LIFEBUILDING***X***

LIFE BUILDING Exchange: Investigating the Intersection of Pro-environmental Behavior, Place Meaning, and High-performance Design

Julia Ann Kriegh, PhD, AIA, Principal Kriegh Architectural Studios | Design + Research

Draft in Print, ACEEE 2020

ABSTRACT

As energy codes become more stringent and building envelopes improve, it is the energy use under the direct control of the occupant that will have the greatest impact on the environment. With regard to the design of the physical environment, we recognize that an approach incorporating both building science and social science is necessary if progress is to be made toward Climate Change goals put forward by the 2015 Paris Agreement.

While social scientists have developed theoretical frameworks to understand people's pro-environmental behaviors and relationships to place, many have overlooked the role of the built environment in that relationship. Conversely, architects focused on high-performance design often do not seek to understand how people make sense of their environments.

This study compares two communities (beyond code and code built) in the Pacific Northwest to understand people's residential energy use behaviors and how that relates to their values, identity, and place attachment. Research methods include benchmarking actual energy consumption, a treatment (feedback) and a survey on perceptions of energy use, concluding with focused interviews.

Findings indicate that energy used for miscellaneous electric loads and appliances (behavior) was on par with space conditioning and domestic hot water (building) each near 50% of the total household energy. Interview and survey data suggests that people will engage in their environment in a way that is likely to be energy conserving when such behavior is supported by their residential setting, when they espouse biospheric values, and are attached to and identify with their homes and communities.

Introduction

Net-zero energy buildings[1] offer a unique opportunity to research and evaluate the effects of multiple high-performance design features in relationship to occupant behavior. Such an undertaking is needed because, in the realm of net-zero energy buildings and regenerative architectural design, architects and building scientists pay inadequate attention to the motivations underpinning people's environmental behaviors. Conversely, the literature on pro-environmental behavior in environmental psychology has paid little attention to the physical attributes of building and site design or innovative technologies that might influence people's motivations to act pro-environmentally with respect to energy use. The purpose of this research is to redress this disparity by investigating the intersection among context- oriented and person-oriented variables that inform sustainable development and behavioral research, thereby stimulating design

---

[1] The U.S. Department of Energy defines a net-zero energy building as "an energy efficient building where, on a source energy basis, the actual annual delivered energy is less than or equal to the on-site renewable exported energy." Retrieved (August 10, 2018) from https://www.energy.gov/eere/buildings/articles/doe-releases-common-definition-zero-energy-buildings-campuses-and).

solutions to advance net-zero goals amid Climate Change as put forward in the 2015 Paris Agreement.[2]

Rational

The significant role of residential and commercial buildings in addressing net-zero Climate Change goals is often misunderstood and underestimated. First, direct GHG emissions from homes account for nearly 50% of all greenhouse gas emissions in the building sector. Second, indirect emissions from electricity use by homes and businesses account for nearly 50% of the total electricity sector. Taken together, residential and commercial buildings account for nearly 30% of all GHG emissions. Furthermore, this number continues to increase (27% since 1990) due to home electricity consumption for space conditioning (heating and cooling), domestic hot water heating, and the rapid rise of miscellaneous electric loads, also known as MELs (EPA, 2016).

Significantly, as the proportional impact of energy used for MELs by personal electronic devices continues to rise, occupant behavior is likely to be an increasingly important factor in energy use. That is, miscellaneous end-use electric loads such as those drawn for laptops, cell phones, tablets, and monitors are at the discretion of the building occupant, and the energy consumption associated with these devices continues to increase not only because there are more of them per household, but also because they are powered more of the time. As a result, occupant-driven electric loads are offsetting gains made in building envelop and equipment efficiencies (Kwatra, Amann, & Sach, 2013), thereby rendering net-zero a target that is not only difficult to meet, but also moving. This problem is magnified when considering the prediction of 30 million more housing units being built by 2040 (EIA, 2015).

Given these difficulties, what types of innovative pathways are available to spur the transition to net- zero and net-positive energy use? When considering the building sector, the Intergovernmental Panel on Climate Change (IPCC) confirms the need for substantial action on Climate Change, suggesting a parallel multi-track approach incorporating the following key concepts in sustainable development: 1) advocating the need for improved land use zoning regulations and stringent building code standards; 2) promoting the design of higher performance buildings and building related technological advances; and 3) shifting individual and collective perceptions, beliefs, values, and worldviews (IPCC, 2014) toward sustainable actions. Certainly, great strides have been achieved independently in all three tracks with increasingly stringent energy codes, advances in high performance net-zero buildings, and a deeper understanding of the psychology behind environmental behaviors in the field of Environmental Psychology. Yet the three tracks have not been integrated in a holistic way such that the performance outcomes of for both buildings and behavior inform and influence higher levels of performance in all three tracks, nor has there been a thorough investigation into the process as a whole, including how to design in support of pro-environmental behavior in the built environment. This study advocates that a holistic approach is essential to spur the transition to net-zero and net-positive energy use in the building sector in general and in residential buildings in specific by 2030.

---

[2] The recently ratified 2015 Paris Agreement[2] on Climate Change outlines a clear objective to limit the rise of global temperature warming to 1.5 degrees Celsius over pre-industrial levels. This 2015 imperative is considered an "essentially net-zero goal,"[2] according to Rachel Cleetus, lead economist and climate-policy manager at the Union of Concerned Scientists (Meyer,2015).

