LIFEBUILDING***X***

Life Building Exchange: Investigating the Intersection of Pro-environmental Behavior, Place Meaning, and High-performance Design.

Julia Ann Kriegh

A dissertation

submitted in partial fulfillment

of the requirements for the degree of

Doctor of Philosophy

University of Washington

2018

Reading Committee:

Lynne C. Manzo, Chair

Elizabeth A. Sanders

Joel Loveland

Program Authorized to Offer Degree:

College of the Built Environments

University of Washington

Abstract

LIFEBUILDING***X***

Life Building Exchange: Investigating the Intersection of Pro-environmental Behavior, Place Meaning, and High-performance Design.

Julia Ann Kriegh

Chair of the Supervisory Committee:

Lynne C. Manzo

Department of Landscape Architecture

The design of the physical environment and people's relationship with that environment are both important factors related to energy conservation. 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—and high-performance design in particular—in that relationship. Conversely, architects focused on high-performance net-zero design often do not seek to understand how people live in and make sense of their environments. Drawing these two approaches together, a mixed-methods study of two housing communities in the Pacific Northwest was conducted to understand people's residential energy use behavior and how that relates to physical and social aspects of their environment as well as their values, identity, and place attachment. Site 1 was designed to state-of-the-art “green” building codes for low energy use, while Site 2 was built according to more conventional code standards. Methods included the introduction of a treatment (a monitoring dashboard showing a household’s energy use) and the administration of a pre- and post-test survey, along with in-depth qualitative interviews of a sub-sample of participants.

Findings indicate that while the energy use scores for both communities were low, miscellaneous electric loads and space conditioning uses consumed over 50% of the total household energy. Additionally, energy use data show that the Green Built Community increased their energy use over the course of the study, while the Code-built Community decreased its energy use. Survey results show that biospheric values and environmental self-identity ratings increased for the Code-built Community over this same time period. Interview 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. Based on the findings, a conceptual framework, Life-Building-Exchange, is offered that encompasses: LIFE—people’s values and place meanings; BUILDING—environmental cues; and EXCHANGE—the locus of reciprocal relationships (buildings and behavior) found in high-performance environments necessary to meet net-zero climate change goals targeted by the 2015 Paris Agreement.

Keywords: High-performance design, residential energy use, net-zero homes, information feedback, pro-environmental behavior, values, place identity, environmental self-identity, and place attachment

Acknowledgements

The completion of this interdisciplinary doctoral program and dissertation was an enormous undertaking and the goal of a lifetime. I could not have completed either the program or this dissertation without the encouragement and guidance of numerous individuals in my life.

Committee Members. To Lynne Manzo, my advisor, whose expertise in environmental psychology and place attachment as well as grounded theory analysis was essential: thank you for teaching me the value of the iterative process, which is so crucial to qualitative research. I am grateful to Liz Sanders, whose careful attention to every detail of the statistical methods used in this dissertation was indispensable: thank you for teaching me the value of forthrightness so crucial to quantitative analysis. I am also incredibly thankful to Joel Loveland, whose deep knowledge of energy research was vital to the analysis of EUIs for high performance design: thank you for teaching me the value of patience. Thank you, Valerie Manusov for your thoughtful feedback on the dissertation during the defense process. Thank you, Linda Steg, Professor, University of Groningen, The Netherlands for sharing your insights on pro-environmental behavior during the proposal phase of the dissertation.

Professional Colleagues. Thank you to my professional colleagues and friends, who have supported me, both logistically and emotionally, in so many ways over the years. I would especially like to thank Jill Sterrett, UW Department of Urban Design and Planning, Nancy Rottle, UW Green Futures Lab, and Heather Burpee, UW Integrated Design Lab for your support and collaboration on so many related projects throughout the journey. To Louisa Peck, editor, Writing Dynamics: thank you for your thoughtful and careful guidance throughout the writing of this dissertation. I would not have been able to do this without you.

Professional Organizations. To the American Institute of Architects, thank you for the Upjohn Award, which funded the purchase of the PowerWise and SiteSage systems so crucial to the fieldwork portion of the research.

Communities. To the Built Green and Code-built Communities, a special thank you for allowing me into your "energy use" lives and to the board representatives who supported the project. To the architects and developers of the two communities: thank you for your permission to use your firm's construction drawings, energy models, and specifications.

Family and Friends. A depth of gratitude goes to my husband, Bill Walker, whose constant care, kindness, and sacrifice over the last six years has made this degree possible: thank you for teaching me the value of focus. To my two sons, Evan and Chris Walker, who have been supportive even as they sailed into the world on their own adventures: thank you for teaching me the value of being flexible. Finally, thank you to my family and friends: James and Cornelia Kriegh, Mary Alice Walker, Deb Clark, and Carol Cassella. I am especially grateful for the guidance of my dear friend Ann Miller from Duke University and my two brothers, Michael and Rick Kriegh, who have taught me so much about climbing Mt. Everest.

Table of Contents

List of Tables

Chapter 5

Chapter 6

Chapter 7

List of Figures

Figure **Page**

Singularity

by Marie Howe

Do you sometimes want to wake up to the singularity
we once were?

so compact nobody
needed a bed, or food or money —

nobody hiding in the school bathroom
or home alone

pulling open the drawer
where the pills are kept.

For every atom belonging to me as good
Belongs to you. Remember?

There was no *Nature.* No
them. No tests

to determine if the elephant
grieves her calf or if

the coral reef feels pain. Trashed
oceans don't speak English or Farsi or French;

would that we could wake up to what we were
— when we *were* ocean and before that

to when sky was earth, and animal was energy, and rock was
liquid and stars were space and space was not

at all — nothing
before we came to believe humans were so important
before this awful loneliness.

Can molecules recall it?
what once was? before anything happened?

No I, no We, no one. No was
No verb no noun
only a tiny tiny dot brimming with

is is is is is

All everything home[1]

---

[1] Retrieved (May 22, 2018) from https://www.brainpickings.org/2018/05/22/singularity-marie-howe-stephen-hawking/.

Chapter 1: Introduction

Net-zero energy buildings[2] 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 pay inadequate attention to 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 pro-environmental behaviors. 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 solutions to advance net-zero goals amid climate change.

Rationale

The recently ratified 2015 Paris Agreement[3] on Climate Change includes a new 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,"[4] according to Rachel Cleetus, lead economist and climate-policy manager at the Union of Concerned Scientists (Meyer, 2015).

---

[2] 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).

[3] In 2017, the United States of America withdrew from the 2015 Paris Agreement, however Washington and California are two Pacific coast states that continue to take steps to slow climate change pledging carbon reductions beyond what governmental policies suggest. Retrieved (August 6, 2018) from https://www.reuters.com/article/us-climatechange-summit-americas/california-and-washington-state-join-carbon-pledge-in-defiance-of-trump-idUSKBN1E625E).

[4] 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.

According to Meyer, the net-zero goal articulated in the agreement aims to "achieve a balance between anthropogenic emissions by sources and removal by sinks[5] of greenhouse gases in the second half of this century" (Meyer, 2015). The difficulty in achieving this balance becomes evident when we break down the total U.S. greenhouse gas (GHG) emissions by economic sector. In 2014, electricity production generated the largest share of emissions at 30%, transportation was next at 26%, industry at 21%, buildings at 12%, and agriculture at 9%, while the 'sink' or offset provided by land use and forestry was only 11% (EPA, 2016). However, these numbers can be misleading. When we consider residential buildings, for example, the challenge becomes greater than may be readily apparent. 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 miscellaneous electric loads, also known as MELs (EPA, 2016).

Significantly, the proportional impact of energy used for MELs by personal electronic devices continues to rise. 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 efficiency (Kwatra, Amann,

[5] The phrase "removals by sinks" refers to the absorption of greenhouse gases also known as offsets provided by land use and forestry (EPA, 2016).

& Sach, 2013), thereby rendering net-zero a target that is not only difficult to meet, but also moving.

Given these difficulties, what types of innovative pathways are available to spur the transition to net-zero energy? 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 improved land use zoning regulations and building code standards; 2) promoting higher performance buildings and building technological advances; and 3) shifting individual and collective perceptions, beliefs, values, and worldviews (IPCC, 2014). 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 standards, 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. The research presented in this dissertation suggests that progress toward the 2015 Paris Agreement's net-zero goal necessitates an interdisciplinary, multi-dimensional, and integrated approach.

Overview and Approach

An interdisciplinary, multi-dimensional, and integrated approach. In the field of Environmental Psychology, it is argued that the relationship between the built environment and human behavior is purported to be dynamic, interdependent, and bi-directional (Clayton, 2012).

However, in fields addressing sustainability, the role of the design of built environments in that relationship is often overlooked. Consequently, this research comprises an interdisciplinary investigation that integrates three lines of inquiry: 1) architectural design features conveyed as environmental cues; 2) values; and 3) place meaning expressed through place identity, environmental self-identity, and place attachment to understand how the dynamic relationships between humans and the built environment co-evolve and can inform high-performance design. Each of these lines of inquiry will be introduced conceptually and then explored in greater depth as the pertinent literature is reviewed in Chapter 2.

Key concepts. Before expounding on the present study in detail, it is useful to review several key terms and concepts that are particularly relevant to this research. First, the term "performance" refers to how buildings fare in terms of energy use and other environmental standards. This pertains especially to net-positive energy buildings and regenerative architectural design, both of which aim to meet high performance design standards found in future-oriented building codes that reach beyond net-zero energy. According to the International Living Building Institute (ILFI), a state-of -the-art high-performance regenerative building is one designed and "informed by its bioregion's characteristics, that generates all of its own energy with renewable resources, captures and treats all of its water, and operates efficiently" (ILFI, 2014, p. 2). This type of future-oriented building design standard takes aim at solving the climate change problem not only by creating sustainable development[6] that meets the needs of the present without compromising the ability of future generations to meet their own needs, but positing that net-positive construction must go beyond immediate needs and contribute to the needs of future

[6] The most frequently quoted definition of sustainability is taken from Our Common Future (1984), also known as the Brundtland Report: "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs." Retrieved (June 1, 2018) from http://www.un-documents.net/our-common-future.pdf.

generations. In this context, net-positive energy occurs when 5% beyond a project's 100% energy needs are supplied by on-site renewable energy on a net annual basis[7] (ILFI, 2014). This dissertation investigates the potential of high performance architectural design features which are necessary to meet net-zero and net-positive energy building standards to act as environmental cues that catalyze and inspire pro-environmental behavior.

Furthermore, this concept of performance includes both stable and dynamic dimensions. The performance is stable in that a physical context is designed and built to achieve certain performance standards (e.g., net-zero energy/water, comfort/well-ness, shelter/security, personal/social needs, 50 to 100-year construction and/or net-zero or net-positive buildings, Passive House, Living Building Challenge, One Planet Living). However, performance is dynamic in that the ways that occupants interface with their environments can vary. This study proposes that regenerative places and sustainable residential developments may serve as a locus of behavior (centers of activity, attention, or concentration) that cue people's responses and thus impact the environmental performance of their home and neighborhood. In this way, the bi-directional place-person interaction or bi-directional exchange is a dynamic construct.

Second, in regard to people, three key theoretical concepts are used in this study to explain the motivational forces underpinning participants' behaviors, pro-environmental and otherwise: values theory, goal framing theory, and the norm activation model (Steg, Bolderdijk, Keizer, & Perlaviciute, 2014a; Van der Werff & Steg, 2015). Values are desirable, trans-situational goals of varying importance that serve as guiding principles in life (Schwartz & Bardi, 2001). Notably, though values are stable and transcend individual circumstances, at their

[7] By contrast the U.S. Department of Energy defines a 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" (DOE, 2015, p. 4).

core they direct what people pay attention to and how they behave, depending on which values are prioritized in a given situation. Goals framing theory posits that goals direct or frame the way information is processed and acted upon, while situational factors provide information about the normative or appropriate action to take in a given situation (Steg, et al., 2014a). When trade-offs among competing values arise, a particular goal frame and set of situational factors increase the likelihood of a person's prioritizing certain values and taking certain actions (Schwartz, 2012; Steg, et al., 2014a) with regard to the environment.

Third, theoretical constructs related to place meaning offer key insights into pro-environmental behavior—in particular place identity, environmental self-identity, and place attachment. Place identity is defined as a person's incorporation of a place into their broader self-concept. It essentially refers to the extent to which people strongly identify with or hold personal feelings and associations in regard to a particular place (Gifford, 2014; Proshansky, Fabian, & Kaminoff, 1983; Twigger-Ross & Uzzell, 1996). Developed over time, place identity often provides a person with a sense of self-esteem, self-efficacy, and self-identity (Carrus, Sopelliti, Fomara, Bonnes, & Bonaiuto, 2014; Gifford, 2014). Environmental self-identity (ESI) refers to the extent to which people see themselves as the type of person who would engage in actions that protect a place or promote the well-being of the environment, a self-concept that may be strengthened by remembering past environmental actions (Van der Werff, Steg, & Keizer, 2013a, 2013b, & 2013c).

Place attachment, according to the framework of Scannell and Gifford (2010a), refers to a multi-dimensional construct including the person (individual and collective), process (affect, cognition, behavior), and place (physical and social). It refers to how an individual or group experiences and develops a meaningful connection to a social or physical place. In this framework, affect refers to the emotional aspects of place bonds. Cognition refers not only to the way one understands and thinks about place but also how a person identifies with it (hence, related to place identity). Behavior relative to place attachment refers to a sense of stewardship and the motivation to restore, enhance, or care for places that hold meaning (Lewicka, 2008, 2010, 2011). The development of place attachment may be immediate or evolve over time, and the experience of these people-place bonds may shift from positive to negative or ambivalent, especially toward a place of residence (Manzo & Devine-Wright, 2014). The emphasis for this research lies on understanding place attachment as meaningful relationships that can be expressed in people's environmental behavior, particularly energy use in the home.

All three of these theoretical constructs related to place meaning suggest that a person may be motivated to put the interests of the environment ahead of, or alongside, self-interest based on past actions and self-constructs (see also Van der Werff et al., 2013a; Whitmarsh & O'Neill, 2010). They may also increase the likelihood of a person's prioritizing values and intentions to act to promote the welfare of the environment. Thus, with respect to place meaning, this research seeks to link identity constructs and attachments to places that are designed with intention to include high-performance principles found in ILFI, International Passive House Association (iPHA), or One Planet Living (OPL) standards. Drawing such connections is important because who we are can include aspects of where we are, which in turn can motivate how we act—a reciprocal relationship (Kimmerer, 2013).

Research Gap

This research seeks to fill a significant gap in the literature. That is, to explore how, in a dynamic process, architectural design features may support and inform the depth of place meaning and inspire the prioritization of values which may motivate behaviors to maintain, enhance, and protect environmental resources in general and residential energy use in particular. Net-positive energy buildings[8] are designed to achieve or exceed pro-environmental climate change goals through multiple strategies incorporating performance standards, and design features and technologies, and on-site renewable resources (e.g., ILFI, iPHA, and OPL criteria). 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 relationship among people, place, and the locus of performance. This research seeks to understand these dynamics and processes via a multi-dimensional, interdisciplinary, and integrated approach.

A conceptual analogy. An analogy of the complex dynamic among people, place, and performance may be borrowed from quantum physics regarding electrons:

> They [electrons] only exist when someone or something watches them, or better, when they are interacting with something else. They materialize in a place, with a calculable probability, when colliding with something else. The "quantum leaps" from one orbit to another are the only means they have of being "real": An electron is a set of jumps from one interaction to another. When nothing disturbs it, it is not any precise place. It is not in a place at all. ~ Rovelli (2014, p. 17)

There is a similar dynamic among people, place, and performance in terms of energy use. Different dynamics between people and place may lead to a different prioritization of values,

[8] 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).

inform our self-concept, enable place attachments, and promote environmental behavior. 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 would promote a higher performance or exchange outcome that supports aspirational net-positive developments coupled with green lifestyles. This dissertation therefore proposes a model of people-place interaction as follows: LIFE—people's values and place meanings; BUILDING—architectural design features as environmental cues; and EXCHANGE—the locus of reciprocal relationships found in higher-performance designs inclusive of both buildings and behavior. This relationship can be expressed in the following way: **LIFE ←→ BUILDING ←→ Exchange.**

Conceptually, the framework for **LIFE**BUILDING***X*** (LBX) builds on the early work of Kurt Lewin from the 1930s, which posits that a person (P) in their psychological environment (E) comprise a life space (L) (Gifford, 2014). Over many decades this has been shorthanded to a formula in which behavior is understood to be a function of the person and the environment working in tandem – typically represented as B = f(P, E) (Proshansky, Ittelson, & Rivlin, 1970). 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 LBX framework proposed in this dissertation 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 dynamic processes dimensions 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 or benchmark behavior and promote higher performance buildings. Importantly, the LBX framework also follows 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).

.

Research Methods

Briefly, the mixed-methods research design (detailed in Chapter 3) employed in this research uses quantitative and qualitative techniques to analyze two Pacific Northwest communities carefully chosen for their similarities in location and demographics. The distinguishing factor is that one (the Built Green Community) was designed in 2013 using net zero-energy building technologies and site planning, while the other (the Code-built Community) was designed in 1991 prior to the development of high performance energy codes and low impact site design features. In each community, participating households were 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. Treatment consisted of access to an energy monitoring dashboard[9] in participants' homes that enabled household members to observe and inform their energy behaviors in real-time. Households' actual electrical energy use (utility billing data and circuit level monitoring data) was also measured at pre- and post-treatment (energy dashboard exposure) periods over the course of 12 months. Following treatment, focused interview questions sought to understand residents' perspectives on why they use energy as they do. Additionally, these questions explored

[9] Dashboard exposure: participants were given 24/7 access to their energy use in real-time via a feedback system with by PowerWise Dynamics and SiteSage. A detailed description of the feedback system is provided in Chapter 3.

possible meanings behind and connections to attachment and identity issues found in the lived experience of place that might promote changes in household energy use.

The following chapter surveys some of the prior research and literature related to residential energy use including: environmental cues, people's environmental values, and people-place relationships.

Chapter 2: Literature Review

Limiting the magnitude of climate change depends on a better understanding of the motivations that drive human behavior toward pro-environmental choices in the context of their built environments. It is also essential to devise ways to apply that understanding of human behavior to make effective design considerations that promote high-performance residential buildings and communities. This literature review investigates prior work pertinent to environmental choices, that is, environmental cues, values, and place meanings leading to a locus of performance (both physical and social). This review focuses on existing lines of inquiry in light of the co-evolutionary and bi-directional relationship between humans and the environment, which I call an exchange (Clayton, 2012; Stern, 2000). First, as I consider environmental cues, the emerging concepts of 'net-positive energy' buildings and 'regenerative' architectural design features are explored. With respect to people's values and their environmentally relevant behaviors, three important aspects of work by Steg and colleagues (2014a) are explored: values, goals, and situational factors. Finally, three dimensions of place meanings are examined: place identity, environmental self-identity, and place attachment.

This research seeks to understand the relationships among three distinct lines of inquiry from the literature on high-performance buildings and communities in connection with net-zero or net-positive energy outcomes. Specifically: 1) the influence of physical architectural design features as environmental cues for behavior, 2) the motivations (values) underpinning peoples' high-performance pro-environmental behaviors,[10] and 3) the role of place meanings people may ascribe to their lived experience of place and attachments that may also influence their level of engagement with their environment and impact energy-related behaviors and outcomes. While

[10] A pro-environmental behavior is defined as "a behavior intended to contribute toward the sustainability of the natural environment" (Schultz & Kaiser, 2012, p. 559).

each of these areas have been investigated in the literature, there is a lack of studies examining the intersection among the array of behavioral motivations found in people's values, place meanings, and responses to environmental cues holistically. Taken together, these dimensions may impact performance outcomes on environmental behaviors broadly and in regard to energy use specifically in the context of residential environments. The following sections will explore each of the above areas of the literature, identifying opportunities to connect the lines of inquiry and provide insight into how they inform the present research.

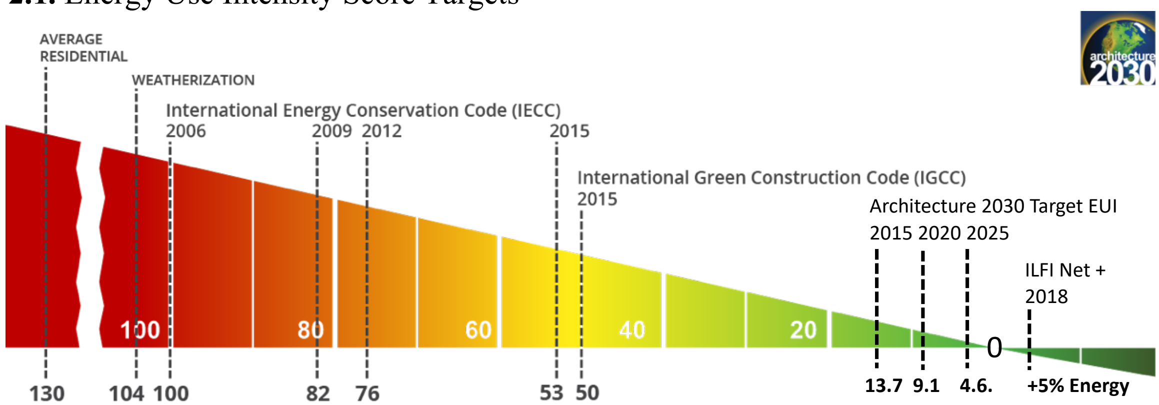
Environmental Cues

Energy use intensity and the challenge of net-zero energy. Along with the recently ratified 2015 Paris Agreement on Climate Change, the Architecture 2030 Challenge[11] acknowledges that buildings represent a primary source of energy consumption, using systems and materials that produce greenhouse gases (EPA, 2016; www.architecture2030.org). In 2015, the U.S. Energy Information Administration (EIA) estimated that 40% of total U.S. energy consumption occurred in residential and commercial buildings (EIA, 2015; see also EPA, 2016). In an effort to grapple with the challenges presented by global climate change, the Architecture 2030 Challenge calls for a reduction in energy consumption, aspiring to reach net-zero energy in the operation of buildings by the year 2030 (www.architecture2030.org). The program benchmarks reductions in energy consumption as measured in terms of energy use intensity (EUI) scores. EUI is an index that rates a building's energy performance as a ratio of energy used to square footage of the building per year (kBtu/sq.ft.yr.). The residential baseline EUI for a single-family house in the US in 1975 was set to 100 and all subsequent EUI scores reference this number. The average residential EUI for a single-family home in the US is currently 45.7

[11] The Architecture 2030 Challenge states that all new buildings, developments, and major renovations shall be carbon-neutral by 2030. Retrieved from www.architecture2030.org.

kBtu/sq.ft.yr. The Architecture 2030 Challenge proposes targeting incremental drops in the EUI scores for all new residential buildings from an initial 70% drop (13.7 EUI in 2015), to 80% (9.1 EUI in 2020), to 90% (4.6 EUI in 2025), and finally to net-zero energy in the year 2030 (www.architecture2030.org). Figure 2.1 below demonstrates the relative positioning of various codes and initiatives in relation to the Architecture 2030 Challenge goals.

Figure 2.1. Energy Use Intensity Score Targets



Source: Architecture 2030, Retrieved (June 22, 2018) from Google Images, https://www.google.com/.

Since 2006, low-energy buildings have become an increasingly standard approach and building with sustainability and high-performance technologies has become more normalized.[12] Even so, net-zero energy remains an ambitious goal, given that the most recent findings of the national Residential Energy Consumption Survey (RECS, 2009) show that gains in efficiency have been offset primarily by new energy consumption patterns (www.eia.gov.org). Significantly, although EUI scores are declining on a per square foot basis, energy use intensity at the individual per household level is increasing. This pattern is largely due to the increase in the number of new homes and the trend toward larger homes, and to the proliferation and increasing variety of consumer electronic devices per home (McNary & Berry, 2012; EIA,

[12] In the state of California, net-zero energy codes are being proposed for adoption for new residential buildings in 2020 and commercial buildings in 2030. Retrieved from www.architecture2030.org.

Drivers, 2015). As more people elect to use more electronic devices more frequently, the goal of net-zero becomes a difficult and moving target.

Consumer electronics. The cumulative effect on household energy consumption of more and "varied consumer electronics has offset efficiency gains" in traditional appliances and heating and cooling systems (McNary & Berry, 2012, p. 204.) To put the impact of consumer electronics (miscellaneous electric loads or MELs) into perspective, consider that saving 50% of U.S. energy now consumed by MELs would be approximately equivalent to eliminating U.S. oil imports from the Middle East. In fact, U.S. MELs alone exceed the primary energy consumption of more than 200 countries globally (Kwatra, et al., 2013). Furthermore, MELs have increased by 27% since 1990 (EPA, 2016). The top 10 appliances and devices drawing residential electric loads and reflecting behavior-driven lifestyle choices include the following: TVs, ceiling fans, set top boxes, personal computers (PC), microwaves, monitors, cordless phones, video game consoles, and DVD/Blu-ray players (Kwatra et al., 2013; Comstock et al., 2012). Significantly, the potential savings from switching to more efficient newer products on the market is estimated at around 50% for both residential and commercial applications (Kwatra et al., 2013). Since consumers are unlikely to upgrade all functioning devices to newer, more efficient models, in order for a reduction in energy use to occur, pro-environmental choices will have to play a greater role in the way people choose to live. While these lifestyle choices are crucial factors in reaching net-zero goals, forward-looking energy codes are also expected to play a pivotal role in reducing energy consumption over the next 20 years.

Energy codes and building energy consumption. With growing awareness of the human influence on climate change (2015 Paris Agreement and IPCC, 2014), building energy codes have received increased attention. A national model for energy codes was originally established in the 1970s due to the energy crisis at that time (www.bcap-ocean.org). These initial residential energy codes primarily addressed improvements to the building envelope. In the early 1980s, 50% of all homes still had single pane windows; by 2009, almost 80% had double or triple pane glass. Similarly, in the early 1980s, only 75% of all homes were insulated; by 2009, that number had increased to almost 90% (McNary & Berry, 2012). During this same time period, as national residential energy codes became increasingly stringent, associated energy savings resulted, benchmarked by the energy use index (EUI: kBtu/sq.ft.yr.). The U.S. residential EUI dropped by 10% in 1980s, another 7% by 2005, and 15% more by 2009 (Misuriello, 2011). Many of the corresponding gains in energy efficiency have been due to regulations (related to building envelope, space conditioning, lighting, and equipment efficiencies) that conserve energy regardless of occupant behavior.

The goal to increase gains in energy efficiency poses an interesting dilemma for the future of energy codes. On the one hand, energy-related building codes have been one of "the simplest and most effective tools available for reducing building energy use" (Cohan, Hewitt, Frankel, 2010, p. 79). On the other hand, the future of energy codes is less straightforward because most of the energy savings have come from areas that are already regulated and becoming a less significant part of a building's total energy usage (Cohan et al., 2010). If the goal is to reach net-zero energy in the building sector, then buildings must produce as much power as they consume (Cohan et al., 2010). Logically, if this balance is to occur, energy consumption on a per-household level must be reduced, while energy generation by renewables must be increased.

Energy codes are likely to provide a key tool in this regard. However, future energy codes ought to include a means for regulating actual energy used, targeting outcome-based reductions (Cohan et al., 2010). Furthermore, as building energy codes become more stringent, regulated loads will continue to decrease as a percentage of overall building energy, such that MELs will account for higher percentages of energy use, necessitating new stipulations in energy guidelines (Cohan et al., 2010).

Future codes. Future energy codes could address the currently unregulated MELs. However, regulating MELs could prove difficult since they are highly influenced by user behavior and involve devices likely to be replaced more frequently than major appliances (Cohen et al., 2010, see also Comstock & Jarzomski, 2012). Recall that for residential buildings, MELs fall into the category of unregulated plug loads. Hence, imposing a total energy use budget might prove effective, noting that such a strategy is likely to involve feedback systems (energy use dashboards) with regard to building performance (Cohan et al., 2010). In addition, buildings could be circuited and metered to obtain data on not only overall energy consumption but also specific MELs driven by occupant behavior (Cohan et al., 2010, p. 84).

Further, the ability to predict the relationship between energy codes and actual energy use by individuals in individual buildings poses challenges. Comstock and Jarzomski (2012) point to voluntary efficiency programs targeting MELs such as ENERGY STAR; however, not all products meet specifications for inclusion and many manufacturers choose to not participate. The federal appliance standards program has been the primary means for regulating most major household appliances and setting equipment efficiency standards. Yet the fastest growing source of energy consumption, MELs, are currently overlooked by both government and most voluntary programs (Comstock et al., 2012; Kwatra et al., 2013; McNary & Berry, 2012; Cohan et al., 2010). Regulatory codes may seek to correct this problem in the future.

Current voluntary programs serve as demonstration projects for energy efficiency. Leadership in Energy and Environmental Design (LEED) for Homes, International Passive House Association (iPHA), International Living Futures Institute (ILFI), and One Planet Living (OPL) are all programs that promote net-zero energy or require net-positive energy. One example, set by the iPHA standard, factors MELs into its outcome-based energy-modeling program. Outcome-based energy-modeling programs comprise just one way to address the current spike in MELs. Another way is regenerative architectural design, which requires that building designs be informed by bioregional characteristics and that they generate all their own energy with renewable resources (ILFI, 2014). In this context, net-positive energy occurs when 5% beyond a project's 100% energy needs are supplied by on-site renewable energy on a net annual basis. Importantly, ILFI net-positive energy buildings are designed to exceed pro-environmental goals through multiple strategies incorporating building and site performance standards and innovative technologies as well as on-site renewable resources. In these cases, no requirement measures an occupant's actual energy use or informs users of the impact of their behavior regarding real-time energy use. In summary, energy codes offer designers both a rearview mirror reflecting how far we have progressed in terms of energy conservation and also a sketch of the future. Looking at energy use nationally, the U.S. RECS offers an important benchmarking tool for measuring energy use in existing buildings, as described below.

U.S. Residential Energy Consumption Survey (RECS). The Residential Energy Consumption Survey (RECS: www.eia.gov) provides a comprehensive data set on U.S. residential energy consumption. RECS involves a periodic survey of U.S. housing units and is implemented by the Energy Information Administration (EIA) (McNary & Berry, 2012). From the first survey conducted in 1978 to the most recent, completed in 2015, RECS has provided researchers from a variety of fields a survey-based data set spanning over 30 years.[13] Briefly, RECS includes a comprehensive two-part survey which McNary and Berry (2012) summarize as follows: (1) an interviewer visits a residence (selected from a random sample of all occupied units in the US) and collects information on all energy consuming devices (end-uses) such as heating and cooling systems, lighting and appliances, as well as electronics and computers. The floor area is measured, the general characteristics of the residence noted, and demographic information for the occupants recorded. (2) From utility companies, the interviewer collects billing information for each residence spanning two years. Once the data are finalized, various statistical models are used to estimate the energy consumed by major end-uses[14] by region across the U.S.

Many factors influence residential energy use, including number of households, structural changes (mix of housing types, regional distribution, and average square footage), intensity, (ratio of energy consumed to square foot of living area), and seasonal weather (EIA, Drivers, 2015). Though these factors are cumulative, during the 1980-2009 period, increases in both the number of housing units and the average size of homes comprised the two most significant factors resulting in an increase in energy consumption per home, while the total average aggregate EUI declined (EIA, Drivers, 2015, p. 1). A closer look at the RECS data over time provides some reasons for the decline in EUI concurrent with an increase in consumption.

Incremental RECS analysis for years 1980-1990, 1990-2001, and 2001-2009 reveals that the largest decline in aggregate EUI occurred between 1990 and 2001. This decrease may reflect the impact of post-1990 appliance standards, building codes, and other energy efficiency

---

[13] The 2009 RECS include data on 12,083 residential units (McNary & Berry, 2012). The 2015 RECS will be released in 2018.
[14] Major end-uses include space conditioning, lighting, water heating, and major appliances.

programs, all of which converged to promote a decline in energy intensity. McNary and Berry's (2012) study supported such a hypothesis. They suggested that homes built in the 1970s and 80s had the least efficient systems within the least efficient buildings, and that since 1980, newer homes have become generally more efficient even as they have become larger. This shift is attributed to efficiencies in equipment and building envelopes (e.g., better wall insulation and double pane glass) (McNary & Berry, 2012). The decline in energy use intensity from 2001-2009 was smaller than that of the previous period, a trend that might be affected by the increase of MELs per home (EIA, Drivers, 2015; McNary & Berry, 2012).

Though efficiency improvements in minor end-uses (small appliances and electronics) were significant, RECS data confirmed that the proportion of overall minor end-uses has steadily increased from 17% in 1978 to 31% in 2005 (McNary & Berry, p. 206) to 52% in 2015 (retrieved, October 10, 2016, from http://www.eia.gov), suggesting that consumer use patterns (behavior) within the home constitute a significant contributing factor. For example, the rate of ownership of personal computers (PCs) and their associated peripherals per household has risen from essentially zero in 1978 to 76% in 2009 for at least one PC and 35% for multiple PCs. In 1978, most homes had one TV, but by 2009, the average had risen to 2.5. Peripheral devices virtually nonexistent 15 years ago, such as DVD, DVR, Blu-ray, and video game stations, are now not only common household items but in many cases never turned off. Rates of rechargeable devices (e.g., cell phones, tablets, laptops) have also dramatically increased. By 2009, more than 57 million homes had 1-3 devices, 36 million had 4-8 devices, and 8 million had more than 8 devices (McNary & Berry, 2012, p. 209 – 210). The number and variety of individual electric end-use devices in U.S. homes continue to increase to such an extent that residential electronics draws have begun to offset building level energy efficiency gains of the last 30 years (McNary & Berry, 2012, p. 210).

RECS data allows a comparison between average consumption rates at the national and regional level and consumption rates of the study research sites. RECS data captures location (e.g., U.S., Pacific Region, Washington State, Marine Climate), building type (e.g., single family), energy used (e.g., total electric energy), and major electric energy uses (e.g., space conditioning, water heating, appliances, electronics, and lighting). This information is useful for understanding how a given household uses energy compared to households of interest in the same region. This dissertation examines the energy use in two residential communities in the Pacific Northwest, one built pre-2000 and the other post-2000. The EUI for each of these communities should reflect low and high-performance buildings tempered by behavioral performance and lifestyle choices associated with MELs.

Environmental cues. Surveying the literature on environmental conservation and psychology, Schultz and Kaiser (2012) found that research on behavioral change and lifestyle choices fell into two camps—studies with an emphasis on the person-context and those with an emphasis on the physical context. Approaches that consider the person include research on values, goals, social marketing, and motivations. Methods that concentrate on physical context include practical structural considerations such as convenience and affordance. Indeed, many of the studies on environmental problems and behavior, some of which are described in the following section, take a person-context oriented approach, emphasizing the role of values, beliefs, and motives in predicting and promoting pro-environmental behavior. Two lines of research with respect to place- or physical-context oriented research are pertinent to this dissertation.

Dietz, Gardner, Gilligan, Stern, and Vandenbergh (2009) discussed the merits of impact-driven household actions that can be undertaken to reduce detrimental environmental outcomes and reduce U.S. carbon emissions. In this case, they proposed 17 household actions in five basic categories that, if undertaken, would have an immediate and lasting impact on household energy use. For each of the behaviors, Dietz et al. estimated the likelihood that a behavior could be changed by calculating the relevant population that had not yet adopted a behavior (behavioral plasticity), the amount of carbon emissions that could be saved (penetration), the reduction in carbon emissions over 10 years, and the percentage of carbon savings expressed as a total of the U.S. individual/household sector emissions. Dietz and colleagues referred to these savings “a behavioral wedge” (Dietz et al., 2009, p. 18452) in order to emphasize the power of behavior as a piece of the carbon emission pie chart. Behaviors are choices that individuals can make if they elect to engage in household-specific actions as shown in Table 2.1.

Key to this dissertation is the idea that, as people engage in some of these energy-related behaviors, the very act of engaging may directly influence a propensity for other pro-environmental actions and indirectly spur feelings of environmental self-identity and influence actions. Engagement may also be related to feelings of attachment to one’s home and involve actions that maintain, improve, and care for it.

Table 2.1. Carbon Emissions Reductions from Household Actions.

Behavior change	Category	Potential emissions reduction (MtC)	Behavior plasticity (%)	RAER (MtC)	RAER (% Indvid./HH)
Weatherization	W	25.2	90	21.2	3.39
HVAC equipment	W	12.2	80	10.7	1.72
Low-flow showerhead	E	1.4	80	1.1	0.18
Efficieint water heater	E	6.7	80	5.4	0.86
Energy Star Appliances	E	14.7	80	11.7	1.87
Low-rolling resistence tires	E	7.4	80	6.5	1.05
Fuel-efficient vehicle	E	56.3	50	31.4	5.02
Change HVAC air filters	M	8.7	30	3.7	0.59
Tune up AC	M	3	30	1.4	0.22
Routine auto mainenance	M	8.6	30	4.1	0.66
Laundry temperatures	A	0.5	35	0.2	0.04
Water heater temperatures	A	2.9	35	1	0.17
Santdby electricity	D	9.2	35	3.2	0.52
Thermostat setbacks	D	10.1	35	4.5	0.71
Line drying	D	6	35	2.2	0.35
Driving behavior	D	24.1	25	7.7	1.23
Carpooling and trip-chaning		36.1	15	6.4	1.02
Total		233		123	20

Category: W= weatherization, E= efficiency, M= maintaining, A= adjusting, D= daily use
Potential emissions: the amount of carbon emissions that could be saved (penetration)
Behavior plasticity: relevant population that has not yet adopted a behavior
Realistic achievable emissions reductions: RAER, the reduction in carbon emissions over 10 years
RAER: percentage of carbon savings expressed as a total of the U.S. individual household sector emissions

Source: Dietz et al., 2009.

A context-oriented approach presents pro-environmental behavior as largely a product of the physical environment in which it occurs (as suggested by Schultz and Kaiser, above) but recognizes the physical attributes of a setting (as this dissertation investigates) as environmental cues in and of themselves that encourage pro-environmental actions in high-performance buildings and communities. Current voluntary code programs such as LEED for Homes, iPHA, ILFI, and OPL serve as a source of aspiration in this regard, as they all promote net-zero energy or require net-positive energy. These aspirational design standards showcase high-performance design features that are explored as environmental cues in this dissertation. The opportunity for this line of inquiry is demonstrated in the work of Steg and Vlek (2009), who illustrated that the physical context may prompt pro-environmental behavior in several ways: first, as a direct influence through availability and convenience (e.g., ready access to public transportation); second, as a mediator between values and social normative beliefs (e.g., active neighborhood recycling program); third, as a moderator between values, personal norms, and behaviors (e.g., predilection toward smart metering), and forth, as a frame activating different motivational goals. Even so, Schultz and Kaiser (2012) asserted that few psychological studies on environmental issues have focused on the role of the physical built environment for promoting pro-environmental behavior. In this dissertation, I investigate the role of architectural high-performance design features as an important environmental cue to promote high-performance behavior as well as high-performance outcomes in terms of energy use in net-zero buildings.

People's Environmental Values

Values theory. In the energy conservation literature, many social and environmental psychologists investigating behavior and the possible motivations behind general environmental actions have maintained a core premise that environmental behaviors are motivated by a set of relevant values, a priori (Abrahamse, Steg, Vlek, & Rothengatter, 2005; De Groot & Steg, 2008; Dietz, Fitzgerald, Shwom, 2005; Dietz, et al., 2009; Schwartz, 1992, & 2012; Schwartz & Bardi, 2001; Steg et al., 2013; Stern, 2000; Van der Werff & Steg, 2015). According to Schwartz, who first identified the importance of value orientations in the early 1970s and wrote about the universal nature of the values in the early 1990s, the structure of values can be summarized as follows (Schwartz & Bardi, 2001, pg. 262):

1. Values are beliefs, cognitive structures that are closely linked to affect [infused with feeling and have an emotional impact]
2. Values refer to desirable goals
3. Values transcend specific actions and situations
4. Values serve as standards or criteria
5. Values guide the selection or evaluation of actions, policies, people, and events
6. Values are ordered by importance relative to one another
7. The relative importance of a set of relevant values guides action
8. Trade-offs among competing values may occur simultaneously

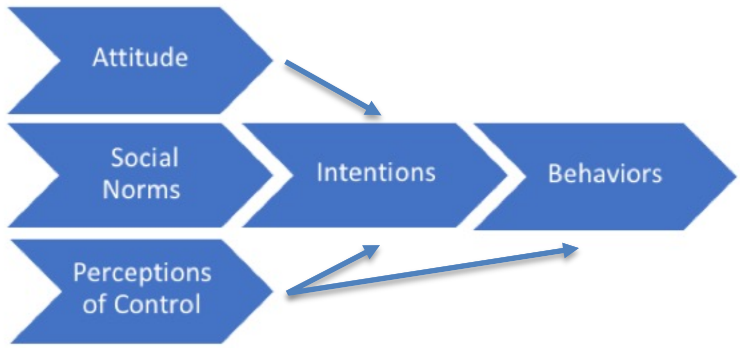
Values theory identifies four key attributes of values. First, values reflect general beliefs leading to preferred outcomes. Second, values are maintained over time and transcend specific situations. Third, values function as guiding principles in one's life, influencing many attitudes, norms, intentions, and actions simultaneously. Finally, values are thought to be relatively stable as they can be prioritized according to their relevance in a given situation and influence a broad range of behaviors (De Groot & Steg, 2008, 2012; Schwartz, 1992, 2012; Schwartz, & Bardi, 2001; Steg & Vlek, 2009 & Steg et al., 2014a; Stern, 2000). Another important feature of this model is the close link to affect, which will be explored in the section on place meanings and person-place bonds later in the literature review.

The value orientations most germane to pro-environmental actions are divided into self-transcendent and self-enhancing categories. Self-transcendent orientations encompass altruistic values (expressing a concern for community and other people) and biospheric values (demonstrating a concern for the quality of the environment for its own sake); self-enhancing orientations include egoistic values (enhancing and protecting self-interests such as status, time, and convenience) and hedonic values (promoting pleasure and feeling good). Notably, strong biospheric values (such as conserving energy to reduce pollution) are considered to be enduring intrinsic motivations (Steg et al., 2014a). Though these value structures themselves are thought to be stable guiding principles in a person's life, in order for a person to be motivated to undertake pro-environmental actions, simply holding the value(s) is not enough. Rather, which values a person prioritizes, which values a person attends to, and which values a person acts upon are selections that are crucial to environmental behaviors.

Behavioral models. According to the literature, the prioritization of values leading to actions may vary based on a number of influential factors. Several prominent models presume that rational thinking drives choices in behavior, including the theories of planned behavior (TPB) and the theory of attitude, behavior, constraints (ABC) focusing on the role of the individual's assessment; the norm activation model (NAM) and the value-belief-norm theory (VBN), where moral considerations are the central drivers; and goal framing theory, which looks at an integrated framework informing environmental behavior (Steg et al., 2013; Stern, 2000; Van der Werff et al., 2015). Each of these early theories offer insights into the present study and are addressed below.

Early research in environmental psychology emphasized the importance of individual rational choices and intentions, which developed into the Theory of Planned Behavior (TPB) (Ajzen, 1991; Ajzen & Fishbein 1975, 1980; Stern, 2011), illustrated in Figure 2.2. The premise was that the stronger one's intentions, based on a reasoned cost/benefit calculus for oneself, one's social capital, and one's efficacy to control outcomes, the more likely a behavior would ensue. All other factors were thought to influence behavior indirectly, including values, beliefs, and other situational factors (e.g., socioeconomics and demographics) through attitudes, norms, and perceptions of control (which may influence via intentions or behavior directly).

Figure 2.2. Theory of Planned Behavior.

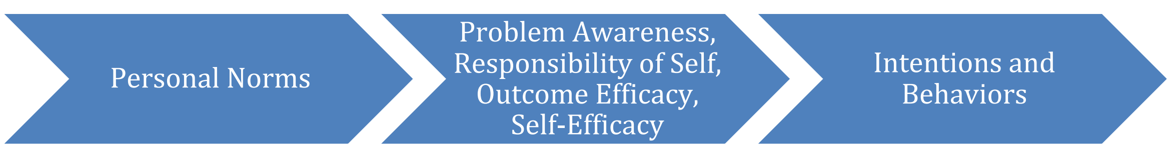


Source: Ajzen & Fishbein 1975, 1980; Stern, 2011.

Another early theory, the Attitude Behavior Context (ABC) Theory (Guagnano, Stern, & Dietz, 1995), suggested that behavior was primarily a function of attitudes and contextual constraints. The core argument in this theory was that individual perceptions influenced individual decisions made in the context of constraints that were consequential in shaping individual and ultimately group behavior with regard to the environment. For example, if a behavior is difficult, time-consuming, or expensive, then this context constrains action and is likely to have a dominant influence on behavior, overriding values favoring actions that are good for the environment (Dietz et al., 2005). Significantly, the TPB and the ABC models signaled the importance of one's perceptions of self and social efficacy (normative expectations) and the influence of contextual factors.

Building on these early theories, later researchers have understood personal norms to be foundational in linking a concern for the environment with environmental behavior. General theories find that personal norms that concentrate on concerns beyond a person's immediate social environment (e.g., self-transcendent or altruistic/biospheric values vs. self-enhancing or egoistic/hedonic values) are stronger among people who engage in pro-environmental activities (Schwartz, 1973; Stern, 2000). The Norm Activation Model (NAM) states that when people feel a moral obligation to act on their personal norms, pro-environmental actions follow (Schwartz, 1973; Steg, Dreijerink, & Abrahamse, 2005). The activation of personal norms is a defining feature of this model. The theory holds that behavior occurs differently in response to personal moral norms activated in individuals who believe particular conditions pose adverse consequences for others with regard to environmental quality, feel a moral responsibility for action, are able to identify actions worthwhile to pursue, and have the capability to engage in those actions. That is, as suggested in the diagram of Figure 2.3, individuals are first aware of problems caused by their behavior, they feel responsible, and they consider solutions before they feel a moral obligation to protect the environment (Steg & De Groot, 2013). Thus, the activation of personal norms is mediated by situational factors.

Figure 2.3. Norm Activation Model.



Source: Schwartz, 1973; Steg & De Groot, 2013.

Stern (2000) first developed the value-belief-norm (VBN) theory of environmentalism to propose a structure that linked a variety of theoretical perspectives espoused by NAM, NEP,[15] and ABC, positing that values in the context of worldviews are central determinants of pro-

---

[15] More generally, the new ecological paradigm (NEP) by Dunlap, Van Liere, Mertig, and Jones (2000) emphasizes that an individual's environmental worldview is a predictor of pro-environmental behavior when aligned with a belief that human activity and a healthy biosphere are linked.

environmental behavior. As is illustrated in Figure 2.4, values are activated as people hold a belief that humans and the environment are linked, an awareness of problems/consequences, and a sense of efficacy/responsibility to impact the outcome, which in turn activates a normative sense of obligation to act (Dietz et al., 2005; Steg & De Groot, 2013; Stern, 2000; Van der Werff et al., 2015).

Figure 2.4. Value-Belief-Norm Theory.

Source: Stern, 2000.

For example, consider the following scenario with regard to NAM: the prioritization of self-transcendent (altruistic or biospheric) values becomes likely when a belief about climate change increases an awareness of consequential pollution from energy production, coupled with a feeling that one needs to establish a preferred solution to these environmental problems by decreasing one's personal role in energy consumption. This combination results in a decision that one ought to take pro-environmental actions in line with activated personal norms, informing an actual behavior to install solar panels on one's home. An important consideration for this dissertation is that each variable in a causal line is related to the next or may be related to other variables, mediating the prioritization of values influencing different types of behavior, such as environmental citizenship (group or organizational) and/or individual behaviors (Steg & De Groot, 2013; Stern, 2000; Van der Werff et al., 2015).

Other research on determinants of behavior examines social (group) normative influences over personal norms (Griskevicius, Cialdini, & Goldstein, 2008). An example of social normative influence is the study in which littering was seen as the social norm, so others followed suit, adding to the littered environment. Building on social normative research is the community-based social marketing (CBSM) method developed by Mckenzie-Mohr (2000 & 2011), which focuses on efforts to change behaviors. Information, media campaigns, and advertising are effective in creating awareness, but programs fostering behavior change are most effective when end-state behaviors are identified and programs developed specifically to address a particular behavior. For example, the installation of an LED light bulb—not its mere procurement— is the end-state behavior required to reduce the use of electrical energy. Whereas CBSM research is context-specific and addresses specific individual behaviors with the goal of changing a particular behavior, this dissertation is interested in a broader understanding of people's motivations to act and a broader range of actions taken in the home around environmental behaviors in general and energy related behaviors in specific.

More recently, the work of Van der Werff and Steg (2015) has pointed out that in order to effectively mitigate climate change, people need to engage in a wide range of pro-environmental behaviors (versus one end-state behavior as CBSM suggests), some of which may be situationally more or less difficult or convenient. First, Van der Werff and Steg (2015) suggested that, with regard to energy use behaviors, a general conception of NAM should be more strongly related to general indicators of energy use in order to predict a wide range of energy-related behaviors, including relatively difficult energy behaviors such as choices of personal transportation (involves time and convenience) or building-related improvements such as the installation of solar energy panels (involves time and cost). Second, they suggested that the more people are aware of environmental problems caused by energy consumption, the more motivated they will be to reduce these problems by changing their energy consumption behaviors. In turn, the more people feel that they can reduce these problems, the stronger their feelings of moral obligation to save energy, which in turn predicts their intention to save energy.

However, research has shown that behaviors often fail to follow this pattern. In some situations, people rationalize their behaviors and may decide to act in accordance with self-interest, saving time and increasing convenience, for example, by driving a car instead of riding a bike or using more energy on home heating instead of making structural improvements on weatherization or for solar energy use. According to Steg and colleagues, such decisions are directed by the predominant goals in a given situation (Steg et al., 2013; Steg, et al., 2014a). The mechanisms by which goals influence environmental behaviors such as energy consumption have been explained in what researchers refer to as goal framing theory, which differs from contextual awareness constraints proposed by earlier theories as goal framing is rooted in value orientations as described below.

Goal framing theory. Goal framing theory (GFT) maintains that behavior is directed by three overarching and predominant goals: hedonic goals toward the gratification of desires, egoistic gain goals toward the protection of one's individual resources, and normative goals to act appropriately (Steg, et al., 2014a). Goal framing theory posits that these three goals in particular hold sway over which information people pay attention to in a given situation and what action alternatives they consider that lead to a selected behavior. The goal most central or focal in a given situation will exert the strongest influence on decision-making while the other goals become peripheral. Hedonic goals, however, are considered a priori strongest while normative goals are weakest and become focal only with external support (Steg, et al., 2014a; Steg, Perlaviciute, Van der Werff, Lurvink, 2014b). Because goals direct or frame the way information is processed and acted upon, it is important to consider what factors might reduce or remove inherent conflicts between hedonic goals, gain goals, and normative goals, particularly in situations that involve conflict between self-interest (hedonic and gain goals) and collective interests (normative goals) (Van der Werff & Steg, 2015). While Steg and colleagues have found that hedonic goals exert the strongest sway in a person's decision-making, the likelihood that those values will be acted upon increases when they are held in conjunction with values (altruistic, biospheric, egoistic, and hedonic) that have been activated. This phenomenon will be further explored in the section following the upcoming review of situational cues. For the purposes of this dissertation, it is important to consider not only ways of reducing conflicts between values but also a variety of ways to support pro-environmental values in relationship to pro-environmental actions in the context of the environment.

Situational cues. The strength of goals may depend not only on individual value orientations but also on cues in a given situation (Steg et al., 2014a). People with strong self-enhancing values may engage in pro-environmental behaviors only when cued to perceive the potential to increase personal gain goals or hedonic goals. In other words, the worthiness of the effort is judged in relation to the self-enhancing goals and values (hedonic and egoistic). In contrast, people with strong self-transcendent values (biospheric and altruistic) are more attuned to normative goals and are more likely to 'do the right thing' for the benefit of the environment with far less regard for the costs to themselves. Normative goals such as recycling are likely to persist when people embrace self-transcendent biospheric values (protecting the earth's ecosystems), especially when they are activated and supported by cues in the context in which the decision is being made. For example, the aforementioned 1990s field experiment by Cialdini, Reno, and Kallgren provided an illustration of this concept, known as the focus theory of normative conduct, showing that people were more likely to litter in an already littered environment (Griskevicius et al, 2008). Similarly, Keizer, Lindenberg, and Steg (2008) demonstrated that people were more likely to litter in an area where buildings were covered in graffiti. These two studies have shown that where norm violations are already evident, people are likely to also violate the norm. Conversely, cues can signal respect for a norm that reveres the environment (the presence of others acting pro-environmentally) and increase the likelihood that a person will follow suit. According to Keizer, Lindenberg, and Steg (2013), observing others acting on self-transcendent values may suppress people's hedonic and gain goals while enhancing the strength of normative goals.

