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The Social Construction of Performance-Based Design

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The Social Construction of Performance-Based Design

by

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Abstract

The Social Construction of Performance-Based Design

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Construction and operation of commercial and residential buildings in the United States have been identified as the single largest sector of energy consumption and contributor to greenhouse gas emissions. Subsequently, buildings must be a primary target for reductions. From short-term incentives, to long-term milestones, building energy efficiency, specifically net zero energy buildings, have emerged as a significant and unprecedented objective for a variety of public and private organizations in the United States. Altering the practices of the building culture requires not only technological innovation, but also an understanding of how practitioners within the building culture see their role in transforming it. Consequently my research seeks to understand how building industry professionals comprehend their capacity to influence the cultural boundaries of their profession in order to account for and mitigate the impacts of energy and emissions in the built environment. Ultimately, this study is an investigation into the social construction of technological change.

The AIA+2030 Professional Series offered by the Denver Chapter of the American Institute of Architects has served as the single case study for this investigation. By limiting local conditions to the Denver-based Series and defining advocates as the self-selected group of participants, I've narrowed this analysis to reflect a workable microcosm of practitioners who are committed to the investigation and integration of net zero energy design, construction, and building operation practices. In order to substantiate this empirical analysis, I employed a triangulated series of data collection and interpretation consisting of: participant observation, interviews, and a survey. Data analysis involved an iterative process of coding and categorizing the primary key words and themes that emerged throughout my investigation.

Each of the perspectives offered during this investigation indicate that architects who are advocates of net zero energy building design perceive that consequential opportunities for fundamental change exist within the social and cultural facets of the building culture. Ultimately, by preferencing social and cultural activism over technological manipulation, these advocates have corroborated the notion that technological change is fundamentally rooted in social change.

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I. Introduction

> To meet the challenges of the coming decades, it is critical that designers consider and adopt values appropriate to the nature of the problems being confronted – both at the individual project scale and globally. Nothing less makes sense (Grondzik, Kwok, Stein, & Reynolds, 2010, p. 4).

This sentiment, expressed by Grondzik et al. (2010), captures an unfolding development that challenges the building industry to respond to broader issues of environmental concern. While this statement can apply to a number of problems facing the built environment, national and international organizations are increasingly applying this line of thinking to impacts associated with building energy consumption.

Over the past decade, in response to concerns related to climate change, legislative and non-governmental organizations have introduced a variety of voluntary and regulatory measures aimed at mitigating the inordinate amount of energy consumed in U.S. buildings. From the popularization of the *2030 Challenge* issued by *Architecture 2030*, which advocates that buildings reduce their reliance upon all fossil fuel greenhouse gas emitting energy to operate by the year 2030; to the passage of the *Energy Independence and Security Act of 2007*, which requires that all new construction or major renovations of federal buildings reduce fossil-generated energy use 55% by 2010, and 100% by 2030 (National Science and Technology Council, 2008), it's apparent that building energy efficiency, specifically net zero energy buildings, constitute a significant and unprecedented objective of various institutional and legislative agendas in the United States.

In light of the current emission impacts associated with U.S. buildings, I presume that altering the course of the building sector from substantial consumption to unprecedented conservation will require a comprehensive transformation of the design, construction, and operational practices associated with buildings. Practitioners who have successfully completed net zero energy buildings have acknowledged that these types of projects challenge professionals to acquire innovative knowledge and integrate alternative procedures while simultaneously attempting to acknowledge, interpret, and respond to the inconspicuous, yet ubiquitous, phenomenon that influence energy consumption.

In 2009, the Seattle chapter of the *American Institute of Architects* (AIA) partnered with *Architecture 2030*, *BetterBricks*, and the *City of Seattle* to develop a training program aimed at assisting the building industry in their efforts towards meeting the proposed energy and emission reduction targets for buildings (AIA+2030 Professional Series, n.d.a). Referred to as the *AIA+2030 Professional Series*, the objective of the program is to offer practitioners the fundamental, "knowledge and leverage to create next-generation, super-efficient buildings—and provide firms with the skills that will set them apart in the marketplace" (AIA+2030 Professional Series, n.d.a). More specifically, the training "aims to provide an overall understanding of specific design strategies and how they can be integrated to provide optimal results" (AIA+2030 Professional Series, n.d.b). At the conclusion of the *Series*, practitioners will have gained forty-hours of cumulative performance-based design training, and will be "provided tools to take back to their firms to help share and implement the knowledge and skills gained" with their respective building industry associates (AIA+2030 Professional Series, n.d.b).

In January of 2011, the Denver chapter of the *AIA* commenced a locally tailored iteration of the *Series*, which represented an exemplary educational effort aimed at fostering technological change for the industry. Adapted from the *AIA Seattle* curriculum, the Denver *Series* was selected as the single case study for this investigation because functionally, it served as the second iteration of the national *AIA+2030 Professional Series* to be offered. Additionally, long-standing social resources in the

Denver market have reinforced my interest in the development of architectural practice in Colorado.

Through the curriculum of the *AIA+2030 Professional Series*, and the perspective of the Denver-based participants, my research seeks to characterize the intersection of performance-based design theory with the deeply embedded cultural characteristics of the building industry, or what Howard Davis refers to as the "building culture" (Davis, 2006). By doing so, I am seeking to explore beyond research and development theories about technological innovation and uncover the realities that exist in practice. In other words, my research is an investigation into the social construction of technological change. Ultimately, this investigation aims to answer the following research question:

> How do architects, who are advocates of net zero energy building design, perceive their role in transforming the sociotechnical sub-practices of the profession?

For the purpose of this analysis, the following key terms are defined as follows:

Architects - Technically speaking, architects are individuals that have been trained and licensed to design buildings and environmental spaces. In the practice of architecture, architects typically serve as the visionary and creative directors of a project who collaboratively guide various building specialists towards meeting the client's goals.

Advocates - Represent a self-selected group of individuals who see net zero energy building design knowledge as valuable to themselves and the world. Specifically for the purposes of this investigation, advocates are those individuals who have enrolled the *AIA+2030 Professional Series*.

Net Zero Energy Building (NZEB); also referred to as Zero Energy Buildings (ZEB) - While scholars have acknowledged that the industry currently lacks a common definition of what comprises a net zero energy building (NZEB), the *Energy Independence and Security Act of 2007* (EISAct 2007) has defined a NZEB as: "a commercial building that is designed, constructed, and operated to: (A) require a greatly reduced quantity of energy to operate; (B) meet the balance of energy needs from sources of energy that will result in no net greenhouse gas emissions; (C) therefore result in no net emissions of greenhouse gases; and (D) be economically viable" (National Science and Technology Council, 2008).

Perceive – Indicates how individual architects personally understand, internalize, and conceptualize the energy challenge and proposed net zero energy solution.

Role – Represents the advocate's sense of responsibility, personal inclination, and practical ability to advance net zero energy design practices and serve as a change agent within the building industry.

Transforming - The alteration of knowledge, rules, habits, and values to specifically account for, and mitigate, energy-related impacts that result from design, construction, and building operation practices.

Sociotechnical – Indicates the combined social relationships and technical practices that reinforce each other to define and give meaning to the varying cultures and practices of architecture.

Sub-practices – Represent the social, technological, and organizational procedures that have been identified as viable energy-based mitigation strategies for the built environment.

Profession – The collective social, political, and institutional aspects that are representative of, and specific to, architectural practitioners.

Performance - For the purposes of this investigation, performance specifically refers to the energy-based facets of building design, construction, and operation. Performance is evaluated by measuring the quantifiable energy use associated with individual buildings. Net zero energy is one measure of building performance.

Design Professionals – Design professionals constitute all individuals who've received either formal or informal training to foster the development of buildings and environmental spaces.

By expanding the research agenda to include the point-of-view of practitioners, I've attempted to gain a more thorough understanding of how innovations, specific to net zero energy buildings, both shape and respond to the prevailing social, technical, and institutional contexts of the conventional building culture. In other words, by surveying those individuals who are actively engaged with the internal pressures of the building culture, my research explores how the goals of net zero energy design complement or compete with the deeply entrenched knowledge, rules, and values of the conventional building culture. By doing so, I've been able to explore beyond the theoretical confines of what has been advised, and reveal what is actually transpiring. Through this empirical analysis, I aim to broaden the discourse of those directly engaged with this challenge; while inspiring additional inhabitants to contribute their perspective.

II. Methodology and Methods

2.1 - METHODOLOGY

I fundamentally align with the notion that interpretations of "reality" are largely influenced by multiple socially constructed perspectives. For that reason, my research is guided by a qualitative, or critical constructivist system of inquiry. By approaching this investigation through an examination based upon the social construction of technology, I've analyzed how technological innovations, specific to net zero energy buildings, both shape and respond to the social, technical, and institutional contexts of conventional building design. Essentially, my aim has been to explore how individual and institutional interpretations about building energy conservation are constructing cultural values related to energy-efficiency.

Committed to the notion that technical change is influenced by, and emerges out of, "local, (cultural), and temporally specific working environments," (Shove, 1998, p.1108) I've chosen to employ the practice of grounded theory for this investigation. In other words, I've allowed for the characterizations and interpretations that unfold throughout the course of my research to guide my analysis and inform my theories. By limiting "local" conditions to the Denver-based *AIA+2030 Professional Series* and defining advocates as the self-selected group of *Series* participants, I've narrowed this analysis to reflect a workable microcosm of practitioners who are committed to the investigation and integration of performance-based design, construction, and building operation practices.

2.2 - SELECTED CASE

The *AIA+2030 Professional Series* offered by *AIA Denver* and the *AIA Denver Committee on the Environment* has served as the single case study for this investigation.

Adapted from the *AIA Seattle* curriculum, the Denver *Series* was comprised of ten, four-hour sessions and was offered on a monthly basis beginning in January and ending in November of 2011. The following individual sessions and corresponding *AIA+2030* learning objectives were presented during the *Series* by, "experts from academia and active practice" (AIA+2030 Professional Series, Sessions n.d.b).

Session 1 - The 2030 Challenge: Setting + Achieving Energy Goals with Integrated Design™

Set energy performance targets early to inform design objectives.

Justify the inclusion of integrated energy efficiency strategies in projects.

Teach other design professionals in their firm and community about advanced energy efficiency strategies for buildings.

Session 2 - Getting to 60: the Power of Targets + Load Reductions™

Describe the energy/carbon objectives of the 2030 Challenge.

Use the Energy Star Target Finder tool to set an Energy Use Intensity target for a project.

Summarize the concept of Energy Use Intensity (EUI) and describe why it is an important tool for setting energy targets.

Session 3 - Accentuate the Positive: Climate Responsive Design™

Produce a building form and orientation strategy that is responsive to site and climatic factors.

Explain why climate responsive design reduces the energy load of a building.

List the site and climate factors that impact a building's performance.

Session 4 - Skins: the Importance of the Thermal Envelope™

Identify critical elements of the thermal envelope responsible for building energy consumption.

Specify strategies for minimizing thermal bridging.

Understand the architectural elements, materials, and construction opportunities for designing a high performance thermal envelope.

Session 5 - Passively Aggressive: Employing Passive Systems for Load Reduction™

Define passive systems and identify specific elements of a passive design.

Evaluate the effectiveness of various passive strategies based on available site resources.

Determine the most successful strategies for a given site.

Session 6 - Illuminating Savings: Daylighting and Integrated Lighting Strategies™

Evaluate various building forms and orientations for optimal daylighting potential.

Compare competing designs to determine the most effective approach to daylighting.

Assess a lighting scheme for its compatibility with an accompanying daylighting design.

Session 7 - Right-sized: Equipment and Controls for Super-Efficient Building Systems ™

Apply right-sizing after passive energy conservation strategies.

Utilize controls to optimize the efficiency of equipment.

Enumerate energy efficient strategies to maintain occupant comfort.

Session 8 - Site Power: Renewable Energy Opportunities™

Identify the major on-site renewable energy strategies for buildings.

Propose an appropriate renewable energy strategy based on site characteristics and resources.

Enumerate the life cycle costs and benefits of on-site renewable energy.

Understand how district energy can provide thermal and electric services and balance neighborhood loads.

Session 9 - The Hand-off + Staying in Shape: Operations, Maintenance + Education™

Explain the benefits of monitoring, evaluation, and education to design firms, clients, and building occupants.

Explain and advocate for commissioning on projects.

Instruct building maintenance and operations staff on optimizing building performance.

Session 10 - Putting it All Together: Achieving 2030 Goals on the Project and at the Office™

Set energy performance targets early to inform design objectives.

Justify the inclusion of integrated energy efficiency strategies in projects.

Teach other design professionals in their firm and community about advanced energy efficiency strategies for buildings (AIA+2030 Professional Series, n.d.c).

Ultimately, the topics covered in each of these sessions represent the proposed sociotechnical sub-practices of the performance-based building culture.

2.3 - METHODS

In order to substantiate this analysis, I employed a triangulated series of data collection and interpretation consisting of: participant observation, interviews, and a final survey. Over the course of the ten-part *Series*, these methods were employed in order to gain insight into the manner in which energy-based performance indicators and design professionals are collectively influencing the design, construction, and building operation practices thought to elicit the desired energy and emission reductions, and ultimately create net zero energy buildings.

A. Participant Observation

By observing the participants in the cultural context of the *Professional Series*, I gained insight into the industry-specific knowledge, tools, and strategies for creating net zero energy buildings; while simultaneously obtaining a first-hand sense of practitioners responses to the perceived demands, risks, opportunities, and barriers associated with those proposed modifications. Throughout this process, I was provided an overview of the emerging energy-related actions, ideas, and values that are presented as a viable means for addressing the building energy challenge. Ultimately, this allowed me to conceptualize and analyze the social and technical, or sociotechnical, sub-practices of net zero energy design.

Data collection primarily involved the use of handwritten notes, and in some instances, included the pre-authorized use of audio recording equipment. Data analysis involved an iterative process of coding and categorizing the primary key words and themes that emerged during each individual session. Throughout the duration of my investigation, the cultural, organizational, and technological realignments, or proposed sociotechnical sub-practices of net zero energy design, were revisited and reinterpreted in order to derive additional themes and concepts about the energy-based transformation mechanisms recommended for practice.

B. Interviews

Throughout the *Series*, a total of seven individual interviews were conducted in order to elicit a more in-depth and contextual understanding of practitioners reactions to how the proposed sociotechnical sub-practices of net zero energy design relate to, and renegotiate, the existing sociotechnical methods of their conventional practice. Each interview followed an open-ended, semi-structured format and was strategically scheduled throughout the duration of the *Series* in response to the interest and availability of the interviewees. Participation was voluntary and open to any willing student and/or instructor.

During the interviews, the following general areas of interest were addressed: how individual motivations for change are supported or hindered by institutional and cultural opportunities to foster change; why practitioners are optimistic and/or pessimistic about change; what they value about energy efficiency and sustainability; how practitioners respond to the process of acquiring new knowledge and skills; and general feelings about positioning the design process as a tool for innovation and architectural practitioners as agents of change. To further contextualize their responses, the interviewees' were asked to share information such as: their educational background; role within the firm; and typical project experience.

Data collection involved the combined techniques of handwritten notes and the pre-authorized use of audio recording equipment. Data analysis involved an iterative process of coding and categorizing the primary key words and themes that emerged during each individual interview. Following each individual interview, I engaged in memoing, or theory building, by interpreting and synthesizing the primary categories, themes, and patterns of meaning that described the interviewees sense of responsibility, personal inclination, and practical ability to advance net zero energy design and serve as change agents within the industry. These various memos were revisited and reinterpreted throughout my investigation in order to derive additional themes and concepts. Ultimately, the major themes that emerged from this open-ended process of coding and memoing contributed to the formation of the final internal and external forces that influence the ability of practitioners to achieve a net zero energy status for their projects. Essentially, these themes provide a deeper understanding of the capacity for action amongst individual practitioners and have informed my analysis of the propensity for change within conventional building culture.

C. Survey

A few months following the conclusion of the individual class sessions, a web-based survey was distributed to each participant enrolled in the *Series* in order to assemble broad-based information about the opportunities and barriers associated with net zero energy design. The specific survey questions were informed by insight gained through the processes of observation, interviews, and memoing. Because the survey was designed to generate feedback regarding individual abilities to implement the proposed net zero energy design practices, it was distributed in March of 2012 in order to provide practitioners with time to reflect on the lessons learned, as well as potentially implement net zero energy design strategies into their practice and projects.

Overall, the survey was distributed via email to sixty-three individuals, with a total of twenty-seven people completing the questionnaire; generating an overall response rate of 42.8%. Ultimately comprised of sixteen questions and one bonus question, the first three survey questions were intended to provide general background information on the *Series* participants. By asking the respondents to indicate their primary role in the building industry; total years of practice; and size of firm or office in which they're employed, I was able to generate the following profile of the *Series* participants, or net zero energy design advocates.

To ascertain the type of professionals who were drawn to serve as net zero energy design advocates, I first asked the respondents to, "select, or write-in, the title that best describes their primary role in the building industry." While the majority of individuals indicated they serve as Licensed Architects (69.2%), the second highest participants

Design Professionals and Principals (each at 15.4%). In total, Licensed Engineers represented the smallest percentage of respondents (at 3.8%).

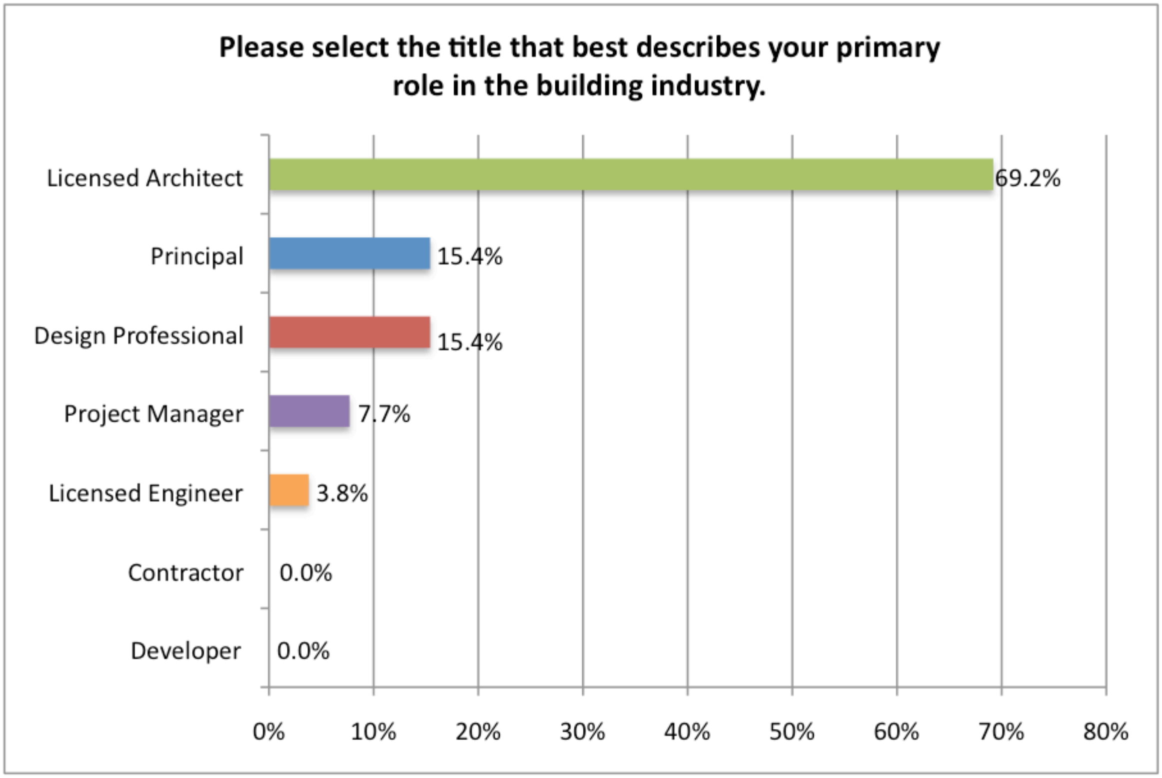

Figure 1 – Survey Question Number One – Primary Role

Next, in order to gauge the amount of professional experience earned by the advocates, I asked the respondents to, "select the range that best describes the number of years they've been practicing." The majority of respondents (65.4%), indicated they've been serving in the building industry for 21 years or more; while junior professionals, or those with ten or less years of experience, represented the second largest majority (19.2%). Individuals with eleven to twenty years of experience represented a slightly smaller proportion of the sample size (15.4%).

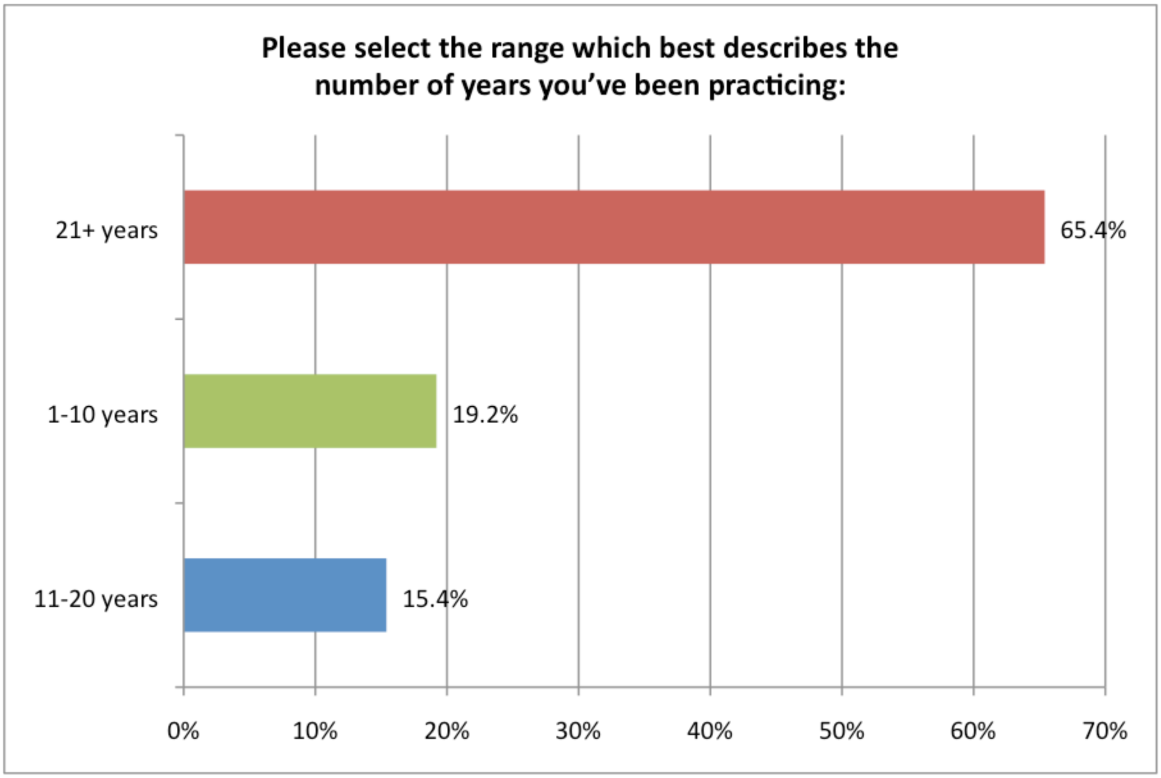

Figure 2 – Survey Question Number Two – Years Practicing

Finally, in order to determine if interest in net zero energy design is trending specifically towards large, medium, or small firms, I asked the respondents to, "select, or write-in, the term that best describes the size of their office or firm." Overall, an even sampling of firm sizes were represented; with large and medium-sized firms tying for the largest majority of representative organizations (each at 29.6%), and smaller firms constituting virtually the same level of participation (25.9%). Representatives from government agencies (11.1%), and those currently unemployed and/or retired (3.7%) represented the smallest number of respondents.

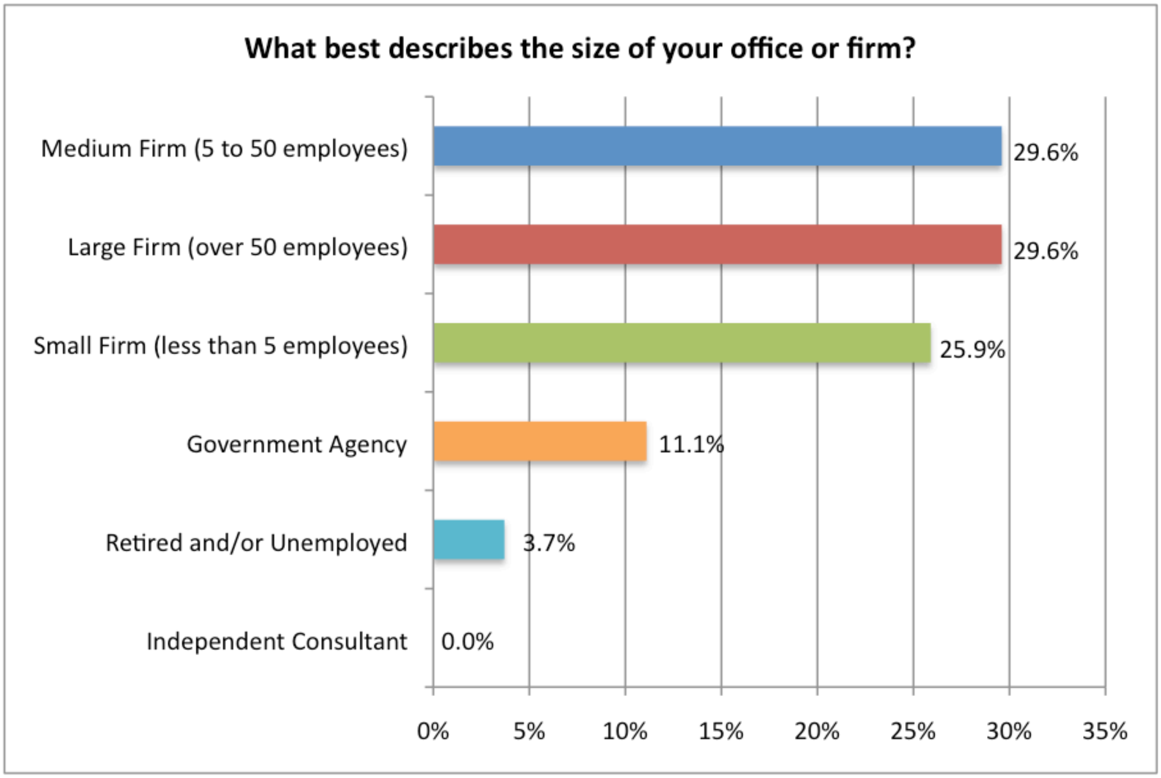

Figure 3 – Survey Question Number Three – Size of Office or Firm

By virtue of these three questions, I not only established a general profile of the net zero advocates enrolled in the *Series*, but I was able to determine that, at this time in the Colorado market, net zero energy design appears to represent a desirable and viable opportunity for a diverse range of professionals, firms, and their subsequent design specializations. While this is a positive finding for the ultimate goal of reducing energy and emissions in the built environment, it should also be valued as an indicator that alternative net zero energy design objectives might not evolve to represent a fragmenting force for Colorado's design professionals and building industry.

2.4 - Representation of Research Subjects

Because my intention is to impartially represent the perceptions of net zero energy design advocates, the identity of all research participants (including: Series instructors, interviewees, and survey respondents) has been kept confidential by dissociating individual names from their responses. Additionally, only those individuals who've provided their consent to participate in this research have been utilized in my research findings. In other words, any and all statements made by students during class sessions were not transcribed during my analysis, nor quoted in this report.

In order to contextualize the statements and ideas provided by willing participants, each statement or survey finding has been assigned a code based on each individual's professional designation and total years of practice. The following chart demonstrates the codes, rather than personal identities, that are associated with each research participant.

Type of Professional	Number of Years in Practice		
	1-10 years Beginner	11-20 years Mid-Level	21+ years Veteran
Architect	AR1	AR2	AR3
Engineer	EN1	EN2	EN3
Design Professional	DP1	DP2	DP3

Figure 4 – Coding of Research Participants

Throughout all phases of this investigation, my primary objective has been to determine how architects, who are advocates of net zero energy building design, perceive their role in transforming the sociotechnical sub-practices of the profession. While my research methods of observation, interviews, and surveying have ultimately enabled me to obtain empirical insight for my inquiry, my analysis was also influenced by research previously conducted by scholars in the fields of Social, Political, and Building Sciences. In the following Chapter, I'll examine the principal theories and research findings that have fundamentally guided this investigation and informed my perceptions. By doing so, I aim to demonstrate the overall purpose of this research, and more specifically, clarify the intent of my research question.

III. Previous Research

The literature that has guided this investigation has been organized into the following research categories: Science and Technology Studies (STS); Sustainability; Performance-Based Design; Policy; and Net Zero Energy Design in Practice. The primary influences from each of these disciplines will be explored in the following sections.

3.1 - Science and Technology Studies

The field of Science and Technology Studies (STS) has inspired the foundational framework and the underlying methodology and methods of my research. Broadly speaking, this emergent paradigm is concerned with the significance and affect of social influences on technological development and cultural change; or as otherwise understood, the "co-construction" of society and technology (Guy & Moore, 2005, p. 231).

Emerging out of opposition to "intellectual and political" conventions which have framed technology as, "a separate sphere, developing independently of society, following its own autonomous logic, and then having 'effects' on society" (MacKenzie, & Wajcman, 1999, xiv), STS scholars (Guy, Hughes, Rohracher, Shove, and Moore) have investigated an alternative framework that "reconnect(s) issues of technological change with the social and cultural contexts within which change occurs" (Guy and Moore, 2005, p. 10). Referred to as a sociotechnical perspective, this interpretation views "technical change as an irredeemably social process" (Shove, 1998, p. 1110) and subsequently broadens the research agenda to include the influence of individual and institutional contexts on technological innovation.

By acknowledging the impact of social and cultural forces, STS theories fundamentally diverge from contrasting ideas centered around America's deeply rooted tradition of technological determinism, which presumes that "technological forces (alone) determine social and cultural changes" (Hughes, 1994 p. 102). In the context of buildings and energy, technological determinism is manifested in the prevailing perspective of various institutions that rely upon the diffusion of advanced technologies for the mitigation of building energy consumption. However, STS scholars who've applied an alternate, *social constructivist* lens to issues surrounding buildings and energy have offered insight into the dynamic influences that inspire action towards mitigation. The compelling logic of such theorists not only informed the central objective of this research; which is to expand energy conservation assessments beyond technology-based tactics, and account for the social and cultural considerations which influence building energy consumption, but have also inspired my interest in tempering theoretically-based analyses with empirically-backed findings.

In their book entitled, *A sociology of energy, buildings and the environment: constructing knowledge, designing practice*, authors Simon Guy and Elizabeth Shove argue that, "designers' practices are much more strongly determined by the contexts in which they operate than by their personal knowledge or individual enthusiasm for energy-efficiency" (Guy & Shove, 2000, pg. 130). Recognizing that practitioner's "actions are enmeshed in various systems, structures, and established conventions," Guy and Shove argue for, "a more contextual understanding of innovation" that reflects a "greater sensitivity (to) the dynamics of practice … (by) drawing upon, rather than ignoring, changing patterns of tacit knowledge and practice" (Guy & Shove, 2000, pg. 137).

