nominally contribute to the Agenda (Alawneh et al., 2018; Alawneh, Ghazali, Ali, & Sadullah, 2019). However, and to the best of the researchers' knowledge, no publications have attempted to propose frameworks that aim at facilitating and evaluating the integration of the SDGs in construction projects. Additionally, the authors were not aware of any research that aims to analyze design approaches on the topics of the SDGs in building projects.

This research aims to address these gaps by proposing two analytical maps that can be used by building design teams during the integrated design process (IDP) (Busby Perkins+Will & Stantec Consulting, 2007; The Institute for Market Transformation to Sustainability (MTS), 2012). The tools are specifically developed to aid designers to understand and integrate the SDGs in building projects as well as to analyze the design approaches used in such integration. The paper starts by presenting a review of the relevant literature regarding the 2030 Agenda, and an overview of some of the current debates regarding sustainability in the built environment as well as its integration and design approaches. The methodology section of the paper presents the two maps and the theoretical frameworks used for their development. Additionally, the paper presents a list of building design questions which are based on the 17 SDGs along with the proposed method of application of the tools in real building projects. To illustrate and test the applicability of the proposed maps and analysis process, a case study for the design on an energy positive and low-carbon building in Quebec (Canada) is used. The methods section of the paper details the specific research tools that were used to apply the proposed methodology to the case study selected. The results section of the paper presents the outcome of the analysis conducted for the case. Since the authors were part of the integrated design team for this project, the paper also synthesizes the observations made during the design process. Finally, the discussion and conclusion sections present some of the broader implications of this research and propose some key directions for future research.

5.4. Review of literature

5.4.1. Sustainability in the built environment

Sustainability is often understood to be the resultant of the balanced intersection between the social, economic, and environmental dimensions. Scholars have also proposed to include the cultural, institutional, political as well as ethical dimensions as core pillars to sustainable design (Doan et al., 2017; Ehrenfeld, 2009). Since the rise of environmental design in the 1960s, the integration of the philosophy of sustainability in building and construction projects has led to the emergence of many doctrines around the topic (Tabb & Deviren, 2014). As suggested by Zuo and Zhao (2014), the current debates surrounding sustainability in the built environment can be categorized broadly around three key questions: (1) why sustainable buildings? (2) what is a sustainable building? and (3) how to achieve sustainability in buildings? Across all these debates, two key polarities can be consistently observed: (A) functionalist approaches which are regulatory in nature (*i.e.*, aiming to establish sustainability in the built environment as a pragmatic field guided by quantitative standards), and (B) humanist approaches which are radical in nature (*i.e.*, aiming to establish sustainability in the built environment as non-regulatory field able to generate radical change and innovation) (Goubran et al., 2017). To provide reasoning for adopting sustainability in buildings, many sources cite the economic benefits as the key motivators; which include energy savings, environmental gains, health and productivity improvement, or return premiums (Eichholtz et al., 2010; Jiang et al., 2009; S. A. Jones & Laquidara-Carr, 2016; Murray & Rivers, 2015; Zuo & Zhao, 2014). While climate change mitigation, awareness, social cohesion, resilience, quality, beauty and environmental stewardship seem to be some of the motivators cited in the more humanist approaches to the topic, a large portion of the design literature still responds to the market need for quantifiable benefits—whether political, social, economic, or environmental—in order to appeal to investors, governments and end-users (Allen et al., 2018b; Brouwer et al., 2012; Raymond J. Cole & Lorch, 2003; DeKay, 2011; Government of Canada, 2018; Gupta & Vegelin, 2016; Hosey, 2012). Today, the definition of sustainability in the built environment has been primarily shaped by the available environmental assessment tools and standards (Cucuzzella, 2015a; Tabb & Deviren, 2014). Furthermore, the debates surrounding the definition of sustainability are inherently linked to and reinforced by the methods available for achieving it in building projects (Arroyo, 2014; Ehrenfeld, 2009; Giddens, 1984; Goubran et al., 2017). On the one hand, scholars suggest that sustainability in buildings can be achieved by satisfying sets of quantifiable criteria (Ade & Rehm, 2019; Bernardi et al., 2017; Boyko et al., 2012; Brandon & Lombardi, 2011; Doan et al., 2017; Kylili et al., 2016), while others are proposing to move away from quantification towards the qualitative comparison of projects with the help of analytical frameworks and maps (Cucuzzella, 2009; Markovich et al., 2018).

It is certain that green building rating tools have gained popularity on an international scale (S. A. Jones & Laquidara-Carr, 2018). Numerous sources which compare green building rating methods are available (they are also referred to as environmental assessment tools, building sustainability assessment tools, green building rating systems, sustainability assessment systems, or sustainable building assessment methods) (Berardi, 2012; Bernardi et al., 2017; Bragança et al., 2010; Díaz-López et al., 2019b; Ding, 2008; Doan et al., 2017; Illankoon et al., 2017; Mattoni et al., 2018). Depending on the geographic origin of the research, different tools have been named as the "most famous", "most used" or "most widespread": in research originating from North America, LEED was identified as the most common (such as (Mattoni et al., 2018)), while in Europe BREEAM was identified as the prevailing system (such as (Bernardi et al., 2017; DLA Piper, 2014)). Though LEED has the most citations in academic literature, BREEAM (originating from the UK) and HQE (originating from France) each have significantly larger numbers of building certified in their portfolio (Bernardi et al., 2017). Thus, for researchers to focus on one or a few of the available methods, they directly limit the scope and implication of their work to regions where these methods are readily used. While the academic literature remains focused on rating and assessment, market reports (such as (Bernstein et al., 2013; DLA Piper, 2014; S. A. Jones & Laquidara-Carr, 2016, 2018)) are highlighting, based on the surveys of practitioners and global market leaders in construction, key problems related to those systems: (1) 80% were in favour of a unified (single) green certification body rather than numerous options, (2) 53% relate the benefit of using a green building rating system to marketing and competitive advantages, also from those who don't use the current systems (3) 79% identified the cost related to rating as the main hurdle for not using the systems (a 20% increase from 2015), and (4) 17% indicated that they find those ratings not ambitious enough. In light of this data, the validity of these tools to support global sustainable development could be questioned and it could be argued that the cost related to rating/certifying buildings could present real hurdles in underdeveloped and developing regions.

Some researchers have also proposed that the available tools distort the definition of sustainable development and overlook the synergies possible between the economic, social and environmental pillars (Berardi, 2012; Boyko et al., 2012; Rashid & Yusoff, 2015). Comparative studies revealed that almost all the most used tools (namely LEED, BREEAM, Green Star, CASBEE, SBTool, and ITACA) have energy as the main credit criterion (Berardi, 2012; Bernardi et al., 2017; Illankoon et al., 2017; Mattoni et al., 2018). While different references highlighted the benefits and gaps in each of those systems, another common finding across the studies is that the economic, institutional and social features of buildings are rarely considered in the tools (Berardi, 2012; Illankoon et al., 2017; Mattoni et al., 2018). Over the years many developments have been made to these systems, which have significantly expanded their scope and scale. However, considering this significant gap, the coherence of these tools with the UN 2030 agenda has to be studied in further depth. Additionally, and due to criticism of the unsuitability of analyzing the sustainability of a building in separation from its surrounding, a number of systems have introduced neighbourhood or regional level assessment methods—including LEED, CASBEE, BREEAM, DGNB (Berardi, 2012; Reith & Orova, 2015). While each of these systems provides specific benefits (in terms of focus categories or minimum requirements), the regional limitations which were mentioned for green building rating methods are still applicable to these tools (*i.e.*, research using one or a few of these tools is limited geographically to regions where tools are readily used).

Díaz-López, Carpio, Martín-Morales and Zamorano in their critical analysis of sustainable building assessment methods published in 2019 (2019) move beyond simple comparisons by assigning existing methods (specifically 36 of 101 identified methods) to 1 of 3 categories: (1) systems, where the level of sustainability of a building (and its sub-systems) is assessed, (2) standards, where minimum performance requirements are used to determine the compliance of a building and its systems with a set of pre-defined criteria, which are usually voluntary, and (3) tools, which are not geared towards compliance or certification but provide design teams with support tools for sustainable design. The methodology proposed in this research falls within the 3rd category—providing tools that can be used by building design teams to support sustainable design decisions.

Scholars have attempted to explore the decision making and design processes in architecture and planning projects but have identified a significant gap in the body of knowledge relating to sustainability decisions (Feria & Amado, 2019). Scholars have also pointed to the fact that sustainability-related decisions in the architecture, engineering and construction industry are still made without enough rigorous analysis (Fischer & Adams, 2011). In the design of commercial buildings, the sustainability decision-making process is solely focused on cost reduction (*i.e.*, upfront or operational cost savings) or on achieving credits for green rating systems (such as LEED or others) (Arroyo, 2014). These narrow-focused approaches reflect the concerns voiced in the literature on the use of assessment systems as design tools—such as those presented in (Cucuzzella, 2015c, 2019a; Ding, 2008). While different theoretical models for planning and design present unique approaches to the topic of sustainability (e.g., as suggested in (Feria & Amado, 2019; Næss, 1994) these include transactive, scientific, advocatory, incremental or synoptic models), none has sustainable development explicitly as a core goal (Feria & Amado, 2019). Additionally, and due to the large number of stakeholders involved in the decision-making process of commercial building design, there are often conflicting interests and a multitude of perspectives being presented during the IDP (Arroyo, 2014; Goubran, Masson, et al., 2019). Moreover, scholars have highlighted many of the sustainability-related decisions, even in the context of the IDP (Busby Perkins+Will & Stantec Consulting, 2007; The Institute for Market Transformation to Sustainability (MTS), 2012), usually come late in the design process—resulting in loss of time and resources and also generating conflicts and tensions in the design team (Arroyo, 2014; Lützkendorf & Lorenz, 2006). Today, with the multitude of adjectives describing projects and even cities (such as eco, resilient, low carbon, sustainable and many others), there is a need for unified definitions and frameworks regarding the urban future (Ahvenniemi et al., 2017;

Arroyo, 2014; Bayulken & Huisingh, 2015; de Jong et al., 2015; Lützkendorf & Lorenz, 2006; Zuo & Zhao, 2014). As highlighted in the recent literature, the 17 SDGs offer an opportunity to bridge the gap between the functionalist and human approaches to sustainability and to provide a unifying framework to guide the development of cities and building projects (Pedersen, 2018; United Nations, 2015; Wysokińska, 2017).

5.4.2. The 2030 Agenda and buildings

The United Nations Conference on Sustainable Development held in 2012, known as Rio+20, concluded with the official text known as the Future We Want: Our Common Vision (United Nations, 2012). This document set out the key guidelines for global collaboration towards a comprehensive approach to sustainability and, in turn, led to the development of the 2030 Agenda and its SDGs (including its 169 targets and 230 indicators) (Gupta & Vegelin, 2016; Gusmão Caiado et al., 2018). The SDGs, which came as a successor to the Millennium Development Goals (MDGs), are structured around what are commonly known as the five Ps (Planet, Prosperity, Peace, People and Partnership) and are considered to be comprehensive to both human and natural needs (Gupta & Vegelin, 2016; Jayasooria, 2016; Le Blanc, 2015; Moyer & Bohl, 2019; Salvia et al., 2019). Since the 2030 agenda came into effect at the beginning of 2016, there has been an increasing number of publications, by both academics and practitioners, which aim at analyzing its goals and targets; exploring its implementation means, processes and progress; studying its connection with existing policies and practices; or criticizing its economic growth focus or the contradictions within its targets (Allen et al., 2018a, 2018b; Diaz-Sarachaga et al., 2018; Lafortune et al., 2018; Le Blanc, 2015; Lior et al., 2018; Nilsson et al., 2018). Some of the available work also explores the consequences and links between the targets of the SDGs and specific economic sectors (Caldés & Rodriguez-Serrano, 2018; Di Foggia, 2018; Santika et al., 2019).

Allen, Metternicht and Wiedmann (2018b) intersected the national progress reports of 26 countries (*i.e.*, reports submitted for review to the UN regarding the implementation progress for the SDGs) with the approaches and methodologies found in the academic literature—including implementation steps (such as action plans, mapping, consultation and others) and evidence-based approaches (such as benchmarking, multi-criteria analysis and others). They were able to find a number gaps in the reports (*i.e.*, gaps between the reports content and the strategies and methods proposed in the academic literature); the most significant of these gaps are prioritization, quantitative modelling, policy evaluation, and need assessment related. They concluded that the current and most common approaches to the implementation of the SDGs are based on fitting and linking the goals with existing policies and programs and that there is a limited number of programs and policies specifically developed based on the agenda (Gusmão Caiado et al., 2018; Salvia et al., 2019). Gusmão Caiado, Leal Filho, Quelhas, Luiz de Mattos Nascimento and Ávila (2018) found that some of the operational hurdles in the implementation of the 2030 Agenda require new strategic frameworks to be developed. They proposed a framework which is rooted in innovation, education, implementation and monitoring (Gusmão Caiado et al., 2018). Their findings are critical in moving forward with the implementation of the SDGs since it indicates the inadequacy of the existing methods and processes to tackle the large scope of the agenda. Moyer and Bohl (2019) analyzed the possibility of achieving a number of human development targets under 5 different future scenarios that they built (namely: status quo, consumption pattern change, decentralized solutions, technology-led, or a combined approach). While they found limitations in the successful implementation of human development targets in all the scenarios explored, their most significant conclusion is that the goals and targets required to be completely reorganized under each of the scenarios (*i.e.*, each scenario dictated its own priorities and presented different needs) (Moyer & Bohl, 2019). Their findings are supported by the multi-criteria analysis conducted by Allen, Metternicht and Wiedmann (2018a), the assessment of the experts' SDG priorities conducted by Salvia, Leal Filho, Walter, Brandli and Griebeler (2019), and the mapping and network analysis completed by Le Blanc (2015). By combining these academic findings, it can be concluded that, not only that existing programs and policies present gaps and limitations to the agenda's implementation, but that the priorities and focus of programs need to be adapted dynamically based on local factors (*i.e.*, political, social, economic and environmental factors) and program-specific factors (*i.e.*, its scope, nature, stakeholders and goals). This is significant in the context of sustainability in buildings since existing standards, programs and codes could present similar gaps and limitations. Additionally, the literature highlights the need for new, and more expansive, frameworks in order to achieve considerable progress in the implementation of the agenda.

In their 2018 paper, Alawneh *et al.* (2018) attempted to explore the nominal contribution of a number of LEED water and energy credits to SDGs 6, 7, 8, 9, 12, 13 and 15 with a specific geographic focus on Jordon (middle east). The authors used a questionnaire, completed by 55 local experts in green building, to propose a contribution index. They followed up this publication by an article (Alawneh, Ghazali, Ali, & Sadullah, 2019) which explores more broadly the contribution of the assessment categories in 6 rating systems available (namely LEED, BREEAM, CASBEE, Green Star, Green Mark and GBI) to SDGs 3, 6, 7, 8, 9, 11,12, 13 and 15 (with a nominal reference to all SDGs). In this 2019 article, the authors use the Delphi method (with 45 local experts) to further validate the contribution index they calculate for each credit category and then propose a framework to integrate assessment indicators into non-residential building projects in Jordan. While these studies highlight some of the synergies that could be available between rating tools and some of the SDGs, the results presented are limited to the geographic area of focus (namely Jordan). Additionally, the paper did not explore how such contributions can be achieved (*i.e.*, they do not present practical examples) and do not provide a concrete methodology for localizing (scaling down) the goals to the project level. Instead, their methodology presupposes that achieving a specific requirement or indicator in the rating system automatically generates a contribution to the SDG. Finally, and in contrast to the findings of researchers focused on the 2030 Agenda, the findings propose positive contributions to the SDGs for all indicators investigated and do not explore some of the trade-offs which might be present as proposed by (Allen et al., 2018a; Gusmão Caiado et al., 2018; Moyer & Bohl, 2019). Furthermore, and although this approach is a positive first step, it reinforces the current building practices and does not aid in the development of new, more sustainable, approaches for building design (Berardi, 2012).To the best of the authors' knowledge, there are no academic or industry references which investigate the critical design integration of the SDGs in building projects, and no references which propose practical tools to help designers in such integration. Additionally, no global-scale studies have been found which investigate the synergies and trade-offs between the SDGs and their targets with various available green building tools (such as LEED, CASBEE, BREEAM and SBTool), their sub-systems (*i.e.*, for new buildings, communities, or neighbourhoods).

Other researchers have proposed expansive and universal methods to assess the integration of SDGs in projects and strategies (Loh et al., 2017). However, the complexity of the assessment process and the lack of customization present hurdles to their use in building projects. As Brandon and Lombardi suggest, the global focus of the agenda makes its implementation complex and requires new collaborations between a bigger number of actors (Brandon & Lombardi, 2011).

Thus, to fully utilize the transformative potential of the 2030 agenda there is a need to explore innovative and collaborative tactics. This would require the SDGs to be introduced in the early design phases of projects (von Geibler et al., 2019). The IDP, which has become common practice for high-performance and green buildings, offers the opportunity for such early integration while fostering constructive collaboration between the different stakeholders of building projects (Busby Perkins+Will & Stantec Consulting, 2007; Kanters & Horvat, 2012; L. Wen & Hiyama, 2016). Although some of the SDGs are linked to quantifiable indicators, mapping tools, which enable a pluralistic understanding of the topics and content of the agenda, are seen to be more adapted for the integration of the SDGs in early phases of building projects (Cucuzzella & Goubran, 2019; Goubran et al., 2017; Guy & Farmer, 2000; Guy & Moore, 2007).

5.4.3. The Integration of sustainability in design

Although the IDP's main goal is to harmonize the design intents of different stakeholders and to streamline the design decision-making process (Busby Perkins+Will & Stantec Consulting, 2007), it does not intend to blur the line between the duties of the different experts: each expert on the team is expected to positively share their knowledge in their respective fields in order to solve the often complex problems connected to the design and operation of sustainable buildings (Hansen & Knudstrup, 2005). The IDP literature usually distinguishes between the architectural and engineering concerns in buildings design—the first dealing with volumetric, aesthetic, material, visual, and functional qualities, while the latter addressing issues related to energy solutions and targets, indoor environment, technology, building systems and controls (Busby Perkins+Will & Stantec Consulting, 2007; Hansen & Knudstrup, 2005; Kanters & Horvat, 2012). Additionally, current practices of IDP are increasingly considering the complete life cycle of buildings—including the building operation and post-occupancy phases (Busby Perkins+Will & Stantec Consulting, 2007; Kanters & Horvat, 2012). To meaningfully consider these late phases requires including the building operators (*i.e.*, building owners and the operation & maintenance staff) within the IDP (The Institute for Market Transformation to Sustainability (MTS), 2012). The operational dimension of the building often addresses issues related to management, maintenance, operation and usage, and programming. Recently, in state-of-the-art sustainable buildings, building operators and owners are also frequently expected to implement awareness and educational programs—these usually entail tours and presentations that describe the sustainability features of their building to the public (Chansomsak & Vale, 2008; “Du Didact. En Archit. / Didact. Archit.,” 2019). It is important to note that the specific dynamics of each IDP team depends on the planning and design model followed and on the decision-making process adopted. In some projects, simpler, more flexible and more inclusive processes are used which could provide stronger connections with the objectives of sustainable development (Cucuzzella, 2009; Feria & Amado, 2019; Næss, 1994). Thus, even in an IDP context, the main pillars of building design can still be considered architectural, engineering, or operational in nature.

Various theoretical models and approaches are available to measure or assess the level of sustainability or its integration in products, services or designs (Bhamra, 2004; Ceschin & Gaziulusoy, 2016; Dewberry, 1995, 1996; Dewberry & Goggin, 1996). In his seminal publications, Brezet (1997) proposed one of the most used theoretical models for categorizing the levels of sustainable design, (what at that time was commonly known as eco-design). He proposed 4 distinct levels: (1) product improvements, (2) product redesign, (3) functional innovation, and (4) system innovation. In their article published in 2001, Fletcher and Goggin (2001) divide eco-design approaches into 3 distinct categories: (1) product-focused: an approach which focuses on improving the efficiency of existing product and services; (2) results-focused: an approach focused on producing the same outcome or result in different, more sustainable manner; and (3) needs-focused: an approach which questions the need to be fulfilled and its mode of fulfilment. Cucuzzella, by using the work of Dewberry (Dewberry, 1995, 1996; Dewberry & Goggin, 1996), Brezet (1997) and Fletcher and Goggin (2001), proposes to combine Brezet’s first 2 levels into what can be considered a product optimization stages, and the last two levels into innovation-based stages (Cucuzzella, 2016). Thus, it can be understood that by increasing the integration of sustainability in a design requires an increased level of innovation. Bhamra (2004) further defines this by distinguishing the two basic levels of sustainable design: (1) incremental, where environmental and sustainability issues are considered as technical problems that should be solved using technology, efficiency, optimization; and (2) innovative, where sustainability issues are used as the driver for new and more radical concept development that can be approached by marrying culture, technology, nature and creativity. In the field of building design, the incremental approaches have been usually linked to the use of sustainability assessment tools—which are rooted in an optimization and eco-efficiency mode of reasoning (Berardi, 2012; Raymond J. Cole, 2005; Cucuzzella, 2009, 2011b; Goubran, Masson, et al., 2019; Lehni & World Business Council for Sustainable Development, 2000). By combining the theoretical models presented, 4 levels of sustainability integration in buildings can be proposed: (1) not considered, (2) following available standard practice (*i.e.*, where a specific issue is considered based on current standard practice), (3) incremental improvement rooted in optimization and efficiency (*i.e.*, rooted in current modes of design and assessment), (4) innovative (*i.e.*, where the design shows signs of functional or system innovations by moving beyond optimization strategies).

5.4.4. Sustainable design approaches

Instead of an incontestable approach to sustainability, which ignores local knowledge along with social, economic and ecologic realities, scholars suggest to understand approaches to sustainability as design logics (Guy & Farmer, 2001; Orr, 2002)—where *logic* can be defined as a group of ideas or concepts, which give meaning to social and physical reality, that can be produced and reproduced, and that can develop through practice (Hajer, 1995; Prishtina, 2018). As such, and based on Schön's ideas, sustainability could be perceived as an emergent property of design thinking through reflection-in-action (Bovati, 2017; Boyko et al., 2012; Cucuzzella, 2015b; A. D. Schön, 1983). Nelson and Stolterman highlight that design enables the creation of objects which reflect the conditions the world "ought to be" by enabling human intentions to reshape the world (Nelson & Stolterman, 2012). For the authors, designers create the "real" world through their endeavours by materializing the sought-after state of the world that the involved parties desire. Jean-Pierre Boutinet (2005) places projects in the "partially determined" mode of anticipation; for him, the project is an anticipation of the desired future. In the context of IDP in building design, this sought after state should encompass the collective desires of the stakeholders and design team (Busby Perkins+Will & Stantec Consulting, 2007; Kanters & Horvat, 2012). The 2030 Agenda, although not often considered as a design project, shares a number of commonalities with projects and design: it presents an outlook for the desired future (*i.e.*, what the world ought to be) which was imagined through an inclusive participatory process (Gusmão Caiado et al., 2018). In fact, the agenda reflects the four characteristics of projects proposed by Boutinet (2005): (1) a global approach that is beyond the sum of its objectives, (2) a singular approach that seeks original responses to specific situations, (3) a tool for dealing with complexity and uncertainty, and (4) an open system (System in this context is used to refer to system thinking approaches (Le Moigne, 1999; Morin, 2008; Morin & Weinmann, 1994)) that allows for modifications (Boutinet, 2005).

Boutinet proposes to analyze projects based on their motivational (technic vs existential) and anthropological (collective vs. individualistic) nature (Boutinet, 1993, 2005, 2014). The motivational axis of Boutinet's map reflects a common tension in building project between social consideration and technological integration—one that has been also explored by Guy and Farmer (2001). Fry (2009)proposes the notion of "futuring" for rethinking sustainability in building projects. For Fry, futuring is a re-directive practice that is tuned towards helping sustain humanity, the planet and other species—an approach that is future driven (Fry, 2009). On the other hand, Fisher calls for rethinking our efficient connected mode of living and to replace them by a more vernacular model that is inherently more resilient—an approach that is history driven (Fisher, 2008). He sees a need for using indigenous talent and practices, local materials, along with traditional and cultural principles in order to succeed in building cohesive communities and to re-connect with nature (Fisher, 2008). Table 5.1 summarizes the key models presented in the literature review and their relevance to the methodology of this paper.

Table 5.1. Summary of theoretical models and literature reviewed and their relevance to the methodology of the article

Subject		Relevant Literature	Specific References
Fields of sustainable building design		Integrated design theory and practice	(Busby Perkins+Will & Stantec Consulting, 2007; Chansomsak & Vale, 2008; Cucuzzella, 2009; “Du Didact. En Archit. / Didact. Archit.,” 2019; Feria & Amado, 2019; Hansen & Knudstrup, 2005; Kanters & Horvat, 2012; Næss, 1994; The Institute for Market Transformation to Sustainability (MTS), 2012)
Integration of sustainability in design		Theoretical models of eco-design (sustainable product design theory)	(Berardi, 2012; Bhamra, 2004; H. Brezet, 1997; J. C. Brezet, 1997; Ceschin & Gaziulusoy, 2016; Raymond J. Cole, 2005; Cucuzzella, 2009, 2011b, 2016; Dewberry, 1995, 1996; Dewberry & Goggin, 1996; Fletcher & Goggin, 2001; Goubran, Masson, et al., 2019; Lehni & World Business Council for Sustainable Development, 2000)
Sustainable design approaches	The motivation and character of the approach	The theory of projects and their trajectories	(Boutinet, 1993, 2005, 2014; Bovati, 2017; Boyko et al., 2012; Cucuzzella, 2015b; Guy & Farmer, 2001; Hajer, 1995; Nelson & Stolterman, 2012; Orr, 2002; Prishtina, 2018; A. D. Schön, 1983)
	The inspiration and influence	Theory and practice of sustainable design (ethics of sustainable design)	(Bovati, 2017; Boyko et al., 2012; Cucuzzella, 2015b; Fisher, 2008; Fry, 2009; A. D. Schön, 1983)

5.4.5. Concluding remarks of literature review

The review of the literature pertaining to sustainability in buildings revealed an ongoing tension between functionalist approaches which aim to establish sustainability in the built environment as a pragmatic field guided by quantitative standards and humanist approaches which aim to establish sustainability in the built environment as a non-regulatory field able to generate radical change and innovation. Sustainability and green rating and certification methods constitute a substantial portion of the available research. Comparative studies of the most prominent certification and rating tools revealed a focus on the environmental dimension and general inattention to the social and economic dimensions of sustainability. Based on the findings reported in the literature, assessment and certification tools were also found to be regionally dependent and presenting some limitations due to the costs needed for certification. Stemming from these limitations, a humanist approach, focused on change and innovation, was found to be the most appropriate for developing a broad approach for integrating the SDGs in building design. To the best of the author's knowledge, there were no references which aimed at utilizing 2030 Agenda itself as the basis of a framework for understanding and approaching sustainability in buildings.

The literature pertaining to the SDGs was mainly distributed between studies that analyze the agenda itself (*i.e.*, focusing on links, synergies and trade-offs between the goals and targets) or its means of implementation (through prioritization and scenario building). The findings of the literature highlight the strong interlinkages between the SDGs and their targets and the tendency to fitting and linking the goals with existing policies and programs. Additionally, the findings of sources in the first category point to the fact that the priorities and focus of programs and projects need to be adapted dynamically based on local factors and program/project-specific factors. The research which aimed at intersecting sustainable building design with the SDGs followed the same strategies, where exiting credits and rating tools were fitted and linked to the goals with a regional and topic-specific focus. To the best of the authors' knowledge, there are no academic or industry references which investigate the critical design integration of the SDGs in building projects, and no references which propose practical analytical tools to help designers achieve such integration.

This research aims to address those two gaps by (1) utilizing the SDGs and the 2030 Agenda as a framework for approaching and analyzing sustainable building design, and (2) design and test practical analytical tools which could be used in the early design stages to meaningfully and critically integrate the topics of the 17 SDGs in the design of buildings.

The IDP literature was found to be the most appropriate when exploring the process of integrating sustainability in building design. The reviewed sources highlighted that the process aims at mediating between the architectural and design concerns, the engineering concerns, and operational concerns. The literature which aimed at assessing the level of integration of sustainability in design distinguished between incremental approaches (which frame sustainability issues as technical problems and are usually focused on harm reduction, optimization and product redesign) and innovative approaches (which frame sustainability issues as a driver for innovations). To understand the approaches to sustainable design, a number of important design and sustainable design theory references were reviewed (summarized in Table 1). The methodology section presents how the integration and design literature was used for constructing the analytical tools for this research.

5.5. Methodology

5.5.1. Mapping the integration of SDGs in building projects

As reviewed in the previous section, the analytical map (Figure 5.2) proposed for assessing the integration of the SDGs in building projects is structured around the three fields (axes) which are usually considered in the IDP (namely, Architecture, Engineering and Operations) (Busby Perkins+Will & Stantec Consulting, 2007; Kanters & Horvat, 2012). By using the levels of integration presented from the available literature (Loh et al., 2017), the map proposes 4 distinct levels of integration for each of the three axes:

Level 3: Innovative integration: This highest-level of integration entails developing innovative approaches to tackle the specific SDG topic in the design and planning for the project;
Level 2: Beyond precedents: This level entails augmenting the available approaches and standards to the SDG topic—*i.e.*, using the criteria of existing approaches or tools while refining them or surpassing their performance requirements;
Level 1: Standard or precedent driven: This level of integration entails using and depending on the criteria in available examples and standards for addressing a specific topic;
Level 0: Not Integrated: Since each of the goals' integration will be analyzed for each of the 3 axes, some goals might only be integrated into one dimension of the project—making them not integrated on the other axes (*i.e.*, integrated at level 0).

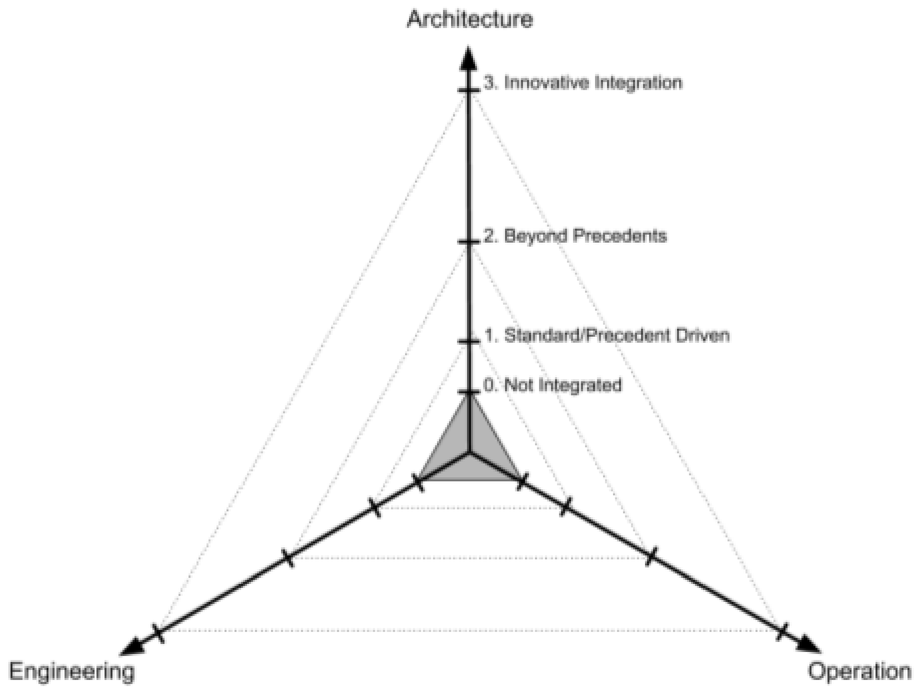


Figure 5.2. Proposed mapping tool for evaluating the SDG integration in building projects.

Since SDG 11 (make cities and human settlements inclusive, safe, resilient and sustainable) has been cited as one of the most relevant to the construction industry (Di Foggia, 2018; Goubran, Masson, et al., 2019; Lynch & Mosbah, 2017), it can be used as an illustrative example for these different levels of integration across the 3 axes. Within SDG 11, the most relevant targets to building projects include: target 11.4 (protecting cultural and natural heritage), target 11.6 (reducing per capita impact of cities—specific attention to air quality and waste management), target 11.8 (access to green and public spaces), and target 11.B (local disaster risk management). Table 5.2 presents some of the possible building features which relate to SDG 11.

Table 5.2. Example of building features which relate to SDG 11 across the 3 axes and the 3 levels of integration (excluding level 1: not integrated)

Axis	Level 1	Level 2	Level 3
Architecture (focus on target 11.8: access to green and public spaces)	Meeting requirements for outdoor and green spaces: such LEED's 30% and 25% of total site area for outdoor and green spaces proposed for new buildings (The U.S. Green Building Council, 2020)	Providing more open and green spaces than the current standard: such as providing more than 30% outdoor spaces and more than 25% green spaces.	Providing more outdoor and green spaces than required by available standards while presenting new approaches for integrating green and outdoor spaces within the building (such as semi-enclosed spaces or seasonal based outdoor-indoor spaces) and maximizing the access to the outdoor spaces and ensuring the high quality of their design.
Engineering (focus on target 11.6 (reducing per capita impact of cities—specific attention to air quality and waste management)	Complying with for pollutants control and air quality standards and controlling waste. This could be based on meeting the criteria proposed by LEED for new buildings on indoor air quality and control of pollutants, as well as collection and storage of recyclables or controlling construction waste (The U.S. Green Building Council, 2020)	Aim at achieving better control on pollutants which affect air quality both indoor or outdoor (such as carbon emissions and chemicals) through the use of advanced filters and avoidance of use. Additionally, focusing on creating a comprehensive waste management strategies and technologies that move beyond than recycling to consider reduction and reuse.	Along with the strategies from level 2, the building could integrate engineered waste management solutions on-site (such as small-scale composting facilities, or a compactor to reduce the emissions related to waste transport). The building could also set zero air pollution targets—by ensuring the use of clean energy technologies.

Table 5.2. *Cont*.

Operation (focus on target 11.4 protecting cultural and natural heritage)	Implement a comprehensive site management policy to reduce harmful chemical use, energy waste, water waste, air pollution, solid waste, and/or chemical runoff: such as meeting the criteria proposed by LEED for operation and maintenance of sites (The U.S. Green Building Council, 2020).	Introducing policies that are centred around protecting, promoting and restoring biodiversity on the site—moving beyond harm reduction. This would entail reintroducing native vegetation to the site beyond the current LEED requirements of 20% from the site area (The U.S. Green Building Council, 2020). The operation could also aim at minimizing disturbances to existing ecosystems on the site.	Developing a non-anthropocentric management and operation plan for the building by considering the well-being of different creatures occupying the site. This could include maintaining and supporting the habitats for animals, insects, and plants as part of the operation plan.

5.5.2. Analyzing the design approaches to the SDG topics

To develop an analytical map for design approaches to the SDGs in building projects, its axes have to be constructed to fit the theoretical underpinnings of design presented by Nelson and Stolterman (2012), the anthropology of projects presented by Boutinet as well as the transformative vision of the 2030 Agenda (Boutinet, 2005; United Nations, 2015). Boutinet's motivational axis can be understood in the context of buildings as the design *character* moving from *human* to *product-focused* (Boutinet, 2005, 2014). Human-focused approaches place the users, society and communities at their core (*i.e.*, focusing their attention on providing people with opportunities through design), while product-focused approaches are concerned with technologies, products and the materiality of the project (*i.e.*, focusing on integrating and improving on the material products). Additionally, the two concepts that Fry and Fisher (Fisher, 2008; Fry, 2009, 2014) present could be used to as the second axis of the analytical map: what could be understood as the design *inspiration* moving from *history* to *future driven* approaches (Fisher, 2008; Fry, 2009; Lévy et al., 2015). History driven approaches are inspired by the traditional and historical ways of doing things and the intent to return to an earlier and more sustainable state (*i.e.*, inspired by how people traditionally used to live, interact together and with nature, build, or use spaces) while future driven approaches aim at innovating new ways by using contemporary tools and systems and to create new states which could be more sustainable (*i.e.*, inspired by the possibility of creating new ways for people to live, interact together and with nature, built or use spaces). Figure 5.3 presents the resulting map.

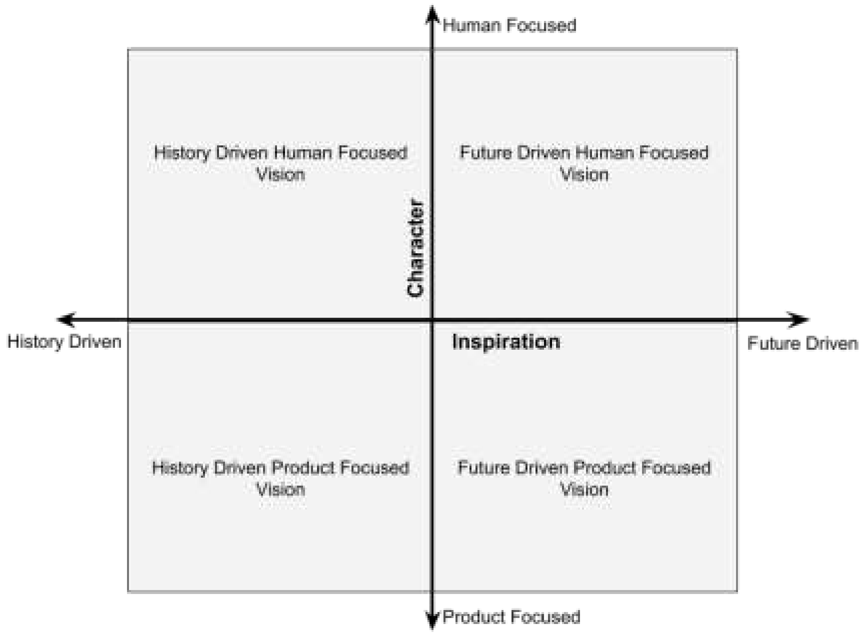


Figure 5.3. Proposed mapping tool for analyzing the sustainable design visions (SDVs) around the SDG topics

Mapping the approaches to the SDGs topics on the two proposed axes provide a mean to analyze the visions manifested in the design—the sought-after state regarding the specific SDG topics. Since the 2030 Agenda presents key goals to be achieved, the different quadrants could be understood as sustainable design visions (SDVs) which embody the design team's proposed mean for attaining the SDGs. The map offers 4 distinct quadrants: (1) history driven human-focused visions; where traditional modes of human interactions are seen as the mean for addressing a specific SDG; (2) Future driven human-focused visions; where new modes of human interaction—such as those depending on information and communication technologies—are seen as the mean for addressing a specific SDG; (3) History driven product-focused visions; where vernacular modes of construction and design are seen as the mean for addressing a specific SDG, and (4) Future driven product-focused visions; where new technologies and products are seen as the mean for addressing a specific SDG.

5.5.3. Adapting the SDGs and their targets for building projects

Although the 2030 Agenda offers a comprehensive and internationally applicable set of goals and targets, they must be reinterpreted to facilitate their application in building projects. The Oslo Manifesto (*The Oslo Manifesto: Design and Architecture for the SDGs*, 2015) offers an example of such interpretation; where the goals are reiterated as broad design questions for creative professionals. Additionally, the recently published architecture guide to the UN 17 SDGs by the Institute of Architecture and Technology (KADK), The Danish Association of Architects and The UIA Commission on the UN Sustainable Development Goals offer another important reference for design teams (Institute of Architecture and Technology (KADK) et al., 2018). However, to cater further to the needs of building design teams, a reinterpretation of the goals was required. provides a list of the 17 goals, their respective building design question accompanied by a list of building-related elements. The building-related elements were extracted from the list of targets for each goal based on their relevance to building projects.

5.6. Method

5.6.1. The Application of the proposed methodology

To apply the proposed mapping tools in the early design phase of building projects, a 4-stage implementation process is proposed. Since not all the 17 goals apply to all projects, the first step aims at identifying and selecting the most relevant SDGs for a given project. This exercise could be completed within the IDP—specifically in early design charettes (Busby Perkins+Will & Stantec Consulting, 2007; Yudelson, 2008a)—and requires intersecting the goals and mission of the project with the 2030 Agenda. Additionally, the design team should also strategize and discuss the means for attaining the selected goals and the synergies between them. The second step aims to assess the integration level of the selected goals. This step could be completed when approaching the end of the schematic phase of the project (Alawneh, Ghazali, Ali, & Sadullah, 2019). The level of integration could be assessed by the design team members and project stakeholders with the help of surveys. The results of this survey should also be discussed collectively in the design charettes. In very large integrated design teams and depending on the team members' expertise (*i.e.*, the coherence of their expertise and roles in the project), the Delphi method could be used to arrive at a consensual assessment of the integration (Mozuni & Jonas, 2017). However, if the

Delphi method is used, the research team will have to ensure the continued anonymity of the responders—which could limit the ability of the researchers to divide the responses based on the team members' roles on the team. The third step of the process entails identifying the specific design features that support the integration of the selected goals in the project. This step can be completed using collective discussions within the IDP or the design charettes (Yudelson, 2008c, 2008a). The identified design features could be linked to specific targets within each goal. Depending on the integrated design team's dynamics and coherence, the Delphi method could be used in place of the collective discussion. Finally, the SDVs can be mapped in order to present the design approaches specific to each of the SDG selected as well as the project's overall vision. The application process is summarized in Figure 5.4. As a final note, if the research is being carried out for multiple projects simultaneously, involves multiple design teams or involves a large number of stakeholders, the Delphi method is recommended in order to further harmonize and validate the results across the cases.

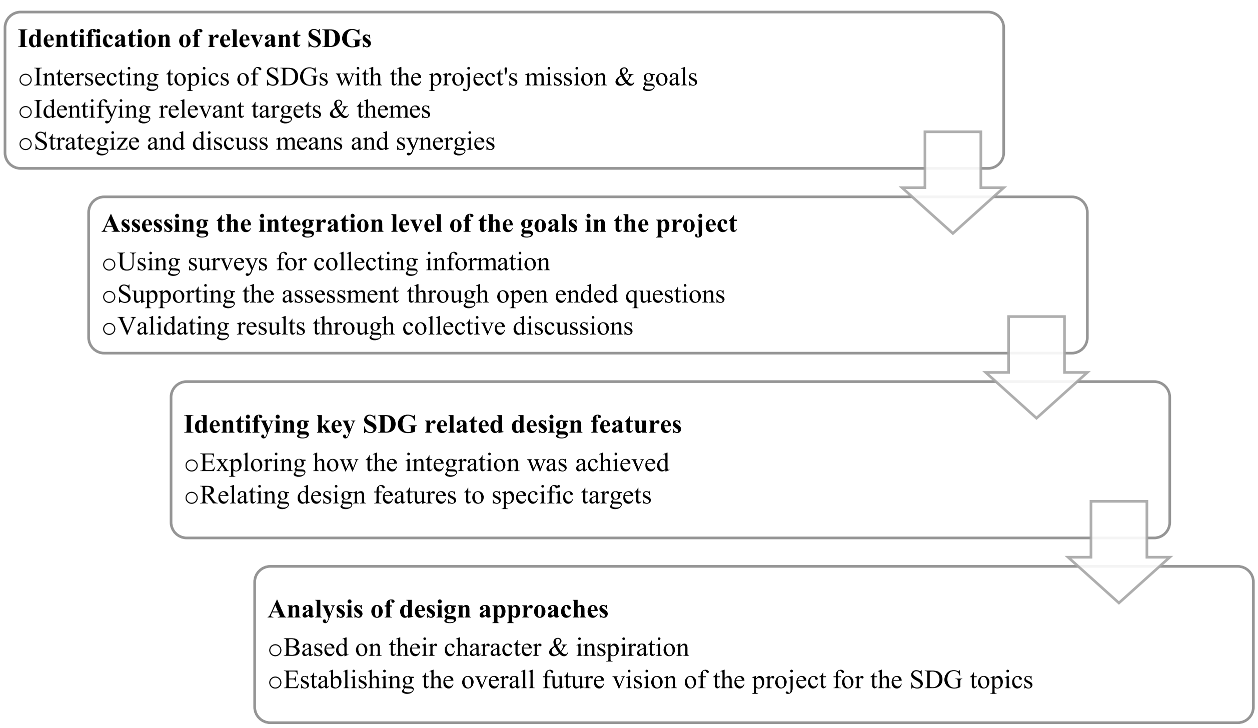


Figure 5.4. The implementation process for proposed tools

For this research, and in order to illustrate the applicability of the analytical maps and methodology proposed, a case study for the design of an energy positive and low-carbon building in Quebec

(Canada) is used. A real-life case study was selected, as opposed to hypothetical examples, in order to better help practitioners and researchers apply and adopt the tools presented. Since the researchers were integrated within the design team of the case study, the paper presents specific insights regarding the project which were gained through the participation in the design charettes and the access to the meeting minutes and presentations. The case study is presented in full detail in the next subsection. Due to the harmony of the design team (*i.e.*, well-integrated design process with no internal conflicts or tensions) as well as the team's specific composition (*i.e.*, small, made of researchers, practitioners and students), the researchers used a simple survey and collective group discussions as methods for collecting the data. Collective discussions are considered an appropriate method for decision making within the IDP since, as a dialectic method, it is able to reveal and resolve dissensus within the team (Hansen & Knudstrup, 2005; Yudelson, 2008c). Table 5.3 details the specific methods used for each of the steps proposed in the methodology.

Table 5.3. Methods used in this research to apply the methodology proposed

Methodology Step	**Method**
Selection of relevant SDGs	Collective group discussion moderated by researchers (Busby Perkins+Will & Stantec Consulting, 2007; Kanters & Horvat, 2012; Yudelson, 2008c)
Assessment of the level of SDGs integration	Survey–quantitative assessment supported with open-ended comments (Lauckner et al., 2012; Neuman & Robson, 2004)
Validating assessment results	Collective group discussion moderated by researchers (Busby Perkins+Will & Stantec Consulting, 2007; Kanters & Horvat, 2012; Yudelson, 2008c)
Identifying design features	Collective group discussion moderated by researchers (Busby Perkins+Will & Stantec Consulting, 2007; Kanters & Horvat, 2012; Yudelson, 2008c) and knowledge gained through the design charettes (as available in the meeting minutes and charette presentations)
Identifying design approaches	Knowledge gained through the design charettes (as available in the meeting minutes and charette presentations)—analysis conducted similar to (Cucuzzella & Goubran, 2019)

5.6.2. Case study description: The UQROP interpretation center in Saint-Jude, Quebec

In order to illustrate, test and validate the proposed method, this paper uses a case study for a high-performance bird interpretation center for Union Québécoise de Réhabilitation des Oiseaux de Proie (UQROP, The Quebec Union for the Rehabilitation of Birds of Prey, https://www.uqrop.qc.ca/en/) in Quebec, Canada. The main mission of the UQROP is to protect the birds of prey and their natural habitats. For their new interpretation center at Saint-Jude (Quebec, Canada), the UQROP decided to augment their commitments to environmental protection by setting ambitious targets: they intend to build a state-of-the-art facility that integrates technologies, systems and design to achieve a well-designed, highly resource-efficient, energy positive, and low-carbon building. The new building will be located on a 22 hectares land in the heart of one of the largest protected forests in the region. The land, currently used by the UQROP for their seasonal activates, encompasses 4 different natural habitats, and features more than 2.5 KM of pedestrian trails. The new interpretation centre is designed to welcome approximately 40,000 visitors per year. This project constitutes an important milestone in the expansion of the UQROP since it will enable them to welcome visitors on the site throughout the year, to expand their educational program through permanent and temporary exhibitions, and to diversify their activities using flexibly programmed spaces. The building will also house a veterinary facility and a winter shelter for birds. Figure 5.5 presents a preliminary design illustration for the building.

Figure 5.5. Preliminary design illustration of the UQROP interpretation center

Notes: © Studio MMA

The UQROP building aims to be one of the most energy-efficient institutional buildings in Quebec and Canada—with a target energy use intensity of 60 kWh/m^2·yr. The building integrates several key technologies such as predictive controls, a building-integrated photovoltaic and thermal system (BIPVT) and a direct expansion CO_2 geothermal system. The integrated design team for the project is composed of more than 20 researchers, practitioners, and artists from the fields of design, architecture, building engineering, controls, animation and museology: including more than 8 students, representatives from the UQROP staff and board, as well as facilitators. The integrated team is a result of a collaboration between the UQROP (a non-governmental, not for profit organization and network), with Concordia University (a publicly owned university—with a number of research centers and programs involved, including the Center for Zero Energy Building Studies (CZEBS)—https://www.concordia.ca/research/zero-energy-building.html and the Concordia University Chair for Concordia University Research Chair in Integrated Design, Ecology And Sustainability for the Built Environment (ideas-be)—http://www.ideas-be.ca/mission.html) and a number of practitioners from the building industry (including structural, and building systems engineering firms as well as the building's general contractor). Additionally, some of the team members are also affiliated with public research institutions (such as CanmetENERGY: The Natural Resource Canada (NRCan) clean energy research division).

Beyond the environmental targets, the building's exhibition spaces were also used as an opportunity for research-creation projects which combine different art and design practices to innovatively communicate information about Quebec's birds of prey, the history of the site and Saint-Jude, as well as the sustainability features of the project. Moreover, the engineering experts on the team are expected to suggest modifications and additions to buildings codes: in order to better adapt the codes to the future challenges and opportunities high-performance buildings offer and to streamline the integration of state-of-the-art technologies in buildings.

The UQROP project constitutes an important case study for this research since the union's mission is centred around biodiversity protection, education, skill-building, partnership, and sustainable tourism. Additionally, the new interpretation center will significantly expand UQROP's sustainability mission to consider challenges related to energy, water, innovation, and equitable growth. The project IDP was initiated in October 2018 and progressed until March 2019—concluding the schematic design phase of the project.

5.7. Results and discussion

During the early design charettes, 8 of the SDGs were identified as relevant focus points for the project: SDG 4 (education), SDG 6 (water), SDG 7 (energy), SDG 8 (sustainable growth), SDG 9 (sustainable infrastructure and innovation), SDG 11 (sustainable cities), SDG 15 (terrestrial ecosystems) and SDG 17 (partnership). By early November, and following several facilitated sessions around these 8 SDGs, a survey for assessing the integration of SDGs in the building was prepared and distributed to the team.

5.7.1. Results

Overall, 18 members of the design team completed a survey—generating more than 430 data points—to assess the integration of the 8 SDGs in the schematic design of the building. Each team member assessed the integration level (from 0 to 3) across each of the 3 axes for each of the 8 selected SDGs. Additionally, for each goal, an open-ended response section was provided for the team members to justify and explain their assessment. To ensure that the team was well informed, the building design question and the building-related elements for each goal were also provided within the survey. The results of the assessment were analyzed on two main levels: (1) compiled overall integration level assessment; where the average integration level across the 3 axes was calculated for each SDG; (2) The axis-based integration level assessment, where the integration level for each axis was calculated for each SDG. Additionally, the responders were divided into three groups: (1) Designers (researchers, students and practitioners in the field of design and architecture) which included 6 respondents; (2) engineers (researchers, students, and practitioners in the field of engineering) which included 8 respondents, and (3) non-designers (managers and facilitators) which included 4 respondents.

5.7.1.1. Compiled overall integration level assessment (8 SDGs)

The compiled overall level of integration assessment for each of the 8 goals is presented in Figure 5.6. The average assessed integration for all the 8 SDGs was assessed to be 1.9—suggesting that the design moves beyond the available standards and criteria. The average integration levels for SDG 6, SDG 7, SDG 9, and SDG 17 were assessed to be 2 or above—with SDG 7 (energy) assessed to be the most integrated in the project (these 4 highly integrated goals will be used for the detailed analysis in the next section of the paper). By comparing the overall assessment completed by each of the three groups, several observations can be made. (A) Designers were the most critical in their assessment: they constantly assessed the integration of each of the 8 SDGs the lowest with an overall average of 1.5. Designers only indicated an integration level of 2 for SDG 7. (B) non-designers consistently assessed the integration to be the highest with an average of 2.4 across all the 8 SDGs. Non-designers also assessed SDG 11 (sustainable and resilient cities) at a significantly higher level than the 2 other groups. (C) The assessment of designer and engineers followed the same pattern where the 4 SDGs highlighted in Figure 5.6 were assessed to be the most integrated into the project.

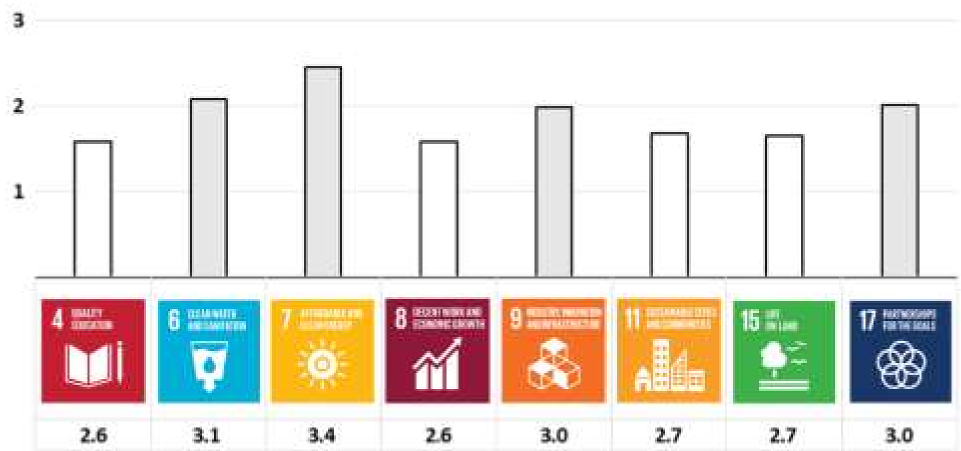


Figure 5.6. Compiled overall integration level assessment for the 8 selected SDGs

Notes: highlighted in grey are the goals which were assessed by the team to have an integration level of 2 or above

The use of one survey revealed differences in the assessment of integration between the 3 groups of responders. Unlike in a Delphi method, where multiple rounds of surveys are used to arrive at a consensual assessment, the research team used a dialectic method through collective team discussion to investigate the reasons behind these differences. The main reasons, as identified during the discussions, included differences in expectations (*i.e.*, designers expected the topics to be integrated more deeply in the design), differences in benchmarking (*i.e.*, where managers, the client and non-designers were comparing the level of integration to conventional construction projects while the other 2 groups used more state-of-the-art references), and differences in the consideration of limitations (*i.e.*, some of the groups assessment was made in reference to the specific limitations of the project—in budget, program and client needs—while others assessed the integration in broader sense). However, the integrated design team identified that these differences are useful within the IDP in order to further develop the project (in subsequent phases beyond the schematic design) and align the collective goals of the different stakeholders. While these variations might be seen as limiting the applicability of the results beyond the specific project, the goal of the assessment process proposed in this paper is to assist the project team in addressing the SDG topics and reflecting on the relevance of their design approaches to the 2030

Agenda. Figure 5.7 presents the compiled overall integration level assessment as rated by each group of responders.

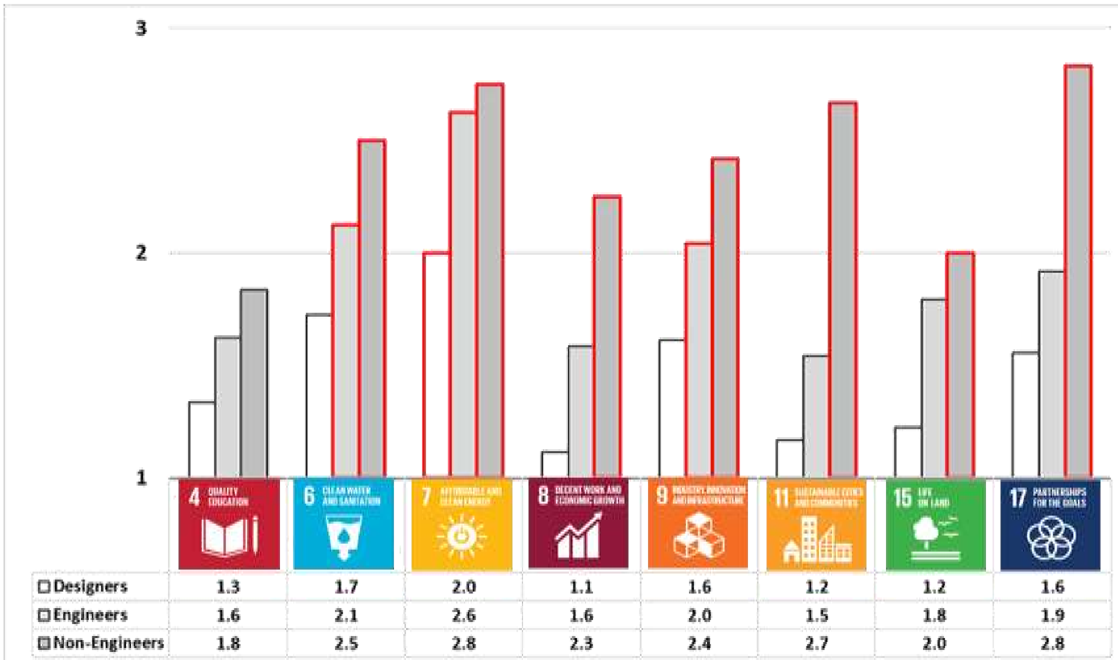


Figure 5.7. Compiled overall integration level assessment for the 8 selected SDGs as rated by each group of responders

Notes: red borders highlight the goals which were assessed by the team to have an integration level of 2 or above.

5.7.1.2. Axis based integration level assessment (4 SDGs)

When analyzing the results of the survey based on their distribution across the 3 axes of the map (Figure 1), the assessment reveals that most of the integration for the 4 SDGs (highlighted in grey in Figure 5) was achieved through the engineering axis. For SDG 6 the engineering integration was assessed to be 2.2; 2.6 for SDG 7; and 2.3 for SDG. However, for SDG 17 (partnership), the results indicated that the highest integration was achieved through the architectural axis—with an average of 2.1. Overall, the team evaluated that the least integration was achieved through the operation of the building. These details can be seen in Figure 5.8. When comparing the assessment of the 3 groups of responders, designers indicated that most of the integration was achieved through engineering and operation interventions. Non-designers rated the integration through engineering to be the highest. Finally, engineers indicated that the integration is more balanced across the 3 axes. The group-based assessment distributions are presented in Figure 5.9, Figure 5.10 and Figure 5.11.

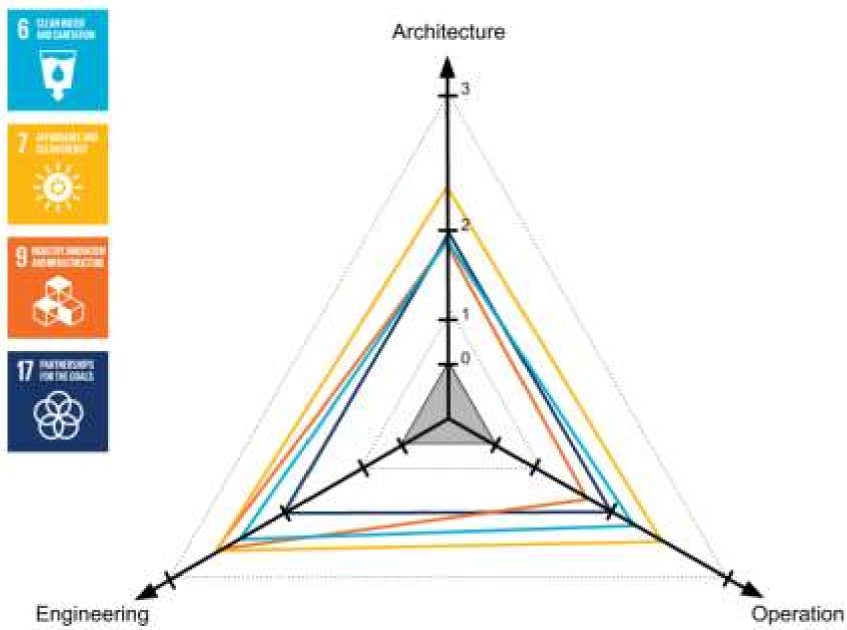


Figure 5.8. Assessment of the level of integration for of SDGs 6, 7, 9 and 17 across the 3 axes for the UQROP interpretation center

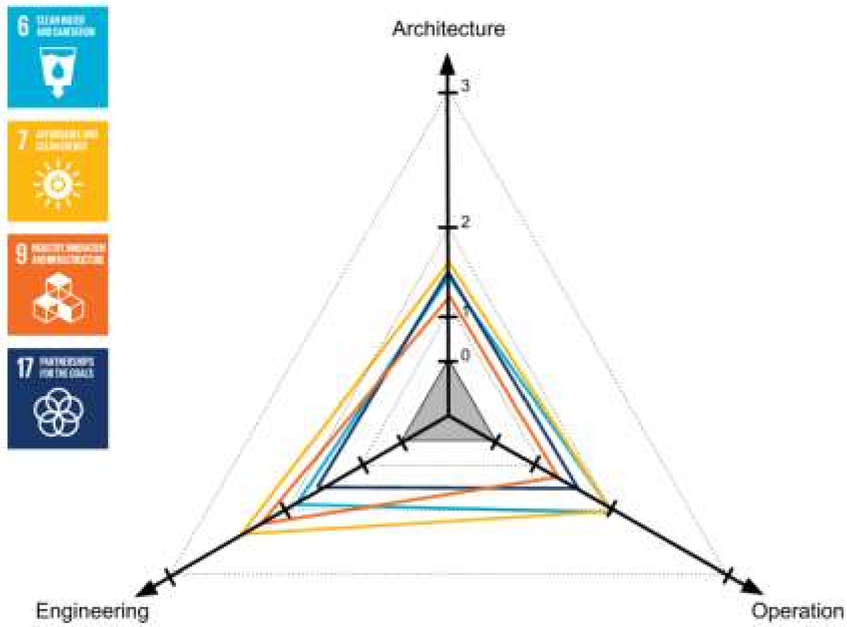


Figure 5.9. Designers' assessment of the integration level for SDGs 6, 7, 9 and 17 across the 3 axes for the UQROP interpretation center

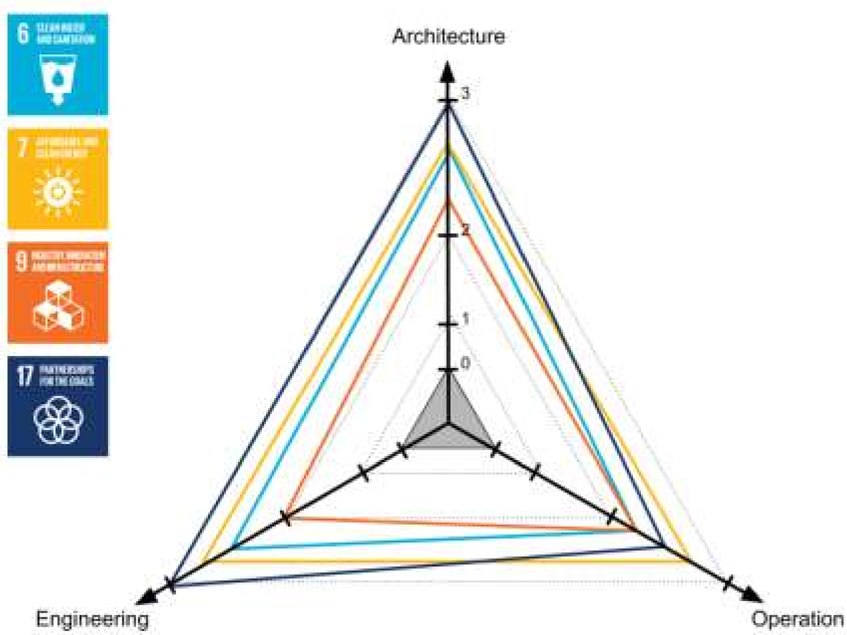


Figure 5.10. Engineers' assessment of the integration level for SDGs 6, 7, 9 and 17 across the 3 axes for the UQROP interpretation center

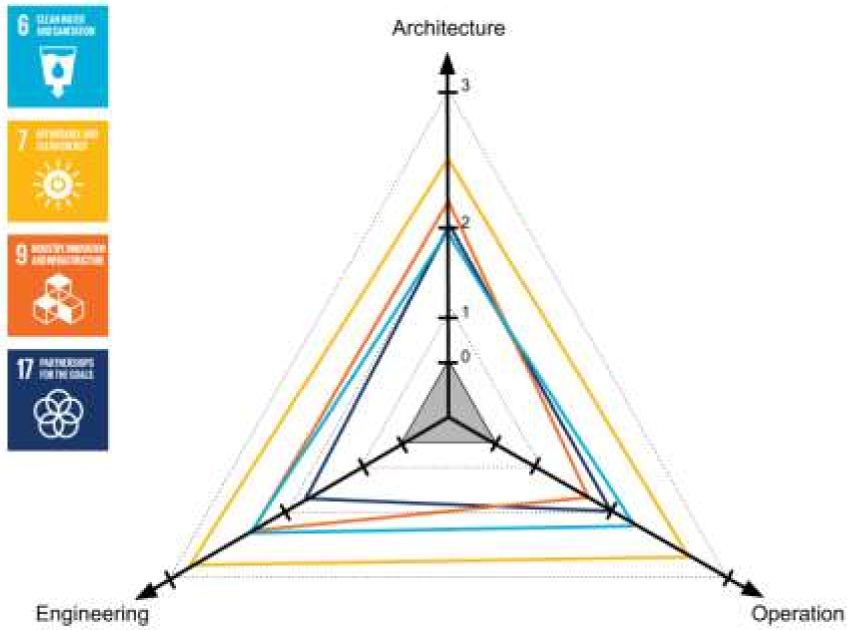


Figure 5.11. Non-designers' assessment of the integration level for SDGs 6, 7, 9 and 17 across the 3 axes for the UQROP interpretation center.