Research Gap

This study seeks to fill a significant research gap. That is, to explore, in a dynamic process, how and why architectural design features may support and inform the depth of place meaning and inspire the prioritization of values to motivate behaviors that maintain, enhance, and protect environmental resources in general and residential energy use in particular. Net-positive energy buildings[3] are designed to achieve or exceed Climate Change goals through multiple strategies incorporating performance standards, design features and efficient technologies, as well as on-site renewable resources (e.g., ILFI, iPHA, and OPL criteria[4]). However, these very performance-based architectural features may also offer physical, environmental cues that inform a person's behavior, raising the behaviors themselves to a higher pro-environmental performance level.

Furthermore, while this research investigates the intersections among pro-environmental actions, values, place meaning, and design, it also suggests that the process is neither linear nor sequential. That is, high-performance, in terms of both the building and a given person's behavior, results from a collection of continually evolving relationships found in the dynamic among people, place, and the locus of life's activities (performance settings). The different dynamics between people and place may lead to a different prioritization of values, inform our self-concept, enable place attachments, and promote environmental behavior. In this study, these unique combinations relate to high-performance or low-performance in terms of energy use. In the best scenario, a person's values and place meanings may promote a higher performance and outcome (exchange) that supports net-positive energy developments. This study therefore offers a model of people-place interactions in the **LIFE** BUILDING ***Exchange*** framework depicted below.

Figure 1. **LIFE**BUILDING***X*** Expression. *Source:* Image by author

Conceptually, the framework for **LIFE**BUILDING***X*** builds on the early work of Kurt

[3] For more information on the design of passive house and zero net energy buildings see Corner, Fillinger, & Kwok (2018); Eley (2016); and sustainable design philosophy, see McLennan (2004).

[4] For more information see ILFI (International Living Future Institute, 2014, 2016); iPHA (International Passive House Association, 2014); OPL (One Planet Living, Framework, https://www.bioregional.com).

Lewin from the 1930s (Gifford, 2014). Notably, Lewin saw the relationship between the person and the environment as bi-directional, meaning that, just as the person influences the environment and the environment influences the person and as such, people are active in their environments (Clayton, 2012). Hence, the **LIFE**BUILDING***X*** framework proposed in this study is similar to Lewin's general model in that it suggests an active relationship between people and place. However, the **LIFE**BUILDING***X*** framework stipulates that a number of dimensions in a dynamic process have a simultaneous role to play, particularly when the outcome is related to energy use in residential settings.

Understanding these dynamics is essential if we are to find effective ways to index influential factors, benchmark behavior and promote higher performance buildings. Importantly, the **LIFE**BUILDING***X*** framework builds on the work of other contemporary environmental psychologists and scholars, particularly research on values (Schwartz, 1973, 1977, 1992, 2012; Steg, Bolderdijk, Keizer, Perlaviciute, 2014a; Stern, 2000, 2011, 2014), place identity (Proshansky et al, 1983), environmental self- identity (Van der Werff, & Steg, 2015; Whitmarsh & O'Neill, 2010), and place attachment (Lewicka, 2011; Manzo & Devine-Wright, 2014; Scannell & Gifford, 2010a and 2010b).

In summary, this **LIFE**BUILDING***X*** research investigates the intersections among pro-environmental behavior, place meaning, and design in both code-built and net-zero energy buildings and communities described as a whole system that is likely to influence the outcomes of higher performance buildings and behavior, both of which are necessary to reach net-zero goals amid Climate Change as put forward in the 2015 Paris Agreement.

Research Methods

The two comparative Pacific Northwest communities were carefully chosen for their similarities in location and demographics (*N* = 24). The distinguishing factor is that one, the Built Green Community (*n* = 12) was designed in 2013 using state-of-the-art net zero-energy building technologies and low impact site design strategies.

Figure 2. Built Green (left) and Code-built (right) Communities. *Source:* Retrieved (August 2, 2018) from Google Images, https://www.google.com/ .

The other, the Code-built Community ($n = 12$) was designed in 1991 prior to the development of high performance energy codes or beyond code standards. Demographics show that the two communities are quite similar and both have a high degree of education, income, and homeownership.

Figure 3. Images of Built Green (left) and Code-built (right) Communities. *Source:* Images by author.

The mixed-methods research design employed in this study uses both, quantitative and qualitative techniques to investigate people's experiences of their residential energy use in their homes, including their perceived and actual energy use. In addition, the present study examines the patterns, perceptions, and motivations that underlie people's pro-environmental behaviors broadly, and residential energy use in particular, in two residential communities located in Washington State. The two comparative Pacific Northwest communities were:

1. Surveyed on their perceptions of energy use and the importance of values, beliefs, goals, place attachment, place identity, environmental self-identity, and design features at pre- and post-treatment study periods.

2. Given a treatment consisting of access to an energy monitoring dashboard in participants' homes that enabled household members to observe and inform their energy behaviors in real-time with moment by moment feedback.

3. Monitored on the households' actual electrical energy use (three years of utility billing data from Puget Sound Energy (PSE) and one year of circuit level monitoring (CLM) data) was also measured at pre- and post-treatment (energy dashboard exposure/feedbck) periods over the course of the study.

4. Interviewed, following treatment, with a series of focused interview questions that sought to understand residents' perspectives on why they use energy as they do. Additionally, these questions explored possible meanings behind and connections to

attachment and identity issues found in the lived experience of place that could potentially promote changes in household energy use.

Research at the two study sites began in June of 2016 with community selection and household recruitment (*N* = 24) to September of 2018 with the final data retrieval and analysis and culminating with the final report writing in August of 2018. Data collection surveys, intervention treatment, and interview sequence for this mixed-methods research design are depicted below.