This tendency for socially-based situational cues to influence behavioral outcomes is particularly salient in the context of the present study's investigation of sustainable high-performance buildings and settings where residents make day-to-day decisions with regard to energy consumption—decisions that may be cued not only by the social actions of fellow residents (as noted in the literature referenced above) but also by extending this line of thinking to include physical cues in the built environment as newly explored in the research for this dissertation (see also Steg et. al., 2014a).

In this research, I suggest that architectural design features may act as environmental cues. For example, in an environmentally sustainable residential community, visible and easily accessed recycle stations, bike barns, as well as attractive gardens and winding walkways may cue a number of pro-environmental behaviors such as zero-waste, biking, organic gardening, and walking. Rooftop solar arrays visible on most homes may signal that it is normal for people to produce renewable energy—an environmental cue which may influence people to conserve energy used in the home. Alternately, the research of Steg and colleagues (2014a) has suggested that people might also use more energy in such circumstances (saving time by leaving electronic devices plugged in and powered all the time), believing that energy conservation is not important because sources of renewable energy are already benefiting the environment. In this case, where multiple goals stand at odds, understanding why people use energy in the ways that they do becomes key. The Integrated Framework for Encouraging Pro-environmental Behavior, described below, suggests one approach to reducing conflicted goals and understanding these behaviors (Steg, et. al, 2014a).

Integrated Framework for Encouraging Pro-environmental Behavior (IFEP). The IFEP proposed by Steg and colleagues (2014a) suggests that it is possible to reduce conflicting goals by aligning values, goals, and situational cues, thereby setting the “frame” for pro-environmental behaviors. The IFEP holds that it is possible for people to address multiple goals simultaneously so that, rather than conflicting, hedonic and gain goals can become compatible with normative goals (supporting self-transcendent values). This alignment might be attainable for several reasons. First, Steg and colleagues (2014a) have found that pro-environmental behaviors are more likely to occur when one’s environmental self-concept is supported and the behaviors contribute to a sense of feeling good (hedonic goal), allowing one to maintain and enhance a positive environmental green self-image (gain goal) in doing the right thing (a situational cue activating normative goals) for the environment. Second, pro-environmental behaviors are more likely when they are perceived to elevate one’s self-esteem and status (Steg et al., 2014a; Whitmarsh & O’Neill, 2010). Important for this dissertation is the hypothetical example that a person who believes it is important to reside in an environmentally sustainable community, own a net-positive energy home, or install solar panels to provide renewable energy may feel good not only about protecting personal and community environmental resources (gain and normative goals), but also about the high visibility of their solar panel array as it increases their feelings of social status and influence (hedonic goal: Steg et al., 2014b) and environmental self-identity (see also Whitmarsh & O'Neill, 2010).

In summary, the Integrated Framework for Encouraging Pro-environmental Behavior (IFEP) seeks to reduce conflict between normative and self-enhancing goals by uniting goals, thus setting the frame for pro-environmental behaviors. Situational cues in the environment support this dovetailing by providing information about the appropriate action in a given situation (social cues signaling values and the appropriateness of doing the right/wrong thing), thus strengthening normative goals, prioritizing biospheric values, and motivating pro-environmental behaviors (Steg et al, 2014a).

This research aims to extend this line of inquiry by looking at the potential of sustainable high-performance architectural design features to act as physical environmental cues in residents' values dynamic. Furthermore, as suggested above, the IFEP is one method or line of reasoning that explains value congruence with goals and behaviors; however, other mechanisms may be worthy of exploration, as suggested by the work on environmental self-constructs and the power of green self-identity by Whitmarsh and O'Neill (2010) noted above. Affective motives may be more complicated and involve emotions beyond hedonic considerations of feeling good, as indicted in research on people's relationships to the natural environment (Schultz & Tabanico, 2007; Clayton, 2012). However, feelings that are centered on place meanings in the built environment might also contribute to people's relationships to place and how they make sense of their experience of place in relationship to pro-environmental behaviors as described below.

Place Meanings

> "As we are all inextricably embedded in a physical context, we are compelled to understand the nature of our relationships to place" (Manzo & Perkins, 2006, p. 335)."

The literature described earlier demonstrates the mechanisms associating values with beliefs, goals, situational cues, and norms leading to environmental behaviors. In doing so, it addresses seven out of the eight core elements in the values structure enumerated by Schwartz and Bardi (2001) as described in the Values Theory section of this study on page 25. However, less attention has been paid to understanding the role of place-related affect and meanings in values orientations. For example, the first item in Schwartz and Bardi's values structure states that "values are beliefs, cognitive structures that are closely linked to affect" (affect is defined as infused with feeling and having an emotional impact). In this section, I examine the literature related to place meaning, particularly the concepts of place identity, environmental self-identity, and place attachment to consider how they might inform value orientations and energy use behavior among participants in this study.

Place identity. Recent writings by Clayton (2012) have indicated that "identity is fundamentally a way of defining, describing, and locating oneself" (p. 165). Additionally, people may maintain multiple identities that are fluid and can vary in significance over a lifetime and across different physical and social contexts (Devine-Wright, 2009; Clayton, 2012). Devine-Wright (2009) has pointed out, however, that some research assumes that physical environments provide a mere backdrop to the ongoing personal and social events in everyday lives, while other research holds that physical places are more significant; rather, they may provide a rich set of cognitive and emotional associations that resonate with a sense of self growing out of experiences with the physical environment.

Self-construct and social-constructs. Clayton (2012) has asserted that self-relevant constructs impact what a person pays attention to when building relationships in both social and physical environments. Identities influence a person's evaluations of self and their social group, and, in turn, self-image can be enhanced when an individual works with a social group for the good of that community (e.g., commons dilemma[16]). Most important, according to Clayton, is an ability to identify with and act in ways that are consistent with a desirable self-image and to make meaning in one's life. For example, connecting with a specific place and connecting to others with shared values can be nurtured through activities in a community garden where environmental self-identity meets social identity. According to Clayton, gardening is a public expression of the self-proficiency that affirms not only a self and a social identity through an individual's participating in a community goal but also a recognition of interdependence with a larger ecosystem and social system (2012). In this example, the phenomena of the self, the social context, and the physical context are intertwined—a significant relationship that is explored in this dissertation in connection to environmental behavior.

Care for the environment. Particularly pertinent to this dissertation are the research findings that link self-identity to concerns, protection, and care for a given place. Carrus, Bonaiuto, and Bonnes (2005) found that feelings of pride in one's place of residence were associated with self-esteem and support for a local protected area. Additionally, a sense of social identity increased concern for the environment and willingness to protect it (Clayton, 2012). Care for place may influence how an individual or group engages with the natural environment as well as the built and social environments—a concept relevant to this dissertation in that it echoes environmental self-identity, defined as the extent to which one sees oneself as a type of person who acts (pro-) environmentally (described in the following section). That is, a person

[16] Commons dilemma is a term used to describe a situation where the actions of the individual that may deplete a common resource are overridden (even though it may be in their self-interest to use the resource) by a collective interest to preserve the resource through group action (Tragedy of the Commons, retrieved (August 16, 2018) from https://en.wikipedia.org/wiki/Tragedy_of_the_commons). A commonly given example is over-grazing, but one could also cite over-fishing, or over use of water resources as well as the pollution of water resources as examples.

may be more inclined to take actions that support a light ecological footprint as an expression of care in protecting a place as well as supporting a green self-identity (see also Whitmarsh & O'Neill, 2010).

Born of experience with the physical environment. Central to place identity is its dynamic quality, with changes occurring over time and in response to physical environments. Identity concepts described by Clayton (2012) and Devine-Wright (2009) are consistent with Proshansky and colleagues' place identity theory that holds that the relationship between self-identity and place and can be strengthened through day-to-day experience over the course of one's life (Proshansky, Fabian, & Kaminoff, 1983). Proshansky and colleagues described place identity as a construct that is a "sub-substructure of self-identity of the person, consisting of perceptions about the physical world in which the individual lives" and includes "a potpourri of memories," interpretations, ideas, and related feelings about specific physical settings and types of settings (Proshansky et al., 1983, p. 59). Furthermore, place identity is rooted in "assimilated values, norms, and attitudes made salient in a person's day-to-day life" (p. 62), place identity is thought to reflect strong emotional attachment to particular places growing out of experiences with the physical environment (Proshansky et al., 1983, p. 61). Place identity is formed through "time-consuming" self-identity cognitions formed by experiences throughout life (Korpela, 2013).

Context and place identity. Clayton (2012) and Devine-Write (2009) explain that the impact of identity on the environment was likely to be indirect—a process embedded within a wider sphere of dynamic forces since identities are shaped by experience. In addition, behavior may be "powerfully affected by forces in the immediate physical and social context" (Clayton, p. 176). Significantly, Clayton maintains that some contexts mandate a high-consumption way of living, others a low level of consumption, while still others enable a fluidity around choices on consumption. By the same token, some communities or groups establish social norms that support environmental choices while others discourage such behaviors.

In sum, the role of self-constructs in the relationship between identity and place may have a great deal to do with the types of environments people choose to occupy and the support that context provides in forming meaningful place attachments and identities. Important to this dissertation is the idea that resident's complex identities are in dynamic relation to their home. In the context of a high-performance (net-zero) home or a neighborhood geared toward environmental sustainability research into the role of self-constructs may help explain why people are motivated to engage in environmental projects. Horton (2003) asserts that a "sustainable culture" (p. 75) is one that includes acting on one's environmental identity with place and aspiring to maintain a coherent environmentally friendly way of living. In this dissertation, I explore the possibility that place identity in relation to the physical environment might influence decisions related to energy use in the context of sustainable developments and high-performance buildings.

Notably, place identity differs from environmental self-identity (ESI). While place identity is born out of the experience of place, ESI is born out of one's perceptions about oneself and environmental issues that may not be associated with any specific place, as described below.

Environmental self-identity. Researchers have found that an environmental identity, in addition to environmental values, contributes to the likelihood of pro-environmental behavior (Clayton, 2012). Clayton reported that in response to questions asking about their motivations for volunteering, participants cited factors both expressive of (the opportunity to express one's values through one's actions) and demonstrative of (the opportunity to benefit the environment) their personal values. Furthermore, values central to identity are most likely to affect behavior (Clayton, 2012). Research by Whitmarsh and O'Neill (2010 and 2011) and by Van der Werff, Steg, and Keizer (2013a, 2013b, & 2013c) has offered insights on environmental self-identity (ESI). According to their studies, ESI mediates the relationship between values and behaviors providing a mechanism by which environmental values can be activated and prioritized to influence environmental behavior.

ESI: a determinant of behavior. The correlational research of Whitmarsh and O'Neill (2011) suggested that self-identity may be associated with a broad range of ecological (green), carbon offsetting behaviors such as waste reduction, water and energy savings, and ecologically-minded shopping. Past environmental behavior was also associated with a green self-identity, indicating a temporal quality to ESI (see also Van der Werff et al., 2013a, 2013b, & 2013c). Whitmarsh and O'Neill posit that, in order to increase the weight of a green self-identity over other non-environmental identities (e.g., being well traveled or dismissing pro-environmental behaviors as not worth the effort), it is important to target people's green self-identity as well as their social-identity within a group where the need to conform is influential (2011).

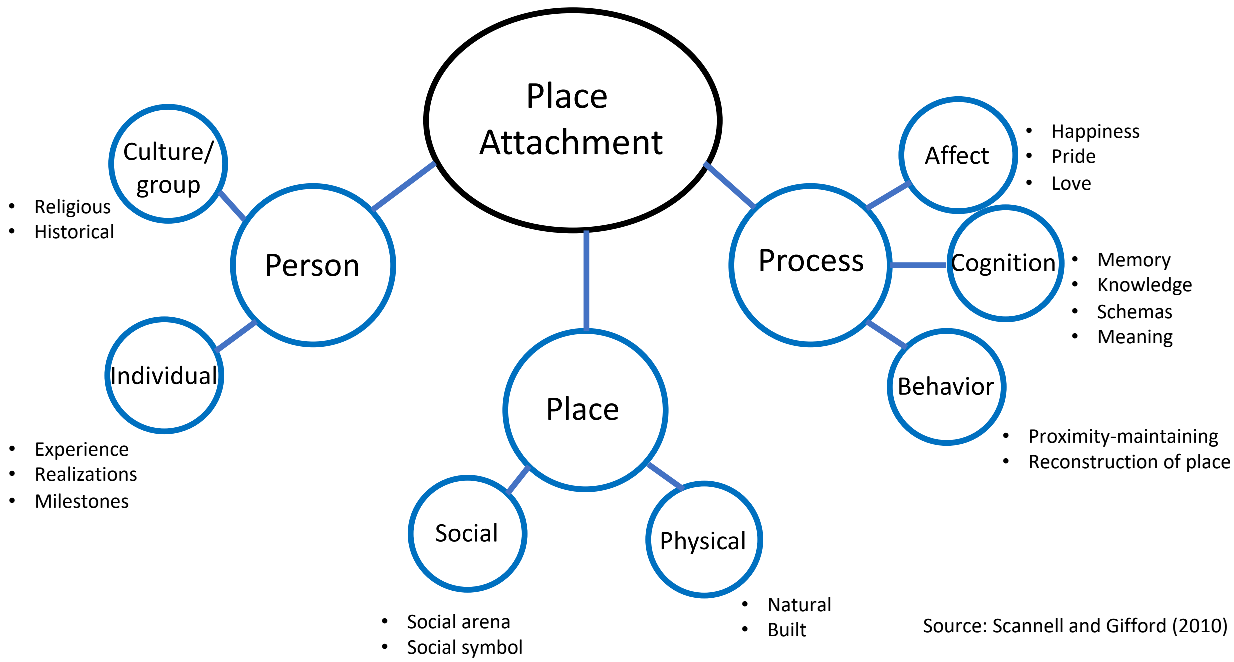
Environmental self-identity (ESI), as defined by Van der Werff and colleagues, is "the extent to which one sees oneself as a type of person who acts (pro-) environmentally (2013a, p. 626). In experimental research, a strong environmental self-identity increases the likelihood that a person will be attentive to a wide range of pro-environmental goals and engage in a wide range of pro-environmental actions (Van der Werff & Steg, 2013a). According to ESI theory, biospheric values form the stable central core on which environmental self-identity is based. Van der Werff and colleagues (2013a) have demonstrated that an individual's environmental self-identity can be strengthened when they are reminded of their past pro-environmental actions, increasing the likelihood that they will continue to act in accordance with their environmental values (p. 627).

Specifically, environmental self-identity is thought to be related to one's intrinsic feelings of moral obligation to engage in pro-environmental behaviors. As such, "obligation-based intrinsic motivation mediates the relationship, suggesting that strengthening environmental self-identity may be a way to encourage behavioral shifts toward a lighter ecological footprint, as people with strong environmental self-identity are likely to engage in pro-environmental actions without external incentives" (Van der Werff et al., 2013c, p. 1258). In line with this research, "to the extent that behaving pro-environmentally is positively valued, people should want to present themselves as supporting the environment; to the extent that people think of themselves as supporting the environment, they should be motivated to act in a way that is consistent with that self-image" (Clayton, 2012, p. 175).

In this dissertation, environmental self-identity is one of the meaningful place relationships explored with respect to conservation behaviors in general and energy conservation behaviors in specific in the context of green-built physical and social environments in communities.

Place attachment. Fundamentally, place attachment is about people's bonds to place. It is a complex multi-dimensional phenomenon that includes affect, cognition, and behavior; and it involves places at varying scales, real or symbolic as well as social relationships, and temporal (memory) aspects (Altman & Low, 1992; Manzo & Devine-Wright, 2014). Recent scholars have held that this multi-dimensional construct can be synthesized into a tripartite framework including person (individual and collective), process (affect, cognition, behavior), and place (physical and social) attributes (Scannell & Gifford, 2010a), as illustrated in Figure 2.5.

Figure 2.5. Tri-partite Model of Place Attachment.



In this model, the person dimension is about who is attached and this can be either an individual or a collective. The place dimension is what the person/collective is attached to, including the social and physical qualities of important places. The process dimension describes the way attachments develop through emotion, thoughts, and behaviors related to what makes a place meaningful (Gifford, 2014).

Moreover, place attachment is a construct that may operate consciously or unconsciously, motivating enduring bonds to place and providing support for goal attainment, a sense of belonging, a sense of identity, and self-esteem (Korpela, 2013). Important to this dissertation is the way bonds to place may be influenced by acts of self-expression as a "means of belonging to a group yet not wholly contained or defined by that group" in one's relationship to home and community (Brewer, 1991, in Clayton, 2012, p. 168).

The concept of place attachment has developed to include aspects that may be temporally different (past memories, immediate experiences, or future aspirations); imagined, symbolic, or linked to objects; and the experience of these emotion-based place bonds may be either positive or negative (Korpela, 2013; Lewicka, 2011; Manzo & Devine-Wright, 2014; Raymond, Brown, & Weber, 2010). Lewicka (2011) argued that scholarly inquiry on place attachment has disproportionately favored the person component and neglected focus on the place or process attributes in the framework. Similarly, Manzo and Perkins (2006) suggest that the literature has tended to focus on the individual's feelings and experiences over people's collective interactions with and emotional connections to place at the community level. These criticisms have their origins in the important role place attachment plays in the lived experience of place.

Role of place attachment. Altman and Low (1992) noted that place attachment serves a number of functions, including as a channel for self-expression, creativity, and the ability to control aspects of one's life; memories, relationships, and experiences both personal and cultural; supporting a person's values and beliefs; and fostering a sense of self and a sense of community. These roles are in keeping with Proshansky et al.'s (1983) assertion that "memories, ideas, feelings, attitudes, values, preferences and meanings... relate to a particular physical setting in which people function constitute place identity—which itself is an aspect to a person's identity" (Altman & Low, 1992, p. 10).

A person with a strong attachment to a particular place might be expected to rank the interests of the place ahead of self-interest and therefore demonstrate an effort to care for and improve places that they consider meaningful in their lives (Carrus et al., 2014; Pretty, Chipeur, and Bamston, 2003, in Manzo & Perkins, 2006). Highly relevant to this dissertation is the transformational role of place attachment in expanding self-based interests to community-based interests as residents elect to engage with and improve places with respect to both social and physical attributes of place.

> If people's identity and values are informed by places they deem significant, then it follows that people's bonds with those places will impact their engagement with those places, whether it be to maintain or improve them, [or to] respond to changes within [them]… (Pretty, et al., 2003, in Manzo & Perkins, 2006, p. 337).

The role of place attachment is fundamental to the investigation conducted in this dissertation with respect to meaningful engagement in places deemed important in the home and community.

Community-based place attachment. Another line of inquiry pertinent to this discussion is community-based place attachment, including a sense of belonging to a group that shares emotional connections, interests, and concerns (Manzo & Perkins, 2006; Mihaylov & Perkins, 2014). According to this line of research, cognitions, emotions, and beliefs about one's local (community) places all impact behavior toward such places. As community members develop emotional connections to a place over time, they tend to show an interest in making improvements to their homes and to get involved in the affairs of the neighborhood. Brown, Perkins, and Brown (2003) have shown that community members who expressed greater feelings of attachment to their communities experienced greater feelings of interconnection. They posited that this attachment was the product of a social process of bonding and feelings of connection. In this regard, when addressing environmental issues, individuals who are able to identify common interests are more likely to feel empowered to act for the benefit of the community.

Manzo and Perkins (2006) noted that empowerment is comprised of reciprocal relationships between communities and their individual residents. A reciprocal relationship based on shared values and emotional ties to fellow residents produces meaningful, sustainable bonds among those working toward a common goal, while shared emotional ties to places strengthen social relationships and collective community action even further. Additionally, Manzo and Perkins asserted that this concept has played a role in the development of walkable, mixed-use communities that promote social interaction in shared public and private outdoor spaces (2006). In their view, a sense of community is established when feelings of mutual trust of social connections, shared concerns, and community values occur alongside place attachment—building common ground. Further, they advocate that it is important to understand the diverse meanings held in common in a community because "people are motivated to seek, stay in, protect, and improve places that have meaning to them" (Manzo & Perkins, 2006, p. 347).

In this regard, this dissertation explores the role of place attachment in a reciprocal relationship where individuals and communities engage in pro-environmental behaviors inspired by the physical attributes and architectural design features in both residential homes and communities. As community members want to be involved in the protection and improvement of their homes and communities in terms of environmental behavior in general and energy use in specific, such practices may inspire new or stronger attachments to place, in turn inspiring a stronger endorsement of ecological behaviors and support for green (sustainable) living.

Dynamic aspects of place attachment. Place attachment is seldom static; rather, it is a dynamic process involving people-place bonds that may encompass different levels of intensity, quality, and duration (Manzo & Devine-Wright, 2014; Manzo & Perkin, 2013). However, the manner in which place attachments are formed has been represented in past literature as static (Devine-Wright, 2009). In cases where place attachments are examined in a context of change, the dynamism of place attachment become clearer. For example, Devine-Wright (2009) proposed a five-stage model of change that includes: 1) becoming aware of change; 2) interpreting implications of change; 3) evaluating potential outcomes of change; 4) coping with and responding to change; and 5) taking an action in response to change. He suggested that such a change model would explain why individuals who experience strong attachment are more likely to pay attention to and respond to changes in the physical environment. This change model also provides insights into a person's and community's ability to respond to place-based circumstances, as is highly relevant to this dissertation.

Seamon's (2014) work on the synergistic dynamism of place also assert that place responses constitute an active component of place attachment as described below. Seamon (2014) outlined six different place responses that activate place attachment in an ever-shifting interchange, resulting in a range of place meanings born out of experience and emotional engagement. Common to all six place processes (interaction, identity, release, realization, creation, and intensification) is the dynamic quality of participation from a person engaging with aspects of place to appreciate, enjoy, show concern and respect, show responsibility toward, care for and/or express love for place (including feelings of disrespect and ambivalence). Aligned with this dissertation is the notion that place attachment and therefore place meaning evolves from a collection of factors supportive of the active engagement of the person in their environment.

Summary. A review of the literature suggests that if people's values, identities, and bonds to place are informed by the places they deem significant, then a person may be motivated to place the interests of the environment ahead of self-interest influenced by place attachments or place identity, and based on past actions. Taken together, these place theories suggest that a person may be motivated to engage in reciprocal relationship building, prioritizing values, and engaging in actions that respect the environment, leading to a coherent environmentally friendly way of living in places that hold meaning for them. By linking values, identities, and affective bonds in the context of place meaning to environmental cues in residential buildings and communities, this dissertation suggests that individuals may seek meaningful relationships of mutual benefit for themselves, their communities, and the physical built environment evolving from a collection of factors in an ever-shifting interchange.

An Integrated Research Agenda

> …We need to devise a 'new, green architecture.' This architecture would be assembled from multiple materialities, times, and spaces which call forth green practices. It would be architecture productive of the performance of green cultural codes and broader green cultural scripts. Although each component of such a green architecture might by itself seem rather insignificant, as a whole such an architecture could enable the assemblage of a specifically green identity, which could be carried with the person and which would result in the production of a coherent green lifestyle (Horton, 2003, p. 75).

As noted earlier, people are more likely to act on their environmental values when these values are prioritized, strengthened, and supported by cues from the context in which those people make decisions (Steg et al., 2014a). This dissertation extends the integrated framework proposed by Steg et al. (2014a) by investigating the role of place meaning in the form of place identities and people-place bonds inclusive of environmental cues as place-based architectural design features in the physical built environment which are theorized to promote effective and enduring pro-environmental behaviors. It is people's values, place meanings, and environmental cues that serve to remind them of what is significant in life and may inspire and empower them to engage with their residential settings in support of the environment, as is so crucial to the Paris Agreement goals on climate change.

Chapter 3: Research Design and Methodology

Overview

In conducting this research, I used a quantitative and qualitative mixed-methods design approach to investigate people's experiences of their residential energy use in their homes, including their actual and perceived 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. 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.

In this chapter, the research design is presented in detail beginning with four research questions followed by a description of the research sample and context for the two comparative study sites. Procedures used in the mixed-methods study design are then delineated, including an explanation of the data collection process and the distinct measures used. This chapter concludes with a description of the data analysis strategy used to answer each of the research questions that guided the study design.

Research Questions

Question 1: How do the Built Green and Code-built Communities compare on their actual energy use?

- Benchmarking energy use intensity (EUI) scores for each of the two communities.
    - Question 1a: What are the differences, if any, between the Built Green and Code-built community participating households on benchmarked EUI scores (kBTU/sq.ft.yr.) derived from two years of extant Puget Sound Energy (PSE[17]) billing aggregated data? In other words, how do the communities differ prior to energy dashboard treatment onset?
- Contextualizing EUI score for each of the communities.
    - Question 1b: For participating households in each community, how do the benchmark EUI scores compare with a number of other third-party metrics, including site-specific energy model EUI score predictions, regional energy use assessments, and national energy use data evaluations?

Question 2: What are the effects of real-time feedback (dashboard treatment) on actual energy use of participating households?

- Testing the significance of change in pre- and post-treatment actual energy use for participating households in each of the two communities (separately).
    - Question 2a: Does exposure to energy monitoring dashboards conveying real-time feedback (i.e., the treatment) correlate with a significant reduction in actual energy use as measured by PSE EUIs for participating households within each community, during high-intensity treatment (Jan-Mar, 2017), medium-intensity

[17] Puget Sound Energy is the utility company serving the two communities of interest in this study.

treatment (Apr-Jun, 2017), and low-intensity treatment (July-Sept, 2017) periods, with or without adjusting for previous benchmark periods?

  - Question 2b: Does exposure to energy monitoring dashboards conveying real-time feedback (i.e., the treatment) correlate with a significant reduction in actual energy use as measured by circuit level monitoring (CLM[18]) for participating households within each community, during high-intensity treatment (Jan-Mar, 2017), medium-intensity treatment (Apr-Jun, 2017), and low-intensity treatment (July-Sept, 2017) periods?
  - Question 2c: How do EUI scores from PSE and CLM sources compare?

- Comparison of participating households from each of the two communities on changes in pre- and post-treatment actual energy use.
  - Question 2d: Are there significant differences in changes in actual energy use as measured by PSE EUIs among the Built Green and Code-built communities during high-intensity treatment (Jan-Mar, 2017), medium-intensity treatment (Apr-Jun, 2017), and low-intensity treatment (July-Sept, 2017) periods, after adjusting for changes in previous benchmark periods?
  - Question 2e: Are there significant differences in actual energy use as measured by CLM EUIs among the two communities during each of the phases of treatment (high-, medium-, and low-intensity)?

Question 3. How do the Built Green and Code-built community households compare demographically and on their perceptions of energy use and pro-environment variables?

- Comparison of participating households from each community on demographics.
  - Question 3a: What are the differences in demographic characteristics, if any, among the Built Green and Code-built communities?
- Comparison of participating households from each community on survey variables prior to dashboard treatment.
  - Question 3b: What are the differences in baseline perceptions of energy use and pro-environmental variables, if any, among the Built Green and Code-built communities?
- Testing the significance of change in pre- and post-treatment survey variables for participating households in each of the two communities (separately).
  - Question 3c: Are there significant changes in perceptions on perceived energy use and pro-environmental variables from pre- to post-dashboard treatment for each community (separately)?
- Comparison of participating households from each community on changes in survey variables from pre- to post-treatment.
  - Question 3d: What are the differences in changes in perceptions of energy use and pro-environmental variables, if any, among the Built Green and Code-built communities?

Research Question 4: What are the relationships among values, attachments, place meanings, and environmental cues on behaviors as they relate to energy use?

- Assessing how people make sense of their experience of place and its relationship to home energy use, and whether energy related behaviors change in relationship to a person's understanding of the physical and social environments and their engagement with them.
    - Question 4a: What role do values, place meanings, place attachment, and identity play in people's understanding of their environmental behaviors related to energy use?
    - Question 4b: How do people understand both physical and social cues in their homes and communities?
    - Question 4c: How do participants respond to information on their energy use with access to real-time dashboard feedback derived from CLM devices in their homes?
    - Question 4d: Using a grounded theory approach, what conceptual model could be developed to capture how different people-place relationships relate to residential energy use?

By answering these research questions, this study aims to investigate how the built environment, including architectural design features, interacts with actual and perceived energy use, pro-environmental behaviors, and whether an energy use intervention, holds promise for influencing energy use, real or perceived.

Research Sample

Study site selection. As previously discussed in Chapter 2, this study compares two communities in a one-year time period to examine the influence of the physical and social built environments on energy related behavior. The two communities selected for comparison in this study sample are a Built Green Community (Site 1)[19] and a Code-built Community (Site 2)[20] located in the Pacific Northwest marine region of Washington State within commuting distance of Seattle as shown in Figure 3.1.[21]

Figure 3.1: Area Map of Seattle and Pacific Northwest.

Source: Retrieved (July 8, 2018) from https://www.google.com/maps.

[19] See glossary in Appendix 2 for more information on the Built Green standard of construction, which is beyond code minimum.
[20] See glossary in Appendix 2 for more information on Code-built construction, which is a minimum energy and structural code allowed by state and local jurisdictions.
[21] The exact city and location of the communities is withheld to protect the anonymity of the study communities.

These sites were selected because of their close proximity to one another in the same Pacific Northwest city and because they have similar demographic characteristics yet distinct differences in architectural building construction characteristics, design philosophy, and social infrastructure. Site 1 is referred to as the Built Green Community due to the highly energy efficient construction of its buildings. Specifically, the Built Green Community, completed in 2013, was built to meet a beyond-code energy performance standard and designed to be a net-zero energy efficient community through the use of high performance advanced construction technology and renewable solar energy. In contrast, Site 2 is designated as the Code-built Community to reflect that it was constructed using conventional building codes, which translates into less energy efficient building construction when compared to Site 1. It was built in 1991 at a time of nascent energy codes,[22] and while designed to have a smaller ecological footprint,[23] was mainly planned to function as a cooperative housing community. Selecting these two sites for the study enables an analysis focused on the salient variables impacting energy use— architectural, philosophical, and behavioral variables.

Study site context. As noted above, both communities are located in the Pacific Northwest region of the US, within commuting distance to Seattle, Washington—a major west coast metropolitan city. In general, the area in which both sites are located has a well-educated, fairly affluent population. Residents typically enjoy choices around income expenditures for housing and utilities, entertainment and recreation, arts and education, modes of transportation, and a variety of other essential and non-essential needs (see Table 3.1).

---

[22] Though residential energy codes have generally been in existence since the 1970s the movement toward greater and greater stringency has come to the fore in the 2000s (www.architecture2030.org).
[23] A cooperative housing community with a small ecological footprint refers to co-housing group's goal to use few resources by sharing them among households (e.g., tools, meals, laundry) (McCamant & Durrett, 1994).

Table 3.1. Area Demographic Characteristics.

Characteristics	Area	U.S.
Total Population	23,576	
Square Miles	27.78	
Total Households	9,709	
Percent Families	72.50%	
Ave. Number persons/household	2.46	
Education Level		
High School Education	98%	84.60%
4- or 5- Year College Degree	60%	27.50%
Graduate Degree	25%	
Ethnicity		
Non-Minority (White)	87%	61%
Minority	13%	39%
Median Household Inclome	$102,906	$57,617
Home Ownership Rate	77.30%	63.50%
Median Property Value	$569,700	$205,000
Median Age	48.5	37.9

https://datause.io/profile/geo (accessed 6.3.18)
https://www.ci.xxxxx.wa.us (accessed 9.26.17)
Specific web address withheld to protect the privacy of research participants

Thus, populations in both communities selected as study sites are not cost-burdened and possess adequate economic resources to exercise choices around energy use in their homes, including the ability to purchase a new high-performance energy efficient home or to make home improvements such as weatherization, space heating and domestic water heating equipment updates, or appliance upgrades related to energy use in an existing home. In addition to their aligned socioeconomic characteristics, another similarity between the two study sites is their close proximity to the downtown district of the city in which they are located. Both lie within walking distance of a major transportation hub, public library, several high-quality public and private schools, as well as shopping, entertainment, and recreation opportunities supporting multiple choices on transportation (walking, biking, busing, or driving). These communities are primarily comprised of single-family homes, duplex townhomes, and townhome rental units (see Figure 3.2). They exhibit similarities in building size and comparable community membership (see Table 5.1 for a comparison of Study Sample Demographic Characteristics).

Figure 3.2. Photo Image of Built Green (left) and Code-built (right) Communities.

Source: Photos by author.

Built Green Community. The Built Green Community (Site 1) was specifically chosen as a study site because it is typical of the New Urbanism[24] communities built to promote walkable, compact, and vibrant neighborhoods. Although New Urbanism is rooted in the 1970s and '80s pattern language theories[25] of Christopher Alexander, not until the 1990s and 2000s did the connection between New Urbanism and sustainability become clearly defined as a set of

[24] New Urbanism involves creating physical built environments that are sustainable and human-scaled. They are designed to be walkable, compact, and vibrant neighborhoods. Retrieved (September 28, 2017) from https://www.cnu.org/resources/what-new-urbanism.
[25] For more information on pattern language theories, see Alexander, Ishikawa, Silverstein, (1977) *A Pattern Language: Towns, Buildings, Construction*.

relationships between development, community, and ecological conservation (Farr, 2008). Sustainability is generally defined as meeting the development needs of the present generation without forfeiting the capability of future generations to meet their own needs.[26] A later initiative developed by Bioregional and Partners, the One Planet Living (OPL)[27] program built off of this definition of sustainability when creating a set of ten guiding principles to be used as a framework for new community developments worldwide. The unique contribution of OPL is found in their explicit goal to use fewer natural resources in their developments. Designed in such a way that its buildings require fewer energy resources to operate, an OPL community should be able to produce all the energy it needs using renewable energy resources. The Built Green Community, sampled in this study, is one of two endorsed OPLs in North America.

The "OPL Principals" program advocates ten criteria: zero carbon, zero waste, sustainable transport, sustainable materials, local and sustainable food, sustainable water, land use and wildlife, culture and community, equity and local economy, and health and happiness. The design of the Built Green Community incorporates these ten principles to varying degrees. Of interest for this study is the degree to which the community uses energy and is capable of net-zero energy, which may be at odds with the requirement for zero carbon because, although all of the single-family homeowners opted to purchase solar photovoltaic panels as a renewable energy source at the time of home acquisition, owners of the rental units did not. Though the community as a whole has been endorsed as a One Planet Community by Bioregional, the zero-carbon goal has not been entirely fulfilled because the community lacks 100% participation, meaning not all

---

[26] The most frequently quoted definition of sustainability is from Our Common Future (1984), also known as the Brundtland Report: "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."
Retrieved (June 01, 2018) from http://www.un-documents.net/our-common-future.pdf.
[27] For more information on the One Planet Living Framework see http://www.bioregional.com/oneplanetliving.

residents enjoy the benefit of net-zero energy. This situation produces not only a disparity between homeowners and renters it is also incongruous with the philosophical design of the community on the principal of equity (see Figure 3.3).

Figure 3.3. Photo of Green Built Community Solar Arrays.

Source: Retrieved (August 2, 2018) from Google Images, https://www.google.com/.

The design philosophy of the Built Green Community was focused on the experience of living in a sustainable community adhering to OPL principles. The developers envisioned a residential project that would espouse environmentally aware and friendly (green) lifestyles requiring little to no attention or effort on the part of the occupants to maintain. As the developer notes[28] on the community's website:

> As a member of [this] community, you don't have to make big sacrifices, learn a bunch of new stuff, or completely turn your life around to live here. We did that for you.

In addition to energy-efficient homes (high-performance building envelope, equipment, and appliances) and the capacity for solar energy production (roof top solar photovoltaic panels), other green attributes of the Built Green Community include shared flower and vegetable gardens, recycling stations, and open space. Cycling and pedestrian amenities such as easily accessible bike storage sheds are available, while landscaped pathways lead to remote perimeter car parking and connector trails to nearby services and recreational opportunities.

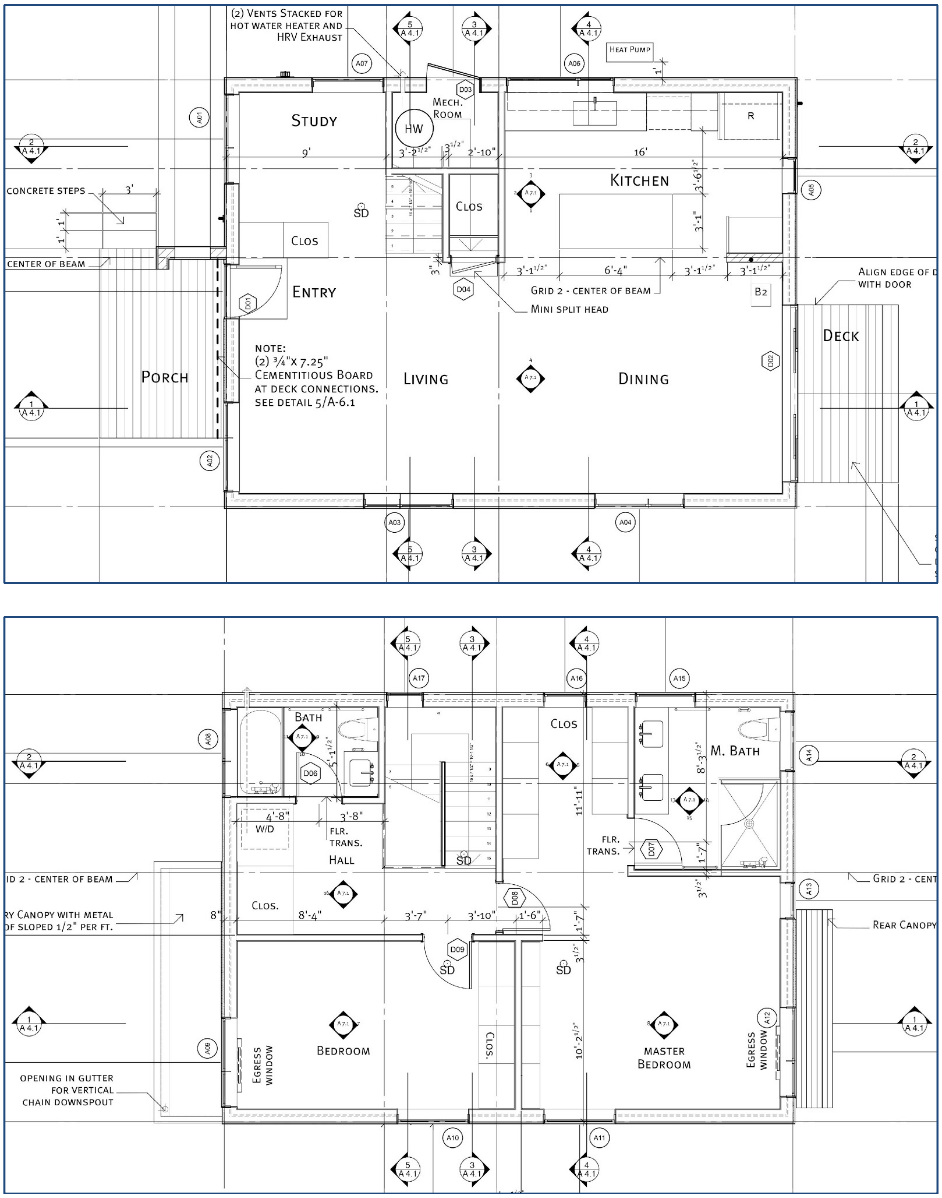
[28] Statement posted by the developer on the community website highlighting the relative ease of living in a sustainable community designed with the One Planet Living principles. Retrieved (September 26, 2017) from (http://xxxxx.com/the-experience/one-planet-living/. Specific web address withheld to protect the privacy of research participants.)

Figure 3.4. Built Green Community Site Plan.

Source: Developer's name withheld to protect privacy of study participants, but permission was granted to use this image.

Of the 43 homes in the Built Green Community, 21 are single-family homes, two are duplex townhomes, and 20 are rental townhome units situated to create both a compact community and a net-zero solar energy community (see Figure 3.4). There are four typical unit plans for single-family homes and two rental units in this development, one representative two-bedroom plan is shown below in Figure 3.5.

Figure 3.5. Typical Built Green Community Unit, 1st and 2nd Floor Plans.



Source: Developer's name withheld to protect privacy of study participants, but permission was granted to use this image.

Figure 3.6. Typical Built Green Community Compact, Low Volume Home.

Source: Developer's name withheld to protect privacy of study participants, but permission was granted to use this image.

Though specific physical housing characteristic and energy performance tables for the Green Built Community are provided in Chapter 4, in general, the structural characteristics related to energy use and efficiency include: the compactness of the floor plan; small square footage of the home; lower volume of the buildings; fewer bedrooms/occupants; greater air-tightness and insulation values for wall/window, floor/ceiling, and roof construction assemblies; selection of high efficiency equipment for space conditioning, domestic hot water, and major appliances; and a homeowner's personal selection of electronics for entertainment and in home office use (see Figure 3.6). The energy performance of a given building can be measured and assessed by comparing the amount of energy the building was planned to use when designed (energy model) with actual energy use after the building has been in operation for at least one year. This comparison is achieved by taking the total energy used, measured in watts, in the course of one year, converted to British Thermal Units (BTU), and divided by the heated area of the building to arrive at the energy use intensity score or EUI (in kBTU/sq.ft.yr.) for the building. An EUI score allows a comparison of energy use among buildings of different sizes, energy uses within a building, different communities, and across time. The Built Green Community is expected to present a lower mean EUI score than the Code-built Community by virtue of its structural characteristics.

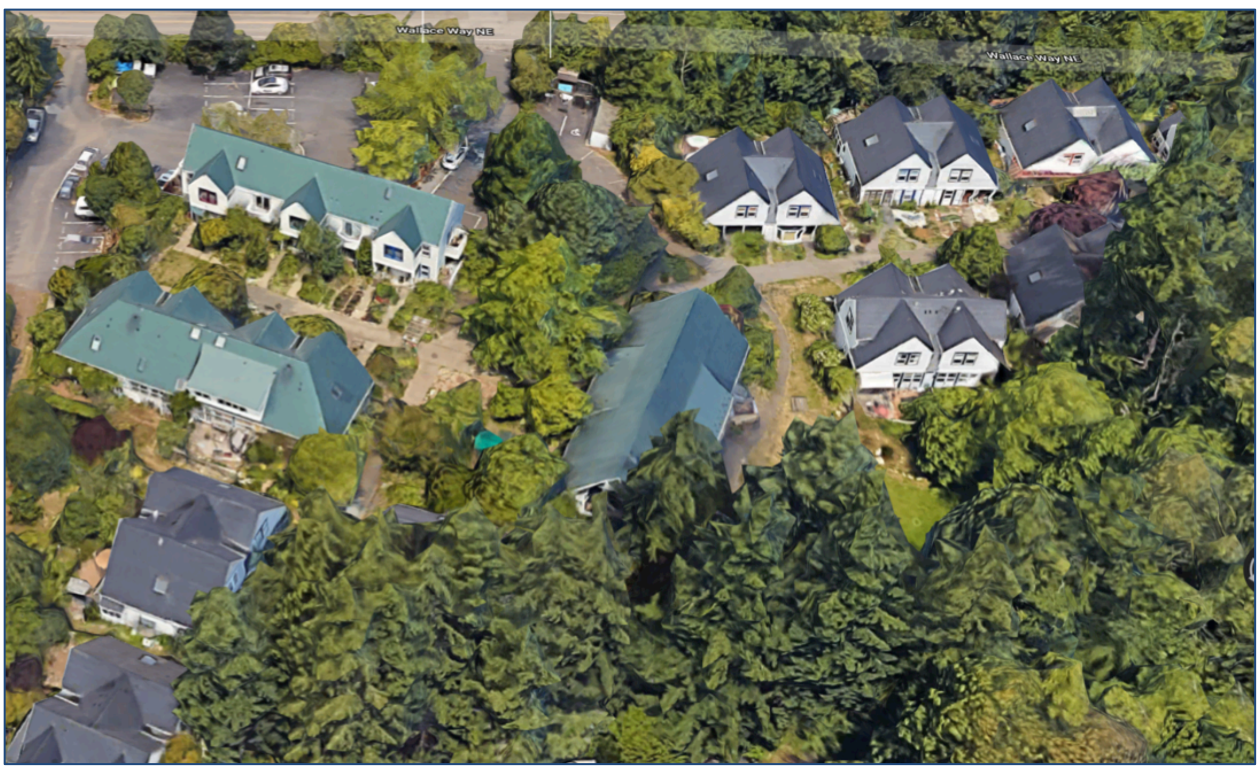
Code-built Community. The Code-built Community (Site 2) was specifically chosen as a study site for two reasons. First, the buildings were built to energy codes that met the minimum legal limit for performance of a building in Washington State and the local jurisdiction (hence the term "code-built" in contracts to the beyond code standards of the Built Green Community). Second, this site is typical of the kinds of communities developed to promote a sense of active community engagement at a time when energy codes and sustainable living had more to do with a life philosophy and less to do with an architectural high-performance design strategy. As their values statement notes:

> We are sensitive to the diverse needs of our members and have adopted values statements from time to time. These include mutual respect in honoring differing beliefs and viewpoints, having a minimal impact on the earth, and creating a place in which all residents are equally valued as part of the community.[29]

29 The Code-built Community values statement, "Who We Are" describes a mix of households, perspectives, and ages. Their shared vision is to offer support and friendship to each other while living and working together and this is seen as their strength. Retrieved (September 26, 201) from http://www.xxxxxx.org/where.html. Specific web address withheld to protect the privacy of research participants.)

The Code-built Community is based on a cohousing typology first developed in Denmark by people looking for a new housing choice that redefined the concept of neighborhood to fit the then contemporary lifestyle of families with both parents employed outside the home (McCamant & Durrett, 1994). First built in the 1970s, such cohousing communities were typically comprised of 15 to 33 private residences designed to be self-sufficient with a shared common facility and dining hall for community meals and gatherings. Rooted in the Danish concept of "living communities," cohousing provides opportunities for a more social and practical home life (McCamant & Durrett, 1994). Cohousing communities are uniquely organized and planned by the residents themselves (see Figure 3.7).

Figure 3.7. Photo of Code-built Community Site.



Source: Retrieved (August 2, 2018) from Google Maps, https://www.google.com/maps.

The people who live in cohousing in general, and in Site 2 in specific, are purposefully engaged in all aspects of ongoing caring and planning for the community.[30] Though this lifestyle philosophy focuses heavily on social concerns, the physical architectural design of the development supports not only the ease of social interaction but also community values, including having a light ecological footprint (in contrast with Site 1 that specifically targets net-zero energy). As such, active community engagement is a valued component of the Code-built Community's design philosophy;[31] it is a cooperative effort first and foremost, one with an emphasis on maintaining a minimal impact on the earth because the plan clusters housing, thereby saving open space; the planners also saved materials and energy by using smaller footprint duplex homes; community members share resources such as laundry facilities, tools, and water heaters, which permits less waste and lowers consumption of non-renewable items; and the homes are built near public transit lines to offer cleaner transportation options.[32]

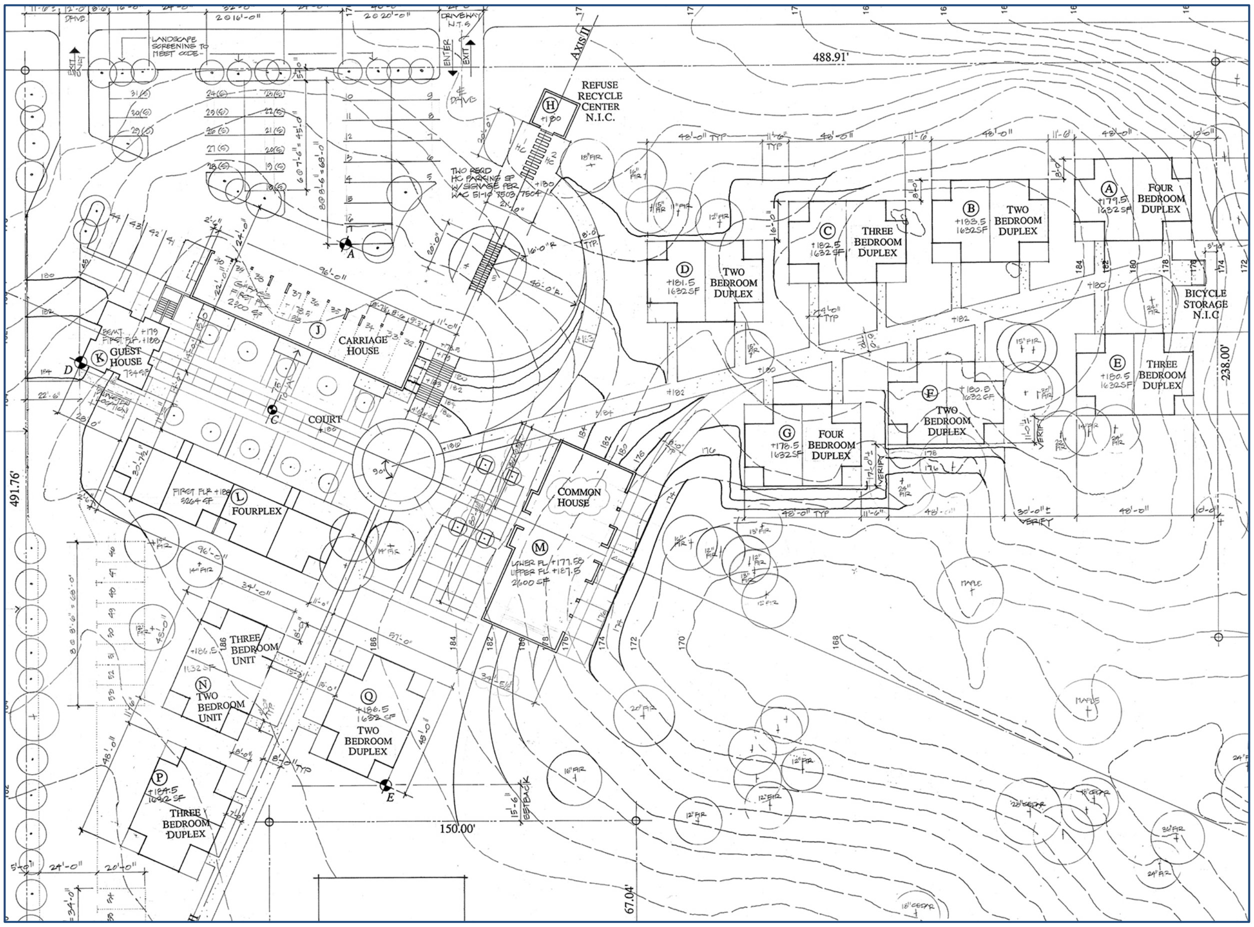
---

[30] Active community engagement is a valued and necessary part of the Code-built Community lifestyle—it is a cooperative effort first and foremost. The Built Green Community philosophy, by contrast, espouses values built around independent lifestyles—with an emphasis on the sustainable design of the physical environment.

[31] Cohousing is a form of intentional community featuring private homes configured around shared open space and community facilities. Community members most often share resources, meals, governance, activities, and food gardens. The legal structure is typically a Home Owners Association or Condo Association. For more information see http://www.cohousing.org/what_is_cohousing.

[32] Retrieved (October 7, 2017) from http://www.cohousing.org/.

Figure 3.8. Code-built Community Site Plan.



Source: Architecture Firm's name withheld to protect privacy of study participants, but permission was granted to use this image.