Based upon their findings, I contend that the *AIA+2030 Professional Series* embodies a compelling framework for this type of investigation because, while developed in response to what have formerly been considered external pressures, the *Series* represents an internally contrived proposition for how to reform the profession, and subsequently the built environment. Developed by individuals that are uniquely qualified to speak and respond to the social and institutional challenges facing building industry practitioners, the *Series* promotes the actions, ideas, and values that have been determined to be viable means for overcoming institutional barriers and enacting or constructing change.

Speaking to this type of innovative paradigm, Simon Guy, in a separate article entitled, "Designing urban knowledge: competing perspectives on energy and buildings," determined that, "one such approach for [future research, would be] to identify and explore the emergence of 'niches' in which radical innovations are nurtured, tested, and promoted" (Guy, 2006, pg. 657). I argue that the *AIA+2030 Professional Series* represents this type of unique environment and subsequently provides a context-rich environment for "mapping the growth and development of ideas about energy efficiency" while simultaneously evaluating the evolving "capacity for action" amongst building industry practitioners (Guy & Shove, 2000, pg. 138).

For many STS scholars, including Wiebe E. Bijker, the significance of accounting for the social factors of technological change extends beyond the benefit of providing a more holistic view of the transformative process and rather, addresses a more fundamental concern related to the democratization of technological development. Arguing that sustainable, long-lasting and substantially-supported politics should be informed by "democratic mechanisms…that connect political decision making to public and societal concerns and debates," Bijker highlights the significance of an inherent duality within scientific and technological values – that of being both informed by, and constructive of, society (Bijker, 2004, pg. 385).

At a time in which the building industry is beginning to internalize and conceptualize adaptive responses to concerns related to climate change, I support Bijkers' position that it is especially important to acknowledge the "choices, interests, (and) value judgements – in short, politics" (Bijker, 2004, p. 376) that are guiding and giving meaning to the next generation of net zero energy buildings. If architecture is to offer a meaningful contribution to the renegotiation of humanity's environmental conundrum, I feel that the transformation process must be tempered by, and reflective of, value-rational questions aimed at assessing: "Where are we going; Is this desirable; What should be done; Who gains and who loses; (and) by which mechanisms of power?" (Flyvbjerg, 2001, p. 60).

In addition to inspiring this research with such paramount and reflective questions, STS scholars have also developed various interpretative lenses for analyzing the interplay between society and technology. In their book entitled, *Sustainable Architectures: Cultures and Natures in Europe and North America*, editors Steven Moore and Simon Guy, identify five "interpretative traditions" which have emerged within the STS discipline, namely: "social constructivist theory, systems theory, actor-network theory, critical theory, and pragmatism" (p. 231). While the premise of each offers significant contributions and reinforcement to this analysis, my research findings are most sympathetic to Thomas Hughes' *Systems Theory* and his interpretation of technological systems. In order to elaborate on this determination, I'll first introduce the fundamentals of Hughes' network-based theory.

A. Technological Momentum

In his essay entitled, "Technological Momentum," Hughes objects to the simplistic premise of technological determinism, and its antithesis, social constructivism; or the idea that "social, or interest groups, define and give meaning to artifacts," and in turn, are responsible for shaping technological and cultural development (Hughes, 1994, p. 103). By presenting a "more complex (and) flexible" explanation he terms "technological momentum," Hughes attributes technological and cultural change to the interplay between technical and social forces (p. 104). Falling "somewhere between the poles of technological determinism and social constructivism," this middle ground doesn't polarize the influences of technological or social forces, but rather unites these two change agents as joint influences, referred to as a technological system (Hughes, 1994, p. 112).

Characterized as embodying "physical artifacts and software," as well as "economic, organizational, political, and even cultural aspects," Hughes interprets technological systems as the interrelated network of material and human systems, which he perceives as intrinsic to all technologies (MacKenzie & Wajcman, 1999, p.11). Based on this observation, Hughes reframes the basic notion of technology to expand beyond isolate knowledge, machinery, or equipment, and encompass the complex social matrices, which underlie all technological innovations.

Subsequently, he defines "technical" as "physical artifacts and software;" whereas, "technology" itself, refers to "technological or sociotechnical systems," (Hughes, 1994, p. 102). Distinguished by the presence of a "technical core" made up of, "hardware and software" (Hughes, 1994, p. 105), Hughes portrays technological systems as, "bureaucracies reinforced by technical, or physical infrastructures, which give them even greater rigidity and mass than … social bureaucracies" (p. 113). Conversely, from this statement, one can conclude that sociotechnical systems are not yet confined by a deeply rooted infrastructure, and are therefore, more malleable than their technological counterparts.

However, further investigation of Hughes analysis reveals another significant consideration, that “mature technological systems” can actually be characterized as, “more social and less technical” because of the, “bureaucracy of managers and white collar employees (who) usually (play) an increasingly prominent role in maintaining and expanding the system” (Hughes, 1994, p. 106). This observation speaks to one of the most compelling aspects of technological momentum, the idea that technological change is time-dependent and that, “the interaction of technological systems and society is not symmetrical over time” (Hughes, 1994, p. 108). Furthermore, this brings to the fore the fundamental significance of social influences on technological development; and clarifies why Hughes, who argues that, technological systems “can be both a cause and an effect; (they) can shape and be shaped by society” (Hughes, 1994, p. 112), prefers the idea of “momentum” to “determinism.”

In addition to philosophically aligning with Hughes’ *Systems Theory*, throughout this investigation, I’ve observed how the building culture encapsulates the essence of a technological system; and subsequently, how the *2030 Challenge* demonstrates that technological change is fundamentally rooted in social change. Based on this premise, my analysis distinguishes between two technological systems currently at play within the building industry. I acknowledge that the identification of only two systems is overly reductive, and that by and large, the culture of building is inherently more dynamic and complex. However, framing the two building cultures as technological systems, allows me to establish a common foundation for evaluating the various forces and structures, which reinforce each paradigm at this specific stage of its development. Most importantly, this uniform lens has helped to clarify my understanding about the propensity for change in the building culture; while one "system" is mature and the other is emergent, the momentum of both is always configured and expanded by social, as well as technical forces which vary in magnitude and influence over the evolutionary course of each system.

B. Building Cultures as Technological Systems

For the purposes of this analysis, the two technological systems will be characterized as, the *conventional building culture*, and the *performance-based building culture*. Predicated on Howard Davis' book, *The Culture of Building*, Davis defines the notion of "building culture" as, "the coordinated system of knowledge, rules, and procedures that is shared by people who participate in the building activity and that determines the form buildings and cities take" (Davis, 2006, p. 3). Based upon this premise, I've interpreted the term building culture to represent the combined social relationships and technical practices that reinforce each other to define and give meaning to the varying cultures and practices of architecture.

If this description sounds familiar, it is because this same definition was previously used to describe the term "sociotechnical" in my research question. What should be inferred from this shared interpretation is the degree to which building cultures and sociotechnical systems are inextricability linked. This joint definition fundamentally speaks to the degree in which social and technical forces are intrinsic to both building cultures and sociotechnical systems. By asking how architects perceive their role in transforming the sociotechnical sub-practices of the profession, I'm essentially seeking to understand how building industry professionals comprehend their agency, or capacity to influence, the cultural boundaries of their profession.

As previously stated, this investigation is intended to provide objective and context-specific insight from the *AIA+2030 Professional Series* as it relates to the actions, ideas, and values that have been identified as viable means for achieving a desired net zero energy status for buildings. From this empirical frame of reference, two paradigms of practice have emerged based upon contrasting energy-based assumptions for buildings: one described in the *AIA+2030 Series* literature as, "the conventional building design (approach which) presumes that a building's energy will be imported in the form of electricity and fuel" (AIA+2030 Professional Series, n.d., d); and the other, which is based upon the notion that,

> Change can only come with the transformation of the profession towards establishing operational energy use targets at the onset of every design, and monitoring the implementation of that energy target throughout the design process (The American Institute of Architects, 2011, p. 14).

Thus, the *conventional building culture*, embodies the traditional organizational, technical, and social forces, which historically, have refrained from accounting for the energy consumption and atmospheric emissions of the built environment; whereas, the *performance-based building culture* embodies the development and integration of alternative, organizational, technical, and social arrangements specifically aimed at achieving a net zero energy status for buildings through the reduction of overall energy needs and elimination of all greenhouse gas emissions during the building's operation.

Borrowing from Hughes analysis, the *conventional culture* represents the more "mature" technological system, comprised of well-established organizational, cultural, and technical practices, and supported by long-standing political and economic influences. At its technical core, lies the existing built environment and a variety of technical tools such as mechanical systems and computer aided design software.

On the other hand, the *performance-based building culture* represents the "younger developing system," which from my observations, is in the process of firmly establishing the limits and structure of its technical core (Hughes, 1994, p. 112). Subsequently, one could characterize the *performance-based building culture* as more of a sociotechnical system based on the notion that, at this point in its development, the momentum of this system is, "more open to sociocultural influences" (Hughes, 1994, p. 101).

C. Cause and Effect

As a more "mature" technological system, Hughes analysis would characterize the *conventional building culture* as "more independent of outside influences and therefore more deterministic in nature" (p. 101). However, in this instance, one can infer that conventional building practices, and their unintentional side effects, have actually caused the conditions that catalyzed the development of a *performance-based building culture*.

This principle of causation is most evident in the variety of voluntary and regulatory building standards issued by legislative and non-governmental organizations in response to concerns related to climate change; and is also clearly defined in the *Architecture 2030* Mission statement:

> (Architecture) 2030's mission is to rapidly transform the U.S. and global Building Sector from the major contributor of greenhouse gas emissions to a central part of the solution to the climate change, energy consumption, and economic crises. Our goal is straightforward: to achieve a dramatic reduction in the climate-change-causing greenhouse gas (GHG) emissions of the Building Sector by changing the way buildings and developments are planned, designed and constructed. (Architecture 2030, n.d.a).

This cause and effect relationship corroborates Hughes other observation that, "As (technological systems) grow larger and more complex, (the) systems tend to be more shaping of society and less shaped by it" (Hughes, 1994, p. 112). Thus, as performance-based advocates attempt to socially construct a new paradigm in reaction to what's currently perceived as a flawed model, it is important to examine how the prevailing social and technical forces of the conventional building culture are influencing and resisting the development of alternative values and practices within the *performance-based building culture*.

In other words, this investigation is based upon the notion that, "the co-evolution of new technologies always takes place against the backdrop of…existing sociotechnical regimes" (Shove, 1998, pg. 1109). Therefore, by examining the *2030 Challenge* through the framework of technological momentum, my investigation explores beyond the technical forces which often dominate the debate, and concentrates on gaining a deeper understanding of the social and cultural considerations which underlie both the momentum for, and resistance to, change within the existing and emergent building culture paradigms.

Despite the relatively fixed nature of mature technological systems, Hughes acknowledges that "System(s) with great technological momentum can be made to change direction if a variety of (their) components are subjected to the forces of change" (p. 112). Thus, if building practitioners are to successfully transform the built environment from energy consumption to energy conservation, its critical to assess how the emerging principles of the *performance-based culture* differ from those standards that have defined the *conventional building culture*. For this reason, both the technical and social forces at play within the *performance-based culture* must be examined for how they're informing the next generation of high-performance architecture.

D. Building Culture Forces

Through my review of the literature, and investigation of the *Series*, I've determined that the primary components exerting control over the prevailing and emerging building cultures can be categorized as either external or internal pressures. The most significant external pressures include environmental and political considerations; whereas, organizational, technical, and cultural aspects represent the most predominant internal influences. The general boundaries of these forces, as well as some working definitions, will be introduced below. Beyond that, a more in-depth exploration of each influence will be expanded upon in the following chapters devoted to additional literary and empirical findings.

1. Environmental Forces

Hughes acknowledges the external nature of the environment by defining it as, "the world outside of technological systems that shapes them or is shaped by them; even though it may interact with the technological system, the environment is not part of the system because it is not under control of the system as are the system's interacting components" (p. 103). Undoubtedly, impressions of the environment inspire various interpretations ranging from philosophical to scientific. However, for the purposes of this analysis, the environment refers to the physical constraints and opportunities that are considered by the building culture as they undertake a project. The question of what should constitute a project's environmental analysis embodies one of the primary differences that has emerged between the *conventional* and *performance-based building cultures*.

2. Political Forces

External political pressures refers to the local and national mandates developed and issued by second or third party organizations and adopted by governmental agencies, which specify the rules and standards that must be followed by those involved in the building culture; for example, building codes, legislative acts, and executive orders.

3. Organizational Forces

Organizational influences refer to the way in which practice is typically structured and activities are conducted. These internal arrangements have coevolved with technologies over time and are upheld by the administration of firms, trade associations, interest groups, and contracts.

4. Technical Forces

As stated earlier, Hughes defines technical as the, "physical artifacts and software" (p. 102). Borrowing from this analysis, technical, as it relates to the building culture, refers to the facilities and resources for producing projects, ie- the mechanical tools and systems utilized for producing the built environment; additionally, technical refers to the three-dimensional infrastructure developed by participants in the building culture.

5. Cultural Forces

Admittedly, ideas surrounding culture can be abstract and varied. However, in the context of this investigation, culture refers to the attitudes, behavior, and fundamental values that are characteristic of a social group, in this case, building industry professionals. Culture manifests itself most clearly through University education programs; individual and firm mission statements; professional associations; the established criteria for judging the built environment; and is ultimately evident in the design strategies employed by those in the building industry.

My review of the literature in the field of *Science and Technology Studies* has offered the theoretical and empirical inspiration for pursuing this investigation. Having gained first-hand experience attempting to integrate alternative sustainability objectives into conventional building projects, I align very strongly with STS scholars who firmly root the propensity for change within the building culture rather than with "abstract model(s) of technical potential" (Shove, 1998, p. 1108). By directly engaging, through both research and practice, with practitioners who are seeking to alter the course of the building industry, I can't deny the mature and pervasive nature of the conventional building culture. However, because I too share the sentiment that practitioners are "active and creative social agents, rather than the passive recipients of science-based research," (Shove, 1998, p. 1108) I'm inspired by the challenge of expanding technical and philosophical horizons in order to locate where opportunities for change truly lie. With this objective, I'll turn to the next chapter devoted to the topic of sustainability.

3.2 - SUSTAINABILITY

Rooted in the Conservation, Preservation, and Environmental Movements, the notion of sustainability is a byproduct of an interdisciplinary framework of influences. In 1987, with the publication of *Our Common Future* by the *World Commission on Environment and Development*, the prevailing definition for sustainability emerged as: "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (The World Commission on Environment and Development, 1987, p. 43). While this interpretation brought to the fore the need to align developmental objectives with much broader considerations, it has been criticized for failing to suggest meaningful alternatives outside of the continued development practices that created the unsustainable conditions requiring reform. A review of the contemporary literature surrounding the topic of sustainability reveals that, while most of the discourse remains framed by concerns related to environmental, economic, and to a lesser extent, social stability, the paradigm has matured and evolved to encompass an expansive and multidisciplinary range of perspectives.

Scholars Moore et al. (2010), who have explored the historical, theoretical, and practical, parameters that have determined the evolutionary course of the concept, have offered numerous interpretations for ways in which to conceptualize and navigate towards a more sustainable future. In *Pragmatic Sustainability, Theoretical and Practical Tools*, practitioners expose the inherent subjective nature of sustainability while underscoring the need for individuals involved in the pursuit of a more sustainable future to embrace the formation of "context-dependent knowledge" as a guiding principle for both framing the problem and exploring possible solutions (Moore, 2010, p. 10). Arguing that, "'sustainability' is less a scientific concept than a historical discourse through which (individuals) might imagine more hopeful futures," (Moore, 2010, p. 3), this expanded horizon undermines the prevailing practice of exclusively locating sustainable solutions within "rule-bound or 'context-independent knowledge' borrowed from elsewhere," such as, the assortment of standardized solutions proposed in various green building rating systems (Moore, 2010, p. 10).

By advocating for a more localized and organic understanding of sustainability, Moore et al. (2010) fundamentally diverge from an impassioned plea offered by Walter Grondzik (2007) to the design community, to establish "real meaning" for the term sustainability which conveys "useful and replicable information" (p. 4). Insisting that one of the various "troubles with sustainability" is the fact that the term, "is often used to describe some amorphous condition that is somewhat or somehow different from the status quo – without any definition or clarification of what that intended condition actually represents" (p. 1), Grondzik advances that quantitative, or measurable, aspects of sustainability are far more significant than any "qualitative construct" that indeterminately confirms preferable actions have been taken, and that the desired "sustainable" results have been achieved.

For Grondzik, "words do often make a difference" (p. 1) and based upon that premise, he argues that the term sustainability "must be benchmarked in such a way that a design team can make rational decisions on the hundreds of issues that come up on any project" (p. 4). Insisting that, until these parameters are fully established, the design community should "refrain from the use of this word as an adjective" (authors emphasis), and reserve its use to describe only those conditions which are "truly sustainable" ie, "that which will reasonably allow future generations to meet their needs" (Grondzik, 2007, p. 5).

While I sympathize with Grondzik's position that the preferable environmental and social conditions being sought are far too significant to merit diluted and hollow applications, I'm not convinced that any single universal or predetermined indicator is practical, or even possible, for addressing the myriad of social, environmental, and economic conditions that require improvement. I agree with Grondzik that, "intellectually honest" guiding principles are a vital component of any discussion and/or measures that seek to foster preferable future conditions. However, I question how exclusively subscribing to methods defined by a reductive quantitative analysis can even begin to account for the variety of interpretations that arise when different individuals are faced with determining how they envision a more sustainable future.

For this reason, I'm more inspired by the reasoning of philosopher Paul Thompson (2010) who asserts that the debate over what sustainability is, and is not, enriches our understanding of the diverse value judgements that are inherent within the various perspectives regarding sustainability. While Thompson, like Grondzik, also supports the framing of various sustainability constructs against the verifiable "functional integrity of the ecological, economic, and social sub-systems on which we depend" (p. 27), he ultimately embraces the value of interpretation as a means with which to inspire individual connections with, and collective motivations for, a more sustainable future.

Thus, if individuals involved in the design community truly wish to advance more sustainable conditions, I argue there's significance to proactively and deliberately framing design intentions against the necessary and fundamental modifications to the dynamic language, methods, and values that influence the larger environmental, social, and economic conditions. In other words, rather than exclusively seeking universal compliance with abstracted and convoluted measures based upon preconceived absolutes, I believe both the design community and built environment will ultimately benefit from multiple and diverse experiments in thoughtful contemplation and conscious action. Or, as pragmatists Moore and Thompson have determined, it's best to "(privilege) action over contemplating the meaning of words, even words like sustainability, because it is through action that meaning is created" (Moore, 2010, p. 15).

Drawing inspiration from the "interpretative flexibility" (Bijker, 2004, p. 376) of sustainability as a social construct, I've specifically focused my research on literature that examines the subjective qualities of this dynamic concept. Notable perspectives include the research findings of Guy and Farmer (2001), who demonstrate through an extensive literature review, that sustainability is a relative concept comprised of multiple perspectives and associated values. By identifying six alternative logics of sustainable design, they exhibit how particular beliefs about sustainability inform different strategies and solutions for the built environment. Ranging from the aesthetic to social, these various logics reveal how the "environment is a contested terrain" (p. 146) with a rich source of varied interpretation.

One of their identified approaches, referred to as the *eco-technic logic*, conceptualizes the environment as an entity that can be managed through science, technology, and objective analysis. As part of this interpretation, environmental issues are typically understood through quantitative analysis and rational scientific methods. Because "negative environmental impacts of buildings are assumed to be the result of a variety of inefficient practices," (Guy & Farmer, 2001, p. 142) this logic presumes that, "the development, inauguration and diffusion of new technologies, that are more intelligent than the older ones," will resolve any environmental problems (Guy & Farmer, 2001, p. 142).

Ultimately, the cornerstone of this conventionally held belief is that pure technical potential exists, but is inhibited by non-technical barriers such as knowledge gaps. Thus, in order to solve environmental challenges, an integrative approach based on science, technology, and management must be deployed in an effort to break down the existing barriers and transfer the technical potential throughout the industry. Supporting the historical trajectory of technological and scientific determinism in the United States, this logic also reinforces the idea of "ecological modernization" in which environmental, economic, and social crises can be overcome through a continued, but refined, path of industrialization and technological development (Guy & Farmer, 2001, p. 142). In other words, individuals need not modify their values or habits, but rather, await the next technological or market-based solution to save them.

As practitioners are faced with quantitative data that exposes the substantial consumption of natural resources by building construction and operation practices, the standardized high-tech science and technology solutions offered by the *eco-technic logic* have undoubtedly emerged as the predominant paradigm for approaching sustainable design. Historically, the tendency to favor the seemingly logical assessments and straightforward solutions offered by this popular approach roots back to principles that underscored the direction of American design professions at the beginning of the twentieth century. As the industrialization of society led to a "growing complexity (of) the tasks that needed to be performed" (Davis, 2006, p. 101), design professionals experienced a progressive reliance upon "explicit scientific knowledge" and a "quantifying mentality that gradually won out over intuitive and 'hidden' knowledge" (Davis, 2006, p. 101). This fundamental shift, which diverged greatly from the trade and craftsman models that preceded it, has underscored virtually every aspect of the contemporary building culture, from licensing criteria to the organization of professional trade organizations (Davis, 2006, p. 100).

Today, as practitioners face the daunting the task of framing and adapting local conditions to issues that are defined by, and expanded to, global levels of risk and reward, the reasoned solutions supported by the scientifically based, and quantitatively verified, *eco-technic logic* offer an incredibly powerful, if not essential, component of informed decision making. However, in my own experience, I've found that individuals attempting to implement even "low-tech" alternative sustainable practices eventually recognize the limitations of analyses based upon predetermined end-results that fail to account for the myriad of social, political, cultural, and economic forces that, in turn, must change. This sentiment was captured by Moore as he reflected on the writings of pragmatist John Dewey, "unsustainability is not a scientific or technological problem, it is a social one. … knowledge that claims to be asocial is not knowledge at all because, in the end, it has to be applied in a social context" (Moore, 2010, p. 9) Thus, the notion of pure technical potential is just that, potential; probabilities based upon abstracted calculations that may or may not reasonably account for the social acceptance, or righteousness, of a particular technological or scientific "solution."

Thus, at a time in which the *eco-technic logic* currently dominates the landscape of sustainable solutions being sought, I contend that it's absolutely critical for professionals to expand the parameters beyond simply technology or science as the explanation of, and salvation for, overcoming the modern environmental, economic, and social crises. Assigning agency to any idealized panacea not only perpetuates the notion that humanity has dominion over nature, but it suggests that society, government, industrial production, and liberal capitalism are absolved of any responsibility. As threats associated with climate change have become more palpable, and the tempo of debate along with the urgency for action has increased, we cannot afford to entertain solutions primarily rooted in deterministic and/or utopian ideals. For, "utopian solutions…are counterproductive to real social progress because they evade the political process it would necessitate to achieve social goals" (Ingersoll, 1996, p. 121).

The significance of expanding the debate beyond proposals that favor only fixed and standardized responses is central to Guy and Moore (2005) who contend there's a greater need to celebrate the diversity of pluralistic sustainable architectural practices. Their constructivist analysis examines how notions of sustainability are representative of a, "specific ensemble of ideas, concepts, and categorizations that are produced, reproduced, and transformed in a particular set of practices [which give meaning] to physical and social realities" (Guy & Moore, 2005, p. 8 – citing Hajer 1995: 44). Subsequently, they interpret sustainable buildings as, "social representations of alternative ecological values" and maintain that, "the challenge of sustainability is more of a matter of local interpretation than of the setting of objective or universal goals" (Guy & Moore, 2005, p. 1).

By preferencing bottom-up, inductive, and highly political approaches to sustainable design, over top-down deductive and linear methods, (Guy & Moore, 2005, p. 224) strike at what I believe is one of the most fundamental threats, and simultaneous opportunities, for the design community: the manner in which the various design professions internally respond to the multitude of external environmental, political, and market-based challenges associated with a global paradigm shift towards sustainability. As the state-of-the-world necessitates a more ecologically attuned perspective from governments, industries, communities, and citizens, designers must utilize this opportunity to embrace their greatest strengths as inspired and visionary leaders capable of synthesizing a diverse range of interests and needs into meaningful and compelling solutions. Not only does this influence the manner in which society's future becomes manifest, but it also determines the degree to which design continues to be appropriated to abstracted levels of standardization, or assumes its greatest potential as a meaningful facilitator of sustainable solutions that extend beyond individual buildings, to society at large.

While this position is not intended to portray a utopian preference towards *architectural* determinism, it is intended to support the idea that, "The organization and design of today's buildings parallel the organization and structure of the building culture that produces them" (Davis, 2006, p. 100). For this reason, at this critical point in the evolution of sustainable design practices, I believe it's paramount that designers seek and embrace diversity and experimentation, both for the potential offered, and the questions inspired. While the assortment of standardized solutions undoubtedly present compelling blueprints of action for issues previously unaccounted for in conventional building practices, I question if the reliance upon standardized solutions is truly the most meaningful response that design, and designers, can offer. By "(standardizing) our interpretation of both the environmental problems and our strategies for creating more sustainable futures," we not only limit the creativity of strategies employees, but also the breadth of issues considered (Guy & Moore, 2005, p. 221). For as scholar Richard Ingersoll (1996) has suggested,

> The higher sense of responsibility toward the environment lies not in the solutions but in the formation of the question. Can there be such a thing as ecological balance if it is not socially determined? Is not the human consciousness the major component both of the cause of the imbalance and of its possible rectification? (p. 144).

The significance of social, as well as geographic context, on the development and implementation of sustainable design practices is central to Mahadev Raman's reasoning in his essay entitled, "Sustainable Design: An American Perspective" (2005). Serving on the *Americas Board* for the multinational professional services firm *ARUP*, while leading their *Building Engineering Group*, Raman offers a globalized and experiential perspective to the circumstances surrounding the practice of sustainable design in the United States. After decades of practice, he asserts that, "The American experience with sustainable design differs from experiences in other parts of the world" (p. 43).

Maintaining that, "Sustainability is not just about energy consumption, (but) about finding the right balance between environmental, economic, and social concerns" (p. 43), Raman also acknowledges that for the most part, "Sustainability in buildings often means minimizing the consumption of resources (water, energy, and materials) but increasingly it also entails maximizing the health, safety and quality of life of their occupants" (p. 43). While a concern for resources transcends geographic boundaries in the 21st century, Raman's review of the prevailing challenges for practicing sustainable design in the United States illustrates how American social norms and cultural values have supported a societal predisposition towards energy consumption.

Reflecting on how, in Europe, higher petrol prices have inspired a more conscientious ethic for overall energy conservation, Raman observes that a relaxed "pressure to conserve," combined with how "Americans also demand much quicker paybacks on investments than individuals in other cultures" (p. 44), demonstrates how prevailing social values in the United States have engendered a culture of building practices which undermine the ability to implement critical sustainable design strategies. For instance,

> Fees in the United States, particularly for engineers, are lower than elsewhere. But salaries for those same professionals are higher. Consequently, the design process in the United States may use half to one-third of the man-hours devoted to the design process in the United Kingdom, for example. That is a staggering difference, which seriously limits the amount of time that can be spent to redefine designs and move them to a higher level (Raman, 2005, p. 45).

Not only does this specific operational practice appear to limit the potential for pursuing experimental design solutions, it also appears to influence the methods that American practitioners rely upon for reforming the built environment. As noted by Raman, as it relates to reform, there's a unique American tendency to, "work through the codes and regulatory structure as a means of implementing change" (p. 43); whereas, "In Europe, individual practitioners are always pushing the boundaries," an approach which "seems to be supported by the economics there" (p. 43). While this observation further accentuates the significance of bottom-up vs. top-down approaches for achieving social reform, it also highlights the need to fully evaluate the effectiveness of the prevailing code and regulatory structures in which American practitioners seek to affect change. What constitutes "success" for these programs? Who are the code writers and whose interests are at stake? To what extent do codes address environmental, economic, and social issues?

Most notably, as Raman attempts to account for the disconnect between "definitions of sustainability" and the "practical application of (sustainability) concepts" he doesn't advocate for the often-touted technological fix, but rather, presents a series of social and cultural modifications to the design process that represent "essential ingredients" for achieving more sustainable outcomes (p. 44). Beginning with a, "commitment to the process, particularly from the owner," (p. 44) Raman then advises that teams embrace a, "non-traditional approach to communication and interaction among the disciplines" (p. 44). In addition to establishing various feedback loops, practitioners are also urged to acknowledge that, "various team members (architects, engineers, owners) communicate and process information differently" and therefore, a "variety of visual aids" should be integrated into the process (p. 44). Finally, rather than assume that simply the specification of advanced technologies will produce the desired results, Raman suggests that teams must make a sincere "commitment to properly follow through," in order to, "ensure that the design intent is being met in all of its depth" (p. 44). By calling attention to these "essential" improvements to the conventional culture of design, Raman emphasizes how the achievement of a more sustainable future is as much socially rooted, as it is influenced by the integration of alternative technologies, tools, and software.

From the geographic provisions and climactic diversity of the landscape, to the financial restraints and regulatory solutions sought by practitioners, Ramans observations ultimately corroborate the argument that context, including the physical, social, political, and cultural, promises to inform a particular set of strategies and "distinct philosophies of environmental place making" based on the values inherent within the prevailing logics of a particular society (Guy & Farmer, 2001, p. 146). While it might be more straightforward if sustainability could be represented by a cohesive definition with universal application, numerous practitioners engaged in sustainable pursuits have demonstrated that the complexity of local preferences often challenge this simplistic ideal. Until we reach a time in which conceptions of sustainability openly account for the, "social, political, psychological, economic, and professional commitments, skills, prejudices, possibilities and constraints" of the systems and actors upon which sustainable solutions reside, (Bijker & Law, 1992, p. 7) I fear that the practical application of many proposed solutions will be compromised. If sustainability is, in fact, embodied by a spirit of standardization, design responses and ideologies face the threat of homogenization. Therefore, if the design professions are to truly offer meaningful contributions to the renegotiation of humanity's environmental conundrum, I strongly advise that members of the design community engage in a sincere assessment of the prevailing values with which the profession aligns. The next section on Performance-Based Design will illustrate the diversity of interpretations that unfold when practitioners are asked to assess their fundamental values.

3.3 - PERFORMANCE-BASED DESIGN

Performance-based design, the key issue of this investigation, represents one of the emerging and alternative approaches to sustainable development. Ranging from examinations into what exactly constitutes performance, to assessments of exemplary performance-based practices, literature associated with this topic reveals the dynamic and subjective nature of this evolving design paradigm. While performance-based design could very well be categorized under STS research or my examination of net zero energy design in practice, for the purposes of this investigation, I've differentiated studies that are specifically devoted to examining the theoretical and conceptual frameworks of performance-based principles. By doing so, I aim to establish a more substantial understanding of the boundaries of this expanding paradigm.

Performance, like sustainability, lacks a universal and explicit definition within the building community. Historically used to describe a broad range of technical and/or aesthetic performance criteria or specifications for the built environment, modern interpretations appear to be narrowing the notion of performance to describe issues related to the energy intensity of buildings. The evolutionary course of this association has been the focus of my literature review as well as a significant component of my research at large.

