Report

Sustainability in Practice
Social Science Perspectives on Architectural Design, Research &
the Implementation of Building Solutions

Author(s):
Bharathi, Krishna

Publication Date:
2014

Permanent Link:
https://doi.org/10.3929/ethz-a-010686669

Rights / License:
In Copyright - Non-Commercial Use Permitted

This page was generated automatically upon download from the ETH Zurich Research Collection. For more information please consult the Terms of use.
Sustainability in PRACTICE
REVIEW COMMITTEE

COMMENTS

“...an interesting, well-written and well-argued thesis, which brings together issues, theories and literatures from architecture, building science, urban geography and STS studies.”

“...a strongly critical stance is taken which is tested conceptually and technically within an interdisciplinary frame.”

“...both purposeful and considered, powerful in its critical position, but reflective in its claims.”

“...presents a strong case for the value of social perspectives on architectural design and building solutions that respond to climate change.”

“...a piece of research that is impactful beyond the University.”

“...contributes to new knowledge about the practice of developing sustainability policies and carbon reduction strategies for buildings and the built environment.”

REVIEW COMMITTEE

Dr. Steven A. Moore, University of Texas
Director, Graduate Program in Sustainable Design
Co-Director, Center for Sustainable Development

Dr. Simon Guy, University of Manchester
Director, Manchester Architecture Research Centre
Head of School Environment, Education and Development and Head of Architecture

Dr. Marianne Ryghaug, NTNU
Deputy Director, Centre for Sustainable Energy Studies (CenSES)

COVER IMAGE

Detail of Stadt 12/47 (Berlin), 2006
© Frank Thiel and VG Bild-Kunst, Bonn

GRAPHIC DESIGN

Krishna Bharathi

No part of the this work may be reproduced without the author’s permission.

SWISS FEDERAL INSTITUTE OF TECHNOLOGY
ZURICH, SWITZERLAND 2014
ISBN 978-3-906327-28-0
Sustainability in PRACTICE
Social Science Perspectives on Architectural Design, Research & the Implementation of Building Solutions

KRISHNA BHARATHI
OVERVIEW

Focused on the relationships between architectural design, research and the implementation of green building solutions, complementary social science approaches were explored through theoretical, experimental, methodological and empirical means.

Since September 2010, a range of works has been developed to engage these interactions, and in 2012 six months of fieldwork was undertaken in Switzerland as an invited researcher to ETH Zürich’s Institute for Environmental Decisions (IED), Natural and Social Science Interface (NSSI).

In partial fulfillment of the Ph.D. requirements in Science and Technology Studies (STS) at the Norwegian University of Science and Technology, Department of Interdisciplinary Studies of Culture, the four articles which comprise the thesis are summarized in the order presented.

Engaging complexity:
Social science approaches to green building design
A theoretic exploration of the positioning of three overlapping social science frameworks that examine the design and analysis of the built environment is presented. Using the notion of assemblage, intersections between the research interests of Science and Technology Studies (STS), critical urban theory, and assemblage urbanism are unpacked to highlight respective areas of focus. Insofar as the comparative contrast aids in situating perspectives contextually, assemblage thinking is argued as an effective point of departure to frame design practices within their broader socio-political landscapes.

Single-authored work published by MIT Press in Design Issues Autumn 2013, Vol. 29, No. 4, pages 82-93 as the issue’s anchor article.

Energy and buildings research:
Challenges from the new production of knowledge
Through the lens of Science and Technology Studies (STS), the state of energy and buildings research as it relates to Mode-2 conceptions of knowledge production is empirically explored. Using survey methodology, experts’ expectations of their current situations, future challenges, and their perceptions of ‘good’ science were assessed, and two sets of challenges linked to knowledge production in building research are outlined.

Published by Routledge Press in 2012 as a co-authored journal article with Dr. Thomas Berker in Building Research & Information Vol. 40, No. 4, pages 473-480. Responsibilities for the survey development, analysis, write-up and review correspondence were shared equally between the authors.
Continued...

Between research and practice:
Experts on implementing sustainable construction

Grounded in the Science and Technology Studies (STS), observations drawn from 31 semi-structured qualitative interviews conducted with Swiss building industry experts provide insight into the relationships between designers, researchers and public authorities. Expert-reported challenges linked to technical dimensions of sustainable construction are discussed, and a series of examples from the empirical data indicate how regulatory frictions and the challenges of implementing construction strategies into diverse domestic and international working contexts are ameliorated.

Published in 2013 as a co-authored journal article with Dr. Lee Ann Nicol in Buildings Vol. 3, No. 4, pages 739-765. As an expert in Swiss building stock policy at ETH Wohnforum - ETH CASE (Centre for Research on Architecture, Society and the Built Environment), Dr. Nicol’s primary role was to verify the accuracy of the institutional relationships outlined.

Framing transitions

Highlighting complementary relationships between architecture, urbanism and social science approaches to sustainable design, strategic areas of reflection that frame critical, transitional challenges are outlined. Synthesized into a critique of the design, construction and research industries, each of the topics raised: ‘sustainability as a design value,’ ‘non-disciplinary perspectives on design,’ and ‘the notion of cities,’ accessibly links relevant trends in academia and the practice of architecture to provide next steps for action.

Single-authored work published by the American Institute of Architects (AIA) in Forward 2013, Vol. 213, pages 105-122 as the issue’s anchor article.

Acknowledgements

This work was made possible with financial and institutional support provided by the Research Council of Norway, several partners through the Research Centre on Zero Emission Buildings (ZEB), and NTNU’s Faculty of Humanities, Department of Interdisciplinary Studies of Culture (KULT), Centre for Technology and Society (CTS). Without question the success of the fieldwork phase of this project was due to the institutional support of the Swiss Federal Institute of Technology (ETH Zurich) and the EU Erasmus Program. Also, many thanks to Columbia University in New York for the visiting scholar position during the final months of this project as Professor Frampton’s singular acumen and genuine interest reinvigorated my efforts as I began to tire. A special thanks to all the experts who took the time to meet with me and who lent their kind support. Not least, the friendship of Frank Thiel - our collaboration continues to be a source of insight. Finally, sincere thanks to each editor and anonymous reviewer who critically engaged in my writing process with their detailed comments and queries. This certainly improved the quality of the work and kept me moving forward.

About the author

Krishna Bharathi (b.1975 Tirunelveli, India) is an artist and licensed American architect (WA #9722; NCARB #67149; University of Washington) with a background in psychology (University of Chicago; Max Planck Institute for Human Cognition, Berlin). Drawing on experience gained from working as both a lead designer and field architect in multiple building typologies and planning scales in Europe, Asia and the U.S., she brings unique insight to the analysis of architectural practices.
## CONTENTS

**INTRODUCTION**  
Framing Perspectives  
Methodology  
Context of Fieldwork  
Conclusion

<table>
<thead>
<tr>
<th>ARTICLE 1</th>
<th>Engaging complexity: Social science approaches to green building design</th>
<th>47</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARTICLE 2</td>
<td>Energy and buildings research: Challenges from the new production of knowledge</td>
<td>61</td>
</tr>
<tr>
<td>ARTICLE 3</td>
<td>Between research and practice: Experts on implementing sustainable construction</td>
<td>75</td>
</tr>
<tr>
<td>ARTICLE 4</td>
<td>Framing transitions</td>
<td>103</td>
</tr>
</tbody>
</table>

**AFTERWORD**  
117
INTRODUCTION

Rationale

The immense complexity of the impacts of climate change worldwide continues to generate many working challenges in understanding its spatial implications. Most commonly associated with increasing food and water supply shortages (World Bank 2012), diverse indicators of its effects have also emerged in the form of documented, as well as projected human migration and loss of life linked to extreme weather events; infrastructure failures, and land subsidence; in addition to sea rise and flooding, especially in coastal regions around the globe. Ultimately in both theory and practice, these relationships have created an intricate web of causality that is difficult to navigate for both laypersons and specialists alike (Adger 1999; Barnett and Adger 2007; IPCC 2001, 2007, 2012; Hayhoe et al. 2010; Schwirtz 2013; Wang et al. 2012; Wolf et al. 2010).

Confluent with these issues, as a significant site of consumption and where the majority of the globe’s population lives, the focus on urban areas of the built environment has emerged as a critical location to mitigate the effects of climate change. Subsequently, within the many overlapping disciplines involved in its design, planning, construction and maintenance, a heavy emphasis has been placed on reduction of CO₂ emissions, since buildings directly emit approximately ten percent of global CO₂ totals. With the inclusion of indirect emissions from the use of electricity in the sector, this figure increases to almost thirty percent (IEA 2010). However:

While there was detailed thinking about how new buildings would perform in a zero carbon world, it took a few individuals to point out that even if we had all new zero carbon buildings, we would only make a very small dent on the emissions of the building stock as a whole. (Swan and Brown 2013, 1)

Thus, decarbonizing the buildings stock - through the combined strategies of refurbishment, retrofit and new construction - has been correctly identified as a multi-faceted goal. Simply put, it is one that needs to be addressed on multiple fronts which encompass social, technical, political and environmental concerns (Ravetz 2008). The strategic accomplishment of this aim is especially pressing when considering that not only is much of the housing infrastructure in developed nations already in place, but also critically, the urban populations in Africa and Asia are anticipated to
double between 2000 and 2030.

That is, the accumulated urban growth of these two regions during the whole span of history will be duplicated in a single generation. By 2030, the towns and cities of the developing world will make up eighty-one percent of urban humanity. (UNFPA 2007)

In current urban policy, tackling this complexity has meant increasingly interdisciplinary research agendas, where spatial policy has come to be more strongly linked to active social policy that interconnects “numerous fields from education, social services, criminal justice to land use planning and economic development” (Helms et al. 2007, 267). Also, within built environment discourses it has been recognized that casting climate protection as the singular protagonist “at the heart of sustainable development” is critically problematic, since doing so diminishes the ability of the design fields involved to contribute necessary strategic support in established action areas such as “energy supply, energy demand and adaptation” (Bulkeley 2006, 206).

Alternatively, another point which illustrates the current milieu of sustainable development endeavors can be gleaned from telling examples in the UK and the Netherlands where adaptation is viewed as a more viable option than mitigation, since “it is easier to accept that climate change is unavoidable than to be convinced that changing your way of life in a small country will have a serious impact on global climate change.” Oddly, this view is seen to be shared amongst developed nations, despite many being large consumers and/or producers of fossil fuels.

More problematic however, is that frequently “policy goals for spatial planning that could contribute to a reduction of damaging emissions are already part of the sustainability discourse,” but appear to have limited impact (de Vries 2006, 227). That is, the simple act of political inclusion within policy discourse is often questionably equivocated with action. Specifically, mitigation initiatives that include promises of greater resource efficiency, better technical installations, and economic promise are often disconnected from the processes of implementation and verification (Bulkeley 2007).

Lastly, a key focal point throughout these discussions is that the problem-solving conception of energy and efficient resource use that tends to emphasize solutions in terms of innovation and emergent markets. This approach tends to overlook contextual indicators which suggest that attaining projected estimated energy savings potentials is a complex process, where often “ambitious targets fail to materialize into comprehensive strategies, effective instruments and transparent results” (Murphy et al. 2012, 459).

Despite these challenges, current literature on carbon and energy consumption in the building stock indicates greater interest in socio-technical and socio-political framings of energy, design and construction issues to better understand for example, “the interplay between physical ‘things,’ rules and people, where regulation, technology, contracts and the way people live, all interact to drive the success or failure” of different ideas (Swan and Brown 2013, 1). Yet, Schweber and Leiringer have also found that in this research area there is “a disproportionate focus on occupants and associated neglect of policy, organizational and implementation challenges,” as well as “an almost exclusive reliance on positivist methodologies” (2012, 482). They argue:

Thus, what is needed is an expansion of the current scope of construction research to embrace interpretivist approaches to complement those that are already in use. (Ibid., 490)

Yet, clearly interpretivist studies pose many theoretical and methodological challenges for practitioners, or as Schön prosaically observes the conflict between architectural theory and technique.

…there is a high, hard ground overlooking a swamp. On the high ground, manageable problems lend themselves to solution through the use of research-based theory and technique. In the swampy lowlands, problems are messy and confusing and incapable of technical solution. The irony of this situation is that the problems of the high ground tend to be relatively unimportant to individuals or to society at large, however great their technical interest may be, while in the swamp lie the problems of greatest human concern. The practitioner is confronted with a choice…remain on the high ground where he can solve relatively unimportant problems according to his standards of rigor, or…descend to the swamp of important problems where he cannot be rigorous in any way he knows how to describe…(1995, 28)

Where Schön frames this conflict within choice, Jeanneret has described tensions embodied in architectural practice as more integral. That is architecture is “a construct of the mind which gives material form to the sum consciousness of its age” (Le Corbusier 1925/1987, 117). However, both perspectives intimate the need for architectural...
practices to respond to a shifting context succinctly described by Mies van der Rohe:

> Economic, technological, and cultural preconditions have changed fundamentally. Technology and economy face totally new problems. It is of crucial importance that they be correctly recognized and that meaningful solutions be found; not only for economy and technology but for our entire social and cultural life. (van der Rohe 1928/1991, 304)

Yet not surprisingly, unraveling the forces active within one’s building milieu has rarely been the primary focus of active practitioners for simple reasons of time and the efficacious use of resources in relation to industry focus. To cite another aptly fitting quotation from van der Rohe:

> We do not like the word ‘design.’ It means everything and nothing. Many believe they can do it all: fashion a comb and build a railroad station. The result: nothing is done well. We are only concerned with building. We prefer ‘building’ to ‘architecture’; and the best results belong in the realm of the ‘building art.’ Many schools get lost in sociology and design; the result is that they forget to build. (Interview with Mies van der Rohe; Norberg-Schulz 1958/1991, 338)

Collectively these perspectives informed the rationale as a practitioner, to temporarily ‘forget to build’ and pursue this doctoral work. In short, the thesis engages interstices between diverse actors converging on the topological theme of sustainability, but more broadly, its undertaking provided time, space and resources to explore and reflect on the relationships between the building arts and society at large.

In the spring of 2000, the Alvar Aalto Academy and the Department of Architecture of the Helsinki University held a seminar on the topic of ‘Research and Practice.’ At that meeting Director Esa Laaksonen illustrated the state of the “operative cloud of architecture,” which ideally, should homogeneously blend practical and research elements, but in fact, in observable practice continues to be quite firmly divided (Figure 1). As an alternative, he modified the diagram by introducing an intermediate area where the interests of both could mingle and posed the question: “What would this theoretical grey border zone of architecture be in practice?” (Laaksonen 2001, 6). This was a critical query in the formulation of this thesis project, since it was precisely within this fluid zone that I intended for my efforts to be located, while simultaneously remaining cognizant of the normative and administrative requirements of an academic setting (e.g. published peer reviewed journal articles, program course requirements, etc.) Subsequently, as a seasoned professional with a background in psychology and indirectly supported by a research center on zero emission building technologies, the topic of green building implementation processes became a reasonable area of study in my doctoral work. Lastly, given my primary funding and research affiliation would reside within a Science and Technology Studies (STS) focused research center, it was also clear from the onset of the project that its design would necessarily need to bridge differing, and at times, seemingly contradictory disciplinary notions of research - both within architecture, but also between architecture and the social sciences.

**Studying the Implementation of Sustainable Building Solutions**

Our role as architects and urbanists is to understand how the different social and cultural processes actually work in different physical environments...but I don’t want to be misunderstood. I don’t think architecture comes later. I think architecture is a prime mover in terms of social engagement. (Interview with Ricky Burdett; Hjemdal 2010, 92)

Baumschlager and Eberle observe that regional architectural transfer is not particularly effective, with the exception of “one of a kind, unique specimens,” such as “public buildings, museums or other cultural facilities,” despite a pervasive sense of globalization (2009, 9). This can be attributed in part to the reality that the physical assembly of architecture is implicated in a highly variegated set of localized practices, which encompass a multiplicity of perspectives. Yet, reinvigorated discussions of energy optimization and the reduction of emissions linked to anticipated resource shortages and the interconnected impacts of climate change have reinvigorated the discourse of integrative practice with a heavy emphasis on knowledge transfer. The range of these current measures spans diverse public, private, social, environmental and economic interests intending to disperse technologies and practices both nationally and internationally, and of use to all of these parties is a better understanding of implementation-oriented initiatives focused on knowledge integration and dissemination.

In his seminal essay, ‘Toward a Critical Regionalism Six Points for an Architecture of Resistance,’ the eminent self-described “writer on architecture” (2002b, 6) Kenneth Frampton argues for an
experimental, contextual, tactile architecture that “maintains an expressive density and resonance” in relation to geographic qualities of place (Ibid., 25). Combining this framework with Laaksonen’s ill-defined area of architectural research (Figure 1), research which typically occurs in the form of case studies focused on discrete buildings, typologies, technologies or the oeuvre of respective institutions or designers, the notion of a hybrid case study developed. That is specifically, one that would support the strengths of architectural analysis with tools from Science and Technology Studies (STS).

Thus, a case study of sustainable development implementation bounded regionally was conceived as having potential use in expanding the format of the architectural case study. It was with this simple study design concept in mind that the project began in September 2010, and following Campbell who asserts that, “action on climate change” is primarily “dependent on how the problem, or series of problems, is defined” (2006, 201), the dissertation work focused on contributing to new knowledge by supplementing:

...positivist research into the correlation between discrete variables and systems modeling with interpretivist studies into the way in which meaning, practices, and institutional environments shape supply and demand for energy and different characteristics of the built environment. (Schweber and Leiringer 2012, 491)

Subsequently, in a thirty-six month schedule: a series of theoretic, experimental, methodological and empirical efforts were undertaken to explore socio-technical readings of green development knowledge practices. Documented in eight works: six published articles to date, one in press, as well as one exhibited sound installation. All works, including the sound piece which was created out of fieldwork interview audio, exhibited at Aalto University in Helsinki and presented in a companion artist talk, underwent editorial and/or peer review. The four most closely related works presented here comprise the coordinated thesis.

Lastly of relevance to note, the role of principal investigator in this study can be best conceptualized within Donald Schön’s action research discourse that posits “reflection-in-action” can position the practitioner to assume the role of a researcher in the practice context through the use of exploratory process, methods and theories unbounded by technical rationality (1983; 1987; 1995; 1998; 2001). Essentially it is useful to consider that the process and outcomes gathered here can only be understood in relation to the ‘source of production’ (Heidegger 1950/2002; Gadamer 1975; Ricoeur 1961; 1976). Or alternatively stated, the knowledge that the ‘source of production’ is a practitioner who has been ‘reflecting-on-action’ for the last three years by taking on the role of a ‘practitioner in the research context’ should critically inform the reader’s understanding of the author’s approach to the work and aid in contextualizing both the selected strategies of analysis and presentation.

**Thesis Structure**

Each of the four published articles included was developed to meet the interests of a diverse spectrum of academic and professional readership. Although each publication is engaged in topics linked to the built environment, the required article formats, tone and writing styles differ greatly. The journal titles and publishers are as follows:

- *Design Issues / MIT Press*
- *Building Research & Information / Routledge*
- *Buildings / MDPI, Open Access*
- *Forward / AIA, American Institute of Architects*

As an article-based dissertation disseminated via rolling publication, the contents of this document were not generated in a sequential fashion, far from it in fact. Rather, they were produced in an iterative manner consistent with the submission and revision processes of peer reviewed journals. As a result, topics do overlap across articles, and certain themes are pursued in greater detail while receding in others. Also it is important to note that two sections as indicated below by asterisk (*) were jointly credited works. (See ‘Overview’ section at the beginning of the document for details.) However as a planned thesis, respective sections were structured with two goals in mind. First, each was written to foreground a unique focus: 1) Engaging complexity, 2) Energy and buildings research*, 3) Research and practice* and 4) Framing transitions. Envisioned as a complete volume, components were coordinated to underscore thematic links between neighboring works and Figure 2 graphically represents the thesis structure. Article 1 ‘Engaging complexity’ is a broad introductory discussion of a range of social science approaches relevant to understanding the design of the built environment. This is followed by Article 2, which more narrowly

Bharathi
focuses on Mode-2 knowledge production within STS and empirically explores its presence/absence in a survey of energy and building researchers. Next, drawing from insight developed during the survey work of Article 2, Article 3 presents a regionally focused discussion of sustainable construction implementation using qualitative interview data analyzed with additional conceptual tools from STS. Lastly, Article 4 synthesizes dimensions of the research project with a futures thinking outlook. As depicted in the graphic, strands of architecture and Science and Technology Studies (STS) were brought together in varying degrees throughout the course of the project. (Figure 2). Next, the remaining introductory sections outline: the overarching field perspectives, methodological strategies, the empirical data and the context of fieldwork that informed the investigation.

FRAMING PERSPECTIVES

The problems of architectural practice & site

Critically, architectural design inquiries are not only about “creating” plans but also very much about the “enactment” of them (Schön 1995, 31). Similarly, the focus of this research is to better understand aspects of the “enactment” of sustainable architecture, and in this thesis it was explored in primarily two interconnected dimensions: the problem of architectural practice and the problem of architectural site or boundaries, which was further articulated in smaller sub-units detailed in the following sections.

The profession and the discipline

As the most pragmatic of the arts, the profession of architecture encompasses different responsibilities than its disciplinary practice, which Anderson conceptualizes as two simple intersecting lines (Anderson 2001, 94). Grounded temporally in invention, historical precedent, complexity and localized uncertainty, the profession survives operationally in, for example, ongoing debates around modernism and postmodernism, whereas other aspects of the practice such as outdated modes of organization (e.g. guilds), and construction techniques not in use, survive in the discipline of architecture (Ibid.). Thus, the concerns of the discipline have described as consisting of:
...a collective body of knowledge that is unique to architecture and which, though it grows over time, is not delimited in time or space. Trabeated (post and beam) systems and wall and vault construction appeared early in the history of architecture and are still studied in purely technical terms; even when viewed purely technically, such systems are necessary to architecture. When, however, these systems are understood to create opportunities and constraints for the definitions of space, the control of circulation, and the play of light, these are issues of the discipline of architecture. (Ibid., 94)

This contrasts with what Schein outlines as the scope of professional knowledge that should hierarchically encompass: a disciplinary or basic science knowledge; followed by applied science knowledge to inform daily problem-solving; and lastly a management component that deals with service delivery, drawing from foundational basic and applied knowledge (1974, 43ff).

Thus comparatively, disciplinary concerns are shown to differ from those of professional practice that do not necessarily inform the stricter reading of Architecture, although professional practice does include strategically necessary knowledge (Anderson 2001). Additionally, the technical complexities involved in changing approaches to the design, planning and construction of more sustainable architectures has further muddied the proverbial waters of this professional/disciplinary relationship.

That is, the problem of identity in architectural practice has been significantly compounded with the expansion of groups included within the building design profession or what Bucciarelli calls the “design collective” which in the loosest sense has been expanded to include “any individual who has a legitimate say in the process, whose words, proposals, claims and supplications matter and contribute to the final form of the product” (2002, 218). Architectural historian and theorist Joseph Rykwert explains:

... it looks as if the business of architecture has been dissolving gradually in what is now called the “design profession” a profession which includes real-estate advisors, quantity surveyors, mechanical and service engineers, lawyers - of course - interior designers (who seem to follow a discipline in turn unrelated to architecture.), and even what are now called fine-art consultants, who provide corporate clients with a ready-made art-collection for their offices. (Rykwert 2001, 8)

The diverse mix of building science researchers can also be implicated in this group and according to Schön their working perspectives have been: 1) problematically fostered by the positivist epistemology embedded in the professionalized, modern research university and 2) poorly integrated into the concerns of architectural design. Together, these trends have been argued as creating the most pressing problems for the practice to date (Schön 1983; 1987; 1995; 1998; 2001). In short, Anderson’s simple diagram of intersection has gained significant complexity as it has ballooned to accommodate the expanding cast of professions involved in building design (Figure 3).

Architectural research

Disciplinary architectural theory has strongly focused on form-function relationships that Schumacher critiques as often being “mere descriptions of new forms and at best new languages rather than theories in the strong sense” (Schumacher 2001, 29). Alternatively, Rykwert observes:

It must seem to some of my colleagues, that research about architectural subjects is a little bit like research on phrenology, or demonology, or even alchemy - fascinating areas of knowledge no doubt, perhaps even sciences, but not related closely to any thriving current practice. (Rykwert 2001, 8)

Although both perspectives touch upon the working utility of architectural research practices, these positions are also particularly illuminating in their stark contrast to practices in architectural building science research that embrace what Schön coins the “technical rationality of professionalism,” while holding additional significance for what they do share. That is, they both lack explicit connections to working practices. Yet, a hierarchy between the viewpoints also exists as Schön observes:

In the epistemological pecking order, basic science is highest in methodological rigor and purity, its practitioners superior in status to those who practice applied science, problem-solving, or service delivery. (2001, 242)

Essentially, this view of technical rationality purports a characterization of architectural design that adjusts technical strategies “to ends that are clear, fixed, and internally consistent,” and suggests that instrumental practices only become professional ones when derived from “the science or systematic knowledge produced by the schools of higher learning” (Schön 1995, 29). This hierarchy in turn has reinforced “a radical separation” between
research and professional interests in the education of architects:

Research, of the kind that was viewed as proper to the “higher schools” - rigorously controlled experimentation, statistical analysis of observed correlations of variables, or disinterested theoretical speculation - finds little place to stand in the turbulent world of practice, which is notoriously uncontrolled, where problems are usually ill-formed, and where actors in the practice situation are undeniably “interested.” The consequence, stronger today than ever, was that the research produced by the “higher schools” seemed to have little to say that was of value to practitioners. (Ibid.)

This schism is hardly a new or an unfavorably perceived conception. For example Walter Gropius has been often linked to upholding the managerial ideal of the practitioner, whose core ability and vision is to coordinate the multiple issues that arise during the process of building - whether social, technical, economic or artistic (1939/1956, 50). Although when situated within its original text, Gropius’ also argues the importance of artistic creativity, three-dimensional imagination, and that New Architecture is akin to throwing open the windows of a room filled with stale air. Despite these qualifications, Rykwert assents that in Gropius’ teachings the main tool he intends to provide young architects is managerial in nature (2001, 10).

However, if the efforts of Gropius’ are considered within the context of his equally influential contemporaries: Le Corbusier (1928/2007; 1947/1964), Hannes Meyer (Schnaidt 1965) and Mies van der Rohe (Neumeyer 1991), it is much more difficult to dismiss the clear interest that all of these practitioners and educators had in the socio-technical, -cultural and -political concerns of their time that respectively culminated in the integration of the building sciences into the actual art of building.

Hence architectural modernism cannot solely be blamed for the current state of practice, nor can any subsequent movement per se. For example Rykwert coincidentally cites in the same text which critiques Gropius, the misappropriation of Venturi et al.’s post-modern thesis, which pitted symbolic ‘ducks’ versus ‘decorated sheds,’ and unintentionally engendered a boom in more economically optimized approaches to building development and land use (Venturi et al, 1972; Rykwert 2001, 11). Similarly relevant and along the same lines, Bucciarelli highlights that field external pressures such as
the changing organization of design practices are reshaping how practitioners conceive and perform design tasks.

Designing is not faithfully represented as simply the art of applied science pursued by an individual at a work station or drafting board. In most cases today, it is the business of groups of individuals who, if they are to be effective, must know how to discuss, deliberate and negotiate with others if their individual proposals and claims are to be taken into account and have meaning. (Bucciarelli 2002, 218)

This active tension between the necessarily limited scope of services involved in the execution of architectural aims and disciplinary conceptions of architectural research highlights key dimensions in the context of how building science integration issues are often approached. Centrally the problem that this section suggests is that trends toward hyper-professionalism or specialization in the building professions - both in working and research practices - reinforces a problematic hierarchical and divisive notion of technical rationality when in fact these relationships are much richer (Figure 4).

Knowledge integration

Comparable to many fields, in architecture the discussion of boundary work has typically focused on the struggle to integrate - working knowledge into theory - and alternatively, theories into working knowledge:

In various fields of research and professional work, not least in architecture, the necessity to incorporate random mutations into strategies of innovation has been asserted into practice and starts to be reflected in theory. The role of chance discoveries in the progress of science and technology is long since proverbial without systematic acknowledgement on the part of epistemology. (Schumacher 2001, 28)

The more we extend, the more we are also forced to trade off knowledge for data, exchanging theoretical concepts for ‘hard facts’. As a result, architects often end up appropriating the knowledge from other disciplines as an ever growing database of strategies from which they can pick something that seems appropriate to the task at hand. (Yeang 2004: viiif.)

Both quotations above acknowledge the complexity of socio-technical change. The first excerpt highlights epistemological challenges to accepting non-linear design processes, and the second describes the more specific problem of critically incorporating the knowledge of relevant fields. Architecture is a unique object-oriented endeavor that reflects the diverse social, technical and environmental concerns of the contexts in which it is produced, despite the documented mobility of design tropes (Guggenheim and Söderström 2009). Therefore, the problem of knowledge integration is not novel and is readily evident in the widespread and frequently asked query: “What is the fundamental knowledge that we architects possess?” (Yeang 2004, vii). Architect and theorist Patrik Schumacher responds that irrespective of the answers provided to this question from within the practice, external pressures under the guise of rationality permeate the justification for the majority of current innovation paradigms.

