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From Law to Turnkey

Negotiating Sustainability in Buildings

Thesis for the degree of Philosophiae Doctor

Trondheim, December 2014

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Preface

All these shelters that we use to call homes have something in common: They are built after a plan contained in the building code and in technical requirements. Looking into the drawing of this abstract plan is the main topic of this thesis.

Starting this PhD research I was confident that in the three years given I would be able to write about everything that has to do with building laws in Norway. Well, I did not. But the main finding offers a good excuse: the reality (including the abstract reality of laws) comes to be through a continuous negotiation. The legal building at the start of this work is not the legal building of today. Nevertheless, I hope that this thesis will shed some light onto how the legal Norwegian building is created, negotiated and communicated before becoming normality.

This thesis is composed of an overview article that bears the name of the thesis, "From law to turnkey: Negotiating sustainability in buildings", followed by the four articles: "The legal dwelling: How Norwegian research engineers domesticate construction law" (accepted at *Engineering Studies*); "Passive House at the crossroads: The past and the preset of a voluntary standard that managed to bridge the energy efficiency gap" (co-authored with Prof. Thomas Berker and published in *Energy Policy* in 2013); The way toward zero emission buildings: The Passive House controversy in Norway" (under review in *Science & Technology Studies*); and "Conspicuous domestication: Expert-based print media coverage of low-energy buildings in Norway (Liana Müller and Thomas Berker, under review at *Communications*).

My two affiliations, the Norwegian University of Science and Technology (NTNU) and the Research Centre on Zero Emission Buildings (ZEB), offered an ideal research arena. I basically commuted between the Institute of Interdisciplinary Studies of Culture at Dragvoll and the main office of ZEB at Gløshaugen during the whole period of research. I enjoyed the meetings and the courses offered by the STS department. At the same time, I was in permanent contact to the most interviewees and I was able to observe the work and the scientific negotiations of the architects, engineers and physicists involved in research on zero emission buildings. Both

research environments are a great place to work at and I am thankful to all my colleagues for that.

Special thanks go to Professor Thomas Berker that supervised this thesis, commented on numerous drafts that preceded the papers, and always found time when I had doubts and questions. He also co-authors two of the papers. In the writing process I learned thoroughly the STS theory and how to not get lost in details. Thanks also to Professor Matthias Haase that gave me expert's advice and connected me with the written sources that clarified my technical questions. Many thanks to Professor Anne Grete Hestnes that had always encouraging words for my work. Thank you Sara and Lucia for your critical comments and thank you Robert for always finding something positive to say about my drafts.

This work would not have been possible without the intensive and very enjoyable collaboration of my informants. Many thanks to all of you!

And last but not least, thanks to my children Marius and Melanie that manage to transform any shelter into a home, and thanks to you, Ralf, for accepting my ups and downs.

Liana Müller

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From law to turnkey:
Negotiating sustainability in buildings

1 Introduction

Climate research results and the broadly accepted opinion that climate change and the deterioration of the environment have an anthropogenic cause (IPCC, 2013) urge national governments and international and supranational organizations to act urgently to mitigate climate change through political and legislative interventions. An increase in buildings' energy efficiency is posited to be a first step toward a sustainable development (IPCC, 2007; McKinsey & Company, 2009). Due to small disruptions and relatively reduced investments, the building sector is considered to have particular potential for energy saving and the reduction of greenhouse gas emissions.

Thus, due to the significant potential of political and technological interventions in the building environment, the reduction of energy use in buildings has become the focus of research, politics and industry. However, the definition of the sustainable development of the building sector remains disputed in the research field, in which various approaches coexist. These approaches include a focus on energy efficiency (supported e.g., by the Passive House Institute), a holistic approach in which the dwelling is a component of a larger system (Butters & Leland, 2012), and change in consumption behavior (Vale & Vale, 1975 and 2000).

Considering all of these approaches, the current thesis provides an analysis of the various processes that are occurring in the research field. It focuses on the interdisciplinary research group of the Norwegian Zero Emission Building Research Center and this group's effort to design pathways for sustainability in buildings. The starting hypothesis of the thesis is that the linear and manageable development from research through legislation to implementation as a trajectory toward a sustainable transition, which is a common policy approach to transitions, does not meet the complexity of the real-life situation. As previously documented in the literature on

dwellings in use (Aune, 2007), the pre-use history of buildings is governed by various rationales, in which the competing interests and intentions of various actors and unexpected events might determine the course of the occurrence (Guy & Shove, 2000).

An assumption of this thesis is that laws in the form of building codes and technical requirements for the construction of buildings play a key role in the success of the construction sector's technological innovation (see also Ryghaug & Sørensen, 2009). Used as tools and norms, these laws force a certain development and (re)direct the flow of financial and human resources. However, the laws are a result of previous developments, and their implementation is affected by the needs and potentials of all of the actors involved. Then, how are the laws decided? Who has the authority and the legitimacy to empower the laws and under what circumstances? At which level are laws created? What is the role of building researchers in the creation and mediation of building laws? How is the planned future building that is stipulated in laws brought/mediated to the public? All of these questions form the base of this thesis.

In the case of sustainable transition in the construction sector, the entanglement between research activity and law is unavoidable. As shown in this thesis, the abstract research is equipped with intervention power through the law. As norms and tools, the laws create new circumstances and serve as irreversible intrusions in the temporarily stable "normality." Moreover, the laws are created in a given context. They embrace a complexity of existing conditions while aiming to improve the status quo.

A sustainable building is not created in a vacuum. As an abstract and ideal entity, it can take various forms. The legal frames should ideally not restrict but rather specify the conditions under which such a building concept can become normality/typical. At the European level, the Energy Performance of Buildings Directive (EPBD, published in 2002 and revised in 2010) drew the broader frames of development. According to the EPBD, all new buildings must be "nearly zero energy buildings" and the used energy must derive, "to a very large extent," from renewable sources. The directive also emphasizes the need for the concerted actions of all Member States (and Norway and Switzerland) and the importance of effective

implementation at the nation state level. Thus, the directive encourages the technological development and the creation of a legal frame at the nation state level while also enforcing the European frames.

In the given context, the directive limits but also legitimizes the choices that are made at the national level. In the current case, the choice refers to the creation of the Building Code and the technical requirements that accompanied the code in Norway. Due to the complexity of the information, the translation of the Directive in building codes is an expert, rather than a political, task. Thus, building researchers are key actors in the adaptation of existing building codes to both local conditions (e.g., climate, tradition, existing building stock, structure of the industry) and new requirements (see also Slaton, 2001).

In this vein, the current thesis examines new aspects of the "building in making," from the pre-legislative research and the role of the building researchers in policy-making and legislation to the role of standards for the success of technological innovation in the construction sector in Norway. Moreover, it studies the role of scientific controversies in the design of sustainable development in buildings and how technological innovation is brought to the public through the written media. The building in making refers to the theoretical image of the future normal building rather than to the building process.

The current thesis primarily focuses on residential buildings, but it also considers office buildings in cases in which the interviewees and written documents specifically addressed them. Residential buildings are particularly significant to the public and open expert discussions regarding the various rationalities of the approaches to sustainable buildings. The interviewees from the Passive House Institute (Germany) and the Research Centre for Zero Emission Buildings (Norway) agreed that the technological innovation in residential buildings is more problematic than that in non-residential buildings due to individuals' increased investments and cultural and emotional aspects. Specifically, the users tend to view the buildings as homes and maintain the status quo, and they may be reticent to changes that affect their routines and sense of aesthetic. Whereas the interviewees described institutions and companies as rational clients, private users were perceived as more difficult to persuade using technological and financial arguments. The experts questioned the

users' ability to maintain low-energy buildings and observed that the users' reticence to accept new technologies might relate to the emotional and cultural aspects of the buildings as homes (see the analysis of the Norwegian Passive House controversy in this thesis). The imagined lay people who favor or impede the technological innovation are private users.

In sum, this thesis addresses the role of experts in a situation in which their domain of expertise is under pressure to deliver sustainability benefits. This pressure manifests itself in the creation of new building laws and technological regulation, the negotiations that precede the legislative phase, the role of standards and their key to success, and how low-energy building concepts are mediated to the public.

This introductory chapter presents the thesis as a whole, including the theoretical background that connects the conclusions of the thesis. Following a short presentation of the articles that build this thesis, I offer a description of the theoretical choices and address the theories that were not included in the articles but, nevertheless, complete and support the aim of the thesis. The theoretical frame is used to connect the four articles in a cross-cutting analysis. This analysis aids in drawing the general conclusions of the thesis and positioning the findings in the broad research that addresses the social aspects of buildings.

Additionally, I present the methods that were used to gather and analyze the data. The final chapter draws the general conclusions of the thesis, addressing its limitations and implications for future research.

For a better understanding of the context in which these processes occur, I present a brief description of the Norwegian buildings and research environments.

2 The Norwegian context

2.1 The Norwegian building environment

Norway is located in Scandinavia, between latitudes 57° and 81° N. With a population of approximately 5 million, Norway is the second least densely populated country in Europe. The cold and humid climate, with large differences between the north and south and the inland and coast, is a challenge for the planners of the building code and the builders. Building code measurements and calculations

are developed for Oslo, which is located in the south of Norway. The first technical requirements for buildings date as early as 1928, and the technical exigencies have since increased (Thyholt, 2006). Thus, the interest in technological innovation in buildings is high. However, due to the various climate zones and the relatively low number of inhabitants, it is difficult to adapt the building code and technical requirements to the local conditions.

The one-family houses predominate the building stock, and 83 percent of the residential buildings are owner-occupied buildings (ssb.no). The buildings are often heated with electric stoves, and the electricity is nearly entirely produced with hydropower. As Aune and Berker (2007) stated, the Norwegian energy consumption is quite special, as the per capita electricity consumption is one of the highest in the world and the system of electric space heaters that is used is effective and cheap. Thus, there are few incentives to change the system. However, the Norwegians consider themselves to be 'world champions' in upgrading the technical standard of their buildings, spending more than 6.2 billion Euros every year to upgrade their households (Aune & Berker, 2007: 61; Risholt et al., 2013).

The high standard of living, described as "the comfort society" (Aune, 2007; Næss & Ryghaug, 2007; Sørensen 2007), is understood in Norway. However, various studies have concluded that the population is aware of the climatic and environmental challenges that it faces. This awareness creates "ambivalence and incertitude" such that "the comfort society" and the "risk society" (Beck, 2001) coexist (Næss & Ryghaug, 2007).

Political intervention is expected to overcome this paradox. Norway is the largest oil producer and exporter in Western Europe and the world's second largest natural gas exporter (EIA). However, Norway can export a greater amount of renewable energy if the clean electricity that is produced by hydropower is not used to heat buildings. The political intention to improve the energy performance of buildings and to extend the export of renewable energy is legitimized both by the fact that the European Directives are compulsory and by appealing to the country's responsibility to contribute to more environmentally and climate-friendly energy production and consumption. Moreover, the clean energy can also be used locally, e.g., in transportation (encouraging the use of electric cars), industry (shifting the gas-

produced energy on the oil platforms with renewable energy), or aluminum production (see also Karlstrøm, 2012). In this way, the CO_2 emissions that are produced in Norway can be reduced.

As indicated above, the country's heating needs are nearly completely covered by hydropower-produced electricity. However, as a part of the common Nordic energy market, Norway imports fossil and nuclear energy in the winter, when the heating need exceeds the energy production and there is insufficient water in the hydropower reservoirs due to a lack of rain. A more energy efficient building stock might overcome this situation. Then, Norway could export renewable energy without being under the constraint to occasionally import fossil and nuclear energy.

An additional disputed topic in Norway and the Member States of the European Union is the country's potential to become "the green battery" of Europe. This concept implies an extension of the grid and a closer integration of the European energy markets (Skjølsvold et al., 2013; Karlstrøm, 2012). It is argued that the export of renewable energy would not only improve the European development of clean energy but also create jobs for the Norwegian industry and bring financial benefits that would extend beyond the end of fossil energy. However, there are various perspectives on the "green battery" concept. Whereas Norway considers it as an opportunity to export its surplus of hydro-energy, the other European States encourage a broader development of energy production (Gullberg, 2013; see also Skjølsvold et al., 2013; Karlstrøm, 2012).

This picture of the country helps us understand the conditions under which the sustainable development of buildings occurs. Guy and Shove stated that, "societies are to some extent shaped by the energy technologies on which they depend" (Guy & Shove, 2000: 4). Additionally, the abundance of natural resources shaped the Norwegian energy policy and even shaped the Norwegian identity as an "energy nation" (Skjølsvold et al., 2013). At the same time, the peoples' expectations of comfort and the energy intensity of routines and habits are steadily increasing.

2.2 The Norwegian building research environment

The research community that was analyzed in two of the current thesis articles is formed by researchers who are often educated at the same research institutions. In

the case of architects, physicists and engineers, the primarily institution is the Norwegian University of Science and Technology (NTNU) in Trondheim. These "close communities" in which "everybody knows everybody else" (Guy & Shove, 2000: 19) accelerate the process of communication and problem solving but, at the same time, restrict the flow of alternative thinking. Research and development (R&D) and incentives and policy-making are managed by only a few institutions, as follows: the Norwegian Research Council, Sintef, NTNU, The Norwegian State Housing Bank, Enova, and The Directorate for Quality of Building. The strong actors who are involved in the various industries synchronize their activity but reduce diversity.

Often, the literature signals discrepancies between the research activities, policy, law and implementation of technology (e.g., Nye, 2007; Aune & Sørensen, 2007; Sørensen, Gansmo, Lagesen & Amdahl, 2008). In Norway, the same institutions are involved in more than one activity and the experts change their affiliations over their career or have multiple affiliations at the same time. Therefore, this gap is not as large as is often described in the literature. The actors also do not need to fight for legitimacy because there is little resistance. However, this thesis shows that conflicting interests might appear and that the actors redefine their role in the new circumstances rather than fighting the decisions. Furthermore, the homogeneity, especially in the research environment, is apparent. The R&D covers a large spectrum of tensions that are related to the pathways that the laws and the research community might follow toward a sustainable development of buildings.

3 Presentation of the articles

The main topic of the current thesis is the roles of research and building researchers in designing paths toward sustainability in buildings and the construction sector. The research question of the thesis is as follows: How is the normal Norwegian building being created, negotiated and communicated before becoming normality? I split this broad and all-encompassing research question into smaller and easier to handle questions, and I answered them in the four resulting articles. In this way, all of the articles follow a common line. The study begins with an examination of the close circle of building researchers in the first article, analyzes the role of standards

developed at the research level in the second article, opens to the larger circle of experts in the third article, and analyzes how the written media brings 'the news' (i.e., the research results, the pilot projects, the building laws) to the public in the fourth article.

3.1 The legal dwelling: How Norwegian research engineers domesticate construction law

The first paper attempts to understand and draw the role of research engineers in the sustainable development of the construction sector. The focus resides on the experts' influence on legislation through their pre-legislative research, participation in advisory boards, educational process, and translation of the law for industry (and, as shown in the fourth paper, for the public). This paper answers the following research questions: How is the best construction law created and domesticated? What is the role of building researchers, and especially research engineers, in the creation of the building code?

The in-depth interviews with experts (i.e., engineers, architects and physicists) who are involved in research on zero emission buildings in Norway and the observations at their meetings over a period of three years, on which this paper is based, suggest that the experts have a complex task. They are both researchers and managers. They manage the knowledge and translate and mediate their results. Their role is not marginal; rather, it is central.

The Research Centre on Zero Emission Building (ZEB) was created in 2009 as a joint unit between The Norwegian University of Science and Technology (NTNU) located in Trondheim and Sintef, "the largest independent research organization in Scandinavia" (sintef.no/home/About-us). ZEB is one of the eleven FME centers (Centers for Environment-friendly Energy Research) that were created and partially financed by the Research Council of Norway.

ZEB has five work packages, covering all aspects of buildings, from advanced material technologies (WP1), climate-adapted low-energy envelope technologies (WP2), energy supply systems and services (WP3), energy efficient use and operation (WP4, which addresses the social aspects of buildings), and concepts and strategies for zero emission buildings (WP5). The center has an international team

and partners with “the whole value chain of market players within the Norwegian construction business” (zeb.no). The center’s vision is “to eliminate the greenhouse gas emissions caused by buildings” through the development of products and solutions.