A. Contested Definitions in the Literature

In 2003, in an attempt to establish a more thorough understanding of, "what is meant by performances in architecture and of architecture" (Kolarevic & Malkawi, 2005, p. 3), a variety of leading architects, engineers, and theorists, gathered at the *University of Pennsylvania* for a symposium devoted to the idea of "Performative Architecture." The result of their two-day conference was the publication of a compendium, which explores the various interpretations and influences of performance-based objectives in the built environment.

Ranging from the conceptual to the technical, their various perspectives reveal that, despite its prevalence within the building community, "the meanings of performance in architecture are indeed multiple and intertwined, and are irreducible to a simple, succinct definition" (Kolarevic & Malkawi, 2005, p. 3). Furthermore, as attempts were made to place the various performance-based interpretations into their proper historical context, the authors discovered that, prior to their publication, "very little (had) been written about performance in architecture" (Kolarevic & Malkawi, 2005, p. 3). Despite its ambiguous nature, and their preliminary evaluation, the overall consensus amongst the contributors was that, "performance in architecture increasingly matters" and it will certainly "underlie discussions about architecture in the future" (Kolarevic & Malkawi, 2005, p. 3). Almost a decade later, their initial prediction has proven quite true.

As the new millennium has proceeded, a growing and robust field of literature has continued to emerge on the subject of building performance. From my review, the most predominant perspectives have arisen from those associated with the environmental and political arenas, notably: building and/or climate scientists and policy makers. Responding to the increased awareness and severity of issues surrounding the environmental impacts of the built environment, these contributions have increasingly associated performance with a building's material, land, water use, and most often, energy intensity.

A report entitled, "High-Performance Commercial Buildings: A Technology Roadmap" (United States Department of Energy, 2001), reveals the preliminary stages of this nuanced alignment. Between 1998 and 1999, a broad-based group of representatives from the commercial building industry, along with representatives of the *Department of Energy*, came together for a series of four workshops to discuss "the current state of the industry, significant trends and opportunities, and ways to align public and private R&D with real world needs" (United States Department of Energy, 2001, p. 4). Inspired by the broader question of "how commercial buildings (should) evolve to enhance human health and productivity," these public and private practitioners approached the turn of the century by asking, "Can we afford the environmental consequences of carrying the 20th century model into the future, or can we create commercial spaces that produce less waste, consume less energy, reduce reliance on cars, and minimize land use?" (United

States Department of Energy, 2001, p. 3). Out of their efforts, four "interrelated" strategies emerged as critical focal points for transitioning the building industry into the 21st century:

> **Performance metrics** - Establish key definitions and metrics for high-performance commercial buildings.
>
> **Technology development** - Develop systems integration, monitoring, and other technologies that enable commercial buildings to optimally achieve targeted performance levels over their life cycles.
>
> **Process change** - Create models of collaborative commercial whole-buildings design and development, and establish the tools and professional education programs needed to support these processes.
>
> **Market transformation** - Stimulate market demand for high-performance commercial buildings by demonstrating and communicating compelling economic advantages. (United States Department of Energy, 2001, p. 14)

As a starting point for stimulating the development of high-performance buildings in the United States, the participating public and private interest groups were encouraged to begin with the rudimentary task of establishing, "core definitions and metrics for high-performance commercial buildings," by defining: what to measure, how to measure it, and finally, how to apply the metrics (United States Department of Energy, 2001, p. 15). Specifically tasked with discovering, "what characteristics would be most highly valued by different categories of customers," these early advocates of high performance buildings recognized that the perceived social value of the metrics, along with their measuring and reporting techniques, represented "core challenges (for) achieving widespread adoption" of this alternative, and reportedly, radical departure for the building industry (Deru & Torcellini, 2005, p. 4). Subsequently, during the initial development stages of performance-based objectives, democratic measures and public participation emerged as significant factors for establishing the foundational boundaries of this pliable concept.

Five years after this initial *Roadmap* was delineated, representatives from the *National Renewable Energy Laboratory* (NREL) sought to provide further clarification on the notion of performance through the publication of the, "Performance Metrics Research Project – Final Report" (Deru & Torcellini, 2005). Arguing that the variety of approaches for assessing performance had created "(disparities which) make it difficult to understand the real energy performance of buildings and to transfer knowledge from one activity to another," (Deru & Torcellini, 2005, p. 12) their report provided linguistic and procedural directives to the industry, which could serve as a "starting point" for performance measures.

Defining the term *performance metric* as, "a standard definition of a measurable quantity that indicates some aspect of performance," the authors revisited the issue of social value and suggested that, "performance metrics need certain characteristics to be valuable and practical" (Deru & Torcellini, 2005, p. 5). Largely intended to offer methodological clarification to researchers involved in the fields of engineering and building science, the five priorities for performance metrics were identified as: "(being) measurable; (having) a clear definition, including boundaries of the measurements; (indicating) progress toward a performance goal; and (answering) specific questions about the performance" (Deru & Torcellini, 2005, p. 5).

Applicable to issues ranging from: energy and resource consumption, human factors, economics, as well as the service quality of buildings, performance metrics were described as a necessary means for, "measuring and tracking progress towards the performance goals," ie. the objectives, agreed upon by the design team, which will guide the design process towards their predetermined and desired results (Deru & Torcellini, 2005, p. 6). While the "Performance Metrics Research Project" marks a significant effort towards standardizing performance as a quantitative characteristic of building energy consumption, these primary definitions portray how performance in the built environment is applicable to any number of building related issues ranging from, at a minimum: thermal energy criteria, to operational objectives of the client, and even the larger social responsibility of development. Thus, at its essence, performance, like sustainability, is an interpretative concept that ultimately represents the interests and values of those involved in pursuing its achievement. In the next section, I'll move from theory to practice and convey how the notion of performance was explored during the *AIA+2030 Professional Series*.

B. Contested Definitions in the Case Study

Between performance-based codes, performance contracts, and the proposed addition of a performance category in the *Leadership in Energy and Environmental Design* (L.E.E.D) green building rating system, this concept has increasingly emerged as a major objective for the building industry. With the rise of this recent trend, one instructor in the *AIA+2030 Professional Series* recognized that practitioners, who are now faced with demonstrating the performance of their projects, might begin to experience a certain level of "anxiety" about this new criteria for judgment. Noting that, "until recently (buildings had) effectively been successful repressors" (DP2) of many resource-based considerations, the widespread promotion of high performing buildings by the mainstream, as well as those within the design community, is rapidly modifying this historical deficiency of environmental accountability. Subsequently, as argued by the instructor, with "the touting of high performance design … you can no longer really be a successful repressor" because, "when people have buildings that are sick, it's hard to sort of just say 'well they were L.E.E.D certified' as opposed to (the buildings) really actually performing well on some level" (DP2).

In an attempt to appease any shared feelings of "performance anxiety," the instructor informed the participants that his primary objective for the training session was to emphasize that,

> As we talk about performance, … we are qualifying, not just sort of quantifying specific resource metrics; but we're tying that to how well a building does, what it's supposed to do. Which is, create a roof, and a great place to be, and spend maybe eight or longer hours every day (DP2).

As the participants engaged in an activity to determine what performance metric was most meaningful to them, a diverse array of values, perceptions, and levels of enthusiasm emerged among the various professionals in attendance. At the conclusion of the training, it was quite apparent that the introduction of new performance-based criteria offers both significant contributions, as well as challenges, to the conventional design process.

Inspired by their shared and divergent perspectives, I utilized my final research survey to further explore what "performance" actually means to advocates of net zero energy design. Included as a bonus question in my research survey, I asked the respondents, "How do you define "building performance"? What matters most to you?" Just as had been demonstrated during my observation of the Series, their written survey responses indicated that, in addition to serving as a quantitative resource and energy-based indicator, performance is valued as a descriptor for many other fundamental design considerations.

Out of the fifteen total written responses submitted, seven individuals indicated that building performance was representative of a balance between responsible resource usage, and a functional, user friendly space for the occupants, building owners, and operations and maintenance personnel. The following captures this shared sentiment, "We use the term High Performance to describe buildings in which both resource efficiency and occupant productivity are simultaneously improved. You need both, not just one or the other" (AR3). For these individuals, it's clear that energy and resource efficiency constitute significant, yet incomplete, aspects of successful building design, construction, and operations. In fact, in their own unique way, each of these seven respondents objected to the notion that performance could be defined only through absolute resource-based assessments.

> It has to be a holistic view that does not end at design. Yes, the building may have been modeled as high performance, but what does operational reality bring? Have the occupants taken on a culture shift from their previous space to the new one? Do occupants understand the control systems? Do facilities personnel understand the lamping and HVAC strategies? Are the systems maintainable? Has the building really been designed and constructed with the user and owner's needs in mind? LEED is a nice checklist, but what closes the loop back to everyday use? (DP1).

Out of the eight other responses received, three additional categories of interpretation emerged: "meeting or exceeding set goals" (AR2); "total cost" (AR2); and "energy use" (EN3). For individuals committed to fulfilling the established goals of a project, performance signified the successful satisfaction of the "intended purposes of the project" (DP3), and resulted in "a happy client" (AR2). Having demonstrated their consideration for the more traditional objectives associated with meeting the client's established project performance criteria, one individual also acknowledged that performance should be valued by the manner in which designers, "(employ) all reasonable energy reducing strategies - regardless of whether "net-zero" is achieved" (DP2). For these individuals, performance in the built environment appears to be client, site, scope, and project dependent. Subsequently, it's likely that their performance criteria may expand to encompass a broad array of design, construction, and operational considerations.

> Individuals who noted the "cost effectiveness" of net zero projects as a primary consideration, not only expressed their concern for what is "(paid) each month in utility costs relative to the comfort (that inhabitants) feel," (AR3) but also addressed the challenge, and need to overcome, design decisions based upon a flawed system of project finance, which rewards cheaper capital costs at the expense of higher operating costs.
>
> To me it matters most that building decisions are based on the TOTAL cost, including greenhouse gas emissions and their effects, life-cycle etc. I think a carbon tax is a great place to start. The time where first cost and creating buildings that are burdens for future generations is over. Developers and building owners have to be mandated through policy to make this change, they have been given the chance and continue to act irresponsibly, citing first cost as the biggest issue! (AR2).

By noting cost-related issues as the primary challenge for improved building performance, these individuals reinforce how, in the *conventional building culture*, the "bottom line" serves as the primary factor driving most design decisions. Subsequently, their views support the findings published in, "Energy-Efficient Buildings: Institutional Barriers and Opportunities" in which the overconsumption of energy within the building sector is argued to be the result of a "massive market failure" within the industry (Lovins, 1992). Arguing that, if each specialist, project phase, product manufacturer, and building occupant were encouraged and rewarded for investing time, expertise, research and development, and personal interest in the conservation of energy resources, Lovins asserts that, the nature of building energy consumption would be quite different. However, because every aspect of project development is influenced by the desire to save money, time, and risk of liability, the *conventional building culture* is presented with very few incentives to break with the status quo of a capitalistic system that externalizes environmental impacts such as the extraction, refinement, and generation of energy resources.

However, for one survey respondent, building performance represents, “the actual, measured metrics from the built project” (AR2). This statement demonstrates how, for high performance projects, traditional bottom line considerations for buildings have expanded beyond only financial factors, to encompass the quantitative “input and output” measurements of energy and/or natural resource flows entering and exiting a building (Dammann & Elle, 2006). By introducing this fundamental modification to the accounting metrics applied to the built environment, the *performance-based building culture* is presenting significant alternatives to the status quo of predominant financial interests which have historically evolved to define a system of shortsighted environmental and social values that persist throughout all phases of a project. While only time will tell if this revised system results in the desired changes, this movement marks a significant effort towards reconstructing an industry-wide practice that is in need of reform. As is true for building projects, active participation and feedback loops are more critical than ever.

Energy use marked the most significant principle of building performance for the remaining individuals who participated in my survey. Defined as simply, “zero energy” (AR3), or “BTUH/SF” (EN3), some individuals noted that this single, energy-centric aspect of building performance represented their most important consideration. Others emphasized that, the paramount objective of using “little to no energy,” must be balanced with the ability to “(create) inspiring and healthy environments” (AR1). While reductive, these definitions closely align with the way in which building performance is portrayed in policy-based literature devoted to net zero energy design.

C. Performance as a Social Construct

While a survey of the literature indicates that performance is closely aligned with energy-based facets of building design, construction, and operations, my investigation has shown that this quantifiable performance indicator is one of many possible appraisals of building performance. As argued during my discussion of sustainability, I'm in favor of diverse and varied interpretations that are reflective of the experiences and context in which practitioners create and construct the built environment. Ultimately, the opportunities and challenges associated with both conventional and net zero energy design require that multiple actors work together to align their diverse and shared objectives for the built environment. Therefore, by titling this research, *The Social Construction of Performance-Based Design*, I've aimed to reinforce how the terminology, practices, values, and structures associated with net zero energy design are formulated by a variety of prevailing and emergent social, political, economic, and environmental forces. By asking the participants to consider and voice their most essential qualities of building performance, I've attempted to remind practitioners of their very essential role in the formation of this evolving design paradigm. In other words, rather than support efforts that seek to bring closure to the definition of performance, this research is intended to inspire the continued pursuit of democratic participation in the establishment of the parameters of this alternative and exciting development for the building industry.

In the next section, I'll present how policy-based initiatives have responded to the environmental impacts of the built environment by establishing interpretative boundaries for the concept of performance that are based upon quantifiable characteristics of the built environment. In many ways, the policy-based interpretations fundamentally diverge from the perspectives offered by the participants in the *AIA+2030 Professional Series*.

3.4 - Policy

The challenge of creating comprehensive and viable energy policies to adequately address the environmental, economic, and national security concerns of the 21st century cannot be overstated. As building scientists and associated researchers have been able to demonstrate that energy efficiency supports each of these critical and interrelated goals, this objective has surfaced as a primary strategy for mitigating significant sources of energy consumption, such as found in residential and commercial buildings.

Energy efficiency programs, which attempt to reduce overall electricity consumption through improved technologies, design, and operations practices, currently represent one of the most significant and "critically underutilized (opportunities) in the nation's energy portfolio" (National Action Plan for Energy Efficiency Leadership Group, 2007, ES-1). As part of the, "Energy Vision Update 2010" published by the *World Economic Forum*, U.S. Energy Secretary, Dr. Steven Chu, cited research results which determined that energy efficiency programs have the, "potential to reduce consumer demand by about 23% by 2020 and reduce (greenhouse gas) GHG emissions by 1.1 gigatons each year – at a net savings of US$ 680 billion" (p. 14). Findings such as these have led to increased global and national attention towards energy efficiency as the, "cheapest, quickest, cleanest, most abundant and most readily available resource" to deploy (World Economic Forum, 2010, p. 25). Because of their significant energy, resource, and emissions impacts, commercial and residential buildings have been identified as one of the key contributors, and subsequent mitigators, for U.S. and international strategies aimed at reducing escalating energy consumption and greenhouse gas emissions (United States Congress, Senate Committee on Energy and Natural Resources, 2009).

A. Building Impacts

Gaining an appreciation of the building energy challenge requires an understanding of the prevailing impacts of the built environment. In 2010, the *United States Department of Energy* (DOE) reported that collectively, U.S. commercial and residential buildings consume 40% of total primary energy and 70% of electricity (United States Department of Energy, 2010). Compared to the other top consuming sectors of transportation and industry, buildings represent the primary energy-consuming division in the United States, consuming about two-thirds of the total power supply. In fact, between 1985 and 2006, electricity generation increased 58% in order to meet the energy requirements of buildings (United States Department of Energy, 2008). Since coal, natural gas, and petroleum constitute 70% of the electric energy mix powering buildings, this escalation ultimately translates into greater depletion of finite natural resources and increased environmental damages from the extraction, dissipation, and emissions of these materials.

In terms of the atmospheric emissions associated with climate change, the building sector contributed 2,517 million metric tons of carbon dioxide (CO2) to the earth's atmosphere in 2007; constituting 40% of the total U.S. CO2 emissions (United States Department of Energy, 2008). From a global perspective, U.S. buildings are responsible for roughly 8% of the world's CO2 emissions; and in 2005, exceeded the combined emissions of Japan, France, and the United Kingdom (United States Department of Energy, 2008).

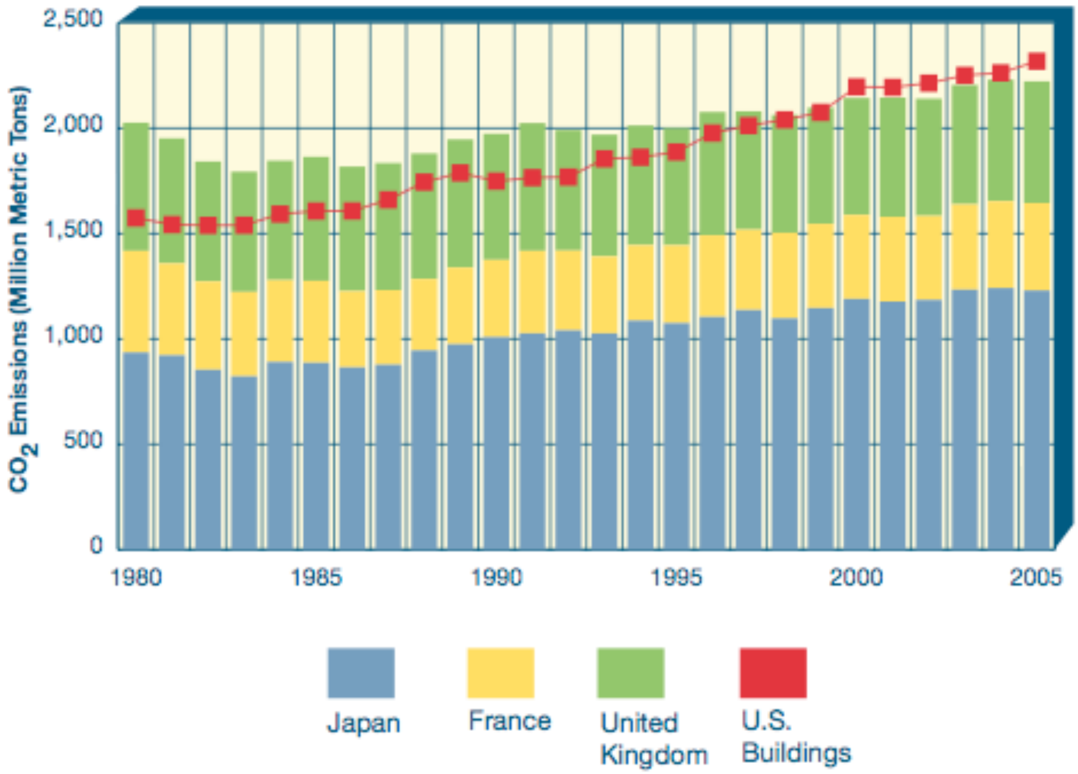

Figure 5 – CO2 Emissions of U.S. Buildings Relative to Japan, France, and the United Kingdom

The current and projected trajectory of increased energy consumption in the building sector further exacerbates the problem. In 2008, the *U.S. Energy Information Administration* (EIA) attributed the large proportion of building energy consumption to population and economic growth (United States Department of Energy, 2008). However, part of this explanation was discredited by recent economic data, which demonstrated that, despite the economic downturn that began in 2007, building energy consumption has continued to grow while other sectors have declined (United States Department of Energy, 2010).

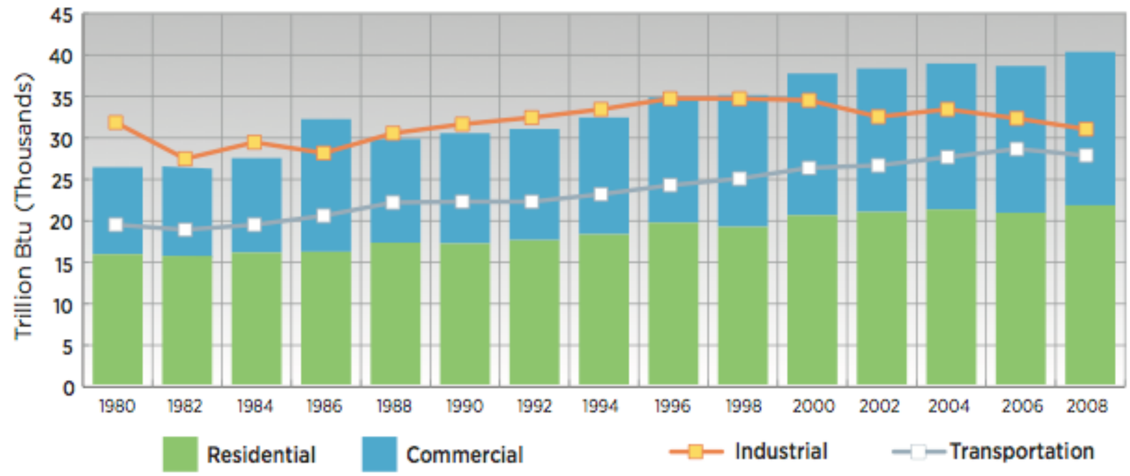

Figure 6 – Growth in Building Energy Use Relative to Other Sectors

Energy codes, which establish baseline efficiency requirements for the design, materials, equipment, and construction of new buildings have subsequently gained increased national attention as a preferred means with which to reduce overall building energy consumption and associated greenhouse gas emissions. However, as a result of this increased emphasis, researchers have determined that, by and large, building energy codes are insufficient for reducing building energy consumption for the following reasons,

> 1) The amount of energy savings available from improvements to any given building component is limited, 2) not all physical components of buildings are regulated by code, and most importantly 3) code language and enforcement mechanisms are focused on building physical characteristics, but a significant portion of building energy use is driven by operational characteristics and tenant behavior (Heller, Heater, & Frankel, 2011, pg. 47).

Subsequently, over the past decade, a number of additional voluntary and legislative efforts have been launched at curbing the energy intensity of buildings. From the rise of the *U.S. Green Building Council* and widespread adoption of the *Leadership in*

Energy and Environmental Design (L.E.E.D.) rating system; to the popularization of the *2030 Challenge*, issued by *Architecture 2030*, and the net zero energy design concept, building energy issues have moved from the fringe into the mainstream and have even begun to permeate significant legislative efforts.

B. Federal Initiatives

Two pieces of legislation best exemplify the federal efforts aimed at mitigating building impacts: the *Energy Policy Act of 2005* (EPACT); and the *Energy Independence and Security Act of 2007* (EISA). Collectively, these measures "define a broad mandate to develop Federal R&D to enable residential and commercial buildings to be more efficient and sustainable and to lower their impacts on the environment" (National Science and Technology Council, 2008). Through these initiatives, the federal government has allocated significant human and financial resources to facilitate a market transition towards energy-efficient private and public sector buildings.

To spur private sector investments, the EPACT includes a commercial building tax deduction, which allows for private building owners, and designers of public buildings, to deduct up to $1.80 per square foot for qualified properties that demonstrate a 50% energy efficiency improvement over requirements outlined in one of the nation's leading energy codes, *ASHRAE Standard 90.1-2004*; a guideline developed by the *American Society of Heating, Refrigerating and Air Conditioning Engineers* (ASHRAE) (Building Energy Codes Program & American Institute of Architects, 2011, pg. 38).

However, because the federal government is the country's largest building owner, many of the provisions are aimed at the public sector. For instance, under the EISA, federal agencies are required to reduce building energy intensity 30% by 2015; meet a minimum of 7.5% of their electricity demands with renewable sources by 2013; and meet

30% of their hot water demands with solar-based technologies in all new and renovated federal facilities (National Science and Technology Council, 2008). Additionally, all new construction or major renovations of federal buildings are required to reduce fossil-generated energy use 55% by 2010, and 100% by 2030 (National Science and Technology Council, 2008).

To ensure compliance with the EISA requirements, the *U.S. General Services Administration* (GSA) established the *Office of Federal High-Performance Green Buildings* (OFHPGB) to oversee the transition of the "342 million square feet of (federal building stock) in more than 2,100 communities nationwide" that is owned or leased by the GSA (National Science and Technology Council, 2008, p. 59). However, in order to coordinate, promote, and disseminate high-performance green building research between the public and private sectors, the EISA also mandated the establishment of the *Office of Commercial High-Performance Green Buildings*.

As part of this organization, Congress authorized, and the DOE created, the *Net-Zero Energy Commercial Building Initiative* (CBI); a consortium of public and private partnerships working to "develop and disseminate technologies, practices, and policies for the establishment of zero net energy commercial buildings" (Commercial Buildings Consortium, n.d.). To help clarify the objectives of these organizations, Congress established the following working definitions for high performance buildings, and zero net energy commercial buildings:

> A 'high performance building' means that a building integrates and optimizes on a life cycle basis all major high performance attributes, including: energy conservation, environment, safety, security, durability, accessibility, cost-benefit, productivity, sustainability, functionality, and operational considerations" (One Hundred Tenth Congress of the United States of America, 2007, Sec. 421).

Zero net energy commercial buildings are high performance buildings that are designed, constructed and operated:

> to require a greatly reduced quantity of energy to operate;
>
> to meet the balance of energy needs from sources of energy that do not produce greenhouse gases;
>
> in a manner that will result in no net emissions of greenhouse gases; and
>
> to be economically viable (One Hundred Tenth Congress of the United States of America, 2007, Sec, 422).

Despite these official interpretations, researchers have determined that, in practice, many individuals currently lack a common definition or understanding of what net zero energy actually means. Therefore, to help clarify the various methodologies, the *National Renewable Energy Laboratory* (NREL) published a report entitled, "Zero Energy Buildings: A Critical Look at the Definition," in which they outline four applications of the concept:

> **Net Zero Site Energy** - A site NZEB produces at least as much renewable energy as it uses in a year, when accounted for at the site.
>
> **Net Zero Source Energy** - A source NZEB produces (or purchases) at least as much renewable energy as it uses in a year, when accounted for at the source. Source energy refers to the primary energy used to extract, process, generate, and deliver the energy to the site.
>
> **Net Zero Energy Costs** - In a cost NZEB, the amount of money the utility pays the building owner for the renewable energy the building exports to the grid is at least equal to the amount the owner pays the utility for the energy services and energy used over the year.
>
> **Net Zero Energy Emissions** - A net zero emissions building produces (or purchases) enough emissions-free renewable energy to offset emissions from all energy used in the building annually (Torcellini, Pless, Deru, & Crawley, 2006).

While the report acknowledges there's no "best" definition of net zero, these various interpretations reveal the significance of context-specific factors in determining and establishing the fundamental boundaries and guiding principles of a net zero energy building project.

Since its inception in 2008, the *Zero Net Energy Commercial Buildings Initiative* (CBI) has established very aggressive goals for transitioning the standard building stock to net zero energy buildings. For instance, by 2030, all new commercial buildings are expected to achieve a net zero energy status; by 2040, 50% of the commercial building stock will qualify as net zero energy buildings; and by 2050, the CBI aims to achieve a complete transformation of all U.S. commercial buildings from standard to net zero (National Science and Technology Council, 2008). Although the CBI acknowledges that, achieving this sector-wide transformation will require, "a focused, multi-year public/private initiative, including coordinated technology development, demonstration and deployment supported by major innovations in policy, financing, project design and delivery, and building energy management," this admission does not diminish the daunting task of reversing the current trends and mitigating the impact of the building sector within the next 40 years (Commercial Buildings Consortium, n.d.).

Nevertheless, as indicated through these legislative efforts, the U.S. government has acknowledged the historical energy and environmental impact of buildings, and is attempting to alter the course of the building sector from one of consumption to conservation. From short-term incentives, to long-term milestones, it's clear that building energy efficiency, specifically net zero energy buildings, constitute a significant and unprecedented part of the legislative agenda. Evaluating the feasibility of meeting these established goals requires an investigation into the proposed federal strategies for navigating this remarkable transition.

C. Reduction Strategies

In 2008, the *National Science and Technology Council* issued the "Federal Research and Development Agenda for Net-Zero, High-Performance Green Buildings," outlining the, "major building technology goals that define the major transformational advances needed for energy, water, and material use for net-zero energy, high-performance green buildings" (p.6). Although the Agenda outlines six primary goals, with sixteen supplemental focus areas, and represents the "consensus assessment of 16 Executive Branch Federal agencies," the plan reveals the elementary stage of the implementation efforts as compared to the ambitious reduction targets outlined in the EISA and EPACT legislation (National Science and Technology Council, 2008, p.6).

From developing the necessary measurement science, technologies, and strategies, to formalizing the processes, protocols, and products that will enable the diffusion of net zero energy practices, the Federal R&D Agenda presents an innovation cycle predominantly dependent upon technological and market-based assumptions and transformations.

Goal 1. Develop the enabling measurement science to achieve net-zero energy, sustainable high-performance building technologies.

Focus Area a. Develop rigorous metrics that enable high-performance building goals to be predicted, assessed, monitored, and verified and new energy-efficient technologies, products, and practices to be developed.

Focus Area b. Enable widespread adoption of high-performance goals by developing practical tools and processes to address the complex interactions of building components and systems throughout the building life cycle.

Goal 2. Develop net-zero energy building technologies and strategies.

Focus Area a. Develop building envelope materials, components, systems, and construction techniques to minimize building energy loads.

Focus Area b. Develop ultra energy-efficient components and subsystems that minimize energy use and satisfy building energy needs.

Focus Area c. Develop supply-side technologies that, when coupled with energy efficiency, can achieve net-zero energy buildings and communities.

Goal 3. Develop the scientific and technical bases for significant reductions in water use and improved rainwater retention.

Focus Area a. Reduce water use through more efficient water-saving appliances, fixtures, and water systems.

Focus Area b. Develop analyses and technologies to overcome environmental, health, and technical barriers to widespread water recycling and increased rainwater harvesting.

Focus Area c. Develop low-impact development practices to significantly reduce stormwater runoff.

Goal 4. Develop processes, protocols, and products for building materials that minimize resource utilization, waste, and life cycle environmental impacts.

Focus Area a. Develop processes that minimize waste generation from building construction, renovation, and demolition.

Focus Area b. Expand life cycle inventory data and perform life cycle assessments to identify the full environmental and public health impacts of product and material choices.

Focus Area c. Develop new building materials and products with minimal environmental and public health impacts over their extended life cycles.

Goal 5. Develop the knowledge and associated energy efficiency technologies and practices needed to promote occupant health, comfort, and productivity.

Focus Area a. Develop technologies to improve indoor environmental quality and reduce building energy consumption.

Focus Area b. Develop the knowledge necessary to support scientifically sound and building-specific standards and codes that address the health and comfort of building occupants.

Goal 6. Enable technology transfer for net-zero energy, high-performance green buildings.

Focus Area a. Develop high-performance building design tools and guidance for urban planners, architects, engineers, contractors, and owner/operators.

Focus Area b. Develop tools and guides that enable the use of modern, adaptive performance-based building codes.

Focus Area c. Analyze cost effectiveness of incentives for adopting and using innovative technologies and practices.

Figure 7 – Goals for Effective Energy, Water, and Resource Use in Buildings

While the Federal R&D Agenda is supported by significant amounts of research, such as, "laboratory studies (which) indicate that new technologies integrated holistically with the building design can reduce energy consumption and CO2 emissions by as much as 70%" (National Science and Technology Council, 2008, p. 8), the Agenda is largely reflective of the technological potential of energy efficiency strategies rather than empirically-verified, energy consumption factors that have been analyzed post-occupancy.