Groping experimentation, the incorporation of random play and a margin of indetermined, “uncontrolled” investment, are now seen to be necessary ingredients of any strategy aimed at innovation. “Uncontrolled” investment? Not quite. There is systematic randomization within definite brackets and constellations and with definite techniques. (Schumacher 2001, 28)

As a reply to the problem of knowledge integration, Schön and Frampton provide two differing positions that informed the shape of this research. Both relate to the site implicated in the creation of architecture, but the former stresses the practitioner, and the latter emphasizes socio-technical context. Centrally, Schön argues: “we should ask not only how practitioners can better apply the results of academic research, but what kinds of knowing are already embedded in competent practice” (1995, 29), which not only suggests that the practitioner should be the source of the investigation, but also its focus. He continues:

If we speak of a scholarship of integration - the synthesis of findings into larger, more comprehensive understandings - then we are inevitably concerned with designing. The scholarship of application means the generation of knowledge for, and from, action. (Ibid., 31)

Yet, Schön’s efforts do not systematically address how the larger sites of practice should be addressed, and it is within this specific context that Frampton’s work shows itself to be particularly useful.

Critical regionalism

Finally all creative action is determined by the fate of the landscape which for the man with roots there is peculiar and unique, his work personal and localized. If a floating population lacks these roots its work easily becomes stereotyped and standardized. (Meyer 1928/1965, 101)
Informed by the 1981 essay ‘The Grid and the Pathway’ by Alexander Tzonis and Liliane Lefaivre on the topographic/rational order dialectic in the approaches of Greek designers Dimitri Pikionis and Aris Konstantinidis, Frampton’s critique of scenographic trends in the design of the built environment identifies two interconnected sites of action (1983a; 1983b; 1994; 2002; 2012). Both involve the scale of the collective, where the first addresses the existing built environment and its potential permutations, and the second, the influence of changing institutions.

Thus the ‘site’ in the deepest meaning of the term needs to be recognized and defined at two different but necessarily interrelated levels; on the one hand, the topos or a transformed, transforming and transformable landscape/townscape and on the other the typos as the evolved, evolving and evolvable institution. (Frampton 1994, 195)

Recognizing that the “history of architecture over the past century and a half can be read as the history of its transformation under the impact of technology,” (Ibid., 190), Frampton's combined schema of topos, tectonic and type are proposed as a conceptual strategy “to reclaim the ‘ground’ within which architecture might be reconstructed as a critical and creative discipline” (Ibid., 195), Specifically each term references:

- Topos, the physical site
- Tectonic, architectural expression through materiality
- Type or Typos, the social context of development

He continues by drawing from Pugin’s mid-nineteenth century writings on the boundless horizon of technological permeation, and suggests architecture as the site where the conflict “between value-free process and the spirit will come to be fought” (Frampton 1994, 190).

…technology has penetrated deeply into the field of building production, not only in terms of the familiar innovations of reinforced concrete and steel frame construction but also in terms of mechanical services. Today some two thirds of the total budget of any large building is expended on mechanical and electrical provisions of one kind or another from air conditioning to piped information. Despite these inroads and the marked tendency to reduce architecture to nothing more than a fairly gratuitous aesthetic effect, that is to say a marketing veil or ‘decorated shed’ drawn over the substance of processes that are exclusively economic, building remains an activity that still resists full commodification by virtue of its ‘archaic’ character. (Ibid.)

Similar to Schumacher’s observations, the external pressures that Frampton presents as the mobilization of entire societies in “service of applied technique and commodification” are also observed to support a Benthamite vision of future society rather than a democratic one (Ibid.). Centrally, critical regionalism subverts universal scenographic tropes of modernism by prioritizing local values and images, while simultaneously and paradoxically, “adulterating” them through the introduction of “autochthonous elements with paradigms drawn from alien sources” (Frampton 1983a, 148ff.). Not intended as a reprisal of vernacular architectures that evolved out the narratives of sun, wind, light and tradition, but rather it calls for the identification of “those recent regional ‘schools’ whose aim has been to represent and serve, in a critical sense, the limited constituencies in which they are grounded” (Ibid.). Essentially, throughout his argument Frampton underscores the need to assess the built environment within its socio-cultural context and uses the comparison of the UK and Switzerland to illustrate.

This infrastructural interplay between technology and culture seems to have ramifications at a more immediate, experiential level as when we compare, say, the means of airport access obtaining today in London and Zurich. Not only has London been slower than Zurich to provide a direct rail link to the city center, but even now this link is inadequately coordinated with the main line and intricacy systems. Zurich, on the other hand, has a rail link that is fully integrated with the federal rail system. One may further note that the Swiss authorities developed an ingenious luggage cart for use on escalators and travelators with absolute safety throughout the terminal and its corresponding rail connections. May we conclude with absolute safety throughout the terminal and its corresponding rail connections. May we conclude that such an innovation and investment depend upon “cantonal” culture, since clearly it is addressed to the convenience and comfort of the ordinary citizen? (Frampton 2001, 125)

As highlighted in the example above, the Swiss approach to development reflects the dimensions of topos, tectonic, and type or typos in its current building production.

Such a regionalism depends, by definition, on a connection between the political consciousness of a society and the profession. Among the pre-conditions for the emergence of critical regional expression is not only sufficient prosperity but also a strong desire for realizing an identity. One of the main springs of regionalist culture is an anti-centrist sentiment - an aspiration for some kind of cultural, economic and political independence. (1983a, 148f)

Yet as Moore carefully observes, critical regionalism uses specific means to frame the tensions born
out of the relationship between technology, place and modernity and as an analytical approach exists within a much broader landscape of architectural theory (2001, 136). In other words, Frampton’s work is only one of many points of access into these issues (Figure 4).

Conclusion

A serious problem for the pioneers in this field is the complexity both of climate change and of the built environment with its diversity of stakeholders including academic and professional disciplines, businesses, government departments and building users. This makes it difficult to comprehend the whole of the problem or to take effective ownership of it. (Lowe 2003, 195)

Although often heavily skewed toward technological solutions, the challenges of sustainable development and retrofit for the architect are expansive in scale and involve topics ranging from the innovation of green products and systems to the broader concerns of social, political, economic and environmental justice. As suggested in the quotation above, it is exactly this dynamically fragmented understanding of linked problems that all industry actors struggle to address in a strategically integrative fashion. Specifically, within academia much of the focus on sustainable endeavors in modern research efforts has been critiqued as being too technologically narrow, avoiding the real complexity of the problems faced (Moffat and Kohler 2008). And alternatively, within the construction oriented industries, criticism has focused on how green agendas have translated primarily into the development of “buildings and systems that pollute, contaminate, and deplete less than their predecessors,” and that are simply becoming “more efficient at the wrong thing,” which is inherently more dangerous, since it erroneously suggests “environmental progress” (McDonough and Braungart 2005, 1f).

This section has mapped out specific problem areas and potential avenues of resolution that informed this doctoral project. First the growing separation between disciplinary and professional concerns of architecture was identified, evidenced in the trend to include an ever-widening pool of expertise that classical formations of architectural theory are ill equipped to address. This was followed by the identification of relevant areas of study in the complementary notions of the architectural site - the practitioner as both the origin and focus of study, and the critical regionalist approach that underscores the importance of locating technical concerns within social context. Thus, to investigate the knowledge of the conditions under which sustainable development efforts come about, the inclusion of additional tools beyond the traditional scope of architectural research was deemed necessary.

Science & Technology Studies (STS) conceptions of knowledge production, expertise, practice & boundary work

Science and Technology Studies (STS) perspectives are widely characterized as providing opportunities to recast the study of the built environment from a study of artifacts to the study of socio-technical networks, where knowledge practices are deconstructed by multiplying the actors. Inclusive of a spectrum of approaches which argue that objects can function as key actors, the theories recognize that a diverse set of drivers both human and nonhuman come together to shape knowledge practices. In particular, the theoretical framework has produced varied strategies for investigating technical expertise in the tracking of disciplinary history, how knowledge practices function as social institutions, and the underpinnings of philosophical knowledge through close observation of actual practice in detailed case studies (Latour 1987; 2005; Knorr Cetina 1999; Bijker 1987; Jasanoff 1987).

Not without critique, both externally and internally, a key element of STS social sciences approaches has been the healthy tendency to query both its conceptual modes of thinking, as well as its methods.

We focus on public controversies that are intractable in the sense that social science is not only able to resolve the dispute but tends to exacerbate it by providing information that can be used in opposing ways by the sponsors of competing frames. (Rein and Schön 1996, 85)

What if explanations resorting automatically to power, society, discourse had outlived their usefulness and deteriorated to the point of now feeding the most gullible sort of critique? (Latour 2004, 229ff)

The outcome of this persistent questioning has led to what Latour describes as a necessary shift from ‘matters of fact’ to ‘matters of concern,’ (2004, 232). Within the context of this research this meant a moving from the studying architecture as a topographical object to a topological one.

Bharathi
That is, not to conceive architecture or sustainable construction as discrete artifacts, but to understand it as an assemblage of relationships with the potential to be mapped (Corner 1999).

Essentially, constructivist approaches aim: 1) to delineate the social affiliations that support technical choices and assert that technology and society are not distinct realms, but in fact develop in tandem; and 2) to underscore that technological entities always bear the influence of social and technical processes (Bijker and Law 1992). In another relevant strand of STS, the Social Shaping of Technology (SST), key efforts have been primarily grounded in cases studies of individual artifacts and systems where social processes have been shown not only direct the development of particular technologies, but also influence broader patterns of development (Sørensen and Williams 2002). And critically, SST analyses explicitly implicate “the uses of technology,” instead of remaining singularly focused on innovation, and therefore according to Sørenson, are unequivocally linked to the concerns of regulation and infrastructure (2002, 20).

Generally however, this area of scholarship has focused on the evolution of technology and its uses by studying political and social actors involved in its developmental processes (Jasanoff 1990; 1987; Wynne 2003; Evans and Collins 2002; 2007; 2008). Similarly, another strand of STS, the Social Construction Of Technology (SCOT) engages notions of how technological developments link to their broader socio-cultural and socio-political environs (Pinch 1986; Pinch and Bijker 2012; Bijker 1995). In short, both approaches are recognized as facilitators of descriptive social actor analyses that emphasize an awareness of disconnects and synergies in knowledge practices (Hess 1997; Law 2004).

Yet, Moore and Karvonen also observe that STS has had limited things to say about design and the built environment despite representing “a messy, active form of socio-technical production with experts being influenced by a variety of technical and non-technical constraints” (2008, 28):

Argued as being capable of offering “the design disciplines a way of thinking critically and analytically about the consequences of design choices,” the authors underscore the potential contribution and relevance of incorporating the perspective into the design practices (Ibid., 31).

This quotation underscores possible approaches STS thinking might contribute to the problem areas outlined in previous sections regarding practice and the extent of the architectural site. Additionally, this connection highlights the relevance of STS understandings of boundary work that have the potential to further integrate aspects architectural thinking.

Stemming from Gieryn’s initial ideas of developing boundaries to establish and maintain scientific legitimacy (1983; 1999), other variations of the concept re-imagine boundary work as a connective practice and have been drawn from the ideas of theorists who assert that a social world is a unit of discourse not bounded by geography, but rather the effective limits of communication (Clarke 1991; Star 1991; Star and Griesemer 1989). In this iteration of STS, the mutual shaping of social and technical order takes precedence. A key example of this thinking is embodied in Fujimura’s understanding of ‘standardized packages’ or ‘bundles of boundary objects’ that create less a less ambiguous workspace and will be discussed in greater detail later in this section (1986; 1988; 1992). Specifically within the study of boundary organizations linked to environmental concerns, Guston recognizes that the concept of ‘standardized packages’ as more “robust” and having the capability to modify “practices on both sides of the boundary” (2001, 400).

Several strands within the larger framework of Science and Technology Studies (STS) were used as a means to study problems areas rooted in architectural practice. And subsequently, in the process of adapting core STS perspectives such
as “the heterogeneous and hybrid socio-technical character of technology and knowledge production; the mutual shaping of social and technology order,” and “the actor-oriented approach combined with critical constructivist perspectives,” (Borup et al. 2006, 287) additional questions and topics of interest developed, which at times complemented the main research area and at others seemed quite antithetical to the immediate temporal constraints of the research schedule.

Inquiry begins with situations that are problematic - that are confusing, uncertain, or conflicted, and block the free flow of action. The inquirer is in, and in transaction with, the problematic situation. He or she must construct the meaning and frame the problem of the situation, thereby setting the stage for problem-solving, which, in combination with changes in the external context, brings a new problematic situation into being. Hence the proper test of a round of inquiry is not only “Have I solved this problem?” but “Do I like the new problems I’ve created?” (Schön 1995, 31)

In the context of this doctoral work the ambition to unearth empirically grounded accounts of the varied and “continuous process of learning and adaptation” (Wahl and Baxter 2008, 72), meant that in studying a social network of actors working at the boundaries of design/research practices but still implicated in sustainable development, current theoretical discussions of knowledge production, practice and expertise also became relevant. Thus, using the linked lenses of architecture and STS, the wider view of social science approaches to development presented in Article 1 narrowed in scope in Article 2 to the knowledge practices of experts involved primarily in research. Subsequently, Article 3 further focused on the perceptions of experts involved in active practice and the structure of regional implementation of sustainable solutions within Switzerland. Lastly, Article 4 outlines key areas for future action. Next, the following sections, provide greater detail of the STS perspectives which underpin the thesis.

The new production of knowledge

The focus of the first chronologically published article of the research project, ‘Mode-2 knowledge production’ a concept originally introduced in The New Production of Knowledge (NPK) (Gibbons et al., 1994) was the driver of the survey conducted in Article 2, and its key characteristics are briefly outlined. Characterized as highly dynamic, the NPK suggests that knowledge production once primarily situated in scientific intuitions and structured by disciplines has become: 1) much more heterogeneous; 2) tied more closely to the context of application; 3) more socially accountable and reflexive; 4) transdisciplinary; and 5) inclusive of more novel quality control. In contrast, Mode 1 knowledge production is described as: 1) relatively homogenous; 2) primarily situated within an academic context; 3) relatively autonomous; 4) disciplinary; and 5) strict in traditional methods of quality control such as peer review.

Not without controversy Nowotny et al. published a follow up book in 2001 titled Re-thinking Science: Knowledge and the Public in an Age of Uncertainty to address some of the main critiques of the approach. Namely, their rebuttals consist of the views that NPK is 1) grounded in sociological literature; 2) located against a post-modern backdrop of dynamically decentered, blurred institutional and public spheres; and lastly 3) functions within a spectrum of contextualized institutions and epistemologies. Centrally, NPK developed out of the assertion that science systems are in flux and moving increasingly toward the incorporation of strategic goals. Similarly, a number of other relevant concepts have emerged along with ‘Mode 2’ knowledge production with differing foci and include, but are not limited to:

- Post-normal science: Focuses on policy relevant science fields and asserts that the limits of rationality in decision-making that enable the acknowledgement of uncertainty, risk and the necessity of value consensus in these processes. Essentially the ability to cope with these conditions shapes post-normal science. Does not address university-industry interaction, product or process innovation. Considered more programmatic, rather than descriptive. (Funtowicz and Ravetz 1993),
- Strategic research/science: Primarily descriptive, but typically used to inform policy goals prescriptively. Emphasizes basic research, gaps between research and uptake; and indicates the emergence of potential regimes (Irvine and Martin 1984; Rip 2002a; 2002b; 2004).
- Innovation systems: Focuses on interactions and iterative processes between all actors implicated in innovation. Primarily heuristic to clarify systems; lacks any descriptive claims. (Edquist 1997; Cooke et al. 1997; Carlsson and Stankiewicz 1991).

According to Hessels and van Lente, Mode-2 thinking is positively considered to be a “dialogic process” and to have “the capacity to incorporate multiple views” in relation to “researchers becoming
more aware of the societal consequences of their work” (2008, 742). Less positive are critics who argue against NPK’s: 1) generality which reports a widely accepted view that the humanities and the social sciences are more reflexive (Mode-2) in thinking than the natural sciences (Godin 1998); 2) presentation of false claims of universality (Shinn 2002); 3) lack of conceptual coherence which does not accommodate diversity well (i.e. organizational, methods of novel quality control) (Rip 2002b); 4) lack of empirical evidence, 5) implicit support for current trends without an adequate future outlook (Weingart 1997); and 6) falsely linear conception of the evolution from Mode-1 to Mode-2 thinking (Etzkowitz and Leydesdorff 1998; 2000).

Although considered successful as a “manifesto,” NPK problematically grapples with unsubstantiated claims of the increasing prominence of transdisciplinarity, reflexivity and novel modes of quality control (Hessels and van Lente 2008, 758). Despite these concerns, the perspective was considered useful in shaping the exploratory survey that was written up in Article 2. The findings from that survey were consistent with this critique and facilitated insight: 1) into which characteristics of knowledge production implicated in green building were of most interest to the primary investigator of this doctoral work; and 2) in designing methods to engage them. Thus subsequently, following Hessels and van Lente who conclude: “the viability of an aggregate Mode-2 claim that is constituted by five attributes is limited,” a narrower focus on the study of the heterogeneous expertise linked to sustainable development within a national context was conducted (Article 3).

Expertise

According to Collins and Evans, the difference in their approach to expertise from “debates about the grounds of knowledge that took place before the ‘sociological turn’ in science studies” is that the authors attempt to shift discussions from those of “truth” to “expertise and experience” (2002, 236). They assert that the Studies of Expertise and Experience (SEE) is a response to the ‘problem of extension’ within political decision-making that has eradicated the boundary between experts and the public (Evans and Collins 2008; Collins 1985; Collins and Evans 2002; 2007). In order to achieve the aims of SEE, a normative theory of expertise is offered to “disentangle expertise from political rights in technical decision-making” by building “categories of expertise, starting with the key distinction between interactive expertise and contributory expertise” (Ibid., 235).

In their normative schema, specialist ‘expertises’ range from individuals who have superficial knowledge of incidental facts to interactional expertise and contributory expertise. Interactional expertise involves specialist tacit knowledge of a subject beyond primary or book knowledge. Although those with interactional expertise would be considered ‘fluent’ in a field, they would not qualify as having contributory expertise, which in this study meant being capable of actually performing design or research work. This notion is supplemented by meta-criteria of external and internal expertise. That is for example, external verification in the form of a professional degree, qualifications or publications and internal criteria such as standing within a professional community. In the study documented in Article 3 Collins and Evans’ criteria was used to confirm the expertise of those chosen for interview after recognizing that further triangulation and justification of the kinds of experts sought out was needed. This was concluded specifically after the survey work presented in Article 2 was conducted. Although the capacity in which it is used in this study is considered justifiable, it is acknowledged that in the context of broader “situated” use (Haraway 1991), the notion is considered problematic by multiple STS scholars. These positions are briefly outlined here to highlight how this dissertation research relates to these relevant criticisms.

Brian Wynne posits that Collins and Evans’ “form of realism seems to demand unconditional surrender to dominant, often scientistic, frames of public meaning” (2003, 413). Wynne suggests that in their work, “public meanings (and identities) are not problematized, but presumed and imposed” (Ibid., 404). In his critique “Seasick on the Third Wave? Subverting the Hegemony of Propositionalism: Response to Collins and Evans,” Wynne centrally questions the assumptive focus of SEE on: 1) “propositional questions” such as risks, rather than public meanings; 2) the Sociology of Scientific Knowledge (SSK) as the “correct entry-point” for differentiating qualities of knowledge; 3) the authors’ selectively historical account of science studies research “which exclusively centers on internalist
sociology of...esoteric sciences;” and 4) a noticeable lack of engagement with contextual decision-making.

According to Wynne, these points collectively highlight “the risk entailed by their analytical as well as normative commitments, of reinforcing an illiberal cultural imagination based on uncritical acceptance of western scientism” (Ibid., 402). Due to this reductively selective perspective Wynne asserts that Collins and Evans have lost sight of “the wider issues of salience and meaning” (Ibid., 404). Though recognizing the seminal efforts of scholars such as Latour (1983; 1987) that spawned the 1980s mainstream of SSK work that includes: Latour and Woolgar (1979; 1986), Collins (1985), Knorr-Cetina (1982), Lynch (1985), Traweek (1988), Pickering (1984) and Pinch (1986), Wynne distinguishes these efforts as explicitly unconcerned “with such externalist questions” (Wynne 2003, 403).

There is a significant general difference between the kinds of process in which scientific laboratories make their interventions in the world outside through technological artefacts and their associated disciplines and consequences, and those in which the wider interventions occur and recur through discursive networks and narratives of scientific knowledge for policy, such as in ‘risk management’ public policy issues and decisions. (Ibid., 404)

Along similar lines Sheila Jasanoff also objects to “the reductionist quality to their analysis that sits uneasily with the complex dynamics of expertise in modern societies, and the richness of writing about it” (2003b, 391). Hardly neutral, she states that the conception of ‘expertise’ has been shown to be context dependent knowledge that is “acquired, and deployed, within particular historical, political, and cultural contexts” which “responds to specific institutional imperatives that vary within and between nation states” (Ibid., 393). Critically, it is her observations regarding national context that was most informative in the design of this research.

Accordingly, who counts as an expert (and what counts as expertise) in UK environmental or public health controversies may not necessarily be who (or what) would count for the same purpose in Germany or India or the USA. Different bodies of expert knowledge come into being, with their associated markers of excellence and credibility, through disparate contingencies of politics and knowledge production in national decision-making settings. (Ibid.)

Centrally both Wynne and Jasanoff agree that ‘realism’ or externally verifiable qualification is an unavoidable reality. However, both underscore that essentialism which neglects context is a significant flaw. Jasanoff illustrates this point succinctly in the following example:

In a litigious society such as that in the USA, expectations of openness, transparency, and the right to look behind formal claims are deeply ingrained in the multiplicity of institutional practices. These grounded expectations influence not only the processes by which the public relates to experts, but also the content and discourses of expertise. Another society, with different traditions for producing and testing public knowledge, might dress up its expertise in other guises. (Ibid., 394)

John Law takes another slightly different route in his critique of normative trends of expertise in STS scholarship, as well as giving limited, qualified support. In his text, “The Greer-Bush Test: On Politics in STS,” he asserts that the STS framework was organized around the “prescription to be non-prescriptive” (2009, 6). He argues that: 1) by outmoding location, specificity and contingency; 2) by assuming both legalist and common world perspectives; 3) and lastly “forgetting that rules and procedures do not actually rule” in messy practice, many of the basic lessons of STS are forgotten.

Using the heuristics of constitution, descriptive prescription and interference, Law highlights the main problem of a relational ontology is that it encourages STS to “abandon” its greatest strength which is “its commitment to description and (this is the crucial point) its concomitant willingness to attend both empirically and politically to the disorderly specificities of the world” (Ibid., 10). He also asserts that like other theoretic methods, STS approaches cannot predict the quality of the information that will be found.

In STS, to describe is to attend to local and...unruly specificities. If we describe well, we can never be quite sure what we will find, what will turn out to be good knowledge, and what will not. (Ibid., 8)

Yet, he does lends his qualified support by suggesting that these methods can:

...be complicated in practice, but in principle STS can help to sort out which community or set or experts can and should speak about what, and how. It’s not that non-creditedialled groups have nothing to say. On the contrary, many have particular forms of expertise. But there are arenas in which the views of (say) publics or politicians cannot properly displace expert technical competence and judgment. (Ibid., 4)

Law constructively suggests that insofar that Collins and Evans’ systematic procedure is used as a tool
to aid in “determining who has the rights to speak about what and how,” it can be of help in separating “expertise from power or blind prejudice, and it is STS’s duty to help in this vital task” (Ibid., 9).

These are all relevant points, which were acknowledged in the research design presented here. Namely that Collins and Evans’ notion of ‘expertise’ was positioned as a supplementary mapping tool of those interviewed and was not used to exclude individuals whose experiences were considered relevant because of the lack of disciplinary qualifications. As Corner observes:

Mapping is a fantastic cultural project, creating and building the world as much as measuring and describing it. (1999, 213)

Finally, the responses to Collins and Evans’ work supported the design decision to evaluate fieldwork sites per their national contexts in relation to factors such as democratic process, resource protection, and regard for construction, design and research sectors linked to sustainable development.

Practice

Earlier theories of practice originated from sociological arguments that attempted to usurp unproductive structure-agency dialectics, which often colluded macro and micro approaches (Bourdieu 1977; 1979; Giddens 1984; Knorr-Cetina and Cicourel 1981; Callon and Latour 1981). Essentially an effort to ameliorate structural and interpretive strands of social science thinking, it has been suggested that these efforts contributed to:

…the understanding of social life as a series of recursive practices reproduced by knowledgeable and capable agents who are drawing upon sets of virtual rules and resources which are connected to situated social practices. (Spaargaren 2011, 815)

Critically, by foregrounding actions rather than individuals, practices are conceived as forming the basis of collective “values, knowledge and capabilities, and not the other way around” (Ibid.). That is, practices stemming from shared social norms are understood to influence how institutions of decision-making are structured.

Centrally, theories of practice recast the analysis of sustainable consumption relationships along the lines of social agency to structure, technology and culture respectively (Ibid.). Although reflecting elements of all three strands, the focus of this research falls primarily within the social agency-technology nexus that acknowledges the mutual roles of objects, technologies and infrastructures in the reproduction of social practices. In other words although social behavior is often directed by existing infrastructure - physical, cultural and political – it can also act as an agenda setter by opposing the very same infrastructure (Shove 2003; 2006; Southerton et al., 2004; Van Vliet et al., 2005).

Subsequent practice theories addressing technology transfer and issues of energy in the built environment have been primarily derived from techno-economic models that assume free agency and have subsequently “marginalized other more structural explanations of innovation and change” (Guy and Shove 2000, 62). However more relevant to design, construction of choice theories do also exist (Cowan 1987) and have been represented in studies conducted on the diffusion of florescent lighting (Bijker 1992) and HVAC systems (Cooper 1988, Wilhite et al. 1996). Each study highlights that linear models of technical change are hardly realistic in their conceptualizations of how research is disseminated into practice, and in contrast involve high degrees of compromise and negotiation that reflect very local institutional conditions.

Of particular use in the formulation of this study was the thinking of Guy and Shove (2000; Shove 2003; Shove 2006) who broaden their scope to look beyond singular technologies. Their work highlights the interaction of communities of practice involved in the production and application of building science by focusing on site specific contextual aspects of energy practices, where the practicalities of construction and development take place. Specifically, they address: 1) the introduction of a building technology and the role building industries play in encouraging demand; 2) how organizational contexts support energy efficient practices; and lastly 3) how the changes in the structure of the real estate sectors impacts the agency of the actors involved. Additionally, they outline four types of research communities that include: Close communities (CC); Co-ordinated Contractors (Co-C): Contracting Knowledge systems (CK) and Networks of Expertise (NE). (Table 1)

Switzerland, which was the empirical focus of Article 3 most closely resembled the characteristics of a close community (Bharathi and Nicol 2013, 755). However, as also observed by Guy and Shove (2000) these categories are not fixed, and
characteristics of a network of expertise (NW) were also present specifically in hybrid forms of agenda setting, (Table 1)

These groupings do not exist in isolation, and were formulated “to explore the implications of each type for the definition, production and promotion of energy-related building research” and impact the “forming and framing of technical research but do not determine the detailed substance of energy conservation” (Guy and Shove 2000, 21; 19). Summarily their findings underscore: 1) the frictions between the site-specific nature of construction and the assumed transferability of building science; and 2) that despite the reality that energy linked recommendations are strongly embedded in technical framings, which are “expected to be relevant and applicable across a wide range of social contexts,” there is a social specificity of practices that are temporally and geographically sited (Ibid., 10ff). Additionally following Callon (1987) who asserts technical change is shaped by the interactions of key figures involved, they argue that the micro-politics of knowledge production strongly influence the understanding of energy efficiency, and therefore:

…it is extremely important to note that the links between research and practice, and hence strategies and ideas about how to cross the divide between them, are configured differently in each environment. (Guy and Shove 2000, 31)

Also of relevance, Guy and Shove report that they too did not find markers of Mode-2 knowledge production such as interdisciplinarity or any radical shift in the reframing of the traditional knowledge production institutions (Ibid., 32).