As a PhD student in the WP 4, I was in permanent contact with the researchers at the ZEB as a member of the group rather than as an outsider. The first interviews signaled that the legal frame is a key factor in the research and implementation of zero emission buildings, and this became the topic of the first article.

Previous studies (Hojem & Lagesen, 2011; Solli, 2013) have shown that the consulting engineers understand environmentally friendly engineering as an application of the current technical requirements. This suggests that the legal frames have a substantial impact on the success of technological innovation toward a sustainable construction sector, sustainable buildings, and a sustainable society, as suggested in the interviews.

Based on the high impact of the legal frame on the sustainable transition of buildings, the paper follows the role of research engineers in the creation, mediation and translation, i.e., domestication of the building code and the accompanying technical requirements. Using two case studies (the specifications of technical requirements for the renovation of old buildings and for new buildings), the paper follows how the research engineers serve as managers through activities other than research. More precisely, the paper shows that the research engineers play a remarkable role in the translation, adaptation and mediation of the European Directives to the Norwegian conditions. These specifications are then combined with the results of their research (the pre-legislative research). These results are submitted to the advisory boards, where they are communicated (translated, mediated) to policy makers and politicians. When the laws are formulated, the research engineers and their colleagues, architects and physicists, translate and mediate the content to the construction industry. Often, the same research engineers are involved in education.

This omnipresence of the research engineers might suggest a coincidence of education and research in the Norwegian case (parallels can be drawn to other cases, such as Sweden, Guy & Shove, 2000). However, small circle of researchers does not

imply homogeneity. The various approaches to the domestication of law create tensions. The paper discusses the advantages and the disadvantages of a close research environment. It claims that expert clusters, such as the research group at the Zero Emission Buildings Research Centre, can develop models of interdisciplinary collaboration such that the co-research is completed by co-management. The domestication of law at all levels is a shared task that allows the research engineers to involve in both research and the planning of the future development of the construction sector and buildings in general.

The laws operate as norms and tools. Moreover, the article concludes that the negotiated construction law is not the ideal law that is created in laboratory conditions; rather, it is the best possible law that is co-produced in a given social, political and economic context. As a consequence, the legal building is neither the most energy efficient nor the most environmentally friendly building. Rather, it is the building that respects the given social, economic and political conditions and the legal specifications.

The further discussion regarding the prescriptive- versus performance-based law, incremental versus holistic view and the creativity stimulated or hampered by law specifications denotes that even small research environments (such as the Norwegian research environment) are confronted with contradictory opinions. The research engineers who offer quantifiable solutions seem to have more effective communication with policy makers and to be better represented in legislation than their colleagues who advocate a more holistic approach. In this case, the legislator must set boundaries around a dwelling, a community or a city, a national border or Europe as a whole. In this way, the legislator defines the paths toward sustainability.

To conclude, the article examines the role of research engineers in managing the future of technological innovation in the construction sector through the domestication of law at all levels. These researchers' ability to negotiate and compromise is as important as their qualities as scientists. Their compromise becomes the legal and normal dwelling.

The paper, however, poses a new question that is related to the processes that accompany the creation and diffusion of standards. How is a specific standard

selected out of a multitude of other (technological or architectural) solutions? The next paper answers this question through a case study of the Passive House standard.

3.2 Passive House at the crossroads: The past and the present of a voluntary standard that managed to bridge the energy efficiency gap (Liana Müller and Thomas Berker)

Energy efficiency in dwellings is generally viewed as the easily achievable goals of climate change mitigation. One of the success stories is the concept of Passive House, a voluntary standard that focuses on energy efficiency. We selected Passive House as a case study because the standard (or, more recently, the Passive House *level*) is proposed and largely supported as the minimum technical requirement in Norway. The article answers the following research questions: How are standards created, developed and promoted? How do they become successful?

Building on interviews, document analysis and observations at the Passive House conference in Innsbruck, the article follows the creation of the standard, the most relevant steps in its development, and the conditions under which the standard can be exported to other climate conditions and building traditions. Ultimately, it depicts the role of standards in the technological innovation in the construction sector and shows that the key to the success of such standards covers more than a robust technology.

The Passive House standard became successful in a specific political and economic context. Moreover, the standard competed with other concepts and standards. With Bruno Latour's (1987) concept of *immutable mobile*, we show that the scientific foundation that remains at the base of the standard was completed by non-technical activities, such as the certification of products, dwellings and people, the creation of a protected market niche, and the increasing professionalization of marketing. The creation of the standard facilitated the information transfer. The Passive House Institute (PHI), the calculation tool and the certification schemes build an unavoidable passage point that allows only specific actors to enter the market of Passive House and simultaneously creates advantages for the certified products that are outside of this market. The invisible ties that maintain the Passive House actors'

connection allow them to meet and communicate and, thus, create a community of like-minded peers. The strict quality assurance and the engagement (even enthusiasm) of the participants reduce uncertainty and create trust among the clients and potential users.

However, when exported to other climate conditions and building traditions, the standard meets resistance. For example, Norway and Sweden adopted the concept but created new standards that fit their local social, legislative, economic and climatic conditions. This derogates from the PHI's script and raises questions regarding the possibility of exporting the immutable mobile without distortion. We depict two possible scenarios when exporting the standard, as follows: either the Passive House is implemented as the PHI-proposed standard or the PHI allows for flexible adaptability. In the first case, the PHI would maintain the exclusive right to decide the development of the standard but would hinder a broad diffusion of the Passive House. In the second case, the coexistence of multiple centers of calculation would create a broader, although looser, actor network with the Passive House philosophy (but not standard) as a base.

The Passive House standard is a success story. Its success is not necessarily due to the numbers of passive houses that have been built across the world. Rather, its success primarily derives from its impact on technological innovation in the construction sector. Especially in Europe, the Passive House is chosen as a reference point for technical requirements (e.g., the case of Norway) or as a standard for energy efficient dwellings (Vorarlberg in Austria). However, the success resides in the common efforts of all of the actors involved and is completed by a story, nearly a myth, in which the Passive House becomes the way toward sustainable development and strict quality and control.

The Norwegian Government's intention to introduce the Passive House standard as a technical requirement met both resistance and acceptance. In 2010, a heated debate took place in an email conversation over several months. The participants were actors who were involved in research, practitioners, physicians and policy makers. The first article draws the borders around the engineers, architects and physicists who are involved in the research on zero emission buildings, and the third article

extends the circle to all of the experts who are involved in the development of the legal dwelling in Norway.

3.3 The way toward zero emission buildings: The Passive House controversy in Norway

The third article follows the contradictory written discussions in the research field regarding the potential paths toward a sustainable transition. Because the Norwegian Passive House level (previously the Passive House standard) is promoted politically as the future technical requirement for all new buildings, the article follows the controversy that accompanies such a decision. Through the study of an email exchange between key actors in the research, industry and policy making environments in Norway, the article depicts the heated arguments that advocated or contested the potential of the standard to become an unavoidable passage point toward sustainability. The article answers the following research questions: What are the content and the context of the controversy? What are the main concerns regarding the consequences that the volume production of passive houses may have on law, policy, research and education? What type of controversy is analyzed?

The international ambitions to reduce the anthropogenic impact on the climate and the environment (e.g., Kyoto Protocol, Energy Performance of Buildings Directive of the European Commission, EPBD) have been translated into national programs (see also Krislov, 1997). The national states have been persuaded to develop paths toward a sustainable development. The building sector is often viewed as that with the greatest intervention potential. Due to its energy saving potential, the Passive House is promoted in Norway as a necessary step toward the nearly zero energy building that was stipulated by the EPBD. The Norwegian controversy broadly follows the critique in other European countries; however, it also addresses the climate- and country-specific tensions that the volume production of passive houses would have at the national level.

An email exchange between experts from various fields serves as the empirical data and is analyzed with grounded theory (Charmaz, 2006). Building engineers, physicists, architects, physicians, policy makers and practitioners used the Internet

to negotiate the robustness of the Norwegian Passive House standard and, thus, the sustainable path dependency (David, 1985) in the construction sector.

The actors who were involved in the controversy can roughly be grouped into the categories of advocates and opponents of the Passive House. However, the written dialogues show that the two groups did not build two opposing opinions. Rather, they often intermingled in arguing for or against a political decision, or built alliances on certain topics, while combating the arguments of their allies in other contexts. The group of mediators, "fans in both clubs" as a participant in the email exchange framed its position, maintained the openness of the discussions, mobilized arguments and facilitated the information flow.

Through the mobilization of actors and arguments, a socio-techno-economic network was created to protect the experts from intruders. In spite of the contradictory discussions, the experts acted as peers when talking about "the others." The lay people and the construction workers were the two imagined actors (Akrich, 1995; Maranta et al., 2003), who were present through the anecdotes but without a real voice. The presence of building workers and the users in a lifetime of a dwelling could not be ignored because they transform the laboratory into a dwelling and the dwelling into a home, respectively. In the experts' controversy, however, they were treated symmetrically to other concerns, i.e., as objects of dispute and as more or less welcome intervention in need of learning and correction.

The law formulation and the law impact constitute the leitmotiv of the controversy. Once is it formulated and implemented, the law has irreversible consequences. In this way, the costs are extended from the financial costs to environmental costs, state and society costs, and research costs/redirection of research. This path dependency (David, 1985) that is created in a socio-economic network (Callon, 1991) changes the structure at various levels (e.g., research, law, society) and, thus, cannot be viewed as a technical dispute alone.

The Passive House controversy extends beyond the intrinsic properties of the technological concept of the Passive House and reaches the broader implications of the introduction of the standard as a technical requirement at other levels, e.g., society, health, culture, research and education. In this vein, the robustness of the socio-technical artifact resides not only on its technological robustness but also on

the socio-technical and cultural artifact as a whole. The boundaries of a legal specification for buildings are extended to multiple social aspects. The employment of a standard as the only solution for all new buildings changes the paths of the social, economic and educational environments. Moreover, the redirection of research that follows the adoption of one strategy has a large impact on the development of future philosophies regarding sustainability in dwellings.

I define the Norwegian Passive House controversy as a path dependence controversy that unfolds as neither purely scientific nor a public dispute. As such, the article offers an analysis of a specific form of controversy in an experts' arena that was enabled by the wide spread of electronic communication. The differentiations between 'we' and 'the others' and the way in which law (as creating path dependency) and costs (as redirection of resources, as societal and environmental costs) are disputed are tracked as characteristic of the experts' communication. The paper discusses the democracy deficit that occurs when the negotiation arenas enable the participation of a larger spectrum of experts but escape the public scrutiny.

The controversy was debated among experts in various fields without the intervention of the public. The fourth article opens the discussion to include the public through an analysis of the media.

3.4 Conspicuous domestication: Expert-based print media coverage of low-energy buildings in Norway (2005-12) (Liana Müller and Thomas Berker)

The implementation of low-energy standards for buildings is promoted as an efficient and un-intrusive intervention toward sustainability. However, the building codes and the technical requirements that enforce the scientific knowledge of the research environments are alien interventions in the private sphere of homes. The media has the role of connecting science and the public.

The main research questions are as follows: How did newspapers and low-energy building expertise interact in Norway between 2005 and 2012? How was the expert-based newspaper coverage related to the actual diffusion of low-energy buildings?

The article is the result of the quantitative and qualitative analysis of 1774 news articles that appeared in the Norwegian written media between 2005 and 2012. We used the on-line archive Retriever to search the articles that addressed the concepts of low-energy buildings in all of the daily newspapers, regional newspapers, periodicals and specialized publications. The following search terms were employed: *low-energy building, passive house, active house, plus-energy house, zero-energy building, zero-emission building and BREEAM*. These concepts are found in the main discourses concerning low-energy building in Norway. For the analysis, we employed QDA Miner (Provalis Research), a qualitative data analysis software program that allowed us to maintain the contact between codes and text, measure the occurrences and the proximities of various codes, and visualize the results.

We observed a strong correlation between the media coverage of low-energy building concepts, the political actions toward a sustainable development of buildings (such as political elections and white papers), and the tensions caused by such decisions in expert environments (e.g., the Passive House controversy).

Using the concept of mediatization, which was borrowed from media studies, we follow the processes of the "enactments" and "performance" of the media. We show that the media relies on experts' knowledge to bring/mediate the news. There are two main types of expert involvement in the media. The first type is the "fictive implementation," in which the experts appear as pioneering users through the home story. In this type, the experts are presented with their families, in their private sphere, enjoying the new facilities and mastering the new technology. The media normalizes the new home, taking the experts from the "ivory tower" and transforming them into peers of the public. The intention is to change the public opinion; however, the experts are persuaded to talk to the public and reformulate the topics of their research and practices to become familiar to the reader. A mutual learning process occurs among the audience, the media and the experts.

The second type of expert involvement is through concrete projects. However, the experts avoid involvement in fiascos as a result of mismanagement or technological faults. This is not the case for prestigious projects such as Brøset and Powerhouse, for which the research institutions NTNU and Sintef and prestigious architecture

offices, public institutions and environmental organizations play a key role. For these projects, the experts are actively involved, both directly through interviews and (more often) through "kronikk," where their texts are reproduced in the media. In this case, the experts address the reader directly through the media. The absence of engagement (in fiascos) and the prevalence of direct engagement ("kronikk") show that the wish for control is particularly strong. The experts are involved on their own terms.

4 Theory and previous studies

In this section, I describe the theoretical choices for the four articles. Furthermore, I address the previous research on sustainable buildings and several theoretical approaches that inform the cross-cutting analysis of all of the papers.

4.1 Description of theoretical choices for the analysis of the four articles

The articles utilized various STS theories. They were not selected from the beginning of the research. Rather, they were selected while the conclusions of the research took shape. Moreover, in the media article, we embraced a transdisciplinary approach, combining mediatization with the STS theory.

4.1.1 Domestication

The term "domestication," i.e., making something familiar or a part of the household, was first employed in media studies (Silverstone & Hirsch, 1992). It was adopted by STS scholars to explain the non-linear and, at times, irrational dynamics of the adoption of new technology in households (Lie & Sørensen, 1996; Haddon, 2011; Berker et al., 2006).

The concept of domestication was developed in opposition to the concept of technological determinism (Sørensen, Aune & Halting, 2000). Domestication states that the robustness of technology cannot be proven in laboratory conditions but can be proven in the society: "The emergence of the domestication concept represented a shift away from models which assumed the adoption of new innovations to the rational, linear, mono-causal and technologically determined. Rather, it presented a

theoretical framework and research approach, which considered the complexity of everyday life and technology's place within its dynamics, rituals, rules, routines and patterns" (Berker et al., 2006). Technological innovation is not only a matter of design and production but also of use and consumption. The domestication of technology "both completes and rekindle the innovation cycle" (Silverstone & Mansell, 1996). As such, the domestication process is perceived as a constructive contribution to the artifact design rather than as a destructive anti-script behavior.

Taking on a life of its own (Silverstone, 2006), domestication can be employed in various research fields, where the non-linearity and the two-method familiarization reveal the process of appropriation.

The building codes and the technical requirements undergo a process of domestication before and while being implemented. Despite the flexibility of this concept, there are two central shared characteristics. First, domestication is not a one-way street. Thus, a study of the domestication of law must follow not only how experts change law but also how the law changes experts (Imrie, 2007). The building engineers' research, their practice, the drawing of plans of future legislation and the law applied in practice must adapt to this somewhat subjective interpretation of the law. Second, if this mutual adaptation is not followed, technical innovation in the construction sector can be compromised. In other words, laws that do not allow for a certain degree of flexibility might be opposed openly or ignored peacefully.

In the context of this thesis, domestication allowed me to follow the creation, communication (translation and mediation) and implementation of law as an expert task. The domestication of law is assisted by experts from pre-legislative research through policy and legislation to implementation and education. In all of these phases, the law transforms the environments, including the research. In this way, domestication is a two-directional process.

4.1.2 Immutable mobile and Actor Network Theory

Bruno Latour's (1987) "Science in action" term of *immutable mobile* is employed to explain how an innovation can remain stable despite its domestication in different contexts. The concept of *immutable mobile* changed the research focus from theories and ideas as monopole of an intellectual elite to the way in which knowledge is

produced and disseminated (Stöckelova, 2012). In addition to the rationality of science, there are many other factors that influence the fate of an idea. The accurateness of a scientific result does not implicitly lead to the success of the tested idea. The way in which the idea is formulated and circulates has the ability to mobilize allies and fight enemies. How an idea prevails and wins recognition over other ideas are aspects that are as important as the scientific acknowledgement.