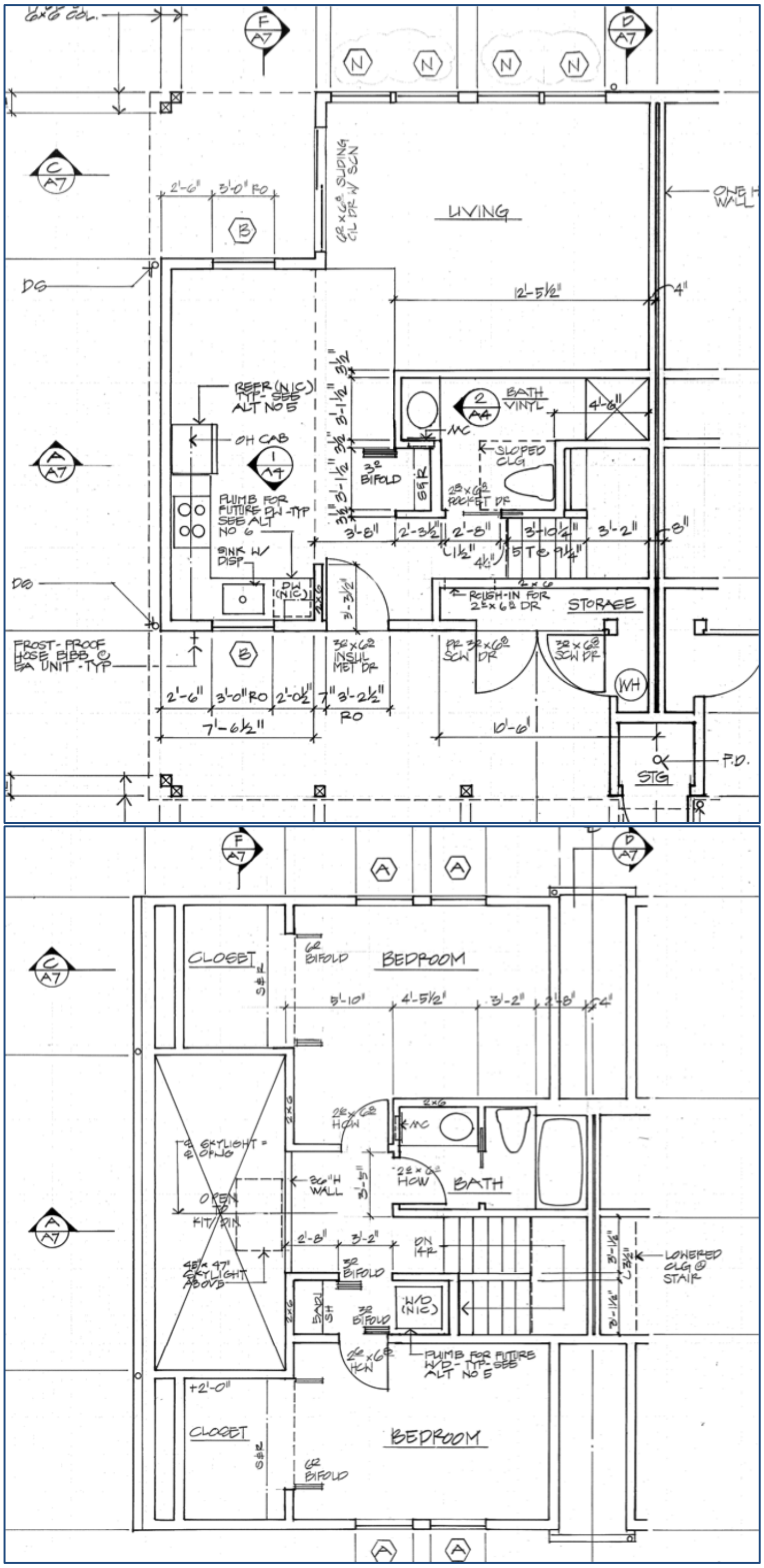
At the Code-built Community, 30 homes (10 townhouse duplexes, one four-plex and six carriage house units) are designed around a pedestrian village concept with open space, a central common house, community gardens, and native woodland. The five-acre property designates one corner of the site for parking to preserve open space. Paved lanes connect all the homes to centralized facilities, creating a pedestrian-oriented neighborhood (see Figure 3.8). The refuse/recycle center and composting projects are elements of pro-environmental programs. The community is landscaped with drought-resistant, native species edible by humans or wildlife. No fertilizers or toxic products are used.[33]

Built in the early 1990s during the early stages of energy code regulations, Site 2's buildings are less stringent in regard to air-tightness and insulation values of wall/window, floor/ceiling, and roof construction assemblies, choice of equipment for space conditioning, domestic hot water heating, and major appliances. Though the buildings have a compact footprint and building form, the massing and orientation are not supportive of rooftop solar or passive solar gains (see Figures 3.9 and 3.10).

---

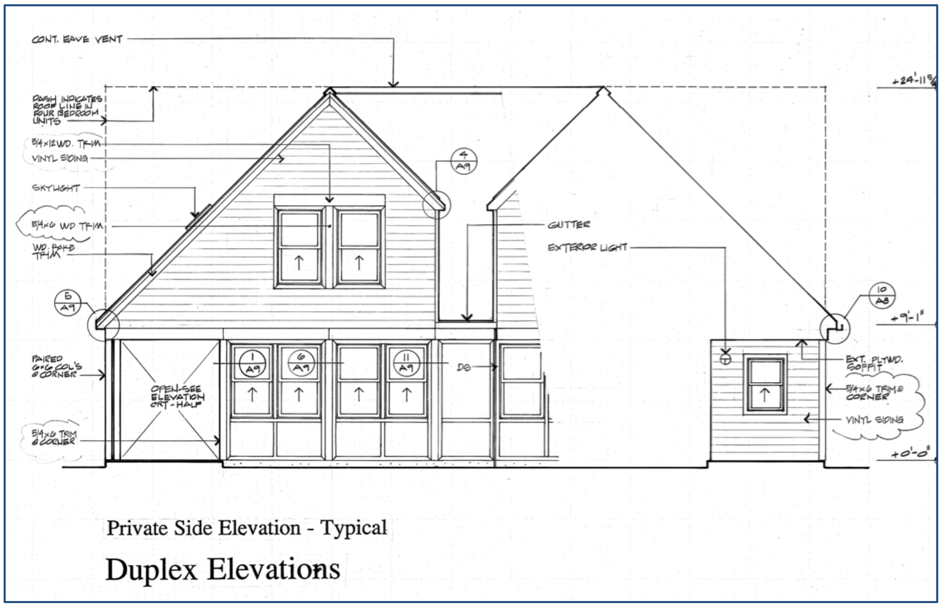
[33] Retrieved (September 26, 2017) from http://www.xxxxx.org/where.html. Specific web address withheld to protect the privacy of research participants.)

Figure 3.9. Code-built Community Unit 1st and 2nd Floor Plans.



Source: Architecture Firm's name withheld to protect privacy of study participants but permission was granted to use this image.

Figure 3.10. Code-built Community Compact, Low Volume Duplex Home.



Source: Architecture Firm's name withheld to protect privacy of study participants but permission was granted to use this image.

In these ways, Site 2 contrasts with Site 1 in architectural building design related to energy use. In addition, the primary space heating system was originally an under-concrete, in-floor hydronic system that, in 2014, was converted to a more energy efficient ductless mini-split heat pump mechanical system similar to that used in the Built Green Community. The Code-built Community is expected to present a higher EUI than the Green Built Community by virtue of its structural characteristics. Specifically, Site 1 was predicted or modeled to be about 44% more efficient than Site 2 by virtue of its advanced construction technology.

Participant recruitment. For each community, I contacted the Homeowners Association (HOA) to explain the purpose and procedures of the research, gain support for the study, and seek help with participant recruitment. An HOA board member then sent an email to all site households explaining the purpose of project and inviting residents to participate (Site 1, n = 43; Site 2, n = 30). Shortly thereafter, I distributed an HOA-approved invitation to a community-wide event[34] (delivered door-to-door at Site 1 and to the commons house mail cubbies at Site 2) where I would introduce the purpose of the research, describe the study design, and allow for a question-and-answer session. Residents who attended were provided a printed overview of the study and encouraged to email me directly if they wanted to participate, an enlistment method that protected the homeowners' privacy and maintained confidentiality. As a follow-up, additional flyers were distributed door-to-door at Site 1 and placed in the commons house mail cubbies of Site 2, after the community-wide event, inviting residents to join the study. Flyers were also posted on the community bulletin boards at each study site.

Residents who emailed with interest in the project were given a study packet containing the following: an invitation from the HOA to participate, an invitational letter from the researcher including a description of the project and process, information on an appreciation gift card drawing at the end of the study, two copies of the University of Washington Informed Consent letter, and two copies of the Puget Sound Energy Billing Documents Access Consent letter. Residents were asked to sign each of the two types of consent letters, keeping one copy and returning the other to a sealed drop box stationed near the mailboxes in both study sites. Once I collected the signed materials, I emailed instructions to the participants with a link to access the online University of Washington website and secure server. Here participants filled out a full registration questionnaire which, once completed, allowed them online access to the survey portion of the study. All participants were encouraged to contact me directly with any questions and reminded that taking part in the study was voluntary, that they could stop at any time, that the project entailed minimal risk, and that the study information was confidential.

---

[34] In each community, the event took place midweek during the spring of 2016, spaced about one week apart. For Site 1, the event took place outdoors in the community open space after work. For Site 2, the event took place in the commons building after dinner. In both cases, the event was hosted by an HOA board member and the researcher, who provided light refreshments at the start of the hour-long meetings.

Additionally, participants were notified that the study received partial funding from the University of Washington, the American Institute of Architects, and Puget Sound Energy for the purchase and installation of the in-home energy monitoring equipment.

Built Green Community sample. Out of the 43 potential participant households, three apartment households, 15 single-family households, and one duplex townhome household registered online between May and July of 2016 to participate in the study, yielding a sample size of 19 for this community (44% of all households). Of these 19 study participants, five were excluded from analysis due to incomplete participation in the entire one-year study and two because they moved out of the community. The remaining 12 households (30% of all households) participated in all phases of the project.

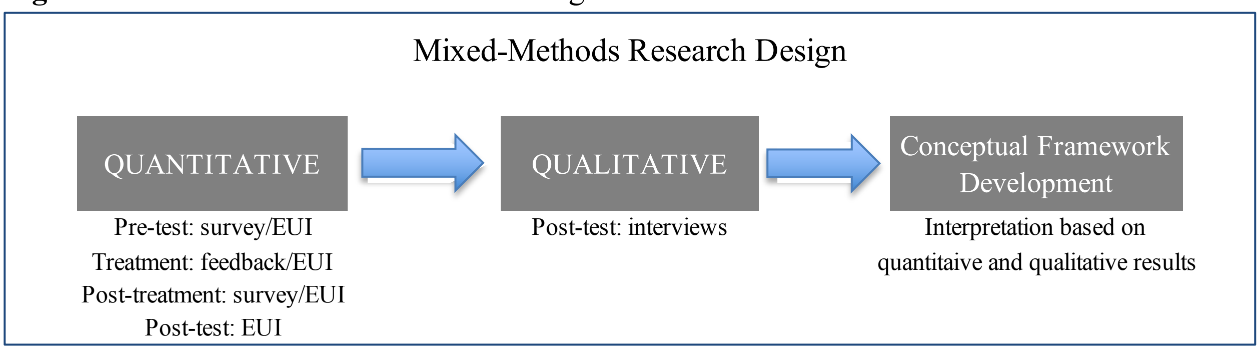
Code-built Community sample. Out of 30 potential respondents, three apartment households, 10 from duplex households, and two from the four-plex building registered online between May and June of 2016 to participate in the study, yielding a sample size of 15 for this community (50% of all households). Of these 15 households, one was excluded from analysis due to incomplete participation in the entire one-year study and two because of technical difficulties maintaining a consistent internet connectivity required for data collection. The remaining 12 households (40% of all households) participated in all phases of the project as defined by the sequential study methodology described shortly.

Recruitment yield. The total combined final sample consisted of 24 households, 12 from each site, participating in all phases of the study ($N = 24$). Households at both sites received treatment and there was no control group. Finally, a subset of households was invited to participate in an in-person focused interview based on changes in their energy use patterns from baseline to post-treatment (energy use feedback). Seeking to capture a wide range of energy use behaviors (e.g., little change, no-change, high degree of change), I invited nine households from each community to interview at the conclusion of the study (*N* = 18).

Procedures

Mixed-methods study design. This study used a mixed-methods approach to gather information on residential energy use from participants recruited into the study (see Figure 3.11). An equal number of households from each study site were quantitatively assessed on their general perceptions of their energy use and actual energy use behavior in the home. At the conclusion of the study, a subset of households was interviewed on their experiences in the home and community with regard to their household energy use.

Figure 3.11. Mixed-Methods Research Design.



The rationale for using a mixed-methods comparative study design was two-fold. First, quantitative self-report surveys alone may be subject to the social desirability bias – that is, respondents may answer in ways they think will cast them in a positive light; in the case of this study, they might over-report energy conserving behavior or that they are living a green sustainable lifestyle. To address this potential bias, an additional method of data collection was utilized—measuring the actual energy used in a home (quantitative). Though the quantitative data yielded important information on when, where, and how much energy was being used, it did not uncover the reasons why residents used energy or the meaning and rationale behind people's behaviors with regard to energy use. For this type of information, in-depth, face-to-face interviews comprised an effective method (qualitative). Once data collected from different methods were analyzed and the results triangulated, the research intends to shed light not only on how much energy was used, but why people used energy in their homes in a particular way. Collecting data at a deeper, more granular level could contribute to the development of a conceptual framework and yield important information with implications for future architectural design work on net-zero energy buildings and communities.

Data collection. Over the course of 12 months, data were collected on each participating household at both sites and organized around four distinct research intervals corresponding to the four seasons (quarters) of the year. Temporally, the research moved from pretest (baseline surveying and energy use benchmarking in the fall), to treatment (real-time feedback dashboard access and prompts/alerts via email in the winter), to post-treatment (measuring change from baseline surveys and energy use benchmarks in the spring), to posttest (interviews in the summer). A detailed timeline of the study is presented in Table 3.2 below, followed by a description of each of the four phases of the research.

Table 3.2. Data Collection Timeline.

Phases	Type of Data Collection	2016							2017								
		Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1. Pretest	*Baseline Survey - T1 Data*	■	■														
	Energy Use Benchmark- Setup			■	■												
	1. Installation of In-home Circuit Level Energy Monitors (CLM)																
	2. Puget Sound Energy Billing Data (PSE) extant data, 2015 & 2016																
	Energy Use Benchmark - Q4 Data					■	■	■									
	1. Inactive: Participants do not have access to real time energy-use (CLM) feedback																
	2. PSE Monthly Billing Data																
Treatment	*Energy Use - Q1 Data*								■	■	■						
	1. High-intensity: Participants have access to real-time energy-use (CLM) feedback using the online dashboard portal and receive prompts/alerts/reports via email																
	2. PSE Monthly Billing Data																
3. Post-treatment	*Survey - T2 Data*											■					
	Energy Use - Q2 Data											■	■	■			
	1. Medium-intensity: Participants have access to real-time energy-use (CLM) feedback using the online dashboard portal and receive reports via email																
	2. PSE Monthly Billing Data																
	Energy Use - Q3 Data														■	■	■
	1. Low-intensity: Participants have access to real time energy-use (CLM) feedback using the online dashboard portal																
	2. PSE Monthly Billing Data																
4. Posttest	*Focused Interviews*																■
	Conduct, record, transcribe in-depth interviews, (*N = 18*)																

Notes: *N* = 24 unless otherwise noted, T = time period, Q = quarter or 3 months of the year

Pretest. The purpose of data collection in this pretest phase is to establish a baseline from which to measure any differences between and within the communities on perceptions and actual energy use before and after a treatment. The survey instrument was designed to ask each head of household[35] in the study about their perceptions related to their energy use (how people believe

[35] In a few cases, a household couple answered questions together— filling out one survey jointly or responding together during the interview session.

they used energy in their homes, their values associated with environmentally related behaviors, and what they believed to be important in making their day-to-day choices around energy use). The survey was implemented both at the beginning (pretest) and toward the end (post-treatment) of the study. During all phases, participant households were also measured on their actual electrical energy use via local utility billing data (current and extant) and an in-home circuit level monitoring device installed specifically for the study.

Survey. The Time 1 (T1) baseline survey sought to understand aspects of people's perceptions on how they use energy in the home with the least possible influence from the study itself. Participants were invited to take the 30- to 45-minute online survey at a time of their choosing during the latter part of June and early part of July in 2016 prior to the installation of the energy monitoring equipment. This initial data collection, investigating participants' perceptions of energy use, pro-environmental behavior and architectural design feature variables, concentrated on the following measures presented in Table 3.3.

Table 3.3. Survey Measures for the Built Green and Code Built Communities.

Survey Measures
Environmental Psychology: Aspects
Values: Altruistic, Biospheric, Egoistic, Hedonic
Beliefs: Awareness of Problem, Solution Efficacy
Goals
Environmental Psychology: Identities
Place Attachment
Place Identity
Environmental Self-identity
Misc. Electric Loads and Behaviors
Computer Workstation, Entertainment Center, Small Home Appliances, Total (Hours/day)
Low Cost Pro-environ Behavior
High Cost Pro-environ Behavior
Architectural Design Features
Environment and Human Well-being
Next Generation Building Systems
Promote Pro-environmental Awareness and Actions
Regenerative Design Features
Accommodating Changing Needs and Uses
Demographics:
Gender, Education Level, Ethnicity, Combined Household Income, Home Ownership, Square Footage of Home, Age of Head of Household, and Number of People in Household

Notes: A 7-point Likert Scale was used on all measures except Values, which used a 9-point Scale and MELs (hours/day), which used a 5-piont Scale.

Extant PSE benchmark data. Archival utility data from the electric utility company, PSE, was collected for participating households in 2015 and 2016. This extant data was used to benchmark the pattern of total energy use prior to the start of study for each household across both study sites. From these data, a mean EUI score was calculated (kBTU/sq.ft.yr.) for each building and each community as a whole.

Adjusted contemporaneous Energy Use Intensity baseline data. The initial data of actual energy use was collected using two independent data sets to establish concurrent data points for each household across both study sites. One data set was gleaned from three months of up-to-date Puget Sound Energy (PSE) utility records that established a current baseline for the overall total household energy use (aggregated energy data in kWhs). The second data set was derived from real-time in-home Circuit Level Monitors (CLMs) connected to the breakers in the household's electrical panel[36] that collected disaggregated household energy use by specific major equipment types or sub-category use types. Table 3.4 illustrates the electric loads monitored in the homes.

Table 3.4. CLM Energy Data Categories for End-use Loads.

Data Categories for Speicific Circuit Level End-use Loads	
1	Total Power (e.g., electrical mains)
2	Space Conditioning (e.g., ductless mini-split heat/cool, wall heater or ceiling fan, heat recovery ventilator)
3	Domestic Water Heater (e.g., heat pump or electric hot water heater)
4	Major Appliances (e.g., range, dryer, dishwasher, refrigerator)
5	MELs for Entertainment Centers (e.g., televisions, game stations, recording devices)
6	MELs for Workstations (e.g., computers, monitors, printers, cell phone charging)
7	MELs for other uses (e.g., range hood, microwave, toaster, coffee/tea pot, entry porch lighting)
8	MELs for other unmonitored significant uses (e.g., hot tub, portable heater or fan, general lighting)

Using two sets of data collected from two independent sources allowed a check on the accuracy and reliability of the more granular level data generated from the in-home circuit monitors. For both sets of data, energy use was collected in real-time and EUIs were calculated on a quarterly basis over the course of one year to correspond with space conditioning energy use demands associated with seasonal heating and cooling needs.[37]

Treatment. During a three-month time period, treatment consisted of giving participants access to real-time CLM feedback which required participants to: 1) log onto the website portal

[36] Connection to the circuit wiring in the electrical panel was made by a licensed electrician in each participant's home.

[37] Typically, space conditioning is the dominant energy use in residential buildings and fluctuates seasonally. When space conditioning energy use data is correlated to weather on a monthly and seasonal basis it is possible to analyze energy used for structural qualities inherent in the building and occupant-driven-energy-use. For example, in the summer months (QT3) the energy load for heating would likely be zero or very low in the Pacific Northwest.

to view a dashboard displaying real-time energy use; 2) interact with the website to pull up information and interpret graphs and pie-charts; and 3) receive multiple daily emails with prompts and alerts on their real-time energy use throughout the first quarter of 2017. Treatment was considered to have a high-intensity level due to the high level of participant involvement. The online "dashboard"[38] is shown in Figure 3.12.

Figure 3.12. Example of PowerWise / SiteSage Dashboard.

Source: Image by author.

---

[38] For more information on informational feedback on energy consumption, see also Faruqui, Sergici, & Sharif, 2010.

This dashboard allowed real-time feedback on energy use in four major end-use categories: 1) space heating and cooling; 2) domestic hot water heating; 3) major appliances; and 4) miscellaneous electric loads (MELS – energy used by electronic devices such as computers, gaming stations, or TV sets). In addition, each participant received emailed alerts highlighting changes in their energy use patterns and potential ways to improve their energy efficiency, an example of which is illustrated in Figure 3.13. In this case, the prompt asks the resident to check whether the range has been intentionally left on for more than an hour.

Figure 3.13. Example of Automated Alert.


SiteSage Alerts
March 10, 2017 at 2:22 PM
SA
Range On Too Long
To:
Reply-To: csm@powerhousedynamics.com

Alert courtesy of PowerWise Systems
SiteSage

Location:

Hi

The SiteSage service has detected that the Range at has been on for more than 60 minutes. Check the equipment on that circuit.

Click here to login to SiteSage to learn more.

Was this alert helpful? Reply to this email and let us know.

Regards,
SiteSage Support
PowerWise Systems

2017 Powerhouse Dynamics, Inc. All rights reserved.
The name SiteSage and the SiteSage logo are trademarks of Powerhouse Dynamics, Inc.

Source: Image by author.

Post-treatment. The purpose of data collection after treatment (exposure to dashboard feedback) was to assess changes (if any) from baseline among households and across communities on perceptions and actual energy use.

Post-treatment survey. The second survey (identical to the initial survey) sought to uncover any changes that may have occurred in people's perceptions on how they used energy in the home after being given access to information about their energy use in real-time (treatment).

Post-treatment Energy Use Intensity. Post-treatment energy use data was collected in two phases. The first phase of post-treatment took place over three months in the spring of 2017, from April to June. Considered to have a medium-intensity level, the treatment consisted of access to the real-time CLM dashboard feedback and included an emailed monthly energy report card but no longer transmitted daily prompts or alerts. The final phase of post-treatment occurred in the third quarter of 2017, from July to September. Considered to have low-intensity, this phase extended dashboard access exclusively and at the discretion of the participant.

Posttest. At posttest, toward the end of the third quarter in 2017, focused interviews were conducted to better understand the role of people's place meanings, attachments, and identities on their energy use. Specifically, in a 60 to 90-minute face-to-face interview, participants were asked a series of questions designed to elicit responses that would capture insights into people's actions and emotions related to their lived experience of place (home and community) with respect to environmental issues in general and energy use in specific. Interview topics are described in Table 3.5 (see also Appendix 1 for the complete instrument).

Table 3.5. Focused Interview Data Collection.

Interview Topics
Background:
Why was this home and/or community chosen as a place to live?
Feelings about living here:
Sense of connection & groundedness
Expressions of identity and values
Supportive of current lifestyle
Caring for place
Sustainability and environmental behavior:
Actions and choices on energy behaviors
Architectural Design Features (ADF) that influence energy use
Dashboard feedback:
Problem Responses
Positive Responses
Stories from beyond the dashboard

Site 1, Built Green Community (n = 8); Site 2, Code-built Community (n = 8), Total N = 18

Measures

The four measures used to collect data (survey data, actual energy use data, and focused interview data) are each paired with an associated research question as described below.

Energy Use Intensity (EUI) data: actual energy use. Several types of EUI measures used in this research were designed to address Research Question 1, which asks: How do the Built Green and Code-built communities compare on their actual energy use at both the household and community level?

Benchmarking aggregated total energy use computing historical EUI scores. Benchmarking the energy use of the buildings themselves permitted a comparison between the inherent energy efficiency of each individual building's structural characteristics (building envelope and equipment) on a per square foot basis (kBTU/sq.ft.yr.). Analyzing energy use on a per-square foot basis allowed for buildings of different sizes and floor plans to be compared on a common unit of measurement. Thus, household mean baseline EUI scores were computed for 2015, 2016, and compared to 2017 (study period) scores to examine patterns of energy use among households and across communities over time. In addition, to account for seasonal weather fluctuations and variability from one year to another the data was adjusted to be weather-normalized.[39] Finally, for those households in Site 2 which used the common laundry, information on dryer use was obtained from the community governance board and used to compute electric usage on a per load per month basis, usage added to the total kWhs for an individual household. Similarly, for those households in Site 2 which shared a hot water heater with another household, information on hot water heater use was obtained from the community governance board and used to allocate usage to the appropriate household unit on a per-person per-household per month basis.

Contextualizing total energy use computing EUI scores. To provide context for the specific EUI scores from the two communities, EUI scores from two additional data sources were computed to create a set of reference scores. Mean EUI scores were derived from 2011 regional data from the Residential Building Stock Assessment Study (RSBA, 2014) for the Pacific Northwest and computed from 2009 national data from the Residential Energy Consumption Survey (RECS, 2009) for the Pacific Region in the Washington State marine climate zone.[40] Taken together, referential mean EUI scores from the 2009 and 2011 studies provided two Pacific Northwest reference points in comparison to which performances of the 2013 Built Green and 1991 Code-Built communities were evaluated.

---

[39] Weather normalized energy is the energy a building would use under average conditions for space conditioning in a given climate. This process accounts for the differences that may occur from one year to the next. Weather normalized data analyzed for this study are designated with a lower case "wn." The methodology for weather normalization used in this study was developed by the Global Environment and Technology Foundation. For more information see http://www.getf.org.

[40] For more information, see the 2014 Residential Building Stock Assessment Metering Study (RBSA, 2014) and the 2009 Residential Energy Consumption Survey (RECS, 2009).

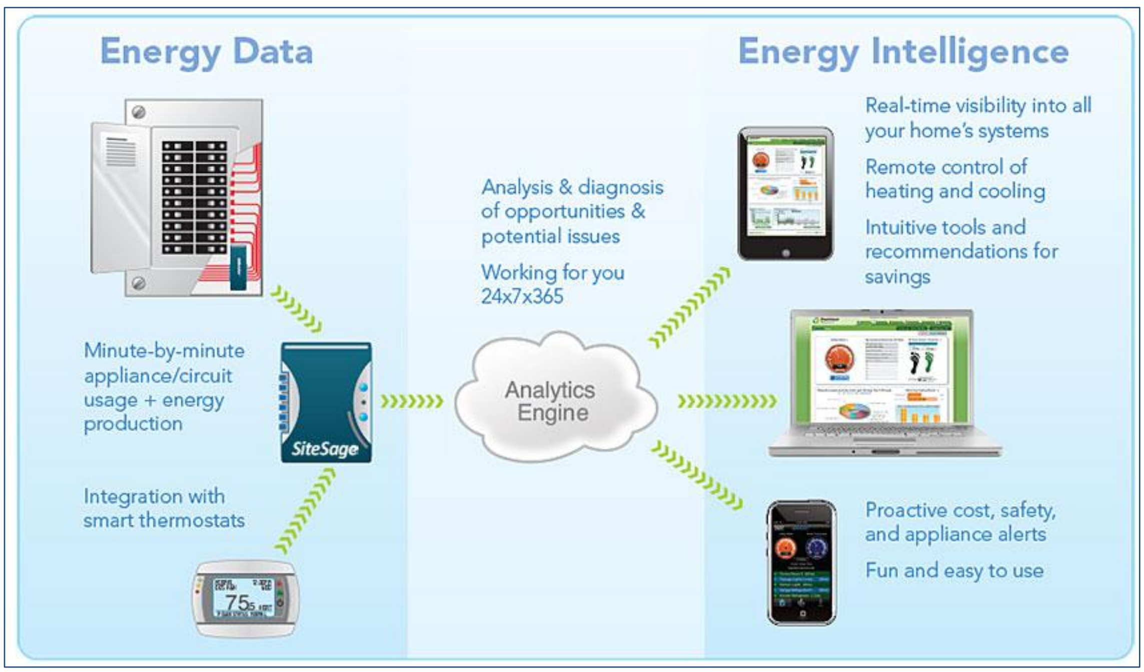
Adjusted contemporaneous EUI scores using in-home circuit level monitoring data. Even as building envelopes improve to meet net-zero energy goals and increasing stringent energy standards are adopted into building codes, energy use performance patterns stemming from occupants' behavior can be just as important to how efficiently a building operates. For an analysis of energy-use patterns driven by occupant behavior, mean EUI's are computed for smaller household devices (e.g. MELs) using circuit specific energy load data. EUI's based on disaggregated energy data are important because these energy uses are controlled by occupant behavior and have the potential to change over time. Furthermore, behavior-related energy use may be influenced by philosophical or community culture as well as architectural design or structural factors.

The Built Green Community's preconstruction energy model's[41] predicted energy use and post-occupancy actual energy use were expected to be lower than those of the Code-built Community by virtue of structural context-oriented factors, meaning the architectural design—high performance advanced construction and equipment technology intended to achieve net-zero energy. Similarly, the energy use for occupant-driven-behavior energy-use patterns for the Code-built Community might reasonably be expected to be lower than those of the Built Green Community's because of people-oriented factors, meaning the philosophical design. Homeowners at Site 1 are not expected to change their behavior in order to live an energy-efficient lifestyle, whereas homeowners at Site 2 are expected to attend to the energy use of their home and community as a whole in order to maintain a light ecological footprint consistent with their community values.

[41] Prior to actual construction, during the architectural design process it is common to model energy use by predicting the total kWhs that a building is likely to use on an annual basis as a part of the permitting process to meet the Washington State and local jurisdictions energy codes.

CLM data systems. Building performance EUIs based on aggregated data for total household electric loads can be disaggregated and measured for specific individual circuits and devices. This level of data segregation, using in-home circuit level monitoring (CLM) equipment, allows an evaluation of how occupants are using energy at the device level. The CLM data was recorded in real-time after sensors were clipped to circuit breaker wires in the electrical panels of participant households. [42] The monitoring technology included both hardware (PowerWise Systems[43]) and software (SiteSage) for gathering data by circuit per end-use electrical loads for devices plugged into wall electrical sockets, as illustrated in Figure 3.14.

Figure 3.14. Power House Dynamics, PowerWise / SiteSage Architecture.



Source: Retrieved (August 12, 2018) from Google Images. https://www.google.com/.

These readings were transmitted to a secure server where I could access and export the data through a web-based portal called SiteSage. This application permitted data analysis on the

---

[42] This installation was conducted by a licensed electrician.
[43] PowerWise distributes monitoring equipment and management software under the trade names, Powerhouse Dynamics (equipment) and SiteSage (control technology software). For more information see http://www.powerwisesystems.com/contact/about.

end-use loads for each metered device in a specified interval and timeframe. In this study, the data collection was transmitted at 15-minute intervals, exported at daily intervals, and the timeframe extended over four consecutive three-month time periods for a total of one year.

CLM monthly totals measured in kilowatts per hour (kWhs) were exported from the SiteSage application into an excel spreadsheet. The per household CLM energy use (disaggregated) data categorized for end-use loads were tabulated as illustrated in Table 3.6.

Table 3.6. Example of CLM Monthly Tabulation of Metered End-use Loads.

DATE		PRODUCTION/ CONSUMPTION MAINS kWH per DAY		INDIVIDUAL CIRCUITS kWH pr DAY												CALCULATED CONSUMPTION TOTALS kWH per DAY		
Days	Date	Solar PV	Main Power	Range	Water Heater	Dryer	HRV	Dishwasher	Refrigerator & MELs	Ductless Mini Split	Living/Dining Rm	Office	Kitchen MELs	Wall Heater	Lights + MELs	Unmonitored	Monitored	Total
		Production	MELs Miscellaneous	Major Appliance	Water Heater	Major Appliance	Space Conditioning	Major Appliance	Major Appliance	Space Conditioning	MELs Entertainment	MELs Workstation	MELs Small Appliance	Space Conditioning	MELs	MELs Miscellaneous	Sum of Circuits	Consumption
1	10/7/16		26.845	0.118	6.007	3.97		0	3.133	1.942		2.287	1.196			8.19	18.653	26.845
2	10/8/16		30.729	3.378	12.056	0		0.004	3.46	0.457		1.653	1.187			8.534	22.195	30.729
3	10/9/16		29.574	1.757	9.588	0		0.977	3.762	2.727		1.687	1.173			7.903	21.671	29.574
4	10/10/16		24.378	0.118	8.4	0		0	3.491	0		2.118	0.754			9.497	14.881	24.378
5	10/11/16		20.108	0.118	4.232	0		0	2.798	0		2.081	0.928			9.951	10.157	20.108
6	10/12/16		38.36	0.117	9.474	7.852		0	2.898	4.069		1.807	1.594			10.549	27.811	38.36
7	10/13/16		32.741	2.581	10.445	0		0	3.2	0		2.222	3.468			10.825	21.916	32.741
8	10/14/16		25.961	0.117	8.506	0		0.982	3.546	0.113		1.532	1.129			10.036	15.925	25.961
9	10/15/16		32.678	0.113	7.395	0		0	3.101	9.673		0.587	1.759			10.05	22.628	32.678
10	10/16/16		38.237	4.783	7.41	3.529		0.947	3.104	5.465		1.308	1.87			9.821	28.416	38.237

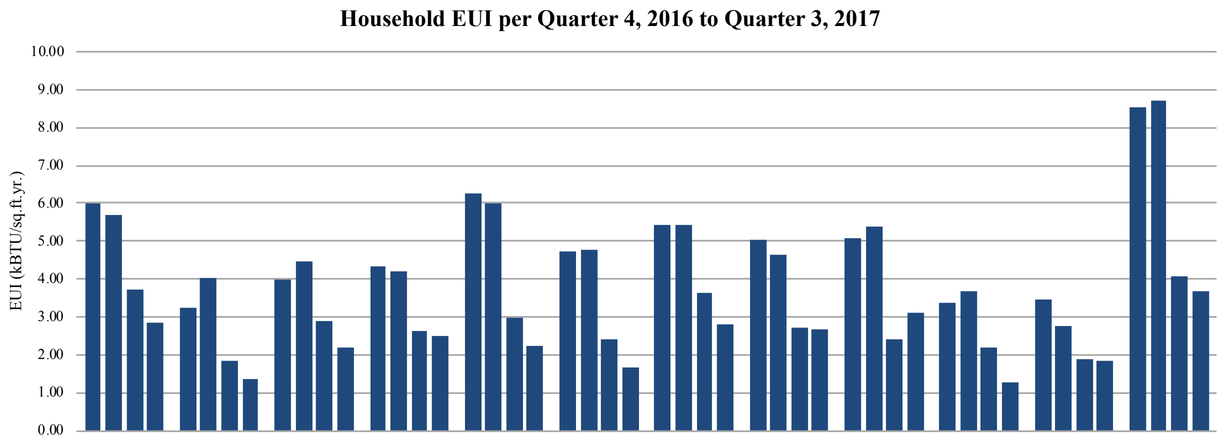
Source: Image by author.

CLM monthly totals were summed in three-month increments aligned with the four seasonal (weather related) quarters of the year. Next, EUI scores for each quarter of the year were computed and weather normalized (kBTU/sq.ft.qt.^{wn}[44]) for each metered end-use load in each individual household. Total mean EUI scores were also computed for each metered end-use

[44] kBTU/sq.ft.qt.^{wn} is an abbreviation for the EUI unit taken in a three-month time period or quarter (qt.) and is weather normalized (wn). If the time period was for an annual EUI the units would read kBTU/sq.ft.yr.^{wn}.

load per community. Finally, a load shape[45] graph was created to establish comparisons among households and across communities[46] as shown in the example of Figure 3.15.

Figure 3.15. Sample of End-use Load Shape Graph.



Source: Image by author.

Total mean EUIs were compared among households and across communities over time using data from energy models, extant and current electric utility company data, and third party regional and national data. Recall that the total building EUI scores indicate how well the building envelope, equipment, and occupants perform as a whole. The circuit-specific EUI scores helped indicate the amount of energy a building occupant used for major end-use loads and to power discretionary in-home devices. Taken together, these two types of data – total building mean EUI scores and circuit specific EUI scores – described a pattern or profile of actual energy use for each household before, during, and after treatment differentially within a community or across the two communities.

---

[45] A load shape is a graph of the variation in the energy use (electrical load) versus time. For more information see http://www.neea.org/resource-center/regional-data-resources.
[46] Where information was available, regional comparisons were also drawn from RBSA (2014) Metering Study data by major end-use load.

CLM data: real-time feedback. Circuit specific EUI scores were also used to measure the effects of treatment addressed in Research Question 2, which asks: What are the effects of real-time feedback on energy use?

Effects of real-time feedback on energy use: benchmark vs. treatment. For each participating household, treatment began with installation of a circuit-level monitoring device connected to the main electrical panel. SiteSage allowed the household to access panel readings in both kilowatts per hour and U.S. dollars for real-time total household energy use as well as energy use for individual major appliances, equipment, and personal electronic devices (listed in the per household CLM energy data are categorizes in the prior section in Table 3.4). In addition, each participant received reports on their energy consumption in the form of prompts and alerts highlighting variations in energy use patterns and suggesting ways to conserve energy.

During the first three-month period of treatment from January to March of 2017, prompts and alerts on how energy was being used and might be conserved were emailed to each household in real-time via SiteSage whenever the program detected a significant change in energy use or a piece of equipment short-cycling (activating more frequently than would be expected). For example, if a refrigerator door were left open for a period of time, the refrigerator would draw electricity on a shorter cycle to keep up with the higher demand for cooling and SiteSage would send an email to the homeowner noting this change.

EUI scores were computed during the treatment period from two sources—PSE utility billing data and in-home CLM data. Using two sources to measure the effects of the dashboard feedback (total energy and circuit specific energy) helped ensure reliability of the data collection and infill any missing data through interpolation.[47] EUI scores were computed for each

---

[47] Overall, there was very little missing data in the CLM data set. The largest amount of missing data was from time

household during the three-month treatment period and compared to three-month periods at pretest, post-treatment, and posttest. After treatment, the survey was administered a second time to determine whether exposure to energy monitoring dashboards had helped to create change in perceived and actual energy use and whether a differential effect between the two study communities could be measured for actual energy use and perceptions on energy use.

Survey data: perceptions of energy use. The survey instrument used in this research was designed to address Research Question 3, which asks: How do the Built Green and Code-built Households and Communities compare on their perceptions of energy use?

Survey instrument. The survey data yielded important baseline data to address the question of similarities and differences between the two communities with regard to residents' perceptions and pro-environmental behavior generally and home energy use specifically. The survey was composed of 24 questions, all of which were either adapted from previously tested and validated measures from the literature or developed for this study based on state-of-the-art sustainable architectural practices, codes, and design standards (see Table 3.7 for Survey Variables). [48] The survey collected the following data:

Housing and socio-demographic characteristics. Housing characteristics were obtained with questions about location, home size, number of people, and number of bedrooms while socio-demographic characteristics were acquired with questions about home ownership, length of residency[49], gender, ethnicity, age, household income, and level of education.

---

periods when the equipment went off line due to a power outage or the homeowner switched off the power.
[48] Beyond code standards include One Planet Living Principles, US Green Building LEED Program, International Passive House Institute, and the International Living Futures Institute.
[49] The survey item for Length of Residency was deleted from analysis because all but one member of the Built Green Community had moved into their homes during the 2013-14-time period when the development completed construction.

Perceptions on energy use. The survey also included a set of questions to discover whether people's perceptions had changed given exposure to real-time feedback on their actual behavior. Table 3.7 below is a summary of the variables, measures, and the origination of the tested and validated scales used in this survey.

Table 3.7. Survey Variables.

Variable	Question/Source of Measures	Scale
Values	*Please rate how important each value is for you AS A GUIDING PRINCIPLE IN YOUR LIFE.* *1. EQUALITY: equal opportunity for all* *2. RESPECTING THE EARTH: harmony with other species* *3. SOCIAL POWER: control over others, dominance* *4. PLEASURE: joy, gratification of desires* *5. UNITY WITH NATURE: fitting into nature* *6. A WORLD AT PEACE: free of war and conflict* *7. WEATLH: material possessions, money* *8. AUTHORITY: the right to lead or command* *9. SOCIAL JUSTICE: correcting injustice, care for the weak* *10. ENJOYING LIFE: enjoying food, leisure, etc.* *11. PROTECTING THE ENVIRONMENT: preserving nature* *12. INFLUENTIAL: having an impact on people and events* *13. HELPFUL: working for the welfare of others* *14. PREVENTING POLLUTION: protecting natural resources* *15. SELF-INDULGENT: doing pleasant things* *16. AMBITIOUS: hard-working, aspiring* *Four Composite variables were constructed based on the above variables: Altruistic, Biospheric, Egoistic, Hedonic.* Values were assessed by means of a short version of Schwartz's value scale (1992) developed by De Groot and Steg (2008). The scale has extensively been tested and validated in various studies (De Groot & Steg, 2007, 2008, 2010; Steg et al., 2005, 2011; Steg, Perlaviciute, van der Werff, & Lurvink, 2014).	9-pt Likert 1 = opposed, 2 = not important, 3, 4, 5, 6, 7 = increasing importance, 8 = very important, 9 = extremely important.
Beliefs	*Below is a set of statements about your awareness of environmental problems or worries about it. Please indicate your level of agreement or disagreement with each statement. 1) I am aware of climate change. 2) I need to worry about global warming.* Beliefs about environmental problems as defined by one's awareness or worries about climate change. All scale items, which measure this dimension, are from previous research (Poortinga & Steg 2004).	7-pt Likert
Efficacy	*Below is a set of statements about your preferred solutions for environmental problems. Please indicate your level of agreement or disagreement with each statement. 1) I can do something about climate change to help solve environmental problems. 2) The free market is the best way to solve environmental problems. 3.To solve environmental problems, the government should give clear rules about what is and what is not allowed.* All scale items, which measure this dimension, are from previous research (Poortinga & Steg, 2004; UW CAP survey).	7-pt Likert
Goals	*Below is a set of statements about your environmental goals. Please indicate your level of agreement or disagreement with each statement. 1) Living in this community increases my motivation to act sustainably. 2) Living in a home that was designed to be a green sustainable home increases my motivation to act sustainably. 3) Living in a home that was designed to be energy efficient decreases my motivation to act sustainably. 4) Living in a home that was NOT designed to be energy efficient increases my motivation to act sustainably.* All scale items, which measure this dimension are newly developed for this study and were based on previous literature on goal framing and social/personal norms (Van der Werff, E., & Steg, 2015; Steg, Bolderdijk, Keizer, Perlaviciute, 2014).	7-pt Likert
Environmental Self-identity	*Below is a set of statements about your environmental identity. Please indicate your level of agreement or disagreement with each statement. 1) Acting environmental friendly is an important part of whom I am. 2) I see myself as an environmental-friendly person. 3) I am the type of person who acts environmentally friendly.* These items were adapted from previous research (van der Werff, Steg, Keizer, 2014; Fielding et al., 2008; Terry, Hogg, & White, 1999).	7-pt Likert

Table 3.7. Survey Variables, continued.

Variable	Question/Source of Measures	Scale
Place Identity	*Below is a set of statements about your feelings of place-identity. Please indicate your level of agreement or disagreement with each statement. 1) My home is very special to me. 2) My home means a lot to me. 3) I am very attached to my home. 4) I identify strongly with my home. 5) Living in this home says a lot about who I am. 6) I feel that this home is a part of me.* All scale items, which measure this dimension were developed and validated in previous studies (Williams & Vaske, 2003; Raymond, Brown, & Weber, 2010).	7-pt Likert
Place Attachment	*Below is a set of statements about your feelings of place-attachment. Please indicate your level of agreement or disagreement with each statement. 1) I miss my home when I am absent for a long time. 2) I am proud of my home. 3) My home is a part of me. 4) I want to be involved in this community's affairs/in what is going on here. 5) I would like my family and friends to live here in the future.* These items were adapted from previous research (Lewicka, 2010).	7-pt Likert
Hours of Use	*Please estimate on average how many HOURS per DAY your household uses electric power for these devices (based on TOTAL NUMBER OF DEVICES in active use and while drawing power in sleep/standby mode. Though a day has 24 hours there may be multiple devices in use throughout the day such as a cell phones, computers, or monitors.* *1. Smart Phone Charging Stations (such as iPhone)* *2. Tablet Charging Stations (such as an iPad)* *3. Computer Work Station Devices: desktops, laptops, monitors* *4. Computer Peripherals: printers, scanners, copiers* *5. Television Sets* *6. TV Peripherals: set sop box, cable TV, recording or streaming devices* *7. Video Game Stations* *8. Entertainment Centers: amplifier, radio, CD/DVD player, movie projector* *9. Electric Space Heaters or Fans (portable)* *10. Small Kitchen Appliances: microwave, coffee/tea maker, toaster oven* All scale items, which measure this dimension, are newly developed for this study. These items were based on previous research (Asensio and Delmas, 2014, PNAS, pp. 1-6; Kwatra, Amann, & Sachs, 2013; McNary et al., 2012).	5-pt Scale 1= less than 4 hr./day, 2 = 4-8 hr./day, 3 =9-24 hr./day, 4 = 25-50 hr./day, 5 = more than 50 hr./day
Low Cost Actions	*Please indicate how frequently you do the following ACTIONS to conserve energy.1) Power off charging station by unplugging devices: cell phone, tablet, laptop. 2) Power off entertainment center by unplugging devices: TV, video game, set top box. 3) Power off desktop workstation by unplugging devices: computer, laptop, monitor. 4) Power off desktop workstation peripherals by unplugging: printer, scanner, copier. 5) Power off small kitchen appliances: microwave, coffee/tea maker, toaster oven.* All scale items, which measure this dimension, are newly developed for this study. All scale items, which measure this dimension, are newly developed for this study. These items were based on previous research (Asensio and Delmas, 2014, PNAS, pp. 1-6; Kwatra, Amann, & Sachs, 2013; McNary et al., 2012).	7-pt Likert
High Cost Actions	*Please indicate how likely you would be to do the following ACTIONS with regard to your home in the next 5 years. 1) Spend 25% more on the cost to build/buy a net zero home. 2) Install or improve a solar panel renewable energy system on your home. 3) Retrofit your home to have a highly efficient building envelope: triple wall and attic insulation / triple pane windows.* These actions are expensive to undertake and therefor asking about someone's willingness to complete this future high cost improvement may give insight into their understanding their values. All scale items, which measure this dimension, are newly developed for this study. All scale items, which measure this dimension, are newly developed for this study. These items were based on previous research (Asensio and Delmas, 2014, PNAS, pp. 1-6; Kwatra, Amann, & Sachs, 2013; McNary et al., 2012).	7-pt Likert

Table 3.7. Survey Variables, continued.

Variable	Question/Source of Measures	Scale
ADF	*Below, you will find 20 ARCHITECTURAL DESIGN FEATURES. After each FEATURE, several examples have been provided to help explain the meaning of the feature. Please rate how important each FEATURE is for you in your existing place of residence.*	7-pt Likert
	1. PLACE: pedestrian and bike friendly, near public transit and services, provides open space for native habitat	
	2. SITE: green roofs, green walls, rain gardens, porous pavers, pea-patch / urban agriculture	
	3. RENEWABLE ENERGY: solar PV array, ground source heating, wind energy, home battery that charges using solar electricity (Power Wall)	
	4. WATER: low flow fixtures (shower/toilet), water harvesting (cistern, grey water), natural hydrology (surface stormwater catchment)	
	5. ENERGY: heat recovery air ventilation system, tight building envelope (continuous air sealing), highly efficient building envelope (triple insulation values, triple pane windows)	
	6. MECHANICAL SYSTEMS: operable windows, highly efficient home heating system and hot water heater	
	7. LIGHTING: LED fixtures, day lighting, automatic dimming and motion detection controls	
	8. BUILDING MATERIALS: 50-100 year building materials, rain screen to prevent mold, renewable building materials, locally sourced building materials	
	9. INDOOR QUALITY: air, thermal, and visual comfort; non-toxic building and finish materials; continuous air filtering	
	10. MONITORING: real time in-home appliance level energy monitoring, dashboard feedback and alerts sent to your smart phone/computer	
	11. EDUCATION: share educational materials about the operations and performance of your home with others	
	12. BEAUTY: human scale, variety of building form, color, texture, materials, landscape, art/sculpture	
	13. BUILD SMALL: preserving open space (small building footprint), home size less than 1600 SF	
	14. CHANGING NEEDS: rentable rooms, universally accessible rooms, flex rooms, caretaker apt. in-home office	
	15. HEALTH: willing to reduce asthma/cancer by reducing use of and demand for electricity generation; commute by bike; take the stairs	
	16. WASTE: seek ways to recycle, compost, reduce packaging, etc. to reduce waste	
	17. BEHAVIOR: change your behavior to be more environmentally friendly; seek ways to enhance your feelings of green-identity, green-place identity, and green place-attachment	
	18. BIOPHILIC: incorporate nature inspired design features into your home and community environments	
	19. INNOVATION: use a small device like a "FitBit" to monitor the energy use in the home, use a remote control thermostat connected to WiFi (NEST)	
	20. BEYOND CODE CERTIFICATION: certification of your home to LEED, Passive House, Living Building Challenge, or One Planet Living design standards	
	Five Composite variables were created using factor analysis from the above variables: Envir./Human Well-being; Next Gen Bldg. Systems; Regen Design Features; Accom. Chg. Needs/Uses	
	All scale items, which measure this dimension, are newly developed for this study. These items were adapted from previously developed code standards (International Living Futures Institute, One Planet Living, International Passive House, LEED architectural design criteria wit the addition of behavior, changing needs and behind code features which are specific to this study.	

Focused interviews. Interviews were conducted with a sample of survey participants to discern why and how people used energy as they did and how they described their lived experience in their homes and community around pro-environmental behavior in general and energy use in specific. These in-depth qualitative interviews enabled an exploration of how people see and interpret their homes, residential communities and living situation through their own experiences.[50] Each interview question was open-ended so that the respondent could answer freely, though at times I interjected prompts to encourage a fuller answer.

Participant selection. Interviewees consisted of a sub-set of the total sample population. The final interview sample of 18 households (head of household[51]) was selected based on an analysis of their energy use patterns (change in quarterly mean EUI scores from baseline to post-treatment) to ensure a diverse range in household energy use. More specifically, Z-scores were computed using mean EUI change scores at baseline to treatment (Jan-Mar 2017) and baseline to post-treatment (Apr-Jun) 2017). A cross tabulation analysis was then conducted to select a sample that represented a wide range of energy use behavior and behavior change. Once qualifying households were identified, I contacted participants to set up the face-to-face interviews. A total of nine interviews were conducted in each of the two sites ($N = 18$).

Interview process. All interviews were conducted in person, with the exception of one Skype interview, over a two-week time period at the end of July and beginning of August 2017. Interviews generally took place at the participant's home, but in a few cases were conducted in the common open space (Built Green Community) or common house (Code-built Community) at the request of the respondent. Interviews were recorded with verbal permission of the participant

---

[50] See Zeisel (2006); Robson & McCartan (2016); Gifford (2016) for more information on focused interviews.
[51] The interview took place with one person from the household in all but a few cases, in which a couple participated. Their answers are recorded, transcribed and analyzed as a single unit of data.

using a small tabletop recorder and cellphone backup while I took field notes. All interviews were conducted using the same introduction and set of 18 questions. Although the interview was intended to be open and conversational with a directed focus, an introduction was read verbatim to set the context.[52]

Interview instrument. The interview questions queried participants on their views and feelings about their energy use in four main areas: 1) Environmental Psychological Aspects—values; 2) Environmental Psychological Attachments and Identities—place identity, environmental self-identity, and place attachment; 3) Environmental Cues—architectural design features (ADF) in the physical and social built environments; and 4) Response to real-time feedback—online dashboard, email prompts, and email alerts (see Appendix 1 for the interview instrument).

Seventeen of the 18 recorded responses from these 60- to 90-minute focused interviews were then professionally transcribed during the month of August in 2017. I transcribed the audio recording for the 18th interview, which took place via Skype at the interviewee's request, immediately following the interview.

Data Analysis Plan

Quantitative data: actual and perceived energy use. The purpose of the quantitative research phase was to investigate whether participating households in the two communities differed on energy use, using both self-reported survey items as well as actual utility billing data and in-home circuit level monitoring. To this end, data from 24 households (12 per site) were analyzed across participating households in each community. Each participating household as well as each community as a whole (across all households) was analyzed on actual energy use

[52] See Appendix 1 for the complete focused interview instrument.

calculating EUI scores before, during, and after exposure to real-time feedback on energy use. A secondary focus of the quantitative analyses was to test whether participating households from the two communities differed on their self-reported pro-environmental values and relationship to place ratings collected in baseline (pretest) and posttest surveys. Research questions 1, 2, and 3 pertaining to the quantitative part of this study are presented sequentially along with their quantitative data analysis plans in the following section.

Research Question 1: How do the Built Green and Code-built communities compare on their actual energy use?