5.7.2. Building Design Features and Sustainable Design Visions

In order to identify the specific building design features and elements which contributed to the integration of the SDGs, the results of the survey were discussed during the team's charettes. Table 5.4 presents a list of the building-related features specific to each of the 8 SDGs selected. Additionally, Table 5.4 also presents the analysis of the dominant SDVs related to each of these 8 SDGs—which are mapped in Figure 5.12. Overall, most of the major design features were found to be technical, technological and product-focused. This focus was justified by the technical nature of the project—as a high-performance energy-positive construction. The overall approach for the project was found to be presenting a future driven vision in relation to the SDGs. As seen in Figure 11, 3 of the 4 most integrated and 5 of the original 8 SDGs are within the future driven section of the map. However, a number of building features were found to be inspired by local traditions and history and were also focused on building positive human interactions. As seen in Figure 5.12, SDGs 4, 8, 15 and 17 are the main contributors to this approach. What is important to note, is that the building was found to have little or no design features which present future-driven human-focused or history-driven product-focused visions. The 4 most integrated SDGs (namely SDG 6, 7, 9 and 17), are presented in more details in the next section.

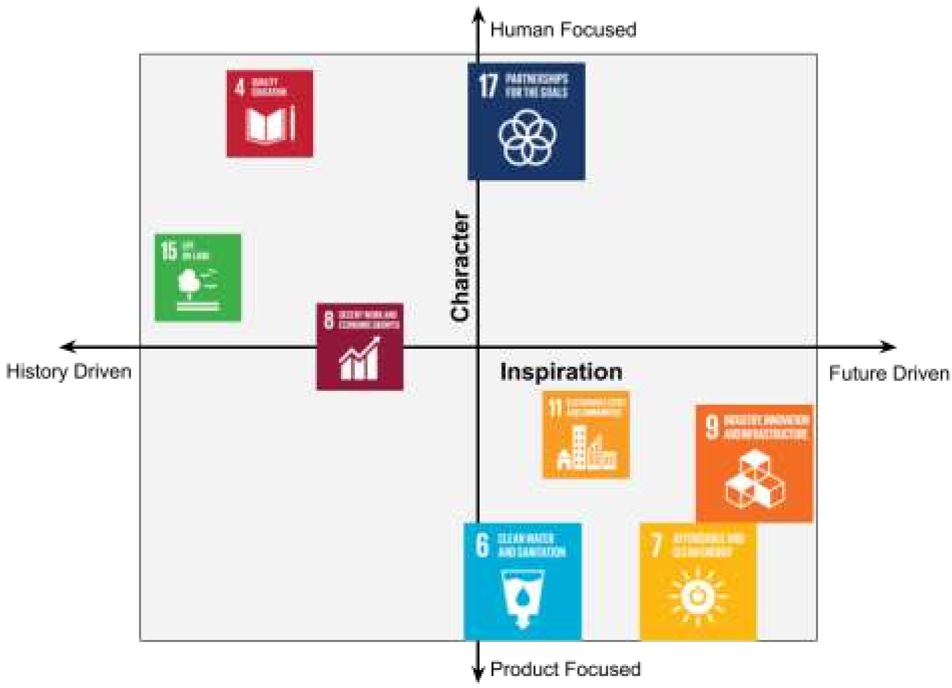


Figure 5.12. Analysis of the SDVs of the 8 SDGs for the UQROP project

Notes: larger icons are used for the goals which were assessed to be most integrated into the project (level 2 and up).

Table 5.4. Analysis summary for UQROP's building design features and SDVs in reference to the 8 selected SDGs

Notes: larger icons are used for the goals which were assessed to be most integrated into the project (level 2 and up).

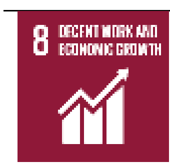
SDG	Building Design Features	SDVs
	- Veterinary clinic - Discovery spaces for hands-on learning - Multi-purpose rooms available for public - Learning activities programmed in space (regarding birds of prey, the site, the environment, the town, and the building). - Promoting traditional art and local artists	Features are human-focused and are driven by direct interactions with nature. The features also are focused on the return to nature and to active and more collective modes of learning. That is both inspired by history and dependent on some modern tools.
	- Compostable toilets - Low water usage equipment - On-site tertiary wastewater treatment - Reducing water demand through synergies between site water management, geothermal, fire-fighting requirements - Stormwater collection and management - Possibility for reusing greywater - Native plants for irrigation water reduction	Mainly product-focused and highly dependent on equipment and technology. The approach is driven by both history (through the local and circular based traditional models) and future (through the use of new technologies).
	- Building-integrated photovoltaic thermal system (BIPVT) - Grid integration - Direct expansion CO_2 geothermal system - Predictive control system - Supporting the research and development of advanced energy systems in buildings	The approach is highly product-focused with the futuristic vision as the main driver.
	- Development of sustainable tourism - The activities programmed in the spaces are in line with sustainable tourism initiatives - The exhibition spaces contribute to promoting and building the local culture of Saint-Jude as well as the natural heritage of Quebec - Use of local timber for the construction	The approach to the topic was found to provide a balance between the human and product/project vision. The design features also aim at incorporating and reconnecting with nature - making the approach slightly more history driven.
	- Hybrid ventilation - Integrated energy solutions—BIPVT and predictive controls. - The building aims to create a precedent and an exemplar for innovation - The building programming (tours, exhibits, movie and other features) will present the research and design of the building - Integrating required site water management with geothermal and fire-fighting requirements in the same retention basin	The approach to innovation is mainly product-focused (with the exception of the collaboration) and is driven by the desire to present new possibilities for the future of sustainability in buildings.

Table 5.4. *Cont.*

11 SUSTAINABLE CITIES AND COMMUNITIES	- Reducing the footprint of the building on the land through building form - Reducing the carbon footprint—with low/zero carbon target—through materials - The expanded IDP adopted—setting a model for collaboration - Building systems with zero-emission targets - Use of timber—allowing carbon sequestration - Activities and programming are centred on the protection of natural heritage	The approach is mainly product-focused with the goal to manage air quality, emissions and waste. The building aims at providing a future example to follow on the topic. However, some human aspects (such as collaboration) and some history driven elements (such as the protection of natural ecosystems) help balance the approach.
15 LIFE ON LAND	- The building's operation is focused on the protection and rehabilitation of birds of prey - The veterinary clinic and the winter shelter aim at ensuring the protection of the natural ecosystem - The building's placement on the site aims at minimizing the damage to the natural ecosystem - Ensuring any trees that are removed during construction will be replanted	The approach is highly focused on protecting the natural ecosystem and improving the bio-diversity—a history driven vision for living in harmony with nature (and specifically birds). The approach—which is educational and hands-on—is based on human interactions. Some products and technologies are also integrated.
17 PARTNERSHIPS FOR THE GOALS	- An expanded futuristic IDP - An effort to create a unique partnership focused on innovation - Collaborations between research, private and public institutions - Adoption of the SDGs in the early design phase	The approach is mainly human-focused (to create partnerships and collaborations). The approach is also slightly future driven since it tries to explore new ways IDP can integrate students and non-practitioners.

Energy was the topic that received most of the team's attention—in terms of both design effort and IDP discussion. SDG 7, which captured the topic of energy, was assessed to be highly integrated across all the 3 axes. A number of key building features relate to this topic. (A) Building-integrated photovoltaic thermal (BIPVT) system. The proposed system covers the entirety of the roof (Figure 5.5). The system aims to both generate electricity and capture useful thermal energy for space and domestic water heating. Although the technology is still considered new, a number of team members have already developed recognized expertise in the field (Researchers on the team have worked on three pioneering BIPVT projects: the Écoterra net-zero energy house (Eastman, QC), the John Molson School of Business building at Concordia University (Montreal, QC), and the Bibliothèque de Varennes (Varennes, QC) (Athienitis, 2015). (B) Grid integration. The electric generation system will also be complemented with grid integration to manage the excess energy produced. (C) Direct expansion CO2 geothermal system. The center will be one of the first institutional buildings to incorporate this recent which is up to 25% more efficient than a conventional geothermal system and also occupies 20–40% less space. The space savings is key for minimizing the damage to the site. (D) Predictive controls. The application of predictive controls—for energy demand and consumption optimization—in early design is a new approach being researched in this project. Although most of the building design features are mainly engineering-driven, their application required deep integration and collaboration in both the operation and design axes.

For the water and sanitation goal (SDG 6), the highest integration was assessed to be achieved through engineering and operation and was realized by a number of key features. A) Composting toilets. One of the first application of composting toilets in an institutional building in Quebec. This required devising a system that fits the intuitional nature of the project, and solving some architectural, engineering, and operational issues. The UQROP plans to use the compost generated for landscaping purposes. B) Synergies between site waste management, geothermal and firefighting requirements. To reduce water demand and waste the team explored key synergies between the water storage systems in the project to strategically use them for heat storage.

For SDG 17, the team cited the unique project's IDP as the key for the partnership topic. The project is one of the first buildings to fully integrate practitioners, researchers, students and affiliates to government research agencies (private–academic–public partnership–non-governmental organization) within the integrated design team. Additionally, the expanded team membership in the schematic phase was also a key for setting a model for collaborative design effort for future high-performance buildings. The coherence in the design team—positively geared toward innovation and meaningful engagement—was also cited as a unique element in this project. Finally, for the topics of innovation and infrastructure sustainable development goal (SDG 9), the team mainly cited the integrated energy solutions (including the features covered in the water and energy and the links between them) as the key innovation in the project. Additionally, hybrid ventilation along with the activities and programming of the building (*i.e.*, educational activities and installations) were cited as key innovations.

<u>5.7.3. Discussion</u>

The findings of this research provide important insights regarding the potential application of the 2030 agenda in the design of buildings. Specifically, the case of the UQROP illustrates the potential for the integration of at least 8 SDGs and the deep integration of 4 SDGs in the pre-design phase of the project. The mapping of the SDVs (presented in Figure 5.12) indicates the variety of design approaches which were used to address these goals. It is important to note that the qualitative tool and assessment proposed (through the two maps presented in this research) do not aim to replace formal quantitative assessment methods available for the building sector (such as credit-based tools, energy codes, green building standards) or the tourism industry (such as those provided by the world tourism organization or the global sustainable tourism council). These quantitative tools could and should be used by design teams while considering the synergies between their criteria and the SDGs. Additionally, consultants for sustainable tourism and environmental tourism practices could be included in the subsequent phases of the project in order to optimize and improve the practices of the UQROP.

When comparing the methodology and results presented in this paper with the available research and literature, two key differences appear.

(1) The available literature which explores the links between sustainable (or green) buildings and the SDGs use the current building practices and rating systems as the basis of their analysis (Alawneh et al., 2018; Alawneh, Ghazali, Ali, & Sadullah, 2019). Alawneh *et al.* (2018; 2019) were able to find that the current practices and criteria in the design of non-residential buildings—through quantitative indicators—can contribute to the SDGs; they specifically found direct links to 9 of the 17 SDGs (Table 5.5 compares their findings with the connections made to the UQROP case). What is important to highlight, however, is that the 8 SDGs selected for the UQROP case intersect with the ones proposed by Alawneh *et al.* (2018, 2019) and the World Green Building Council (Czerwinska, 2017)—with the exception of SDG 4. However, and in spite of the similarity in findings, the main difference between this research and other available research lies in the approach followed. As illustrated by Wackernagel (2017) in the case of the SDG index, the SDG indicators with available data do not encompass all the topics of the agenda and leave some of the most urgent problems unaddressed. The qualitative approach proposed in the paper (through the 2 analytical maps) uses the SDGs as its underpinning and is focused on deeply incorporating the agenda in the design process—rather than using it as a method for assessment. This approach enables building designers to openly discuss and integrate the SDGs and to analyze the potential connections and synergies between their buildings and the SDGs (Busby Perkins+Will & Stantec Consulting, 2007) in the early design phases (*i.e.*, the ideation and pre-schematic phase). It also removes the risk of credit optimization approaches to the 2030 Agenda—which are commonly

used with available building certifications (Cucuzzella, 2009; Goubran et al., 2017; Touloupaki & Theodosiou, 2017). Said otherwise, connecting available building assessment criteria with the SDGs would mean that all projects addressing those common criteria are also addressing the SDGs—even if unintentionally. The tools proposed in this research aim to raise awareness around the 2030 Agenda—its topics and targets—and to address the agenda through innovation. It is important to note that Alawneh *et al.*'s (2018, 2019) method and findings, which are highly centred on measurable indicators and existing credit criteria, can be used in later project phases (*i.e.*, following the schematic phase) to quantify the contribution of the building to the selected SDGs. However, it is important to note that based on the 4 levels of integration proposed in this research only targeting LEED credits requirements (as proposed in (Alawneh et al., 2018)) would result in a level 1 integration of the goals.

(2) Comparing the previous research findings regarding the contribution of buildings to the SDGs with the potential links, presented in Table 5.5, shows that many goals remain unexplored. Other research, which focused on healthcare, energy and even urban ecosystems, was able to explore the relations between these particular sectors and the 2030 Agenda on a comprehensive level. Common to their findings is the broad connections, synergies and trade-offs across all the 17 SDGs—highlighting the potential of each sector, strategy, project or plan to address any of the goals (Loh et al., 2017; Maes et al., 2019; Nilsson et al., 2018; Nunes et al., 2016; Santika et al., 2019). The design questions and links presented in Appendix (I) could be used as a starting point for researchers to explore the broad interactions and synergies between construction and the 2030 agenda.

Table 5.5. Comparing the connections and contributions of buildings to the SDGs proposed in this research and in examples from other references

	SDGs																
Reference	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
Alawneh *et al.* (2018, 2019)			◙			◙	◙	◙	◙		◙	◙	◙		◙		
WGBC * (Czerwinska, 2017)			◙				◙	◙	◙		◙	◙	◙		◙		◙
UQROP Case				◙		◙	◙	◙	◙		◙				◙		◙
Potential links **	◙	◙	◙	◙	◙	◙	◙	◙	◙	◙	◙	◙	◙	◙	◙	◙	◙

* World Green Building Council; ** As presented in (Goubran, 2019a). .

5.8. Limitations and future research

his study presents several limitations due to (1) the assumptions used in the development of the analysis maps; (2) the methods deployed, and (3) the specific characteristics of the case study used. One of the assumptions used in the study is the disconnect of the current planning and design process from the sustainable development objectives. Although the current prevailing practices do consider certain environmental, social and economic factors in the design, the researchers were unable to find theoretical or practical models which have sustainable development, in its broad definition, as their core objective (as opposed to cost, energy, or sustainability credits optimization objectives)—this assumption is supported by the work of (Arroyo, 2014; Cucuzzella, 2015c, 2019a; Ding, 2008; Feria & Amado, 2019; Fischer & Adams, 2011; Goubran, Masson, et al., 2019; Lützkendorf & Lorenz, 2006; Næss, 1994). Additionally, this research does not explicitly compare, analyze or map the interaction between these rating and certification tools and the SDGs—thus not highlighting the possible synergies between the 2030 Agenda and the green building rating tools. Authors assumed the familiarity of building design teams with the specific systems and codes they wish to implement and considered this mapping beyond the scope of this paper. The methods of this research also present a number of limitations. Due to the specific nature of the case study (*i.e.*, focused on the early design phase of the project) and the composition of the integrated design team (*i.e.*, made of a group with dissimilar expertise between students and practitioners, and roles between designers and researchers), this research only used one survey and collective group discussions as a mean for gathering and validating data. This method results in limitation due to the divergence in the data collected. It also limits the validity of the results to the specific case studied. However, it is important to note that the case study is mainly utilized to test the applicability of the proposed methodology in a real-life context in order to help guide practitioners in its implementation and to present its visual outcomes. The number of responders—which constituted all the design team excluding the authors—was beyond the control of the authors. The responses of the UQROP design team regarding the level of integration of the SDGs in the project are not globally applicable ratings and do not constitute an exhaustive best practice reference guide. While the restrictions on the validity of the results beyond the specific project might be seen as a limitation, the collective discussion revealed that the differences in the assessment to be important in improving the design in subsequent phases.

Future research should focus on exploring the tools required to incorporate the 2030 Agenda at the different design phases of projects—including the post-occupancy phase—by soliciting assessments from the users of buildings which integrated the SDGs in their design. Future research should overcome some of the limitations reported in this study by providing clear examples or references that can help the design team members in the assessment process. Additionally, practitioners and design teams should utilize the maps proposed in this paper to analyze building projects with different goals and missions—such as projects that have clear social or cultural missions or that have a community development focus. Additionally, by reassessing the integration of the SDGs achieved through some of the approaches used in the UQROP project (such as the BIPVT system or synergies in water storage and demand) potential integration level benchmarks could be established for different building elements. This future analysis and research, which would use methods to validate data across multiple case studies (such as the Delphi method), could help identify new building design features that are specifically relevant to each of the 17 different SDG. In turn, a practical reference for SDGs building design can be compiled and made available. Additionally, another line of research should focus on mapping and clarifying the direct and indirect links between the SDGs and the mainstream certification, assessment tools and green building codes globally. Finally, the possible application of the SDVs map could be explored beyond the building IDP; its use could be tested in the analysis of projects in the context of design competition on the local, national or international levels (Chupin et al., 2015; Rönn et al., 2011; Strebel & Silberberger, 2017); and in the development of strategies or plans at the institutional level (Loh et al., 2017).

5.9. Conclusions

With the rise of the 2030 Agenda as a unifying framework for sustainability, the building sector has been struggling to fully incorporate its goals and targets. Based on the review of the recent literature, the current incorporation challenges were traced back to the focus on existing environmental assessment criteria rather than on the possible synergies between buildings the SDGs. The integrated design process, which has become common in sustainable building projects, was perceived as the most appropriate setting for addressing these gaps. This paper developed and tested mapping tools which analyze (1) the integration of SDGs in building projects, and (2) the design approaches to the SDG topics—named sustainable design visions (SDVs). The first tool was designed based on the distinction between the architectural, engineering and operational concerns, which is seen in the IDP literature (Busby Perkins+Will & Stantec Consulting, 2007; The Institute for Market Transformation to Sustainability (MTS), 2012), and on the need to distinguish between meeting already established criteria (*i.e.*, standard-based) and innovative approaches (Loh et al., 2017). The second tool was constructed based on the work of Fry, Fisher and Boutinet (Boutinet, 2005; Fisher, 2008; Fry, 2009) and aims to assess the character of the design approach (between product and human-focused) and its inspiration (history vs future driven). In order to further facilitate the integration and use of the 2030 Agenda in building design, a comprehensive list of the 17 SDGs was created which incorporates design questions and presents building-specific elements extracted from the 2030 Agenda. Additionally, an overall process for the use of these two tools was proposed.

To test the applicability of these tools in building projects, the new UQROP bird interpretation center in Saint-Jude Quebec was used as a case study. This new building aims at being state-of-the-art energy positive and low carbon facility which will host activities focused on natural heritage protection and sustainability education. The researchers were directly involved in the project within an expanded integrated design team made of more than 20 researchers, students and practitioners. For the UQROP case, 8 of the 17 SDGs were identified as relevant topics of focus. With the help of a survey, the design team rated the integration of the 8 goals to be above 1—indicating a move beyond current standards. Through the open-ended comments and collective discussion in the design charrettes, the specific building design features for each of the 8 goals were identified. The design visions regarding the project's highly integrated SDGs were found to be mainly product and technology-focused and future driven. When comparing the methods and findings of this paper with the available literature, it was clear that they are better geared towards the ideation and early design phases of building projects. Additionally, the approach to the SDGs proposed in this research echoed that which was used by researchers outside the field of construction and buildings (Loh et al., 2017; Maes et al., 2019; Nilsson et al., 2018; Nunes et al., 2016; Santika et al., 2019).

This paper aims to bridge integrated building design with the broader sustainable development goals as presented in the agenda 2030 of the United Nations (United Nations, 2015). To achieve this, the SDGs were localized to the specific project and building design features level. This research and the analytical tools it presents bring forth important insights for architects and design teams regarding the use of SDGs as a framework for integrating and analyzing the sustainability in buildings. This research contributes directly to the theory and practice of sustainable building design and construction by presenting insights into the possible local and case-specific applications of the 2030 Agenda. The research also provides important practical tools that could inform private and public building design and construction practices.

5.10. Chapter Postscript

The 2030 Agenda's approval in 2015 marked a global milestone in sustainable development (United Nations, 2012, 2015; Wysokińska, 2017). Previous chapters in this thesis stressed the need for new tools and frameworks to help building designers integrate the SDGs in projects. Although several frameworks have been proposed for achieving the SDGs, they remain mostly conceptual in nature and are not adapted to the specific needs of construction and building projects (Gusmão Caiado et al., 2018). The literature on sustainability in the built environment showed deep divisions in the approaches and paradigms advocated for and published. Some scholars propose that sustainability is an emergent property that is composed of both subjective and objective characteristics, and others insist that it can be measured and accomplished through strict guidelines and a checklist approach. On the other hand, research regarding the 2030 Agenda has mainly focused on analyzing and studying the goals and targets themselves (*i.e.* their interactions, and the synergies and trade-offs that exist between them). The research that explored the intersection between green and/or sustainable buildings and the SDGs has been fixated on green building certification and assessment tools (such as LEED, BREEAM, Green Star and others) (as seen in Alawneh et al., 2018; Alawneh, Ghazali, Ali, & Asif, 2019; Alawneh, Ghazali, Ali, & Sadullah, 2019). Finally, the integrated design process (IDP) emerged as the approach most used in building projects for the integration of sustainability or sustainable development (as seen in Busby Perkins+Will & Stantec Consulting, 2007; Hansen & Knudstrup, 2005; Kanters & Horvat, 2012; The Institute for Market Transformation to Sustainability (MTS), 2012). Until the publication of this chapter, there were no published studies that examine the *active integration*[34] of the SDGs in the building design projects and no references which propose practical analytical tools to help designers achieve such integration.

This research proposed two analytical maps that can be used by building design teams during the integrated design process (IDP) to fill this gap. The tools are built on a theoretical framework of major design and sustainable design works (including Berardi, 2012; Bhamra, 2004; Boutinet, 1993, 2005, 2014; Bovati, 2017; Boyko et al., 2012; H. Brezet, 1997; J. C. Brezet, 1997; Ceschin & Gaziulusoy, 2016; Cole, 2005; Cucuzzella, 2011, 2015, 2016, 2009; Dewberry, 1995, 1996; Dewberry & Goggin, 1996; Fisher, 2008; Fletcher & Goggin, 2001; Fry, 2009; Goubran et al., 2019; Guy & Farmer, 2001; Hajer, 1995; Lehni & World Business Council for Sustainable Development, 2000; Nelson & Stolterman, 2012; Orr, 2002; Prishtina, 2018; Schön, 1983). This complex framework was used to build a mapping methodology for evaluating the level of integration of the SDGs in building projects, as well as the design approaches followed by designers regarding the SDG topics. In addition, and using existing references (such as Institute of Architecture and Technology (KADK) et al., 2018; *The Oslo Manifesto: Design and Architecture for the SDGs*, 2015), the chapter provided a reinterpretation of the SDGs and their targets that fits the context of building projects as seen in Appendix (I).

To test and validate the proposed methodology, the case study for the design of UQROP's interpretation center in Saint-Jude (Quebec) was used. The project consists of an interpretation center that aims to be one of the most energy-efficient in the province and expand the biodiversity protection and wildlife rehabilitation mission of the union. The researcher was directly involved in IDP of the project, which took place between October 2018 and March 2019.

The project team selected 8 of the 17 SDGs to be the most pertinent for the project. Later, only four were collectively evaluated to be integrated into the project beyond the currently available standards and guidelines. As presented in Figure 5.6 and Figure 5.8, in the project, which was

34 As opposed to "passive integration", where no change or addition in the design process is required. This type of integration would be a result of the work that aims to links existing certification criteria with the SDGs – where designers would perceive that by attaining a specific credit criteria, they would be contributing to the realization of the SDGs

highly centred on the renewable energy and energy conservation strategies, SDG 7 was evaluated as the most integrated. The team also generally indicated that most of the high integration level (*i.e.* beyond the current standards) was achieved through engineering interventions (rather than the design/architecture and the operation). This translated directly into the future-driven, product/project focused design approach seen in Figure 5.12. It is also important to note that, across the 8 SDGs studied, the integration level was assessed lowest by designers, followed by engineers and then non-engineers – hinting at the varying levels of lenience in the evaluation between different stakeholders in the project.

This chapter's findings provide important insights, references and tools for designers, architects, and developers regarding the potential for the integration of the SDGs in building projects from the early design phases. Additionally, the case study provides an illustrative practical example of the integration of 8 SDGs and models for critical and deep integrations for 4 SDGs. The mapping of design approaches – defined as sustainable design visions (SDVs) – also exemplified the variety of available approaches to tackle the SDGs in buildings. While the study has several limitations (related to some assumptions made, the methods used, and the case study's unique character), it does offer significant improvement and an important contribution in the approach to SDG integration compared to the previously published literature.

The findings of Chapter 4 and Chapter 5 point to the fact that buildings, seen as an outcome of a design process, can also embody designers' visions for achieving sustainable development. Chapter 6 and Chapter 7 take this conceptual leap by considering sustainable buildings, including their architecture and design features, as a manifestation of the designers' vision for achieving sustainable development – and as part of creating a more sustainable future (Fry, 2009). From an anthropological lens, this is rooted in the theoretical definition of *design futuring* and the *anticipatory nature* of design projects, as presented in the work of Nelson and Stolterman (2012), Boutinet (2005, 2014), Fisher (2008) and Fry (2009, 2014), and as explored in Chapter 2 . This is illustrated in Figure 5.13, which builds on the relationship diagram (Figure 3.2). The definition of these future visions can be based on the mapping proposed in Chapter 5, and Figure 5.14 illustrates this relationship. These two chapters postulate that sustainability[35] can be understood an outcome of critical design thinking and as a result of a sustainable development[36] driven reflection-in-action design approach (Bovati, 2017; Boyko et al., 2012; Coleman, 2012; Cucuzzella, 2015b; Frame & Brown, 2008; Le Moigne, 2013; A. D. Schön, 1983).

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35 In this context, sustainability as a property becomes emergent – not only its manifestation/application in the design project or building

36 Defined based on the SDGs

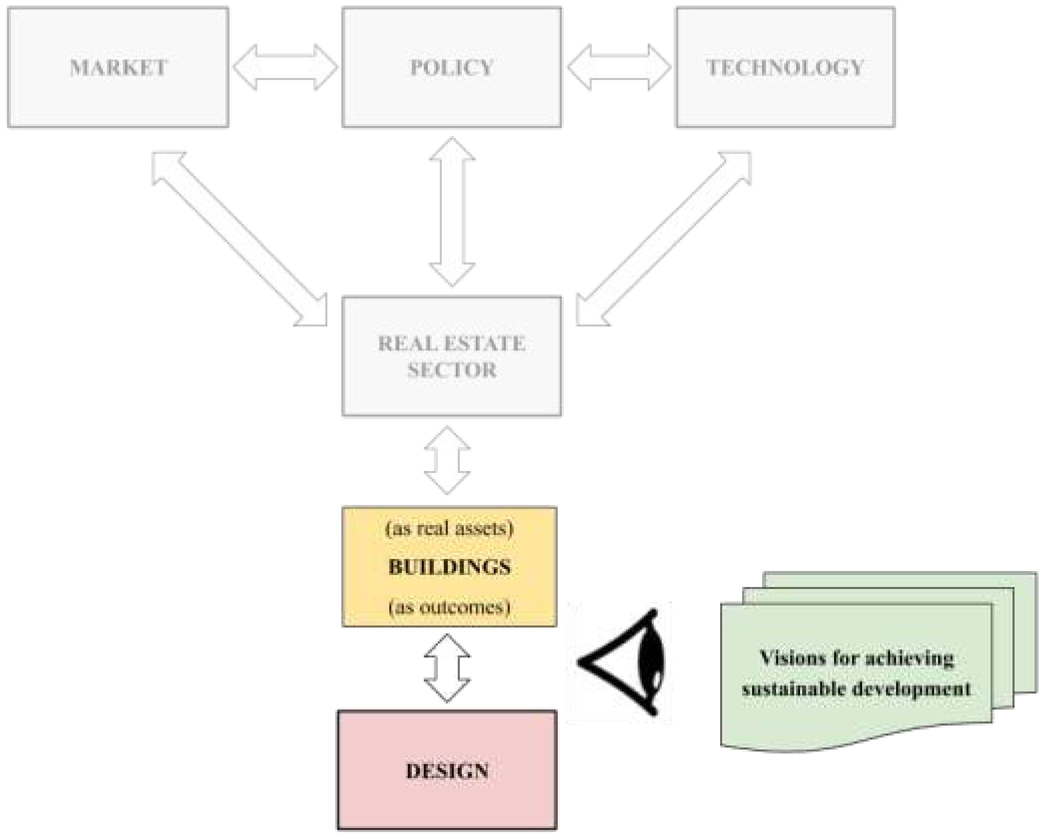

Figure 5.13. The relationship between design, buildings and the SDVs

Note: in this context, the SDVs imply the visions proposed by building designers for achieving sustainable development

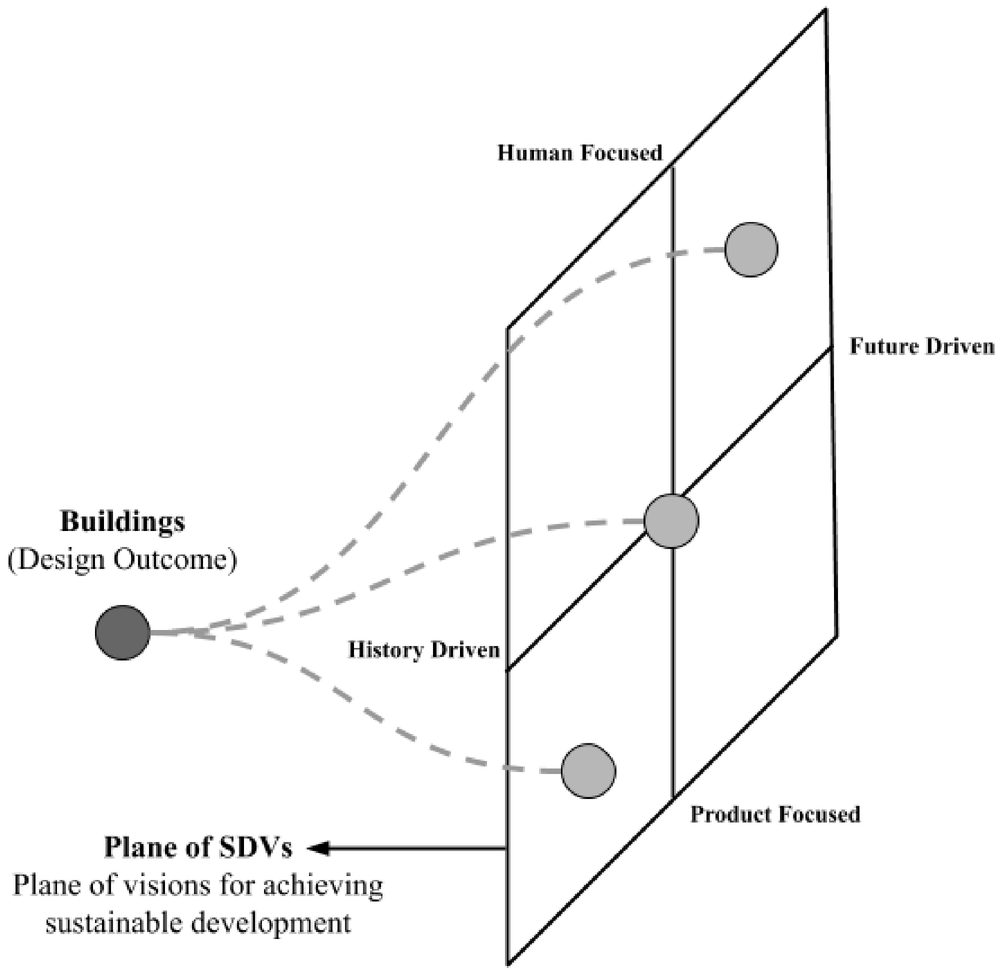

Figure 5.14. Further elaboration on the relationship between buildings and the SDVs

Note: the building could be presenting multiple visions across the different challenges, themes, or goals of sustainable development

Chapter 6 attempts to tackle a major methodological challenge and gap in the design analysis literature by presenting a theoretically founded methodology for distinguishing between *critical and deep approaches* and *shallow (or even what can be considered status-quo) approaches* to sustainable design. Additionally, it explores the consequences of these approaches on the design outcomes. Specifically, it illustrates how the diverging modes of sustainable design reasoning (or design decision making) manifest in projects, impact the role of sustainable design features in buildings, and the future sustainability outlook of designers.

CHAPTER 6.
SUSTAINABILITY IN ARCHITECTURAL DESIGN PROJECTS – A SEMIOTIC UNDERSTANDING

6.1. Foreword

Previous research, such as the work of Cucuzzella (2009, 2011, 2016) proposed that two opposing approaches to sustainable design exist: one based on a technical rationality and the other on a problem setting rationality[37]. This chapter develops on this distinction and characterizes the technical and problem setting rationalities as two distinct *modes of design reasoning*: defining them as *deductive* and *abductive* sustainable design reasoning, respectively. The chapter's main objective is to investigate how to differentiate between these two modes of reasoning in architectural projects. It aims to understand their implications on the role of sustainable design features in buildings, and on the future outlook for sustainable development in architectural projects.

The chapter uses a theoretical framework that is based on the semiotics of C.S. Peirce to achieve this goal. The chapter holds that technical approaches, or *deductive* sustainable design reasoning, stop the process of semiosis or meaning-making. And that, *abductive* design reasoning can allow the continuous development and evolution of meanings – or semiosis *ad infinitum.* In this context, deductive reasoning can be understood as being "characterized by or based on the inference of particular instances from a general law"[38] or, more specifically, as a mode of presenting fixed meanings based on convention and habit. On the other hand, abductive could be understood as providing possibilities for meanings to emerge:

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37 This distinction is supported by a large number of key publications including the work of (Berardi, 2012; Bhamra, 2004; H. Brezet, 1997; J. C. Brezet, 1997; Ceschin & Gaziulusoy, 2016; Raymond J. Cole, 2005; Cucuzzella, 2009, 2011b, 2016; Dewberry, 1995, 1996; Dewberry & Goggin, 1996; Fletcher & Goggin, 2001; Goubran, Masson, et al., 2019; Hajer, 1995; Keitsch, 2012; Lehni & World Business Council for Sustainable Development, 2000; Liodakis, 2010; Moe, 2007; Pawłowski, 2008; Robert et al., 2005; Scardigno, 2014; United Nations, 2015, 2016; Vandevyvere & Heynen, 2014).

38 Definition from Oxford dictionary

"An Abduction is a method of forming a general prediction without any positive assurance that it will succeed either in the special case or usually..." (Buchler 1955 - p299)

In an architectural project, a sustainability feature or design element that is applied based on a deductive reason can only hold one meaning and has a limited function. On the other hand, elements resulting from abductive reasoning[39] can simultaneously hold different meanings and perform multiple functions in the project.

The chapter uses documents extracted from the international competition for the new Montreal Planetarium[40] to create triads of sustainable design signs – where meanings emerge through both texts and design-objects. The chapter also theorizes, based on the work of Perkins-Buzo (2017), and Lang (1987), the distinction between the designed-object (*i.e.* the conceptual project) and the constructed object.

Chapter 6 is grounded on theories of semiotics. It also builds on architecture and social theories focused on the questions of quality, judgement, competitions and excellence [41], as well as design and sustainability literature. The chapter aims to answer the following questions:

1. How is meaning established and how does it emerge in sustainable design?
2. How can a theory focused on the meaning of sustainable design help address questions regarding the concept's definition, its manifestation, and its communication in architecture projects?
3. What can different modes of design reasoning tell us about the role sustainability features play in projects? How do they relate to the outlook regarding sustainable development?

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39 Which tend to be more innovative, experimental and critical

40 "Le Projet du Nouveau Planétarium de Montréal", launched in 2008 and concluded in mid-2009

41 Such as the work of (Andersson et al., 2013; Barley & Tolbert, 1997; Barthes, 1985; Baudrillard, 1995; Bonenberg & Kapliński, 2018; Boudon, 2000; Boutinet, 2005; Buchler, 1955; Chupin et al., 2015; Chupin, 2011; P. Collins, 1971; Cucuzzella, 2015b; Fisette, 1997; Fry, 2009; Giddens, 1984; Kaelin, 1983; Krampen, 2013; Yuan Li, 2017; Nelson & Stolterman, 2012; Oliveira & Sexton, 2016; Owen & Lorrimar-Shanks, 2015; Perkins-Buzo, 2017; Rönn et al., 2011; A. D. Schön, 1983; Simon, 1996; Strong, 1996; Turner et al., 2015; Zeisel, 2006)

4. What is the relation between sustainable design reasoning and the judgement of sustainable architecture?

Chapter 6 constitutes an important contribution within the thesis and a methodology which will be later operationalized in the analysis of sustainability in awarded green buildings presented in Chapter 7.

This single-authored chapter published in a journal. The thesis author is the publications' only-author and a contributor. The chapter-specific publication details can be found in Appendix (C). The keywords for this chapter are listed in Appendix (B). The published chapter reference is:

Goubran, S. (2019). Sustainability in architectural design projects–a semiotic understanding. *Social Semiotics*. https://doi.org/10.1080/10350330.2019.1681062

6.2. Published abstract

The potential of semiotics to theorize and analyze the field of sustainable architecture is still largely unexplored. This paper uses a triadic structure for defining sustainable design signs and distinguishes two separate modes of sustainable design reasoning: namely deductive and abductive sustainable design reasoning. This theoretical framework is used to analyze two architectural projects submitted for an international design competition in Montreal, Canada. The architectural texts, considered in this paper the representamen of the signs, prove to be indicative of the mode of reasoning deployed. The analysis also reveals that the mode of reasoning used dictates the types of signs produced, the role designed-objects have in the signs, as well as the functional possibilities design elements perform in the project. The paper proposes that deductive sustainable design reasoning brings to a halt the process of semiosis—presenting a status-quo approach—and that abductive sustainable design reasoning allows semiosis ad infinitum—presenting a future driven outlook. Additionally, a gap appeared between the open form of critical judgement proposed for competitions and the conceptual fixation inherit in deductive sustainable design reasoning. This paper presents a theoretical contribution that provides new possibilities for researchers to model and analyze sustainability in design projects

6.3. Introduction

Buildings are historic, cultural, social, and technological artifacts (Doyle, 1991; Gieryn, 2002; Goss, 1988). In an effort to understand buildings, previous research has attempted to assimilate the built environment in social theory (Gieryn, 2002; D. Lawrence & Low, 1990; Leach, 1997). On the other hand, wide cultural, technical, and natural principles govern architecture[42] as a social, economic and practical activity (Nelson & Stolterman, 2012). One can argue that the designing buildings[43], in all their complexity, requires both critical and reflective practice; borrowing some features from the artistic process (O'toole, 1992; A. D. Schön, 1983). What has been made certain by previous research is architecture's ability to convey meaning (Doyle, 1991; Eco, 1981; Krampen, 2013).

There have been many attempts to propose parallels between language and architecture—where both can be understood as systems of communications ("Du Didact. En Archit. / Didact. Archit.," 2019). This notion of the built environment as an indefinite code waiting to be 'decoded' by the urban navigator has become progressively common. However, if we use Barthes' recommendation, decoding the built environment requires a person who is a geographer, urbanist, architect, historian, and psychoanalyst (Barthes, 1985 - p 9). Others scholars proposed to see architecture as a language in itself and used theories of semiotics and semiology to understand it and to expose its visible or concealed meanings (Abd. Manan & Smith, 2014; Doyle, 1991; Gieryn, 2002; Klee, 2018; Lazutina et al., 2016; Wang & Heath, 2011). However, less focus has been placed on using these theories to understand the architectural project (*i.e.* the process of architectural design itself) and specifically to understand the phenomenon of sustainable architecture as manifested in architectural design.

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42 The term "architecture" is used to indicate the act, art and practice of designing objects that occupy the built environment.

43 This is specific to designing building of quality. This notion of quality in architecture has been heavily debated for centuries – and is still an ongoing debate. Vitruvius (1914).proposed a triadic structure composed of beauty, usability and durability. Today the concept is more focused on ideas of responding to and catering to various human needs (Hough & Kratz, 1983; Purcaru, 2015; Van Wezemael et al., 2011).

Projects have been theorized as a social and anthropological phenomenon (Boutinet, 2005; Lang, 1987). Sustainability, on the other hand, is understood as a complex socially constructed philosophy[44]—made of multi-layered and interconnected natural, social, ethical and ideological characteristics (Fry, 2009; S. Walker, 2006; World Commission on Environment and Development, 1987). The definition, constituents and breadth of the philosophy of sustainability have experienced many developments and changes since its emergence (Hajer, 1995; Liodakis, 2010; Moe, 2007; Pawłowski, 2008; Robert et al., 2005; United Nations, 2015, 2016). However, the application of sustainability in the field of architecture has resulted in the creation of new approaches, shifts in practice as well as the establishment of different standards and norms (Keitsch, 2012; Scardigno, 2014; Vandevyvere & Heynen, 2014). Today, several questions are still being debated such as (1) what sustainability means in architecture, (2) how does sustainable design manifest and differentiate in building projects, and (3) how sustainability is communicated in architectural design projects. In other fields, semiotics is used to theorize and model multidisciplinary practice (Barley & Tolbert, 1997; Yuan Li, 2017). However, the potential of semiotics to theorize and analyze the field of sustainable architecture—specifically relating to the production of meaning in design—is still largely unexplored.

This paper explores how semiotics can provide the theoretical basis for examining and modelling the dynamic processes involved in sustainable architecture design. Previous research has shown that two rationalities of sustainable design are present—the technical rationality and problem setting rationality (Cucuzzella, 2016). The paper develops on this view and defines the technical and problem setting rationalities as two distinct modes of reasoning: defining them as deductive and abductive sustainable design reasoning, respectively. By studying the signs of sustainability in design projects, the paper proposes a methodology for differentiating between these modes of reasoning, to investigate their styles of signification, and their consequences on architectural projects and their analysis. The hypothesis of the paper is that deductive sustainable design reasoning brings to a halt the process of semiosis and abductive sustainable design reasoning allows semiosis *ad infinitum.*

44 The word "philosophy" in this case could be substituted with the word "ideology" – understood as a set of ideas, views, and beliefs what determine behaviour and actions (Ponzio, 1993; Prishtina, 2018).

"[T]o say that a hypothesis is plausible is itself a plausible hypothesis, and so it goes ad infinitum: we have a logical circle that can never reach its own point of departure." (Fisette 1997 - p 73).

To study the proposed hypothesis, the paper uses a corpus of documents extracted from the international competition for new Montreal Planetarium (Le Projet du Nouveau Planétarium de Montréal) launched in 2008 and concluded in mid-2009. The information and data for this competition is available through the Canadian Competition catalogue/Catalogue des Concours Canadiens (CCC) (Canadian Competitions Catalogue (CCC), 2010; Chupin & Canada Research Chair in Architecture Competitions and Mediations for Excellence (CRC ACME), 2002). This two-step competition is considered important in the context of Montreal for a number of reasons: 1) it was an international competition, 2) it received very high visibility and the built project became an important icon for tourism in the city's Olympic complex, 3) it was one of the first projects to require Leadership in Energy and Environmental Design (LEED®) platinum certification—the highest level possible (Cucuzzella, 2015a), and 4) as highlighted in the jury report and the second stage competition brief, the environmental approach of the submitted projects—their innovation and the quality of integrating LEED© credits —constituted the highest percentage (20%) in the judgment criteria. The selection of projects within the framework of a competition is critical since competitions have been theorized as a democratic method for the production of knowledge and architectural quality with a long tradition in the field (Andersson et al., 2013; Chupin et al., 2015; Rönn et al., 2011; Turner et al., 2015).

Two projects will be used in this analysis: the winning project by Cardin Julien + Ædifica, SNC Lavalin, Dupras Ledoux, and Fauteux et associés (referred to as *Cardin Julien + Ædifica*) as well as a runner-up project by Atelier Big City & L'OEUF (referred to as *Atelier Big City & L'OEUF*). The main texts that will be used are the architectural texts of the second step of the competition — which are required as part of the submission folders for the projects—as well as the design panels. In accordance with the competition requirements, the original architectural texts were provided in French. In this paper, the statements are translated to English by the author, and the original French statements are provided for reference in the footnotes. Discourse analysis will be used to analyze the statements that appear in the text in order to identify the reasoning modes deployed (Michel Foucault, 1993; van Dijk, 2008b, 2008a). Additionally, critical discourse analysis approaches will be used to highlight and relate the specific arguments presented with the broader situation of the project including information presented in the jury report (Hodge & Kress, 1995b, 1995a; Michel Foucault, 1993)

6.4. The application of semiotic theory in architecture design projects

The theoretical ground of this paper is founded on the semiotics of C. S. Peirce. The Essential Peirce Volume 2 (EP2) edited by the Peirce Edition Project (Houser et al., 1998), The Philosophical Writings of Peirce (Buchler, 1955) and The second volume of the Collected Papers (CP2) (Hartshorne et al., 1994) are used as primary sources. The works of Deledalle (2000), Fisette (1997), and Hoopes (1991)[45] are used as secondary print sources. This paper views sustainability cues in architectural design projects as triadic signs that can be reproduced or created. For consistency, the general terminology adopted is that the sign has a representamen, an object, and an interpretant (Figure 6.1)[46].

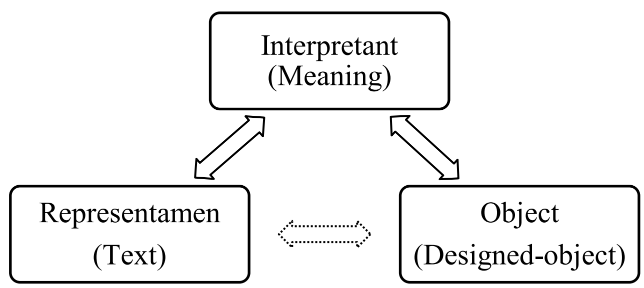

Figure 6.1. The triadic structure of sustainability signs in architecture design

Notes: The triadic structure is based on the writing of C. S. Peirce and distinction of elements is based (Andersson et al., 2013; Yuan Li, 2017; Sheriff, 1989).

45 Specifically, Chapter 8: On the Nature of Signs

46 The word representamen has been specifically used interchangeably with other words such as sign, vehicle, or sign-vehicle (Buchler, 1955; Hoopes, 1991; Houser et al., 1998).

In order to establish the triad of sustainable design signs, each of the 3 members[47] (namely the representamen, object and interpretant) have to be understood and defined. Peirce articulates the definition of the triad's members as well as the general relation between them:

> *"A Representamen is the First Correlate of a triadic relation, the Second Correlate being termed its Object, and the possible Third Correlate being termed its Interpretant, by which triadic relation the possible Interpretant is determined to be the First Correlate of the same triadic relation to the same Object, and for some Possible Interpretant." (EP2.290)*

> *"A Sign, or Representamen, is a First which stands in such a genuine triadic relation to a Second, called its Object, as to be capable of determining a Third, called its Interpretant, to assume the same triadic relation to its Object in which it stands itself to the same Object. The triadic relation is genuine, that is its three members are bound together by it in a way that does not consist in any complexus of dyadic relations. That is the reason the Interpretant, or Third, cannot stand in a mere dyadic relation to the Object, but must stand in such a relation to it as the Representamen itself does." (Buchler 1955 - p100)*

As understood in the previous passages, the relation between each of the 3 members is equivalent and cannot be reduced to any number of dichotomies. However, he does not refute the possibility of more complex relations but rather indicates that simplifying signs further than a triad would only distort their reality. Instead, he proposes that "four can be analyzed into threes" (Deledalle, 2000).

Peirce gives the interpretant a clear definition:

> *"[..] the idea in the mind that the sign excites, which is a mental sign of the same object, is called an interpretant of the sign." (EP2.13)*

47 Peirce uses the word "members" to describe the elements of the triad

While Deledalle (2000) uses the Sir W. Hamilton's definition of the word representamen found in the Century Dictionary[48], Peirce defined the term more broadly:

> *"[Representamen is an] object serving to represent something to the mind." (Sir W. Hamilton, 1887)*

He also distinguishes between the first sign and the subsequent signs as well as between the representamen and its ground. Additionally, he makes specific how the representamen relates its object[49] and creates new signs.

> *"A sign, or representamen, is something which stands to somebody for something in some respect or capacity. It addresses somebody, that is, creates in the mind of that person an equivalent sign, or perhaps a more developed sign. That sign which it creates I call the interpretant of the first sign. The sign stands for something, its object. It stands for that object, not in all respects, but in reference to a sort of idea, which I have sometimes called the ground of the representamen." (Buchler 1955 - p99)*

Peirce elaborates further on the specific relation between a representamen and its object.

> *"The object represented is supposed not to be affected by the representation. That is essential to the idea of representation. The Representamen is affected by [the] Object but is not otherwise modified in the operation of representation. It is either qualitatively the double of the object in the Icon, or it is a patient on which the object really acts, in the Index; or it is intellectually linked to the object in such a way as to be mentally excited by that object, in the Symbol." (EP2.171)*

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48 The dictionary is now found online at http://www.global-language.com/CENTURY/

49 Sometimes named sign-object

"But a Representamen mediates between its Interpretant and its Object, and that which cannot be the Object of the Representamen cannot be the Object of the Interpretant." (EP2.276)

Throughout his writing, Peirce highlights the fundamental role the representamen plays in the triadic relation. As seen in the previous quotes, Peirce clarifies that the representamen is a "first". Deledalle (2000) clarifies that the process of semiosis can only be set-off through a representamen and that, in semiosis, the interpretant of one sign becomes representamen in another (Deledalle, 2000). In fact, the process of semiosis can only continue infinitely as long as the interpretant becomes the representamen in a different sign.

"[A sign (or representamen) is] anything which determines something else (its interpretant) to refer to an object to which itself refers (its object) in the same way, the interpretant becoming in turn a sign, and so on ad infinitum" (CP2.303)

In this paper, the representamen is the linguistic—or textual—form of the sign (referred to as *text*), the object is that which stands for the representamen (referred to as *designed-object*), and the interpretant is the meaning and it exists in the realm of ideas, concepts and thoughts[50]. Objects can be dynamical (*i.e.* the real object) or immediate (*i.e.* as represented by the sign). On the other hand, the process of semiosis could be potentially short-circuited when arriving at a final interpretant by force of habit—in turn bringing the process of semiosis to an end (Fisette, 1997).

In the context of architectural design projects, a linguistic representamen, as presented in the reports and descriptive texts, corresponds to what the designers (or design team) have to "say". Li proposes that "saying" could be taken as the representamen since it is naturally distinct from "doing"—which in the case of architectural design would correspond to the designed-object (*i.e.* the object that designers create) (Yuan Li, 2017). In fact, Peirce elaborates on the linguistic forms of a representamen in *The Categories Defended*. He clarifies that "any general word, [or] sentence […]" are from a class of representamen that will fulfil its function "solely and simply because it

50 A similar distinction and definition is proposed by Li (2017)

will be interpreted to be a representamen" (EP2.163). He then clarifies further in *The Three Normative Sciences:*

> *"A representamen is either a rhema, a proposition, or an argument. An argument is a representamen which separately shows what interpretant it is intended to determine. A proposition is a representamen which is not an argument, but which separately indicates what object it is intended to represent. A rhema is a simple representation without such separate part." (EP2.204)*

Sheriff argues in the *Fate of Meaning* that literary text could be considered rhematic (Sheriff, 1989). So, while the text is itself is a sign (made of terms, propositions and arguments), its interpretant is not restricted to arguments and could take the form of "a rhema, a proposition, or an argument" (EP2.204). Through semiosis, this interpretant becomes the representamen that determines a new interpretant—another rheme, proposition or argument—and so on to infinity (Deledalle, 2000; Fisette, 1997).

In architecture design projects, text is used to describe, clarify and specify the design. Andersson, Zettersten and Rön (2013) offer a description of the text' role in architecture projects in their preface of *Architectural Competitions – Histories and Practice:*

> *"[…] the descriptive text has no value in itself, but is intended only to clarify the knowledge that is already deposited in the images and being conveyed through visual impressions. It is an already formed environment which is being revealed to the observer as design. The pictures transmit experience. The text on the other hand is intellectual in character, appealing to reason. Consequently, text and image represent two very different understandings of knowledge which are both to be found in architectural competitions, and which are made manifest in the mode of communication and visualization of knowledge to the observer." (Andersson, Zettersten, and Rönn 2013 - p10-11)*

While Andersson, Zettersten and Rön do not specifically articulate the relation between text and images (considered in this paper the designed-objects), 4 important observations could be extracted: 1) that descriptive text and images are distinct elements of the project, 2) that each element conveys a different dimension of the project—text appealing to reason the images transmitting experiences, 3) that the descriptive text does not affect the images but that the text is affected by the images, and 4) that the knowledge indented to be conveyed (that could be understood as the design's meaning) has a simultaneous relation to both text and images. These observations reveal the triadic relation of—*text-images-meaning*— in architectural projects that cannot be reduced to dichotomies. Additionally, Peirce's indication that "the object is supposed not to be affected the representation, and the representamen is affected by the object" (EP2.171) stands in parallel to observation 3 taken from Andersson, Zettersten and Rön's text (*i.e.* the descriptive text is affected by the designed-object, but doesn't affect it).. Since the descriptive texts of architectural design projects ought to represent designed-objects, it could be considered a representamen within the context of a specific design problem or design element.

There is a needed distinction between the designed-object and the design documents on one hand and the real project on the other. This distinction can be understood based on Perkins-Buzo's proposal that the design documents present the object that is intended to be built (Perkins-Buzo, 2017). These intentions surely embody certain real-life limitations (such as codes, costs, time and resources) and goals (such as needs and market demands) as proposed by Lang (1987 - p38). In real-life situations, building designs change continuously until the last phases of the construction (changes that might include removal of features or changes in specifications) (Lang, 1987). Thus, we can propose that in design documents, where the project first becomes a physical object that exists in the environment beyond the mind of the planner (Perkins-Buzo, 2017), foreground the intentions of the designer. Thus, the paper proposes that sustainable design reasoning can be best understood from these early design documents.

The concept of the three irreducible categories of being[51] (namely firstness, secondness and thirdness) plays a key role in the semiotic understanding of signs—including sustainable architectural signs (Fisette 1997; EP2.196).

51 Firstness is "being in terms of positive qualitative possibility", secondness is "being in terms of actual fact" and thirdness is "being in terms of laws that will govern phenomena in the future" (Fisette 1997 - p 6).

> *"Philosophy has three grand divisions. The first is Phenomenology, which simply contemplates the Universal Phenomenon, and discerns its ubiquitous elements, Firstness, Secondness, and Thirdness, together perhaps with other series of categories. The second grand division is Normative Science, which investigates the universal and necessary laws of the relation of Phenomena to Ends, that is, perhaps, to Truth, Right, and Beauty. The third grand division is Metaphysics, which endeavors to comprehend the Reality of Phenomena. Now Reality is an affair of Thirdness as Thirdness, that is, in its mediation between Secondness and Firstness." (EP2.196)*

This trichotomy presents the distinction between phenomena and their occurrences—the *types* and their *tokens* (Fisette 1997 - p 6). Using explorations of semiotics in artistic practice, we can propose to correlate firstness with abductive reasoning as a mode of providing possibilities for meanings to emerge and to correlate thirdness with deductive reasoning as a mode of presenting fixed meanings based on convention and habit.

> *"An Abduction is a method of forming a general prediction without any positive assurance that it will succeed either in the special case or usually, its justification being that it is the only possible hope of regulating our future conduct rationally, and that Induction from past experience gives us strong encouragement to hope that it will be successful in the future." (Buchler 1955 - p299)*

The interpretation of Boudon (2000) is key for understanding the application of the modes of reasoning to architecture projects.

> *"[We] dissociated the principle of abduction (which innovates) from that of deduction (which establishes) and induction (which discovers) [...] It is this categorical memory [induced by deduction] which is questioned by abduction in its investigative work" (Boudon 2000 - p 84)* [52]

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52 The original French quote: "[N]ous avons dissocié le principe de l'abduction (qui innove) de celui d'une déduction (qui établit) et d'une induction (qui découvre) […] C'est cette mémoire catégorielle [induite par deduction] qui est questionnée par l'abduction dans son travail d'enquête"

This view allows us to distinguish between abduction, which innovates by investigation, and deduction, which establishes by regulation and habit. When these different modes of reasoning are applied in design, and sustainable architecture in specific, they offer different limitations, possibilities and regularities for the formation meanings, the role of objects and the construction of signs.

6.5. Modes of reasoning and sign trichotomies in architecture design

Cucuzzella (2016) proposes a theoretical model that distinguishes between problem-solving and problem setting approaches in design. She describes discourse in problem-solving approaches as prescriptive and universal while discourse in problem setting approaches as contextual and reflective. Concrete examples can help highlight these approaches and correlate them with deductive (resulting in what could be understood as problem-solving) and abductive (resulting in what could be understood as problem setting) modes of reasoning. The two selected projects in the Planetarium competition present two different approaches to environmental and sustainable design. Each of the two analyzed projects presents a reflection and introduction relating to LEED® requirements and how they fit within the proposed project.

> *"Beyond the abstract accounting required for the LEED qualification, our understanding of architecture is changing. [...] [H]owever, the tension between juxtaposition and integration is exacerbated today by the LEED requirements and the proliferation of electro-mechanical devices that are involved in the operation of the building (and even in the city itself)." Atelier Big City & L'OEUF* [53]

In this short reflection, *Atelier Big City & L'OEUF* put in question the LEED© system: they indicate that, unless applied critically, this credit scheme can create tensions and juxtapositions that might not be in line with critical ecological approaches. Although the statement does not

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53 Original French quote: "Au-delà de la comptabilité somme toutes abstraite requise pour la qualification LEED, notre appréhension de l'architecture se transforme. […] [C]ependant la tension entre la juxtaposition et l'intégration est aujourd'hui exacerbée par les exigences LEED et la prolifération des dispositifs électro-mécaniques que l'on souhaite faire participer au fonctionnement du bâtiment (et même de la ville)." Atelier Big City & L'OEUF

directly present any concrete innovation (reiterating the concerns voiced by many scholars and practitioners), it signals a reflexive and critical approach to the project LEED® platinum certification requirement. *Atelier Big City & L'OEUF* question the ability of LEED®—its credits and requirements—to define the sustainability of the project. The reflection directly relates to Boudon's (2000) description of abductive exploration and its questioning of deductive rules and categories. In *Atelier Big City & L'OEUF* project, the topics of ecology and sustainability emerge across all the text and are integrated with and inseparable from the description of the architecture. They focus their discussion on the critical integration and mediation between functions, spaces, quality and technology.

On the other hand, *Cardin Julien + Ædifica* present the sustainability of their project differently. About 50% of their text is dedicated to the environmental discourse thart they organize under sub-titles, which are based on the LEED® categories (namely water, energy, materials, etc.) (Cucuzzella, 2015b). Unlike *Atelier Big City & L'OEUF* which integrated the sustainable and ecological with the architectural description, *Cardin Julien + Ædifica* concentrated all the sustainability-related information at the end of the text—after presenting the spatial and architectural details of the projects. This text, in fact, directly represents the project from the perspective of LEED©, its categories and credits.

> *"The topics below address the most important elements of the LEED accreditation system that we plan to participate in." Cardin Julien + Ædifica* [54]

This pragmatic approach does not question the directives of the certification; instead, it confirms their relevance in defining the project. The main argument presented by the text is that 'in addition to attaining the spatial and museological design requirements, the project also tackles all the categories and credits required to attain the LEED© Platinum level'.

54 Original French quote: "L'ensemble des thèmes ci-dessous traitent des éléments les plus importants prescrits au système d'accréditation LEED et auxquels nous prévoyons participer." Cardin Julien + Ædifica

Cardin Julien + Ædifica's approach to sustainability remains grounded in the credit and code requirements when describing the specific sustainability features of their project. The case of the ventilation system clearly highlights their approach. The representamen describes this environmental feature based on other higher-order signs—such as laws, best-practice, codes, and guidelines. It establishes the meaning of these signs based on conventions. For this specific ventilation feature, only one figure is presented on the panels (Figure 6.2).