The success of these knowledge-objects is conditioned by their ability to "act at a distance on unfamiliar events, places and people." The condition is "inventing means that (a) render them *mobile* so that they can be brought back; (b) keep them *stable* so that they can be moved back and forth without additional distortion, corruption or decay, and (c) are *combinable* so that whatever stuff they are made of, they can be cumulated, aggregated, or stuffed like a pack of cards" (Latour, 1987: 223).

The place where an immutable mobile is created, made stable and can be improved or changed becomes the center of calculation and control. The knowledge is collected, evaluated and recombined at the center. Then, it is exported and imposed as reality to the periphery.

The standardization of a technical concept is as dramatic an example as Latour's cartography, as it allows the mobility, stability and combinability of knowledge. The coding process that resulted in the Passive House standard allows construction materials, technological devices, thickness of walls and roofs, and U values of the components to become a specification of the standard. The dwelling cannot be moved, but the standard allows the knowledge about this dwelling to become mobile and known in a location where it cannot be viewed. Additionally, the abstraction of the concept allows it to multiply and take various forms while respecting the basic recipe.

We can further state that any standardization leads to the creation of immutable mobiles. As "recipes of reality," the standards order "people and things to produce outcomes desired by someone. As such, they are part of the technical, political, social, economic, and ethical infrastructure that constitutes human societies" (Busch, 2011: 13). The standards as immutable mobiles reduce the hazard and impose unavoidable conditions. This situation increases the role and power of the center,

which gains control over the development of the standard and how it travels toward the periphery.

Various actors interpret this critical moment when the *immutable mobile* leaves the center and reaches the periphery differently. Whereas Eden (2009) viewed the standard as a common frame that can be adapted "across time and space," adapting to "changing knowledge and practice" (Eden, 2009: 388), Stöckelova (2012) considered that the immutability and the mobility that are attributed to knowledge-objects neglect the local conditions in which they were created and the necessity to adapt while traveling (Stöckelova, 2012: 288). Stöckelova suggested the use of other concepts, such *fluidity* (de Laet & Mol, 2000), to ease the adaptation of a technical object to the local reality. The fluidization of the knowledge-object allows technology to adapt such that broader targets can be achieved. Additionally, the motivation of a technological innovation is not the success of the innovation itself; rather, the motivation is its ability to improve the status quo *after* it is proven to be successful (Berker, 2010: 68).

Gorman described the concept of immutable mobile as a "highly idealized model of scientific practice" because "Real science seldom follows the blueprint." We follow the creation of the Passive House standard as an example of the success of innovation through energy efficiency in buildings. In spite of the barriers that were raised against technological innovation, this case study shows how, under certain conditions, an actor network created, developed, promoted and exported a "recipe" (Busch, 2011) of success.

Latour's story that accompanies the term *immutable mobile* is an ideal parallel to the stories that were provided in the study interviews. Specifically, the drawing of the map of Sakhalin after the initiating journey is parallel to the creation of the Passive House standard after Professor Bo Adamson's trip to China; the combination of scientific knowledge with intuition; and the creation of an actor network that enabled the creation of an immutable mobile. The creation of a center of calculation, the Passive House Institute, and a map, the Passive House Planning Package (PHPP), allows the Passive House standard to travel without distortion. The knowledge accumulates at the center, allowing a continuous adaptation of the standard.

The similar steps that were used in the creation of immutable mobiles and the study of a case helped us to identify factors that facilitate technological innovation.

4.1.3 Mediatization

The term mediatization is borrowed from media studies (Lundby 2009). The name remains a matter of dispute among scholars who proposed mediation, mediatization or medialization (Weingart, Rödder & Franzen, 2012), with each term representing a slightly different approach (Couldry, 2008; Livingstone, 2009). Broadly, the term refers to the influence and the role of media on the society. In this vein, Hepp et al. described mediatization as "long-term interrelation processes between media change on the one hand and social and cultural change on the other" (2010: 233). The step from the individual act of mediation to a secular process of mediatization is based on the observation that "in our present media-saturated society media are inside society" (Hepp, Hjarvard & Lundby, 2010). In this sense, mediatization is placed among other fundamental developments, such as globalization and individualization (Schulz, 2004; Krotz, 2008).

However, the most specific use of the term mediatization describes processes that are allowed and facilitated through information and communication technologies rather than the face-to-face method: "communication via medium, the intervention of which can affect both the message and the relationship between sender and receiver" (Hjarvard, 2008: 114; Hepp et al., 2008; Driessens et al., 2010: 311).

Driessens et al. (2010) studied mediatization through practice theory. They did not insist on the influence of the media in society; rather, they studied "how and to what extent do media anchor, control, and/or organize political practices" (Hepp, Hjarvard & Lundby, 2010: 225; Driessens et al., 2010).

Mediatization is used to explain, for example, the impact of the media on science. The mediation of knowledge as assumed by the Mode 2 *new production of knowledge* (Gibbons et al., 1994) maintains a close relation between the public and the scientists through the media. In this vein, in a study on the role of environmental research scientists, Väliverronnen (2001) concluded that the contact with the media is a part of the routine and that the knowledge is communicated in a mediated fashion. She depicted the role of the scientist who is involved with the media as a

popularizer, interpreter, adviser/advocate, promoter/manager and critic. The social robustness of knowledge is also gained through mediatization while the knowledge is co-produced at various levels. By contrast, Rödder and Schäfer (2010) found that, at least in routine activities, the formative influence of the media on science is weak and that only a small number of scientists engage with the media. This phenomenon is typical to Mode 1 of knowledge production, in which the scientists produce the knowledge without external influence.

In the current study of media articles on low-energy building concepts, we employed the term mediatization to follow building scientists' and other building experts' involvement with the media. In the current case, for some experts, the mediatization was a routine practice. However, the experts preferred to be presented in the media on their premises and to maintain control of the mediatized topics.

4.2 Overview of the relevant literature

4.2.1 The robustness of building laws and standards

In the articles that build this thesis, we found that the robustness of the technology is only an aspect of the robustness of a dwelling. Especially the Passive House controversy addressed the broad implications of the technology, including the redirection of funds and research, the social implications and the impact on the health of users. All of these aspects address the social robustness, or as Novotny (2003) termed, "the socially robust knowledge." Researchers deliver not only technologically and theoretically valuable knowledge but also societally relevant knowledge (Wehrens, Bekker & Bal, 2014).

This expert-produced knowledge enters the real world and the society through many doors; one of these doors is the law. In the case of the building technology, the building codes and the technical requirements empower the knowledge by delivering it to the society. Thus, the building codes and the technical requirements must be robust.

The building code and the technical requirements represent the legal frame in which the buildings are "legal." Additionally, these laws are used as an intervention tool (Hojem and Lagesen, 2011; Solli, 2013) that has the power to redirect the

development of buildings and the building sector and that has a remarkable impact on research and development in general. These laws refer to standards that facilitate a quick and efficient product development, lighten the adaptation of the industry to the new legal conditions, allow control and secure a minimum quality standard (Russell, 2009, 2012 and 2014; Busch, 2011; Slaton, 2001; Vinsel, 2011).

Many of the standards that are proposed by the building code and the technical requirements are not mandatory. They receive their power from the black-boxing complexity of the law. Through the product development, and the development of building routines, standards create a new reality, as they become "recipes" (Busch, 2011).

A core of studies (e.g., Chappells and Shove, 2004; Williamson, Soebarto & Radford, 2010; Vale & Vale, 2009) has problematized the implementation of building codes and technology in general as the only tool and measure toward sustainable buildings. These studies have not contested the necessity of technology innovation or the immanence of building codes. However, they have warned that the technology deterministic approach of legislation and policy making as well as the insufficient planning of implementation and control of technical requirements might slow or even compromise the sustainable development of buildings.

In this vein, architectural studies have shown that the building codes fail to both cover the socio-cultural diversity of the specified area and achieve the expected environmental performance (Williamson, Soebarto & Radford, 2010). "Generic needs" neglect the users' expectations and behaviors and, thus, diminish the effect of the technological and architectural quality of the buildings.

In the same vein, Chappells and Shove questioned the absolute value of comfort as a reference value ("a feeling of contentment, a sense of cosiness," Chappells and Shove, 2004: 3) that forms the basis of building regulations regarding the indoor environments. Treating the question of comfort from a philosophical (rather than a technical) perspective, the authors showed how the "different meanings of comfort have been socially produced and how certain definitions have fallen in and out of favour." They showed that comfort is not an absolute value and that there are great variations in comfort over time, societies and people. As a consequence, it is difficult to capture comfort in technical requirements.

However, the formulation, mediation and implementation of the law must all pass the robustness test. Various studies have indicated that the omission to offer implementation frames, the lack of accuracy of execution, the insufficient control, and the neglect of clients' and users' needs and expectancies can impede the efficiency of the building laws.

Gill et al. (2010) and Stevenson and Leaman (2010) studied the post-occupancy of low energy dwellings and concluded that the neglect of the human factor diminishes the expected performance of dwellings. The authors advocated users' greater involvement in the design and a careful understanding of users' needs and expectations. Glad (2012) viewed the social learning and the greater understanding of the social processes as vital for the development of energy reduction strategies.

Using the social practice theory as a foundation, Foulds, Powell and Seyfang (2012) studied the implications of Passive Houses for energy-consuming practices in the UK. The results suggested that "the introduction of technology could provide scope for certain performances, but did not literally result in energy savings, as per design intent." The users' practices, which were dominated by "learning by doing," led to unexpected paths of consumption. The authors claimed that a technological design that better suits the users' know-how and the embodied practices would facilitate the success of energy policies.

Other studies have concluded that conditions other than the robustness of technology and the theoretical viability of building laws can hamper intervention success. Raslan and Davies (2012) indicated that the adaptation strategies at the industry level, the lack of enforcement measures and inconsistent implementation of the law reduce the efficiency of the building code's energy performance criteria.

At the PLEA (Low Energy Architecture Conference), Cole, Brown and McKay observed a shift in thinking during the last years. Specifically, architects now view the reduction of energy consumption as a social and ethical challenge rather than a technological and technocratic solution (Cole, Brown & McKay, 2010). This article signals that the law must include aspects other than technology and address architectural means and social aspects.

In sum, the innovation in the construction sector has a socio-technical nature that destroys the myth of law as an ideal intervention tool. Thus, the innovation in the construction sector accounts for a multitude of factors and conditions.

As the brief descriptions of the articles suggest, the leitmotif of the current thesis is technology in all of its forms, including the creation and diffusion of a standard, standard development, technological research, technological disputes and translation and mediation of technology in laws and media. Due to its function as shelter, home and experiment, the role of the building in the transition toward sustainability is a central topic in the engineering research, architecture, building physics, sociology, and science and technology studies (STS) literature. This thesis builds on the existing research, especially the STS literature, and offers a new puzzle tile to the broad picture of sustainable development in buildings and the construction sector, with a special focus on the creation, translation/mediation and the role of building codes and technical requirements in technological innovation in buildings.

There are several theoretical approaches that can inform the four articles but were not included in the article frames. The most intriguing and the most appointed aspect of the future dwelling was the aspect of sustainability. I address the notion of sustainability in the following section as the background for the cross-cutting analysis of the papers. Following the main line of the thesis, the role of experts in the sustainable development of buildings, I address the concept of Mode 2 (Gibbons et al. 1994) as a plausible production of knowledge for the studied research environment.

4.2.2 Managed sustainable transition and its traps

The awareness of the anthropogenic impact on the environment combined with resource depletion concerns mobilized the international community to accord increased attention to further development in all sectors. The wealthy countries tend to increase their consumption, and the poorer countries need resources to increase their population's life standard and develop their economy as the world population increases. How can all of these developments be mastered while offering a livable earth to future generations?

The Brundtland Report, also known as "Our common future," from 1987 defines sustainability as "paths of progress which meet the needs and aspirations of the present generation without compromising the ability of future generations to meet their needs." Since the publishing of this report, the notion of sustainability has been used to defend and legitimize decisions and to intervene in the private sphere. However, the report redirects the discourse regarding development. Specifically, it states that the borders are not around the nation states because we have a common future and our needs cannot be compromised at the expense of future generations. In this way, the responsibility is delegated to international bodies, which are expected to concert the common development and to national institutions, which should develop policies that are in compliance with the supranational directives.

The idealized image of impartial managers is not far from the idea of sustainable development. As a generic and generous term, sustainability becomes confusing to apply. Guy discussed the "contested nature of the sustainability concept," which fails to understand the complexity of the buildings and neglects the diverse social interests and agendas (Guy, 2010). For the transition process of buildings, he proposed "pragmatic ecologies" that should respect the "contextual values" of the buildings and the "enactment of alternative design logics" that are adapted to the "environmental challenge" (Guy, 2010: 21). Furthermore, he stated that the "fluid futures" as a result of hybrid transitions through sustainable architecture should be employed as alternatives to rigid building codes (Guy 2011). Other authors, such as Jensen, Jørgensen, Elle and Lauridsen, continue to employ the sustainability term in the context of architecture but pose a broader approach that includes social and environmental sustainability as intrinsic values of the transition (Jensen et al., 2012).

Sustainability as defined in "Our common future" assumes that a managed sustainable development is both necessary and possible (see also Kemp & Lorbach, 2006; Markard, Raven & Truffer, 2012). Because it is difficult to implement extensive interventions in the private sphere (e.g., routines, lifestyle) in liberal societies without violating personal rights, technological development is often promoted. Furthermore, because dwellings consume a large amount of energy and interventions are relatively unproblematic (compared with energy reduction interventions in, for example, industry or transportation, see BPIE report) and

promise a noteworthy impact, the sustainable building has become a target of intervention.

In the discourse of sustainable development that became a leitmotif in all industrial sectors, energy efficiency in dwellings is viewed as the easily achievable goal. It is argued that the intervention (i.e., to build more energy efficient dwellings and refurbish old dwellings) can considerably reduce energy consumption and greenhouse gas emissions (BPIE Report, EU Report). In other words, technological innovation in the building sector is regarded as the key to the success of a sustainable development.

Thus, what is the aim of the sustainable development? Where should we draw the borders such that the process remains manageable?

Various scholars have strongly advocated transition management and the multi-level perspective (Kemp & Lorbach, 2006; Kemp, Schot & Hoogma, 1998; Markard, Raven & Truffer, 2012; Geels, 2005; Vebong & Geels, 2007). These scholars have opened the technological transitions to a more holistic approach in which users, stakeholders and institutions are actors of the transition. They have also considered the communication between various socio-technical systems, viewing the transition as a "co-evolution of technology and society" (Geels 2004). The transition management approach to sustainability (also in buildings) seems to be the closest approach to the official or political approach to sustainability. However, the theory met with criticism.

The critics of the multi-level approach to the sustainable transition have addressed the "lack of agency," stating that the approach neglects power and politics (Smith et al., 2005; Shove & Walker, 2007). Moreover, Elzen et al. drew on the complexity of the environment to be managed, claiming that the effectiveness of the development resides also on the political opportunity structures (Elzen et al., 2011; Geels, 2011). Genus and Coles (2008) recommended a co-evolutionary application of technological approaches, whereas Konrad, Truffer and Voß (2008) supported the multi-level approach but encouraged broader multi-regime dynamics (or multi-regime interactions, as termed by Raven and Verbong 2007) as the basis for the analysis and design of sustainable processes.

An additional criticism of the transition management model regards the "operationalization and specification regimes," in which scholars have indicated the inconsistence of concepts, such as the interchangeable use of "regime" and "system" (Markard & Truffer, 2008; Geels, 2011) and the presentation of socio-technical regimes as "homogeneous" (Smith et al. 2005, Geels 2011). Smith et al. discussed the changes in the regimes as a response to the selection pressures. Moreover, Shove and Walker (2007 and 2008) questioned the manageability of sustainability. The authors provided examples of intended sustainable transitions that resulted in increased concerns, such as the introduction of air conditioning in previously naturally ventilated buildings and the paper-less toilet that utilizes a seat warmer, deodorizer, bottom washer and dryer (Shove and Walker 2007: 767).