Meanwhile, as the market for high performance and net zero energy buildings has expanded, researchers have gained increased opportunities to analyze the effects of energy efficiency measures as they've actually been implemented. In doing so, several studies have revealed the deficiencies of design-based energy predictions derived from computer-based modeling assumptions that cannot accurately predict environmental and human-based impacts, such as: operations and maintenance practices, occupant behavior, and building use patterns (Heller, Heater, & Frankel, 2011; New Buildings Institute, 2012). Therefore, while some policy-makers have characterized "technologies that improve building efficiency … as the low-hanging fruit in meeting (U.S.) energy challenges," they've done so simply because, "they are relatively inexpensive compared to other climate change mitigation strategies" (United States Congress, Senate Committee on Energy and Natural Resources, 2009, pg. 1); not because these technological "solutions" have definitively reduced energy or emissions in the built environment.

Increased awareness of discrepancies between design intentions and post-occupancy analyses indicates that, as net zero energy building design increasingly gains traction as a preferred strategy with which to lessen the impact on climactic and atmospheric conditions, policy measures should intensify their use of feedback loops to evaluate how legislative intent is being met by the proposed solutions. In the next section, I'll review significant findings from research devoted to examining net zero energy design in practice. Taking a closer look at the required modifications from the perspective of the practitioner has reaffirmed that energy reduction efforts primarily consisting of technological development and dissemination, in conjunction with market-based modifications, don't begin to constitute the entirety of strategies needed for advancing net zero energy design solutions. Rather, as design professionals become actively engaged in implementing net zero practices, they're dramatically expanding the interpretative boundaries of the building energy challenge.

3.5 - Net Zero Energy Design in Practice

As previously stated, one of the primary objectives of my research has been to expand net zero energy design considerations beyond the theoretical confines of what's been advised and reveal the reality of what's transpiring. One of the primary challenges of this expanded research agenda is the lack of resources that offer the perspective of practitioners who've actively engaged in pursuing a net zero energy status for their projects. This, in part, could be the result of the very small number of projects, and project teams, who've actually achieved this low energy milestone. Through a review of the limited amount of literature that explores net zero energy design applications, I've learned that, despite the ambitious legislative mandates and voluntary challenges, this alternative design technique has yet to take hold in the U.S. marketplace.

A. Conditions in the Field

In March of 2012, the *New Buildings Institute* (NBI) published a comprehensive status update on the achievement of net zero energy within the U.S. commercial building sector. Based on their analysis of buildings constructed between 1994 and 2012, a total of only twenty-one "occupied commercial buildings with either measured net zero energy results (15 cases), or credible modeled expectations for such results (6 cases)" exist within a variety of climate zones in the United States (New Buildings Institute, 2012, p. 9).

> In addition to these operational zero energy buildings, their study identified thirty-nine low energy buildings that "demonstrated energy efficiency levels in the range of the documented ZEBs (zero energy buildings)" (New Buildings Institute, 2012, p. 4). Referred to as *Zero Energy Capable* (ZEC) buildings, these structures are described as having the potential to achieve a net zero energy status pending financial and logistical considerations such as, the availability of "space for installing PV panels, (and) the abundance of solar radiation for the building location" (New Buildings Institute, 2012, p. 12).

While the NBI report helps to demonstrate the unique nature of net zero energy commercial buildings in the U.S., the analysis also reveals that expanding this limited market is not dependent upon the diffusion of advanced technologies, or expanded access to greater financial means for building owners. Rather, after reviewing the actual strategies used to achieve significant energy reductions, the analysts determined that, "the efficiency levels needed for ZEBs are readily obtainable, with current technology and at reasonable incremental costs, for many common building types" (New Buildings Institute, 2012, p. 5). While this "key overall conclusion" seems to bode very well for the desired transition of energy consumption in the commercial building sector, it ultimately reinforces the need to expand research and legislative agendas beyond the investigation of technological and market-based assessments and solutions.

In contrast to the "technology roadmaps" which examine the technological potential for net zero energy buildings, the NBI status report presents a series of recommendations obtained from projects that have actually achieved the desired energy reductions. Consequently, their recommendations extend beyond the pursuit of technological "fixes" and acknowledge the interplay between the technical and social forces influencing the pursuit of a dramatically diminished energy profile for U.S. buildings.

From identifying and providing "practical guidance" to the marketplace of "the conditions where zero energy buildings are most feasible; to "(developing) a better basis for benchmarking performance;" and finally, to encouraging the "measurement and communication" of net zero project results; the NBI recommendations convey how advancing zero energy buildings is ultimately dependent upon cultural, operational, and technical modifications to conventional design processes (New Buildings Institute, 2012, p. 32-34). In other words, by investigating the processes as they've actually been implemented, and focusing on the actual outcomes, versus the theoretical intentions of low energy "solutions," the NBI report highlights how context serves as a significant influence on building energy consumption. Additionally, by attaining the perspective of practitioners who've engaged in the day-to-day challenges of net zero energy building design, the Status Update reveals the invaluable quality of empirical insight.

B. Perspective of the Practitioner

Fortunately, another study obtained and provided an even more in-depth perspective of practitioners engaged in net zero energy building projects. In 2010, *Environmental Design and Construction Magazine* (ED+C) hosted a series of roundtable discussions aimed at exploring net zero principles in practice; specifically, the "concepts, processes and software needed to achieve innovative (net zero) facilities" (On the Record: NZE Expert Roundtable I, 2010a, para 1). Roughly twenty participants from the public and private sectors participated in the discussions and presented the unique perspectives of: owners, architects, engineers, sustainable design consultants, project managers, and mechanical and technological systems representatives. Through a series of articles that offer contextual insight into the types of modifications that result from net zero energy pursuits, these individuals revealed the events that transpired on the following net zero energy projects: the *Research Support Facilit*y at the *U.S. Department of Energy's National Renewable Energy Laboratory* (NREL) in Golden, Colorado; and the *Aldo Leopold Legacy Center* in Baraboo, Wisconsin.

While each project materialized out of its own social, organizational, and technical contexts, the roundtable discussions revealed that the various practitioners shared many significant influences, beginning with a personal and professional commitment to achieve energy optimization and/or environmental protection. Additionally, for each project team, the achievement of net zero appeared to rely upon the integration of alternative knowledge, innovative procedures, and scientific philosophies that deviated outside of their traditional design conventions. Their shared experiences begin to convey that, in order for the building industry to successfully achieve a transformation from energy consumption to conservation, the building culture will be challenged to embrace alternative knowledge, procedures, and values that are specific to net zero energy building design. The following sections will explore some of the firsthand design wisdom unveiled during the roundtable discussions.

1. Knowledge

At the most fundamental level, net zero projects require that the project team have a basic understanding of energy and environmental design principles related to thermodynamics and solar geometry; in other words, the inconspicuous natural phenomenon which ultimately influence energy consumption. However, beyond this basic understanding, practitioners must also learn to translate and apply that knowledge to their individual specializations while attempting to create a unified and coherent whole. This essence of this process was discussed during the roundtable as follows,

> This kind of architecture is completely dependent on the initial phase of a project, where you are letting the sustainability goals, the site and the program shape the design — from the very first sketches, trying to figure out how to daylight every single space, yet control heat gain and glare, while also creating a beautiful building. Fundamentally, you are letting the site, daylighting, solar control, and the program all come together to shape and sculpt the architecture (On the Record: NZE Expert Roundtable I, 2010a, para 8).

Once the scientific principles have been established, practitioners must learn to speak a common, standardized language specific to net zero energy design. From determining the appropriate definition of net zero, to establishing the required metrics for the energy calculations, the roundtable participants revealed how the success of a net zero project is very much dependent upon practitioners calibrating their expectations in order to establish the optimal guiding principles for all energy-based design decisions.

As is evidenced by these alternative design procedures, "calculating" the success of a net zero project requires coordination on many new and unprecedented levels. Although historical language and metric barriers exist between the various building industry specializations, it's clear that net zero projects challenge team members to overcome these individual and collective obstacles. From engaging in a shared energy-based specialization, to learning how to speak and comprehend one common language, the success of a net zero project requires that the fragmented building industry collectively overcome any existing knowledge barriers and cultural divisions in order to perform and comprehend unconventional energy-based assessments.

Another notable and unique skill set required for net zero projects is the scientific and technical process of energy simulation. Similar to the computer-aided design software that's preceded it, energy simulation programs hold the promise of revolutionizing the building industry by providing designers with the ability to scrutinize the energy-based impacts of their design decisions. Because of these technologies, numerous practitioners have access to powerful tools that allow for the intangible nature of energy to become more perceptible.

While the roundtable participants acknowledged that the industry currently lacks a single, comprehensive energy modeling program, the general consensus seemed to indicate that the overall benefits of energy simulation outweigh the unperfected state of performance assessment instruments. From managing and processing large amounts of data, to facilitating long-term cost and energy-based trade-off analyses, simulation is clearly portrayed as an essential tool for net zero energy building projects. One roundtable participant captured this sentiment with the following statement,

> In regards to performance or energy modeling being part of the design process to help inform good low-energy decisions — let's not beat about the bush. This approach is very much at the crux of achieving net-zero energy facilities, and there is definitely a need within the industry to think about the design process and analysis in an entirely new way, not just modify existing practices (On the Record: NZE Expert Roundtable II, 2010b, para 1).

While it appears that net zero projects place overwhelming faith in this technological advancement, the roundtable participants also acknowledged several significant challenges that result from relying upon these tools. This first opinion emphasizes the challenge of integrating the software into practice,

> The issue … is that most building-performance simulation tools are deemed not compatible with architects' working methods and needs, but that the most impact is made when their feedback is incorporated right at these earliest stages. From the perspective of many architects, such tools are judged as too complex and cumbersome (On the Record: NZE Expert Roundtable II, 2010b, para 2).

Another comment acknowledged the validity of simulation results,

> We recognized that to go beyond relative modeling and start to predict actual absolute performance, we needed to do some kind of benchmarking of our model

> to figure out if the simulation results were reasonable and believable. We started to realize that getting our models to predict believable absolute results might be difficult because we know that energy models are only as good as the input data we enter. It's the classic garbage-in-garbage-out situation (On the Record: NZE Expert Roundtable II, 2010b, para 6).

Finally, and possibly most critically, the need to go beyond simulation and provide real-world verification was addressed,

> We've found that the energy models are definitely not the same as reality, so our design teams have really been focusing on actual real measured energy use rather than just modeled energy. We've completed a handful of zero-energy buildings and the monitoring always turns up something unexpected (On the Record: NZE Expert Roundtable II, 2010b, para 6).

Observations such as these reveal how net zero projects rely upon much more than the diffusion of advanced technologies; and demonstrate how technological potential is also dependent upon proper education, application, and interpretation. Subsequently, in order to meet the alternative demands of net zero energy projects, the roundtable participants conveyed how they were ultimately compelled to modify their conventional design procedures.

2. Procedures

As portrayed during the roundtable discussions, successful net zero projects ultimately rely upon a constant process of energy budgeting; a practice that involves assessing and balancing a project's energy needs against its potential alternative energy supplies. Just as the particular definition of net zero serves to inform all decisions, so too does the "energy budget." Typically interpreted as the *energy use intensity* (EUI), or energy use per square foot per year, calculating and maintaining the integrity of this target necessitates a series of alternative practices unique to net zero projects, beginning with project team integration (Torcellini et al., 2006).

In order to gain the necessary input for determining the project's energy budget, net zero projects typically involve the early integration of all relevant project practitioners. By collectively establishing the EUI early on in the design process, the entire team is able to benchmark their individual decisions against an agreed upon target (Torcellini et al., 2006). Essentially another form of conceptual alignment, one roundtable participant described the merits of this process as follows,

> This creates an informed process for orientation and building form and also creates a trusted set of data that exists from the earliest point on. You get away from the silo thinking where nobody trusts each other's data. Critical energy factors, form and other decisions then trickle down to more-detailed decisions (such as building envelope and HVAC) without loss of fidelity (On the Record: NZE Expert Roundtable I, 2010a, para 9).

Furthermore, the transformative effect of an inserting an energy target into the practice of architectural design was also acknowledged,

> It was imperative upfront that the integration of all of the energy features represented in this facility were thought about before determining the buildings architecture. Importantly, the energy and other performance goals drove the architecture rather than the reverse (On the Record: NZE Expert Roundtable I, 2010a, para 9).

With the energy target established, the project team was then able to begin the process of monitoring and maintaining the integrity of the energy budget throughout the various stages of design, construction, and building occupancy. During the various design phases, this verification process was achieved through an ongoing process of design and simulation. According to a roundtable participant, this process diverges from standard practice in the following way,

> There were fewer distinctions between schematic design and design development. It was a continuous unfolding of the design. We design with an energy model; we get feedback from the owner; we design; we get energy model and get feedback from the owner (On the Record: NZE Expert Roundtable I, 2010a, para 10).

While iteration after iteration is simulated throughout the various stages of design and construction, net zero energy architecture necessitates that this type of measurement and verification continue into the stage of building occupation. As expressed by one roundtable practitioner,

> The Net Zero Energy Building concept is really a measurement of operation. It is not a measurement at the end of the design energy model. And it gets proven out over a year of operation (On the Record: NZE Expert Roundtable I, 2010a, para 12).

By expanding design assessment beyond construction administration, and into building operations, net zero energy design fundamentally modifies the conventional phases of project delivery. Not only does this practice promise to revolutionize the way in which buildings are evaluated, but the process of attempting to validate simulation results against real-world conditions ultimately serves as a testament to the contextual significance of human and environmental conditions on building energy efficiency. For these reasons, recent analyses of net zero energy in practice have increased their attention on the significance of measured vs. modeled energy consumption trends.

C. Post-Occupancy Analysis

One year after publication of the roundtable discussions, researchers who were intrigued by discrepancies between energy modeling results and actual, post-occupancy energy consumption levels, conducted a study to compare the impact of: design variables, operational characteristics, and tenant behavior on total building energy use. After identifying twenty-eight building design and operation characteristics that largely impact building energy consumption, the analysts assigned low, baseline, and high levels of performance conditions to each variable. Established from “research and field observations of actual building performance characteristics that (are) found in the building stock today," these performance values were selected because they did "not represent extreme or theoretical conditions" (Heller, Heater, & Frankel, 2011, p. 2).

Using building energy modeling software, the analysts then studied the impact of individually modifying the ranges of each performance variable over the sixteen different U.S. climate zones. In doing so, they were able to determine the significance of operational and tenant impacts, as compared to design characteristics, on total building energy use. According to their report,

> … if you were to ask most people about building energy efficiency, the vast majority would describe physical features like insulation, efficient HVAC and lighting, or alternative energy systems. The perception in the market is that the responsibility for building energy performance is in the hands of architects and engineers and is relatively set once the building is constructed. This perception represents a significant barrier to broad societal goals to substantially improve building energy performance and reflects an extremely inaccurate perception of how buildings work. In fact, a significant percentage of building energy use is driven directly by operational and occupant habits that are completely independent of building design, and in many cases these post-design characteristics can have a larger impact on total energy use than many common variations in the design of the building itself (Heller, Heater, & Frankel, 2011, p. 2).

As demonstrated through these findings, and the preceding empirical analyses, pushing the boundaries of energy conservation by targeting net zero energy use holds the promise of fundamentally modifying the knowledge, procedures, and cultural values that have historically characterized the conventional building culture. By shifting the focus from anticipated to verified, or outcome-based energy targets, net zero energy design is effectively renovating the culture of building by prioritizing "post-construction building characteristics and operation that are currently outside the scope of energy codes, policy initiatives, and general perceptions in the building industry" (Heller, Heater, & Frankel, 2011, p. 50).

Subsequently, in order to transform buildings from units of energy consumption to units of energy production, findings in the literature, as well as my empirical analysis, indicate that practitioners will be challenged to expand the scope of conventional design considerations and compose a new and innovative design agenda that's responsive to the multitude of factors that influence building energy consumption. In my opinion, one of the most decisive issues at this juncture is whether or not the majority of individuals within the building industry will choose to embrace this transformative challenge and serve as active participants in the proliferation of net zero energy buildings.

D. Advocacy

Two of the most active and vocal advocates for net zero energy buildings have been the non-profit organization *Architecture 2030*, and the professional organization, the *American Institute of Architects* (AIA). Initiated by architect Edward Mazria in 2002 as a special project within his architectural practice, *Architecture 2030* produced its first findings on building sector energy consumption in 2003, revealing that the building sector is responsible for 48% of total U.S. energy consumption and greenhouse gas (GHG) emissions, and 77% of total U.S. electricity consumption (Architecture 2030, n.d.b; Hawthorne, 2003). Following this call to action, the *American Institute of Architects* adopted a "Sustainable Architectural Practice Position Statement" in 2005, which called for,

> a 50 percent reduction from the current level of fossil fuel consumption used to construct and operate new and renovated buildings by the year 2010 and further reductions of remaining fossil fuel consumption by 10 percent or more in each of the following five years with the ultimate goal of zero fossil fuel consumption by the year 2030 (The American Institute of Architects, 2005).

Architecture 2030 issued the *2030 Challenge* in 2006, calling on the international architecture and building community to reduce the fossil fuel and GHG-emitting energy consumption for all new buildings, developments, and major renovations by 50% immediately, and progressing incrementally towards carbon neutrality by the year 2030. Today, six years after its initial issue, the *2030 Challenge* calls for an immediate 60% reduction.

The *American Institute of Architects* was the first organization to adopt the *2030 Challenge*; and to gauge the progress of their members towards achieving this goal, the AIA launched the "2030 Commitment Program" in 2009. Established as a voluntary effort, the program requests that interested organizations submit a signed commitment letter agreeing to the following terms of the *AIA 2030 Commitment Program*:

> Within two months of the commitment date, establish a team or leader to guide the development and implementation of the firm's plan;
>
> Within six months of signing the commitment, the firm will implement a minimum of four operational action items from the list provided (Suggested items include, the tracking and modification of: office energy use, waste reduction and supplies; transportation; and meeting procedures). These actions will be undertaken while the long-term sustainability plan is in development;
>
> Within one year of signing the commitment, the firm will develop a sustainability action plan that will demonstrate progress toward the AIA's 2030 goals.
>
> At the conclusion of the year, and each year thereafter, the firm will report on the progress of the firm's design portfolio towards meeting the 2030 goals by using the AIA 2030 Commitment Reporting tool (The American Institute of Architects, 2009).

By the end of 2010, one-hundred thirty five sole practitioner and multi-national organizations had submitted their commitment letters to the AIA; demonstrating that, within the industry, a commendable number of firms were compelled by the notion that, Architects need to accept responsibility for their role in creating the built environment and, consequently, believe we must alter our profession's actions and encourage our clients and the entire design and construction industry to join with us to change the course of the planet's future (The American Institute of Architects, 2005)

One year following the establishment of the *2030 Commitment Program*, the AIA published a summary of the annual progress reports submitted by firms who'd signed the *Commitment* during its inaugural year (The American Institute of Architects, 2011). While the report indicates that progress is being made, it also reveals there's a significant gap between the ambitions of the *2030 Commitment*, and the actual achievements of the committed organizations.

Although the pledge to "measure and report (the) annual progress of a firm's design portfolio towards the 2030 goals," is referred to as the "most critical aspect of the AIA 2030 Commitment," (The American Institute of Architects, 2011, p. 22) only fifty-six of the one hundred and thirty five participating organizations disclosed this information for publication in the Annual Report. Out of those, it was determined that only 12% of the combined design portfolio's, weighted by gross square feet, have met the current 2030 target of reducing a buildings energy consumption by 60% below the national average of the 2003 *Department of Energy Commercial Buildings Energy Consumption Survey* (The American Institute of Architects, 2011, p. 12). Of note, is the fact that this 12% figure is based upon the Predicted Energy Use Intensity (PEUI), calculated with energy modeling software during the design phase, rather than actual metered energy use, determined post-occupancy (The American Institute of Architects, 2011, p. 10).

Referred to by the AIA as a "quantitative measurement of (the) profession's actual progress towards the goal of carbon neutral design," (The American Institute of Architects, 2011, p. 14) the data presented in the First Annual Report reveals that the industry is currently at a very elementary stage of comprehension and implementation towards achieving the desired energy and emission targets of the *2030 Challenge*. Through the following admission, the AIA's First Annual Report acknowledges the enormity of the task at hand.

> The data clearly shows that many firms are designing buildings to meet the 2030 energy targets for a portion of the work within their practice, but the transformation of the market by making incremental energy efficiency improvements uniformly across a firm's practice clearly has many more complex challenges than just a desire to design and build green (p. 14).

Inspired by the "complex challenges" facing design professionals who seek to advance net zero building design, I've dedicated the final component of my research report to my own empirical findings obtained from observing, interviewing, and surveying individuals engaged in the Denver iteration of the *AIA+2030 Professional Series*.

IV. Empirical Findings

As threats associated with climate change have become more palpable, the tempo of debate and the urgency for action has increased. Faced with quantitative data that exposes the substantial consumption of natural resources by building construction, operation, and design practices, numerous organizations and individuals have embraced the widespread adoption of standardized high-tech science and technology solutions as the predominant paradigm for mitigating the impacts of energy and emissions in the built environment. At this juncture, the manner in which the building industry, specifically architectural practitioners, responds to the internal and external forces of influence associated with a global paradigm shift towards sustainability is critical.

The *eco-technic logic*, which conceptualizes the environment as an entity that can be managed through science, technology, and objective analysis, has emerged as the prevailing line of reasoning for reducing energy consumption in the built environment. Subsequently, my primary research intention has been to temper analyses, based upon the theoretical potential for reduced energy consumption, with an empirical investigation into the social construction of technological change. By expanding the research agenda to include the point-of-view of practitioners, I've gained a more thorough understanding of the social and cultural considerations that underlie both the momentum for, and resistance to change within the emergent and existing building cultures.

Admittedly, by virtue of registering for the *AIA+2030 Professional Series*, the enrolled participants represent a self-selecting group of advocates who see net zero energy knowledge as valuable to themselves and the world. However, throughout the course of this investigation, I've discovered that a shared desire to learn more about net zero energy design does not automatically translate into common motivations for attendance, shared expectations from the program, and universal values towards net zero energy architecture.

Nonetheless, amongst the diverse array of individual perspectives gathered throughout my investigation, several common themes emerged as significant internal and external forces of influence for advancing net zero energy buildings. As previously submitted in the chapter on *Science and Technology Studies*, the primary components exerting control over the prevailing and emergent building cultures can be categorized as either internal or external pressures. Cultural, organizational, and technical aspects represent the most significant internal forces; whereas, environmental and political considerations constitute the most predominant external forces.

By sharing the statements and survey responses of net zero energy design advocates, as gained throughout the course of my investigation, I'll present the most predominant themes, or sub-categories of influence to emerge as either opportunities or challenges for advancing net zero energy buildings. Following this comprehensive presentation, I'll synthesize these empirical findings in order to address my primary research question which seeks to determine: how architects, who are advocates of net zero energy building design, perceive their role in transforming the sociotechnical sub-practices of the profession.

4.1 - Cultural Forces

Cultural forces, defined as the attitudes, behavior, and fundamental values that are characteristic of building industry professionals, emerged as one of the most significant motivators for advocates of net zero energy building design. Manifested most clearly through the topics of: change, responsibility, leadership, and art and science, these cultural influences can be classified as distinguishing characteristics of advocates who are committed to the advancement of net zero energy buildings.

A. Change

One of the initial and most prevalent themes to emerge from the *Series* was the recognition and acceptance of the need for change within the building industry. Originally acknowledged by the *Series* Moderator during the introduction of the first class session, the notion of change was presented as a generally accepted necessity, yet unfulfilled endeavor. As suggested by the Moderator,

> So I'd ask you the question: Are we, as architects, ready to change? Are we ready to embrace this challenge? Now that we know that, in fact, buildings are the single biggest piece of the equation. And I know that a lot of architects, as a profession, we're saying that yes we are ready to change. In fact, we've already implemented quite substantial change; but I'd argue, at the same time, I don't think that we're there yet. … Why haven't we been able to do more …? What's wrong? (AR3).

While the admission of feeling a lack of accomplishment was left as a rhetorical question, I believe it set the tone for valuable and constructive contemplation amongst the *Series* participants. As pioneers of this emergent design paradigm, advocates may find that addressing the fundamental barriers to the proliferation of net zero energy buildings presents a compelling design challenge that rivals the creation of the low energy structures themselves.

One interviewee captured the essence of this monumental paradigm shift as they reflected on how cultural attributes and organizational parameters currently serve as primary barriers for achieving change within the industry. From their experience, "There's an inertia to how we've always done business; and there's a cultural change to how we need to do business" (AR3). Although they expressed their personal desire to implement the recommended net zero design modifications, they tempered those ambitions by acknowledging the momentum for change within the industry.

> We have brought back and presented some of the information that we've learned in the 2030 (Series). So we're absolutely trying to fundamentally change how we do business based on what we're learning. That's a slow step process; it's not a quantum leap process. And we'll just be exploring it with each new project (AR3).

For another interviewee, the magnitude of the desired transformations extends far beyond architecture and the design professions, and represents an awakening for society at large.

> For me it's about the bigger picture, it's not about chasing the latest trend to get work – I think it's a fundamental change in the way we're thinking – not just as a community – and not just as a country - but as an overall global community we need to think about what we're doing because we're just going to run out of energy (AR3).

By framing the topic of culture as a significant impediment to the development of net zero energy buildings, these *Series* participants have reinforced how characterizing the performance-based building movement as simply a technological challenge largely misrepresents some of the most essential forces of influence. Rather, as presumed at the onset of my investigation, attaining the perspective of net zero energy design advocates demonstrates how technological change is fundamentally rooted in social change.

B. Responsibility

Statements in support of the need to pursue and implement fundamental change within the industry often inspired the next most predominant themes to emerge: responsibility and leadership. While the subject of responsibility was most often addressed as an issue of individual and professional accountability, the topic of leadership was conveyed as a collective opportunity for the profession at large.

Ultimately, both themes emerged as strong motivators for a compelling number of advocates.

For one interviewee, having a sense of responsibility extended beyond the challenge of energy conservation and represented a fundamental quality of being a licensed design professional.

> I feel it's my professional duty to be licensed in the state that I practice architecture in. It's a responsibility to the citizens of that state that I'm taking full responsibility for the buildings that I'm building (AR3).

Historically, the roots of this association conceivably date back to the beginning of the nineteenth century when architecture emerged as a professional practice. Scholars Owen and Dovey (2008) described the initial foundational principles of the profession as encompassing the following "three forms of legitimacy,"

> The first was a reliable and exclusive body of knowledge acquired through substantial education, which was linked to the rise of scientific rationality and technical reasoning. The second was the promise to use such knowledge in the service of society. Finally, the profession guaranteed the competence of its members (Owen & Dovey, 2008, p. 11).

Today, these principles evidently continue to imbue practitioners with a sense of responsibility towards the greater good. During a presentation to the Denver community at the conclusion of the *AIA+2030 Professional Series*, Edward Mazria, of *Architecture 2030*, acknowledged and celebrated how this cultural attribute serves as a significant influence on the net zero movement. After describing the initial sense of dismay the design community felt when faced with the realization that the building sector was largely responsible for substantial carbon emissions, Mr. Mazria conveyed the following:

> Why did this shock the building sector, especially the architectural and planning community? Because architects, and planners, and landscape architects go through schooling and are essentially brought up into the profession to be, in a sense, utopian; that everything we do is helpful. At 19 years old you walk into school, you walk into a design studio, and the first problem is, redesign downtown

> Philadelphia so that it works, and it's a really pleasant place, and that it works for people. You're given low-income housing projects; make life better for people. You go through five years of that. Maybe you go to graduate school another year or two, and then you go out into the profession. So to tell architects that they pollute, and that they're part of this problem, really jars their professional pride and what they do. And so, they're predisposed to do the right thing (Mazria, 2011).

During my investigation, recurrent statements about one's sense of responsibility suggested that, amongst net zero energy design advocates, a sense of personal accountability for one's work is a central and shared value. Subsequently, I utilized my final research survey to determine what inspires the greatest sense of responsibility for advocates of net zero energy building design.

In response to the question, "What best describes your personal interest in net zero energy design," the survey respondents were asked to select any of the provided reasons and rank them as either: *Most Influential*, a *Significant Consideration*, or *Least Influential*. Amongst the factors ranked as *Most Influential*, the overwhelming majority (74.1%) of individuals selected that they were primarily motivated by "Personal Reasons," described as, "a moral obligation to do the right thing; which in this case, represents mitigating unintentional environmental consequences caused by energy consumption in buildings."

The second *Most Influential* motivator (46.2%) was the stated objective that, "Business as Usual Needs to Change, and the design industry as a whole needs to establish a new agenda tailored to meet the challenges of the 21st century." Overall, these two justifications notably surpassed the other alternative options of: Professional Development, Business Development, and Marketing Purposes, reinforcing how change and responsibility currently serve as fundamental values for net zero energy design advocates and primary guiding principles for the emergent performance-based building culture.

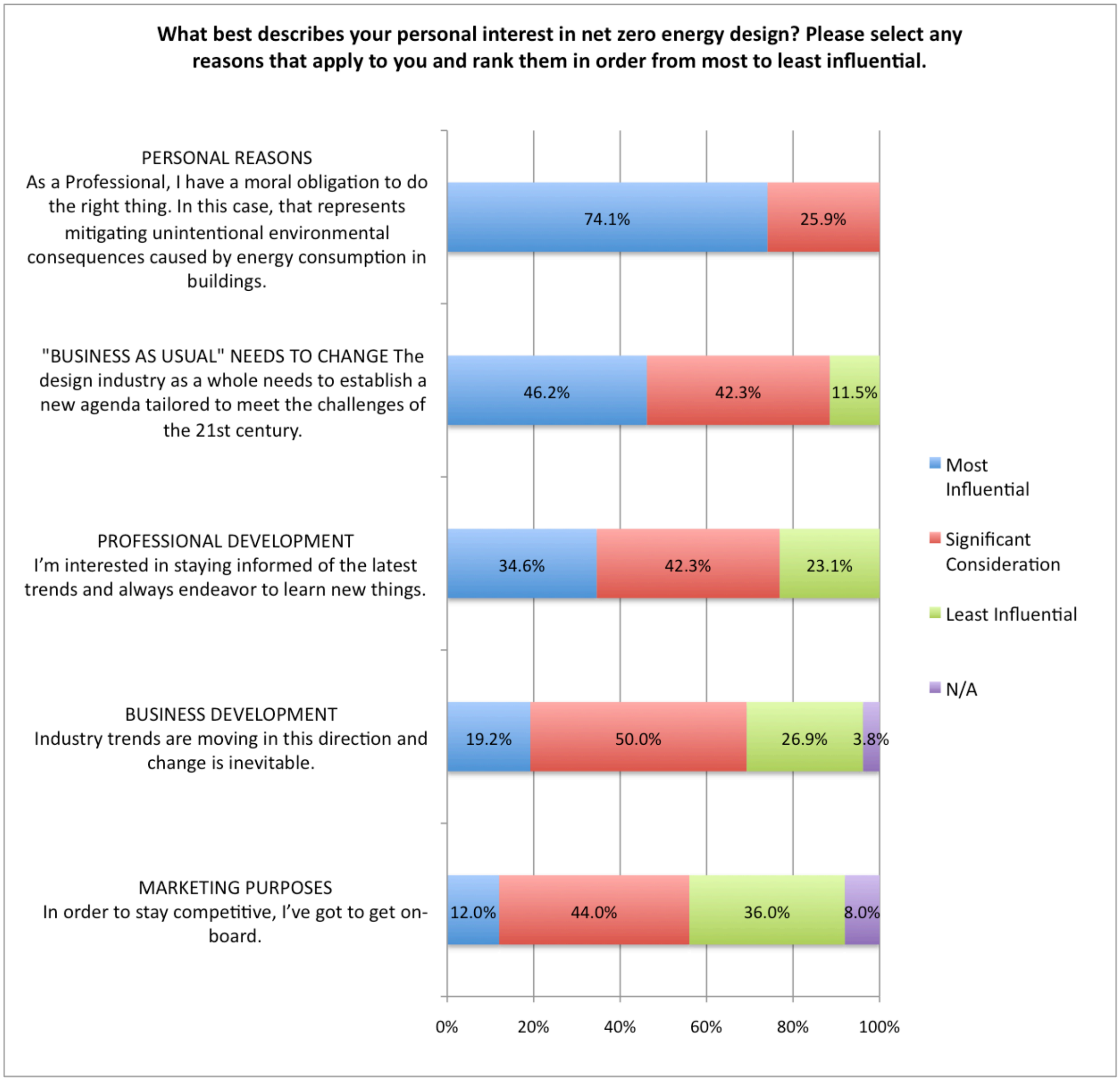

Figure 8 – Survey Question Number Five – Personal Interest

In fact, for the *Series* Moderator, accepting the responsibility to change actually serves as a central component of the net zero energy design challenge. This admission was expressed in response to the breaking news of the 2011 Tohoku earthquake and subsequent tsunami, in which the Moderator stated,

> (The Tohoku earthquake) reminds me that we can never forget that we live on a dynamic planet that's always changing; and one of our responsibilities as

> designers is to be attuned to that, and aware of that, and ourselves be ready to change. And I think that's a lot of what the 2030 Series is all about (AR3).