- Benchmarking EUI scores for each of the two communities.
    - Question 1a: What are the differences, if any, between the Built Green and Code-built community participating households on EUI scores (kBTU/sq.ft.yr.) derived from two years of extant Puget Sound Energy billing aggregated data? In other words, how do the communities differ prior to energy dashboard treatment onset?
    - Analysis: Using Excel, mean EUI scores (kBTU/sq.ft.yr.^{wn}) were computed and weather normalized for each of the two comparison communities prior to the start of the study using 24 months of PSE extant energy data (kWh) from 2015-16. Two-group *t*-tests in SPSS were then used to compare communities' energy use.
- Contextualizing EUI score for each of the communities.
    - Question 1b: For participating households in each community, how do the benchmark EUI scores compare with a number of other third-party metrics including: site specific energy model EUI score predictions; regional energy use assessments, and national energy use evaluations on aggregated data?

- Analysis: First, predicted energy model EUI values were obtained from the engineering company[53] which generated them for the Built Green Community and from the RePower[54] initiative which generated them for the Code-built Community. Second, 2011 EUI values were drawn from the Northwest Energy Efficiency Alliance (NEEA) Residential Building Stock Assessment Study (RSBA, 2014). Third, 2009 energy data (kWh) was retrieved from the U.S. Energy Information Administration (EIA) Residential Energy Consumption Survey (RECS, 2009) website. From these sources, mean EUI scores (kBTU/sq.ft.yr.) were computed in Excel. These household metrics are reported descriptively for each community.

Research Question 2: What are the effects of real-time feedback (dashboard treatment) on actual energy use of participating households?

- Testing significant change in pre- and post-treatment actual energy use for participating households in each of the two communities (separately).
  - Question 2a: Does exposure to energy monitoring dashboards conveying real-time feedback (i.e., the treatment) correlate with a significant reduction in actual energy use as measured by PSE EUIs for participating households within each community, during high-, medium- and low-intensity treatment periods, with or without adjusting for previous benchmark periods?

---

[53] Ecotope is a Seattle based engineering firm hired by the developer to prepare an energy and mechanical study for single-family and multifamily prototypes, August 14, 2011.
[54] RePower was an initiative that, with the help of $4.9 million in seed funding from the U.S. Department of Energy's Better Buildings Neighborhood Program, worked to reduce energy use and provide home energy assessments from August 2010 to 2014. Retrieved (July 12, 2018) from https://www.energy.gov/eere/better-buildings-neighborhood-program/.

- Analysis: For each community, 1-group *t*-tests were conducted to compare the mean change in PSE EUI scores against a null of zero (no use) from pretest (Oct-Dec 2016) to each treatment period.
- Question 2b: Does exposure to energy monitoring dashboards conveying real-time feedback (i.e., the treatment) correlate with a significant reduction in actual energy use as measured by closed circuit monitoring (CLM) for participating households within each community, during high-, medium-, and low-intensity treatment periods?
- Analysis: First, mean PSE EUI scores (kBTU/sq.ft.yr.^{wn}) were computed and weather normalized for the household using 12 months of PSE adjusted data (kWh) between October 2016 and September 2017. Next, mean CLM EUI scores (kBTU/sq.ft.yr.^{wn}) were computed and weather normalized using 12-months of CLM data (kWh) between October 2016 and September 2017 retrieved from the PowerWise Systems' SiteSage online portal. Third, the data from Site 2 was adjusted to proportionally attribute shared hot water heating and dryer use to individual households.[55] Fourth, the data were aligned with EUI values drawn from the RSBA (2014) report and then mean EUI scores were calculated from data retrieved from the RECS (2009 EIA) website (kBTU/sq.ft.yr.). Finally, for each community, 1-group *t-tests* were conducted to compare the mean change in CLM EUI scores against a null of zero (no use) from pretest (Oct-Dec 2016) to each treatment period.
- Question 2c: How do EUI scores from PSE and CLM sources compare?

---

[55] Hot water heating and dryer use data were adjusted to account for individual household use of communal equipment.

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

- Comparison of participating households from each of the two communities on changes in pre- and post-treatment actual energy use.
  - Question 2d: Are there significant differences in changes in actual energy use as measured by PSE EUIs among the Built Green and Code-built communities at during high-, medium-, and low-intensity treatment periods, after adjusting for changes in previous benchmark periods?
  - Analysis: Two- group *t*-tests were used to compare communities on mean PSE EUI pre-post changes.
  - Question 2e: Are there significant differences in actual energy use as measured by CLM EUIs among the two communities during each of the phases of treatment (high, medium-, and low-intensity)?
  - Analysis: Two-group *t*-tests were used to compare communities on mean CLM EUI scores pre-post changes.

Research Question 3. How do the Built Green and Code-built community households compare demographically and on their perceptions of energy use and pro-environmental variables?

- Comparison of participating households from each community on demographics.
  - Question 3a: What are the differences in demographic characteristics, if any, among the Built Green and Code-built communities?

- Analysis: Respondents' self-reported (survey) personal and household characteristics were analyzed in SPSS using 2-group chi-square tests of independence.

- Comparison[56] of participating households from each community on survey variables prior to dashboard treatment.
    - Question 3b: What are the differences in baseline perceptions of energy use and pro-environmental variables, if any, among the Built Green and Code-built communities?
    - Analysis: Two-group *t*-tests were used to compare on pretest (baseline) self-reported survey variables.
- Testing the significance of change in pre- and post-treatment survey variables for participating households in each of the two communities (separately).
    - Question 3c: Are there significant changes in perceptions on perceived energy use and pro-environmental variables from pre- to post-dashboard treatment for each community (separately)?
    - Analysis: One-group *t*-tests were used to test the significance of non-zero change on survey rating scale variables.
- Comparison of participating households from each community on changes in survey variables from pre- to post-treatment.
    - Question 3d: What are the differences in changes in perceptions of energy use and pro-environmental variables, if any, among the Built Green and Code-built communities?

[56] The comparison used a 2-group *t*-test; 1-group *t*-tests determined the nature and significance of the change between pretest and posttest, for each site separately.

- Analysis: Two-group *t*-tests were conducted to test mean differences among the communities on pre-post changes for each survey rating scale.

Qualitative data: focused interviews. Responses prompted by the following questions were collected from selected households from each community. This qualitative data was then coded and analyzed for trends both within and across communities as described briefly below and in detail in Chapter 6, with the end goal of illuminating the meaningful interactions among environmental behavior, identity, and design in net-zero energy homes and communities.

Research Question 4: What are the relationships among values, attachments, place meanings, and environmental cues on behaviors as they relate to energy use?

- Question 4a: What role do values and place meanings play in people's understanding of their environmental behaviors related to energy use?
- Question 4b: How do people understand both physical and social cues in their homes and communities?
- Question 4c: How do participants respond to information on their energy use with access to real-time dashboard feedback derived from circuit level energy monitoring devices in their homes?
- Question 4d: Using a grounded theory approach, what conceptual model could be developed to capture how different people-place relationships relate to residential energy use?[57]
- Analysis: Data were analyzed using ATLAS.ti software for cycles of textual data coding, generating code memos, and identifying key themes and patterns in

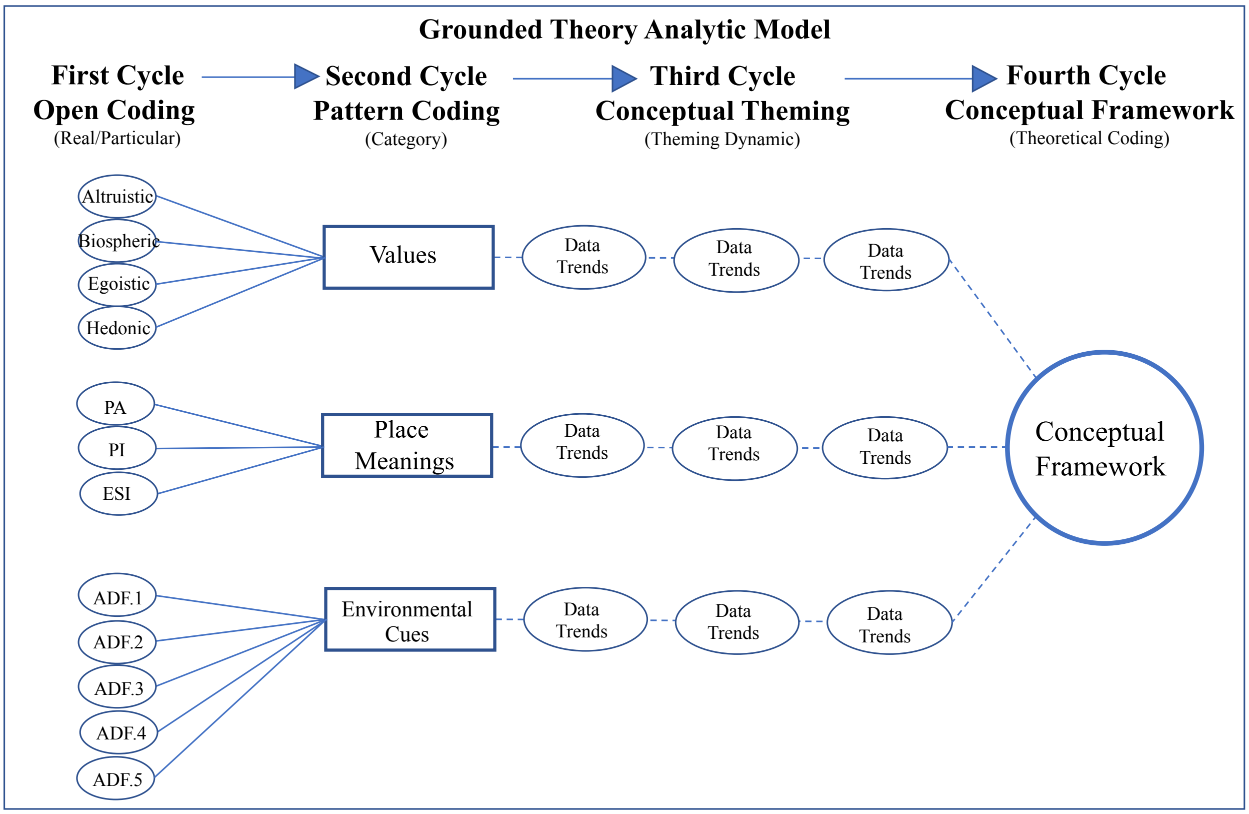
---

[57] Findings related to research question 4d will be reported in the Chapter 7.

alignment with a grounded theory approach (Saldana, 2009; Corbin & Strauss, 2008; Creswell & Creswell, 2018) described in detail in Chapter 6.

Data analysis process. Using coding techniques common to qualitative inquiry, excerpts from the interview transcripts were assigned a significant essence-capturing attribute in four cycles of coding, as illustrated in Figure 3.16.

Figure 3.16. Grounded Theory Analytic Process Model.



The first cycle, known as Open Coding, analyzed the data using codes that were derived from the survey instrument implemented and consisted of twelve attributes, the first four of which refer to types of values: 1) Biospheric; 2) Altruistic; 3) Egoistic; and 4) Hedonic. Similarly, three specific codes were used to capture different aspects of place meaning relationships: 5) Environmental Self-identity; 6) Place Identity; and 7) Place Attachment.

Finally, five codes were used to capture key aspects of people's experiences of place: 8) Environment and Human Well-being; 9) Next Generation Building Systems; 10) Regenerative Design Features; 11) Accommodating Changing Needs Over Time; and 12) Promoting Pro-environmental Awareness and Actions.

The second cycle – Pattern Coding – was based on the themes and issues identified as prominent in the relevant literature and distilled the first cycle codes into three code groups, labeled Values (first cycle codes 1-4), Place Meanings (first cycle codes 5-7), and Environmental Cues (first cycle codes 8-12).

The third cycle – Conceptual Theming Dynamic Coding – is an analytic process investigating the trends, underlying structure, and dynamic qualities found in Pattern Coding. For example, a narrative revealing several conflicting values statements and behaviors may be expressive of how a person grapples with trade-offs that are being considered among self-transcendent values (biking is good for the environment) and self-enhancing values (driving takes less time and effort than biking). In this example, a conceptual theme and data trend that I call "trade-offs" was developed.

The forth cycle – Theory Development Coding – describes the resulting analytic process of interpreting and integrating data across the entire coding process into a coherent whole descriptive of a behavioral interchange between the person and the environment. Engaging this grounded theory process, I sought deeper insights regarding why people engage in pro-environmental behaviors in their homes and communities and how people make sense of their lived experience with regard to their pro-environmental behaviors broadly and home energy use specifically.

The next three chapters present the findings from this study. Chapters 4 and 5 will address quantitative findings for the energy data analysis and the survey data analysis, respectively. Chapter 6 summarizes key findings from the qualitative interview data, and Chapter 7 provides a different take on the qualitative data synthesizing it into five major energy use profiles that form the basis of a new conceptual framework that I call “Life-Building Exchange.”

Chapter 4: Results for Actual Energy Use

As indicated in Chapter 3, the purpose of the quantitative analysis of observable energy use was to address the first and second research questions about how the Built Green and Code-built communities compared on their actual energy use, both before and during the dashboard treatment period.

To set the context, two prior research studies that collected similar information on energy use provide a reference for the structural characteristics of the housing unit, usage patterns, and demographics for households in the Pacific Northwest. Each of these characteristics is presented below for the two comparison communities and the two contextual studies, followed by an analysis of how the Built Green and Code-built Communities as a whole compared on their actual observed energy use.

Energy Use Context

Prior research on residential energy use for context. As described in Chapter 1, research examining residential energy use has been conducted both nationally by the U.S. Energy Information Administration (EIA) by means of the Residential Energy Consumption Survey (RECS, 2009) since 1978 (www.eai.gov) and regionally by the Northwest Energy Efficiency Alliance (NEEA) through the Residential Building Stock Assessment (RBSA) conducted in 2011 (RBSA, 2014). These two historical studies set the context for the energy analysis and findings related to the Built Green and Code-built communities.

As described in Chapter 3, two years of energy data were collected on each of the participating households in the Built Green and Code-built communities in order to set a benchmark for how these particular buildings used energy prior to the start of the study. Benchmarking data was derived by computing quarterly EUIs for 2014-2015 and 2015-2016 from extant Puget Sound Energy (PSE) utility billing data for each participating household. During the treatment period, the same data was also collected from PSE records (i.e., from the fourth quarter of 2016 and the first three quarters of 2017[58]). Additionally, information on the Built Green Community's pre-construction energy model and the Code-built Community's post-construction as-built energy model was obtained. All data were converted to EUI scores (kBTU/sq.ft.qt.) per quarter of analysis.

The results reporting housing and structural characteristics are presented below and the findings are discussed subsequently beginning with benchmarking through the all phases of the research. Table 4.1 presents the number of recruited households within each comparative study.

Table 4.1. Number of Households Recruited.

Site Status	Recruited Metered Site Status				Surveyed
	Study Sites		Regional		National
	Site 1	Site 2	Puget Sound	Northwest	
Continuously Active	10	9	31	90	184
Removed from Study	7	2	5	11	
Replaced Metering Site	0	2	1	3	
Replaced/Repaired Metering Device at Baseline	2	1	0	0	
All Active Sites Included in the Study	12	12	32	104	184

Notes: Source of study sites data: current metered study from October 2016 to September 2017
Source of regional data: 2014 RBSA Metered sites in 2011; national data: 2009 RECS

Structural characteristics. Studies on residential energy use tabulate structural characteristics (e.g., square footage, number of people in the home, and air tightness) of the housing unit in addition to energy usage (kWhs), and household demographics (e.g., age of occupants). Contextual household demographics are addressed in Chapter 3 briefly and in Chapter 5 in greater detail. Household structural characteristics are tabulated below for the two

---

[58] Similarly, data from 2014-2015 and 2015-2016 were taken from the fourth quarter of the prior year and the first three quarters of the following year to align the data with the study period. These years are abbreviated to 2015, 2016 and 2017.

comparison communities and comparative studies where information was available or applicable.

Household Demographics. Compared to the average home represented in the regional and the national studies, the Built Green and Code-built Communities have characteristics that would be expected to yield better energy performance. For example, the average number of occupants per home in the Built Green Community is 17% fewer than the average in the Northwest and 25% fewer than indicated in the national study. By comparison, the Code-built Community average number of occupants per home is about the same as other homes in the region and 11% less than the average recorded in the national study. On average, the Built Green Community has a balanced age group of occupants with an equal representation among children, adults, and seniors. The Code-built Community, regional, and national groups have a higher proportion of adults to children and to seniors. Results are shown in Table 4.2.

Table 4.2. Average Occupant Age and Number per Household.

Age Category	Average Number of Occupants per Household/Site				
	Study Sites		Regional		National
	Site 1	Site 2	Puget Sound	Northwest	
Minors (0-17)	1.67	1.80	0.89	0.73	0.78
Adults (18-64)	1.75	2.00	1.76	1.41	1.80
Seniors (65+)	1.60	1.00	0.38	0.56	0.41
Average number of occupants per household	2.25	2.67		2.71	3.00

Notes: Source of study sites data: current metered study from October 2016 to September 2017
Source of regional data: 2014 RBSA Metered sites in 2011; national data: 2009 RECS

Floor Area. The average floor area for Site 1 is 30% smaller than the average home in the region and 14% smaller than those surveyed for the national study, while the Site 2 is 46% and 33% smaller respectively.

Table 4.3. Average Floor Area.

Study Region	Average Floor Area and Number of Sites			
	Square feet		*Sites*	
Study Sites				
Site 1- Built Green Community, Gross Floor Area	1495		12	
Site 2- Code-built Community, Gross Floor Area	1163		12	
Regional				
Puget Sound, Conditioned Floor Area	2132		37	
Northwest, Conditioned Floor Area	2145		104	
National				
Single Family detatched, region 4, division 10, marine climate	1737		184	
All Comparison Sites	1734	(Ave.)	349	(Total)

Notes: Source of study sites data: current metered study from October 2016 to September 2017
Source of regional data: 2014 RBSA metered sites in 2011 and national data: 2009 RECS

Air-tightness. The air-tightness (an indicator of quality construction and materials) of the homes in Built Green Community is 78% better (2 air changes per hour vs. 9.2) than the regional study average. Furthermore, the air-tightness for the Code-Built Community is 45% better (5 air changes per hour vs. 9.2) than the regional average.

Table 4.4. Building Air-tightness.

Study Region	Average Blower Door Air Tightness and Number of Sites			
	ACH50		*Sites*	
Study Sites				
Site 1- Conditioned Floor Area cottages	2.0		3	
Site 2- Conditioned Floor Area cottages	5.0		3	
Regional				
Puget Sound, Conditioned Floor Area	10.9		36	
Northwest, Conditioned Floor Area	9.2		102	
All Comparison Sites	7	(Ave.)	144	(Total)

Notes: Source of study sites data: current metered study from October 2016 to September 2017
Built Green Community- Evergreen Certified LLC, 2012; Code-built Community- Heat Holders, 2011
Source of regional data: 2014 RBSA metered sites in 2011 (WA State code minimum is 5ACH 50 Pascals)

Insulation values. The building R-values[59] for wall, floor, and ceiling construction assemblies in the Built Green and the Code-built communities, as shown in Table 4.5, reveal significantly higher insulation values (almost double) for Site 1 over Site 2. Importantly, Site 1 has double the amount of glazing on average at 33% of the all area versus Site 2, which has 16% of the wall area in glazing, a difference which could reduce the overall performance of Site 1 buildings. In addition, the U-value for the windows in both communities is higher than would be common in a high performance buiding under Passive House[60] standards, which recommend a U-value of 0.17 – 0.20 Btu/hr.sf.°F. Site 1 and 2 windows, by contrast, are 0.3 and 0.4 Btu/hr.sf.°F, respectively. Architects and engineers may use a window with a higher U-value and make up the difference in overall house energy performance with additional building insulation, as is likely to be the case with Site 1.

---

[59] R-values indicate the capacity of an insulating material to resist heat flow. The higher the R-value the greater the insulating properties. For example, an exterior wall assembly with an R 40 is better than R 20. U-values indicate the amount of heat transmission through a building for a given thickness of a material. The lower the U-value the better the insulating properties. For example, a window with a U-value of 0.3 is better than U-value of 0.4. Retrieved (August 16, 2018) from https://www.merriam-webster.com/dictionary/R-value.
[60] A Passive House is designed to be highly-insulated, air-tight, and primarily heated by passive solar gain and internal gains from people and equipment. The window U-value recommendation for a Passive House is ≤0.14 Btu/hr-sf-°F. Retrieved (June 15, 2018) from http://www.efficientwindows.org/standards_passivhaus.php).

Table 4.5. Building Construction Assemblies.

Site 1: Year Built 2013	Site 2: Year Built 1990
Assembly	Assembly
Double 2x4 Walls (R 35) homes and (R 28) apartments	2x6 Walls (R 19)
Winsdows/ Glass Doors/ Skylights U-value 0.3, ave 33% of wall area	Winsdows/ Glass Doors/ Skylights U-value 0.4, ave 16% of wall area
Ceiling Flat (R 48) Ceiling Vaulted (R 60)	Ceiling (R 38)
Floors (R 38) Slab on Grade (R15) continuous	Floors (R 30) Slab on Grade (R 10)
Source of data from development documents	Source of data from Ecotope study, 1990

Notably, on average, the structural characteristics for the two study sites exhibit a better quality of construction, smaller size, and slightly fewer people than the average found in the regional and national studies. Thus, by virtue of these structural characteristics, we would expect the two comparative communities to use less energy and therefore have lower EUI scores than the average home in the Pacific Northwest. We would also expect Site 1 to perform better than Site 2 for similar reasons, including the significantly higher insulation values in the walls, floors, and ceiling construction assemblies. These findings are illustrated in Figure 4.1 in the next section of this chapter, where a comparison of the Built Green and Code-built communities' actual energy use is presented.

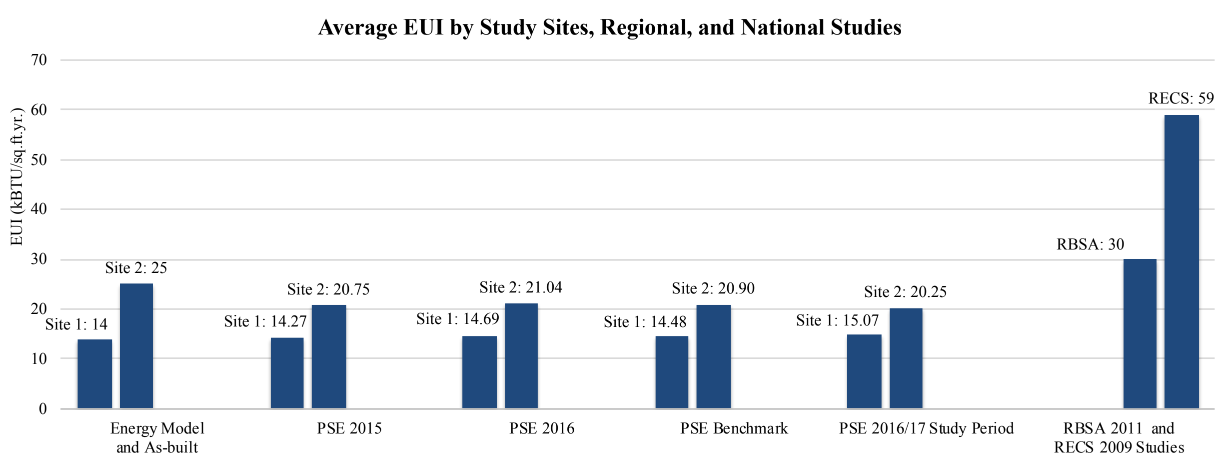
Actual Energy Use

Research Question 1: How do the Built Green and Code-built communities, as a whole, compare on their actual energy use?

Energy model. The physical housing characteristics impacting the energy performance of a given building can be assessed by comparing the amount of energy the building was planned to use when designed (energy model) with actual energy consumed after the building has been in operation for at least one year. The Built Green Community homes were modeled to have an average EUI of 14 (Ecotope, 2011), which is about half the average of Pacific Northwest homes (EUI 30, RBSA) and about a quarter of the average west coast home depicted in the national data (EUI 59, RECS) as presented in Figure 4.1.

The Code-Built Community homes were modeled to have an as-built energy average EUI of 25 (RePower, 2011), which is about 16% better than the average in the Northwest region (EUI 30) and about 57% better than the national average (EUI 59). The typical home in the Code-Built Community is likely to be about 50% more efficient than the national west coast average in terms of EUIs (25 vs. 59). However, the Code-Built Community EUI of 25 exceeds the Built Green Community EUI of 14. Notably, both study sites demonstrate EUI scores significantly better than the average home in the region. Even so, Site 1 is predicted or modeled to be 44% more efficient than Site 2 by virtue of its advanced construction technology and energy efficient equipment. The comparative EUI scores are exhibited below in Figure 4.1.

Figure 4.1. Contextual EUI Scores.



Benchmarking EUI scores for comparison of housing community sites. To set a benchmark from which to evaluate the performance of the two comparison communities during the yearlong study, typical EUI performance ratings were established. First, mean EUI scores were computed from two years of extant Puget Sound Energy billing data, both per year and as an average of the two years. The sample of households situated in the Built Green Community (Site 1) exhibited lower EUI scores when compared with households in the Code-built Community (Site 2) across all three measures computed for 2015, 2016, and the benchmark average of the two years, as can be seen in Figure 4.1.

Contextualizing EUI scores for comparison of housing community sites. A comparison of the two subject communities with other third-party studies shows that both communities perform better than the RBSA regional (EUI 30) and RECS national (EUI 59) averages when comparing total household energy use. Though both sites have low EUI scores by comparison, Site 1 shows an increase in energy use from the model EUI 14 to the benchmark EUI 14.5, while Site 2 has decreased in energy use from the as-built EUI 25 to the benchmark EUI 20.90. All results are presented in Figure 4.1.

Adjusted contemporaneous EUI scores for comparison of housing community sites. Worthy of note is that the average EUI scores for Site 1 computed from PSE billing data during measured 15.1, higher than any other year evaluated from 2011 through 2017. The average EUI 20.2 score for Site 2 during this same time period was lower than for any other year from 2011 through 2017. All scores are exhibited in Figure 4.1.

Change in PSE EUI scores across time between housing community groups. As noted above, the EUI percent change scores across all time intervals in the study period, shown in Table 4.6, show that for the two study communities the trend in energy usage has been divergent. The Built Green Community has demonstrated an 8% increase in energy use, from an initial 2011 pre-construction energy modeled EUI of 14 to an actual EUI of 15.1 in 2017 (PSE data), on average. In contrast, the Code-built Community has demonstrated an overall 19% decrease in energy use, on average, from the 2011 as-built energy model EUI of 25 to an EUI of 20.2 in 2017 (PSE data). Exploring the possible reasons why energy use might shift at a total of 27% difference between the two communities, EUI scores were evaluated per household with data associated with more specific devices and uses within the home.

Table 4.6. PSE Mean EUI Scores and Percent Change.

Study Site	EUI: kBTU/sq. ft. yr				*% Change from Energy Model*		
	Ener. Mod. As-built	2015 PSE	2016 PSE	2016-2017 Study Period	2105	2016	2016- 2017
Site 1- Built Green Community	14	14.3	14.7	15.1	2%	5%	8%
Site 2- Code-built Community	25	20.8	21.0	20.2	-17%	-16%	-19%

Note: Site 1- Energy Model EUI source Ecotope, 2011; Site 2- As-built EUI source RePower, 2011

Adjusted contemporaneous PSE EUI and CLM EUI scores for comparison of households across community sites. In terms of annual EUI scores computed for each household from CLM and PSE data, the values presented in Figure 4.2 and 4.3 are close to each other. Differences between the two sets of data are attributed to differences in when the data was actually recorded, if the data was estimated by the utility company, or if missing data was imputed[61] for CLM data. For Site 2, PSE data was also adjusted to attribute energy use to a household where domestic hot water was shared between two households[62] and to attribute energy use for the laundry to a household where a community laundry facility was utilized. Using SPSS statistical analysis

[61] There were two methods of imputation used to account for missing data in CLM data reports. If a small amount of data was missing, then k = 6 Nearest Neighbor Imputation was used, where k is the average of the 6 nearest data points. If a larger amount of data was missing, then Hot Deck Imputation was used, where data from a similar household is supplied for the missing data points.

[62] Hot water adjustments were calculated on a per person per household basis and added or subtracted to the energy use for a household. Dryer use adjustments were calculated on a per load basis from the communities billing records. Washing machine use was not measured directly for any household.

software, no significant difference was found between the PSE utility company reported data and the CLM site monitored data. Though this variability in the range in EUI scores across the two sites was found, the overall expected outcomes remained evident. That is, the Built Green Community consistently demonstrated lower EUI scores when compared to the Code-built Community.[63] For example, in Figures 4.2 and 4.3, as can be seen in both data sets, the range for Site 1 is from a low EUI of 10 to a high EUI of 25 and the range for Site 2 is a low EUI of 12.5 to a high EUI of 27. Notably, the mean energy use is lower for Site 1 (EUI 14.8) compared to Site 2 (EUI 20.95). That is, Site 1 performed 30% better than Site 2 based on CLM data. However, that the expected value based on the energy model was for Site 1 to perform 44% better than Site 2.

[63] Identification numbers for Site 1 are from 101 to 112 and Site 2 are from 201 to 212.

Figure 4.2. Annual EUI Scores per Household Derived from PSE Data.

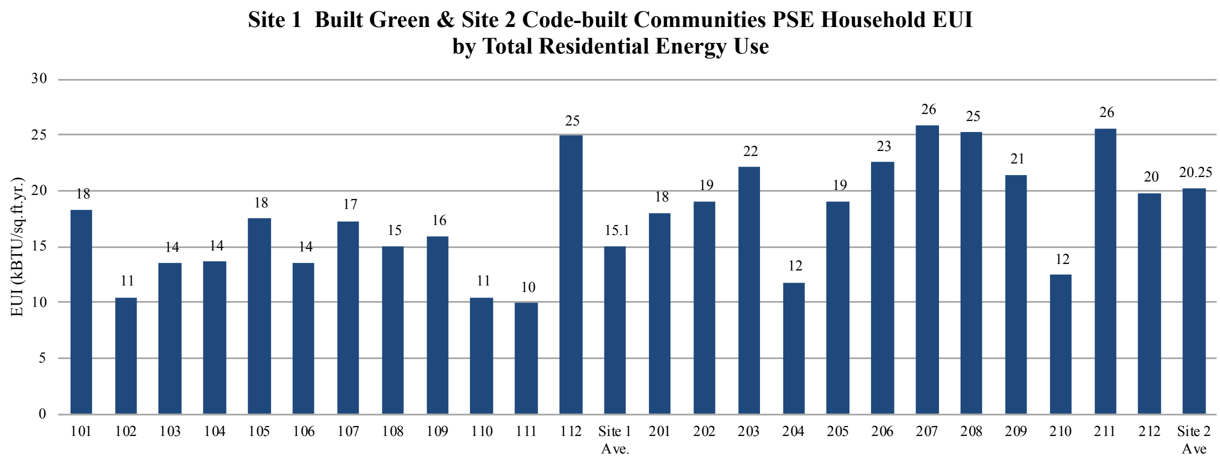
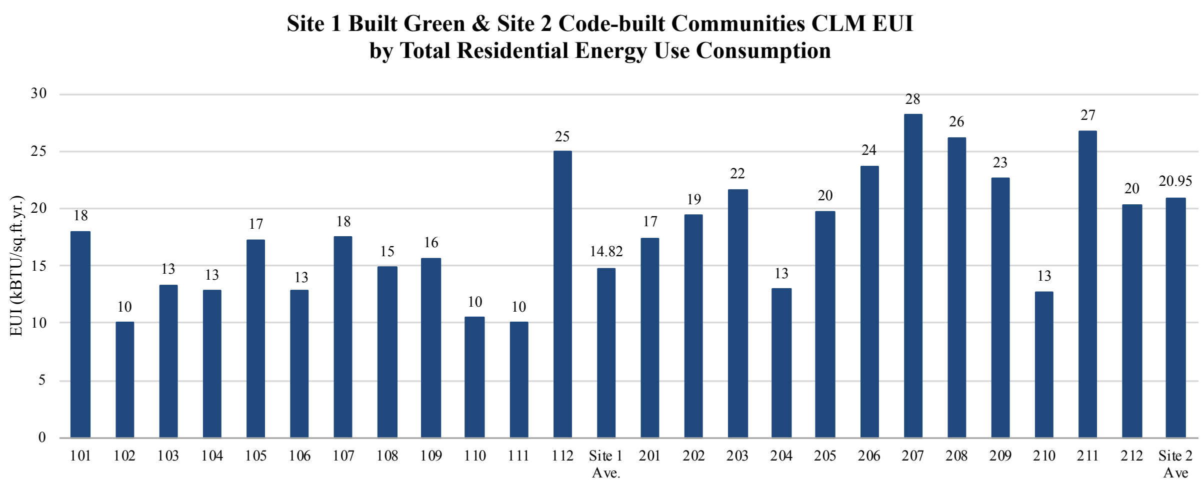
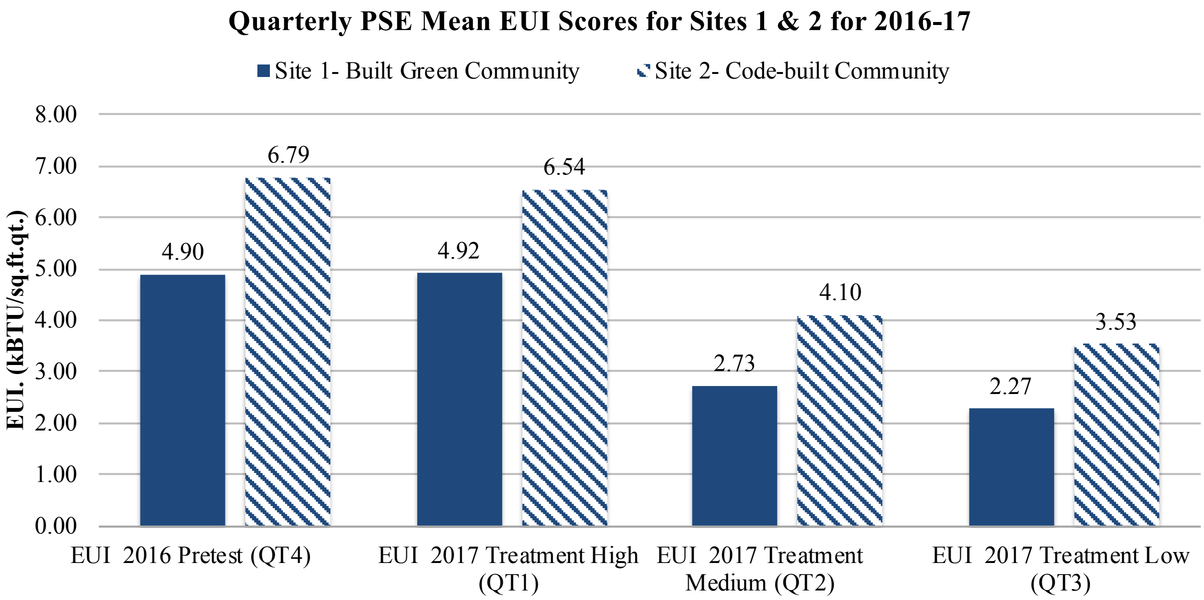


Figure 4.3. Annual EUI Scores per Household Derived from CLM Data for the Study Period.



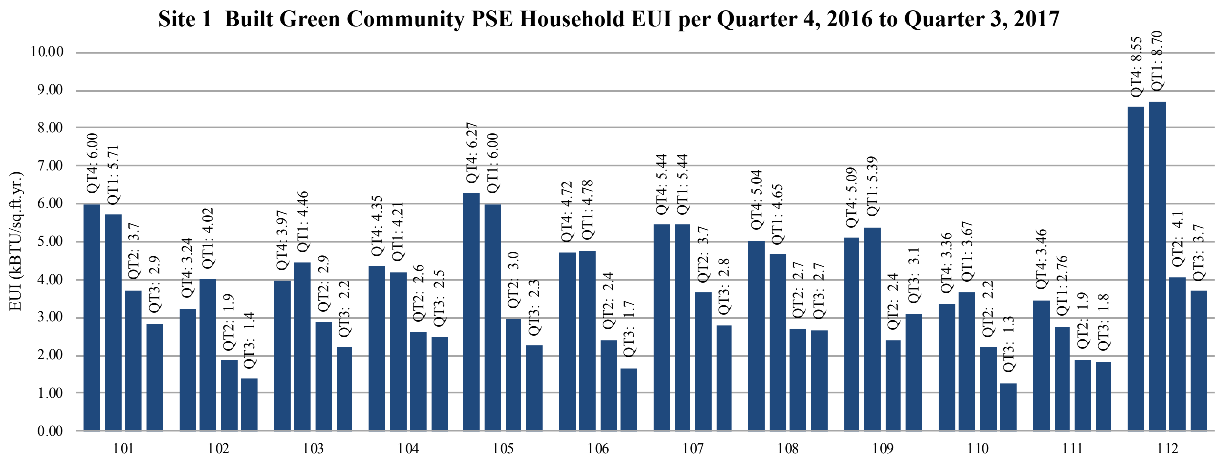
Quarterly Data. Presented, the data in Figure 4.4 are presented per site per quarter. These charts illustrate a general pattern of decrease for energy use from the winter months (QT4, 2016 and QT1, 2017) to summer months (QT2 and QT3, 2017) for both community groups.

Figure 4.4. Quarterly PSE Mean EUI Scores per Site.



Individually, quarterly PSE mean EUI scores per household from baseline QT4, 2016, and during treatment QT1, 2017, show mixed results. Of Site 1 households, 42% increased their energy use after baseline, and 58% decreased. Site 2 showed a similar pattern in that 42% of Code-Built Community households increased their energy use while 50% decreased and 8% showed no change, as is illustrated in Figure 4.5.

Figure 4.5. Quarterly PSE Mean EUI Scores per Household.



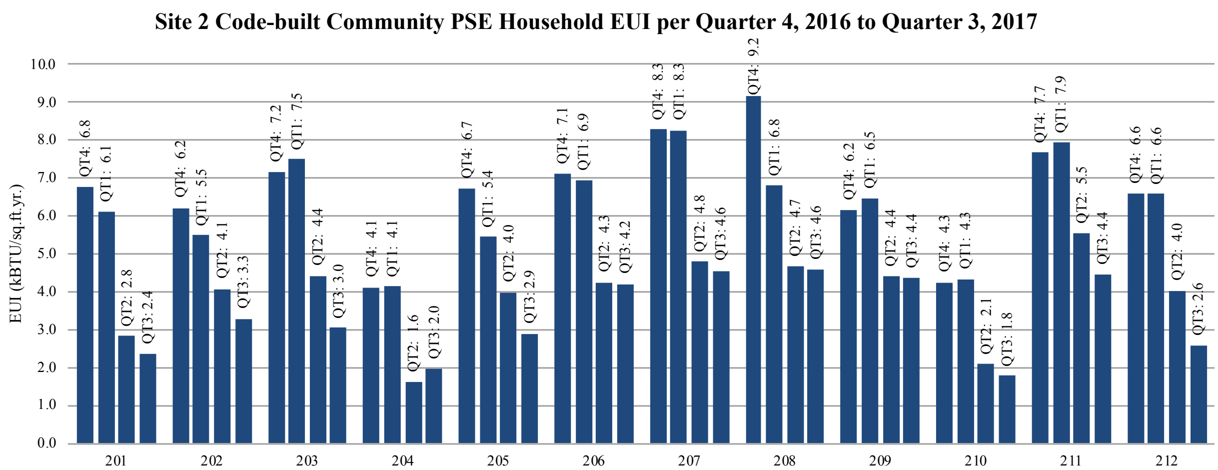


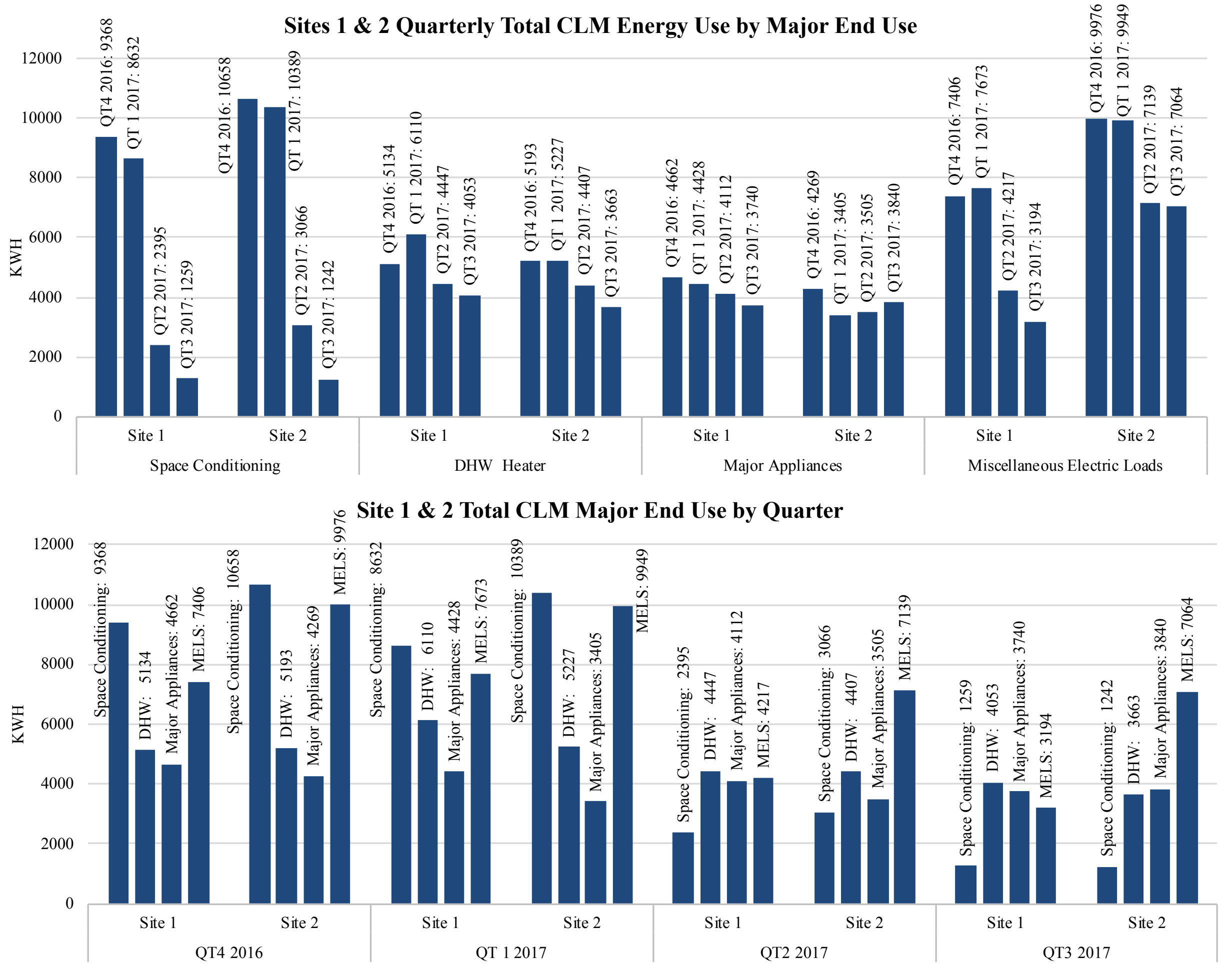
Figure 4.5 also shows that, as expected, the pattern of energy use is similar for both communities, with higher usage in the winter quarters and lower use in the spring and summer quarters, with the Built Green Community using less energy than the Code-built in almost every case. An extreme case in the Site 1 group is household 112, for which several factors likely contribute to the higher EUI score. First, it is a ground floor unit with slab on grade construction and insulation values. Second, the floor area of the unit is smaller while the energy using equipment (space heating, domestic hot water, major equipment, entertainment, and

workstations) is similar to that of other households. That is, the energy used will yield a higher EUI by virtue of a smaller denominator (floor area) to the numerator (kBTU/sq.ft.qt.). A somewhat extreme energy use seen in the Site 2 group is household 207. In this case, among others with high quarterly winter values, the household reported using portable space heaters to augment the central home heating system. Household 208 also demonstrated a high energy use in the first part of the winter followed by a plateau in the summer months. This household reported using a significant amount of energy on specialized electronics as a hobby (e.g., custom-built visual and audio home entertainment center). These individual factors, indicating the potential impacts of specific energy uses, are explored in greater detail using energy data derived from circuit level monitoring in the following section of this chapter and in interview data forthcoming in Chapter 6.

Adjusted contemporaneous community EUI scores for major end-use CLM data. In terms of adjusted contemporaneous data (derived in-home CLM), the EUI scores comparing the two communities on major end-use loads for equipment such as space conditioning including ductless mini-split and heat recovery ventilator units, domestic hot water heater, refrigeration and/or major appliances including ranges, dryers, dishwashers, and refrigerators are presented in Figure 4.6 as a bar chart in kilowatts per hour both by usage type and by quarter.

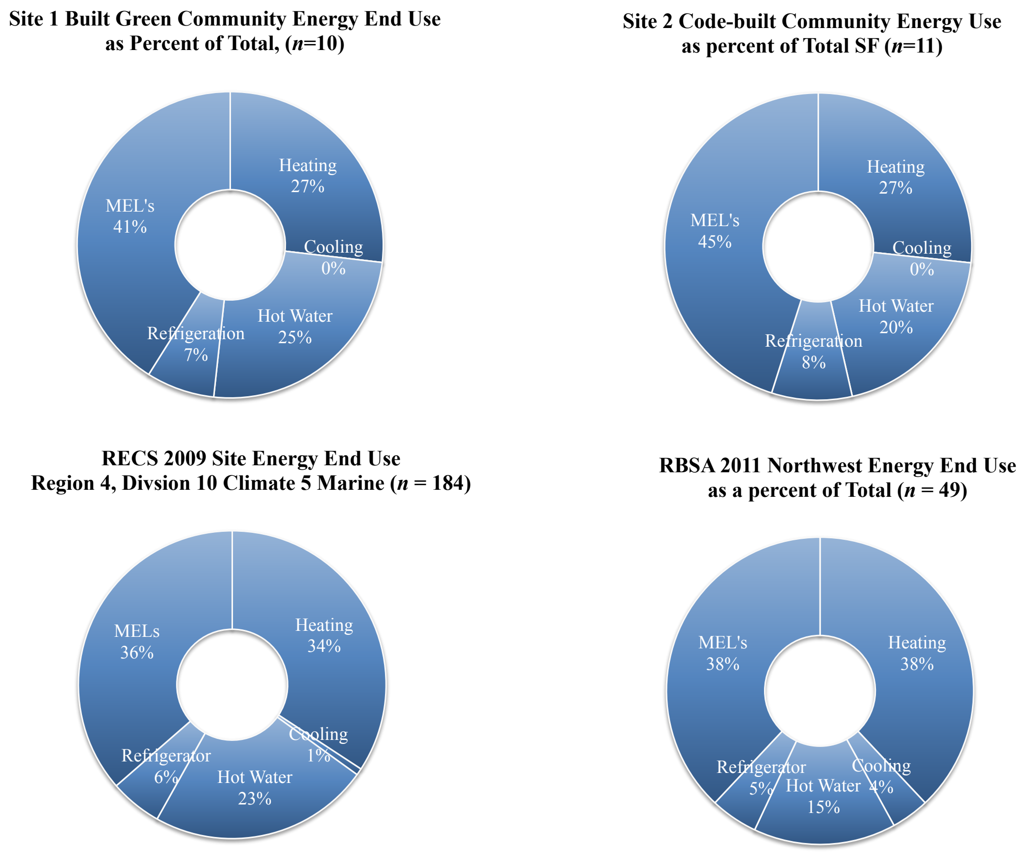
Comparing energy used per community by quarter for major end-uses reveals that, on an average per household basis, Site 1 consumed less energy (1804 kWh) than Site 2 (2113 kWh) for space conditioning over the course of the year; Site 2 consumed less energy (1541 kWh) vs. Site 1 (1645 kWh) for domestic hot water heating and less energy on major appliances (1252 vs. 1412 kWh). As a group, Site 2 consumed on average a substantially higher amount of MELs over the course of the year than did Site 1 (2844 vs. 1874 kWh).

Figure 4.6. Comparing CLM Energy Use for Major end-uses per Community by Quarter.



Proportional energy use for major end-uses. As noted in Chapters 1 and 2, the proportion of energy devoted to MELS has been consistently increasing nationwide. When community household CLM EUI scores are compared with data for regional and national EUI scores as a percentage of overall annual energy use, all show high percentage rates. As the charts in Figure 4.7 show, for single family homes over the last 8 years the MELs (energy loads typically under the direct control of the user) have significantly increased from 36% RECS in 2009 to 38% RBSA in 2011, and to 41% Site 1 and 45% for Site 2 in 2017 as a proportion of total household energy use.

Figure 4.7. A Comparison of Single-family Electrical Consumption by End-use as a Percentage of Total Household Energy.



In contrast, as we would expect, space heating has fallen as a percentage of total household energy, on average, from 34% in 2009 to 27% in 2017 by virtue of better structural characteristics. Most importantly, the balance between space heating and MELs has shifted from the 2009 and 2011 studies, which show space heating as about equal to MELs, to 2017 when MELs represented a significantly higher percentage of total energy consumption (41% for Site 1 and 45% for Site 2 MELs vs. 27% for heating) for single family detached homes.

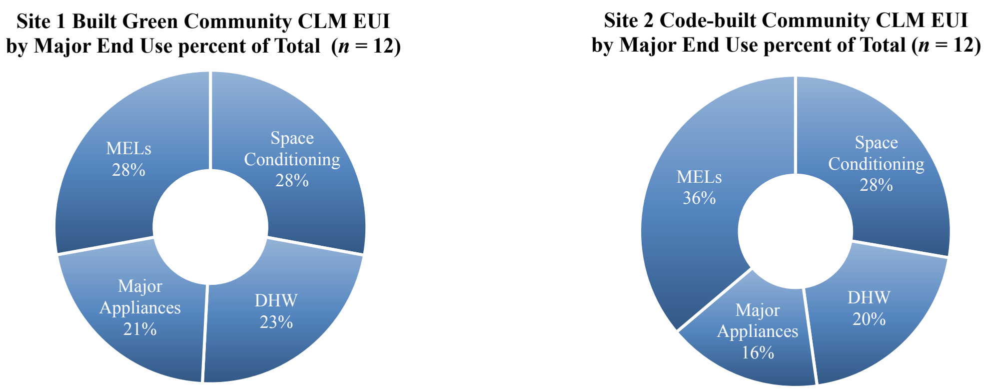
This overall balance shift is to be expected for several reasons. First, it is in keeping with greater stringency in energy codes that have resulted in higher performance building envelopes and equipment (e.g., increased in quality of construction, insulative properties, and equipment efficiencies), thus reducing space conditioning loads. Second, at the same time, our society has witnessed a proliferation of personal electronic devices such as personal computers, monitors, printers, smartphones, and tablets. Recall that although EUIs are declining on a per-square-foot basis (as is evident when comparing energy data from the two communities to the RECS and RSBA data), energy use intensity at the individual per household level is likely to continue increasing as people elect to use more electronic devices more frequently in more homes (McNary & Berry, 2012; EIA, Drivers, 2015).

Further investingtion shows that participant households[64] from the two study communities display slightly different patterns of use with regard to Major End-use energy consumption. Instead of breaking out energy used for refrigeration as in the prior evaluation, this next evaluation includes kitchen range, dryer, and refrigerator. In the charts presented in Figure 4.8, percentages in the energy chart are more evenly distributed within the communities. However, between communities, Site 1, the newer community, has a higher percentage (21% vs.16%) allocated to major equipment, while Site 2, the older communtiy has a higher percentage (36% vs. 28%) allocated to MELs. Space conditioning and domestic hot water are about the same for both communities, though space conditioning is the second highest use. Recall that though the Site 1 homes are more efficient by virture of their construction, the homes in Site 2 may use less energy as a percentage of the total in these two categories by virture of their smaller footprints (area), shared walls (duplex construction), and shared resources (hot water heaters). In addtion, Site 1 reported experieincing a high degree of equipment mallfunction related to newer heat pump hot water heater technology. In this case, the hot water heaters failed

[64] All participating households includes single-family, townhomes, and apartments in both study sites.