Geels and Schot made a concession to the criticism of the multi-level perspective and provided "conceptual refinements." They developed a "typology of four transition pathways: transformation, reconfiguration, technological substitution, and de-alignment and re-alignment" (Geels and Schot, 2007).

While according credit to transition management theories, Berkhout, Smith and Stirling (2004) questioned the key concept, the manageability of the transition:

"Managerial aspirations are confounded by the incommensurable dimensions of technological performance, strongly divergent sociopolitical interests and perspectives, recursive interrelationships between the social and evaluative context, and the profound and ever-present exposure to surprise" (Berkhout, Smith and Stirling, 2004: 13-14).

With this, the authors raised the problem of unintended side effects, showing that "the very notion of public interest itself is highly problematic." They critiqued the niche-based model as being "unilinear," "unilatent" and "unidimentional" and proposed the orientation of the "processes of regime change that are more *multilineal*, *multivalent* and *multidimensional*." Thus, the contexts in which the transition occurs influence the processes of change in socio-technical regimes. Their framework for the model of transition management differs from that for the niche-regime-landscape model that was proposed by Kemp and Lorbach (2006). Markard, Raven and Truffer (2012) argued:

"This framework produces four different contexts for regime change, distinguishing between 'purposive transitions' (deliberate change caused by outside actors), 'endogenous renewal' (deliberate change fostered by regime members), 'reorientation of trajectories' (spontaneous change resulting from relationships and dynamics within a regime) and 'emergent transformations' (the unintended consequence of changes wrought outside prevailing regimes)."

With this, the authors came closer to Jørgensen and Sørensen's (2002) development arenas but continued to plea for the manageability of the transition. Similarly, Berkhout, Smith and Stirling (2004) referred to "conceptual arenas."

All of these studies deny the linearity of the technology innovation and open the discussion of a socio-technical, political and institutional interpretation of innovation. Nevertheless, building researchers focus on technological innovation that allows us to maintain or even increase the life standards. They nurture the existing behaviors, even if they often intervene in routines. Energy efficiency through increased insulation is often promoted as an efficient and unproblematic intervention. Without contesting the potential of the intervention, the literature has shown that the manageability of the process of research and implementation might not have the expected results. In this vain, Guy and Shove (2000) addressed it as "the erratic character of technology innovation," showing that the insulation as robust technology alone does not necessarily increase energy efficiency. They drew the discussions through the path dependencies of the processes and presented the various approaches and routines that accompany the process.

Standards as recipes help the diffusion of innovation and secure quality; however, as shown in the literature, the implementation of standards in the reality of buildings might be problematic. The systems of implementation are complex, and the results are socially, culturally and climatically dependent. The "technical convergence" is combined with "cultural diversity" (Guy & Shove, 2000). In the same vein, Farmer and Guy (2010) supported a sustainable design as the "co-evolution of socio-technological approaches that develop from practical experience." According to the authors, all of the actors involved should contribute and learn about "values, beliefs and practices" and include all of these aspects in the built environment (Farmer & Guy, 2010: 376).

In the same vein, Elzen and Wieczorek highlighted the "co-evolution of technical and societal change" and, thus, the greater consequences of the transition through technology innovation. They also addressed sustainability in the "technical, socio-economic, cultural, spatial, environmental preservation, distribution of wealth, etc." spheres (Elzen & Wieczorek, 2005).

Using the notion of "framing" (Callon, 1998 and 1999; Goffman, 1974), rather than "path dependency" (David, 1985), Skjølsvold (2013) opened the discussion on sustainability by showing that "the way actors frame natural resources leads them to different conclusions in the question of sustainability" and, thus, "there are multiple 'sustainabilities'" (Skjølsvold, 2013: 11). Similarly, the Passive House controversy demonstrated that the sustainability in buildings has various solutions that are dependent on the boundaries/frames. Moreover, the solutions toward sustainability might differ when framing the building with regard to its various functions as home, technological product, and energy user.

In the same vein, Geels (2010) acknowledged the complexity of sustainable transitions, proposing a multi-disciplinary map and more reflexive studies. However, rather than focusing on recipes of "how to do it," he highlighted that sustainability might have different meanings for different actors and that it is difficult to fulfill all of these needs and expectations. Rather than pleading for a voluntary behavioral change, he considered the public authorities and the civil society as drivers of a sustainable transition (Geels, 2010: 507).

4.2.3 Knowledge production: Mode 2

The above studies discuss sustainable development as a complex task that is difficult to frame and has possible unexpected consequences. The sustainability approach combines different forms of knowledge. In this way, the production of knowledge and research undergo a transformation process. Mode 2, or *the New Production of Knowledge (NPK)* (Gibbons et al., 1994), offers a model of knowledge production "in the context of application." The NPK rejects the idea that knowledge is primarily produced in scientific institutions in the frame of scientific disciplines and explains knowledge production as a transdisciplinary result of heterogeneous collaboration (Hessels & van Lente, 2008).

The authors who initiated the NPK identified five major attributes that characterize Mode 2, as follows: *the context of application, transdisciplinarity, heterogeneity, reflexivity/social accountability and novel quality control* (Gibbons et al., 1994; Nowotny et al., 2003; Hessels & van Lente, 2008). The borders between basic and applied research dissipate, and knowledge transfer occurs continuously. "Pure" science becomes applied science, "any technology is 'transferred'; and knowledge is subsequently 'managed'" (Nowotny et al., 2003: 186).

The transdisciplinary co-production of knowledge (i.e., "the mobilization of a range of theoretical perspectives and practical methodologies to solve problems," Nowotny et al., 2003:186) extends beyond interdisciplinary collaboration, as it is "much more dynamic" (Hessels & van Lente, 2008: 741). Moreover, knowledge is not only produced at scientific institutions but at various levels. The actor network is enlarged, including research institutions, industry, policy-making organizations, etc., resulting in the heterogeneity of knowledge production.

The reflexivity of the NPK resides in the ability of actors and networks to build a "dialogic process" that "incorporates multiple views": "This relates to researchers becoming more aware of the societal consequences of their work" (social accountability) (Hessel & van Lente, 2008: 742). Quality control addresses the broader scrutiny of the research that, beyond peer review, undergoes an economical, political, social and cultural scrutiny (Nowotny et al., 2003; Hessels & van Lente, 2008).

In a further work, Nowotny, Scott and Gibbons (2003) described the changing research environment as a result of factors other than research. Again, they underlined the transdisciplinary nature of knowledge production as a result of "steered priorities" at various levels (i.e., the supranational, national and system levels).

With the differences between Mode 2 and Mode 1 (i.e., the traditional knowledge production was gradually replaced by Mode 2), knowledge production is not monopolized by scientists.

Returning to the current thesis, the knowledge production as described by Gibbons and Nowotny not only reflects the transdisciplinary work in the Zero Emission Building Research Centre, it also urges policy makers, legislators, and various

experts (including experts who are not involved in building research) to intervene in the creation of the future building. The new model of knowledge production should better explain knowledge production in the era of the knowledge society and the risk society (Nowotny et al., 2001). Valid knowledge does not solely refer to the knowledge that is produced in scientific institutions. Rather, it includes the knowledge that is produced at the borders of disciplines with the participation of the society "in the context of its application," which is also known as social-robust knowledge (Gibbons et al., 1994) or socially distributed knowledge (Nowotny et al., 2003).

However, Mode 2 is not universally accepted. The *New Production of Knowledge* was criticized for not being new (Etzkowitz & Leyesdorff, 2000), for having conceptual problems (Rip, 2002), and for assuming a non-existent distinction between the basic and applied research in Mode 1 (Godin, 1998; Hessels & van Lente, 2008). Let us closely consider the arguments against the generalization of Mode 2 and the relevance of these critiques for the current study.

Etzkowitz and Leyesdorff claimed that Mode 2 is not a new form of knowledge production; rather, it is the form that existed prior to academic institutionalization. The problem solving approach preceded the so-called Mode 1 due to the need to solve "practical problems through scientific means" (Etzkowitz & Leyesdorff, 2000: 116). The authors proposed the Triple Helix model, which considers knowledge production at the meeting spheres of university, industry and government. Weingart argued that even the transdisciplinary-formulated problems that were proposed by Mode 2 are often solved at the disciplinary or multi-disciplinary level (Weingart, 1997; Hessels & van Lente, 2008).

Addressing the conceptual strength of Mode 2, Rip (2002) questioned the five features that describe the NPK. The author did not observe a spring of organizational diversity and novel types of quality control in the multi-disciplinary collaboration and the oriented research. Moreover, he considered that the patchwork nature of science cannot be squeezed into one or another model, neither Mode 1 nor Mode 2 (Rip, 1997 and 2002; Hessels & van Lente, 2008). Rip referred to "the richness of knowledge production, in its various modes" and refused to define a single mode in a definite historical time segment (Rip, 2002: 117).

Collins and Evans (2002) examined knowledge production from a different perspective. In their "Third wave of science studies" that they referred to as "Studies of Expertise and Experience," they studied the means of "making decisions based on scientific knowledge before there is an absolute scientific consensus" (Collins & Evans, 2002: 241). Because the decisions of a qualified elite are no longer accepted as legitimate and the "truth" is not the exclusive characteristic of scientific knowledge, the public may and should contribute to decision-making. As such, the political and legislative decisions are viewed as the result of the interaction of two communities of experts, the experts with expertise (who are traditionally understood as experts) and the experts without expertise ("laymen" without a degree but with experience in the field). As such, the authors proposed an alternative to the transdisciplinary collaboration that was described in the NPK. In this alternative, decisions are the result of experts' level and include the public as an expert without expertise but with experience.

The various theories that were presented in this section generate the following questions for the cross-cutting analysis: How is sustainability negotiated? What is a robust socio-technologic device? How manageable is the transition management? How much Mode 1 or Mode 2 can be observed in research environments?

5 Negotiation legitimacy: Beyond measuring energy efficiency, toward sustainability

The 2011 report of the Buildings Performance Institute Europe (BPIE), "Europe's buildings under the microscope. A country-by-country review of the energy performance of buildings," measured and compared the performance of buildings of the Member States and Switzerland and Norway. It began with a quote from Sir William Thomson, Lord Kelvin: "If you cannot measure it, you cannot improve it." This is a strong statement that legitimizes intervention, as measurement is conducted to lead to improvements.

To some extent, the current thesis follows the consequences of this statement. That which can be measured gains support for improvement. That which performs poorly from an energy efficiency approach becomes an emergency and priority that

requires intervention. The advantage of technology is that we can quantify its results. This is a strong argument when communicating with policy makers, legislators, politicians, and the media. The increasingly strict building laws and the building standards are a consequence of the high credit that is accorded to the measurement of technological innovation. However, does this focus on measurement compromise non-measurable values? The results of the current thesis show that the "measurability" of building performances remains the key factor in defining a sustainable building but that the influence of actors other than engineers is increasing.

The EPBD report encourages the involvement of various actors inside the measurable frames:

"…this report wants to encourage a wider debate on how stakeholders in the building sector can collaborate to transform the European building stock into a highly efficient living and working environment which enables society to become more sustainable, in all aspects of the word's meaning (BPIE)."

The European and international agreements and legislation (e.g., the Kyoto protocol, the BPIE report, the Concerted Actions proposed by the European Commission, the EPBD) treat the need for increased sustainability in buildings as an emergency. The reality is framed as a crisis that requires intervention. The climate crisis, the economic crisis, and the energy crisis (see also Skjølsvold, 2012) compete for intervention legitimacy and resources. This competition is evident in the four thesis articles, in which the actors, especially the experts, argued for pathways that are "safe" for all actors. Although previous studies have shown experts' relatively low interest in building sustainability in Norway (e.g., Ryghaug, 2003), the current study shows that the interest of all actors has increased. The sustainability discourse became unavoidable. The increased interest of all involved actors in the development of the sustainable building supports the Mode 2 NPK theory, revealing the learning process that takes place inside the actor network. The actors learn to communicate with each other and support the mutual priorities of various groups. They also develop a common language that is connected to sustainability and enlarge the meaning of the concept of the sustainable building with other aspects of sustainability (e.g., social sustainability and environmental sustainability).

Mode 2 is the form of knowledge production in the studied group at the Zero Emission Building Research Centre. The research is applied and closely linked to policy-making and industry. The interviewees presented transdisciplinary groups as the ideal form of collaboration, and the most of them had knowledge in related fields. The interviewed experts were also aware of the immediate response of, for example, the media and users, who questioned or did (not) respect the technological design. In this way, a new form of control that is specific to Mode 2 was evidenced. However, the actual form of collaboration is rather interdisciplinary. The most current forms of control are those that are described by Mode 1, i.e., the peer review and the scientific evidence forms of control that validate the results before they are communicated to the public.

Nevertheless, the current thesis reached conclusions that are similar to those of other STS researchers (e.g., Guy and Shove, 2000; Groak, 1992), suggesting that the buildings researchers view buildings as static objects that can be improved. The models, or the result of their research, can then be embedded in immutable mobiles (Latour, 1987) in the form of standards and exported as recipes (Bush, 2011). However, the researchers who typically perform interdisciplinary work and have connections with the builders, policy makers, legislators, and social science researchers are aware of the complexity of the situation. As shown, they do not view the technological innovation as the panacea of sustainable development; rather, they view it as an unavoidable ingredient.

However, they simplify the complexity of the building in such a way that the development becomes manageable. By fragmenting the dwelling in separate spheres (e.g., technological, social, and economic aspects), the building researchers can apply their knowledge and competence and improve at least an aspect of the task. They often accept that they cannot master the complexity and, thus, offer a solution or a model of what can be managed. By studying imaginary households and their virtual cohabitation with the dwellings, the experts perform simplifications such that the dwelling becomes "ideal" but also manageable.

Guy and Shove (2000) wrote: "Energy policy makers and building researchers appear to share a remarkably uniform view of change and how it comes about. Yet it is a view that is often at odds with the every day experiences of those who construct

and inhabit the built environment." The study of user behavior and the processes and experiences at the construction site is beyond the scope of the current thesis. However, the claim that the building researchers and the policy makers have a similar view of the path towards sustainability is not surprising. Although I do not know why this is the case, I can answer the question of how this similar view developed.

The first article of the current thesis studies the role of building researchers, and especially research engineers, in the process of the creation of law. It shows that in addition to conducting research, they serve as managers and build the advisory boards for policy making. In Norway, the same institutions and often the same researchers are involved in research, advisory boards, and education. Thus, it is not surprising that their arguments and strategies are reflected in the policymaking.

The interviews with research engineers strengthen Guy and Shove's affirmations. However, the broad connotation of "building researchers" is not accurate in the Norwegian case. The interviews and the observations at the Research Centre on Zero Emission Buildings support the conclusion that the research engineers (but not all building researchers) have a substantial influence on policymaking and the creation of the building law and the technical requirements for the construction sector. This finding can be explained by the research engineers' greater development of communication tools. The countable and measurable findings are more easily transformed into law text and, especially technical requirements, than is sustainable development through architectural means. The interviewed architects complained that their results are not reflected in construction laws and that the increased focus on technological solutions limits the architectural potential. The interviewed architects did not reject technology; rather, they advocated a looser legal frame that allows for local adaptation. However, loose frames seem to be incompatible with the managed transition that has been adopted in Norway.

Building researchers other than the research engineers do not necessarily have a closer relation to the construction workers and the users. As reflected in the Passive House controversy article, the experts build a common front and share the same beliefs when discussing "the others." This might not be surprising because the environment of their work is the sterile laboratory of laws and measurements in non-

contaminated environments. Their results are not the reality but, rather, the potential most energy efficient dwelling. For an idealized dwelling, they would need ideal construction workers and ideal users. The interviewees blamed "the others" of not respecting the scripts and reacting irrationally. This shared view of researchers and policy makers is at odds with the construction workers' and users' stories.

Regardless of the borders that they drew, the studied building researchers promoted technical innovation as the key towards sustainability. The other participants (with predilection the construction workers and the users) were viewed as barriers or as participants who required additional knowledge. The building researchers' "universal forms of knowledge" (Guy & Shove, 2000: 132) is an abstract form that does not address competing interests, market mechanisms and the reality of the building.