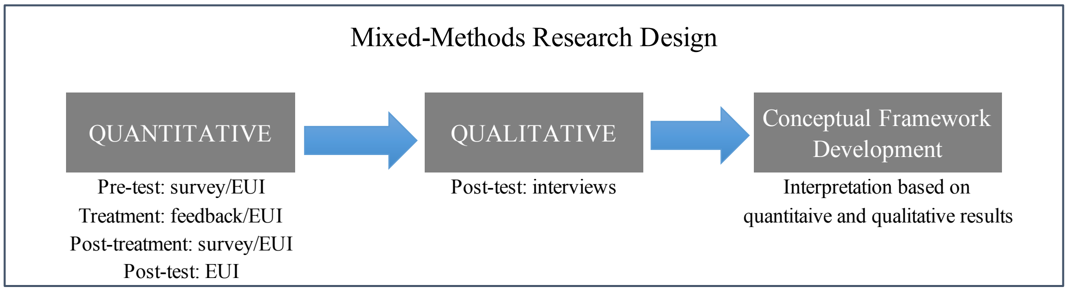

Figure 4. Mixed-Methods Research Design. *Source:* Image by author.

Research Questions and Methods of Analysis

Specifically, the study investigated the following: 1) participant households' actual residential baseline energy use and whether use differed across the two communities studied; 2) participant response to an intervention using real-time feedback on residential energy-related behavior and whether intervention effects differed across the two communities; 3) participant perceptions of their residential energy use and whether perceptions differed across the two communities; and 4) how relationships with the physical context of their residence and community may be linked with participants' energy use, and whether those relationships differed across the two communities. To conduct these investigations, the following research questions and analyses were developed.

1. How do Built Green (recently built high-performance buildings) and Code-built (older lower-performance buildings) Communities compare on their actual energy use? (Benchmarking EUI or energy use intensity scores in kBTU/sq.ft.yr.) score variables)

    - Analysis 1a: Mean EUI scores were computed prior to the start of the study in Excel. Two-group t-tests in SPSS were then used to compare and benchmark EUI scores.

    - Analysis 1b: Predicted energy model EUI scores and comparison third party national and regional EUI scores (2009 RECS and 2011 RSBA) were obtained and computed in Excel.

2. What are the effects of real-time feedback (treatment) on actual energy use? (Testing the significance of change in pre- and post-treatment EUI score variables)

- Analysis 2a: 1-group t-tests were conducted to compare the mean change in PSE EUI scores against a null of zero (no use) from pretest to each treatment period.

- Analysis 2b: Mean PSE and CLM EUI scores were computed and weather normalized using 12 months of PSE. 1- group t-tests were conducted to compare the mean change in CLM EUI scores against a null of zero (no use) from pretest to each treatment period.

- Analysis 2c: Collapsed across both communities, paired-sample t-tests were conducted to test whether PSE and CLM EUI scores differed.

- Analysis 2d: Two- group t-tests were used to compare communities on mean PSE EUI pre-post changes.

- Analysis 2e: Two-group t-tests were used to compare communities on mean CLM EUI scores pre-post changes.

3. How do community households compare demographically and on their perceptions of energy use and pro- environment variables? (Testing the significance of change in pre- and post-treatment survey variables on values, place attachments/identities and architectural design features as environmental cues.)

    - Analysis 3a: Respondents' self-reported survey demographic characteristics were analyzed with SPSS data analysis software using 2-group chi-square tests of independence.

    - Analysis 3b: Two-group t-tests were used to compare on pretest (baseline) self-reported survey and pro- environmental variables.

    - Analysis 3c: One-group t-tests were used to test the significance of non-zero change on survey rating scale variables on pro-environmental variables from pre- to post-treatment.

    - Analysis 3d: Two-group t-tests were conducted to test mean differences among the communities on pre-post changes for each survey rating scale on pro-environmental variables from pre- to post-treatment.

4. What is the relationship among values, attachments, place meanings, and environmental cues on behaviors as they relate to energy use? (Post-study qualitative interviews on how people make sense of their experience of place.)

    - Analysis 4a,b,c,d: ATLAS.ti data analysis using grounded theory to determine the role of values and place meanings, physical and social cues, and information on energy use in people's environmental behaviors related to energy use?

Key Findings

Energy Use Data. Three overarching energy use observations stand out. First, Site 1 has lower energy loads, but Site 2 reduced energy overall more than Site 1. Second, for both Site 1 and Site 2, MELs comprised a high proportion of total energy consumption, followed by space conditioning – two areas where occupants can exercise a high degree control as could be seen in the high degree of variability across the two sites in these categories. Unaccounted for MELs had the greatest variability in terms of end use, with portable space heaters reported most, followed by highly mobile devices for both entertainment and workstations (laptops, tablets, and cell phones) as well as avocational uses reported by almost every household. Third, treatment exerted a greater effect on Site 2, a pattern attributable to several causes: a) Site 1 might have been unresponsive because their actual energy use was already very low by virtue of the structural characteristics of their homes; b) the culture of Site 1 might philosophically perceive that their energy use is low and therefor did not feel a need to respond to the treatment; c) Site 2 might have both physical and social characteristics as well as philosophical perceptions that would support their responses to the treatment.