> *"The supply of air through the raised floors is geared towards achieving better air quality in the building. [...] A complete air quality management plan will be provided. [...] The thermal comfort expected by the engineers is in accordance with ASHRAE 55-2004." Cardin Julien + Ædifica* [55]

55 Original French quote: "L'apport d'air par la conception de planchers surélevés se veut une recherche d'une meilleure qualité d'air dans le bâtiment. […] Un plan de gestion de la qualité de l'air complet sera prévu. […] Le confort thermique prévu par les ingénieurs est conforme à la norme ASHRAE 55-2004." - Cardin Julien + Ædifica

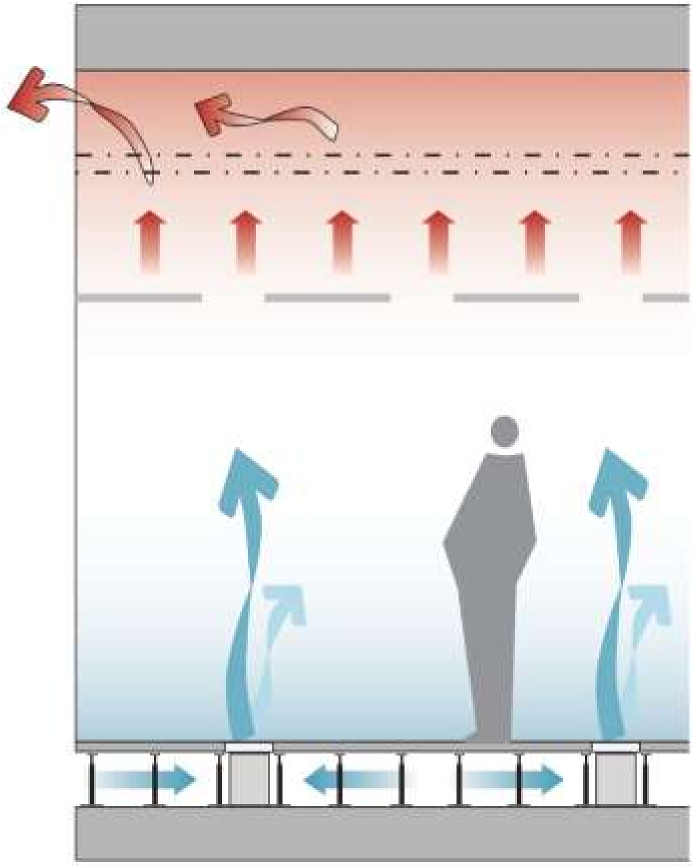

Figure 6.2. Elevated floor ventilation as presented by *Cardin Julien + Ædifica*

Notes: © *Cardin Julien + Ædifica* retrieved from (Canadian Competitions Catalogue (CCC), 2010)

By looking at the content of the statement, the representamen can only be understood as a legisign. Thus by considering the signs hierarchy, their interpretants can only be argumentic—and in turn, their objects can only be symbolic (Krampen, 2013 - p 41). Within the triadic structure proposed earlier and based on the ideas of Krampen (2013 - p 44), Figure 6.2 can be understood as a symbol for the representamen defined by the ASHRAE 55-2004 guideline (as a convention). Thus, the representamen is an argument for achieving the specific ASHRAE guideline (a necessary part of achieving a complete connex) and the figure is symbolic to this achievement (Krampen, 2013 - p 43). Purely deductive design reasoning creates a limitation in the process of signification since it can only allow argumentic-symbolic-legisigns to be created. For these signs, the final interpretant is present and accessible to the reader—which is the specific conventions, rules or codes referenced. Thus, these argumentic-symbolic-legisigns refuse to be further interpreted and lead to short-circuiting the process of semiosis. In the example of the ventilation, the sign cannot be interpreted further than the argument of achieving the guideline. In this context, the argument can be understood as the sign's final interpretant.

Kaelin argues that a purely aesthetic sign could be a rhematic-iconic-qualisign (Kaelin, 1983). However, a representamen describing sustainability features based on the qualities and functions of elements and objects—avoiding references to habits, and codes yet moving beyond the simple sensory or perceptible level—can be understood as a sinsign (Krampen, 2013 - p 45). In fact, and if we take Perkins-Buzo's approach (2017), the designers' description aims to communicate an object of "actual existence" (Buchler 1955 - p101). This can be seen in the case of the solar wall description proposed by Atelier Big City & L'OEUF.

Figure 6.3, which depicts the instances the wall appears on the panels—presents the relations indicated in the text and mirrors its description.

> *"Basic strategies for sustainable development quickly crystallized the geometry of the building and established the importance of a solar wall. This wall, which crosses the interior on three levels, becomes an architectural landmark and a strong scenographic element. It organizes air flows around it and allows pre-conditioning of air within it. The approach to sustainable development is inseparable from architecture; it is part of the scenography." Atelier Big City & L'OEUF* [56]

56 Original French quote: "Des stratégies élémentaires de développement durable ont rapidement cristallisé la géométrie de l'édifice et établi l'importance d'un mur solaire qui, en traversant l'intérieur sur trois niveaux, devient, un repère architectural et un élément scénographique fort autour et dans lequel s'organisent la distribution et le pré-conditionnement des flux d'air : L'approche au développement durable est indissociable de l'architecture; elle est partie prenante de la scénographie." Atelier Big City & L'OEUF

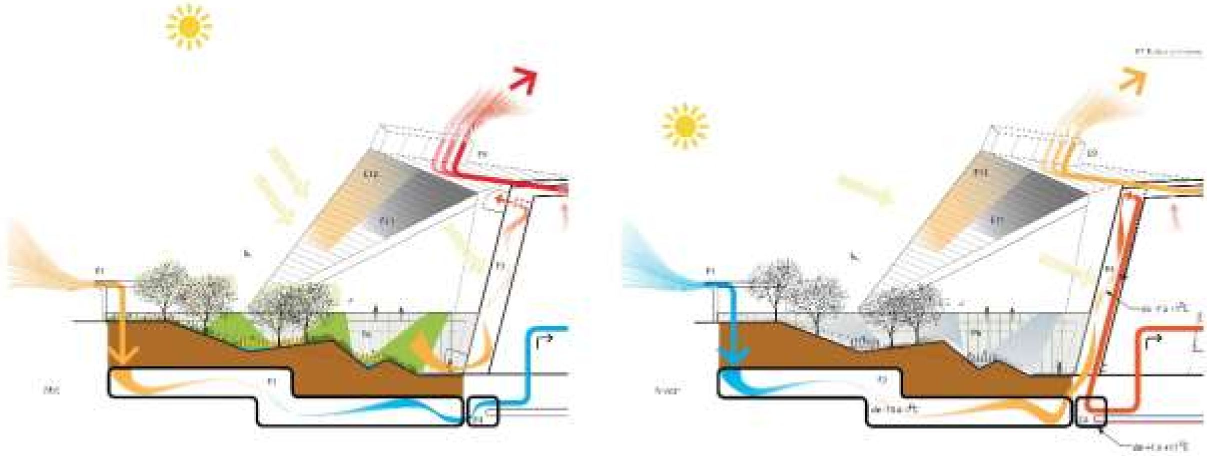

Figure 6.3. Solar wall as presented by *Atelier Big City & L'OEUF*

Notes: (left) in section view and (right) in an environmental diagram. © *Atelier Big City & L'OEUF* retrieved from (Canadian Competitions Catalogue (CCC), 2010)

Within this context, this solar wall, which is a key sustainability feature in the project, presents a new design hypothesis. It is a result of an innovative—abductive—process that combines geometry, technical knowledge, knowledge of the natural sciences, and knowledge of the principles of air movement and its buoyancy. The hypothesis captures a firstness—the possible qualitative existence of such a wall which combines the described features and organizes the spaces as indicated. Most importantly, further interpretation is required in order for meanings specific to the project to fully emerge. This sign builds a connection with a broad concept; that of sustainable development. Since the notion of sustainability mentioned in the text can be considered an open-context[57], the interpretant remains rhematic: open for different interpretations through continuous semiosis (Krampen, 2013 - p 42 & 44). The designed-object depicts the relations and characteristics described in the text making their relation iconic. Thus, in the specific case of the solar wall, a rhematic-iconic-sinsign is constructed. This sign can be taken a representamen, in continuous semiosis, which, in turn, can create higher-order signs before arriving at a possible final interpretant (Fisette, 1997 - p 15). These cases exemplify Boudon's (2000); abductive mode

57 Krampen (2013) uses connex and context interchangeably

of sustainable design reasoning—where meaning emerges by semiosis—functions in contrast to deductive sustainable design reasoning, which establishes meaning based on guidelines and convention.

Using Li's (2017) concept of sign coupling, it can be argued that, in the in abductive design reasoning, the representamen (the text) and the object (the designed-object) undergo coupling. In this case, both the text and designed-object become an intrinsic part of the sign that cannot be separated—ideas which have been also proposed by De Biasi & Biasi (2000). Li's (2017) ideas of institutionalization will be explored further in the discussion on the denotative and connotative functions of architecture objects.

6.6. The role of designed-objects and the risks of abductive reasoning

The roles and characteristics of designed-objects are important aspects to analyze in architectural design projects. From the previous examples, it was seen that designed-objects can only exist as symbols in argumentic signs and that they can exist as icons (as well as indexes or symbols) in rhematic signs. These limitations are based on the hierarchy of signs and their trichotomies (Fisette, 1997; Krampen, 2013). However, in projects, statements refer to objects or elements that are not directly identifiable in the design documents—since not all objects are represented on the panels. By combining this with the ideas relating to dynamical and immediate objects, we can propose that when objects are being referred to in the text, 1) designed-objects can have a dynamical existence when they have a positive qualitative existence in the design documents, or 2) designed-objects only have an immediate possibility when they cannot be identified or isolated in the design documents.

The last passage of the text presented by *Cardin Julien + Ædifica*, a proposal for an educational program on the environmental features of the building is proposed, legitimized by possible innovation credits that were attained in a previous Montreal project.

> *"In addition, we also plan to set up an educational program demonstrating the functioning of the building systems using screens, panels and pamphlets. The program will focus specifically on water management, energy performance and any other intervention which proves to be interesting for visitors. This program has*

already been the subject of an innovation credit for the Tohu project." Cardin Julien + Ædifica [58]

Despite the museological integration required for achieving the credit[59], this proposal does not appear in the panels of the projects—in drawings or illustrations. Instead, the team establishes the legitimacy of the proposed strategy based on proven ability to generate credits—a previous experience or precedent. This deductive approach, that establishes its legitimacy based on previous experience and convention, presents an incomplete sign with no designed-object. For this sign to be interpreted as an effective environmental strategy in the project, a fictional immediate object is needed—since the "real" object is non-existent.

On the other hand, in *Atelier Big City & L'OEUF's* project, an abstract description of the green roof is presented that is coupled with various illustrations in the drawings (Figure 6.4).

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58 Original French quote: "De plus, nous prévoyons aussi la mise sur pied d'un programme éducatif démontrant le fonctionnement des systèmes relatifs notamment à la gestion de l'eau, la performance énergétique et tout autre intervention dont la démonstration s'avère intéressante pour les visiteurs, ceci à l'aide d'écrans, de panneaux et de pamphlets. Ce programme a déjà fait l'objet d'un crédit d'innovation dans le cadre du projet de la Tohu." Cardin Julien + Ædifica

59 In the TOHU, the educational program is integrated within all the CESM site and concentrated in the TOHU building. The program at TOHU required different features and spaces to be designed to specifically accommodate tours and visits related to LEED® and environmental design.

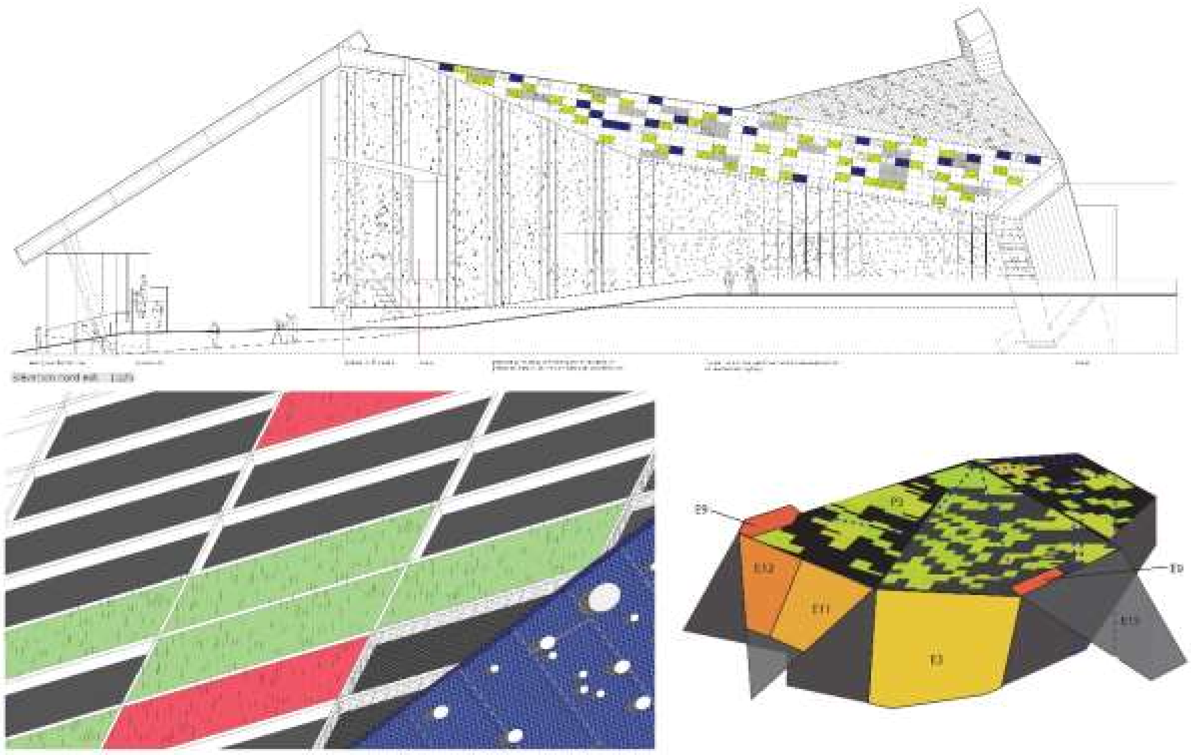

Figure 6.4. Presentation of the green roof by *Atelier Big City & L'OEUF*

Notes: (top) in section view, (bottom left) in detail view, and (bottom right) in the environmental diagram. © *Atelier Big City & L'OEUF* retrieved from (Canadian Competitions Catalogue (CCC), 2010)

The traditional notion of the green roof is challenged in order to provide, by abduction, a new design hypothesis that combines ideas from astronomy and ecology. Although many fictional immediate objects can emerge by reading the textual description, the proposed design (which is significantly detailed in about 8 drawings on the panels) provide a dynamical designed-object that confronts any fictional immediate objects imagined. Said otherwise, any immediate objects that are created by interpretants are eliminated by the designed-object present on the panels. This confrontation between the immediate and dynamical objects can, in fact, be observed through the Jury's comments. The green roof, when judged by the members of the jury, resulted in a mismatch between the imagined (fictional immediate objects) and the dynamical designed-object proposed.

"The imagery of the celestial map is broken by the heaviness of the volume; the green roof does not match this image" Jury [60]

Wilson (2018) provides a meaningful reflection that captures the tensions that arise around fictional immediate objects, their interpretation. It also hints to possible conflicts between immediate and dynamical objects.

"[W]e are satisfied with this "cheap truth" in the cases of statements about fictional objects because, in those cases, we disregard their dynamical objects and consider only whether the statement made about the fictional object conforms to the immediate object upon conventional interpretations of the proposition [...]. It involves considering how [we believe] the fictional object should be interpreted." Wilson (2018)

Understood this way, the case of the educational program proposed by *Cardin Julien + Ædifica* results in a fictional immediate object. The dynamical object of this feature is disregarded and is instead validated by the design team's previous experience—its validity is established by convention. On the other hand, in *Atelier Big City & L'OEUF*'s green roof, the immediate object of the imagined universe and stars is confronted with a dynamical object that has a qualitative existence. In this case, the interpretation of the designers did not conform with the jury's belief on how it should be interpreted.

6.7. The distinction between denotation and connotation

One of the main questions that arise when discussing architectural objects, including sustainability-related ones, is their *functional* dimension. Umberto Eco (1981 - p 24) proposes that architecture has two functions, namely denotative and connotative. He indicates that the denotative function denotes the functional uses, while the connotative function relates to broader social—or systemic—uses of the object. He proposes that, although we tend to associate more the denotative functions with objects, their connotations (understood as their social and cultural meanings) are as

60 Original French quote: "L'imagerie de la carte céleste est brisée par la lourdeur du volume; le toit vert ne correspond pas à cette image" – Jury

important (Eco 1981 - p 24). Krampen (2013 - p 57) proposes, using Preito's (1975) logical arguments, that the differentiation between these two functions can be understood in terms of iterations of cognition (what he names *calculus*): where denotative requires at least one cognitive iteration and connotation requires two or more iterations to be understood. These iterations can be correlated with the process of semiosis—as the process of meaning-making.

As proposed earlier, abductive design reasoning produces elementary level signs such as rhematic-iconic-sinsigns. The sinsign's mode of operation—where the singular and aesthetic forms are realized and where relationships between elements are emphasized—results in coupling the text and the designed-object (Fisette, 1997; Krampen, 2013). Additionally, this link is enforced further by iconic designed-objects since their bear some similarity with the representamen. Thus, we can propose that in architectural rhematic-iconic-sinsigns the denotative function is always present while the connotative function remains open for interpretation—through semiosis. This can be seen in the solar wall and green roof examples that were extracted from *Atelier Big City & L'OEUF*'s project.

On the other hand, signs that have the potential to halt the process of semiosis—namely argumentic-symbolic-legisigns that are produced as a result of deductive design reasoning—can suspend the *functions* of designed-objects on the connotative level without direct inference to their denotation. This has been also proposed by Li (2017) and defined as connotational Institutionalization[61][62] and decoupling.

> *"[connotational Institutionalization and decoupling] empties a sign of its denotative meaning and transitions the sign in its totality to a "mere signifier" in the eyes of adopters.*

61 More details on institutionalization and structuration (Barley & Tolbert, 1997; Giddens, 1984; Yuan Li, 2017).

62 Li (2017) presents two kinds of institutionalization: denotational and connotational. In the denotational kind, the sign brings the three components of the sign closer (a coupling process) which could be achieved through typification, objectification, or theorization. In the connotational kind, the sign is emptied from its denotational meaning and is used as a signifier – exemplifying Barthes' idea of mythification. In this definition, institutions could be understood as "shared rules and typifications that identify categories of social actors and their appropriate activities or relationships" (Barley & Tolbert, 1997).

Being a mere signifier means that the denotative meaning [...] loses its significance" (Yuan Li, 2017)

In *Cardin Julien + Ædifica*'s project, the use of timber clearly exhibits Li's (2017) connotative institutionalization. The team proposes the use of timber, as an environmental intervention that intersected with a number of LEED© materials and interior air quality credits. The text referencing the timber is highly focused on its environmental characteristics—its connotative function. The only illustration for the wood included in the panels presents an abstracted image of a general structure (Figure 6.5).

"[N]otably by the strong presence of wood in the building structure [...], all the wood used will be FSC-certified given the importance it has in the project. The use of wood will also reduce the project's impact in relation to greenhouse gases. Cardin Julien + Ædifica [63]

And the figure was accompanied with the following text:

"CO_2 sequestration (impact of the cut compensated by replanting and the sequestration it induces) [and] Substitutes for materials that consume a large quantity of fossil fuel to manufacture" Cardin Julien + Ædifica (extracted from panel) [64]

63 Orignial French quote: "“[N]otamment par la forte présence du bois dans la structure du bâtiment […], tout le bois utilisé sera certifié FSC compte tenu de l'importance qu'il revêt dans le projet. L'usage du bois permettra aussi de réduire l'impact du projet au niveau des gaz à effet de serre." Cardin Julien + Ædifica

64 Original French quote: "“Séquestration du C02 (impact de la coupe compensé par la replantation et la séquestration qu'elle induit) [et] Substitue à des matériaux dont la fabrication est fortement consommatrice d'énergie fossile" Cardin Julien + Ædifica

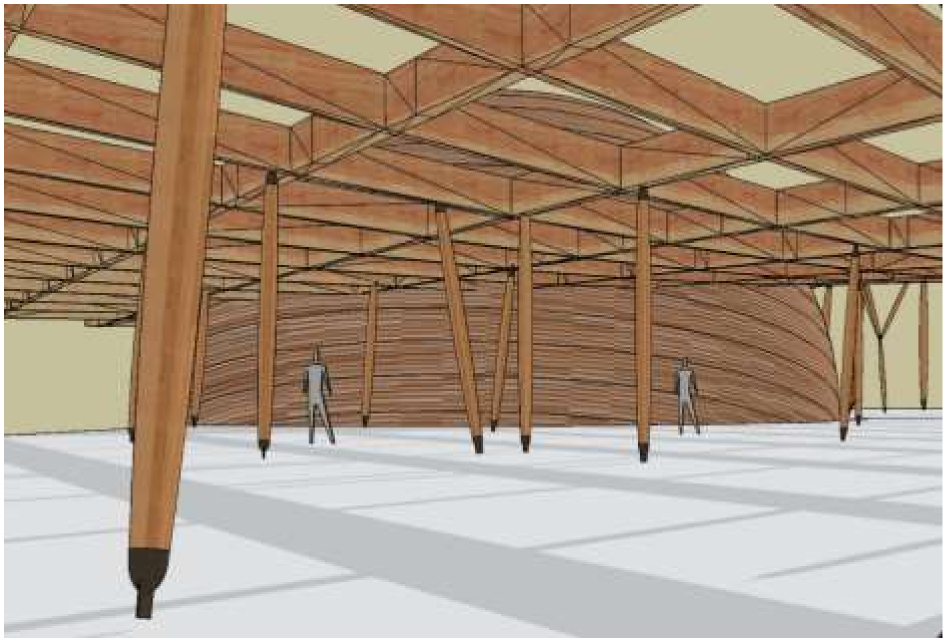

Figure 6.5. Wood structure as presented by *Cardin Julien + Ædifica*

Notes: © *Cardin Julien + Ædifica* retrieved from (Canadian Competitions Catalogue (CCC), 2010)

The denotative function of the wood, as a structural material with benefits beyond the environmental, has not been addressed in the project's text or panels. This was noticed by the jury as highlighted in their comments.

> *"The levels of decision and precision in the design leave some things requiring more details: some elements seem contradictory, including the treatment of the wooden structure" Jury* [65]

It is important to note that not all architectural signs that are a result of deductive design reasoning focus on the connotative functions. In some argumentic-symbolic-legisigns, both the denotative and connotative functions of the object could be presented. However, these functions are merged and not necessarily distinguished. Additionally, in these signs, the denotative function does not serve in the process of meaning-making. *Cardin Julien + Ædifica* propose a retention basin for

65 Original French quote: "Le niveau de décision et de précision du design laisse à désirer : certains éléments semble contradictoire, dont le traitement de la structure en bois" – Jury

rainwater that they intersect with the LEED© requirements of environmental site design and water efficiency. The only presentation of the strategy is a diagrammatic sketch of the basin and its interaction with the building (Figure 6.6).

> *"As for the demand for water, the latter will be controlled by means of the accumulation in the retention basins which, via the filtering marsh, will ensure a continuous and natural purification of the rainwater. This innovative strategy achieves a 55% reduction in water use compared to municipal water." Cardin Julien + Ædifica* [66]

> *"As for the management of rainwater, we propose using a filtering marsh for treating and naturally purifying the rainwater. The water will be redirected in a tank for the use of the mechanical equipment of the Planetarium" Cardin Julien + Ædifica* [67]

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66 Original French quote: "Quant à la demande en eau, cette dernière se fera à l'aide de l'accumulation dans les bassins de rétention qui, via le marais filtrant, assurera une épuration continue et naturelle des eaux de pluie. Cette stratégie novatrice permet une réduction de 55% de la consommation d'eau par rapport aux eaux municipales." Cardin Julien + Ædifica

67 Original French quote: "Quant à la gestion des eaux de pluie, nous proposons un traitement et une purification naturelle des eaux pluviales par la mise en place d'un marais filtrant, l'eau sera réacheminée dans un réservoir pour l'usage des appareils sanitaires du Planétarium" Cardin Julien + Ædifica

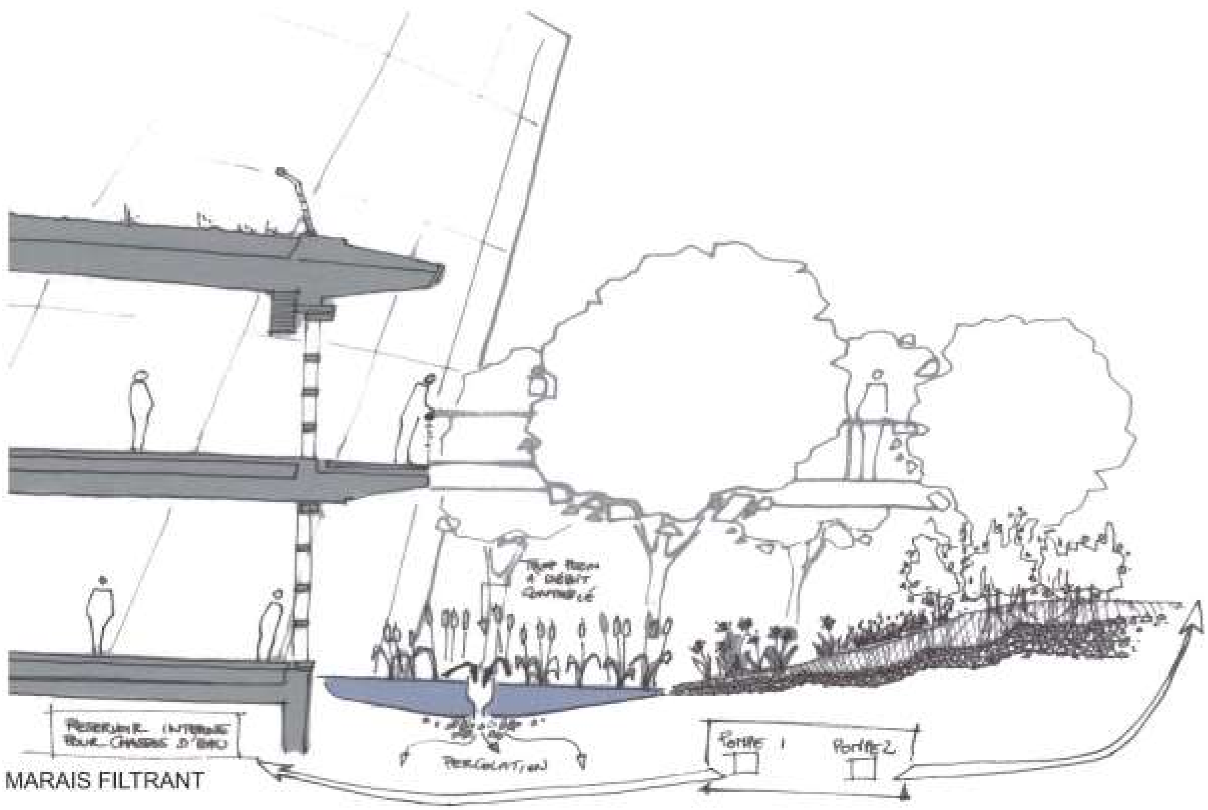

Figure 6.6. Diagram of water management on-site as presented by *Cardin Julien + Ædifica*

Notes: © *Cardin Julien + Ædifica* retrieved from (Canadian Competitions Catalogue (CCC), 2010)

The sign can still be considered an argumentic-symbolic-legisigns. It can be interpreted as a method of application ecological water management structured around the LEED© requirements (specifically for achieving the reduction in water usage required). The designed-object, the sketch, is a symbol of this method. The holistic ecological, human and natural character of the designed-object is clearly highlighted—what can be considered its connotative function. The representamen (*i.e.* text) also presents the denotative function of the designed-object—namely purifying water, reducing water demand and rainwater use. Both functions are presented in the sign simultaneously with no distinction.

However, the argument presented in the sign can still be valid if the denotative function was absent and even if the designed-object Figure 6.6) was not presented. This could be achieved by reformulating the statement to reference directly the credits sought after—*To achieve the LEED© platinum credits for rainwater management, water-efficient landscape design, innovative* *technologies for water management and water use, filtering marches will be added to the landscape and rainwater will be used in sanitary fixtures resulting in the required 55% reduction in use*. This type of criteria driven discursive formation can be seen in other parts of their text: such as the example of the educational program, presented previously, as well as the case of bicycle parking in the same project.

> *"[T]he standard for bicycle parking prescribes 5% on the number of full-time employees. We plan to install 30 bike parking facilities which will also allow access to visitors" Cardin Julien + Ædifica* [68]

Based on these examples, we can argue that in deductive design reasoning, connotative functions of objects become the end goal—they are an intrinsic part of the final interpretant of the sign. The denotative functions only serve and enforce the connotations. This process can be related to Barthes' idea of mythification (1972). On the other hand, abductive design reasoning focuses on the denotative functions of objects. This focus is critical for communicating the relationship between the elements required for formulating the sign. For the signs created by abductive sustainable design reasoning, the connotative functions of objects emerge through semiosis. In abductive reasoning, an unclear denotative function could contradict the rhematic interpretant—leading to confusion; as seen in the green roof case in *Atelier Big City & L'OEUF*'s project.

What is also important to note is that the cases of pure deductive sustainable design reasoning, where objects are fictional and immediate and where the connotative functions are foregrounded, might even hint to sustainability as a pure simulacrum—where the notion has no relation to any reality whatsoever and it becomes a simulation of its own (Baudrillard, 1995).

> *"There is a plethora of myths of origin and of signs of reality - a plethora of truth, of secondary objectivity, and authenticity. Escalation of the true, of lived experience,*

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68 Original French quote: "[L]a norme concernant les stationnements de vélos prescrit 5% sur le nombre d'employés à temps plein. Nous prévoyons installer 30 stationnements de vélos ce qui permettra aux visiteurs d'y avoir accès également." Cardin Julien + Ædifica

resurrection of the figurative where the object and substance have disappeared." (Baudrillard 1995 - p5)

6.8. Discussion

6.8.1. Modes of design reasoning, signs and judgment

Judgement can be considered a tradition in the field of architecture and specifically in architecture competitions. Chupin (2011), through the exploration of the history and practice of judgement, proposes a complex model for judgement, which he calls *judgement by design*. In this model, he proposes an analogy between judgement and design in the way they arrive at decisions. Although there are similarities between the dynamic process of design formulation and judgement, one can question the relevance of innovation within the jury's mandate for selecting one or a group of winning projects. Not to undermine the complexity of the process of judgment, which in some cases involves reviewing and selecting from more than 500 projects, the end goal is to *discover* the most suited project[69]—ultimately building a conclusion rather than a hypothesis (Collins, 1971; Chupin, 2011). This is clearly indicated within Zeisel's (2006)[70] spiral model (Figure 6.7), which Chupin (2011) uses as the basis of his judgement model. What is most important to highlight are the conceptual shifts—the leaps in our the understanding of the vision of process and product—required to arrive at *suitable* decision both in design and judgement (Zeisel, 2006). We can propose a parallel between these shifts and the levels of semiosis of architecture design signs: the initial images at the entry of the spiral correspond to the immediate objects that are then tested against the presented projects and their dynamical objects (in what is labelled the image-present-test cycles).

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69 This process of judgment as discovery could be correlated with Boudon's (2000) definition of inductive thinking – that which discovers.

70 Originally published in 1981 and revised in 2006

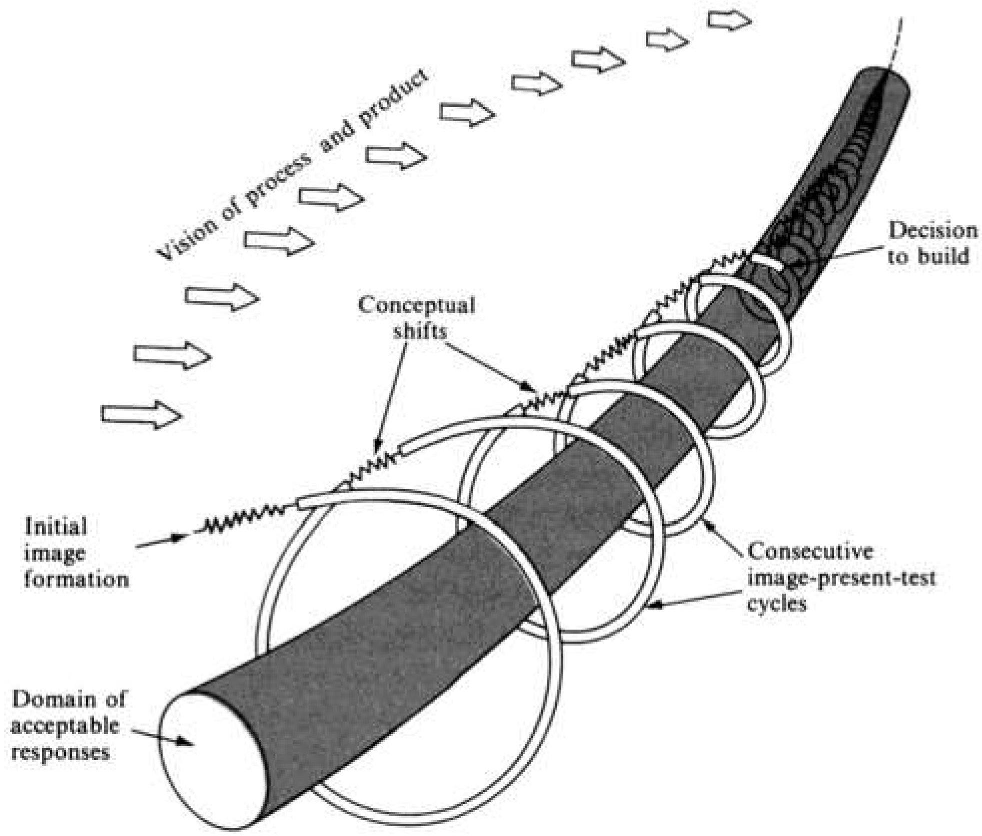

Figure 6.7. Zeisel's (2006 - p30) spiral model

Notes: As used by Chupin (2011)

Within the exploration of design reasoning in architecture projects, we can start to see how deductive sustainable design reasoning—and its resultant argumentic-symbolic-legisigns—could potentially resist these forms of open-judgement. These signs create a fixed conceptual ground that oppose the conceptual shifts proposed by Zeisel (2006) and that Chupin (2011) indicated to be crucial for arriving at judgements (*i.e.* in that context the word is understood as decisions based on judgement). In fact, depending on their occurrence in specific competitions, these argumentic-symbolic-legisigns might dislocate Zeisel's (2006) "domain of appropriate responses" to include them and exclude other signs that are less established and more experimental. This phenomenon has been explored by Cucuzzella (2015b) in different competitions. Cucuzzella reports that in this specific competition for the Planetarium of Montreal, the universal and technical approach to sustainability adopted by the winning project (*Cardin Julien* + *Ædifica*) put other projects that presented "experimental approaches" at a disadvantage—since they were seen as lacking the technical rigour and direct application of ecological guidelines (Cucuzzella, 2015b). She concludes:

> *"[W]e can now wonder if the competition format [...] is indeed compatible with the legitimate demand for environmental performance, and if it should not be reformulated by taking into account the space for exploration and innovation and the search for quality"* Cucuzzella, (2015b)

6.8.2. Modes of design reasoning and outlook

We have explored how the modes of sustainable design reasoning can affect how sustainable design features are described (textually) and presented (visually) to build complex signs. These modes have also been correlated with the shifting and placement of focus on the connotational or denotational meanings of objects, and they have been shown to affect how projects can—or cannot—be judged. One of the unique characteristics of projects is their anticipatory nature —the project has to be understood as a mode of imagining and shaping the future (Boutinet, 2005). More specifically, for sustainability in the built environment, this idea has been explored and defined as design *futuring*—where designs become forward-looking and catered to future scenarios (Fry, 2009, 2014).

In deductive reasoning, previous habits and conventions—which have known and predictable outcomes and can be replicated are used to establish design decisions and meanings. By replicating an established sustainability feature in a project, you are creating a *token*-based on past experience and knowledge. However, the specific application of this approach would require knowledge of the project—a type of minimal present knowledge—in addition to past experience. We can correlate this approach with what has been defined as *Status-Quo* in other research fields (Henderson, 2015). In other cases, where present knowledge of the project was missing, the jury commented on the apparent superposition of sustainability features on projects.

On the other hand, in abductive sustainable design reasoning, more diverse types of past knowledge (beyond the established approaches) are used and combined with present knowledge relating to the project to propose new signs. These new produced signs—new *types*—provides a future outlook that embodies the notions of anticipation and futuring: they provide hypotheses that could be tested and explored in the future (Fry, 2009). We can define these approaches as *Futured*. Figure 8 provides a comparison between the two modes of reasoning and their outlooks. With this view, it can be proposed that the future outlook can be further explored since “architectural projects is a practicable method for investigating the future and testing ideas” (Andersson, Zettersten, and Rönn 2013 - p11). These sustainable design visions can be analyzed based on their character (*i.e.* human vs technological focused) and their inspiration (history vs future driven) (Goubran & Cucuzzella, 2019).

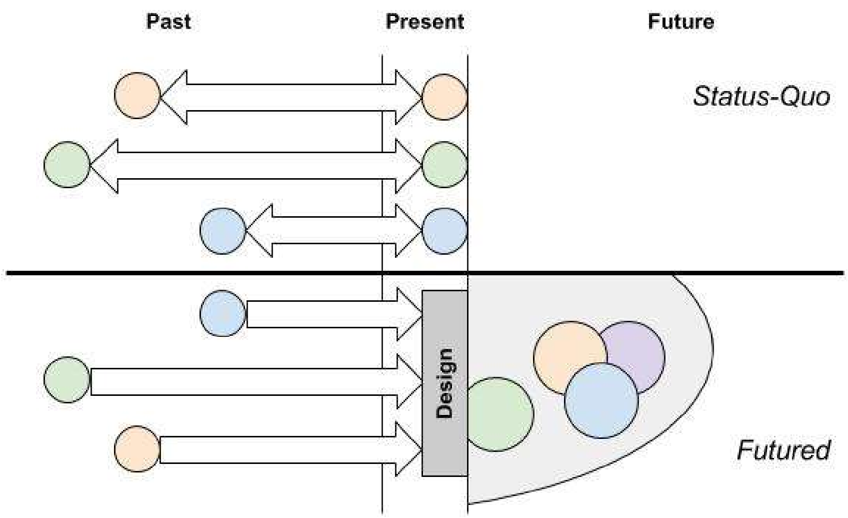

Figure 6.8. *Status-Quo* versus *Futured* approaches

Notes: Status-Quo approaches (top) aim at replicating past experiences and knowledge based on habit and Futured approaches (bottom) aims at synthesizing past knowledge with new knowledge to create new design hypotheses with a future outlook

6.8.3. On the roles of text and objects in architecture design

We have prioritized the analysis of the architectural texts where design teams describe and present their own projects—what was taken to be the representamen of the sustainable design signs. This approach provides the ability to ground the interpretation of the modes of reasoning on the linguistic structure, to compare the modes of reasoning in statements and discourse, and most importantly to understand how these statements build or weaken the links between designed-objects and texts[71]. However, this method could have three main shortcomings or contradictions.

The first relates to the comprehensiveness of the architectural text. Like all texts produced in an institutional setting and submitted in a formal setting, the documents analyzed followed requirements related to limits on the number of words, text structure and tone. In *Cardin Julien + Ædifica*'s project, for instance, the jury report highlights the passive environmental strategies used in the project (seen in Figure 6.9). These passive strategies, although bundled under categories that relate to LEED® credits, were not explicitly mentioned or articulated in the architects' description (Figure 6.9 shows some of these strategies). The reasons for excluding these strategies from the project description cannot be interpreted accurately. However, by exploring these design strategies on the presentation panel, they appear to be new design hypotheses: they present innovations that bridge material, technical and natural sciences with form-making. Thus, although the architects' texts are critical to building meaning in sustainable design, the complete dependence on texts could present limitations to the analysis. Future work will have to focus on developing means to mediate between the text and objects and to consider accounting for objects that are presented with no descriptive text. This can be achieved by broadening the corpus to include texts generated by the architects outside the competition or in interviewing the design teams regarding the projects.

71 Couples or decouples the sign if we use Li's terms (Li, 2017)

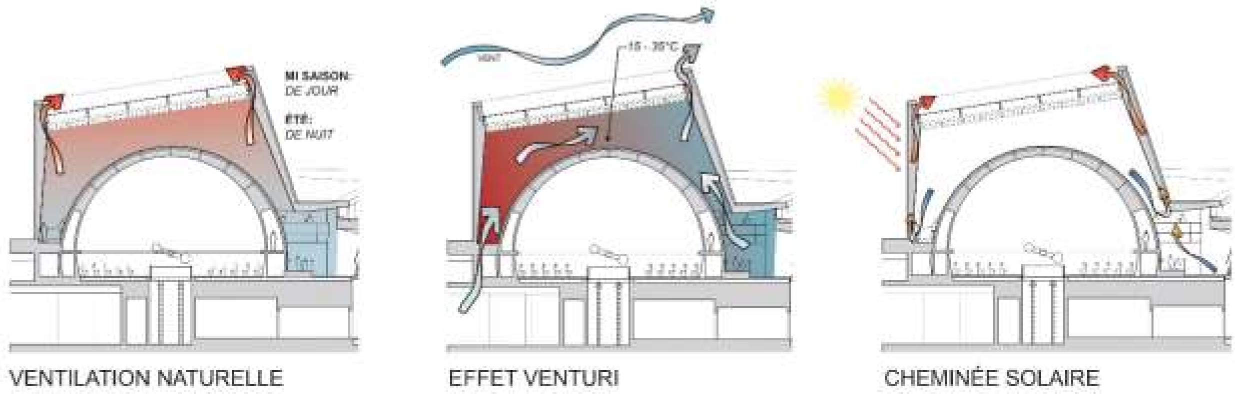

Figure 6.9. Some of the passive environmental strategies presented by *Cardin Julien + Ædifica*

Notes: © *Cardin Julien + Ædifica* retrieved from (Canadian Competitions Catalogue (CCC), 2010)

The second comment comes in contrast to the first. It relates to the limitations of the design panels on communicating environmental strategies in design projects. Within the same limitations proposed on text, the panels' format and number are also subject to project-specific requirements and regulations. Although designers, and architects in specific, are able to create technical, illustrative, and descriptive presentations to communicate their design and designed-objects, there still remains a question on how some environmental strategies could be meaningfully presented: strategies such as the use of recycled materials, the placement of windows to create interactions with exterior spaces or even the more abstract concepts such as biodiversity. The possibilities of meaningful representation for environmental strategies are in fact a scope of current architectural research in academia and practice. Although concretely, the project might be deploying some strategies that are described in the text, these objects might not be presented on the panels due to the lack of meaningful representation. Future work needs to focus on understanding this gap and exploring methods to overcome these limitations in the analysis of sustainable design signs.

While the first two limitations could apply to architectural projects in general, scholars of design competitions argue that competitions could be immune from such shortcomings. Researchers propose that the underlying epistemology of competitions includes both text and imagery as tools by which architectural projects provide solutions to specific design problems (Andersson et al., 2013, 2016; Chupin et al., 2015; Tostrup, 1999).

> *"Architectural competitions are based on three fundamental presuppositions: (a) that drawings and visualizations may transmit credible knowledge and (b) that quality in architecture is something that may be seen and transmitted via images. And in a principal view, (c) that architectural projects is a practicable method for investigating the future and testing ideas." (Andersson, Zettersten, and Rönn 2013 - p11)*

The third and final shortcoming relates to the overarching modes of reasoning in projects—namely deductive or abductive design reasoning. In the analysis, examples were used to highlight the polarities being investigated—deductive/abductive, connotative/denotative, and immediate/dynamical. Each of the two projects used in the examples exhibited tendencies towards a specific mode of reasoning. However, in both projects, some elements of each mode were present—such as the passive strategies of *Cardin Julien + Ædifica* shown in Figure 6.9 or in cases in *Atelier Big City & L'OEUF* where codes and standards were used to justify ecological design decisions. This raises several questions about whether one project can be said to have an overarching mode of reasoning and how such a mode could be assessed. If one mode of reasoning is selected qualitatively for a project[72], it would disregard instances of other modes. A quantitative comparison, where for example saying that 10 objects are based on deductive reasoning and 5 are based on abductive reasoning to justify its overarching deductive reasoning, disregards the relative importance of these objects to the project[73]. Developing combined measures that capture both the qualitative and quantitative occurrences might provide a solution for this limitation.

6.9. Conclusion

In this paper, we have attempted to use Peirce's (1991) triads to explore and understand sustainable architecture design signs. The paper proposed to correlate the representamen of the sign with the architectural text of projects, the object of the sign to the designed-objects that are illustrated in design documents, and the interpretant to the meaning generated. Previous literature had proposed

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72 Qualitatively in this context means based on the qualities of the text and linguistic structure,

73 Where one designed-object could be relatively more important in the design – having spatial, functional and structural effects that are more significant than others. Example: the passive design strategies of Cardin Julien + Ædifica which showed a tendency towards abductive reasoning helped shape and refine the cones which cover the theatre – one of the most distinctive feature of the project.

two approaches to sustainable design—technical and reflective (Cucuzzella, 2016). The paper correlated these approaches, using ideas of Boudon (2000), to the modes of reasoning proposed by Peirce and elaborated by Fisette (1997): where technical approaches are correlated to deductive sustainable design reasoning and reflective approaches are correlated to abductive sustainable design reasoning. By using documents extracted from the international design competition for the new Montreal Planetarium, the distinction between the two modes of reasoning is made clear from the statements and descriptive texts. The paper then used the two projects to highlight the effects these modes of reasoning have on the production of sustainable design signs, and to explore the roles designed-objects occupy in each of these modes of reasoning. Additionally, the paper proposed that in abductive sustainable design reasoning text and designed-objects are coupled to denote while in deductive reasoning the sign is decoupled and focused on connotative meanings. Table 6.1 presents a summary of the characteristics proposed for the two modes of reasoning.

Table 6.1. Summary of semiotic characteristics of deductive and abductive sustainable design reasoning

Mode of sustainable design reasoning	Deductive	Abductive
Mode	Established meaning through code, precedents and habit.	Create new hypotheses with potential new meaning(s)
Text	Heavily referencing established systems and conventions	Focused on the relationship between elements
Designed-objects	Occupy a symbolic status	Could be icons, indexes or symbols. But are mainly iconic in illustrating the relations and properties proposed in the text
Meaning	Arguments the necessity of the sign within an established system.	Proposes that the sign belongs to an open system with many possible interpretations. Fin
Signs created (minimum level)	Argumentic-symbolic-legisigns	Rhematic-iconic-sinsign
Final interpretant	Immediate and present.	Dynamic and requires interpretations
Existence of objects	Immediate objects sufficient for validity	Dynamical objects required for formalizing the intended meaning
Functional focus	Focused on connotative—or merges connotative and denotative	Denotative meanings prioritized—connotations open to interpretation
Process of semiosis	Short-circuited	Ad-Infinitum

In the discussion section, the judgement process in architecture was studied based on the ideas of Chupin (2011) and Collins (1971). In regard to sustainability in architectural projects, a gap appeared between the open form of critical judgement proposed for competitions and the conceptual fixation inherit in deductive sustainable design reasoning and their argumentic-symbolic-legisigns. By intersecting the characteristics of deductive and abductive sustainable design reasoning, the first was correlated with *Status-quo* definition and the second with the concept of *Futuring*. Futured signs present an opportunity to be further analysed based on the nature and inspiration of their future outlook. Finally, some of the limitations of the approach and pending questions were presented in the final section of the discussion with some ideas for future research directions.

This paper seeks to contribute to the theoretical modelling of sustainability in architectural design projects. The paper proposes a methodological shift in the understanding sustainability features in architectural projects—to be understood as triadic signs composed of text, designed-objects and meaning(s). Additionally, the paper proposes a combination of analysis, based on semiotics and discourse analysis, to extract and define the modes of reasoning around sustainability issues in design. Future work should attempt to use the approach proposed in this paper to study sustainability in architectural projects with a specific focus on the role of abductive design reasoning and the generation of future outlooks.

6.10. Chapter postscript

The similarity between architecture and language, as well as architecture's ability to convey meaning, have been previously theorized (Abd. Manan & Smith, 2014; Barthes, 1985; Doyle, 1991; "Du Didact. En Archit. / Didact. Archit.," 2019; Eco, 1981; Gieryn, 2002; Klee, 2018; Krampen, 2013; Lazutina et al., 2016; Martin & Lachance, 2018; Wang & Heath, 2011). However, before this publication, almost no studies have attempted to use semiotics theories to understand the phenomenon of sustainability in architectural design.

Using the semiotics of C.S. Peirce, the chapter establishes and theoretically validates the triadic nature of sustainable design signs[74] in architectural projects (Andersson et al., 2013; Buchler, 1955; Deledalle, 2000; Fisette, 1997; Hartshorne et al., 1994; Hoopes, 1991; Houser et al., 1998; Yuan Li, 2017; Sheriff, 1989). This triad is composed of: (A) a representamen (text), (B) an object (designed-object), and (C) an interpretant (meaning).

Chapter 6 answers key questions relating to what sustainability "means" in architecture, how its meanings are communicated, and how they come to existence, are realized and replicated. The chapter distinguished, based on the available literature and through the semiotic model proposed, between two modes of design reasoning (or design approaches): *deductive* and *abductive* design reasoning. Boudon's (2000) writing is used to theoretically differentiate between abduction, which innovates by investigation, and deduction, which establishes by regulation and habit. Using the descriptive text and design panels of two projects in the Montreal Planetarium competition's final

74 "[A sign (or representamen) is] anything which determines something else (its interpretant) to refer to an object to which itself refers (its object) in the same way, the interpretant becoming in turn a sign, and so on ad infinitum" (CP2.303)

phase[75], the two modes of reasoning and their resulting signs are exemplified, studied and discussed.

The first level of analysis of the two projects validates Boudon's (2000) proposition that the abductive mode of design reasoning—where meaning emerges by semiosis—functions in contrast to deductive design reasoning, which establishes meaning based on convention and guidelines. Additionally, and by combining the theory of institutionalization and its application to semiotics (Barley & Tolbert, 1997; Giddens, 1984; Yuan Li, 2017), it was made clear that in abductive modes of reasoning, descriptive texts and designed-objects become coupled and inseparable.

By investigating the role of designed-objects (or sustainable design features and design elements) in the projects, it was illustrated that deductive reasoning does not depend on the designed-object qualities, or even its existence in the panels. While, on the other hand, the meaning of sign resulting from abductive design reasoning is contingent on the ability of designed-objects to conform to the text. Using the ideas proposed by Umberto Eco (Eco, 1981; Krampen, 2013; Prieto, 1975) on the distinction between connotative and denotative functions in buildings, it was seen that signs resulting from deductive reasoning have the connotative functions of objects as their end goal – stressing on the elements' social and cultural meanings. This, in turn, empties the sign from its denotative or actual functions. By intersecting these ideas with the model of architectural judgement proposed by Chupin (2011), the chapter proposed that denotive sustainable design reasoning dislocated and marginalized the more innovative and experimental approaches – putting them at a disadvantage. This was supported by Cucuzzella's (2015b) observations of the judgement in the context of architectural competitions.

To further the analysis, the chapter explored the outlook and visions that emerge as a result of the two modes of reasoning. In deductive reasoning, previous habits and conventions are used to establish design decisions and meanings. By replicating an established sustainability feature in a project, only a *token* can be created, further validating established conventions. On the other hand,

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75 Two projects used are: (A) the winning project by Cardin Julien + Ædifica, SNC Lavalin, Dupras Ledoux, and Fauteux et associés (referred to as *Cardin Julien + Ædifica*) as well as (B) a runner-up project by Atelier Big City & L'OEUF (referred to as *Atelier Big City & L'OEUF*).

abductive design reasoning proposes a new hypothesis, which can only be tested in the future to then be validated or refuted (Buchler, 1955) – thus creating *new types* (Fisette, 1997). Consequently, signs that are a result of deductive reasoning are considered to represent a *status-quo approach* while those that are a result of abductive reasoning are considered *futured* – and representative of a future outlook worth studying (Andersson et al., 2013; Goubran & Cucuzzella, 2019).

While some limitations were reported, the study provides an important methodological contribution that could help scholars, designers, and jury panels in architectural projects differentiate between critical and non-critical design approaches to sustainability. Within the context of the thesis, Chapter 6 provides the essential methodological foundation on which design approaches can be analyzed in completed building projects – beyond the interpretative paradigm.

Chapter 7 builds on the intellectual, practical and theoretical contributions of the various chapters of the thesis to attempt an analysis of how recognized sustainable Canadian public buildings, specifically recent projects that received sustainable building awards in Canada, address the topics of the SDGs. Chapter 7 is an interdisciplinary inquiry that uses a variety of methods and can be considered a conclusion for the thesis.

CHAPTER 7. SUSTAINABLE DEVELOPMENT AS UNDERSTOOD FROM CANADA'S MOST AWARDED PUBLIC GREEN BUILDINGS

7.1. Foreword

Chapter 7 serves as a practical application for developed ideas and methods. In this final chapter, the methodologies proposed in Chapter 4 (SDG mapping and textual analysis), Chapter 5 (level of sustainable development integration and SDVs), and Chapter 6 (semiotic framework for distinguishing between innovative and status quo approaches) are combined. For this, the chapter develops a sequential analysis process that starts by filtering through the design, descriptive and judgement texts of the projects, before adding a layer of critical content analysis, design analysis and comparisons. The main aim is to understand the sustainable design character of these projects. Specifically, how sustainable development is conceptualized and manifested in a group of Canadian buildings that were repeatedly recognized for their excellence and sustainability.

The chapter's corpus selection builds onto the findings presented in Goubran, 2020; Goubran, Cucuzzella, et al., n.d., to select public, institutional and educational buildings (that have at their core of their program community service goals), which are distributed across Canada (to ensure that no regional biases are present). The cases' selection also prioritized projects that are an outcome of competitions or public tenders or that received significant academic or discipline-based media to ensure data availability.

While Canada's most awarded green buildings are successful in addressing a certain group of sustainable development topics, the chapter proposes that they are neglecting important social, economic, and cultural challenges and are not utilizing their full potential to realize sustainable development. As such, the chapter explores the potentials and gaps that these buildings present, and aims to extract, from these practical cases, some of the tensions that arise between green and sustainable design.

The chapter aims to answer the following questions:

1. Which of the SDG topics do Canada's most recognized contemporary green buildings address? Are there key gaps?

2. What are the prevailing approaches to sustainable design in the awarded Canadian buildings?
3. How are building designers tackling the sustainable development challenges highlighted in the 2030 Agenda - in terms of discipline and integration degree?
4. What sustainable development visions do these buildings offer? What are the prevailing perspectives?

This chapter is based on current ongoing research with Dr. Carmela Cucuzzella and Dr. Jean-Pierre Chupin. Thus, the chapter has been prepared as a draft for a future co-authored manuscript, for which the thesis author is the main contributor. The chapter specific status is detailed in Appendix (C). The keywords for this chapter are listed in Appendix (B).

The meta-data pertaining to Canadian architecture awards presented in this study has been collected under a contract from the Canada Research Chair in Architecture, Competitions and Mediations for Excellence (CRC-ACME - crc.umontreal.ca) and, therefore, belongs to this entity. However, the thesis author collected the specific documents collected for the analysis (building drawings, images, photos, studies, textual, media, presentations, etc.). The data has been used after the secondary data owner has granted appropriate permissions. It is important to note that using the information in an un-opinionated publication or scholarly research does not imply ownership of primary data – whose copyrights reside with the concerned organization and architects, designers, office managers consortiums or archives concerned.

The chapter builds on a number of publications beyond the content of this thesis, including:

Cucuzzella, C., & Goubran, S. (2019). Infrastructure as a Deeply Integrated Sustainable Urban Project. *Journal of Sustainability Research*, *1*(1), 1–29. https://doi.org/10.20900/jsr20190005

7.2. Introduction

Awarded buildings are often promoted in research, education, policy, and practice. Having passed the judgement of judges composed of peers and experts, these venerated buildings are assumed to offer exemplary and inspiring models. Unlike prizes and awards that gain their significance from their history or prominence of their issuers, a large number of sustainable building awards have been established in the last ten years (Manan et al., 2010; Po-chi & Bonnie, 2011), and their issuers are not limited to prominent professional orders (Roudbari, 2018) or renowned not-for-profits (Dixon, 2017; Ivy, 2007). While questions around the broad definition of excellence in architecture and discussions about the value of different awards are still the subject of professional and academic debates, we propose that sustainable building awards offer a distinct and independent area of inquiry – based on the work of Oliveira & Sexton, 2016; Owen & Lorrimar-Shanks (2015).

Sustainability in architecture has been a contested topic. Previous research has shown that competing definitions, diverging design approaches and conflicting judgement-logics are at the core of the debate around sustainable architectural design and assessment (Cucuzzella, 2015b; Cucuzzella & Goubran, 2020a; Farmer & Guy, 2005; Guy & Moore, 2007). This study seeks to define sustainability in buildings through its alignment with sustainable development (Goubran, Masson, et al., 2019). We use the United Nations Sustainable Development Goals (SDGs), detailed in the 2030 Agenda, as a framework for defining sustainable development objectives (Pedersen, 2018). The SDGs provide a globally accepted definition that is supported by global and local commitments for at least the next ten years. Canada adopted the agenda in 2015, and the government indicates that it "presents Canada, and the world, with a historic opportunity to positively shape how societies of tomorrow grow and develop sustainably and inclusively to the shared benefit of all" (Government of Canada, 2018). Beyond outlining the key topics to address, the agenda embodies a call for "transformative" actions and visions (Baue, 2019; Bojer, 2017). In the context of sustainable design, transformative approaches have been linked to methods that move beyond harm-reduction, product-improvements and resource-optimization (Bhamra, 2004; H. Brezet, 1997; Ceschin & Gaziulusoy, 2016; Raymond J. Cole, 2005; Cucuzzella, 2011b, 2016; Dewberry, 1995, 1996; Dewberry & Goggin, 1996; Fletcher & Goggin, 2001; Lehni & World Business Council for Sustainable Development, 2000; Y Li et al., 2019).

While some of the SDGs seems to be focused on issues that span beyond one building or institution, the UN and its affiliate organizations have called for scaling down the goals to inform local and single project activities (Institute of Architecture and Technology (KADK) et al., 2018, 2020). Previous research has already shown that the building sector has a major role in providing the infrastructure and spaces for development to happen, moving beyond project-level improvements and environmental-footprint reduction (Goubran, 2019a; Goubran & Cucuzzella, 2019). In response to those political, public and financial pressures, the green building sector, its practitioners and scholars, have been working on finding alignments between current practices and the SDGs, or on shifting their focus towards addressing these goals (Alawneh, Ghazali, Ali, & Asif, 2019; Alawneh, Ghazali, Ali, & Sadullah, 2019; Czerwinska, 2017; B. Wen et al., 2020).

In this study, we propose that public buildings, which are designed to provide services to communities, ought to address the environmental, social, cultural, and economic objectives of the SDGs, and we specifically set out to understand if and how they do so. To investigate this, we focus on a select group of Canadian buildings that garnered a considerable number of awards, specifically sustainability-focused recognitions, between 2010 and 2015. The study aims to specifically select cases from across Canada. Thus, the analysis becomes focused on representative public Canadian buildings from each region that are recognized for their excellence in sustainability and green design. The analysis attempts to understand how the architects and design teams of these exemplary projects attempt to address sustainable development through their work, which materializes their visions for a more sustainable future (Goubran & Cucuzzella, 2019). The paper combines 4 different analysis processes to create a methodology aimed at distilling the architectural vision presented in the projects. Through this analysis, we specifically aim to answer the following questions:

1. Which of the SDG topics do Canada's most recognized green buildings address? Are there key gaps?
2. What are the prevailing approaches to sustainable design in the awarded Canadian buildings?
3. How are building designers tackling the sustainable development challenges highlighted in the 2030 Agenda - in terms of discipline and integration level?
4. What sustainable development visions do these buildings offer? What are the prevailing perspectives?

7.3. Methodology

7.3.1. Analytical framework and methods

To answer the proposed research questions, the study deploys an analysis sequence composed of four steps. Specifically, the methodology proposed aims to understand the overlaps between the project and the 2030 Agenda, understand the modes of sustainable thinking, the domains and level of integration of the SDG topics in the project, and the future sustainability visions of the buildings project. Figure 7.1 presents an overview of the methodology, explained in further detail in the subsequent paragraphs.

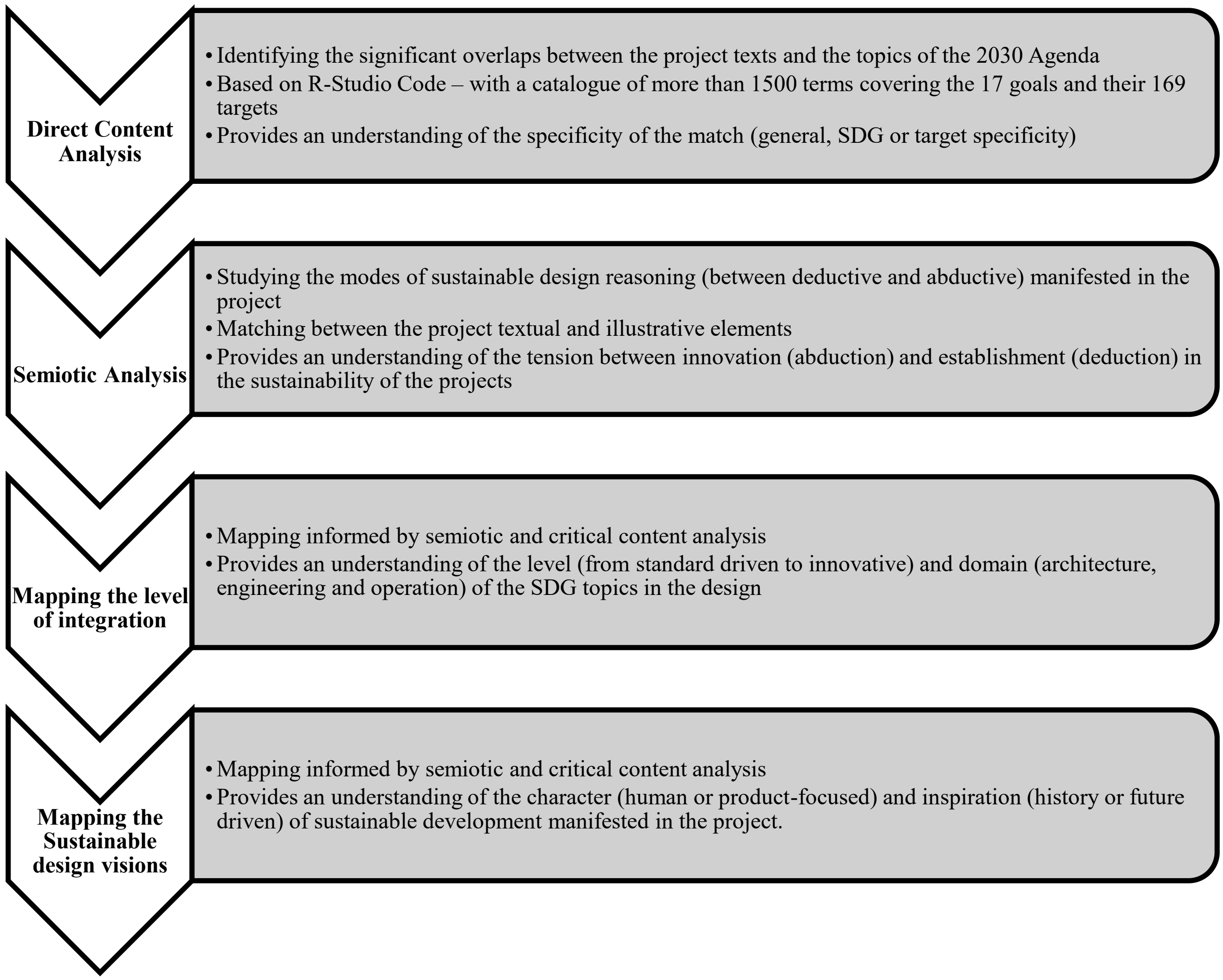

Figure 7.1. Overview of methodological steps, showing the 4-levels of analysis proposed

For the direct content analysis, we utilize a previously developed keyword catalogue and process (Goubran et al. - unpublished manuscript). The keyword catalogue contains 1503 terms, including 564 with asterisks. The keywords are distributed across each of the SDGs and their targets and included in an 18th category (miscellaneous). Specifically, keywords in the miscellaneous category are general terms that apply to sustainable development but are not specific to one of the 17 SDGs;

adversely, SDG level keywords are broad terms that relate to the SDGs but do not address one of its targets specifically. Finally, target-level keywords are those that address a specific target within the agenda. The catalogue was validated through 2-paths: qualitatively and comparatively to other published studies (such as Alawneh et al., 2018; Alawneh, Ghazali, Ali, & Asif, 2019; Alawneh, Ghazali, Ali, & Sadullah, 2019; GRESB, 2019; The Association for the Advancement of Sustainability in Higher Education, 2019). We adopt a previously developed R-studio program to analyze the texts of the various architectural projects. We identify a significant match between the texts and an SDG if the matches exceed the median matches per SDG returned for each project[76]. This is to ensure that the analysis reports only SDGs that are of significant focus in the analyzed documents. We report the outcome of the analysis based on the distribution of matches, in the percentage of matched words to the total number of words[77].