The study of boundary work

Boundary work has been argued as being important in identifying the edges of differing nodes of knowledge particularly in policy relevant applications (Fox 2011; Guston 2001; Jasanoff 1990), but developed from initial efforts to identify science from non-science and assert intellectual control (Gieryn 1983; 1999). STS variations have developed from the work of social world theorists who assert that a social world functions as a unit of discourse not bounded by geography, but instead by the effective limits of communication. Critically, actors are characterized as operating in differing social spheres or communities of practice

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>Close Community (CC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Influence of government, research &amp; industry</td>
<td>• Informally negotiated agendas. All three groups are implicated.</td>
</tr>
<tr>
<td>Relationship between building science &amp; practice</td>
<td>• Interactive</td>
</tr>
<tr>
<td>Positioning the energy problem</td>
<td>• Disciplinary boundaries are relatively flexible. Technical readings are imbued with social understanding</td>
</tr>
<tr>
<td>Additional Details</td>
<td>• Characteristic of countries with small populations&lt;br&gt;• Occupational divisions are not as rigid (i.e. people switched between industry, government and academia as their careers developed)&lt;br&gt;• Similar educational and professional experiences.</td>
</tr>
<tr>
<td>DESCRIPTION</td>
<td>Co-ordinated contractors (Co-C)</td>
</tr>
<tr>
<td>-------------</td>
<td>---------------------------------</td>
</tr>
</tbody>
</table>
| Influence of government, research & industry | • Research community responds to policy but has the potential to agenda set.  
• Industry not directly involved | • Commissioned research by governmental project officers.  
• Industry not directly involved | • Formal agenda setting by government project officers, but in collaboration with industry and the research community. |
| Relationship between building science & practice | • Building science is remote from industry. | • Building science is remote from industry.  
• Under increasing pressure to be useful. | • Formal cooperation and informal networking generates collaborative interactivity. |
| Positioning the energy problem | • The priorities are largely technical research community dominates. | • Priorities of a largely technical population of governmental project officers dominate. | • Extensive networking of interests fosters socio-technical understandings of issues. |
| Additional Detail | • Distinctly formal relationships between a central agency which agenda sets and researchers who execute  
• Decisions about research priorities depend on aggregative data and statistical analysis. | • Distinctly formal relationships between those who agenda set and researchers who execute | • Disciplinary boundaries and sectoral divisions are correspondingly complex |
| | • Funding sources interact with sizable research groups  
• Limited numbers of experienced research groups compete for projects commissioned by a central core of government officers | • Both research and project management are fragmented  
• Projects are typically shorter than Co-C and more specific.  
• List of potential contractors is generally longer. | • Funding sources create alliances between research providers and users. |
| | • Depends upon a clear distinction between knowledge producers (i.e. the technical experts) and consumers (i.e. users and practitioners).  
• Classic model of research, development and dissemination. | • Depends upon a clear distinction between knowledge producers  
• Difficult to cultivate specialty knowledge, retain research roles & diminishes interdisciplinarity. | • The structural network of communication relationships between diverse regional and national agencies, universities, utilities, industry and private research centers impact how specific problems are defined, addressed and conceptualized as socio-technical change. |
| | • Interests of practitioners and users are not directly represented  
• Little interest in the routine practices of the building industry, i.e. habits of designers and users, commercial concerns of companies involved in producing and selling building materials, etc. | • Interests of practitioners and users are not directly represented | • Involvement of industry requires more technologically oriented communities of researchers to broaden interpretations of relevant research |
| | • Linear language of research, development & dissemination guides programs of technology transfer which aim to overcome market barriers believed to impede the otherwise inevitable uptake of proven energy-efficient technologies. | • Linear language of research, development & dissemination guides programs of technology transfer which aim to overcome market barriers believed to impede the otherwise inevitable uptake of proven energy-efficient technologies. | • Encourages a blurring of boundaries, sometimes to the point at which the production of new knowledge is explicitly seen as a process of co-production. |
and capable of relating to respective, normative material practices (Clarke 1991, Star 1991; Star and Griesemer 1989).

Boundary work is situated within “the material/organizational structure of different types of boundary objects” or “the structure of informatic and work process needs and arrangements” (Star 2010, 601ff.). In the study of sustainable development implementation, governance arrangements have been suggested to function as the infrastructure of boundary work (Clark et al 2010). Unlike top-down or command-and-control governmental approaches, governance espouses a flexible process both vertically and laterally, where the public and private sectors, in addition to government institutions, play roles in the design, implementation and assessment of policies. Thus, by highlighting how organizations work together to formalize change, a map of governance arrangements can support the investigation of “the transformation of complex social production systems rather than changes solely within a particular organization” (Moore and Hartley 2008, 4). However findings also indicate that flexible governance arrangements present challenges in assigning responsibility (Walti et al. 2004) and effectively identifying lines of communication between organizational cultures (Blewitt 2008).

More broadly understood, this material/organizational structure or infrastructure might simply refer to cultural contexts, working languages and social standards. In this study it was explicitly interpreted to include the governance network of institutions and policies - local, regional, national, supranational and global - linked to regulatory processes and strategies for resource use, that create common framing conditions. Another way to conceptualize the context of boundary work is as a structural system in which boundary objects of varying scales and assemblies are implicated. These conditions can for example, shape the direction of which building solutions are locally deemed more or less sustainable within a particular assembly or context.

Functioning as the interface between groups with different perspectives of what qualifies as needed or reliably valid knowledge, boundary work involves diverse “boundary objects” that support the connection of knowledge practices with action (Star and Griesemer 1989; Clark et al. 2010; Hoppe 2010). As Guston observes:

The potential for stabilization (or destabilization) resides in the notion of the boundary object. It is something that develops over time from reliable cooperation between multiple communities of practice and effectively serves to span their operational discourses by facilitating discussions surrounding shared concern. As a link between multiple social worlds that fosters knowledge sharing in the form of both material practices and concepts, key ideas implicated in the discussion of boundary objects that informed this research were specifically: translation, object worlds and standardized packages (Star 1988; 1989; 1996; 2010; Star and Griesemer 1989; Fujimura 1986; 1992; Bucciarelli 2002; Latour 1986; Bijker 1995). The following sections outline salient supportive concepts in the literature that were of relevance.

Translation

Resting between differing social worlds such research and professional practice, science and non-science, boundary objects can be differently purposed by groups on either side of the boundary without losing their respective identities (Star and Griesemer 1989). Capable of many forms that can encourage the “adoption of an innovative idea, product or technique” (Fox 2011, 72), they achieve this through the standardization of meaning. The interpretive flexibility of boundary objects is considered to be the most extensively explored aspect of the model of boundary work (Bijker 1995; Star 2010), since the spatiality of boundary objects provides a site of ambiguity where the act of translation can occur. That is, objects can inhabit multiple communities of practice and are capable of having their informational parameters re-contextualized for respective groups. According to Bowker and Star (1999), boundary objects facilitate the action of translation, are malleable and capable of accommodating the uses of multiple groups of actors, but are simultaneously stable enough to retain common, identifiable attributes. Context is also critical to these processes. For example, building research, science and professional practices produce conclusions based on differently structured
boundaries but:

More than that, the processes of translation and interpretation required to produce more energy-efficient buildings are themselves socially situated (Guy and Shove 2000, 10)

Within the design, construction and planning sectors, translation of meaning regularly occurs through the use of texts, such as technical and programmatic specifications, but additionally through drawings, demonstration projects, public presentations, and the processes involved in competitions. Star is clear that excessive focus on the interpretive flexibility of boundary objects, has frequently been erroneously colluded “with the process of tacking back-and-forth between the ill-structured and well-structured aspects of the arrangements” (2010, 601), rather than engaging in discussions of how boundary objects can shape the translation of knowledge across them.

Star continues, highlighting that standardization often occurs to “make equivalent the ill-structured and well-structured aspects of the particular boundary object” and uses the illustrative example of geographical information systems (GIS), which flatten the content of “older cartographic and qualitative representations” when entered into larger, normative mapping systems (Ibid., 613). In other words a detailed local map, a boundary object in itself, is more strongly structured in its “individual-site use,” in comparison to the role it plays in a standardized database of coordinates, where it functions less strongly when “structured in common use” (Bowker and Star 1999, 297).

Specifically, “when the movement between the two forms either scales up or becomes standardized, then boundary objects begin to move and change into infrastructure, into standards… and into things and….other processes” that have not yet been fully identified and explicated to date (Star 2010, 605). This observation underscores that the frictions created in the translation of knowledge across boundary objects are critical dimensions of the process of boundary work, and that boundary objects and by extension their translation are moving targets. In terms of the urban landscape, the mobility of meaning present in boundary artifacts implicated in sustainable development creates opportunities to examine the heterogeneous arrangements involved in its implementation.

Object worlds

Bucciarelli’s notion of ‘object worlds’ denotes places “where specific scientific/instrumental paradigms fix meaning” and was developed specifically in the context of the engineering professions where respective object worlds reflect unique modes of representation, as well as specialized instruments (2002, 220). He elaborates:

In a previous work I used the phrase ‘object worlds’ to refer to the worlds of individual effort where an engineer, working for the most part alone, applies his or her expertise to particular tasks appropriate to his or her discipline. I claimed that different participants, with different competencies, skills, responsibilities and interests, inhabit different worlds. As such, while admittedly working on the same object of design, they see the object differently. (Ibid.)

Using the notion of ‘language’ Bucciarelli differentiates between the “languages of design” that include more “vulgar” languages of “negotiation and deliberation” and are not considered part of the “languages of object worlds” (Ibid.). The main characteristic of an object world language is that it is “proper.” That is, it is uniquely specialized and varying from other languages (Ibid., 223). These linguistic elements include boundary object artifacts that are not limited to: sketches, models, mock-ups, schedules, reference texts, prototypical hardware, tools, suppliers’ catalogues, codes and unwritten rules (Ibid.). Critically, if experts singularly relied on their proper languages “without bringing these artifacts into play, exchange would bog down and dry up in analytical exactness” (Ibid., 231). In particular he underscores the use of sketches, mock-ups and schedules to negotiate the terms between actors with “different responsibilities and technical interests” (Ibid., 230ff.) that in some regards materially capture the often intuitive, contradictory and sometimes fact-lacking nature of design (Hilpinen 1993).

It is recommended practice in the organization of any design effort, of any complexity whatsoever, to first sit down and try to break up the task into a set of subtasks which might be independently pursued. Usually this will be done in terms of the different operations the object of design must perform. (Bucciarelli 2002, 225)

Continuing, he illustrates the unique working challenges faced by the design professions, that contrast actual design practice in the following simplified vignette:
A bicycle, for example, must include apparatus that will transmit the force one exerts on the pedals back to drive the rear wheel (or should we consider a front wheel drive?); a structure must support the weight of the rider; some components must permit braking of the vehicle; and perhaps an electrical system for powering lights and a head lamp ought to be made an integral part of the design. Once these subsystems, these subtasks, have been defined and lines are drawn around them, certain ‘interface requirements’ must be constructed and adhered to by individuals working in any two different domains. If such independently pursued tasks can be established, then participants would hardly have occasion to meet together save at some final step at which point the design would be assembled. (Ibid.)

Arguing that this separation of tasks is not possible, since it requires an a priori knowledge where boundaries should be drawn, Bucciarelli suggests that if the “more significant feature of designing” is actually present, “uncertainty will be rampant” since:

One cannot foresee all of the interactions that will be required among participants working within different worlds, now organized around subtasks. As a result, interface requirements are themselves subject to redesign and negotiation as design proceeds. Of course for some design tasks the intensity of interaction might be minimal, e.g., for a product which is a redesign of last year's model, last year's organization will serve and object world language differences may matter little. But for the truly innovative projects, e.g., the first editions of a start-up, uncertainties abound and the unknown, as well as the probable but not-so sure, restrict the ability to break the task into independent subtasks, which would remain so throughout the design process. (Ibid.)

Within design object words, boundary objects provide opportunities for inquiry “of the whole and its interfaces within, as well serving to illustrate hard technical features or function when deployed by participants from different object worlds” (Bucciarelli 2002, 231). Therefore within the design context Bucciarelli explains that unplanned artifact making is an important part of the fluid design process and that the formality of proper language does not allow space for needed experimental thinking. However, it is in his concluding statements that he adds a particularly crucial additional point:

That is, as he implicates the boundary objects or the artifacts of language used to compose the subsequent design artifact within a larger network of objects that exist beyond of the constraints of for example a building, and he opens up a very relevant segue to the work of Joan Fujimura.

Standardized packages

The meta-concept of “standardized packages” also serves as an interface between multiple social worlds (Fujimura 1986; 1988; 1992), but effectively scales up the concept of “boundary object” by focusing on activities of “fact and skill” stabilization rather than destabilization (Latour 1987; Latour and Yaneva 2008). The concept supports the description of topological objects such as sustainable construction and the expertise affiliated with it by allowing for a broader engagement with the socio-technical landscape involved in built environment discourses. Unlike Star and Griesemer’s narrower notion of “boundary objects” (Star 1988), “standardized packages” pool together several boundary objects such as concepts, technologies, and/or organizations (Star and Griesemer 1989). Thus, the outcome is the production of a “less abstract, less ill-structured, less ambiguous, and less amorphous” workspace that is narrower and potentially more robust but not definitive (Fujimura 1992, 169).

The main aim in expanding the notion of boundary objects to standardized packages is to provide the means for analyzing how collective action is managed across social worlds to achieve enough agreement at various times “to get work done and to produce relatively (and temporarily) stable ‘facts’ ” (Ibid., 168). Centrally she argues that the “gray box” of a standardized package manages to accommodate both the understanding of “collective work across divergent social worlds and fact stabilization” (Ibid., 169).

Standardized packages and their component boundary objects “facilitate interactions and cooperative work and increase their opportunities for being transferred into, and enrolling members of, other worlds” (Ibid., 170). Through varying means, resources such as “concepts, skills, materials, techniques, instruments,” etc. are transferred at interfaces where people or social worlds intersect (Ibid.).

Following Star and Griesemer’s (1989) shift to multiple translations which downplay
Latour’s prominence of the individual, Fujimura simultaneously takes on “an ‘ecological’ approach framed in terms of understanding science as collective action from the viewpoints of all the actors and worlds involved” (1992, 171). Additionally, she recognizes that the weaknesses of both - Star and Griesemer’s case of cooperation in the design process of a museum and Latour’s work on Pasteur reside in their reliance on narrative and the constraints of using historical documentation (172). However Fujimura also points out that the strength in Star and Griesemer’s work is that is attempts to provide a more heterogeneous mix of viewpoints that support why boundary objects need to be implicated in multiple transactions to build consensus and diffuse tensions. Essentially, Fujimura claims that when used cooperatively the concepts of standardized packages, boundary objects and translation can indicate how varied social worlds temporally interact to collectively craft “facts” (1992, 203).

Also of relevance is that depending on the scale of analysis, boundary objects and boundary organizations such as knowledge transfer groups can be understood as both: 1) in the singular, and also 2) as part of a collective. Critically according to Guston, boundary organizations are inherently more flexible than sociologically derived notions of “boundary spanning organizations,” since a boundary organization “draws its stability not from isolating itself from external political authority but precisely by being accountable and responsive to opposing, external authorities” (2001, 400).

To the extent that boundary objects and standardized packages provide stability, however, they do so only through the consent of actors on both sides of the boundary, for example, to the extent that researchers voluntarily engage in patenting or politicians accept patents as a measure of productivity. (Ibid.)

The active engagement with boundary objects such as standards reflects another type of material interaction that has been argued as necessary for design professionals to aggregate their interests and actively influence, rather than simply meeting regulatory standards (Guy and Shove 2000; Fox 2011). Despite the strong normative aspects of building standards, which are predominantly recognized as financial or legal necessities, this suggests that like boundary organizations, there is some interpretive space or latitude within standards for a disciplinary practitioner to not only meet a standard, but to potentially engage in shaping it.

Moreover, the existence of boundary objects or standardized packages may not be all that is necessary for stabilization. More general changes in culture or more specific changes in practices may be necessary as well. (Guston 2001, 400)

In other words, standards as boundary objects are not static, fixed entities, but are a contextual “set of work arrangements that are at once material and processual,” residing between “communities of practice” where they are “ill structured” (Star 2010, 604). This was similarly anticipated in its scaled up form of standardized packages.

Conclusion

Yet, with buildings, we confront not one object, not even one standardized system, but a unique assembly of many component parts. In order to conceptualize design processes and comprehend the interaction of shifting populations of manufacturers, suppliers, occupiers, developers, builders and professional experts, we have had to adapt and extend existing methods and concepts. (Guy and Shove 2000,11)

Guy and Shove observe that drawing from sociological perspectives of STS are helpful up to a point, but require additional strategies both theoretically and methodologically when studying less controversial and more diffuse issues implicated in “ordinary technologies of energy efficiency or the publicly invisible process of building construction” (Ibid.). Following more moderate Science and Technology Studies perspectives that advocate the mutual shaping of society and technology, STS thinking was used to develop richer characterizations of sustainable development implementation. This was accomplished by creating a hybrid approach somewhere between the positioning of architectural and STS approaches to yield “more realistic and more useful accounts of the relationship between knowledge and practice and of the social processes ordering” sustainable development efforts (Ibid., 12).

Also, in line with Ryghaug and Sørenson, implementation efforts were understood “as an assemblage of policy-making, market processes, and professional and industrial practices,” where a research focus on expert stakeholders was rationalized as a leaner pathway to achieving more energy efficient, responsible development by engaging in the study of how a “limited number of supply side actors” are influenced and regulated,
rather than “a huge variety of demand side constituencies” (2009, 985).

This observation also dovetails into Schön’s practitioner/researcher thesis that the new forms of scholarship rightly lie “much closer to practice” (1995, 34).

The new categories of scholarly activity must take the form of action research. What else could they be? They will not consist in laboratory experimentation or statistical analysis of variance, nor will they consist only or primarily in the reflective criticism and speculation familiar to the humanities. (Ibid., 31)

A perspective that is also supported by STS scholar Jasanoiff:

Experts who are closest to a particular area of practice appear best equipped to spot the weaknesses and uncertainties of claims that fall within their field of vision. Inside their own domains, experts impose on each other a degree of critical peer scrutiny that society can ill afford to do without. (2003a, 160)

Thus, this section outlined a series of STS tools to approach long-standing architectural research problems, as well as design perspectives to balance STS understandings of the urban landscape. Or to more succinctly summarize the approach of this work by paraphrasing Lombardo - to study the urban landscape is to engage in a form of cultural analysis that “implies the physical space of the city as well as the network of ideological constructions of different kinds around it” (1993, xxiv).

Following this conceit Article 1, “Engaging complexity: Social science approaches to green building design,” outlines the broader horizon of the principal investigator’s interests (Bharathi 2013). Although technically published after Article 2, it was in fact, written, submitted and accepted for publication prior to Article 2. However, as clearly indicated in the scope and format of subsequent thesis articles 3 and 4, it was quickly recognized that in order for the project work to be presented as a coherent thesis, it would necessarily need to become more narrowly focused not only: a) to meet the interests of its financial backing and b) accommodate the norms of peer-reviewed journals, but c) more importantly, to produce a viable Ph.D. thesis within a 36 month schedule following the requirements of a Science and Technology Studies (STS) focused department.

Now, the next sections will provide more detail into the research methods used to explore these ambitions.

METHODOLOGY

Working Assumptions & Data

Guy and Shove approach implementation issues by looking at “research managers and others involved in funding and promoting building science” (2000, 9), however also implicated in this framing are disciplinary and professional practices. Their work of mapping various research management regimes was of particular use in determining the context of research that, given the limited time frame, the fieldwork should occur within to more easily explore the intended research focus of sustainable construction implementation from the perspective of a practitioner/researcher. They observe that frequently “the problem of implementation is consequently positioned, fair and square, as a problem for individual practitioners” (Ibid.). However, their findings contradict this assumed operational capacity of practitioners, and this was a critical departure point for the methodological focus of this work.

However, our three case studies suggest that opportunities for adopting energy-saving strategies are anything but standardized, individualized or economically determined. They show that technologies and energy-related practices are selectively appropriated within specific social contexts. These accounts of practice make it clear that similar technical strategies do and do not make sense for different reasons and at different moments in time, and that their adoption depends on the sometimes competing perspectives and priorities of a whole network of organizational actors. Whatever else the picture is certainly not one in which proven knowledge is seamlessly transferred from research to practice. (Ibid., 10)

This meant that a key departure from more traditional architectural and STS approaches was to not focus entirely on a single or discrete buildings, developments, technologies or organizations, but to focus on a variation of development approaches within a region.

Long affiliated with the planning and design of cities, landscapes and buildings, mapping is particularly instrumental in the construing and constructing of lived space. In this active sense, the function of mapping is less to mirror reality than to engender the re-shaping of the worlds in which people live. While there are countless examples of authoritarian, simplistic, erroneous and coercive acts of mapping, with reductive effects upon both individuals and environments, more optimistic revisions of mapping practices situate mapping as a collective enabling enterprise, a project that both reveals and realizes hidden potential. (Corner 1999, 213)
Hence by combining architectural notions of mapping with those of STS, an effort to produce a robust and idiosyncratic explanatory ‘map,’ was attempted, rather than simply producing a ‘traced’ reproduction (Deluze and Guattari 1980/1987, 12). Using the descriptive capacity of STS to unpack the nature of socio-technical networks, the ambition methodologically was to expand the architectural notion of the case study to address more of the institutional infrastructure of sustainable development. Guy and Shove are careful to distance themselves from standard methodologies of how to discuss their findings in order “to identify and explore alternative ways of viewing social and technical change, and to reflect on the roles of policy makers and other actors implicated in such processes” (Ibid., 12). In this vein and on a much smaller scale, a case study of implementation derived from the perspectives of experts within a single national context was developed. Specifically, after a period of evaluating a number of countries which included Norway, The Netherlands and the UK, the ‘close community’ of Switzerland was selected for study (Bharathi and Nicol 2013, 755) and will be described in greater detail in the following section.

The scope and practice of architectural design have often erroneously been referred to as narrowly focused on the aesthetic dimensions of building artifacts that are produced in a linear process. Having direct experience in practice coordinating interdisciplinary teams responsible for designing and implementing sustainability strategies in numerous large-scale campus projects had already prepared me for the working reality, that when dealing with experts deeply engaged in sustainable development, this could not be further from the truth in describing the architect’s role. Therefore it was assumed that despite the principal investigator’s specialist, tacit knowledge of architectural design, construction and interview methods, there would be a learning curve in getting reasonably, conversationally acclimated to the level and the diversity of expertise that would be encountered during fieldwork conducted in the Swiss context. Thus, a mixed-methods approach was deployed and two main sources of data were used - survey and in-depth expert interviews. Combined, these empirical sources of information informed the case study analysis presented in Article 3.

In the social sciences combining qualitative and quantitative investigative strategies within a

### Survey Questions

1. Which type of institution is your current employer?
2. What is the name of your employer?
3. Please list the two largest ongoing research activities relevant for building energy research at your institution.
4. How much public funding does your research institution receive in Euro annually?
5. How much private funding does your research institution receive in Euro annually?
6. Compared with last year, how is your institution doing this year so far?
   - [Private funding]
   - [Public funding]
   - [Temporary staff]
   - [Permanent staff]
   - [Media coverage]
7. ... and next year: How do you expect things will develop?
   - [Private funding]
   - [Public funding]
   - [Number of temporary staff]
   - [Number of permanent staff]
   - [Media coverage]
8. What is the largest group among your colleagues
9. Which of these disciplines would you say do most of your colleagues identify with?
10. Where are you based now?
11. In your opinion, building energy research currently is:
    - Ranked (1 low - 5 high):
      - [dealing with high financial risks]
      - [applied research]
      - [interdisciplinary research]
      - [solving societal problems]
      - [dealing with high degrees of uncertainty]
      - [dependent on support from industry]
      - [based on scientific principles]
      - [reflecting on its methods]
      - [aware of its effects on society]
      - [relevant for policy makers]
      - [able to take up knowledge produced by practitioners]
      - [oriented towards problem solving]
      - [networked internationally]
      - [differentiated in subdisciplines]
      - [acting in complex settings]
      - [concerned about cost efficiency of proposed solutions]
      - [aware of end-users’ demands and wishes]
      - [flexible]
      - [involved in societal discussions]
      - [dealing with consequences of peak oil]
      - [dealing with climate change]
      - [fragmented nationally]
12. In your opinion, building energy research should be
    - (1-5):
      - [dealing with high financial risks]
      - [applied research]
      - [interdisciplinary research]
      - [solving societal problems]
      - [dealing with high degrees of uncertainty]
      - [dependent on support from industry]
      - [based on scientific principles]
      - [reflecting on its methods]
      - [continued...]

Table 2: Survey Questions
single study has become a widespread technique in exploratory and evaluative research (Bazeley 2003, Creswell and Tashakkori 2007, Teddlie and Yu 2007, Yin 2008). Although the trend has been occurring for some time, it has been controversial especially in the 1980s “based on the assumption that using different data types or different methods necessarily implied creating a conflict in ontology and epistemology” (Bazeley 2003, 117). Currently, the mixed methods approach has become widely accepted particularly in the areas of social research and evaluation, since many researchers have deduced that combining approaches as both a necessity and an inevitability (Ragin 1992).

Survey

Science and Technology Studies (STS) are most frequently associated with case study work loosely following anthropological modes of description and observation study (Geertz 1983; Knor-Cetina 1983). However, as the oft cited Geertz himself surmises, anthropological methods of mapping “the interplay between...cultural, political, social, and intellectual life overall” highlight the workings and assumptions of a “special and specialized profession, a trade, a craft, a métier” (2002, 2).

A born fox (there is a gene for it, along with restlessness, elusiveness, and a passionate dislike of hedgehogs), this seems to me the natural habitat of the cultural...social...symbolic...interpretive anthropologist. (Ibid., 14)

Similarly, an architect conducting research, represented by whichever animalistic avatar best suits your id, possesses cultivated proclivities of their very own. That is, the a priori assumptions, the subsequent structure and execution of a work reflects both the trappings of the principal investigator's disciplinary and practical experiences.

Unquestionably, social science case study methods provide avenues to explore complex phenomenon at a depth that large sample surveys do not. However, in mixed-method research, sample surveys can also be of supplemental use. Recognized as the most used tool in applied social research, standardized surveys are designed to provide focused, topical insight within a specific time frame. Typically, a researcher is interested in a larger group of persons, but collects information from a smaller cross-sectional sample of persons in order to draw inferences regarding the larger group. According to Kelly et al. (2003) the primary reported advantages of the strategy can include:

- The production of data derived from observable real-world phenomenon.
- Generalizable findings to a relative population dependent on sampling scope.
- The ability to produce data within a finite time frame, which can support the planning process of research and accommodate the generation of deliverables.

Additionally, potential problems can include:

- The significance of the data can be compromised in studies structured to maximize coverage without adequate consideration for the relevance of the collected data, the framing of problems, or their theoretical implications.
- Lack of empirical detail or depth.
- Control of the response rate.

In survey design the authors’ assert that the clarity of the research question is paramount, as is knowledge of the area of research. Centrally, survey research is best used to widen the investigator’s “base of experience” in order to investigate linked areas of inquiry (Ibid., 262).

Piloting, sampling, and sampling error are key issues within survey design. Piloting can be used to troubleshoot potentially unclear questions. In the survey research included in this thesis research that culminated in the joint publication by Dr. Thomas Berker and myself and was titled, “Energy and Buildings Research: Challenges from the New Production of Knowledge,” (2012) a pilot testing phase would have certainly improved the flow of the online questionnaire itself (Table 2), and also potentially would have improved the response rate of the survey as well. For example, in forty-two survey responses only twenty-four respondents answered more than twenty-five percent of the questions, which were subsequently included in the analysis. In particular, comments provided by respondents suggested that the relatively high dropout rate was linked to a lack of clarity surrounding the use of the word ‘institution’ in one of the first questions that gave unclear signals about the target group of the survey. Lastly, in terms of data collection flow, it is atypical to conduct survey work prior to an exploratory qualitative interview phase. However, this also highlights the unpredictability present in even ‘controlled’ research. Given the opportunity and the time constraints of the project and expectations within the workplace, it was only reasonable to participate, and naturally, the findings did inform my subsequent efforts.

Sampling is another important part of the survey
design and begins in the decision to randomly or non-randomly sample. Random sampling is appropriate when the research questions focus on identifying statistically significant trends within the general public using large sample sizes. Non-random samples are employed in qualitative efforts and are typically used for “exploratory work” (Kelly et al 2003, 264). Specifically the aim is to intentionally engage persons with specific attributes within certain populations. Techniques include:

1. Purposeful sampling: a specific population is identified and only its members are included in the survey (i.e. only patients who had an appendectomy).
2. Convenience sampling: the sample is made up of the individual who are easiest to recruit.
3. Snowballing: the sample is identified as the survey progresses; as one individual is surveyed he or she is invited to recommend others to be surveyed. (Ibid.)

Kelly et al. conclude that although larger samples potentially hold greater statistical validity, sampling size ultimately relies on three factors: “the resources available, the aim of the study, and the statistical quality needed for the survey” (2003, 264). In short, sample size raises a number of issues regarding sampling error and reliability in proving hypothesized causality - the perceivable effect of one set of variables has upon another set. Given sample size and response rate can bias findings, and that the survey data presented in this thesis did in fact, involve a small survey sample, it is relevant to explore the topic of small sample sizing in greater depth, particularly because the tally of interviews comprising the qualitative sample (31) was although also small, was purposefully targeted.

For some two decades the fact has been gaining rec-ognition that the theory of sampling which assumes that the sample contains a large number of individuals is inadequate for many practical purposes. (Rider 1930, 577)

In his 1930 essay “A Survey of the Theory of Small Samples,” Paul Rider argues it is the mathematical conception of the universe in which the sampling occurs that determines the strength of the conclusions drawn. Contemporaries Molina and Wilkinson (1929) expand on his argument in their discussion stating that when research conclusions are correctly deduced they “are usually quite definitely dependent upon the a priori assumptions made,” and that this is true in particular in the case of small samples. They underscore that in a small sample, a diversity of findings still result and therefore, it...
is especially important to review the assumptions embedded in the design of investigatory tools, and in particular, to assess the findings in relation to the previous experience of particular problems with the relevant 'technician' knowledgeable in the field.

A considerable space is, therefore, devoted to the solution of a problem in which the sample is only five, taking up a wide variety of these a priori assumptions. They give, in consequence, a wide range of numerical results, appearing in the form of probable errors in the mean of the sample. Each set of assumptions is briefly discussed indicating how the sampling technician may be able to make a selection consistent with his a priori knowledge of a particular problem. (Molina and Wilkinson 1929, 632).