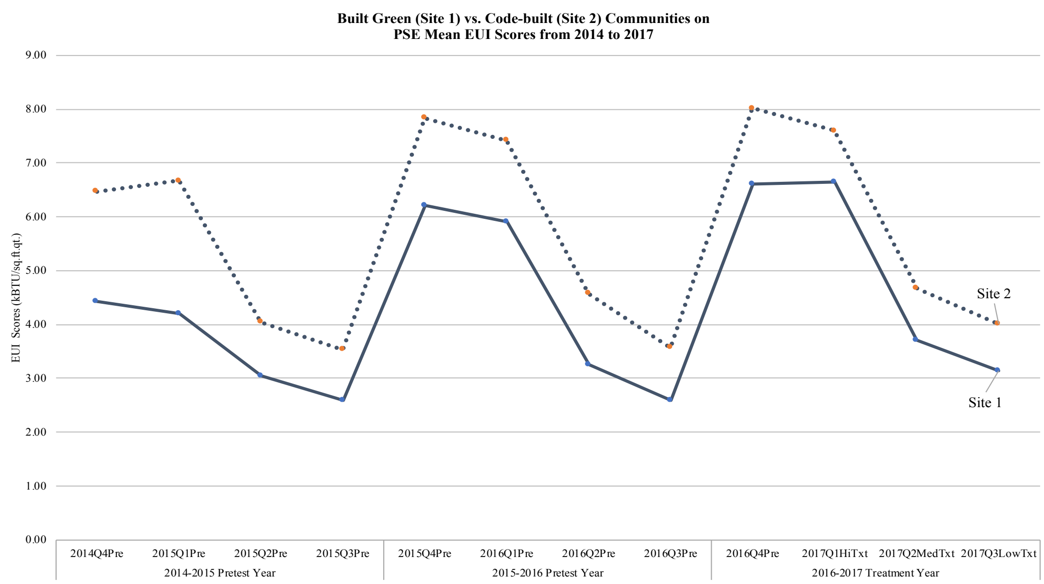

Figure 5. Comparison of Mean EUI Change Scores for PSE Data Across Time. *Source:* Image by author.

Survey Data. Noteworthy findings in the self-reported survey data showed that the two sites were quite comparable on demographic information. The two sites were also comparable on pre-treatment environmental, place, and architectural features variables. However, over the period of the study, Built Green Community households exhibited a significant decrease on hedonic values mean scores, and Code-built Community households showed a significant decrease in place identity mean scores. However, there were no significant differences between sites on self-report changes (only trends). In other words, there is little evidence that the dashboard treatment is associated with changes in people's perceptions of their values and behaviors around energy use, however actual energy consumption is affected.

The actual energy used by households did show trends for decreases between baseline and post- treatment, irrespective of which housing community was examined (albeit the Built

Green Community used less energy at the outset, and the Code-built Community decreased energy more than the Built Green Community across time and after treatment.) This can add to the evidence to support the idea that behavior change may have to occur first, before perceived changes. That is, these findings support the potential for the use of in-home energy dashboards to have an effect on actual energy behavior, especially targeting MELs and space conditioning equipment uses as these are areas where occupants can exhibit a high degree control.

Importantly, interviewing a broad range of participants in each community on their energy use will add to the supporting evidence on why and how people use energy in ways that may not be detectable with survey data or actual energy use.

Moreover, the survey data showed that over time on the mean scores for biospheric values, the Code- built Community increased whereas the Built Green Community decreased. On environmental self- identity mean scores, the Code-built Community increased whereas the Built Green Community decreased. On hedonic values mean scores, the Built Green Community had a greater decrease than did the Code-built Community. Both communities increased on mean scores for their perceptions of the importance of being able to accommodate changing needs over time. Taken together, for the Code-built Community, these increases/decreases on perceptions (self-transcendent/self-enhancing values, environmental self-identity, and the importance of accommodating changing needs over time) correlate with the effects of the dashboard treatment and demonstration of overall reductions in actual energy use.