As perceptions about climate change and the environmental impacts of the built environment have become more intense, it's quite logical that those with a sense of moral responsibility to do the right thing would support the adoption of alternative design practices aimed at mitigating the unintentional consequences of development. However, by affirming their support of a fundamental paradigm shift for the building industry, in which design is responsive to contemporary social and environmental global objectives, these advocates have exemplified how technological systems, or building cultures, can be both a cause and effect; (they) can shape and be shaped by society (Hughes, 1994). In other words, rather than portray the net zero energy building movement as an autonomous phenomenon, aimed at simply the technological diffusion of low energy building solutions, these advocates have illustrated how prevailing forces within the conventional building culture are informing alternative values within the *performance-based building culture*.

C. Leadership

In addition to expressing a moral inclination that design should be responsive to the challenges of the 21st century, several *Series* participants associated the notion of responsibility with architects taking a leadership role in driving the desired change throughout the industry. As expressed by one instructor,

> This is really about building a foundation for architects to – we really need to kind of take leadership now in the energy, right? We've been leaning on our buddies in mechanical engineering too long, right? How can we own the energy problem and use design to solve that? (AR2).

For the *Series* Moderator, the potential leadership opportunities afforded to architects who embrace the integration of alternative energy solutions effectively represents a transformative opportunity for architects to assume a pivotal leadership role, not only within the design community, but also for the country. After reciting the following proposition offered by President Obama during his 2011 State of the Union Address, the Moderator contextualized the timeliness of the net zero movement for the building industry with the following statement. First, from President Obama,

> This is our generation's Sputnik moment. Two years ago, I said that we needed to reach a level of research and development we haven't seen since the height of the Space Race. And in a few weeks, I will be sending a budget to Congress that helps us meet that goal. We'll invest in … clean energy technology -- an investment that will strengthen our security, protect our planet, and create countless new jobs for our people (President Barack Obama, 2011).

Next, the reaction of the *Series* Moderator,

> To me that was a very powerful statement, and I think it's really exciting that what we've been talking about, what we've been trying to achieve for many years is now being really acknowledged at the highest levels within our government. It's also, I think, amazing that we are on the verge of having a national energy policy for the first time in 40 years and no longer being the only industrialized country in the entire world without a national energy policy. And I think it's really cool that we can be the sort of rocket scientists of our generation; and of course that requires a lot of education (AR3).

For another interviewee, there was a sense of pragmatism as to why architects should offer guidance for meeting the "daunting," yet "compelling," goals of the 2030 Challenge. Stating that, "architects need to lead because it's not going to be industry driven" (AR3), this individual acknowledged how, architects are not only characteristically well suited for leadership, but top-down support for a cause serves as a motivating force for change within the profession.

> I don't know that we're prepared (to serve as rocket scientists) but I think that, … we're passionate, and you need people with passion; and we've visionary, and you need people with vision. So it's not a well-greased, well-financed effort at this point, but there's clearly leadership at the top that's saying that this is important to us. And I think that any time you have that kind of clear direction, it's going to happen (AR3).

Again, Edward Mazria of *Architecture 2030* shared this same sentiment by suggesting that the development of, and dedication to, a revised design agenda represents one of the most significant forces for change within the industry. Optimistically looking beyond failed governmental attempts to address climate change, Mr. Mazria placed his faith for much needed leadership within the design community.

> The good news is, that the building sector does not transform because of policy, and it doesn't transform because of politics. It transforms when the design leadership in the building sector lays out a new agenda, and then they start practicing it; and then everybody follows in, jumps in. And that's how the building sector transforms. So that's the good news (Mazria, 2011).

Of course, for top-down leadership to be effective, practitioners must also serve as active and engaged advocates and implement the desired changes. However, within the field, this type of bottom-up campaigning may challenge the conventional guidance architects have historically offered their clients. One interviewee described this type of scenario by addressing their frustration with individuals who assume a "defeatist attitude" and fail to demonstrate the type of initiative that could inspire alternative, low energy design solutions. In doing so, they revealed the type of transformative conversations that net zero advocates might be challenged to pursue with their clients.

> I absolutely think it's his responsibility to educate his clients on why this is critical, and why they can't do it any other way. … There's a lot of people with that attitude that just sit back and say, 'Yeah, you know, I see that in the magazine and that's cool, it's net zero. Gee, I wish my clients would do that.' And I think it's our responsibility as a profession to say, 'Well, maybe you don't need ten thousand square feet; maybe you only need nine thousand square feet. Let's offset those costs that you say you can't afford by designing some things a little bit more efficient, (and) not have as much storage space (AR3).

In addition to supporting the idea that architects should assume a leadership role in advancing net zero energy building design, these collective statements have implied that advocates should serve as change agents with their clients, the design community, and society at large. While design appears to represent the preferred means which to exert this new type of leadership, advocates might find that this new role leads them to question traditional values associated with conventional design, while also adopting alternative responsibilities within the profession. Specific statements that revealed such emerging cultural and professional transformations were conveyed in discussions about the mutual significance of art and science.

D. Art and Science

When asked if any cultural aspects provided either opportunities or barriers for the proliferation of net zero energy building design, one interviewee identified what many architects' consider to be the quintessential "core of the discipline" - building aesthetics (Owen & Dovey, 2008, p. 11).

> The whole aesthetic issue is definitely a barrier. … You know, the glass box as the generic example that architects idealize. … To me I see it as empty at this point. But I don't think that everyone agrees that beauty can kind of dazzle us and we forget what else it means (AR2).

While this architect ultimately conceded that, "the best solutions are going to be those that mend both … the beautiful and energy efficient together" (AR2), their critique of the predisposition to favor form over energy consumption signifies one of the most extraordinary value shifts between the *conventional* and *performance-based building cultures*. For this individual, traditional judgment criteria based upon the visual merits of aesthetics no longer appeals as the most significant determinant of respectable design.

> When I see a beautiful building that I know is low–e, single pane glass, you know, it feels empty to me now. Even though it may be beautiful, I don't value it as much. I can't accept it as a good thing. You know, it's just irresponsible, I think, to do only that (AR2).

Not alone in this view, another interviewee conveyed a similar critique as they expressed their desire for more comprehensive evaluation criteria for determining what constitutes “good design.”

> We have become such a visual culture; and so much of how people judge architecture, or write about it, give it awards, (is) all based on the photographs. And it has no understanding of what it’s like to be in that space, or to live there, or to work there, or walk through there everyday. Does if function well? Does it make you happy? Does it enhance your life to be there? You can’t tell from a photograph. And so, … we’re only judging by the photographs. So I have a real kind of feeling that, we need to make places that really work well, and that really affect people in a positive way when they’re actually in them, and are sustainable (DP1).

For each of these individuals, the advancement of energy criteria as a primary driver of design was portrayed as something that would “actually improve the whole conversation about aesthetics, and what is beautiful, and what is desirable” (DP1). In other words, rather than a threat to the status quo, these advocates view the net zero design challenge as a welcomed, and constructive, expansion of the design problem.

Thus, within the *performance-based building culture*, the historic cultural characteristic of an autonomous architecture primarily dedicated to the aesthetic dimensions of form is fundamentally shifting (Owen & Dovey, 2008, p. 11). While my observation and interviews have confirmed that net zero energy advocates do honor the significance of aesthetics as an essential component of the built environment, there were numerous suggestions that building design should evolve to be more reflective of a balance between art and science. One interviewee expressed this sentiment as follows,

> Times have changed and we really need to expect more from our buildings; and it’s becoming more of a science and less of an art, and that’s sad but true. The trick is really to keep as much art in that science as possible (AR2).

Drawing inspiration from one of the iconic leaders within the field, one instructor highlighted the significance of maintaining the artistic integrity of the built environment by presenting Renzo Piano's view as their personal inspiration.

> I think Renzo says it best, that he, "can hardly see a separation between shape, function, structure, technology, technical equipment and science; between science and art there cannot be a barrier; they speak the same language and require the same energy." And the key here is ART – there can be no barrier. And if you have a home that is completely off-grid and is really, really ugly it's very difficult to sell. So you have to begin to think about the art in your architecture and there are architects all over the country, and all over the world that are beginning to do that (AR2).

Ultimately, I believe one interviewee captured what appeared to emerge as the quintessential point of view expressed throughout the *Series*.

> I think that the resolution of those two things (art and science) is really going to be the answer. I don't think we can accept really good energy solutions that are not beautiful; because ultimately, I think everyone around it who uses those buildings will reject them, so they won't last. … And so I think that's why architects need to get smarter, and better, and be able to solve those problems because if we let engineers, they'll solve them in a way that we may not find aesthetically acceptable. So architects need to be in on that, up front (AR2).

In addition to offering a sound endorsement for how architecture and energy science might evolve to coexist, this interviewee addressed another recurring topic raised throughout the *Series*: the perceived difference in cultural values between those who value either art or science; in other words, the perceived variance between architects and engineers. While often conveyed in a humorous way, there was frequently a distinction drawn between the priorities of these two groups of professionals. The following statement, offered by one of the *Series* instructors, depicts the essence of this recurring contrast.

> Now that (the architect has) shown you all kinds of pictures of pretty buildings, and you're all fascinated, I'm going to really back-in and start talking about kBtu's, watts, and all of those things that engineers love to talk about (EN2).

Beyond drawing a distinction between the creative and the technical qualities of each profession, many advocates reflected on how the role of the architect might modify as a result of meeting the demands of net zero energy architecture. While the following statement expresses some reservation about expanding the professional boundaries, the overall concensus appeared to suggest that, with this transformation, architects would be afforded valuable opportunities for enhanced leadership and professional growth.

> I perceive a danger in the architectural profession, that we become building engineers; and I think there's a danger there. That being said, I think it's the architect's responsibility to spearhead that effort and be the go-between that we are, between the client and the design team behind us that make these things happen (AR3).

In addition to providing added value to the collaborative efforts of the project team, one instructor recognized how architects, through focused strategic planning, could actually enhance the design process for engineers.

> Maybe our responsibility as architects is, if you really think about the building, (is) reducing the loads (through) passive strategies. (If we) really start to embrace those, it makes the mechanical engineering a lot easier. If you reduce the loads through daylighting, thermal mass, a great insulated building - just some basic strategies (the engineer) can get a smaller system in there that's more efficient, more cost effective. It really becomes a fairly effective way of delivering that end result. It's not just picking that ground source heat pump; it's not that mechanical system that's the magic bullet. It's really a combination of providing the architecture that's going to do it, and then a small, efficient system. So, really emphasize that kind of process in the way you work with the engineers (AR2).

Suggesting that engineers have unfulfilled potential to contribute to the design efforts, another interviewee expressed how net zero energy design might catalyze a more collaborative design relationship between architects and engineers.

> We think, you know, engineers can be a hindrance to design, but we have to think differently that they can add a lot of value. … I think good engineers will come to the table with ideas (and) they won't want you to do a solution before they get their chance to say what they've been thinking about, or new ideas. Just like, you know, an architect would. So I think that's an opportunity (AR2).

Ultimately, both an architect and an engineer relayed how the challenge of net zero energy building design transforms the conventional responsibilities of each profession. First, the perspective of the architect,

> As architects, before (the 2030 Challenge), energy was something that an engineer brought to the table. And they started talking about kBtu's and you'd sort of daydream, or whatever. That whole world's changed. We need to own that energy problem. We can't just sort of off-source it to the engineer. So it forces us to actually learn more about energy in buildings, and what those metrics mean (AR2).

Next, the engineer,

> (The Architect) talked about putting a lot of weight on your engineers … but I think it goes both ways. Engineers as a profession, we need to start caring about shading coefficients, and u-values, thermal bridges in building envelopes. … All of us across the spectrum of the design team really need to start understanding better what our other colleagues are doing throughout the industry (EN2).

These shared realizations reinforce how net zero energy building design necessitates a transformation of the sociotechnical sub-practices of the entire building industry. While net zero design is often portrayed as an architectural design challenge, the process of tempering aesthetic solutions with energy-based scientific reasoning impacts the cultural, organizational, and technical facets of all design professionals. Furthermore, as modern environmental and social conditions challenge the presumption that design is a question of art versus science, practitioners are envisioning new categories with which to describe their design intent. In the next section, I'll explore some of the prevailing implications found to be associated with industry wide reformation.

4.2 - Organizational Forces

While it's undoubtedly unique to each practice, the conventional building culture entails a certain alignment of organizational, technical, and cultural aspects and qualities.

For the purposes of this investigation, organizational forces are defined as the way in which practice is typically structured and activities are conducted. Throughout my investigation, three topics emerged as the predominant organizational forces that currently influence the achievement of net zero energy buildings: integration, education, and budgetary considerations. In the following sections, I'll explore the interpretations of each theme, and how they're currently perceived as offering either opportunities and/or challenges to the development of net zero energy buildings.

A. Integration

Within the context of net zero energy building design, integration broadly refers to a contemporary process of team engagement and project delivery. Promoted specifically as a way to address oversights that are believed to result from historically fragmented design teams with exclusive technical specializations, the co-concepts of *Integrated Project Delivery* (IPD) and an *Integrated Design Process* (IDP) were introduced during the first class session as foundational building blocks for creating, "next-generation, super-efficient buildings" (AIA+2030 Professional Series, n.d.b). Together, these strategies represent the preferred methods of net zero energy design advocates who seek to amend conventional design protocols that have failed to integrate comprehensive energy-based planning and accountability.

Subsequently, integrated design was presented during the *Series* as a process by which the entire project team collectively incorporates energy-based objectives into all phases of project delivery by means of analyses that synthesize: climate, building use, energy loads, and mechanical systems. Central to this practice is the objective that project teams work collaboratively towards a common goal of reduced energy consumption. Thus, as a distinct modification to *conventional* design, integrated design represents one of the most overt operational alterations of between the *conventional* and *performance-based building cultures*.

While integrated design was introduced as an essential design strategy during class sessions, it was also recognized during several interviews as a beneficial, yet underutilized, alternative. For one interviewee, the lack of an integrated team was identified as a long-standing operational barrier for achieving a net zero energy status for projects.

> I think the way that we've traditionally done projects has some barriers because typically, the architect has done his design and then handed it over the wall to the engineers and the rest of the team. And I think in order to do net zero you really need everybody together; that real integrated design process up-front (AR2).

Another interviewee acknowledged that, despite attempts within their firm to practice integrated design, there was still a tendency to resort to the fragmented ways in which practice has historically been structured and activities conducted.

> I don't think we exploit (integrated design) as much. I don't think we talk to each other enough about how can we reduce, how can we build better buildings. I think we're still stuck in the mind frame that you know it's the project manager who doles out the responsibilities; everybody's got their little responsibility and we kind of like come together as a group (AR3).

Subsequently, that same individual expressed their faith in a new generation of young designers who could potentially help transform the profession. In doing so, they illustrated the significance of operational and cultural entrenchment as impediments to change.

> I place a lot of hope on the younger people that are coming into the company and I think if we can start to get them excited about doing integrated design and start to develop the tools and start to work together and say 'Hey, we can do this better.' I think that's part of the challenge; and I think that as the younger people say, 'Hey we can do this,' and the older guys go (grumble) 'I don't know,' and then they look at it and say 'Yeah, I guess you could' (AR3).

In a similar vein, another interviewee, who attributed the lack of collaboration amongst the design team to the attitudes and behavior of architects, demonstrated how progress is not simply determined by proposed modifications to the structure and activities of the design process; because ultimately, the success of any modification is contingent upon changing cultural values.

> Part of (the architect's) responsibility too, is really bringing everybody on board. And you know, that's where I think the attitude, that whole kind of chauvinistic, I'm the big ego architect needs to go away; and it's more, 'Yeah, I'm leading this team and we're all in it together, and we're gonna do this great thing.' That can kind of help facilitate the change (AR2).

This observation highlights the significance of addressing the deeply entrenched knowledge, rules, and values of the conventional building culture that might be challenging the proliferation of alternative organizational procedures. Rather than presume that proposed net zero energy design modifications are compatible with the prevailing cultural, organizational, and technical boundaries of the profession, advocates might consider how an assessment of the prevailing sociotechnical norms could reveal significant resistance barriers that require attention. In other words, by conducting a self-examination of the combined social relationships and technical practices that influence their own ability to achieve a net zero energy status for their projects, advocates might be better suited to proactively inform and advance alternative strategies for the performance-based building culture.

Essentially, attempts to advance the net zero energy design movement, without prioritizing the integration of individual insight, falsely assumes that social forces aren't intrinsic to the creation of the built environment. This proposition is supported by an additional survey question that evaluated the perceived need for inclusivity in the creation of net zero energy buildings. By asking the survey participants to, "rank, in order of importance, the types of professionals they believe should attend future net zero energy design trainings," I learned that, for net zero energy design advocates, increased collaboration is perceived as an essential means for meeting the 2030 targets.

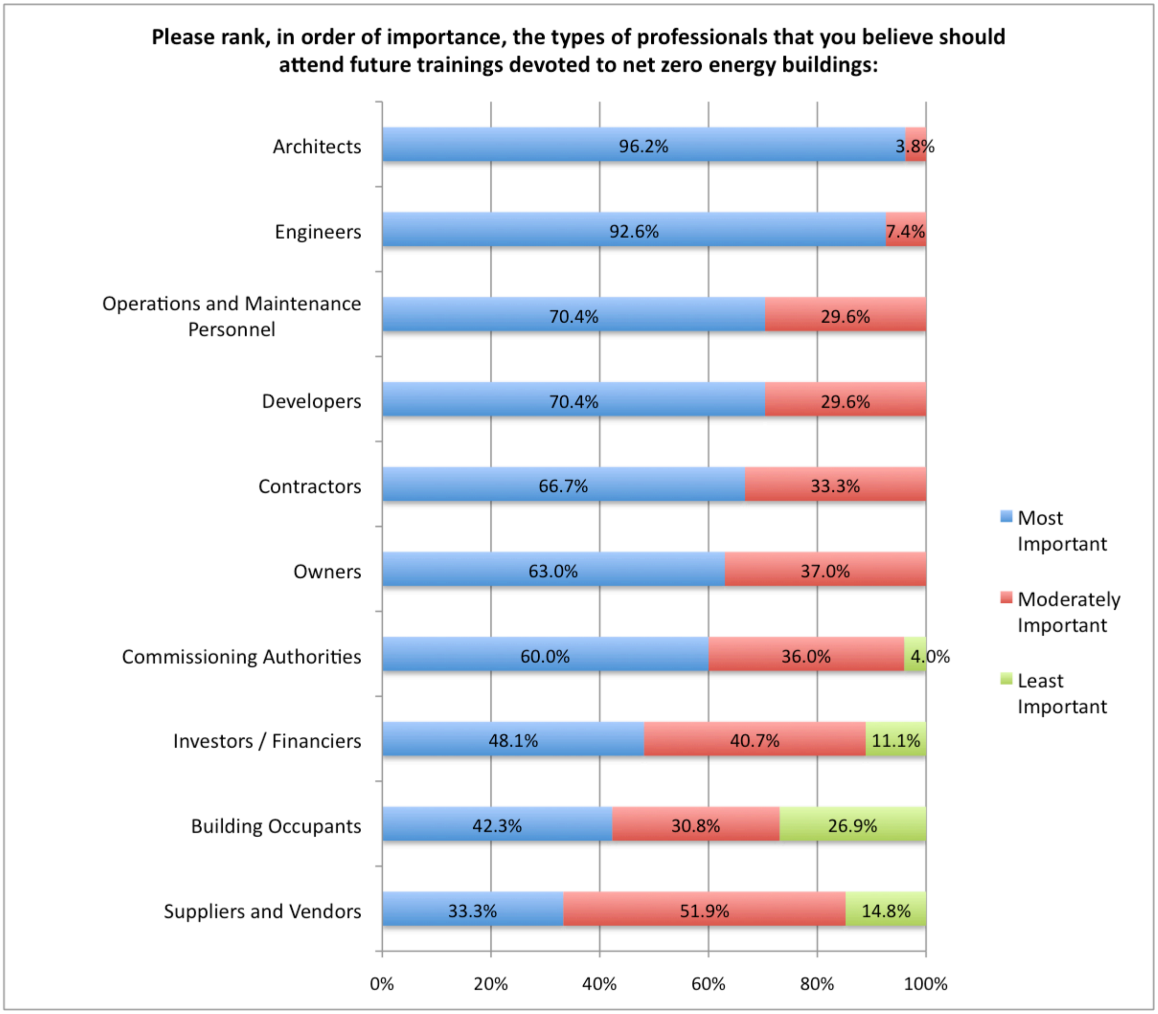

Figure 9 – Survey Question Number Seventeen – Training Attendees

While there was an overwhelming preference given to architects and engineers, one survey respondent essentially characterized integration as an imperative,

> I voted for all because while the specific topics may vary in the training, the need for it does not. It might be easy to assume that the engineers will figure it out because of their trade, but we've seen that even those on the cutting edge still need training about the actual project realities. Owners, investors, developers all need their own track to understand why this is relevant. Don't leave anybody out, it has to be industry wide (DP1).

Ultimately, this appeal for comprehensive training and collective involvement from all members of the design team spotlights another recurring theme from the *Series* - the issue of education and the monumental task of preparing an entire industry to meet the challenges associated with reduced energy and emissions in the built environment.

B. Education

Depicted as both an operational challenge as well as an opportunity, the topic of education was one of the most prevalent themes raised throughout my investigation. Ranging from discussions about formal and continued educational challenges, to addressing the need for greater information sharing throughout the industry, several advocates addressed the barriers that currently result from the academic preparedness of design professionals. Whether resulting from perceived shortcomings in university or college education programs, or simply the challenge of staying abreast of emerging design developments, the overall concensus was that, throughout the industry, "there's a lot of education left to be done out there" (AR3).

Curious about the different impressions of preparedness stemming from university or college programs, I utilized the final survey to ask the *Series* participants if they believed their formal education had prepared them to address the challenges associated with net zero energy building design.

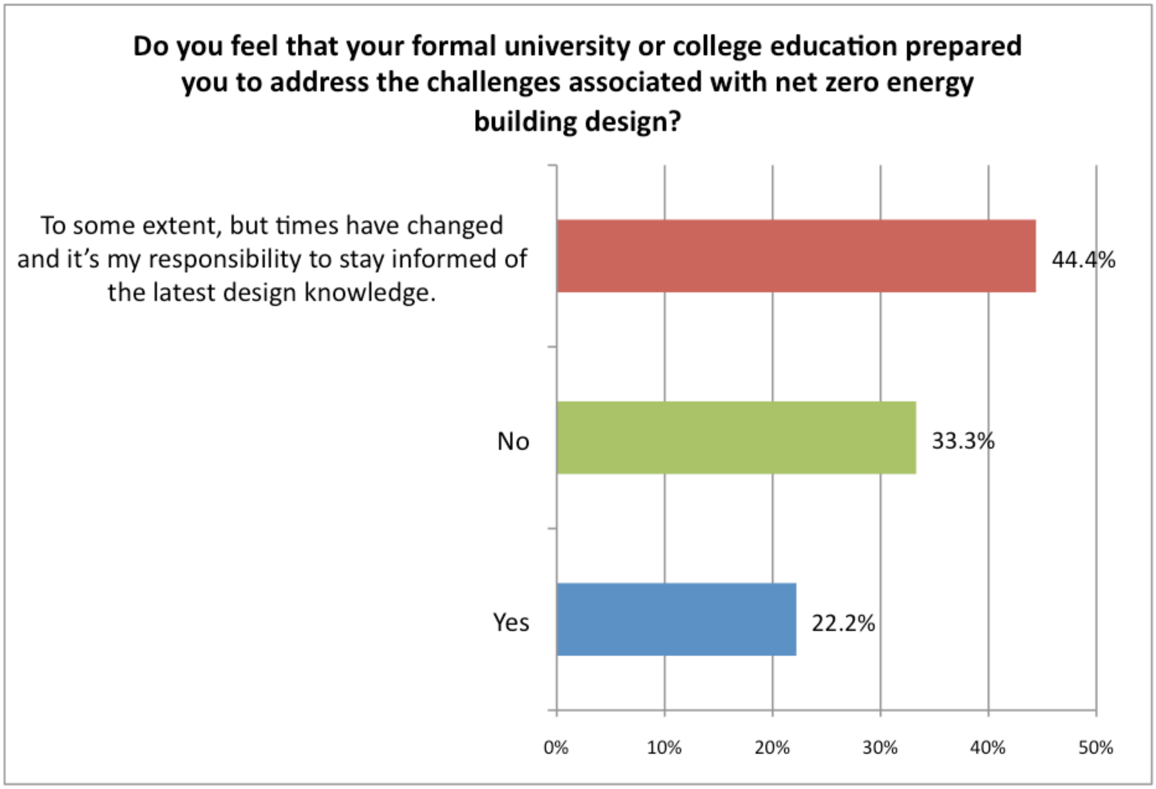

Figure 10 – Survey Question Number Six – Educational Preparedness

While the majority of respondents (44.4%) indicated their "training had prepared them to an extent," they also acknowledged that, "because times have changed, it's (their) responsibility to stay informed of the latest design knowledge." Amongst the remaining survey respondents, there was a relatively even distribution of noes (33.3%) and yeses (22.2%); indicating that, amongst these net zero energy advocates, there's a diverse sense of readiness resulting from formal training. Three respondents reinforced this interpretation with the following comments about their formal educational experiences.

> Environmental consciousness and response was addressed for the purposes of sighting structures and capturing natural ventilation, sunlight, etc. But the need to reduce carbon footprints by practicing sustainable design and using net-zero analysis was not even mentioned in the late 60s (AR3).

> To a certain extent, this is simply a matter of "smart design." I was in school in the 70s & 80s and had lived through the first energy crisis, so energy and water conservation have always been a priority (AR3).

> I completed graduate school in 2007. At the time only one studio specifically dealt with this topic, and some miscellaneous class work in LEED and daylighting. It was not under a specific umbrella of net zero or sustainable building design (DP1).

While it appears that each of these individuals was presented with varying opportunities to integrate environmental considerations into their formal training, my investigation ultimately reinforced the need to modernize design curricula in order to better prepare practitioners to address the environmental and social challenges of the 21st century.

Mr. Mazria also recognized this opportunity as he discussed the significance of educational institutions in meeting the targets of the *2030 Challenge*.

> The schools, unfortunately, are behind. … If a student comes out of architecture school and he can't design to zero net energy or carbon neutral, he's gonna have a hard time getting a job at any of the big firms, I can tell you that. Any of the big firms are not gonna hire these kids. They're gonna hire the ones from the schools that know how to get the buildings to ZNE (zero net energy). You won't find DLR hiring anybody that can't get a building to ZNE, and they're huge. So that's happening. The schools have to move (Mazria, 2011).

A recent 2010 graduate, who discussed the shortcomings of their Masters program, corroborated his statement.

> A lot of people chose this particular school because they thought it was the place for sustainability and environmentally good design. … And the school had won (two prestigious awards), and so people thought that indicated that was the major focus here; and it was not at all. … The students organized a meeting - that was a large meeting full of students and faculty - where the faculty and administration had to listen to the students. And (they) went around the room giving individual stories about why they came to this school, and how disappointed they were that there was no green building certificate program, no green building courses, (and) green building was not integrated into the existing courses (DP1).

While updates to university and college programs may help inform future generations of design professionals, my research also revealed that educational challenges extend well beyond the classroom, and into society at large. In a statement depicting the true novelty of net zero energy design in practice, one interviewee conveyed some of the educational demands practitioners might face when pursuing such unconventional projects.

> I think that probably 80% of our clients in the public sector, with the exception of the federal government, … don't really know what net zero really means. And case in point, there was the Denver Museum of Nature and Science recently … who put out an RFP for a major addition, and the goal for the addition was to be Net Zero. And when the questions came back as to how they defined net zero - was it on-site, off-site, a combination of the two - they hadn't even contemplated that. So here was a major institution, with a major goal to get to net zero, that didn't really understand it (AR3).

Not alone in recognizing the extent of indoctrination needed amongst individuals outside of the design community, other interviewees shared similar points of view. Speaking to the challenge of convincing clients to extend their investment horizons from short to long-term gains, one architect expressed that, "We have a lot of clients … who need a lot of education, who really don't care so much about energy performance; they are more cost driven" (AR3).

For another architect, occupant education serves as a critical component that, if disregarded, can jeopardize not only the success of the project but also the reputation of design professionals.

> No one had told (the occupants) about any of the (sustainability) features. … and so, the people in the building were never educated on what these features mean, why they were done, how to use them, what it means for energy. So I think by not doing that education piece, if they take any surveys, that poor architect is just going to get crammed. … You know, sometimes it's a very limited group that we deal with, and they make decisions for a very large group. That very large group doesn't understand why those decisions (were made) or feels like they were

> imposed. It can be very hard to 'reculturalize' that group of people moving in (AR2).

Admissions such as these help to clarify why, in the final research survey, education was ranked as the *Most Influential* challenge facing advocates who attempt to achieve a net zero energy status for their projects. Described as encompassing: "personal levels of preparedness; the comprehension levels of associates and clients; and the time, money, and abilities required to educate themselves, their associates, and their clients, etc.," educational challenges clearly extend well beyond the isolate integration of alternative energy-saving technologies, and encompass the adoption of alternative operational practices and cultural values for practitioners, as well as those who inhabit the built environment.