In the second level of analysis, we attempt to distinguish deductive and abductive sustainable design reasoning – as proposed by Goubran (2019b) (summary presented in Table 7.1). In sustainable architecture design, deductive reasoning is argued to be less focused on the design-problem and more fixated on establishing design sustainability through codes, precedents, and habits. On the other hand, abductive reasoning can lead to innovations, where new hypotheses are proposed and tested, and depend on establishing new connections between the design elements of projects. Goubran (2019b) argues that only the latter can lead to a "futured" vision (as per the ideas of (Fry, 2009, 2014)– with new possibilities and progress can happen in the field of sustainable architecture. This approach's theoretical grounds are founded on the semiotics of C.S. Peirce, elaborated in the following publications (Buchler, 1955; Deledalle, 2000; Fisette, 1997; Hartshorne et al., 1994; Hoopes, 1991; Houser et al., 1998).

We depend on the extracted data (text, architectural drawings, pictures and illustrative and analytical figures) for each project to deduce the mode of reasoning deployed for the identified

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76 Example, if the texts match with 10 SDGs with a median of 3 matches per SDG, only SDGs with 4 or more matches will be considered significant).

77 The total number of words reported represents the total number of words processed: with related words joined and stop words removed. Example: "the sustainable building" is counted as one word: "sustianablebuiling"

SDGs in the first step – namely, whether the project proposes a new sustainable design hypothesis or establishes its sustainability in a deductive manner. For this process, discourse analysis is used to analyze the statements that appear in the texts, and critical discourse analysis approaches will be used to highlight and relate the specific arguments presented (both in images and text) with the broader situation of the project, including information presented in the jury reports, media and other project presentations (Hodge & Kress, 1995b, 1995a; Michel Foucault, 1993; van Dijk, 2008b, 2008a)

Table 7.1. Summary of semiotic characteristics of deductive and abductive sustainable design reasoning – adapted from Goubran (2019b)

Mode of sustainable design reasoning	**Deductive**	**Abductive**
Mode	Establishes meaning through code, precedents and habit.	Creates new hypotheses with potential new meaning(s)
Text	Heavily referencing established systems and conventions	Focused on the relationship between elements
Designed-objects	Occupy a symbolic status	Could be icons, indexes or symbols. But are mainly iconic in illustrating the relations and properties proposed in the text
Final interpretant	Immediate and present.	Dynamic and requires interpretations
Existence of objects	Immediate objects sufficient for validity	Dynamical objects required for formalizing the intended meaning
Functional focus	Focused on connotative—or merges connotative and denotative	Denotative meanings prioritized—connotations open to interpretation

The analysis specifically focused on the designers' description of the projects and aimed to access earlier design texts, where the design intentions are the most vivid and where the project first becomes a physical object that exists in the environment beyond the mind of the planner (Perkins-Buzo, 2017). Other descriptive texts for projects will be used to discuss how architects' intention has been interpreted, criticized or inflated by award issuers (through jury reports) and critics (through news and magazine articles). The cases where projects' contribution to sustainable development are being inflated beyond architects' original intentions might be pointing to new forms of "green-washing" – namely sustainable-development washing.

In the next steps of the analysis, we build onto the content analysis conducted to map the integration of the identified SDGs into the projects and the sustainable design visions around them. We depend on the frameworks developed by Goubran and Cucuzzella (2019).

- For the integration mapping (seen in Figure 7.2), we follow the 3-field, 4-level approach (which the authors based on the work of Busby Perkins+Will & Stantec Consulting, 2007; Kanters & Horvat, 2012; Loh et al., 2017),
  - where the integration of an SDG topic can happen within the
    - architecture, concerned with the spatial, experiential and tectonic character of a project
    - engineering, concerned with the technical, systems and performance attribute of the project, and/or
    - operation of a building, concerned with the operation, maintenance, and daily functioning of the project.
- and at varying levels, ranging between:
  - Level- 0 (no integration)
  - Level 1 (standard or precedent driven)
  - Level 2 (beyond precedents)
  - Level 3 (innovative integration)[78]
- For the analysis of the design approach (seen in Figure 7.3), we follow the 4-quadrants map that the authors proposed (which they based on the work of Boutinet, 1993, 2005, 2014; Bovati, 2017; Boyko et al., 2012; Cucuzzella, 2015; Fisher, 2008; Fry, 2009; Guy & Farmer, 2001; Hajer, 1995; Nelson & Stolterman, 2012; Orr, 2002; Prishtina, 2018; Schön, 1983) where a sustainable design vision's:
  - character oscillates between
    - Human focused approaches: places the users, society and communities at their core

78 As it is clear from the process, the identification of the sustainable design mode of reasoning directly feeds into the understanding of the level of integration (where only abductive reasoning to topics can potentially lead to innovative integration).

        - Product focused approaches: is concerned with technologies, products and the materiality of the project
    - inspiration oscillates between
        - History driven approaches: inspired by how things have been done or are being done – i.e. looking at precedents, and history for inspiration (including natural processes)
        - Future driven approaches: is concerned with imagining new ways and states and situations for sustainable development to happen

When comparing and contrasting the approaches to the agenda, we utilize the planetary boundary based[79] three-category concentric circle model proposed by Waage et al. (2015) and utilized by Lucas et al. (2016) for the SDGs: where SDG 17 represents the overarching container, SDGs 13, 14 and 15 constitute the natural resources outer circle, which contains the infrastructure circle including SDGs 2, 6, 7, 8, 9, 11 and 12, and finally including SDGs 1,3,4,5 and 10 in the wellbeing category at the core.

79 Here the limits to growth thesis (Meadows et al., 1972) is revisited and integrated into the understanding of the 2030 Agenda

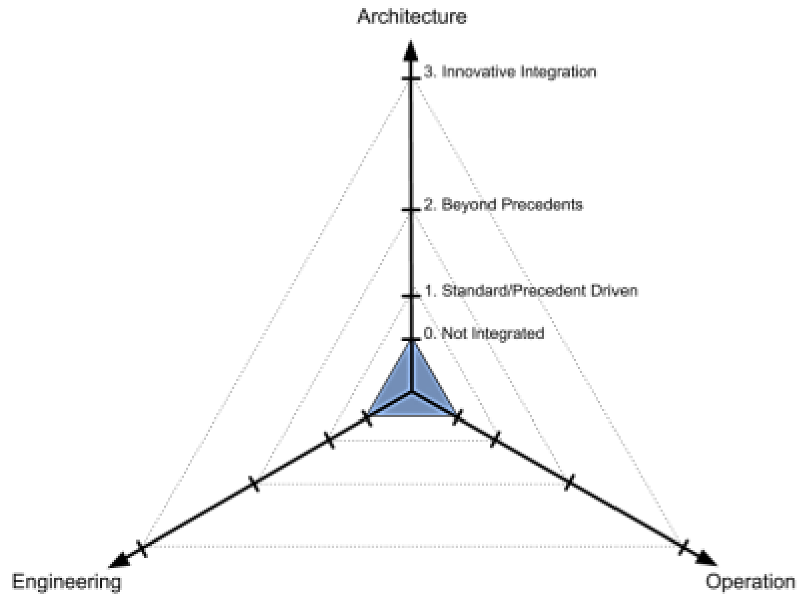


Figure 7.2. Mapping tool for evaluating the SDG integration in projects – adapted from Goubran and Cucuzzella (2019)

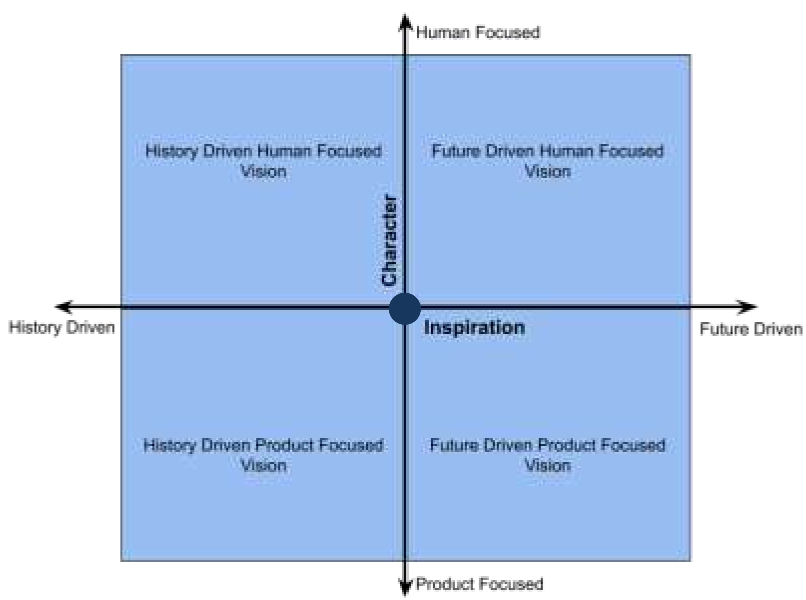


Figure 7.3. Mapping tool for analyzing the sustainable design visions (SDVs) around the SDG topics. *The further away from the axis, the clearer the vision, and the middle portion constitutes an unclear vision* – adapted from Goubran and Cucuzzella (2019)

7.3.2. Selection of corpus and data acquisition and analysis

Efforts to document how architecture and architectural design projects can help directly attain or support the achievement of the SDGs have been on the rise in the last years (Institute of Architecture and Technology (KADK) et al., 2018, 2020)[80] Some of the international awards, such as the LafargeHolcim foundation awards (LafargeHolcim Foundation, 2020a, 2020b), specifically structure their awards around themes directly aligned with the SDGs and sustainable development agenda (people, planet, prosperity, place (instead of peace), and progress(instead of partnership)), and they even embed their mission within the sustainable development publications such as the Brundtland Report (World Commission on Environment and Development, 1987). However, this is not the case in Canada, or any of the Canadian architecture awards. Thus, there is no coherent Canadian corpus of projects with *a priori* links to the SDGs.

The study follows a more exploratory approach, where it aims to understand how buildings that have been recognized for sustainable and green excellence consider, address and, potentially, contribute to the SDGs. Informed by documentation and analysis of green awards and awarded the buildings (Goubran, 2020; Goubran, Cucuzzella, et al. - unpublished manuscript), we develop a process for selecting representative green-awards-winning buildings from across Canada, which leads us to choose five representative cases for the analysis (presented in Table 7.2):

1. Limit the scope of the research between 2010 and 2019. This is informed by the significant increase in Canadian green awards post-2009 (as reported by Goubran, (2020)) and on the availability of data for the buildings. **A total of 215 buildings with green awards are extracted (receiving close to 255 awards and recognitions).**
2. We isolate buildings that received multiple green or sustainability-focused awards. **A total of 46 projects are identified.**
3. We inductively conclude that six key geographic regions exist in Canada: namely, **Atlantic, Quebec, Ontario, Prairies, British Columbia** and the **territories**[81]

80 None of the examples listed in these publications include Canadian projects – although examples from other developed nations are available.

81 No awards and awarded buildings were available in Canada's territories

4. We select the public building with the most green-awards for further analysis. Public buildings are considered as those which are meant to provide services to a broad audience and include libraries, municipal projects, educational facilities and interpretation centers. Thus, all the cases selected have gone through multiple filters for excellence through awards (usually focused on different building aspects) as well as media critiques

Table 7.2. Details of the selected case studies

Building	**Year**	**Location**	**Architect**	**Client**	**Cert.**	**Sqm (avg. $/sqm)***	**Awards****
Bibliothèque du Boisé	2013	Montreal, Quebec	Consortium Labonté Marcil, Cardinal Hardy, Eric Pelletier architectes	City of Montreal	LEED Platinum	5,960 ($2,408)	21
Centre for Interactive Research on Sustainability (CIRS)	2011	Vancouver, British Columbia	Perkins + Will Canada	UBC Properties Trust	LEED Platinum	5675 ($6,520)	16
Bill Fisch Forest Stewardship and Education Centre	2015	Whitchurch-Stouffville, Ontario	DIALOG	The Regional Municipality of York	LEED Platinum and Petal Certified by living building challenge	372 ($8,333)	8
Halifax Central Library	2014	Halifax, Nova Scotia	Schmidt Hammer Lassen with Fowler Bauld & Mitchell	Halifax Regional Municipality/ Halifax Public Libraries	LEED Gold	14,500 ($3,973)	6
Amber Trails Community School	2015	Winnipeg, Manitoba	Prairie Architects	Public Schools Finance Board (Seven Oaks School Division)	LEED Platinum	7,897 ($3,040)	5

*Averages obtained from various sources - rounded up.
**Total documented number awards (including green awards, which are specified within the analysis)

Following the cases' selection, an extensive data collection process was carried out. Data for competitions were retrieved when available through the Canadian Competition catalogue (CCC) at ccc.umontreal.ca. ("Canadian Competitions Catalogue (CCC)"). Request for proposal data was retrieved through the various stakeholders and clients (through direct emails and requests for access to public information). Submissions binders for awards were requested, and the CRC-ACME (Jean-Pierre Chupin, 2017) facilitated their retrieval. Public and mediatized data available on the web and library repertoires (such as *Canadian Architect, ArchDaily and other architecture focused outlets*) were retrieved through online and physical searches. Documents are divided into three categories: A) Descriptive design texts (including technical descriptions when available), B) Project presentation texts, and C) Judgment and assessment texts. The results will report on on the observable differences across these categories. In total for the five cases, more than 350 documents were collected, which were then filtered for analysis.

7.4. Analysis and Results

7.4.1. Bibliothèque du Boisé *(2013)*

7.4.1.1. Project Context and data

This project is an outcome of a two-step design competition launched by the City of Montreal in 2009 (at the time, titled The Saint-Laurent Library). Cardinal Hardy Labonté Marcil Eric Pelletier architectes in consortium (known now as Lemay) submitted the winning entry. The building was commissioned near the end of 2013. In their description of the project, architects of the library boast slogans such as "the greenest library in Canada" (Lemay, 2020a) and as a "pioneering sustainable library" (Lemay, 2020b). Between 2010 and 2017, the building has garnered 21 provincial, national, international awards and mentions, including at least 6 that are green-focused (Lemay, 2020b). The full list of awards the building received is available in Appendix (J).

"Far from a monumental approach" (ArchDaily, 2014), the building is imagined as a continuation of the landscape, the project aimed to blend through its floating roof, which reacts and interacts dynamically with its natural context. The building's vertical glass exhibition atrium aims to demark a new encounter between the visitors and the park while creating unique experiences within its spaces (Canadian Architect, 2010). These design gestures are made clear through the conceptual sketch Figure 7.4 and the artistic renders of the project Figure 7.5. The journey into the park through the library is clearly visible from the site plan in Figure 7.6, which also shows the large green roof.

Figure 7.4. Conceptual sketch of the Bibliothèque du Boisé as presented in the competition (nd.)
© Consortium Labonté Marcil, Cardinal Hardy, Eric Pelletier architectes

Figure 7.5. Renders of the Bibliothèque du Boisé as presented in the competition (2010)
© Consortium Labonté Marcil, Cardinal Hardy, Eric Pelletier architects

Figure 7.6. Site plan of the Bibliothèque du Boisé as presented in the competition
© Consortium Labonté Marcil, Cardinal Hardy, Eric Pelletier architectes

The constructed project boasts a rich variety of construction materials: wood and timber elements cover the interior surface of the roof and many of the interior surfaces; a hybrid steel structure (which led the project to receive a provincial steel award in the category of green buildings, commercial-institution and the jury favourite); Zinc cladding for the dynamic roof structure (which led for the project to receive an international zinc-focused award in the category of sustainable buildings), and various forms and languages of glass surfaces. This variety brings depth to the architecture and strengthens its dialogue with the surrounding, as seen in Figure 7.7.

Figure 7.7. Exterior views of the Bibliothèque du Boisé (2014)
© Consortium Labonté Marcil, Cardinal Hardy, Eric Pelletier architectes

The interior of the building offers a range of opportunities for interaction, learning and exchange. In many cases, the windows frame the view to park – establishing the strong connection required within the competition brief. The roof, which defines the exterior design, extends its influence on the interior spaces by continuing its bends and folds to create openings that allow natural light to enter into the structure's interior spaces. These architectural qualities are visible in Figure 7.8.

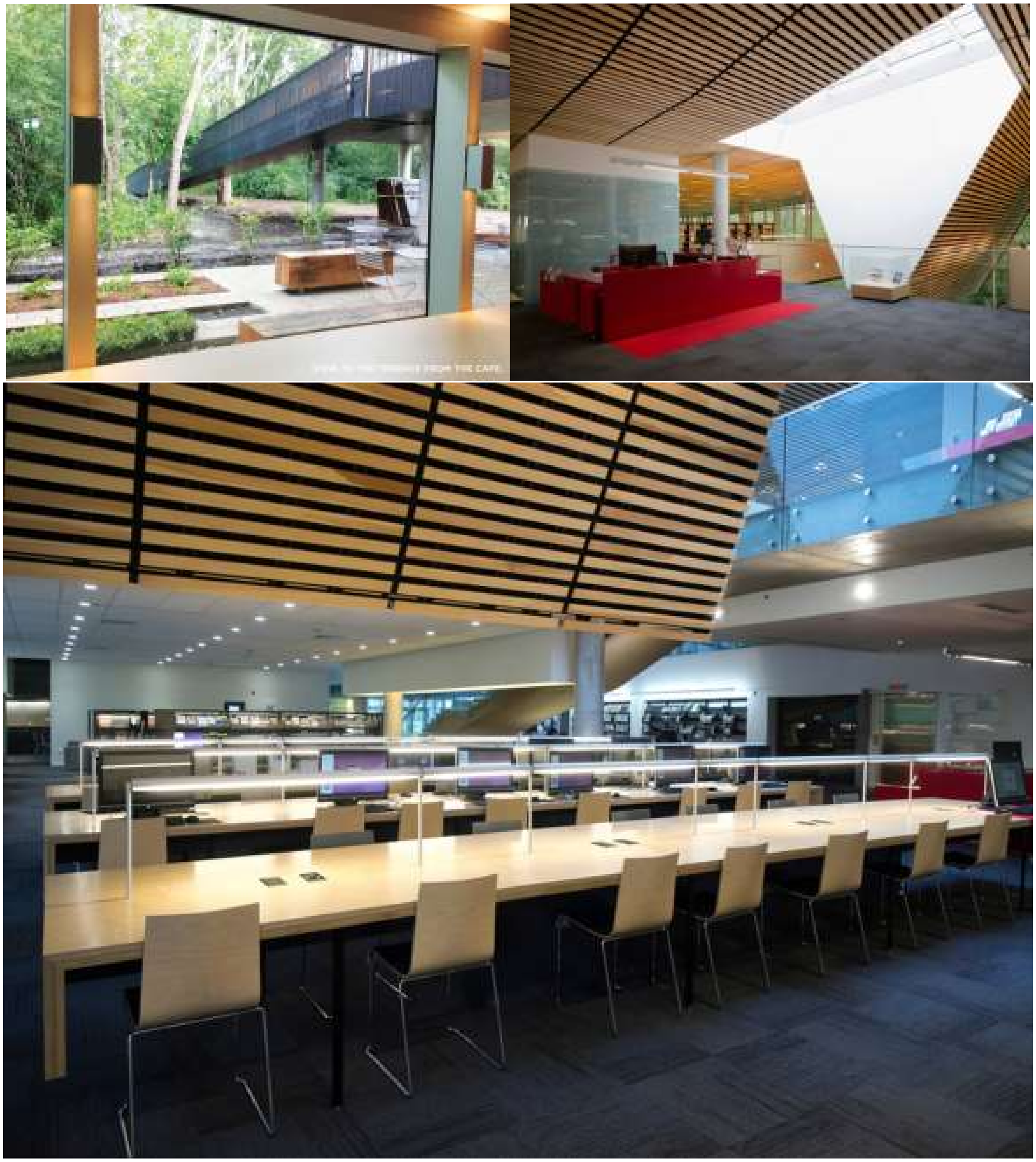


Figure 7.8. Interior views of the Bibliothèque du Boisé (2014)

© Consortium Labonté Marcil, Cardinal Hardy, Eric Pelletier architectes

The background of the project, being a public design competition within Montreal's cultural development initiatives, is defining for its outcomes. The competition program clearly states that "The City of Montréal wishes to carry out an innovative project, where users will live an enriching experience and where a sustainable development approach is essential" – and where issues of "occupational health and safety, and universal accessibility" are deeply integrated (Arrondissement de Saint-Laurent & Ville de Montréal, 2009). Yet, in the description of sustainable development, the program stresses the objective for attaining the LEED Gold certification and geothermal energy use. Besides those two elements, the building's connection and integration within the surrounding parks were of great importance. This wish to create a unique and sensibility integrated project (from a sustainability perspective) within the LEED Gold standard's strict guidelines was reported by Cucuzzella (2015, 2020) as a source of confusion. Additionally, Cucuzzella (2015) reports that, during the judgement process, tensions arose around what constitutes "sustainability" for this cultural project: oscillating between the technical requirements and its socio-cultural imperative.

For the Bibliothèque du Boisé, multiple categories of documents are available for the analysis; the competition documents (including the panels and architectural texts, and the jury report for step 2), general description of the project as provided by the architects, news and advertising texts, and award related documents (including award submission and presentation documents, as well as jury comments). Full list included in Appendix (K).

7.4.1.2. Direct Content analysis

The project documents' direct content analysis returned a significant overlap with seven SDGs along with the miscellaneous category. In total, 249 matches (6.3% of the text) were recorded: 189 matches (or 4.8% of the text) with SDG specific keywords, including 84 unique terms. The matches ranged from 2 to 79 across 10 SDGs (excluding SDGs 1, 5, 10, 13, 14 and 17), with a median of 5 matches (7 SDGs had matches above the median). The raw outcomes of the direct content analysis are available in Appendix (L).

The highest occurring matches were for SDG 11 (Sustainable cities and communities) for keywords related to urbanization and urban design approach, green building strategies and community, as well as SDG 8 (Decent work and economic growth) for keywords focused on culture (addressing target 8.9). The texts appeared to have a significant focus on SDG11 – with the goal's matching constituting close to 2% of the overall text content analyzed, with a total of 79 matches (constituting 31.7% of the matches) across all documents (except one award announcement for a private regional award – the GPD). This is illustrated in Figure 7.9.

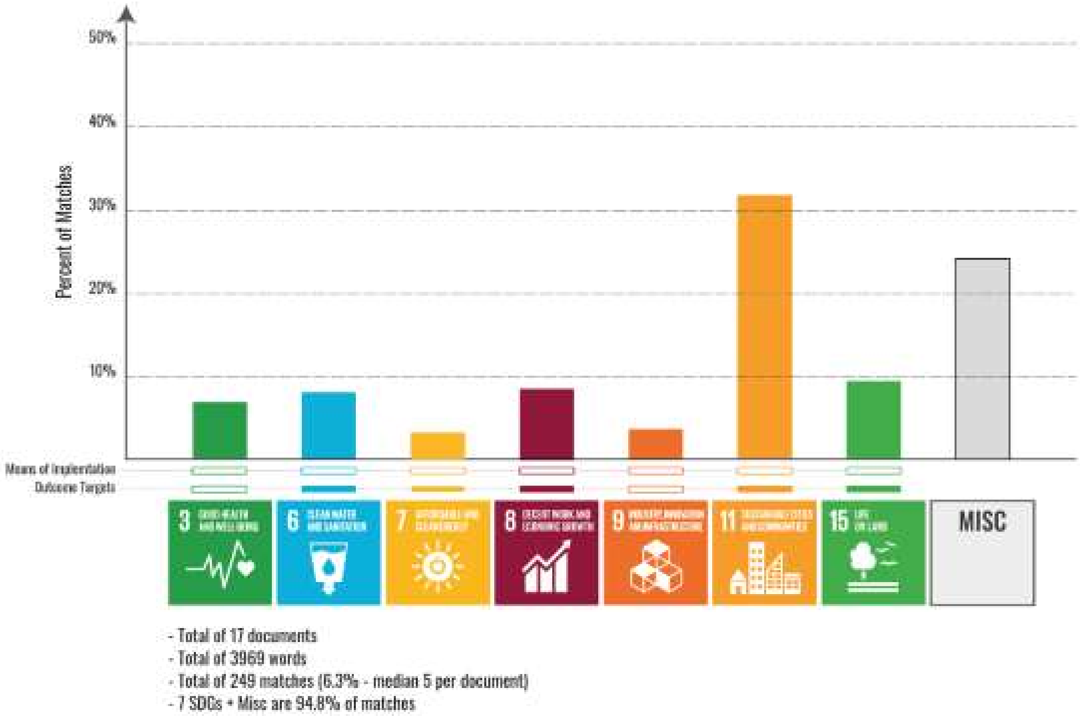


Figure 7.9. General distribution of significant content matches with the SDGs for the Bibliothèque du Boisé

The project's text also touched upon target specific keywords, including aspects of sustainable transport (11.2), open and public spaces (11.7). The building's context, namely the forest, also resulted in a significant overlap with issues related to SDG 15 (life on land), sometimes addressing issues related to animals, the conservation of the forest, and natural habitats. Additionally, the text also addressed issues related to water, SDG 6 (clean water and sanitation) and specifically water usage (target 6.4) and energy, SDG7 (affordable and clean energy) and specifically its reduction and savings (target 7.03).

From Figure 7.10, there is an almost equal distribution between SDG specific matches and generic sustainability keywords across the different types of documents (with about one quarter in each type of document, addressing general sustainability issues). Except for SDG11, which received the most attention across all document types, the focus on sustainability issues shifts. For example, it is clear that energy and innovation issues, which were significant in the design texts, received significantly less attention in the presentation and judgment documents. Adversely, issues related to health and wellbeing, which were only broadly mentioned in the design texts, are augmented by the presentation and judgment texts. Finally, the issues related to habitat, biodiversity, and land protection were central in both design and judgment texts but received less attention in the project's mediatized accounts.

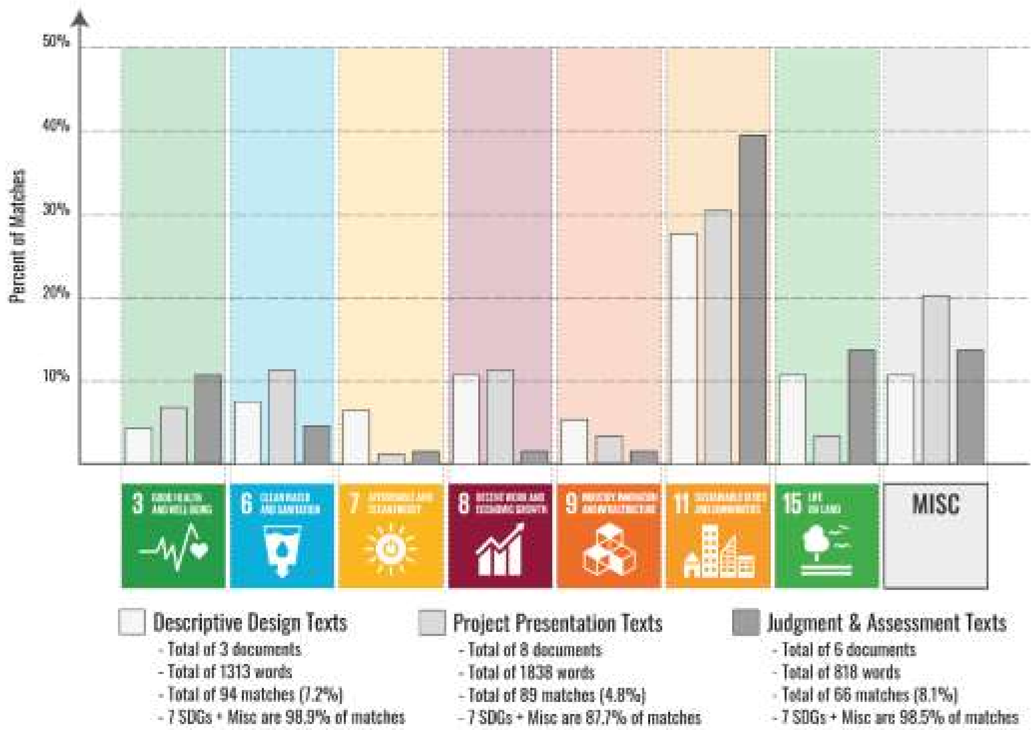


Figure 7.10.. Distribution of significant content matches with the SDGs by document type for the Bibliothèque du Boisé

7.4.1.3. Analyzing the project's sustainable design characteristics

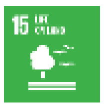
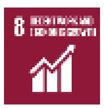
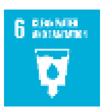
In accordance with the study conducted by Goubran (2019b), we start by study the competition panels and text of the buildings to understand the initial sustainable design approach of its architects. This is followed by the analysis of other presentation texts, as well as the judgement assessment documents.

The documents were highly descriptive of the urban and architectural "gestures" of the project – where the library becomes an extension of both the city, and the natural landscape. While issues of culture, education, and harmony with nature are raised through the architects' descriptive image, the documents limit their description of green and sustainable features to what the notion of "harmony with nature". This description usually remained highly technical and responsive to the LEED criteria (even framing the building's sustainability innovations within the LEED's enhanced water management rhetoric).

The architect's description and illustration of "sustainability" in the competition panels clearly embeds the building's environmental approach in what can be considered a highly deductive design mode – referencing the LEED certification texts and other standards (such as ASHRAE 55) directly. Furthermore, the architectural and experiential character of the building remains absent from the environmental design panel. Cucuzzella (2020a, 2020b), in her analysis of the project within its competition phase, placed its sustainability in a high degree of facility and as driven by the technical rhetoric. The descriptive text also confirms this duality. Again, this contrast between the description of the spatial and functional experience of the library, which is innovative and engaging in character, and the technical description and certification driven description of the building's environmental features remained clear in the architect's submission to the RAIC's green building award 8 years after its design.

However, in the RAIC's Green Building Awards jury comments the environmental and experiential connections are truly made clear in relation to daylight, "The spaces within the library take full advantage of daylight and create a diversity of places for the community to utilize now, and in the future", materials "Healthy, natural materials, and beautifully daylight spaces provide an environment that is open and modern, as well as warm and welcoming," and its fit to the site "The Bibliothèque du Boisé is a well-crafted project connecting the city with its surrounding landscape attempting to restore a healthy interrelationship with nature and water on the site." The analysis of the 17 documents listed in Appendix (K) and other secondary media and architectural drawings of the project revealed important insights regarding the buildings' sustainable design approach, the integration of sustainable development issues in its design and the architect's sustainability vision topics. The analysis outcomes are presented in Table 7.3.

Table 7.3. Analysis outcome for the Bibliothèque du Boisé (organized in decreasing frequency of matches)

SDG	Keywords	Overarching sustainable design approach	Level & domain of integration			Sustainable design vision
			Architecture	Engineering	Operation	
	*Urban* *Community* *Transport* *Open spaces*	*Abductive*: the designers were successful in creating a new type of socio-urban typology for the library. The Jury commended this approach – highlighting in success in negotiating the library's urban character and offering.	*Level 3:* the architecture innovates its city-based, communal and urban approach.	*Level 0.*	*Level 0.*	*Human* in character and *slightly future driven* in its inspiration
	*Animal* *Forest* *Conservation* *Wetland*	*Abductive*: proposes a new connection between the urban and the natural – both from the exterior and interior	*Level 3:* the architecture innovates its city-approach, communal and urban approach	*Level 1:* technically, within the building standard driven approaches are implemented – including the use of native species	*Level 0.*	*Slightly Human* in character and *slightly future driven* in its inspiration
	*Culture* *Workers* *Occupational health & safety*	*Balanced between deductive and abductive*: the project, rightfully, addresses the library's program as a cultural project – aiming to support the growth and development of its users.	*Level 1*: while innovating in its structure, the program remains functional and expected (as proposed by the jury reports)	*Level 1*: here is the focus remains on the traditional OHS issues	*Level 2*: The project's operation (through its functions) is expected to set an example of a modern library through its imaginative interpretation	*Human* in character and *slightly future driven* in its inspiration
	*Flood* *Water use* *Rainwater* *Water consumption*	*Deductive*: the project depends on established methods and standards for addressing water issues	*Level 1:* established methods integrated in the architecture	*Level 1*: established norms were guiding the technical development.	*Level 0.*	Does not present a clear vision

Daylight Comfort Health Recreation	*Slightly abductive*: the issue of daylight is imaginatively explore within the library and integrated with aspects related to view and connection to the natural	*Level 3:* issues of daylight and comfort highly influential in the architectural language of the building	*Level 1.* on a technical level, the building	*Level 3. T*he experience of health and wellbeing is expected to be generated from the operation and use of the spaces (activating the design)	*Slightly human* in character and with no clear inspiration
Technology	*Slightly abductive*: the architects define and frame innovation within the context of rethinking the role of the library as a space for diffusion	*Level 2:* the combination of the human, environment and architecture is thought thoroughly in the project	*Level 0.*	*Level 2*: in its operation, the building aims to set a new standard that builds on the expectations set in this modern library program.	*Slightly human* in character and *slightly future driven* in its inspiration
Energy saving Efficiency Solar	*Deductive* and focused on meeting the requirements of standards for energy issues	Level 0:	Level 1: issues of energy are precedent and code-driven.	Level 0:	*Slightly product-focused* in character and with no clear inspiration

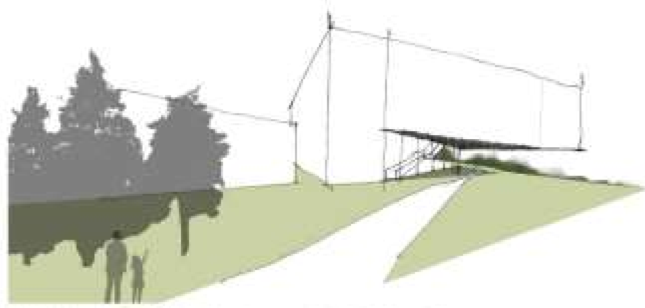
7.4.2. Centre for Interactive Research on Sustainability - CIRS (2011)

7.4.2.1. Project Context and data

The idea of the CIRS, which has its roots in 1999, has been commonly credited to John Robinson, who shared the Nobel Peace Prize in 2007 with Al Gore (*Bio – Professor John B. Robinson*, n.d.). The building was designed to be the "most sustainable building in North America" (Perkins + Will, 2013). Today, the building is widely named "North America's Greenest Building" (Cayuella & Pilon, 2015; Edward Keegan, 2012). Designed by Perkins + Will Canada and its leading architect when Peter Bubsy, the building was commissioned in September 2011, and received its LEED Platinum certification in 2012 (Cayuella & Pilon, 2015). While initially designed according to the International Living Future Institute standard, it never attained the Living Building Challenge certification (Edward Keegan, 2012). Between 2011 and 2014, the building received at least 16 provincial, national and international awards, including at least 10 that are green-focused (UBC Sustainability Initiative, n.d.). These honours include being placed on the World Architecture News' (WAN) longlist for the sustainable building of the year in 2013, and RAIC's green building award in 2014. The full list of awards the building received is available in Appendix (J).

Designed as a living laboratory, each step in the planning, design, construction and even the operation of the building are considered part of the center's research agenda (Cayuella & Pilon, 2015; The University of British Columbia, n.d.), and are meant to serve as an example and case study for the "future of sustainable buildings". In fact, in what can be considered a type of institutional eco-didactic manifesto by UBC (Cucuzzella et al., 2020), the CIRS was designed to put sustainable systems on display (Perkins + Will, 2011, 2013). Also, and due to the inclusion of research and researchers within its development, the building has also been featured in various scholarly publications. It is often presented as an exemplary structure and case study for its performance and impact reduction and its goal to improve its surroundings and its occupants' health and wellbeing (examples, Salehi et al., 2015; Yudelson & Meyer, 2013). This goal of "improving" or "reducing" impact (Haworth, 2011) was framed within the "net-positive" and "regenerative" themes of the project. Specifically, the seven net-positives as explained by Robinson, "net-positive energy; structural carbon neutrality; operational carbon; net-zero water; turning passive occupants into active inhabitants; promoting health and productivity; and promoting happiness". This vision was translated architecturally as "air quality, light and wood" by Peter Bubsy (Edward Keegan, 2012).

Set at the corner of the campus' "Sustainability Street", which crosses its ground floor in what was named the *desire line*, the building was designed to be a gateway for the newly landscaped sustainable green space (this is seen in the initial sketch Figure 7.12 and its site plan Figure 7.13). The building serves as a milestone to the campus, which embodies the University of British Columbia's (UBC) commitment to advancing sustainability research and knowledge. The project was conceived in coherence from its urban, natural and educational context. Connected to its neighbouring buildings' loops and grids, the building exchanges energy and recovers energy from its surroundings, and combines it with geothermal heating. Additionally, the building exchanges water with its surrounding landscape (the bio-swale).



Initial sketch of CIRS showing the pre-existing 'desire line'.

Figure 7.11. Initial sketch of the CIRS (2011) - © Peter Busby of Perkins and Will

The building aims to extend its surroundings' natural elements by integrating a living green roof and a living green façade. Of course, core to its design was the educational mission – dubbed as experimental on every level (Edward Keegan, 2012; Perkins + Will, 2013). Composed of two four-storey wings linked by an atrium, the building's architectural party is simple and focused on its function (seen from the site plan Figure 7.12). The atrium leads to the naturally lit 450-seats auditorium, which is topped by the green roof, which serves as the view-feature for interior facing spaces in the upper storeys. The remaining floors are dedicated to lab-spaces, academic offices, meeting rooms and social spaces. The corner of the building, which is most prominent within its site, is dedicated to the wastewater-reclamation area, which is put on display for all traffic (seen in Figure 7.12, Figure 7.13 and Figure 7.19).

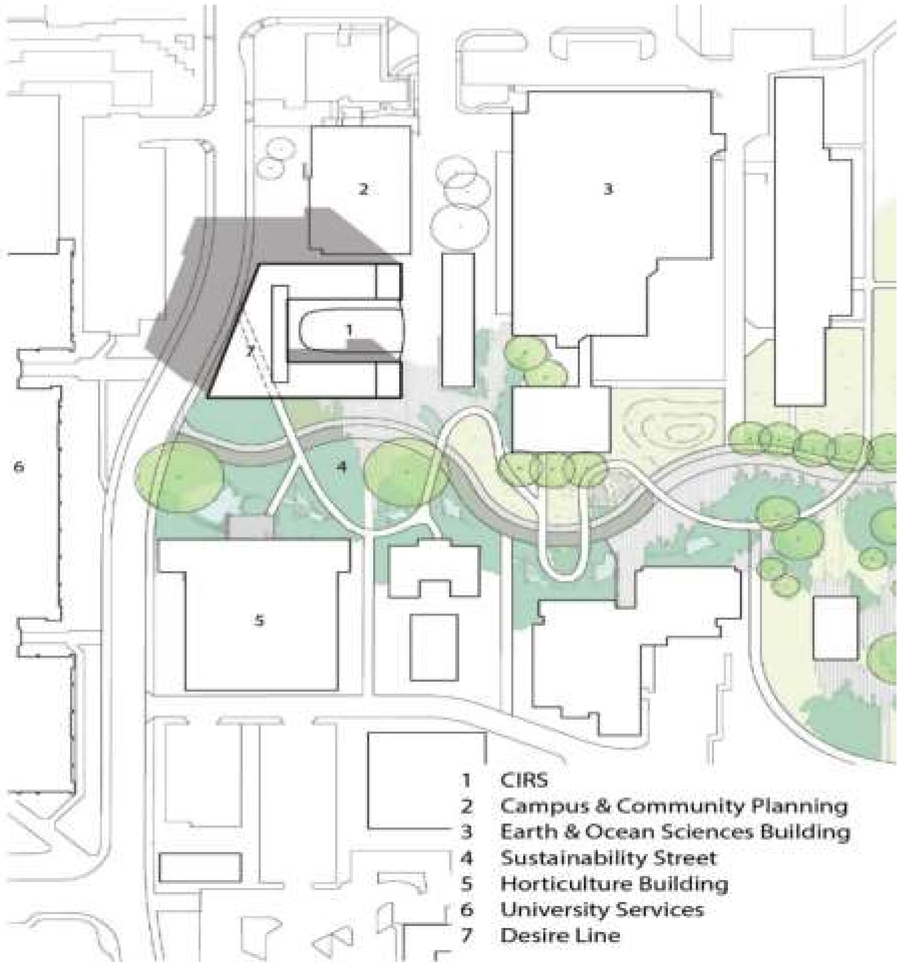


Figure 7.12. Site plan of the CIRS (2011) - © Peter Busby of Perkins and Will

The building exterior is anything but "green and curvy", even though that was the inspiration of its visionary originator (Edward Keegan, 2012). Instead, the building features a modern glass curtain wall partially covered with orange panels, which is sometimes topped with solar shading devices or metal meshes (which were supposed to be covered in greenery seen in Figure 7.18). The ceiling of the entrance area, and the portion of the sustainability street that crosses it, put on display wooden panelling, extending to the building's interior, which is crossed by concrete columns. Thus, the building materials' composition is made clear from the exterior of the building: timber, metal, glass and concrete. This is clear from Figure 7.13.

Figure 7.13. Exterior views of the CIRS (2011) - © Peter Busby of Perkins and Will

The interior puts the building's timber structure on display. Here, reclaimed timber from an infested forest is used to create a bolted timber structure: an approach that helped stop the decay and release of carbon, while creating a potentially reusable assembly. The building's narrow floor plates and its U-shaped design allow for daylight to penetrate deep into the building spaces. Also, the auditorium is also designed to be naturally lit. (Edward Keegan, 2012; Perkins + Will, 2013). The labs and offices are designed with flexibility in mind using movable portioning systems, which are mostly translucent with the goal of maximizing daylight. Of course, this presented a research opportunity that UBC psychologists used to study daylight's effect on building users (Edward Keegan, 2012; Perkins + Will, 2013). On top of the atrium, a semi-transparent solar array is put on display. These features are clear in the interior images presented in Figure 7.14.

Figure 7.14. Interior views of the CIRS (2011) - © Peter Busby of Perkins and Will

The sustainability features of the building are complex and highly interconnected. Framed around the "Seven Net-Positives", the building aims to turn its passive occupants into active inhabitants through sustainability innovation (Perkins + Will, 2011; The University of British Columbia, 2012). The water strategies deployed aim to return excess water to be utilized on campus, the energy harvesting system returns about 600-megawatt-hours of surplus energy to the campus grid and removes close to 170-tonnes of GHG emissions. The building structure, made of wood, stores more than 900-tonnes of carbon-reducing its footprint by close to 90% when compared to other buildings on campus (Athena Sustainable Materials Institute, 2011; Cayuella & Pilon, 2015; Edward Keegan, 2012; Perkins + Will, 2011). On the materials level, LCA methods have been used early in the design process in order to reduce the footprint and achieve the carbon neutrality goal set by the client (*i.e.* UBC) (Athena Sustainable Materials Institute, 2011)– this was also critical in the context of carbon taxes imposed by local regulations (T. Walker & Goubran, 2020). Of course, the building's interior and exterior are completing with various sensors that capture data, not only of performance but also of the interactions between the building, its systems, and its occupants. One of the system's key innovations is their flexibility, modularity, and replacement, which are expected to increase the building's usable life towards the 100-years mark (Cayuella & Pilon, 2015). A summary of the sustainability features of the building are presented in Figure 7.15.

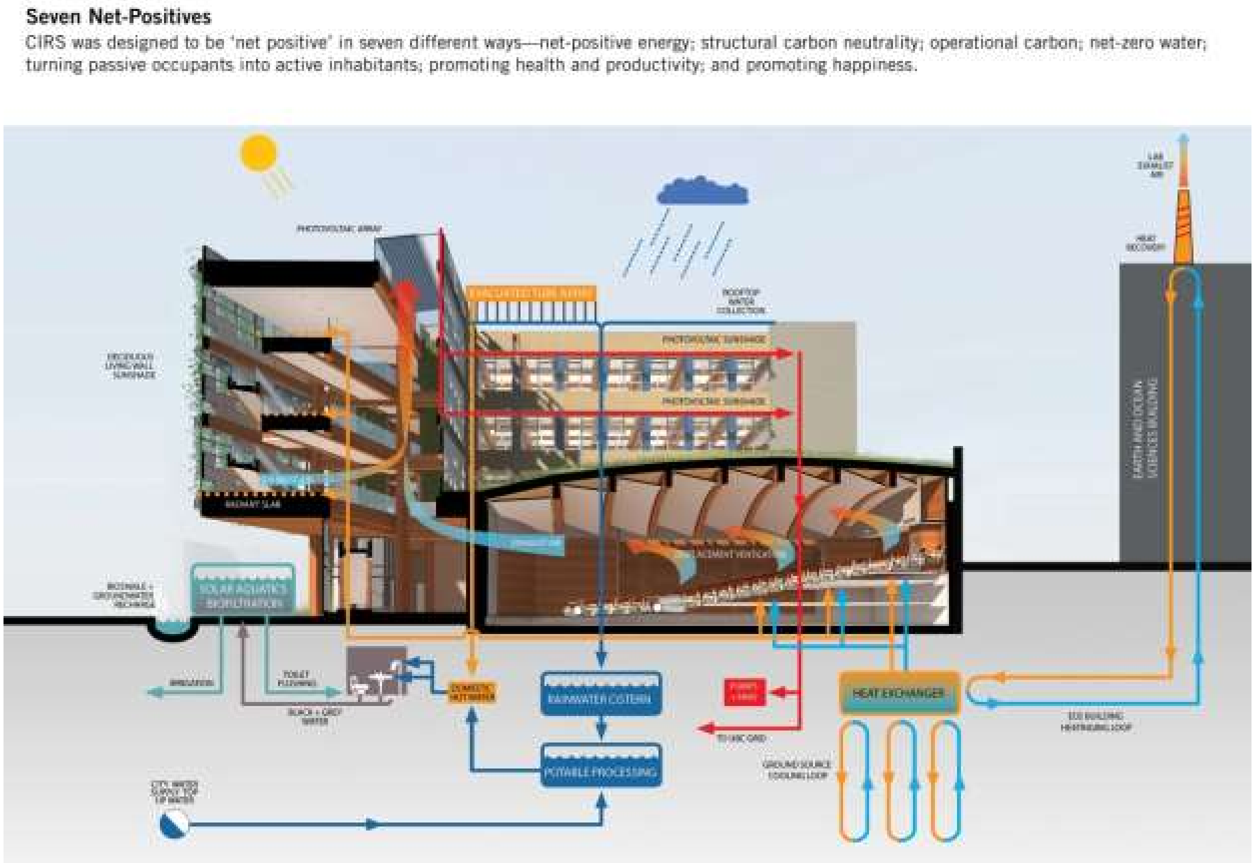


Figure 7.15. Sustainability features of the CIRS (2011) - © Peter Busby of Perkins and Will

For the CIRS, description of the project as provided by the architects, the client (*i.e.* UBC) news and advertising texts, and award related documents (including award submission and presentation documents, as well as jury comments) are available for the analysis. Additionally, a descriptive architectural text that was submitted by the design team for the RAIC green award was also available for analysis. Full list included in Appendix (K).

7.4.2.2. Direct Content analysis

The project documents' direct content analysis returned a significant overlap with eight SDGs along with the miscellaneous category. In total, 1220 matches (12.4% of the text) were recorded: 762 matches (or 7.7% of the text) with SDG specific keywords, including 136 unique terms. The matches ranged from 2 to 131 across 15 SDGs (excluding SDG 1 and SDG 5), with a median of 29 matches (8 SDGs had matches above the median). The full outcomes of the direct content analysis are available in Appendix (L).

The highest occurring matches were for SDG 6 (Clean water and sanitation) for keywords related to flooding, rainwater, water-filtration (also bio-filtration, which links to target 6.3) and water consumption. This is followed by SDG 9 (Industry, Innovation and Infrastructure) for keywords focused on research, technology (addressing target 9.b), and clean technologies. The texts had no specific focus in terms of the SDGs, but had a significant portion dedicated to general development and sustainability terms, which shows close to 40% match (458 matches) with the miscellaneous category. This is illustrated in Figure 7.16.

The documents touched upon target specific keywords mainly in three SDGs:

- SDG 6: issues such as bio-filtering, water quality and wastewater (focused on target 6.3), water conservation (6.5), and harvesting (6.a).
- SDG 11: issues related to transport (11.2), construction waste and water quality (11.6), access to public and open spaces (11.7) and sustainable materials (11.c).
- SDG 12: issues related to lifecycle, footprints (12.2), chemicals and plastics (12.4), 4Rs (12.5) and local products (12.b).

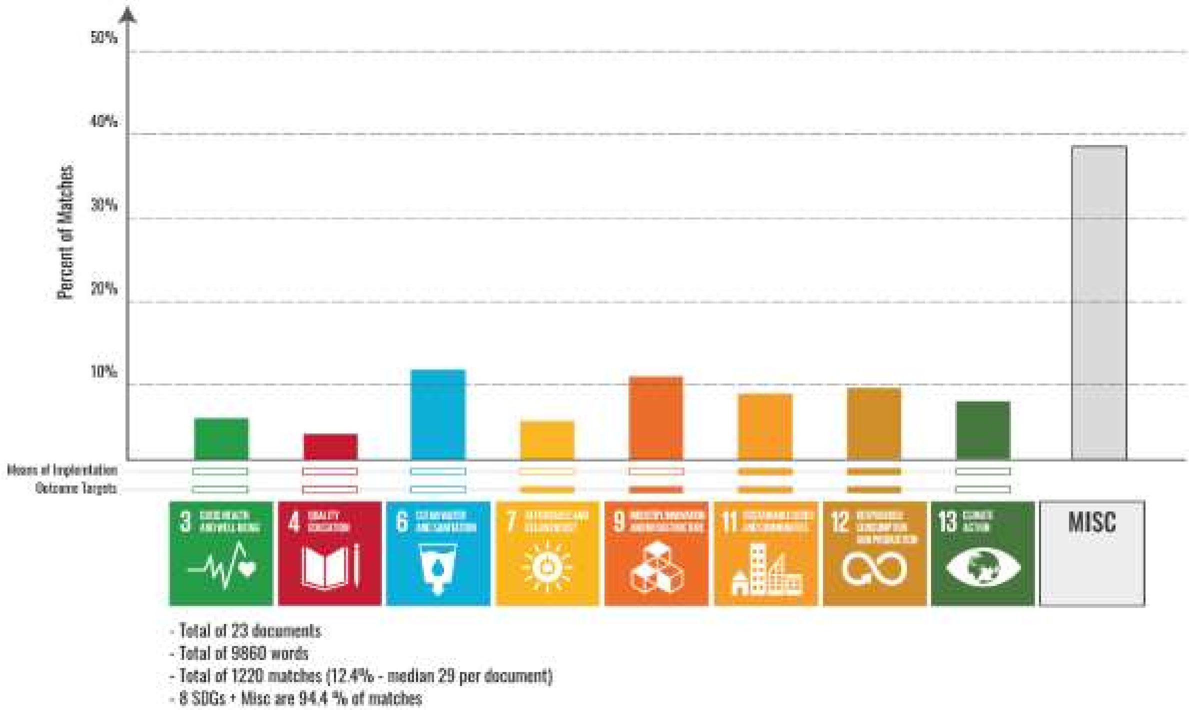


Figure 7.16. General distribution of significant content matches with the SDGs for the CIRS

From Figure 7.17, there are some discrepancies between how different types of documents describe and explain the CIRS' sustainability. At the same time, descriptive design texts present a broader coverage of the SDGs with a significant focus on issues of sustainable consumption and production (SDG12) and innovation (SDG 9). The project presentation texts follow through the same pattern but with more attention given to the building's water-treatment functions (which is one of the building's key sustainability elements). Adversely, the judgment and assessment texts are highly focused on technology and research issues and the urban dimensions (SDG 11 and targets 11.c and 11.7). It is worth noting that while the building is supposed to present exemplary solutions in education (and specifically the sustainability education), the judgment and assessment texts do not match with any of the topics related to SDG 4 (quality education), and SDG 13 (climate action). Also, it is clear that while the building presents a significant overlap with the topics of sustainability and sustainable development, most of the focus of the text remain on generic issues that are not specific to any of the SDGs, especially the judgement and assessment text where close to 60% of the matches was in the miscellaneous category.

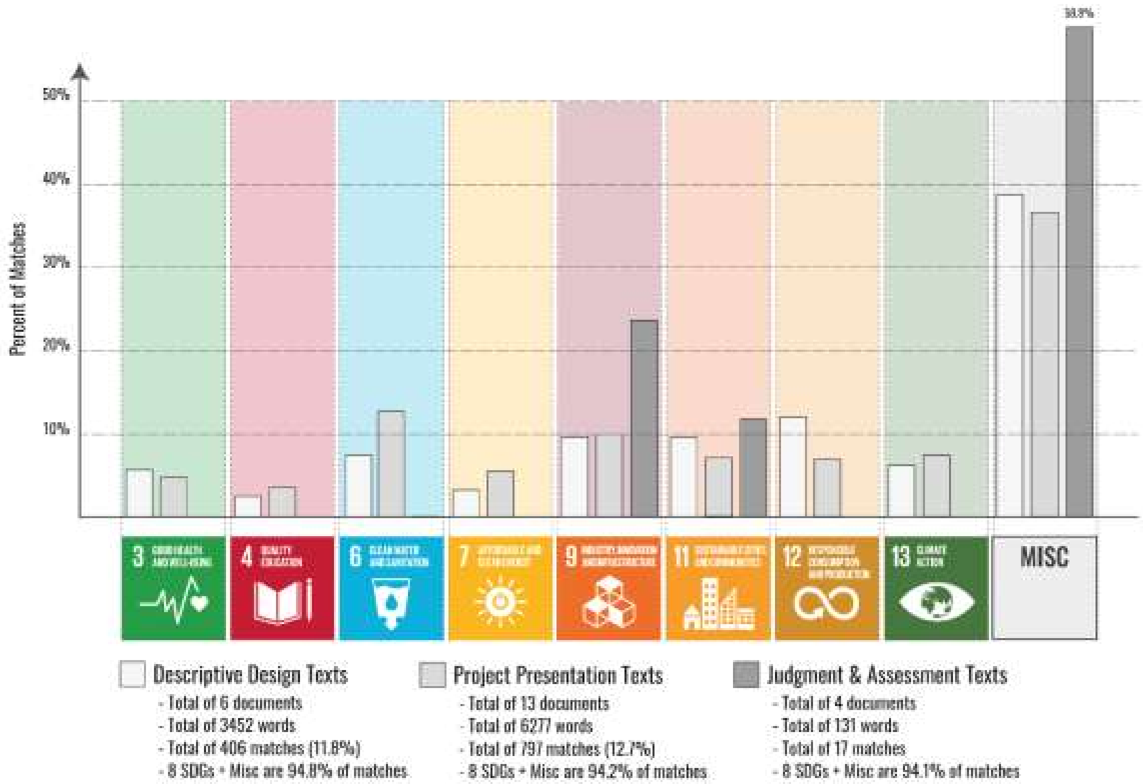


Figure 7.17. Distribution of significant content matches with the SDGs by document type for the CIRS

7.4.2.3. Analyzing the project's sustainable design characteristics

Described from its onset as a "living-lab" and "research tool", the designer's narrative around this project is highly centred on its environmental performance – and much less focused on its architecture. Here the building is "a showcase" for sustainability technologies and best-practices. A description which is highly fragmented and focused on the conative function of its elements – instead, the description, as seen in the Perkins + Will's report (2011), is often framed around its environmental goals: "

- *Net-positive energy, Net-zero water, Net-zero carbon construction, Net-zero carbon operation*
- *A building that learns from its users; a building that helps its users learn from it*
- *Every workspace daylit, naturally ventilated, temperature and air under individual control*
- *Minimize building waste*

- *LEED Platinum*
- *Living Building Challenge".*

In most of the documents that describe or present the project, these principles appear to lead the narrative. The exact processes of how these goals are actualized or how they come together to create a sustainable "place" is barely made clear. Often, detailed descriptions include other argumentic-symbolic-legisigns (Krampen, 2013) are deployed. A vivid example is the utilization of timber. Here the designers indicate that "beetle-killed wood" is utilized to maximize carbon sequestration. While the timber is put on display, very little function (architectural, social or IEQ) is attribute to the material. In the later descriptions of the project (such as Cayuella & Pilon's (2015) HPB article), the wood-structure is linked to the building's possible dismantling. The building's structure consultant, Paul Fast, was quoted reflecting on the use of wood:

> *"Wood is the most sustainable construction material, low-embodied energy, quickly renewable resource. From a structural point of view, the modern engineered materials such as glue-laminated timber have increased the strength of wood so that they have a much greater structural capacity. Finally, the warmth wood brings to the building – it creates an ambiance that is just fantastic".*

Another clear example is the description of its energy features, which is usually framed as follows: "captured waste heat from a nearby building, on-site fuel cells; a photovoltaic array; solar hot water collectors; ground source heat pumps; glazing treatment that ensures solar heat gain/loss is minimized for each orientation" (Perkins + Will, 2011). While listing more state-of-the-art and best practices, the reader is often left to imagine why and how these elements come together to create the space and deliver quality architecture. In many ways, this symbolic and connotative narrative leaves the viewer with many complications to resolve. SABMag's jury commented that: "Given its scale, the risks taken by the client and design team in the name of research are huge," and Architectural Institute of British Columbia (AIBC) 's innovation award jury commented, "Here's the thing. This building is actually an energy producer. That should be celebrated". The RAIC's jury comments touched upon some of the possible social outcomes of the buildings. Yet, they highlight "fosters a culture of innovative research and celebrates the building systems."

The strong focus on the systems and their performance leads the analysis towards understanding their successes and exemplarity. However, Cayuella & Pilon (2015) also point to the fact that, as a research tool and design experiment, parts of the building and the interventions were bound to failure. A few years after its completion, published articles, such as that of Salehi et al. (2015), have proved "the building shows approximately 60% higher energy consumption during its first year of operation than the initial model prediction". Also, what was meant to be the first Canadian building on track for certification by the living building challenge (Perkins + Will, 2013), became the first building to apply for the certification, after failing to attain it. Cayuella & Pilon (2015) highlight that daylight, water, and solar shading were the design's guiding categories. The building was intended to achieve a successful daylighting strategy, with daylight available in 100% of the occupied spaces (even its auditorium). However, Salehi et al. (2015) indicate that part of the increased load is due to unexpected lighting loads. A discussion with one of the project consultants revealed that the living wall (Figure 7.18) was also unsuccessful, failing to accommodate native climbing plants. This leaves mainly the advanced water filtration system, the solar aquatics as the key replicable innovation Figure 7.19.

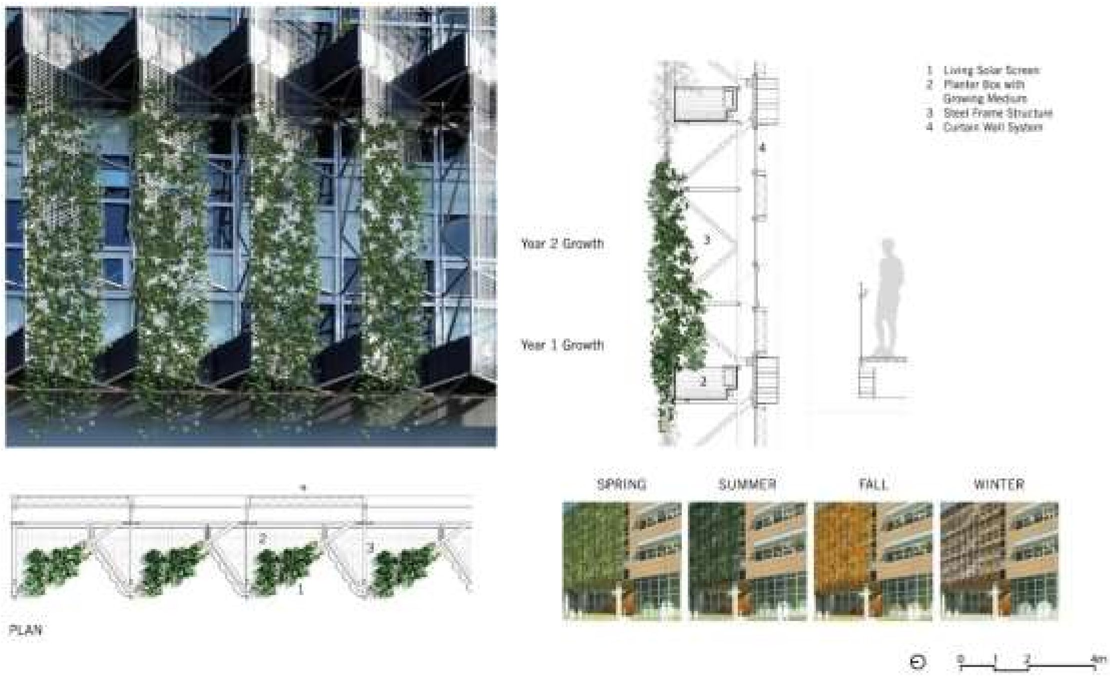


Figure 7.18. Living solar screen of the CIRS (2011) - © Peter Busby of Perkins and Will

Figure 7.19. Solar aquatics filtration system of the CIRS (2011) - © Peter Busby of Perkins and Will

While the project's successes and failures are beyond this study's focus, the case highlights the risks of applying innovations without proper design integration (*i.e.* surface integration). Also, while recognizing buildings' exceptional and exemplary performance is important, a question arises on the applicability of architecture awards, which involve judgment (Chupin, 2011), to deliver such recognition (as opposed to certification or standard-based assessment)[82]. The analysis outcomes are presented in Table 7.4

82 Some jury members, such as those in the SABMag award, commented that: “[…] the metrics are beginning to confirm that this is a very high-performance building.”