Measures	Site 1 (n = 12)						Site 2 (n = 12)						Site 1 vs. Site 2 on *Change*		
	Pretest		Posttest		*Change*		Pretest		Posttest		*Change*				
	M	*(SD)*	*M*	*(SD)*	*M*	*(SD)*	*M*	*(SD)*	*M*	*(SD)*	*M*	*(SD)*	$t(22)$	p	d
Values (1-9)															
Altruistic	7.96	(1.28)	7.85	(0.85)	-0.10	(0.92)	7.81	(1.29)	8.02	(1.06)	0.21	(0.47)	-1.05	.307	-.43
Biospheric	8.31	(0.74)	8.22	(0.63)	-0.09	(0.67)	8.17	(0.76)	8.58	(0.56)	**0.42**	**(0.76)**	**-1.74**	**.096**	**-.71**
Egoistic	4.35	(1.31)	4.25	(1.24)	-0.10	(0.52)	4.33	(1.23)	4.31	(0.99)	-0.03	(0.62)	-0.31	.763	-.12
Hedonic	6.81	(1.26)	5.69	(1.40)	**-1.11**	**(1.24)**	6.35	(1.33)	6.19	(1.25)	-0.15	(1.29)	**-1.85**	**.078**	**-.76**
Beliefs (1-7)															
Awareness of Problem	6.63	(0.88)	6.75	(0.45)	0.13	(0.57)	6.79	(0.58)	6.71	(0.86)	-0.08	(0.29)	1.13	.270	.46
Solution Efficacy	4.89	(0.97)	4.89	(1.07)	0.00	(0.59)	4.81	(0.67)	4.50	(1.27)	-0.31	(0.74)	1.12	.276	.46
Goals (1-7)	4.55	(0.87)	4.67	(0.78)	0.12	(1.02)	4.44	(0.75)	4.48	(0.99)	0.04	(1.11)	0.18	.862	.07
Environmental Self-identity (1-7)	6.42	(0.72)	6.17	(0.67)	-0.24	(0.56)	6.17	(0.80)	6.42	(0.64)	0.25	(0.67)	**-1.91**	**.070**	**-.80**
Place Identity (1-7)	5.57	(0.94)	5.42	(0.98)	-0.15	(1.11)	5.43	(1.30)	4.94	(1.08)	**-0.49**	**(0.73)**	0.88	.390	.36
Place Attachment (1-7)	5.18	(0.74)	5.38	(0.97)	0.21	(1.14)	5.46	(1.03)	5.22	(0.97)	-0.25	(0.57)	1.23	.231	.50
Misc Electric Loads (Hours/day)															
Computer Workstation	11.42	(3.80)	11.25	(4.33)	-0.17	(6.31)	12.75	(3.14)	14.08	(3.09)	1.33	(4.92)	-0.65	.523	-.27
Entertainment Center	12.00	(7.83)	14.17	(8.99)	2.17	(12.40)	14.58	(8.12)	12.58	(8.64)	-2.00	(5.98)	1.05	.306	.43
Small Home Appliances	4.00	(3.91)	5.42	(4.23)	1.42	(6.04)	4.67	(2.81)	5.17	(2.72)	0.50	(3.18)	0.47	.646	.19
Total	27.42	(11.41)	30.83	(15.38)	3.42	(20.81)	32.00	(8.61)	31.83	(11.13)	-0.17	(8.40)	0.55	.586	.23
Low Cost Pro-enviro Beh (1-7)	3.20	(1.83)	3.60	(1.51)	0.40	(1.02)	3.12	(1.26)	3.20	(1.97)	0.04	(1.78)	0.60	.553	.25
High Cost Pro-enviro Beh (1-7)	2.47	(1.34)	2.55	(1.91)	-0.06	(1.01)	3.61	(1.91)	3.25	(1.75)	-0.36	(1.85)	0.48	.638	.20
Architectural Design Feat (1-7)															
Enviro/Human Well-being	5.82	(1.10)	6.10	(0.76)	0.28	(1.27)	6.17	(0.67)	6.14	(0.70)	-0.03	(0.71)	0.74	.469	.30
Next Gen Building Systems	6.17	(0.53)	6.29	(0.44)	0.12	(0.44)	6.19	(0.55)	5.95	(0.97)	-0.24	(0.67)	1.55	.136	.63
Promote Pro-enviro Aware/Act	4.81	(1.78)	4.90	(1.38)	0.08	(1.63)	4.67	(1.57)	4.91	(1.72)	0.24	(1.30)	-0.27	.793	-.11
Regen Design Features	5.75	(1.42)	6.00	(1.69)	0.25	(0.62)	4.75	(0.94)	5.33	(1.61)	0.58	(1.84)	-0.59	.559	-.24
Accom Chg Needs/Uses	5.00	(0.93)	5.54	(1.03)	**0.54**	**(0.96)**	6.08	(0.90)	6.38	(0.71)	0.29	(0.58)	0.77	.450	.31

Note. The Built Green (Site 1) and Code-built (Site 2) Groups significantly differed at pretest and at posttest on one architectural design feature rating (accommodating changing needs and uses). Pre-Post change values in boldface indicate either a trend for significance ($p < .10$) or were significant ($p < .05$).

Table 1. Comparison of Housing Community Groups on Survey Variables. *Source:* Image by author.

Interview Data. Rather than parsing the data issue by issue or question by question across all interviewees, this study used Grounded Theory analysis to focus on five households that manifested distinct, prototypical ways of interacting with their surroundings, understanding their environments, and using energy. Taking this holistic approach enabled drawing connections between people's lived experience of place as articulated in the qualitative data with the quantitative data on actual energy use and perceptions of energy use from the survey data. The predominant behavioral trends that emerged from the data illustrate how different person-place process dimensions in different physical and social contexts are likely to underpin a person's motivation to engage in pro-environmental behavior and shape the likelihood of likelihood of energy conservation behaviors to achieve high-performing buildings, regardless of whether the building envelope itself was structurally built to encourage a low EUI. This alignment of the qualitative and quantitative data allowed a deeper investigation into how people respond to their environments in ways that lead to certain types of prototypical energy use patterns, or profiles. From these five profiles, a conceptual framework for understanding people's energy performance was developed.

A Conceptual Framework

The **LIFE** BUILDING ***Exchange*** or **LIFE**BUILDING***X*** is a conceptual framework developed from the findings of this study as a way to understand the dynamic processes likely to shape a person's energy-related environmental behaviors in the places where they live. **LIFE**BUILDING***X*** focuses specifically on the collective significance of values, meaningful person-place relationships, and physical and social environmental cues that may elicit a behavioral response and associated EUI. The locus of performance where person-place experiences occur are the residential settings in which people make day-to-day choices with respect to home energy. Each of the **LIFE**BUILDING***X*** terms used in the framework is described in greater detail below.

The term **LIFE** is intended to capture the people side of the people-place relationship, including values, place identity, environmental self-identity, and place attachment. It references the processes by which a person evaluates, identifies with, or experiences a bonding relationship to meaningful places which is likely to influence their behavior. For an individual, these process dimensions may be based on cognitive (biospheric, altruistic, hedonic and/or egoistic values), affective (place attachment), or self-concept (place identity and environmental self-identity) dimensions.

The term **BUILDING** refers to those features and aspects of one's physical and social environments that cue a person's environmental response and enhance or suppress environmentally friendly behaviors generally, and in energy conservation behavior specifically. That is, high-performance buildings – and even conventionally built places – can provide cues that prompt inhabitants to favor pro-environmental behaviors that impact their energy use. This connection suggests that high performance outcomes (e.g., low EUI buildings) may depend on the type and quality of a person's experience with **BUILDING** and **LIFE** factors that go into shaping a person's energy- related environmental behaviors in the places where they live.