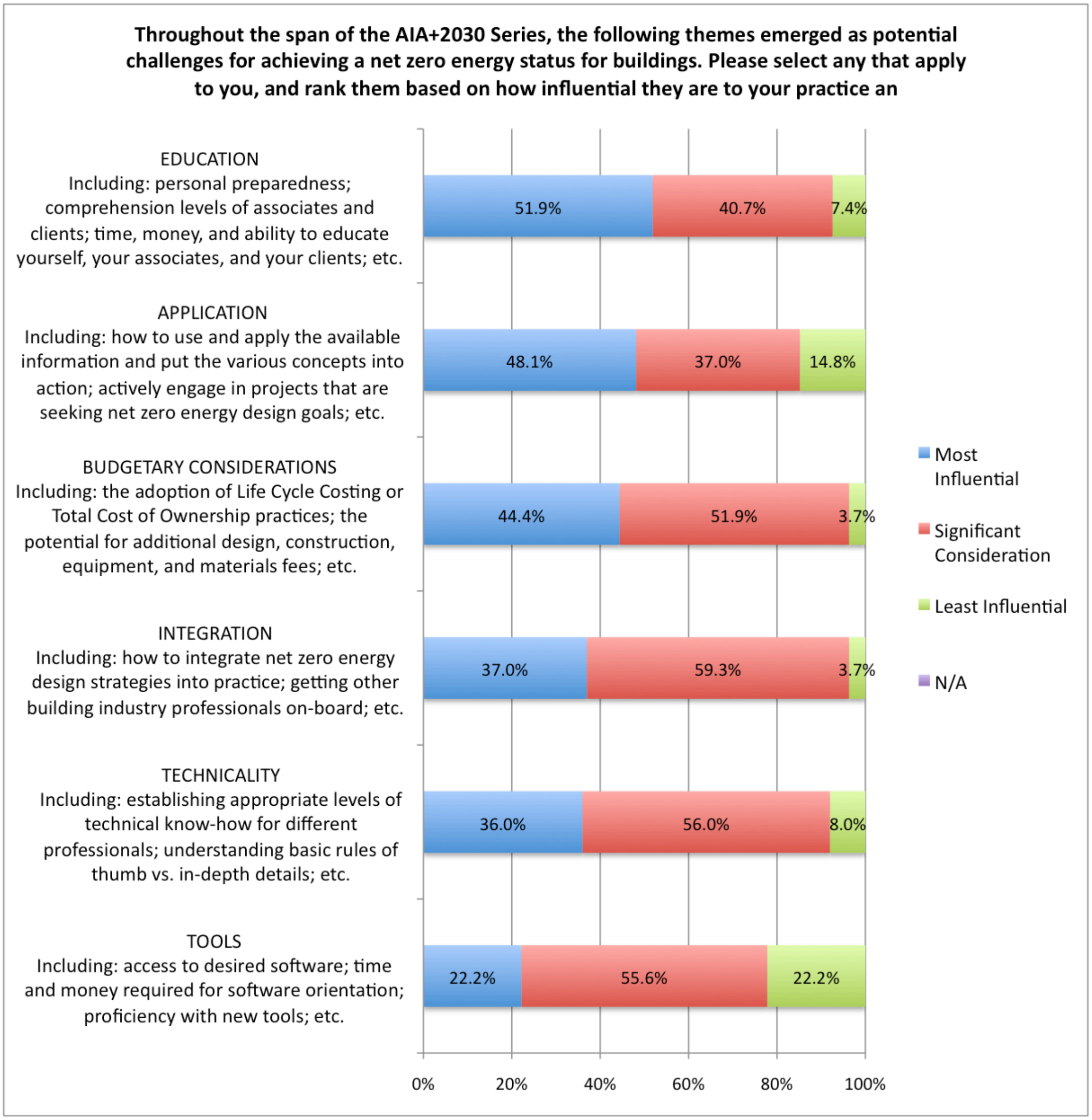

Figure 11 – Survey Question Number Seven – Potential Challenges

By selecting education as their most significant challenge, the survey respondents not only revealed the magnitude of the paradigm shift between conventional and net zero energy building design, but they established how educational preparedness serves as an essential building block for the alternative net zero energy design movement. Faced with this recognition, one architect expressed how the challenges associated with net zero energy design have caused members of their practice to contemplate alternative functions for design professionals,

> As a firm, we're in the midst of realizing ... that we really need to become educators; and that's not something that we're sure how we're going to implement. … But it's becoming increasingly clear to us that, that role is something that we need to play (AR2).

Not only are the cultural values of change, responsibility, and leadership implicit in this statement, they notably converge under the topic of education. While this admission reveals the cultural sensibilities of net zero energy design advocates, it also demonstrates the pragmatic nature of design professionals who are committed to transforming the building culture; and in turn, addresses the second ranked *Most Influential* challenge of net zero energy design: Application (48.1%).

1. Application

Inherently associated with the topic of education, application was described in the survey as: "the exercise of applying the available information and putting the various concepts into action;" as well as, "the process of actively engaging in projects that are seeking net zero design goals." Because the theme of application essentially entails the task of implementing zero energy principles into practice, perceptions of its attainability are suggestive of the current capacity for attaining fundamental change within the conventional building culture.

Beyond the revealing survey results that ranked application as the second *Most Influential* challenge of net zero energy design, two interviewees expressed their reservations about applying net zero principles in practice.

> Trying out new technology, for instance chilled beam technology, it's a little scary because there's a liability associated with that. So you just have to say, lets look at the science, lets use the appropriate science, but lets not just grab onto anything just because its new. We have to constantly filter this through a logic system, a logic filter (AR3).

> It scares me about whether we're really up to the challenge. … We've got all these tools, but then there's the reality; … and you hear about LEED buildings that are platinum, and then you measure the energy use, and it didn't come out. … I don't think we're ready to get it right. … I think we're going to learn a lot of lessons; we're going to model, and work, and analyze, and try. We're going to learn a lot from doing, and failing, and seeing what happens; and people are not going to be real impressed by that (DP1).

While it's doubtful that such fundamental change could occur without experimentation, my research has revealed a compelling need for net zero energy advocates to foster a symbiotic relationship between the objectives of education and application. Until these two tools are structured in a way to fundamentally support each other, the momentum of change towards the time-sensitive milestones of the *2030 Challenge* might be compromised by unfulfilled opportunities for practitioners to effectively engage in applying net zero principles in practice. Again, this presumption was supported by my survey findings.

In order to assess how comprehensive net zero design education influenced the ability of practitioners to apply alternative performance-based principles in practice, I utilized the final survey to ask a series of questions aimed at determining the rate, and type of net zero design applications within the field. Asking first, whether or not the *Series* participants have been able to apply any of the lessons learned directly to their projects, I discovered an encouraging sixty to forty percent ratio of yeses (59.3%) to noes (40.7%).

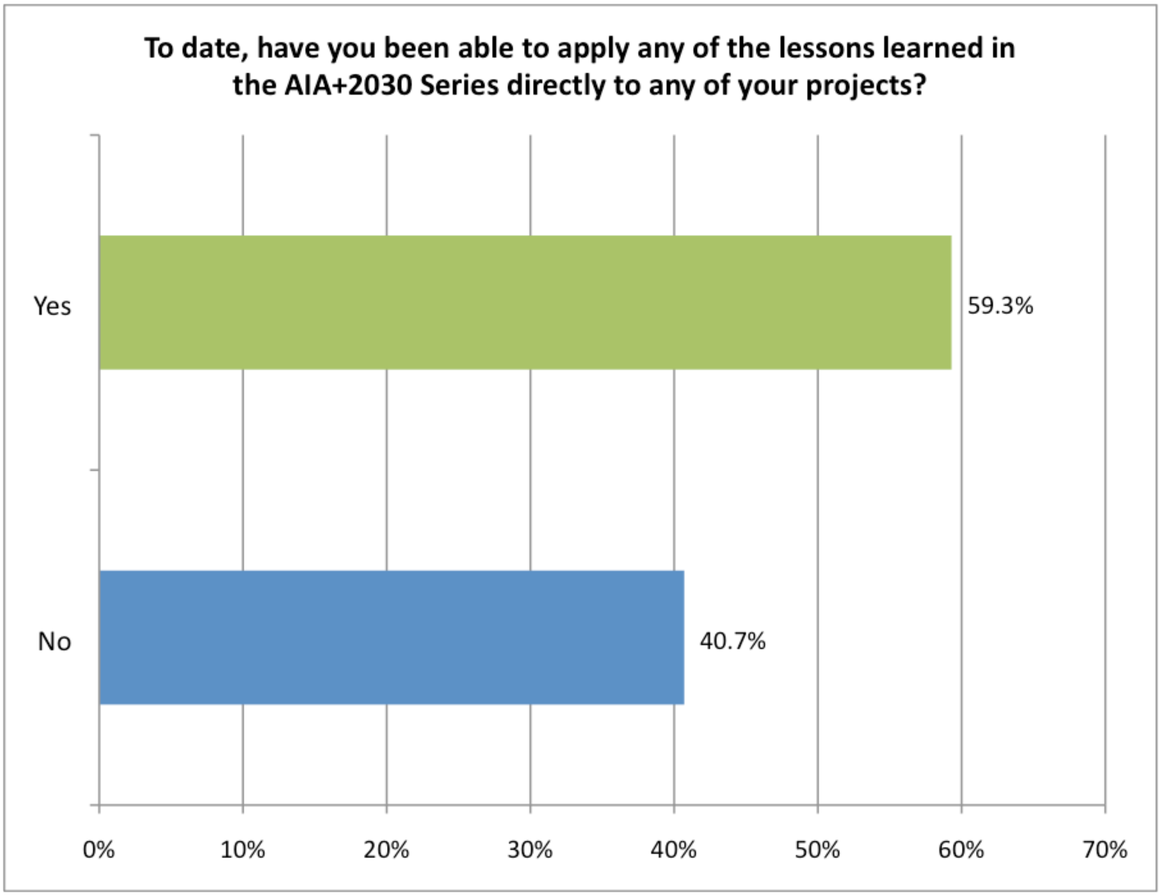

Figure 12 – Survey Question Number Ten – Apply Lessons Learned

If the respondents had not yet applied any of the lessons learned to their projects, I asked them to, "rank the Session(s) and corresponding topics (they were) most interested in applying." Out of the ten class sessions, one particular subject was overwhelmingly ranked as the, *Most Interested* in Applying (100%) - Session 5: Passively Aggressive: Employing Passive Systems for Load Reduction. Alternately, participants were *Least Interested in Applying* the lessons learned in, Session 9: The Hand-off + Staying in Shape: Operations, Maintenance + Education (18.2%).

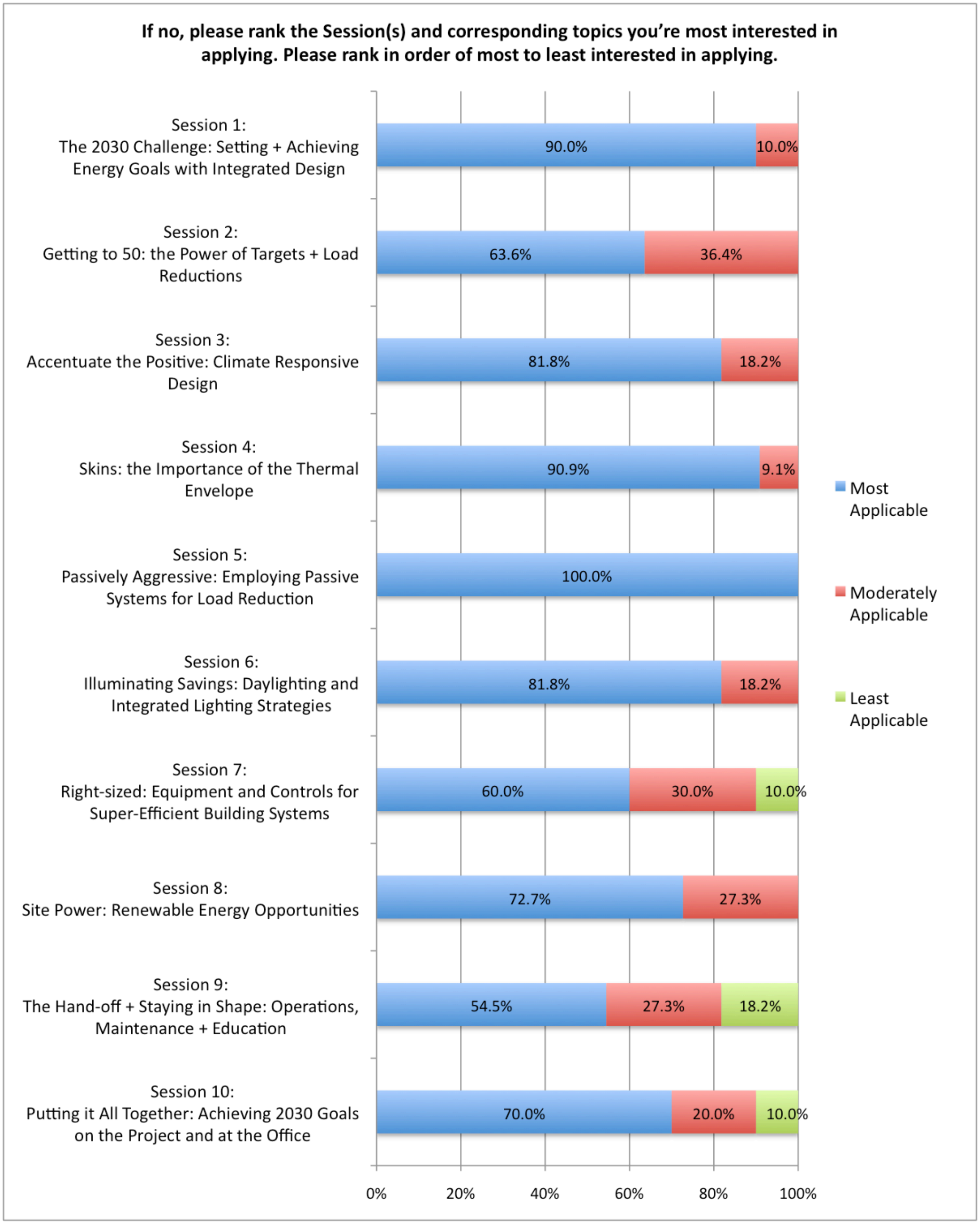

Figure 13 – Survey Question Number Twelve – Sessions Most Interested in Applying

Because the attendance profile of the *Series* participants was overwhelmingly architects, I was not surprised by the preference for passive design strategies covered in Session 5. However, because research continues to demonstrate that operational impacts "can have a larger impact on total energy use than many common variations in the design of the building itself," advocates may find that the topics covered in Session 9 will offer significant advancements for reducing energy consumption, as well as enhanced leadership opportunities for advocates of net zero energy building design (Heller, Heater, Frankel, 2011, p. 2).

For individuals who have been able to integrate net zero strategies into their projects, I asked them to rank the sessions and corresponding topics that have been *Most*, *Moderately*, and *Least Applicable*. Tied for the *Most Applicable* net zero energy design concepts (each at 62.5%), were the topics covered in: Session 4: Skins: the Importance of the Thermal Envelope; and Session 6: Illuminating Savings: Daylighting and Integrated Lighting Strategies. Tied for the *Least Applicable* net zero energy design concepts (each at 25%) were the topics covered in the following three class sessions: Session 2: Getting to 50: the Power of Targets + Load Reductions; Session 8: Site Power: Renewable Energy Opportunities; and Session 9: The Hand-off + Staying in Shape: Operations, Maintenance + Education.

Figure 14 – Survey Question Number Eleven – Strategies Most Often Employed

While each class session offered valuable strategies, all intended to build upon the others in order to provide a comprehensive representation of the recommended design practices, the topics addressed in the three *Least Applicable* sessions arguably represent some of the most striking and essential modifications between conventional and performance-based design. In other words, the act of establishing an energy use intensity target, that's based upon the integration of alternative energy supplies, and ultimately dependent upon the active support of the building occupants, largely determines whether or not the energy and emission reduction targets of the *2030 Challenge* will be met. One instructor, who shared their experience working on a net zero energy project, acknowledged the collective significance of the operational modifications covered in these *Least Applicable* sessions.

> What we've come to learn, and this is the second point about why metrics are so important, once we've really sort of gotten the language and the fundamentals it's actually an important design tool. It's not just proving you've done it, but we start with that. It's actually sort of the data driven design part. You know all of the other things that feed into design, make sure that performance and energy, and starting with that energy pie and creating the baseline and figuring out our targets. So that whole rigor, ... performance, and then tracking and getting the real data from our clients is the next step. So that metric is really the key to the goal setting, the design process, as well as the end result, and tracking and working with your client during occupancy. So, I think we've come a long way but I'd be curious when you get into it, more conversations about what people are finding as far as ways to use metrics and tools because that's such a challenge (AR2).

Thus, while the overall reported rate of application amongst the survey participants was notable (at 59.3%), a closer look at the strategies being applied reveals there are significant gaps to be filled. Framing the *Least Applicable* strategies against the moderate amount of projects that have actually achieved the reduced energy milestones of the *2030 Challenge*, or the ultimate objective of a net zero energy status, implies that concentrated measures should be taken to expand the application rate of all, and especially, the *Least Applicable* net zero energy design strategies.

2. Lessons Learned

Notably, throughout the course of my investigation, an opportunity for future growth emerged that exemplifies the type of program that could help to expand the application rate, while also informing a symbiotic relationship between the objectives of education and application. Centered upon the critical significance of "lessons learned," the topic was first conveyed during an interview, in which one architect expressed their belief that, as an industry, design professionals would benefit from increased disclosure and communication about unintended design deficiencies.

> I know that there was a colossal failure with the insulating system at the new (building), but no one ever made a presentation on, here's what went wrong. So I'm not sure we do a good job of lessons learned (AR3).

Based on that identified need, the interviewee went on to recommend the following,

> I really hope (there's) a kind of debrief at the end of (the *Series*), just to get everyone's thoughts out there; kind of as you're doing with your project. Because I think it could really benefit all of us to say 'Yeah, I hear the struggles we're having; I hear the hurdles.' Because … the lessons learned are so critical at this stage of the game (AR3).

Intrigued by the degree to which design professionals would be willing to disclose both the successes and failures of their performance-based projects, I cited a pertinent finding from the "AIA 2030 Commitment, First Annual Report," and surveyed the participants with the following question:

> The AIA 2030 Commitment, First Annual Report (May 2011) states that: "Open dialogue regarding the challenges faced in transforming how firms design projects and operate as a firm is critical if we are committed in our desire to reduce the negative impacts of the design and construction industry on the climate."

> Based on this recognized need for greater information sharing within the industry: Would you personally be willing to engage in a dedicated forum, or program, aimed at sharing and advancing net zero energy design strategies?
>
> Shared information could include: best practices, preferred rules-of-thumb, success stories AND project failures, modeled vs. actual recorded building energy use, life cycle costing results, etc.

Through a show of overwhelming support, the majority of respondents (59.3%) indicated that "Yes, (they) would be willing to share all information openly." The majority of remaining responses expressed their support for a lessons-based forum, but differed in opinions on "open or anonymous" sharing of "all or selected" information. Overall, only 3.7% of the respondents indicated, "No, (they) would not be willing to share any project information."

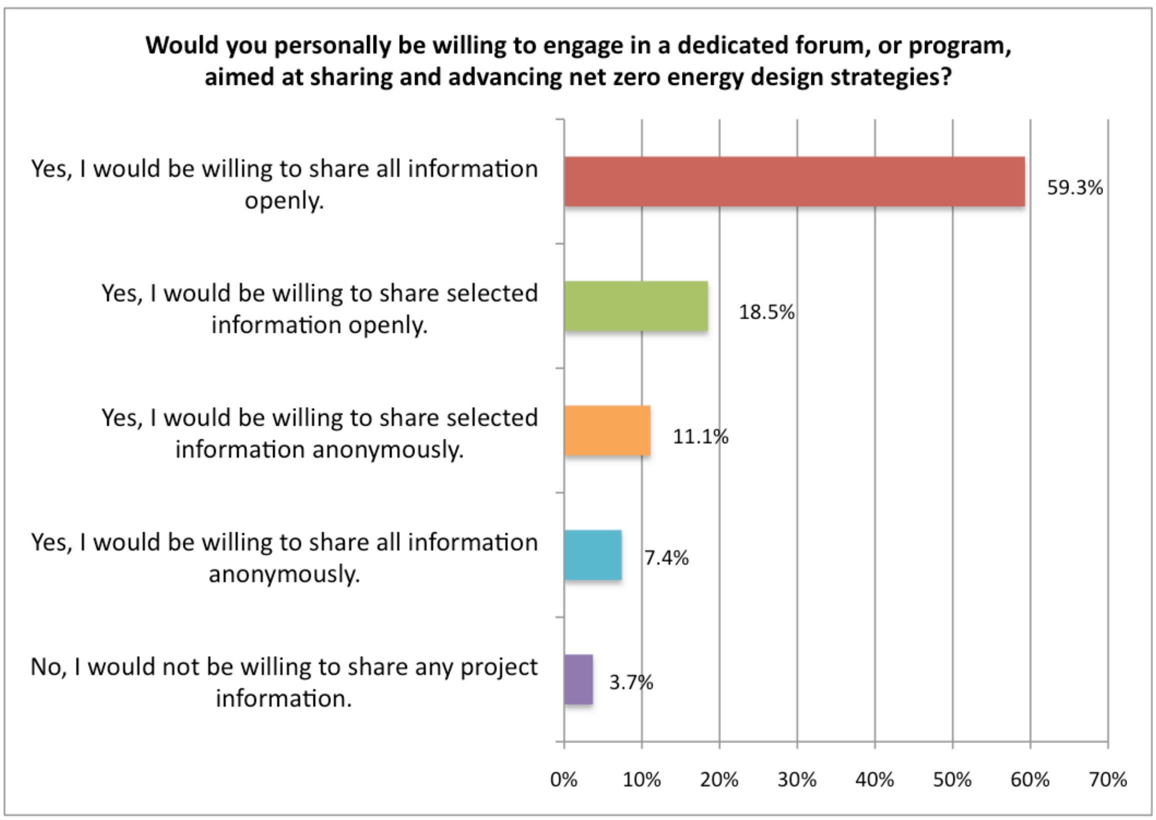

Figure 15 – Survey Question Number Nine – Forum for Information Sharing

Through additional comments provided by the survey respondents, I've determined that, amongst the majority of net zero energy design advocates, imaginative opportunities dedicated to fostering the proliferation of applied vs. theoretical knowledge, would be greatly beneficial and very well received. As stated by one design professional, "The challenge is too great to be met without open sharing and helping each other" (DP1); and for another architect, "Sharing is the only way we are going to get there!" (AR3). Additionally, during the final class session, one architect summarized the following perspective of individuals involved in a panel discussion entitled, *2030 and Firm Culture – Integrating Sustainability Into Your Firm*,

> Maybe one take away, just sort of piecing together some of what I'm hearing. … Maybe one thing that the AIA, or a similar organization like this, … can find a way where we can actually leverage what each other's individually doing in a more meaningful way. We can't all attend everything. We can't all learn things on our own. The whole sustainable design initiative is so important that the competitive guards need to come down, and we just need to … share with each other what we're doing. … It seems like we need to figure out a way to collaborate and to share that information; whether it's metrics for buildings; or a great process that we learned; or somebody's tested out a new tool; and we need to get it out there (AR2).

In addition to these overt statements of support for increased information-sharing, responses to another survey question offer support for why a lessons based forum is so critical for the proliferation of net zero energy buildings. Designed to assess the levels of preparedness for meeting the targets of the *2030 Challenge*, I presented the following survey question, "Tomorrow, if your firm were awarded a project pursuing a net zero energy status, how would you describe the preparedness of you and your business associates to achieve a net zero status for the project?"

While a compelling number of respondents (44%) indicated they were, "Prepared, (because they've) done this type of work before," the majority of respondents (52%)

expressed they would be “Challenged, (and) would have a significant, but manageable learning curve.”

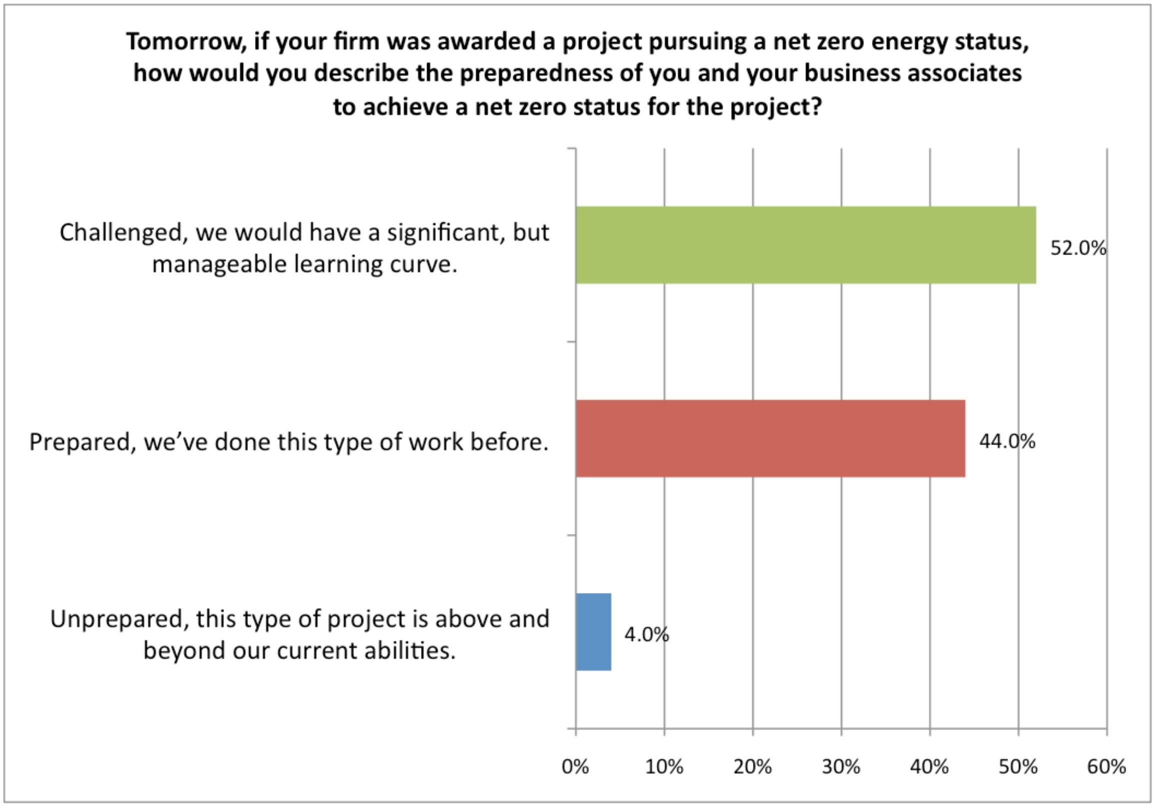

Figure 16 – Survey Question Number Sixteen – Preparedness to Achieve Net Zero

Thus, in order to advance the levels of preparedness, and increase the effectiveness of future performance based design pursuits, advocates might consider actively engaging in efforts to foster the development of an information-sharing network aimed at advancing the lessons learned from net zero energy design problems. Because the net zero energy design challenge extends well beyond the built environment, and encompass fundamental modifications to the cultural and organizational facets of practice, the facilitation of applications-based feedback loops might actually serve as one of the most compelling and essential design responses.

C. Budgetary Considerations

Returning to the themes identified in the survey that produce the greatest challenges for achieving a net zero energy status, the third highest ranked selection was the issue of budgetary considerations (44.4%) (Figure 11). This wide-ranging topic was described in the survey as including: "the adoption of Life Cycle Costing or Total Cost of Ownership practices; and the potential for additional design, construction, equipment, and materials fees."

In previous chapters, I've presented research that's argued that overconsumption of energy within the building sector is the result of a "massive market failure" in the building industry (Lovins, 1992). At the crux of this argument is the notion that the practice of rewarding cheaper capital costs at the expense of higher operating costs has not only established a flawed system of financial reward as it relates to accounting for energy efficiency, but it's created a system of values that persist throughout all phases, and amongst all actors, involved with a project.

As a result of this flawed system, advocates of performance-based design have supported alternative accounting models, such as Life Cycle Costing. However, this proposed modification strikes at fundamental methods and values associated with project finance for conventional building design. Favoring long-term over short-term investment decisions, the modified life-cycle accounting process requires that the entire project team, especially owners, investors, and financiers, account for and integrate all costs associated with a building project from acquisition to disposition.

Speaking in favor of this alternative holistic assessment, one interviewee acknowledged how it not only inspires investments in long-term energy savings, but also provides opportunities for architects and design professionals to expand their professional expertise, and in turn, advance net zero energy design solutions.

> I think the idea of up-front spending vs. life cycle spending is really where we need to be looking. So you may spend more now but it will pay you back over 5 years, 10 years, whatever it is. You just can't look at only that first cost. So, I think that's what we're seeing is people willing to do a little bit more upfront because overall they're gong to save money once they pay out that upfront cost. I think that with the way fuel prices go, you know, that's a good strategy and that you'll probably end up saving money. Not everybody sees it that way; and it's hard when you have a limited budget to make those kinds of decisions but that's where again, I think the architects and the team can … (compare) systems; (and) part of that comparison should be the life cycle cost of that system so that people can really make educated decisions. And we can help them do that (AR2).

Another interviewee, who's completed several net zero energy design projects, ultimately attributed the achievement of a net zero status to modified investment practices that preference long-term savings over short-term gains.

> You can design a better building if you understand big picture stuff; that only gets you thirty-forty, maybe fifty percent (energy) savings. And if you really want to dial it down to that last zero percent, it costs money. Active systems is what it takes to get that last bit. Unless we're willing to change our lifestyles, which we're not. So that's the big hurdle - the value, that long term investment in energy efficiency. Because most people, the people doing work today who are building, are not long-term owners, so they don't capitalize on those (AR3).

Additionally, another *Series* participant, who trained as an architect but is serving as a real estate developer, conveyed the tangible difficulties professionals face when integrating alternative design decisions that challenge the traditional investment standards of building inhabitants.

> I learned that sustainability, including energy savings, and the use of natural light, was of little, to any, interest to the tenants. It's really all about first costs for this market. If a better design, window shading, energy efficiency, and the like could

> be provided, at no extra cost, they're ok with that; otherwise, not. As a developer, I would ignore the competition at my own peril. Unless the client, in this case the tenant, has an interest in sustainability, and cost savings of some sort can be guaranteed there's really little ability, as a developer, to incorporate much of this into the designs. I know that there's a lot of talk about architects educating clients, and influencing clients. And, at least in this market, I would say that the real estate brokers have far more influence than the architects. They have the tenant's ear. They show multiple properties. For them, it's all about making the deal. And I have many broker friends, they're nice people, but they don't sell design. They sell what the tenant wants. So in the end, what I think is required, are mandates. … And I just think that's what it's going to take to level the playing field to incorporate any sustainability into these types of projects (AR3).

While this individual conveyed their support for the external forces of legislative mandates to drive the market, each of these various perspectives reveals how ultimately, internal forces of the building culture must also adapt and respond to advance net zero energy buildings. To that point, as the *Series* progressed, and the need for operational and cultural reform became more evident, another participant conveyed the disadvantages of attempting to facilitate net zero energy building design without accounting for the influence of individual and institutional impediments.