Essentially they argue that if the “interpreter” of the data is aligned closely enough with area of study, he or she might have “a reasonably good idea as to the value of the general average of items produced under these same essential conditions” (Ibid., 643).

For example in co-authored Article 2, the survey conducted included a roughly consistent twenty-four-response sample set that targeted individuals for their links to building and energy research. It was argued that if the Mode-2 hypothesis is correct, then disciplinary distinctions were losing importance. Therefore, it was anticipated that these researchers would either:

- Continue to guard their expertise within their disciplines and possibly intensify their efforts when their knowledge is devalued in favor of alternative skills in higher demand.
- Or alternatively, connect to disciplinary traditions and trends open to integrated and user-oriented approaches.

Evidence to support both Mode-1 and Mode-2 ways of thinking were found. Respondents reported that energy and buildings research is an applied science that deals with climate change and should be interdisciplinary and internationally networked, which complies with basic notions of the new production of knowledge in the Mode-2 hypothesis. Alternatively, respondents also reported views that aligned with traditional Mode-1 norms evidenced in the support for traditional quality measures of ‘good science’ such as the use of scientific principles and peer review. In addition, respondents unilaterally rejected financial dependence on the building industries.

However, it was the aspects of Mode-2 thinking that were missing - a connection with the context of application that is industry, novel quality control, as well as a perception of financial risk that caught my attention as the co-principal investigator and practicing architect. Essentially, I recognized that my interest was in conducting targeted interviews with persons documented as working closer to the edges of research and practice, or those squarely in the expanded ‘grey zone of architecture.’

It cannot be overemphasized that the problem by its very nature is indefinite since it would be a rare instance indeed to find a mathematical expression which would completely and exactly summarize the a priori knowledge, impressions and beliefs in the mind of any person confronted with its solution. (Ibid., 645)

Here, Molina and Wilkinson underscore that the study of moving or “indefinite” problems require evaluative methods that are also ‘on the move.’ Similarly, although the implementation of green building solutions had been the focus of this dissertation work since day one of this project, the findings from the survey phase of the project were explicitly central in: 1) informing what scope of research investigation could be effectively undertaken to address the boundaries between energy research and practice in greater detail; 2) narrowing what types of experts should be targeted for interview; and 3) determining which national context would be most appropriate given the limited time frame.

Interviews

In the following section, the context of fieldwork will be described in greater detail. However, its of relevance to quickly outline why Swiss experts were ultimately selected as the focus of the in-depth interviews than for example, experts from any other country. From a sustainability perspective it was an observation from a seven country comparative study of net zero energy building definitions versus national building codes that was the key determining factor. Marzal et al. (2010) looked at the approaches of seven countries - Austria, Canada, Denmark, Germany, Italy, Norway, Switzerland and the U.S.

One of the particularities of the Swiss approach was that is was the only county where embodied energy was also taken into account. That is, the sum total of the energy necessary for an entire product life-cycle, and this is a point that is particularly of importance in building construction. For example Buchanon states that responsibly harvested wood is the most sustainable building material with approximately 640 kilowatt-hours (kW) per ton of embodied energy, which is followed by:
<table>
<thead>
<tr>
<th>Interviews</th>
<th>Description</th>
<th>Discussion Guide</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Silvia</td>
<td>Senior Research Scientist, Consultant, Energy Transitions</td>
<td>General: How is sustainability approached?</td>
</tr>
<tr>
<td>2. Katrin</td>
<td>Architect/Planner, City Project Manager</td>
<td>- Age / Gender / Nationality</td>
</tr>
<tr>
<td>3. Urs</td>
<td>Director of Energy/Mobility Research Institute, Upcoming Executive Director of Sustainability Knowledge Transfer Organization</td>
<td>- Educational / Professional Background</td>
</tr>
<tr>
<td>4. Armin</td>
<td>Architect, Technical Director of Certification Label, Educator</td>
<td>- Professional / Current Affiliation</td>
</tr>
<tr>
<td>5. Christian</td>
<td>Engineer, Research Scientist, Educator</td>
<td>- Role / Length of Affiliation</td>
</tr>
<tr>
<td>6. Roland</td>
<td>Architect, Current Executive Director of Sustainability Knowledge Transfer Organization</td>
<td>--- Past Efforts: What was learned?</td>
</tr>
<tr>
<td>7. Hansjürg.</td>
<td>Engineer, Senior Research Scientist, Educator, R&amp;D</td>
<td>- Project Type / Scale / Budget / Timeline</td>
</tr>
<tr>
<td>9. Michael</td>
<td>Architect, Senior Project Architect</td>
<td>- Team Selection Parameters / Composition</td>
</tr>
<tr>
<td>11. Arno*</td>
<td>Architect, Research Scientist, Software Developer, Educator, R&amp;D</td>
<td>- Modes / Levels of Internal/External Technology Transfer, Communication</td>
</tr>
<tr>
<td>12. Veronika</td>
<td>Engineer, Communications Officer of Sustainability Knowledge Transfer Organization</td>
<td>- Distribution between management and technical functions</td>
</tr>
<tr>
<td>13. Silvia</td>
<td>Engineer, Senior Research Scientist, Consultant</td>
<td>- Forms of contractual agreements</td>
</tr>
<tr>
<td>14. Étienne</td>
<td>City Project Manager, Energy Label</td>
<td>- Business development focus</td>
</tr>
<tr>
<td>16. Reto</td>
<td>Architect, Firm Owner, Educator</td>
<td>--- Current Efforts: What is different?</td>
</tr>
<tr>
<td>17. Jörg</td>
<td>Architect/Engineer, Firm Owner</td>
<td>- Same queries as ‘Past Efforts’ section</td>
</tr>
<tr>
<td>18. Diego</td>
<td>Engineer, Project Manager</td>
<td>--- Linkages: What connections were important?</td>
</tr>
<tr>
<td>19. Thomas</td>
<td>Engineer, Senior Project Manager</td>
<td>- Nature or level of link to parent/subsidiary initiatives, research groups.</td>
</tr>
<tr>
<td>20. Kornelia</td>
<td>Architect, Firm Owner</td>
<td>- Role of Laws / Standards / Planning / Authorities / Certification Schemes</td>
</tr>
<tr>
<td>21. Farwad</td>
<td>Architect, Firm Owner</td>
<td>- Contracting / Subcontracting</td>
</tr>
<tr>
<td>24. Heinrich</td>
<td>Architect, Firm Owner, R&amp;D</td>
<td>- Funding / Accessibility</td>
</tr>
<tr>
<td>27. Yves</td>
<td>Executive Director, Sustainability Knowledge Transfer Organization, Educator</td>
<td>- Anticipated future projects / products / production / inputs / outputs and goals.</td>
</tr>
<tr>
<td>29. Annette</td>
<td>Architect, City Project Manager</td>
<td>- Next steps...</td>
</tr>
<tr>
<td>30. Jan</td>
<td>Engineer, Senior Research Scientist, Educator</td>
<td></td>
</tr>
<tr>
<td>31. Andreas</td>
<td>Architect, Firm Owner, Cooperative Housing Construction Management</td>
<td></td>
</tr>
</tbody>
</table>

Total: 31  
*Interviewed 2x  
**Interviewed 22
• Brick at 4 times more embodied energy than wood;
• Concrete at 5x;
• Plastic at 6x;
• Steel at 14x;
• Aluminum at a 126 times more than wood.

Therefore, in very simple total life cycle costing terms, a building with large volumes of aluminum components can hardly be considered sustainable, regardless of how much energy it saves (Buchanon 2000, 9ff.). This is certainly a critical filter in understanding how more or less sustainably built a building is in terms of raw materiality, instead of assuming the stance that the right combination of high performance technologies manipulated within the ‘correctly’ formed equation will result in an appropriate disembodied number. Thus using my judgment as a qualified architect, the Swiss approach to operationalizing green construction warranted closer study.

In gathering candidates that might participate in the research sample, individuals were targeted by their involvement in a range of development case types to maximize the potential of diverse information that could be gathered. Following Flyberg (2011) an information-oriented purposeful selection was comprised of persons involved in the following types of development cases:

• Extreme or deviant types in order to obtain information on unusual exceptional cases.
• Maximally variant types to obtain information about the significance of varied circumstances for case process and outcome (i.e. scale, organization, project typology)
• Critical cases types to support logical deductions.
• Paradigmatic cases to develop benchmark scenarios within the case domain.

Each sub-unit or interviewee was not considered as discrete case but rather, their views were recognized as “crucial pieces of evidence,” which collectively provide regional narratives of current expert perspectives on sustainable development issues (Kelemen and Vogel’s 201, 431).

Using the Swiss Society of Engineers and Architects’ (SIA) official interdisciplinary trade publication, TEC21, a trade journal which focuses on architecture, engineering and environmental concerns, a pool of experts linked to implemented, sustainable construction projects in Switzerland within the last ten years was developed. Additionally, contacts were gathered through relevant sustainability literature, journal articles, the regional websites of the 2000-Watt Society, as well as the construction department websites of the largest cities located within those regions: Zürich, Basel, Geneva, and Lausanne. Contacted via email and telephone at their primary place of practice, thirty-one interviews with experts regularly involved in a range of research and design work were conducted in person February to June 2012. Operationally, each recorded qualitative interview lasted between 1½ to 2 hours and followed an discussion guide that was not used verbatim, but rather was used to direct and deepen the conversation around specific sustainable development efforts largely determined by the interviewee. (Table 3)

Case Study

Within both architectural research and science studies, case studies are the typical building block of analysis. However, in each field they are structured very differently. In architecture, case studies almost always address specific buildings or groups buildings linked to an architect or a building typology. Technical case studies usually focus on the integrative construction details of particular products or systems, and more socially oriented community based design studies emphasize the link between group process to project development and outcomes.

In STS, the focus of case studies has also been historically artifact based. Like the diverse range of artifacts analyzed, so too are the analyses and the theoretical frameworks applied which span “different views of what constitutes valid explanation, argument and evidence” (Ryghaug 2003, 48). More broadly with the social sciences a case study can be range of entities, relatively bounded or a process (Ragin and Becker 1992), but critically they are always considered from a particular perspective or perspectives with a specialized interests that relate to more general ones (Stake 1995; 2008).

Irrespective of disciplinary positioning case studies are widely understood as empirical units that are theoretical constructs (Ragin 1992); not focused on causal relationships that are co-variational in nature (Gerring 2004); and are developed for both educational and research purposes (Scholz and Tietje 2002). According to Johansson (2003, 2004, 2007) case study methodology, as developed within the social sciences, is critical in architectural research and is characterized by a purposeful selection of a case or cases to study, in addition to triangulation, which is normally conducted by means of multiple-
method data collection.

Purposeful sampling techniques are primarily used in qualitative studies and are typically described as, for example: individuals, groups of individuals, or institutions based on specific purposes associated with answering a research study’s questions (Teddlie and Yu 2007). Maxwell (1997) further explicates the meaning of purposeful sampling as specific settings, persons, or events that are selected for critical information that they can uniquely provide. Johansson explains that architectural case study requires both an understanding of the current situation, but also its historic context. However he also adds that although case studies in architecture are inclined to be historic, they need not be, since casework may also include design processes. For example this might encompass temporal complexity. It has also been observed that the focus of a case study may change for the researcher as the case progresses, as well as for the audiences of the research as it is disseminated (Ragin and Becker 1992).

It is characteristic of case study methodology that the boundaries, and often even the focus of the case, change through the research process. Also, a case study focusing on a particular phenomenon might be read as an investigation of a different phenomenon. (Johansson 2007, 50)

Thus, a more appropriate description of what type of case study was conducted in this research project is encapsulated in Scholz and Tietje’s notion of embedded case studies.

Embedded case studies involve more than one unit, or object, of analysis and usually are not limited to qualitative analysis alone. The multiplicity of evidence is investigated at least partly in subunits, which focus on different salient aspects of the case. (2002, 5)

Conceptualized to more easily blend into a mixed-methods approach, in cases addressing regional or planning issues, a primary unit may be “different interests groups that are involved or affected,” and the smallest units may be organizations, groups or respective individuals (Ibid).

Output

Lastly, a quick aside on texts. Although the main product of the social sciences, scholarly writing within architecture is not a medium most designers are trained within or employ. Yet, textual formats have evolved over time and have been shown to

<table>
<thead>
<tr>
<th>At a glance</th>
<th>Detail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Central Europe, bordered by Germany in the north, Austria and the Principality of Lichtenstein in the east, Italy in the south and France in the west.</td>
</tr>
<tr>
<td>Geographic Area</td>
<td>41,285 sq km [15,940 sq mi] with a N-S length of 220 km [137 mi] and a E-W span of 350 km [217 mi].</td>
</tr>
<tr>
<td>Regions</td>
<td>The Jura, the Plateau and the Alps.</td>
</tr>
<tr>
<td>Water</td>
<td>6% of Europe’s fresh water, 1500 Lakes</td>
</tr>
<tr>
<td>Productive Area</td>
<td>The surface area without lakes, rivers, unproductive vegetation and no vegetation equals roughly 30,753 sq km [11,870 sq mi], 31% covered in forests</td>
</tr>
<tr>
<td>Seasons</td>
<td>Spring (March to May) / Autumn (September to November)</td>
</tr>
<tr>
<td>Climate</td>
<td>Moderate. July to Aug: daytime temp. range is 18 to 28 °C [65° - 82° F]; From January to February the range is -2 to 7 °C [28° - 45° F]. In spring and autumn, the daytime temp. range is 8 to 15 °C [46° - 59° F]. The lowest point is Ascona, in Canton Ticino, 193 m [643 feet] above sea level which has a Mediterranean climate. The highest point is the Dufour Peak, in Canton Valais, at 4,634 m [15,199 ft], with an arctic climate. In plan, Ascona and Dufour Peak are 70 km (43 mi) apart.</td>
</tr>
<tr>
<td>Politics</td>
<td>EEA member, neutral. federal parliamentary republic with 6 core institutions: 1) decentralized federalism 2) referendum democracy 3) seven-headed presidency or directorate system, 4) a permanent grand coalition, 5) hidden or quasi-corporatism and 6) highly independent central bank</td>
</tr>
<tr>
<td>Structure</td>
<td>Comprised of 26 semi-autonomous members, it is a confederation constituted by 20 cantons and six half-cantons, evenly split between Catholic and Protestant denominations with a total of 2,842 municipalities or communes.</td>
</tr>
<tr>
<td>Population</td>
<td>7.9 million in 2011 with roughly 75% living in urban areas.</td>
</tr>
<tr>
<td>Cities</td>
<td>Five largest agglomerations in decending order: Zurich, Geneva, Basel, Bern, and Lausanne</td>
</tr>
<tr>
<td>Language</td>
<td>More than twelve languages spoken. Four official Swiss languages: German, French, Italian and Romansh.</td>
</tr>
<tr>
<td>Density</td>
<td>193 people per square km [500 per sq mi] of the productive area in 2008.</td>
</tr>
</tbody>
</table>

Table 4 Relevant Summary Details of Switzerland
embody embedded structures of prioritization that ultimately influence a reader’s perception of events, situations and perceived facts by what is assumed as basic knowledge in a field (Bazerman 1988). This alludes to a relevant point derived from STS analyses of text, which indicate that specific conflicts or controversies within a discipline inform and shape accepted facts, and frequently argumentation is often adapted “to the goals of the scientist, against a background of audience knowledge and assumptions.” Similarly, it has been shown in academic production that texts “emerge” from “negotiations among authors, editors and referees” (Keith and Rehg 2008, 221). Recognizing this, a conscientious effort was made throughout the project to disseminate its finding in diverse publication outlets.

Conclusion
The points raised in this section highlight areas of reflection that arose during the development, the data analysis and subsequently the published output of this research project. Cumulatively, the intent of the framing perspective employed and the methods outlined in these introductory paragraphs were intended to engage the divide that the scientist/novelist C.P. Snow coined as “The Two Cultures” in a lecture he gave in 1959 in Cambridge. Speaking about the growing separation between science and non-science, Snow believed that:

..the intellectual life of the whole of western society is increasingly being split into two polar groups. When I say the intellectual life, I mean to include also a large part of our practical life...(Snow 1959/1990, 169)

The sequestering of practical architectural concerns from those of the discipline and the building sciences also mimics this cultural segregation and his observations are a call to integration, since polarization “is sheer loss...to us as people, and to our society,” that is simultaneously “practical and intellectual and creative loss” (Ibid., 171). The articles presented here are an effort to engage the space between the intellectual life of building and: notions of collective interest (Article 1); the perspectives of researchers engaged in the building sciences (Article 2); the perspectives of regionally located actors engaged in implementation efforts (Article 3); and lastly, futures oriented thinking (Article 4).

CONTEXT OF FIELDWORK

Switzerland
A strongly fragmented political system that has been described as a microcosm of Europe in its cultural and linguistic diversity, the Swiss Confederation, combines a unique blend of post-war structural federalism, decentralized political organization and direct democracy in its system of governance (Gstöhl 2002). Since the turn of the century the Swiss population has roughly doubled from 3.3 million in 1900 to 7.9 million in 2011, with nearly three quarters of the population living in urban areas, and slightly more than a third living in the five main cities and their surrounding suburbs of Zurich, Geneva, Basel, Bern, and Lausanne (Federal Statistics Office) (Table 4).

These patterns have led to discussions of the development of Swiss mega-city regions (Thierstein et al. 2008) and metropolitan blocks (Dessemontet et al. 2010) with two areas having been widely identified, one in the northern part of the country organized around the city of Zurich and another in the French-speaking Lake Geneva area (Thierstein et al. 2008). However, in reality both the area around Bern and the Ticino region also function as independent metropolitan areas, in addition to Zurich and the Lake Geneva areas. And despite being the third largest city in terms of population, Basel has been shown to function as part of the greater Zurich area in terms of commuting patterns (Dessemontet et al. 2010) (Figure 5).

The home to many ethnicities, who collectively speak more than twelve languages, there are officially four official Swiss languages - German, French, Italian and Romansh. Significantly, the role of language has been shown to outweigh the influence of factors such as: age, religion, education and party affiliation in voting preferences (Kriesi, 2005); the cleavage between Protestants and Catholics as well as rural-urban conflicts in Swiss integration issues post World War II (Gstöhl 2002). Despite clear roots in the feudal legacy of power distribution (Lane 2001), language consistently functions as the critical marker of identity that shapes public space and political discourse within Switzerland’s organizational cultures (Erk 2003).

The strong reorientation of the close community of Swiss building, design and research sectors was precipitated by the oil crisis in 1973, when the sharp increase in energy costs highlighted the poor
quality of building construction and inefficient energy consumption linked in part to extremely low fuel costs (Zimmermann 2001). Although territorial energy consumption, greenhouse gas intensity and emissions per person are comparable to the inhabitants of other developed nations (Figure 6), the country heavily relies on imports for approximately 80 percent of its needed fossil fuels and other combustibles. Also, despite producing roughly 56 percent of its electricity domestically, Switzerland requires additional imports due to greater demand in the colder months (Swiss Federal Office of Energy). Second only to the transport sector, the Swiss building sector has been identified as an important source of greenhouse gas (GHG), at 19.7 Mt of CO$_2$e, which includes indirect emissions from the consumption of electricity. Direct emissions accounted for 17.6 Mt of CO$_2$e in 2005 or 89 percent of building emissions. Hence, the building sector has become an area of intense focus, as it provides opportunities to further significantly reduce GHG emissions through primarily retrofits (6.1 Mt of CO$_2$e), but also by shifting to alternative heating systems (4.2 Mt of CO$_2$e), more efficient new construction (0.7 Mt of CO$_2$e), and LED lighting (0.3 Mt of CO$_2$e) (EU Eurostat).

Relevant Legislation & Other Incentive Programs

Current energy policy outlined in the Swiss federal constitution that impacts the building stock is detailed in Section 6, Article 89. This five-point section highlights that although the federal government identifies strategic
sectors where energy reduction measures must be addressed, cantons and communes or the regional and local levels, retain significantly more power in determining their implementation. This legislation is supported by greater detail by the Energy Act and the Carbon Dioxide Act (Federal Authorities of the Swiss Confederation).

Energy Act (SR 730)
The Energy Act says little about technical building performance standards with the exception that targeted reductions in residential energy use in 2030 should equal that of the year the Energy Act was enacted (1999). However, it does state the responsibilities of the respective cantons regarding energy consumption in the existing building stock and new construction, including specifications for consumption caps and monitoring (Nicol et al. 2012).

Carbon Dioxide Act (SR 641.71)
Revised in 2011 and enacted on January 1, 2013, the new legislative scope includes an increase in the tax to 60 CHF by 2014 from a provisionary tax of 36 Swiss francs (CHF) per ton of CO$_2$ that came into effect in 2008. Originally designed to encourage Switzerland to meet its emissions reduction commitments under the Kyoto Protocol, the legislation specified that the average, fossil fuels based CO$_2$ emissions between 2008 and 2012 should fall below 10 percent of 1990 levels.

In its current form, the law requires that one third of the tax revenues, up to a maximum of 300 million CHF, must be used to reduce CO$_2$ emissions from buildings. To this effect, the Confederation provide funding to the cantons through two streams. The first can be used to subsidize building envelope renovations. Here, the cantons are eligible to receive this money on the condition that they agree to a subsidization program that is harmonized at the national level.

As a result, the cantons have created the Buildings Program, described in the next section. The second stream can be used to increase the use of renewable energy sources, heat recovery, systems, as well as update or install other energy-saving technical installations in buildings. Respective cantons may pre-qualify for this support, if they already have in place energy-efficiency and energy-reducing subsidization programs in place (Nicol et al. 2012).

The Buildings Program
Developed by the Conference of Cantonal Energy Directors (EnDK) in cooperation with the Federal Office of Energy and the Federal Office of the Environment to provide subsidies for energy-saving building envelope renovations and the use of renewable energy sources. In 2010 and in 2011, approximately 120 million CHF from the CO$_2$ tax was allocated to building envelope renovation subsidies. To qualify for subsidies, buildings must have been built prior to 2000 and achieve specific envelope transmission requirements or meet Minergie standards. Concurrently, approximately 60 million CHF from the CO$_2$ tax was dedicated to cantons with existing programs for subsidizing the use of renewables and heat recovery systems. Additionally, (and separately from the Buildings Program) the cantons complemented this amount with an additional 80 to 100 million CHF of their funds (Nicol et al. 2012; EnAW).

Standards, Labels & Knowledge Transfer Organizations
As highlighted earlier, the Confederation provides guidelines for general spatial policy and energy laws; however, the explicit power to implement energy and building standards resides within respective cantons. Though this does introduce problems at the level of uniformity in development standards, steps have been made to coordinate the use of standards across cantons. The most prevalently used building standards originate from the Swiss Association of Architects and Engineers and the Conference of cantonal energy directors, which both also function as key knowledge transfer organizations (SIA; EnDK). In addition, another widely used standard and labeling system is Minergie, a Swiss trademarked sustainability brand for new construction and renovations and aims to reduce heat demand to 90 percent or less of the limit of SIA standard 380/1 (Minergie). Lastly, although in development at the time of this research was conducted, the Sustainable Construction Standard Switzerland (SNBS) which was developed by the Swiss Network for Sustainable Construction (NNBS), attempts to balance Minergie’s technical standards with social and environmental construction criteria and incorporates the SIAs Recommendation for Sustainable Building Construction (SIA Norm 112/1). Both the SIA standards and those from the
EnDK - Model Energy Standards for Cantons, MuKEEn - are legally binding only once a canton officially adopts them into law, and the policy aim is that each will do so at least in part (Nicol et al. 2012). Also it is notable that revisions to the SIA standard have been made to reflect energy targets outlined in the MuKEEn. Furthermore, several references are made in the MuKEEn to Minergie, which although is not currently, directly mandated by law, is often cited as an eligibility requirement to qualify for federal building subsidies and bank loans.

SIA Standards

The SIA represents four professional groups who engage in issues of architecture, civil (or structural) engineering, technology and the environment. Besides developing building standards, the SIA has a high media profile in the discussions on spatial development in Switzerland, is involved in many aspects of academic and professional training, promotes practice-oriented public procurement processes and provides services of legal counseling. The most pervasively used in Switzerland, the SIA standards outline minimum construction requirements for buildings and provide planning guidelines in regard to heating, energy consumption as well as mechanical and electrical installation optimization strategies for renovations and new construction for an array of building types. The standards related to energy efficiency and use are located in SIA 380/1, which concerns the appropriate and efficient use of
energy for room heating and hot water systems, in addition to SIA 380/4, which promotes the efficient use of electricity in buildings and installations.

**EnDK, MuKEn Standards & the GEAK Label**

Since 1979, the conference of cantonal energy directors (EnDK) has acted as the common energy competence center for the cantons, coordinating the cooperation between the cantons in issues of energy and representing their shared interests. The model energy standards for cantons (MuKEn) developed by the EnDK, includes both requirements for new building construction and renovations, as well as strategies to attain these targets with an emphasis on the existing building stock (MuKNe). The group explicitly opts to focus on implementation issues and not ideological ones (EnFK). The EnDK also oversees a cantonal building energy certificate program (GEAK), which provides potential buyers or renters transparent, comprehensible, building energy consumption information to inform their decision-making. The label is still a voluntary measure, which also has several designations such as ‘GEAK Light’ which involves self-reporting, and ‘GEAK Plus’ which includes external expert verification (EnDK).

**Minergie Label & Standards**

Frequently used as the primary benchmarking tool for Swiss politics, financing mechanisms, cantons, communities, private and public building owners, Minergie is heavily marketed as combining energy efficiency in buildings with better comfort and added value. Since its inception in 1998, the label has become a widely accepted standard and trademarked brand for new building construction and renovations, although not without controversy concerning its potential restriction of architectonic expression (Baublatt 2011). The baseline Minergie label requires approximated a 25 percent greater efficiency than current SIA standards in energy use linked to heating, domestic hot water and ventilation (38 kWh/m²). The Minergie-P label requires higher building performance and involves a highly insulated building envelope, similar to the German Passivhaus standards (30 kWh/m²). The standards involved in Minergie-A are even higher and are comparable to Nearly Zero Energy Buildings (NZEB; Minergie), and lastly, the option of fulfilling additional requirements related to indoor environmental comfort and building materials would allow for the Minergie-ECO label to be used.

**Swiss Energy Program**

The Energy 2000 program was launched in 1990 and later became the Swiss Energy program in 2001 (Swiss Energy). The program provides housing owners and managers informational services and functions as a platform that unites a range of activities within the field of renewable energy and energy efficiency under a single initiative. In addition to the building stock, the umbrella program focuses on renewable energy, transportation, industrial and service companies, electrical appliances, municipalities and towns, education and training, and communication. Managed by the Swiss Federal Office of Energy (SFOE), the program intends to bridge the scope of energy and energy efficiency by fostering close working relationships between the federal government, cantons, communes and a range of partners located in both private and public sector industry, consumer and environmental groups.

The Energy City award is one of its most effective programs that is marketed as not only a brand, but as a comprehensive process that supports communities in long-term management strategies to attain sustainable, local energy policies. To achieve the designation, a municipality must meet at least half of the possible measures in the following areas of energy policy (implemented or planned): 1) development planning, regional planning, 2) municipal infrastructure, 3) supply, waste disposal, 4) mobility, 5) internal organization, and 6) communication, cooperation. Developments that meet at least three quarters of the measures outlined receive the “European Energy Award Gold.”

**Novatlantis & The 2000-Watt Society**

The vision of the 2000-Watt Society, originally developed by the Swiss Federal Institutes of Technology (ETH), is to reduce the primary energy consumption per person in Switzerland from today’s roughly 5500 Watts to 2000 Watts by 2050. To achieve this goal, Novatlantis takes findings from research within the ETH domain (Figure 3)
and applies them to projects promoting sustainable urban development (Novatlantis). Political support for the goals of the 2000-Watt Society continues to gain momentum, as evidenced in the 2008 referendum in the city of Zurich, where seventy-six percent of the population voted in support of integrating the plan to significantly reduce energy consumption across policy sectors by 2050 into the city’s constitution. Subsequently, the public approval of this approach has been acknowledged by the Swiss Federal Council, as shown by its continued inclusion in its Sustainable Development Strategy (Swiss Federal Council 2008; 2012).

Swiss Network for Sustainable Construction & Sustainable Construction Standard Switzerland

The Swiss Network for Sustainable Construction (NNBS) is an umbrella organization that aims to balance social, economic and ecological ambitions in its efforts, specifically through a label that is currently in its pilot phase. Launched in Bern in 2013, this public-private initiative is an association that serves as a central platform, connecting and coordinating sustainable construction actors nationwide to create synergies for the building sector and the national economy. The meta-label, the Sustainable Construction Standard Switzerland (SNBS), was developed on behalf of the Swiss Federal Office of Energy.