The term ***Exchange*** refers to the type, quality, and intensity of people-place interactions and engagements with place. An environmentally friendly behavior likely to make an impact on energy use is indicative of an exchange in which a person makes a commitment to pro-environmental behavior and high-performance outcomes – a process that I call "saturation." Whether enduring (highly saturated) or temporary (low saturation), this commitment entails an active engagement with place. This engagement may have a collective benefit for their community, in which case the person can be understood as an engaged citizen. The engaged citizen, is a person who lives in a particular place and maintains an allegiance to the well-being of that community; that is, their actions support the greater good of the community and collective environments.

Alternatively, a person's engagement with place could have more personally-oriented benefits, in which case they can be understood as an engaged individual. An engaged individual is a person whose actions are based on individualistic or personal reasons to benefit themselves and their personal environments such as their individual residence. Conversely, a person might not be invested or engaged with their place or community. These individuals can be understood as disengaged citizens and disengaged individuals. A disengaged citizen is one whose actions do not support the needs of the community or the greater good of the environment. A disengaged individual is a person whose actions are not directed toward the benefit of the environment, the community, or themselves with regard to environmental conservation or energy use. Whether a person responds as an engaged or disengaged citizen or individual, findings of this research show that the process is dynamic and includes values, place meanings, and environmental cues dimensions that people access and respond to in order to make sense of their experience of place.

Key Findings For The Conceptual Framework

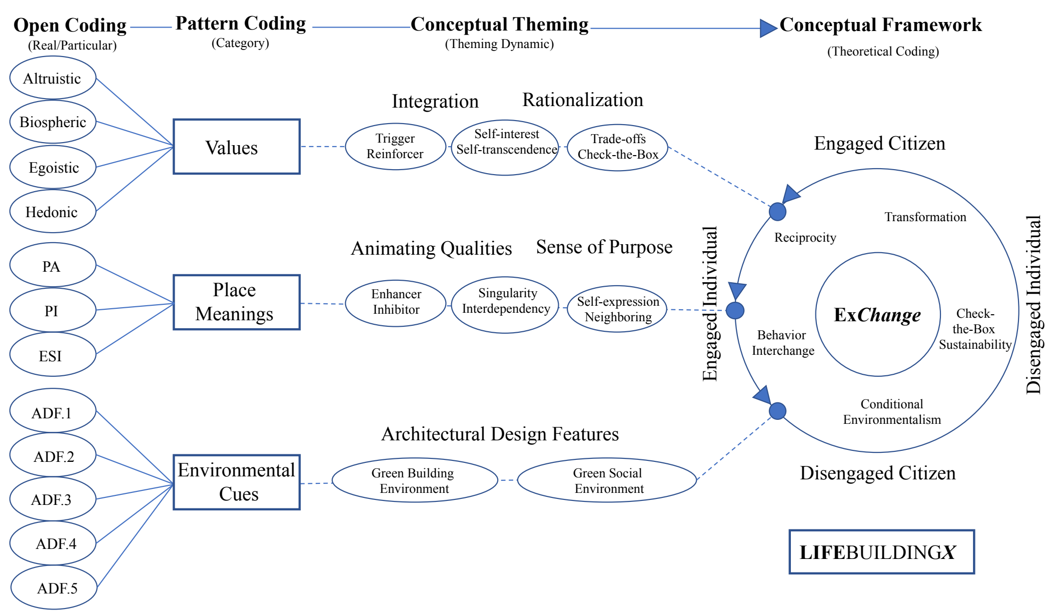

Figure 6. LIFE BUILDING Exchange Framework, condensed. *Source:* Image by author.

The findings of this research show that when it comes to environmental actions, particularly those related to energy use, one of five prototypical forms of **LIFE**BUILDING***X*** emerged: (1) reciprocity, (2) transformation, (3) behavior interchange, (4) check-the-box sustainability, or (5) conditional environmentalism. Each prototype is described below.

Reciprocity. Reciprocity is a way of being in the world that is based on an enduring relationship of mutual benefit for self, other humans, other species, and the planet (see also Kimmerer, 2013; Manzo & Perkins, 2006). With regard to environmental behaviors, a reciprocal relationship would “use and replenish but not endanger or deplete” resources, as descried by one resident.

Transformation. Transformation refers to a way of living that affirms pro-environmental behaviors captured in the phrase offered by one interviewee: “Be the change you want to see.” As implied by this statement, transformation refers to an emerging process that orients a person in a new direction, toward behavioral change, focusing their attention on pro-environmental behaviors at the community level.

Behavior Interchange. Some interviewees’ narratives demonstrated a particular dynamic in which they engaged in specific actions themselves or encountered others in the community engaging in pro-environmental behaviors that inspired them to take further environmental actions (see also Griskevicius et al., 2008; see also Van der Werff, 2013a & 2013b). Behavior Interchange is a way of living that is likely to affirm one’s intentions as pro-environmental but more effective when past behaviors were repeated as captured in this resident’s phrase: “What you practice grows stronger.”

Check-The-Box Sustainability. Some study participants exhibited a type of “check-the-box” environmentalism based on a belief that their home was energy efficient by design, so no environmentally conscious behavior was required of its occupant. “Just by living here, so many aspects of sustainability could be taken care of and we can check-the-box on sustainability” because it was all done for us, as descried by one resident.