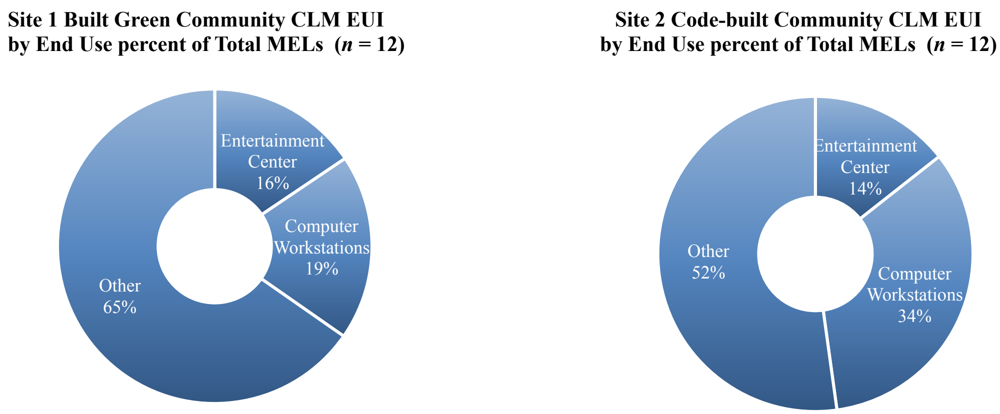
and defaluted to all electric heating instead of the more efficient heat pump technolgy. Finally, Site 1 reported using the cooling feature on their space conditioning units or ceilng fans more frequently than did Site 2, where the use of operable skylights was noted as a passive cooling feature.

Figure 4.8. Electrical Consumption by Major End-use as a Percentage of Total Household Energy Use (CLM data).



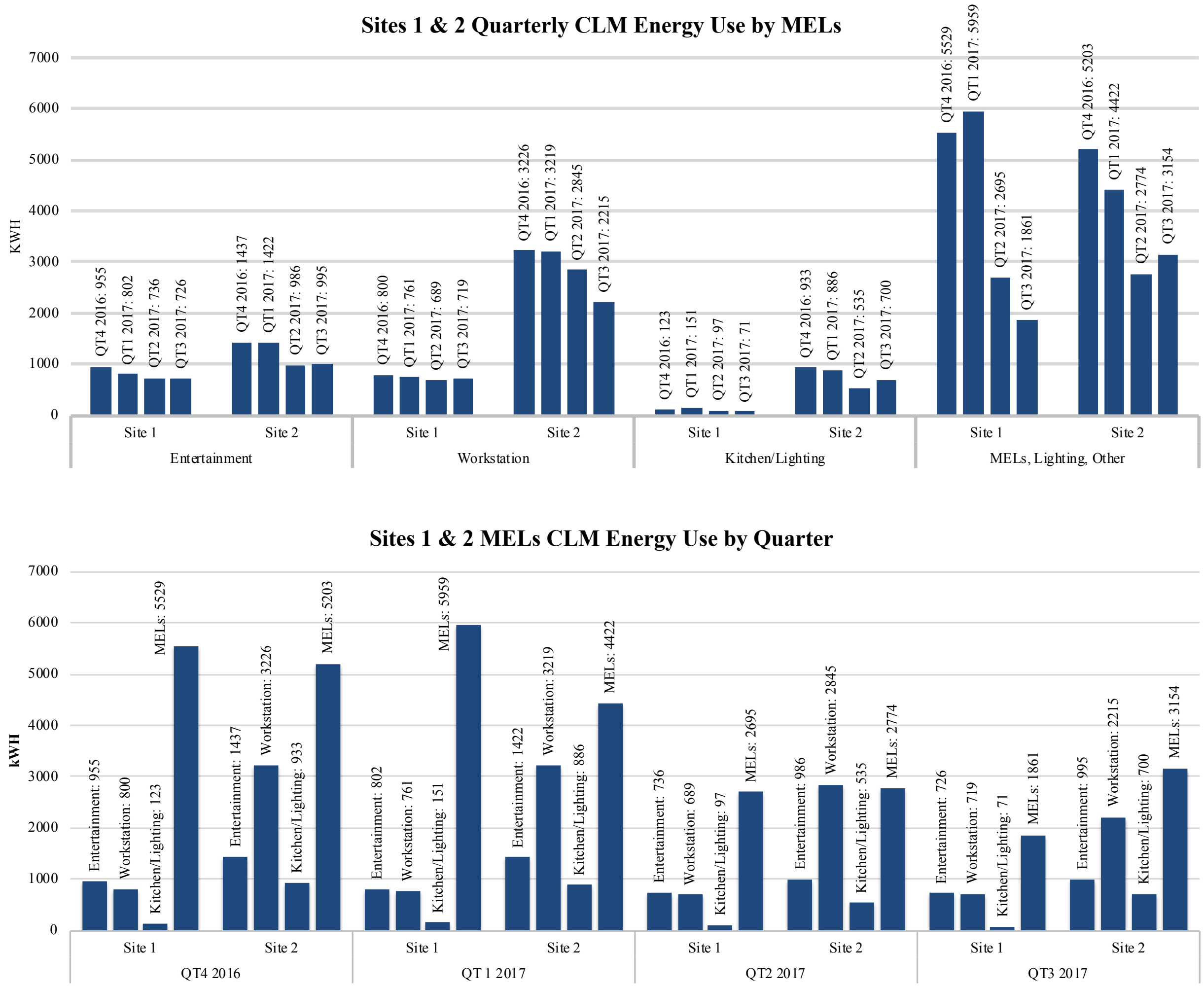
Proportional energy use for MELs. Investigating energy consumption in the MELs category, we find that the two communities diverged in respect to three subcategories: entertainment centers, computer workstations, and other unacccounted electrical loads. In these sub-categories, when compared to Site 2, Site 1 had a higher percentage of use for entertainment centers at 16% versus 14% and other unknown uses higher at 65% versus 52%, while workstatons were lower at 19% for Site 1 versus 34% for Site 2. Energy use percentages are shown in Figure 4.9.

Figure 4.9. Electrical Consumption by Sub-category as a Percent of Total Household MELs (CLM data).



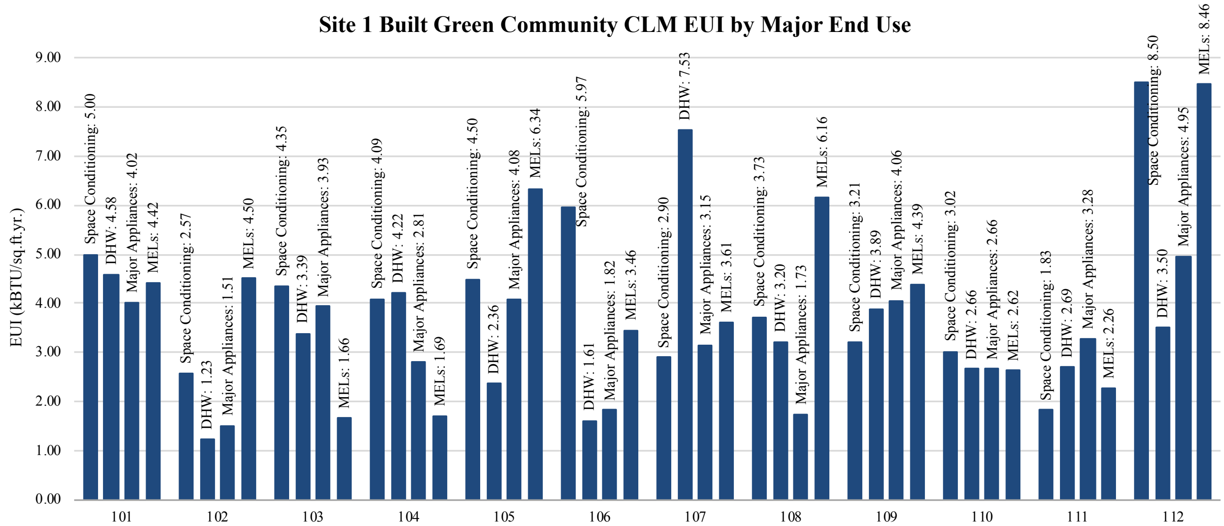
Quarterly energy use for MELs. These patterns of usage are further supported when we investigate the consumption of MELs per quarter between the two comparison study sites. Figure 4.10 shows that in all subcategories except MELs (lighting & other), Site 2 consumed more energy than Site 1. Specifically, for Site 2 versus Site 1, entertainment centers consumed 403 versus 268 kWh; workstations used 247 versus 959 kWh, kitchen small appliances and lighting used 37 versus 254; and MELs consumed 1296 versus 1337 kWh (Site 2 vs. Site 1). The high use of MELs in the winter months of QT4 and QT1 for both sites may be an indicator of axillary space conditioning heaters and in the summer months of QT2 and QT3 an indication of the addition of space conditioning fans. The high rate was also indicative of other individual uses not identifiable in this data, some of which were uncovered during interviews with households (see Chapters 6 and 7).

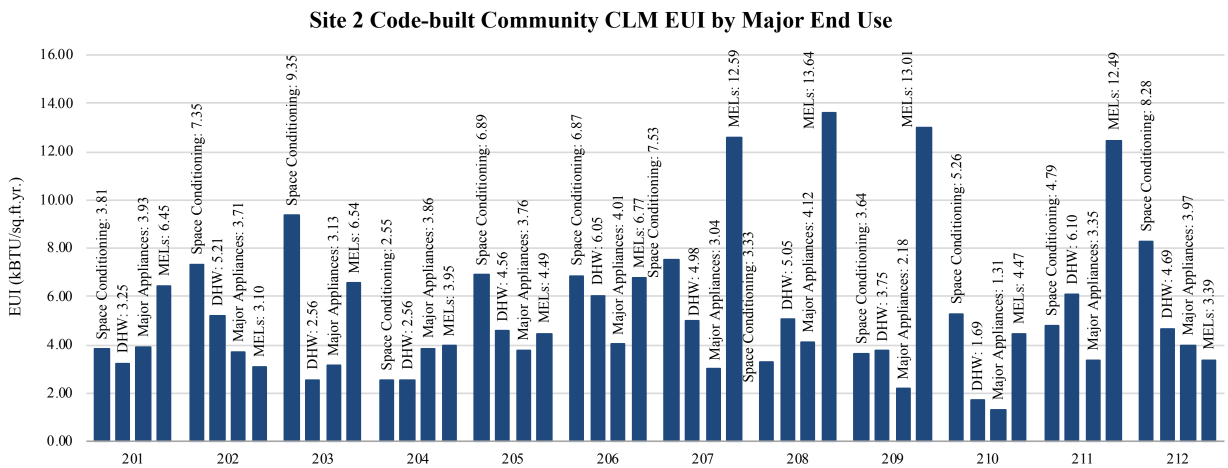
Figure 4.10. Comparing CLM Energy Use for MELs per Community by Quarter.



Adjusted Contemporaneous household mean EUI scores for major end-use CLM data. In terms of EUI scores per household for major end-uses, the load shape for EUIs is presented in Figure 4.11 Among households in Site 1, highest frequency of use showed 42% going to space conditioning and 33% to MELs. Among households in Site 2, the highest frequency of use was split at 50% for space conditioning and MELs. The variability across both sites, primarily in space conditioning and MELs, illustrates the importance of loads over which occupants exhibit the greatest control. For example, in Site 1, several households demonstrate more extreme energy use for domestic hotwater use, noteably households 101 and 107 which reported a high use of the washer and dryer use for hobbies and energy spent for comfort habits (long showers). In Site 2, the high MELs in household 207 were attributed to portable space heating (self reported) whereas the MELs for household 208 were attributed to hobbies (self reported). MELs were also used for entertainment centers and computers as well as kitchen-related appliances such as instant hot water, as was reported by 209 and 211. To investigate these uses further, dissaggreageted CLM data for MELs were explored and the results are presented in the following section.

Figure 4.11. Annual CLM Mean EUI Scores for Major End-use between Households per Site.





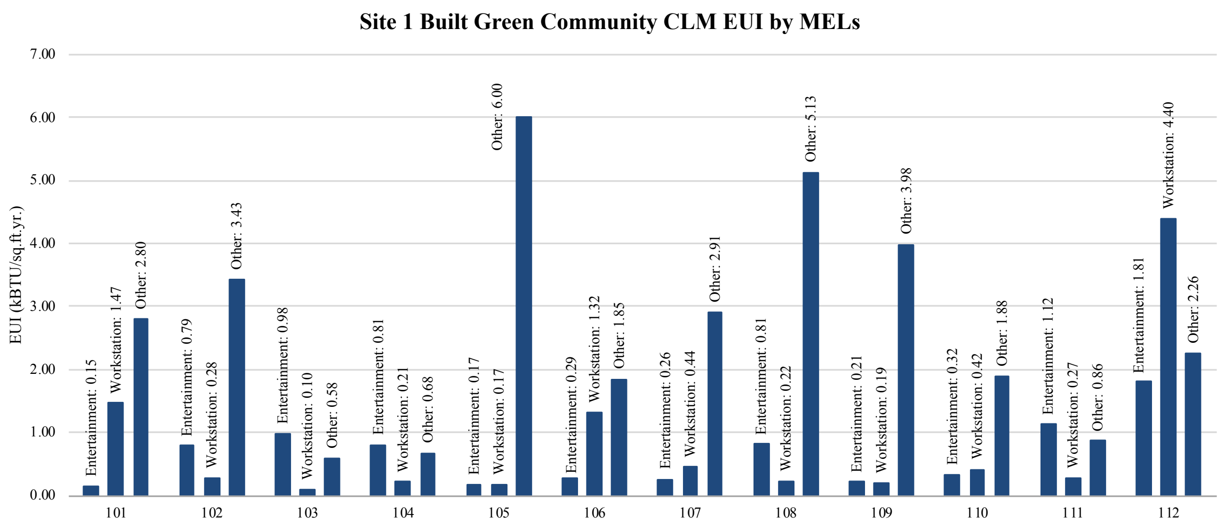
Adjusted Contemporaneous household mean EUI scores for MELs disaggregated data. With respect to MELs, the highest frequency (75%) of households in Site 1 showed 'other uncountable energy use' as greatest, often attributable to plug-in space heaters and fans.[65] In other high use categories, 25% of households used energy on entertainment centers while home computers used only 8% for Site 1 households. For 75% of Site 2, the highest frequency of usage

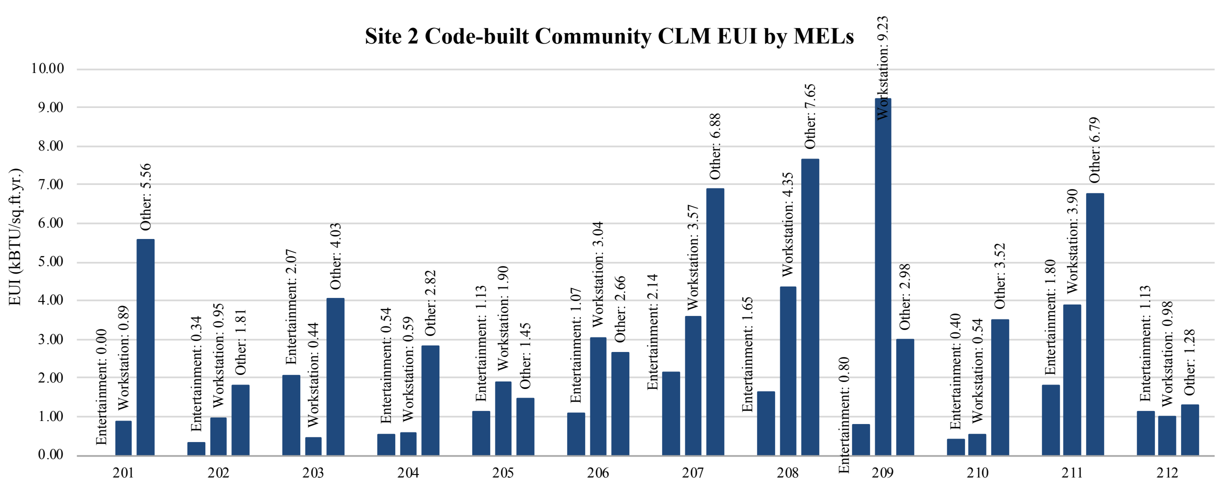
[65] As reported during the qualitative interviews.

was ‘other uncountable energy use,’ with 17% credited to home computers and only 8% to entertainment centers. Figure 4.12 presents the CLM EUI by MELs figures for each community.

One reason for the high frequency of unaccountable energy uses was the portability of mobile devices. Multiple computers, smartphones, tablets, and smart sound systems and speakers in each household were used and charged not necessarily in one location or for a single purpose. The variability in EUIs for MELs in the sub-categories shown in Figure 4.12 would lend support to mobility and diversity of devices, as was confirmed during interviews.

Figure 4.12. A comparison of annual CLM Mean EUI scores for MELs between households.





Reported MELs Devices. Many households interviewed reported use of devices credited to MELs that were specific to their household and their way of life. Details appear in Chapter 6; however, uses tended to fall into four main categories including:

1. Axillary space conditioning devices were reported in many cases when the ductless mini-split with one supply head failed to adequately condition spaces on all levels of the home.
2. Multiple mobile devices were reported as not being charged or used in one location or for one purpose (e.g., households used their computer equipment for streaming programs and movies).
3. Avocational use patterns such as music equipment, large format printing equipment, felting arts and hobby projects, and homemade electronic projects such as computers and media consoles were observed in many households.
4. Food preparation and storage equipment for bulk canning and freezing were observed in multiple households.
5. Comfort uses including high use of the washer/dryer for laundry and recreational cooking were reported during the winter months in particular, such as bread or brownie baking to alleviate boredom and heating a pizza stone for homemade pizza.

Comparing the actual energy use in these two communities, I find that the major consumption of energy is not likely to be based on major uses such as space conditioning and domestic hot water, but rather on activities that people want to engage in for entertainment, computer-based work and enjoyment, comfort (axillary space heating and cooling), hobbies, food preparation, and avocations and these are lifestyle choices. The notion that energy use could or should be discounted as a “lifestyle factor” for green communities is one that likely should be re-evaluated. For the Built Green Community, the engineers who created the energy model "applied a lifestyle factor of 0.75 to miscellaneous plug loads and clothes dryer energy to account for an expected heightened focus on energy use in the targeted home buyers" (Ecotope[66]). Recall that the percentage of energy used in both the Built Green and the Code-Built communities for miscellaneous uses and major appliances (including dryers) was over 40% of the household energy consumption, over half of which cannot be accurately accounted for due to lifestyle choices. That is, individual choices were involved in the proliferation, mobility, and increased use of a variety of consumer electronic devices per home. With this realization in mind, the following section presents results for the effects of feedback on energy used, provided in real-time, to inform and alert households of their energy consumption for major end-uses and sub-categories previously described over which occupants have a large degree of control.

Treatment and Actual Energy Use

Research Question 2: What are the effects of real-time feedback (dashboard treatment) on actual energy use of participating households?

Results show a change in actual energy use among households between sites across time on energy use intensity scores. As described in Chapter 3, the data is divided into three-month increments (quarters) that correspond to the calendar year and seasonal weather patterns as well as to the treatment periods in the study. Recall that for pretest (Oct-Dec), the 2016 QT4 baseline was established in the fall of 2016. Three levels of treatment occurred in the winter, spring, and summer of 2017. Intensive or high-treatment took place in 2017 QT1 (Jan-Mar), followed by a medium-treatment in 2017 QT2 (Apr-Jun), and closing with a passive or low-treatment in 2017 QT3 (Jul-Sept). As anticipated, in every time period measured, each community (as a whole)

---

[66] Ecotope, report withheld to protect the identity of the community.

decreased[67] their energy use from the fall of 2016 to the summer of 2017, with Site 2 using more energy than Site 1 as presented in Table 4.7.

Table 4.7. Comparison of Average EUI Scores Across Time.

	CLM EUI: kBTU/sq. ft. qt.				*% change CLM by Quarter*		
Study Site	EUI 2016 Pretest (QT4)	EUI 2017 Treatment High (QT1)	EUI 2017 Treatment Medium (QT2)	EUI 2017 Treatment Low (QT3)	QT4 to QT1	QT4 to QT2	QT4 to QT3
Site 1- Built Green Community	4.90	4.92	2.73	2.27	0.4%	-44.3%	-53.6%
Site 2- Code-built Community	6.79	6.54	4.10	3.53	-3.7%	-39.6%	-47.9%

Note: All data is derived from PSE utility billing

However, two critical questions remain with regard to actual energy use. First, was there a significant difference among households that could be attributed to the effects of the treatment and second, did one community decrease their energy use more than or than the other during or after treatment?

To ascertain the effects of real-time dashboard feedback (treatment) on actual energy use, a statistical analysis was conducted using SPSS software to compare EUI means in a variety of time periods, notably, for two years prior to the study period. That is, if treatment had any effect on energy-related behavior, statistical analysis would detect a pattern of significant energy use differences between quarters in each of the prior two years compared to the study year.

Specifically, mean EUI scores derived from PSE utility data were computed on a quarterly basis beginning in QT4 of 2014 through QT3 of 2016, with time intervals set to correspond with the study period time intervals. Recall that intensive or high-treatment included full access to the dashboard energy use information for each household and customized messages

[67] There was a slight increase for Site 1, the Built Green Community between quarter four of 2016 and quarter one of 2017 from a mean EUI of 4.90 to 4.92.

(alerts) on specific energy use (derived from individual CLM) emailed daily, medium-treatment included access to the dashboard and customized reports emailed monthly, and low-treatment included access to the dashboard only.

The results of this analysis are presented sequentially. First, for each of the two sites, 1-group *t*-tests were conducted to test whether participating households' mean EUI scores differed significantly from zero at pretest (QT4 2016), during the high, medium, and low intensity treatment periods (QT1 2017, QT2 2017, and QT3 2017, respectively). In fact, comparison yielded a trend for the Code-built Community (Site 2) to decrease energy more than the Built Green Community (Site 1) from baseline QT4 2016 through the period of low-treatment in QT3 of 2017 ($p < 0.10$), as indicated in Table 4.8.

Table 4.8. Comparison of PSE Mean EUI Data.

PSE EUI Scores during Treatment Year	Site 1 (n = 12)		Site 2 (n = 12)		Site 1 vs. Site 2		
	M	*(SD)*	*M*	*(SD)*	*t(22)*	*p*	*d*
Baseline QT4 2016	**4.96**	**(1.51)**	**6.68**	**(1.45)**	**-2.86**	**.009**	**-1.17**
High-treatment QT1 2017	**4.99**	**(1.49)**	**6.33**	**(1.30)**	**-2.36**	**.027**	**-.96**
Medium-treatment QT2 2017	**2.78**	**(0.71)**	**3.89**	**(1.15)**	**-2.85**	**.009**	**-1.16**
Low-treatment QT3 2017	**2.35**	**(0.73)**	**3.34**	**(1.06)**	**-2.67**	**.014**	**-1.09**

Note. N = 24 households; energy use measured as kBTU/sq.ft.qt._wn. for the Built Green Community (Site 1) and the Code-built Community (Site 2); values in **boldface** indicate either a trend for significance (p < .10) or significance (p < .05).

Next, each site was evaluated separately across the three-year time period using 1-group *t*-tests. Not surprisingly, results showed a trend for significance (*p*s < 0.10) in the spring and summer quarters of 2014-2015 pretest year. In the 2015-2016 pretest year, in all time periods, mean EUI scores were significantly different than zero (*p*s < 0.05). Again, 2-group *t*-tests were used to assess whether household energy use differed across sites; not surprisingly, results showed that Site 2 consumed more energy than the Site 1 (*p*s < 0.05). More interestingly, when the difference between the two communities was compared from pretest QT4 to the subsequent three quarters in each year, a significant decrease in energy use appeared for Site 2 more than for Site 1 at multiple time points. Comparison results shown in Table 4.9 depict a significant difference from baseline QT4 through the period of low-treatment in QT3 ($p < 0.05$) in 2015 and 2016 pretest years – a pattern consistent with the trend in 2017 for the same time interval.

Table 4.9. Comparison of Mean EUI Change Scores for PSE Data.

PSE EUI Changes Over Time	Site 1		Site 2		Site 1 vs. Site 2		
	M	*(SD)*	*M*	*(SD)*	*t*	*p*	*d*
2014-2015 Pre-Treatment Bechmark Year							
14QT4 to 15QT1	-0.21	(0.60)	0.21	(0.76)	-1.33	.201	-.61
14QT4 to 15QT2	**-1.37**	**(0.42)**	**-2.43**	**(0.72)**	**0.20**	**.001**	**1.76**
14QT4 to 15QT3	**-1.83**	**(0.31)**	**-2.93**	**(0.90)**	**3.47**	**.003**	**1.59**
2015-2016 Pre-Treatment Benchmark Year							
15QT4 to 16QT1	-0.25	(0.37)	-0.37	(0.56)	0.62	.540	.27
15QT4 to 16QT2	-2.43	(0.95)	-2.96	(0.47)	1.67	.111	.71
15QT4 to 16QT3	**-2.97**	**(0.96)**	**-3.87**	**(0.73)**	**2.48**	**.022**	**1.06**
2016-2017 Treatment Year							
16QT4 - 17QT1 (Baseline to High-Treatment)	0.03	(0.41)	-0.35	(0.80)	1.45	.162	.59
16QT4 - 17QT2 (Baseline to Med-Treatment)	-2.18	(0.98)	-2.79	(0.81)	0.16	.107	.69
16QT4 - 17QT3 (Baseline to Low-Treatment)	**-2.61**	**(1.00)**	**-3.34**	**(0.91)**	**1.89**	**.073**	**.77**

Note. Site 1: $n = 9$ (2014-2015), $n = 11$ (2015-2016), $n = 12$ (2016-2017); Site 2: n = 10 (2014-2015), $n = 11$ (2015-2016), $n = 12$ (2016-2017). Energy use measured as kBTU/sq.ft.qt._wn. for the Built Green Community (Site 1) and the Code-built Community (Site 2) computed from PSE data. Values in **boldface** indicate either a trend for significance ($p < .10$) or significance ($p < .05$).

Finally, to investigate whether a significant change could be found between the two communities, comparing prior pretest years to the treatment year and whether one community performed better than the other in terms of energy reductions, 2-group *t*-tests were conducted on their changes between time points. As presented in Table 4.10, Site 2 displaying a trend for significance ($p < 0.10$) when I compared QT1 treatment change scores in 2017 to QT1 pretest change scores in 2015, and that Site 2 performed significantly better than Site 1 ($p < 0.05$) during this time period. That is, Site 2's decrease in energy use after treatment was significantly higher than Site 1's for this time period. Results do show a significant difference ($p < 0.05$) for Site 1 when comparing QT2 and QT3 treatment change scores in 2017 to pretest change scores in 2015. However, the difference between the two sites was not significant for these time intervals. When I conducted the same tests for significance on treatment to pretest differences on change scores for 2016, results showed a trend for significance ($p > 0.10$) only in quarter three for Site 2, with no significant differences between the two sites in this year. In other words, observing significant change depended on which year was tested for differences to see if the treatment had an effect. Compared to 2015, the 2017 treatment year differences were greater, but compared to 2016 the 2017, treatment year showed no significant differences, only a trend for significance in quarter three for Site 2.

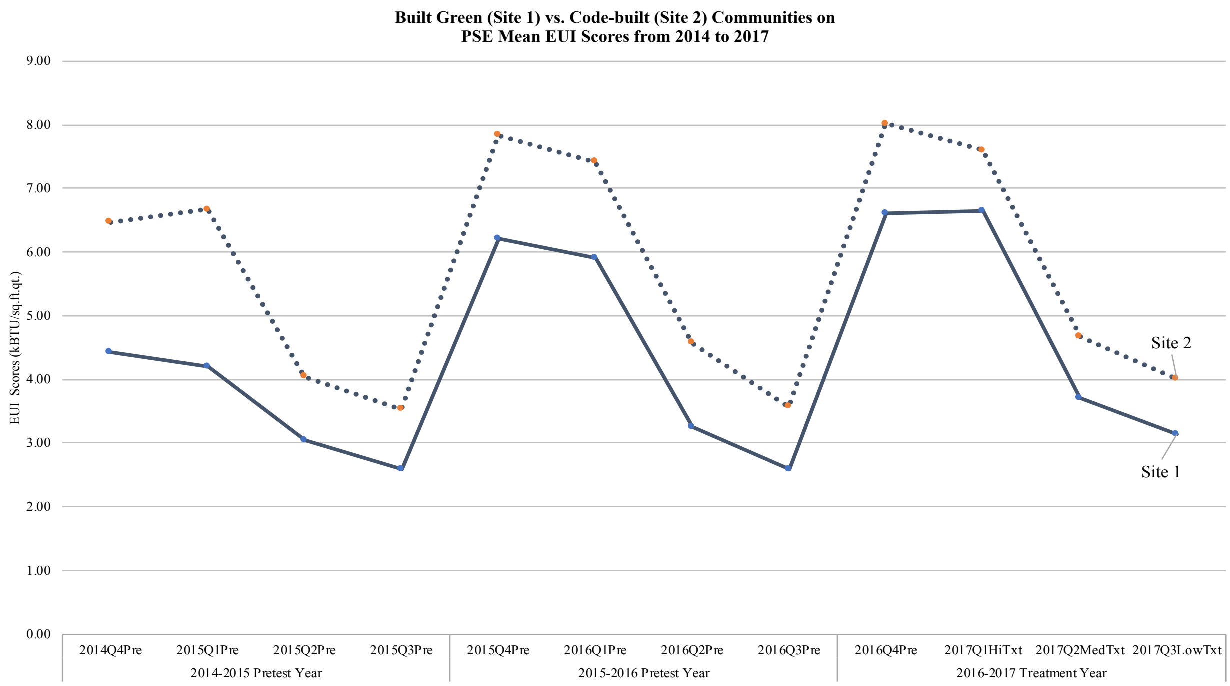
Table 4.10. Mean EUI Change Scores for PSE Data from Treatment to Pretest Differences.

PES EUI Changes during Treatment, Adjusting for Benchmark Year Changes	Site 1		Site 2		Site 1 vs. Site 2		
	M	*(SD)*	*M*	*(SD)*	*t*	*p*	*d*
Treatment Change, Subtracting Benchmark 2015 Change							
16QT4 - 17QT1 (Baseline to High-Treatment)	0.22	(0.71)	**-0.66**	**(1.05)**	**2.11**	**.050**	**.97**
16QT4 - 17QT2 (Baseline to Med-Treatment)	-0.70	(0.69)	-0.40	(1.24)	-0.647	.527	-.30
16QT4 - 17QT3 (Baseline to Low-Treatment)	-0.72	(0.74)	-0.53	(1.40)	-0.352	.729	-.16
Treatment Change, Subtracting Benchmark 2016 Change							
16QT4 - 17QT1 (Baseline to High-Treatment)	0.20	(0.41)	-0.01	(0.96)	0.67	.508	.29
16QT4 - 17QT2 (Baseline to Med-Treatment)	0.18	(0.58)	0.23	(0.85)	-0.185	.855	-.08
16QT4 - 17QT3 (Baseline to Low-Treatment)	0.30	(0.57)	0.56	(0.87)	-0.854	.403	-.36

Note. Site 1: $n = 9$ (2017 vs. 2015), $n = 11$ (2017 vs. 2016); Site 2: $n = 10$ (2017 vs. 2015), $n = 11$ (2017 vs. 2016). Energy use measured as kBTU/sq.ft.qt._wn. for the Built Green Community (Site1) and the Code-built Community (Site 2) computed from PSE data. Values in **boldface** indicate either a trend for significance ($p < .10$) or significance ($p < .05$).

The results graphed in Figure 4.13 may offer a clearer representation of the energy use pattern over time. As shown in this graph, the two sites maintained their cyclical pattern of energy use across the three years.

Figure 4.13. Comparison of Mean EUI Change Scores for PSE Data Across Time.



However, to test whether the total overall change from the beginning time point and the ending time point differed for the two sites (i.e., treatment had a greater effect on Site 2, but Site 1 had low energy use overall) a 2-group *t*-test was conducted to compare sites on their overall differences between QT4 of 2014 and QT3 of 2017, as well as QT4 of 2015 and QT3 of 2017 for the households that had a complete data set in all years. The results of this test are shown in Table 4.11, which depicts a significant decrease overall, showing more energy use reduction for Site 2 ($ps < 0.05$) in both time periods.

Table 4.11. Overall Change Across Time Periods.

PSE EUI Total Change by Site	Site 1		Site 2		Site 1 vs. Site 2		
	M	*(SD)*	*M*	*(SD)*	*t*	*p*	*d*
Benchmark 2015 to Post-Treatment 2017	**-2.06**	**0.62**	**-3.35**	**0.82**	**3.87**	**.001**	**1.78**
Benchmark 2016 to Post-Treatment 2017	**-2.65**	**0.87**	**-3.89**	**0.89**	**3.32**	**.003**	**1.42**

Note. Site 1: n = 9 (17QT3 vs. 14QT4), n = 11 (17QT3 vs. 15QT4); Site 2: n = 10 (17QT3 vs. 14QT4), n = 11 (17QT3 vs. 15QT4). PSE mean EUI scores measured as kBTU/sq.ft.qt._wn for the Built Green Community (Site1) and the Code-built Community (Site 2); values in **boldface** are significant (p < .05).

Finally, when a 1-group *t*-test was conducted for combined sites, results showed that the overall change was significant across both yearly comparisons (*p*s < 0.001), suggesting again that the treatment had a greater effect for Site 2, as indicated in Table 4.12.

Table 4.12. Combined Sites, Overall Change Across Time Periods.

PSE EUI Total Change across Sites	*M*	*(SD)*	*t*	*p*
Benchmark 2015 to Post-Treatment 2017	**-2.74**	**0.97**	**-12.28**	**.001**
Benchmark 2016 to Post-Treatment 2017	**-3.27**	**1.07**	**-14.35**	**.001**

Note. Combined $n = 41$ (17QT3 vs. 15QT4); PSE mean EUI scores measured as kBTU/sq.ft.qt._wn for the Built Green Community (Site1) and the Code-built Community (Site 2); values in **boldface** are significant ($p < .05$).

Summary of Key Findings

A summary of key findings in the current research with regard to residential electricity consumption converted to energy use intensity (EUI) scores for the two comparison community groups is presented below.

- At the conclusion of the study in September of 2017, PSE mean EUI scores for the Built Green (Site 1) and the Code-built (Site 2) community groups were substantially lower than their counterparts at the regional and national level: Site 1, EUI 15.07; Site 2, EUI 20.25; RBSA 2011, EUI 30; and RECS 2009, EUI 59.
- On average, Site 1's mean EUIs were consistently lower than Site 2's across all timeframes, though each community demonstrated some dissimilarities in energy use. Notably, from the time of the energy model to the end of the study, Site 1 increased energy use by 8%, while Site 2 decreased energy use by 19%.

- Comparing the average energy use by major end-use categories as a percentage of total energy use, Site 2 had the largest percentage of MELs at 45% compared to Site 1 at 41%, compared to the earlier external studies from RBSA 2011 at 38% and RECS 2009 at 36%. When major appliances were added to the comparison as a percentage of the total household energy use, Site 1 consumed 31% on MELs, 31% on space conditioning, 26% on domestic hot water heating, and 12% on major appliances, while Site 2 consumed 38% on MELs, 30% on space conditioning, 21% on domestic hot water heating, and 11% on major appliances. Essentially, over two thirds of the energy loads are attributed to uses under the direct control of the occupant, that is, MELs and space conditioning.
- Statistical analysis shows that Site 1 used less energy than Site 2 in every time period studied. However, tests show that treatment had a greater effect on Site 2.
- Comparing the average energy use for sub-categories as a percentage of the total MELs, Site 1 used 16% on energy for entertainment centers, 19% on computer workstations, and 65% on other (unaccounted for consumption), while Site 2 used 23% on energy for entertainment centers, 26% on computer workstations, and 51% on other (unaccounted for consumption). These unaccounted for MELs uses are reported to be attributable to mobile devices falling into four major categories as described below.
- Households interviewed at the conclusion of the study reported the use of devices that could be credited to MELs. These findings are given in Chapter 6; however, uses tended to fall into four main categories including:
    - Axillary and portable devices for space conditioning (including space heaters, fans, and dehumidifiers) and multipurpose mobile devices (such as laptops, tablets, smartphones, smart speakers);

- Avocational use patterns such as music equipment, large format printing equipment, felting arts and hobby projects, and homemade electronic projects such as computers and media consoles;
- Food preparation and storage equipment for canning and freezing;
- Comfort uses, including high use of the washer/dryer for laundry and recreational cooking.

Three overarching energy use observations stand out. First, Site 1 has lower 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 can be seen in the high degree of variability across the two sites in these categories. Unaccounted-for MELS have 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 perhaps 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 social characteristics and philosophical perceptions that would support their responses to the treatment. To investigate reasons behind the energy use patterns for these two communities, Chapter 5 presents the results from survey responses on perceptions on energy use. To explore how and why people used energy in their homes in general and with regard to MELs in specific, Chapter 6 presents the results from household interviews on peoples' motivations underpinning pro-environmental behaviors in their homes and communities.

Summary and Limitations of Actual Energy Use Findings

Although significant decreases can be noted in each community's change from baseline and post-treatment, a trend for these changes can be posited only if the benchmarking period is considered. One limitation was sample size: with so few households, the statistical power to detect effects was quite low. Another limitation was that both communities received treatment; it is not possible to know how the communities might have used energy differently without a control group of allowing comparison measurements of a parallel population without the in-home dashboard. Other limitations include that: 1) only two years of benchmarking data were available; 2) both of these sites were relatively modern (1991 and 2013) architecturally designed communities – communities not necessarily typical of most multifamily development sites in the country; 3) the climate in the Pacific Northwest is milder than that in other parts of the state and country, a circumstance that allows for the use of high efficiency heat pump technology not appropriate for the extreme temperature swings found in other regions. Future research could be expanded to include the full range of architecturally designed sites, which would also help to increase sample size.

The next chapter presents an exploration of participants' perceived energy use and self-reported pro-environmental ratings to see how the communities differed both at baseline and during the treatment period.

Chapter 5: Results for Perceptions of Energy Use and Pro-Environmental Variables

As described in Chapter 3, the purpose of the quantitative analyses on the survey variables (including participant demographics, perceived energy use, and pro-environmental variable ratings) was to investigate how the two communities differed, both prior to and during the dashboard treatment periods. To this end, data from 24 participating households (12 from Built Green Community and 12 from the Code-built Community) were analyzed.

Demographic Characteristics

Respondents' self-reported personal and household characteristics are summarized by group and combined in Table 5.1. As can be seen, the majority of the participating household survey respondents were female, white, between the ages of 46-65, owned their home, and earned a modest/middle-class household income. Chi-square tests comparing the two building community groups on these variables showed no significant differences on any of these characteristics (ps > 0.05). Although not shown in the table, the number of people living in the home averaged $M = 2.46$ ($SD = 1.06$; *Range* = 1 to 4), and the number of bedrooms in the home averaged $M = 2.50$ ($SD = 0.83$; *Range* = 1 to 4). Again, there were no significant differences between the two community groups (2-group t-test ps > 0.05). Overall, these data demonstrate that the household participants from the two communities were similar to each other; additionally, these demographics appear similar to the area as a whole (see Chapter 3 for a description of area demographics).

Table 5.1. Study Sample Demographic Characteristics.

Characteristic	Site/group 1 (n = 12)		Site/group 2 (n = 12)		Combined (N = 24)	
	n	*(%)*	*n*	*(%)*	*N*	*(%)*
Gender						
Male	6	(50%)	3	(25%)	9	(38%)
Female	6	(50%)	9	(75%)	15	(63%)
Education Level						
2-year Community College	1	(8%)	0	(0%)	1	(4%)
4- or 5-Year College Degree	1	(8%)	5	(42%)	6	(25%)
Graduate Degree	10	(83%)	7	(58%)	17	(71%)
Ethnicity						
Non-Minority (White)	12	(100%)	11	(92%)	23	(96%)
Minority (Asian)	0	(0%)	1	(8%)	1	(4%)
Combined Household Income						
$100,000 or Less	7	(58%)	5	(42%)	12	(50%)
$100,001 - $250,000	5	(42%)	7	(58%)	12	(50%)
Home Ownership						
Rent	2	(17%)	0	(0%)	2	(8%)
Own	10	(83%)	12	(100%)	22	(92%)
Square Footage of Home						
Less than 1,000 SF	2	(17%)	2	(17%)	4	(17%)
1,001 SF - 2000 SF	10	(83%)	10	(83%)	20	(83%)
Age of Head of Household						
26-45	2	(17%)	1	(8%)	3	(13%)
46-65	5	(42%)	10	(83%)	15	(63%)
Over 65	5	(42%)	1	(8%)	6	(25%)

Note. Chi-square tests showed no differences between the Built Green Community (Site 1) and the Code-built Commtunity (Site 2), groups (p s > 0.05).

Perceived Energy Use and Pro-Environmental Variables

Comparison of communities at baseline. Pretest (baseline), posttest (after dashboard treatment), and pre-post change descriptive statistics are presented in Table 5.2 for both the Built Green and Code-built communities. Prior to testing for the significance of pretest-posttest change, 2-group *t*-tests were used to test whether household participants' survey responses differed for the Built Green vs. Code-built communities at pretest. Results showed that there were no significant differences between sites on any pretest. This provided some assurance that household participants from the two sites were similar prior to dashboard treatment.

Pre-Post change for each community (separately). Next, 1-group *t*-tests were conducted for pretest-posttest change scores for each community separately to determine whether significant change had occurred between pre- and post-treatment. These results showed that, on hedonic values, Built Green Community households had a significant decline ($M = -1.11$, $SD = 1.24$), $t(11) = -3.10$, $p = 0.010$), whereas on the architectural design feature "Accommodating Changing Needs," variable, the Built Green Community showed a trend for a substantial increase ($M = 0.54$, $SD = 0.96$), $t(11) = 1.95$, $p = 0.078$). Results for the Code-built Community showed a trend for an increase on biospheric values ($M = 0.42$, $SD = 0.76$), $t(11) = 1.91$, $p = 0.083$), and a significant decrease on place identity, ($M = -0.49$, $SD = 0.73$), $t(11) = -2.31$, $p < 0.041$).

Comparison of communities on pre-post changes. Finally, 2-group *t*-tests were used to test whether the two communities differed significantly from each other in their pretest-posttest changes. Results showed that there was a trend for significance on three outcomes (see Table 5.2). On biospheric values, the Code-built Community increased whereas the Built Green Community decreased. On hedonic values, the Built Green Community had a greater decrease than did the Code-built Community. Finally, on environmental self-identity, the Code-built Community ($M = 0.25$, $SD = 0.67$) increased whereas the Built Green Community decreased.

Table 5.2. Comparison of Housing Community Groups on Survey Variables.

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 ($p < .05$).

Testing for significant pretest-posttest change across communities. Given that there were few differences found between the two sites, data were collapsed into one combined sample and then 1-group *t*-tests were used to test whether there were significant changes overall from pre- to post-dashboard treatment on survey variables (a larger sample allows for increased power to detect differences). Results showed significant changes on two outcomes: on hedonic values, the sample as a whole exhibited a significant decrease ($M = -0.63$, $SD = 1.33$, $t(23) = -2.32$, $p < 0.029$) whereas on architectural design feature "Accommodating Changing Needs," the sample as a whole had a significant increase ($M = 0.42$, $SD = 0.79$), $t(23) = 2.59$, $p = 0.017$).

Summary and Limitations of Survey Findings

There were several noteworthy findings from these analyses. First, the self-report survey data showed that the two sites were quite comparable on demographic information as well as pre-treatment environmental, place, and architectural variables. Over the period of the study, Built Green Community households exhibited a significant decrease on hedonic values, and Code-built Community households showed a significant decrease in place identity. 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.

This said, the actual energy used by households (reported in Chapter 4) did show trends for decreases between baseline and post-treatment, irrespective of which housing community 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 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, recall that the survey data showed that over time on biospheric values, the Code-built Community increased whereas the Built Green Community decreased. On environmental self-identity, the Code-built Community increased whereas the Built Green Community decreased. On hedonic values, the Built Green Community had a greater decrease than did the Code-built Community. Both communities increased on 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.

Study limitations for these findings are similar to those noted for the actual energy use analyses (see end of Chapter 4). In addition to those limitations, it should be noted that survey self-report data can be prone to misinterpretation of what is being asked, cognitive load, as well as social desirability effects (i.e., reporting what people believe they should say rather than what they actually believe or do). Knowing this was a limitation, at the outset of the study, I included actual energy use in addition to self-report survey variables.

Though the quantitative data yielded important information on how much energy was being used and how the communities compared to each other, it did not uncover the reasons why residents use energy in their homes nor reveal the meaning behind people's behaviors with regard to energy use. Gathering this type of information required interviews with participants and analysis of the qualitative data they provided.

Chapter 6: Results for People's Experience of Place and Household Energy Use

Overview

Research question four was centered on the relationship between people's experiences of their residential environments and their home energy use. Specifically: a) What role do values and place meanings play in people's understanding of their environmental behaviors related to energy use?; b) How do people understand both physical and social environmental cues in their homes and communities?; c) How do participants respond to information on their energy use given access to real-time dashboard feedback derived from circuit level energy monitoring devices in their homes?; d) Using a grounded theory approach, what conceptual framework could be developed to capture how different people-place relationships relate to residential energy use? This chapter presents the findings from analyses of qualitative interview data that address these questions.

As noted in Chapter 3, a sample of survey participants from each community was interviewed for approximately one hour each during the final quarter of the study. Interview participants were purposefully selected on the basis of their energy use at baseline, coupled with their energy change from baseline to the end of the study (decrease, no change, and increase). The analyses and results presented here are organized around three main dynamic interactions—values, place meanings, and environmental cues—that emerged as critical aspects of how people understood their environmental behaviors related to energy use. Though these findings and the terms generated are derived from the interview data of this dissertation using grounded theory methods, prior research that aligns with and supports these findings is referenced when applicable.

Values Dynamic

The first key finding was that values play a critical role in people's experience of their housing and residential community, as well as their environmentally related behavior (for more information on values see also Schwartz, 2012; Steg et al., 2014a; Stern, 2000). The ways that people tended to reconcile their values with their behaviors revealed a dynamic relationship among values, experience, and behavior that I characterize as the "Values Dynamic." In particular, when individuals across both study sites sought to reconcile their values with their behavioral choices in order to help make sense of their experiences, they responded to their values in three main ways. They either sought congruence among their various values and behaviors so that they were not in direct, obvious conflict, they sought to integrate their values in one coherent system, or they sought to rationalize conflicts among their co-existing and often disparate values and behaviors.

Value congruence. Participants frequently sought congruence between their values and behaviors around energy use in the home, and pro-environmental behaviors in general (see also Moser, 2009; Van der Werff et al., 2013a; Whitmarsh & O'Neill, 2010). When this search for congruence occurred, it was likely to be accompanied by a circumstance or situation that triggered a prioritization of values. For some, it was their desire for efficiency; for others it was a desire to express environmental self-identity or demonstrate that a holistic way of living has multiple benefits for the person and the planet.

When the participants sought congruence between their values and their behaviors around energy use in the home or pro-environmental behaviors in general, a particular circumstance was likely to act as a trigger, resulting in an explicit prioritization of values or reinforcing a specific value to remain salient. Value "triggers" direct a person to focus on certain values over others so that values are in alignment with their behaviors within the home and community. Similarly, recognizing one's past behaviors or witnessing other's behaviors may "reinforce" certain values over others. In such cases, the behavior reminds a person of the values that are important in their lives and is likely to provide feedback such that the value remains prominent leading to pro-environmental behaviors. When values were reinforced with positive feedback, they were likely to be stronger and more enduring over time. Examples of reinforcers included dashboard feedback on energy use coupled with lower monthly energy bills and social norms that inspired innovative approaches to pro-environmental behaviors such as car sharing.

Triggers. Triggers are keenly focal events, circumstances, or desires that direct people to act on their values. For example, the trigger for Chris,[68] a member of the Code-built Community, centered on his desire to achieve "efficiency" via solutions that could be applied across many areas of his life. As Chris explained: "I always pay attention to efficiency, and I try to make decisions about how I just live to be as efficient as possible…" With respect to energy use, while Chris has many high-end electronic devices in his home that use energy, he has focused on selecting or building those that operate with the highest energy efficiency. Whenever possible, he applied his penchant for efficiency to a "macro scale" and sought ways to apply them across multiple households for the benefit of his community:

> ... I like to focus the energies and talents I have on making as big an impact as possible, and I see that I have a much bigger impact when I'm affecting thirty households, as opposed to my own.... [For example] I've been involved in the heat [retrofitting the heating system] and the heat recovery ventilator [selection and installation of clean air filtering] system.

Furthermore, Chris used the energy dashboard information not only to lower his own energy use over the course of the study, but also to recalibrate the way hot water was being

[68] All interviewees were given a pseudonym to protect their privacy.

metered for the entire community. This approach gave him a sense of greater congruence between his efforts, behaviors, and his pro-environmental values triggered by his desire for efficiency.

A similar values dynamic was found in the Built Green Community. However, in this case the participants' values were triggered by a desire to demonstrate their environmental self-identity to others. For example, the prominent solar panels on most of the homes in the Built Green Community prompted passersby to stop and engage in conversations on energy use with Harry and Sally. These residents felt that such interactions offered them opportunities to affect others outside the community by demonstrating that their environmental way of life was beneficial for themselves, others, and the planet. Furthermore, Harry and Sally expressed their environmental self-identity as a relationship with nature that was reciprocal.

> It's demonstrating that this style of life works for us, the community, and the world, the earth actually. We often get asked questions. We tell them [passersby], yes, the solar panels do work…. We do have people we're influencing all of the time…. When I was really young, I spent a lot of time out in the fields and forest… and I got to understand in a very personal way that I was part of [nature]… that there is no separation between us. So, it's a way of life…. And in the long run, it saves money… [however] it's the living beings on the planet that we need to save, because if we don't save them, we're not saving us. It's simple.

In the two examples provided above, triggers influenced the prioritization of values motivating behaviors that were congruent with participants' self-transcendent values and helped to cultivate a phenomenon that could be characterized in a phrase offered by one interviewee: "be the change you want to see." That is, to be value congruent may require active and engaged participation in one's circumstances.

Reinforcers. Reinforcers are behaviors or circumstances that remind a person of the significance of their existing values and are likely to provide feedback to them such that the value remains prominent, leading to pro-environmental behaviors. For example, when a person recalls their past pro-environmental behavior or witnesses another person's environmentally friendly behaviors, then their biospheric values (respecting/protecting the earth) are likely to remain highly relevant, prompting them to continue acting on these values. For example, for Sam, a participant in the Built Green Community, the information on energy use from his PSE utility billing ("my energy bills are about $1 a day") coupled with information gleaned from his energy dashboard reinforced his efforts to conserve energy by reminding him of the positive impact on his energy bill. Sam's efforts to consume less energy resulted in multiple, ongoing energy conservation behaviors consistent with his pro-environmental values.

> Being involved in the study has made me think more because I can look online and see what the dashboard is saying…. I've got to be more careful. It does take forethought, but… becomes second nature [once you're in the habit]…. For instance, I'll use the laptop more than a desktop. If it's just me, I'll use the toaster oven rather than the regular oven. Even tiny things: I unplug the coffeemaker.... I've got everything on a power [strip]…. I have both the [heater] breakers flipped [to the off position] because there's no point in leaving it connected…. I try to use as little energy as possible, and it would be nice to be a net producer [with solar energy] than a consumer.

Study participants also indicated that witnessing the actions of others in the community reinforced their pro-environmental behaviors and inspired them to bring their values and behavior into alignment. For example, Mike and Sue explained that where they live in the Built Green Community reinforced and inspired their innovative approach to transportation:

> It's a positive feedback cycle: everybody around us is trying to make the community better, so I want to participate. You can't complain about what's wrong with your community or with the world if you aren't doing anything to make it better.… I would love to not buy a car and just participate in a community car share program.

In summary, participants' anecdotes revealed that, when they were seeking value-behavior congruence, "triggers" helped them to prioritize salient values over others while “reinforcers” provided a robust feedback cycle to strengthen their values and foster ongoing pro-environmental behaviors.

Value integration. Across both study sites, participants sought to integrate seemingly disparate self-transcendent and self-enhancing values (see especially Steg et al., 2014a; Van der Werff, & Steg, 2015). When this integration occurred, the resulting environmental behaviors were likely to produce multiple, lasting benefits for the individual, the community, and the environment. Indeed, values had a more enduring (sticky) quality when they were born out of a sense of commitment serving both self-interest and the environment. When the integration of values was shared with important others (family or neighbors) and supported by both self-interest and community-interest toward environmentalism, then biospheric values held sway. In these cases, actions were likely to be pro-environmental such that to care for the environment and to care for each other on a day-to-day basis offered a means to sustain both the planet and a community.

Values integration occurs when seemingly diametrically opposed values are assimilated into one coherent system of values and behaviors and then exert an even greater influence to promote enduring pro-environmental behaviors. Across both study sites, the trend for values integration occurred around self-interest and self-transcendence; additionally, in the Code-built Community, a trend for community environmentalism surfaced that was not apparent in the Built Green Community.