> I just keep thinking I need to go back to business school because I'm trying to figure out how I get the fee so that I can afford to have the employees that are in the office come to the 2030 thing and go learn x, y, z piece of software and still get an hourly rate for it. And maybe I'm just the stupidest guy in the room but I feel like that's a challenge that we as a small firm face and I'm not quite sure how to overcome it. … There's extra work here to be able to make the project do what it needs to do and, you know society at large, I'm not sure they're buying into the extra fee, unless you've got a really sophisticated client (AR2).

Through this and other similar admissions, it became clear that, at this stage in the development of net zero energy buildings, advocates shoulder additional time, effort, and financial liability to integrate low energy design strategies into their projects. While this observation may appear to undermine previously presented research which argued that, "the efficiency levels needed for ZEBs (zero energy buildings) are readily obtainable, … at reasonable incremental costs, for many common building types" (New Buildings

Institute, 2012, p. 5), it actually highlights one of the major challenges associated with financing performance-based design projects - the impact of hard construction costs vs. soft costs such as design fees.

At this early stage of net zero energy building development, it's been reported that only a very few project teams have disclosed the incremental cost impacts of their projects, specifically those associated with design fees (New Buildings Institute, 2012). Subsequently, there's a shortage of available and comparable data that normalizes financial statistics based on climate zone, time of construction, location of the project, and project type (New Buildings Institute, 2012, p. 19). Therefore, although previous research has celebrated the financial feasibility of net zero energy projects, it's done so without being able to fully account for the operational impacts absorbed by design professionals. As stated in the report,

> Even in the rare cases where sound initial attempts are made to quantify total initial incremental costs and savings of a green building, changes are often not tracked through the many revisions that occur before completion (New Buildings Institute, 2012, p. 19).

Throughout my investigation, several participants substantiated these findings by acknowledging how absorbing additional soft costs presents a considerable challenge for design teams to manage. Speaking to the impact of the additional time and money associated with energy modeling, two design professionals provided the following input. The first from an architect interviewee,

> So I think, obviously there's a market driven component, there is an ethic driven component, and there's also just kind of a, can we afford this as architects component. So for instance, right now we are trying to figure out what's the best modeling tool that we can use, that will hook into our Revit models that will give us good up-front information that might be able to scale to provide more and better information as we develop our design - without breaking our bank. Because for the most part, our clients are not paying for this. So that's really tough, and it's even tougher in this kind of economy. So its questions like that,

> that we have to deal with on a business level; and balance that with our ethical commitment to sustainability (AR3).

The next from a survey respondent,

> The added cost HAS to be taken into account. That cost is borne by either the client or the architect and is NOT an acceptable up-charge to the architect's fees at this point. Add to this the accuracy of existing models and it is not a viable business model yet for the vast majority of projects out there. As most of us work on small budget and scale projects, the modeling cannot pay for itself yet. The system needs to evolve, become more user-friendly and cost-effective before it will be an accepted part of the design process for most projects (AR3).

A review of the budgetary considerations raised throughout my investigation reveals why advocates of net zero energy building design perceive operational modifications to conventional design as essential components of the net zero energy design movement. By favoring the adoption of Life Cycle Costing as a preferred sociotechnical sub-practice of the performance based building culture, these advocates have demonstrated how the emergent building culture is evolving in response to perceived inadequacies of the conventional building culture. An exploration of the technical forces found to influence net zero energy building design further illustrates this point.

4.3 - TECHNICAL FORCES

As previously stated, the third and final internal force exerting control over the prevailing and emergent building cultures are technical forces. For the purposes of this analysis, technical forces refer to: the facilities and resources for producing projects, ie- the mechanical tools and systems utilized for producing the built environment; as well as the three-dimensional infrastructure developed by practitioners in the building culture. Throughout my investigation, one topic emerged as a significant, and indispensible, technical force influencing the development of the performance based building culture: energy modeling.

Introduced during the *Series* as an essential tool for evaluating the achievement of a project's net zero energy status, the underlying advantage of energy modeling appears to be the ability to conceptualize and visualize the abstract nature of energy-based impacts in the built environment. By producing various visual aids such as bar graphs and line diagrams, energy modeling analyses seem to have gained favor amongst net zero design advocates for their ability to demonstrate what different energy-based systems and power demands "look" like.

Although it was acknowledged that building energy loads are ultimately abstract and dynamic, it was also noted that loads are the result of individual choices, and can therefore be controlled. Thus, by expanding the boundaries of professional practice to encompass the acts of monitoring, tracking, and controlling all energy-based design decisions, net zero energy design advocates are advancing the notion that the quantitative visualization analyses associated with energy modeling represent essential tools with which to transform buildings from units of energy consumption to units of energy production.

Although a fundamental criteria of net zero energy building design is that numbers, based on energy loads, ought to inform all design, operations, and maintenance decisions, some participants expressed their hesitation with this emergent design practice. After describing the various stages of energy analysis, one design professional shared their disappointment in the non-tacit nature of the modeling process.

> So first you start with energy analysis, which is telling you some general forms, the geometry and massing, what's going to be better. And then when you've answered those questions, you start making the building more specific and you move into energy modeling. … And you have to design that way, and (it's) not the way anyone has ever designed before. So it's actually a big change to the design process. It's more than aesthetics; and it's more than, do it and then check it somewhere at the end and tweak it. It's really like, get a reading that can guide

> you, because your gut cannot. So you have to use these tools, different tools at different stages. But you have to constantly be using these tools to evaluate alternatives that you can't just evaluate from your experience. And that's actually, I think, that's kind of surprising. … I think it needs to get to a level where you really, in your gut, understand from years of experience … and you don't have to run a model to know that this shape is gonna be the efficient shape. That's when it really works. And we know so little about it, that we have to run all these models; and we're making the whole thing so complicated (DP1).

For another interviewee, the integration of various phases of energy modeling analysis raised practical business-related concerns,

> I think that culturally, …our sensibilities align with constantly looking back. That's what we do as architects. There's not a project that goes out the door when we're not already thinking, 'Oh I could have done this, I could have done this.' So, I think that that kind of weaving of technology in with the design process is very much in keeping with how we do business. So what makes it difficult, is we already lose money on projects without the overlay of going back and forth with technology as well. So, we could be planning our own obsolesce, if we're not too careful (AR3).

For one instructor, disappointments with energy analysis software present one of the greatest challenges for their small firm,

> Well, I'm curious, … is there anybody who feels like they've found the perfect tool for metric measurements? Because I know that one of the frustrations that we have is not being of the size where we can devote a full time person, or really resource, to this end of things very well. We have to rely on really good tools that are easy to use; and so far, we haven't really found the solutions. … I guess I look at the imperative here as something that's maybe a little loosey-goosey compared to LEED or HERS or some of the indexes. So I kind of think of it as, well, measure anything. Count something … whether it's an EUI, or HERS score, but count something because I think that's critical. But I feel frustrated with the software tools that are available; you're always having to do file transfers. So that's a frustration we have as a firm that we haven't overcome yet (AR2).

As each perspective continued to reaffirm how technological change is fundamentally rooted in social change, I began to question if the contestable, yet critical, practice of energy modeling would gain traction within the *performance based building culture*. Therefore, in order to discern if practitioners fundamentally support the emergence of energy criteria as a primary means of assessment and standardization, I utilized my research survey to question how individuals feel about quantitative energy data, such as energy modeling results, informing design decisions for their projects.

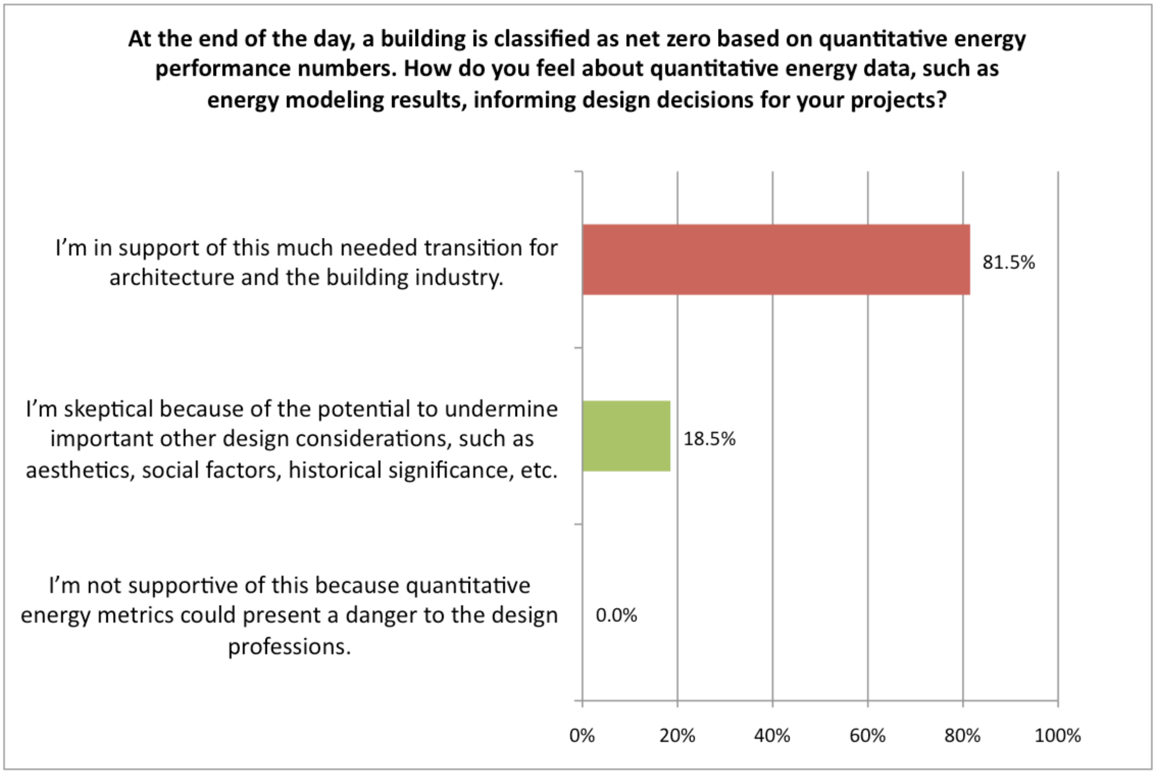

Figure 17 – Survey Question Number Thirteen – Energy Modeling Informing Design

While an overwhelming majority (81.5%) of the survey respondents indicated they're, "in support of this much needed transition for architecture and the building industry," a smaller percentage of individuals (18.5%) expressed their skepticism towards this trend "because of its potential to undermine important other design considerations such as: aesthetics, social factors, and historical significance." However, because of the various hesitations expressed, I was surprised to find that none of the survey respondents indicated they were not in support of this alternative quantitative influence. Rather, as advocates of net zero energy building design, these respondents appear strongly committed to the integration of energy modeling analyses as an integral sub-practice of the *performance based building culture*, and the establishment of quantitative energy data as a primary criterion for judgment.

Further evidence for this observation was provided through my next survey question; which asked if the respondents were "in favor of predetermined energy performance targets becoming standard requirements in RFP's and RFQ's?"

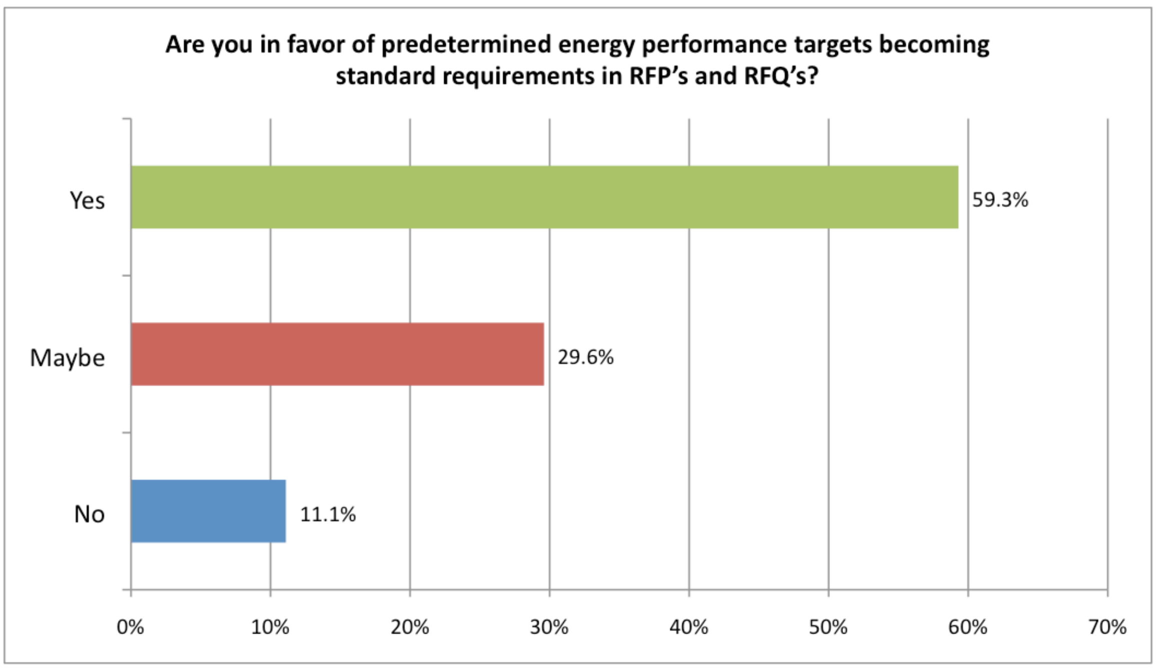

Figure 18 – Survey Question Number Fourteen – Energy Targets for RFP's and RFQ's

With 59.3% of the respondents indicating "Yes," and 11.1% indicating "No," the survey indicated that a compelling number of net zero energy design advocates support the implementation of performance-based contracting, which awards payment upon the successful achievement of expected performance measures, or verified outcomes. A statement in favor of these types of alternative, results-based agreements was offered by one of the *Series* instructors,

> I think the traditional model is, we're going to do (energy modeling according to the standards of) LEED, … (and) these (models) have benefits. But the more specific we can get about the benefit of an actual number, and the performance of what can be expected to achieve, and what we set as the target, it gets them more engaged as a client to actually to be committing. Because there's a lot of trade-offs here to actually reach those numbers and you need them all on-board on what the goal is and what you're trying to achieve for the projects (AR3).

However, despite compelling indications of support for the integration of predetermined energy performance targets, several survey respondents conveyed the following reservations about the use of quantitative evaluation criteria.

> Again, it is an issue of cost and accuracy. The cost of modeling to insure that the project will meet those goals needs to be included in the fees for the project. The accuracy of that modeling needs to be exact enough to give architects and clients a comfort level that the virtual model will match the reality. Please note, the issue of humans using the buildings is as difficult to control in the virtual model as it is in reality (AR3).

> RFP's must define performance goals, but the means of achieving them must be directed by the design team. The extent to which a design team is held to the building's performance is an area of debate, too, because it is influenced by the extent to which a design team can remain involved with a building after substantial completion and occupancy (DP1).

> Unfortunately, building occupants rarely use their buildings the way that they say they will during design when parameters are set for modeling. Therefore, there are many reasons why buildings rarely perform as modeled (AR2).

While each comment addressed discrepancies between modeled assumptions and operational realities, there was still the implication that, if coordinated and executed properly, energy modeling might offer agency to design professionals who seek to meet predetermined energy use targets.

Nonetheless, despite an overwhelming show of support for energy criteria to serve as a primary means of assessment and standardization, some individuals conveyed how ultimately, social forces supersede the impacts of technical forces. As expressed by one survey respondent, "The only issue with (predetermined energy performance targets) is that attaining the goal of a specific target is contingent (upon) the client's decision, which the design industry has no control over" (AR3). One instructor illustrated the reality of this sentiment,

> So one of the tangible take-away's from 2030 that we've implemented in the office was starting to use BEOP modeling software; and we did that for a house. We went through and we had this thing all sort of dialed in, and it was a very efficient project, and it was a negotiated contract. The Client and General Contractor came on board and we went over the modeling … and then it just got dumbed down, and dumbed down, and dumbed down, and they just kept taking things away. It was so clear that the rut was very deep that they were running in (AR2).

Each of these shared perspectives reveals the significance of social impacts on technological change, and essentially undermines the notion that any isolate, technical, operational, or cultural force could facilitate the desired changes within the industry. Therefore, as the *Series* progressed, and advocates recognized the breadth of challenges facing the proliferation of net zero energy buildings, there was a growing tendency to look externally towards alternate forces of influence. Subsequently, the next and final theme emerged: the external forces of political influence.

4.4 - Political Forces

For the purposes of this investigation, external political forces refer to local and national mandates often developed and issued by second or third party organizations and adopted by governmental agencies. Favored for their legal authority to specify the rules and standards to be followed by those involved in the building industry, legislative mandates were portrayed as a powerful and inevitable resolution for how to overcome barriers and revise the deficiencies of the conventional building culture. One interviewee best captured this sentiment,

> I think that (the 2030 goals are) definitely meet–able. It's definitely going to take a financial commitment in order to meet them. But I don't think that, by and large, we're going to get there without some legislation mandating those kinds of changes. So it's great that some architects are taking the Challenge and doing that with their buildings, but it's not going to be widespread until it's mandated. And I know other countries are doing that, so I'd like to see more on that route. … While I'm hopeful that we'll get there, I don't think that we'll ever meet the ultimate goal of the 2030 Challenge to be net zero by 2030 without someone telling everyone they have to do it. Because … it's voluntary and not everyone's going to do the right thing because it may cost them more, or may make them change what they've always done; you know, there's a number of resistance filters people have to doing things that are different (AR2).

As previously discussed in the chapter on Policy, several legislative measures have included market-based incentives to lessen the financial impact of advancing performance-based design. Subsequently, these aspects of influence were also addressed as essential components of political force. As stated by one architect interviewee,

> There's got to be some incentives. The only other option is if the cost of energy just dramatically starts going up, and it's not. If the cost of energy, if we keep it deflated like we do in this country - and its because of our perceptions and what we're used to – there's never going to be any market-driven engine to really implement these systems. … Or as a society, we can decide that we want to invest in this stuff, and continue to give rebates, continue to give grants, and push the technology along in that fashion; but ultimately, its gonna have to be market driven to really take hold (AR3).

Ultimately, the presumed influence of legislative mandates and market-driven programs were revealed through my final research survey, in which I asked the respondents to: "rank the measures and initiatives that they believed would best promote the achievement of net zero energy buildings by the stated deadlines of the 2030 Challenge." Out of the five provided choices, Local or National Legislative Mandates, described as including: Building and/or Energy Codes, Climate Action Plans, etc., were overwhelmingly ranked as the *Most Influential* means with which to facilitate the development of net zero energy buildings (at 74.1%). Ranked as the second highest *Most Influential* force for change were, Financial and/or Market-Driven Programs, such as Tax Rebates, Incentives, and Deductions (at 59.3%).

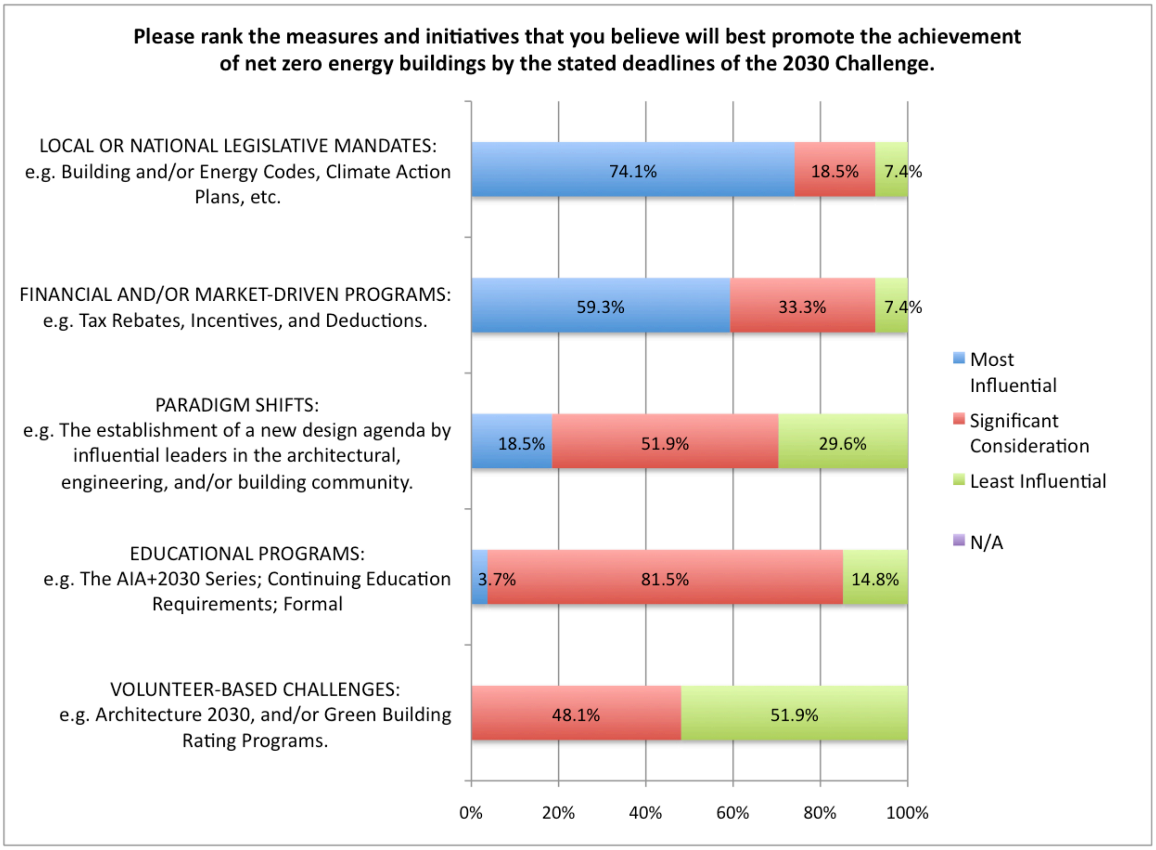

Figure 19 - Survey Question Number Eight – Promotional Measures

By preferencing both of these external forces, while subjugating the cultural and operational influences of paradigm shifts, educational programs, and volunteer-based challenges, these survey respondents offer significant insight into how advocates of net zero energy building design perceive their ability to advance the objectives of the performance based building culture and serve as change agents within the industry. Despite the compelling amount of support shown throughout my investigation to transform the prohibitive internal forces of the conventional building culture, at this stage of the emergent *performance-based building culture*, external forces of influence are depicted as the preeminent and indispensable factors for advancing change.

While this certainly doesn't negate the relevance of enthusiasm shown for internal reform, it reveals how advocates perceive their sense of agency or capacity to influence the cultural boundaries of their profession. Utilizing the comprehensive insight I've gained about the range of prevailing forces of influence on net zero energy design advocates, I'll now address the essential question of this investigation: How do architects, who are advocates of net zero energy building design, perceive their role in transforming the sociotechnical sub-practices of the profession?

V. Final Interpretation

By asking how architects, who are advocates of net zero energy building design, perceive their role in transforming the sociotechnical sub-practices of the profession, I'm seeking to understand how building industry professionals comprehend their agency, or capacity to influence, the cultural boundaries of their profession in order to account for and mitigate the impacts of energy and emissions in the built environment.

Through their shared statements and survey responses, individuals enrolled in the *AIA+2030 Professional Series* have demonstrated that net zero energy design advocates are inspired by an array of compelling internal and external forces of influence. While each design professional undoubtedly possesses their own sense of responsibility, personal inclination, and practical ability to advance net zero energy design, my investigation revealed specific and predominant forces of influence that currently inspire committed practitioners to seek fundamental change for the building industry.

Beginning with a moral obligation to "do the right thing," and attempt to mitigate the unintentional environmental consequences caused by energy consumption in buildings, advocates of net zero energy building design are compelled by external environmental forces, which in turn, have inspired their alignment with unconventional cultural values. By preferencing the ideas of change, responsibility, leadership, and the advancement of art and science as guiding design principles, advocates support the notion that, "business as usual" needs to change, and the design industry as a whole needs to establish a new agenda tailored to meet the challenges of the 21st century.

As part of this new agenda, advocates favor the implementation of modified organizational and technical sub-practices that specifically account for what are perceived to be deficient processes within the *conventional building culture*. In other words, the proposed sociotechnical sub-practices of the *performance-based building culture* have arisen in reaction to prevailing social and technical forces of conventional design that are based upon the "(presumption) that a building's energy will be imported in the form of electricity and fuel" (AIA+2030 Professional Series, n.d.d). Alternative forms of project team integration; enhanced education and information-sharing; and modified financial and energy-based accounting practices embody the preferred actions, ideas, and values that advocates regard as viable means for overcoming institutional barriers and enacting change.

While cultural values can be categorized as primary forces that influence the adoption of alternative organizational procedures, the process of attempting to implement the desired sociotechnical sub-practices reveals the duality of culture as a simultaneous driver and obstacle of change. Ultimately, by characterizing culture as a counter-force of both influence and resistance, these advocates have further accentuated how the attitudes, behavior, and customs of social groups provide the momentum for, and resistance to, the transformation of technological systems, or more specifically, building cultures.

Ultimately, by characterizing the competing cultural norms of various social groups as a counter-forces of both influence and resistance, these advocates have further accentuated how attitudes, behavior, and customs provide the momentum for, and resistance to, the transformation of technological systems, or more specifically, building cultures.

Nonetheless, as cultural forces increasingly emerged as obstacles for the proliferation of net zero energy buildings, advocates expressed their enhanced reliance upon external forces of influence to enable the transformation of the built environment. Although advocates assigned agency to political and market-based incentives, my investigation revealed that the success of these forces is ultimately dependent upon fundamental modifications to cultural, organizational, and technical conventions of the building culture.

As advocates framed the technological "potential" of meeting the 2030 targets against the individual and institutional modifications that ultimately underlie such potential, they illustrated how practitioners are "active and creative social agents, rather than passive recipients of science-based research" (Shove, 1998, p. 1108); or, as discussed in the section on Science and Technology Studies, how technical change is an "irredeemably social process" (Shove, 1998, p. 1110).

In accordance with this premise, throughout the course of my investigation, some advocates revealed they'd been specifically contemplating how design professionals are best suited to exert the necessary and most effective influence on the net zero building movement. By offering their personal insight into this quandary, these reflective design professionals effectively synthesized the general sentiments acquired throughout my investigation and revealed how some advocates specifically perceive their role in transforming the sociotechnical sub-practices of the profession. While many of their propositions echo the same overall themes that emerged as primary forces of influence, three distinct motifs emerged as descriptors for the way in which advocates are best suited to advance net zero energy design practices and serve as change agents within the building industry. These interpretations are centered upon the themes of: leadership; the expansion of professional boundaries; and advocacy.

In regards to leadership, the most compelling statement in support of why architects are best suited to guide the industry towards a net zero energy future was offered by an individual who'd been involved with a number of net zero projects. Subsequently, they were able to frame the role of the architect within the context of the proposed net zero energy design modifications; and in doing so, convey how they perceive architects to be practically able and naturally inclined to advance change within the industry.

> I think it's a better use of my time, really making sure that the client understands the situation, buy's off on the situation, and we come up with a creative solution. So that aesthetically, what we're talking about looks good, and is presented in a nice way, and that the person doing the real rocket science is somebody down the line. I'm really happy working with energy modelers. I'm really happy working with mechanical engineers, who are proactive about their systems. I think that needs to be their specialty and not necessarily ours. We have to understand those systems; I don't think it's critical that we engineer those systems, that we necessarily understand all those numbers. We have to know how to implement those though in an aesthetically pleasing way, or else we're kind of doomed to generic-looking buildings. And I'm ok with making certain design decisions based sustainability, but if they all start looking the same and start looking generic; and they all look like eastern-block concrete apartment buildings I've got a big issue with that. I think architects need to be the shepherd for all of these pieces and put them together (AR3).

While this perspective essentially supports the traditional role of architects as visionary and creative project directors who collaboratively guide various building specialists towards meeting the client's goals, this individual expanded that function by conveying how architect advocates are ultimately responsible for tailoring design responses to the environmental and social well being of inhabitants.

> A building has the opportunity to enhance people's lives in a lot of different ways. One is that they tread more lightly on the earth, they have less of an impact; which I think is critical. But I think the architect's role is really to utilize that opportunity to enhance people's lives and make sure they don't get sick in their buildings; make sure they're happy in their buildings; make sure they're comfortable in their buildings; and make sure they like looking (at), and being in, their buildings. And that's what I think the architect's role really needs to be, is integrating all of those things (AR3).

While other advocates shared the sentiment that design should be responsive to challenges of the 21st century, they expressed how accepting alternative design intentions also necessitates an expansion of the traditional boundaries of architects and other design professionals. Whether serving as an educator for their clients, the building industry, or society at large; or facilitating the development of an information-sharing network to advance the lessons learned on performance-based design projects; these advocates expressed that the role the practitioner should ultimately expand in order to facilitate the integration of alternative cultural, organizational, and technical values. One instructor illustrated this imperative by presenting some of the basic responsibilities advocates should consider integrating into their daily practice,

> The idea is, if you're interested in performance … performance means a lot of different things, and hopefully it's as much qualitative as it is quantitative. And there's all these little elements that you can touch (on) a project; whether it's setting goals and concepts; whether it's doing integrative design; whether it's doing cost benefit analysis and good energy modeling; whether it's good commissioning or M&V (measurement and verification) that's meaningful, or using occupant feedback. There's all these sort of tools that are there, and we just need to start, I think, choosing some of them, and enacting some of them (DP2).

Beyond integrating the proposed sub-practices of net zero energy design, other advocates expressed how architects must look beyond simply expanding their personal and project-based responsibilities and address the larger issues at hand. As expressed by one architect,

> So going beyond just sort of the outreach and education that we feel as a firm we need to do …, we also need to think about the bigger issues and start to sort of get our fingers outside of the standard boundaries of our profession (AR2).

By contextualizing this sentiment with the type of philosophical discussions they and their colleagues have begun to engage in, this advocate demonstrated how embracing a fundamental paradigm shift for the industry essentially entails a willingness to question and address conventional customs, values, and norms.

> 2030 has also caused us to have discussions inside the firm, … to what's the right way to do things; let's ask the bigger questions. I know that on the energy side, we've wondered about the Edison vs. Tesla conversation. It seems like Tesla

> won, we've got AC everywhere; but with … more and more PV's are coming on, it raises the question about distributed vs. centralized infrastructure, and I think that's a question that needs to be discussed (AR2).

Of course, in order to truly catalyze a transformation of the built environment, several advocates acknowledged how architects and design professionals must advance their performance-based convictions and embrace an advocacy role within the larger industry and society at large. For one design professional, the imperative to champion alternative energy solutions is inspired by the environmental forces at the root of the net zero energy design challenge.

> This 2030 Challenge, I think, is very timely but I would also suggest that 2030 is only 19 years away. So it's a long time when you talk about the kind of increase of carbon pollution that we're seeing on an annual basis and it really is the time to move ahead and assume some advocacy, play a leadership role, and do what you can in your practice to make sure that we're minimizing the threats that we're facing (DP3).

For another individual, assuming the role of an advocate is perceived as providing architects with an opportunity to expand their influence beyond individual buildings and, in turn, gain political power; while at the same time, advance net zero energy design by means of the coveted increase in interchange.