The SNBS aims to cover all aspects of sustainable design while taking into account Swiss design and construction traditions and integrating proven tools and labels. Drawing from the SIA 112/1 Recommendation for Sustainable Building Construction, the planning standard and label

<table>
<thead>
<tr>
<th>At a glance</th>
<th>Detail</th>
</tr>
</thead>
</table>
| Legislation       | Energy Act [SR 730]  
 |                   | Carbon Dioxide Act [SR 641.71] |
| Linked Program    | The Buildings Program |
| Standards         | MuKNe  
 |                   | SIA  
 |                   | Minergie  
 |                   | SNBS |
| Voluntary Labels  | GEAk  
 |                   | Minergie  
 |                   | SNBS |
| Award Program     | Energy City |
| Knowledge Transfer Organizations | EnDK  
 |                   | SIA  
 |                   | Novatlantis  
 |                   | NNBS |
| EnDK / EnFK       | Conference of cantonal energy directors / Cantonal energy departments |
| Novatlantis       | Part of the ETH domain |
| ETH Domain        | 1. ETH Zurich, Swiss Federal Institute of Technology Zurich  
 |                   | 2. EPFL Lausanne, Swiss Federal Institute of Technology Lausanne  
 |                   | 3. PSI, Paul Scherrer Institute  
 |                   | 4. WSL, Swiss Federal Laboratories for Snow & Landscape Research  
 |                   | 5. Empa, Swiss Federal Laboratories for Material Testing & Research  
 |                   | 6. Eawag, Swiss Federal Institute of Aquatic Science & Technology |
| MuKne             | Model energy standards for the cantons |
| GEAk              | Swiss cantons’ building energy certification program |
| SIA               | Swiss association of architects and engineers |
| SNBS              | Sustainable construction standard Switzerland |
| NNBS              | Swiss network for sustainable construction |

Table 4: Relevant Summary Details of Switzerland
comprises criteria for key construction aspects relating to the ‘three pillars’ of sustainability: society, economy and environment. Baseline technical criteria targets will be equivalent to Minergie-ECO with additional construction criteria covering social and environmental dimensions (NNBS). Although in development during the empirical data collection phase of this research, as a clear example of the convergence of standards, it is included here.

CONCLUSION

Within architectural scholarship there are many existing examples of projects that are well integrated into their sites, incorporate current construction practices of the time and convey symbolic meaning in their spatial sequence and material expression. In the development of each and every one of these artifacts there were mitigating factors that originated from specific, contextual conditions linked to available resources, both in terms of materials and aggregate knowledge practices which influenced their constructed outcomes. And despite being cast within narratives of progress, persistent technologies within the practices of building tend to remain. As Frampton observes:

The edict that each successive technological innovation must ipso facto eliminate its predecessor does not always apply, either in civil engineering or in building culture, and in this regard we may note that we are still using essentially the same system of reinforced concrete construction that we did over a century ago. (2001, 125)

Essentially, the central research focus of this thesis, the implementation of sustainable building, is a current iteration of very old architectural problems - the perpetually revisited questions of practice, professionalism and boundaries. Seen heuristically, these framings provided opportunities to consider how theoretic tools from Science and Technology Studies (STS) – a field comparatively quite new and whose mainstream approaches have been shown to still rely heavily on sociological sources – might be capable of shedding relevant insight on a topological object such as sustainable construction implementation. In addition, as an architect and urban designer, this research opportunity provided a first hand opportunity to participate in ongoing efforts within STS to retool and extend its existing concepts to better fit the examination of processes pertinent to the design, construction and management of the urban landscape. That is, this thesis represents current boundary work between the fields of architecture and Science and Technology Studies.

Similar to Guy and Shove, the ambition of this study was not to explicitly understand the human dimension better or “how to overcome non-technical barriers to energy efficiency” (2000, 11), but more specifically focused on efforts to develop richer characterizations of the relationships between research, practice and their institutional frameworks (Articles 1 and 2) that culminated in a detailed case study of implementation processes of sustainable development in Switzerland (Article 3). Therefore, although the main conclusions drawn from this research were both very broad (Article 1 and 4) and alternatively very specific (Articles 2 and 3), more generalizable conclusions can be deduced from the hybrid theoretical and methodological strategies of architecture and STS employed in this work.

The first and broadest conclusion of this thesis is simply that a very real need exists for this work, despite the challenges “inter- and cross disciplinary research pose” (Schweber and Leiringer 2012, 482). Rather, in line with Schön (1983; 1987; 1995; 1998; 2001), this effort reflects the unique potential of the practitioner as social scientist.

Perhaps there is an epistemology of practice that takes fuller account of the competence practitioners sometimes display in situations of uncertainty, complexity, uniqueness, and conflict. (Schön 1995, 29)

I would argue that this expanded practice involves assuming the role (if only temporarily) of the dedicated researcher, since:

…while policymakers and scholars routinely affirm the importance of organizational, social and behavioral issues in the implementation of policies aimed at promoting sustainable construction, these aspects remain relatively underexplored. (Schweber and Leiringer 2012, 482).

Secondly, practitioners potentially bring an invaluably deep understanding of field precedent, as well as a practical knowledge of the trades and the industries involved in design and construction processes. This situated knowledge is not only of explicit use while navigating numerous and often discordant narratives found in empirical fieldwork, but also in the practicalities of organizing academic work. Essentially, experienced design practitioners are Bharathi
better positioned to quickly and critically recognize comparative shortcomings or advancements in their discipline than solely dedicated researchers lacking this experience reasonably can. In terms of the work presented here, a novice to the professional practice of architecture would have been unlikely to acquire a strong understanding of the range of discussion topics and tensions which underpin the broader concerns of sustainable construction implementation and identify key informants in only twelve months prior to fieldwork.

If there is any area where construction researchers have something special and unique to contribute, it is in the appreciation of the social, financial, organizational, and institutional opportunities and constraints shaping the industry’s engagement with issues of energy and buildings. (Schweber and Leiringer 201, 487)

Thirdly, the trend in the building sciences and in many cases STS and the social sciences to separate sustainable or energy efficient architecture from architecture as a whole is recklessly short-sighted, yet highlights a long-standing source of tension within the design disciplines.

Architecture’s perennial search for legitimacy in the face of technoscientific modernization, which no sooner undermines one field than it promptly proceeds to reinforce another, is perhaps the most poignant manifestation of the way in which our ever-escalating rate of change creates a level of destabilization that the species can hardly assimilate. Over the last 40 years architecture has turned first this way and then that in an effort to validate its socio-cultural role. Thus architects have constantly shifted their ideological ground from science envy to art envy and back again, crossing the hypothetical frontier between C.P. Snow’s two cultures with impunity and opting eventually for either one side of the other of this divide, that is to say electing to practice as architect/engineers (Renzo Piano) or as architect/artists (Frank Gehry). (Frampton 2002, 330ff.)

And ultimately, this polarization confuses the potential that is embedded within architectural practice. Careful consideration of the sustainability discourse in both approaches - architectural and STS - will be critical to undermining this false dialectic rather than reinforcing it.

Finally, moderate STS approaches are useful in broadening the entrenched design perspectives that Guy and Moore articulate as circular arguments centered on whether society at large needs “revolution or reformation, more or less technology, more or less pious behavior, to embrace or abandon the city, or to develop clearer definitions or standardization” (2007, 15).

Though voices within the design fields have been engaged in the socio-cultural/technical critique of building for some time (Frampton 1983a; 1983b; 1994; 1998; 2002; 2012), STS perspectives provide alternate analytic tools to unpack how these processes actually occur. The considered fusion of the perspectives - where architectural analyses can provide strategies to better understand scale, site and design; and STS can offer opportunities to rethink how buildings and building are conceptualized through a close study of practices using theoretical notions such as boundary objects, packages, object worlds and translation - suggests a way forward to reintroduce the context specific layers of meaning already present in the building arts.

And this leads to the last conclusion that is regarding the case selection of Switzerland which provided a fertile fieldwork site to explore how boundary objects in the form of building standards, legislation, knowledge transfer groups, voluntary labels and award programs were bundled together into standardized packages capable of being translated across object worlds.

In all this we are returned to the political and the phenomenological and hence to what I would like to call the cantonal; the canton that envelops both the idiosyncrasies of the site and the experience of the body. The ideological domination of techno-science tends to suppress the intersubjective, the one thing that by definition is never ‘value-free’. I am of course alluding to the ideal of direct democracy, to the idea of the canton as the site within which the institution must be brought into being. (Frampton 1994, 195)

As previously noted, the high level of environmental design standards achieved in Switzerland implicitly reflects its broader socio-political and -technical history. Achieving a similar trajectory of success in differing country contexts will simply not come from the flat transfer of facts - e.g. calculation methods or construction details. Rather it is clear that building technologies should be understood as being shaped by their context of concerns - such as the practices from which they developed.

To summarize, the cover sections intended to provide an overview of the framing perspectives, methodology and context of fieldwork, and each of the following respective articles included highlights that a hybrid approach that meshes Architecture and STS - has the potential to integrate the “knowledge required to construct and use these artifacts, as well as the cultural practices that engage them” (Guy and Moore 2007, 18).
References


---, and B. Latour. 1981. Unscrewing the big Leviathan: how actors macro-structure reality and how sociologists help them to do so. In *Advances in Social Theory and

Bharathi


Pugin, A. Welby 1836/1841. Contrasts: or, A Parallel between the noble edifices of the fourteenth and fifteenth centuries, and similar buildings of the present day; Shewing the present-day decay of taste. 2nd edition. London: Charles Dolman.


Scholz, Roland, and Olaf Tietje. 2002. Embedded Case Study


Engaging complexity: Social science approaches to green building design

Introduction

Every design discipline has its own way of seeing, evident in the range of artifacts, theories, methods, and contextual discourses each produces. Given that the practice of design is broadly understood as a reflective, inquiry-driven endeavor undertaken by a diversity of “fragmented” knowledge cultures, the success of designers who opt to tackle new realms of application requires a greater awareness of connections, not only between theory and practice within a discipline, but also between different types of relevant theories and practices across disciplines. In an era where pluralistic concerns must be balanced with ontological understanding, all designers should consider how disciplinary framings can shape their solutions. A very simple illustrative example that cuts across field boundaries is to consider “drawing,” rather than a specific discipline, as an analytic frame - one that reveals particular types of understanding and generates formal conclusions relative to, but distinct from, other modes of production. De Frietas observes that employing a multiplicity of “approaches and applications” in processes of making, not only reveals differences in “systems of logic,” but also broadens the scope of analytic opportunities available during “the early phases of discovering and evaluating ideas prior to the development of specific artifacts or systems.” From this perspective, this essay delves into a family of social science framing approaches that address the built environment to provide insight into increasingly complex design problems, which fall within multiple domains of knowledge and disciplinary areas of expertise.

Like most of the design professions, the practice of architecture is inextricably object oriented, with its strongest affinity to the building scale and the narrative of the design architect’s intuitive relationship to it. However, as buildings continue to evolve into more complex assemblies, modern architects have been required to develop design and coordination competencies that differ from their professional predecessors; skills which span a wide range of building systems planning, construction, management, and visualization skills. And thus, although the need to appropriate relevant competencies of neighboring fields has steadily existed, the requisite knowledge base necessary to perform building design tasks is shifting in some respects. Evidenced in the increasing demand for specialty consultants who regularly participate as part of the design and construction of buildings, high performance development teams embracing sustainability most notably reflect this change. This need signals to potential shifts in how the design of the built environment is understood, and subsequently suggests that as the number of roles involved in building design processes continues to expand, the conception of the architectural design artifact itself, the building, is also shifting. So, while the design professions broadly assert that, “sustainable design must be capable of changing user behavior,” implicit in this statement is that the same professions must also be capable of changing themselves. Recognizing that social science perspectives are widely viewed as recasting design research “from a study of things to a study of people,” this essay focuses less on a “what to do” and “how to do it” approach in relation to building design, and instead explores how social science approaches augment how the design of the built environment is understood. From this departure point, the bridging concept

of assemblage - derived from intersections between the research interests of Science and Technology Studies (STS), critical urban theory, and assemblage urbanism - is unpacked to highlight social science approaches to engaging complexity in building design.

The Challenges of Engaging Complexity

Added to these issues is the question of what knowledge base architecture should be founded on. What is the fundamental knowledge that we architects possess? Architects of every variety often ask, “How can we work from principles when what we do is produce artifacts?” Yet during the design and construction of buildings, they regularly translate a wide range of concepts into simple design heuristics and inadvertently consume the theories of neighboring fields. Whether in the form of applied science embedded in building technologies or in social theories of human interaction used to justify program placement, the process of effectively mobilizing a wide breadth of knowledge is necessarily heuristics-oriented. Therefore, it is not altogether surprising that unifying theories rarely factor into the practical working knowledge of most architects, nor that theoretic architectural discourse is regularly observed as struggling to communicate to wider audiences. This gap highlights the potential accessibility that a broader social science perspective might add to current approaches to understanding architectural building design by opening up alternate ways of thinking about how design both engages complexity and shapes it.

Arguably, this iterative notion has been acknowledged for some time and in many rhetorical forms. Fletcher and Goggin point out the phenomenon of “reciprocal action,” which attributes to design the achievement of “environmental, economic, and social policy goals at national, regional, and international levels,” and in turn, the understanding of “the role of design in creating more sustainable forms of living and working is a reflection of the broadening concerns and issues that are increasingly accepted as influencing the work of designers.” In sustainable construction efforts, this relationship has translated into examples that include the promising work of researchers of Moffat and Kohler, who propose methods rooted in a social ecological systems (SES) framing to expand building boundary conditions that reflect this stance. By assessing the total sum of material flows in and out of multiple housing block developments and emphasizing the physical flows between buildings within larger parcels of land, the work provides an alternate way of understanding architecture within the urban landscape from a dynamically linked, multi-site perspective.

Notably, social and environmental interests consistently encourage a framing of design problems and planning on an urban scale, instead of conceptualizing the design objects as functioning solely within the scales of the building.

This example also highlights how mixing divergent approaches can generate conflicts between varied theoretic sources. The weakness in the conceptual mash-up in this case stems from what transitions researchers Smith and Stirling highlight in social-ecological systems (SES) literature as “understandably,” infrequent consideration of “the dynamics of technological change in any detail.” Here, inadequately addressing the overlaid source material’s

9. Ibid.

Bharathi
assumptions toward its field of interest (e.g., dynamics of ecological behavior) poses clear drawbacks to sustained mappings onto building and urban scale development processes. However, the case also highlights valuable, ongoing boundary work where issues of social justice, ecology, and the responsible use of resources mediate the design of buildings. In addition, the example illustrates issues specific to building design relationships, underscoring that further efforts need to be made in this area to flesh out building designers’ understanding of: “What conflicts exist when incorporating social science approaches into the inherently object-rooted endeavors of building construction and design?”

What Can Social Science Perspectives Add to Understanding Building Design?

For architects, disciplinary boundaries are not always clearly defined. Practitioner, scholar, and large practice sustainability leader Ken Yeang observes that, “while the need to know originates in one discipline, the required knowledge itself often belongs to many others.” He continues, further elaborating the challenge facing building designers in the following statement:

The more we extend, the more we are also forced to trade off knowledge for data, exchanging theoretical concepts for ‘hard facts.’ As a result, architects often end up appropriating the knowledge from other disciplines as an ever growing database of strategies from which they can pick something that seems appropriate to the task at hand.

Here, Yeang highlights that added complexity, whether in the form of technical, social, economic, or environmental issues, creates challenging conditions for those who design and construct buildings. His statement suggests that errors of overemphasis, omission, or even explicit misunderstanding in the process of knowledge appropriation in building design endeavors are not infrequent occurrences. However, what is also important to recognize is that neighboring fields, including the social sciences, make the same errors of overemphasis, omission, or inadvertently misread source material in their own genuine efforts to extend the understanding of the built environment.

In the work of sociologist Thomas Gieryn, a central aim in social science inquiry is described as intending to reveal causal relationships embedded in social practices. Gieryn states that assessing the “recursive qualities” of the buildings through the use of the “theoretical orientation developed initially for the study of machines” is a means to rethink what buildings actually do, as opposed to what the design fields might claim. However, the adopted mainstream social science reading of buildings as “technological artifacts, made material objects, and humanly constructed physical things” lacks notable balance with longstanding traditions in the design discourses of architectural, landscape, urban design, and planning, which clearly contradict this perspective. It could also be argued that this approach omits a critical aspect of the object of study and instead reinforces problematic reductive notions of what the urban form comprises. Yet, despite these potential pitfalls, employing perspectives outside the fields of architecture and urbanism, that use differing analytic mechanisms and as a result produce alternate readings, can potentially highlight dominant framings within the respective fields. Centrally, comparative examination of where the emphasis is placed or omitted in framing perspectives yields a better understanding.

15. Yeang, Foreword, vii-viii.
16. Ibid.
18. Ibid.
understanding of analytical positioning:

The focus is on the recursive qualities inherent in technological artifacts, at once, the product of human agency and a stable force for structuring social action. Buildings, as any other machine or tool, are simultaneously the consequence and structural cause of social practice.\(^{19}\)

In this quotation, Gieryn stresses the relationship between social and technical aspects of an artifact, but neglects scale or specific functional markers that typically are critical typological identifiers in construction and design discourses. However, he also acknowledges that shortcomings exist in applying a social science approach to socio-spatial phenomenon and writes that “sociologists once believed that scientific truths ‘floated free in the air,’ detached from material moorings in the bodies of investigators, the wires and tubes of experimental instruments, or the doors and walls of laboratories.”\(^{20}\) Continuing facetiously, he concludes: “sociologists could take buildings more seriously, but maybe not too seriously.”\(^{21}\)

In addition to wry humor, Gieryn's analysis also underscores what social science framings effectively address. For example, he describes how the iterative socio-material process during the design effort of a Cornell University biotechnology lab takes form in the interaction between participants of planning meetings and presentation renderings, and he draws attention to the ephemeral “shaping and editing” process that occurs during design processes.\(^{22}\) This method of observation is of explicit use to the design fields because it empirically usurps the traditional assumptive notion of linear building design processes, which within the practice today still strongly relates to project pricing, public rollout, and delivery schedules. Similarly, researchers Guy and Farmer also recognize that the strategies proposed in conjunction with building development are constantly in the process of being shaped by many different actors, rather than solely determined by strict technological innovation or aesthetic or economic concerns. In their work, they show how framing perspectives categorically anchor differing architectural discourses, which in turn are linked to proposed solutions. Within each discourse the authors highlight what is considered “subjective” or “objective,” offering insight into how decision-making in proposals for the built environment can shift, depending on which framing mechanism is used.\(^{23}\)

By treating these competing views as environmental discourses that take material form in the shape of buildings, we can recognize the tension between alternative environmental beliefs and strategies. Thus, by adopting an interpretative framework, and by exploring the notion of discourse, we highlight the social production of space, place, and the environment.\(^{24}\)

The previous example of sociologist Gieryn’s work illustrates one of many social science efforts involving the superimposition of an external practice’s perspective (e.g., sociology, etc.) to the evaluation of processes within a separate practice (e.g., design of the built environment). In contrast, the collaborative work of academic architect Simon Guy and practitioner/researcher Graham Farmer locates their efforts from a vantage point distinctly within the field (e.g., by parsing specific rhetorical directions within the architectural discourse on sustainable buildings). However, they also use the social science analytic of discourse analysis in their work. Both approaches frame architectural complexity in the profession from alternate valid points of access and highlight how social science perspectives have the potential to add

19. Ibid.
20. Ibid., 45.
21. Ibid., 65.
22. Ibid., 41.
24. Ibid., 140.
to the conceptual understanding of design endeavors and resulting outcomes.

However, both approaches also raise additional queries, such as: What other fruitful points of analytic access exist? Could design processes benefit from an even closer social science orientation? If so, what might those benefits be? And what concepts have the most potential use? Keeping in mind how field framings can impact analysis of the built environment, the bridging concept of assemblage is discussed as having the potential to facilitate greater connectivity between perspectives on building design located within and outside the practice of architecture. In the following sections, the implications of the concept of assemblage thinking in relation to building design are comparatively traced within its root concepts: the social science perspective of STS, critical urban theory, and assemblage urbanism.

The Process of Locating Emphasis

How do we take knowledge from another discipline, and adapt it to our own? 25

Conceptually, assemblage is broadly accepted as a late twentieth century translation of the concept, “agencement,” from the work of scholars Deleuze and Guattari, whose “philosophical apparatus” has only been “partially linked” to the majority of current theoretic orientations using the term. For example, De Landa’s focus on issues of social complexity and multiplicity falls more squarely within the vein of Deleuzo-Guattarian inquiry, than the work of Latour, Callon, and other scholars who focus on actor-network-theory, etc. However, assemblage continues to gain traction “in a descriptive sense, to describe the coming together of heterogeneous elements within an institution, place, built structure, or art form,” 26 and along these lines, it shows promise in the discussion of complex, multifaceted problems, such as sustainable development issues. Although as a concept it is no more critical than “notions like capital, labor, space, or urbanism,” 27 it does provide alternatives to the rigid prerequisites of network, class, and systems thinking, which prioritize organizational problem situations. 28 The potential of assemblage thinking in relation to the built environment appears to lay in its connective possibility beyond strict organizational or disciplinary concerns. However, to substantiate this claim, further inquiry is needed to locate its origins of thought and the potential assumptions they bring to building design efforts. The following sections begin to explore the intersections between three central perspectives involved in current assemblage debates that focus on the built environment.

Science & Technology Studies

STS has been described as sharing a “basic disposition” within the constructivist tradition, where the normative or conventional boundaries between society and technology are dissolved. 29 Despite assertions that the field is anti-perspectivalist, 30 the philosophy of science and political scientist Landon Winner suggests that two primary identifiable strategies are salient in the approach. 31 The moderate views of scholars such as Bijker and Pinch “maintain the notion that society is an environment or context in which technologies develop,” 32 they incorporate a malleable view of the contexts in which knowledge is constructed and accept that a diversity of wholes can be

32. Ibid., 366.
generated from a heterogeneous mix of elements. This view contrasts with the more extreme views of Callon and Latour, who assert that “the modern world is composed of actor networks in which the significant social actors include both living persons and nonliving technological entities.” Central to STS work challenges Merton’s views that “research needs to be disentangled from the social and the psychological, and entangled solely with logic, with facts, and with methods for determining the facts.” Much of the STS efforts have focused on the social context of scientific knowledge and suggests “that methods in natural science and social science barely catch their own performativity” and tend to distance themselves and their inquiries from “multiplicity, shape shifting and the indefinite.” In STS “construction,” the emphasis is placed on the iterative, back-and-forth processes of how ideas are formed, with the recognition “that scientific knowledge and technologies do not evolve in a vacuum; rather, they participate in the social world, being shaped by it and simultaneously shaping it.”

**Critical Urban Theory**

In contrast, the explicit focus of critical urban theory is distinctly different, engaging in the “politically and ideologically mediated, socially contested and therefore malleable character of urban space - that is, its continual (re) construction as a site, medium, and outcome of historically specific relations of social power.” In Brenner’s view, critical urban theory recognizes inherited historical urban knowledge and its specificity, which scholar Anique Hommels coined as the “obduracy” of the built environment. She illustrates the concept by providing interconnected examples of where existing urban formations, such as expansive roadway systems and the construction of public train systems by competing groups and to differing technical standards, can set the trajectory for subsequent respective but connected outcomes, such as suburban housing models and difficulty in introducing effective public transportation or linking parts of existing systems. Fundamentally, a core aim of critical urban theory is to simultaneously highlight and critique “ideology (including social-scientific ideologies),” as well as “power, inequality, injustice and exploitation” in the urban context. The approach asserts “that another, more democratic, socially just and sustainable form of urbanization is possible, even if such possibilities are currently being suppressed through dominant institutional arrangements, practices, and ideologies.” Although critical urban theory does not appear to share overtly rhetorical interests in the discussion on assemblage, theoretical discussions locating the interests of assemblage urbanism regularly include critical urban theory within their scope.

**Assemblage Urbanism**

Assemblage urbanism, described as being primarily concerned with the questions, “what is the city, what is urban life made of, how do cities organize collective life?”, claims roots in both approaches, and tries to extend STS analyses beyond laboratory studies to the built environment while also claiming the theoretical stance that critical urban theory uses to ground its political and ideological motivations. Conceptually, the combination signals a compelling direction for the interests of both fields as a means to potentially open up alternate ways to understand the built environment and as a means to...
deepen the understanding of what constitutes meaningful contextual process. Assemblage urbanism blends STS constructivist approaches with the agenda of critical urbanism, with its aim being to “move away from a notion of the city as a whole to a notion of the city as multiplicity, from the study of ‘the’ urban environment to the study of multiple urban” assemblages. Assemblage urbanism blends STS constructivist approaches with the agenda of critical urbanism, with its aim being to “move away from a notion of the city as a whole to a notion of the city as multiplicity, from the study of ‘the’ urban environment to the study of multiple urban” assemblages.44 Brenner et al. summarize the beneficial uses of assemblage urbanism, outlined in McFarlane’s 2011 text, as follows: 1) as a descriptive empirical tool to aid in understanding how existing urban configurations are composed, 2) to raise researchers’ awareness of the “problematic of materiality,” and 3) as a means to encourage critical future visions of the city imbued with “a political sensibility containing a distinctive image of the desirable city-to-come.”45 Assemblage urbanism looks to combine strands of constructivism in the first two points with the critical urbanist agenda of the third.

The melding of social constructivist and urban scale-focused approaches potentially addresses the criticisms leveled against each respective body of scholarship. Specifically, in critical urbanism, the weakness voiced has been in its assumptive stance of dialectics in relation to capitalist development, which presumes to represent “the whole of the process” and requires a “necessary causal relationship between content and action.”46 In constructivist approaches, both veins have come under heavy criticism from Winner for “almost total disregard for the social consequences of technical choice.” In particular he critiques an overrepresented focus on innovation, favored conceptions of which actors are involved in social processes, as well a limited approach to the “dynamics evident in technological change.”47 Meanwhile, sociologist and historian of science Olga Amsterdamska critiques their tendencies toward postmodern absurdist relativism.48

Thus not surprisingly, combining the approaches also has its challenges, as evidenced in debates concerning how the concept of assemblage should be rightfully deployed: as an empirical description, a methodological tool, or an ontological perspective. Specifically, the intent to apply assemblage thinking ontologically to urban issues has been flagged as deeply problematic for the vagueness of its claims by proponents of theories oriented by institutional class, such as critical urbanism.49 Researcher Ignacio Farías argues:

If we stick to assemblage thinking in its Deleuzian inspiration...or to the version of it we find in actor-network theory...that is, as an ontological argument, this [approach] has only little if anything in common with the Marxian inspired project of critical urbanism.50 He continues, asserting that assemblage approaches significantly diverge from the “notion of power as a resource a ruling class possesses and of knowledge as an ideological construct” needing to be revealed, and that critical urbanism does not reflect the “engagement with the world that ANT and other assemblage perspectives” represent.51 Parallel to this view, McFarlane describes the interaction of assemblages as “a symbiosis defined less by conflict and contradiction and more by the lines of flight that run through them, where ‘line of flight’ names the possibility of creating something new.”52 In this regard, Brenner et al. acknowledge the potential to provide “some important new prospects onto the urban question,” although the authors also express concern regarding the ambiguity of the aims of assemblage and ask whether it elects “to deepen, extend, transform or supersede the analysis of capitalist structurations of urbanization.”53

The line of Brenner et al.’s critique logically follows their position as critical
urbanists, but it overlooks the problems that arise from assemblage urbanism’s mix of both types of constructivism found in STS. McFarlane acknowledges that assemblage urbanism resonates more strongly with the more radical form of constructivism, along the lines of Latour and Callon, but with two exceptions:

First, more than ANT, assemblage, due to its focus on relations of exteriority, attends to the agency of the interactions and the component parts, rather than the former alone: The agencies of the assemblage’s human and nonhuman parts are not exhausted by the interactions alone. 54

Second, assemblage urbanism accepts “the possibilities of human and nonhuman relations holding together in uneasy interactions,”55 and this perspective recognizes the subsequent consequences of physical interventions.56 Given the interest in assemblage urbanism to overlap with the social justice agenda of critical urbanism, in which historical formations are important, the seemingly contradictory desire to locate assemblage urbanism in close proximity to Actor Network Theory is necessarily mediated by more moderate forms of STS constructivism.57

In addition, despite Latour’s keen observation that unless “a way to do for buildings the reverse of what Marey managed to do for the flights of birds and the gaits of horses” is found, “architectural theory will be a rather parasitical endeavor that adds historical, philosophical, stylistic, and semiotic ‘dimensions’ to a conception of buildings that has not moved an inch,”58 superimposing a strictly ontological constructivist ANT-based reading onto activities in architecture and urbanism is potentially reductively problematic in a singularly critical dimension. Specifically, as Reinhold Martin points out, “for Latour as for so many others, the problem of postmodern semiotics is that its signs (and we must assume, its decorated sheds) are insufficiently real.”59

Another well-known example of this tension is evident in an exchange between scholars surrounding the interpretation of a series of bridges constructed by divisive New York planner Robert Moses, which sparked an academic debate in the early 1990s that, according to Winner, inadvertently highlights the “political naïve” conclusion-making of STS constructivism, evident “through the use of postmodernist interpretive irony.”60 Winner argues that public infrastructure was constructed in part to segregate the city, which can be traced through the effect of the role of bridges in the city, as well as the documented personal history of Moses during this particular political period. Woolgar and Cooper counter that a “measure of impartiality” resides in readings of the structure outside a political artifact, and that Winner’s reading introduces a prejudicial analysis. Winner concedes that of course multiple readings of text/technologies are valid analytically, but that it is “wrong to suggest that the issue is simply not decidable” in terms of what is socially just.61 As a debate that perpetually re-emerges,62 the discussion hints at the potentially problematic ambiguity in assemblage urbanism’s outlined agenda which like the constructivism Winner critiques, fails in its current form to “move beyond elaborate descriptions, interpretations, and explanations to discuss what ought to be done.”63

55. Ibid.
60. Winner, “Upon Opening the Black Box and Finding It Empty,” 374.
61. Ibid.
63. Winner, “Upon Opening the Black Box and Finding It Empty,” 374.