Conditional Environmentalism. Conditional environmentalism relates to an exchange, often temporal in nature, that does not require an enduring commitment and may be related to a “purchase” of something involving money, time, or convenience. Those who exhibited this type of exchange did not express long-term commitment or engagement in their community. Their behaviors tended to be short-term, rationalized, or negotiated in some way.

Conclusion

By investigating pro-environmental behavior in residential high-performance buildings and neighborhoods compared to those more conventionally built this research looked at the dynamics of values, place meanings, environmental cues, and exchange interactions. This approach explored a deeper understanding of the ever-shifting collection of factors therein, an investigation which, to the knowledge of this researcher, has not been conducted in this configuration to date. By linking high performance energy efficient technologies in the built environment with a deep understanding of pro-environmental human behavior, this study maintains that a multi-dimensional, integrated research and design agenda is needed to answer critical questions about residential energy use in an effort to reach net-zero Climate Change goals targeted by the 2015 Paris Agreement.

Future Directions, Limitations, and Dissemination to Practice

Future Directions and Limitations. Ongoing research might seek to investigate a larger more diverse random sample to increase the power and significance of findings. For example: 1) collaborating with other researchers conducting residential studies, such as national RECS and regional RBSA that investigate only structural characteristics, by implementing the behavioral survey and interview methods developed for this study on these much larger random samples; 2) continuing research to increase the data set on the community level with additional residential communities to capture a wider range of physical and social characteristics; and 3) revising the survey to increase power by reducing the number of questions with a greater focus on values, place identity, environmental self-identity, and place attachment as well as consolidating the questions on architectural design features.

Dissemination to Practice. To realize net-zero energy goals and for research like this to exert an impact on practice, it is crucial to collaborate with agencies and organizations that develop energy codes (e.g., City planning departments) and beyond-code organizations (e.g., International Living Future Institute) to incorporate a behavioral component such as the **LIFE**BUILDING***X*** conceptual framework into energy requirements. In this regard, this research and the **LIFE**BUILDING***X*** framework would support the incorporation of a behavioral component for meeting performance and outcome-based codes and standards. In this way, as the structural components of building performance increase in efficiency and energy codes move toward more stringent outcome-based standards with a requirement for certification of energy performance in residential settings, residents may have options to change structural (physical building) characteristics or behavioral characteristics to achieve a low energy performance profile.

Understanding a household's energy profile includes establishing a baseline **LIFE**BUILDING***X*** index or profile from which to measure the contribution of behavioral components in energy performance now and in the future. To this end, it would be productive to create computer coding for the **LIFE**BUILDING***X*** conceptual framework to be coupled with actual energy consumption data in a software program and dashboard display for use by residents, designers, and developers of sustainable design.

Closing. This research investigated the ability of the physical built environment to play a rich and active role in support of sustainable living and suggested that high-performance buildings (along with place attachment, identity relationships, and values) may act as dynamic, interdependent, and bi-directional constructs. Moreover, both physical and social environments have the potential to create a reinforcing environment (cue) in which to practice sustainable behavior. This research contributes to the literature in four respects:

- Developing a holistic conceptual framework inclusive of physical and social contexts. The **LIFE**BUILDING***X*** Index describes the intersection among— values, place meanings, environmental cues, and actual behavior as a whole mutually influential system.

- Examining the role of the physical built environment to: 1) serve as environmental cues; 2) "house" place meanings; and 3) comprise the nexus of higher performance buildings and behaviors—the locus of performance in an exchange between person and place.

- Investigating meaningful place relationships such as place identity, environmental self-identity, and place attachment as significant to pro-environmental behavior models.

Encouraging and actively participating in a transdisciplinary approach to the study of pro-environmental behavior in the context of high-performance net-positive energy buildings and sustainable settings in architecture to support the goals of the 2015 Paris Agreement, 2014 ICPP, and the Architecture 2030 Challenge mitigating the risks of Climate Change.

References

Annual Energy Outlook 2015 with projections to 2040 (p. 15). Retrieved (June 11, 2015) from www.eia.gov/forecasts/aeo.

Architecture 2030 Challenge Targets: U.S. Residential Regional Averages. U.S. Environmental Protection Agency, EIA. Retrieved (June 11, 2015) from www.architecture2030.org/files/2030_Challenge_Targets_Res_Regional.pdf.

Clayton, S. (2012). Environment and Identity. In S. Clayton (ed.), *The Oxford Handbook of Environmental and Conservation Psychology* (p. 164-179). New York: Oxford University Press.

Corner, D., Fillinger, J. C., & Kwok, A. G. (2018). *Passive House Details: Solutions for High-performance Design.* New York, NY: Routledge.

Eley, C. (2016). *Design Professional's Guide to Zero Net Energy Buildings*. Washington, DC: Island Press. Energy Information Administration (EIA, 2015). Drivers of US Household Energy Consumption, 1980-2009. Retrieved (June 11, 2015) from www.eia.gov.

Environmental Protection Agency (EPA, 2016). Sources of Greenhouse Gas Emissions, 1990-2014. Retrieved (October 26, 2016) from: www.epa.gov/ghgemissions/sources-greenhouse-gas-emission.

Gifford, R. (2014*). Environmental Psychology: Principles and Practice. Colville, WA: Optimal Books*. Griskevicius, V., Cialdini, R. B., & Goldstein, N. J. (2008). Social Norms: An Underestimated and Underemployed Lever for Managing Climate Change. Retrieved (August10, 2018) from www.ijsc- online.org, IJSC 3 (2008): 5-13.