The transition management theory and its critics view the various sectors as a whole entity that can communicate, synchronize its activities and targets, and adapt. However, as the interviews and media analysis demonstrate, various researchers have proposed sustainable paths of development that are sustainable when considered separately but might be costly, inefficient or even a waste of resources when considered in combination. It is apparent that competing interests, such as the cultural tensions between energy efficiency and wood stoves or the fight for legitimacy and resources between energy efficient buildings and district heating, mobilize the public through the means of the media.

These two examples show that sustainable development involves not only robust technology and good concepts but also how such solutions are concerted through policies. The previous investments in distribution pipes and the construction of power plants lose their meaning and potential if the low energy buildings become normality. Additionally, the construction of inefficient dwellings cannot be justified. Is technology the only concern when sustainable development is at stake?

In the current thesis, I offer a picture of the dwelling in making before the dwelling meets the user. Specifically, I examine the building research, the negotiations and the translations that are necessary for the dwelling to take the form of a law text and how this text is brought to the industry and the public. In this vain, the thesis discusses *the legal dwelling*, *the normal dwelling*, and *the technologically right*

dwelling and concludes that these are negotiated, rather than absolute, values. The science is a dialog and a circulated knowledge (Sørensen et al., 2008).

I also show that the complexity of the building assumes the collaboration of all actors, from experts to legislators, policy makers, politicians, builders and users. The socio-technical concept is best served through a transdisciplinary "hybrid management" (Miller, 2001; Wehrens, Bekker & Bal 2014).

The data of this thesis can be considered empirical evidence for the Mode 2 of knowledge production in the building sector. The building research is compared with other research areas (such as health and social science) and is closely linked to policy making, industry and the legislation process. Due to the complexity of the sustainable building, close collaboration between these actors is necessary. Sustainable development as a target cannot be achieved by combining the various disciplines; rather, the boundaries of the disciplines must be at least partially relaxed. As Berker and Bharathi found, the building researchers (not only in Norway) "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" (Berker & Bharathi, 2012).

However, the analysis of the interviews that constitute the data of this thesis depicts that much is needed to transition from interdisciplinary communication to the Mode 2 transdisciplinarity. The considerable role of building engineers partially shadows the intervention of other actors, e.g., architects. Moreover, key actors such as users and construction workers have only a marginal involvement.

Nevertheless, the knowledge production concerning buildings follows the Mode 2 model. The steered research through a priority setting at various levels is a key finding of the thesis. As described in Mode 2 *New Production of Knowledge*, the building researchers and other types of experts negotiate the legitimacy of their decisions, supporting the supranational (e.g., the EU Directives), national (the programs of various ministries) and system decisions (e.g., the priority areas as identified by the Research Council). As Nowotny et al. stated, "Although typically broad in their scope, these programmes are often the product of an awkward – and unstable – compromise between 'political' goals, promising science, and available

research capacity" (Nowothny et al., 2003: 182). The research result is 'robust' if it serves the society and its broader aims (as described above, the sustainable development of the building sector). The scientific 'truth' alone does not receive political and financial support.

Sustainable transition is employed as a national policy in Norway. Moreover, the sustainable building is a research priority and has both legal (see the Building code) and financial support (Enova.no). However, more importantly, all actors' awareness of sustainability in buildings increased during the last decade (see Ryghaug's (2003) study, which concludes that energy efficiency is not a priority in architectural offices. Ten years later, the interest in energy efficiency increased considerably). Through research centers such as ZEB, the researchers learn to conduct transdisciplinary work. Such groups gain a considerable influence in policy making and legislation. Symmetrically, the industrial partners and the Research Council support the financial stability of the research group. The financial support targets the applied research and the technological, social, environmental and economic robustness of the "new building." The various actors at all levels intermingle in the process of knowledge production. However, the building researchers became key actors in research, legislation and policy-making.

As shown in the media article, the communication of building researchers and other key actors with the public is often mediated. The experts use media to persuade the users and the potential clients of "their" scientific truth. However, the technology and the science communication follow the media logic rather than the scientific communication that is observed in the experts' arenas.

Rödder et al.'s (2012) relation between science and the media is reminiscent of Luhmann's system theory, in which each system has its own logic. Weingart observed the "systematic and institutionalized differences" (Weingart, 2012: 20) between the knowledge production and means of communication in the research environments and through the mass media. He observed that the mechanisms that are characteristic of scientific research, i.e., knowledge production that follows a certain agenda, the competence formally constituted through certificates, quality control, and the creation of communities of scholars "constituted by a network of topics, problems, and answers" (Weingart, 2012:19). The media also "'create' their

own 'reality'" by observing the society and capturing the readers' interest (Weingart, 2012:18). This should explain both scientists' and the public's trust in scientific communication and "why a conflation of media used and public addressed in scientific communication is perceived as problematic by scientists." He highlighted the possible competition between scientific communities and the media in "the attribution of reputation (Weingart, 2012:20)." Moreover, that which is a breakthrough achievement for scientific research is not necessarily breakthrough news for the media (Badenschier & Wormer, 2012).

These issues form the main difference between two articles of this thesis. The article on the negotiations that take place through the Norwegian Passive House controversy offers a pattern of knowledge production and communication in the research environment and policy making, whereas the analysis of media coverage of low energy buildings follows the mediatization of knowledge that has been produced in the research and policy making arenas and is brought to the public. The two arenas have different logics, follow different aims and produce different results. However, the various forms of knowledge meet in the moment when the buildings come into use. Weingart viewed the medialization of science as a "coupling of systems," i.e., the media and the research environment are systems that enjoy mutual services (Weingart, 2012:30).

Nevertheless, science needs the public's legitimacy of science, which is achieved through the media (Franzen et al. 2012: 5; Weingart et al., 2012: 364). In the case of low energy buildings in Norway, the experts, especially the building researchers, aim to legitimize their research and decisions in the media using the media's logic. Nevertheless, the media reports the experts' research results and projects rather than offering a critical view of the development. The low energy building is primarily covered in the media when a political decision is made and, thus, has a "time dependent background" (Badenschier and Wormer, 2012: 64).

Due to the normal science (i.e., difficult to frame as sensation) that mantles the research on low energy buildings, the media's report of the research results differs from that of the research communities. Specifically, the focus becomes the potential change in lay people's lifestyle patterns rather than technological achievements. Thus, the "*intensity*," "*framing*" and "*positioning*" of the actors in the frame are

relevant to assure the news worthiness of the information (Bauer, 2012:37). As remarked by Weingart (2012), this can create unease in the media-science relationship.

6 Sustainable transition of buildings: An expert task with a transdisciplinary challenge?

This PhD research is a part of the WP4 in the Zero Emission Buildings Research Center, a work package that studies the social aspects of the creation, implementation and maintenance of low energy dwellings. As the title "From law to turnkey" suggests, my research covered mostly aspects that are related to the creation and mediation of building codes and technical requirements. The focus was on the role of building researchers in the key nodes of technological innovation.

Building researchers are at the center of designing the sustainable transition in buildings. The experts' knowledge and expertise remains at the base of most political decisions. The complexity of the scientific information propelled the experts in a strong position in legislation and policy making, and the experts' knowledge is the decisive and ultimate argument for or against a certain development. The results of this study suggest that the technological innovation will take place due to an expert decision rather than a political decision. Moreover, expert knowledge is used to legitimize the political decisions.

Experts' knowledge is highly valued in all arenas. However, the research environment does not embrace the idea that the scientific truth is one and absolute. By contrast, the scientific (in the current case, the technological) knowledge opens the door to alternatives. The parallel developments in the same field (e.g., engineering) or in competing fields (e.g., engineering and architecture) create a multitude of complementary but also competing forms of knowledge. In this way, the predominance of experts and expert knowledge does not limit the controversies and the alternatives; rather, it enriches them in a new direction. As shown, even in the moment of mediation and mediatization through newspapers, the experts' message is strongest. An expert's task is to decide how "knowledge is formed and forms other parts of the society" (Sørensen et al., 2008).

The results of this thesis signal that there might be communication difficulties at the expert level. Nevertheless, despite the disadvantages of small research communities, such as the Norwegian research environment, such research groups have the potential to develop new models of cooperation. However, such interdisciplinary groups remain the exception, and the experts tend to stick to their routines and forms of knowledge and ignore or neglect the knowledge that other professions contribute. The complexity and the exigencies of the technological innovation, and the sustainable transition in general, might be easier to manage in transdisciplinary groups, as described in the Mode 2 of knowledge production (see also Moe, 2007). The transition from interdisciplinarity (experts from various fields working together) to transdisciplinarity (experts who have knowledge in various fields and are open to learn and accept other types of knowledge) is the challenge.

The interviews with the experts who were involved in research on zero emission buildings in Trondheim suggest that the architects, engineers and physicists were willing to cooperate; however, they found it difficult to understand each other. The routines and the communication of scientific results raise challenges for such groups. Additionally, a deeper mutual appreciation of the work and ideas might enhance teamwork. Nevertheless, the junction of knowledge has an impact on the creation of prototypes. The mutually developed projects and devices can join experts from different fields. Thus, the co-education of the future generation of experts in the ZEB is a first step towards transdisciplinarity.

The interviews also revealed that the architects in Norway often conduct office tasks. They plan the dwellings but are typically not a part of the construction team. The interviewed architects claimed that the architects (and not only the research architects) in Norway have limited tasks in the construction of buildings. However, this claim requires additional scrutiny. An ideal collaboration should encourage all actors to be present in all phases of the project. Furthermore, the work of engineers is artificially removed from the planning phase, in which the role of the architect is stronger.

Moreover, the clients' and users' involvement in the planning and execution of building projects might bring the expert's knowledge closer to the reality of the building in use. The experts' stereotypes of users hamper the development of

sustainable buildings because the prototypes that are developed in the sterile reality of research ignore the diversity of the users' expectations and needs and the reality of the building in use.

The media analysis suggests that there are knowledge gaps and missing critical public opinion concerning the low energy buildings and sustainability in buildings in general. The little public resistance alleviates the implementation of the building law and technical requirements but does not reveal the unexpected results. The trust in the political class and research is surprising. However, such attitudes allow experts and policy makers more freedom of action.

In sum, the current thesis focused on a group of researchers and their role in the creation of the sustainable building. As shown, the experts (the building researchers, researchers in other fields and policy makers) embrace the Mode 2 of knowledge production. Together, they participate in a sustainable transition within the building sector. However, they do not necessarily agree on the paths to follow:

They continue to have different approach preferences regarding the building law and the technical requirements (as in the Passive House controversy or in the expert' dispute on prescriptive versus performance based requirements).

They do not consistently agree on the forms of cooperation and their role in the transdisciplinary collaboration.

They do not have the same understanding of sustainability; this mirrors the ambiguity of the political concept.

The building researchers have different attitudes towards mediatization as part of their job. Whereas some actors are actively involved in communication through the media, others avoid publicity.

However, the common line is that all of the interviewed and observed actors considered the transition towards sustainability in buildings as a mandatory condition for a sustainable society. Moreover, building technology is largely acknowledged as a helpful improvement tool. The question is not whether technology is necessary; rather, the question is what type of technology should be adopted.

As this thesis indicates, in the new production of knowledge (Mode 2) controversies and negotiations are the rule rather than the exception. Even in relative

homogeneous research environments, such as the Norwegian research groups, tensions and disputes are a part of the transdisciplinary collaboration. As long as the tensions do not lead to a rupture in dialogue, they prove to be constructive.

The collaboration and negotiation processes that are described in the thesis present a pattern of transdisciplinary work in a Norwegian research group in a period of three years (2010-2013). However, the description is also relevant beyond the empirical cases as evidence of the knowledge production that is described in Mode 2. Moreover, it shows that the actors who are involved in the new knowledge production can also serve as door-keepers (excluding e.g., the active participation of the users) and that transdisciplinary work is achieved only partially and in exceptional groups.

The limitation of the current thesis is that it focuses nearly exclusively on the processes in the research environment and neglects the role of key actors such as policy makers, lawyers, lobby groups, politicians, practitioners and users. A next step is to study the meeting arenas between researchers and all of the neglected actors and to analyze these forms of cooperation and the negotiation processes that take place at these levels.

I agree with Moore and Karvonen's (2008) critique that the STS researchers accord more attention to technology than to design. Their understanding of design is "not as the application of abstract knowledge but as the principal method used by society to envision how we want to live in the future" (Moore & Karvonen, 2008: 30). Indeed, the design of the built environment deserves the same attention as the technological innovation. Their context-bound and context-rich design breaks with the "contemporary notion that a building is a commodity that should be designed at a distance by experts" (Moore & Karvonen, 2008: 39-40).

The current thesis primarily focuses on technology as a result of the interviews because the interviewees advocated or argued against technological solutions. This focus is likely also a consequence of the overall policy design that tends to intervene through technological improvement rather than through a contextual design. Furthermore, the interviewed experts framed the building of the future as an expert task.

I was not a passive observer; rather, I was a part of the research group. I learned that the status of the social researcher as observer results in communication difficulties. Thus, before claiming that the "experts" must develop better models of communication, we (we, the other types of experts) should consider accepting an active role and greater involvement. Rather than judging as critics, we should be a part of the team and participate.

7 Method

As a non-Norwegian, the study of the social aspects of technological innovation in the construction sector in Norway was a challenge. I had to learn about the research and the communication in the Norwegian culture until the last conversation I had with the researchers. Some of my estimations might be a well-known matter of fact for Norwegians who are involved in research. However, I had an advantage because I did not take the facts for granted and questioned the status quo. Some of the answers in the interviews and some of my conclusions completed the knowledge about the creation of the legal dwelling.

The data for this thesis were gathered through in-depth interviews, observation, and document analysis. For data analysis, I used the constructivist approach of grounded theory (Charmaz, 2007). These methods allowed me to draw a comprehensive picture of the building in making. The methods aimed to bring order to the complicated research data (Law, 2004).

However, why did I employ these methods? I met and spoke with the people who were involved in the analyzed processes to observe the development from the inside. The interviews also helped me to depict the other methods that I used to complete the data.

I used the method of observation in two circumstances. First, I observed the work of my colleagues in the ZEB over a period of three years to better understand their role in the sustainable development of buildings. Second, I participated as an observer at the Passive House conference in Innsbruck to complete the information that was gathered through interview and document study. The peer meetings follow rules that differ from the communication to the public, and the conference offered me the opportunity to observe the communication process from the inside.

The analysis of various forms of documents (leaflets, World Wide Web, email exchange, conference papers, and newspaper articles) confirmed and completed the interviews. The email exchanges between actors who were involved in the Passive House controversy were particularly insightful and allowed me to follow the negotiation processes from inside the group.

In the following section, I present a detailed description of the data collection and analysis.

7.1 Gathering data through interviews

As previously mentioned, the interviews are the base of the thesis. As Bogner, Littig and Menz underlined, interviews with experts "shorten time-consuming data gathering processes" and, especially at the beginning of a research project, expert interviews can offer particularly valuable information (Bogner, Littig & Menz, 2009: 2). The authors further stated: "Experts are generally of research interest above all because they are in a position to actually put their own interpretations into practice" (Bogner, Littig & Menz, 2009: 7). These statements support my decision to begin my investigation with interviews.

The first set of fourteen interviews took place at NTNU in Trondheim between October 2010 and December 2011. Each of the interviews lasted between one hour and one hour and thirty minutes. All of the interviewees worked at SINTEF or/and NTNU, and most of them were connected to ZEB. The research environment is relatively small, all of the researchers know each other, and I promised to anonymize the gathered data. Therefore, I do not provide extensive information about the fourteen interviewees. However, the interviewees are engineers, architects and physicists, and some of them have both architecture and engineering backgrounds. Their competence often surpassed the borders of their disciplines, and some of the interviewees have been practitioners or involved in policy-making and the development of incentives before or while engaging in research. They communicate both with each other and with non-research environments.

The interviews were conducted in the English, Norwegian and German languages. All of the interviews were recorded digitally and transcribed. I began to analyze the data while I transcribed the interviews. The semi-structured character of the

qualitative interviews allowed me to continuously adapt the questions to the interview stories and to adapt the interview guides for the subsequent interviews in light of the gathered information. Often, the discussions continued after the official interview ended and in other meetings. Meeting the interviewees over a period of three years, listening to them present their work, and continuing the discussions that began in the interviews were helpful activities.