Bharathi
Conclusion

Architectural building design has a long tradition of drawing inspiration from and aspiring to balance environmental, social, and technical aims in its aspirations for the built environment. However, in modern practice with green ambitions, these interests are often skewed toward primarily technical considerations within the building scale.

Most buildings are no longer simple vessels, shells formed around use, but machines of enormous complexity, coursed through by numerous systems that control the environment of its interior and connect it to the external world.  

This quotation from architects Kieran and Timberlake highlights the reality of the growing complexity of technical building installations, but it also supports the assertion that the increasing weight of technology-related considerations in building design tends to dominate the process, even when environmental interests are placed in the foreground during programming and conceptual design. In the previous sections, combining the aims of building design with social science approaches highlights a variety of ways to engage complexity, and in each example, it is the urban scale that is intended to represent the collective interest and links the analytic framings. Shifting the emphasis to the social in the analysis of building design has been shown to shed light on research topics ranging from the production of knowledge shaped by spaces within buildings, to how the design of the built environment relates to concerns of social justice, as well as how the construction of design discourse relates to proposed building solutions.

At a time when ideas of urbanity are being rethought globally, and as buildings and how we produce them begin to change, so will the professions affiliated with their design. As a problem orientation, assemblage thinking has the potential to act as a conceptual design umbrella across professions and design scales. In the endeavor to build responsibly, designers face genuine challenges in reflectively developing and implementing solutions that support the facilitation of nothing short of a revolution in the way the built environment is conceived, constructed, maintained, consumed, destroyed, and reused. Yet to actively participate in shaping the agenda for our globally interconnected urban landscape, the inherently mixed character of design must be analytically explored to the fullest extent to achieve what Frampton refers to as “the realization of certain expressive vales.”

The ongoing discussions at the crossroads between STS, critical urban theory, and assemblage urbanism suggest that stronger engagement with the interests of the social network of actors surrounding built environment case studies could facilitate alternate readings of what occurs during design processes and could more accurately reflect the varied and “continuous process of learning and adaptation.” Centrally, revealing the intersections between these approaches yields benefits similar to what DiSalvo observes in the construction of publics, where “the opportunity to contribute to an emerging, reinvigorated discourse on the public occurring across the arts, humanities, and social sciences,” can “offer a position from design studies that expresses a distinctly intimate knowledge of the made and the making of things.” In addition, specifically within the publics constructed around the discourse of built environment sustainability, critical interactions between green design interests and collective political action could be further articulated.

Insofar as the approach emphasizes processes of reanimating the interaction between roles previously seen as static, assemblage thinking is recognized as a useful analytic lens through which the multiplicity of design practice can be meaningfully reconsidered.
Bibliography


Bharathi
Energy and buildings research: Challenges from the new production of knowledge

Introduction

The future of energy and buildings research is integrally linked to the extended view of the built environment, as well as to research and those who conduct it. Along with the observation that topics of investigative focus and their analytic criteria have changed considerably over time, it cannot be assumed that what researchers think of as interesting challenges today will yield conclusions that are considered relevant tomorrow. Therefore, the current changes in the relation between research and society need to be explored in the field of energy and building research. A social study of science is useful to provide this wider context.

The motivating rationale behind this paper was initially generated from observations made in 2003 by one of the authors who interviewed 14 architects and engineers working in a large Norwegian interdisciplinary building and energy research project called SmartBuild. Dubbed a ‘user-oriented’ project aiming at the development of energy-efficient buildings, this project explicitly presented itself as an interdisciplinary crossover between application and basic research. Not surprisingly, a topic raised by every interviewee was the paramount importance of end-users and interdisciplinary collaboration for their research. However, the analysis of the interviews revealed that for half of the interviewees, interdisciplinary work was actually a way of not dealing with end-users’ demands. These demands, they argued, were the problem of their respective colleagues from other disciplines who work with users. This was in stark contrast to the other half of the interviewees who eloquently described how they genuinely enjoyed professional discussions between disciplines, in addition to engaging issues involving end-users. These researchers, who promoted holistic views on building performance, also worked to develop additional working methods based on tight interdisciplinary collaboration, such as in advanced integrated facades, coordinated design and building processes (Reed and Gordon 2000). Thus, despite their opposing claims, the first group remained firmly rooted in a traditional scientific mindset, based on a clear vision of research that does not engage with its users at all. However, the second group represented something new, which according to leading observers of science and technology is in the process of becoming the pervasive mode of knowledge production. In the aftermath of Gibbons et al.’s The New Production of Knowledge (1994), the idea has been accepted that traditional research institutions find themselves in an ever-more-complex heterogeneous landscape of knowledge producers. Scholars of the relationship between science and society argue unanimously that knowledge producers increasingly need to engage in context and problem-driven research conducted in interdisciplinary teams. This is necessary to adequately address the complexity involved in issues related to the built environment. Recognizing that the future of energy and buildings research strongly relates to the overall development of research in society forms the basis for the work presented here. In addition to a discussion of recent theorizing about new roles of science in society, the self-reported views of active energy and buildings researchers on the current state and future challenges of their work was gathered to investigate the divergence between traditional research approaches and new forms of knowledge production within energy and buildings research.

1. The project was funded 2002-2008 by the Research Council of Norway. The interviewees were participants in the research project and working as researchers at the two main project partners NTNU and Sintef. For more information about how both groups were distinguished and other findings of the interviews, see Berker (2004).

2. For the project’s self-description, see http://www.ntnu.edu/energy/smartbuild/.
The New Production of Knowledge

Traditionally, society is seen as an important context of science but not as part of its content. In the history of science such an understanding of scientific autonomy is usually connected with the normative structure of science described by the sociologist of science Robert K. Merton (1942/1973). His four principles, known as CUDOS norms (Communalism of research findings, Universal validity of findings, Disinterestedness, and Organized Skepticism), draw a strongly guarded line between universal science and partial interests of parties that populate society. Supported by post-Second World War science and technology policy, these norms created a fundamental division between ‘basic’ science, which is located ‘outside’ of society and ‘applied’ science which operates within society. So called ‘science push’ models of technological innovation, often traced back to Vannevar Bush’s *Science: The Endless Frontier* (1945), suggest that universal principles discovered by science are subsequently applied to create the new technologies that society may or may not need.

Since the 1960s these ideals and the corresponding practices of science, as well as engineering and architecture, have increasingly come under attack from various sides. Often this led to a romantic defense of pre-industrial forms of indigenous cultures, while modern technologies, and frequently, their protagonists and principles were blamed for the unintended consequences of modernization (Beck et al. 1994). These criticisms were aimed primarily at those seen as responsible for the kind of technocratic large scale planning that characterized the societies involved in the Second World War and that was continued in the 1950s and 1960s. A corresponding critique of technology policy for a linear understanding of development (e.g. the ‘science push’ model) called for a democratization of science, technology and planning. With social scientists and anthropologists entering the secluded laboratories of modern science (Latour and Woolgar 1986) and producing outsider accounts of scientific research as it was happening, a less normative and more descriptive appraisal of scientific practice was established.

These studies described in great detail how science was more closely bound to its societal contexts than Merton’s norms would allow. The ensuing conflicts were triggered by the counterattack of the promoters of Mertonian science. These so-called ‘science wars’ gained intensity from a conflation of the older strand of modernization critique with the newer efforts of describing scientific practices, a confusion which occurred on both sides of the confrontation. These conflicts have long since subsided and today hardly anyone within social studies of science asks whether Mertonian norms should be valid or not. Instead, researchers explore how these norms are reinforced and which competing norms exist. The fact that science is increasingly subject to extra-scientific demands is not any longer controversial. Additionally, as Jacob (2005) notes, there is equally little doubt today that science is a distinct activity, which cannot be reduced to societal factors.

A common contemporary way of analyzing the links between science and society distinguishes different kinds of science with varied degrees of societal involvement. In an early form, the theory of finalization (Weingart, 1997) claims that mature branches of science are less autonomous and more directed by non-scientific contexts of application. More influential in current discussions, Funtowicz and Ravetz (1993) acknowledge the advent of a special kind of science, which they called post-normal science. They claimed that

---

3. For ethnographies engaging with engineering and architectural practice, see Latour (1996) and Yaneva (2009) respectively.
under certain conditions, characterized by high decision stakes (i.e. high risk and urgency) and high uncertainty, a new kind of science that goes beyond professional consultancy and applied science has evolved. Specifically, this is a science that manages to ‘make ignorance usable’. What they called ‘postnormal’ science relies on an extended peer community, which includes those affected or with special knowledge about the problem. Using the example of climate change induced sea-level rise, they claimed that this also changes the role of scientific values:

Public agreement and participation, deriving essentially from value commitments, will be decisive for the assessment of risks and the setting of policy. Thus the traditional scientific inputs have become ‘soft’ in the context of the ‘hard’ value commitments that will determine the success of policies for mitigating the effects of a possible sea-level rise. (Ibid., 195)

This description of new forms of evaluating scientific outcomes is similar to what Gibbons et al. (1994) called ‘social robustness’ as a dominant quality criterion within ‘the new production of knowledge’. According to their diagnosis the whole of knowledge production has entered into ‘a new mode’ and not only in specific research areas. Judged by the number of related publications, their ‘Mode-2’ description is the most influential and broadest effort to describe current transformations of knowledge production to date (Hessels and van Lente 2008, 748). In addition to society and its values having a say in deciding what is valid knowledge, Mode-2 theoreticians state that meaningful information is increasingly produced ‘in the context of its application’, where the context of scientific production ‘talks back’, and no longer passively receives the outcomes of science, but rather actively intervenes in its production. Reacting to feedback on their first book (Gibbons et al. 1994), the authors contended that there may very well be different degrees of contextualization of science (weak, strong and middle range). But the authors still claimed that all forms of knowledge production are moving towards a new, less secluded mode (Nowotny et al. 2003). Consequentially, the authors mobilized a broad range of observations that knowledge production is becoming increasingly problem orientated, more interdisciplinary, flexible, reflexive and dynamic, user oriented, more distributed in international networks, and less firmly institutionalized.

The central conceptual criticisms of this work focus on the dualism created when a seemingly coherent new mode is contrasted with an older one (i.e. Mode-2 versus Mode-1). This narrow binary representation has been accused of doing injustice to actual practices (Etzkowitz and Leydesdorff 2000, 116) and creating an unnecessary lock-in of how knowledge is produced, instead of engaging a broader variety of generative methods (Rip 2000). However, despite these criticisms, Hessels and van Lente (2008) showed that a large majority of publications discussing Mode-2 do so in affirmative ways.
In their current forms, the engineering and architectural professions have had a relatively short history of establishing boundaries around their specific expertise. The concept of the ‘architect as master builder’ or the ‘hero engineer’ no longer exists. This is attributed to the evolution of structure and architecture – both economically and conceptually into literally hundreds of specialties and sub-specialties (Kieran and Timberlake 2004, 29). However, both the engineering and architectural professions recognize that narrow specialization is problematic in developing robust solutions for the built environment and resist this categorization for education and practice. Layton (1971), one of the pioneers of engineering studies and an engineer himself, was one of the first scholars who sought to purge the field from the reputation of being ‘just’ application (e.g. of physics) by stressing its universal aspects. In the same way, architects have asserted to define their specific expertise distinguishing their knowledge from the provision of basic shelter. Many, like architect Mario Botta for example, refer to ‘the much profounder spiritual need to shape our habitat’ and the ‘aesthetic, emotional and symbolic meanings’ of architecture (Botta 1997, 10). The tension between practical divisions of labour and holistic views also characterizes debates around the year 1900 on the newly established early Western polytechnic education system, where the integrated training of architects with engineers was a much discussed topic and led to differing outcomes on the way the professions organize (Stevens, 1998, 168ff).

Despite the longstanding ‘sibling rivalry’ between architects and engineers (Saint 2007), the current renewed interest in sustainable performance criteria, holistic building design and construction methods is providing new opportunities to negotiate professional identities in practice (Abel 2004; Hardy 2008; Kieran and Timberlake 2004; Larsen and Tyas 2003; Lepik 2010). It could be argued that architects known for groundbreaking projects can do so because of access to the best available engineering collaborators, as well as to greater financial resources or cost per square meter for construction and design budgets. Inversely, it could also be claimed that in projects with smaller budgets and ambitions, the specialized roles of team members dominate, reinforcing professional boundary conditions, where architects address non-technical issues and engineers address technical ones. This is obviously not true in every case, although it is not to say that financial resources and accepted professional norms do not affect outcomes.

The fact that architects and engineers collaborate regularly in professional practice is not a surprise. However, most practitioners would also acknowledge that there are significant limits to what interdisciplinary collaborations entail in the field and to what degree research actively influences the practice. It is often because of the very site specificity of sustainable design that innovative strategies are difficult to implement. Whether this is due to lack of equitably distributed liability amongst researchers and practitioners, the additional time needed for innovation in design and construction, mistrust in the use of relatively young technologies, difficulty securing financing a long chain of actors (supply and operation), or a combination of these factors, the presence of these deterrents is relatively consistent in the process of most sustainable development efforts. This divide between academic research and the practice in the field of architecture is arguably greater than in the engineering fields,

---

4. For an in-depth account of the Norwegian side of the story, see Berre (2003).
since the development of practical architectural knowledge does not map well to historically Western deductive methods of abstract knowledge formation. Nor is it aided by a lack of collected, detailed studies and longitudinal studies. However, the pressing necessity to develop coordinated implementable sustainable strategies for the built environment presents itself to be a great opportunity to encourage a closer relationship between research and practice. As the practice becomes more aware of the economic and practical realities of what green construction entails, and the research fields move toward more heterogeneous and collaborative methods, new modes of energy and buildings research appear to be on the cusp of widespread reach.

A New Mode of Building and Energy Research?

According to the Mode-2 hypothesis, disciplinary divisions, as well as boundaries between applied science and basic science, systematically blur. The question now is how well energy and buildings research and researchers are prepared to meet these challenges. Based on the previous argumentation, it is plausible that either energy and buildings researchers continue to guard their specific expertise, possibly intensifying their efforts when their knowledge is devalued in favor of alternative skills more in demand within interdisciplinary work. Or alternatively, researchers connect to traditions and trends within their disciplines, which are open for integrated and user-oriented approaches. In the latter case, it would be interesting to ascertain whether building and energy research has lessons to offer other disciplines, which according to Mode-2 research are undergoing similar developments.

To explore whether and to which degree building and energy researchers embrace Mode-2 knowledge production, a questionnaire focusing on these issues was distributed in mid-2011 among active European contributors to the field. If the Mode-2 hypothesis is correct, then discrete disciplines are losing importance. Therefore, in the experiment design, the presupposed underlying population of the study was intentionally weakly defined as self-assigned ‘energy and buildings researcher’. Since little is known about the size from which the sample is drawn, the following exploration cannot be statistically representative. Still, as will be shown in the following results section, respondents present a consistently coherent image of the current state of building and energy research in relation to the Mode-2 hypothesis.

In June 2011, 150 targeted participants were contacted via e-mail to complete an online questionnaire consisting of 28 questions. The participants’ addresses were selected according to two criteria: Roughly one-third of the addresses were institutional (such as ‘info@. . .’) with the expectation that the respective institutional contacts would use their local knowledge to distribute the e-mail to appropriate individuals. The other two thirds of the addresses consisted of persons actively contributing to the field, among them the Northern and Central European contributors to the five last volumes of the academic journals Building Research & Information and Energy and Buildings. In addition, respondents were encouraged to forward the questionnaire to people they knew contributed to the field.
Results

Forty-two responses to the questionnaires were received. Of these responses only 24 have answered more than 25 percent of the questions and were subsequently included in the analysis. Two comments given by respondents suggest that the relatively high dropout rate was related to the unqualified use of the word ‘institution’ in one of the first questions which gave respondents unclear signals about the desired target group of the survey.

The combined distribution method resulted in a sample consisting of respondents mainly employed at universities (82 percent). Almost 40 percent of the respondents were trained as architects and 62 percent were either additionally or exclusively trained as engineers. In their day-to-day work they did research (89 percent), teaching (56 percent) and consultancy (29 percent).5 These numbers show that respondents were primarily university researchers who are often also engaged in teaching and - to a lesser degree - also serve as consultants. Although the selection has introduced a bias towards traditional university research, this is not considered problematic in the context of the present study. If the post-Mertonian norms of post-normal science and Mode-2 knowledge production have arrived at universities (that had formerly been once the main protagonists of Mertonian science), then it can be assumed that a significant change has occurred. However, it is important to bear in mind that the focus of the survey is mainly about university researchers when interpreting the results. Their institutional affiliation clearly shapes their perspective of the field.

State of the Art in Energy and Buildings Research

When asked for the current state of energy and buildings research, the strongest support was for the description ‘applied research’ along with the statement that the work is ‘dealing with climate change’ (Figure 1). While this sends a clear message pointing in the direction of post-normal science and Mode-2 research, there were opposing findings as well. Descriptions such as ‘dealing with high financial risks’ and ‘flexible’ had the lowest acceptance. Thus, high risk, the defining criterion of post-normal science, at least in its monetary form was not seen as important for energy and buildings research. Even though roughly one-third of the respondents said that they were (at least sometimes) serving as consultants, they seemed little involved in activities afflicted with financial risk.

In the next question the descriptions were turned into normative statements, exchanging ‘currently is’ with ‘should be’ (Figure 2). Here ‘interdisciplinary research’ scored highest. The next highest ranking values were assigned to ‘international networking’, ‘dealing with climate change’, ‘applied research’ and reflection on methods. The only result not fitting this list of characteristics valued high in Mode-2 research was that being based on ‘scientific principles’ actually ranked second highest. This is consistent with the general skepticism of involving research in ‘financial risk’ or dependence on industry support, which are among the lowest ranked items.

Comparing the respondents’ description of the current state of energy and buildings research and their normative prescriptions, three areas where the respondents were particularly unsatisfied with the current state of affairs were found. These topics where the respondents showed the largest discrepancy between the two queries was with regard to the topics of ‘reflecting on its

5. Multiple responses were possible, therefore the categories add up to more than 100%.
methods’, the awareness of ‘end-users’ demands and wishes’ and involvement in ‘societal discussions.’ Thus, the respondents saw the largest need to augment practices in areas central to Mode-2 research: reflexivity, user-orientation and societal involvement.

**Quality Criteria**

In the next two questions respondents were asked about how the recognition of quality in building energy research is currently determined and how it should be determined (Figure 3). Traditional quality criteria such as ‘scientific quality’ and ‘peer review’ scored high in the description of the status quo and even higher in the responses to what should be the case. However, among the four highest ranking criteria, non-traditional qualities like ‘relevance for environmental problems’ and ‘the effects of research’ were also represented. At the other end of the scale, ‘aesthetics’ scored very low both as current and desirable criterion. In the normative dimension it was only surpassed by ‘lobby interests’, which scored intermediately in the respondents’ description of the current state.

**Interdisciplinary Collaboration**

The high valuation of interdisciplinary collaboration, apparent in the previous sections, is reflected in the respondents’ actual research efforts. All but one respondent said that they have been involved in interdisciplinary work with collaborators from an average of five different disciplines. The topics for this collaboration were extremely diverse. Indoor environmental quality (IEQ) was the only one, which was mentioned more than once (four times). In two cases the collaborative goal was an evaluation of different aspects of existing buildings.
The Future

An open-ended question was included addressing the respondents’ expectations of focus areas within energy and buildings research in the immediate future (e.g. until 2020) and the long-term (e.g. 2020-2050). The primary combination of short- and long-term predictions anticipated the perfection of passive measures in the short-term and the development of active systems including renewable energy production in the long-term. A second group suggested varied scalar forms of integration between disciplines, between systems infrastructure (e.g. integration of water recycling, transport and telecommunication). Respondents predominantly shared the long-term expectation that energy and buildings research would shift focus from the building level to district, urban, regional, national or even European levels. Refurbishment was equally often mentioned as a short- and long-term focus area.

Discussion: Two Sets of Challenges

Based on the empirical exploration presented in the previous section and the discussion of energy and buildings research in the context of ‘the new production of knowledge’, two separate sets of future challenges are identified. The first one is related to the researchers’ self-description. Their portrayal of energy and buildings research is an applied science which deals with climate change and that should be interdisciplinary and internationally networked. This complies with basic descriptions of the new production of knowledge.
which was put forward as the Mode-2 hypothesis. However, there are also areas where the respondents are more in line with traditional Mertonian CUDOS norms than with Mode-2 or any other assumption about a new production of knowledge. The respondents are overall positive towards traditional quality criteria for good science such as ‘scientific principles’ and ‘peer review’. Moreover, they unanimously reject financial dependence on the building industry. These statements exist alongside a clear commitment to quality criteria controlled by extra-scientific parties, such as users and the environmental impacts of the research. However, it also suggests that the university researchers studied here are, in principle, ready to sacrifice scientific independence - but only to certain parties. Dividing not only between science and non-science (a necessity when following Mertonian norms), there is also a further set of distinctions being introduced between different nonscientific parties (e.g. industry versus users; financial versus environmental benefit). This poses new challenges to research: who is the ‘user’ of the research who is allowed to set the agenda (Shove and Rip 2000)? And who is speaking legitimately for the environment?

A second set of future challenges for energy and buildings research stems from the respondents’ own expectations of future research topics. Subjects were related to the integration of greater functionality into individual buildings, greater integration and infrastructure coordination. With buildings simultaneously gaining more internal complexity and greater external infrastructural connectivity, the need for integration of different kinds of expertise will only increase. In this respect the respondents’ call for methodological reflection is an adequate answer to the challenges awaiting energy and buildings research.
Conclusion

This article started with the observation of two different ways of conducting user-oriented and interdisciplinary energy and building research. If the Mode-2 hypothesis does in fact describe a secular trend within knowledge production, then the group of researchers that wholeheartedly engaged with end users’ practices and other disciplines’ expertise holds the key to the future.

While the actual outcome is uncertain, it is clear that the two sets of challenges for building energy research articulated in the above discussion will not go away soon. How the relationships between research and various extra-scientific factors (e.g. users, industry and environment) are defined will profoundly influence the direction of energy and buildings research in the next decade and far beyond. Similarly, a central factor shaping the field will be how and under whose lead will energy and buildings research achieve a tighter integration between different kinds of expertise.

The transition from one mode of knowledge production to another is not effortless. Instead, it is marked by frictions and hybrid forms - this is also acknowledged by the original authors of the Mode-2 hypothesis. Conflicts arise above all when expertise is devalued and existing hierarchies are challenged. For protagonists of Mode-1 knowledge production, the active engagement with extra-scientific parties, such as end-users, as well as tight interdisciplinary integration is difficult or may even prove to be impossible. However, evidence presented in this paper suggests that many building energy researchers are well prepared to participate in this ‘new production of knowledge’. Their efforts draw on a broad range of disciplines which are driven by a desire to contribute to the design and implementation of ‘good’ buildings, and a willingness to address contextual factors. The further development of interdisciplinary and context-sensitive approaches (including the management of contextual factors) is one of the most important challenges energy and buildings research faces in the next decade and beyond. Strong engagement with this position has significant potential to generate a wide array of research initiatives outside the building sector.
References


Between research and practice:
Experts on implementing sustainable construction

Introduction

While buildings play a central role in the cumulative effects the built environment has on rising worldwide emissions, it has also been repeatedly shown that the construction and design industries possess significant potential to mitigate the accelerating negative impacts of development through sustainable construction.\(^1\)\(^2\) However, the complexity involved in methods of calculation and evaluation has encouraged a primary focus on energy and efficient resource use within much of current operational discourse.\(^3\) Also, the process of attaining projected estimated energy-savings potentials has not always been adequately recognized as non-linear and highly influenced by diverse actors, and therefore often “ambitious targets fail to materialize into comprehensive strategies, effective instruments and transparent results.”\(^4\) Finally another growing concern indicated in the literature is that the narrower perspectives often associated with technology policy, with its focus on innovation linked to economic stimulation, as well as management policy with its emphasis on calculable losses, strongly shape how the regulation of sustainable development is being formed.\(^5\)\(^6\)

Within the field of the Science and Technology Studies (STS) the design and construction of buildings have been argued as scientific practices, since “science is nothing but a space that obtains authority precisely from and through sporadic negotiations of its flexible and contextually dependent borders and territories.”\(^7\) Subsequently, a central STS critique of sustainable construction implementation has been regarding the lack “appreciation of the social contexts of energy saving action and of the socially situated character of technical knowledge.”\(^8\) Additionally, scholar Elizabeth Shove argues in her article, “Gaps, Barriers and Conceptual Chasms: Theories of Technology Transfer and Energy in Buildings,” that notions of technical potential, the discourse of gaps and barriers, as well as the focus on technology transfer often create a problematic “web of taken-for-granted belief strong enough to encapsulate” the wide range of sectors affiliated with the design and management of the built environment and “elastic enough to span countries and continents.”\(^9\) She suggests that by recognizing differing countries possess varied histories linked to alternate temporal patterns of development and actor networks, technological approaches to energy efficiency and the technologies themselves would be better understood as part of “unique socio-commercial” narratives that defy simple strategies of transfer. It is within this STS perspective of situated actor networks that the research presented in this article was formulated to develop a better understanding of the knowledge practices and concerns of Swiss experts linked to the implementation of energy efficiency measures and green development strategies.\(^10\)\(^11\)

Therefore in alignment with Shove, it is critical to acknowledge that as an analysis of a single case country - Switzerland, universal claims about the building industries cannot be deduced from the set of interviews presented here. Rather, the aim in this article is to situate aspects of the socio-technical process of sustainable construction within a specific country context through: 1) in-depth interviews with a subset of heterogeneous research and design actors and 2) reflection on expert-reported challenges.

As a research site, Switzerland was chosen primarily because it is well
known as a leader in environmental protectionism, but is also highly regarded internationally for its design and construction industries, in addition to housing a number of respected research and teaching institutions. Seen as a linguistic microcosm of Europe, but also recognized as sharing important parallel governance structures with much larger federal states, the overall transparency of the country's system of regulation, meant that all of the experts interviewed perceived to be working under a coordinated regulatory umbrella. Thus, this location provided a unique opportunity to explore expert perceptions of the relationships between energy research, practice, and sustainable construction.

Through semi-structured qualitative interviews, 31 experts were asked to reflect on their work in relation to industry trends. From these interviews ‘snapshots’ of the state of sustainable construction implementation from experts working within the Swiss context were developed. Given the small sample size this study is considered as exploratory and intended to gage current trends within the research and professional practices implicated in sustainable construction implementation. Central questions of interest were: What constraints were most explicit to them? What were their concerns, how were they framed and what did this suggest about their working context and expertise? How for example, were regulatory and disciplinary institutions viewed? New types of knowledge integrated? Perceived challenges mediated? Subsequently, the article is structured as follows: after outlining the framework used to shape this research, key terms are defined. Next, relevant aspects of Switzerland are detailed, and an overview of the empirical work is presented. Lastly, findings drawn from the data that show how experts mediate diverse challenges linked to sustainable construction are discussed.

The Built Environment as a Socio-Technical Network

Although the spectrum of scholarship referenced as Science and Technology Studies (STS) presents a variety of argumentation and terminology, all positions argue that artifacts can function as key actors and recognize that a diverse set of drivers both human and nonhuman mutually inform decision making. Primarily grounded in case studies, STS research has demonstrated sophisticated strategies for deconstructing technical expertise in the tracking of disciplinary history, how knowledge practices function as social institutions, and the underpinnings of philosophical positioning through close observation of actual practices. Of particular use in the analysis of socio-technical networks – which in this research centers on the relationships between sustainable construction implementation, research and professional expertise - is the notion of boundary work. Initially the concept evolved out of the perceived need to establish and maintain scientific legitimacy. However, other contemporary theorists alternatively posit that boundary work: functions as the interface ‘between communities with different views of what constitutes reliable or useful knowledge’; is focused on linking knowledge practices with action; occurs within social worlds not bounded by geography, but rather by the effective limits of communication; and lastly operates in concert with “boundary objects” that sit between and facilitate “multiple translations” of meaning across different social worlds. Fujimura's meta-concept of “standardized packages” also serves as an “interface between multiple

Bharathi and Nicol


social worlds,\textsuperscript{30} but effectively scales up the concept of “boundary object” and emphasizes its links to activities of “fact and skill” stabilization rather than destabilization.\textsuperscript{31-32} Fujimura’s work in particular provided an accessible tool to conceptualize how sustainable construction and the expertise affiliated with it fit into a broader socio-technical landscape of built environment discourse. Specifically, unlike Star and Griesemer’s narrower notion of boundary objects,\textsuperscript{33} standardized packages pool together several boundary objects such as concepts, technologies, and/or organizations.\textsuperscript{34} Thus, the outcome is the production of a “less abstract, less ill-structured, less ambiguous, and less amorphous” workspace that is narrower, but not definitive.\textsuperscript{35} For example this concept could be illustrated in diverse scenarios of sustainable construction: 1) as a bundle of technologies that are prescribed by a building standard (e.g. a building R value requirement that necessitates a particular insulation thickness and mechanical ventilation to achieve its performance); 2) by how discrete technologies can be prioritized over others within building subsidy programs (e.g. heat pumps or photo-voltaic panels); 3) by how the calculative assumptions embedded in a software modeling tool shape spatial design outcomes; 4) or how the development of certain building typologies can be encouraged or discouraged through lending practices, architectural competition processes etc. Essentially, within the operational context of this study, this concept helped determine the selection criteria in finding experts to participate in a purposeful qualitative sample\textsuperscript{36-39} of individuals linked to boundary objects implicated within standardized packages such as, for example boundary organizations which might include research institutions, public authorities or other knowledge transfer groups (See Figure 5) and also opened up the interview pool to include the perspectives of experts involved in planning projects and mobility infrastructure. Additionally, during the interview phase of this research, this concept informed which types of socio-technical relationships were pursued for discussion.