Table 7.4. Analysis outcomes for the Centre for Interactive Research on Sustainability (CIRS) (organized in decreasing frequency of matches)

SDG	**Keywords**	**Overarching sustainable design approach**	**Level & domain of integration**			**Sustainable design vision**
			Architecture	**Engineering**	**Operation**	
6	Flood Bio-filter Runoff Wastewater Water treatment	*Slightly abductive*: the building combines new technologies for water management and filtration and attempts their integration in the context and in research.	*Level 2:* beyond the simple integration based on standards, the building design aims to highlight and put-on display its water management tools.	*Level 3:* the new solar-aquatic system is implemented and integrated on the building and urban scale to move beyond current performance norms.	*Level 1:* the building operation aims to meet the project team's goals and does not present any specific operational innovations.	*Product focused* in character and *future driven* in its inspiration.
9	Research Technology	*Abductive:* The building's goal as a research tool is a novel approach that has led the designers to take some design risks and for testing some hypotheses (leading to failures in features).	*Level 2:* Elements are added to the building beyond the standard and precedent requirements to allow them to be used for research (such as the living façade)	*Level 2:* the building's structure and equipment are used to meet the standard's requirements and are also used to advance research (such as the use of large scale wood without precedents for shrinkage)	*Level 3:* the operation of the building as a test facility for sustainability sciences, while not the first globally, is still a highly innovative integration of SDG 9.	*Product focused* in character and *future driven* in its inspiration.
12	Building materials Resource Reduction, reuse, recycling Embodied carbon Chemical Life cycle	*Slightly Deductive:* The selection of building materials followed a highly functional and pragmatic process – mainly focused on carbon accounting. Yet, the use of beetle-killed wood is an innovative addition.	*Level 1:* Architecturally, building materials are used to meet the project's functional requirements and do not present any specific innovation.	*Level 2:* From a structural perspective, the use of wood (which is not certified) aimed to move beyond standards' requirements.	*Level 1.* Standard approaches are applied.	*Product focused* in character with no clear inspiration
11	Community Open space Durability	*Slightly abductive:* The design utilizes the unique location on campus to create a new hub that is	*Level 2:* the building's attempt to integrate flexible space design and future use scenarios moves	*Level 0.*	*Level 1.* Like most campus research centers, the building is designed to act as a	*Product focused* in character and *slightly future*

	accessible and inclusive (on the human and urban levels).	beyond current practices. Yet, its urban integration on campus remains expected and grounded.		gathering and event space for the sustainability community.	driven in its inspiration
Carbon Greenhouse gas	*Deductive:* established methods are used to reduce and optimize the carbon footprint of the project.	*Level 0.*	*Level 2.* Standard driven technologies and approaches are used to reduce emissions. Some innovations in terms of district-level energy integration, are included.	*Level 1.* Standard driven technologies and approaches are used to reduce emissions.	*Product focused* in character with no clear inspiration
Daylight Health Wellbeing	*Slightly deductive:* the building balances its standard driven approach by attempting a 100% daylight access to spaces.	*Level 2.* The building's design and interior experiences were highly influenced by the project's daylight and indoor environment quality goals, requiring the design to move beyond the current norms.	*Level 1.* Daylight is designed to meet the current performance norms and expectations.	*Level 2.* The introduction of a high level of controllability and personalization is a step beyond the current requirements.	*Slightly Product focused* in character with no clear inspiration
Solar Energy consumption Hydro Grid	*Deductive:* The building applies best practice in terms of its energy.	*Level 2.* The building's integration of the solar panels in the building elements exceeds available precedents(with semi-transparent PVs used as shading elements, for example).	*Level 1.* The building's energy systems use state-of-the-art best practices (for solar and geothermal). While some of the district energy ideas are novel, they are still fit within the norms	*Level 0.*	*Product focused* in character with no clear inspiration
Learning opportunities Training	*Slightly abductive: T*he building aims to create learning opportunities for the campus community	*Level 2.* While standards (such as LEED) expect an awareness and teaching component, the building	*Level 0.*	*Level 3.* The training happens in the daily interaction of the building users with its	*Product focused* in character and *slightly future*

and hands-on training for sustainability	went beyond the requirements by creating an experiential test facility for students.		systems and facilities and the experience of the displayed technologies.	*driven* in its inspiration

7.4.3. Bill Fisch Forest Stewardship and Education Centre (2015)

7.4.3.1. Project Context and data

The Bill Fisch Forest Stewardship and Education Center, often shortened to BFFSEC, is usually included in various lists featuring the "most sustainable budlings in Canada" (DIALOG, n.d.). In addition to LEED Platinum, the building is the first to be fully certified, since 2018, by the Living Building Challenge in Ontario and one of the few worldwide (Canadian Wood Council, 2016).. The Living Future organization describes the building as "an integral part of one of the most successful forest regeneration projects in the world to help residents of York-Region, and the extended community, learn about the importance of natural resources and forest ecosystems." (Living Future, n.d.). Between 2015 and 2018, the building received at least 8 provincial, national and international awards, all of which are green and sustainability-focused (DIALOG, n.d.). The full list of awards the building received is available in Appendix (J).

From its inception, the building was designed to be in a state of harmony with nature, and as the CEO of the International Living Future Institute indicates, to be "a model example of humanity's ability to reconcile our relationship with nature" (DIALOG, 2018). The initial design sketch (Figure 7.20) illustrates this design intent. Occupied in April 2016, the building design was initiated through several design charrettes where its goals and targets were identified. These included: "

- *A high-performance building envelope to reduce heating and cooling loads, including highly insulated walls (R40) and roof (R60) combined with triple-pane, argon-filled window glazing;*
- *Window-to-wall ratio limited to below 30% to minimize heat loss;*
- *Window positioning to maximize natural lighting;*
- *East-west orientation, south-facing glazing and large overhangs to maximize solar heat gain in winter and minimize it in summer;*
- *Energy reduction strategies such as continuous dimming of lighting systems in suitable areas, heat recovery ventilation, LED lighting, and low-energy-use electrical equipment;*

- *Net-zero water use based on captured rainwater to supply toilets and urinals and a biological filtration device to treat all wastewater on-site; and,*
- *Renewable energy provided by a roof-mounted solar panel array to generate 38 mWh of clean energy annually."*

- Active participation from building staff to achieve energy goals and green operations. (as proposed by the CaGBC, 2017)

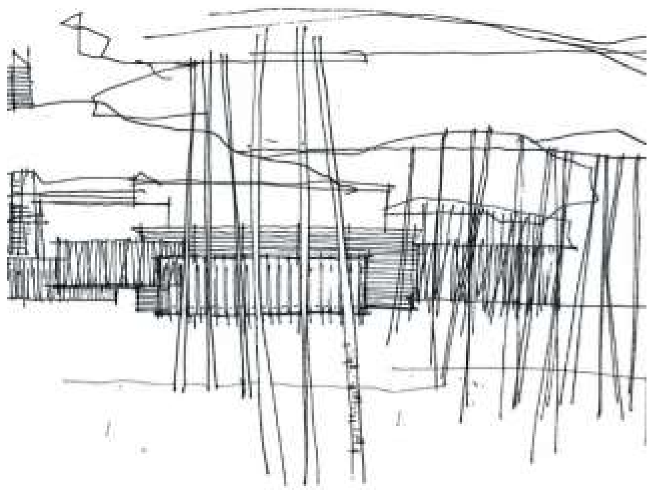


Figure 7.20. Conceptual sketch of the Bill Fisch Forest Stewardship and Education Centre (2015) © DIALOG

DIALOG designers brought together a large interdisciplinary team, including forest education experts, arborists, and ecologists, to realize their goal for creating a "demonstration project" for forest stewardship. One of the ways this was achieved was through the focus on the building materials- which is constructed mainly using Cross-Laminated Timber (CLT), as both its structural material and interior finish, and features wood cladding (Canadian Wood Council, 2016). This has resulted in the building garnering some timber and wood related prizes and awards, including one from Forest Stewardship Council (FSC) and another from the Canadian Wood Council. In a symbolic gesture, the building was designed with a 90-years life-cycle to reflect its surrounding forests' resilience.

This one-storey building's functions are relatively simple (seen in Figure 7.21), featuring a multi-purpose room for meetings, a community educational program (including a classroom and admin space), and supporting service spaces. The exterior of the building (seen in Figure 7.22) is designed to reflect this simplicity, with clear story operable windows in almost all occupied spaces; the building façade is composed of wood and stone and features a large overhand. The interior of the building (seen in Figure 7.23) displays the warmth and richness of the CLT and features an expansive open space with minimal partitions. The building even integrates natural patterns to ensure the exterior environmental continuity into the occupied spaces, such a foliage stamps onto the concrete floors (Living Future, n.d.).

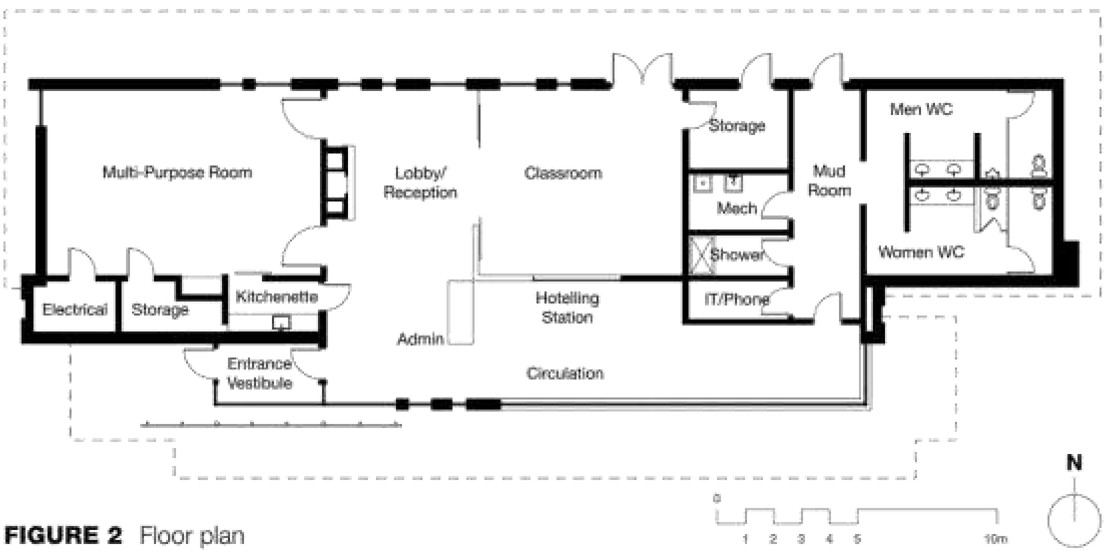


Figure 7.21. Plan of the Bill Fisch Forest Stewardship and Education Centre (2015)

© DIALOG

Figure 7.22. Exterior views of the Bill Fisch Forest Stewardship and Education Centre (2015)
© DIALOG

Figure 7.23. Interior views of the Bill Fisch Forest Stewardship and Education Centre (2015)
© DIALOG

While very compact, the building features a myriad of sustainability features (summarized in Figure 7.24), leading to its net-positive energy and net-positive water. The building combines technology and meticulous planning to achieve performance, as highlighted by the jury of SABMag's award: "this benchmark project goes beyond net-zero energy by meticulously pursuing a range of familiar conservation strategies […]" (SABMag, 2016). The building's water management is exemplarity in its ability to reduce, reuse and return all water utilized by the building back to nature – in a form that is "cleaner" than originally received (Dovetail, 2019). On the energy front, the building combines passive and active systems to maintain comfort levels throughout the year while utilizing natural ventilation (Canadian Wood Council, 2016). Overall, the building is expected to return 8 Mwh/year to the grid. Of course, the materials selected for the construction and interior reflected an awareness of their footprint, embodied carbon, and health consequences (CaGBC, 2017a). Beyond these technical innovations, the building's role as "nature's classroom", which is created to be accessible – exceeding current standards for disability, strongly distinguishes the structure from other interpretation centers in Canada and globally. (Living Future, n.d.). In some cases, the symbolic, and even poetic, selection of materials, patterns, the inclusion of design elements, and design of views help the building be part of the forest and serve as an added didactic layer of nature's fragility its ingenuity.

Figure 7.24. Sustainability features of the Bill Fisch Forest Stewardship and Education Centre (2015) © DIALOG

For the BFFSEC, a description of the project as provided by the architects, multiple sustainability narratives through the CaGBC, Living-Future Institute are available, and the Canadian Wood Council are available. Additionally, advertising texts and award related documents (including award submission and presentation documents, as well as jury comments) were available for content analysis. The full list of documents analyzed is available in Appendix (K).

7.4.3.2. Direct Content analysis

The project documents' direct content analysis returned a significant overlap with seven SDGs along with the miscellaneous category. In total, 854 matches (12.55% of the text) were recorded: 638 matches (9.38 of the text) with SDG specific keywords, including 120 unique terms. The matches ranged from 1 to 190 across 15 SDGs (excluding SDG 1 and SDG 2), with a median of 30.5 matches (7 SDGs had matches above the median). The full outcomes of the direct content analysis are available in Appendix (J).

The highest occurring matches were for SDG 15 (Life on land) for keywords related to forests and forestry, conservation and (also natural habitat links to target 15.5 and soil erosion with links to 15.03). SDG 15 had almost double the matches of the second-highest matched SDGs. The text touched upon issues related to SDG 4 (Quality education) with keywords focused on educational facilities (addressing target 4.a) and university education (addressing target 4.3). This is then followed by SDG 12 (sustainable consumption and production) with keywords related to footprint (addressing target 12.2), control of chemicals (12.4), 4Rs (12.5) and procurement practices (12.7). Thus, the text exhibited a clear focus on issues related to biodiversity and habitat protection. SDG 15 related keywords constituted close to 2.8% of the overall text with 190 matches in all documents (23.3% of the matches). General development and sustainability terms also constituted one quarter (25% of the matches). This is illustrated in Figure 7.25.

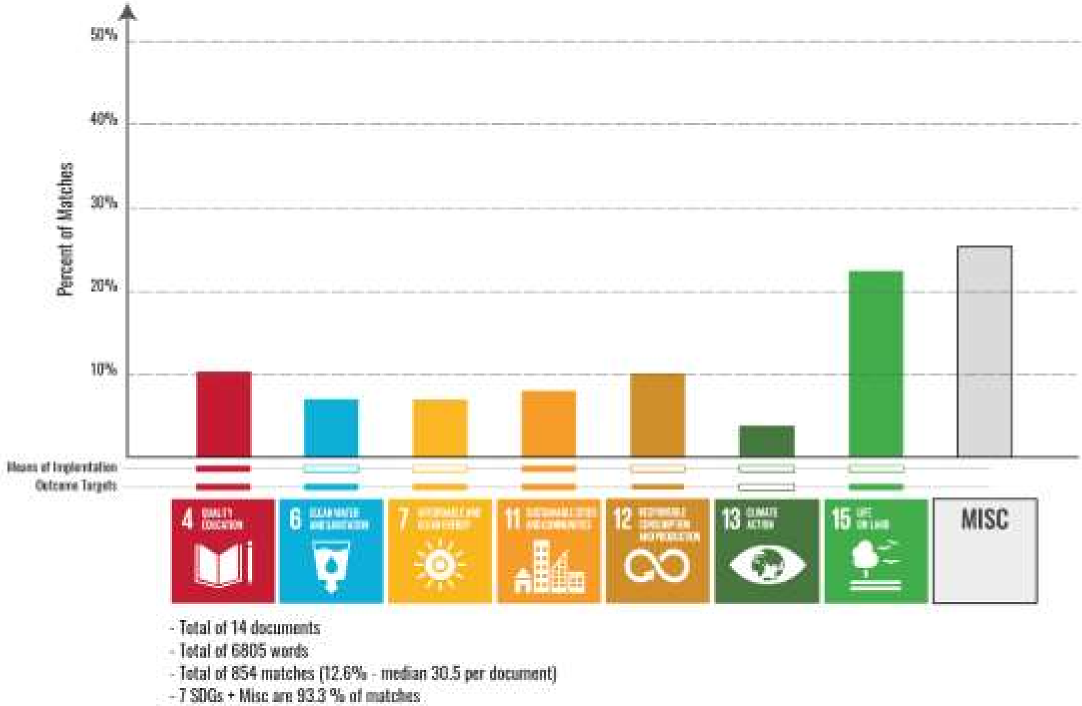


Figure 7.25. General distribution of significant content matches with the SDGs for the BFFSEC

Figure 7.26 shows that the descriptive and presentation texts showed a more balanced content that touched upon the different goals, the judgement texts were highly focused on the SDG 15 and the miscellaneous category. Interestingly, the extensive focus is on judgment and assessment texts placed on the energy issues (SDG7), which was not a key area of focus in the project's description. When comparing the descriptive and presentation texts, it is clear that the latter underscored further the project's educational dimension (SDG 4). Adversity, judgment text failed to include any terms related to education.

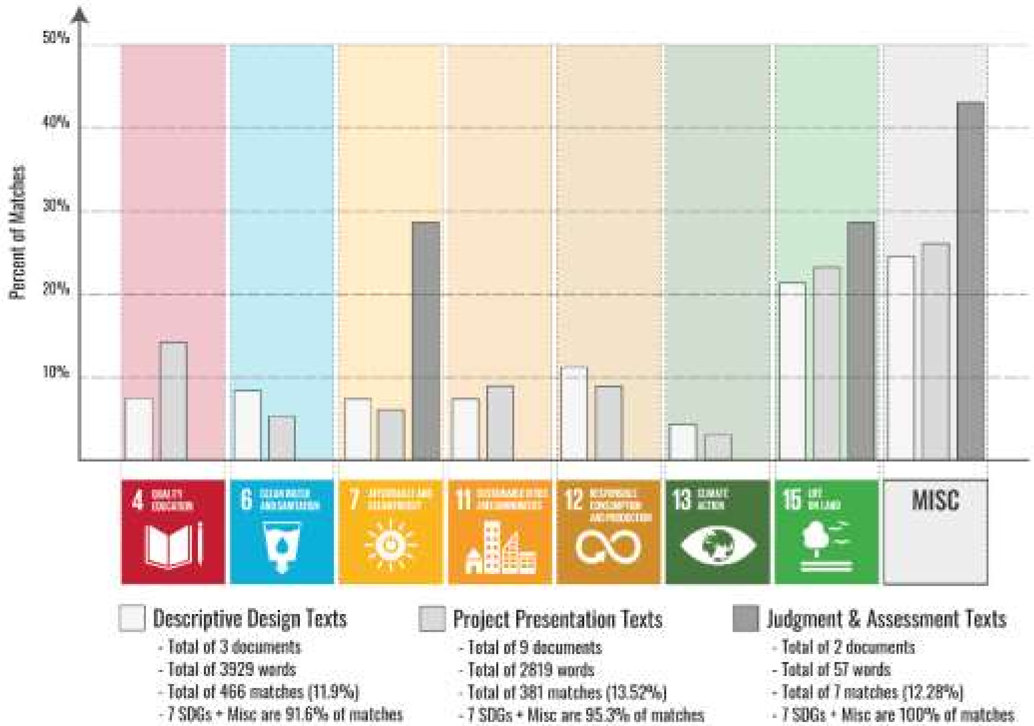


Figure 7.26. Distribution of significant content matches with the SDGs by document type for the BFFSEC

7.4.3.3. Analyzing the project's sustainable design characteristics

While the center's early design documents were not available to study, the architects provide documentation of the design process, including the building's initial concept development as a living eco-system, describing it as "A building as part of a forest ecosystem" (DIALOG, n.d.). This is clearly seen in the initial sketch in Figure 7.20. The designers' description of the project embeds the project in its natural context and stressing on its educational mission:" promot[ing] the significance of forest ecosystems through spaces for education, corporate, and community meetings". The designers clarified four key areas for integration in the design, as highlighted in (Living Future, n.d.) "

- *Energy: the facility runs primarily on the electricity generated by solar panels*
- *Water: the facility captures rainwater, returning it to the watershed as clean as when it entered the facility.*
- *Place: the facility is uniquely rooted in its place, reflecting the natural landscapes that surround it.*

- *Beauty: the facility provides delight and wonder, inspiring all who visit it and reinvigorating visitors' and occupants' connection to the natural world."*

Being the first Ontario contender for the Living Building Challenge, the building presents an interesting mix, and sometimes tensions, between technical, cultural, natural and human experiential dimensions. One of the key areas where this tension appears is in the use of wood. The designer's describe how the timber used allows the "centre exists in harmony with its site. […] In addition, it provides delight and wonder, inspiring all who visit it." (DIALOG, n.d.). This message is strongly echoed by the Living Future presentation of the project highlights how the wood used (in its different engineered, natural, and salvaged varieties), allows "the building was always conceived of being 'of the forest', and not 'in the forest'" (Living Future, n.d.). On the other hand, Canadian Architect (2018), SABMag (2016), and the Canadian Wood Council (2016) present the wood and timber selection and design process in this building as a highly technical endeavour, featuring structural innovations, allowing it to further reduce it carbon footprint, support the restoration of the surrounding habitat (by using infested wood), and allowing the building to achieve its "90-years life cycle".

The building's spatial program as an educational and forest stewardship center and its context (close to the Hollidge Tract network of trails) also established a sustainability narrative that is focused on access to knowledge regarding sustainable development habitat protection. Additionally, an important human dimension in the project and its surroundings is its inclusive and accessible design and surroundings. The living building future presentation highlights how the building's design exceeds the current associability standards, and the project's surrounding integrates an accessible trail. Yet, these issues were hardly mentioned in the LEED highlight of the building (CaGBC, 2017a) nor in the building's presentation in any of the awards (Canadian Wood Council, 2016; SABMag, 2016).

While the extended areas of sustainability focus this project offers are commendable, the description and illustrations of its sustainability features are strongly embedded in the Living Building Challenge's areas of concern. DIALIOG's principle was quoted saying that "Every design and engineering effort was driven by the belief that 'living buildings' take responsibility for the ecosystems, […]supportive of carbon neutrality […] based on the Living Building

Challenge's very strict definition of net-zero energy use" when sharing the lessons for designing the building after its certification in 2018 (Canadian Architect, 2018).

Thus, it is clear that Full Petal Certification this building attempted (and achieved) served as the key justification for the awards it received and it being "Heralded as one of the most sustainable buildings in Canada" (DIALOG, n.d.) However, while the building is designed to boast exceptional performance and serve well its programmatic requirements, the building design itself does not offer any new innovations. This is clearly captured in SABMag's jury comment: "The first Living Building Challenge contender in Ontario, this benchmark project goes beyond net-zero energy by meticulously pursuing a range of familiar conservation strategies" (SABMag, 2016). The analysis outcomes are presented in Table 7.5.

Table 7.5.. Analysis outcomes for the Bill Fisch Forest Stewardship and Education Centre (organized in decreasing frequency of matches)

SDG	**Keywords**	**Overarching sustainable design approach**	**Level & domain of integration**			**Sustainable design vision**
			Architecture	**Engineering**	**Operation**	
15	*Conservation* *Natural habitat* *Soil Erosion*	*Slightly deductive*: the building's approach to conservation and land protection is rooted in the requirements of the site and the certification.	*Level 2.* While standards expect an awareness and teaching component, the building went beyond the requirements by integrating the region's programming into the building.	*Level 1.* Standard driven strategies for site selection and protection were implemented.	*Level 2.* The training happens in the daily interaction of the building users with its systems and facilities and the displayed technologies' experience.	No clear character and *slightly history driven* in its inspiration
4	*Educational facility* *University education*	*Slightly abductive*: the designers ensured to integrate the site and region's activities into the design to create a novel educational experience – in harmony with nature.	*Level 2.* While standards expect an awareness and teaching component (including using the building as a teaching tool), the building went beyond the requirements by integrating the region's programming and its activities into the building.	*Level 0.*	*Level 3.* The activities that happen within the building are key for realizing its educational mandate – and the building's integration with its surrounding further supports this.	*Slightly human focused* in character and *slightly history driven* in its inspiration
12	*Footprint* *Embodied carbon* *4Rs* *Chemical control*	*Slightly abductive*: while the strategies implemented for reducing embodied carbon are based on best practice, the selection of the materials, which are	*Level 2.* While standards expect a high level of consideration for material issues, the designers have integrated these requirements in design language to	*Level 2.* The designers exceeded the standard requirements by presenting innovative design solutions on the	*Level 0.*	*Slightly product focused* in character and *slightly history driven* in its inspiration

		inspired by the surrounding, presents a unique language for this site.	augment the interior and exterior quality.	structural and finishing level regarding timber and other low-carbon materials.		
	Adaptation Durability Natural heritage	*Slightly abductive*: The designers have utilized the urban context of this project in order to explore new possibilities for building in harmony with nature – with a focus on durability and the protection of the site's natural heritage.	*Level 2.* The designers aimed to sensibly address the site's natural heritage delicately by combining the experiential, technical, and educational considerations for the program. The parking design also aims to move beyond current standards to imagine a new typology that is more natural.	*Level 1.* Standard driven strategies for site energy are applied in the building. Some consideration for the life-cycle and increasing the service life attempt to move beyond the current practices.	*Level 0.*	No clear character and *slightly history driven* in its inspiration
	Solar energy Net-zero Energy efficiency Gird	*Slightly Deductive:* Best practices in renewable energy and energy-efficiency are applied in the project – based on available codes and standards (to achieve net-positive energy). However, broader contextual factors were also considered (Such as shading and disruption)	*Level 1.* Standard driven strategies for site energy are applied in the building, including its orientation and glazing ratios.	*Level 1.* Standard driven strategies for site energy are applied in the building, including the use of solar technologies.	*Level 2.* The building's dependence on natural ventilation and some passive strategies requires users' active participation in energy management and control – a process that moves beyond the current best-practices.	*Product focused* in character and *slightly future driven* in its inspiration

Rainwater Water consumption	*Deductive*: Best practices in water conservation and filtration are applied in the building.	*Level 0.*	*Level 2.* Standard driven strategies for water-related issues are integrated. However, the building attempts a net-water positive approach for improving the water quality in the site.	*Level 0.*	*Product focused* in character and with no clear inspiration.
Low carbon Greenhouse gas	*Slightly deductive*: The building puts to use a variety of best practices to lower its carbon footprint and emissions. However, the innovative use of wood presents a departure from current standards.	*Level 2:* The designers' focus on embodied carbon and their innovative integration of wood products have helped create a number of sustainability synergies while also reducing the project's embodied carbon.	*Level 1.* Standard driven strategies for site energy reduction are implemented and help control site emissions.	*Level 1.* The integration of passive strategies helped further reduce the emissions of the building.	*Product focused* in character and with no clear inspiration.

7.4.4. Halifax Central Library (2014)

7.4.4.1. Project Context and data

Dubbed as an international competition (Fowler Bauld & Mitchell, n.d.), the Halifax Central Library was inaugurated in 2014 after many years of planning. The building was a result of a request for proposal (RFP) that contrasted submissions from four prominent architects. For more than 15 years, Halifax's Central Library's planning, design and construction took center stage in the city (Schmidt Hammer Lassen Architects, n.d.). Halifax's Public Libraries authority (Halifax Central Library, n.d.) documents this process proudly to showcase the rigour in the planning and process, which led the building to be awarded in 2014 Canada's most prestigious architecture award, the *Governor General's Medal in Architecture*. However, SHL reports three prominent awards for the building. Further research showed at least three more awards (with a total of six awards, including at least one, SABMag's Green Building Award, that is green-focused). Additionally, the building was shortlisted in 2015 for the *World Building of the Year* award at the World Architecture Festival (Bradley, 2015). The full list of awards the building received is available in Appendix (J).

The planning process for this building started in 1987 when the feasibility of a building was first studied. Regional studies (Terrain Consulting, 2004) followed by local studies for The Spring Garden Road/Queen Street Area Joint Public Lands Plan were then conducted in 2006, and concluded that the library's best location would be at the corner of Spring Garden Road and Queen St. (Environmental Design and Management Ltd. & Urban Strategies Inc, 2006). The city, the public libraries authority and consultants collected various stakeholders' input during these two studies through public consultations, workshops, and townhouses. Afterwards, HOK completed a study in June 2008 for its program and space requirements, which was heavily reliant on a comprehensive and inclusive consultation process (HOK, 2008). HOK concluded the following recommendations for the library, which guided the drafting of the Expression of Interest (EOI) and the RFP, and included a sustainable design meeting LEED Silver requirement at the minimum: "

- *A civic landmark and a source of pride and inspiration for all residents.*
- *A centrepiece of the Capital District, contributing to the economic revitalization of the downtown and sparking cultural and learning activities.*

- *An accessible, bright, and welcoming destination for adults, youth, families and newcomers*
- *providing opportunities for civic and social interaction as well as quiet individual use.*
- *An environmentally friendly, sustainable building.*
- *A rich resource centre for knowledge, learning and personal growth.*
- *An asset to the branch libraries by providing resources which assist them in being more responsive to local community needs.*
- *An adaptable and flexible space that will be able to meet the changing needs of users and*
- *accommodate new innovative technologies and new demands." (HOK, 2008, p. iv).*

This was followed by a series of consultations and general meetings to approve the program and its funding as a priority infrastructure project (Halifax Central Library, n.d.). While not organized as a traditional open architectural competition, the selection process was through a public request for proposals that consisted of multiple steps and included various stakeholders. In summer 2009, the call for EOI was published and received six bids, four of which were invited to submit proposals by November 2009 (Halifax Central Library, n.d.). After evaluation, the committee, with the help of an external consultant (The creative class group, 2010), recommended the team composed of Fowler Bauld & Mitchell Ltd. (FBM – Halifax, NS) and Schmidt Hammer Lassen Architects (SHL – Aarhus, DK). Available documents on the library's website indicate that this selection was based on the team's ability to integrate "the complexities of the site" and the need for creating "a unique landmark design for downtown Halifax, one which is compatible with its immediate context but truthful to its time and purpose" (The creative class group, 2010, p.16). After selecting FBM and SHL, the design moved into three public consultation stages between July and September, during which the first sketches of the building started to emerge (Figure 7.27). This approach is similar to that described by Jacobsen et al. (2020), where the process of competition requires designing with the future users and moves beyond the simple selection of a winner (Chupin, 2011). At that time, LEED was selected as the guiding principle for the sustainability interventions – while the earlier concept of the roof and indoor gardens tuned down[83].

Figure 7.27. Initial sketches of the Halifax Public library during the consultation process (2010)
© Schmidt Hammer Lassen architects with Fowler Bauld & Mitchell

The lead architects describe the building as "the most significant public building built in Halifax in a generation, and represents the diverse communities, talents, and creativity of the residents of Halifax throughout the municipality and present this to the world" (Schmidt Hammer Lassen Architects, n.d.). The design features four volumes, which are stacked vertically with horizontal

83 This disappearance can be clearly seen from the loss of these green concepts between the July and August presentations by the architects.

twists to create the shifts in the façade alignment, which allows the creation of an expansive roof terrace and garden that provides a unique view onto the City of Halifax and its waterfront. The building's transparency combined with its complex form contributes to "its drama," as described by the jurors of SABMag (SABMag, 2015). The building exterior is seen in Figure 7.28, and its roof terraces and garden are seen in Figure 7.29.

Figure 7.28.. Exterior of the Halifax Public Library (2014)
© Schmidt Hammer Lassen architects with Fowler Bauld & Mitchell

Figure 7.29. Roofs of the Halifax Public Library (2014)
© Schmidt Hammer Lassen architects with Fowler Bauld & Mitchell

SABMag, in their presentation of the building in their award, also indicated that, while the building is environmentally conscious and is certified at LEED Gold Standard level, "its most important attribute is its contribution to social sustainability, providing multiple types of community space and facilitating community interaction" (SABMag, 2015). Some of the social and cultural sustainability features include the First Nations Circle and the war memorial space, and a multi-purpose 300 seat auditorium. Most importantly, the library design process is exemplary for its consultation process (Schmidt Hammer Lassen Architects, n.d.). This was explicitly mentioned in the Jury's comment when awarded the Governor General Medal "The jury commends the process of early user engagement that led to the design, and the public's embrace of the building is a testament to its value."

The building's urban design approach aimed at a city center revitalization through the extension of the library's space to create "create vibrant plazas within the surrounding urban context" (Fowler Bauld & Mitchell, n.d.)– seen in Figure 7.30. This approach aimed to instill the building as "a cultural hub accessible to everyone; the building is a catalyst for the regeneration of the downtown area" (Canadian Architect, 2015).

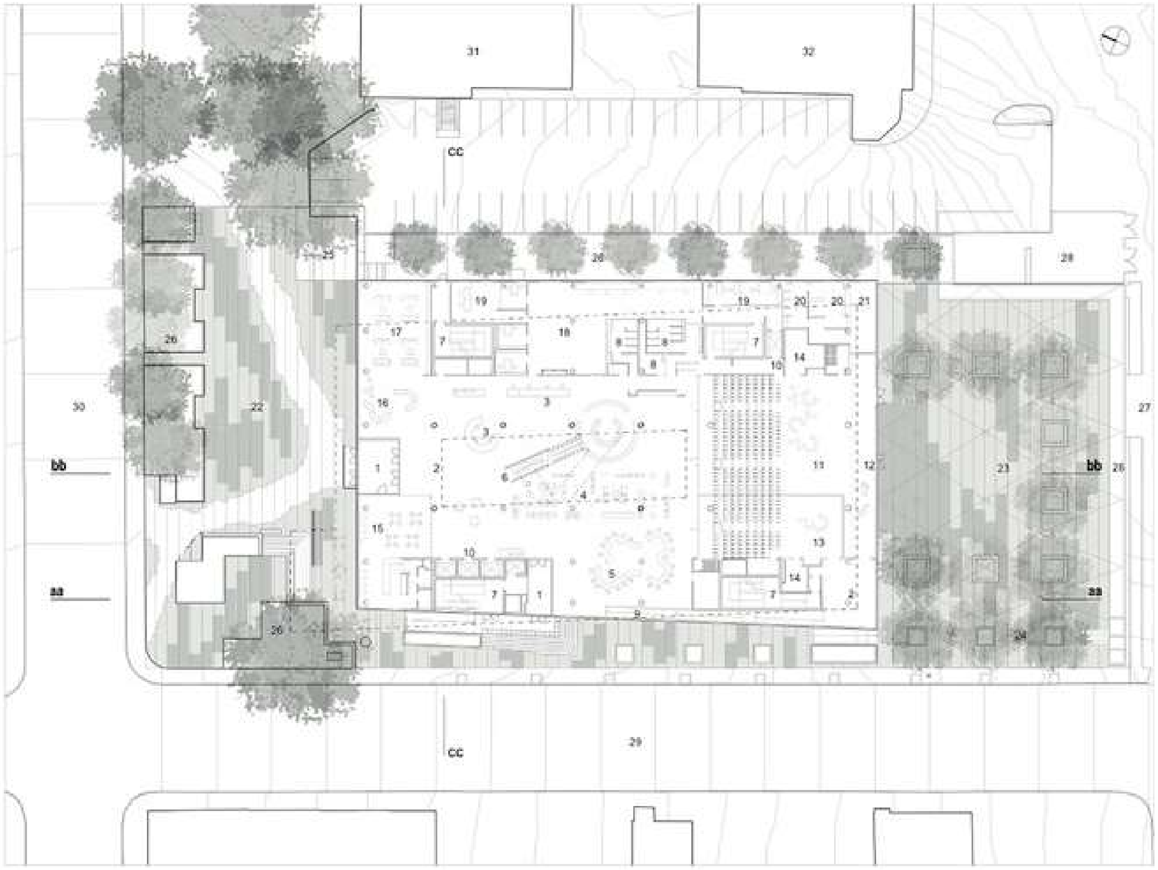


Figure 7.30. Site plan of the Halifax Public Library (2014)
© Schmidt Hammer Lassen architects with Fowler Bauld & Mitchell

The building's interior reflects the complexity of its exterior. It features a variety of bridges and stairs that crosses its atrium. Its spaces embrace the city residents' ambitions by dedicating a whole floor for children and introducing new interactive and creative areas such as gaming stations, music studios, and boardrooms for local entrepreneurs. Figure 7.31 presents some of the interior spaces.

Figure 7.31. Interior of the Halifax Public Library (2014)
© Schmidt Hammer Lassen architects with Fowler Bauld & Mitchell

The building's environmental features, which are aligned with the LEED credit requirements, are listed on the library's website and include water, energy, material, and indoor environment design features (Halifax Central Library, n.d.). One of its innovative features is the green building awareness and education program, an aspect that highlights its "eco-didactic" approach (Cucuzzella et al., 2020).

For the Halifax Central Library, documents related to the design process (including EoI and RFP), the design development, general description of the project as provided by the architects, news and advertising texts, and award related documents (including award submission and presentation documents, as well as jury comments) are available. The full list of documents analyzed is available in Appendix (K).

7.4.4.2. Direct Content analysis

The project documents' direct content analysis returned a significant overlap with eight SDGs along with the miscellaneous category. In total, 221 matches (5.1% of the text) were recorded: 173 matches (or 4.0% of the text) with SDG specific keywords, including 71 unique terms. The matches ranged from 2 to 61 across 13 SDGs (excluding SDGs 1, 5, 13 and 17), with a median of 8 matches (8 SDGs had matches above the median). The full outcomes of the direct content analysis are available in Appendix (L).

By a large margin, the highest occurring matches were for SDG 11 for keywords related to community building, urban aspects, adaptation, and green building strategies. The goal's matching constitutes close to 1.5% of the overall text content analyzed, with a total of 61 matches across all documents. This is followed by SDG 6 (16 matches) for keywords related to rainwater and water consumption management. This is illustrated in Figure 7.32.

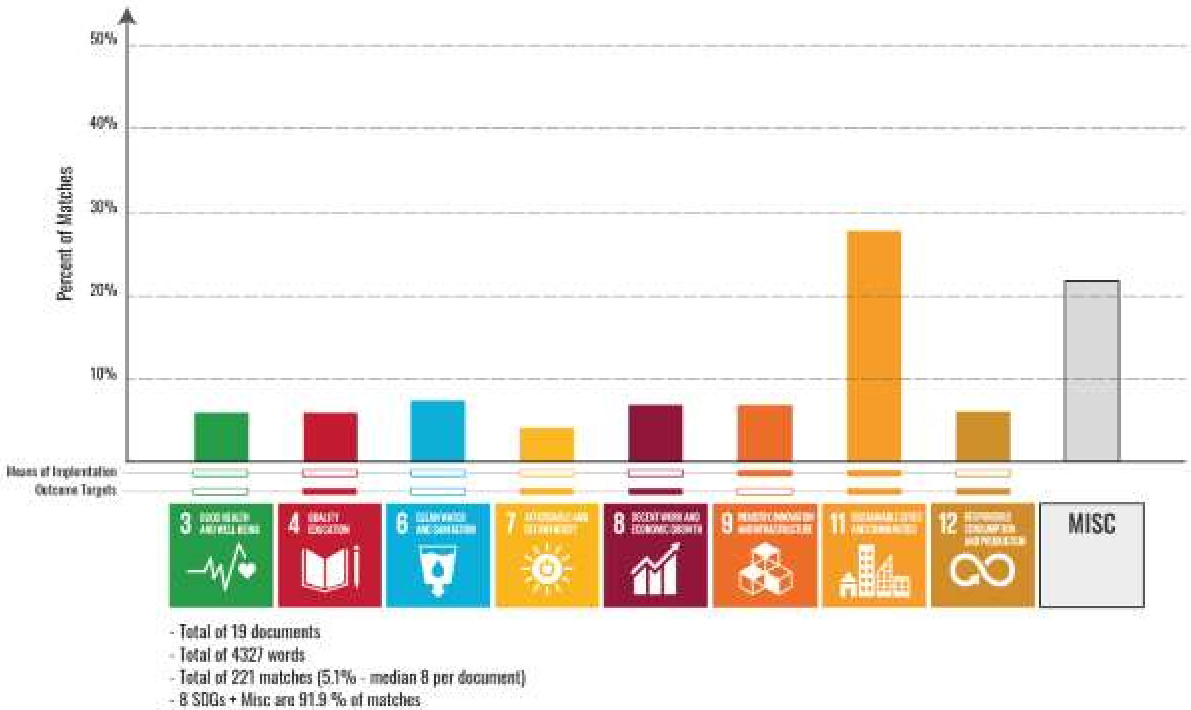


Figure 7.32. General distribution of significant content matches with the SDGs for the Halifax Public Library

The project's text also touched upon target specific keywords in six SDGs. The biggest focus was on SDG 11, sustainable transport (11.2), heritage (11.4) and open and public spaces and children (11.7). The texts also address issues of literacy (4.3), internet access (9.c), culture (8.9), workers and working conditions (8.8), energy efficiency (7.3) and procurement (12.7).

Figure 7.33 shows that descriptive design texts are less specific to the SDG topics – with more than one-third matching with the miscellaneous category instead of 20% or less for the presentation and judgment texts. It is also clear that the urban issues, as represented in the matches with SDG 11, are magnified in the presentation and judgement texts far beyond the original project's description. A similar pattern is also seen for SDG 4 (Quality education) and innovation (SDG 9). Technical issues related to energy, health and wellbeing, and water are barely mentioned in the judgement texts. This, in turn, might be signalling the grounding of the project in the realm of social or human-focused sustainable development.

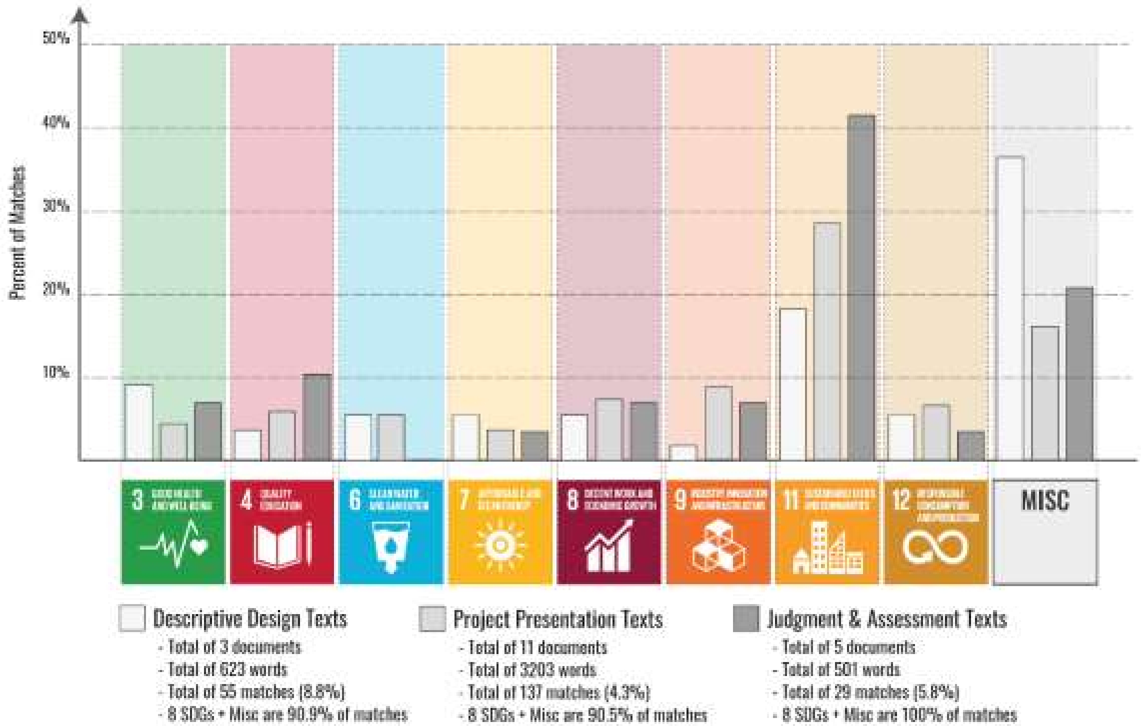


Figure 7.33. Distribution of significant content matches with the SDGs by document type for the Halifax Public Library

7.4.4.3. Analyzing the project's sustainable design characteristics

The library's early design documents that led to the contract's granting were not publicly accessible and were not made available by the library authority (since they were submitted under contract to a consultant and were not in their possession). Instead, they made available several presentations and reports analyzing and assessing the various proposals, including the winning entry. The earliest design documents are a group of published presentations by the design team (SHL + FBM) which were used during the design development phase which involved the public. There, we see an interesting duality between the human and environmental dimensions and goals of the project.

The description of the architects do not explicitly mention the environmental performance of the building; instead, they are highly focused on the experiential, cultural and spatial characteristics of the building and on the public consultation process of its design process – which was described as a "co-creation" process (schmidt hammer lassen architects + Fowler Bauld & Mitchell, 2014). The architects take pride in the collective development of the design, which was open to locals but also streamed online to "ensure[…] all future users of the library had a substantial influence on the design process" (Schmidt Hammer Lassen Architects, n.d.). In their design proposal, the design team is quoted by the project review consultants:

> *"We recognize the value of these documents and are excited by their vision of a bustling, vibrant city. We are eager to engage in the challenge of meshing the aspirations of HRM by Design with the goals of a library as a centre for learning, partnership and culture. The balancing of the desire for a building of monumental character with the desire for animated, pedestrian-friendly, accessible facades is one such challenge." (The creative class group, 2010, p.16)*

SHL describe that their building is meant to " […] represents the diverse communities, talents, and creativity of the residents of Halifax throughout the municipality and present this to the world," and FBM indicates that "It's the new cultural hub for the region and it has delivered on the promise to be a place for everyone." In the comment for the Governor-General Medal, the jurors also stated that: "The process of early user engagement that led to the design, and the public's embrace of the building is a testament to its value."

Yet, in the consultation phase, a separate and almost imposed presentation on the LEED system's benefits is added. There, the LEED facilitation expert (Solterre Design – Halifax) presents facts that appear to almost shame a Canadian audience: "Canada among the most wasteful nations: • High energy consumption; • High water use; • High waste generation". Here we observe a clearly deductive reasoning process, with precedents of successes and justification of the certification process (which was noted as not necessary by the public) by establishing the worth of the standard and its sustainability intents. The LEED consultants summarize the green design features from previous public workshops in: "connection to nature, daylight, green roof, green power and alternative energy, and bringing nature indoor". On the other hand, the Halifax Public Libraries present the building's environmental and sustainability elements in more technical terms. Organized around the LEED themes, the narrative describes how the library aims to minimize its ecological footprint and impact – this includes listing some of its green technological gadget and design features in what appears to be a deductive approach for establishing and grounding the building within the LEED and mainstream green design logics. (Halifax Central Library, n.d.).

Moving into the preliminary design sketches and not explicitly labelled as green strategies, the architect's sensibility and ability to fuse the environmental, technical, social and cultural becomes vivid through their sketches (seen in Figure 7.34). Even in its final form, the jurors of SABMag's green awards realized that this building's sustainability approach is highly unique, indicating that "the project balances its architectural, social and environmental aspirations and provides a great model for the design of environmentally responsible community buildings." This is also very well illustrated in the inclusion of historical, cultural and playful spaces to gather the community and build knowledge. Moreover, the First Nations circle constitutes an important programmatic addition that is highlighted in most of the descriptive texts and project presentations. It is certain that the designers here used green design principles as a basis for delivering an innovative project – on the architectural, spatial and experiential dimensions. The analysis outcomes are presented in Table 7.6.

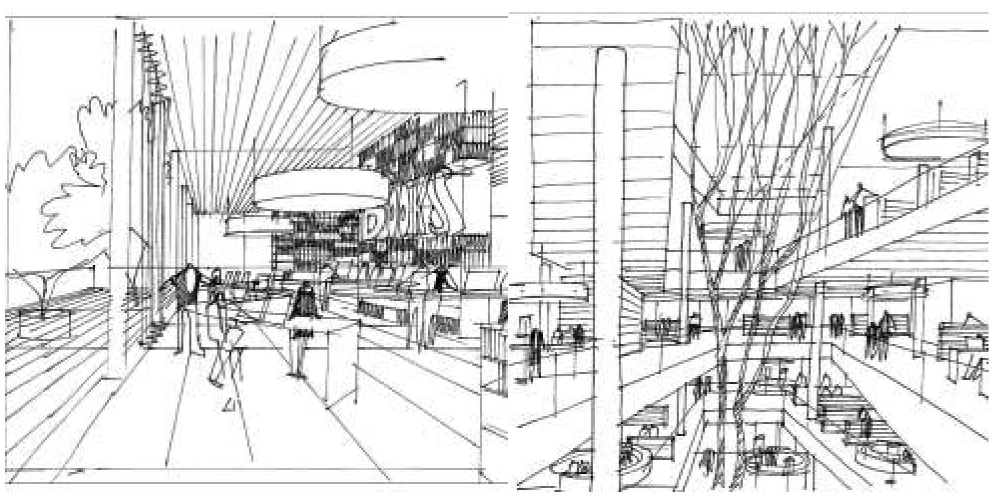
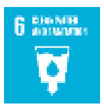
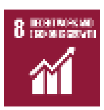


Figure 7.34. Design sketches for the Halifax Public Library (2014)
© Schmidt Hammer Lassen architects with Fowler Bauld & Mitchell

Table 7.6. Analysis outcome for the Halifax Central Library (organized in decreasing frequency of matches)

SDG	Keywords	Overarching sustainable design approach	Level & domain of integration			Sustainable design vision
			Architecture	Engineering	Operation	
	*Community* *Urban* *Heritage* *Public space* *Transport*	*Abductive.* The building proposes a new concept for creating a public hub for knowledge exchange through its architecture and functions.	*Level 3.* The design mediates between the library's urban role as a catalyst for development, the library's critical heritage context, and the community. It proposes a new model for the library that is tailored to the needs of the city.	*Level 0.*	*Level 2.* The building's functions and expected inter-media exchange platforms (ranging from formal, art-based, or informal), exceeds current norms.	*Human* in character and *slightly future* driven in its inspiration
	*Rainwater* *Water consumption*	*Deductive.* The design responds to the environmental goal set for the project around the management of water.	*Level 1.* The designers integrate the need for water management with the experiences of the building (through the design of roofs)	*Level 1.* The building strives to conform to best practices related to the management of water.	*Level 0.*	Does not present a concrete vision
	*Culture* *Economy* *Workers*	*Slightly Abductive.* The design explores the potential of utilizing the library as a public hub and as a cultural impetus for the city.	*Level 3.* The architecture of the building, while distinct, adds to the architectural and intellectual culture of the city.	*Level 0.*	*Level 3.* The building's functions and daily operations (including its public functions) presents a new inspiration and a facilitator for development of the city.	*Human* in character and *slightly history* driven in its inspiration

	Technology *Internet*	*Slightly abductive.* Here innovation is mobilized to serve the social, cultural and economic goals of the project.	*Level 0.*	*Level 0.*	*Level 2.* Technologies and innovations within the library (such as the gaming, or musical spaces and boardrooms) aims to create a new definition for this typology.	*Slightly Human* in character and *slightly future driven* in its inspiration
	Daylight *Community health* *Indoor air quality*	*Abductive.* The building's approach to health proposed a non-medical approach – that is highly experiential in its interior spaces and its connection with the city.	*Level 3.* The architecture creates spaces conducive to improving the community's health and well-being by creating an elaborate and moderated interior space that is highly engaged and well connected to the city and its heritage.	*Level 1.* The building conforms to the expected standards around daylight and indoor environment quality.	*Level 0.*	*Slightly Human* in character and *slightly future driven* in its inspiration
	Literacy *Schooling*	*Slightly abductive.* The building functions include new forms of knowledge that could evolve our collective understanding of the modern library/	*Level 1.* The architecture meets the users' expectations by providing quality educational spaces.	*Level 0.*	*Level 3.* The building integrates functions such as adult learning, First Nations Circle, music and gaming, which reshape a library space's dynamics as a space for practical exchange and co-development.	*Human* in character and *future driven* in its inspiration

Landfill *Procurement* *Future proof*	*Deductive.* The building follows best practices around the use of sustainable, local and low-impact materials.	*Level 0.*	*Level 1.* The building applies a range of best practices.	*Level 1.* The designed operation of the building considers sustainable procurement practices, as per the current best practices.	*Slightly product-focused* in character and with no clear inspiration
Solar energy *Grid* *Energy efficiency*	*Slightly deductive.* While complying with the current best-practices, the building integrates various technologies and performance expectations within a well-formulated architecture.	*Level 2.* The building's architecture presents the possibility of creating an elaborate architecture, which also meets the expected high performance.	*Level 1.* The building applies best practices around the management of energy.	*Level 0.*	*Slightly product-focused* in character and with no clear inspiration

7.4.5. Amber Trails Community School (2015)

7.4.5.1. Project Context and data

This school is set in a new neighbourhood area in the north of Winnipeg was set to welcome young students from birth to grade 8. The school acts as a gathering space for this new development due to the absence of community spaces in the area. The building was designed as a prototype for a sustainable school that could be replicated in other Winnipeg areas (prairie architects inc., 2016). Originally targeting LEED Gold, the building was selected as the greenest school in Canada in 2017 by CaGBC; the building was the first LEED Platinum school in Manitoba in the second in all of Canada (prairie architects inc., n.d.). Between 2015 and 2018, the building received at least 5 provincial, national and international awards of excellence, four of which are green and sustainability-focused. The full list of awards the building received is available in Appendix (J).

The building's design and planning aim to compartmentalize the spaces and centralize the community spaces such as the learning commons and entry commons (prairie architects inc., n.d.). The outside of this building (seen in Figure 7.35) features large south-facing windows that create a strong connection between the learning commons and the street. These common spaces are well connected to the school’s facilities, including its street-facing gymnasium and community kitchen. Here, the designers have rethought the school gym typology to meet the needs of the surrounding community – to realize an inclusive community space connected to the surrounding neighbourhood and its trails (Canadian Architect, 2017) – as seen in the site plan (Figure 7.36). While programmatically beneficial, the designers also utilized this to ensure that energy consumption can be controlled when the building is serving the community before and after school hours (SABMag, 2017) – zoning seen in Figure 7.36. The building’s surroundings are also activated, including learning spaces (such as the outdoor classrooms, the learning courtyard for the earlier years students), and community gardening spaces. Most of the exterior is cladded with masonry bricks, which enabled the building to collect a masonry-focused green merit award in 2018.

Figure 7.35. Exterior views of the Amber Trails Community School (2015) - © Prairie Architects Inc.

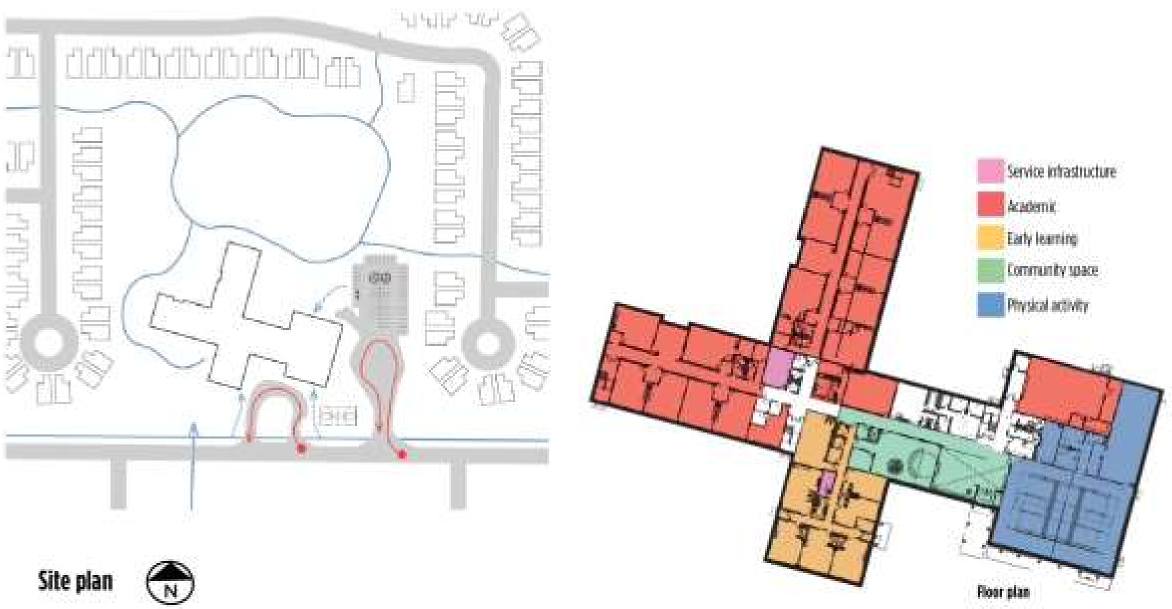


Figure 7.36. Site and zoning plans of the Amber Trails Community School (2015) - © Prairie Architects Inc.

The building's interior is strongly connected to its outdoor spaces and surroundings by including at least three large windows in each classroom, which are also visually connected with glass to the school's hallways. The double-height common learning space and entrance are vibrantly lit in the morning through large windows and spill out their light in the night to communicate their liveliness to the residents. The building also features a variety of multi-purpose and skill development spaces. The interior features wood cladding on the ceiling and some walls, bright pastel colours and white paint and the floors are covered with a rich wooden-floor. The building's interior is seen in Figure 7.37.

Figure 7.37. Interior views of the Amber Trails Community School (2015) - © Prairie Architects Inc.

The building's sustainability features several standard technologies for energy, a ground source heat pump, radiant floors, active chilled beams for fresh air and cooling; energy recovery ventilators; and variable speed pumps (SABMag, 2017). This leads the school to save close to 70% energy when compared to a prototypical school and significantly decrease its carbon footprint (due to the elimination of natural gas) (CaGBC, 2017b). The building also boasts a range of impressive water conservation strategies – leading to more than 60% saving in water use per student in comparison to similar schools. The building's comfort considerations include highly localized HVAC controllers, maximization of natural light and view, as well as a strict plan for controlling and managing indoor air quality. In addition to these technological additions, the building uses its facilities to educate young students about green building technologies (through didactic features – such as transparent wall panels) and sustainable living (such as through the student-run organic vegetable farm) (CaGBC, 2017b; Canadian Architect, 2017) – seen in Figure 7.38.

Figure 7.38. The experiential and didactic sustainability education features of the Amber Trails Community School (2015) - © Prairie Architects Inc.

For the Amber Trails Community School, documents related to the design process (including EoI and RFP), the design development, general description of the project as provided by the architects, news and advertising texts, and award related documents (including award submission and presentation documents, as well as jury comments) are available. The full list of documents analyzed is available in Appendix (K).

7.4.5.2. Direct Content analysis

project documents' direct content analysis returned a significant overlap with seven SDGs along with the miscellaneous category. In total, 392 matches (18.01% of the text) were recorded: 323 matches (or 14.84% of the text) with SDG specific keywords; including 71 unique terms. The matches ranged from 1 to 130 across 11 SDGs (excluding SDGs 1, 5, 9, 10, 14, and 17), with a median of 7 matches (7 SDGs had matches above the median). The full outcomes of the direct content analysis are available in Appendix (L).

The highest occurring matches were for SDG 4 (quality education) for keywords related to curriculum (addressing target 4.7), inclusive learning, learning opportunities, and different types of educational facilities (addressing target 4.a). The texts had 130 matches (5.97% of the overall content analyzed and 33.2% of the matches) with SDG 4. This is followed, with a large margin of difference, by SDG 11 (sustainable cities and communities) for keywords related to durability, community development, green and open spaces for children (addressing target 11.7), air quality and construction waste (addressing target 11.6) and sustainable transportation (addressing target

11.2). When contrasted to the other cases, the texts presented less content related to general development and sustainability, with only 17.6% (69 matches) of the matches related to the miscellaneous category. This is illustrated in Figure 7.39.

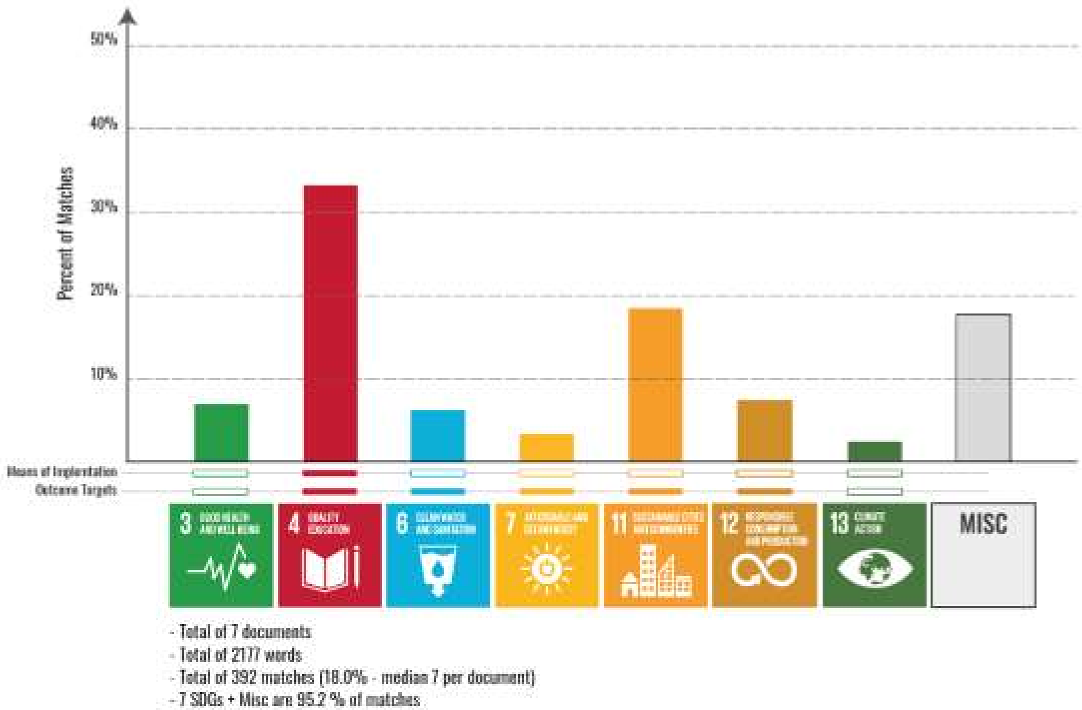


Figure 7.39. General distribution of significant content matches with the SDGs for the Amber Trails Community School

Figure 7.40 shows that the three text categories of documents followed a similar pattern in their description and coverage of the SDG topics. However, it is interesting to note that judgment and assessment texts focused less on health and well-being (SDG 3) and sustainable consumption and production (SDG 12). Additionally, they were more generic in their coverage of the project, with the highest portion of non-target specific keywords and the most considerable portion of matches with the miscellaneous category.