International Living Future Institute (2014). *Living Building Challenge 3.0: A Visionary Path to a Regenerative Future.* Retrieved (February 12, 2016) from http://www.living-future.org/lbc.

ILFI (2016). Net Zero Energy Building Certification. Retrieved (October 26, 2016) from https://living- future.org/netzero.

International Passive House Association (2014). Active for more comfort: Passive House, Information for property developers, contractors and clients. Darmstadt, Germany: International Passive House Association. Retrieved (February 12, 2016) from http://www.passivehouse-international.org.

IPCC, 2014a: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, (p. 27). Retrieved (June 11, 2015) from http://www.ipcc.ch/report/ar5/syr/.

IPCC, 2014b: Climate Change 2014, Summary for Policymakers, (p. 1-5). Retrieved (November 24, 2014) from www.ipcc.ch/report.

Kimmerer, R. W. (2013). *Braiding Sweetgrass: Indigenous Wisdom, Scientific Knowledge, and Teachings of Plants*. Minneapolis, MN: Milkweed Editions.

Kriegh, J. A., 2018. *LIFEBUILDINGX, LIFE BUILDING Exchange: Investigating the Intersection of Pro- environmental Behavior, Place Meaning, and High-performance Design*. ProQuest Dissertation Publishing, University of Washington, Seattle, WA.

Kwatra, S. Amann, J., and Sachs, H. (2013). Miscellaneous Energy Loads in Buildings. Retrieved (June 11, 2015) from www.aceee.org.

Lewicka, M. (2011). Place-attachment: How Far have We Come in the Last 40 Years? *Journal of Environmental Psychology*, 31, p. 207-230.

Manzo, L. C. & Devine-Wright, P. (2014). *Place Attachment: Advances in Theory, Methods and Applications*. New York, NY: Routledge.

Manzo, L. C. & Perkins, D. (2006). Finding Common Ground: The Importance of Place-attachment to Community Participation and Planning. *Journal of Planning Literature*, 20(4), p. 335-350.

McLennan, J. F., (2004). *The Philosophy of Sustainable Design*. Kansas City, MO: Ecotone Publishing Company.

Meyer, Robinson (2015). A-readers-guide-to-the-Paris-agreement. Retrieved (October 7, 2016) from http://www.theatlantic.com/science/archive/2015/12/a-readers-guide-to-the-Paris- agreement/420345.

One Planet Living Framework, Retrieved (June 11, 2015) from https://www.bioregional.com.

Proshansky, H. M., Ittelson, W. H., & Rivlin, L. G., (1970). *Environmental Psychology: Man and His Physical Setting*. New York, NY: Holt, Rinehart and Winston, Inc.

Scannell, L. & Gifford, G. (2010a). Defining Place-attachment: A Tripartite Organizing Framework. *Journal of Environmental Psychology*, 30, p. 1-10.

Scannell, L. & Gifford, G. (2010b). The Relations Between Natural and Civic Place-attachment and

Pro- environmental Behavior. *Journal of Environmental Psychology*, 30, p. 289-297.

Schwartz, S. H. (1973). Normative Explanations of Helping Behavior: A Critique, Proposal, and Empirical Test. *Journal of Experimental Social Psychology*, 9, p. 349-364.

Schwartz, S. H. (1977). Normative Influences of Altruism. *Advances in Experimental Social Psychology*, L. Berkowits (ed.), 10, (p. 221-279). New York: Academic Press.

Schwartz, S. H. (1992). Universals in the Content and Structure of Values: Theoretical Advances and Empirical Tests in 20 Countries. In M. P. Zanna & M. P. Zanna (eds.), *Advances in Experimental Social Psychology*, 25, (p. 1-65). San Diego, CA: Academic Press.

Schwartz, S. H. (2012). An Overview of the Schwartz Theory of Basic Values. *Psychology and Culture*, 2(1). Retrieved (October 30, 2016) fromhttp://dx.doi.org/10.9707/2307-0919.1116

Steg, L., Bolderdijk, J. W., Keizer, K., & Perlaviciute, G. (2014a). An Integrated Framework for Encouraging Pro- environmental Behavior: The role of values, situational factors and goals. *Journal of Environmental Psychology*, 38, p. 104-115.

Stern, P. C. (2000). Toward a Coherent Theory of Environmentally Significant Behavior. *Journal of Social Issues*, 56 (3), p. 407-424.

Stern, P. C. (2011). Contributions of Psychology to Limiting Climate Change. *American Psychologist,* 66 (4), p. 303-314.

Stern, P. C. (2014). Individual and Household Interactions with Energy Systems: Toward Integrated Understanding. *Energy Research & Social Science*, 1, p. 41-48.

Van der Werff, E., & Steg, L., (2015). One Model to Predict Them All: Predicting Energy Behaviors with the Norm Activation Model. *Energy Research & Social Science*, 6, p. 8-14.

Van der Werff, E., Steg, L., & Keizer, K. (2013a). I am what I am, by Looking Past the Present: The Influence of Biospheric Values and Past Behavior on Environmental Self-Identity. *Environment and Behavior*, 46, p. 626-657.

Van der Werff, E., Steg, L., & Keizer, K. (2013b). The Value of Environmental Self-identity: The Relationship between Biospheric Values, Environmental; Self-identity and Environmental Preferences, Intentions and Behavior. *Journal of Environmental Psychology*, 34, p. 55-63.

Whitmarsh, L. & O'Neill, S. (2010). Green Identity, Green Living? The Role of Pro-environmental Self- identity in Determining Consistency Across Diverse Pro-environmental behaviors. *Journal of Environmental Psychology*, 30, p. 305-314.