**Key Terms**

Since the terms ‘stakeholders,’ ‘experts and expertise,’ ‘sustainable construction,’ and ‘drivers and barriers’ are frequently referenced, they are briefly outlined here to indicate how they have informed this study.

**Stakeholders**

The concept of stakeholders and their management references the organization of groups/individuals around specific focal issues, where a smaller group represents much larger groups of individuals\textsuperscript{40} and reflects a greater mix of actors.\textsuperscript{41-42} Sustainable construction is a suitable example of such a focal point as it is not a topic that is relevant to single individuals and organizations, but is globally important. In addition, critically acknowledged across the literature is that no single group can effectively change common practice.\textsuperscript{43} Rather, harnessing the interest and input of actor networks who are not directly involved in decision making processes but are both impacted and have the potential to impact others is an important aspect of an issue oriented conception of stakeholders.\textsuperscript{44-45} According to Feige et al., research conducted in the Swiss context has shown that in sustainable construction efforts,
key stakeholders fall into three main categories where ‘internal, strategic stakeholders’ are concerned with different phases of the project’s life cycle, and ‘both internal and external stakeholders,’ as well as ‘external, normative stakeholders’ represent an interest in all phases of a project’s life cycle. In this view, ‘planners/designers’ are indicated as functioning in a categorical role of ‘internal, strategic stakeholders,’ along with investors, manufacturer/suppliers, banks/financial institutions and end users/owners. ‘Researchers/educators’ are designated as ‘external, normative stakeholders’ beside civil society and non-governmental organizations (NGOs), the media, environmental groups and the interests of future generations. Lastly, this schema recognizes a diverse range of actors involved and creates horizontal links across the categories through the ‘main concerns’ of each grouping such as ‘regulation,’ ‘knowledge,’ ‘corporate social responsibility,’ ‘economic feasibility,’ and ‘personal beliefs’ which bridge the categories. Also, a distinction is provided in regard to technology between the interests of ‘planners/designers’ and ‘researchers/educators,’ where the former group is focused on its “creative and efficient application,” second to “knowledge” and the latter group emphasizes “knowledge,” second to “technology.”

Experts who fell within the overlapping zones were targeted for interview (Figure 1).

**Experts & Expertise**

The term ‘experts’ is not a neutral term that denotes social-cognitive capacities. Rather, ‘expertise’ is explicitly recognized as context dependent knowledge that is social and performative. Following STS relational theories, ‘expertise’ references “one’s position in a network of other actors rather than a substantive theory of expertise, in which the nature of expertise itself is the object of investigation.” Specialist ‘expertises’ range from individuals who have superficial knowledge of incidental facts to interactional expertise and

---


contributory expertise (Figure 2). Interactional expertise involves specialist tacit knowledge of a subject beyond primary or book knowledge. Although those with interactional expertise would be considered ‘fluent’ in a field, they would not qualify as having contributory expertise, which in this study meant being capable of actually performing design or research work. This notion is supplemented by meta-criteria of external and internal expertise. That is for example, external verification in the form of a professional degree, qualifications or publications and internal criteria such as standing within a professional community. In this study, the experts selected for interview held specialist, tacit knowledge linked to the research, design and implementation of sustainable construction and had externally verifiable qualifications.

**Sustainable Construction**

Common elements in definitions of sustainable construction have been found to involve energy consumption, reduction, and optimization; conservation of nature; the quality of the built environment and indoor health standards. Although all concepts encourage more holistic perspectives, the scope of construction research is understood as explicitly artifact oriented, involving processes that begin prior to construction, though planning and design, construction, use, and eventual demolition. Essentially by linking local building processes to broader, contextual concerns, such as resource protection, the construction agenda has been broadened by sustainability agendas. Critically, research framed by the term ‘sustainable construction’ typically articulates technical concerns as distinct from economic, environmental and social ‘pillars’ primarily referenced in planning focused frameworks, where technical concerns are a subset of economic priorities. In relation to the interview sample it was considered an important selection criterion that interviewees were linked to complete or ongoing physical projects. In line with the understanding of experts and expertise, it was assumed that this indicated

---

Figures and diagrams are not transcribed in this text format.
that interviewees respectively had direct experience in implementation issues (Figure 3).

**Drivers & Barriers**

Institutions can take the shape of legislation or organizations that can manifest in habits, traditions and social practices. Typically, the development of rule making is considered a key source of friction within the regulation of issue driven concerns such as sustainable construction, and can be precipitated by a combination of agency fragmentation and informational asymmetries. Informational asymmetries refer to ‘gaps’ in the decision-making processes between key actor groups such as the building and real estate sectors; construction and management; construction and use; in addition to urban-scale planning and building project development. As previously noted in the introduction, the concepts of gaps and barriers like information asymmetries have been argued within STS scholarship as oversimplifications of more complex processes. However, since pervasively used in working practice, it was considered relevant as interviewers to become familiar with these topics in order to recognize them, and subsequently redirect interviewees to focus on issues linked to specific boundary objects, the interaction between them and their experiences with the aim of teasing out possible relationships relevant to the notion of sustainable construction as examples of standardized packages. Drawing from current literature and 83 questionnaires, Pitt et al. rank widely reported drivers and barriers of sustainable construction, highlighting which social, institutional and material actors are seen as more or less challenging (Figure 4). Next, relevant details regarding institutional and material actors in the Swiss context are provided.

---


Case Country Switzerland

The radical shift in the Swiss building and design sectors was precipitated by the oil crisis in 1973, when the sharp increase in energy costs highlighted the poor quality of building construction and inefficient energy consumption linked in part to extremely low fuel costs. Although territorial energy consumption, greenhouse gas intensity and emissions roughly match European consumption patterns per capita, the country heavily relies on imports for approximately 80 percent of its needed fossil fuels and other combustibles. Also, despite producing roughly 56 percent of its electricity domestically, additional imports are needed in the colder months due to greater demand.

Second only to the transport sector, the Swiss building sector has been identified as an important source of greenhouse gas (GHG), at 19.7 Mt of CO$_2$e, which includes indirect emissions from the consumption of electricity. Direct emissions accounted for 17.6 Mt of CO$_2$e in 2005 or 89 percent of building emissions. Hence, the building sector has become an area of intense focus, as it provides opportunities to further significantly reduce GHG emissions through primarily retrofits (6.1 Mt of CO$_2$e), but also by shifting to alternative heating systems (4.2 Mt of CO$_2$e), more efficient new construction (0.7 Mt of CO$_2$e), and LED lighting (0.3 Mt of CO$_2$e).

Federal Legislation

Figure 5 highlights the links between current federal legislation, construction standards and knowledge transfer organizations. Current energy policy outlined in the Swiss federal constitution that impacts the building stock identifies strategic sectors where energy reduction measures must be addressed. However the respective cantons retain significantly more power in determining their implementation. This constitutional edict is supported by more detailed legislation in the form of the Energy Act and the Carbon Dioxide Act.
Figure 5: Overview of Key Relationships

- **Legislation**
  - 2011 Carbon Dioxide Act (SR 641.71)
  - 1999 Energy Act (SR 730)

- **Knowledge Transfer Organizations**
  - Conference of Cantonal Energy Directors
  - Swiss Association of Architects & Engineers
  - Novatantsis / ETH
  - NNBS Swiss Network for Sustainable Construction

- **Construction Standards**
  - MuKEn E<sup>DK</sup>
    - Model energy standards for the Cantons
  - **sia** E<sup>DK</sup>
    - Standards
    - New construction & renovation standards
  - **MINERGIE®**
    - New construction & renovation standards
  - **SNBS**
    - Sustainable Construction Standard Switzerland

- **Voluntary Labels**
  - **G</sup>EEK & **E<sup>DK</sup>
    - Swiss Cantons’ Building Energy Certificate Program
  - **G</sup>MINERGIE®
    - Trademarked sustainability brand
  - **SNBS**
    - Sustainable Construction Standard Switzerland

- **Award Program**
  - European Energy Award
The Energy Act explicitly outlines the responsibility of the cantons regarding energy consumption in the existing building stock and new construction, including specifications on, for example maximum allocations from non-renewable sources used for heating and hot water, and individual metering of heating and hot water. Yet, the legislation says little about building performance standards with the exception that by 2030 targeted reductions in residential energy use should equal that of the year the Energy Act was enacted (1999).

The main impact of the Carbon Dioxide Act (CO₂ Act), first enacted in 2000 but revised in 2011, on the building industries is related to the provisional tax affiliated with the law, which states that one third of the tax revenues, up to a maximum of 300 million CHF, must be used to reduce CO₂ emissions from buildings. This revenue is distributed to the cantons in two funding streams. The first source can be used to subsidize building envelope renovations, and the cantons are eligible to receive this money on the condition that all of the cantonal allocation programs are harmonized with each other. This falls under the name of the Buildings Program. The second stream of funding can be used by the cantons to increase the use of renewable energy sources, implement heat recovery, and update or install other energy-saving technical installations in buildings. Individual cantons may be eligible for these monies if they already have energy-efficiency and energy-reducing subsidization programs in place.

**Construction Standards & Voluntary Labels**

As stated previously, the Confederation provides guidelines for general spatial policy and energy laws; however, the explicit power to implement energy and building standards resides within respective cantons. Although this does introduce problems at the level of uniformity in development standards, steps have been made to coordinate the use of standards across cantons. The most prevalently used building standards originate from the Swiss Association of Architects and Engineers (SIA) and the Conference of Cantonal Energy Directors (EnDK), which are both organizations that function as key knowledge transfer groups. The EnDK also oversees a voluntary Cantonal building energy certificate program (GEAK), which provides potential buyers or renters transparent, comprehensible, building energy consumption information to inform their decision making. In addition, another widely used standard and labeling system is Minergie, a Swiss trademarked sustainability brand for new construction and renovations which outlines a baseline heat demand reduction to 90 percent or less of the limit of SIA standard 380/1. Both the SIA standards and those from the EnDK, the Model Energy Standards for Cantons or MuKEn, are legally binding only once a canton officially adopts them into law, and the policy aim is that each will do so at least in part.

Notably, revisions to the SIA standard have been made to reflect energy targets outlined in the MuKEn. Furthermore, several references are made in the MuKEn to Minergie, which although is not currently, directly mandated by law, is often cited as an eligibility requirement to qualify for federal building subsidies and bank loans. Frequently used as the primary benchmarking tool for Swiss politics, financing mechanisms, cantons, communities, private and public building owners, Minergie has been heavily marketed as combining...
energy efficiency in buildings with better comfort and added value. Since its development in 1994 by Ruedi Kriesi at the Swiss Federal Institute in Lausanne (EPFL), the label has become a widely used trademarked brand for new building construction and renovations, with a primarily technical focus on a combination of strategies that include controlled ventilation, selective double-glazing, external shading and insulation. Criticized as dimensionally simple approaches rooted in solutions that were once calculated manually, Minergie has not been without controversy concerning its potential restriction of architectonic expression and innovative non-standard solutions.75

Knowledge Transfer Organizations

There is a range of active knowledge transfer organizations in Switzerland that are linked respectively to the federal government (Swiss Energy), the cantons (EnDK), professional groups (SIA, home to both architects and engineers) and the university system (Novatlantis). As mentioned in the previous section the EnDK and the SIA are also affiliated with construction standards, and the EnDK also supports the GEA label. Swiss Energy is an extension of the Federal Office of Energy, and Novatlantis is part of the ETH domain, which is made up of the two Federal Institutes of Technology (ETH Zurich and EPF Lausanne), four research institutes (PSI, WSL, Empa and Eawag), as well as a strategic management body (the ETH Board) and an independent appeals body (the Internal Appeals Commission of the ETH). Lastly, although the Swiss Network for Sustainable Construction (NNBS) was still in its pilot phase during the time this research was conducted, it is mentioned here since it highlights the development of standardized package to support the production of sustainable construction. That is, the alignment between the boundary objects of a knowledge transfer group, existing labeling systems and construction standards from the SIA and Minergie.76 77 Currently the existing groups create a patchwork of overlapping services, although Swiss Energy is the most comprehensive provider.

The Swiss Energy program was originally launched in 1990 as the ‘Energy 2000’ program.78 The initiative provides housing owners and managers informational services and functions as a platform that unites a range of activities within the field of renewable energy and energy efficiency under a single initiative. In addition to the building stock, the umbrella program focuses on renewable energy, transportation, industrial and service companies, electrical appliances, municipalities and towns, education and training, and communication. Managed by the Federal Office of Energy, the program intends to bridge the scope of energy and energy efficiency by fostering close working relationships between the federal government, cantons, communes and a range of partners located in both private and public sector industry, consumer and environmental groups.

Novatlantis takes a similar, but regionally, targeted approach. Based on the vision of the ‘2000-Watt Society’ developed by the Swiss Federal Institutes of Technology (ETH), the ambition of the plan is to reduce the primary energy consumption per person in Switzerland from today’s roughly 5500 Watts to 2000 Watts by 2050. To achieve this goal, Novatlantis takes findings from research within the ETH domains and aims for a coordinated, holistic approach to promote multi-scalar sustainable development.79 Political support for the goals of the 2000-Watt Society continues to gain momentum, as
evidenced in a 2008 referendum in the city of Zurich, where 76 percent of the population voted in support of integrating the plan into the city’s constitution to significantly reduce energy consumption across policy sectors by 2050. Subsequently, the public approval of this approach has been acknowledged by the Swiss Federal Council, as shown by its continued inclusion in its Sustainable Development Strategy. Also, the initiative has been further acknowledged through the national Energy City award program (Figure 5).

Empirical Work

As stated in the introduction, Switzerland provides a unique opportunity to explore stakeholder perceptions of the relationships between energy research, practice, and sustainable construction. Through semi-structured qualitative interviews with experts having specialist tacit knowledge, observations regarding these relationships were developed. Central questions of interest were: What constraints were most explicit? What were their concerns, how were they framed and what did this suggest about their working context and expertise? How for example, were regulatory and disciplinary institutions viewed? New types of knowledge integrated? Perceived challenges mediated? Also, a complementary aim of this research was to develop a better understanding of sustainable construction expertise.
Table 1: Interviewee Descriptions

<table>
<thead>
<tr>
<th>By Education</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. 1. Architecture &amp; Planning (n = 20)*</td>
</tr>
<tr>
<td>- Architect, Planner, Educator</td>
</tr>
<tr>
<td>- Architect, Planner, City Project Manager</td>
</tr>
<tr>
<td>- Architect, City Project Manager</td>
</tr>
<tr>
<td>- Architect, Research Scientist, Prototype Research &amp; Design</td>
</tr>
<tr>
<td>- Architect, Research Scientist, Software Developer, Educator, Prototype Research &amp; Design</td>
</tr>
<tr>
<td>- Architect, Firm Owner, Executive Director of Sustainability Knowledge Transfer Organization</td>
</tr>
<tr>
<td>- Architect, Firm Owner, Federal Advisory Panel Participant</td>
</tr>
<tr>
<td>- Architect, Firm Owner, Prototype Research &amp; Design</td>
</tr>
<tr>
<td>- Architect, Firm Owner, Cooperative Housing Construction Management</td>
</tr>
<tr>
<td>- Architect, Firm Owner</td>
</tr>
<tr>
<td>- Architect, Firm Owner</td>
</tr>
<tr>
<td>- Architect, Firm Owner</td>
</tr>
<tr>
<td>- Architect, Firm Owner</td>
</tr>
<tr>
<td>- Architect, Firm Owner, Educator</td>
</tr>
<tr>
<td>- Architect, Firm Owner, Educator</td>
</tr>
<tr>
<td>- Architect, Firm Owner, Senior Project Architect</td>
</tr>
<tr>
<td>- Architect, Competition Design, Graphics</td>
</tr>
<tr>
<td>- Architect, Energy Modeling</td>
</tr>
<tr>
<td>2. Engineering Specialty (n = 10)*</td>
</tr>
<tr>
<td>- Engineer, Research Scientist, Educator</td>
</tr>
<tr>
<td>- Engineer, Senior Research Scientist, Educator, Prototype Research &amp; Design</td>
</tr>
<tr>
<td>- Engineer, Senior Research Scientist, Educator</td>
</tr>
<tr>
<td>- Engineer, Senior Research Scientist, Consultant</td>
</tr>
<tr>
<td>- Engineer, Senior Project Manager</td>
</tr>
<tr>
<td>- Engineer, Project Manager</td>
</tr>
<tr>
<td>- Engineer, Communications Officer of Sustainability Knowledge Transfer Organization</td>
</tr>
<tr>
<td>- Executive Director of Sustainability Knowledge Transfer Organization, Educator</td>
</tr>
<tr>
<td>* Architect, Specialist in Building Physics, Technical Director of Certification Label, Educator</td>
</tr>
<tr>
<td>* Architect, Engineer, Sustainability Consultant, Firm Owner</td>
</tr>
<tr>
<td>3. Other (n = 3)</td>
</tr>
<tr>
<td>- Senior Research Scientist, Consultant to City Mobility Planning, Energy Transitions</td>
</tr>
<tr>
<td>- Director of Energy / Mobility Research Institute, Upcoming Executive Director of Sustainability Knowledge Transfer Organization</td>
</tr>
<tr>
<td>- City Project Manager, Energy Award Program</td>
</tr>
</tbody>
</table>

Method
The SIA’s official interdisciplinary trade publication, TEC21, for architecture, engineering and environmental concerns was used to develop a pool of experts linked to implemented, sustainable construction projects in Switzerland within the last ten years. Additionally, contacts were gathered though relevant sustainability literature, websites within the ETH domain such as the 2000-Watt Society, as well as the construction department websites of the largest cities located within the regions of Zurich, Basel, Geneva, and Lausanne. Interviewees were contacted via email and telephone at their primary place of practice, and 31 semi-structured interviews were conducted in person from February to June 2012. Each recorded qualitative interview lasted between 1½ to 2 hours and followed a discussion guide that was developed to encourage the interviewee to discuss the details of specific sustainable construction projects linked to implementation issues and the links between past, current and future efforts. Ample opportunities to deepen the conversation around project specific sustainable development implementation issues were available and encouraged by the experienced interviewer (Figure 6).
Summary Results

Interviews

First, to highlight the heterogeneous expertise represented in the interview sample, a description of each interviewee categorized by education is provided below. The two individuals indicated by asterisk (*), were qualified as both engineers and architects and therefore were counted twice to surpass the total 31 interviews by 2 counts (Table 1). Subsequently, in order to verify the perspectives represented in the interview sample, the external expertise of study participants were coded by education; by highest qualification; by practice and by position. This highlights that the interviews conducted captured the current views of Swiss experts with the following characteristics (Table 2):

A. The sample reflects the views of experts trained primarily within the design disciplines of architecture and planning, as well as the engineering design disciplines, 60.6 percent and 30.3 percent respectively, with an additional 9.1 percent representing other types of training, specifically economics and geography. It is important to note that as indicated by asterisk (*), two the interviewees were qualified as both engineers and architects, therefore the total surpasses 31.

B. Grouped by highest qualification, 71.0 percent of the interview sample held a professional degree with 22.6 percent holding a doctoral qualification and 6.4 percent holding other types of qualifications, specifically a MBA and a Bachelor’s Degree respectively.

C. (a.) Parsed by practice, the primary activity of the interviewees mainly involved design work at 58.1 percent, followed by research activities at 19.3 percent, the management and/or coordination of research at 12.9 percent, and lastly the management and/or coordination of design at 9.7 percent.

(b.) Assessed by secondary practice, the majority of interviewees engaged in the management and/or coordination of research at 29.0 percent, followed by education related activities at 25.8 percent, consultancy/advisory at 22.6 percent, other activities at 12.9 percent, and finally research related activities at 9.7 percent.

(c.) Evaluated by tertiary practice, interviewees’ responses were much more diverse with 51.6 percent reporting a range of activities unrelated to sustainable construction, followed by 19.4 percent indicating consultancy and/or advisory activities, 16.1 percent engaged in activities related to education, and 12.9 percent involved in managing or coordinating design.

D. Aggregated by stakeholder type, primarily planners and designers were represented at 54.8 percent, followed by the interests of research and education at 35.5 percent, and lastly by the public authorities at 9.7 percent.

Collated Responses of Interviews by Practice (Category C)

Under the practice category in Table 2, responses were collapsed around the activities of design and research. This indicated that: (d.) 67.7 percent of those interviewed were primarily involved in design, and design management and/or coordination activities, followed by the remaining 32.3 percent of the sample that was primarily involved in research, and the management and/or coordination of research. Next all responses from Category C were collated similarly with the exclusion of ‘other’ activities as it was recognized that many of these activities occur simultaneously and that the hierarchy of
<table>
<thead>
<tr>
<th></th>
<th>Men</th>
<th>Women</th>
<th>Total (n)</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Education</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Architecture &amp; Planning *</td>
<td>16</td>
<td>4</td>
<td>20 *</td>
<td>60.6 %</td>
</tr>
<tr>
<td>2. Engineering Speciality *</td>
<td>8</td>
<td>2</td>
<td>10 *</td>
<td>30.3 %</td>
</tr>
<tr>
<td>3. Other</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>9.1 %</td>
</tr>
<tr>
<td>Total</td>
<td>24</td>
<td>7</td>
<td>33 *</td>
<td>100.0 %</td>
</tr>
<tr>
<td>B. Highest Qualification</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Professional degree</td>
<td>18</td>
<td>4</td>
<td>22</td>
<td>71.0 %</td>
</tr>
<tr>
<td>2. Ph.D.</td>
<td>4</td>
<td>3</td>
<td>7</td>
<td>22.6 %</td>
</tr>
<tr>
<td>3. Other</td>
<td>2</td>
<td>-</td>
<td>2</td>
<td>6.4 %</td>
</tr>
<tr>
<td>Total</td>
<td>24</td>
<td>7</td>
<td>31</td>
<td>100.0 %</td>
</tr>
<tr>
<td>C. Practice</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Primary</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Design</td>
<td>15</td>
<td>3</td>
<td>18</td>
<td>58.1 %</td>
</tr>
<tr>
<td>2. Research</td>
<td>4</td>
<td>2</td>
<td>6</td>
<td>19.3 %</td>
</tr>
<tr>
<td>3. Management / Coordination of Research</td>
<td>4</td>
<td>-</td>
<td>4</td>
<td>12.9 %</td>
</tr>
<tr>
<td>4. Management / Coordination of Design</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>9.7 %</td>
</tr>
<tr>
<td>Total</td>
<td>24</td>
<td>7</td>
<td>31</td>
<td>100.0 %</td>
</tr>
<tr>
<td>b. Secondary</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Management / Coordination of Design</td>
<td>8</td>
<td>1</td>
<td>9</td>
<td>29.0 %</td>
</tr>
<tr>
<td>2. Education</td>
<td>8</td>
<td>-</td>
<td>8</td>
<td>25.8 %</td>
</tr>
<tr>
<td>3. Consultancy / Advisory</td>
<td>3</td>
<td>4</td>
<td>7</td>
<td>22.6 %</td>
</tr>
<tr>
<td>4. Other</td>
<td>4</td>
<td>-</td>
<td>4</td>
<td>12.9 %</td>
</tr>
<tr>
<td>5. Research</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>9.7 %</td>
</tr>
<tr>
<td>Total</td>
<td>24</td>
<td>7</td>
<td>31</td>
<td>100.0 %</td>
</tr>
<tr>
<td>c. Tertiary</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Other</td>
<td>13</td>
<td>3</td>
<td>16</td>
<td>51.6 %</td>
</tr>
<tr>
<td>2. Consultancy / Advisory</td>
<td>5</td>
<td>1</td>
<td>6</td>
<td>19.4 %</td>
</tr>
<tr>
<td>3. Education</td>
<td>2</td>
<td>3</td>
<td>5</td>
<td>16.1 %</td>
</tr>
<tr>
<td>4. Management / Coordination of Design</td>
<td>4</td>
<td>-</td>
<td>4</td>
<td>12.9 %</td>
</tr>
<tr>
<td>Total</td>
<td>24</td>
<td>7</td>
<td>31</td>
<td>100.0 %</td>
</tr>
<tr>
<td>D. Position (Stakeholder Type)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Planners &amp; Designers</td>
<td>15</td>
<td>2</td>
<td>17</td>
<td>54.8 %</td>
</tr>
<tr>
<td>2. Research &amp; Education</td>
<td>8</td>
<td>3</td>
<td>11</td>
<td>35.5 %</td>
</tr>
<tr>
<td>3. Public Authorities</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>9.7 %</td>
</tr>
<tr>
<td>Total</td>
<td>24</td>
<td>7</td>
<td>31</td>
<td>100.0 %</td>
</tr>
</tbody>
</table>
tasks performed in practice are perpetually in flux. This aggregative method shows that when those interviewed engage in activities linked to sustainable construction: (e.) 46.6 percent of those activities were related to design, and 17.8 percent were respectively participating in research; education; as well as consultancy and/or advisory work linked to knowledge transfer organizations. Yet critically, as highlighted in Tables 1 and 2 even within a small sample populated by primarily architects and engineers, a spectrum of practice is represented within these groups.

Challenges Linked to Technical Aspects of Sustainable Construction

Though responses were broadly consistent with mainstream barriers of affordability; lack of client demand, awareness, business case understanding; and planning policy, additional challenges were unearthed around technical aspects of sustainable construction and were grouped by concerns that were social, regulatory and technology oriented. Social concerns related: to coordination issues between the construction sectors, between the construction sectors and the public consumer; to aspects of sectoral ambivalence; and to differing regional development styles. Regulatory challenges were connected to the perception of: liability; the influence of the banking industry on the direction of development; and the convergence of certification schemes and building codes. The last types of challenges were linked to specific technologies, resources and technological expertise. Specific concerns focused on: differing regional prioritization; lack of effective knowledge transfer; as well as intra-regional and national–international level mismatches (Figure 7). The comparison to existing barriers in the literature was considered useful, since it notably highlighted that amongst the Swiss experts interviewed the lack of proven technologies was never claimed as problematic, nor was the lack of a single labeling and/or measurement standard.

Discussion

Recognizing that in the design practices, research and teaching are often critical aspects of the practice, it was also assumed that our interview material would provide examples of how experts move between the viewpoints of internal and external stakeholders. And in fact, interviewees were clear that this movement was important: to integrating knowledge practices between the jurisdiction of cantons; across the trades to keep the estimated costs of construction down; or in the process of raising support for research and demonstration projects. For example, those whose primary practice was design or technical research reflected that their visible involvement in advisory positions to the canton or state through knowledge transfer groups was critical in shaping the direction of how sustainability aims were perceived by the public and ultimately, realized in practice.

In accordance with the STS notion of boundary work, the primary aim of the qualitative interview process was to unearth how the overlapping concerns of differing social worlds (e.g. architecture, engineering research, design, regulation, knowledge transfer groups, infrastructure, etc.) intersect
with processes of sustainable construction implementation. By recognizing that implementation efforts are “an assemblage of policy-making, market processes, and professional and industrial practices,” it was expected that a diversity of potentially conflicting perspectives would be present in the respective interviews, since the specificities of boundary objects or parts of standardized packages often diverged in material form, (i.e. technical artifacts, tools or organizations), despite the fact that all the discussions were grounded in the energy narrative of the Swiss context.

The boundary objects of standards and knowledge transfer groups were most significant in the context of this study. Interviewees expressed varying degrees of concern regarding widely adopted labeling and certification schemes, however knowledge transfer groups such as Novatlantis were viewed more or less positively concerning its promotion of multiple pathways to achieve sustainable construction goals and effectively engaging both the building sectors and the wider public. Essentially the coordinated, but flexible approach in support of a range of sustainable solutions allowed the organization to effectively operate in concert with a variety of technical solutions. Additionally, programs supported by Swiss Energy, the EnDK and the SIA were also recognized as supporting sustainable construction efforts either through financial support or by providing technical guidelines.

However interviewees also highlighted other diverse vectors of knowledge transfer in the form of architectural and planning competitions, boundary processes in their own right, international research collaborations centered on construction projects, and international exchange amongst firms with multiple offices. For example an architect who worked as a city official in Basel argued that holding planning competitions was an efficient way to legitimize and promote its public process, while involving the ‘best’ design talent and further refining the positioning of the city’s green policy goals through verifiable
construction outcomes. Other practitioners suggested that architectural competition processes introduced innovative concepts into the professional discourse and were a means to garner public support while diminishing the perceived risk of unconventional strategies.