A second set of four interviews that form the base of the second article "Passive House at the Crossroads" took place in Germany in June and July 2011. Each of these interviews lasted between one and a half hours and three hours. The interviewees were key actors in the Passive House scene. Two of the interviewees, an architect and a physicist, were employed at the Passive House Institute, whereas the other two interviewees were involved in product development (an engineer) and in the design of Passive Houses and renovation of old dwellings to the Passive House standard (an architect). The four interviews did not offer sufficient data for research. Thus, I completed the data with document analysis and observation at the 15th International Passive House Conference 2011 that was held in Innsbruck.

However, the four interviews were of great relevance to the study, as they helped me to depict the insider view of the process of creating and spreading the successful Passive House standard. The four interviewees were involved in the research (including product development), planning and execution of Passive House projects. Their experiences and opinions were of great relevance to my research. They also showed interest in the work of ZEB and were excited to follow the development of Passive House in Norway. The interviewees extended the discussions from the standard to the political processes that took place in various countries, helping me to depict the key to success and the resistance that the standard continues to meet.

These interviews were conducted in the English and German languages. Two of the interviews were transcribed by a professional. However, I soon learned that performing the transcription was helpful. First, I began the analysis while transcribing and immediately determined the main topics of the article. Second, the transcriber spoke fluent English but did not understand the technical terminology. Therefore, I had to correct and complete the transcriptions.

The advantage of interviews over other research methods is that they allow both the interviewer and the interviewee to look into each other's eyes (inter-view, Kvale, 2004). Following a flexible set of questions, semi-structured in-depth interviews allow the participants to tell stories and reflect on their relevant experiences (Charmaz, 2007: 25). The current thesis conducted in-depth interviews with architects, engineers and physicists to gather the data.

Charmaz wrote: "How you collect data affects which phenomena you will see, how, where and when you will view them, and what sense you will make of them" (Charmaz, 2007: 15). This quote helps me to consider the relevance of the interviews that I analyzed. Did I ask the correct questions? Could I have asked more questions? The fuzzy borders of the qualitative interview allow a continuous adaptation of the interview guide but, at the same time, create a slippery terrain. Both the interviewer and the interviewee might feel uncomfortable or have the feeling that they missed the purpose of the interview (interviewer) or were not heard (the interviewee).

However, in the case of the current thesis, the interviewees were experts who were confident in their knowledge of their work and willing to speak about their experiences. I experienced the interviews as pleasant and the interviewees as cooperative and competent. The interviews took place in a given context. The experts answered my questions as members who belonged to a group and represented their institutions. This is relevant data for the thesis because institutions become actors (see also Bogner, Litting & Menz, 2009).

7.2 Observation

Two of the articles focused on the analysis of in-depth interviews and were completed through the data collection method of observation.

The observation at the ZEB meetings over a period of three years helped me to depict the forms of communication between experts and how the knowledge transfer occurs. Although the researchers have experience with interdisciplinary communication, the presentation of their findings takes various forms. Moreover, because I was a part of the group, the observation was not passive. I had the opportunity to enter the laboratories; however, this visit was a presentation of the lab

rather than an observation of experts at work in the STS tradition (as described by Latour & Woolgar, 1979; Knorr-Cetina, 1981).

The observed colleagues knew that I carefully listened to them, although I am not sure if they were initially aware of my interest in how they communicated the information ("shadowing," Czarniawska, 2007). After my presentations in the close circle of the research center, they understood that my goal was to observe their work. They often joked that I could use a recorder during the meetings and use them as interviews.

The second participant observation that I used in an article took place at the 4-day 15th International Passive House Conference that was held in Innsbruck in 2011. In this case, I had the opportunity to follow how the insiders of the group of Passive House certified experts and products communicate their findings and success stories. The presentations covered technological, economic and management aspects of the concept. The thematic sessions were accompanied by exhibitions of certified components, poster sessions and visits to Passive House projects in Vorarlberg. The social events allowed the participants to meet and discuss topics, thus tightening the personal relationships. The newcomers were presented in sessions, encouraged and congratulated for their achievements. My impression was that after four days, all of the conference attendees felt as though they belonged to the group, shared the same targets, and had commonalities. The conference was a sample of network building, which might be more important than the knowledge transfer at the conference. These observations completed the interviews with the experts who were involved in the Passive House development.

During the observations, I took extensive notes, which I further developed in the days following the observation. However, I did not perform a traditional ethnographic observation. I primarily used the information to fill the gaps that were left by the other research methods that I employed. I often reformulated the notes into paragraphs, which were later incorporated into an article.

7.3 Written sources/documents

Riles defined documents as "artifacts of modern knowledge practices, and, in particular, knowledge practices that define ethnography itself" (Riles, 2006: 7). The

current thesis is neither an ethnography nor practice studies. However, the documentation of knowledge in written sources has been of importance. In addition to information, the documents revealed knowledge regarding the communication and negotiation of information. Latour and Woolgar labeled the documents that become immutable because of their quality to be transferable without distortions (Riles, 2006) as "inscriptions" (1986).

7.3.1 Websites, booklets and conference proceedings

In the article "Passive House at the crossroads," Prof. Thomas Berker and I used written sources to follow how the Passive House scene presents itself to the public. Whereas the observation at the Passive House conference is a sample of network building among involved experts, the websites of the Passive House Institute and the connected links, booklets and conference proceedings are means of exporting the knowledge and persuading the "outsiders" about the robustness and the potential of the concept. At the same time, the written sources present the insiders' view of the standard and its implications. The outsiders are not participants; rather, they are recipients of the information.

7.3.2 Analysis of email exchanges between key actors

Through the internal channels of the ZEB research center, I found a document of email exchanges between experts in various domains that was suggestively named "Den store passivhus debatten, 30 april – 31 august 2010" (The large Passive House controversy/debate). In the fifty emails that were sent to seventy-six participants, the Passive House standard was advocated, contested and negotiated. Twenty institutions were represented, and twenty-five of the participants actively contributed to the debate. The first email mobilized a whole research world. The emails represent an arena of collaboration and negotiation between key actors, i.e., peer researchers.

The use of private emails as research data raises ethical problems. At the beginning of the email exchange, the experts did not expect the public to have access to their written conversation. However, the email exchange became increasingly accessible to non-participants. On the other hand, the experts did not seem to restrict the circle of participants and mobilized as many opinions as possible. Thus, I wrote the article

and requested their permission to publish the results. All of the quoted participants directly or indirectly allowed me to use the email exchange as data.

The political context in which the email exchange took place was relevant. In 2008, the Norwegian Government proposed the Passive House standard as a technical requirement for all new dwellings. This mobilized both supporters and opponents of the concept. All of the actors struggled to be heard and to participate in the debates. I sent the completed article to all of the quoted participants, and all of them allowed me to publish the results. Moreover, they supported my efforts and encouraged me to bring their discussion to the public. This showed that the participants do not consider the email exchange as private. Rather, they consider it to be a platform of communication without time and space restrictions. With the ethical constraints overcome, I published an article on their written conversation.

7.3.3 Qualitative analysis of news articles on low energy buildings

In the "Media analysis," Thomas Berker and I followed the media coverage of low energy buildings between 2005 and 2012. An analysis of the newspaper articles allowed us to depict how the low energy buildings reach the public. We analyzed all of the Norwegian newspapers and, thus, included both the national and the local discourses. Because the Passive House concept shapes the political decisions, we began the analysis with the articles that were published in 2005, when the Passive House was first presented in the media as a solution for technical innovation.

We selected the newspaper articles using the on-line archive Retriever and the following search words: *low energy house, passive house, active house, plus energy house, zero energy building, zero emission building, and BREEAM.* From the initial 2338 articles, we deleted the articles that were irrelevant to the current purpose and analyzed the remaining 1774 articles. The newspaper articles completed the picture of the building of the future, showing how the news regarding low energy concepts were brought to the public.

7.4 Data analysis

For the data analysis, I used the grounded theory methods that were described by Charmaz (2007). The data collection and analysis often intermingled. The

systematical analysis of qualitative data aimed to "elucidate the key forms of action undertaken by participants in a particular situation" (Clarke & Friese, 2007). The first pieces of data that were obtained from interviews helped me to define the next steps in the research, reformulate and complete the interview guides and determine the most suitable methods. I wrote the initial memos from the start of the data collection, when the interviews were in mind. From the memos, I developed the codes.

The codes helped me to organize the data. I marked the texts with words or short sentences, following the similarities and the differences of how the topics were treated and how the codes intermingled, completed or competed with each other. The codes and the memos were used to develop the broader analysis paths of the research, marking the most discussed issues.

Most of the data analysis was a long process of repeatedly reading the texts and finding certain patterns. The analysis of the email exchange was especially challenging but also the most exciting time of the analysis. After writing the article, I returned to the data and confronted it with the final analysis. I then selected the quotes that supported the results of the analysis.

For the analysis of the newspaper articles, we used QDA Miner, a qualitative data analysis software program, to develop and compare the coded information. We also used the program to visualize the results. The visual results had a control function that showed the match between our perception while analyzing the text with the grounded theory method and the figurative representation of the results following the analysis with the QDA Miner.

QDA Miner aided in the analysis of the large number of articles. It visualized the results and served as feedback for the conclusions. A modest suggestion for my colleagues is as follows: when working with a large amount of data, it is helpful to learn to use a software program.

7.5 Data assessment/discussion

The data collection and analysis occurred in a given context. My observations, the interviewees' reports and my interpretations of their reports are not the absolute truth; rather, they are the creation of a possible reality. As Gubrium and Holstein

stated, “Every act of ‘seeing’ or ‘saying’ is unavoidably conditioned by cultural, institutional, and interactional contingencies” (1997: vii). This statement does not imply that social research is superfluous; rather, it suggests that researchers must be aware of their role in the processes that they study. The interviewers’ questioning (and not only the final draft of the thesis) intervenes in the course of the process development. The selected methods both study and create reality (Law, 2004). The social researcher’s role is as follows:

“Reluctance to standardize data collection and unwillingness to sacrifice depth for generality are matters of analytic necessity, not technical inadequacies. A world comprised of meanings, interpretations, feelings, talk, and interaction must be scrutinized on its own terms. Qualitative inquiry has always maintained this commitment, now more than ever” (Gubrium & Holstein, 1997:13).

Indeed, the analysis of the data showed that the building research does not mirror the “objective” scientific truth. Different truths compete for attention, funds and legitimacy. Thus, the current thesis did not focus on *what* happened but, rather, *how* the current situation developed.

Qualitative data analysis allows the researcher a freedom of choice. No determined pathways impede the analysis. However, at the same time, this freedom is a source of concern: have I selected the correct methods? Could I do more? Is my interpretation of the results accurate? Is there an accurate analysis? These doubts cannot find a definitive judgment. However, I can justify my choices and critically consider the limitations. My observations and understandings might differ from those of the interviewed and observed actors (Czarniawska, 2007).

One limitation of this thesis is that it analyzed a relatively small number of interviews. I attempted to overcome this limitation by using other data gathering methods to complete the missing information. A second limitation is that I neglected many categories of actors. I did not interview the actors who were involved in construction or in policy making, for example. I did not address the users; rather, I exclusively considered the imagined user. Therefore, the next step in this line of research is to complete the data with additional interviews that represent various actors and, thus, overcome the one-sided view of the conclusions. Such an

investigation would allow a comparison of the results and potentially present a parallel reality that might view the sustainability of buildings from a different angle. Now, I present the results of this three-year research, which took the shape of four papers.

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Article 1:
The Legal Dwelling: How Norwegian Research Engineers Domesticate Construction Law

Abstract

The considerable amount of energy spent on the construction, maintenance and demolition of buildings draws attention to sustainable development in the construction sector. Regarded as both tools and frameworks, laws are expected to sustain and speed technological innovation.

With the STS theory of domestication and in-depth interviews with building researchers studying zero emission buildings in Norway, I discuss the role of research engineers in the domestication of law, i.e., the translation of European Directives for building codes and technical requirements, and the mediation of these legal frameworks for industry and practitioners. I classify two main and opposing ways of domesticating the law in "inside the box" and "outside the box" approaches. The domestication of law accounts for numerous aspects and thus simultaneously becomes a technological, cultural, political and legislative activity.

The paper contributes to a better understanding of the legislative roles of research engineers.

Keywords: research engineers, low-energy building, construction law, domestication

1 Introduction

The considerable amount of energy spent on the construction, maintenance and demolition of buildings draws attention to sustainable development in the

construction sector. Regarded as tools and frameworks, laws are expected to sustain and speed the process. The building codes and accompanying technical requirements comprise a set of standards that steer the development and norms of building quality and construction in a particular direction. At the same time, construction laws are sensible to the reality of markets and implementation.

Comprehensive literature covers the role of standards and standardization in technological innovation and the tensions between the need for rules and variety. Russell defines standardization as a "social process by which we come to take things for granted", "a necessary stage in the process of innovation".[1,2] Although standards have the power to create reality and to establish a new order of things, they become unnoticeable when successful—they become normality.[3]

Standards have been described as "written instruments" that allow communication and efficiency and install uniformity[4], as technology-forcing instruments[5] or as a "recipe for reality" [6]. In the same vein, Bowker and Star regard standards as a way of "sorting things out", thus empowering or discriminating things and creating order through simplification.[7] Standards have been seen as fertile conditions[8] but also as barriers for variety[9]. Analyzing workplace environments, Slaton and Abbate see the ordering and simplifying power of standards as critical, showing how simplifying some systemic aspects may create the need for additional and more skilled labor elsewhere.[10]

Nevertheless, their faculty allow the coordination of technological and political powers[11,12], transforming them into efficient intervention tools used by national,

[1] Russell, "Industrial Legislatures", 2009: 662, 664.

[2] Russell, "Modularity", 2012.

[3] Russell, "Open standards and the digital age", 2014.

[4] Slaton, "Reinforced Concrete and the Modernization of American Building", 2001.

[5] Vinsel, "Federal regulatory management of the automobile in the United States", 2011.

[6] Busch, "Standards: Recipes for Reality", 2011.

[7] Bowker and Star, "Sorting things out", 1999.

[8] Metcalfe and Miles, "Standards, Selection and Variety", 1994.

[9] Krislov, "How Nations Choose Product Standards and Standards Change Nations", 1997.

[10] Slaton and Abbate, "The hidden life of standards", 2001.

[11] Hughes, "Networks of Power", 1983.

international and supranational organizations (e.g., the European Union[13]) to achieve environmental targets. The products' uniformity and unidirectional development represent a remarkable advantage for markets in adapting and reducing the costs of technological intervention.

Due to the role accorded to building codes, experts and institutions that develop and impose standards have the power to participate in the creation of reality.[14, 15] Building researchers are also a part of this process by formulating building code standards and technical requirements.

This article addresses the interface between research engineers and the law and their involvement in legislation-related activities, including the standardization of a more sustainable building sector. These engineers are involved in research and education rather than in actual engineering projects. Even if they are involved in projects (as is the case with pilot projects), they still act as advisors. In this role, research engineers may perceive the sustainable development and innovation in the construction sector differently than do, e.g., the consulting engineers that Hojem and Lagesen,[16] and Solli[17] described. While the practicing consulting engineers perceived construction laws as a push toward sustainability because of the already existing mandatory requirements, the research engineers studied here were involved in determining the best possible laws that could lead to sustainability.

After introducing research engineers as actors in the legislative process and offering a theoretical frame for the analysis, I will discuss the dimensions of the domestication of law in Norway: prescriptive versus performance-based law; incremental versus holistic development; and the law's immanence and impact on creativity. The discussion and conclusion will sum up these topics, depicting the research engineers' role in the domestication of building laws and formulating two ways of domesticating the law: "inside the box" and "outside the box".

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[12] Brunsson, Jacobsson, and Associates, "A World of Standards", 2002.

[13] Krislov, "How Nations Choose Product Standards and Standards Change Nations", 1997: 29, 137.

[14] Russell, "Modularity", 2012.

[15] Slaton, "Reinforced Concrete and the Modernization of American Building", 2001.

[16] Hojem and Lagesen, "Doing Environmental Concerns in Consulting Engineering", 2011.

[17] Solli, "Navigating Standards – Consulting Engineering Practices", 2013.