Self-interest and self-transcendence. Residents expressed an appreciation for circumstances that supported not only self-transcendent values such as altruistic (concern for people) and biospheric (concern for the environment) values but also self-enhancing values such as egoistic (protecting one’s resources) and hedonic (seeking pleasure) values concurrently. In such cases, a household might value renewable solar energy and be motivated purchase and maintain a solar array because it produces clean energy, which is beneficial for the planet, and value their extremely low energy bills, which often amount to no more than the utility's monthly service charge. In this case, the motivations behind these actions are partially driven by self-transcendent biospheric values; however, self-serving egoistic values also played a role. Furthermore, this assimilation of values was likely to promote an enduring commitment to other pro-environmental behaviors—a phenomenon that I characterize as values "stickiness." For example, Mike and Sue, members of the Built Green Community, demonstrated their commitment to renewable energy not only by maintaining their solar array, but also by not using the air conditioning in their home over the course of the summer. As Mike explained, he integrated his biospheric and egoistic values into a coherent system of behaviors:

> Our energy bill in the winter is $8.37, which is the cost of the fee to hook [solar panels up to the utility grid] it up [each month.] And if we don't use the AC over the summer, we build up enough credits to basically pay for the winter… it's sustainability and it's self-serving.

Their increased sense of commitment (stickiness) to environmental values and recognition of supporting self-serving values influenced subsequent environmental behaviors, even though these actions may have been less convenient or less comfortable.

In some cases, concern for both sustainability and self-interest emerged when community members thought about accommodating changing needs over time with respect to choices on where and how to live. Across both communities, this concern arose out particularly around interviewees' discussions about aging. For example, as Anne moves toward retirement, she described the benefits of having a smaller home and less property to take care of, living near others in an energy efficient home—all of which contribute to improving the environment, serve her need to be more connected to other people, and support her desire to live in a newly-designed home with a master suite on the main level—meeting her needs as she ages. Notwithstanding her missing the beauty of her prior home, Anne expressed her feelings this way:

> We wanted a smaller place with less property to take care. I felt it was important as we got older to be in a place where we were more connected to people, rather than in a place more remote, like where we lived before. However beautiful it is – and I do miss it – it got kind of isolating. And, we liked the houses [here]. We liked the concept of the sustainable design, and being so close to town.… I like living in a way that supports some incremental contribution to improving our environment than not. And in that sense, "Oh, it's really cool to have solar panels," and know that that's contributing to this conversion of energy away from fossil fuels. And just the way the place is constructed, with really thick, well-insulated walls…. And it feels like a very functional, nicely designed house.

These two illustrations show how biospheric values and self-serving values are integrated by an individual, and that when both are addressed concurrently, one's values become more "sticky" or enduring.

A noteworthy difference between the two study sites appeared when residents sought to integrate their self-enhancing and self-transcendent values. Individuals in the Code-built Community had chosen to move there primarily because of the inviting social community and sustainability was achieved through the collective efforts of the community. In contrast, individuals in the Built Green Community had chosen to move there primarily because of the inviting "green living" concept, energy efficient homes and the promise of an "involvement-free" sustainable green lifestyle achieved via sustainable architectural design features.

However, sustainability and community interests can go hand in hand, as was particularly evident in the Code-built Community. Code-built Community members were actively engaged in the care of both the physical and the social infrastructure—and this care comprised an expression of their individual and collective values. Importantly, though biospheric and altruistic values were a part of the social fabric of the community, an individual's personal values, feelings of social connection, and sense of ownership were also satisfied because individuals made contributions to the physical infrastructure of the community. Jane, a Code-built Community member, describes this integrated experience as "connected-to-the-people-around-us-culture" in this passage:

> I'm very proud to say I live in cohousing… this kind of friendly and welcoming and connected-to-the-people-around-us culture, which is really facilitated by the physical design as well as what's called the social design of cohousing, that is very much an expression of who we are as people. I would say living here is very much an expression of my values…. I feel that I've been able to contribute to it. Because we work on it physically – clean the gutters, clean the siding, weed the lawn, sit in meetings that discuss the many things that need to get done – I feel connected to the whole facility, in the way you might in your own house when you painted that bathroom or fixed this pipe, that you feel greater ownership over it.

Another resident, Carol, from the Code-built Community emphasized a broader relationship-based meaning for the term "energy" as including both billable electric energy and non-billable social energy:

> When people talk about it [energy efficiency] they tend to talk about the energy that you get billed for, but [for me] energy savings is [evident when] I can ask my neighbor, "Hey, could somebody help me, I can't manage this." Or, on the other side, it's the neighbor who calls me and says, "The ambulance is on its way," and then I can put my energy in that. I think that saving the billable [energy] is important for the planet and for future generations and that's true. But the other [social] energy is as important…. That's... where the meaning comes from.

In the above examples from the Code-built Community, residents didn't necessarily wear the environmental self-identity "badge," yet they maintained a light ecological footprint in their community because they supported community values. The values held by the community suggested that to care for the environment and to care for each other on a day-to-day basis was the means to sustain both the planet and their community—thus integrating values and behaviors for the self and for important others.

In contrast, few members of the Built Green Community referred to personal relationships with their neighbors. Rather, they spoke about enjoying the concept of living in a sustainable community. Individuals in the Built Green Community intentionally opted to extend less commitment and share fewer interactions with each other. As Kyra described, they wanted the feeling of a close-knit community but without having to interact. In this way, people's independence trumped their interdependence:

> For things like that to happen, you either need to have a co-housing type governance structure with really involved members, or you need to have a property manager that is providing that leadership role. [We] heard from a lot of people that that [co-housing] was too much commitment, too much expectation of shared time together or interaction, and there were a lot of people that wanted that feeling, but not to have to interact as much... the governance is still working itself out.... It's not been entirely successful yet.

The narratives of Jane and Carol demonstrate two opportunities where values integration occurred. In the first case, both self-transcendent values and self-enhancing values were assimilated into one coherent system of values and behaviors and had an influence on promoting enduring pro-environmental behaviors. In the second, pro-environmental values and behaviors supported both the physical and social aspects of the individual and the community this integration of values and behaviors became the means to achieve a sustainable planet and to sustain the self within the Code-built Community.

Rationalizing behavior. When study participants sought to rationalize inconsistencies across their values, intentions, and behaviors, the process often involved making trade-offs that served to justify pro-environmental behaviors (even when difficult or inconvenient), but participants rationalized non-environmental behaviors as well. In either case, one set of actions was justified because of another set of actions and values that participants believed to be sustainable (see also Van der Werff et al., 2013a, 2013b, 2013c). The phenomenon was more likely to sanction inaction when it was based in a sense that one's behaviors were inconsequential, engendering a check-the-box response according to which little engagement was required of the individual. For example, a check-the-box conceptualization was evident among some homeowners in the Built Green Community, who felt that they had taken care of the environment "up-front" and no longer had to think about sustainability or make efforts to lower their energy use because they had purchased an energy efficient home with renewable solar energy panels. Their "job" toward sustainability was already done with no further action needed on their part. Examples from the narrative data exploring different types of value-behavior rationalization are presented below.

Trade-offs between egoistic values (time and effort) and biospheric values (non-polluting) were rationalized in a vivid portrayal of doing the weekly shopping by Sue, a Built Green Community homeowner. She recounted: "We do like pack mules... that's what feels normal…. I feel terrible when I drive somewhere that I don't have to be driving…. I feel good that I'm [not driving]." These pro-environmental actions took place even when friends applied peer pressure and "… they're like flabbergasted. I had a friend visit from Los Angeles who just could not believe that I was making her walk up the hill." The trade-off framed the question, ought a person endure the burden of hand carrying groceries six blocks or should they indulge in the expediency of driving—to walk (inconvenient and non-polluting) or to drive (convenient and polluting)? This household employed a coping strategy to justify their behavior each time they left home on foot and left the car behind. Their approach transcended home life and carried over into their daily three-hour roundtrip work commute into Seattle, though they admitted that the "commute can be a little grueling" when not using a car. As can be seen from this example, rationalizing behavior was not always a negative for the environment but rather could amount to a coping strategy for supporting difficult, though admirable, behavior.

In contrast, trade-offs between time, effort, and energy usage were rationalized as a justification for non-environmental behaviors as recounted by Rick who lives in the Code-built Community. He rationalized that because he owned an electric car, there was no reason not to use it, even though he understood that the car required electrical energy for battery charging:

> I would probably ride my bike to the store more if I didn't have an electric car. The fact that I have an electric car makes me feel less bad about jumping in the car and going to the store.… I think about it in terms of "hey, I'm not burning gas." It would be more painful to get in the car and drive the [gas-powered] car for a 2-minute trip; it's bad for the car and hard on the engine. But, neither of those apply with the electric car. Less reason not to.

Kyra, who lives in the Built Green Community, rationalized that using energy to meet her needs and wants was justified because, in her words, "Oh, we have solar, I don't feel guilty about the air conditioning, but I wonder how much it's really using."

In the two cases presented above, the homeowners rationalized their non-environmental behaviors when they traded one green behavior, such as owning an electric car or renewable energy, as justification for non-environmental behaviors, such as taking the car for a two-minute drive to do the shopping rather than walking or using air conditioning rather than experiencing higher indoor air temperatures.

Check-the-box sustainability. An important aspect of the values dynamic emerged when community members reported that they did not need to concern themselves with environmental behaviors in the home because, in the Built Green Community, the homes were sustainable by virtue of their design and construction. The home's features provided residents with a sense that they had "checked-the-box" on living sustainably and that their job regarding energy efficient behavior was done. As Dave described:

> We don’t have to think about sustainability. Just by living here, you can take care of so many aspects of it and you could check the sustainability box because it was all done for you. You can live in the house and know that you have a far more energy-efficient life.

Another significant check-the-box aspect of the Built Green Community development came to light when long-term maintenance contracts for the homes and equipment were discussed by Kyra:

> But what’s cool [is], the guys were just out cleaning everybody's solar panels last week… it was a contract with [the solar company], who did the installation. I'm not quite sure, because I didn't pay attention, because I'm not paying for it, which is great! So, the idea that they make it easy, attractive, and affordable for people to live sustainably is great, but then [they] also set up long-term systems for maintenance.

Because the development was marketed as sustainable by design, the check-the-box phenomenon described above had the unintended consequence of offering little motivation to conserve energy. As Anne described, “you don’t feel the pain” living in the Built Green Community:

> Oddly enough, because of the solar energy [program] and selling energy back to the grid, we get an eight-dollar electric bill a month, so we don't get a bill and go, “Oh, my God, we had 100 dollars-worth of energy use this month!” If we were actually paying our own frigging energy bill,” then we might go, “Hmm, we should really be trying to think about how to reduce.”

While these residents valued sustainable living and made a commitment to it by “paying for it up-front” with the initial purchase of the home and roof top solar array, they ceased to pay attention to the initial value-behavior commitment in their daily choices and actions regarding energy use.

The values dynamic is one of a number of factors that shapes a person’s pro-environmental behavior broadly and energy use specifically. In addition, the data in this study show that place meanings also shape a person’s behavior. The next section describes these findings in greater detail.

Place Meanings Dynamic

Findings from the interviews illustrate the importance of place attachment, place identity, and environmental self-identity in people's interactions with their residence and communities, including their environmentally-related behavior (see also Clayton, 2012; Gifford, 2014; Manzo & Devine-Wright, 2014; Proshansky et al., 19). Taken together, participants' place meanings, place attachments, and place-related identity constitute what I call the "Meanings Dynamic" because these are neither static nor unidimensional but a multifaceted collection of emotions, cognitions, and behaviors that influence environmental actions.

For study participants, place meanings formed through a fluid process involving feelings in response to their homes and communities that engendered actions, some of which were pro-environmental. Place meanings were likely to differ for different people in different contexts, yet a few key trends emerged from the interview data. First, place meanings provided what I call "animating qualities" – that is, place meanings can either facilitate or inhibit residents' environmental behaviors. Second, when residents felt a sense of purpose with respect to their place, they were likely to be inspired to take actions. This sense of purpose trended toward concepts involving singularity and interdependence. That is, people took a holistic approach to life that emphasized the interconnectedness of all things including their residential setting and their behaviors. Third, place meanings enabled residents desire for self-expression and to make improvements that were beneficial for themselves, the community, and the planet. Below, the main trends in the Meanings Dynamics are described with examples from the narratives of study participants across both sites.

Animating qualities. Interview data demonstrated that the meaningful relationships residents had with their homes and communities catalyzed and enhanced a person's behavioral engagement with their environments. However, in some cases, the meanings people expressed had a negative effect that inhibited a person's sense of belonging to and involvement with their place of residence. In a few cases, people expressed ambivalence toward their physical or social environments. Each of these animating qualities is explored in further detail below.

Enhancers. In both the Built Green and Code-built communities, residents expressed emotional responses to their places of residence that supported their environmental actions. These are what I call "enhancers." For example, in the Built Green Community, Mike and Sue conveyed their love of place not just because it was an expression of how they live in an environmentally friendly way, but also because it was a source of pride and expressed their place-identity:

> Sue: I think it's something that we really loved, we wanted to live here because of it [pro-environmental aspects]. It stands out and it's knowing that we would like the rest of the world to look [this way] too, but we get to actually participate in this place that does look that way.
>
> Mike: People walking or biking by outside, who don't live [here] and we hear them talking about "Oh, look at all these houses" or "Isn't this such a cool development?" And there was a whole group of maybe 10 or 15 cyclists and I could hear someone yelling about the solar panels. So, that's just kind of cool and that happens all the time.

Mary, a resident of the Code-built community conveyed a deep sense of connection to place – for her, it was a safe haven and a refuge that nourished her relationship with community:

> It feels like home and I feel happy when I am here. I feel connected to the place physically. I mean when we come home and get out of the car it is decompression-- "Ah, we are home." I feel that way about the whole community not just our house…. That part feels safe and warm… this is more than a home, a physical home. It is a community. It is very much connected. Deeper than neighborhood it feels like my extended family. It is the place that "houses" that [feeling]. It would be hard to imagine leaving. That would feel very uprooted [and] from a grounded standpoint, it would feel disruptive.

Similarly, in the Built Green Community, Kyra expressed strong place attachment:

> I do feel very attached to it…. We feel a part of the neighborhood because we've invested in creating it together. We built the gardens together and you build community that way.

In the Code-built Community, Joe and Becky took concrete action to reduce their energy footprint, a stance which afforded them a sense of pride and satisfaction with their contributions toward energy reduction and sustainability. Informed by their dashboard, they confirmed that hot water comprised one of their largest energy uses. In response, they took multiple actions — showering less frequently, installing an on-demand hot water tap, and using the community laundry facility.

In all cases where residents described their home and community as holding a great deal of positive meaning, these feelings deepened and nurtured their engagement in their environments (see also Gifford, 2014).

Inhibitors. In contrast, other interviewees described how negative experiences in their homes and communities had lessened their emotional bonds with their homes and their sense of place identity (see especially Manzo, 2003). These are what I call "inhibitors." For example, Anne, a member of the Built Green Community, expressed disappointment after moving into her home. Her main source of disillusionment was the experimental nature of some of the sustainable technologies that have failed, coupled with great expectations for a carefree green sustainable life promised by the developer, which left her feeling, in her words, "ripped off." She also felt unsupported because there was no community-wide problem-solving network nor expectation that the sustainability principles of One Planet Living framework (see also https://www.bioregional.com/) would be upheld in the long run. When Anne first bought her home in the Built Green Community, she expected that her home would prove not only well built but to have sustainability "built in." However, for Anne, this was not the case:

> … some of the technology was too new and hasn't worked out…. It makes me feel that, on paper, at time zero, it's perfectly sustainable—the PaperStone [counters], efficient water heater, and ductless mini-split. And then it breaks down.… [There is no] community-wide problem-solving around those issues that would maintain a sustainability standard. [Perhaps] that's because these are individually owned homes and there's a sense that we don't have any kind of community-wide obligation to have those standards. The CC&Rs [covenants, conditions & restrictions that regulate the use of property] don't have anything in it about One Planet Living. [There is no] committee or clearinghouse… people feel ripped off, quite honestly.

Anne's disappointment in the technology created a negative experience that inhibited feelings of place attachment.

Similarly, Joe, a member of the Code-built Community, expressed negative feelings (inhibitor) toward the physical home; however, he simultaneously expressed feelings of connection toward his social community (enhancer). This combination created conflicting feelings in his relationship to place that several members of the Code-built Community also felt:

> What I like least is the actual house itself. I love the location, and I grew to appreciate the community and everything we have at co-housing. I think it's totally awesome, but there's a lot of things about the actual house [that] I do not like. Now I have a big garden that I help maintain for the community, I get more satisfaction out of knowing that the community is enjoying it…. I think those outweigh [my negative feelings about the house].

Place meanings occurred not only as influenced by such positive or negative individual experiences but also with respect to the larger community, a trend that was expressed as a shared sense of purpose.

Sense of purpose. A second salient trend that emerged from the interview data is that place meanings often provided participants with a sense of purpose that exceeded caring only for oneself. That is, place meanings fostered values and actions that surpassed only self-interest. In such cases, a phenomenon that I call "singularity"[69] occurred. Singularity is defined as a person's willingness to allow their individual needs and purposes to fade in deference to feelings of unity and belonging to the greater community or environment. Singularity was demonstrated when a common or shared purpose motivated a search for solutions that benefited the greater common good in people's communities or the environment. This shared purpose was also expressed by some interviewees as a type of interdependency among people, place, and other species. Interdependency could be expressed as a "process of mutual dependencies," which included concerns for equality, ecology, economy or health, social well-being, and financial well-being as mutually dependent attributes of sustainability.

Singularity and interdependency. The narratives relayed by some study participants evinced a sense of singularity and interdependency (related but distinct facets of a sense of purpose as described above) that occurred not only in the home but also within the community and across communities. This sense manifested as a shared sense of purpose (belonging and connectedness with the community and concern for the environment) with mutual benefit for the self, the community, and the planet.

For Maggie, a member of the Code-built Community, feeling connected to her community increased her sense of singularity and fostered her sense of place identity:

> Our values [are] to share the planet [and] to live cooperatively. [I found this community to be one where the] people were hard on the issues, kind to each other, and the energy was respectful and enjoyable and that spoke mountains... I am a community-minded cooperative person who believes we're all connected, and this does live my values, more so than living in a place where I barely know my neighbors and I have everything that's mine…. My identity is to have a common house which is in the center where we all go

---

[69] In quantum physics a singularity is a point where some property or properties become infinite. I characterize singularity as a point of action inclusive of the individual and the physical and social contexts of which individuals are a part. Retrieved (August 16, 2018) from http://www.singularitysymposium.com/definition-of-singularity.html.

> for our: mail, information, food, meetings, and the laundry. That's our place [where] we're meeting …. It ground[s] me.… It's a wonderful place to come home to, it feels very safe [and the] community is here to help out…. I can be very alone but I'm not isolated, and that's really important.

The One Planet Living framework behind the Built Green Community helped Harry to express an environmental self-identity. This identity carried over into his views on habitat "co-ownership" in this way:

> The 10 [One Planet Living] principles are helpful guidelines [that] by their very essence help us be mindful…. All these plants out here I planted mindfully because I wanted a safe place for the birds…. We own it in concert with a number of beings, and so every time I walk out the door I'm reminded now do things in a mindful way so that you're not causing difficulty for the other neighbors, the little ones, the big ones, the flying and the crawlers and all the rest of them…. It's really a process.

Harry's sense of singularity was demonstrated when took mindful actions that increased habitat diversity and benefited the greater good—a shared sense of purpose.

Jane, a homeowner in the Code-built Community, found common purpose in thinking about sustainability as a larger practice in life and described her way of living in community by demonstrating a sense of interdependency:

> I was blown away by the tight-knit-community feel, the wonderful, friendly design of the community where the houses are pushed close to the path and you can see everyone and it encourages all these informal interactions that are very neighborly and very warm and inviting. The landscape is very mature and has variety from community garden to woodland, to orchards. I was delighted that the storm-water management is actually handled by the forest in a very appropriate way. The design worked with the topography appropriately and the interdependencies of relationships between neighbors as evidenced from: activities to maintain the facilities, voluntary [communal] meals five nights a week, and friendliness of neighbors to one another. The physical environment definitely grabbed me emotionally… it just clicks. The values of having a light footprint on the land and using fewer resources [by] sharing laundry, garden tools, and small houses with almost no storage, all cause people to be interdependent. That is a value that I prefer. And people of all ages. I love to live where there are children running about and elderly and people in the middle and having that mix seems more well-rounded…. It is about interdependencies, where we are mutually dependent on each other.

In the Code-built Community, Joe and Becky liked the idea of "merging their actions in with other people." By having community meals, which were primarily vegetarian, using organic produce from their community gardens, they demonstrated the interdependencies of relationships between neighbors. Finally, the central location of the neighborhood afforded them the opportunity to walk rather than take the car and they felt good about this because they were already engaged in actions that benefited themselves and the environment the moment they walked out the front door:

> It's sustainable participating in the common meals. It certainly makes it [so] we're not going out to eat and we don't have to cook in our home all the time…. [It's sustainable] any time you are merging your actions in with other people…. Whenever we need to go somewhere, we don't have to [take] the car, we just walk out the door and then we're already on our way, that's the beauty of that.

A positive sense of purpose gave people's experience of place greater meaning and influenced their willingness to engage purposefully in their homes and in their communities. Two other trends that emerged were the need for self-expression and the need to cultivate personal relationships with neighbors. These two trends are addressed below.

Self-expression. Data analysis revealed that it was important for residents to cultivate a sense of self-expression through the built environment by personalizing their homes and gardens. When avenues for self-expression were found in the physical built environment, people were likely to express a sense of attachment to their homes that fostered feelings of caring for their place in general and environmentalism more broadly. It was also likely to deepen their place identity.

In the Built Green Community, some people sensed an expectation that nothing could or should be changed because the homes were already so thoughtfully and sustainably designed that nothing more was needed. Residents were not expected to personalize their home or cultivate self-expression through changes to the home. However, some, like Rob, felt that his inability to make changes to his home suppressed his ability to have a greater sense of place identity:

> There's an architecturally enforced homogeneity. We're kind of doing graffiti on the architect's artwork here…. I couldn't do anything, no matter how beautiful it would be. I couldn't do it without the approval of the architectural review committee and Lord knows what that means…. I think communities are more interesting when each house has its own character. If I were to put up a railing, I would have to get the agreement of every other neighbor that has the same house design, and we'd all have to choose the same railing.… I'm very, very happy having a vegetable garden [for self-expression]… that's a little patch of freedom.

Maggie preferred to live in the Code-built Community where she felt that she could express her individualism:

> I have the doors open and I can go out and I have all of this room to roam… I have lots of choice…. I look at my friend's place in the [Built Green] community, they're gardeners, their place is resplendent. And they were told they had to cut back on that, that it didn't fit in. And they said to me, Hey, if they really make us take out our flowers, we're moving. Because that's their expression. Here it's the opposite…. I prefer this to that…

Additionally, the Code-built Community allowed more opportunities for self-expression through home modifications, and this freedom supported a feeling of place attachment. For Joe and Becky, the changes helped them feel at home: "I feel very attached to the house, every little improvement that we make helps us feel comfortable here."

Neighboring. Interviewees also found that cultivating relationships in their community contributed to a sense of neighboring that many community members revealed as key to living sustainably and sustaining the community. Cultivating relationships in the neighborhood was a vital and intentional aspect of the Code-built Community that many community members felt was key to sustainability. Maggie, a member of the Code-built Community described the importance of the relationship building process this way:

> It's intentional…. Just the thought that goes into it, the process is the value, more than the outcome. I like that our community will grapple with [issues]. I wish some people would

> take better care of their yards and their gardens and help out. But it's not important enough to me to make it more structured and say, "Well, everybody will and you're going to plant a--" That's not worth it to me. I'd much rather have the organic. But it's a balance… things will change… that's consensus. We work on consensus.

In the Code-built Community, Jane felt that promoting a sense of neighboring was an important aspect of building community:

> By having very positive and frequent social interactions with my neighbors…. [It] is a very soft, but important, constant process. To make sure that we hang together as a group and support each other. That's done through conversation and interaction. That's a very important part of sustainability, separate from a technological or energy choice.

Jane goes on to explain that she also values sharing resources with her neighbors:

> [Here] there is a reduction of use of resources. Every tool you buy, every product you need came from somewhere and [has] embodied energy. Here we share [things] to a degree that we don't need as much of it individually. That is an expression of that value of living more lightly on the land and more efficiently. Because economics, of course, is part of that triad of sustainability. To reduce energy use or be more efficient with energy use is an extension of that [triad]…. It's an extension of the larger-value system…Energy efficiency is one piece of that larger question of how we reduce our footprint in a way that still facilitates living day to day but is an expression of our desire to not extract unnecessary resources from the larger world…. If you think about that sustainability triad, the social, the ecological and the economic, [this community is] a really unique experiment in trying to figure out how to optimize all of them [even as] one of those in the triad [may be] privileged over the other two [at any given time].

By contrast, few members of the Built Green Community referred to personal relationships with their neighbors. Rather, they spoke about enjoying the concept of living in a Built Green Community more abstractly or specifically referenced the community gardens as a way to participate in a community activity or work group.

In summary, a key trend in the place meanings dynamic occurred when individuals felt themselves to be a part of a greater whole, a phenomenon I characterized as singularity. That is, feelings of unity led to actions for the mutual benefit of person-place-environment. There was less separation between humans and the environment, which supported taking pro-environmental behaviors. Additionally, when residents felt that there were interdependencies among equity, ecology, and economics in the Code-built Community or among health, social well-being, and financial well-being in the Built Green Community, they felt that there was a greater environmental impact and that they were a meaningful part of a system of actions larger than themselves. The sections discussing the Values Dynamic and the Place Meanings Dynamic, above, both describe aspects of the person side of the people-place relationship. The following section on environmental cues describes the influence of the physical context on pro-environmental behavior and residential energy use.

Environmental Cues Dynamic

Findings from the interviews illustrate the importance of the physical context for residents' environmentally related behavior in their homes and communities. Often the built environment served to ground, hold, and focus residents' attention on sustainable ways of living, serving as a cue to support the prioritization of a person's environmental values (see also Steg et al, 2014a) and as a place to for meaningful relationships and attachments to occur (see also Gifford, 2014). As such, environmental cues afford opportunities for place meanings to be catalyzed, nurtured, and sustained, and for desirable values to be triggered and prioritized. The physical features and social infrastructure that study participants described as being important to them helped them prioritize pro-environmental values, supported place meanings and attachments, and either facilitated or thwarted their ability to engage in pro-environmental behaviors.

The trend across both study sites was for individuals to describe their experience of place with an emphasis on either the physical attributes of the home and community (built environmental cues), or the shared social interactions through neighboring circles and workgroups (social environmental cues) that supported their ability to engage in different aspects of sustainable living. Overall, various environmental cues provided a means for people to cultivate, nurture, and grow self-expression, relationships among neighbors, and relationships with the environment around them – a phenomenon I characterize as the Environmental Cues Dynamic.

In order to elucidate what it was about the physical and social contexts that may have functioned as a cue for environmental behavior, interviewees were asked about the importance of a set of architectural and place-related features (physical and social) that might be present in their homes and communities. The architectural design features referenced in the interviews are often used by architects when designing low energy buildings, namely: OPL, LEED, ILFI, iPHA standards. Collectively, for the purpose of this study, these criteria are referred to as Architectural Design Features (ADF). This section reports interviewees' explanations of why and how these criteria were meaningful to them in relation to their actual energy use and pro-environmental behaviors. These data shed light on whether residents themselves found certain architectural design features influential with respect to their engagements and relationships with place.

Since the purpose of these features is to support sustainable low energy buildings the terms Green Built Environmental (GBE) cues and Green Social Environmental (GSC) are used to designate cues that promote "green" buildings and "green" behaviors in the physical and social context respectively. Architectural Design Features related to GBE cues were clustered into four areas including: environment and human well-being, next generation building systems, regenerative design features, and accommodating changing needs over time. In contrast, the fifth area GSE cues focused on pro-environmental awareness and actions promoting opportunities for community building around sustainable practices, education, and information on energy use behaviors. Not surprisingly, study participants expressed a wide variety of responses related to the architectural design features of their homes and communities. The following sections describe the kinds of design features people focused on, what these meant to them, and in some cases, what values were a part of the experience. The stories are organized around the five above-mentioned ADF categories presented in greater detail in Table 6.1 and supported with examples from the narrative data in the following sections.

Table 6.1. Architectual Design Features.

Codes	Architectural Design Features					
ADF 1 Enviro/Human Well-being	**Improve Health** reduce asthma/cancer by reduction in electrical energy, commute by bike; take the stairs	**Reduce Waste** recycle, compost, reduce packaging	**Behavior** sustainable actions, seek ways to enhance your feelings of green-identity, green-place identity, and green place-attachment	**Biophilic** incorporate nature into home/ community design	**Building Materials** quality long lasting, 50-100 year building materials, rain screen to prevent mold, renewable building materials, locally sourced building materials	**Beauty** human scale, variety of building form, color, texture, materials, landscape, art/sculpture; architecture /aesthetics- love the way the home & community look
ADF 2 Next Generation Building Systems	**Water** low flow fixtures (shower/toilet), water harvesting (cistern, grey water), natural hydrology (surface stormwater catchment	**Energy** heat recovery air ventilation system, tight building envelope (continuous air sealing), highly efficient building envelope (triple insulation values, triple pane windows)	**Mechanicals** operable windows, highly efficient home heating system and hot water heater	**Indoor Air Quality** air, thermal, and visual comfort; non-toxic building and finish materials; continuous air filtering	**Lighting** LED fixtures, day lighting, automatic dimming and motion detection controls	**Build Small** preserving open space (small building footprint), home size less than 1600 SF
ADF 3 Promote Pro-environmental Awareness and Action	**Monitoring** real time in-home appliance level energy monitoring, dashboard feedback and alerts sent to your smart phone/computer	**Education** share educational materials about the operations and performance of your home with others	**Innovation** use a small device like a "FitBit" to monitor the energy use in the home, use a remote control thermostat connected to WiFi	**Beyond Code Certification** certification of your home to LEED, Passive House, ILFI, or OPL design standards		
ADF 4 Regenerative Design Features	**Site Features** green roofs, green walls, rain gardens, porous pavers, pea-patch / urban agriculture	**Renewable Energy** solar PV array, ground source heating, wind energy, home battery that charges using solar electricity				
ADF 5 Accommodating Changing Needs and Uses Over Time	**Place** pedestrian and bike friendly, near public transit and services, provides open space for native habitat	**Changing Needs** rentable rooms, universally accessible rooms, flex rooms, caretaker apt. in-home office				

Environment and human well-being. One emergent trend from the interview data was that residents responded to architectural design features they believed related to improving human and or environmental health and well-being. This included reducing car use and increasing walking or biking; reducing waste; seeking ways to take sustainable actions and to incorporate nature into the home; using long-lasting, renewable building materials and construction methods; responding to beauty in building form, texture, or color in the built environment or landscape, and to general architectural aesthetics. Each of these will now be addressed in turn.

Building materials. The Built Green Community tended to express concerns over the experimental nature of the materials used in their community, while the Code-built Community referenced a lack serviceability in the overall building designs. For example, in the Built Green Community, Harry and Sally reported that “some of the things work really well, and some of the things are abysmal,” citing as an example the front porch composite decking material that “will move out and pop up, and it's really dangerous.” Similarly, Anne was particularly disappointed in the poor quality of the countertops and the failure of the hot water heater, while Kate and Alice expressed disappointment in the difficult operation of the windows. In contrast, in the Code-built Community, Mary explained that the buildings were built with materials that were not considered sustainable such as the vinyl siding, windows, and asphalt composition roofing shingles. While still discussing replacing the vinyl siding, the community undertook a costly retrofit to replace all the roofs using materials with a high content of recycled aluminum and to replace the windows on the commons house with wood that they considered to be sustainable. In each of these examples, residents of the Green Built Community not only expressed disappointment in the actual materials, but also expressed their frustration. They felt they had been “ripped off” by the marketing promises of sustainability, which inhibited their trust in the durability and sustainability of their environment. Furthermore, the community had no means to understand how replace the failing materials with materials that were both durable and sustainable as there was no established information or vetting process; therefore, they considered replacements that were not necessarily as sustainable (countertops) or as energy efficient (hot water heaters). In the Code-built Community, residents felt frustrated that the vinyl siding, in particular, was a highly visible non-sustainable material inconsistent with their values. This situation inspired them to opt for the higher priced metal roofs and wood windows retrofit options, which they researched at great length and determined to be in line with their values, sustainable, and highly durable. This process enhanced their feelings of place attachment as well as providing material with greater potential to increase building envelope energy performance.

Improving health. A major feature for study participants in both communities was being located near the center of town where they could walk or bike to many services, which they considered an opportunity to support their health through exercise and support the environment through reduced emissions. The location of the communities also provided opportunities for chance meetings that easily took place outside the home on the pathways, walking to town, or commuting to Seattle, which residents characterized as enhancing the community’s social health. In both communities, the location supported a healthier lifestyle for the resident and a healthier environment in line with their values (both egoistic and biospheric). In addition, the chance meetings supported their ability to develop relationships among others in the community, exchange information on maintenance concerns, gardening tips, and recycling, thus supporting pro-environmental behaviors.

Reducing waste. In both communities, the concept of zero-waste was greatly valued, with recycling centers highly visible and easy to access (located on the route of travel to car and bike parking). Similarly, composting bins were located on route to or near organic gardens. Not surprisingly, the social aspects of the Code-built Community afforded residents an opportunity to educate and inform each other about aspects of sustainability that they care deeply about—in one case, the philosophy and practice of reduce, reuse, and recycle. Mary noted that the community offers activities "related to our values that we benefit from, that we care deeply about, but would have a lot harder time sustaining as a single-family household." She also felt that this was easily achieved, explaining that all her family does to support composting is to "throw our compost into a barrel and other people take it from there." Harry and Sally in the Built Green Community discussed the importance of being socially and physically embedded in a community, which supported their formation of an "Earth Squad" and "putting up signs as reminders for people about how they can increase their ability to recycle." Participating in their community's zero waste program was an activity that supported their environmental self-identity, was in line with their self-transcendent values, and facilitated their ability to engage in pro-environmental values.

Saving Resources. Both communities related stories about saving resources, but residents in the Code-built Community drew an important distinction between actually saving resources and maintaining a way of living that does not require resource conservation. The argument I heard repeatedly in the Code-built Community was that, by limiting resource use (including energy), they limited pollution, saving humans and by extension other species, which they held to be more important than saving what they perceived as the predominant consumer-based lifestyle in the US. For example, Pam asked, is sustainability "really about saving humans or is it about saving as much of this hedonistic way of life as we can?" Her neighbor, Jane, put it this way: “If you want to reduce your energy use, reduce the number of things that you’re buying and using that require all that energy.” The Code-built Community, more often than the Built Green Community, practiced resource conservation in support of their biospheric values and environmental self-identity.

Beauty. The idea of beauty and aesthetics emerged as a theme in the interviews when interviewees discussed their experience of their housing. Overall, participants described their appreciation of the human scale of the design; the variety in building form, color, and materials; the organic gardens and woods; and the “cool” solar panels (for those in the Built Green Community). However, many focused on the inability to see natural beauty from the windows of their homes as something they sorely missed. The desire for natural beauty affected feelings of attachment for Rick, who lives in the Code-built Community, as he described his view: “In terms of beauty? It is not really a great place to live…. None of our windows give us a natural view.” Similar feelings of longing for natural beauty were found in the Built Green Community. Anne related that what she likes “least is the fact that I can’t look out my window and see a forest and pond and I miss the sense of physical natural beauty that we had in our old place.” In both sites, where views overlooking a natural environment or setting were lacking, individuals held negative or ambivalent feelings toward place attachment. Anne was motivated to improve the landscaping around her home to be more expressive of her biospheric values and increase her feelings of connection to her home.

Next generation building systems. This ADF criteria refers to sustainable building systems, including the following: water conservation, energy conservation, mechanical heating and cooling, mechanical or natural air ventilation, electric or day lighting, and preserving open space by building with a small footprint. Of these six sub-categories, respondents mentioned their building envelope and mechanical systems, lighting, and smaller footprint as described below.

Envelope and mechanicals. Not unexpectedly, members of the Built Green Community were more likely to mention the sustainable construction aspects of their home as something that held special meaning for them. Many Built Green community members were proud that their home was well insulated; however, like Harry and Sally, many also reported a "freezing" problem:

> This house has 11-inch walls. There's about a 1-1/2-inch width space between both 2x4 walls all the way around, so it's a house and then a house built inside of it and [it is double] insulated... so that's why when we close the window it stays [at the same temperature]. We almost never use [the ductless mini-split heater]. About May, we turn it off, and it stays off until it gets cold…. [However] the hot air down here doesn't go upstairs… the upper floor stays uncomfortably [cold].

Even residents in homes within the Code-built Community enjoyed certain design features that helped with heating and cooling. In particular, those households with venting skylights noted that the passive ventilation worked well, but only if their unit had an open loft space to promote air movement. In one such household, Jane described her home as "breathing":

> [Our home stays] nice and cool through passive cooling, and I can feel it when I open up the skylight. Even in the winter time, open up that skylight and all of a sudden, it's like the whole house is breathing…. I don't know why but that tickles me every day, that we have fresh cool air… it makes it extremely comfortable and pleasant, and it's all fresh.

The heating and cooling equipment in the homes for both communities consumed among the highest amount of energy. The equipment under the direct control of the resident, but when it failed to distribute heating or cooling effectively, residents were quick to add an inefficient plug in space heater or fan significantly altering their energy use. Because the mechanical system was insufficient to prevent residents from "freezing" or "overheating," it did not support a resident's ability to be sustainable. Notably, this system promoted a high degree of energy consumption, which was the exact opposite of the purpose of the ductless mini-split heating and cooling system.

Lighting. The responses to lighting were mixed across the two sites. In the Built Green Community, adjacent homes typically screened southern sun, so although the homes were bright (Harry and Sally refer to their “Sky House”), they achieved little in the way of passive solar heating gains. Respondents in the homes that were primarily oriented in an east-west direction with little shading from the western sun commonly reported substantial overheating and glare. Rob, a Built Green Community member, noted that the lack of external shades was “something that just makes me furious. [External shading] is such an obvious thing to do, and it makes the house so much more comfortable.” By contrast, most households in the Code-built Community were considered dark because they were situated such that very little sunlight penetrated the building or reached the living spaces. This issue was due to the close proximity of mature trees as well as adjacent buildings and the duplex unit configuration. One homeowner, Pam, took actions to mitigate the lack of natural light: “We actually position our beds right next to the windows so that the window is to the back of us so that we can read when we go to bed without turning on the light.” For this respondent, not wasting energy by turning on lights was important, so much so, that she has her family practice a “lights out” drill each winter using no electric lighting for a week. Not surprisingly, this household’s energy use was low.

Smaller Building Footprint. Though members of both communities appreciated the smaller footprint of their homes, most commented on the lack of storage space. In addition, across both communities, almost all interviewees lamented the lack of a dedicated room in which to pursue such avocations as playing music, bike and kayak maintenance, food preparation, art and textile projects, gardening and woodworking, as well as functional spaces such as a mud room, entry room foyer, and recreational equipment storage space (e.g., for bikes, skiing equipment, and camping gear). Pam summed it up: “We live in the Pacific Northwest. It’s cold. It’s wet. It’s muddy. We don’t have a space where we can store an outdoor layer of things.”

While smaller footprint buildings support lower energy use, some residents in both communities felt that the buildings’ small size so compromised the functionality of the home that they were considering moving because their activities and self-expression were inhibited. For example, growing, preparing, and storing food was an important activity for some residents, who reported that freezing or canning such food aligned with their biospheric values and supported meaningful activities in their lives, yet the kitchens and pantries were too small to comfortably produce the food or practically store it.

Regenerative design features. These design elements address building and site features that relate explicitly to renewable electric energy (e.g., solar panels) or naturally collecting, filtering, and releasing water (e.g., rain gardens, porous pavers, gardens). Both communities referenced solar renewable home energy and car charging along with the importance of community gardens as features they would or did enjoy, that aligned with their values, and that facilitated their environmental behaviors. Several participants brought up the importance of having a place outside the home that they could go to and they referred to this as their “third place.”

Solar renewable energy. The high visibility of the rooftop solar panels held importance for many in the Built Green Community as a symbol of the community’s commitment to the One Planet Living principles and green living practices. Kyra remarked that “you can see the solar on the roofs, it's visible, and it's right there when you walk around.” She, like others, believed the solar panels could influence “people's behavior or their impression of the place” in support of environmental values as well as environmental self-identity. In the Code-built Community, many residents like Mary expressed exasperation because "most of the units are oriented ass backwards for solar" PV panels to function properly. Mary saw this arrangement as a missed opportunity for the community that made it difficult to avail themselves of solar renewable energy, something that she and her neighbors valued as beneficial for the environment and the community in addition to being in line with their biospheric values.

Energy saving innovations. Both participant groups mentioned that their communities had committees exploring the possibility of converting a section of their car parking lots to power electric car charging stations by constructing carports with roof top solar arrays. In the Built Green Community, Kyra favored finding ways to make vehicular transportation options more sustainable for those who, like herself, needed to be driving for health reasons. She was trying to "figure out how to put solar panels over the parking lot and have car-charging stations."

Similarly, the Code-built Community was also in the process of considering car-charging stations but were weighing the trade-offs inherent in lithium battery technology. Chris explained, "there's only a couple of places in the world that mine it…. Are we going to deplete yet another resource in a single generation?" While both communities were looking at ways to support a more environmental choice around transportation in support of their biospheric values, only the Code-built community was weighing the cost of resource depletion. This negative aspect of possibly depleting a resource inhibited the community from acting. One question neither community thought to ask was whether the solar carport project could be scaled up as a solar farm to provide additional renewable energy for the rental homes in the Built Green Community, thereby increasing equity for all residents. Similarly, in the Code-built community, no participants mentioned the possibility of a solar farm providing energy to the community's individual homes or the commons house.

*Gardens and site features***.** For both communities, the importance of the site planning, walkability, and community gardens was tremendous. The gardens were not only ecological but also nourishment for the body, spirit, and community. Several examples from members of the Built Green Community include Rob: "I'm very, very happy having a vegetable garden... that's a little patch of freedom;" Anne: "This kind of community activity around the gardens—I find it spiritually pleasing;" And Harry: "I call it roots…. So there's definitely a relationship, a very deep relationship." Similarly, for the Code-built Community the gardens and grounds furnished inspiration. Maggie loves having a garden outside her home:

> [I] love that I have plants right here [where] I can open the door and pick some beans. I love having an orchard and a community garden, and woods…. Does it inspire me? Oh, yes. I live here, and I want to feel proud of it…. I want to love where I live.

In addition to the gardens, the winding pathway layout and adjacency to the front porch was an important design feature for residents when welcoming and interacting with neighbors. Jane described sitting on the front porch as a "hallowed tradition" that was important because she and her husband "really enjoy sitting out there and talking with our neighbors and making other people know that they're welcome in our lives and that we are interested in enjoying the community."

Additionally, the winding paths in the site designs of both communities were intentionally designed to support chance meetings. A Code-built Community member described the phenomenon of impromptu meetings as more important than official community meetings. The winding pathways were seen as intentionally inefficient, as Mark describes, so that "It's very hard to get in and out of this place as fast as you may want to…. But that's intentional." Mark maintains that he knows more about the needs of his neighbors because "I run into and talk to my neighbors [more on paths] than [in] our official forums." Comparably, in the Built Green Community homeowners also referenced the site layout, which promoted interactions among people as Anne says:

> People do cross paths, literally, like run into each other going by each other's houses, or in the parking lot. I think there are things about the layout that definitely contribute to interactions with people.

A third place. For members of the Code-built Community, because their homes were so small and proximate to neighbors, it was important to have access to areas in the community that offered additional places to occupy – what some referred to as a "third place." For Pam, close proximity to neighbors was balanced with a "third place." She talked about connections to community this way:

> The "third place" that is not your home or your work, so the common house, is also important. And also, the little spaces around the community, landscaping, you know, places to stand and talk, places to sit and watch the kids play, designing for this is important.

The ability to have a "third place" that affords some privacy, winding paths enhancing the likelihood of chance encounters, or gardens that supported self- expression were all site features that supported community values, feelings of belonging, and connection. These associations in turn supported environmentally friendly behaviors such as organic gardening and sharing information in support of energy conservation behaviors, such as shared maintenance contracts. As one resident reported, if her neighbors were having their ducts cleaned, she would have hers done at the same time.

Accommodating changing needs and uses over time. In the interviews, residents discussed design features in their homes and communities that they felt would accommodate their needs over time in support of aging-in-place, in-home offices, rentable rooms, hobbies, choices in transportation, and habitat diversity.

As people reflected on having lived in their communities over time, two ideas featured prominently in both communities—the option to live on one floor level to accommodate aging and the need for versatile space. Maggie describes trying to visit her friends in the Built Green Community with her husband who was in a wheelchair: “There's no bathroom downstairs and there's steps into the building.” She wonders, “Why are we building places, and then selling them at a high price for people who have the money who are probably elderly, or in that age bracket, but if they sprain their ankle, they have to go upstairs?” Alice, a member of the Built Green Community, chose to live in one of the few accessible rental units. Her reasons were accessibility and affordability first and sustainability second. “Because if the first two hadn't been in place, it wouldn't have mattered how ecological it was.... [However, living] here I feel like I’m living the way that we’re supposed to live [sustainably].” Living in an environment that supports changing needs over time has several implications for maintaining social connections in that community. Residents also require some flexibility in the physical context of their home to meet changing family dynamics (maturing families) and to accommodate in-home office needs or hobby space, so that the family will not feel compelled to leave the community, severing social ties or feelings of place attachment or identity.

Promoting pro-environmental awareness and actions. The design features in this category refer to items that promote pro-environmental awareness and actions through social and educational aspects of living in the community, such as: in-home energy monitoring; educational classes on sustainable practices; innovations like a remote-controlled thermostat or indoor air quality monitor; and the importance of certificates for the home such as compliance with LEED, OPL, ILFI, or iPHA standards. Respondents focused primarily on the work groups and committee structures that supported environmental choices.

Just as the physical environment supported a shared infrastructure that enabled ecological alternatives for the communities, so, too, the community-based governance structure supported environmental choices for residents' day-to-day actions. Equally important, by working in groups, community members learned to depend on, trust, and respect the opinions of others in their community. Day-to-day engagement was an important aspect of the Code-built Community, as Carol noted: "Everybody's on committees. That's part of the deal, and because we're involved in consensus; we all make decisions about the whole place." By working in groups to achieve consensus, Code-built Community members have learned to respect the opinions of others. "Consensus... does take time and people get frustrated. [However,] I've learned to depend on it… I've come to value others' opinions. It's a process [in which] everybody gets heard and…it's an important one." For this community, sustainability was an equally desirable option that typically aligned with positive and desirable ecological community-based values. Mary recollected:

> In our community, the physical environment is critical to supporting the shared values. Without the shared infrastructure, we would not be able to gather, to share resources, or even to eat together. We make bulk purchases such as LED light bulbs. We got the bus stop put right in front of the development so people had transportation choices. It is equally "easy" to walk, ride a bike or take the bus as it is to take the car. Choice is supported in this way. People can be intentional.

Though similar work groups have assembled in the Built Green Community, the governance structure was still forming. Kyra explained that although the community does talk about work groups and has a "Bike Circle, a Zero Waste Circle, and a Parking Circle," the groups have not evolved to the extent that she "had imagined and hoped they might."

Floor plans that support social functionality. The home floor plans and site layouts supported different goals in each of the communities. The layout of the homes in the Built Green Community suggests a greater concern for personal privacy by maintaining varying degrees of privacy (public front porch and private back deck) within the community. Dave explained, "You have this range of different spaces that give you the opportunity to interact as you choose within the community." Conversely, floor plans and site layouts in the Code-built Community place value on visibility even inside the home.

In the Built Green Community, for example, the kitchen is located at the back of the unit furthest from the public path, tucked away in a side alcove such that the homeowner can neither see nor be seen from the pathway. The kitchen and a private outdoor deck were often located in the rear of the unit. In the Code-built Community, by contrast, signaling welcome from the kitchen (the room nearest the entry door and public path) was viewed as a chance to engage with neighbors. Pam describes the trade-off: "Complete privacy [such that] people can't tell what you're doing versus opening up to the community and being available."

In the above remarks, community members reported that when they felt that they were supported by either the physical or social context of their environments, they were likely to feel that their place attachments and place meanings were also supported, as were their efforts to engage in sustainable living either individually or at the community level. Furthermore, not only did the environmental settings serve as locales in which actions and meaningful relationships occurred, but also as cues to prioritize values, increasing the likelihood of pro-environmental behaviors.

In addition to cues in the physical and social context, this study also considered peoples' responses to real-time feedback on their actual energy use, information that community members could access to monitor and reduce their energy use if they chose. In the next section, I report on how people in both communities responded to their energy monitoring dashboards and how these responses may have acted as environmental cues.

Responses to Energy Monitoring Dashboard

As indicated in Chapter 4, the Code-built Community significantly reduced their energy use after exposure to the dashboard conveying information on their energy use in real-time, while such a reduction did not transpire in the Built Green Community. Broadly, many interviewees in the Code-built Community reported that they took the time to investigate their energy use, consulting the dashboard feedback to modify their behavior. They were generally willing to explore and test out strategies to modify their equipment or behaviors to see whether in doing so they lowered their energy use (e.g., insulate their hot water heater or take fewer shorter showers). In contrast, many interviewees in the Built Green Community noted that they had intended to monitor their dashboard and pay attention to their energy use, but did not spend much, if any, time trying to understand the information or seeking ways to alter their behavior. Rather, Built Green Community interviewees often rationalized their behavior, offering reasons such as the following: the dashboard took too much time from their busy lives; they received too many alerts; the information was spurious; their solar power made them already energy efficient; or their home's built-in energy efficiency assured that their use was low.

Several contrasting factors plausibly explain why the two communities diverged in their responses to the dashboard, alerts, and the use of SiteSage portal. First, in Chapter 5, recall that quantitative results on perceptions of home energy use, values, and people-place constructs, indicated a significant decrease in hedonic values and increase in biospheric values for the Code-built Community over the Green Built Community. It would thus make sense that the Code-built community would reduce their energy use in accordance with the increase in their self-transcendent values. Second, earlier in this chapter, qualitative results on place meanings and home energy use indicated that Built Green Community members were likely to maintain a check-the-box attitude on sustainability in regard to their energy use. That is, they felt their sustainable homes excused them from any responsibility to curb their energy use. It would thus make sense for the Built Green Community to feel they had already made their contribution to sustainability when they purchased their homes. In addition, qualitative analyses revealed that members of the Built Green Community who purchased solar panels (renewable energy) at the time of home acquisition felt they did not have to monitor their actual energy use and became aware of it only if they had to actually pay an energy bill. Recall that homes with solar panels built up energy credits during the summer months, so many residents felt they had no way to know how much energy they were using over the winter until their credits ran out. Ironically, the dashboard information would have given the Built Green Community interviewees exactly the information they needed in real-time to monitor and change their behavior if they had chosen to look at their dashboards on a regular basis.

The two divergent responses from each of the communities beg the question, why was the Code-built Community better motivated to use the dashboard and change their behaviors than was the Built Green Community? Is it possible that the check-the-box syndrome was stronger a priori than real-time information? Qualitative analyses suggested that the range of issues arising for the Green Built Community did not always differ from those for the Code-built Community, suggesting that multiple factors taken together shape one's behavior on energy use, including, as has been demonstrated in prior chapters, values, place meanings, and environmental cues, in addition to real-time information.

Negative responses to the dashboard. A few examples from the interview narratives point to specific problems that came to light, including feelings of anxiety, limited time, need for simplification, need for community support, waning interest, and lack of interest in reducing energy use because of renewable solar energy.

Anxiety and feeling too busy. One Built Green Community homeowner reported that she felt overwhelmed, saying, “We can’t cope with all that. I mean, everybody’s busy, not just us.” For Anne:

> When you get stuff like that by email and you’ve got 500 other emails, you just can’t deal with it right then and there. That’s the problem. Something that's in the home that's right near where the devices are that are relevant, like the refrigerator, the stove and the hot water heater and the washer/dryer and all that stuff. I think it would be a lot more useful. And then translate it into, here’s what you should do about that.

Difficult interface and feeling too busy. Kyra thought that she might consider using a dashboard if it had simple graphics, a simple interface, and simple actions (e.g., the “Shimmy” tool used in the UK is a simple-to-operate, integrated display board near the front door of the home). Kyra, a member of the Built Green Community, explained:

> I think we're too busy, [we] don't need another thing…. So if you had a simple visual… I think that's helpful, but to rely on having to take those extra steps and that level of detail on a daily basis…. It's too much for the average person.