Of those interviewed, an image of multi-headed expertise emerged: practitioners and researchers displayed multiple types of working competence in design, research, management, education and advisory activities. This is consistent with the group of experts that were targeted. As articulated earlier in this section, this finding could also be argued as a general reflection of the nature of disciplines being studied, which are typically conceptualized as ‘problem solving professions’ or alternatively, that these traits are evident in individuals working close to the borders of professional and research practices which intersect sustainable construction implementation efforts. Although too small of a research sample to substantiate here, the choice of the Swiss “close community setting” of experts as an object of study was carefully considered in relation to its geographic location, system of governance, dense multicultural pattern of urbanization and energy context, in addition to its strong history of design, construction and infrastructure development. No doubt, these combined factors have been central in the “forming and framing” of how these Swiss researchers and practitioners approach sustainable construction as Guy and Shove argue for the respective contexts of Finland, Sweden and Ireland.\textsuperscript{84}

**Context Counts**

It goes without saying that context counts. However, typically in the comparison of construction practices, differing working milieus also signify alternate institutional contexts that create challenges for coordination. It became clear
in the organizational phase of this study that gaining access to experts in the German-speaking part of the country was a much more straightforward process than in the French-speaking part of the country. Despite this, with the exception of 5 interviewees, every person interviewed reported that their respective working practice spanned multiple cantons, and approximately one-third of the interviewees worked in both French and German-speaking areas. Additionally, sixteen of the interviewees reported international working experience linked to sustainability construction. In the case of Switzerland, where four national working language contexts exist under the same federal regulatory rubric, interviewing experts operating in varying regions of the country provided an opportunity to look at the activities of actors operating within differing linguistic contexts. Those working in multiple regions expressed the view that federal laws were interpreted differently by cantons in differing language areas, which is consistent with documented ethno-linguistic divisions in the organizational cultures of Swiss public space and political discourse and highlights the interpretive flexibility of federal laws.

**Domestic**

As previously discussed Novatlantis functions within the ETH domain as a knowledge transfer organization that makes research findings more accessible to the public in an effort to attain the goals of the 2000-Watt Society. Originally launched in three test-pilot regions, Zurich, Basel and Geneva, regional approaches have since diverged. As the fieldwork process progressed it was repeatedly reported by interviewees that the aims affiliated with the 2000-Watt Society were being prioritized differently in the French-speaking part of the country in comparison to the German-speaking areas. Specifically, variations in the working cultures of the German- and French-speaking sites have been significant enough to slow the momentum of the program’s coordination efforts in predominantly French-speaking test regions, while continuing to gain increasing support in German-speaking areas. According to a city official in Geneva, the planning influence of neighboring France and the strong local presence of the United Nations (UN) subsidiary headquarters has encouraged the culture of French-speaking Switzerland to look more to Europe than internally. This highlights the critical link between boundary objects such as knowledge transfer groups and local actors.

Alternatively, described as healthy competitors, the neighboring primarily German-speaking cities of Basel and Zurich have provided the main successes of the 2000-Watt Society to date. Although the ‘push-pull’ strategy is employed across all the program sites between - the ETH domain - on one side of the knowledge transfer group Novatlantis, and - businesses, as well as cities/cantons, and the public - positioned on the other, both cities have positioned their implementation strategies very differently. For example the city of Zurich has taken a top-down process, which has been led by the city mayor and supported by a strategic management team made up of Novatlantis and a steering committee of directors, which oversee 6 related taskforces that address the city's energy strategy; stakeholder participation; design, integrated planning; environmental and health (HVAC); IT, Smart Grid; and facility management. Whereas in Basel, a much less formal bottom-up structure exists where the city has spearheaded efforts test a small fleet of hydrogen fueled vehicles, and also engages in several public-private partnerships focused on the

---

concepts of smart grids, energy hubs, electricity storage, the utilizations of river water, building retrofit, PV integration, quick charging electric vehicles and natural gas driven hybrids. In these neighboring cities, differing organizational practices developed out of local conditions and play an important role in the type of sustainable development projects that are prioritized.\(^{90}\)

International

Numerous interviewees had previously or were currently working internationally. This highlighted another trend in how international working contexts shape and are shaped by design and research actors. Specifically, practitioners working internationally within the EU context underscored the challenges of working in what was perceived as more restrictive regulatory contexts such as Germany, as well as the importance of the economic strength and local expertise of the domestic labor market to support the implementation of atypical sustainable construction strategies. Alternatively, university researchers working within non-European, non-Western contexts raised a slightly different point on resource mismatch and international expertise. For example, efforts to demonstrate the applicability of strategies developed in Switzerland to attain Nearly Zero Energy Buildings (NZEB) in more humid East Asian climates ran into technology linked difficulties in the field. Specifically, two problems arose that were implementation related. First a certain type of cabling necessary for a technical assembly was not available and no comparable replacement could be found locally. Second, the lack of available local skilled labor created a significant challenge to installing, maintaining and repairing the technical assemblies proposed. In the first EU example, this caused practitioners to restructure their contractual agreements to reflect Swiss billing practices and opt only to work outside of Switzerland on more higher profile projects. In the East Asia example, since partnering universities and the local authorities supported the project work, the main reported focus here was to expand the design analysis to accommodate local construction practices. This example highlights how learning can occur on both sides of an object and that depending on how that object is grouped with another object – here an institutional - can encourage actors to pursue alternate subsequent actions.

\textit{Mediating Frictions between Regulation & Innovation}

The Convergence of Standards

The perception that stable, proven technologies already exist was very strong amongst the experts interviewed. Therefore, the focus of perceived challenges centered on dissatisfaction with the specifics of building standards and financing mechanisms, which were perceived as steering development in a particular direction. As mentioned previously, efforts to harmonize cantonal standards have been underway for sometime, and none of the interviewees objected to this trend. Although the concern regarding the strength of the Minergie label seems to be at odds with this assertion, the following example clarifies the distinction that was frequently made by interviewees. Specifically for example, a researcher and former active practitioner found it problematic that owner requirements for bank financing included meeting the criteria for Minergie standards, which prescribed a specific bundle of technologies.

The same interviewee also observed that originally he had assumed ‘superior solutions’ would supersede lesser solutions, but now recognized that developing a local demand for construction assemblies that are deemed ‘risky’ by lending institutions was a considerable challenge. According to Pitt et al. interviewees should have perceived the presence of fewer, coordinated standards positively. However, this was not the case amongst the interviewees. Practitioners frequently expressed frustration over the convergence of building standards in Switzerland as restricting the exploration for alternative methods to reduce energy consumption and emissions. However, another expert raised the point that labels do have value especially in development contexts where sustainable construction knowledge is not high and benchmark values are needed.

Now much more than a voluntary label, Minergie plays a significant role in Switzerland's building code and the label combines several building technologies in the aim to reduce energy consumption. Specifically, the technical focus has been a combination of controlled ventilation, selective double-glazing, external shading and insulation. Although criticized by one researcher for reflecting dimensionally simple approaches rooted in solutions that were once calculated manually, the label continues to evolve, evidenced by its growing number of sub-labels. In a discussion with one of the lead technical consultants to the Minergie label, it was explained that although their group did not act as a general advisor to owners or the building sector, they would regularly be involved in demonstration projects. The aim behind their participation in these projects were not to highlight specific technologies that were considered appropriate for mass implementation, but rather it was an effort to work out complementary technical strategies with the design team, as well as verify the appropriateness of the standard. As one architect who participated in a museum demonstration project explained the benefit of collaborating with the technical group of the label was an opportunity to influence the logic of the standard. Again another example of mutual learning, but it also highlights what Fujimura describes as fact stabilization in the form of lending practices that support a particular bundle of technologies that Miniergie standards indirectly require to meet its performance criteria.

Liability

Liability was a consistent concern for researchers involved in sustainable construction projects. According to one interviewee, ‘the researcher’s dilemma’ centered on when their oversight of a project should end. Although the oversight of construction drawings and construction are a critical part of achieving intended sustainability goals, typically financial liability and lack of construction management experience limits researcher involvement. In the interviews this presented itself in two types of responses – sectoral ambivalence and attempts to integrate into the normative system. In the former type of response, some firm owners expressed a lack of interest in discussing energy efficient strategies, one going so far as to refer to it as ‘boring’. However, that particular interviewee, a business owner and educator had overseen the design and construction of multiple Minergie certified projects, which underscored that his expressed ambivalence was not for a lack of technical expertise.

In the latter type of integrative response, many of the researchers interviewed simultaneously worked in advisory or consultancy roles to industry, local and/or federal levels of government. Two specific examples are worth mentioning.
here. The first is an example of an architect researcher who created a spin-off consultancy to distance his more practice-oriented liability from his host research institution, reduce the amount of trade-to-trade coordination necessary during bidding and construction, as well as retain specification development or oversight of the technology implementation. The second example is of a firm owner who worked with local train authorities to develop an alternative means of achieving a target level of insulation performance for service buildings housing technical installations. In both of these examples, interviewees explicitly varied their modes of practice and moved back and forth between the roles of internal and external stakeholders – that is between positions of design and research, where the role of technology is prioritized differently.

91. Anecdotally, one interviewee, who was a qualified mechanical engineer, researcher and educator, even went so far as to self-finance a building project, hire a design team and implement his prototype system of integrated building technologies. However, according to both the project architect and the energy modeler, the introduction of atypical construction details was still a strong source of friction between the design team and the construction trades in terms of perceived liability, schedule and cost. A. Feige, H. Wallbaum, H. and S. Krank, “Harnessing stakeholder motivation: towards a Swiss sustainable building sector,” 508.


Conclusion

Coordinating the rapidly expanding body of literature on energy, its infrastructure, policy and climate change in an intelligible way with current industry practice and ongoing research on buildings, planning, sustainability and the built environment poses significant challenges. As an exploratory, qualitative assessment, the concerns of Swiss development experts involved in sustainable construction efforts provide insight into understanding where frictions exist in the overlap between researchers, practitioners and public authorities that share similar green ambitions of implementing sustainable construction within a significantly broader landscape of actors.

Essentially, the framework of science studies was used as an approach to investigate practices linked to sustainable construction. And subsequently, in the process of adapting core STS perspectives such as “the heterogeneous and hybrid socio-technical character of technology and knowledge production; the mutual shaping of social and technology order;” and “the actor-oriented approach combined with critical constructivist perspectives,” additional information regarding the frictions experienced by local actors surfaced as a supplementary area of study. Specifically, Science and Technology Studies (STS) perspectives were used to strategically inform how sustainable construction can be conceptualized within a broader socio-technical network and instances where social affiliations supported technical choices in the Swiss context were highlighted. In particular, the notions of boundary objects and standardized packages were useful as constructs to identify experts affiliated with sustainable construction implementation efforts, structure the discussion goals for the interviews, and in the analysis identify relationships worthy of further study such as processes of negotiation involved in the development of building standards, and the workings of knowledge transfer groups. Centrally, the key contribution of the STS framework in this research area is its potential ability to expand the operational understanding of the architectural case study in ways meaningful to the concerns of sustainable construction implementation. Unique to the Swiss context was the perception that domestically, there was not a lack of existing technologies and methods available to achieve sustainable construction and that converging building codes were a potential hindrance to atypical solutions. This latter challenge in particular highlights the notion of bundled boundary objects, which create standardized packages that although
are not rigidly fixed provide:

…for a greater degree of fact stabilization than using boundary objects. Simultaneously, however, standardized packages are also similar to boundary objects in that they facilitate interactions and cooperative work between social worlds and increase their opportunities for being transferred into, and enrolling members of, other worlds. They serve as interfaces between multiple social worlds which facilitates the flow of resources (concepts, skills, materials, techniques, instruments) among multiple lines of work.94

In this exploratory study of Switzerland an effort was made to depict the socio-technical web that connects specific building technologies to building standards that are in turn, generated, supported and regulated by institutional practices though the use of in-depth expert interviews. The examples presented illustrated how complementary pathways for sustainable construction can be crafted out of separate tools, technologies and organizations. Similar to Shove’s work with building experts, this study also underscores that:

…they [experts] do not have contextually disembodied technologies transferred upon them. Instead they acquire and develop knowledges which mesh with and which emerge out of local, culturally and temporally specific working environments.95

These findings are consistent with Switzerland’s steady success in sustainable development implementation efforts grounded in its strong national traditions of resource protection, design, infrastructure, construction quality, and research, which are additionally supported by its high standards of living. Therefore as a frontrunner in the process of operationalizing sustainability goals, further empirical casework on how sustainable construction is implemented, challenges mediated, circumvented and/or problem situations recast is warranted in the Swiss context to deepen the preliminary conclusions drawn here.


Bharathi and Nicol
Bibliography


Bharathi and Nicol


Swiss Network for Sustainable Construction (NNBS, Netzwerk Nachhaltiges Bauen Bharathi and Nicol


Framing transitions

Architects, like the buildings we produce, are temporal.

We reflect the attitudes of the environments where we work, the site-specific pressures of time and place, into the spaces that we design. That is, irrespective of typology or complexity, every piece of architecture is implicated within a wider landscape of social, political and technical decision-making. Collectively our choices support seemingly disparate, but intertwining narratives, which influence and are influenced by the built environment in the shape of federal, state and local policies that create the basis for land use, energy consumption, building standards, construction and funding mechanisms.

Undeniably, architecture is rooted in long standing traditions that are artifact oriented. However, as we face the immense task of transitioning the built environment to a more sustainable state, the relevance and, indirectly, the longevity of the practice has been repeatedly called into question. This suggests that, as professionals, we must critically interrogate our positions on what constitutes architectural authenticity, and candidly ask ourselves about the current condition of the discipline.
According to scholar Chris Abel, architectural pedagogy continues to undermine the practice by encouraging “architects to see themselves primarily as form-givers in a role set apart from other professions and classes - an attitude strongly encouraged by an academically inclined education system - rather than as equal members of a design and production team.”1 Practicing architects and educators Kieran and Timberlake take a different stance, arguing that the discipline’s diminishing influence is the result of a gradual process of institutionalization “by means of separate educational programs, separate licensing and insurance requirements, and separate professional organizations” and imply that this trend has been accelerated by the architect’s loss of involvement in the product engineering of building materials.2 Urban planning and policy think tank strategist Allison Arieff highlights yet another symptom of growing isolation, evidenced in the habitual struggle of theoretic architectural discourse to communicate to wider audiences.3

Each of these observations reflects a mix of concerns that engage notions of legitimacy, identity, technology, education, society and environmentalism. Yet, as in every challenging situation, room for change also exists. Kenneth Frampton has observed, “since the emergence of the profession, a salient, often undeclared aspect of architectural practice has been the reconciliation of conflicting values through the creation of inflected form”4 that is present irrespective of project typology. He articulates that, in our modern context, managing the typically variegated processes of design has been overwhelmed by complexity of other types, specifically “the constantly escalating rate of technological change and the greatly increased scale of urbanization.”5 Recognizing that architecture is not only about formal strategies, but involves the resolution of conflicting values, Frampton intimates that its practice is as much about understanding context as it is about building artifacts. Essentially, this means that as the disciplinary viability of architecture is called into question, the field’s continued relevance depends on the directions taken in the academic and practical education of architects. And critically, these temporal choices must not only be grounded in historical context, but must also be farsighted and resilient enough to support the efforts of future practitioners. With this in mind, the following sections propose three strategic areas of reflection that frame critical, transitional challenges for the discipline.

Sustainability as a design value

In a design discipline where professionals often ask, “How can we work from principles when what we do is produce artifacts?”6 shifting the understanding of sustainability to function as a multi-scalar framing, rather than as discrete, physical building solutions is easier said than done. In their work, researchers Farmer and Guy argue that object oriented outcomes often result from the dominantly “physicalist” interpretation of buildings that “has underpinned the production of a series of mainly technical, resource saving initiatives epitomized by the concept of best practice,” with a tendency to emphasize “the efficacy of particular technologies.” The researchers assert that representations of sustainable buildings spring from the two following assumptions: First, the central environmental challenges are “essentially physical in nature and global in scale,” and second, that technological solutions

Bharathi

---

5. Ibid.
Stadt 14/12 (Berlin), 2010
© Frank Thiel and VG Bild-Kunst, Bonn
are capable of resolving the environmental damage already done. These conceptions frame the current context of sustainable construction. That is, they delineate the temporal arena where development strategies are conceived and subsequently operationalized. Evidenced in for example, the assumption that the ‘greenness’ of a building can be objectively calculated through the use of powerful, but limited evaluative methods such as life-cycle analyses. It is not surprising then, that even many architectural pioneers do not stray very far from ambition of technological optimization given the interpretive ambiguity that this goal often holds, in addition to the legitimate value that benchmarking has in relation to the implementation of higher construction standards. However, as Frampton points out, “irrespective of whether it is bureaucratically enforced or ideologically adopted” this approach also has the unfortunate tendency “to reduce the creation of built-form to the production of free-standing objects, whether the object in question is merely a technological instrument or the occasion for a spectacular aesthetic display.”

The professional bias to view buildings as discrete artifacts runs deep for other straightforward reasons as well. It is a simple and obvious reality that the primary service the profession offers is the design and construction of form. Kieran and Timberlake go further; observing that the fetishistic focus on aesthetic aspects of building design partially stems from a general loss of agency throughout the construction process. Specifically, they suggest that because of the inclusion of more engineered building systems and greater construction related liability carried by each of the trades, the control of architectural expression has shifted in many design arenas from the architect to the construction and engineering members of the team. This observation links to a broader, but no less critical debate in the practice regarding agency, that elicits perspectives grounded in a wide spectrum of experience. For example Dana Cuff argues that integration of the business of architecture with good design is not only possible but also necessary. Whereas Sami Rintala states that, “raw capitalism cannot - and will not - create good environments.”

So, how can we collectively as a discipline, begin to legitimately bridge these deeply entrenched beliefs? If dismantling institutionalized, rote approaches to design can happen though intelligent critique and strategic intervention, where and how do we begin in this time and place?

Non-disciplinary perspectives on design

Social science thinking on design and construction presents options to explore the relationships between society and its architecture, from the unique perspective of the interaction between objects and the cultures in which they are embedded. Perspectives such as Science and Technology Studies (STS), Social Shaping of Technology (SST), critical urban theory and assemblage urbanism have steadily gained in popularity, since they provide research methods that have shown in iterative design, development and construction processes, how objects and individuals have the power to direct outcomes in tandem. Although to the ears of design professionals some of this scholarship lacks a notable balance with longstanding traditions within architectural, landscape and urban planning discourses, more moderate social science framings have shown to be capable of acting as accessible provocations.
in examining the implications of architecture, urban planning and open space within its societal contexts.\textsuperscript{18}  

For example, an empirical study conducted by researchers Guy and Farmer highlights how social science discourse analysis can help practitioners understand the impact of their project framing concepts. In their research, environmental concept strategies for buildings were sorted by descriptive language used, and a pattern of connections to proposed solutions was found. By framing aggregates of design concepts as environmental discourses that take architectonic form in buildings, the researchers empirically illustrate “the tension between alternative environmental beliefs and strategies.” In other words, by meaningfully employing an interpretative framework outside the practice of architecture and “exploring the notion of discourse,” complementary ways of understanding the social production of space, place, and the environment can be developed.\textsuperscript{19} This type of analysis offers fresh insight into how the trajectory of architectural decision-making can be managed and directed depending on which concept framing is used. Also, Guy and Farmer’s efforts critically underscore the delicate boundary between subjective and objective design solutions.\textsuperscript{20} In short, these framings offer alternate theoretical instruments to unpack the links between the ‘what,’ ‘why’ and ‘how,’ or the connections that shape current, working architectural knowledge practices.

As a discipline, architecture faces legitimate challenges as it consumes the theories, and inadvertently the assumptions of neighboring fields, whether applied science in the form of building technologies or sociology, geography and anthropology in theories of space production. The reality is that practitioners frequently convert a wide range of concepts into simple heuristics and facts, though often lacking a depth of understanding in the source field’s drivers. To further complicate matters is the observation that, “while the need to know originates in one discipline, the required knowledge itself often belongs to many others.”\textsuperscript{21} Practicing architect, educator and scholar Ken Yeang asserts however, that it is not for a lack of interest in accurately absorbing the knowledge of other fields that errors are made. Rather, the problem lies in critically assimilating knowledge from wide ranging areas of expertise, which are also rapidly expanding. He continues, alluding that frequently, comprehensive understanding is traded for data, and “architects often end up appropriating the knowledge from other disciplines as an ever growing database of strategies from which they can pick something that seems appropriate to the task at hand.”\textsuperscript{22}

Yeang’s observations imply that the prevalent, unexamined practice of mixing and matching formal strategies with technical ones undermines the development of practitioners capable of holistic decision-making. In this same vein, pervasive examples of environmental ‘green washing,’ are not so different from trends that have reduced principles of the modern movement to formal styling. This point is recognizable in buildings worldwide, which are often incompatible with local climates, but are made habitable by the use of heating, ventilation and cooling systems. Ultimately all of these examples show the existing need for continuing, non-disciplinary research focused on integrating architectural knowledge, and that current scholarship on how the building sectors acquire, appropriate, and implement information can provide valid insight into the implications of design work.
The notion of cities

Discussion about sustainable construction tends to focus on the fabrication of buildings and their attendant processes. But the building alone soon becomes a white elephant if not seen in the larger context of cities. In a recent interview, Ricky Burdett, an architect and educator, acknowledges that the ability to manage linked, complex urban problems, first requires better tools to assess the relationships between them. He reasons that “in terms of the economics of running cities” it is “the shape of the city” over its discrete “buildings and their technology” that has the potential to act as a springboard for human progress and serve the needs of many. When considered within a global, societal perspective, urban areas become the most strategic sites to develop, test, implement and refine strategies to responsibly reduce carbon emissions and energy use while achieving balanced infrastructure development targets. In terms of their impact, cities pose compelling contradictions. As producers of the brunt of the carbon emissions which contribute to global warming, urban centers also house the majority of the world’s population. As a result, the notion of cities and their accompanying issues of urbanism are quickly becoming inseparable from discussions involving the future of the profession of architecture. Within this view, coordinated efforts to transition the built environment to a more sustainable state not only reflect strategic economic and environmental necessities, but also represent the ongoing process of striving for an architectural utopia in terms of the well being of its citizens. Practically speaking, the physical transformations needed to achieve more sustainable urban futures will simultaneously provide viable opportunities to mitigate the burdens of climate change on the most vulnerable, an increasingly diverse group which no longer includes only the poor, disabled, elderly and very young of developing nations.

To many, the assertion that cities are a “key part of the solution” is hardly revelatory. However, the explicit linking of environmental concerns and the built environment, to issues of social justice is often overshadowed by the potential for sustainable development to act as a driver for new managerial protocols and economic growth in its “construction, operation, maintenance and disposal.” This unbalanced focus has skewed architectural
education, research and industry aggressively toward “a market-based interest in developing new technologies for new constructions, and the inherent bias towards simple regulatory solutions, in particular enhanced building codes and standards,” which are primarily “considered only for the effects of final operating energy in new construction.” More importantly, it has been shown that this approach does not yield its intended results, especially since new construction comprises a small part of the total building stock. For example, it has been observed that in Canada “greenhouse gas emissions and energy consumption per capita continue to increase,” despite the fact that “best practices are borrowed from countries around the globe, green certifications are becoming the norm in architecture, public transportation systems are being built, and ecocommunities develop.” This indicates that neither technological, nor regulatory solutions are enough, even when coordinated on a master planning level. Critically practitioners should be explicitly aware that “if an innovation, a technology, a strategy, a policy, a plan, a way of thinking becomes categorically ‘sustainable,’ economic, social and political” benefits often follow. Centrally, what is important to recognize here is the scale of these pressures is enormous and can inadvertently encourage reductive, repetitive strategies in architectural expression. Think of pervasive, suburban single-family detached housing developments, big box retailing and ubiquitous strip shopping malls where economic risk is the central criteria for sustainability. True, often architects have little control in determining the extent of the site or program flexibility. However, actively participating in local, regional and national professional organizations can create opportunities to collectively exert pressure on scales beyond the ones we typically work.

Conclusion

According to anthropologist Marc Augé in our current phase of ‘supermodernity,’ seemingly programmed public space is primarily dominated by solitary non-spaces that are typically incomplete, void of meaning and lack cultural coherence. He observes a society, which appears less capable of producing spaces that yield the genuine communal benefits of place. Obliquely, his work is a critique that also implicates the shortcomings of mainstream architectural practice, which often appears disinterested in actively questioning what constitutes design integrity and professional civic responsibility. Michael Sorkin envisions an alternative in his statement “a useful urbanism needs to take a stand about what it is.” It is a reminder to practitioners to not only participate in shaping the expressive potential of the built environment through their respective projects, but also a call for architects to carefully reconsider the boundaries of the discipline and support broader coordinated efforts - social, technical, aesthetic and environmental. We know that cities symbolically represent shared interests far beyond optimized technological performativity or visions of aesthetic perfection. That, the built environment is not just a composition of buildings, monuments, infrastructure and open spaces, but reflects the vitality of mixing diverse perspectives. However, simply knowing Architecture is about more than the creation of discrete buildings is absolutely not enough anymore. We cannot continue to mirror unexamined contemporary attitudes into the spaces and technologies that we

Bharath
design, but must continuously challenge how the notion of the architectural artifact both informs and is formed by its temporal context; a context affected by the actions of each practitioner. Thus as a reflexive practice, as a mode of thinking - every individual involved in the building industries - must critically consider which framing perspectives they prioritize in their work and engage in the collective, public debate of how those values can be expressed through design.
Stadt 7/12 (Berlin), 1999
© Frank Thiel and VG Bild-Kunst, Bonn
Bibliography


Bharathi


Sorkin, Michael. All over the map. London: Verso, 2011.


AFTERWORD

Since arriving in Norway the autumn of 2010, I've had the chance to travel through a wide swath of Scandinavia, as well as a good portion of Europe. Not surprisingly there have been more than a few ‘lost in translation’ moments after I began conducting fieldwork interviews. These instances almost always offered glimpses of clarity and when I was lucky, humor as well. Below is one of my favorites exchanges which began with a pretty standard request to interview a well known academic and practitioner on the topic of knowledge transfer.

On 1/12/12 4:00 PM, "Leibundgut Hansjürg" <leibundgut@arch.ethz.ch> wrote:

Dear Mr. Srikrishna,

I am not interested to contribute to your work. There are hundreds of people collecting information from those who try to change the system (like myself) but only a few of people, who really are working on the change. You will not learn anything about the problems of the transfer of knowledge from theory into practice until you try to do it.

I'm very sorry.

Kind regards

Hansjürg Leibundgut

Not a great way to start six months of fieldwork, but with nothing to lose, I responded quickly:

Am 12.01.2012 um 16:08 schrieb Bharathi Srikrishna:

Dear Prof. Leibundgut,

I understand your view coming (myself) from over ten years of practice in the US. I contacted you specifically since your work reflects a point of view very different from much of the discussion on the 2000 Watt society/Minergie standards. If fact, you are one of very few researcher/practitioners/building owners/educators who pushes an alternate agenda in more than one realm. For example, the renovation and the building are on the cutting edge not only in terms of technology, but also in the methods used in design, in addition to how the projects are poised to influence commercial and residential re/development; not to mention discussions within the practice. It's more the story of these projects that interests me, and it's this rich mix of roles that I think up and coming architects need to understand better. To give them an opportunity to see that there is a need to work in many ways to achieve the change we need - your perspective, willingness and success in achieving this - is unique.

Sincerely,
Miss Krishna Bharathi

Soon after...

On 1/12/12 4:20 PM, "Leibundgut Hansjürg" <leibundgut@arch.ethz.ch> wrote:

Dear Mr. Srikrishna,

It seems, that you are well informed about our work here in Zürich. Your email reflects a special way of treating things in the broad range of Construction. I therefore change my mind. You are welcome for a discussion.

Kind regards,

H.J. Leibundgut
I’m glad to say that this unusual chain of emails led to a very rewarding meeting that began with a few moments of priceless confusion on the face of my interview subject when we met face-to-face for the first time, and he finally realized that I was not male. More important this exchange reminded me that the ability to perform the strange gymnastics often required to get things done in practice is not only about quickly identifying how to effectively communicate ideas to diverse personalities operating in varied contexts, but in a simpler sense to just not take ‘no’ for an answer. Certainly, I’m persistent by nature, but I can’t take all the credit because I’ve been fortunate to have been supported and mentored by many people along the way who have helped shape my ethical identity and capacity for compassion. Although there isn’t enough room here to name them all, I would like to dedicate this effort to a number of key individuals. I know that without your respective support and willingness to openly share your thoughts with me, I would not be the person I am, and this project would not have conceptually taken root in the form that it has. Thank you.

JEYA BHARATHI,
DR. AIYANADAR BHARATHI,
CARLYNE WORMLEY,
JEAN McFADDIN,
DR. DOUG BRUSTER,
DR. RALPH HERTWIG,
DAVE MILLER,
IAIN ROBERTSON,
DR. BRIAN McLAREN,
STEVE BADANES,
DAVID HEWITT,
DR. VIKRAM PRAKASH,
KENNETH FRAMPTON,
& DOMINIK BUECKERS.

Krishna Bharathi
Monday November 18, 2013
Greenpoint, Brooklyn, New York.
“...an interesting, well-written and well-argued thesis, which brings together issues, theories and literatures from architecture, building science, urban geography and STS studies.”

“...a strongly critical stance is taken which is tested conceptually and technically within an interdisciplinary frame.”

“...both purposeful and considered, powerful in its critical position, but reflective in its claims.”

“...presents a strong case for the value of social perspectives on architectural design and building solutions that respond to climate change.”

“...a piece of research that is impactful beyond the University.”

“...contributes to new knowledge about the practice of developing sustainability policies and carbon reduction strategies for buildings and the built environment.”