The exclusive focus on research engineers' work can be regarded as a limitation of this research. Indeed, the paper neglects the work of architects and physicists; in addition, this paper will exclude domestication of laws on the construction site and the impact of other domestication experts, e.g., the lobbying work of various actors, the practical work of lawyers, and the role of policymakers, in shaping legislation. However, research engineers' involvement at all levels in the domestication of law and their key role in creating a new normality deserves particular attention.

2 Black-boxing or Making European Law Norwegian

This paper is the result of analyzing 14 semi-structured interviews with architects, engineers and physicists involved in research on zero emission buildings in Norway and observations at meetings held at the Research Centre on Zero Emission Buildings (ZEB) in Trondheim, Norway, over a period of three years (2010-2013). Thirteen of the interviewed researchers were part of the ZEB team, and one was involved in research at the Norwegian University of Science and Technology (NTNU). The interviews took place between October 2010 and December 2011 and lasted between one hour and one hour and thirty minutes. The role of research engineers is thus drawn on their reflections on their work and on their colleagues (i.e., architects and physicists) in terms of the role that research engineers play in legislation.

In 2009, the Research Council of Norway launched the Research Centre on Zero Emission Buildings (ZEB) as a joint unit between the Norwegian University of Science and Technology (NTNU), located in Trondheim, and Sintef, "the largest independent research organization in Scandinavia"[18], which is also involved in developing standards. ZEB is one of the eleven Centres for Environment-Friendly Energy Research (FME). The research covers all aspects of the buildings "from cradle to grave", addressing advanced material technologies (WP1), climate-adapted, low-energy envelope technologies (WP2), energy supply systems and services (WP3), energy-efficient use and operation (WP4), and concepts and

[18] Sintef.no/home/About-us (last seen on June 30, 2014).

strategies for zero emission buildings (WP5).[19] The vision of the center is "to eliminate the greenhouse gas emissions caused by buildings" through products and solutions development.

ZEB has an international team of engineers, architects, physicists and social scientists, along with "the whole value chain of market players within the Norwegian construction business" as partners.[20]

For the Norwegian building researchers who were interviewed in this study, the existing law clearly represents an unavoidable starting point. They have a special relationship with the law: the law is a topic of discussion as long as it does not yet apply. At the moment a decision becomes law, it serves as a reference point for future research. The researchers cannot offer solutions that are illegal. The law is interesting to them, not only in its application, but also in its genesis and in the development of technical solutions that are better than legal requirements. However, defining the starting point drives the research in a certain direction and influences future legislation. Research engineers' roles extend from research to management, i.e., designing the future legal framework and redirecting research and education, what Law names "an alchemy of multiplicity. Of pluralism. Of different logics and necessities[21]."

At the systemic level, small communities and experts belonging to various institutions that know one another form Norwegian R&D environments.[22] Often the same expert is involved in more than one R&D group. An interviewee describes the communication as efficient and compares the group to a family:

"In Norway, we know each other, and that's really the way it works. We are really lucky in Norway that there are very few people. And most architects and building engineers have gone to the university here in Trondheim. We know each other. If you have two or three friends in your network, you know the other person you are going to contact in the authorities, in a big construction company, or something like that. [It is] really almost a family because we are such a small country" (C).

[19] zeb.no (last seen on June 30, 2014).

[20] zeb.no (last seen on June 30, 2014).

[21] Law, "The Manager and His Powers", 1997, p. 6.

[22] Guy and Shove, "The Sociology of Energy, Buildings and the Environment", 2000.

Guy and Shove[23] have already studied such groups and see in this "smallness" a lucky circumstance that facilitates efficiency and communication. Nurturing a large degree of coincidence between education and research, Norway's research environment is at a first glance homogeneous, with reduced conflict potential and quick problem-solving structures.

However, careful scrutiny reveals a tense and multifaceted research environment. The familiar milieu does not necessarily translate into homogeneity and convergence of targets. There are voices that, without necessarily opposing the present development (or being "politically incorrect", as one interviewed architect said), feel certain unease with the current situation. For example, several interviewees address the problematic association of ZEB's work in developing zero emission buildings with the well mediatized and politically encouraged Passive House standard.

Developed by Swedish professor Bo Adamson and German physicist Wolfgang Feist, the Passive House standard increases focus on insulation to maintain a comfortable interior climate without active heating and cooling. The Passive House was introduced as a voluntary standard, especially in central European countries.[24] In Norway, the standard was adapted to climatic and local conditions, and Sintef developed two new Passive House standards for residential and non-residential buildings. In 2008, a Norwegian climate agreement proposed the Norwegian Passive House standard as a technical requirement for all new buildings by 2020. In 2012, prime minister Jens Stoltenberg presented the government's "Norwegian Climate Policy", proposing the introduction of the Passive House as a technical requirement by 2015; however, the Passive House *level*, not the *standard*, has to be achieved. This important distinction can be seen as a political concession given the tensions that appeared in various environments (e.g., research, construction industry and architecture).

The political decision to introduce the standard as a mandatory technical requirement for all new buildings ignited a heated controversy among building researchers in Norway that breaks up the idealized perceived harmony. The

[23] Guy and Shove, "The Sociology of Energy, Buildings and the Environment", 2000.

[24] Müller and Berker, "Passive House at the crossroads", 2013.

following quotations address the problematic perception of a homogenous research environment:

"I think that it is influencing possibilities but also through attitudes and attention because I have noticed that [people from outside] automatically think that what we are working with is Passive House technology. And no matter what we present, or say, or do, we always get placed in this little box…This is looked at as one group and I think that's the problem" (K).

"This connection between Passive House and ZEB just worries me because, for me coming in, I didn't know anything about what a zero emission building was, so I started Googling. Every time I put ['zero emission building'] in, it was coming up with Passive House" (L).

In contrast, research engineers from Sintef see their legislative involvement as a part of their work and their deciding power as a given:[25]

"Sintef has been very active in developing the regulations for Norway. We have had big projects in developing, laying the groundwork for targets and also making the calculation rules for different kinds of buildings" (A).

"Our knowledge, our experience and our research results will be important for legislation" (M).

The first group's attempt to distance itself from a particular trend and the second group's empowerment as an influential driver of the status quo signal conflicting attitudes and interests. Metaphorically, the interviewees talk about "inside box" and "outside the box" ways of thinking. I will discuss these two approaches with domestication as a theoretical framework.

3 Domesticating the Law

"Domestication" describes the process of translation and mediation that laws experience from their inception to their implementation. Originally developed within media studies[26] and then extended to the acceptance of new technology in

[25] See also Jacobsson, "Standardization and Expert Knowledge", 2002.

[26] Silverstone and Hirsch, "Consuming Technologies", 1992

households[27], domestication describes the taming process of new devices.[28,29] To become a normal part of household or family life, technological devices have to be adapted to a particular household's life.

The concept of domestication has been developed in opposition to technology as conceived through deterministic theories of linear innovation.[30] Domestication states that the robustness of technology can only be proven in society, not in laboratory conditions: "The emergence of the domestication concept represented a shift away from models which assumed the adoption of new innovations to the rational, linear, mono-causal and technologically determined. Rather, it presented a theoretical framework and research approach, which considered the complexity of everyday life and technology's place within its dynamics, rituals, rules, routines and patterns."[31] Technological innovation is not only a matter of design and production but also of use and consumption. The domestication of technology "both completes and rekindles the innovation cycle".[32] As such, the domestication process is perceived as a constructive contribution to the artifact design, not as a destructive anti-script behavior.

The domestication approach was applied to multiple factors that impact society. As a concept, the domestication perspective has taken on a life on its own[33]. I will use domestication to follow the translation and mediation processes that the law experiences and to examine the role of research engineers in these translations. I will ask how, not if, these processes take place.

Despite the flexibility of this concept, there is a central characteristic that every domestication study shares: domestication is never a one-way street. Thus, a study of the domestication of law would have to examine not only how experts change the

[27] Lie and Sørensen, "Making Technologies Our Own?" 1996.

[28] Haddon, "Domestication Analysis, Objects of Study, and the Centrality of Technologies in Everyday Life", 2011.

[29] Sørensen, "Domestication: the Enactment of Technology", 2006.

[30] Sørensen, Aune and Halting, "Against Linearity", 2000.

[31] Berker et al., "Domestication of Media and Technology", 2006, p. 1.

[32] Silverstone and Haddon, "Design and Domestication of ICTs", 1996.

[33] Silverstone, "Domesticating Domestication", 2006, p. 229.

law but also how the law changes experts.[34] The research, the practice, the drawing of plans for future legislation, and the law as applied in practice must adapt to this somewhat subjective interpretation of the law. According to studies conducted within the domestication framework, not catering to this mutual adaptation could, in the worst-case scenario, compromise technical innovation in the construction sector because laws that did not allow a certain degree of flexibility could be openly opposed or peacefully ignored.

Research engineers are involved in the domestication of law at two stages of the process: the European policy goals are domesticated in the Norwegian legal and technical space, and the resulting building code and technical requirements are translated and mediated for the industry and practitioners.

In 2010, a recast of the Energy Performance of Buildings Directive (EPBD) drew a common legislative framework for all member states. However, being just a framework, the EPBD could not be applied as given and had to be adapted. Experts in the construction sector translated this supranational law into Norwegian law. This act was not a law-to-law transcription, where the supranational law is seasoned with national ingredients, but a complex process of divorcing the law from its context, breaking it into pieces, transforming it into a virtual building that fulfills legal specifications, adorning it with the national attire (e.g., a building tradition, the availability of resources, or climatic conditions) and, finally, re-inscribing it in the language of the law.

Even if the EPBD was accepted without heated debate (most likely because its acceptance is unavoidable), EPBD implementation as national law caused tensions to flare in the research environment. One interviewee says that the directive uses a "children's system, meaning that you should be nice and good and do the right things, but it doesn't tell you how to do it" (H). Thus, EPBD domestication has to first define what "nice and good" means for the Norwegian conditions and then, through requirements, instruct practitioners on how this domestication should be performed.

[34] Imrie, "The Interrelationships between Building Regulations and Architects' Practices", 2007.

Research engineers develop the standards that act as the foundation for future legislation and create policymaking advisory boards. In this way, they domesticate the EU Directive, applying it to real domestic conditions and reacting to subsequent developments. They attempt to foresee the law's implications and to combine the need for sustainable building development with building market realities. However, the codification of the message is not their only responsibility: in the next phase of domestication, research engineers are involved in demystifying codes and acting as mediators for practitioners and the industry.

Some interviewees warn that the legal requirements are partially unclear. Craftspeople might use this lack of clarity to avoid some requirements and renovate "as usual". On its way through codification, the law seems to be changing its down-to-earth characteristics, and the dwelling becomes a virtual reality with multiple options to get a form. Often, building companies ask the research engineers to clarify the legal specifications. In the following quotation, a research engineer reveals the complexity of the codified information and the need for translation:

"I looked into the new regulation that came in 2010, and I couldn't find that phrasing anymore. I had to contact the people at the National Office of Building Technology and Administration and ask how the regulations should be dealt with. And then I got a long email from a lawyer, and I had to read it three times before I understood what she actually meant" (C).

If it appeared in the text of a previous requirement, the discussed requirement still applied because it had not been abolished in the new law. However, this complexity was not self-evident. It cannot be taken for granted that everybody involved in building construction will understand requirements in the same way. The law fails to anticipate the complexities of implementation. In this phase, the research engineers act as mediators between legislators and practitioners. The process of understanding and translating the law is the taming process, when the law is taken from the abstract/coded environment and domesticated to be a part of everyday practices in the construction sector.

In Norway, this phase's domestication of the building code and of technical requirements is mostly achieved through Sintef-organized courses for practitioners. A research engineer explains her role as follows:

"[I give courses] for the industry and builders, the carpenters building houses and doing renovation, so that they can see the effects of the new regulations that surface because there much anxiety in the industry about regulations…You need to not make them so afraid and give them a practical view on what does it actually means for you" (C).

This fear of incomprehensible rules is also addressed in the action plan of the Norwegian Home Builders' Association, which explicitly mandates that Sintef clarify the legal circumstances of implementing the Norwegian Passive House standard and to explain the implications of this intervention for building producers.[35] The law's ability to adapt to local conditions might have an impact on its success as a policy tool.

Numerous studies mention the relevance of building codes and technical requirements as intervention tools toward sustainable building development. Hojem and Lagesen claim that "the far most important way of [consulting engineers] could address environmental concerns was to fulfill legal regulations and frameworks".[36] At least in the case of consulting engineers in Norway, the authors conclude that the laws and regulations "seem to be the most effective instruments to shape the environmental practices of consulting engineers."[37] Similarly, Solli underlines that "the potential of technical requirements to enable more energy efficiency is perceived to be high [by consulting engineers]."[38] Clarifying such laws to produce efficient political tools requires professionals to engage with environmental measures.

The domestication of law is a common task for building researchers. However, as we have seen with the Norwegian Passive House standard as a technical requirement, collaboration between experts is made difficult by their different approaches and expectations. The next chapter will focus on conflicts among building researchers that primarily appear due to their different opinions about how to domesticate the law.

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[35] Boligprodusentenes handlingsplan for passivhusnivå i, 2020.

[36] Hojem and Lagesen, "Doing Environmental Concerns in Consulting Engineering", 2011.

[37] Hojem and Lagesen, "Doing Environmental Concerns in Consulting Engineering", 2011, p. 123.

[38] Solli, "Navigating Standards – Consulting Engineering Practices", 2013.

4 Dimensions of Domestication

Not all interviewed researchers agree about how the law applying to new dwellings should be domesticated. In this section, I will distinguish the three most important dimensions of the law on which they disagree: prescriptive versus performance-based law, incremental versus holistic development, and the law's impact on creativity.

4.1 Between the exploration and exploitation trap

All interviewed building researchers acknowledge and accept the role of standardization and the need for rules. Disagreement about how to domesticate supranational law in Norway starts when researchers try to define the construction sector's target, continues with discussions in favor and against prescriptive and performance-based regulations, and ends with differing visions of future development, i.e., the linear view versus the holistic view.

As their names imply, *prescriptive* requirements prescribe/define mandatory technical solutions, whereas *performance*-based requirements only specify the required results, opening the way to various solutions. To take an example from the interviews, the mandated heat recovery ventilation system in each new dwelling is a prescriptive requirement, whereas requiring in-door air to have a certain quality irrespective of ventilation (e.g., natural ventilation or mechanical ventilation) is a performance-based requirement. Let us see the arguments for and against measures for taming European law and, almost literally, making it domestic, i.e., Norwegian.

The interviewees usually saw the advantages and disadvantages of choosing one of the options: prescriptive or performance-based laws. They weighed the alternatives, but, for the sake of practicality, they generally stuck to one option or the other. For example, one interviewee offered the following:

"Even though there is opposition between flexibility and rigidity, it is good to have a set of rules that you will follow because it is easier for people who do not have much knowledge about this, but it is also good to have flexibility to allow for creativity and new solutions that could be better than a set of rules…However, I think that at this stage when so much new, it is important to have a defined set of concepts that

you can follow, even though it might hamper some creativity and new projects. [The performance-based law will confuse some people], just a few people will know how to do it…It is good to have these concepts defined in a way" (A).

This approach to domestication favors the adoption of given pathways. Its advocates sacrifice the ill-timed "wishful" liberalities and stick to rigid directions for development. In this way of ordering things[39], the uniformity attained through standards and standardization (i.e., the set of rules often mentioned in interviews) would favor the transition toward sustainability.[40,41]

One of the main arguments in favor of prescriptive laws is that they offer a clear way forward and are easier to implement. The abundance of information is perceived as disturbing when the law moves beyond the theoretical platform and is implemented by the construction industry. The clarity of the concepts should guarantee that at least the mandatory quality is achieved and that risks are avoided. Reading between the lines, it is better to have many adequate buildings than some exceptional buildings and many buildings that fail the energy efficiency test. To be a legal dwelling, it is enough that the dwelling respects the legal prescriptions (see also Solli[42]).

In addition, supporters see prescriptive laws as clear political signals about future development. These laws will encourage the construction industry to comply with the new requirements and will give the market time to adapt. When talking about introducing the Passive House concept as a requirement, one interviewee said that it "should be a symbol for the authorities to say that this is something that we want. Now it is a regulation" (C). It seems that there is a need for certain rules for the industry as a whole. The rules will apply to all, avoiding the chance that some parts of the construction industry favor milder legal conditions, which might slow the process of innovation, while others take the financial risk of following stricter requirements. The market will also adapt and offer a larger (and cheaper) variety of technological devices.