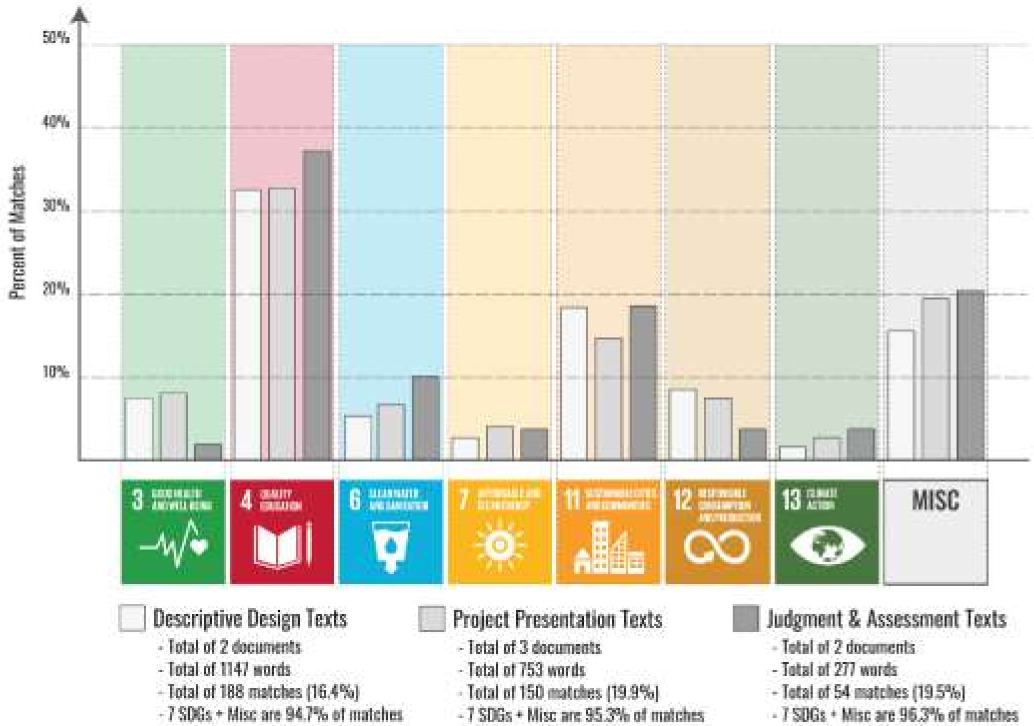


Figure 7.40. Distribution of significant content matches with the SDGs by document type for the Amber Trails Community School

7.4.5.3. Analyzing the project's sustainable design characteristics

Early design documents of this project were not accessible to analyze. However, ample documentation regarding how the building was designed and how it integrates sustainability imperative was available through public and private information outlets. The architects' description of the building presents two versions of sustainability – one that is deductively established through its success in meeting the stringent LEED Platinum criteria and the other as a community-focused and driven structure that is innovative in its architectural parti and its sensible approach to its new urban surroundings. Different descriptive and judgement documents recreate this dichotomy. The analysis reveals that this dualism was created by the conflicting interests of the stakeholders involved.

The project owner explains their commitment to green buildings by clarifying in a post titled "LEED'ing sustainability": "[LEED] is a rating system that is recognized as the international mark of excellence for green building in 150 countries. Since 2002, the Canada Green Building Council

(CaGBC) and LEED Canada have been redefining the buildings and communities where Canadians live, work and learn." (Seven Oaks School Division, n.d.). On the other hand, Canadian Architect reports that the stakeholder group meetings had a strong influence and inspiration for the school to act as a community hub by "creati[ng] a design that would facilitate an open and easily accessible facility for community use, and act as a community hub to be connected to the community's network of walking trails." (Canadian Architect, 2017). What is noticeable is the success of the designers in balancing between these two visions.

The descriptive and presentation texts attempt to establish the building's sustainability deductively – by embedding it within the mainstream green building criteria of savings and use reduction. Canadian Architect reports:

> *"This is the first school in Manitoba to be certified LEED Platinum, and only the second in Canada following the lead of the Dr. David Suzuki Public School in Windsor, Ontario. […] school has achieved an overall energy use reduction of 68 percent less than a model building, exceeding energy use expectations while simultaneously achieving over 60 percent water reduction (10 percent over the estimated savings). Originally targeting LEED Gold; geothermal heating, in-floor heating, and efficient lighting fixtures further helped reduce the energy needs of the school and achieve higher certification." (Canadian Architect, 2017)*

Yet, the creative and original approaches of the designers in terms of the development of the architectural parti to meet the users' aspirations are made clear in their description:

> *"This design requirement challenged the typical design notion that the gymnasium should be a windowless, large mass tucked at the back of a school. Instead, the design of the new Amber Trails Community School, demonstrates that these new prototype school facilities are open and accessible to all, with the vibrant glow of activities spilling out through the windows on many dark, Winnipeg winter nights." (prairie architects inc., n.d.)*

Furthermore, the designer's ingenuity in mediating between the energy, program and users' requirements was exemplified in the zoning approach that allows separation in the school zones for areas expected to be used before and after school hours (prairie architects inc., 2016). The judgement and project presentation text in the SABMag and CaGBC Greenest School Awards both highlight the educational innovations of the project: including student-run agri-spaces, a season-based program and sustainability curriculum, didactic green-design installations serving as teaching tools for the students, and a focus on health, wellbeing and control in the classroom spaces (CaGBC, 2017b). The SABMag jury comment highlights the success of the project in balancing those two dimensions:

> *"This project encourages social interaction and community engagement through the physical organization of its multiple programs. Operating before and after regular school hours increases the efficiency of building use, while energy and water consumption reductions of close to 70% are remarkable. Programs such as the community farm raise awareness around broader aspects of sustainability. A community school in the truest sense." (SABMag, 2017)*

The analysis outcomes are presented in Table 7.7.

Table 7.7. Analysis outcome for the Amber Trails Community School (organized in decreasing frequency of matches)

SDG	Keywords	Overarching sustainable design approach	Level & domain of integration Architecture	Engineering	Operation	Sustainable design vision
4	*Curriculum* *Learning* *Opportunities* *Education*	*Abductive.* The design combines a multitude of features to deliver quality education complemented by sustainability awareness building.	*Level 3.* The architecture creates spaces conducive to improving the community's health and well-being by creating an elaborate and moderated interior space that is highly engaged and well connected to the city and its heritage. 3	*Level 0.*	*Level 3.* The architectural design depends heavily on the building's daily functions (as a school and community hub) to realize its sustainability goals. Specifically, curriculum and student-run programmes present key features in the education delivery.	*Human* in character and *future* driven in its inspiration
11	*Community* *Transport* *Open space*	*Slightly abductive.* The building design and integration as a hub for the new residential neighbourhood creates a new precedent that could be replicated in other communities.	*Level 2.* The building's urban considerations presents a new typology for sustainable schools that could be replicated in new developments.	*Level 0.*	*Level 2.* The building operates as a hub and neighbourhood and its extended operation hours serves an important role in community development.	*Human* in character and *slightly future driven* in its inspiration
12	*Energy use* *VOCs* *4Rs*	*Deductive.* The design uses best construction and material selection practices.	*Level 0.*	*Level 1.* Material selection and construction waster is managed based on the guidelines presented by current certification standards.	*Level 0.*	*Slightly product focused* in character with no clear inspiration
3	*Comfort* *Indoor air quality*	*Slightly deductive:* The building applies best practices in daylighting	*Level 2.* The design rethinks the typology of some of the communal	*Level 1.* The building fulfils the requirements for	*Level 2.* The building includes individual controls in spaces to accommodate	*Slightly product focused* in

Daylight *Health and wellbeing*	and comfort in learning spaces. The design provides daylighting in spaces that traditionally don't include them (such as the Gym)	spaces (such as the Gym and learning commons) to create an increased level of comfort and well being.	comfort and indoor air quality as suggested by current guidelines.	the different users' needs for spaces.	character with no clear inspiration
Rainwater *Water consumption and conservation*	*Slightly deductive.* The building adopts best practices while also utilizing the program and operational schedule to maximize water savings.	*Level 0.*	*Level 2.* The technical water management strategies are combined with the usage patterns and schedules to maximize the water savings and treatment beyond the current standards.	*Level 1.* Management of rainwater is integrated with the building operation by maximizing the use of rain and stormwater in the landscaping (including the agricultural activities)	*Product focused* in character with no clear inspiration
Energy consumption *Energy-saving and performance*	*Slightly deductive.* The building adopts best practices while also utilizing the program and operational schedule to maximize energy savings.	*Level 2.* The building design considers the operation schedule to develop its zoning and spaces to ensure energy savings are attained during partial operations.	*Level 1.* The building energy systems are designed to maximize savings and optimize the building's performance.	*Level 2.* Site emissions are reduced by considering the usage pattern and minimizing wasted site energy.	No clear character and *slightly future driven* in its inspiration
Greenhouse gas *Carbon*	*Deductive.* The building follows best practices in reducing emissions – by maximizing the use of non-carbon intensive sources of energy.	*Level 0.*	*Level 1.* The building heating system excludes natural gas to reduce GHGs emissions.	*Level 2:* Site emissions are reduced by considering the usage pattern and minimizing wasted site energy.	*Product focused* in character with no clear inspiration

7.5. Discussion

The cases presented a broad coverage of the agenda (as seen in Figure 7.41). When looking at the combined outcome of the cases (seen in Table 7.8), we find that only four infrastructural goals (based on the Waage et al.'s (2015) categories) readily addressed in all the cases (SDG 6,7, 11, and 12), with only SDG 11 presenting key design innovations and the remaining goals approached primarily from a managerial and harm-reduction approach. The goals which were addressed in some cases were divided between the natural resources (SDG 13 and SDG 15), infrastructure (SDG 8 and SDG 9), and wellbeing categories (SDG 3 and SDG 4). Innovative approaches appeared only in SDG 4 (delivery and development of curriculum and education for sustainable development) and SDG 15 (mediation between the urban and natural environments). For the goals that were not tackled, some could be considered beyond the programs' focus (such as SDG 14). The lack of focus on food-related issues (SDG 2) contradicts urban and community farming opportunities seen in some of the cases (including the Amber Trails School and CIRS). However, the wellbeing goals, including SDG 1 (poverty), SDG 5 (gender), SDG 10 (reduced inequalities) that are under-addressed puts in question the contribution of the buildings to the development agenda. Some of these issues, including gender and inequality, were considered critical areas of focus in Canada's voluntary review of progress towards the SDGs, especially these issues are interconnected in some cases (such as that of the indigenous and immigrant communities) (Government of Canada, 2018).

What is interesting to highlight is that the area of concern in these buildings significantly overlap with the focus topics of some of the building industry green and sustainable building standards – including the potential contribution of LEED to the Agenda (Alawneh, Ghazali, Ali, & Sadullah, 2019), and the overlaps between these standards intents and the SDGs (Goubran et al., unpublished manuscript). Architecturally, we observe a clear dichotomy in projects that attempt to innovatively (or abductively) address some sustainability issues (especially those that are managerial in essence). We find that building elements are both technically and experientially described, rendering different images to the same features. This was particularly clear in the BFFSEC case, which required a more experiential rhetoric to be developed for the Living Building Challenge certification.

By comparing the cases(comparison shown in Figure 7.42) based on the qualitative analysis conducted (presented in Table 7.3 to Table 7.7), we find an overall tendency towards deductive approaches to sustainable design, with more innovations (or tendency to move beyond the current standards) on the architectural and operation axes. None of the buildings presented an overall trend towards innovation across the 7 or 8 significantly matched SDGs, with the overall project level integrations for all cases was ranked between 0 and 2. It is clear that the cases tended to move beyond current precedents and standards on the architectural dimension, while they presented more conservative and standard driven approaches on the engineering dimension (except for the CIRS). The operational dimension saw a large variation, ranging from standard approaches to novel approaches seen in the Amber Trails case (especially as it related to utilizing the program and operation schedule for realizing environmental and social goals).

Both the BFFSEC and the CIRS adopted a similar design approach that is focused on adopting sustainability approaches beyond the current industry-standards touching upon the architectural, engineering and operational dimensions – with CIRS tending towards more innovations in the engineering and operation (with the integration of more novel technologies and sustainability gadgets). The two libraries' sustainable design visions were more human and future driven – with design elements that are highly social and human-centred design features that aim at reimagining how functions can be delivered in spaces and in harmony with the social and urban context. The CIRS appeared to be highly focused on integrating products and technology (which was part of the design goals as a showcase). However, this integration was driven by a vision to envisioning a future imaginary of what a sustainable building can achieve – focused on researching and developing sustainable technologies in the industry. On the other hand, the BFFSEC presented a slightly product-focused vision, yet it was highly inspired by nature and the natural cycles – tending towards a more history driven approach. Amber Trails school presented a new imaginary for a neighbourhood school, yet except for SDG 4, most of its sustainability features were product-oriented – creating an almost balanced approach in character.

When comparing the approaches based on the most addressed and matched SDGs (Figure 7.43), We find larger discrepancies in the overarching approaches and distribution. SDGs 11 and 4 tended to be addressed in a more innovative and abductive manner, with SDG 15 more balanced. Yet, the infrastructural gals (SDG 12, SDG 6, and SDG 7) were tackled using more deductive approaches.

We observe that SDG 11 and SDG 15 generated highly innovative architectural solutions focused on rethinking typologies and negotiating the urban and natural relationship (highly complex issues involving cultural and ethical considerations). On the other hand, approaches to education (SDG 4) were highly innovative on the operational level (with the creation of curriculum and programs, combined with architectural features). The energy (SDG 7) issue featured standard-based engineering approaches but was integrated architecturally beyond the current practices and based on each project's context and objectives. SDG 6 and SDG 12 were more integrated on the engineering dimension, with projects following more stringent regulations than those proposed in best-practices – by adopting LCA and footprint accounting methods in materials or exceeding the savings and conservation levels in water, for example. When looking at the sustainable design vision for each of the goals, we see a clear bias towards a future driven inspiration – except for SDG 15 that appeared to be more balanced. Yet, the infrastructural SDG 6, 7, and 12 appeared to approach this vision by focusing on product and technology integration and product characteristics. On the other hand, SDG 4, 11 and 15 were more focused on the human dimension – including the experiential, cultural and human/natural relation.

Overall, we observe that the projects and the SDGs that featured product-focused and future-driven visions tended towards universal solutions (which are a-contextual and not directly built upon the program), while those that had human-focused visions addressed the specific programs and context of the project.

Looking at the outcomes more in-depth[84], we find that the larger projects (by square foot) were less successful in matching with the Agenda's keywords. However, we find no relationship between the number of awards a building received and its overlaps with the Agenda's topics. Instead, we also found that the more the visions that were more human in character were integrated in a slightly more creative and innovative manner. We also found that the innovative integration of the SDG topics happened mostly in the architectural dimension – with a strong correlation between those two variables (*i.e.* an alignment between abductive mode of design reasoning and innovative integration in architecture). We also see that the integration dimension has a strong

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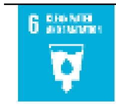
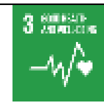
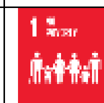
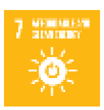
84 Kendall's Tau correlations were used to understand the connection between the variables.

relationship with the sustainability vision's character, with integration in architecture resulting in more human-inspired visions. Yet, the level and area of integration did not affect the vision's inspiration (history vs. future). These findings suggest inherent tensions between the architectural and engineering integration of sustainability in the buildings analyzed – a idea previously proposed by Cucuzzella (2015, 2020) in Canadian green buildings.

Table 7.8. Coverage of the SDGs across the five cases

Tackled in all cases				**Tackled in some cases**				**Not tackled***	
SDG	**Comments**	**Most occurring keywords (Targets)**	**Approach**	**SDG**	**Comments**	**Most occurring keywords (Targets)**	**Approach**	**SDG**	**Comments**
	Water-related issues appeared to be highly driven by current standards with a set of practices replicated in all buildings. Innovations were mainly incremental in achieving higher efficiency and/or reduction.	Storm and Rain water Water consumption and usage (6.4) Biofiltration (6.3) Toilets/urinals Wastewater treatment (6.3)	Approached as a managerial concern – with a focus on efficiency, consumption reduction, and control of negative impact (6.3 and 6.4)		When addressed, it oscillated between best-practices on the technical dimension or an area of innovation in architecture and operation. Yet, it was broad with little focus on any of the human development agenda's targets.	Daylight Health and wellbeing comfort Indoor air quality	Mainly approached as a board managerial concern, driven by compliance and improvements in function delivery..		No addressed in any of the cases. The buildings
	Energy-related issues appeared to be mainly driven by standards on the technical dimension. Some innovations	Solar Energy-saving and efficiency (7.3) Clean energy Net-zero energy	Approached as an infrastructural concern – with a focus on efficiency (7.3)		When addressed, education was seen as an architectural and operational innovation area, focusing on creating	Education Curriculum Inclusive learning Learning opportunities Training	Education within the buildings was a human development concern that was focused on creating opportunities		Addressed in some cases, and mainly focused on food production (such as in the Amber Trails Community

	were present architecturally (through adaptive spaces, form and program-driven design)				learning opportunities.		and providing access.		school) or on irrigation issues.
	Urban issues appeared to be an area of architectural concern where innovations are presented.	Community Public spaces (11.7) Resilient, green and sustainable buildings (11.c) Transport (11.2) Heritage (11.4)	Approached as opportunities for creating new urban models and typologies – to set examples (in sustainability and resilience) to follow.		When addressed, economic development was focused on cultural development and improving the physical environment for workers. It was an issue barely addressed technically and featuring some innovations in the architecture and operation.	Culture (8.9) Workers (8.8) Productivity	The working conditions and workers productivity issues were highly managerial in their approach. While the cultural development angle enabled the creation of new models.		Barely addressed, in any of the case with only a mention of gender (inclusivity and access) in the BFFSEC.
	Material and waste issues were mainly tackled based on the current best-practices, across the architecture, engineering and operational dimensions.	4Rs (12.5) Waste Life cycle Natural resources Footprint (12.2) Chemicals (12.4)	Approached as a managerial concern with a potential for augmenting building quality– with focus on compliance, efficiency and		Innovation and infrastructure were interpreted technically in the cases when addressed to innovate in the functions and experiences of the buildings.	Research Technology (9.b)	Approached through technology integration and innovation showcase.		Barely addressed, with brief mentions of inclusion and inclusive space and issues related to people with disabilities.

reduction (12.2, 12.4, and 12.5)						
	13	Climate change issues were tackled mainly based on current best-practices across the architecture, engineering and operational dimensions. Yet, it was broad with little focus on any development agenda's targets.	Carbon (CO2, low-carbon) GHGs	Approached as a managerial concern – with a focus on efficiency, reduction, and control of negative impact.	14	Barely addressed with the exception of the mentions of research (in CIRS) and views (in Halifax)
	15	When addressed, it was seen as an architectural opportunity for innovation. Yet, an area of concern requiring technical compliance with standards.	Forests Natural habitat (15.5) Conservation Native plants/species	Approached as an opportunity to reimagine the relationship between buildings and the natural environment – in line with current best-practices.	16	While mentioned in all cases, the areas of concern were road and focused on local community engagement, decision-making, and social justice. But the buildings did not present a

		clear approach to these issues. The issue was only mentioned within the context of partnership for the development of the projects.

* Or not presented insignificant matches (*i.e.* below median)

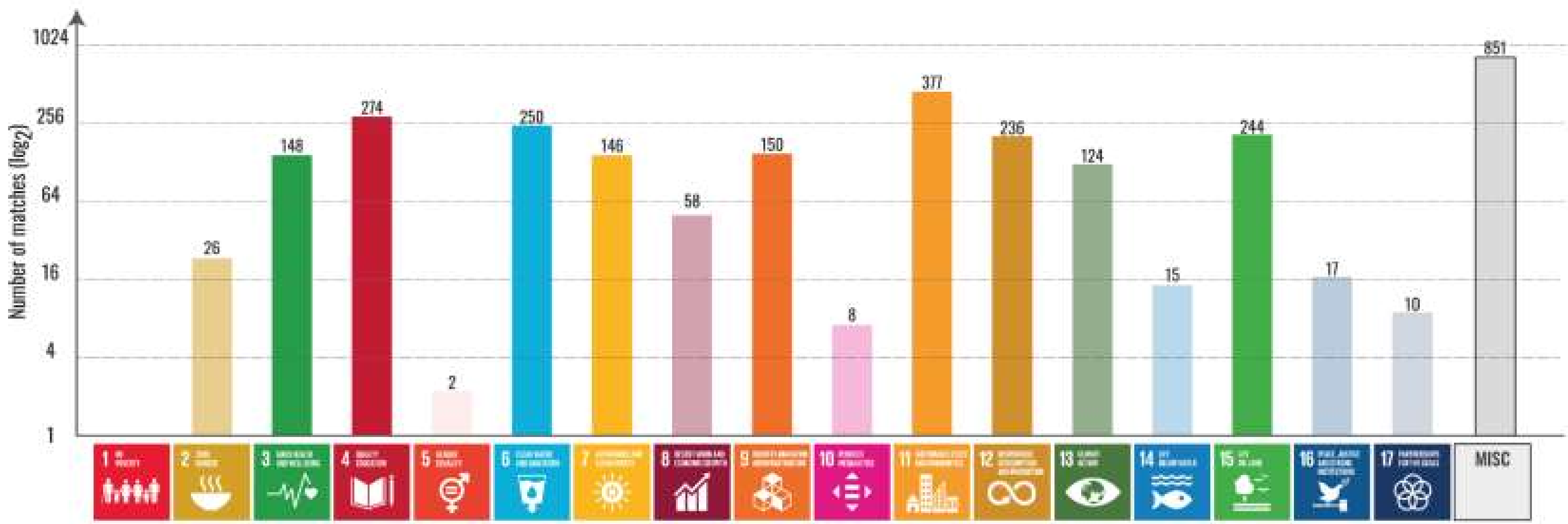


Figure 7.41. Compiled number of matches across the 17 SDGs for all five cases analyzed – presented log_2 scale

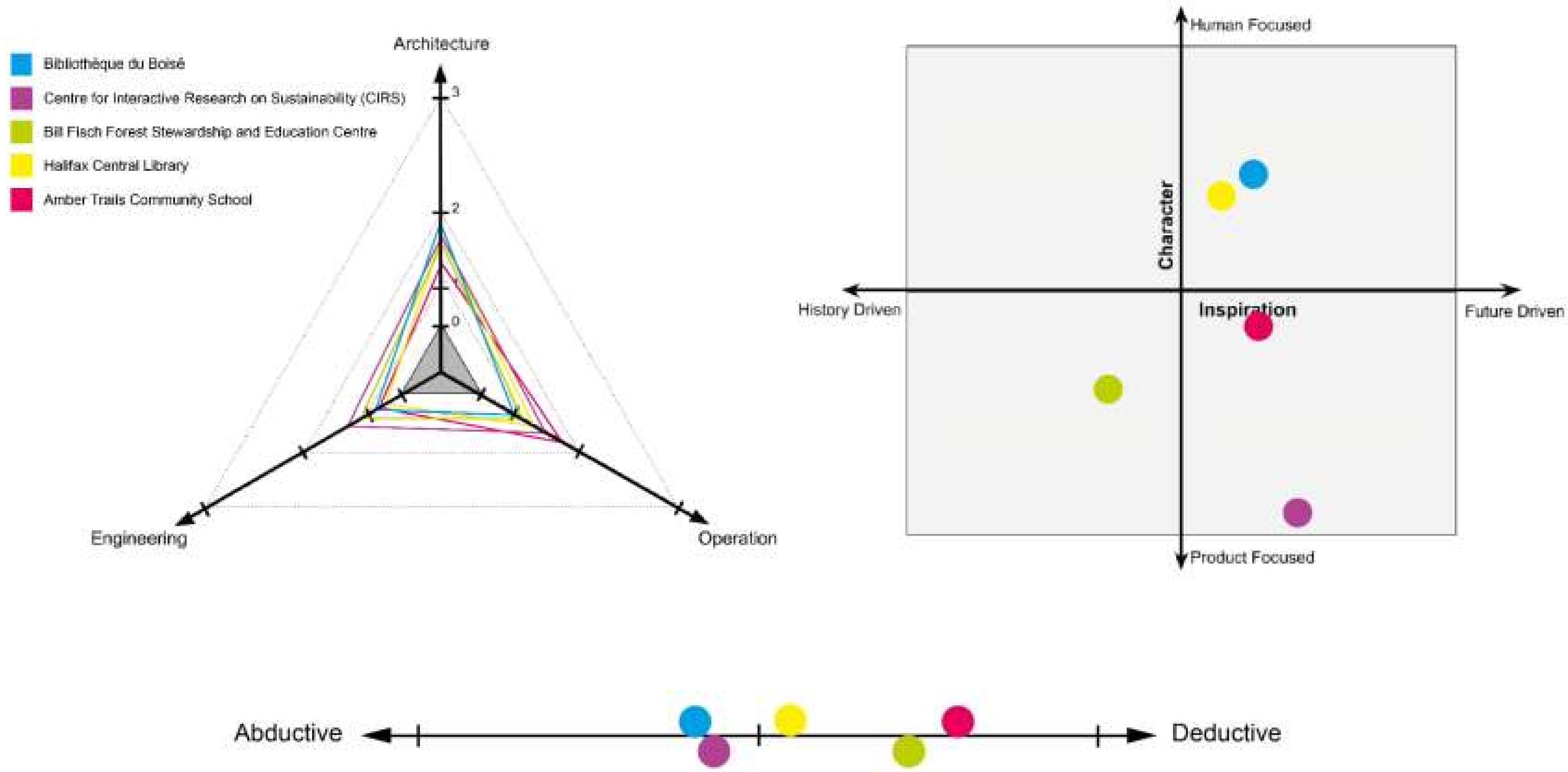


Figure 7.42. Combined analysis of the five cases

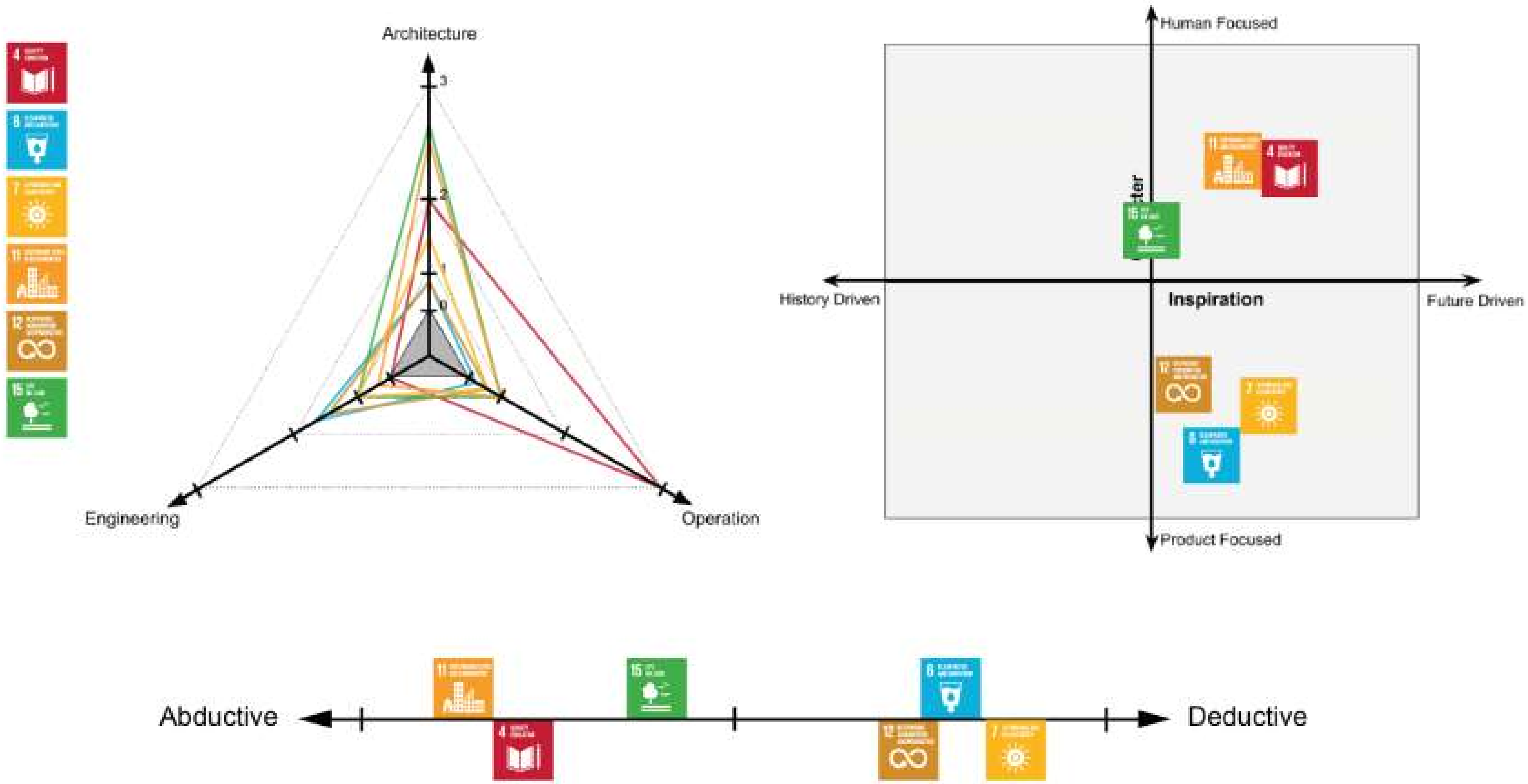


Figure 7.43. Combined analysis of the six SDGs most addressed and with the most matches.

7.6. Conclusion and areas of future inquiry

This study proposes that public buildings should address environmental, social, cultural, and economic challenges. Precisely, for a building to be labelled sustainable – or promoted as exemplary in sustainability – it ought to be aligned with today's definition of sustainable development as outline in the 2030 Agenda and its SDGs. In Canada, green and sustainable architecture awards have been on the rise, offering recognition for a broad range of sustainability practices – from the holistic project standpoint to the excellence in the utilization of specific materials. The research selects five of the most awarded buildings across Canada – which have also received many sustainability awards. The buildings presented a broad geographic coverage and ranged in their date of completion between 2011 and 2015, with all of them receiving sustainability awards post-2015.

The research aimed explicitly at charting the overlaps between these projects and the 2030 Agenda and analyzing their design approaches, discipline of integrations and visions around the Agenda's topics. To achieve this, the study used a range of methods in a sequential methodology – starting with quantitative direct content analysis, critical content analysis and semiotics, and analytical mapping. In total, more than 80 textual documents were studied and ranged from original design submissions, jury and assessment reports, architect's and owners' descriptive texts, media, news and magazine articles, expert studies and eco-fact books, and award jury reports and media releases. Additionally, design drawings, presentation panels and images of the projects were studied simultaneously with the texts – following the methodology proposed by Goubran (2019b).

The five projects presented a large discrepancy in the overall matches with the 2030 Agenda, ranging from 5% to 18% of each project's overall text. In four of the five cases, the most considerable overlaps were observed with the miscellaneous category of terms, which are broad terms related to sustainable development and not focused on a specific topic within the Agenda, and it constituted close to 30% of the overall matches. Each project presented its particular overlap profile, with SDG 11 (by the largest margin), SDG 12, SDG 6 and SDG 7 emerging as the common goals across the cases. With the exception of SDG 11, all of these goals appeared to be addressed in projects following best-practice, code and standard driven approaches with very limited design innovations (on the architectural, engineering and/or operational side). It was also clear that these themes overlapped with the areas of concern of predominant sustainable rating tools such as LEED (Alawneh, Ghazali, Ali, & Sadullah, 2019). Other projects addressed SDG 4, SDG 15 and SDG 9 at a very significant level, sometimes constituting their mean area of focus. These presented a range of approaches, which were highly informed by the specific project context and program. Some goals were barely addressed, including many human focused goals (such as SDG 1, SDG 5 and SDG 10) and food (SDG2).

The project-based analysis for the level and domain of integration showed that the architecture and operation dimensions provided more space for innovation. For the case of the CIRS, which was the most technical, we observe a more balanced integration between the domains – which is in line with previous publications (Goubran & Cucuzzella, 2019). We observe an overwhelmingly future driven inspiration in terms of vision – except for the BFFSEC center, which was highly inspired and embedded in its natural context. Adversely, the projects presented a distribution between the human and product character. Similar analysis on the SDG level revealed that infrastructural goals appeared to be more generative of engineering solutions and that human and environmental goals were more conducive for architectural and operational innovations. SDG 11, while also an infrastructural goal proposed by Waage et al. (2015), appeared to be an anomaly since most projects presented highly innovative and visionary approaches to urban issues. From the analysis of the cases statistically, we found that larger projects had fewer matches with the Agenda's keywords – a finding requiring further research.

This study's findings further support the premise that current standards and approaches guide the design outcomes and dictate normative approaches to the sustainability challenges (Cucuzzella, 2019a). The research also sheds light on buildings' potential to address the 2030 Agenda topics and their specific contribution to the sustainable cities and communities goal (SDG 11). Additionally, the range of public buildings studied presented exemplary solutions to educational challenges and imaginative approaches to negotiating the urban-nature relationship. In projects that featured stakeholder engagement and non-normative requirements (*i.e.* beyond the requirements and criteria of certifications and standards), such as the Halifax library, the BFFSEC and the Amber trails school, innovations in addressing the sustainability issues appeared to be an emergent outcome – resulting in exceeding standards' criteria. Thus, it is highly recommended for project owners to include contextual requirements beyond the certification criteria that could introduce sustainable design innovation. Considering the strong influence of owners on the topics addressed, with most of them requiring LEED or more stringent certifications to demonstrate their commitment to environmental design, it is recommended that mandates related to the un-tackled goals be added to project briefs. This is critical since we observe that the BFFSEC included accessibility-related mandates and resulted in some overlaps with the topics of SDG 10.

This research showed some limitations, includes the absence of participatory approaches and dependence on published (or mediatized) documents. Also, the limited number of projects and Canada's geographic focus restricted the possibility of making broad conclusions. However, the combined framework and multi-step methodology present several possible areas of future research. This includes selecting different corpus to explore specific trends between building typologies, geographic locations, and evolutions over-time (for example, between 2010 and 2020). Also, by comparing pre- and post- construction documents, the shifting sustainability focus across the project phases and between different entities.

7.7. Chapter Postscript

Chapter 7 confronts Canada’s most awarded sustainable buildings with the 2030 Agenda. In this approach, the buildings were seen as design outcomes that manifest the designer’s sustainable design visions structured around the SDGs' topics. To do this, the chapter used a multi-step methodology that combines direct content analysis, critical content analysis and semiotics, and analytical mapping.

The study initially hypothesized that the buildings would be neglecting important social, economic and cultural challenges and are not utilizing their full potential to realize sustainable development by adopting normative and technical approaches. However, the analysis revealed a broad range of variations in their approaches. Yet, their 2030 Agenda coverage was mainly consisted of resource-focused goals (such as SDG 12, SDG 7 and SDG 6). Chapter 7 concludes that Canada’s most awarded sustainable public buildings readily aim for technical improvements and technology integration and neglect some of the systemic social, economic and cultural challenges. Tensions between human-focused innovations and technical requirements are hindering them from realizing their full potential as catalysts for sustainable development.

CONCLUSION

CHAPTER 8. CONCLUSION

8.1. Summary of problematic and approach

Even before formally defining sustainability and sustainable development in the 1980s, environmental and ecological concerns were integrated into building design and architecture and have passed through several phases. Today, there are competing definitions, approaches and motives for sustainability in the built environment. With the institutionalization of the environmental movement and its assessment schemes in the 1990s, the definition of sustainability in building has been confused and equated to "doing less damage" or "being more efficient" (Cucuzzella, 2015a; Tabb & Deviren, 2014). The process of attaining sustainability in buildings has also been reduced to attending to measurable indicators or multi-parameter optimization problems (Boyko et al., 2012; Rashid & Yusoff, 2015; World Commission on Environment and Development, 1987). Sustainability tools, standards and systems are overwhelming designers with criteria, checklists and procedures (Doan et al., 2017), yet fail to be comprehensive (*ex.* giving much less focus to the contextual, social and economic debates) (Bernardi et al., 2017; Brandon & Lombardi, 2011; Doan et al., 2017). Additionally, designers have been pushed to comply with these approaches since the topic remain politically charged and economically driven – and where investors, governments, and end-users are focusing on communicating their commitment to sustainability (Acuff et al., 2005; Bernstein et al., 2013; DLA Piper, 2014; S. A. Jones & Laquidara-Carr, 2018; Sandström et al., 2017; World Economic Forum, 2016a). Thus, this research argues that if sustainability in buildings has to be political and economically driven, it would be advantageous to ensure that the approaches we adopt are aligned with the current discourses and global agendas. Especially if such an alignment could diversify and expand sustainable design's (A) scope, (B) methods, and even (C) benefits (Pedersen, 2018).

The incremental and efficiency-driven approaches to sustainable building design pose various limitations – especially since they are disconnected from global sustainable development goals (Boschmann & Gabriel, 2013; Brandon & Lombardi, 2011; Doan et al., 2017). Additionally, the definition of sustainable quality and excellence, predominantly outlined by the methods in place, undermines projects' context and puts in question qualitative and critical methods for integrating, designing, and judging buildings. Thus, this thesis aimed at reconciling sustainable building design with the broader sustainable development agenda. It uses the 17 UN Sustainable Development Goals (SDGs) as its organizing principle; since they articulate a comprehensive framework and a transformative vision for addressing systemic challenges: such as equality, health and wellbeing, economic sustainability, biodiversity, and social and cultural practices (United Nations, 2015; Wysokińska, 2017). The agenda in this context is seen as an opportunity for the building sector to expand its focus beyond energy performance, capitalize on synergistic prospects, and reconcile sustainable design requirements with the world's most pressing challenges (Allen et al., 2018a; Bernardi et al., 2017; Diaz-Sarachaga et al., 2018; Doan et al., 2017; Eizenberg & Jabareen, 2017; Gibberd, 2015; Lafortune et al., 2018; Le Blanc, 2015; Lior et al., 2018; Nilsson et al., 2018).

The thesis started by reviewing the available multi-disciplinary literature on sustainable building design and analyzing the structure of their arguments and world views to address these questions. The purpose of this exploration was to explore the current applications of sustainability and sustainable development – and the means to expand their focus in practice. This objective was attained in three research manuscripts and a short reflection. Sustainability analysis and assessment methods appeared to be the most influential tool for generating change in the understanding and application of sustainability in the built environment; as seen through their role in shaping the real world in Gidden's (1984) structuration process Three parallel paths of inquiry emerged :

1. Understanding how market and policies are influencing the scope of sustainability in buildings – and where material selection processes appeared to be an essential area of influence. This was explored in **one** manuscript.
2. Establishing the limits of the current methods in enabling buildings to realize their potential role in attaining the 2030 Agenda and developing tools to facilitate the integration of the SDGs in building projects. This was completed in **three** manuscripts.
3. Studying if and how recognized buildings can communicate visions of a more sustainable future – beyond the prescriptive requirements of codes, standards and certifications. This was completed in **one** manuscript.

8.2. Summary of outcomes and contributions

In this thesis, the topic of sustainability in the buildings was studied from different lenses. Chapter 2 provided an in-depth critical review of the topic. It started by showing that the concept of sustainability has matured significantly since it was first conceived in the 1970s, and that the human-natural-economic nexus is increasingly being accepted as the framework for the topic. The review exposed the fragmented nature of the sustainable building design research- further clarifying the practical and conceptual gaps between the practice of sustainability in the building industry and the evolution of sustainable development on a global level. The chapter then underscored the emergence of two competing analysis and assessment methods that are highly embedded in regulation and the other more radical in its approach. It was also clear that regulatory approaches have become guiding to the definition and practice of sustainability – leaving less space for design-leading approaches to be adopted in practice. This finding was in line with the available literature (such as Berardi, 2012; Boschmann & Gabriel, 2013; Cucuzzella, 2009, 2015b, 2015a; Cucuzzella & Goubran, 2020; Ding, 2008; Jefferies & Coucill, 2020). This finding allowed Chapter 2 to present a theoretical analysis of the different approaches' paradigms, propose a new vision for comprehending sustainability in buildings, and present the main characteristics of the analysis methods that could assist in advancing our understanding of sustainability in buildings. The findings of Chapter 2 established the theoretical lenses that were adopted in the remainder of the thesis.

Chapter 3 studied the current trends in sustainable real estate. It found that, while cost savings were the core motivation for real estate investors to adopt green building certification and standards, the market is now witnessing noteworthy transitions that include broader issues related to social, economic and wellbeing matters (Eichholtz et al., 2010; Sandström et al., 2017). The case of carbon taxation or trading made clear that it required the sector to move beyond the calculation of monetary savings – towards accounting for site and embodied carbon emissions: a shift that internalizes critical social and economic variables. By investigating the developments and increasing adoption of timber technologies, which are supporting these zero-carbon imperatives, it was clear that technical and regulatory changes will lead to deep transformations in the real estate industry – which requires further studying. The chapter also found that real estate owners, being private or public, have the most critical role to play in adopting and shaping the application of sustainability principles in the industry.

Chapter 4 developed on the limits of the current sustainability assessment certification tools and schemes. It explored the coverage of the current sustainability assessment tools in reference to the topics of the 2030 Agenda – in the design, operation and investment dimensions. A keyword catalogue, direct content analysis, and qualitative analysis of approaches were developed and used to assess these standards. The inquiry revealed that the design and operation standards are primarily focused, in content and through their scoring, on sustainable production and consumption, energy, water, and economic development. Finally, the three standards' foci (specifically on SDG12, SDG3, SDG6, SDG7, and SDG11 as well as their targets) ignore potentially significant synergies with human-focused goals and may result in trade-offs. It was also clear that the standards' intents were concentrated on incremental improvements, with a general absence of transformative visions for sustainability.

Chapter 5 built on these earlier and proposed and tested new frameworks for analyzing the SDGs' integration in building projects. The first explores the level and domain of integration of the SDG topics in the design; the second aims to map the sustainable development visions design solutions. The analytical frameworks were tested in the integrated design process for an energy-positive design project, revealing a range of innovative integration strategies and sustainability visions ranging from the human and history driven, to the highly technological and futuristic vision. The tool was also seen as useful by the project stakeholders in structuring their approach and understanding the project's contribution to sustainable development. The findings of those two chapters' established the inability of current standards in triggering innovative integration of the SDGs topics in buildings and the potential of analytical frameworks in structuring their sustainability approach in building projects' early design phases.

Chapter 6 provided a theoretical and methodological framework to distinguish between innovative and status-quo approaches to sustainability in buildings. This is to address a fundamental knowledge gap in the available sustainable design literature and build on previous research on the topic, such as the work of Cucuzzella (2009, 2011, 2016). The study finds, through the applications of Peirce's (1991) semiotics, that the two approaches represent two non-overlapping modes of reasoning: 1) deductive sustainable design reasoning: which establishes sustainability by convention, focuses on connotation and where designed-objects are only symbolic, and 2) abductive sustainable design reasoning: which creates new hypotheses and meanings, focuses on establishing new connections and denotation, and where designed-objects are illustrative of the proposed novel connections. These findings shed light on the process whereby sustainability is produced and re-produced in architecture and how the different modes of reasoning can affect the judgement process in projects (based on the work of Chupin (2011) and Collins (1971)).

Chapter 7 combined the methodological tools developed in Chapter 4, Chapter 5 and Chapter 6 to study five Canadian buildings – which have been exceedingly recognized for their excellence in design and sustainability. Chapter 7 found that these projects presented mostly deductive approaches lacked innovative integration to the SDG topics, and ignored vital human development SDGs (such as poverty, gender issues, equity and partnership). However, the SDG analysis addressed in these buildings revealed that human and urban-focused goals were approached more innovatively and creatively than resource-focused topics. The analysis revealed that stakeholders' involvement and availability of clear social, cultural, economic design directives enabled innovations to emerge. The study found an overlap between the areas of concern of mainstream sustainability tools (such as LEED) and those of the building and observed innovation emerging around topics that are less prescriptive in these schemes. Thus, it is recommended that owners, who wish to address sustainability meaningfully, provide concrete directives to designers' issues of concerns to facilitate contextual and project-specific innovations. Additionally, it is recommended for sustainability certification schemes to broaden their scope and develop their approaches away from incremental guidelines to enable design innovations in projects.

Overall, the thesis provided broad coverage of the tensions between the current practice of sustainability in buildings and the concept of sustainable development, as outlined in the 2030 Agenda. The thesis provided an understanding of the contractions and between the two approaches – and established their theoretical incompatibilities. Motivated by the emerging need for developing more comprehensive and qualitative frameworks for the critical integration of sustainable development issues in building projects, the thesis developed and deployed novel analytical methods that could be used in the design, judgement and analysis of sustainable buildings.

8.3. Linkages and relationships between chapters' outcomes

Although the chapters are composed of separate manuscripts, they exhibit meaningful relationships that tie them and the thesis together. This is achieved through the overarching problematic of the thesis. To illustrate this, Figure 8.1 presents the key conclusions of each chapter and the linkages and progressions between the manuscripts. It also illustrates how the structure of the thesis enabled it to reach its research objectives.

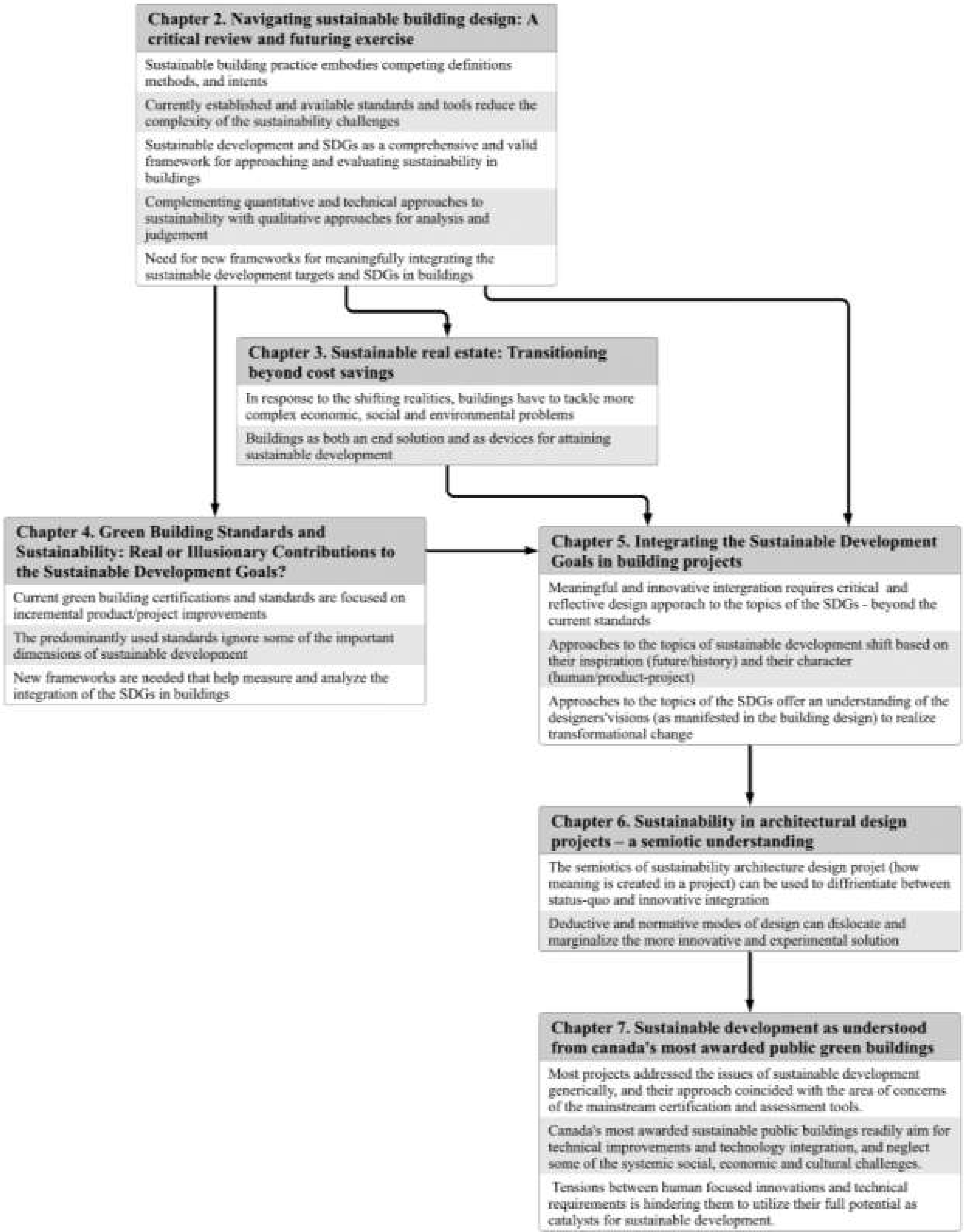


Figure 8.1. Summary of chapters' conclusions and interlinkages

8.4. Limitations

While each manuscript presented its specific methodological limitations, the overall research had several limitations.

First, in most studies, no direct input, in the form of interviews or surveys, from industry practitioners or representatives was collected (*i.e.* architects, competition judges, or members of professional or industry associations) to develop the tools frameworks. Specifically, in the studies that utilize architectural documents to analyze buildings, this lack of input could have resulted in some information asymmetries due to the over-mediatization of the documents available for analysis. However, this was balanced by the active participation in some project design processes, which validates some of the frameworks and tools developed.

Another clear limitation is variation in the case studies across the different manuscripts. While this variety was useful and essential for advancing some of the concepts proposed, it resulted in a lack of comparability regarding the developed methods and frameworks. An attempt to rectify this was made in the combined analysis presented in Chapter 7.

The extensive scope of the work and the substantial number of chapters present another limitation. Due to the variety in the research directions, the diversity in the publication venues, and the large number of manuscripts included, some parts of the research have considerable overlaps or present marginal arguments to the main thesis.

Also, the study focused on contemporary Canadian architecture, which might have biased the findings towards product or future-driven design interventions. A study on the vernacular and historic buildings would have resulted in different outcomes.

The last limitation is the use of argumentative research approaches across the studies. While this does not weaken the work outcomes, this research approach moves away from the topic's orthodoxy, predominantly framed through functionalist and technical methods.

8.5. Future research

This research opened the space for serval new research directions, which can be organized around three key themes:

1. Expansion of presented work:
    - Studying in more depth the shifts and tensions emerging in the literature on sustainable building design, using bibliometric and other research-output analysis methods. This would be an extension of the review of the literature presented in Chapter 2.
    - Investigating through primary data (financial and market), some of the trends extracted in the reviews and analysis of market reports to further understand the update of broader social and cultural sustainability are imperative by the industry and their financial implications. This would be an extension to work presented in Chapter 3 and in (Goubran, Masson, et al., 2019).
    - (in progress) Investigating in more detail the role each key stakeholder in the industry (such as policy-makers, investors and designers) plays in the advancement of the agenda. This would be an extension of the work presented in (Goubran, 2019a) on construction's general role in the 2030 Agenda.
    - Expanding the analysis of assessment and analysis tools beyond the three presented in Chapter 4. This would facilitate the validation of the method and aid in creating a catalogue for the overlaps between the available systems and the 2030 Agenda.
    - Expanding the overall analysis corpus to a broader range of awarded buildings – including international cases, from competitions or awards that specifically aimed at developmental solutions. This would be an extension of the work presented in Chapter 7.
2. Developments and improvements
    - Integrating direct input from industry experts, including from certifications agencies (such as the WGBC and its various chapters), to test the validity and applicability of the tools presented in Chapter 5
    - Developing and improving the tools and frameworks presented by testing them in more case studies. This would require testing the maps presented in Chapter 5 can be

used in the IDP context of building projects and the maps and frameworks of Chapter 4, Chapter 5 and Chapter 5 within the competition and award judgment processes. This testing can also be supported by input from industry experts.
- Developing on the material suitability and sustainability stream of work – presented in Chapter 3 and elaborated on in (Goubran, Masson, et al., 2020) - to include more building materials (beyond timber) and a larger range of case study locations.

3. New avenues of research:
    - Studying the implications of these broader sustainable building design concerns on the urban morphology, urban composition, and resource demands of built spaces. This would be to inform policymakers on the changes to the possible changes in energy and resource consumption due to developmental approaches (in line with the work of Fuso Nerini et al., 2018; Santika et al., 2019). This can also inform developers and designers of new spatial configurations for urban environments that could maximize synergies in energy and other resources.
    - Automating parts of the analysis process using AI and machine learning to develop tools – to assist in the analysis of sustainability in buildings. This can be used in the context of judgment and certification. While still depending on qualitative and quantitative methods, these tools can help ensure the repeatability of analysis conclusions – and the cross-validation (which can help institutionalize them in the industry).
    - Creating new accreditation or verifications systems that specifically cater to the needs of public building owners and which derive their areas of concern from the social, cultural and economic obligations of these entities – rather than market-driven imperatives
    - Developing catalogues of best practices for Canadian Buildings – similar to the work of McMinn & Polo (2005) and reflecting the outcomes of the current architecture for the SDG guides (Institute of Architecture and Technology (KADK) et al., 2018, 2020). This would provide the opportunity for educators and practitioners to retrieve innovative sustainability solutions.

- Exploring extending the proposed methodologies to the analysis of historic, vernecual non-avantgarde and contemporary architecture – to broaden the vocabulary of integration approaches.

8.6. Closing remarks

Overall, the thesis moved from a broad investigation of sustainable buildings to a focused exploration of the processes and means that could lead to the emergence of deep sustainability approaches in building projects. The need to reconcile how we design and build with the global development agendas, as presented by the SDGs, emerged as an imperative for reconciling sustainable buildings with sustainable development. The work adopted a range of approaches – that varied significantly in theoretical depth to address the topic. This enabled the thesis to contribute to a new understanding of sustainable building design – as a non-autonomous field made up of a collection of interdependent disciplines. Additionally, sustainable building design is an area that requires a new type of scientists who are not value-free; who are uncertain, value constituted, imaginative and holistic; who view science as a means for human development; who are generalists, speculative and imaginative; who are aware of their biases; and who are dialectic in their logic.

Building design projects have an evident potential as catalysts for the development process. However, attaining this possibility is highly contingent on applying critical design and analysis methods. The fundamental tension between the need to follow prescriptive standards and schemes and innovatively imaging a new future for mending unsustainable situations creates a significant roadblock. While economic and political gains from "sustainable design" are a reality, public building owners are responsible for addressing the fundamental challenges facing communities and must move beyond their desire to communicate commitments to the "sustainability" agenda. Additionally, the certification system issuers have a moral and ethical obligation to realize the influence they pose on the industry and to enforce and link what needs to be sustained with what needs to be developed.

The work presents several key theoretical contributions to the field of sustainable design, including a critical analysis of the current research landscape; an understanding of the external forces that are shaping the industry's future directions; the relevance of sustainability agendas in overcoming present dichotomies; an illustration of the limits of existing assessment tools; new definitions for meaningful integration of sustainability in building projects; and a foundation for distinguishing between innovative and status-quo approaches to the sustainable design. Across the work, assessment methods and tools profoundly influenced the definition, practice, and judgment of sustainable architecture. Thus, the work focused its practical contribution on developing and testing new tools that could work across different building design and judgment situations. The study's outcomes can enable the building industry and governmental bodies to accelerate the uptake and implementation of the 2030 Agenda in the built environment. The findings also paved the way for new areas of inquiry on the topic, that are more grounded in architecture and its related design fields.

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APPENDIX (A) – THE SDGS

As presented in the 2030 agenda and follow up documents (United Nations, 2015)

Goal 1: No poverty	End poverty in all its forms everywhere
Goal 2: Zero hunger	End hunger, achieve food security and improved nutrition, and promote sustainable agriculture
Goal 3: Good health and well-being	Ensure healthy lives and promote well-being for all at all ages
Goal 4: Quality education	Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
Goal 5: Gender equality	Achieve gender equality and empower all women and girls
Goal 6: Clean water and sanitation	Ensure availability and sustainable management of water and sanitation for all
Goal 7: Affordable and clean energy	Ensure access to affordable, reliable, sustainable and modern energy for all
Goal 8: Decent work and economic growth	Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
Goal 9: Industry, Innovation, and Infrastructure	Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation
Goal 10: Reducing inequalities	Reduce income inequality within and among countries
Goal 11: Sustainable cities and communities	Make cities and human settlements inclusive, safe, resilient, and sustainable

Goal 12: Responsible consumption and production	Ensure sustainable consumption and production patterns
Goal 13: Climate action	Take urgent action to combat climate change and its impacts by regulating emissions and promoting developments in renewable energy
Goal 14: Life below water	Conserve and sustainably use the oceans, seas and marine resources for sustainable development
Goal 15: Life on land	Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
Goal 16: Peace, justice and strong institutions	Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels
Goal 17: Partnership for the goals	Strengthen the means of implementation and revitalize the global partnership for sustainable development

APPENDIX (B) - CHAPTER SPECIFIC KEYWORDS

**As per the original publication

Chapter 2. Navigating sustainable building design: A critical review and futuring
Sustainable building design; sustainable development; sustainability assessment; paradigms

Chapter 3**. Sustainable real estate: Transitioning beyond cost savings
Sustainable real estate; Carbon taxation; Timber Construction; Built Environment; Market Transition

Chapter 4. Green building standards: Real or illusionary contributions to the sustainable development goals?
Real Estate, Sustainable Building Standards, Green Building Standards, Sustainable Development Goals, 2030 Agenda

Chapter 6**. Sustainability in architectural design projects – a semiotic understanding
Reasoning; sustainability; Architecture; Design competition; Green buildings; Sustainable Design Visions

Chapter 5**. Integrating the sustainable development goals in building projects
Sustainable Development Goals; Integrated design; Design for sustainability; Sustainable building practice

Chapter 7. Sustainable development as understood from Canada's most awarded public green
Architecture Awards; Sustainable buildings; Sustainable Development goals; Architecture discourse; environmental design

APPENDIX (C) - CHAPTER SPECIFIC DETAILS

Chapter 2. Navigating sustainable building design: A critical review and futuring

This chapter remains, for now, an unpublished manuscript (ready for submission with minor edits). This will be a single-authored chapter. The research is completed under the supervision of my thesis director, Dr. Carmela Cucuzzella, and with input from my committee member, Dr. Thomas Walker and Dr. Bruno Lee. I intend to publish this manuscript in one of the following journals (Sustainability (MDPI), Sustainable Development or Journal of cleaner production)

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Chapter 3. Sustainable real estate: Transitioning beyond cost savings

Walker, T., & Goubran, S. (2020). Sustainable real estate: Transitioning beyond cost savings. In D. M. Wasieleski & J. Weber (Eds.), *Sustainability* (Vol. 4, pp. 141–161). Emerald Publishing Limited. https://doi.org/10.1108/s2514-175920200000004008

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- Publication type: Book chapter
- Peer-Reviewed, single-blind
- APC or other fees: none
- Embargo Period: None (removed since September 2017)
- Number of authors: 2 (acting as co-first authors)
- The thesis author is co-author and the main contributor
- Work completed under the supervision of Dr. Thomas Walker
- Statement of contribution:

  T Walker was invited by the book and book series editors to contribute to this book, which part of a book series titled *Business and Society 360*. We acted as co-first authors for the paper. I acted as the main contributor to this chapter; I completed most of the research (more than 75%), most of the writing (more than 75%), and most of the required revisions. I developed the content and chapter outline. T Walker supervised the work and provided comments and edits throughout the process.

- Chapter specific acknowledgement (as published):

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Chapter 4. Green building standards: Real or illusionary contributions to the sustainable development goals?

- Target Journal: Building Research & Information
- Status: Ready for submission
- Publication type: Journal article
- Peer-Reviewed, double-blind
- APC or other fees: None
- Embargo Period: None (Open-Access)
- Number of authors: 4
- Thesis author is the first author and the main contributor
- Work completed under the supervision of Dr. Thomas Walker
- Statement of contribution:

  Tyler Schwartz worked on co-developing the analysis tool and completed the coding required for the content analysis. Dr. Carmela Cucuzzella assisted in developing and conducting the qualitative analysis. Dr. Thomas Walker supervised and funded the project and validated the manuscript and its findings.

- Chapter specific acknowledgement:

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Chapter 5. Integrating the sustainable development goals in building projects

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- Status: Published (online August 2019)
- Publication type: Journal article
- Peer-Reviewed, double-blind
- APC or other fees: none
- Embargo Period: None (Open-Access)
- Number of authors: 2
- Thesis author is the first author and main contributor
- Work completed under the supervision of Dr. Carmela Cucuzzella and Dr. Bruno Lee
- Statement of contribution (as published):

  Sherif Goubran conducted the literature review, developed the methodology and designed the mapping tools. Carmela Cucuzzella contributed equally to the application of the methodology in the case study. Sherif Goubran analyzed the data. Sherif Goubran wrote the paper with input and guidance from Carmela Cucuzzella.

- Chapter specific acknowledgement (as published)

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Chapter 6. Sustainability in architectural design projects – a semiotic understanding

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- Publication type: Journal article
- Peer-Reviewed, double-blind
- APC or other fees: none
- Embargo Period: 18 months
- Thesis author is only-author and contributor
- Work completed under the supervision of Dr. Viviane Namaste and Dr. Carmela Cucuzzella
- Chapter specific acknowledgement (as published)

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Chapter 7. Sustainable development as understood from Canada's most awarded public green

This chapter remains for now an unpublished manuscript (ready for submission with minor edits). This will be a multi-authored chapter with the thesis author as first-author. This work is being done under the supervision of Dr. Carmela Cucuzzella and Dr. Jean-Pierre Chupin. I intend to publish this manuscript in on of the following journal (Frontiers of Architectural Research, Architectural Design, arq: Architectural Research Quarterly, International Journal of Architectural Research, Montreal Architectural Review, Architecture and Culture or Cities)

- Statement of contribution:

  I completed the data collection (more than 90%). Tyler Schwartz worked on co-developing the analysis tool and completed the coding required for the content analysis. I completed the analysis, and its illustrations. I developed the content and study outline, and drafted the presented version of the manuscript in its entirety. It was agreed that the final manuscript might undergo changes and revisions Dr. Carmela Cucuzzella, and Dr. Jean-Pierre Chupin.

- Chapter specific acknowledgement and disclaimer

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APPENDIX (D) – FOR CHAPTER 2

Quantifying "quality" of sustainable buildings

The assessment of quality in buildings has been heavily debated in the literature, resulting in the emergence of various solutions – in the engineering, design, and business fields alike. In the construction and project management fields, the demand for performance and quality measures has been directly answered through key performance indicators, noting that most of the metrics deal with time, cost, safety and elimination of errors (D. Gann & Whyte, 2003). One of the key metrics for building engineers to assess the quality of ecological and green buildings (or even the quality of sustainability assessment tools) is its ability to reach the design objective and goals. Performance measurements have been advocated to building designers as appropriate quality measures (Torcellini et al., 2006) - since they provide meaningful and quantifiable performance indicators that would enable engineers to adapt and improve future designs. Energy management systems available for buildings enable designers to create modifications in the operation in order to mitigate certain performance issues without the need for design changes or modifications (Hernández et al., 2018).

As presented previously, many buildings certified or rated using mainstream tools have failed to live up to their predicted or design performance highlighting the inconsistency of energy ratings and labels tools (Newsham et al., 2009; Scofield, 2013). One of the approaches to solving these issues was in the integration of simulation and estimation tools in the project's early phases in order to control and minimize the compromises in quality relating to energy performance (Hamedani & Smith, 2015; Hemsath & Bandhosseini, 2015), or utilizing parametric form generation tools that consider energy performance (Touloupaki & Theodosiou, 2017). Other approaches to improving performance and building quality are based on parametric analysis and simulation for design solutions; these approaches aim to minimize the risk factors related to building performance (B. Lee & Hensen, 2015).

Attempts have been made to develop holistic design quality measures that 1) move beyond the arguably subjective methods of the architecture and design fields (which usually use awards or competitions as a measure for quality), 2) standardize the definition of quality, 3) engage the all the involved stakeholders in projects, and 5) enable the comparison between buildings based on their quality. Some of such tools include the design quality indicator (DQI), PROBE (post-occupancy review of buildings), and the Housing Quality Indicator (D. M. Gann et al., 2003). The DQI - which assesses the building's build quality, functionality and impact from the different perspectives of all stakeholders - has been popularized in the UK in the 2000s (Whyte & Gann, 2003). However, debates are still ongoing on the ability of quantitative measures to gauge design quality.