Others in the Code-built Community also rationalized that they were too busy with full lives to take up watching their energy use, which one resident dubbed an “extra hobby.” Rick and Gail did not look at the dashboard, rationalizing that they have “very full lives. We don’t have time to take on the extra hobby of monitoring our electricity usage and figuring out ways to change [our behavior].”

Waning or lack of interest. Others used the dashboard initially and but found their interest in it waned. This Code-built Community resident wished that the dashboard was more obvious. Mary recalled:

> We looked at our dashboard in the beginning and got a sense of our use. It would have been more useful if the dashboard was mounted in a place where it could be seen easily and on a daily basis. Where the kids could see it and test it out. Our son, when we first got the dashboard, went around and turned things on and off to see how it affected the dashboard… The entertainment center is always switched on and off– everything is on a plug strip and it is easy to switch off. The computers and office workstation however, are left on all the time. It would be interesting to know the energy use in the regard. It was surprising to find that the family did not look into the dashboard or alerts more.

Those with solar photovoltaic panels seemed uninterested in their energy use and did not review their dashboard on any regular basis; gaining a more precise gauge of their energy use through the dashboard was not as compelling as reviewing their monthly energy bill from the utility company. Mike and Sue, members of the Built Green Community, said that they "figured that we had energy to burn until we ran out…. because we had built up credits…. We just knew the balance of what we're generating versus what we're using is good enough." Yet, Mike and Sue's energy usage went up over the course of the study when they began using a space heater, running the air circulation on high continually, doing "excessive amounts of laundry," adding electronic devices for surround sound to every room, running their computers in the office and guest rooms, etc.… In this household, Mike, the person who received the alerts, made trade-offs between conflicting values—biospheric (assumed low energy use), egoistic (assumed low energy bills), and hedonic (assumed they could use energy for pleasure and comfort without knowing the impact on the household overall energy use).

Positive responses to the dashboard. Study participants who found their dashboards and alerts useful not only looked at them routinely but also took the time to implement some strategies to save energy. In some cases, this created a positive feedback cycle because these households found the information enlightening, confirming, and inspiring.

Confirmation. Jane, a member of the Code-built Community, described her curiosity and the experiments she conducted to understand her energy use and to save energy:

> I checked it almost daily. I found it fascinating to be able to monitor in full in real-time. When I discovered that [the] hot water heater was using the most energy… I made a real point to take shorter showers…. It affected my behavior because I was conscious. I could see on a bar graph that the longer the hot shower, the more energy was being consumed. That was easy to do on the dashboard, so that was really super great to interact with… I appreciate the dashboard…. I thought it worked fine and it gave me information that caused me to reflect and change my behavior…. That [space heater] takes a huge amount of energy and... as soon as we bought that you could see the difference [so] I was checking it by the hour. Turn it on, let's check, turn it off.... I would say it's responsible for an extra 40 dollars a month…

For Sam, a member of the Built Green Community, the dashboard was a way to visually represent his energy use and distinguish which efforts he undertook to conserve energy worked well and which did not:

> Probably [looked at dashboard] once a month… I realized that my footprint was… smaller than average. That was good reinforcement, to have an actual visual representation… Every time we get the notice, maybe once a month, I'll take a look…. What gets noted gets done…. I was really happy to find my electricity bill last month was less than a dollar a day. Absolutely [the alerts were helpful]. That's one of the reasons I turned down the water heater [after] finding out how much [energy it] was using. That really helped…. It's interesting to see where I can make improvements because without the dashboard… you could do it on the basis of trial and error, but then that's such a long process.

Timing of information. Similarly, this member of the Built Green Community expressed the importance of knowing one's energy use at the time of use; however, he made an important distinction: the time to know is in the moment of decision, because once the energy is spent, it is too late. Every time Harry and Sally used energy, they asked themselves whether the use was based on "need" or "want" and guided their choices accordingly.

> I wasn’t worried about baselines and [dashboards] because I’ve been living this way so long… but as far as I was concerned, we were already at the bottom of using [energy]. If I used the dryer… I needed to do that and I don’t do it unless I need to. Need and want are very different and so we live more on need…. Is this a want or a need? They [alerts] were just annoying…. When we get alerts, we’d say, Well, of course. We know why we’re using more electricity on that.

Sustainability was a big part of how this couple wanted to live, but not with computer technologies such as dashboards and energy alerts. They had already made a conscious decision about how they were going to use a particular type of energy before they used it, rendering the dashboard useless. Keeping with their practice of not using energy, they didn’t have their computer or their cell phones turned on most of the time so they did not get alerts very often and did not look at their dashboard.

The dashboards did inform some participating households who put that knowledge into action, exploring ways to lower their energy use and energy bills. For others, results show that, although people believed that the dashboard could function as a visual cue to remind them of their energy use patterns, their engaging in pro-environmental behaviors did not depend on the dashboard, but rather on a range of factors underpinning their motivation to be cognizant of and intentional with their energy use.

The importance of an energy budget. Each household showed a tendency to create a personal energy budget. That is, people who were engaged in pro-environmental behaviors on the whole and who paid attention to their energy use nonetheless maintained certain occasions when they knowingly used more energy. Interestingly, the qualitative analyses found that, regardless of the type of physical home or social environment, people had a personal reason to spend energy on projects they deemed worthy. Several examples are illustrated by stories that I categorized according to the type of activity that they deemed worthy of energy use: felter/photographer, pizza maker/baker, engineer/musician, and food preparer/preserver.

One member of the Built Green Community recounted increased energy usage due to excessive running of the washer/dryer in the felting of hats for pre-mature infants in a local hospital. Another described his digital art and computer-based photography projects, describing his large format printing equipment as an elective use of energy. Several households reported the comfort their children found baking bread and cookies during the long, dark days of winter. For example, in one interviewee's household, a young adult found pleasure making pizza using a one-inch steel plate heated in a 500-degree oven for hours a day during the winter months. Increased energy use was also due to electronic recording equipment and music systems including speakers, amplifiers, and the like was reported by members of both the Built Green Community and the Code-built Community. Similarly, all-day food preparation and preservation activities sometimes spanned the course of a week as households in both communities cooked, canned, and froze food stores (adding chest freezers to their energy use) from organic gardens.

With regard to energy use, these stories matter and constitute an important aspect of how and why people use energy. While it was predicted in the energy modeling and design of the homes that people in the Built Green Community would use less energy than a comparative code-built household, this study demonstrated that patterns of energy use are more complicated. The Built Green Community did use less energy over all due to the structural characteristics of their high-performance buildings. Yet, the Code Built Community reduced their energy use significantly more than the Built Green Community. Furthermore, the energy use model created for the Built Green Community's engineering study underestimated the amount of energy that would be used there due to an assumption that the project would attract residents of a more environmental bent. Thus, the solar arrays were sized for reduced energy demands, making it difficult for these homes to maintain net zero when occupied by residents who rationalize an expansive energy budget.

Summary of Qualitative Findings.

These narratives reveal a dynamic constellation of values, meanings, and environmental cues that people access to make sense of their experience of place with respect to sustainability broadly and energy use specifically that was likely to affect discernable patterns of behavior. The patterns of behavior suggest that the individual will engage in an exchange between themselves and the environment. Importantly, values could shift in importance in the presence of circumstantial factors in physical and social contexts, including environmental cues and place meaning. Meaning was found in a person's conceptualization of place attachment, place-identity, and environmental self-identity and these feelings about place activated a process of engagement with the environment. Environmental cues found in the physical and social contexts provided a focus and a grounding for the experience of place to take shape. The exchange phenomenon where behaviors and actions take place is likely to strengthen the experience and cultivate ensuing person-place relationships. The process of forming this constellation of engagement occurred on two levels—the engaged individual (personal level) and the engaged citizen (community level)—and was likely to result in pro-environmental behaviors.

It is this life-building-exchange—a dynamic constellation of values, meanings and cues—that people access to make sense of their experience of place, and when they do, there is a high likelihood that the exchange will impact their actions on sustainability broadly and energy use behaviors specifically. In the following chapter, this constellation of factors is explored in greater detail.

Chapter 7: Five Major Energy Use Profiles

Overview

This chapter expands on the analysis of the qualitative data presented in Chapter 6 by linking data from the interviews with the quantitative data from Chapters 4 and 5. Rather than parsing the data issue by issue or question by question across all interviewees, this analysis focuses on five households that manifested distinct, prototypical ways of interacting with their surroundings, understanding their environments, and using energy. Using a 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 energy conservation behaviors to achieve high-performing buildings, regardless of whether the building 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, I developed a conceptual framework for understanding people's energy performance, presented below and followed by the five prototypical examples.

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**BULIDING***X*** (LBX) focuses specifically on the collective significance of values, meaningful person-place relationships, and physical and social environmental cues that may elicit a behavioral response. 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 LBX terms used in the framework is described in greater detail below.

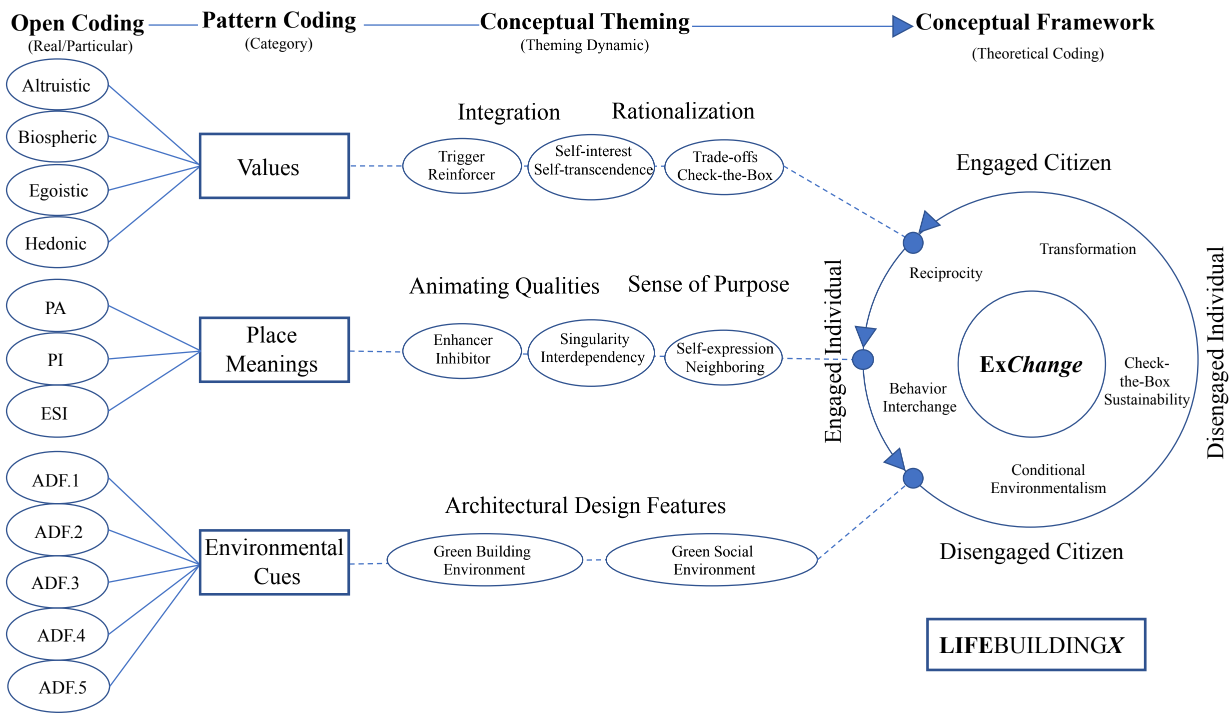
The term **LIFE** is intended to capture the people side of the people-place relationship, including values, place identity, environmental self-identity, and place attachment. It references the processes by which a person evaluates, identifies with, or experiences a bonding relationship to meaningful places which is likely to influence their behavior. For an individual, these process dimensions may be based on cognitive (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 and net-zero energy 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 **Ex*change*** 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 an enduring 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 the collective environment. 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 and 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. A graphic illustration (Figure 7.1) of the process is depicted below in the Life Building Exchange conceptual framework.

Figure 7.1. **LIFE** BUILDING ***EXCHANGE*** Conceptual Framework.



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 of these 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). Interviewees who expressed a sense of reciprocity typically espoused values that were likely to be both biospheric and altruistic and to center on the importance of unity and worthiness of all components of the ecosystem. Such respondents were likely to express place attachments that radiated out beyond the home and immediate neighborhood to the larger community and Pacific Northwest region. Individuals who demonstrated reciprocity typically had a strong environmental self-identity and served as highly engaged citizens in their communities; that is, their attention was focused on pro-environmental behaviors for the mutual benefit of their community as well as themselves. Reciprocity often characterized their way of engaging with the world around them and as their way to confirm a sense of connection to all things and all places. With regard to environmental behaviors, a reciprocal relationship would "use and replenish but not endanger or deplete" resources, as descried by one resident (see Profile 1, this chapter).

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 changes. In these exchanges, respondents exhibited either an integration of or a trade-off between self-transcending and self-enhancing values embodying some aspects of sustainability at the individual level with future aspirations to consider engaging at the community level. For example, one respondent who biked to do grocery shopping was considering selling her car altogether and initiating a car sharing program. A person demonstrating the transformation exchange was likely to express feelings of place attachment for their home and intended to be involved in the affairs of the community at some point in the near future. Individuals were apt to experience place identity or environmental self-identity broadly and to be highly engaged as individuals yet somewhat disengaged as citizens of the larger community, instead, focusing their attention on pro-environmental behaviors for their own benefit (see Profile 2, this chapter).

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). Witnessing pro-environmental behaviors, whether their own or others, inspired repeat environmental actions that reinforced such behaviors (see also Van der Werff, 2013a & 2013b). This type of respondent typically espoused both biospheric and egoistic values, resulting in actions that were simultaneously self-serving and serving the environment or the greater community (see also Steg, et al., 2014a and 2014b). They were often strongly attached to their home and their immediate community. However, they were less likely to express environmental self-identity and tended to be less consciously engaged as citizens, focusing their attention instead on specific, concrete actions. 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 phrase: "What you practice grows stronger" (see Profile 3, this chapter).

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. In regard to their values, they often made trade-offs between self-transcending and self-enhancing principles and actions. For example, a respondent in the Built Green Community remarked that he didn't have to think about sustainability. "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 him. This resident then rationalized that he didn't need to pay attention to his energy monitoring dashboard, that living in a Built Green community exonerated him form further behavior modifications, and that he could use whatever energy he wanted without environmental concerns. Yet, this household's energy use increased over the course of the study, and the baseline EUI also increased, suggesting that his energy-related behavior did not conform to his professed value of sustainability. Such respondents might be attached to their home and their immediate community, but they were less likely to experience place identity or environmental self-identity, even if they valued the environment and held biospheric values. These residents tended to be less engaged as individuals or as citizens, focusing their attention on other aspects of life (see Profile 4, this chapter).

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. Such participants were likely to prioritize self-enhancing values over self-transcendent values and to care about self-interest over sustainability. They were likely to be less attached to their home or residential community than were other participants, or to express strong place identity or environmental self-identity, even if they valued their physical or social environments on some level. On the whole, a resident expressing conditional environmentalism expressed a low level of interest in environmental issues, resulting in either non-action or a rationalization of non-environmental behaviors (see Profile 5, this chapter).

Five Prototypical Exchange Profiles

In this section, five energy use profiles (three from the Built Green Community and two from the Code-built Community) are presented to illustrate each prototypical exchange. Each profile description begins with a Life Building Exchange Index which summarizes the data trends that appeared after multiple cycles of coding the qualitative data. Initially, Code Frequencies (CF) were tabulated through open coding and pattern coding; next, a Model

Frequency (MF) was tabulated to capture conceptual theming and theory development code cycles. The code and model frequencies are presented in the LBX Index Tables at the front of each profile type, followed by a description of the exchange.

Profile 1. Reciprocity

As evidenced by the frequency of codes in Table 7.1, this profile was typified by trends toward strong biospheric values, environmental self-identity, and strong place attachments that were triggered by a sense of belonging to the physical environment and demonstrated a reciprocal exchange between person and place.

Table 7.1. LIFEBUILDING***X*** Index: Reciprocal Exchange.

Code First cycle coding	**Frequency (CF)**	**Model** Second cycle coding	**Frequency (MF)**
Value: Biospheric	**18**	Value: Integration	6
Value: Altruistic	9	Value: Trade-off	1
Value: Hedonic	2	**Value: Trigger/Congruence**	**10**
Value: Egoistic	4	*Meaning: Enhancer*	*10*
Meaning: Envr. Self-identity	**20**	Meaning: Awareness	0
Meaning: Place Attachment	**20**	Meaning: Inhibitor	1
Meaning: Place Identity	12	**Meaning: Singularity**	**13**
Architectural Design Features 1	**12**	**Cue: Green Building Envr.**	**13**
Envr./Human Well-being		Cue: Green Social Environment	10
Architectural Design Features 2	6	Exchange: Behavior Interchange	4
Next Gen Building Systems		Exchange: Check-the-Box Sustain.	0
Architectural Design Features 3	9	**Exchange: Reciprocity**	**9**
Promote PEB Aware/Action		Exchange: Conditional Environ.	0
Architectural Design Features 4	*10*	Exchange: Transformation	4
Regen Design Features		EUI: Change from Baseline	VL-HI*
Architectural Design Features 5	4	EUI: 3 Yr. Ave. / Study Period	13.7 / 13.5
Accp, Chg Needs/Uses,		EUI: Community Ave. / Modeled	15 / 14

*Very low EUI at baseline with High increase over the course of the study. **Bold** indicates highest frequency while Italic indicates close second highest frequency.

Reciprocity case illustration. Harry and Sally exemplify a household in which reciprocity was key. For them, being mindful of how to live in unity (singularity) with other living things (reciprocity) was as important as sustainability and community. For example, they provided an enhanced habitat for the birds, and the birds provided them with birdsong and activities worth viewing – a reciprocal relationship. Harry purposefully established the densest plantings on the three acres:

> All these plants out here I planted mindfully because I wanted a safe place for the birds…. We're not the only ones that own this [land]. We own it in concert with a number of beings and [need to] do things so that we're not causing difficulty for the other neighbors, the little ones, the big ones, the flying and the crawlers and all the rest…

Reciprocity is a way of being in the world based on an enduring relationship of mutual benefit for self, fellow humans, other species, and the planet. Members of this household live as engaged citizens of the planet not only by creating habitat diversity on their land but also by mindfully sharing their experience of organic farming with neighbors in their community, participating in the Garden Circle (farming) and the Earth Squad (zero-waste) programs and readily sharing their knowledge about rooftop solar panels with all who stop to ask questions.

Harry and Sally's narrative and analysis profile make evident that their biospheric and altruistic values are expressed as a desire for unity and balance among all elements of the global ecosystem, an outlook they have embraced as guiding principles. "It's inherent in our lifestyle." They have deep-seated feelings of place attachment that radiate beyond the home and immediate neighborhood to the larger community and Pacific Northwest region: "Everybody is participating, and there's a whole big web" (singularity and common purpose). As engaged citizens, they possess an environmental self-identity that catalyzes a focus of attention on pro-environmental behaviors for the benefit of their community at large. "The profit we're looking for is [that] we really need the cultures of the world to start thinking and living, really absorbing and being clean energy." Reciprocity orients their approach to engaging with the world around them: "It's really nice for us to be able to contribute... and it comes full circle."

In short, reciprocal relationships with other species and their own role in that relationship are central to the lives of these gardeners: “The mindfulness that is taught all the time is an important part of our intentionality.” This household’s valuation of common purpose inspires them with a sense of efficacy: they see themselves as empowered to create change, live in a holistic way, and take actions to jump scale from individual to community level. As Harry explained, for them, a way of life that embraces mutually beneficial actions for all lives on the planet “fits like a glove.”

Harry and Sally demonstrated a quality of singularity evident in their sense that “that there is no separation between us. And this is part of our lungs and we’re part of that plant’s lungs too. It’s a way of life.” The gardeners’ lived experience of place in the Built Green Community is one that they experience as fully saturated people-place interactions and engagements as citizens of the planet**.**

Specific architectural design features came to light with respect to the home itself when Harry and Sally began to talk about their residence in terms of environmental qualities. Affectionately naming their home “the Sky House,” Sally and Harry enjoyed its daylighting opportunities, which their prior house did not feature. “The last place we lived in, the kitchen and the dining and living room were on the north end, and so it wasn’t light like this…. We call this ‘the Sky House.’” Substantial daylighting meant the Sky House had little need of electric lighting, which fit well with their views on not spending energy.

They were not “energy spenders” with regard to miscellaneous electrical loads, with one exception: Harry and Sally endorsed spending energy in the kitchen. Though many households in the study tended to have at least one way to spend energy on a project or as a source of comfort, this household’s way to “spend energy” was aimed at food processing. In their household, Harry and Sally "make everything from scratch," using the kitchen to its fullest: "We'll cook all day and then freeze quite a bit of that." This household used kitchen appliances heavily and was the only study participant in the Built Green Community to report a freestanding chest freezer, explaining that "it's the old farmstead kind of lifestyle." Their intrinsic motivation to act sustainably was supported by their home environment – space to grow, cook, and freeze food.

In this household, moving from attention to intention to action was paramount. If they made decisions with greater awareness, those choices could connect with their environmental self-identity, feelings of place-attachment, values, and actions. Their ability to make an environmentally friendly decision was itself a reinforcement of their values, catalyst for meanings, and support for whatever actions were required – recycling, composting, walking, and so forth. Philosophically, being present in the moment was essential to their mode of living: "Between Buddhism and the Native American practices, we get a lot of positive reinforcement…. The mindfulness that is taught is an important part of that intentionality."

Because of the layout of the community, "people are naturally present," reinforcing positive feelings and interactions by virtue of the arrangement of the design; parking, recycling, and mailboxes, located along winding pathways (entwining public and private spaces) inspire people to engage in two or three conversations just walking from and returning to their front doors. These gardeners were connected physically, socially, and emotionally. Harry expressed the sentiment that they "don't live in the center of town but live by the well."

Energy use profile. Over the course of the study, this household did not look at their dashboard. They did not see the point. They used energy only for things that were necessary or, in their words, "based on need, not want." For Harry and Sally, the information on the dashboard was irrelevant because questions on energy use must be asked before the energy is spent. When asking themselves whether they "need" this or "want" this, need was the final arbiter:

> I wasn't worried about baselines because I've been living this way so long, I figured we were already at the bottom of [energy use].… If I use the dryer, I need to do that and I don't do it unless I need to.… [The alerts] were just annoying because, of course, we know why we're using more electricity on that.

The **LIFE**BUILDING***X*** Table 7.1 lists the energy use intensity (EUI) score for this household and suggests that its quantitative EUI energy use patterns align with the qualitative data drawn from the resident interviews. The three-year home energy use intensity score average for this home (EUI 13.67) was 8.9% below the average value for the Built Green Community (EUI 15). Though their energy use did increase over the course of the study from baseline (very low to high), their average weather normalized energy use during the course of the one-year study held at an EUI of 13.51 – a level 3.5% lower than the predicted EUI of 14 modeled by the energy engineering consultants at pre-construction. These findings are consistent with the couple's narrative profile as an example of reciprocal exchange modeled by engaged citizens in the Built Green Community.

Profile 2. Transformation

This profile was epitomized by trends toward having biospheric values strengthened by an environmental self-identity and empowered by feelings of place attachment that were triggered by actions in the physical environment, demonstrating an emerging transformational exchange. Transformation differs from reciprocity in that the individual is in the process of changing their behaviors, intentions, or level of involvement in the affairs of the community toward greater environmentalism and social engagement. In addition, while reciprocity is based on the idea of something given in return for mutual benefit or relationship, transformation is characterized by a person's behaviors that are self-serving even if that person recognizes that their actions might also serve the environment or greater community.

Table 7.2. LIFEBUILDING***X*** Index: Transformation Exchange.

Code First cycle coding	**Frequency (CF)**	**Model** Second cycle coding	**Frequency (MF)**
Value: Biospheric	**16**	Value: Integration	5
Value: Altruistic	12	Value: Trade-off	4
Value: Hedonic	12	**Value: Trigger/Congruence**	**8**
Value: Egoistic	7	**Meaning: Enhancer**	**11**
Meaning: Envr. Self-identity	**19**	Meaning: Awareness	0
Meaning: Place Attachment	*18*	Meaning: Inhibitor	5
Meaning: Place Identity	3	Meaning: Singularity	0
Architectural Design Features 1	**14**	**Cue: Green Building Envr.**	**14**
Envr./Human Well-being		Cue: Green Social Environment	9
Architectural Design Features 2	7	*Exchange: Behavior Interchange*	*6*
Next Gen Building Systems		Exchange: Check-the-Box Sustain.	2
Architectural Design Features 3	11	Exchange: Reciprocity	1
Promote PEB Aware/Action		Exchange: Conditional Environ.	0
Architectural Design Features 4	*9*	**Exchange: Transformation**	**7**
Regen Design Features		EUI: Change from Baseline	VL-HI*
Architectural Design Features 5	3	EUI: 3 Yr. Ave. / Study Period	- / 10.5
Accp, Chg Needs/Uses,		EUI: Community Ave. / Modeled	15 / 14

*Very low EUI at baseline with High increase over the course of the study. **Bold** indicates highest frequency while Italic indicates close second highest frequency.

Transformational exchange case illustration. This particular profile is well illustrated by a young professional couple living in the Built Green community. Before purchasing their home, they researched and specifically sought out a community where they could continue to develop and practice pro-environmental activities consistent with sustainable green living and congruent with their environmental values and environmental self-identity. Given the capacity for the Built Green Community to offer this, positive bonds to their home quickly developed. Sue recalled:

> [We found] everything we were looking for in a community…. We [knew we] were moving into a group where we'd feel comfortable living and [a house] that was well built…. The sustainability was the big thing, and we loved the architecture.

Furthermore, with a sense of pride, Mike enjoyed that the community and its environmental identity attracted notice from passersby:

> I think it stands out, but it's just knowing that that's how we would like the rest of the world to look, too. But we get to actually participate in this place that does look that way…. It's happened on multiple occasions [that] people [are] walking or biking by outside who don't live [here] and we hear them talking about, "Oh, look at all these houses" or "Isn't this such a cool development?".... That's cool and it happens all the time.

The couple held overlapping values consisting of biospheric values (seeking a sustainable home and community), egoistic values (enjoying homeownership, solar energy), as well as hedonic values (organic gardening, dedicated space for hobbies). An example of their overlapping values was found in Mike's comments about sustainability and self-interest: "It's sustainability and it's self-serving, so we have all the gardens, and you can plant vegetables for yourself, and you can pick them. And everyone's committed to that."

Mike and Sue exhibit behavior transformation with their intentions to become more involved in the affairs of the community gardens, to promote car sharing, and to offer a bike maintenance tool-sharing cooperative to the rest of the community in exchange for access to a covered workshop space. However, these community level intentions have not yet been implemented. Meanwhile, Mike and Sue felt that just by living in the Built Green Community, where so many community members were engaged in various sustainable activities, they felt a "positive feedback cycle" that inspired them to "want to be more involved" in sustainable living activities in the community. Their exchange exemplifies the transformational prototype because they had identified the need to change some aspects of their life to be more sustainable and they intended to create positive change in the future. Sue described it this way:

> Part of it's a positive feedback cycle. Everybody around us wants to participate in the community, which then makes me feel like everyone's trying to make the community better, so I want to participate... you can't complain about what's wrong with your community or with the world if you aren't doing anything to make it better.

Mike and Sue were exemplars of people who "bought" the green life with the purchase of their highly efficient renewable energy home and were willing to walk the talk with a "grueling" three-hour roundtrip work commute in order to live in the Built Green Community. In addition, they carried groceries "like pack mules," demonstrating a green standard of living that epitomized the trade-off between convenience (driving) and non-polluting behaviors (biking).

Mike and Sue's attachment to place and their environmental self-identity were meaningfully affirmed by the purchase of their home in a community where they believed they would share values with the community. "It feels like home" because they not only owned it but also had dedicated space to practice music (a passionate avocation for both of them). They also articulated positive feelings of place identity. Beyond feeling that the area was "massively more aligned with our values," Mike and Sue felt that the layout of their community facilitated their ability to interact with neighbors. Sue explained that they "decided to go for a walk in the community and ended up talking to two different people for 20 minutes" and that this type of interaction was something they would do again.

Mike and Sue's commitment to sustainability faltered somewhat when they became complacent on some key energy use issues. Three circumstances that may have derailed their motivation and actions resulting in a Life Building Exchange in which they were neither engaged citizens nor engaged individuals were: 1) an over-reliance on the high-performance attributes of the building to yield low energy use regardless of their behaviors; 2) an over-reliance on the energy bill (solar credits) as a viable indicator of their energy use, even though they had circuit level monitors and a real-time dashboard system to inform them in greater detail; and 3) an assumption that they did not need to pay attention to their energy use dashboard because their house was already so green. They may have felt they had earned a "pass" on some behaviors because they live in a green home:

> I installed one [space heater] in the third bedroom at some point over the winter because I spend a lot of time in there and it was just freezing…. I think that this [original] system leaves something to be desired.... [It does] little to nothing upstairs.

Mike also admitted that they did not see their energy use "increasing per month" because they "were basically using the bill as our foundation. [Though our energy use] through April was increasing per month because we added the [space] heater...." Like other residents in the Built Green Community, Mike and Sue assumed that the energy efficiency built into the home, along with the renewable energy from solar, meant that they did not have to pay attention to their actual energy usage. Mike explained, "we just knew the balance of what we're generating versus what we're using is good enough." Consequently, as their energy use increased over the course of the study, they were blindsided by the inconsistency of their environmental values and their actual energy use. In hindsight, Mike noted, "[I thought we] had energy to burn until it ran out."

For the most part, this household consistently demonstrated an ability to live a green lifestyle that was congruent with their values and supported by their positive bonds to their home. However, they demonstrated a mixed commitment to green living as engaged individuals. More engaged on an individual level at present, they voiced intentions to become more involved at the community level as engaged citizens at some point in the future—a transformational aspiration. Currently, Sue rationalized that community activities were scheduled at the last minute or at a time when working people could not attend. In this regard, while they were engaged individuals, they remain disengaged at the community level. Nonetheless, their overall exchange model was consistent with the process of transformation: their values and self-concepts were environmental, albeit not always supported by their actions with regard to energy use. Importantly, their future aspirations for projects such as community car sharing and community solar-powered electric car-charging stations demonstrated their evolving, thus transformational, understanding of green living.

Energy use profile. Over the course of the study, neither Mike nor Sue used the dashboard. As noted above, they were motivated to act sustainably but were making assumptions about their energy use that was inconsistent with energy conservation and their environmental self-identity. Living in a green home decreased their motivation to use the dashboard and to use energy with intention versus not using more that they might be billed for. They did, however, look at their monthly PSE utility bill and felt that they knew that, on balance, they were generating more energy than they were consuming. As long as their power bill was drawing on credits, they assumed that they did not need to think about it. Using the circuit-level energy monitor dashboard to enable them to be more intentional about their energy use did not occur to them.

The **LIFE**BUILDING***X*** Index Table 7.2 lists the energy use intensity score for this household and suggests that the quantitative EUI energy use patterns are somewhat in alignment with the qualitative narratives and analysis. The one-year home energy use intensity score for this home (EUI 10.5) was 30% below the average value for the Built Green Community (EUI 15). Though their energy use did increase over the course of the study from baseline (very low to high), their average EUI for the household was still 25% lower than the predicted EUI of 14 modeled by the energy engineering consultants at pre-construction. If the EUI of 10.5 were the only metric on energy use, it would appear that this household was high performing. The narratives of Mike and Sue illustrate that their low energy use may have had more to do with having just moved in, as they accumulated more "stuff" (energy-using equipment) over the course of the year. Furthermore, their lack of interest in the energy use information characterizes a household likely to continue to increase energy use, as was the case for Mike and Sue regardless of their many other pro-environmental actions (gardening and biking), values, place meanings or cues in the environment. Should they actually engage in community activities with their neighbors, as they hope to do, their behaviors may be supported in a way that strengthens their environmental values strengthen over self-enhancing values, increasing the likelihood of more pro-environmental behaviors.

Profile 3. Behavioral interchange

This profile is characterized by the actions a person engages in to improve their home and then their community. The exchange is well illustrated by one respondent living in the Code-built Community whose pro-environmental behaviors were founded on principles of efficiency (see Table 7.3). As an engaged individual, this interviewee was a problem solver by training who, once he had solved a problem for himself, then shared his knowledge with his social community, which typifies the concept of Behavior Interchange. By integrating altruistic and egoistic values, supported by feelings of place attachment and environmental self-identity, this resident engaged in multiple pro-environmental actions. Furthermore, investigating and solving issues of efficiency within his home has become his way to connect, engage, and integrate his values, thereby strengthening his feelings of connection with his community as he escalates his solutions to a macro level.

Table 7.3. LIFEBUILDING***X*** Index: Behavior Interchange Exchange.

Code First cycle coding	**Frequency (CF)**	**Model** Second cycle coding	**Frequency (MF)**
Value: Biospheric	6	**Value: Integration**	**7**
Value: Altruistic	**10**	Value: Trade-off	4
Value: Hedonic	8	Value: Trigger/Congruence	3
Value: Egoistic	**10**	**Meaning: Enhancer**	**10**
Meaning: Envr. Self-identity	7	Meaning: Awareness	1
Meaning: Place Attachment	**12**	Meaning: Inhibitor	3
Meaning: Place Identity	4	*Meaning: Singularity*	*8*
Architectural Design Features 1	*14*	**Cue: Green Building Envr.**	**13**
Envr./Human Well-being		Cue: Green Social Environment	8
Architectural Design Features 2	**15**	**Exchange: Behavior Interchange**	**11**
Next Gen Building Systems		Exchange: Check-the-Box Sustain.	0
Architectural Design Features 3	11	Exchange: Reciprocity	3
Promote PEB Aware/Action		Exchange: Conditional Environ.	1
Architectural Design Features 4	3	*Exchange: Transformation*	*9*
Regen Design Features		EUI: Change from Baseline	VH-HD*
Architectural Design Features 5	5	EUI: 3 Yr. Ave. / Study Period	27.3/25.5
Accp, Chg Needs/Uses,		EUI: Community Ave. / Modeled	22/25

*Very High EUI at baseline with High Decrease over the course of the study.
Bold indicates highest frequency while Italic indicates close second highest frequency.

Behavior interchange case illustration. This exchange is well illustrated by a resident of the Code-built community whose key focus was on making improvements in the efficiency of building, mechanical and electrical systems in his home. An introvert by nature, Chris sought to maximize efficiency as a way to: 1) align his values with what he finds meaningful; 2) put his expertise in to specific project-based actions; 3) cultivate people-place bonds; and 4) become involved in the community's affairs. On the whole, Chris exhibited an exchange that was based on altruistic values integrated with egoistic values catalyzed by strong feelings of place attachment and some feelings of environmental self-identity. His values were congruent with his behaviors around efficiency. With respect to many building systems (water, energy, mechanicals, lighting), Chris's behaviors were often aligned with his values. With respect to many architectural design features related to well-being (walking and biking, reducing waste, recycling and composting), Chris also experienced value congruency.

Chris frequently demonstrated environmentally friendly behaviors (designing most of the engineered systems for the 30-home community) stating; "I've been involved in the roofing. I've been involved in the heat. I've been involved in the heat recovery ventilator. Actually, I designed most of it." In regard to his own home, Chris has addressed efficiencies of saving time, money, and energy resources in every way possible: "Efficiency is one of my top priorities in everything I've ever designed, whether it's energy efficiency, or functional efficiency, or interface efficiency." Furthermore, Chris finds a sense of purpose in his actions:

> My interests and both my activities are more on the macro scale, so I like to focus the energies and talents I have on making as big an impact as possible. And I see that I have a much bigger impact when I'm affecting thirty households, as opposed to my own.

His behavior regarding efficiency demonstrated his commitment to sharing his skills and expertise for sustainability with both self- and community-interest to save the community money on their energy bills—an exemplar of behavioral interchange.

The single most attractive draw to the Code-built Community for Chris and his wife was that it was laid out as a "pedestrian village," a safe social environment for children where everyone knows everyone. Secondly, Chris "liked being near to restaurants, and good shopping, and entertainment… [and] this seemed to be a nice [combination of] all of our priorities." Living in the community affords a supportive social environment likely to enhance their feelings of connection to people through shared childrearing (altruistic values) as well as their enjoyment of leisure activities such as eating out at nearby restaurants (hedonic values). Their biospheric values were demonstrated when they were able to sell one of their cars: "We highly value the walking neighborhood."

In contrast to the walkability of the community's central location in town and the social structure of the co-housing community, both of which positively support Chris' current lifestyle, he had "never loved the buildings…. I wouldn't say that was ever a reason for staying…. It was the social community environment" that gave Chris a sense of connection to his home and community. As much as this homeowner embraced the community, he acknowledged trade-offs around features of the actual home, revolving around personal comfort in heating, cooling, daylight, and additional space in trade for a well-equipped kitchen to support his passion around cooking (hedonic and egoistic values).

> We bought it because… it had a much nicer cooking space, and cooking is one of my passions. It's actually one of the smaller units. We would rather have had a three bedroom… but we took the smaller unit to get the [better] kitchen.

Additionally, "this is a very dark and cold house, which is comfortable in the summer, but in the winter it's really chilly and dark." Chris also discussed the trade-off between daylight and trees:

> Growing up in California, [sunlight] was no problem, and then the house in Seattle sat on top of a hill, and there were no trees, so we always had plenty. These trees out here, this grove of enormous trees, they were all about this high when we moved in…. That [amount of shade] would be a major consideration today, especially in the northwest.

Chris was involved in a number of community conversations about solar PV panels but the number of surrounding trees made them unsuitable, even if the design of the roofs and orientation were suitable (which most of them are not). The return on investment, even on the most promising buildings and various energy credits, was not high enough. He would rather see the effort (time and money) put toward better insulation and air sealing.

Energy use profile. Chris was inspired to look for ways to lower his energy use through optimizing equipment. For example, in Chris's household, "every computer we have has been designed by me for minimum power consumption. So, [while] most computers run 300 watts or more, mine run at about 40 watts." However, the carbon footprint calculator, which compares homes in the same zip code, was discouraging for this homeowner. Chris may have had a small home in terms of area, but he had a very high amount of miscellaneous energy loads. He found the dashboard alerts "very annoying…I found it kind of creepy sometimes, like bordering on Big Brother-ish. I could deduce all kinds of stuff about what was going on in the house."

Even so, by investigating the dashboard over the course of the study, he discovered that the hot water heaters (shared between two households) were not operating as efficiently as the community had assumed, rendering their mechanism for cost sharing obsolete. While looking into his own energy data on the hot water heater, he was able to come up with a justification for the community to purchase new hot water heaters as well as develop a new formula for assessing usage and a billing structure that could be used community wide.

> That was one of the revelations in [the] data– how expensive those water heaters really are. It's by far our biggest expense. I was stunned. I think 50% of our electricity use in this duplex is just hot water…. Once I understood what was using the energy, I realized [I needed to] investigate ways to replace that thing with a heat pump water heater.

While Chris has designed or selected most of the pieces of equipment in his home to have minimum energy consumption the sheer number of pieces of equipment including an outdoor spa, complex home entertainment system, custom computer workstation, and gourmet kitchen yield a high EUI. The **LIFE**BUILDING***X*** Table 7.3 lists the energy use intensity (EUI) score for this household and suggests that the quantitative EUI energy use patterns are in alignment with the qualitative narratives and analysis. The three-year home energy use intensity score average for this home (EUI 27.3) was about 9.2% higher than modeled (EUI 25). During the course of the one-year study, the EUI was 25.5 – about 16% higher the average value for the Code-built Community (EUI 22) during the same period. Chris is highly invested in preserving his current way of life by making it more efficient despite using as much or more energy employing technology and equipment. His way to "spend energy" while operating with a systems approach at a thirty-home macro level demonstrated a singularity around efficiency, but as the EUI for this household demonstrates, efficiency alone does not reduce energy use.

Profile 4. Check-the-box sustainability.

This profile was typified by study participants who exhibited a type of "check-the-box" environmentalism based on a belief that their home was already environmentally green, so no environmentally-conscious behavior was required of its occupant. For example, the respondent living in the Built Green Community who illustrates this profile trended toward both strong biospheric and egoistic values, environmental self-identity, and place attachment. However, in her interview, Kyra avowed that she didn't have to think about sustainability because so many aspects of sustainability were already designed into the home. This resident then rationalized that she need not pay attention to her energy use and furthermore, that she and others in her community lacked the time to pay attention to energy-related behaviors, substantiating her view on check-the-box sustainability.

Table 7.4. LIFEBUILDING***X*** Index: Check-the-Box Sustainability Exchange.

Code First cycle coding	**Frequency (CF)**	**Model** Second cycle coding	**Frequency (MF)**
Value: Biospheric	**13**	**Value: Integration**	**8**
Value: Altruistic	6	Value: Trade-off	2
Value: Hedonic	1	Value: Trigger/Congruence	1
Value: Egoistic	*12*	**Meaning: Enhancer**	**9**
Meaning: Envr. Self-identity	**11**	Meaning: Awareness	0
Meaning: Place Attachment	**11**	Meaning: Inhibitor	7
Meaning: Place Identity	7	Meaning: Singularity	2
Architectural Design Features 1	9	**Cue: Green Building Envr.**	**12**
Envr./Human Well-being		Cue: Green Social Environment	6
Architectural Design Features 2	8	Exchange: Behavior Interchange	4
Next Gen Building Systems		Exchange: **Check-the-Box Sustain**	**8**
Architectural Design Features 3	*10*	Exchange: Reciprocity	3
Promote PEB Aware/Action		Exchange: Conditional Environ.	0
Architectural Design Features 4	**11**	Exchange: Transformation	3
Regen Design Features		EUI: Change from Baseline	Ave-NCh*
Architectural Design Features 5	1	EUI: 3 Yr. Ave. / Study Period	14.7 / 15.1
Accp, Chg Needs/Uses,		EUI: Community Ave. / Modeled	15 / 14

Average EUI at baseline with No Change over the course of the study. **Bold indicates highest frequency while Italic indicates close second highest frequency.

Check-the-box sustainability case illustration. The interview data from Kyra, a working professional and mother of two teenagers, is representative of the check-the-box sustainability LBX type, characterized by her belief that she had already fulfilled her responsibility toward sustainable living by virtue of buying a built green home. As member of the Built Green Community, she aspired to demonstrate that it was possible to live in a sustainable way with net-zero energy, yet she did not feel any responsibility to pay attention to her energy use – an apparent contradiction between values and actions that came up repeatedly during the interview. In fact, a check-the-box sustainability point-of-view may promote reoccurring contradictions among values, actions, and environmental self-identity with respect to energy use, contradictions likely to lead to increased energy consumption. Though Kyra stated that her biospheric values and environmental self-identity were important to her, they did not strongly influence her behaviors, which may be related to her interest to "make it easy" to be green. She attributes the origins of her values to her upbringing:

> I think for myself and my family growing up, there was a lot of attention paid to our own personal impact on others and on our environment, and on trying to live in such a way that we either make things better or definitely don't make things worse. This community and this house is definitely a demonstration of the best that I could possibly do.

Kyra strongly identified with the idea that, though a person should be cognizant of their personal impact on the environment, it should also be easy for people to live sustainably. For Kyra "the point is *not* to have to spend time on the home, but to have the home and maintenance systems in place so the homeowner doesn't have to [devote attention to them]." However, the very practice that inspired her – to do no harm, to improve the environment, and to pay "a lot of attention" – may have been undermined for her and others in the Built Green Community. That is, community members literally "bought" into the concept of sustainability when they purchased their homes, renewable solar energy panels, and maintenance contracts. Kyra commented, "It is easy to be here. People can move in in and live sustainably without trying, and that's really nice." Thus, by design, Kyra asserted that she need not devote attention to her energy use and in fact repeatedly made trade-offs in which she prioritized comfort (physical and emotional) over energy conservation, believing that the design of her home with renewable energy gave her license to do so. For example, she asked, "How do you balance that [energy use] with health and happiness? Maybe baking healthy homemade bread and eating it keeps [my kids] from being incredibly depressed in the winter."

Although Kyra believed strongly that the net-zero energy aspect of her home and the OPL program had addressed "all lifestyle choices towards a zero-carbon lifestyle," she also recognized conflicting perspectives. For example, she understood that car use and transportation comprised a large percentage of home energy use, yet she rationalized that she needed to drive her car for health reasons and because she was busy. Her belief was that electric cars made it easy for people like her to be sustainable and still drive as much as they wanted to, thus maintaining their accustomed lifestyles and not changing their behaviors:

> So, the thing that's next for this community is to figure out how to put solar panels over the parking lot and have car-charging stations for people who need to be driving.… I drive my car around a lot, and I wish I didn't, but just because of my busy life…. I have some pretty serious health problems, and I have very little energy, so it's just hard because I'm running after the kids and working all day, and just that extra little bit – I can't do it. Everybody has different needs and special needs or whatever we want to call it, and it's easy to say, "Everyone should ride their bikes like [they] do in Holland," but it's not that simple.

Clearly, Kyra felt a strong sense of environmental self-identity and also held a belief that she had checked-the-box on sustainability when she moved into the community. However, Kyra was less sure of herself when she acknowledged that, in order for people to truly live sustainably, a shared sense of purpose was necessary, explaining that, "the point was to demonstrate that it's possible for people to live this way, and that it's easier to live this way if others around you are living that way, so you have a shared purpose. And I think that's part of what brings people together." Furthermore, Kyra commented that some in the community were just beginning to feel a shared sense of purpose, which was expressed through the various committee groups. She reported "a Bike Circle, and there's a Zero Waste Circle, and these [are] committees. I'm on the Parking Circle, working on parking and electric cars [issues]." However, Kyra believed that the committees were not functioning as well as they could have been and wondered whether for those things to happen, the community needed "to have a co-housing type governance structure with really involved members, or to have a developer or property manager." Notably, she was again operating on the assumption that a green lifestyle has to be easy and that, for that to happen, someone specifically designated for that purpose was needed to orchestrate it.

According to Kyra, the designers of the development explored co-housing as one of the models for community governance but determined that a co-housing structure was “too much commitment and too much expectation of shared time.” In actuality, the connections that the development group sought to exclude were the very ones that she found necessary; that is, connection and a shared sense of purpose are derived from investing time interacting with others in order to build community. Kyra explained:

> I think we feel a part of the neighborhood because we’ve all invested so much in creating what is here and are part of it—together. We built the gardens together, and you build community that way. I think about it because the value of this house has doubled in three years and it would make a lot of financial sense for me to sell it and move somewhere else. But I’m kind of attached. It’d be hard to live somewhere else.

Kyra acknowledged the time and effort needed to build community by working on communal projects together. Yet, she found it difficult to sustain relationships within the community, noting that “There’s a lot of compromise living with other people nearby... There’s also people you enjoy and people you don’t. You can choose your friends, but you can’t choose your family. Same with the neighbors, I guess.”

In telling her story, Kyra has identified two key issues involving both the social and the physical aspects of living sustainably: 1) choosing one’s sustainable home in a neighborhood versus choosing one’s neighbors to support sustainable living; and 2) choosing to engage in pro-environmental actions versus declining to think about it because energy efficiency is made easy. Fundamentally, Kyra questioned whether sustainable living depended more on the social or physical attributes inherent in the lived experience of place. She rationalized that the community was not just about energy use and environmental impact, it was also about health, social well-being, and financial well-being. Kyra claimed that even though her home did not always achieve net-zero, given that she had "two teenagers who take hot showers and [have] iPods, or iThings plugged in all day long," she had renewable energy so she could in good conscience prioritize her children's well-being over energy conservation. Furthermore, Kyra explained that she used a plug-in heater in the upstairs rooms and used air conditioning in summer, neither of which, in her view, entailed consequences for the environment: "Oh, we have solar, I don't feel guilty about the air conditioning."

Energy use profile. Kyra did not look at her dashboard or pay attention to the prompts or alerts on her energy use, justifying her actions by saying that she was too busy. Kyra indicated that she might consider using a dashboard if it had a simpler interface and involved no computer or password. Kyra explained that she did not have time to look at "a bunch of detailed information about your energy use [or] to rely on having to take those extra steps and that level of detail on a daily basis … It's too much for the average person." Kyra valued the information on an intellectual level, but this standpoint did not translate into action.

> I think the information [dashboard] becomes most valuable if it can be relayed in a way that changes people's behavior. I kind of forgot the whole thing [energy monitor and dashboard] was there. I'm personally very interested because… One Planet [Living is] about behavior change. Everything about that framework is meant to design projects to influence people's behavior and lifestyle.

Kyra acknowledged that green buildings may cause residents to use more energy than they might in regular buildings because they think, "Oh, it's green, it's cool." She wondered "how can we take the information created by this monitoring system and relay it to people in a way that does influence their behavior on a day-to-day basis?" She did not voice the viewpoint that it might be necessary to develop ways to actively engage people in pro-environmental behaviors, the antithesis of a check-the-box sustainability outlook.

Kyra's story furnishes an example of how having it easy to be green comprises a central tenet of sustainable living, yet her narrative contains many apparent contradictions. Kyra's lived experience of place in the Built Green Community was one that she expressed as an individual engaged on an intellectual level but too short of time to pay attention to energy use on a day-to-day basis. Rather, she chose to live in a development built to be green in lieu of exercising green behavior choices daily, thus exemplifying the Check-the-Box Sustainability Exchange.

The **LIFE**BUILDING**X** Table 7.4 listing the energy use intensity (EUI) score for this household suggests that its quantitative EUI energy use patterns align with the qualitative narratives and analysis. The three-year home energy use intensity score average for this home (EUI 14.7) is about 2% lower than the average value for the Built Green Community (EUI 15). The energy use for his household did not increase over the course of the one-year study from baseline (no change); however, the average weather-normalized EUI for the household at 15.1 and was higher (8%) than the predicted EUI of 14 modeled by the energy engineering consultants at pre-construction. These EUI scores suggest not only that Kyra's energy use is static, but also that her profile is an example of the check-the-box sustainability exchange modeled by a semi-engaged individual in the Built Green Community.

Profile 5. Conditional environmentalism

This profile is characterized by what I call conditional environmentalism. Under circumstances when it was convenient or cost little in terms of time, money, or effort, the participant engaged in pro-environmental behaviors. Because the environmental behavior was frequently evaluated in terms of self-enhancing values, even if a person espoused biospheric values, they were likely to ask a series of questions evaluating the worthiness of any effort toward the pro-environmental behavior in relation to their own needs and interests. This type of self-questioning often led to a rationalization of behavior not necessarily in the best interest of the environment, but rather in the best interest of the individual. In LBX Index Table 7.5 it can be seen that for this profile, little distinction appeared between altruistic, hedonic, and egoistic values, along with some feelings of place attachment and environmental self-identity triggered by the physical environment. Such participants were likely to prioritize self-enhancing values over self-transcendent values and self-interest over sustainability. They were less likely to be attached to their home or residential community or express strong place identity or environmental self-identity, even if they valued their physical or social environment on some level.

Table 7.5. LIFEBUILDING***X*** Index: Conditional Environmentalism Exchange.

Code First cycle coding	**Frequency (CF)**	**Model** Second cycle coding	**Frequency (MF)**
Value: Biospheric	**10**	Value: Integration	3
Value: Altruistic	4	Value: Trade-off	4
Value: Hedonic	3	Value: Trigger	5
Value: Egoistic	5	**Meaning: Enhancer**	**6**
Meaning: Envr. Self-identity	**5**	Meaning: Awareness	4
Meaning: Place Attachment	**9**	Meaning: Inhibitor	3
Meaning: Place Identity	3	Meaning: Singularity	0
Architectural Design Features 1	*11*	**Cue: Green Building Envr.**	**11**
Envr./Human Well-being		Cue: Green Social Environment	5
Architectural Design Features 2	**12**	Exchange: Behavior Interchange	5
Next Gen Building Systems		Exchange: Check-the-Box Sustain.	1
Architectural Design Features 3	1	Exchange: Reciprocity	0
Promote PEB Aware/Action		Exchange: Conditional Environ.	7
Architectural Design Features 4	4	Exchange: Transformation	0
Regen Design Features		EUI: Change from Baseline	VH-NCh*
Architectural Design Features 5	1	EUI: 3 Yr. Ave. / Study Period	28/25.6
Accp, Chg Needs/Uses,		EUI: Community Ave. / Modeled	22/25

*Very High EUI at baseline with No Change over the course of the study. **Bold** indicates highest frequency while Italic indicates close second highest frequency.