> I strongly believe that it's not just good business, but there's this sort of moral obligation to do the right thing. Part of that, I think, is really getting to the architect's next role. It's not just taking it (net zero) into the project, it's that advocacy role. We're recognizing that we have larger opportunities because of the scale issue; when you start getting into planning projects, as opposed to just architecture projects, you get more opportunities for that advocacy role because you're actually potentially making a policy issue as you push planning and urban design initiatives forward with large cities. … Of course there's a lot of support within the firm to have that advocacy role; going out to a conference, making sure that people are attending all the different (seminars); you know, not just bringing that information back, but also getting the word out. The whole dialogue we have as a profession is really important (AR2).

Finally, for another advocate, expressions of public support for the emergence of a performance-based building culture must extend beyond the building industry and into the larger community. Again, as visionary and creative leaders, architects and design professionals are perceived to be the most qualified for guiding society towards an alternative energy future in the built environment.

> I think a design education, which I'm guessing pretty much everybody in the room sort of comes from, gives us a base to be leaders in this area. And I think that there're things that we're doing, like the 2030 educational series, that are great; but I just want to reiterate that I see this imperative for the A/E/C (architecture, engineering, and construction) community to sort of evangelize the stuff to a greater society because that's really where we're going to make a bigger impact (AR2).

Each of the insightful perspectives offered throughout the course of my investigation have indicated that architects, who are advocates of net zero energy building design, perceive their role in transforming the sociotechnical sub-practices of the profession by means of social and cultural activism rather than simply technological manipulation. By engaging in an empirical analysis with individuals who see net zero energy building design knowledge as valuable to themselves and the world, I've corroborated the notion that technological change is fundamentally rooted in social change. Rather than contend that net zero energy buildings will proliferate simply as a result of an integrative approach based on science, technology, and management, these advocates have illustrated that consequential opportunities for fundamental change exist within the social and cultural facets of the building culture. Accordingly, the prevailing perspective that emerged from my investigation is that, in order to advance net zero energy building design, architects and design professionals must expand the traditional boundaries of their profession and serve as social leaders who will guide the building industry and society towards an alternative energy future for the built environment.

As a technological system, the momentum for change within the emergent *performance-based building culture* is configured and expanded by social as well as technical forces that vary in magnitude and influence over the evolutionary course of its development. At this preliminary stage, advocacy, leadership, and the expansion of professional boundaries have emerged as the favorable forces of influence for catalyzing fundamental change within the conventional building culture. While the effects of these mobilizing social forces will be evident in the future, at this time, they appear to embody a quintessential response to the imperative of the *2030 Challenge* as perceived by its founder, Edward Mazria.

> We're talking about, the planet is at stake; the planet is at stake. So, if this community doesn't do it. If the state doesn't step up; if the architects at the state don't step up; if the energy office at the state doesn't step up to the plate; if the architects in their practice, and planners, and builders, and designers, and interior designers, don't step up, we lose the planet. It's essentially as simple as that, given the projections. If we believe the projections. If you want to believe Exxon Mobile, you can believe them. But I believe NASA, and I believe our National Center for Atmospheric Research, … and I believe that all these guys are not pulling the wool over our eyes. … If you believe that, then you move, and you don't let anything get in your way (Mazria, 2011).

By titling this research, *The Social Construction of Performance-Based Design*, I've intended to remind practitioners of their very essential role in the formation of this evolving design paradigm. Erroneously, the task of achieving a net zero energy status for buildings is often portrayed as simply a technological design challenge requiring political and/or market-based interventions. However, insight offered by these net zero energy design advocates demonstrates that fundamental modifications to the complex social matrices underlying the conventional building culture, and society at large, constitutes a critical component of this alternative design problem.

As practitioners internalize and conceptualize adaptive responses to concerns related to climate change, one of the greatest threats and simultaneous opportunities for the building industry is the manner in which the design community internally responds to the multitude of influences associated with a global paradigm shift towards sustainability. If design professionals are to assume their greatest potential as meaningful facilitators of sustainable solutions that extend beyond individual buildings to society at large, advocates should proactively and deliberately frame alternative design intentions against the environmental, social, cultural, and political conditions requiring reform. As inspired and visionary leaders, capable of synthesizing a diverse range of interests and needs into meaningful and compelling solutions, architects and design professionals are in a unique position to unite both technological and social forces as joint influences for change. Ultimately, by embracing their rich cultural tradition of utilizing design knowledge in service of society, architects have the capacity to inform a new chapter within the building culture, an alternative generation of structures for the built environment, and effectively serve as change agents for this very compelling cause.

Appendices

Appendix A – Open-Ended Interview Questions

Background Questions:

- How long have you been practicing?
- What type(s) of project(s) have you had the most experience with?
    - Public/Private; Schools, Healthcare, Residential, Commercial,
- Have you had the opportunity to work on any net zero projects?
    - If not, what do you attribute as the primary reason?
    - If so, can you tell me about the project?

Sense of Responsibility / Personal Inclination:

1. Why do you think it's important to get on board with the *2030 Challenge*?

Practical Ability / Application:

2. According to the *Architecture 2030* reduction targets, as of 2011, buildings should be on their way to achieving a 60% reduction of energy consumption increasing to carbon neutral over the next 19 years.
    - Are you optimistic and/or pessimistic about the building industry being able to achieve these targeted reductions and why?
    - Do you think there's a disconnect between the objectives and vision of *Architecture 2030* and its practical application?

Transition Opportunities and Barriers:

3. While it's unique to each firm, present practice (or business-as-usual) represents a certain alignment of organizational, technical, and cultural aspects/qualities. I'm interested in how these existing structures provide opportunities and/or barriers for the development of net zero energy buildings.

- By **organizational**, I mean the way in which practice is typically structured and activities are conducted. Do you see organizational aspects of the profession as providing opportunities or barriers for net zero energy design?
- By **technical**, I'm referring to the means of production for projects – essentially, the resources utilized for producing buildings. These can be thought of as machine and computer-based, or even human-resource based such as the "technical staff" in firms. Do you see technical aspects of the profession as providing opportunities or barriers for net zero energy design?
- Ideas of **culture** can be a bit abstract, but essentially I'm speaking of the attitudes, behavior, and fundamental values that are characteristic of the architectural professional. Do you see cultural aspects of the profession as providing opportunities or barriers for net zero energy design?

Learning Objectives:

4. An integrated design process is considered to be fundamental to the creation of net zero energy compliant buildings.
    - Have you been involved in a project(s) that incorporated an integrated design process?
        - If not, have you found that this concept is being promoted as an alternative yet? (by your firm, by owners, in RFQ's, etc.)
        - If not, what do you think is required to facilitate the adoption of integrated design practices?
        - If so, how would you describe your experience with this strategy? Do you agree that it is a fundamental component of net zero energy design?
5. As an architect, what are your thoughts on energy use and performance goals driving architectural design rather than the reverse? More specifically, do you think there is a conflict between aesthetics and net zero energy design?
6. Follow-up /Clarity Question…

APPENDIX B – FINAL SURVEY SUMMARY

SurveyMonkey

1. Please select the title that best describes your primary role in the building industry.

	Response Percent	Response Count
Contractor	0.0%	0
Design Professional	15.4%	4
Developer	0.0%	0
Licensed Architect	**69.2%**	**18**
Licensed Engineer	3.8%	1
Principal	15.4%	4
Project Manager	7.7%	2
	Other (please specify)	1
	answered question	**26**
	skipped question	**1**

2. Please select the range which best describes the number of years you've been practicing:

	Response Percent	Response Count
1-10 years	19.2%	5
11-20 years	15.4%	4
21+ years	**65.4%**	**17**
	Other (please specify)	1
	answered question	**26**
	skipped question	**1**

3. What best describes the size of your office or firm?

	Response Percent	Response Count
Large Firm (over 50 employees)	**29.6%**	**8**
Medium Firm (5 to 50 employees)	**29.6%**	**8**
Small Firm (less than 5 employees)	25.9%	7
Government Agency	11.1%	3
Independent Consultant	0.0%	0
Retired and/or Unemployed	3.7%	1
	Other (please specify)	0
	answered question	**27**
	skipped question	**0**

4. Please describe your company's commitment level for attaining a net zero energy status for your current and/or future projects:

	Response Percent	Response Count
VERY COMMITTED - net zero energy design objectives are standard practice for our projects.	19.2%	5
SOMEWHAT COMMITTED - select net zero energy design objectives are beginning to be integrated into our projects.	**65.4%**	**17**
INTERESTED - but not ready to commit to accounting for the energy impacts of our projects.	11.5%	3
NOT A PRIORITY - unless it's directed by the client.	3.8%	1
	Other (please specify)	0
	answered question	**26**
	skipped question	**1**

5. What best describes your personal interest in net zero energy design? Please select any reasons that apply to you and rank them in order from most to least influential.

	Most Influential	Significant Consideration	Least Influential	N/A	Rating Average	Response Count
PERSONAL REASONS - As a Professional, I have a moral obligation to do the right thing. In this case, that represents mitigating unintentional environmental consequences caused by energy consumption in buildings.	**74.1% (20)**	25.9% (7)	0.0% (0)	0.0% (0)	1.26	27
BUSINESS DEVELOPMENT - Industry trends are moving in this direction and change is inevitable.	19.2% (5)	**50.0% (13)**	26.9% (7)	3.8% (1)	2.08	26
MARKETING PURPOSES - In order to stay competitive, I've got to get on-board.	12.0% (3)	**44.0% (11)**	36.0% (9)	8.0% (2)	2.26	25
"BUSINESS AS USUAL" NEEDS TO CHANGE - The design industry as a whole needs to establish a new agenda tailored to meet the challenges of the 21st century.	**46.2% (12)**	42.3% (11)	11.5% (3)	0.0% (0)	1.65	26
PROFESSIONAL DEVELOPMENT - I'm interested in staying informed of the latest trends and always endeavor to learn new things.	34.6% (9)	**42.3% (11)**	23.1% (6)	0.0% (0)	1.88	26
					Other (please specify)	0
					answered question	**27**

	skipped question	**0**

6. Do you feel that your formal university or college education prepared you to address the challenges associated with net zero energy building design?

	Response Percent	Response Count
Yes	22.2%	6
No	33.3%	9
To some extent, but times have changed and it's my responsibility to stay informed of the latest design knowledge.	**44.4%**	**12**
	Other (please specify)	4
	answered question	**27**
	skipped question	**0**

7. Throughout the span of the AIA+2030 Series, the following themes emerged as potential challenges for achieving a net zero energy status for buildings. Please select any that apply to you, and rank them based on how influential they are to your practice and ability to achieve a net zero energy status for your projects.

	Most Influential	Significant Consideration	Least Influential	N/A	Rating Average	Response Count
EDUCATION - Including: personal preparedness; comprehension levels of associates and clients; time, money, and ability to educate yourself, your associates, and your clients; etc.	**51.9% (14)**	40.7% (11)	7.4% (2)	0.0% (0)	1.56	27
TOOLS - Including: access to desired software; time and money required for software orientation; proficiency with new tools; etc.	22.2% (6)	**55.6% (15)**	22.2% (6)	0.0% (0)	2.00	27
INTEGRATION - Including: how to integrate net zero energy design strategies into practice; getting other building industry professionals on-board; etc.	37.0% (10)	**59.3% (16)**	3.7% (1)	0.0% (0)	1.67	27
BUDGETARY CONSIDERATIONS - Including: the adoption of Life Cycle Costing or Total Cost of Ownership practices; the potential for additional design, construction, equipment, and materials fees; etc.	44.4% (12)	**51.9% (14)**	3.7% (1)	0.0% (0)	1.59	27
TECHNICALITY - Including: establishing appropriate levels of technical know-how for different professionals; understanding basic rules of thumb vs. in-depth details;	36.0% (9)	**56.0% (14)**	8.0% (2)	0.0% (0)	1.72	25

etc.						
APPLICATION - Including: how to use and apply the available information and put the various concepts into action; actively engage in projects that are seeking net zero energy design goals; etc.	**48.1% (13)**	37.0% (10)	14.8% (4)	0.0% (0)	1.67	27
					Other (please specify)	0
					answered question	**27**
					skipped question	**0**

8. Please rank the measures and initiatives that you believe will best promote the achievement of net zero energy buildings by the stated deadlines of the 2030 Challenge.

	Most Influential	Significant Consideration	Least Influential	N/A	Rating Average	Response Count
FINANCIAL AND/OR MARKET-DRIVEN PROGRAMS: e.g. Tax Rebates, Incentives, and Deductions.	**59.3% (16)**	33.3% (9)	7.4% (2)	0.0% (0)	1.48	27
LOCAL OR NATIONAL LEGISLATIVE MANDATES: e.g. Building and/or Energy Codes, Climate Action Plans, etc.	**74.1% (20)**	18.5% (5)	7.4% (2)	0.0% (0)	1.33	27
VOLUNTEER-BASED CHALLENGES: e.g. Architecture 2030, and/or Green Building Rating Programs.	0.0% (0)	48.1% (13)	**51.9% (14)**	0.0% (0)	2.52	27
PARADIGM SHIFTS: e.g. The establishment of a new design agenda by influential leaders in the architectural, engineering, and/or building community.	18.5% (5)	**51.9% (14)**	29.6% (8)	0.0% (0)	2.11	27
EDUCATIONAL PROGRAMS: e.g. The AIA+2030 Series; Continuing Education Requirements; Formal training offered at the University or College level.	3.7% (1)	**81.5% (22)**	14.8% (4)	0.0% (0)	2.11	27
					Other (please specify)	0
					answered question	**27**

skipped question	0

9. The AIA 2030 Commitment, First Annual Report (May 2011) states that: "Open dialogue regarding the challenges faced in transforming how firms design projects and operate as a firm is critical if we are committed in our desire to reduce the negative impacts of the design and construction industry on the climate." Based on this recognized need for greater information sharing within the industry: Would you personally be willing to engage in a dedicated forum, or program, aimed at sharing and advancing net zero energy design strategies? Shared information could include: best practices, preferred rules-of-thumb, success stories AND project failures, modeled vs. actual recorded building energy use, life cycle costing results, etc.

	Response Percent	Response Count
Yes, I would be willing to share all information openly.	**59.3%**	**16**
Yes, I would be willing to share selected information openly.	18.5%	5
Yes, I would be willing to share all information anonymously.	7.4%	2
Yes, I would be willing to share selected information anonymously.	11.1%	3
No, I would not be willing to share any project information.	3.7%	1
	Other (please specify)	3
	answered question	**27**
	skipped question	**0**

10. To date, have you been able to apply any of the lessons learned in the AIA+2030 Series directly to any of your projects?

		Response Percent	Response Count
Yes		59.3%	16
No		40.7%	11
		answered question	27
		skipped question	0

11. If yes, which Sessions(s) and corresponding topics represent the strategies you've been able to employ? Please order from most to least applicable.

	Most Applicable	Moderately Applicable	Least Applicable	Rating Average	Response Count
Session 1: The 2030 Challenge: Setting + Achieving Energy Goals with Integrated Design (e.g. Integrated Design Process and Integrated Project Delivery)	31.3% (5)	**56.3% (9)**	12.5% (2)	1.81	16
Session 2: Getting to 50: the Power of Targets + Load Reductions (e.g. Energy Star Target Finder tool and Energy Use Intensity)	31.3% (5)	**43.8% (7)**	25.0% (4)	1.94	16
Session 3: Accentuate the Positive: Climate Responsive Design (e.g. utilizing climate data and site characteristics to conduct a Site Resource Inventory)	31.3% (5)	**50.0% (8)**	18.8% (3)	1.88	16
Session 4: Skins: the Importance of the Thermal Envelope (e.g. architectural elements, materials, and construction opportunities for designing a high performance thermal envelope)	**62.5% (10)**	25.0% (4)	12.5% (2)	1.50	16
Session 5: Passively Aggressive: Employing Passive Systems for Load Reduction (e.g. successful passive strategies based on available site resources)	43.8% (7)	**56.3% (9)**	0.0% (0)	1.56	16
Session 6: Illuminating Savings:					

Daylighting and Integrated Lighting Strategies (e.g. strategies for maximizing natural light while controlling for glare and unwanted heat gain)	**62.5% (10)**	37.5% (6)	0.0% (0)	1.38	16
Session 7: Right-sized: Equipment and Controls for Super-Efficient Building Systems (e.g. right-sizing and controls to optimize the efficiency of equipment)	37.5% (6)	**56.3% (9)**	6.3% (1)	1.69	16
Session 8: Site Power: Renewable Energy Opportunities (e.g. on-site and off-site renewable energy opportunities)	31.3% (5)	**43.8% (7)**	25.0% (4)	1.94	16
Session 9: The Hand-off + Staying in Shape: Operations, Maintenance + Education (matching performance with expectations; commissioning, training, and performance monitoring)	6.3% (1)	**68.8% (11)**	25.0% (4)	2.19	16
Session 10: Putting it All Together: Achieving 2030 Goals on the Project and at the Office (e.g. examining the movement from in-class exercises to on-site implementation)	12.5% (2)	**68.8% (11)**	18.8% (3)	2.06	16
				Other (please specify)	0
				answered question	**16**
				skipped question	**11**

12. If no, please rank the Session(s) and corresponding topics you're most interested in applying. Please rank in order of most to least interested in applying.

	Most Interested In Applying	Moderately Interested in Applying	Least Interested in Applying	Rating Average	Response Count
Session 1: The 2030 Challenge: Setting + Achieving Energy Goals with Integrated Design (e.g. Integrated Design Process and Integrated Project Delivery)	**90.0% (9)**	10.0% (1)	0.0% (0)	1.10	10
Session 2: Getting to 50: the Power of Targets + Load Reductions (e.g. Energy Star Target Finder tool and Energy Use Intensity)	**63.6% (7)**	36.4% (4)	0.0% (0)	1.36	11
Session 3: Accentuate the Positive: Climate Responsive Design (e.g. utilizing climate data and site characteristics to conduct a Site Resource Inventory)	**81.8% (9)**	18.2% (2)	0.0% (0)	1.18	11
Session 4: Skins: the Importance of the Thermal Envelope (e.g. architectural elements, materials, and construction opportunities for designing a high performance thermal envelope)	**90.9% (10)**	9.1% (1)	0.0% (0)	1.09	11
Session 5: Passively Aggressive: Employing Passive Systems for Load Reduction (e.g. successful passive strategies based on available site resources)	**100.0% (11)**	0.0% (0)	0.0% (0)	1.00	11
Session 6: Illuminating Savings:					

Daylighting and Integrated Lighting Strategies (e.g. strategies for maximizing natural light while controlling for glare and unwanted heat gain)	**81.8% (9)**	18.2% (2)	0.0% (0)	1.18	11
Session 7: Right-sized: Equipment and Controls for Super-Efficient Building Systems (e.g. right-sizing and controls to optimize the efficiency of equipment)	**60.0% (6)**	30.0% (3)	10.0% (1)	1.50	10
Session 8: Site Power: Renewable Energy Opportunities (e.g. on-site and off-site renewable energy opportunities)	**72.7% (8)**	27.3% (3)	0.0% (0)	1.27	11
Session 9: The Hand-off + Staying in Shape: Operations, Maintenance + Education (matching performance with expectations; commissioning, training, and performance monitoring)	**54.5% (6)**	27.3% (3)	18.2% (2)	1.64	11
Session 10: Putting it All Together: Achieving 2030 Goals on the Project and at the Office (e.g. examining the movement from in-class exercises to on-site implementation)	**70.0% (7)**	20.0% (2)	10.0% (1)	1.40	10
				Other (please specify)	1
				answered question	**11**
				skipped question	**16**

13. At the end of the day, a building is classified as net zero based on quantitative energy performance numbers. This circumstance establishes numerical quantitative data as a primary criteria for judgment. How do you feel about quantitative energy data, such as energy modeling results, informing design decisions for your projects?

	Response Percent	Response Count
I'm in support of this much-needed transition for architecture and the building industry.	**81.5%**	**22**
I'm skeptical because of the potential to undermine important other design considerations, such as aesthetics, social factors, historical significance, etc.	18.5%	5
I'm not supportive of this because quantitative energy metrics could present a danger to the design professions.	0.0%	0
Other (please specify)		2
answered question		**27**
skipped question		**0**

14. Are you in favor of predetermined energy performance targets becoming standard requirements in RFP's and RFQ's?

	Response Percent	Response Count
Yes	**59.3%**	**16**
No	11.1%	3
Maybe	29.6%	8
	If maybe, please list any contingencies that would apply:	5
	answered question	**27**
	skipped question	**0**

15. During the design phase, how often do you educate or engage with your clients about energy reduction strategies associated with post-construction building operations and maintenance?

	Response Percent	Response Count
Always, this is standard practice.	**56.0%**	**14**
On occasion, as budget and time allows.	40.0%	10
Rarely, this is often outside of our scope.	4.0%	1
Never, and I'm not interested because this is not the responsibility of design professionals.	0.0%	0
Other (please specify)		2
answered question		**25**
skipped question		**2**

16. Tomorrow, if your firm was awarded a project pursuing a net zero energy status, how would you describe the preparedness of you and your business associates to achieve a net zero status for the project?

	Response Percent	Response Count
Prepared, we've done this type of work before.	44.0%	11
Challenged, we would have a significant, but manageable learning curve.	**52.0%**	**13**
Unprepared, this type of project is above and beyond our current abilities.	4.0%	1
Other (please specify)		3
answered question		**25**
skipped question		**2**

17. Please rank, in order of importance, the types of professionals that you believe should attend future trainings devoted to net zero energy buildings:

	Most Important	Moderately Important	Least Important	Rating Average	Response Count
Architects	**96.2% (25)**	3.8% (1)	0.0% (0)	1.04	26
Building Occupants	**42.3% (11)**	30.8% (8)	26.9% (7)	1.85	26
Commissioning Authorities	**60.0% (15)**	36.0% (9)	4.0% (1)	1.44	25
Contractors	**66.7% (18)**	33.3% (9)	0.0% (0)	1.33	27
Developers	**70.4% (19)**	29.6% (8)	0.0% (0)	1.30	27
Engineers	**92.6% (25)**	7.4% (2)	0.0% (0)	1.07	27
Investors / Financiers	**48.1% (13)**	40.7% (11)	11.1% (3)	1.63	27
Owners	**63.0% (17)**	37.0% (10)	0.0% (0)	1.37	27
Operations and Maintenance Personnel	**70.4% (19)**	29.6% (8)	0.0% (0)	1.30	27
Suppliers and Vendors	33.3% (9)	**51.9% (14)**	14.8% (4)	1.81	27
				Other (please specify)	1
				answered question	**27**
				skipped question	**0**

18. BONUS QUESTION How do you define "building performance"? What matters most to you?

		Response Count
		15
	answered question	15
	skipped question	12

Page 1, Q1. Please select the title that best describes your primary role in the building industry.		
1	unemployed graduate of Master of Architecture program	Mar 23, 2012 12:38 PM

Page 1, Q2. Please select the range which best describes the number of years you've been practicing:		
1	not practicing yet	Mar 23, 2012 12:38 PM

Page 2, Q3. Do you feel that your formal university or college education prepared you to address the challenges associated with net zero energy building design?		
1	Environmental consciousness and response was addressed for the purposes of sighting structures and capturing natural ventilation, sunlight, etc. But the need to reduce carbon footprints by practicing sustainable design and using net-zero analysis, was not even mentioned in the late 60s.	Mar 29, 2012 3:52 PM
2	To a certain extent, this is simply a matter of "smart design." I was in school in the 70s & 80s and had lived through the first energy crisis, so energy and water conservation have always been a priority.	Mar 29, 2012 9:30 AM
3	Only if you specifically chose those particular classes.	Mar 28, 2012 10:12 AM
4	I complete graduate school in 2007. At the time only one studio specifically dealt with this topic, and some misc classwork in LEED and daylighting. It was not under a specific umbrella of net zero or sustainable building design.	Mar 21, 2012 10:12 AM

Page 4, Q1. The AIA 2030 Commitment, First Annual Report (May 2011) states that: "Open dialogue regarding the challenges faced in transforming how firms design projects and operate as a firm is critical if we are committed in our desire to reduce the negative impacts of the design and construction industr...		
1	Certain clients have financial considerations that we can not divulge.	Mar 29, 2012 9:36 AM
2	The challenge is to great to be met without open sharing and helping each other.	Mar 23, 2012 12:46 PM
3	Sharing is the only way we are going to get there!	Mar 22, 2012 11:23 AM

Page 6, Q1. If no, please rank the Session(s) and corresponding topics you're most interested in applying. Please rank in order of most to least interested in applying.		
1	These sessions were all great and full of knowledge. The issue for applying the knowledge and ressources shared in the session has to do with having and taking the time to digest and assimilate the knowledge. Also our firm is also applying some of the practices shared. The session only reinforced the appraoch and the practice the firm is implementing	Mar 22, 2012 11:28 AM

Page 7, Q1. At the end of the day, a building is classified as net zero based on quantitative energy performance numbers. This circumstance establishes numerical quantitative data as a primary criteria for judgment. How do you feel about quantitative energy data, such as energy modeling results, informing ...		
1	The added cost HAS to be taken into account. That cost is borne by either the client or the architect and is NOT an acceptable up-charge to the architects fees at this point. Add to this the accuracy of existing models and it is not a viable business model yet for the vast majority of projects out there. As most of us work on small budget and scale projects, the modelling can not pay for itself yet. The system needs to evolve, become more user-friendly and cost-effective before it will be an accepted part of the design process for most projects.	Mar 29, 2012 9:46 AM
2	We cannot accomplish enough by just applying general principles and rules of thumb. Buildings are too complex and our knowledge is too little. also motivation is easily compromised without specific measurable goals and accomplishments.	Mar 23, 2012 12:52 PM

Page 7, Q2. Are you in favor of predetermined energy performance targets becoming standard requirements in RFP's and RFQ's?		
1	unfortunately, building occupants rarely use their buildings the way that they say they will during design when perameters are set for modelling. therefore, there are many reasons why buildings rarely perform as modelled. energy modelling can only be used as a comparison of possible systems and percentage of improved performance and not as a goal setting tool for actual energy used when the building is occupied.	Apr 2, 2012 10:20 AM
2	Again, it is an issue of cost and accuracy. The cost of modeling to insure that the project will meet those goals needs to be included in the fees for the project. The accuracy of that modeling needs to be exact enough to give architects and clients a comfort level that the virtual model will match the reality. Please note; the issue of humans using the buildings is as difficult to control in the virtual model as it is in reality.	Mar 29, 2012 9:46 AM
3	RFP's must define performance goals, but the means of achieving them must be directed by the design team. The extent to which a design team is held to the building's performance is an area of debate, too, because it is influenced by the extent to which a design team can remain involved with a building after substantial completion and occupancy.	Mar 26, 2012 2:31 PM
4	Without these targets it won't happen. Sometimes the targets may seem unattainable, but the impossible can become possible when we have to do it.	Mar 23, 2012 12:52 PM
5	The only issue with this is that attaining the goal of a specific target is contingent of the client's decision which the design industry has no control over.	Mar 22, 2012 11:30 AM

Page 8, Q1. During the design phase, how often do you educate or engage with your clients about energy reduction strategies associated with post-construction building operations and maintenance?		
1	My professional role does not require me to have client contact or be engaged about sustainability goals.	Mar 29, 2012 4:04 PM
2	Not working currently, but when I do this is a conversation I will expect to have ongoing with all clients.	Mar 23, 2012 12:53 PM

Page 8, Q2. Tomorrow, if your firm was awarded a project pursuing a net zero energy status, how would you describe the preparedness of you and your business associates to achieve a net zero status for the project?		
1	We're a government agency, not a design firm. We would hire an A/E team who was prepared.	Mar 23, 2012 2:08 PM
2	Unemployed.	Mar 23, 2012 12:53 PM
3	The result would depend on assembling the right team of consultants	Mar 22, 2012 11:31 AM

Page 9, Q1. Please rank, in order of importance, the types of professionals that you believe should attend future trainings devoted to net zero energy buildings:		
1	I voted for all because while the specific topics may vary in the training, the need for it does not. It might be easy to assume that the engineers will figure it out because of their trade, but we've seen that even those on the cutting edge still need training about the actual project realities. Owners, investors, developers all need their own track to understand why this is relevant. Don't leave anybody out, it has to be industry wide.	Mar 21, 2012 10:25 AM

Page 9, Q2. BONUS QUESTION

How do you define "building performance"? What matters most to you?

1	The bottom line is what you pay each month in utility costs relative to the comfort you feel.	Apr 6, 2012 8:41 PM
2	maximizing energy efficiency user friendly controls/equipment to help owners maximize energy efficiency. low maintenance and long lasting materials healthy for occupants highly insulated building shell with little to no weather infiltration	Apr 2, 2012 10:24 AM
3	0 energy	Mar 29, 2012 5:24 PM
4	Striking a balance between the good functional performance of a facility for the occupants while acheiveing aggressive sustainable goals that use net-zero metrics as the gauge for success.	Mar 29, 2012 4:10 PM
5	Cost. The present value and long term costs for a net zero building should and can be cost effective.	Mar 28, 2012 1:21 PM
6	Building performance captures the operations and maintenance of a facility over its life. The more passive and simple systems which are incorporated in a building design, the better chance that the building will achieve positive building performance throughout its service.	Mar 27, 2012 6:42 AM
7	That a building is comfortable, functional, sturdy and long-lasting with minimal maintenance required and using resources that do not negatively impact the environment nor compromise the quality of life for future generations.	Mar 23, 2012 12:59 PM
8	The overall sustainability of a project is not only measured in the energy performace, meeting net zero, but also in the satisfaction of its users and the adaptability and flexibility of the spaces to accomodate change in uses	Mar 22, 2012 11:34 AM
9	energy use - BTUH/SF	Mar 21, 2012 3:20 PM
10	Satisfying the intended purposes for the building while employing all reasonable energy reducing strategies - regardless of whether "net-zero" is achieved.	Mar 21, 2012 3:04 PM
11	We use the term High Performance to describe buildings in which both resource efficiency and occupant productivity are simultaneously improved. You need both, not just one or the other.	Mar 21, 2012 2:51 PM
12	Building performance is meeting or exceeding set goals. What matters most to me is a happy client.	Mar 21, 2012 2:44 PM
13	Building Performance is the building ability to use little to no energy while still creating inspiring and healthy envirionments. What matters the most to me is creating the way we build and life to creat structures that don't use any more energy then they can make.	Mar 21, 2012 10:33 AM

Page 9, Q2. BONUS QUESTION

How do you define "building performance"? What matters most to you?

14	It has to be a wholistic view that does not end at design. Yes, the building may have been modeled as high performance, but what does operational reality bring? Have the occupants taken on a culture shift from their previous space to the new one? Do occupants understand the control systems? Do facilities personnel understand the lamping and HVAC strategies? Are the systems maintainable? Has the building really been designed and constructed with the user and owner's needs in mind? LEED is a nice checklist, but what closes the loop back to everyday use?	Mar 21, 2012 10:25 AM
15	Building performance is the actual, measured metrics from the built project. To me it matters most that building decisions are based on the TOTAL cost, including greenhouse gas emissions and their effects, life-cycle etc. I think a carbon tax is a great place to start. The time where first cost and creating buildings that are burdens for future generations is over. Developers and building owners have to be mandated through policy to make this change, they have been given the chance and continue to act irresponsibly, citing first cost as the biggest issue!	Mar 19, 2012 7:31 AM

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