Others have proposed that architecture judgment, in the processes of competitions and awards or recognitions, forms a type of filter for excellence and constitutes a type of peer-review for identifying quality in design projects (Chupin et al., 2015; Chupin & Collyer, 2020; Jensen, 2017; Strong, 1996; Van Wezemael et al., 2011; Welch, 1984)

APPENDIX (E) – FOR CHAPTER 2

Five debates as explained by Burrell and Morgan (2004)

The ontological debate: Nominalism - realism

The nominalist position assumes no real structure to the world (social world) outside the individual's cognition. The external world is made of labels, concepts, and names used to describe, comprehend and negotiate the external world. On the opposite end, the realist world is external to the individual; it is a world made of rigid, tangible and real structures. Realists believe that, in the real world, there might exist structures or entities that we still are not aware of and that we, therefore, have no names for. The realist view holds that a real-world exists independently from the individual's appreciation of it: ontologically, in the realistic view, the world is before the existence and consciousness of any single human being.

The epistemological debate: Anti-positivism - positivism

The positivist epistemological approach seeks to explain and predict what happens in the social world by searching for regularities and relationships. There is a debate on whether hypothesized regularities can be verified (through experiments and observation) or if they can only be falsified but never proven. What is true of both approaches is that they both imply that the growth of knowledge is cumulative. The anti-positivist view is relativist: the world can only be understood from the perspective of individuals. Anti-positivists reject the standpoint of the "observer" (which is central to the positivist approach) and maintain that the world can only be understood by occupying the frame of reference of the participant(s). An extreme anti-positivist view rejects objective knowledge of any kind.

The human nature debate: Voluntarism - determination

This debate is central to the social science theory since it defines the relationship between man and society. The deterministic view regards human activities as a result of the situation or environment. The voluntarist views humans as autonomous and free.

The methodological debate: Ideographic - nomothetic theory

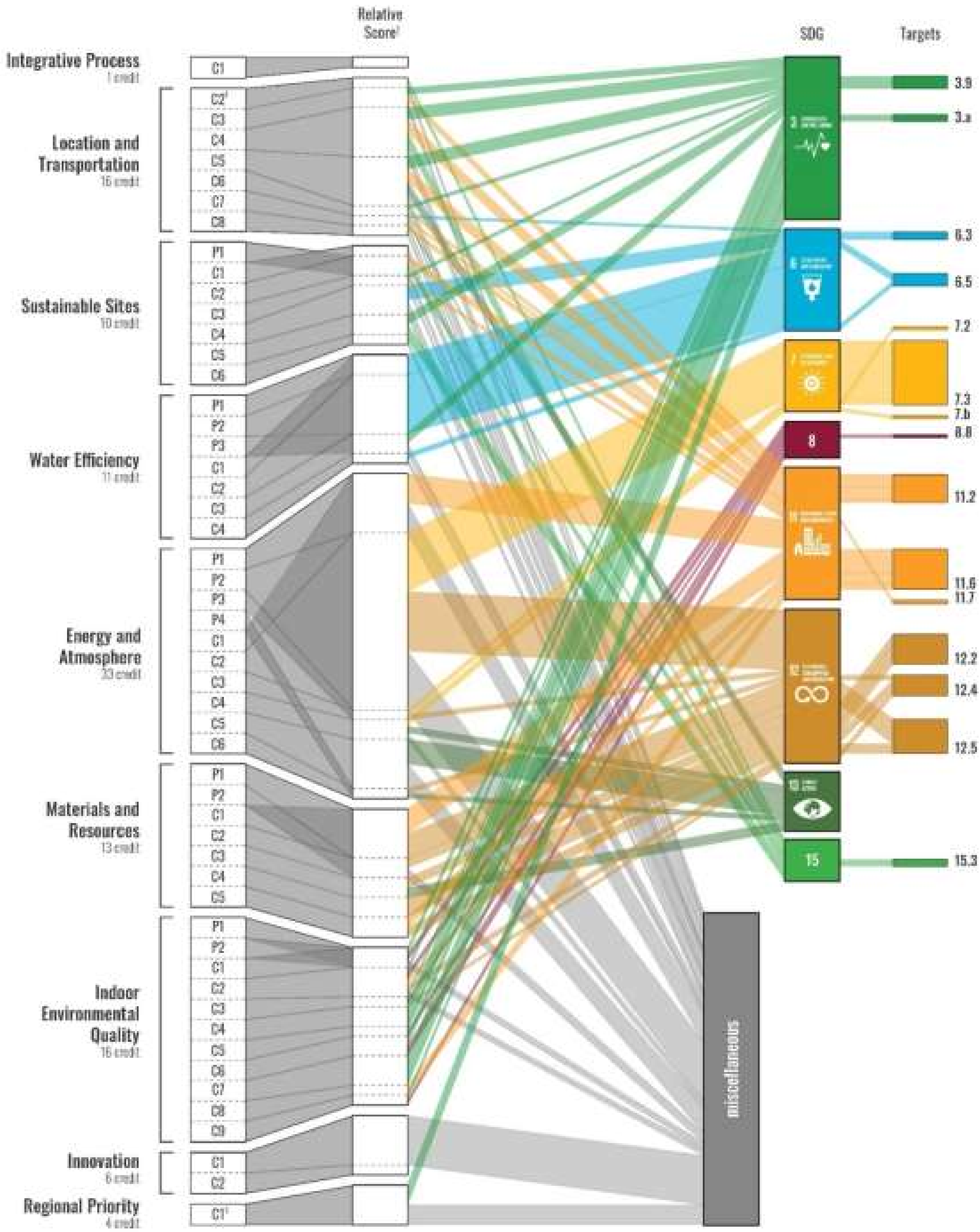
The ideographic approach to social science is the subjective one. It stresses the importance of getting close to the subject of study and exploring (or unfolding) its nature and characteristics during the investigation. The nomothetic approach stresses the process and protocol and uses formal methods (like those used in the natural sciences). It follows a scientific revolution: hypothesis, scientific testing, quantitative data, analysis and validation.

The Regulation and Radical Change Debate

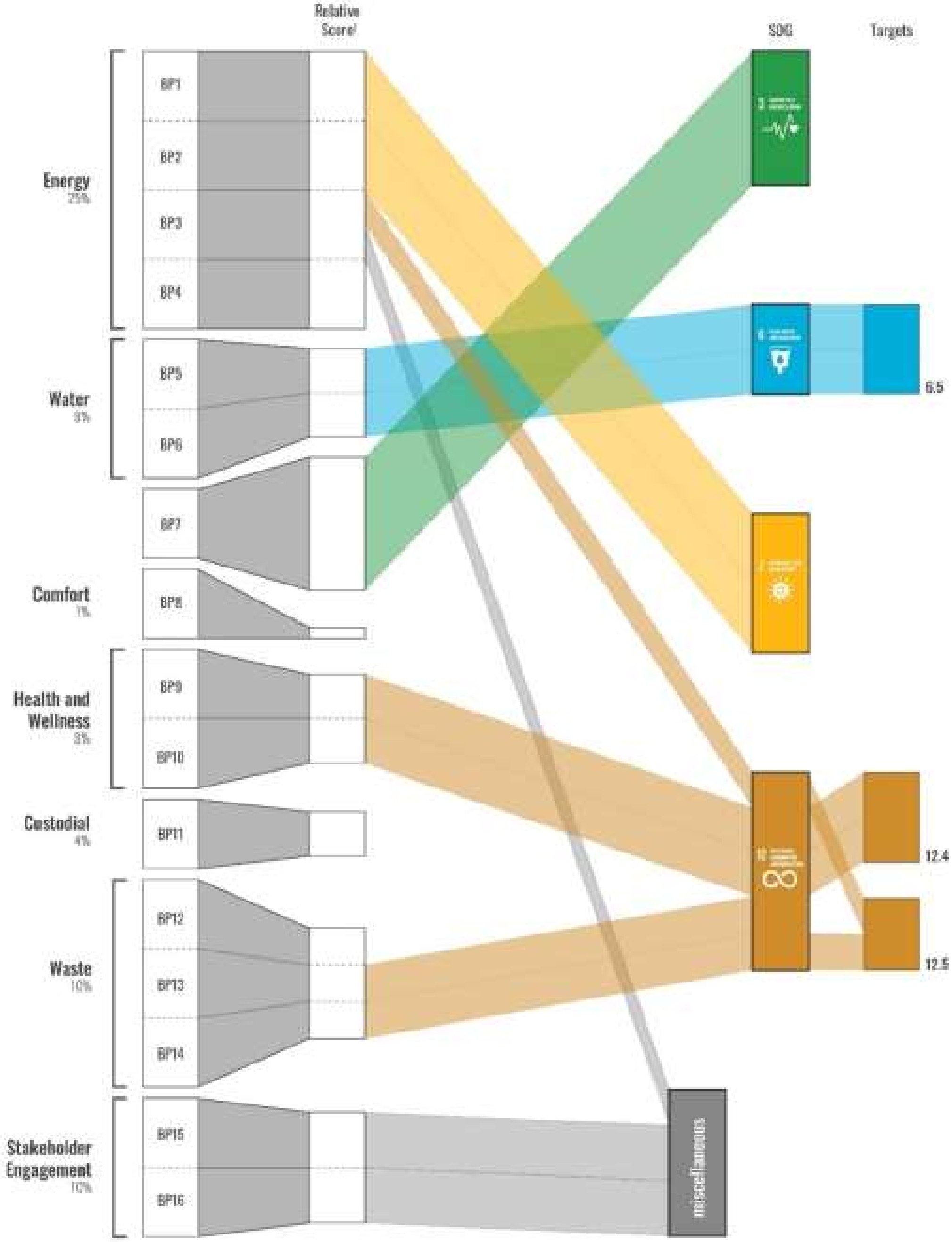
The sociology of regulation refers to the theories that provide an explanation for society in terms of cohesiveness. It looks at why and how society is maintained as an entity. On the other hand, the sociology of radical change aims to find explanations for the changes, conflicts, and contradictions that exist in society. It focuses on man's emancipation from structures and seeks alternatives. The regulation and radical change constitute the second dimension for analyzing social theories. They are able to present two contrasting options for analyzing and social processes.

APPENDIX (F) – FOR CHAPTER 4

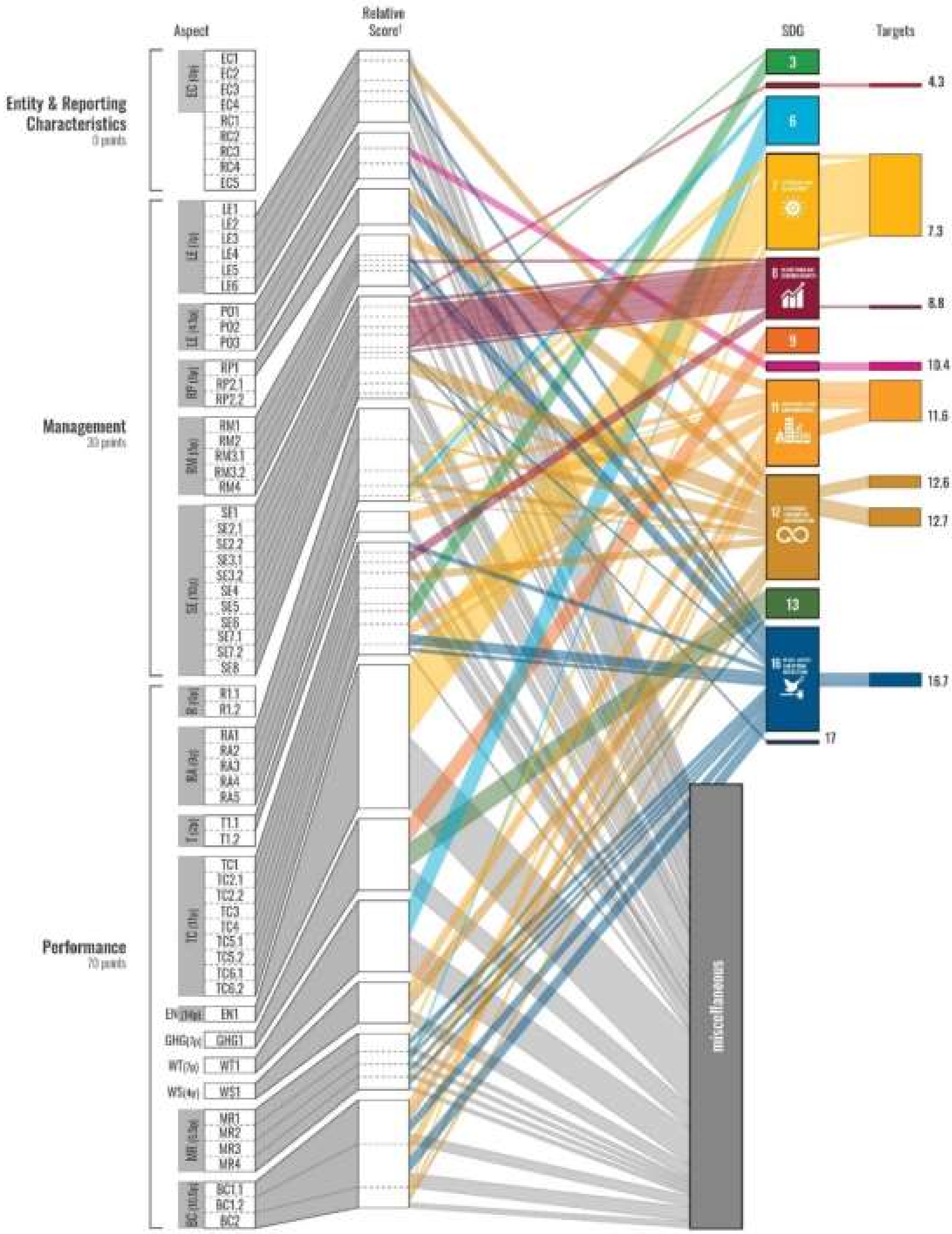
Attribute level assessment of green and sustainable building and real estate standards and the 2030 Agenda – Full maps (A, B and C)



A) LEED Building Design and Construction V4.1 (New Construction)



B) BOMA BEST V3 (Universal)



C) GRESB 2020 Real Estate (Performance)

APPENDIX (G) – FOR CHAPTER 4

Details of the attributes for LEED V4.1 BD+C (New Construction) and the summary results of the direct content and qualitative analysis.

Category	Status	ID	Name	Score (110)	Notes	Text Analyzed	Sustainability Raking	Sustainability ranking comments	SDG matches	SDG + misc matches	Target matches
Integrative Process	Credit	C1	Integrative Process	1		To support high-performance, cost-effective project outcomes through an early analysis of the interrelationships among systems.	1	Focused on environmental performance	0	0	0
Location and Transportation	Credit	C1	LEED for Neighborhood Development Location	16	Not included in SDG links analysis since it aims to replace all credits in the category	To avoid development on inappropriate sites. To reduce vehicle distance traveled. To enhance livability and improve human health by encouraging daily physical activity.	2	Managing for triple bottom line (Environment and social/health)	2	3	0
Location and Transportation	Credit	C2	Sensitive Land Protection	1		To avoid the development of environmentally sensitive lands and reduce the environmental impact from the location of a building on a site.	1	Focused on environmental performance - reduction	1	2	0
Location and Transportation	Credit	C3	High Priority Site	2		To build the economic and social vitality of communities, encourage project location in areas with development constraints and promote the ecological and community health of the surrounding area.	3	Building new value (community value)	2	3	0
Location and Transportation	Credit	C4	Surrounding Density and Diverse Uses	5		To conserve land and protect farmland and wildlife habitat by encouraging development in areas with existing infrastructure. To promote walkability, and transportation efficiency and reduce vehicle distance traveled. To improve public health by encouraging daily physical activity.	2	Managing for triple bottom line (Environment, social and health)	3	4	1
Location and Transportation	Credit	C5	Access to Quality Transit	5		To encourage development in locations shown to have multimodal transportation choices or otherwise reduced motor vehicle use, thereby reducing greenhouse gas emissions, air pollution, and other environmental and public health harms associated with motor vehicle use.	2	Managing for triple bottom line (Environment, social and health)	3	4	2
Location and Transportation	Credit	C6	Bicycle Facilities	1		To promote bicycling and transportation efficiency and reduce vehicle distance traveled. To improve public health by encouraging utilitarian and recreational physical activity.	2	Managing for triple bottom line (Environment, social and health)	2	3	1
Location and Transportation	Credit	C7	Reduced Parking Footprint	1		To minimize the environmental harms associated with parking facilities, including automobile dependence, land consumption, and rainwater runoff.	1	Focused on environmental performance - reduction	3	4	0
Location and Transportation	Credit	C8	Electric Vehicles	1		To reduce pollution by promoting alternatives to conventionally fueled automobiles.	1	Focused on environmental performance - reduction	1	2	0
Sustainable Sites	Prereq	P1	Construction Activity Pollution Prevention	0	Combined with Sustainable Sites C2	To reduce pollution from construction activities by controlling soil erosion, waterway sedimentation, and airborne dust.	1	Focused on environmental performance - reduction	0	0	0
Sustainable Sites	Credit	C1	Site Assessment	1		To assess site conditions before design to evaluate sustainable options and inform related decisions about site design.	0	Assessing current situation can only assist in future solutions	0	1	0
Sustainable Sites	Credit	C2	Protect or Restore Habitat	2		To conserve existing natural areas and restore damaged areas to provide habitat and promote biodiversity.	1	Focused on environmental performance - protect biodiversity	2	3	1
Sustainable Sites	Credit	C3	Open Space	1		To create exterior open space that encourages interaction with the environment, social interaction, passive recreation, and physical activities.	3	Building new value (community value and connection between social/environmental)	2	3	1
Sustainable Sites	Credit	C4	Rainwater Management	3		To reduce runoff volume and improve water quality by replicating the natural hydrology and water balance of the site, based on historical conditions and undeveloped ecosystems in the region.	1	Focused on environmental performance - decrease harm	1	2	2
Sustainable Sites	Credit	C5	Heat Island Reduction	2		To minimize effects on microclimates and human and wildlife habitats by reducing heat islands.	1	Focused on environmental performance - protect biodiversity	2	2	0
Sustainable Sites	Credit	C6	Light Pollution Reduction	1		To increase night sky access, improve nighttime visibility, and reduce the consequences of development for wildlife and people.	2	Managing for triple bottom line (Environment, social and health)	1	2	0

Water Efficiency	Prereq	P1	Outdoor Water Use Reduction	0	Combined with Water Efficiency C1	To reduce outdoor water consumption.	1	Focused on environmental performance - reduction	0	0	0
Water Efficiency	Prereq	P2	Indoor Water Use Reduction	0	Combined with Water Efficiency C2	To reduce indoor water consumption.	1	Focused on environmental performance - reduction	0	0	0
Water Efficiency	Prereq	P3	Building-Level Water Metering	0	Combined with Water Efficiency C4	To support water management and identify opportunities for additional water savings by tracking water consumption.	0	Assessing current situation can only assist in future solutions	0	0	0
Water Efficiency	Credit	C1	Outdoor Water Use Reduction	2		To reduce outdoor water consumption.	1	Focused on environmental performance - reduction	1	1	0
Water Efficiency	Credit	C2	Indoor Water Use Reduction	6		To reduce indoor water consumption.	1	Focused on environmental performance - reduction	1	1	0
Water Efficiency	Credit	C3	Cooling Tower Water Use	2		To conserve water used for mechanical processes and cooling tower makeup while controlling microbes, corrosion, and scale in the condenser water system.	1	Focused on environmental performance - reduction and conservation	1	2	0
Water Efficiency	Credit	C4	Water Metering	1		To support water management and identify opportunities for additional water savings by tracking water consumption.	0	Assessing current situation can only assist in future solutions	1	2	1
Energy and Atmosphere	Prereq	P1	Fundamental Commissioning and Verification	0	Combined with Energy and Atmosphere C1	To support the design, construction, and eventual operation of a project that meets the owner's project requirements for energy, water, indoor environmental quality, and durability.	1	Focused on meeting project requirements - predominantly economic	0	0	0
Energy and Atmosphere	Prereq	P2	Minimum Energy Performance	0	Combined with Energy and Atmosphere C2	To reduce the environmental and economic harms of excessive energy use by achieving a minimum level of energy efficiency for the building and its systems.	1	Focused on environmental performance - reduction	0	0	0
Energy and Atmosphere	Prereq	P3	Building-Level Energy Metering	0	Combined with Energy and Atmosphere C3	To support energy management and identify opportunities for additional energy savings by tracking building-level energy use.	0	Assessing current situation can only assist in future solutions	0	0	0
Energy and Atmosphere	Prereq	P4	Fundamental Refrigerant Management	0	Combined with Energy and Atmosphere C6	To reduce stratospheric ozone depletion.	1	Focused on environmental performance - reduction	0	0	0
Energy and Atmosphere	Credit	C1	Enhanced Commissioning	6		To further support the design, construction, and eventual operation of a project that meets the owner's project requirements for energy, water, indoor environmental quality, and durability.	1	Focused on meeting project requirements - predominantly economic	1	2	0
Energy and Atmosphere	Credit	C2	Optimize Energy Performance	18		To achieve increasing levels of energy performance beyond the prerequisite standard to reduce environmental and economic harms associated with excessive energy use.	1	Focused on environmental performance - reduction	2	3	1
Energy and Atmosphere	Credit	C3	Advanced Energy Metering	1		To support energy management and identify opportunities for additional energy savings by tracking building-level and system-level energy use.	0	Assessing current situation can only assist in future solutions	2	2	1
Energy and Atmosphere	Credit	C4	Grid Harmonization	2		To increase participation in demand response technologies and programs that make energy generation and distribution systems more efficient, increase grid reliability, and reduce greenhouse gas emissions.	1	Focused on environmental performance - reduction and control	2	3	2
Energy and Atmosphere	Credit	C5	Renewable Energy	5		To reduce the environmental and economic harms associated with fossil fuel energy and reduce greenhouse gas emissions by increasing the supply of renewable energy and carbon mitigation projects.	1	Focused on environmental performance - reduction	1	2	0
Energy and Atmosphere	Credit	C6	Enhanced Refrigerant Management	1		To reduce ozone depletion and support early compliance with the Montreal Protocol while minimizing direct contributions to climate change.	1	Focused on environmental performance - reduction	2	2	1
Materials and Resources	Prereq	P1	Storage and Collection of Recyclables	0	Combined with Materials and Resources C1	To reduce the waste that is generated by building occupants and hauled to and disposed of in landfills.	1	Focused on environmental performance - reduction	0	0	0
Materials and Resources	Prereq	P2	Construction and Demolition Waste Management Planning	0	Combined with Materials and Resources C5	To reduce construction and demolition waste disposed of in landfills and incineration facilities by recovering, reusing, and recycling materials.	1	Focused on environmental performance - reduction	0	0	0
Materials and Resources	Credit	C1	Building Life-Cycle Impact Reduction	5		To encourage adaptive reuse and optimize the environmental performance of products and materials.	1	Focused on environmental performance - reduction and optimization	2	2	2
Materials and Resources	Credit	C2	Building Product Disclosure and Optimization - Environmental Product Declarations	2		To encourage the use of products and materials for which life-cycle information is available and that have environmentally, economically, and socially preferable life-cycle impacts. To reward project teams for selecting products from manufacturers who have verified improved environmental life-cycle impacts.	1	Focused on environmental performance - control	1	2	1

Materials and Resources	Credit	C3	Building Product Disclosure and Optimization - Sourcing of Raw Materials	2		To encourage the use of products and materials for which life cycle information is available and that have environmentally, economically, and socially preferable life cycle impacts. To reward project teams for selecting products verified to have been extracted or sourced in a responsible manner.	1	Focused on environmental performance - control	2	2	1
Materials and Resources	Credit	C4	Building Product Disclosure and Optimization - Material Ingredients	2		To encourage the use of products and materials for which life-cycle information is available and that have environmentally, economically, and socially preferable life-cycle impacts. To reward project teams for selecting products for which the chemical ingredients in the product are inventoried using an accepted methodology and for selecting products verified to minimize the use and generation of harmful substances. To reward raw material manufacturers who produce products verified to have improved life-cycle impacts.	1	Focused on environmental performance - control	1	1	2
Materials and Resources	Credit	C5	Construction and Demolition Waste Management	2		To reduce construction and demolition waste disposed of in landfills and incineration facilities by recovering, reusing, and recycling materials.	1	Focused on environmental performance - reduction	2	2	2
Indoor Environmental Quality	Prereq	P1	Minimum Indoor Air Quality Performance	0	Combined with Indoor Environmental Quality C1	To contribute to the comfort and well-being of building occupants by establishing minimum standards for indoor air quality (IAQ).	1	Focused on well-being related performance – meeting minimum standards	0	0	0
Indoor Environmental Quality	Prereq	P2	Environmental Tobacco Smoke Control	0	Combined with Indoor Environmental Quality C1	To prevent or minimize exposure of building occupants, indoor surfaces, and ventilation air distribution systems to environmental tobacco smoke.	1	Focused on well-being related performance – meeting minimum standards	0	0	0
Indoor Environmental Quality	Credit	C1	Enhanced Indoor Air Quality Strategies	2		To promote occupants' comfort, well-being, and productivity by improving indoor air quality.	1	Focused on well-being related performance – meeting requirements	2	3	1
Indoor Environmental Quality	Credit	C2	Low-Emitting Materials	3		To reduce concentrations of chemical contaminants that can damage air quality, human health, productivity, and the environment.	1	Focused on well-being related performance – meeting requirements	4	5	2
Indoor Environmental Quality	Credit	C3	Construction Indoor Air Quality Management Plan	1		To promote the well-being of construction workers and building occupants by minimizing indoor air quality problems associated with construction and renovation.	1	Focused on well-being related performance	3	3	1
Indoor Environmental Quality	Credit	C4	Indoor Air Quality Assessment	2		To establish better quality indoor air in the building after construction and during occupancy.	1	Focused on well-being related performance	1	1	0
Indoor Environmental Quality	Credit	C5	Thermal Comfort	1		To promote occupants' productivity, comfort, and well-being by providing quality thermal comfort.	1	Focused on well-being related performance	2	2	0
Indoor Environmental Quality	Credit	C6	Interior Lighting	2		To promote occupants' productivity, comfort, and well-being by providing high-quality lighting.	1	Focused on well-being related performance	2	2	0
Indoor Environmental Quality	Credit	C7	Daylight	3		To connect building occupants with the outdoors, reinforce circadian rhythms, and reduce the use of electrical lighting by introducing daylight into the space.	2	Managing for triple bottom line (Environment/energy and social)	1	1	0
Indoor Environmental Quality	Credit	C8	Quality Views	1		To give building occupants a connection to the natural outdoor environment by providing quality views.	2	Managing for triple bottom line (Environment/nature and social)	1	1	0
Indoor Environmental Quality	Credit	C9	Acoustic Performance	1		To provide workspaces and classrooms that promote occupants' well-being, productivity, and communications through effective acoustic design.	1	Focused on well-being related performance – meeting minimum standards	2	2	0
Innovation	Credit	C1	Innovation	5		To encourage projects to achieve exceptional or innovative performance.	1	Focused on performance – meeting requirements or minimum standards (we assess the general credit - not specific innovation credit options available in the catalog)	0	1	0
Innovation	Credit	C2	LEED Accredited Professional	1		To encourage the team integration required by a LEED project and to streamline the application and certification process.	0	LEED professional does not add external (community) knowledge	0	0	0

Regional Priority	Credit	C1	Regional Priority: Specific Credit	4	No specific regional priority credits were analyzed	To provide an incentive for the achievement of credits that address geographically specific environmental, social equity, and public health priorities.	3	Building new value (community and local/place-based focused development) - (we assess the general credit - not specific innovation credit options available in the catalog)	1	2	0
								Total	66	90	26

Details of the attributes for BOMA BEST V3 (Universal) and the summary results of the direct content and qualitative analysis.

Category	Status	ID	Name	Score (100)	Notes	Text Analyzed	Sustainability Raking	Sustainability ranking comments	SDG matches	SDG + misc matches	Target matches
Energy	Requ.	BP1	Preventative Maintenance Program	6.25	Score assumed to be equally distributed	Is a Preventative Maintenance Program in place at the building?	1	Meeting environmental performance .	0	0	0
Energy	Requ.	BP2	Energy Assesment	6.25		Has an ASHRAE Level 1 Energy Assessment been conducted in the last five (5) years?	0	Assessing current situation can only assist in future solutions	1	1	0
Energy	Requ.	BP3	Energy Management Plans	6.25		Is an Energy Management Plan in place at the building?	1	Focused on environmental performance	1	1	0
Energy	Requ.	BP4	Energy Reduction Targets	6.25		Is an energy reduction target in place at the building?	1	Focused on environmental performance	1	2	1
Water	Requ.	BP5	Water Assesment	4	Score assumed to be equally distributed	Has a Water Assessment been conducted in the last five (5) years?	0	Assessing current situation can only assist in future solutions	1	1	1
Water	Requ.	BP6	Water Management Plan	4		Is a Water Management Plan in place at the building?	1	Focused on environmental performance	1	1	1
Air	Requ.	BP7	IAQ Monitoring Plan	12		Is an Indoor Air Quality Monitoring Plan in place at the building?	1	Focused on environmental performance	1	1	0
Comfort	Requ.	BP8	Occupant Service Request Program	1		Is an Occupant Service Request Program in place?	1	Focused on well-being related performance	0	0	0
Health and Wellness	Requ.	BP9	Hazardous Building Materials Management Program	4	Score assumed to be equally distributed	Is a Hazardous Building Materials Management Program in place at the building?	1	Focused on environmental performance	1	1	1
Health and Wellness	Requ.	BP10	Hazardous Chemical Products Management Program	4		Is a Hazardous Chemical Products Management Program in place at the building?	1	Focused on environmental performance	1	1	1
Custodial	Requ.	BP11	Green Cleaning Program	4		Is a Green Cleaning Program in place at the building?	2	Managing for triple bottom line (environment, social and health)	0	0	0
Waste	Requ.	BP12	Source Separation Program	3.33	Score assumed to be equally distributed	Is a Source Separation Program in place at the building?	1	Focused on environmental performance	0	0	0
Waste	Requ.	BP13	Waste Audit	3.33		Has a Waste Audit been completed for the building in the past three (3) years?	0	Assessing the current situation can only assist in future solutions	1	1	0
Waste	Requ.	BP14	Waste Reduction	3.33		Is a Waste Reduction Work Plan in place at the building?	1	Focused on environmental performance	1	1	1
Stakeholder Engagement	Requ.	BP15	Environmental Policy	5	Score assumed to be equally distributed	Is an overarching Environmental Policy guiding the building's management?	1	Focused on environmental performance	0	1	0
Stakeholder Engagement	Requ.	BP16	Occupant Environmental Communication Program	5		Is an Occupant Environmental Communication Program in place at the building?	3	education, awareness value	0	1	0
OTHER			ENERGY STAR ® assessment	9	Excluded from analysis - No text available						
OTHER			Purchasing	3	Excluded from analysis - No text available						
OTHER			Site	10	Excluded from analysis - No text available						
								Total	10	13	6

Details of the attributes for GRESB Real Estate 2020 (Performance) and the summary results of the direct content and qualitative analysis.

Category	Aspect	Status	ID	Name	Score (100)	Notes	Text Analyzed	Sustainability Raking	Sustainability ranking comments	SDG matches	SDG + misc matches	Target matches
Entity & Reporting Characteristics	Entity Characteristics	Description	EC	Entity & Reporting Characteristics	0	Entity & Reporting Characteristics section is not scored	Information provided in the Entity and Reporting Characteristics aspect identifies the reporting entity's characteristics that remain constant across different reporting periods (year-on-year).	0	Not sustainability related	0	0	0
Entity & Reporting Characteristics	Entity Characteristics	Required	EC1	Reporting entity	0		Identify the participating entity. This information will be displayed in the GRESB Portal and in the entity's Benchmark Report(s).	0	Not sustainability related	0	0	0
Entity & Reporting Characteristics	Entity Characteristics	Required	EC2	Nature of ownership	0		Describe the ownership status and characteristics of the participating entity.	0	Not sustainability related	0	0	0
Entity & Reporting Characteristics	Entity Characteristics	Required	EC3	Entity commencement date	0		Describe the activity commencement or establishment date of the entity.	0	Not sustainability related	0	0	0
Entity & Reporting Characteristics	Entity Characteristics	Required	EC4	Reporting year	0		Set the entity's annual reporting year.	0	Not sustainability related	0	0	0
Entity & Reporting Characteristics	Reporting Characteristics	Required	RC1	Reporting currency	0		Set the currency for which the entity's real estate portfolio of assets is denominated.	0	Not sustainability related	0	0	0
Entity & Reporting Characteristics	Reporting Characteristics	Required	RC2	Economic size	0		Gross Asset Value ("GAV") is a metric used in GRESB data analysis to identify the size of the portfolio.	0	Not sustainability related	0	0	0
Entity & Reporting Characteristics	Reporting Characteristics	Required	RC3	Floor area metrics	0		Metrics are needed to ensure comparability for benchmarking and reporting purposes. Set the reporting units used by the entity.	0	Not sustainability related	0	1	0
Entity & Reporting Characteristics	Reporting Characteristics	Required	RC4	Property type and Geography	0		Describe the location of the entity's assets by country, as well as the portfolio composition per property type. GRESB uses the information to create country and regional rankings.	0	Not sustainability related	0	0	0
Entity & Reporting Characteristics	Reporting Characteristics	Required	RC5	Nature of entity's business	0		The entity's primary business activities during the reporting year is used to determine which GRESB Components are applicable and should be completed. Refer to section Introduction for an overview of the 2020 Assessments Structure.	0	Not sustainability related	0	0	0
Management	Leadership	Discription	LE	Leadership	0	Leadership section has a total of 7 points	This aspect evaluates how the entity integrates ESG into its overall business strategy. The purpose of this section is to (1) identify public ESG commitments made by the entity, (2) identify who is responsible for managing ESG issues and has decision-making authority; (3) communicate to investors how the entity structures management of ESG issues and (3) determine how ESG is embedded into the entity.	3	Building new value through leadership	0	0	0
Management	Leadership	Required	LE1	ESG leadership commitments	0		This indicator assesses the entity's commitment to ESG leadership standards or principles. By making a commitment to ESG leadership standards or principles, an entity publicly demonstrates its commitment to ESG, uses organizational standards and/or frameworks that are universally accepted and may have	3	Building new value through commitment to ESG leadership	0	0	0

							obligations to comply with the standards and/or frameworks.					
Management	Leadership	Required	LE2	ESG objectives	1		Clear Environmental, Social, and Governance (ESG) objectives help participants identify material issues and integrate them into the overall day-to-day management practices. Integrating ESG practices into the overall business strategy fosters alignment between management of ESG issues and the overall strategy of the entity. It also demonstrates commitment to monitoring ESG objectives and meeting targets.	2	Managing for triple bottom line	0	1	0
Management	Leadership	Required	LE3	Individual responsible for ESG	2		This indicator identifies resources allocated to ESG management. Having personnel dedicated to ESG issues increases the likelihood that the entity's ESG objectives will be properly managed and targets will be met.	2	Managing for triple bottom line	1	2	0
Management	Leadership	Required	LE4	ESG taskforce/committee	1		This indicator identifies the existence of an internal task force focused on ESG components, which demonstrates a structured approach towards integrating ESG practices across the entity.	3	Building new value through (public involvement)	0	1	0
Management	Leadership	Required	LE5	ESG senior decision-maker	1		The presence of senior management dedicated to ESG increases the likelihood that the objectives will be met. A structured process to keep the most senior decision-maker informed on the entity's ESG performance increases accountability and encourages continuous improvement.	2	Managing for triple bottom line	1	2	0
Management	Leadership	Required	LE6	Personnel ESG performance targets	2		This indicator identifies whether, and how, ESG issues are addressed in personnel performance targets. It also identifies how the ESG-related objectives outlined in LE2 are reflected within the organizational structure. Including ESG factors in annual performance targets for employees can increase the entity's capacity to improve ESG performance.	2	Managing for triple bottom line	0	1	0
Management	Policies	Required	PO	Policies	0	Policies section has a total of 4.5 points	This aspect confirms the existence and scope of the entity's policies that address environmental, social and governance issues.	0	Assessing the current situation can only assist in future solutions	0	0	0
Management	Policies	Required	PO1	Policy on environmental issues	1.5		This indicator describes the existence and scope of policies that address environmental issues. Policies on environmental issues assist entities with incorporating ESG criteria into their business practices.	1	Focus on environmental performance/issues	0	1	0
Management	Policies	Required	PO2	Policy on social issues	1.5		This indicator describes the existence and scope of policies that address social issues. Policies on social issues assist entities with incorporating ESG criteria into their business practices.	1	Focus on social performance/issues	1	2	1

Management	Policies	Required	PO3	Policy on governance issues	1.5		This indicator describes the existence and scope of policies that address governance issues. Policies on governance issues assist entities with incorporating ESG criteria into their business practices.	1	Focus on governance related performance/issues	1	2	0
Management	Reporting	Required	RP	Reporting	0		Institutional investors and other shareholders are primary drivers for greater sustainability reporting and disclosure among investable entities. Real estate companies and managers share how ESG management practices performance impacts the business through formal disclosure mechanisms.	3	Building value - formal disclosure can push towards public good	0	0	0
Management	Reporting	Required	RP1	ESG reporting	3.5		This indicator assesses the level of ESG disclosure undertaken by the entity. It also evaluates the entity's use of third-party ESG reporting review to ensure the reliability, integrity, and accuracy of ESG disclosure. Disclosure of ESG information and performance demonstrates an entity's transparency in explaining how ESG policies and management practices are implemented by the entity, and how these practices impact the business. In addition, third-party ESG disclosure review increases investors' confidence in the information disclosed.	3	Building value - formal disclosure can push towards public good	2	3	1
Management	Reporting	Required	RP2.1	ESG incident monitoring	0		This indicator intends to identify whether the reporting entity has a defined process in place to communicate any ESG-related misconducts to its stakeholders if the entity has incurred any environment, social or governance fines and/or penalties at its investment properties or elsewhere.	2	Enforcing management for triple bottom line	0	0	0
Management	Reporting	Required	RP2.2	ESG incident occurrences	0		This indicator intends to ensure the communication of any ESG fines and/or penalties to the reporting entity's investor. Recurring misconducts and penalties can increase the risk profile of the portfolio as they impose financial, management and regulatory burdens on the entity.	3	Building value - formal disclosure can push towards public good	0	0	0
Management	Risk Management	Required	RM	Risk Management	0	Risk Management section has a total of 5 points	This aspect evaluates the processes used by the entity to support ESG implementation and investigates the steps undertaken to stay abreast of material ESG related risks.	2	Managing for triple bottom line	0	0	0
Management	Risk Management	Required	RM1	Environmental Management System (EMS)	2		This indicator assesses the entity's use of a systematic process to manage environmental impacts, risks and opportunities. An Environmental Management System (EMS) is an internal framework that structures all procedures, projects and tactics into a cohesive program which aligns the sustainability efforts at entity level. An EMS can assist entities in managing and improving their environmental performance, complying with environmental laws and regulations, identifying financial	1	Focus on environmental performance/management of environmental risks	1	2	1

							savings through more efficient operating practices, and improving the standing of the business with staff, client companies, partner organizations and other stakeholders. Use of an aligned or certified EMS framework provides assurance to both the business and external stakeholders that environmental impacts are measured and acted upon using a recognized and proven methodology. Periodic reviews of the EMS ensure its continuing suitability and effectiveness for the entity.					
Management	Risk Management	Required	RM2	Process to implement governance policies	0.5		This indicator examines specific actions taken to limit exposure to governance-related risks. It is linked to PO3 in the Policy Aspect, and refers to the implementation of the policy that addresses risks from exposure to governance issues (as defined in PO3).	1	Managing governance risks	1	1	0
Management	Risk Management	Required	RM3.1	Social risk assessments	0.5		This indicator identifies the variables included the entity's social risk assessments. Risk assessments refer to the identification and quantification of processes, systems and/or scenarios that could potentially cause harm to the entity and its underlying investors. It is important that entities monitor their exposure to social related risks, as these can negatively impact reputation and expose the entity to civil and criminal penalties. RM3.1 asks whether certain social issues are assessed in a risk assessment by the entity, which is different from the existence of social policies (PO2).	1	Managing social risks	2	2	0
Management	Risk Management	Required	RM3.2	Governance risk assessments	0.5		This indicator identifies the variables included in the entity's governance risk assessments. Risk assessments refer to the identification and quantification of processes, systems and/or scenarios that could potentially cause harm to the entity and its underlying investors. It is important that entities monitor their exposure to governance-related risks, as these can negatively impact reputation and expose the entity to civil and criminal penalties. RM3.2 asks whether certain governance issues are assessed in a risk assessment by the entity, which is different from the existence of governance policies (PO3).	1	Managing governance risks	1	1	0
Management	Risk Management	Required	RM4	ESG due diligence for new acquisitions	1.5	Reporting section has a total of 3.5 points	This indicator identifies if the entity performs asset-level environmental and/or social assessments as a standard part of the due diligence process for new acquisitions. Risk assessments help to reduce exposure to long-term sustainability risks. Integration of sustainability risk assessments into the acquisition process demonstrate a commitment to ESG management, a focus on mitigating risks that might impact returns, and a forward-	2	Managing for triple bottom line	0	1	0

							looking approach to the development of the portfolio.					
Management	Stakeholder Engagement	Required	SE	Stakeholder Engagement	0	Stakeholder Engagement section has a total of 10 points	Employees are key stakeholders in any business. Entities can make use of sustainability reporting metrics to boost employee engagement, motivation, recruitment and retention of talent, work-life balance, teamwork and leadership development. Employee engagement may also contribute to the successful implementation of sustainability best practices across the entity. Furthermore, proper understanding of workplace-related ESG issues, and how these issues are reported will help the entity with its branding as an employer.	3	Creating a public and shared value for ESG management and issues	0	0	0
Management	Stakeholder Engagement	Required	SE1	Employee training	1		This indicator examines the types and content of training received by employees responsible for this entity. A more skilled and aware workforce enhances the entity's human capital and may help to improve employee satisfaction. Employee training and development contribute to improved business performance.	3	Creating a public and shared value through awareness and education	2	3	1
Management	Stakeholder Engagement	Required	SE2.1	Employee satisfaction survey	1		This indicator examines whether and to what extent the entity engages with employees regarding their satisfaction. Employee satisfaction surveys help entities understand critical issues within the business, engage with their staff and increase employee satisfaction, which may contribute to improving retention rates and overall productivity. Using widely applied employee satisfaction surveys should be translated into easily interpretable metrics that can help analyze and compare outcomes, despite the many variations between departments and teams.	1	Focused on social performance	1	1	0
Management	Stakeholder Engagement	Required	SE2.2	Employee engagement program	1		This indicator evaluates an entity's response to the outcomes of an employee satisfaction survey. Proactive responses demonstrate commitment to the employee engagement process and to developing, maintaining and enhancing employee satisfaction.	1	Focused on social performance	1	1	0
Management	Stakeholder Engagement	Required	SE3.1	Employee health & well-being program	0.75		This indicator evaluates the presence and extent of an entity's program for promoting employee health and well-being. A complete process to promote employee health and well-being contains needs assessment, goal setting, action and monitoring. Such a process helps entities take systematic action to create value and manage risks.	1	Focused on social/well-being performance	1	1	0

Management	Stakeholder Engagement	Required	SE3.2	Employee health & well-being measures	1.25	This indicator evaluates the scope and quality of the entity's employee health and well-being program.	1	Focused on social/well-being performance	1	1	0
Management	Stakeholder Engagement	Required	SE4	Employee safety indicators	0.5	This indicator is intended to describe metrics collected by the entity to understand health, safety and productivity of employees. Monitoring and reporting on occupational health and safety is an indicator of good management and allows for a continuous understanding of entity health and safety issues. Maintaining records of the number of incidents among employees over time helps to analyze incidents and to identify areas where improvements are necessary.	1	Focused on social/safety performance	2	2	1
Management	Stakeholder Engagement	Required	SE5	Inclusion and diversity	0.5	This indicator identifies the metrics used by the entity to monitor diversity at governance and workforce level. Diversity of boards of directors has become a clear priority for investors and is considered to positively impact investment decisions and increases the entity's competitiveness.	1	Focused on social/inclusion performance	2	2	0
Management	Stakeholder Engagement	Required	SE6	Supply chain engagement program	1.5	This indicator describes the management practices and requirements the entity uses to manage supply chain risks. The procurement process is an effective way to integrate the entity's sustainability-specific requirements into their supply chain. This indicator applies to existing and new contracts.	2	Managing for triple bottom line	1	1	1
Management	Stakeholder Engagement	Required	SE7.1	Monitoring property/asset managers	1	This indicator examines the methods used by a participant to monitor property/asset managers' compliance with the participant's ESG-specific requirements. Monitoring compliance ensures that property/asset managers are held accountable for implementing ESG requirements as set out by the entity.	2	Managing for triple bottom line	0	1	0
Management	Stakeholder Engagement	Required	SE7.2	Monitoring external suppliers/service providers	1	This indicator examines the methods used by a participant to monitor external suppliers' and/or service providers' compliance with the participants ESG-specific requirements. This indicator refers to suppliers other than the property / asset managers covered in SE7.1.	2	Managing for triple bottom line (multi-parameter sustainability risk reduction)	0	1	0
Management	Stakeholder Engagement	Required	SE8	Stakeholder grievance process	0.5	This indicator identifies the existence of a grievance mechanism at the reporting entity. An entity's procurement decisions and activities can lead to significant negative sustainability impacts in the supply chain, including human rights violations, even when entities operate optimally. Grievance mechanisms play an important role to provide access to remedy and reflect an entity's commitment to ESG management. An entity should establish a mechanism for stakeholders in the supply chain to bring this to the attention of the entity and seek redress.	1	Focused on social performance	1	2	1

Performance	Reporting Characteristics	Required	R	Reporting Characteristics	0	Reporting Characteristics section is not scored	Information provided in the Reporting Characteristics aspect identifies the reporting scope and boundaries of the entity's standing investments portfolio during the current reporting year. This information is used to determine the structure of the Performance Component response, as well as for peer benchmarking purposes.	0	Not sustainability related	0	1	0
Performance	Reporting Characteristics	Required	R1.1	The entity's standing investments portfolio during the reporting year	0		Portfolio composition determines the scope of the Performance Component, and forms the basis for entity classification and GRESB peer-group allocation. In this context, GRESB aims to benchmark participants within similar property types. If that is not possible, property types are aggregated into groups of property types with similar characteristics (property sectors). It is therefore, essential that the portfolio boundaries reported by the entity are accurate and complete to ensure relevant outcomes and comparisons.	0	Not sustainability related	0	0	0
Performance	Reporting Characteristics	Required	R1.2	Countries/states included in the entity's standing investments portfolio	0		The reporting of the entity's assets by country along with their percentage of GAV are used by GRESB to create country and regional peer groups.	0	Not sustainability related	0	0	0
Performance	Risk Assessment	Required	RA	Risk Assessment	0	Risk Assessment section has a total of 9 points	This aspect identifies the physical and transition risks that could potentially adversely impact the value or longevity of the real estate assets owned by the entity. Moreover, it tracks the efficiency measures implemented by the entity over a period of three years.	1	Focusing on identifying unknown risks	0	0	0
Performance	Risk Assessment	Required	RA1	Risk assessments performed on standing investments portfolio	3		This indicator identifies if the entity has performed environmental and/or social risk assessments on its standing investments over the last three years. ESG risk assessments of standing investments demonstrate an ongoing commitment to ESG management, a focus on mitigating risks that may negatively impact returns and a forward-looking approach to the development of the portfolio.	1	Focusing on identifying unknown risks	0	1	0
Performance	Risk Assessment	Required	RA2	Technical building assessments	3		The intent of this indicator is to examine the steps taken by the entity to understand the efficiency, water, and waste improvement opportunities available to the entity.	1	Focused on environmental performance	1	2	0
Performance	Risk Assessment	Required	RA3	Energy efficiency measures	1.5		The intent of this indicator is to improve environmental performance within a portfolio, focusing on opportunities to increase the energy efficiency of assets. This indicator examines measures (or projects) undertaken to reduce the portfolio's energy consumption. Usually, the implementation of these measures is the result of technical building assessments, which are focused on investigating the energy use and requirements of the building based on its characteristics and installed equipment.	1	Focused on environmental performance	3	3	2

Performance	Risk Assessment	Required	RA4	Water efficiency measures	1		This indicator intends to review the steps taken by the entity to reduce water consumption across the portfolio. Along with energy performance, water consumption is a key indicator of environmental sustainability performance in real estate portfolios.	1	Focused on environmental performance	2	2	0
Performance	Risk Assessment	Required	RA5	Waste management measures	0.5		This indicator intends to review the entity's steps to reduce its waste production/generation and obtain optimized disposal methods. Along with energy performance and water consumption, waste management is a key indicator of environmental sustainability performance across real estate portfolios.	1	Focused on environmental performance	4	4	1
Performance	Targets	Required	T	Targets	0	Targets section has a total of 2 points	Environmental performance targets guide entities and their employees towards measurable improvements and area a key driver for integrating sustainability into business operations. This aspect confirms the existence and scope of performance improvement targets.	1	Focused on environmental performance (improvement and gains in efficiency)	0	0	0
Performance	Targets	Required	T1.1	Portfolio improvement targets	2		Environmental performance targets guide entities and their employees towards measurable improvements and are key determinants for integrating ESG into business operations. GRESB assesses the existence of credible targets, not the ambition level of these targets.	1	Focused on performance (improvement and gains in efficiency)	1	2	1
Performance	Targets	Required	T1.2	Science-based targets	0		Science-based targets provide companies with a clearly defined pathway to future-proof growth by specifying how much and how quickly they need to reduce their greenhouse gas emissions. Setting science-based targets demonstrates a formal commitment to reducing GHG emissions to meet the Paris Agreement's goals – to limit global warming to well-below 2°C above pre-industrial levels and pursue efforts to limit warming to 1.5°C. Science-based targets can strengthen investor confidence regarding transition risk and guide the entity in its transition to a low-carbon economy. GRESB assesses the existence of science-based targets, not the ambition level of these targets.	1	Focused on performance (improvement and gains in efficiency)	0	0	0
Performance	Tenants & Community	Required	TC	Tenants & Community	0	Tenants & Community section has a total of 11 points	Local community is another important stakeholder group of real estate companies. Indicators on community engagement examine the strategies used by the entity to involve with the local community.	3	Creating a public and shared value	0	0	0
Performance	Tenants & Community	Required	TC1	Tenant engagement program	1		This indicator describes the entity's approach to engaging tenants on ESG issues. It identifies whether the entity has adopted a formal tenant engagement program and identifies the issues covered. An effective tenant engagement program facilitates communication with the	1	Verification of performance	1	2	0

						landlord and provides a path for tenant indicators, needs, concerns and suggestions to be integrated into operational and ESG decision-making.					
Performance	Tenants & Community	Required	TC2.1	Tenant satisfaction survey	1	This indicator examines whether and to what extent the entity engages with tenants regarding their satisfaction. Tenant satisfaction surveys help entities understand critical issues within the portfolio, engage with their tenants, and increase tenant satisfaction, which may contribute to improving retention rates and productivity. Using widely applied tenant satisfaction surveys should be translated into easily interpretable metrics that can help analyze and compare outcomes, despite the many variations between tenants.	1	Focused on social performance (assessment)	1	1	0
Performance	Tenants & Community	Required	TC2.2	Program to improve tenant satisfaction	1	This indicator examines how the entity responds to issues identified in tenant satisfaction surveys. Tenant satisfaction surveys are conducted to identify key issues and concerns, which can then be addressed through improvement measures and/or programs adopted by the landlord. Defining measures and improvement targets based on the outcome of the survey and implementing those measures demonstrates commitment to the tenant engagement process and to the development and maintenance of tenant satisfaction.	1	Focused on social performance (improvement)	0	1	0
Performance	Tenants & Community	Required	TC3	Fit-out & refurbishment program for tenants on ESG	1.5	This indicator assesses how the entity addresses ESG issues in the fit-out and refurbishment of tenant space. A fit-out and refurbishment program helps to align the views and actions of landlords and tenants during an early stage of the occupancy, prior to the tenant/occupier going into occupation. Guidance and support from the start of the lease reinforce the importance placed on ESG issues and creates the basis for sustainably operated buildings.	3	Creating a public and shared value by establishing a shared vision	1	2	0
Performance	Tenants & Community	Required	TC4	ESG-specific requirements in lease contracts (green leases)	1.5	This indicator describes the strategies to promote ESG performance through lease contracts. The content of lease contracts is the starting point for the relationship between the landlord and the tenant, and defines both parties' respective rights and duties.	3	Creating a public and shared value by establishing a shared vision and responsibility	0	1	0
Performance	Tenants & Community	Required	TC5.1	Tenant health & well-being program	0.75	The indicator evaluates the presence and extent of an entity program for promoting health and well-being through its real estate assets and services. A complete process to promote tenant, customer and community health and well-being contains needs assessment, goal setting, action and monitoring. Such a process	1	Focused on social/well-being performance	1	1	0

							helps entities take systematic action to create value and manage risks.					
Performance	Tenants & Community	Required	TC5.2	Tenant health & well-being measures	1.25		The indicator evaluates the scope and quality of a program for promoting health and well-being through an entity's real estate assets and services.	1	Focused on social/well-being performance	1	1	0
Performance	Tenants & Community	Required	TC6.1	Community engagement program	2		This indicator examines the strategies used by the entity to support communities associated with its operations. A structured and comprehensive approach to community engagement demonstrates the extent of integration of community engagement issues into the entity's overall strategy.	3	Creating a public and shared value	2	2	1
Performance	Tenants & Community	Required	TC6.2	Monitoring impact on community	1		This indicator examines the topics considered by the entity to understand its impact on social and environmental conditions in communities associated with its operations. The operation of real estate assets can have positive or negative impacts on the local community. These impacts will often differ per property type. Monitoring helps an entity manage the impact of the operation of an asset on the community.	2	Managing for triple bottom line (multi-parameter sustainability risk reduction)	2	3	1
Performance	Energy	Required	EN	Energy	0	Energy section has a total of 11 points	The following six sections of the Performance component, i.e. Energy, GHG, Water, Waste, Data Monitoring & Review and Building Certifications are populated using information reported by GRESB participants at the asset level through the GRESB Asset Spreadsheet. Check tab Instructions for guidance on how to interpret the fields and fill in the data.	2	Managing for triple bottom line (multi-parameter sustainability risk reduction)	0	0	0
Performance	Energy	Required	EN1	Energy consumption for this property type	14		Energy consumption accounts for a large share of a building's environmental footprint. Data measurement and consistent reporting of energy consumption help entities to conceptualize overall energy consumption, increase the energy efficiency of their portfolio, and reduce economic and environmental impacts associated with fossil fuel energy use.	1	Focused on environmental performance	1	2	1
Performance	GHG emissions for this property type	Required	GH1	GHG emissions for this property type	7		Greenhouse gas (GHG) accounting has developed significantly in recent years. Many countries have introduced mandatory GHG emissions reporting, in addition to entities often setting their own voluntary GHG emission targets. Evaluating emissions within participants' portfolios has become standard practice, and entities are increasingly looking at emissions throughout their value chains.	1	Focused on environmental performance	2	3	0

Performance	Water use for this property type	Required	WT1	Water use for this property type	7		Consistent collection of water consumption data provides property companies and fund managers the information to monitor their environmental impact, reduce the burden on potable water consumption and wastewater systems, assess exposure to risks of disruptions in water supplies, and reduce water expenditures.	1	Focused on environmental performance	1	2	0
Performance	Waste management for this property type	Required	WS1	Waste management for this property type	4		Consistent collection of waste data gives property companies and funds the information they need to monitor their environmental impact, assess their process efficiency and set targets to reduce the amount of waste produced. Information on a portfolio's produced hazardous and non-hazardous waste, together with disposal destinations, are valuable insights for participants to manage environmental impacts and to discover unnecessary financial burdens.	1	Focused on environmental performance	2	3	1
Performance	Data Monitoring & Review	Required	MR	Data Monitoring & Review	0	Data Monitoring & Review section has a total of 5.5 points	Submitting ESG data for third-party review improves data quality and provides investors with confidence regarding the integrity and reliability of the reported information.	3	creating public value through transparency	0	0	0
Performance	Data Monitoring & Review	Required	MR1	External review of energy data	1.75		Third-party review on ESG data provides investors and participants with confidence regarding the integrity and reliability of the reported information. This indicator refers to the energy consumption data reported across the whole portfolio.	1	Focused on environmental performance	2	3	0
Performance	Data Monitoring & Review	Required	MR2	External review of GHG data	1.25		Third-party review on ESG data provides investors and participants with confidence regarding the integrity and reliability of the reported information. This indicator refers to the GHG emissions data reported across the whole portfolio.	1	Focused on environmental performance	2	3	0
Performance	Data Monitoring & Review	Required	MR3	External review of water data	1.25		Third-party review on ESG data provides investors and participants with confidence regarding the integrity and reliability of the reported information. This indicator inquires about the review of water consumption data across the whole portfolio.	1	Focused on environmental performance	2	3	0
Performance	Data Monitoring & Review	Required	MR4	External review of waste data	1.25		Third-party review on ESG data provides investors and participants with confidence regarding the integrity and reliability of the reported information. This indicator inquires about the review of waste performance data across the whole portfolio.	1	Focused on environmental performance	2	3	0
Performance	Building Certifications	Required	BC	Building Certifications	0	Data Monitoring & Review section has a total of 10.5 points	Publicly disclosed asset-level building certifications and ratings provide third-party verified recognition of sustainability performance in new construction, refurbishment and operations. Building certifications affirm that individual assets are designed and/or operated in ways that are	1	Focused on performance and compliance	0	0	0

							consistent with independently developed sustainability criteria					
Performance	Building Certifications	Required	BC1.1	Building certifications at the time of design/construction	4.25	BC1.1 + BC 1.2 have a maximum of 8.5	This indicator assesses the entity's use of green building certifications awarded for design, construction and/or major renovation (refurbishment). Green building certificates provide a measure of asset quality that may provide benefits for occupants, society and the environment. Building certifications also serve as an additional layer of transparency and accountability to inform investors and occupiers on the ESG performance of an asset.	1	Focused on performance and compliance	3	4	0
Performance	Building Certifications	Required	BC1.2	Operational building certifications	4.25	BC1.1 + BC 1.2 have a maximum of 8.5	This Indicator intends to assess the entity's use of green building certifications for building operation and maintenance. Green building certificates provide a measure of asset quality that may provide benefits for occupants, society and the environment. Building certifications also serve as an additional layer of transparency and accountability to inform investors and occupiers on the sustainability performance of an asset.	1	Focused on performance and compliance	2	3	0
Performance	Building Certifications	Required	BC2	Energy Ratings	2		This indicator assesses the entity's use of energy ratings and benchmarking. Energy ratings are often government-mandated and provide a measure of the energy efficiency performance of buildings. As such, they enable tenants and investors to identify buildings that are both environmentally friendly and have lower utility costs. Publicly disclosed asset-level building certifications and ratings provide third-party verified recognition of ESG performance in new construction, refurbishment and operations. Typically, building certifications affirm that individual assets are designed and/or operated in ways that are consistent with independently developed ESG criteria.	1	Focused on performance and compliance	3	4	1
									Total	65	101	16