Conditional environmentalism case illustration. On the whole, one resident of the Code-built Community, Rick, illustrated an exchange based on a mix of strategies including integration, trade-offs, and triggers. While his values centered on biospheric principles catalyzed by feelings of place attachment, his behaviors were generally inconsistent with biospheric values and dependent on the situation. Although Rick was conceptually aligned with pro-environmental values, he found ways to get around energy-saving actions by rationalizing his preferred behaviors. For example, he felt the fact that design of his home was green, having a smaller footprint and using less energy than his previous home, rendered the "hobby" of monitoring his energy use not worth his time. Rick's exchange is characteristic of a person who engages in conditional environmentalism due to an ability to rationalize his non-environmental behaviors to suit his personal desires even as he professes to value protecting the environment.

Rick recalled the trade-offs and concessions made when he and his family decided to live in the Code-built Community. The natural beauty characterizing his prior home was traded in for a home in town, which he believed to comprise a more convenient location. Rick also valued the opportunity to live in the co-housing community. Ultimately, "it was location and community" that shaped their decision. Rick explained:

> The trade-offs have pluses and minuses. I'm not really attached to this house at all. The community, I'm sure that I am. But in terms natural beauty it's not really a great place to live. We moved into the community because we wanted less property to take care of. We had a pretty good size property [at our previous home], so not having as much yard to maintain was appealing. On the down side, we don't have as much [property] to look over—none of our windows give us a natural view.

Rick enjoyed the social connections of the community: "Socially, I would say the community is very welcoming, and when you depart or arrive it's an event that's noticed by people." However, Rick did not feel a connection or sense of identity with the home itself because he and his family cannot make changes to personalize it since the long and "arduous process" required to make any modifications was not worth the time and effort.

Rick felt it was important to live sustainably and had chosen to optimize the reduction of the family's waste stream above any other pro-environmental actions, believing that "We put more energy into composting and recycling than most normal American families." Rick felt there was little to do for the energy aspect of sustainability. According to Rick, one benefit of living in an adjoining structure is heat conservation:

> Since we have neighbors on both sides, we don't have to heat as much as some of the other units do. We have huge solar gain, especially upstairs. Yes, we have a lot of windows on the south side. I think that we don't have to put as much [thought, energy, or cost] into heating as some of the other units do.

Furthermore, “A lot of times we have power strips that stuff is plugged into, but it’s a matter of convenience” to leave them energized. Thinking about ways to reduce energy in his home prompted Rick to recount a trip to the UK where reducing energy use is a high priority.

> In the UK, every single outlet had a switch. They seem more focused on energy efficiency.... Even their showerheads had an electric power switch.... There was one place [and it was] our last day and all of us were trying to have showers. We ran out of hot water. There was a separate handheld showerhead. I switched the flow so it was coming out of the handheld and I was able to get hot water again. So, I think maybe the electric thing had said “you have used too much hot water; now you are done….” It is not insignificant to run electricity into [the] shower—it was important.

Interestingly, Rick did not think about the amount of power needed to heat the water to a higher temperature, or the quantity of water being used. He found a way around the built-in conservation measures to satisfy his individual use, rationalizing that he was leaving and needed a hot shower.

In general, Rick also did not think about his energy use, believing that he spent significantly less money on electricity now than he did when he lived in a single-family home. “So, our energy use seems a lot less by comparison. In our budget, it’s a very small line item.” As a result, he lacks the incentive to pay attention to the family’s actual energy use. By focusing on the cost of energy versus the amount of energy used, Rick rationalized that fundamentally resource conservation was about himself personally saving money over the saving a shared resource such as energy. Finally, Rick rationalized his behavior with respect to car use, which exemplified conditional environmentalism. Though electric energy powered his car and his destination was only two minutes away, he felt he had no reason to limit use of his car.

> The fact that I have an electric car makes me feel less bad about jumping in the car and going to the store. I think about it in terms of “hey, I’m not burning gas.” [Also,] it would be more painful to get in [a gasoline burning] car for a two-minute trip, hard on the engine. But, neither of those apply with the electric car, [so there’s] less reason not to.

Energy use profile. This household rarely looked at their dashboard and paid little attention to their alerts. They assumed that the information was spurious because it reported short cycling on the heat pump. Rather than take the time to understand the short cycling and what might be causing it (an extraordinarily cold weather pattern with a unit that could not keep up with demand), they turned on their gas fireplace and the short cycling alerts stopped. Rick was not concerned with the use of energy; therefore, he did not concern himself with how he consumed energy or electric resources. For a person who exemplifies conditional environmentalism, maintaining comfort matters more than energy conservation. With regard to home energy use, it is a conditional exchange – saving time, not energy, and purchasing thermal comfort or convenience by "working around" conservation behaviors, as with the gas fireplace.

Most notably, Rick characterized monitoring the family's energy usage as a "hobby" in which he did not have time to engage because "we weren't trying to change our behavior. We have very full lives. We don't have time to take on the extra hobby of monitoring our electricity usage and figuring out ways to change it."

Within the proposed Life Building Exchange framework, members of this household could be considered disengaged individuals with an exchange characterized as conditional environmentalism. Throughout the interview, multiple examples arose of rationalizing behavior in favor of energy use as a matter of convenience and time saving rather than taking a more pro-environmental action regarding energy use.

The **LIFE**BUILDING***X*** Table 7.5 lists the energy use intensity (EUI) score for this household and suggests that the quantitative EUI energy use patterns align with the qualitative narratives and analysis. The three-year home energy use intensity score average for this home (EUI 28) was about 27% higher than the average value for the Code-built Community (EUI 22).

Though their energy use did not increase over the course of the study from baseline (very high to no change), the average weather normalized EUI for the household during the one-year study period was 25.6 and was higher (2.4%) than the predicted EUI of 25 modeled by the energy engineering consultants at pre-construction. Despite the fact that this unit has the advantage of "huge solar gains" and shared walls to limit heat loss through the envelope, the energy use was second highest among all those interviewed in the community, suggesting not only that Rick's profile provides an example of a conditional exchange modeled by a disengaged individual but also that their energy use is simply average. This type of exchange requires less intention, attention, or engagement as his strategy is to rationalize behaviors that contradict his professed values, exemplifying a conditional environmental exchange.

LIFEBUIDNG***X*** **Conceptual Framework**

The five prototypical Life Building Exchange profiles presented in this chapter are descriptive of the predominant behavioral patterns derived from the study data, explaining why and how a person is likely to engage in environmental behaviors with regard to residential energy use. In addition, the profiles illustrate how different person-place process dimensions in different physical contexts underpin a person's motivation to engage in pro-environmental behavior (individually or collectively) and shape the likelihood of energy conservation behaviors to achieve high-performing buildings whether or not the building itself is structurally built to have a low EUI.

The signature characteristic of the **LIFE**BUILDING***X*** framework is that it stipulates that a number of dynamic process dimensions—values, place meanings, and environmental cues—be considered holistically with regard to actual energy use and perceptions on energy use. Furthermore, the exchange is likely to be more enduring when the experience is reciprocal and presents mutual benefits for the person, the community, and the planet. Additionally, when processes encompass self-transcending and self-enhancing values, strong feelings of place attachment, strong associations with environmental self-identity or place identity in a supporting physical or social environment, then the exchange is likely to be highly saturated, promoting an enduring commitment to pro-environmental behavior (engaged citizen) resulting in high-performance outcomes (low energy use). At the other end of the spectrum, when the exchange is thought to have little meaning, seen as unnecessary, or supports only self-enhancing values, then the individual is not likely to engage in a lasting behavior (disengaged individual) and the behavioral exchange is more likely to be temporary, resulting in a low-performance outcome (high energy use).

Chapter 8: Conclusions and Applications

Introduction

Prior research addressing climate change (IPCC, 2014) confirms the need for substantial action using a parallel multi-track approach that includes: 1) advocating for improved building code standards; 2) promoting higher performance buildings; and 3) shifting individual and collective perceptions, values, beliefs, and worldviews. Independently, there have been advances in all three tracks, yet they have not typically been integrated in comprehensive way such that both buildings and behavior are simultaneously considered to achieve the higher performance outcomes crucial for achieving net-zero goals. This research suggests that a holistic approach incorporating both design and behavior is necessary if progress is to be made toward the 2015 Paris Agreement's net-zero goal. The research presented in this dissertation has taken such a holistic approach and sheds light on how an understanding of the interface between people and place offers a critical step in the transition toward net-zero energy.

With regard to residential energy consumption and environmental behavior, prior research has independently investigated the roles of structural building characteristics, values, pro-environmental behavior, and place meanings, yet little is known about how these roles interact to influence energy use in residential settings. For example, longitudinal studies on energy consumption, such as the large residential surveys RECS (2009) and RBSA (2014), examine trends in residential energy consumption primarily by looking at structural characteristics to advance regulatory energy codes. However, these studies do not address the motivations behind a person's actual energy consumption. Similarly, beyond code standards such as ILFI or LEED that look toward the future standards do not include a behavioral component to shift performance outcomes toward net-zero energy. Research on carbon emission reductions resulting from household actions identify specific behaviors that affect energy use at the household level (e.g., behavioral wedge: Dietz et al., 2009), but do not focus on predicting or fostering behavioral change. Research on values orientations predict the likelihood that pro-environmental behaviors will take place (Steg, et al., 2014a & 2014b), but these studies do not attend to the influence of place meaning on such behaviors. Conversely, research on place identity, environmental self-identity, and place attachment sheds light on meaningful person-place relationships, and statistical analyses of place attachment has been connected to pro-environmental behavior (Raymond, Brown, & Weber, 2010; Scannell & Gifford, 2010b), but none of this research investigates the potential influence of place meaning on reducing residential energy use.

The present study fills this gap by investigating and comparing two residential communities with regard to their energy use by: 1) monitoring actual energy use; 2) surveying perceived energy use, the importance of related people-place concepts, and architectural design features; 3) implementing a treatment to investigate the effects of real-time energy feedback on residential energy use; and 4) interviewing residents on their experiences related to their residential setting broadly, and on their energy use behaviors specifically. Using a mixed methods approach, this 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.[70]

Furthermore, the conceptual framework that emerged from the grounded theory analysis of interview data, which I call **LIFE**BULIDING***X***, builds on the work of Kurt Lewin's formula

---

[70] Net-zero goals are called for by both the 2015 Paris Agreement and the Architecture 2030 Challenge.

from the 1930s: person + psychological environment = life space (Gifford, 2014). Notably, the relationship between person and environment is bi-directional, meaning that, just as the person influences the environment and the environment influences the person. People are active agents in their environments. The LBX model is similar to Lewin's general model in that it suggests an active relationship between people and place that results in a performance outcome impacting both the person and the environment.

The LBX model builds on the work of other environmental psychologists as well. For example, the values, place identity, environmental self-identity, place attachment dimensions have been researched by scholars such as Altman & Low (1992); Clayton (2012); Lewiska (2011); Manzo & Devine-Wright (2014); Proshansky et al. (1983); Scannell & Gifford (2010a); Schwartz (2012); Steg et al. (2014a & 2014b); Stern (2000); Van der Werff & Steg (2015); Van der Werff, Steg, & Keizer (2013a, b, c); and Whitmarsh & O'Neill (2010). What the LBX conceptual framework contributes to the prior research is its emphasis on a multi-dimensional nexus of specific factors coalescing holistically in one model. The LBX model also operationalizes the research in reference to energy use in residential settings and net-zero buildings, providing ways to index and benchmark higher performance buildings and behaviors.

In this study, the LBX framework focuses specifically on the collective significance of LIFE (values as guiding principles; place meanings inclusive of place identity, environmental self-identity, and place attachments) as well as BUILDING (physical and social environmental cues). Furthermore, in this study, residential settings where people make day-to-day choices with respect to home energy use constitute the loci in which people-place experiences occur. I characterize the process by which a person makes these choices, the motivations that figure in making them, and the expression they ultimately take as an Exchange between Life and

Building. Linking values, identity constructs, and emotional bonds to places designed with intention to include features found in the design of high performance buildings (e.g., ILFI imperatives) carries significance because who we are can include aspects of where we are and in turn motivate what we do—a reciprocal relationship. That is, in a dynamic process, architectural design features may support and inform the depth of place meaning and inspire the prioritization of values which may motivate behaviors to maintain, enhance, and protect environmental resources in general and residential energy use in particular.

Findings

In this chapter, I briefly revisit key findings across the various methods employed in this study to consider the implication and applications of this research. The discussion begins with a recap of key trends regarding participants' actual energy use, followed by a summary of perceived energy use based on survey data, and then major trends from the in-depth interview. It concludes with an account of the study's limitations and directions for future research.

Actual energy use. With regard to actual residential electricity consumption, at the conclusion of the study, PSE mean EUI scores for the Built Green and the Code-built community groups were substantially lower than their counterparts at the regional and national level: Built Green, EUI 15.07; Code-built, EUI 20.25; RBSA 2011, EUI 30; and RECS 2009, EUI 59. Not surprisingly, the Built Green Community used less energy than Code-built Community in every time period studied. However, tests show that treatment (energy use dashboards) had a greater effect on the Code-built Community. Notably, from the time of the energy models[71] to the end of

[71] The energy model for the Built Green Community was created, in 2011 by Ecotope, before construction began to predict how much energy the buildings would consume. The as-built energy model for the Code-built community was created in 2011, as a part of a citywide initiative called Repower.

the study, the Built Green Community increased its energy use by 8%, while the Code-built Community decreased energy use by 19%.

Comparing the average energy use by major end-use categories as a percentage of total energy use, the two sites displayed similar patterns of consumption. Built Green consumed 31% on MELs, 31% on space conditioning, 26% on domestic hot water heating, and 12% on major appliances, while Code-built consumed 38% on MELs, 30% on space conditioning, 21% on domestic hot water heating, and 11% on major appliances. Essentially, two thirds of the energy load is attributed to uses under the direct control of the occupant – that is, MELs and space conditioning. As a percentage of total MELs consumed, the Built Green Community used 65% on other unaccounted for consumption uses while the Code-built Community used 51% with the remainder attributed to entertainment centers and computer workstations. These unaccounted for MEL uses are reported (in the interviews) to be attributable to mobile devices and discretionary uses falling into four major categories:

- Axillary and portable devices for space conditioning (including space heaters, fans, and dehumidifiers) and multipurpose mobile devices (such as laptops, tablets, smartphones, smart speakers);
- Avocational hardware for pursuing hobbies and creative endeavors such as equipment for making music, printing large format images, felting pursuing other and hobby projects, and homemade electronic projects such as computers and media consoles;
- Food preparation and storage equipment for canning and freezing;
- Miscellaneous activity-based energy uses including high use of the washer/dryer for small loads of laundry and recreational cooking for emotional support.

Three overarching energy use findings stand out. First, the Built Green Community has lower energy loads, but the Code-built Community reduced energy overall more than the Built Green Community, suggesting that philosophical and behavioral characteristics are as important as structural ones. Second, for both the Built Green and Code-built communities, MELs comprised a high proportion of total energy consumption, followed by space conditioning – two areas where occupants can exercise a high degree control, as can be seen in the high degree of variability across the two sites in these categories. Unaccounted-for MELS have 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 hardware reported by almost every household. This prevalence suggests that it is important to account for discretionary energy uses when designing and engineering a net-zero building. Third, treatment exerted a greater effect on the Code-built Community, a pattern potentially attributable to several causes: a) the Built Green Community might have been unresponsive because their actual energy use was already very low by virtue of the structural characteristics of their homes; b) the Built Green Community might have been unresponsive because their perceived their energy use was already low; c) participants in the Code-built Community might have social characteristics and espouse an environmental stance that would support their responses to the treatment.

Perceptions on energy use. Several noteworthy findings emerged from the analysis of survey data on perceived energy use and pro-environmental variable ratings as well as on architectural design features. First, the survey data showed that the two sites were comparable on demographics of the sample as well as pre-treatment environmental, place, and architectural variables. Over the period of the study, Built Green Community households exhibited a significant decrease in Hedonic values, and Code-built Community households showed a significant decrease in Place Identity variable ratings. However, no significant differences arose between sites on other change scores variables (only trends). In other words, there is little evidence that the dashboard treatment was associated with changes in people's perceptions of their values or energy use behaviors.

Even so, the actual energy used by households (collected as PSE data) did decrease between baseline and post-treatment, irrespective of which housing community was examined. However, the Built Green Community did use less energy at the outset, and the Code-built Community decreased energy more than the Built Green Community across time and after treatment. Such findings lend empirical evidence to support the argument that behavior change may have to occur before change scores reported in the pre-posttest survey would reveal statistical significance. In other words, these findings support the potential for use of in-home energy dashboards to have an effect on actual energy behavior, especially targeting MELs and space conditioning as these are areas where occupants can exert a high degree control.

Moreover, the survey data showed that, over time, ratings on biospheric values and environmental self-identity increased in the Code-built Community, whereas they decreased in the Built Green Community. Both communities increased their ratings on the importance of being able to accommodate changing needs over time and decreased on hedonic values. For the Code-built Community, these trending increases/decreases on perceptions correlate with the effects of the dashboard treatment and demonstration of overall reductions in actual energy use.

Though the quantitative data yielded important information on how much energy was being used and how the communities compared to each other, it did not uncover the reasons why residents use energy in their homes or reveal the meanings behind people's behaviors with regard to energy use. To address these two questions, in-depth, face-to-face interviews were conducted to ask residents about their experience of place with regard to energy use.

People's experience of place. A subset of study participants was selected purposefully for interviews to gather qualitative data on people's place-related thoughts, feelings, and perceptions of their energy use behaviors. In this way, the interviews sought to shed light on a range of factors related to energy use that could not be captured by looking at EUI data or from statistical data on perceptions of energy use, pro-environmental behavior, and architectural design features from the survey variables.

With respect to the dashboard information on real-time energy use, those households in either community who actively looked at the dashboard data and used the information to change their behaviors lowered their EUI scores, though not in all cases. For example, one household having a low EUI score at the outset and demonstrating reciprocity (a belief in the holistic relationship between humans and the ecosystem based on mutual benefits) did not consult the dashboard, believing that the time to consider energy use was before the energy was consumed. Conversely, an interviewee demonstrating behavior interchange (a focus on actions that increase an individual's sustainability with the potential to share these environmental outcomes with the larger community) looked at his dashboard regularly and did lower his energy use, but maintained one of the highest EUI scores of both communities primarily due to his penchant for electronic devices that, although efficient, were many.

Given the diversity of approaches inherent in the person-place dynamic, how might architects and designer create places that to support a greater sense of meaning toward energy efficiency in their environments? Is it possible to design in such a way that encourages people to nurture and grow their meaningful relationships? If, as was the case with the Built Green developers, there is no expectation for the people who live in the development to engage in pro-environmental behaviors based on their own beliefs, values, and feelings, then an unintended consequence may emerge that residents become less likely to pay attention to, and feel responsible for, their own environmental behaviors and energy use. Ironically, such green developments may inadvertently design out the behavioral component that is so critical to environmental well-being, raising a key question of how green design can still foster pro-environmental behavior beyond simply choosing to live in a green community. In the next section, I highlight the most significant architectural design features reported by interviewees that may provide the nexus for important values to become salient, place meanings to emerge, and effects of real-time feedback to shape behavior with respect to energy use.

Interviewees from both communities mentioned multiple architectural design features as supportive of their energy conservation behaviors, experience of place, or people-place relationships. Data demonstrated that supportive features included natural light and ventilation, well-functioning mechanical systems, flexible or additional space for changing needs over time, and the physical layout of the home (privacy for the Built Green Community and openness for the Code-built Community) as well as gardens for self-expression and winding paths for connecting to and meeting with neighbors. Built Green Community participants referenced two distinct negative responses to cutting-edge technology failures with either materials (composite decking and counters) or equipment (water heater failure and inadequate heating and cooling systems). In both sites, a natural view was sorely lacking. Natural light was either too extreme in the Built Green Community (overheating and glare) or insufficient in Code-built Community (dark and cold spaces). For both sites, people’s responses to the gardens and winding pathways were overwhelmingly positive, both as a way to meet other people and as a means for personal self-expression. The solar panels in the Built Green Community were considered an enormous asset, not only for energy production, but also for people to notice energy-related sustainability features; similarly, the gardens served as a visual reminder of beauty and the importance of food production, both of which supported people's environmental self-identity and translated into pro-environmental behaviors. In the Built Green Community, people tended to enjoy the architecture of their homes and the landscape architecture of the community, while in the Code-built community, residents tended to have issues with the architecture of their homes but felt that the social benefits far outweighed the physical shortcomings of their homes. Finally, the Code-built community tended to reference the importance of having what they called a "third place" on the grounds—the commons house, organic garden, fields, forest, and smaller landscaped areas for casual meetings. All these architectural features served not only as environmental cues to help prioritize the significant pro-environmental values, but also as places and features supportive of meaningful people-place relationships.

Interview data reveal a dynamic constellation of values, meanings, and environmental cues that contribute to how people make sense of their experience of place with respect to sustainability and energy use specifically, and these elements were likely to affect patterns of behavior in discernable ways. The data suggest that the individual will engage in their environment in a way likely to be pro-environmental and energy-conserving when supported by their residential setting. Notably, in terms of the Values Dynamic, values could shift in importance depending on circumstances within the physical and social context. In terms of the Meanings Dynamic, positive place attachments, and strong place-identity and environmental self-identity helped residents engage with their homes and communities and supplied a key part of their reasons for engaging in pro-environmental behaviors. Environmental cues found in the physical and social contexts not only provided a focus and grounding for the experience of place but also supported pro-environmental values, catalyzed meaningful people-place relationships, and fostered pro-environmental behaviors. Interview data further indicated that participants engaged in two capacities —as individuals and as citizens—and this engagement was likely to result in pro-environmental behaviors if the person was actively engaged in their homes and communities in either capacity.

Finally, when considering the Life Building Exchange conceptual framework that emerged from the qualitative data per the grounded theory approach (Strauss & Corbin, 2008; Saldana, 2009), findings show that this dynamic exchange between people and place – between life and building – impacts environmental actions, particularly on how and why people use energy, in one of five ways: (1) reciprocity, (2) transformation, (3) behavior interchange, (4) check-the-box sustainability, or (5) conditional environmentalism. Moreover, it is the particular holistic pattern of behavior that will shape the likelihood of high performance energy conservation behaviors to achieve high-performing buildings, whether or not the building itself is structurally built to have a low EUI.

Furthermore, the most influential factors distinguishing the two sites were the differences between their physical and social contexts – that is, their architectural, philosophical, and social characteristics or the lack thereof. Within the communities, households where individual or collective behaviors demonstrated reciprocity, transformation, or behavior interchange tended to have lower energy use and EUI scores, while households showing a behavioral pattern of check-the-box sustainability and conditional environmentalism tended to have higher energy use.

Limitations and Future Research

In this section, I recognize the limitations of the study at hand and discuss implications for future research. Given its level of specificity, this study carries limitations on the transferability of its research findings. Other limitations of the study include assumptions that people were truthfully participating in surveys, reviewing dashboard information, and responding to interview questions and that, to the best of their ability, their responses reflected their views. However, because survey instruments relied on self-reporting, it is possible some bias might have influenced responses. As this study did not make use of large random sample surveys, controlled experiments, or social marketing research designs, the information it generated is not intended to be used for causal conclusions or transferred to other sample groups.

Study limitations for these findings are similar to those noted for the actual energy use analyses (see end of Chapter 4). In addition to those limitations, it should be noted that survey self-report data can be prone to misinterpretation of what is being asked, cognitive load[72], as well as social desirability effects (i.e., reporting what people believe they should say rather than what they actually believe or do). Knowing at the outset of the study that this would pose a limitation, I included actual energy use as a quantitative check to self-reported survey variables.

Although significant decreases in energy use could be seen among participants in each community from baseline to post-treatment, a trend for these changes emerges only when the benchmarking period is accounted for. One limitation was the sample size: with so few households, the statistical power to detect effects was quite low. Another limitation was that both communities received treatment; it is not possible to know how the communities might have used energy differently without some of the population functioning as a control group lacking the

[72] Cognitive load refers to the amount of effort it takes to answer the questions and complete the survey.

in-home dashboard. Still other limitations include that: 1) only two years of benchmarking data were available; 2) both of these sites were relatively modern (1991 and 2013) architecturally designed communities – communities not necessarily typical of most multifamily development sites in the US; and 3) the climate in the Pacific Northwest is milder than that of other parts of the state and country, which allows for the use of high efficiency heat pump technology not appropriate for extreme temperature swings found in other regions. Future research could expound on the current study by including a full range of architecturally designed sites, which would also help to increase sample size. Nonetheless, this study has unique strengths and contributes to the body of knowledge on residential energy use in ways delineated below.

Unique Strengths

The analysis and triangulation of information from multiple data sources in a mixed methods research design was intended to mitigate survey bias and small sample size issues, yielding a broad sense of energy use behaviors and perceptions, a specific account of energy use behaviors (actual), and a deep understanding of place meaning through narrative inquiry to generate an in-depth perspective on environmental behavior broadly and energy use specifically. The addition of a qualitative component focusing on residents' personal understandings of their place meanings, experiences, and identities offered yet another perspective on the subject and resulted in a far more complete exploration.

In this dissertation, I have focused my research on the dynamics of values, place meanings, environmental cues, and exchange interactions by investigating pro-environmental behavior in residential high-performance buildings and neighborhoods compared to those more conventionally built. This approach explored a deeper understanding of the ever-shifting collection of factors therein, an investigation which, to the knowledge of this researcher, had 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 dissertation 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.

The **LIFE ←→ BUILDING ←→ Exchange** conceptual framework that I developed in considering the net-zero building challenge serves architects and researchers in three ways. First, it provides a relational framework describing the dynamic interactive processes between people and their environment, taking into consideration specific dimensions of pro-environmental behavior and specific architectural design features with respect to energy use in residential settings. The LBX is inclusive of the following dimensions: LIFE—people's values and place meanings; BUILDING—environmental cues; and EXCHANGE—the locus of reciprocal relationships found in high-performance buildings and behavior. Second, the LBX serves as an index identifying five prototypical ways that people engage in their residential settings: (1) reciprocity, (2) transformation, (3) behavior interchange, (4) check-the-box sustainability, and (5) conditional environmentalism. Third, the LBX index offers a holistic approach toward net-zero goals inclusive of high performance buildings and behavior that can be used as a tool by architects and energy/building code developers seeking to include outcome-based performance metrics in their design solutions. The LBX index along with an EUI have the potential to establish an energy performance outcome target for a particular building project in relationship to one of the five behavioral prototypes.

Future Research and Applications

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 RECS and RBSA that investigate only structural characteristics, by implementing the behavioral survey and interview methods developed for this dissertation 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; 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.

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 of Seattle) and beyond-code standards (e.g., ILFI) to incorporate a behavioral component such as the LBX index into energy requirements. In this regard, this research and the LBX index 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 and energy codes move toward 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 performance profile. Understanding a household's energy profile includes establishing a baseline LBX index profile from which to measure the contribution of behavioral components in energy performance now and in the future.

In terms of design, future uses of this research would include using the LBX index to establish a benchmark and discuss both structural and behavioral options to meet energy goals with potential developers and homeowners interested in new residential projects aiming toward net-zero and net-positive buildings. Future residential designs could include a dashboard built into the home for easy reference (akin to a "Shimmy" the UK). In addition, it would be productive to collaborate with a computer engineer to design a smart device that could read the signature of mobile MELs so that wherever these devices were plugged in and charging, their energy use could be read. As these devices are often multi-purpose, the need to categorize them as entertainment or home office, camera or phone, novel or newspaper may be obsolete. It is the energy from these miscellaneous mobile devices that should be benchmarked, regardless of where they are plugged in and consume energy. An energy signature independent of a circuit would allow energy monitoring at the device level. In addition to the dashboard, future research could test the persuasive/informative messaging about the tie between household energy use and climate change.

Finally, again in collaboration with a computer engineer, a computer application could be produced that would allow a resident to take the behavioral survey and respond to the interview to automatically assess their behavioral performance, providing them with a personal LBX Index. This application could be combined with a smart device indicating the performance of the building in which the user resides. In this way, the performance of both the building and behavior could be benchmarked. Suggestions for reductions in energy use could then be paired with real-time dashboard information. In this way, the energy signature of the building could be read holistically. Additionally, similar to a health monitoring watch that tracks the exercise and sleep patterns of a person, a wearable energy monitor that tracks the energy health of the home—

that I call an “EnerFit” –could be developed so that a person could read their energy use from a personal mobile device and could also be connected to a dashboard in the home. Similar to an exercise “FitBit” that gives real-time feedback on a person’s healthy exercise and sleep patterns, an “EnerFit” would provide real-time feedback on a person’s home health energy use and conservation.

Contributions of the Research

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 and communities, along with place attachment, identity relationships, and values, 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 LBX 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 an interdisciplinary approach (architect and scholar) 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.

In Closing

On reflection, I ask a few questions about possibility and probability. What is the probability that human societies make "quantum leaps" from one orbit to another "in order to be real?"[73] That is, when jumping toward net-zero goals, is it possible to meet the needs of the present without compromising the ability of future generations to meet their own needs? For this to happen, architects, scholars, developers, and policy makers must make the leap from code minimum or even net-zero to net-positive construction, going beyond our immediate needs and contributing to the needs (verses wants) of future generations. But then how do we account for the behavioral component when focusing on innovative design? Perhaps, if it is possible to remember that our experience in place is such that *"*every atom belonging to me [is] as good [as] belongs to you,"[74] we can then exist in a reciprocal relationship along with place as a singularity. "All everything home."[75]

---

[73] See Rovelli (2016, p. 17) and page 8 of this dissertation.
[74] "Singularity," a poem by Marie Howe (after Stephen Hawking).

(Retrieved (May 22, 2018) from https://www.brainpickings.org/2018/05/22/singularity-marie-howe-stephen-hawking/) and page XV of this dissertation.
[75] "Singularity," a poem by Marie Howe (after Stephen Hawking).

(Retrieved (May 22, 2018) from https://www.brainpickings.org/2018/05/22/singularity-marie-howe-stephen-hawking/) and page XV of this dissertation.

References

Abrahamse, W., Steg, L.,Vlek, C., & Rothengatter, T. (2005). A Review of Intervention Studies Aimed at Household Energy Conservation. *Journal of Environmental Psychology*, *25*(3), p. 273-291.

Alexander, C., Ishikawa, S., Silverstein, M. (1977) *A Pattern Language: Towns, Buildings, Construction*. New York, NY: Oxford University Press.

Altman, I. & Low, S. M. (1992) *Place Attachment*. New York: Plenum Press.

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.

Cialdini, R. B., Reno, R. R., & Kallgren, A. (1990). A focus theory of normative conduct: Recycling the concept of norms to reduce littering in public places. *Journal of Personality and Social Psychology*, *58*, p. 1015-1026.

Carrus, G., Sopelliti, M., Fornara, F., Bonnes, M., & Bonaiuto M. (2014). Place-attachment, Community Identification and Pro-Environmental Engagement. In L. Manzo & P. Devine-Wright (eds.), *Place-attachment: Advances in Theory, Methods, and Applications* (p.165-175). New York, NY: Routledge.

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.

Cleetus, Rachel (2016). Delivering on the Paris Climate Agreement: The Oxford 1.5 Degrees Conference Charts a Path. Retrieved (October 25, 2016) from ucsusa.org/rachel-cleetus/.

Cohan, D., Hewitt, D., and Frankel, M. (2010) The Future of Energy Codes. *ACEEE Summer Study on Energy Efficiency in Buildings, 8*, p. 78-87.

Comstock. O. and Jarzomski, K. (2012). Consumption and Saturation Trends of Residential Miscellaneous End-Use Loads. *ACEEE Summer Study on Energy Efficiency in Buildings, 9*, p. 63-74.

Cole, Raymond, (2012). Transitioning from Green to Regenerative Design. *Building Research and Information*, *40*(1), p. 39-53.

Cole, R.J. & Kashkooli, A. M. (2013). Clarifying Net Positive Energy. *Conference Paper, CaGBC National Conference and Expo.*, Vancouver, BC.

Corbin, J. & Strauss, A. (2008). *Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory*. Thousand Oaks, C: Sage Publications, Inc.

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

Creswell, J. W., & Creswell, J. D. (2018). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. Thousand Oaks, CA: Sage Publications, Inc.

De Groot, J. I. M., & Steg, L. (2008). Value Orientations to Explain Beliefs Related to Environmentally Significant Behavior. *Environment and Behavior, 40*(3), p. 330-354.

De Groot, J. I. M., & Steg, L. (2010). Relationships Between Value Orientations, Self-determined Motivational Types and Pro-environmental Behavioral Intentions. *Journal of Environmental Psychology, 30*, p. 368-378.

Desai, P. (2010). *One Planet Communities: A real-life guide to sustainable living*. West Sussex, UK: John Wiley & Sons.

Desai P. & Riddlestone, S. (2016). Bioregional: One Planet Living. *The 10 Principles.* Retrieved (February 12, 2016) from http://www.bioregional.com.

Devine-Wright, P. (2009). Introduction to the special issue: Place, Identity, and Environmental Behavior. *Journal of Environmental Psychology, 30*, p. 267-270.

Devine-Wright, P. (2014). Dynamics of Place-attachment. In L. Manzo & P. Devine-Wright (eds.), *Place-attachment: Advances in Theory, Methods, and Applications* (p. 165-175). New York: Routledge.

Dietz, T., Gardner, G. T., Gilligan, J., Stern, P. C., & Vandenbergh, M. P. (2009). Household Actions can Provide a Behavioral Wedge to Rapidly Reduce US Carbon Emissions. *Proceedings of the National Academy of Science, USA, 1-6* (44), p. 18452-18456.

Dietz, T., Fitzgerald, A., Shwom, R. (2005). Environmental Values. *Annual Review Environmental Resources, 30*, p. 335-372.

Dillman, D., Smyth, J., & Christian, L. (2009). *Internet, Mail, and Mixed-Mode Surveys, The Tailored Design Method*, (p.15-40). Hoboken, NJ: John Wiley & Sons.

Diamond, R. (2003) A Lifestyle-based scenario for US buildings: Implications for Energy Use. *Energy Policy, 31*, p. 1205-1211.

Energy Information Administration (EIA, 2015). Drivers of US Household Energy Consumption, 1980-2009. Retrieved (June 11, 2015) from www.eia.gov.

Eley, C. (2016). *Design Professional's Guide to Zero Net Energy Buildings*. Washington, DC: Island Press.

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.

Faesy, R., Finlayson, I. (2012). Accelerating Energy Efficiency in the New Construction Market with Stretch Codes. *ACEEE Summer Study on Energy Efficiency in Buildings, 8*, p. 80-91.

Farr, D. (2008). *Sustainable Urbanism: Urban Design with Nature*. Hoboken, NJ: John Wiley & Sons.

Faruqui, A., Sergici, S., & Sharif, A. (2010). The Impact of Informational Feedback on Energy Consumption—A Survey of the Experimental Evidence. *Energy, 35,* p. 1598-1608.

Gifford, R. (2009). Environmental Psychology: Manifold Visions, Unity of purpose. *Journal of Environmental Psychology, 29*, p. 387-389.

Gifford, R. (2014). *Environmental Psychology: Principles and Practice*. Colville, WA: Optimal Books.

Gifford, R. (2016). *Research Methods for Environmental Psychology*. West Sussex, UK: John Wiley & Sons.

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.

Guagnano, G. A., Stern, P., & Dietz, T. (1995). Influences on Attitude-Behavior Relationships: A Natural Experiment with Curbside Recycling. *Environment and Behavior, 27*, p. 699.

Horton, D. (2003). Green distinctions: The Performance of Identity among Environmental Activists. *The Social Review*, p. 63-77.

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.

Keizer, K., Lindenberg, S., & Steg, L. (2008). The Spreading of Disorder. *Science. 322* (5908), p. 1681-1685.

Keizer, K., Lindenberg, S., & Steg, L. (2013). The Importance of Demonstratively Restoring Order. PLoS ONE 8(6): 65137. Retrieved (August, 10, 2018) from https://doi.org/10.1371/journal.pone.0065137.

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

Kopec, D. (2006). *Environmental Psychology for Design*. Fairchild Publications, Inc. New York.

Korpela, K. (2013). Place-attachment. In S. Clayton (ed.), *The Oxford Handbook of Environmental and Conservation Psychology* (p. 148-163*)*. New York: Oxford University Press.

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

Lewicka, M. (2008). Place Attachment, Place Identity, and Place Memory: Restoring the Forgotten City Past. *Journal of Environmental Psychology, 28*, p. 209-231.

Lewicka, M. (2010). What Makes Neighborhood Different from Home and City? Effects of Place Scale on Place Attachment. *Journal of Environmental Psychology, 30*, p. 35-51.

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. (2003). Beyond House and Haven: Toward a Revisioning of Emotional Relationships with Places. *Journal of Environmental Psychology, 23*, p. 47-61.

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.

McCamant, K., Durrett, C., & Hertzman, E. (1994). *Cohousing: A Contemporary Approach to Housing Ourselves*. Berkeley, CA: Ten Speed Press.

McKenzie-Mohr, D. (2000). Promoting Sustainable Behavior: An Introduction to Community-Based Social Marketing. *Journal of Social Issues, 56* (3), p. 543-554.

McKenzie-Mohr, D. (2011). *Fostering Sustainable Behavior: An Introduction to Community-Based Social Marketing*. Gabriola Island, BC, Canada: New Society Publishers.

McKenzie-Mohr, D., Lee, N., Schultz, P., Kotler, P. (2012). *Social Marketing to Protect the Environment: What Works*. Los Angeles, CA: Sage Publications.

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

McNary, B. & Berry, C. (2012). How Americans are Using Energy in Homes Today. *ACEEE Summer Study on Energy Efficiency in Buildings, 1*, p. 204-215.

Mihaylov, N. & Perkins, D. (2014). Community Place Attachment and its Role in Social Capital Development. In *Place Attachment: Advances in Theory, Methods and Applications*. Manzo & Devine-Write (eds.). New York, NY: Routledge.

Misuriello, H. (2011). Recent Energy Efficiency Advances in Building Energy Codes. ACEEE Webinar. Retrieved (June 11, 2015) from www.aceee.org.

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.

Moser, G. (2009). Quality of Life and Sustainability: Toward Person-environment Congruity. *Journal of Environmental Psychology, 29*, p. 351-357.

Perlaviciute, G. & Steg, L. (2014). Contextual and Psychological Factors Shaping Evaluations and Acceptability of Energy Alternatives: Integrated Review and Research Agenda. *Renewable and Sustainable Energy Reviews, 35*, p. 361-381.

Proshansky, H. M., Favian, A. K., & Kaminoff, R. (1983). Place-identity: Physical World Socialization of the Self. *Journal of Environmental Psychology, 3*, p. 57-83.

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.

Raymond, C., Brown, G., & Weber, D. (2010). The Measurement of Place-attachment: Personal, Community, and Environmental Connections. *Journal of Environmental Psychology, 30*, p. 422-434.

Residential Building Stock Assessment (RBSA, 2011). *Single-Family Characteristics and Energy Use. Prepared for the Northwest Energy Efficiency Alliance (NEEA).* Seattle, WA: Ecotope.

Residential Building Stock Assessment (RBSA, 2014). *Metering Study. Prepared for the Northwest Energy Efficiency Alliance (NEEA)*. Seattle, WA: Ecotope.

Residential Energy Consumption Survey (RECS, 2009). Data: Site Energy End Use, Region 4, Division 10, AIA Zone 4, Climate 5, and Marine. Retrieved (June 11, 2015) from www.eia.gov.

Robson, C. & McCartan, K. (2011). *Real World Research: A Resource for Users of Social Research Methods in Applied Settings*. West Sussex, UK: John Wiley & Sons.

Rovelli, C. (2014). *Seven Brief Lessons on Physics*. New York, NY: Riverhead Books.

Saldana, J. (2009). *The Coding Manual for Qualitative Researches*. London, UK: Sage Publishing 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.

Schultz, W. P. (2001). The Structure of Environmental Concern: Concern for Self, other People, and the Biosphere. *Journal of Environmental Psychology, 21*, p. 327-339.

Schultz, W. P. & Kaiser, F. (2012). Promoting Pro-Environmental Behavior. In S. Clayton (ed.), *The Oxford Handbook of Environmental and Conservation Psychology* (p. 557-580). New York, NY: Oxford University Press.

Schultz, W. P. & Tabanico, J. (2007). Self, Identity, and the Natural Environment: Exploring Implicit Connections with Nature. *Journal of Applied Social Psychology, 37* (6), p. 1219-1247.

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. In *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., & Bardi, A. (2001). Value Hierarchies Across Cultures: Taking a Similarities Perspective. *Journal of Cross Cultural Psychology, 32*, p. 268-290.

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

Steg, L. (2008). Promoting Household Energy Conservation. *Energy Policy, 36*, p. 4449-4453.

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.

Steg, L. & De Groot, J. (2013). Environmental Values. In S. Clayton (ed.), *The Oxford Handbook of Environmental and Conservation Psychology* (p. 81-92*)*. New York, NY: Oxford University Press.

Steg, L. & De Groot, J. (2010). Explaining Prosocial Intentions: Testing Causal Relationships in the Norm Activation Model. *British Journal of Social Psychology, 49*, p. 725-743.

Steg, L., De Groot, J., Dreijerink, L., Abrahames, W., & Siero, F. (2011). General Antecedents of Personal Norms, Policy Acceptability, and Intentions: The Role of Values, Worldviews, and Environmental Concern. *Society & Natural Resources, 24* (4), p. 349-367.

Steg, L., Dreijerink, L., & Abrahamse, W. (2005). Factors Influencing the Acceptability of Energy Policies: A Test of VBN Theory. *Journal of Environmental Psychology, 25* (4), p. 415–425.

Steg, L., Perlaviciute, G., Van der Werff, E., Lurvink, J. (2014b). The Significance of Hedonic Values for Environmentally Relevant Attitudes, Preferences, and Actions. *Environment and Behavior, 46* (2), p. 163-192.

Steg, L., Van Den Berg, A., & De Groot, J. (2013*). Environmental Psychology: An Introduction.* West Sussex, UK: BPS Blackwell and John Wiley & Sons.

Steg, L. & Vlek, C. (2009). Encouraging pro-environmental behavior: An integrative review and research agenda. *Journal of Environmental Psychology, 29*, p. 309-317.

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.

Tabachnick, B. & Fidell, L. (2007). *Using Multivariate Statistics*. Pearson, Boston, MA.

Twigger-Ross, C. & Uzzell, D. (1996). Place and Identity Processes. *Journal of Environmental Psychology, 16*, p. 205-220.

U.S. Department of Energy (DOE, September 16, 2015). Retrieved (August 10, 2018) from https://www.energy.gov/eere/buildings/articles/doe-releases-common-definition-zero-energy-buildings.

U.S. Green Building Council (USGB) (2016). Online *LEED for Homes Reference Guide and Rating System* PDF. Retrieved (February 12, 2016) from http://www.usgbc.org/leed.

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.

Van der Werff, E., Steg, L., & Keizer, K. (2013c). It is a Moral Issue: The Relationship between Environmental Self-identity, Obligation-based intrinsic Motivation and Pro-environmental Behavior. *Global Environmental Change, 23*, p. 1258-1265.

Williams, D. R. & Vaske, J. J. (2003). The Measurement of Place Attachment: Validity and Generalizability of a Psychometric Approach. *Forest Science, 49* (6), p. 830-840.

Whitmarsh, L. (2009). Behavioral Responses to Climate Change: Asymmetry of Intentions and Impacts. *Journal of Environmental Psychology, 29*, p. 13-23.

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.

Zeisel, J. (2006). *Inquiry by Design*. New York, NY: W. W. Norton & Company.

Appendix 1: Interview Instrument

Introduction: As you know, with my research broadly, I am interested in learning about people's use of energy and how the design of their home might affect their energy use. However, in these interviews, I am curious to know more about your **feelings** toward your home and how you **interact** (think, feel, and act) with the physical aspects of your home and community's design, especially in regard to energy use and in what ways this might be meaningful to you.

First, let's start with some background information:

Q1. When did you move here?

Q2. Thinking back on the time when you first moved here, do you recall why you chose this place?

a) What are some of the main reasons why you chose to live here?
b) Can you tell me more about that?
c) What do you recall being really important to you as you made your choice?

Now I would like to know more about how you feel about this place.

Q3: What do you like best about living here? (First allow free form response.)

a) What aspects of individual housing unit do you like best?
b) What community aspects do you like best?
c) Are there any physical attributes of this place that you like in particular?
d) Can you tell me more about that? Why?

Q4: What do you like least about living here?

a) What do you like least about your: individual housing unit, community aspects and physical attributes?
b) What would you like changed?
c) Why is that?

Q5: Do you a have sense of connection to this place or feel attached to it in anyway?

a) Broadly, how do you feel about this place?
b) How would you characterize your connection to it?

Q6: Do you feel established, connected, or grounded to this place?

a) In what way?
b) What is it about this place that makes you feel this way?
c) Tell me more about that.

Q7: Do you feel that this place is an expression of who you are as a person?

a) Do you identify with this place?
b) In what ways?
c) How does this place align with your values?
d) How does it "fit" with your image of yourself or lifestyle?

Q8: In what ways do you feel this place supports your current and desired lifestyle with respect to the environment, both physically and emotionally?

a) How does it support you hopes and aspirations?
b) Why is that important to you?

- An example might be someone who rides their bike finds it easy to do so because the streets have designated bike lanes and this makes them feel….

Q9: Do you enjoy taking care of your place and making improvements?

a) In what way?
b) How are these things important to you?

- An example: Keeping your solar panels in good operating order or the garden well cared for might make you feel….

As you know, I am interested in sustainability and environmental behavior so now I'd like to ask you a few questions related to that.

Q10: How do you feel that your actions impact the environment around you, both in your home and in the community?

a) Do you see yourself as engaging in conservation and sustainable actions?
b) What are these?
c) Can you tell me more this?

Q11: Are there things that you do on a day-to-day basis that you think are environmental?

a) Can you tell me more about the things you do?

- An example: some people may make choices about the transportation they use, or what they do inside their home that they think is good for the environment.

Q12: How does doing these things make you feel?

a) In what ways are doing these things meaningful to you?

Q13: In what ways, if any, do you feel that the design of your home and community encourage you to think about the environment or act in ways that benefit the environment?

a) Do you think that the design of your home influences your energy use? [If so:] In what ways?

—Probe for each if not explicitly mentioned in initial response:

- Home:
    - What are they?
    - The solar array on your roof
    - The amount of daylight in your home
    - The sustainable materials in your home
    - The efficient heating and air filtering systems
    - Energy efficient appliances
    - The energy efficient hot water tank
    - The smaller footprint of you home
    - The windows and building envelope
    - Any other design features that are important for you

- Community-level features that you think influence your energy use?
    - What are they?
    - The rain gardens
    - The vegetable gardens along
    - The winding pathways leading to your home,
    - The emphasis on bike and walking paths
    - The remote parking
    - The car recharging station
    - The community spaces
    - Any other design features that are important for you

Now I'd like to ask some questions about the energy use dashboard that was installed in your home. (Thank you for allowing me to have that installed.)

Q14: Did you look at the dashboard feedback at all?

If YES: How often?

a) How did you react when you saw the feedback?
b) In what ways was the information you were provided useful?
c) Was there anything about it that was not useful?
d) Did receiving the feedback influence your actions in any way? How?

IF NOT, or VERY LITTLE:

a) What deterred you from looking at this feedback?
b) What, if anything, would have made it more useful?

Q 15: How did you feel about the "alerts" emailed to you giving you information on your energy use in your home?

a) Were you interested in the energy alerts?
b) Can you tell me how they may have been helpful to you?
c) Did you seek to customize your alerts on the dashboard or contact me to revise defaults?
d) Did you change your behavior or seek information because of the alerts?
e) What was the most important thing that you learned because you had access to the dashboard and alerts?

Finally, I am curious about your interest in the UW energy use study more broadly:

Q 16: Why did you want to learn more about your energy use?

Q17: What surprised you about what you learned?

Q18: What else would you like to share about your experience knowing more about your energy use?

Thank you so much for your participation!

Appendix 2: Glossary of Terms

AC	Air conditioning
ACH	Air changes per hour—this is a measure of the air leakage of a building, calculated using a blower door at a standard pressure difference of 50 pascals between inside the home and outside, referred to as ACH50.
Air Leakage	Air leaks from the building are given at a rate of X times the volume of the building per hour at ACH50. A leaky building might be 10 ACH50, while a high-performance building is typically 1 ACH50 or less. Retrieved (August 16, 2018) from https://www.energyvanguard.com/)
Altruistic	Concern for the well-being of others (Steg, Van Den Berg, De Groot, 2013)
ANOVA	Analysis of variance
ASHP	Air source heat pump
ATLAS.ti	Qualitative data analysis software (https://atlasti.com/)
Benchmarking	Comparison of the measured performance of a building's energy use to other established measures (e.g., EUI in 2014 compared to 2015, 1016, and 2017). Retrieved (August 16, 2018) from https://www.merriam-webster.com/dictionary/benchmark)
Biospheric	Concern for the well-being of the environment (Steg, et al., 2013)
Btu/hr.	British thermal unit per hour—is a measurement of the amount of thermal energy necessary to raise the temperature of one pound of liquid water by one-degree Fahrenheit (Retrieved (August 8, 2018) from https://www.eia.gov/energyexplained/index.php?page=about_btu)
Built Green	Homes are designed to reach beyond current WA state building and energy codes (e.g., 5-Start Built Green: 30% energy use improvement above current WA State Code and pre-wired for any future solar installations or installed solar PV). (Retrieved (August 8, 2018) from https://www.builtgreen.net)
Code-built	Building and energy codes in a given area sets the minimum legal limit for performance of a building. Building codes are state laws. States or local governments can choose to adopt one of the national model energy codes, a modified version of the model code, or their own state-specific code. (Retrieved (August 8, 2018) from https://www.energy.gov)
DHW	Domestic hot water heater
DMS	Ductless mini-split heat pump mechanical unit
Egoistic	Concern for protecting one's own resources (Steg, et al., 2013)
EL	End-Use Load—is the amount of electric energy in kWhs that a device uses.
ESI	Environmental Self-identity (also Green Self-identity) is about one's incorporation of pro-environmental beliefs and actions into a larger concept of the self (Van der Werff, Steg, & Keizer, 2013; Whitmarsh & O'Neill, 2010).
EUI	Actual measured energy use intensity score measured in kBTU/sq.ft.yr.
GBE	Green Built Environment—represents physical sustainable attributes

GSE	Green Social Environment—represents social sustainable attributes
Hedonic	Concern for gratification and pleasure (Steg, et al., 2013)
HP	Heat pump
HVAC	Heating, ventilation, and air conditioning
IDT	Indoor temperature
ILFI	International Living Futures Institute (https://living-future.org/)
kBTU/sq.ft.yr.	Kilowatt, British thermal unit, per square foot, per year
kW	Kilowatt
kWh	Kilowatt hours
kWh/yr.	Kilowatt hours per year
LED	Light-emitting diode
MELs	Miscellaneous end-use loads
NEEA	Northwest Energy Efficiency Alliance
OPL	One Planet Living Principles (https://www.bioregional.com/oneplanetliving/)
PA	Place Attachment is a cognitive-emotional bond that people develop towards a place that may be positive or negative and consists of person, place, and process dimensions. The person dimension describes person who is attached as an individual or part of a collective. The place dimension includes what the person is attached to, including the social and physical qualities of important places. The process dimension relates to how people express and experience their attachment through emotional bonds (e.g., joy, pride, love, (un)happiness), cognitive aspects (e.g., knowledge, memories, and beliefs), and behaviors (e.g., frequent visits to or care and maintenance) related to what makes a place meaningful (Gifford, 2014).
PEB	Pro-environmental behavior (e.g., actions that benefit the environment)
iPHA	International Passive House Association (https://www.passivehouse-international.org/)
PI	Place Identity is about one's assimilation of place into a larger concept of the self. It provides a person with a sense of self-esteem, self-efficacy, and a sense of distinctiveness (Gifford, 2014)
PSE	Puget Sound Energy utility company (https://pse.com/)
QT, qt	Quarter, specifically in reference to three months of the calendar year
RBSA	Residential Building Stock Assessment (RBSA, 2014)
RECS	Residential Energy Consumption Survey (RECS, 2009)
SF	Single-Family
SPSS	Quantitative statistical analysis software (www.ibm.com/DataStatistics/SPSS)
sq. ft.	Square feet
W/sq. ft.	Watts per square foot[76]

[76] Source for all glossary terms: RBSA, 2014, p. x-xii (unless otherwise noted).