APPENDIX (H) – FOR CHAPTER 4

Keyword Catalog for the SDGs and their targets

Keyword	SDG Target
10 year framework*	12.01
abuse against	16.00
*access of women to enabling technolog**	*05.b*
access to affordable energy	07.01
access to clean energy	07.a
access to clean water and sanitation	03.00
access to communication technolog*	09.c
access to education	04.05
access to electricity	07.01
access to energy	07.00
access to financial service*	01.04
access to food	02.01
access to ICT	09.c
access to information	16.10
access to information technolog*	09.c
access to market*	14.b
access to medic*	03.b
access to mobile telecommunication service*	09.c
access to reproductive health	05.06
access to resource*	14.b
access to science, technology and innovation	17.06
access to the internet	09.00
access to water	06.00
accessible public space*	11.07
accessible transport*	11.02
accessible water	06.00
accountability	16.00
accountable institution*	16.06
adapt*	11.00
adaptation to disast*	02.04
adaptive capacit*	13.01
address social issue*	10.04
adequate hygiene	06.02
adequate sanitation	06.02
administration of justice	16.03
adolescent girl*	02.02
adolescent*	03.07
adoption of environmental technolog*	09.04
affordable access	09.00
affordable credit	09.03
affordable drinking water	06.01
affordable energy	07.00
affordable housing	11.01
affordable medic*	03.00
afforestation	15.00
africa	09.a
Age discrimination	10.00
ageism	10.00
agricultur*	02.00
agricultural capacit*	02.00
agricultural export subsid*	02.b
agricultural orientation index	02.00
agricultural policy	02.a
agricultural practice*	02.00
agricultural productivity	02.00
agriculture productivity	02.00
aid for trade	08.a
aids	03.03
air contamination	03.00
air pollution	03.09
air quality	11.06
alcohol	03.05
alcohol abuse	03.00
alcoholism	03.05
alternative energ*	07.00
animal waste	12.00
animal*	15.00
antenatal care	03.00
antiretroviral	03.00
antiretroviral therap*	03.00
aquifer*	06.06
arable land*	15.00
arbitrary detention*	16.00
arms	16.00
arms trafficking	16.04
artisanal fisher	14.00
atm	08.10
atms	08.10
automobile*	11.00
availability of data	17.18

average global temperature*	13.00	caring for countr*	misc
awareness	misc	cars	12.00
awareness for sustainable development	12.08	certified building*	11.00
bank*	08.10	changing weather pattern*	13.00
basic education	04.00	chemical contamination	12.04
basic literacy	04.00	chemical inventor*	12.04
basic literacy skill*	04.00	chemical pollution	12.04
basic need*	01.02	chemical*	12.04
basic service*	01.04	child abuse	16.02
bathroom*	06.00	child death*	03.02
batteries	07.00	child development	04.02
battery	07.00	child health	03.01
bee	15.00	child labour	08.07
bees	15.00	child mortality	03.02
beijing platform for action	05.06	child sensitive	04.a
benchmarking	misc	child soldier*	08.07
benefits to developing countr*	14.07	childbirth	03.01
bicycl*	11.02	childhood	04.02
bike*	11.02	children	11.07
biking	11.02	children education	04.05
biodiversity	15.00	children under 5	02.02
biodiversity loss*	15.05	circular economy	12.00
biodiversity value*	15.09	cities	11.00
bio-filter	06.03	civil registration*	16.09
bio-filtration	06.03	civil society	16.00
biological diversity	15.06	civil society partnership*	17.00
biomedical	03.00	clean energy	07.00
birth registration*	16.00	clean energy research	07.a
birth reporting	16.09	clean energy technolog*	07.a
bodily autonomy	03.00	clean fuel technolog*	07.02
briber*	16.05	clean fuel*	07.a
building assessment*	11.00	clean production	12.01
building certificat*	11.00	clean technolog*	09.00
building material*	12.00	clean water	06.00
capacity building	17.00	cleaner fossil fuel technolog*	07.a
capacity building support	17.18	cleaner fossil-fuel*	07.a
capacity for climate change adaptation	13.03	cleaner production	12.00
capacity for climate change mitigation	13.03	climate action	13.00
capacity for health risk*	03.d	climate adaptation	13.00
capacity for planning	13.b	climate and gender	13.00
capacity for sustainable production	12.a	climate and infectious disease*	13.00
capacity of developing countr*	02.a	climate and politic*	13.00
capacity of local communit*	15.c	climate change	13.00
capitalism	12.00	climate change adaptation	11.b
car	12.00	climate change education	13.03
carbon	13.00	climate change management	13.00
carbon capture	13.00	climate change mitigation	11.b
carbon conversion	13.00	climate change planning	13.00
carbon dioxide	13.00	climate change polic*	13.02
carbon mitigation	13.00	climate change-related planning	13.b

climate early warning*	13.00
climate event*	01.05
climate goal*	07.00
climate hazard*	13.00
climate impact*	13.00
climate law and regulation*	13.00
climate law*	13.00
climate laws and regulation*	13.00
climate mitigation	13.00
climate polic*	13.00
climate refugee*	13.00
climate regulation*	13.00
climate related hazard*	13.01
climate resilience	13.00
climate-related event*	01.05
climate-related extreme event*	01.05
co2 capture	13.00
co2 conversion	13.00
co2 emission*	misc
coastal area	14.05
coastal biodiversity	14.00
coastal conservation	14.05
coastal ecosystem*	14.02
coastal habitat*	14.00
coastal park*	14.00
coastal resource*	14.00
coastline*	14.00
combat terrorism	16.a
comfort	03.00
commercial enterprise*	12.00
commitment by developed countr*	17.02
communicable disease*	03.04
communication technolog*	17.08
communications skill*	04.04
communities	11.00
community	11.00
community engagement	16.07
community health	03.00
computer literacy	04.04
conflict resolution*	16.00
conflict*	16.00
conservation	15.00
conserve	misc
conserve marine area*	14.05
conserve ocean*	14.c
conserving resource*	12.00
construction waste	11.06
consume resource*	12.00
consumer level*	12.00
consumerism	12.00

consumption	12.00
consumption and production	12.a
contaminated land*	15.00
contamination	misc
contamination of water	03.09
contraceptive use	03.00
contraceptive*	05.06
cooperation	misc
coral bleaching	14.00
coral reef*	14.00
corruption	16.05
country participation	16.08
creativity and innovation	08.00
crop	02.00
crop diversity	02.00
crop loss*	12.00
crops	02.00
cultural diversity	04.07
cultural heritage	11.04
culture*	08.09
curricul*	04.07
customary law*	05.a
dam	06.00
dams	06.00
data bank*	09.00
Data Monitoring	17.00
daylight*	03.00
death rate	16.01
death*	03.00
debt	17.04
debt sustainability	17.00
decent entrepreneurship	04.04
decent job*	08.03
decent work for all*	08.05
decent work*	08.00
decentralisation	11.00
decision making	16.07
decoupling	08.04
deep decarbonisation	12.00
defecation	06.00
deforestation	15.02
demand response*	07.b
demolition waste	11.06
dental	03.00
desalination	06.a
desertification	15.03
detained person*	16.03
developing countr*	17.00
developing state*	10.00
development	misc

development assistance commitment*	17.02	early childhood	04.00
development assistance*	10.b	early childhood development	04.02
development countr*	17.09	eco tourism	misc
development finance*	misc	ecological	misc
development impact*	11.06	ecological tourism	misc
development of vaccine*	03.b	ecology	misc
development oriented polic*	08.03	economic benefit*	14.07
development plan*	12.01	economic development	09.00
diarrhoeal disease*	06.00	economic disast*	01.05
differential treatment	10.a	economic growth	08.00
direct participation structure*	11.03	economic harm*	misc
disabilities	10.00	economic inclusion	10.02
disability	10.00	economic polic*	02.a
disability and education	04.a	economic productivity	08.00
disability and family support	03.00	economic resource*	01.00
disability and inclusion	03.00	economic shock*	01.05
disability and politics of location	03.00	economic support	17.01
disability sensitive	04.a	economy	08.00
disadvantaged	01.00	ecosystem management	14.00
disaggregated data	17.00	ecosystem restoration	15.00
disast*	11.00	ecosystem*	misc
disaster exposure	01.05	education	04.00
disaster management	11.00	education faciliti*	04.a
disaster preparedness	11.05	education for all	04.00
disaster prevention	13.01	education for children	04.05
disaster risk management	11.b	education for girl*	04.00
disaster risk reduction	11.b	education for sustainability	04.07
disaster strateg*	11.00	education for women	04.00
disaster victim*	11.05	education in developing	04.00
discriminat*	10.00	education indicator	04.05
discriminatory polic*	10.03	education indigenous people*	04.05
disease*	03.00	educational facilit*	04.a
diversification	08.02	educational financing	04.a
diversity	misc	educational support	04.a
doctor*	03.c	effect of disast*	11.05
Doha Declaration	03.b	effective climate change planning	13.b
doha development agenda	17.00	effective learning	04.a
doha development round	02.b	effective partnership*	17.17
doha development round / doha round	02.00	efficiency	misc
doha round	02.00	efficient use	12.02
domestic technolog*	09.b	electrical power	09.00
domestic violence	05.02	electricity	07.00
domestic work	05.04	electricity infrastructure*	07.00
drinking water	06.01	electrification	07.01
drought*	15.03	embodied carbon	12.00
dryland*	15.00	emission*	misc
dumping	06.03	employee engagement	08.00
durability	11.00	employee health	08.00
durable	11.00	employee health and well-being	08.00
duty-free	17.12	employee satisfaction	08.00

Employee training	04.00
employment	08.00
employment, education or training	08.06
empower	10.00
empower girl*	05.00
empower women	05.00
empowerment	05.00
empowerment of women	05.00
EMS	misc
enabling technolog*	17.08
enabling technology for women	05.b
end hunger	02.00
end poverty	01.00
endangered specie*	15.05
ending poverty	01.00
energy	misc
energy assessment	07.00
energy consumption	07.00
energy efficiency	07.03
energy generation	07.02
energy in developing countr*	07.b
energy infrastructure*	07.a
energy management	07.00
energy market*	07.00
energy mix	07.02
energy performance	07.00
energy rating*	07.00
energy research	07.a
energy saving*	07.03
energy service*	07.01
energy technolog*	07.00
energy use	12.00
energy-efficient	07.00
enforced disappearance*	16.00
enhance agricultural productive capacit*	02.a
enhance polic*	17.14
enhanced representation	10.06
enrolment	04.00
enrolment in higher education	04.b
ensure equal opportunit*	10.03
enterprises	08.00
entrepreneurship	08.00
environment	misc
environmental	misc
environmental degradation	misc
environmental disast*	01.05
environmental efficiency	misc
environmental footprint	misc
environmental harm*	misc
environmental impact of building*	11.06
environmental impact of cit*	11.06
environmental impact*	misc
environmental initiative*	04.07
environmental issue*	misc
environmental management system*	misc
environmental performance	11.06
environmental polic*	misc
environmental priorit*	misc
environmental risk management	11.b
environmental shock*	01.05
environmental standard*	misc
environmental sustainability	misc
environmental technology	09.04
Environmental, Social, and Governance	misc
environmentally friendly	misc
environmentally sensitive land*	15.00
environmentally sound technolog*	17.07
equal access	16.00
equal access to education	04.00
equal education	04.00
equal opportunities	05.00
equal opportunity	10.03
equal participation	05.00
equal pay	08.05
equal right*	01.04
equal rights to economic resource*	misc
equal rights to women	05.a
equality	misc
equality of states	10.06
equitable education	04.00
equitable sanitation	06.00
equitable sanitation and hygiene	06.02
equitable trading	17.10
equity	misc
eradicate invasive species	15.08
eradicate poverty	01.01
esg	misc
ESG decision-making	16.00
ESG disclosure	12.06
ESG fine*	16.00
ESG leadership	misc
ESG polic*	16.00
essential health-care	03.08
essential medic*	03.b
ethical	misc
ethnicity	10.00
expand energy infrastructure*	07.a
expand financial service*	08.10
exploitation	misc
exploitation of children	16.02

exploitation of girl*	05.02
exploitation of women	05.02
exports of developing countr*	17.11
exposure to climate-related event*	01.05
exposure to disast*	01.05
external debt	17.04
extinct	15.00
extinct spec*	15.00
extinction	15.05
extreme climate event*	01.05
extreme poverty	01.01
extreme weather event*	13.00
facilitate international support	09.a
facilitate support	09.a
family planning	03.07
farm income*	02.03
female circumcision	05.03
female genital mutilation	05.03
feminism	05.00
finance sustainable forest management	15.b
financial assistance	10.00
financial flow*	10.b
financial inclusion	01.00
financial institution*	08.10
financial market*	10.05
financial regulation*	10.05
financial resource*	15.a
financial service*	08.03
financial soundness	10.05
financing	08.00
fine particulate matter	11.00
fish spec*	14.00
fish stock*	14.04
fisher*	14.00
fisheries management	14.06
fisheries subsid*	14.06
fishing	14.00
fishing practice*	14.00
flood*	06.00
flow of arms	16.00
food	02.00
food commodity markets	02.c
food gap	02.00
food hygiene	03.09
food losse*	12.03
food price*	02.c
food production	02.03
food reserve*	02.00
food security	02.00
food shortage*	02.00

food supply	12.03
food waste	12.03
food-energy-water nexus	misc
footprint	12.02
for employment	04.04
forced displacement	misc
forced labour*	08.07
forced marriage	05.03
foreign aid	10.00
foreign direct investment*	10.b
foreign investment*	10.00
forest management	15.b
forest*	15.00
formal education	04.03
fossil fuel energy	13.00
fossil-fuel subsid*	12.c
fossil-fuel*	07.00
fostering innovation*	17.00
free trade	17.00
freedom	16.00
freshproduce	02.00
freshwater	06.04
freshwater ecosystem*	15.01
freshwater withdraw*	06.04
fuel subsid*	12.c
full employment	08.00
fundamental freedom*	16.01
fundamental principles of official statistic*	17.00
funding sustainable development	13.a
future proof	12.00
future-proof growth	08.00
gdp	08.00
gender	05.00
gender discrimination	05.01
gender disparities in education	04.05
gender equ*	05.00
gender inclus*	10.00
gender sensitiv*	04.a
gender-based violence	05.02
genetic diversity	02.00
genetic diversity of seed*	02.00
genetic resource*	misc
geography of poverty	16.00
ghg	13.00
girl*	05.00
global citizenship	04.07
global education	04.00
global financial market*	10.00
global food waste	12.00
global governance	16.08

global health risk*	03.d
global jobs pact	08.b
global mean temperature	13.00
global partnership for sustainable development	17.05
global partnership*	17.00
global resource efficiency	08.00
global stability	17.00
global support for conservation	15.c
global temperature	13.00
global trade	08.00
global warming	13.00
good governance	misc
governance	16.00
governance and gender	05.00
governance and polic*	misc
governance and risk*	misc
governance polic*	16.00
governance risk*	16.00
governance-related	16.00
grant*	04.b
green building certification*	11.00
green building*	11.00
green climate fund*	13.a
green econom*	07.00
green space*	11.07
greenhouse gas*	13.00
grid	07.00
grids	07.00
gross domestic product	08.00
gross domestic product growth	08.01
hand-washing	06.02
harassment	10.03
harmful subsid*	12.c
harmful traditional practice*	05.03
harvest loss*	12.00
hate crime*	16.00
hazardous building material*	12.04
hazardous chemical*	12.04
hazardous waste*	12.04
health	03.00
health and welfare	03.08
health in resource-constrained setting*	03.00
health personnel*	03.c
health polic*	03.08
health risk reduction	03.d
health risk*	03.00
health risks reduction*	03.d
health worker densit*	03.00
healthy	03.00
healthy live*	03.00

hepatitis	03.03
heritage	11.04
high-value added sector*	08.02
historical condition	11.04
hiv	03.03
holistic disast*	11.b
homeless*	10.00
homophobia	10.00
honey bee	15.00
honey bees	15.00
household expenditure*	10.01
housing	11.01
human capital	misc
human resource*	04.c
human right*	misc
human rights law*	10.03
human settlement*	11.00
human trafficking	08.07
human well-being	misc
humanitarian	misc
hunger	02.00
hungry people	02.00
hydroelectric*	07.00
hydropower	07.00
hygiene	06.00
IAQ	03.00
ice loss	13.00
ict infrastructure*	09.00
illegal arms	16.00
illegal fish*	14.00
illegal wildlife product*	15.00
illicit financial flow*	16.00
illicit trafficking	15.00
illness	03.00
ilo	08.b
impact of cit*	11.00
impact of development*	11.06
improved nutrition	02.00
improvement in energy efficiency	07.03
improving mortality	03.00
improving water	06.00
in harmony with nature	12.08
inadequate housing	11.00
inadequate water	06.00
inappropriate site	15.00
inclusion	10.02
inclusion and education	04.00
inclusive	04.00
inclusive decision-making	16.07
inclusive economic growth	08.00

inclusive employment	09.02
inclusive growth	08.00
inclusive institution	16.00
inclusive learning	04.a
inclusive societ*	16.00
inclusive space*	11.07
income distribution	10.01
income equality	01.00
income growth	10.01
income inequality	10.00
income of indigenous people*	02.03
increasing life expectancy	03.00
indigenous	misc
indigenous education	04.05
indigenous knowledge	misc
indigenous people income*	02.03
indigenous peoples income*	02.03
indigenous population*	15.00
Indoor air	03.00
indoor air quality	03.00
industrial diversification	09.00
industrial infrastructure	09.04
industrial sector	08.03
industrialisation	09.02
industrialization	09.02
industry’s share of gross domestic product	09.02
inequalities	10.00
inequalities of outcome	10.03
inequality	10.00
infant	03.01
infant mortality	03.02
infants	03.01
infected	03.00
informal settlement*	11.00
information and communication service	misc
information and communication technology	09.00
information and communications technology	09.c
information technolog*	17.08
information technology for women	05.b
information technology skill	04.04
infrastructure development	09.a
infrastructure upgrade	09.04
infrastructure*	misc
inland freshwater	15.01
innovat*	misc
innovations and health	02.00
institutional capacity	13.03

insurance	08.10
Integrate climate change	13.02
integrate sustainability	12.06
integrated plan*	11.b
integrated polic*	11.b
integrated policies and planning	11.b
integrated policy and planning	11.b
integrating sustainability	09.04
integrity of reported information	17.00
integrity of the reported information	16.00
inter-generational	misc
intergovernmental organization*	16.08
internally displaced	16.00
international aid	17.00
international conference on population and development	05.06
international cooperation	17.00
international health polic*	03.00
international health regulation	03.00
international infrastructure*	09.01
international instrument*	16.00
international labour organization	08.b
international law	14.c
international population and housing census	17.00
international support	17.01
international support for capacity-building	17.00
international trade	08.a
internet	09.c
internet access	09.00
internet of things	misc
invasive alien species	15.00
invasive species	15.08
investment in development	02.a
investment promotion regime*	17.05
IOT	misc
irregular migration	misc
irrigation	02.00
job	08.00
job creation	08.00
jobs	08.00
judiciary	16.00
justice	16.00
kaitiakitanga	misc
kelp	14.00
knowledge sharing	17.06
labour market	08.00
labour productivity	08.02
labour right*	08.08
labour-intensive sector	08.02

lake	06.06
lakes	06.06
land	15.00
land conservation	15.01
land consumption	15.00
land contamination	15.00
land degradation	15.03
land locked developing countr*	misc
land loss*	15.00
land restoration	15.03
land use and sustainability	15.00
land, plant and soil resource	15.00
landfill*	12.00
lands	15.00
latrines	06.00
law of the sea	14.00
leadership development	04.00
leadership development for women	05.00
learning opportunit*	04.00
least developed countries	misc
leave no one behind	misc
legal identit*	16.00
legume*	02.00
life cycle assessment	12.00
life-cycle	12.00
life-cycle impact*	12.02
life-cycle information	12.02
lifelong learning	04.01
literacy	04.06
literacy skill*	04.00
livability	11.00
livable communit*	11.00
living in poverty	01.02
local breed*	02.05
local communit*	16.07
local culture	08.09
local culture development	12.b
local government polic*	11.b
local government*	13.01
local material*	11.c
local planning	15.09
local plant*	15.00
local product*	12.b
local spec*	15.00
loss of biodiversity	15.05
low impact agriculture	misc
low impact farming	misc
low impact horticulture	misc
low-carbon	13.00
low-carbon econom*	12.00
lowincome	01.00
macroeconomic stability	17.13
macroeconomic*	17.13
maize	02.00
malaria	03.03
malnourished	02.02
malnutrition	02.02
manage environmental impacts	11.06
manage forest*	15.00
managed forest*	15.00
manufacturing employment	09.02
marginalis*	05.00
marine	14.00
marine area*	14.00
marine biodiversity	14.a
marine conservation	14.00
marine debris	14.01
marine ecosystem	14.02
marine environment	14.00
marine fisher*	14.00
marine life	14.00
marine nutrient pollution	14.01
marine park*	14.00
marine pollution	14.01
marine resource*	14.00
marine resources conservation	14.00
marine science*	14.03
marine technolog*	14.a
market access	17.12
market distortion*	12.c
material footprint	12.02
material good*	12.00
materialism	12.00
materials good*	12.00
maternal and child health	03.01
maternal mortality	03.01
means for ending poverty	01.a
measles	03.00
measurement of progress	17.19
medical	03.00
medical research	03.b
mental health	03.04
micro financing	08.00
microb*	03.00
microfinanc*	01.04
micro-organism	15.00
migrant remittance	10.00
migrant right*	misc
migrant worker*	08.08
migration	10.07

migration and polic*	misc
migration polic*	10.07
miles travel*	11.02
mitigation	11.00
mitigation action	13.a
mobile network	09.00
mobile networks in developing countr*	09.c
mobile telecommunication	misc
mobile telecommunication service for women	05.b
mobility	10.07
mobility for people with disabilities	11.02
mobilize financial resource*	17.03
mobilize knowledge	17.16
mobilizing fund	13.a
modern electricity	07.00
modern energy	07.b
modern slavery	08.00
monitoring of financial market*	10.05
monitoring sustainable development	12.b
Montreal Protocol	12.04
mortality	03.00
mortality rate	03.00
mothers	03.01
motor vehicle*	11.00
mountain ecosystem	15.04
multimodal transport*	11.02
multi-stakeholder partnership*	17.16
municipal waste management	11.06
narcotic drug	03.05
narcotic drug abuse	03.05
national budget	17.01
national health risk*	03.d
national park*	15.00
national parks and reserves	15.00
national reserve*	15.00
national security	misc
national strategy	08.b
native plant*	15.00
native spec*	15.00
natural disast*	misc
natural habitat*	15.05
natural heritage	11.04
natural hydrology	06.05
natural outdoor environment*	11.00
natural resource*	12.00
natural system*	13.00
neonatal mortality	03.02
network infrastructure*	09.00
net-zero energy	07.00
non-communicable diseas*	03.04

non-discrimination	05.01
non-discriminatory law*	16.b
non-discriminatory polic*	16.b
non-formal education	04.03
non-performing loan*	10.05
non-violence	16.00
north-south cooperation	17.06
numeracy	04.06
nutrition	02.00
nutritional disease*	02.02
nutritional need	02.00
nutritious	02.00
nutritious food	02.01
obesity	02.02
obsolescence	12.00
occupational accident*	08.08
occupational health	08.08
occupational health and safety	08.08
occupational safety	08.08
ocean acidification	14.03
ocean conservation	14.c
ocean health	14.a
ocean temperature*	14.00
ocean warming	13.00
ocean*	14.00
Oceanographic	14.a
oceanography	14.00
open defecation	06.02
open space*	11.07
organized crime*	16.04
organized learning	04.02
over crowding	11.00
overconsumption	12.00
overfishing	14.00
ozone deplet*	12.04
paris agreement	13.00
paris principle*	16.00
parity	05.00
participation of developing countr*	16.08
participation of local communit*	06.b
participation of women	05.00
participatory	17.00
participatory decision-making	16.07
participatory planning	11.03
partnership for sustainable development	17.16
partnership strateg*	17.17
partnership*	17.00
peace	16.00
peaceful coexistence	16.00
peaceful societ*	16.00

peri-urban	11.a
permaculture	15.00
persons with disabilities	08.05
phone service*	09.00
physical abuse	16.00
physical activit*	03.00
physical infrastructure*	09.a
physician*	03.c
plant bank*	02.05
plastic*	12.04
poach*	15.07
police	16.00
policies for poverty eradication	17.15
policy coherence	17.14
policy coordination	17.13
polio	03.00
political inclusion	10.02
political participation	05.05
pollution	misc
pollution from construction	11.00
poor	01.00
poor and vulnerable	01.00
population	11.00
population growth	misc
position of women	05.00
post-harvest	12.03
poverty	misc
poverty dimension*	01.02
poverty eradication	01.b
poverty in developing countr*	01.00
poverty line	01.00
poverty mitigation	01.00
poverty polic*	01.a
PPP	17.17
precarious employment	08.08
premature mortality	03.04
pre-primary education	04.00
preschool*	04.02
preservation	11.04
prevent violence	16.a
preventable death*	03.00
prevention	12.05
primary education	04.02
procurement	12.07
production	12.00
productive activit*	08.03
productive capacit*	02.a
productive employment	08.05
productive ocean*	14.00
productivity	08.00

programme evaluation	17.00
programme ownership	17.15
programmes on sustainable consumption and production	12.01
progress on sustainable development	17.19
promote sustainable tourism	08.09
promoting local culture*	12.b
promoting local product*	12.b
promotion of gender equality	05.c
promotion of shared responsibilit*	misc
pro-poor	01.b
prosperity	misc
protected area	15.00
protected fauna	15.00
protected flora	15.00
protected species	15.07
psychological abuse	16.00
public allocations for gender	05.c
public health	03.00
public hygiene	03.09
public institution*	16.00
public policy	misc
public procurement	12.07
public space*	11.07
public transport*	11.02
public, public-private and civil society partnership*	17.17
public-private partnership*	17.00
qualified teacher*	04.c
quality education	04.01
quality job*	08.00
quality of life	misc
race	10.00
racial	10.00
racism	10.00
rainwater	06.00
raising capacity	13.b
raw material*	12.02
recover	12.05
recreation	03.00
recycle	12.05
recycled water	06.00
recycling	12.05
reduce inequal*	10.00
reduce vehicle*	11.00
reduce waste	12.05
reducing malaria	03.00
reducing mortality	03.00
reduction	12.05
reforestation	15.02
refrigerant*	12.04

refugee crisis	misc
refugee right*	misc
refugees and health service*	03.00
refugees and learning	04.00
refurbish*	12.00
regional development planning	11.a
regional infrastructure*	09.00
regulatory measure*	16.00
reliability of reported information	17.00
reliability of the reported information	16.00
reliable energy	07.00
religion	10.00
religious inclusion	10.02
remittance*	10.c
renewable energy	07.00
renewable energy source	07.02
renewable power	07.00
renewable*	misc
renovation*	12.00
representation for developing countr*	10.06
representation in intergovernmental organization*	10.06
representation in international institution*	10.06
representative decision-making	16.00
reproductive health	03.00
reproductive healthcare service*	03.07
reproductive right*	05.06
research and development	09.05
research and development spending	09.05
research*	09.00
resilien*	11.00
resilience to disast*	13.01
resilient	11.00
resilient agricultural practice*	02.04
resilient agriculture	02.00
resilient building*	11.c
resilient infrastructure*	09.a
resource efficienc*	misc
resource need*	11.00
resource*	12.00
resources for developing countr*	17.03
resource-use efficiency	09.04
responsible	misc
responsible production chain	12.00
retail	12.00
retail industry	12.00
retrofitting	09.04
reuse	12.05
reuse technolog*	misc
reusing	12.05

right of developing countr*	03.b
right to education	04.00
right to justice	16.00
rights to land*	01.04
rising sea	13.00
risk management	misc
risk reduction strateg*	11.00
river	06.00
river basin*	06.06
rivers	06.00
road mortality	03.06
road safety	11.02
road traffic accident*	03.06
road traffic	03.06
road*	09.00
rule of law	16.00
runoff*	06.00
rural	11.00
rural area*	11.a
rural infrastructure*	02.00
safe cit*	11.00
safe drinking water	06.00
safe work	08.00
safe work environment	08.08
sanitary facilit*	06.02
sanitation	06.00
sanitation and hygiene	06.02
sanitation management	06.00
sanitation service*	06.02
scholarship*	04.b
school	04.00
school enrolment*	04.00
science cooperation agreement*	17.00
scientific capacit*	12.a
scientific personnel	09.05
scientific research	09.05
sea	14.00
sea grass	14.00
sea level rise	13.00
secondary education	04.00
secure work	08.00
security threat*	16.00
seed bank*	02.05
sensitive land*	15.00
sewerage	06.00
sex	10.00
sex education	03.07
sexism	10.00
sexual abuse	16.00
sexual and reproductive health	03.07

sexual and reproductive health-care	03.07
sexual exploitation	05.00
sexual health	03.07
sexual healthcare service*	03.07
sexual relation*	05.06
sexual violence	05.02
shanty	11.00
share knowledge	17.16
share of global export	17.11
site contamination	15.00
skill for employment	04.04
slavery	08.07
slum	11.01
slums	11.01
small farm*	02.03
small island developing stat*	misc
small size enterprise*	08.03
small-scale financial service*	09.03
small-scale fisher*	14.b
small-scale food producer*	02.00
small-scale industr*	09.03
smart building*	misc
smart cit*	11.00
smart construction	misc
smart grid*	misc
smart home*	misc
sme	08.03
smes	08.03
smoking	03.a
social disast*	01.05
social inclusion	05.00
social inequalit*	10.00
social justice	16.00
social polic*	08.00
social protection	01.00
social protection measure*	01.03
social protection polic*	misc
social protection system*	01.03
social responsibilit*	misc
social risk assessment*	misc
social security	10.04
society	misc
socio-economic impact*	misc
soil	15.00
soil contamination	03.09
soil degradation	15.00
soil erosion	15.03
soil pollution	03.09
solar	07.00
solar energy	07.00
solar power	07.00
solid waste	11.00
south-south cooperation	17.06
special treatment*	10.a
stable employment	08.00
stable job*	08.00
standard of living	01.00
statistical capacity-building	17.19
stolen asset	16.00
strategic plan for biodiversity	15.00
strategies of partnership*	17.17
strategy for youth	08.b
stunted growth	02.02
stunting	02.02
substance abuse	03.05
suburban	11.00
sufficient food	02.01
suicide	03.04
supply chain*	12.00
support ecosystem conservation	15.a
support medical	03.b
support to developing countr*	17.01
support to end trafficking	15.c
sustainability	misc
sustainability awareness	12.08
sustainability best practice*	misc
sustainability performance	misc
sustainability risk*	misc
sustainability report*	12.06
sustainable	misc
sustainable agriculture	02.04
sustainable aquatic ecosystem*	14.00
sustainable building*	11.c
sustainable cit*	11.00
sustainable communit*	11.00
sustainable consumption	12.00
sustainable consumption and production	08.04
sustainable development	misc
sustainable development education	04.07
sustainable development goal*	misc
sustainable development indicator*	misc
sustainable economic growth	08.00
sustainable energy	07.00
sustainable energy service*	07.b
sustainable fisher*	14.07
sustainable fishing practice*	14.04
sustainable food production	02.00
sustainable human settlement planning	11.03
sustainable industrial*	09.02
sustainable infrastructure*	09.01

sustainable investment	misc
sustainable irrigation	06.00
sustainable livelihood*	15.c
sustainable management	12.02
sustainable material*	11.c
sustainable pattern of consumption	12.a
sustainable pattern of production	12.a
sustainable patterns of consumption	12.a
sustainable patterns of production	12.a
sustainable planning	11.03
sustainable power	07.00
sustainable practice*	12.06
sustainable procurement	12.07
sustainable product*	12.00
sustainable public procurement	12.00
sustainable public transport*	misc
sustainable resource us*	12.00
Sustainable site development	15.03
sustainable site*	15.00
sustainable societ*	misc
sustainable supply chain*	12.00
sustainable tourism	misc
sustainable tourism tool*	12.b
sustainable transport*	misc
sustainable urban*	11.00
sustainable water management	06.00
sustainable withdrawal*	06.00
sustainably use biodiversity	15.a
sustaining biodiversity	15.a
targeted capacity building	17.09
tax evasion	16.00
taxation	12.c
teacher training	04.c
teacher*	04.c
tech industr*	09.b
technical education	04.03
technical skill*	04.04
technolog*	misc
technological capabilit*	09.05
technological capacity	12.a
technological innovat*	09.b
technological support	09.a
technology cooperation agreement*	17.00
technology for sustainable development	misc
technology transfer	17.00
telecommunication service*	misc
tele-work*	misc
temperature	13.00
terrestrial ecosystem*	15.04
terrorism	16.a
tertiary education	04.03
theft	16.00
third world	misc
threatened spec*	15.00
to finance	08.00
Tobacco	03.a
toilet	06.00
toilets	06.00
torture	16.00
torture of children	16.02
tourism	08.09
town planning	11.00
trade	misc
trade commitment*	08.a
trade diversity	02.00
trade financ*	08.a
trade promotion	08.a
trade restriction*	02.b
Trade support	08.a
traffic accident*	03.06
traffic safety	03.06
trafficking	16.00
trafficking of children	16.02
trafficking of protected species	15.07
trafficking of women	05.02
training	04.03
transaction cost*	10.c
transborder infrastructure*	09.01
transboundary cooperation	misc
transparen*	16.00
transparent institution*	16.06
transport infrastructure	11.02
transport system	11.02
transport*	11.02
treatment of substance abuse	03.00
tree species	15.00
tropical disease*	03.03
tuberculosis	03.03
under nourish*	02.00
under-5 mortality	03.02
unemploy*	08.00
universal access	11.07
universal access to information technolog*	09.c
universal education	04.00
universal health	03.00
universal health coverage	03.08
universit*	04.03
unpaid care	05.04
unpaid work*	05.04
unregulated fish*	14.06

un-sentenced detainee*	16.00
unstable societ*	16.00
untreated wastewater	06.00
urban area	11.00
urban development*	11.00
urban plan*	11.00
urban sustainability	11.00
urban*	11.00
urinal*	06.00
use of communication technolog*	05.b
use of water	06.00
utilization of genetic resource*	02.05
vaccin*	03.08
value added sector*	08.02
value chain*	09.00
vehicle*	12.00
victims of violence	16.00
violence	16.00
violence against children	16.02
violence against girl*	05.02
violence against women	05.02
violence rate*	16.00
VOC	12.04
vocational education	04.03
vocational skill*	04.04
vocational training	04.00
volatile organic material*	12.04
voting right*	10.06
vulnerable	misc
vulnerable nation*	10.00
vulnerable population*	misc
wage polic*	10.04
walkability	11.00
waste	12.00
waste diversion	11.06
waste from construction	12.00
waste from demolition	12.00
waste generation	12.05
waste management	11.06
waste polic*	12.00
waste water management	06.03
wasteful consumption	12.c
wastewater	06.00
wastewater treatment	06.03
wasting	02.02
water	misc
water access*	06.00
water and sanitation management	06.b
water assessment*	06.05
water balance	06.05
water conservation	06.05
water consumption	06.00
water contamination	06.00
water disast*	06.00
water ecosystem*	06.00
water efficiency	06.00
water for all	06.01
water harvesting	06.a
water infrastructure*	06.00
water management	06.05
water polic*	14.00
water pollution	06.00
water quality	06.03
water recycling	06.03
water related disease*	03.09
water resource and polic*	14.00
water resource*	14.00
water resources and polic*	14.00
water resources management	06.00
water reus*	06.00
water scarcity	06.04
water sensitive revitalisation	misc
water supply	06.00
water treatment	06.03
water use	06.04
water, sanitation and hygiene for all	03.00
waterborne disease*	03.09
water-energy-food nexus	misc
water-related disast*	11.00
water-related ecosystem	06.06
water-use efficiency	06.04
wave power	07.00
wealth distribution	01.00
weapon seizure*	16.00
weapon*	16.00
weighted tariff average*	17.00
well-being	03.00
well-paid job*	08.00
wetland*	15.00
wildlife	15.00
wildlife habitat*	15.00
wildlife trafficking	15.07
wind	07.00
wind power	07.00
wind turbine*	07.00
women empowerment	05.c
women entrepreneur*	17.00
women in work	05.00
women leadership	05.05
women manager*	05.05

women migrant*	08.00
women ownership of land	05.a
women trafficking	05.02
women's advancement	05.00
women's education	04.00
women's empowerment	05.00
women's health	05.00
women's reproductive health	05.00
women's right*	05.00
women's sexual and reproductive health	05.00
women's sexual health	05.00
work	08.00
work opportunit*	08.00
worker*	08.08
workforce in developing countr*	03.c
work-life balance	08.00
workplace equality	05.00
world health organisation	03.00
world trade	misc
world trade organization	17.00
world’s hungry	02.00
youth	misc
youth employment	08.b
youth health	03.07
youth in employment	08.06
youth in training	08.06
youth not in employment, education or training	08.06
youth strateg*	08.b
youth unemployment	08.00
zero carbon	12.00

Correlation of keywords with agenda and standard parameters

SDG	Distinct Words	SDG/Target Word Count	Count per Distinct Words	# of Targets	Distinct/Targets
1	43	0	0.000	7	6.143
2	73	0	0.000	8	9.125
3	126	42	0.333	13	9.692
4	84	3	0.036	10	8.400
5	65	0	0.000	9	7.222
6	81	23	0.284	8	10.125
7	61	24	0.393	5	12.200
8	104	25	0.240	12	8.667
9	59	2	0.034	8	7.375
10	65	1	0.015	10	6.500
11	116	47	0.405	10	11.600
12	116	65	0.560	11	10.545
13	62	17	0.274	5	12.400
14	65	0	0.000	10	6.500
15	90	7	0.078	12	7.500
16	93	31	0.333	12	7.750
17	76	1	0.013	19	4.000
Misc	124	170	1.371	N/A	N/A
Totals	1503	458	0.176	169	8.573
				Excluding Misc	

Keyword to Word Count	
average	0.17648
stdev	0.17958
Spearman's Rho	0.70421
t value	5.41061
p value	7.2226E-05

Keyword to Target	
average	8.57321
stdev	2.24080
Spearman's Rho	0.74941
t value	6.62068
p value	8.14124E-06

APPENDIX (I) – FOR CHAPTER 5

SDGs design questions and elements of focus
adapted from and based on (Institute of Architecture and Technology (KADK) et al., 2018; *The Oslo Manifesto: Design and Architecture for the SDGs*, 2015; United Nations, 2012, 2015)

Sustainable Development Goal	**Building design question**	**Building-related elements**
Goal 1: End poverty in all its forms everywhere	How does the project contribute to ending poverty?	- Control over land and resources - Resilience to climate-related events and natural disaster
Goal 2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture	How does the project contribute to ending hunger or providing food security, nutrition and sustainable agriculture?	- Access to food - Small scale food production - Food security - Climate adaptation
Goal 3. Ensure healthy lives and promote well-being for all at all ages	How does the project contribute to health and well-being?	- Access to health facilities - Mental health and well-being - air, water, soil pollution - contamination control
Goal 4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	How does the project contribute to education and lifelong learning?	- Skill building - Hands-on sustainability learning opportunities - vocational training - Diversity, inclusion, and equality - Accessibility for building and individual educational spaces - Building capacity for using communication and information technologies - Indigenous knowledge
Goal 5. Achieve gender equality and empower all women and girls	How does the project advance gender equality and empowerment?	- Safe environments - Participation of women in leadership - Access to resources and education - use of technologies
Goal 6. Ensure availability and sustainable management of water and sanitation for all	How does the project contribute to sustainable water management and sanitation?	- Reduction of wastewater - Capturing rain and stormwater - Recycling and reusing greywater - Eliminating hazardous dumping - Water use efficiency - Water management systems - Protect and restore water ecosystems - Sanitation management
Goal 7. Ensure access to affordable, reliable, sustainable and modern energy for all	How does the project contribute to transitioning towards renewable energy?	- Clean energy and renewables - Energy efficiency and conservation - Access to energy - Clean energy technology - Energy research, technology and, innovation - Energy infrastructures

Sustainable Development Goal	Building design question	Building-related elements
Goal 8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	How does the project help in achieving sustainable growth and inclusion and promote employment?	- Sustainable tourism - Promotion of local culture - Work/job creation - Equal access to jobs and training - Work insertion - Resource efficiency
Goal 9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation	How does the project contribute to innovation?	- Innovation in design - Technology integration - Scientific and design research - Retrofitting - Environmental and sustainable technologies
Goal 10. Reduce inequality within and among countries	How does the project help reduce inequality?	- Policies for inclusion - Non-gender bias or socio-economic class spaces - Non-discriminatory access
Goal 11. Make cities and human settlements inclusive, safe, resilient and sustainable	How does the project improve the resilience, safety and sustainability of urban settlements?	- Protection of cultural and natural heritage - Air quality - Waste management - Resource efficiency - Disaster risk reduction - Reduction of the human footprint - Reduction of emissions and waste - Considerate urbanization - Participatory and inclusive processes - Mobility
Goal 12. Ensure sustainable consumption and production patterns	How does the project promote sustainable consumption and production patterns?	- Efficient use of natural resources - Food waste - Life cycle thinking - Chemical control - Procurement and sourcing - Promoting local culture and sustainable tourism - Minimizing impacts
Goal 13. Take urgent action to combat climate change and its impacts	How does the project help in the fight against climate change?	- Climate adaption and mitigation - Reporting on emissions, climate risks and impacts - Raise awareness on climate change and its risks
Goal 14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development	How does the project help in sustaining water eco-systems?	- Reduce marine pollution or waste that could reach waters - protecting coastal ecosystems and sites
Goal 15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss	How does the project help in protecting ecosystems and biodiversity?	- Protection of forests - Reducing degradation of natural habitats - Protect threatened species - Raising awareness on illegal trafficking of wildlife products - Managing invasive species - Protect biodiversity

Sustainable Development Goal	Building design question	Building-related elements
Goal 16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels	How does the project promote peace, justice and accountability?	- Creating safe spaces - Integrated, collective, democratic and inclusive decision making - Access to information and knowledge
Goal 17. Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development	How does the advance partnership?	- Collaboration - Promotion of sustainable technologies and process - Public-private partnerships - Partnerships with civil society - Building momentum for progress for sustainable development

APPENDIX (J) – FOR CHAPTER 7

Projects awards and recognitions

Bibliothèque du Boisé (2013) - as listed by (Lemay, 2020b)

Year	Award	Organization
2010	Excellence Award	Canadian Architect Award
2013	Project of the Year	Gala élixir du PMI-Montréal
2013	Winner in Green Building Project	Awards of Excellence in Steel Construction (CISC)
2013	Jury's Choice	Awards of Excellence in Steel Construction (CISC)
2013	Winner in Commercial - Institutional Project	Awards of Excellence in Steel Construction (CISC)
2014	Award for Project Excellence	Project Management Institute (PMI)
2014	Winner	Canadian Green Building Award
2014	Finalist in People's Choice Award	Cecobois Award of Excellence
2014	Winner in Green Building	International VMZinc Award
2015	Winner in Institutional	Canadian Interiors' Best of Canada
2015	Finalist	FX International Interior Design Awards
2015	Finalist, Institutional Building	OAQ Award of Excellence
2015	Winner in Library	Grands Prix du Design
2015	Grand Prix in Architecture	OAQ Award of Excellence
2016	Canada's Top Three Greenest Buildings – Silver category	Corportate Knight Magazine
2016	Platinum in Institutional Architecture	The American Architecture Prize
2016	Bronze Winner in Cultural Architecture	The American Architecture Prize
2016	Finalist for WAN Civic Building Awards	WAN Awards
2016	Honorable Mention	Asia Pacific Interior Design Awards for Elite
2017	Conseil régional de l'environnement de Montréal	Green parking certification
2017	Green Building Award	RAIC Awards of Excellence
2017	Awards of Excellence: Green Building	Royal Architectural Institute of Canada

Centre for Interactive Research on Sustainability - CIRS (2011) – as listed by (UBC Sustainability Initiative, n.d.)

Year	Award	Organization
2011	Design and Architecture	Treehugger Best of Green
2012	Wood Design Award	Canadian Wood Council Awards
2012	Design Merit Award	Perkins+Will Design Biennale
2012	New building (award)	National Council of Structural Engineers Associations (NCSEA) Excellence in Structural Engineering Award
2012	Excellence in Urban Sustainability Finalist	GLOBE Awards for Environmental Excellence
2012	Best Office or Commercial Design & Readers' Choice Winner	Treehugger Best of Green
2012	Award for Engineering Excellence	Association of Consulting Engineering Companies – BC (ACEC-BC)
2012	Award for Education or Healthcare Structures	Institute of Structural Engineering (IstructE) Commendation
2012	Architectural Innovation Award	Architectural Institute of British Columbia (AIBC)
2013	Green Building Award	Wood Works! BC Awards
2013	Sustainable Development Award	Golder Associates Awards
2013	Sustainable Building of the Year, Longlist	World Architecture News WAN
2013	Clean50, Top 5 Project	Delta Management Group
2014	Winner	Canadian Green Building Awards (SABMag)
2014	Excellence in Building	ISCN Sustainable Campus Excellence Award
2015	Green Building Award	RAIC Awards of Excellence

Bill Fisch Forest Stewardship and Education Centre (2015) – as listed by (DIALOG, n.d.)

Year	Award	Organization
2015	Environmental Building Award	Ontario WoodWorks! (Canadian Wood Council)
2016	Ontario Regional Award	Canadian Green Building Awards (SABMag)
2016	Technical Merit Award	Canadian Green Building Awards (SABMag)
2016	Architecture	Architizer A+ Awards
2016	Learning Special Mention	Architizer A+ Awards
2016	Public Project of the year	Ontario Public Works Association
2017	Public Project of the year	American Public Works Association
2017	Leadership Award	Forest Stewardship Council (FSC)

Halifax Central Library (2014) – complementing those listed by (Schmidt Hammer Lassen Architects, n.d.)

Year	Award	Program/Organization
2014	Award of Merit	Lieutenant Governor's Design Awards in Architecture
2015	Winner	Canadian Green Building Awards (SABMag)
2016	Winner	Governor General's Medals in Architecture (RAIC)
2017	Winner	Mayor's Awards for Architecture (Halifax Regional Municipality)
2018	Design Excellence Award: Public Category	Maritime Architectural Design Awards
2018	Excellence in Urban Architecture	Halifax Urban Design Awards (UDA – RAIC)

Amber Trails Community School (2015)– complementing those listed by (prairie architects inc., n.d.)

Year	Award	Organization
2017	Winner - Institutional (Large)	Canadian Green Building Award (SABMag)
2017	First Prize	The Greenest School in Canada (CaGBC + Canada Coalition for Green Schools)
2017	New Construction (institutional)	Excellence in Green Building (CaGBC)
2018	Education for sustainability	Manitoba Excellence in Sustainability (Gov. of Manitoba)
2018	Educational Excellence (Award of Merit)	Manitoba Masonry Institute (MMI) Design Awards

APPENDIX (K) – FOR CHAPTER 7

Documents used in Direct Content Analysis

* Word count represents the total number of words processed: with related words joined and stop words removed. Example: "the sustainable-building" is counted as one word: "sustianablebuiling"

Bibliothèque du Boisé (2013)

Descriptive and design text

Descriptive and design text

Document Type	Author and/or Publisher	Word count*	Phase
Competition Architectural text	Cardinal Hardy Labonté Marcil Eric Pelletier architectes in consortium (known now as Lemay)	948	Pre-Construction
Award Architectural Text (RAIC Green)	Cardinal Hardy Labonté Marcil Eric Pelletier architectes in consortium (known now as Lemay)	326	Post-construction
General web-description	Cardinal Hardy Labonté Marcil Eric Pelletier architectes in consortium (known now as Lemay)	39	Post-construction

Project presentation

Document Type	Author and/or Publisher	Word count*	Phase
Award announcement	Canadian Architect	386	Pre-Construction
Award announcement	SABMag	255	Post-construction
Award announcement	GPD - Library	125	Post-construction
Award announcement	RAIC Green	239	Post-construction
Award announcement	American Architecture Prize	166	Post-construction
Award announcement	OAQ - grand prix	232	Post-construction
Magazine Article	Archdaily	137	Post-construction
Magazine Article	UrbanNext	298	Post-construction

Judgement and assessment

Document Type	Author and/or Publisher	Word count*	Phase
Competition Jury report	Competition Jury	214	Pre-Construction
Award Jury comment	Canadian Architect	126	Post-construction
Award Jury comment	Archizinc Trophy	200	Pre-Construction
Award Jury comment	RAIC Green	189	Post-construction

Award Jury comment	SABMag	25	Post-construction
Award Jury comment	OAQ - grand prix (Translated)	64	Post-construction

Centre for Interactive Research on Sustainability - CIRS (2011)

Descriptive and design text

Document Type	Author	Word count*	Phase
General web-description	Perkins + Will	540	Post-construction
General web-description	UBC building manual (Regenerative Design)	500	Post-construction
General web-description	UBC building manual (living lab)	54	Post-construction
General web-description	UBC building manual (Optimization Projects and design problems)	159	Post-construction
General web-description	UBC building manual (executive summary)	1848	Post-construction
Award Architectural Text (RAIC Green)	Perkins + Will	351	Post-construction

Project presentation

Document Type	Author and/or Publisher	Word count*	Phase
Carbon Footprint analysis	Athena Sustainable Materials Institute	372	Post-construction
Wood design case study	think wood (CIRS case study)	989	Post-construction
Award announcement	RAIC Green Building	102	Post-construction
Award presentation	Architectural Institute of British Columbia (AIBC)_innovation	158	Post-construction
Award presentation	BC Wood Works!	398	Post-construction
Award presentation	SABMag	207	Post-construction
Award presentation	RAIC Green Building	243	Post-construction
Magazine Short announcement	architizer.com	81	Post-construction
Magazine Article	High Performance Buildings magazine article	1551	Post-construction
Magazine Article's captions	High Performance Buildings magazine article (captions and data)	743	Post-construction
Building inauguration announcement	UBC Opening announcement	554	Post-construction
News article	ArchDaily	334	Post-construction
News article	Architect Magazine	545	Post-construction

Judgement and assessment

Document Type	Author and/or Publisher	Word count*	Phase
Award Jury comment	Architectural Institute of British Columbia (AIBC)_innovation	13	Post-construction
Award Jury comment	SABMag	22	Post-construction
Award Jury comment	RAIC Green Building	79	Post-construction
Award Jury comment	ISCN Sustainable Campus Excellence Award	17	Post-construction

Bill Fisch Forest Stewardship and Education Centre (2015)

Descriptive and design text

Document Type	Author	Word count**	Phase
General web-description	DIALOG Architects	225	Post-construction
Sustainability features	International Living Future Institute	2714	Post-construction
Sustainability features	Brochure by Canadian Wood Council	990	Post-construction

Project presentation

Document Type	Author and/or Publisher	Word count**	Phase
Award announcement	Architizer A+Awards	167	Pre-Construction
Award announcement	SABMag	197	Post-construction
Award announcement	Rethinking the future award	280	Post-construction
Certification anoucement	Living Building Challenge Certification news - Dialog	352	Post-construction
Magazine Short announcement	Canadian Architect highlight (opening - 2015)	320	Post-construction
Magazine Article	Canadian Architect, Dialog sharing lessons	413	Post-construction
Magazine Article	Wood building & Design Magazine	450	Post-construction
News Article	CaGBC highlight	459	Post-construction
News Article	FSC highlight	181	Post-construction

Judgement and assessment

Document Type	Author and/or Publisher	Word count**	Phase
Award Jury comment	SABMag	44	Post-construction
Certification Consultant comment	International Living Future Institute Comment	13	Post-construction

Halifax Central Library (2014)

Descriptive and design text

Document Type	Author	Word count**	Phase
General web-description	Schmidt Hammer Lassen (SHL)	131	Post-construction
General web-description	Fowler Bauld & Mitchell (FBM)	126	Post-construction
Sustainability features	Halifax Public Library	366	Post-construction

Project presentation

Document Type	Author and/or Publisher	Word count**	Phase
Overview of design process	The Coast	1065	Pre-Construction
Award announcement	Governor General's Medals in Architecture (RAIC)	47	Post-construction
Award announcement	SABMag	238	Post-construction
Award presentation	Maritime Design Awards (excellence): Public	114	Post-construction
Magazine Short announcement	Canadian Architect (Opening of Building)	135	Post-construction
Magazine Short announcement	Canadian Architect (Gov. General Medal))	254	Post-construction
Magazine Short announcement	Architect Mag	172	Post-construction
Magazine Article	Archdaily	247	Post-construction
Magazine Article	Canadian Architect	608	Post-construction
News article	CBC (Gov. General Medal)	211	Post-construction
News article	CBC (loss of international award)	112	Post-construction

Judgement and assessment

Document Type	Author and/or Publisher	Word count**	Phase
Request for proposal review panel report	Halifax Regional Municipality and Halifax Public Library	139	Pre-Construction
Request for proposal consultant report	The Creative Class Group	220	Pre-Construction
Award Jury comment	Governor General's Medals in Architecture (RAIC)	54	Post-construction
Award Jury comment	SABMag	36	Pre-Construction
Award Jury comment	Halifax Urban design Awards (urban Architecture)	52	Post-construction

Amber Trails Community School (2015)

Descriptive and design text

Document Type	Author	Word count**	Phase
General web-description	Prairie Architects	313	Post-construction
Sustainability features	Prairie Architects	834	Post-construction

Project presentation

Document Type	Author and/or Publisher	Word count**	Phase
Short announcement	Seven Oaks School Division (project overview)	48	Post-construction
Award announcement	Greenest School (CaGBC)	417	Post-construction
Award announcement	SABMag	288	Post-construction

Judgement and assessment

Document Type	Author and/or Publisher	Word count**	Phase
Award Jury comment	SABMag	34	Post-construction
Award Jury statement	Statement by CaGBC for greenest school: reposted by canadian architect, Building.ca and on-sitemag	243	Post-construction

APPENDIX (L) – FOR CHAPTER 7

Outcome of Direct Content Analysis

Bibliothèque du Boisé (2013)

Document	Word Total	Global Total	Match	Misc Total	SDG Total	SDG 1	SDG 2	SDG 3	SDG 4	SDG 5	SDG 6	SDG 7	SDG 8	SDG 9	SDG1 0	SDG1 1	SDG1 2	SDG1 3	SDG1 4	SDG1 5	SDG1 6	SDG1 7	MIS C
Design competition text (Translated)	948	60	6.3%	18	42			2			5	4	6			16	1			8			18
RAIC Green	326	31	9.5%	7	24			2			2	2	3	4		9				2			7
Lemay	39	3	7.7%	0	3								1	1		1							
Canadian Architect	386	10	2.6%	3	7								4			2				1			3
SABMag	255	24	9.4%	4	20		2	2	2		7		1			2	3				1		4
GPD - Library	125	1	0.8%	0	1						1												
RAIC Green	239	25	10.5%	8	17			4			2	1	1			7				2			8
American Architecture Prize	166	15	9.0%	2	13				1				3	3		6							2
OAQ - grand prix	232	8	3.4%	1	7				2				1			4							1
Urban Next	298	3	1.0%	0	3											3							
Archdaily	137	3	2.2%	0	3											3							
Design compeition Jury report (translated)	214	11	5.1%	4	7						2	1				3				1			4
Archizinc Trophy	200	14	7.0%	4	10						1		1			2				5	1		4
RAIC Green	189	26	13.8%	8	18			7						1		8				2			8
Canadian Architect	126	12	9.5%	0	12											11				1			
SABMag	25	1	4.0%	0	1											1							
OAQ - grand prix (Translated)	64	2	3.1%	1	1											1							1
Total	3969	249		60	189		2	17	5.00		20	8	21	9		79	4			22	2		60
Percentages from total		6.3%		1.5%	4.8%		0.1%	0.4%	0.1%		0.5%	0.2%	0.5%	0.2%		2.0%	0.1%			0.6%	0.1%		1.5%
Percentages from matches		100.0%		24.1%	75.9%		0.8%	6.8%	2.0%		8.0%	3.2%	8.4%	3.6%		31.7%	1.6%			8.8%	0.8%		24.1 %
weighted Average		25.3		6.9	18.5		0.1	1.3	0.3		2.1	1.2	2.4	0.5		7.1	0.4			2.7	0.1		6.9

Centre for Interactive Research on Sustainability - CIRS (2011)

Details	Word Total	Global Total	Match	Misc Total	SDG Total	SDG 1	SDG 2	SDG 3	SDG 4	SDG 5	SDG 6	SDG 7	SDG 8	SDG 9	SDG10	SDG11	SDG12	SDG13	SDG14	SDG15	SDG16	SDG17	MISC
Perkins + Will	540	87	39.1%	34	53			11	3		8	7	1	4		3	7	7		1	1		34
UBC building manual (Regenerative Design)	500	82	36.6%	30	52		2	4	1		6	1	1	2	1	12	12	9		1			30
UBC building manual (living lab)	54	5	40.0%	2	3									1		1	1						2
UBC building manual (Optimization Projects and design problems)	159	16	31.3%	5	11						4	1					3	2	1				5
UBC building manual (executive summary)	1848	165	40.0%	66	99		2	5	4		9	2		24		18	23	4	1	2	2	3	66
Perkins + Will	351	51	39.2%	20	31		1	3	2		3	2		8		5	3	3				1	20
Athena Sustainable Materials Institute	372	62	32.3%	20	42			7	5		2	4		5		4	7	7		1			20
think wood (CIRS case study)	989	106	34.0%	36	70			4	4		14	7	1	6		9	7	10		8			36
RAIC Green Building	102	18	50.0%	9	9				1					3		3	1	1					9
Architectural Institute of British Columbia (AIBC)_innovation	158	34	58.8%	20	14			1	3		1	1		4			3	1					20
BC Wood Works!	398	58	31.0%	18	40			6	1		4	2	2	7		6	7	5					18
SABMag	207	28	35.7%	10	18			1			7	3		1		1	3	1	1				10
Canadian Architect/RAIC Green Building	243	35	42.9%	15	20			2	1			1		6		7	2	1					15
architizer.com	81	19	42.1%	8	11									7		3	1						8
High Performance Buildings magazine article	1551	163	36.2%	59	104		3	6	4		34	15	1	15		12	9	3	2				59
High Performance Buildings magazine article (captions and data)	743	80	21.3%	17	63		4	2	1		22	7		5		3	8	5	3	3			17
UBC Opening announcement	554	86	44.2%	38	48		1	1	5		2	1	5	10		4	3	13	1	1		1	38
ArchDaily	334	48	35.4%	17	31		1	4	1		3	2	1	7		2	3	6				1	17
Architect Magazine	545	60	40.0%	24	36		1	4	2		12	1	1	3	1	2	1	6		2			24
Architectural Institute of British Columbia (AIBC)_innovation	13	2	100.0 %	2	0																		2
SABMag	22	2	0.0%	0	2									1		1							
RAIC Green Building	79	11	63.6%	7	4								1	2		1							7
ISCN Sustainable Campus Excellence Award	17	2	50.0%	1	1									1									1
Total	9860	1220		458	762		15	61	38.00		131	57	14	122	2	97	104	84	9	19	3	6	458
Percentages from total		12.4%		4.6%	7.7%		0.2%	0.6%	0.4%		1.3%	0.6%	0.1%	1.2%	0.0%	1.0%	1.1%	0.9%	0.1%	0.2%	0.0%	0.1%	4.6%
Percentages from hits		100.0%		37.5%	62.5%		1.2%	5.0%	3.1%		10.7 %	4.7%	1.1%	10.0 %	0.2%	8.0%	8.5%	6.9%	0.7%	1.6%	0.2%	0.5%	37.5 %
weighted Average		101.1		37.4	63.8		1.4	4.4	2.9		12.3	5.0	0.8	10.2	0.1	8.4	9.2	5.4	0.8	1.7	0.4	0.7	37.4

Bill Fisch Forest Stewardship and Education Centre (2015)

Details	Document Word Total	Global Total	Match	Misc Total	SDG Total	SDG 1	SDG 2	SDG 3	SDG4	SDG 5	SDG 6	SDG 7	SDG 8	SDG 9	SDG10	SDG11	SDG12	SDG13	SDG14	SDG15	SDG16	SDG17	MISC
Architizer A+Awards	167	27	11.1%	3	24				7		1	1				2	4			9			3
SABMag	197	28	28.6%	8	20				4		3	2					4	1		6			8
DIALOG	225	45	20.0%	9	36				5		5	2			1	3	3	4		12	1		9
SABMag	44	6	50.0%	3	3							2								1			3
Rethinking the future award	280	39	30.8%	12	27			1	7		4	3				3	3			6			12
International Living Future Institute Comment	13	1	0.0%	0	1															1			
Living Building Challenge Certification news - Dialog	352	38	15.8%	6	32			2	9		1	2				3	5	1		9			6
FSC highlight	181	24	4.2%	1	23				7			1				4	1			10			1
Canadian Architect highlight (opening - 2015)	320	53	34.0%	18	35			1	5		2	3	1		1	4	5	1		12			18
Canadian Architect, Dialog sharing lessons	413	61	32.8%	20	41			6	5		1	5		1		5	5	6		6	1		20
CaGBC highlight	459	63	31.7%	20	43			2	7		4	3				7	5	1		13	1		20
Wood building & Design Magazine	450	48	22.9%	11	37			1	3		4	3				6	2	1		17			11
International Living Future Institute	2714	300	22.0%	66	234			16	13	2	24	20	6	2	2	29	37	7	1	69	2	4	66
Brochure by Canadian Wood Council	990	121	32.2%	39	82			1	16		10	12		1		2	12	9		19			39
Total	6805	854		216	638			30	88	2	59	59	7	4	4	68	86	31	1	190	5	4	216
Percentages from total		12.55%		3.17%	9.38%			0.44%	1.29%	0.03%	0.87%	0.87%	0.10%	0.06%	0.06%	1.00%	1.26%	0.46%	0.01%	2.79%	0.07%	0.06%	3.17%
Percentages from hits		100%		25.29%	74.71%			3.51%	10.30%	0.23%	6.91%	6.91%	0.82%	0.47%	0.47%	7.96%	10.07%	3.63%	0.12%	22.25%	0.59%	0.47%	25.29%
weighted Average		158.08		37.59	120.49			7.28	10.11	0.80	12.21	10.98	2.44	1.00	0.88	13.75	18.23	4.86	0.40	34.99	0.96	1.60	37.59

Halifax Central Library (2014)

Document	Tokenized Word Total	Global Total	Match	Misc Total	SDG Total	SDG1	SDG2	SDG3	SDG4	SDG5	SDG6	SDG7	SDG8	SDG9	SDG10	SDG11	SDG12	SDG13	SDG14	SDG15	SDG16	SDG17	MISC
Schmidt Hammer Lassen (SHL)	131	5	3.8%	0	5				2					1		2							
Fowler Bauld & Mitchell (FBM)	126	7	5.6%	2	5						1		1			2			1				2
Halifax Public Library	366	43	11.7%	18	25		1	5			2	3	2			6	3			3			18
The Coast	1065	18	1.7%	2	16				1				4		1	4	5			1			2
Governor General's Medals in Architecture (RAIC)	47	4	8.5%	1	3								1			1			1				1
SABMag	238	26	10.9%	7	19			2	1		5	2		1		3	3			1	1		7
Maritime Design Awards (excellence): Public	114	6	5.3%	2	4						1		1			1			1				2
Canadian Architect (Opening of Building)	135	7	5.2%	0	7				2		1		1			3							
Canadian Architect (Gov. General Medal))	254	15	5.9%	2	13			2			2	2	1			5			1				2
Architect Mag	172	7	4.1%	3	4											4							3
Archdaily	247	18	7.3%	2	16				2		2	1	1	1		9							2
Canadian Architect	608	24	3.9%	2	22		1	2	1		1		1	9		2	1		1	1	2		2
CBC (Gov. General Medal)	211	5	2.4%	1	4										1	3							1
CBC (loss of international award)	112	7	6.3%	0	7				1		1			1		4							
Halifax Regional Municipality and Halifax Public Library	139	7	5.0%	1	6			1	2			1				2							1
The Creative Class Group	220	11	5.0%	1	10				1				2	2		4	1						1
Governor General's Medals in Architecture (RAIC)	54	3	5.6%	1	2											2							1
SABMag	36	6	16.7%	3	3											3							3
Halifax Urban design Awards (urban Architecture)	52	2	3.8%	0	2			1								1							
Total	4327	221		48	173		2	13	13.00		16	9	15	15	2	61	13		5	6	3		48
Percentages from total		5.1%		1.1%	4.0%		0.0%	0.3%	0.3%		0.4%	0.2%	0.3%	0.3%	0.0%	1.4%	0.3%		0.1%	0.1%	0.1%		1.1%
Percentages from hits		100.0%		21.7%	78.3%		0.9%	5.9%	5.9%		7.2%	4.1%	6.8%	6.8%	0.9%	27.6%	5.9%		2.3%	2.7%	1.4%		21.7%
weighted Average		17.2		3.3	13.8		0.2	1.0	0.8		0.9	0.6	1.6	1.5	0.3	3.7	1.8		0.3	0.7	0.3		3.3

Amber Trails Community School (2015)

Details	Document Word Total	Global Total	Match	Misc Total	SDG Total	SDG1	SDG2	SDG3	SDG4	SDG5	SDG6	SDG7	SDG8	SDG9	SDG10	SDG11	SDG12	SDG13	SDG14	SDG15	SDG16	SDG17	MISC
Greenest School (CaGBC)	417	84	17.9%	15	69		2	8	29		4	3				11	7	3		1	1		15
SABMag	288	52	21.2%	11	41		3	4	15		6	2				6	4	1					11
Prairie Architects	313	55	10.9%	6	49			2	30				1			12	4						6
SABMag	34	10	40.0%	4	6				2		1					2					1		4
Statement by CaGBC for greenest school: reposted by canadian architect, Building.ca and on-sitemag	243	44	15.9%	7	37			1	18		3	2				8	2	2			1		7
Seven Oaks School Division description	48	14	21.4%	3	11				5			1				5							3
Prairie Architects	834	133	17.3%	23	110		2	12	31		10	5				28	12	3		6	1		23
Total	2177	392		69	323		7	27	130		24	13	1			72	29	9		7	4		69
Percentages from total		18.01%		3.17%	14.84%		0.32%	1.24%	5.97%		1.10%	0.60%	0.05%			3.31%	1.33%	0.41%		0.32%	0.18%		3.17%
Percentages from hits		100%		17.60%	82.40%		1.79%	6.89%	33.16%		6.12%	3.32%	0.26%			18.37%	7.40%	2.30%		1.79%	1.02%		17.60%
weighted Average		87.20		14.91	72.29		1.55	7.06	25.88		5.74	3.00	0.14			16.39	7.27	2.08		2.49	0.70		14.91

Compiled totals

	Document Word Total	Global Total	Match	Misc Total	SDG Total	SDG1	SDG2	SDG3	SDG4	SDG5	SDG6	SDG7	SDG8	SDG9	SDG10	SDG11	SDG12	SDG13	SDG14	SDG15	SDG16	SDG17	MISC
Total	27138	2936		851	2085		26	148	274	2	250	146	58	150	8	377	236	124	15	244	17	10	851
Percentages from total		10.82%		3.14%	7.68%		0.10%	0.55%	1.01%	0.01%	0.92%	0.54%	0.21%	0.55%	0.03%	1.39%	0.87%	0.46%	0.06%	0.90%	0.06%	0.04%	3.14%
Percentages from hits		100%		28.99%	71.01%		0.89%	5.04%	9.33%	0.07%	8.51%	4.97%	1.98%	5.11%	0.27%	12.84%	8.04%	4.22%	0.51%	8.31%	0.58%	0.34%	28.99%
weighted Average		89.82		25.73	64.09		0.70	4.33	5.83	0.20	8.44	5.08	1.54	4.29	0.31	9.46	8.87	3.34	0.44	10.11	0.52	0.65	25.73