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[39] See also Bowker and Star, "Sorting Things Out", 1999.

[40] Metcalfe and Miles, "Standards, Selection and Variety", 1994.

[41] Law, "The Manager and His Powers", 1997.

[42] Solli, "Navigating Standards – Consulting Engineering Practices", 2013.

According to these interviewees, the prescriptive laws are encouraging, almost forcing, the industry to adapt and provide the new technological solutions that are needed to fulfill the requirements. In addition, strict requirements will encourage future technological development in a given direction: "My experience is that whenever you set a regulation, it will influence the technology" (H). Consequently, interviewees see technical requirements as a vehicle for future innovation. Through the process of taming and timing the law, research engineers change the conditions of involved industries and the market.[43] The domestication of law creates path dependency.[44] As described by Hughes[45], the coordination of political and technological power is part of the domestication process.

Prescriptive regulations thus act as efficient instruments in creating a new normality because all partners involved in the taming of law – engineers, architects, physicists, policymakers, and the construction sector – arrive at a compromise (G). In this way, it is easier to legitimize the decision to raise a standard to the level of technical requirements that the Norwegian Passive House standard sought to achieve by 2020.[46] The taming of law through negotiations and compromise empowers and legitimizes the resulting law.

Some of the interviewed research engineers argue that, despite the advantages of prescriptive laws and regulations, the impact of such legal specifications are diminished by the overlooked issues. Supporters of performance-based regulations affirm that too much attention is given to the energy efficiency of buildings in use, while other important aspects are neglected. The evaluation of a dwelling should not be restricted to use and should go through the whole life cycle analysis (LCA). The

[43] For the power of organizations that develop and impose standards, see Russell, "Modularity", 2012.

[44] For "path dependency" see David, "Clio and the economics of QUERY", 1985.

[45] Hughes, "Networks of Power", 1983.

[46] Müller and Berker, "Passive House at the crossroads", 2013. Considering the concept of Passive House, there is need for specifications. The concept is a performance-based standard; the requirements relate to the performance of the building and not to the way in which the dwelling should be built. However, advocates for performance-based requirements affirm that the performance expected from a Passive House makes some technological devices (e.g., a heat recovery ventilation system) prerequisites; thus, it is indirectly prescriptive.

neglect of relevant aspects of construction, such as energy use and the greenhouse gasses emitted in the material production, transportation, execution, and demolition of buildings, leads to an incomplete picture. Consequently, despite increased energy efficiency, the impact of dwellings on the environment will not improve. This "cradle to grave" approach would encourage research engineers and architects to look for other solutions than if the energy efficiency target were so precisely specified. Some supporters of performance-based regulations said that the prescriptive standardization might help the industry, but it increases the expenses of the dwellings' architectural qualities. It is another way of taming the law that changes the calculation tool, extending the measurement of energy used in buildings to energy used "from cradle to grave".

These interviewees argue that a "broader view" in performance-based technological regulations will favor the redirection of research. The exclusive focus on energy efficiency will result in "a storage house for fiber glass with a room for people inside" (H). The quotation refers to the increased insulation that is to blame for reducing a building's living space. This research engineer and numerous architects advocate a focus shift toward investing more in material development and away from restrictive regulations. An interviewee offers the following:

"Maybe it is not necessary to implement Passive House requirements by 2016, and if technology instead develops in a way that does not require us to reach those requirements, we could just jump around and over them and solve them in a different way with energy systems, with interactive measurements systems" (K).

Avoiding reducing technical requirements to a standard, even if it is a performance-based standard, draws another approach for the domestication of law: more freedom changes research premises and encourages diversity. In contrast, narrow path dependency will turn discriminated solutions into dead-ends. Even if there is some research freedom, legislation has the power to redirect resources (i.e., money, education, product development and affordability, the market). As described by Vinsel, the advantage of performance standards is their ability to influence development while not intervening too much. Vinsel calls performance standards the

"liberal technology of governance", delineating their power of intervention while avoiding resistance.[47]

From the domestication perspective, the taming of law toward prescriptive regulations would prevent duality and thus ease and speed the industry and market's adaptation to the new reality; in addition, it might overly hinder domestication in the construction and use phase. Taming toward performance-based law would open up a larger variety of solutions and allow for local adaptation without deviating from the script; domestication is thus made part of the law's implementation.

The dilemma of choosing between two alternatives is not a new one. The dual need for uniformity and diversity is largely documented in literature. For example, Metcalfe and Miles see the standardization process as an "order-imposing process" that might have some inhibitory and reductionist effects. However, standards can be "the basis on which variety is constructed".[48] Writing about the management of construction innovation in Great Britain, Graham Winch states that regulations result in "the British system [that] can apparently have simultaneously too much and too little innovation – there are plenty of new ideas, but they tend not to achieve good currency" because the system is somehow "a victim of the exploration trap, where everything tends to be designed from first principles for every project."[49] As a result, performance-based laws do not necessarily lead to more innovation in building construction. Still, choosing prescriptive regulations can lead to an "exploitation trap". In terms of domestication, the translation of EPBD into Norwegian law confronts the same dilemma. There is no such thing as a best solution, and both prescriptive and performance-based laws have advantages and disadvantages for research and for the construction sector's sustainable development.

Interestingly, both groups invoke the scarcity of time as the reason for the acceptance of one system or another. Supporters of prescriptive regulations affirm that there is the need to start somewhere and to stop continuing to build in the

[47] Vinsel, "Federal Regulatory Management of the Automobile in the United States", 2011: 8.

[48] Metcalfe and Miles, "Standards, Selection and Variety", 1994:246.

[49] Winch, "Zephyrs of Creative Destruction", 1998, p. 271.

current inefficient manner, whereas supporters of performance-based laws suggest that there is no time to solve the issues individually and that there is a need for a rushed change in all aspects of dwelling construction. These arguments show the urgency to opt for one of the solutions, as two solutions can hardly coexist.

4.2 About the speed of domestication

The invoked scarcity of time raises the question of incremental versus holistic development. There is some correlation between this dimension and the prescriptive versus performance-based law, but they do not overlap completely. Indeed, most of the interviewed supporters of prescriptive laws see linear, step-by-step, stair-like development as the most suited pathway. Gradual development is seen as efficient, encouraging and motivating. Advocates for incremental development praise the clarity of standards and argue in favor of gradual learning and adaptation of industry:

"It is good to have regulations that come gradually and are more and more strict gradually, so that you could adapt step by step, and then you can relate to these regulations and try to do even better, so in a way it is a sort of reference space for trying to do better…It would be good if the government could say as they have said in Norway now that they will have stricter and stricter regulations at least every five years…So that they can see that we build for the future" (A).

The interviewee proposes the domestication of law through an incremental approach, due to the increased previsibility for actors involved with the law. To build for the future, one needs some security about what the future will be. This approach is also presented as advantageous for research because laws and regulations define the minimum standard from which research engineers must begin improving technology and developing concepts.

The holistic approach broadly encompasses performance-based law arguments, but it also crosses legislative borders and touches on some organizational and systemic questions. In addition to the need to see the development of dwelling construction as a process that has to be analyzed holistically, the interviewees argue that there is a need for more coordination and dialogue between different actors, e.g., between ministries:

"If the department of environment would create incentives or regulations to reduce the consumption of resources or to consume them more efficiently, the department of finance would most likely try to come up with countermeasures because they would see that the economic growth is decreasing" (K).

Therefore, domestication of law that does not respect other systems' targets might expect counter-reactions. In the same vein, Slaton and Abbate show how standards may simplify some aspects while creating different needs within the system.[50]

The domestication of law toward a holistic approach sees building law as a part of a larger system and addresses the need to aggregate and anticipate the reaction of possible actors. The research engineers who advocate for a holistic domestication approach plead for mainstream sustainability instead of incremental intervention (F). These two domestication approaches ultimately dispute two anticipated path dependencies that both claim to save time and resources: whereas the incremental intervention relates to the advantages of gradual industry and market adaptation, the holistic approach advocates for aggregated problem solving.

4.3 The law's immanence and its impact on creativity

We have seen that there is no consensus among experts about what laws are best or what requirements should be implemented. However, the dispute is not about whether the law should be domesticated but how it should be domesticated. There seems to be a consensus that building codes and technical requirements are necessary. What is the reason for this argument? Does the law have an impact on researchers' creativity?

The first legal requirements for buildings applied to aspects related to construction stability and have gradually been extended to requirements that improve the health of the people using the buildings. Because of scarce resources and harsh climate conditions, Norway's technical requirements for buildings date as early as 1928 and have increased in technical exigencies ever since.[51] These measures were a direct consequence and answer to the need for healthy and comfortable dwellings.

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[50] Slaton and Abbate, "The hidden life of standards", 2001: 96, 136.

[51] Thyholt, "Varmeforsyning i lavenergiboliger i områder med fjernvarmekonsesjon", 2006.

The new laws and requirements related to energy efficiency and the reduction of greenhouse gas emissions are not legitimated by immediate necessity. The user's direct benefit has to be reinvented and reinterpreted. There is no doubt expressed about the need for improvement, and there seems to be a consensus among interviewees that the way we are living constitutes an improper use of resources. However, laws in the construction sector can hardly be seen as products of the democratic process.

In the construction sector, law is perceived as a framework for activity and has a double role as a norm (i.e., how to build) and a tool (i.e., how to achieve targets). The interviewees do not question the need for a legal framework. Even the legitimacy of the supranational law, the EU Directive on Energy Performance of Buildings, as a mutual/common framework for all European states is not disputed.[52] On the contrary, the interviewees describe the common EPBD framework as a welcome joint effort of European states to achieve the goals for energy efficiency and the reduction of greenhouse gas emissions. "The CO_2 emissions are democratic" (J): they do not respect borders and have on a worldwide impact. The interviewees argue that to make a difference, all European countries have to agree on a common legislative approach.

Building researchers accept the democratic spread of consequences as a legitimate argument to enforce the European policy about redirecting energy consumption in dwellings, reducing greenhouse gas emissions, and increasing the use of renewable energy sources.[53] All interviewed building researchers argue for a common European framework that would also push the "slow-comers" to act. Norway is seen as part of the European system and not as an isolated and self-sufficient entity. Norway has a high degree of hydropower and already high-standard technical requirements for dwellings, but this progress is not seen as a reason to stop improving. In this way, the supranational law is used to legitimize national laws and

[52] As an EEA member, Norway implements the Directive as if it were a full EU member state.

[53] The declared reason for creating the EU is the need for a common market to avoid conflicts. The emphasis on energy efficiency is rather new.

requirements and to present them as the best translation of EPBD to Norwegian conditions. As one interviewee adds, "It would be harder for the politicians to get the high requirements through if the EU hadn't set this standard in the first place" (A).

An interviewee expresses the law's immanence as follows:

"If you want to achieve a zero emission building, it's impossible if you start drawing nice staff. And then how can you transform this staff in zero emission buildings? No, that's something out of question" (J).

He makes two points: there is a need for a common target to reduce energy consumption in dwellings, and the most efficient way to reduce consumption is to use the law to enforce the common target.

Again, disagreements appear when domesticating EPBD into national law: Would stricter laws and regulations encourage or restrict innovation? How much room is left for creative solutions in a strictly regulated environment? What impact does the law have on researchers' creativity?[54]

Some interviewees see laws and regulations as inspiring. They affirm that the long-term goal encourages and stimulates research to look for new and creative solutions. One can be creative within legislative limits, and stricter regulations direct and focus attention in a precise direction. One interviewee says that "[i]t can make you think about new solutions; you cope with new alternatives. It forces me to think about new solutions" (B). This attitude is embraced by many of the interviewed researchers, who perceive the requirements as a way of avoiding bad practices or spreading resources in too many directions that potentially lead to inefficient solutions.

However, there are other interviewees who also spot the disadvantages of legislation that is too narrow to allow the development of creative design solutions. For them, bad domestication causes a dramatic shift in researchers' roles because new legal conditions redirect research. In addition to the fact that they "limit the architectural possibilities" (B), regulations are seen as being too limited in scope (F). The

[54] For the possible inhibitory consequences of standards, see Krislov, "How Nations Choose Product Standards and Standards Change Nations", 1997:15.

technological specifications that are "almost made a prerequisite" bars the way for alternative solutions and thus hampers creativity and narrows research freedom:

"The traditional architectural means of saving energy and making other environmental efforts is getting restricted because of the latest laws. Energy efficiency can be an important part of the design, and architects should handle it" (F).

Supporters of performance-based requirements prefer to combine the law's calculable and quantifiable approach with the traditional architectural means. This group of research engineers extends the borders of research from dwellings to neighborhoods, communities and cities. Regarded as a unit within a whole, the sustainable dwelling is just one piece in a large puzzle. Moreover, domesticated law should not be just a norm that addresses today's dwellings; it should also have implications for future legislation and research.

To conclude, research engineers perceive the law differently, according to the topic of their research and to the way they draw the borders of sustainable innovation. The same law appears to stimulate creativity for some researchers, while others feel restricted and inhibited in their work. Although some engineers prefer clear laws and defined baselines/starting points, others (particularly architects) encourage flexible approaches with floating boundaries. Creativity has different sources and different applications: from the "even-better" engineering approach to the "jump over and see it from a different angle" approach that is typical for both engineering and architectural means. At the level of research engineers, the domestication of law is thus to a high degree related to activities in which these actors are involved.

5 Discussion: Outside the Box, Inside the Box or Both?

The "legal dwelling" is an artifact produced where engineering, architecture, physics, law and policy meet. This paper primarily addressed engineering work, focusing on the contribution of engineers involved in research about the creation, mediation and translation of law, i.e., the domestication of law. Thus, ZEB researchers codetermine the legal conditions in which a building can be planned, constructed and demolished, thus creating a building's virtual legal space: the "legal dwelling". All interviewees acknowledge the necessity of standards and

standardization but do not agree about the way toward zero emission buildings. The question is how, not if, to domesticate the laws. The laws and regulations do create order and previsibility in various environments. However, sorting things out while deciding the correct standards and accompanying implementation is accompanied by conflict and disagreement.

With their power in developing and domesticating laws and regulations, the studied research engineers have a tremendous influence on the development of future legal dwellings. The domestication of law is a highly political, not innocent, activity.

I observed two ways to domesticate the law: metaphorically, the interviewees talk about the "inside the box" and "outside the box" perspectives. They position themselves in one of these groups and defend their choice, still acknowledging the other group's merits. Even if the research engineers find their place in the grey zones between two extremes, they generally lean in one direction or the other.

The "outside the box" perspective defines a group consisting of both research engineers and architects (see Hogg and Terry[55] for the abstractions/archetypes of group features). Colleagues describe those connected with "outside the box" thinking as these "outside the box" thinkers describe themselves: they prefer liberal/performance-based laws and thus insist on the freedom of choice. They are also seen as embracing the holistic view, as being able to solve many problems in the same project. Their preference for creative solutions that are adapted to the site is difficult to standardize and quantify the results—a significant drawback. The fact that their solutions cannot be characterized simply in numbers and figures makes communication with policymakers rather difficult.

The counter-picture is the analytical way of thinking, which is often connected to interviews with engineers. It is the picture of the manager, who is able to achieve incremental but steady development. Interviewees describe this group as having better communication with policymakers because of their ability to present their ideas quantitatively and to offer a viable picture of the results. On the negative side, they are blamed (and sometimes blame themselves) for thinking narrowly "inside

[55] Hogg and Terry, "Social Identity and Self-Categorization Processes in Organizational Contexts", 2000.

the box" and looking mostly at incremental changes (and thus missing the "broader view").

Seen from outside as a homogeneous research group, the ZEB team revealed under closer scrutiny that smallness does not mean harmony. It is not only different knowledge that hardens communication; different routines, approaches, priorities and tools also separate them. Different professions and different specializations within the same profession, as is the case of research engineers, aggregate the existing knowledge in different ways. To a high degree, the deciding power belongs to research engineers. In the domestication of law, the building researchers dispute the power relations that negotiate which knowledge is accepted, promoted or enforced.

Even if the breakup of the two categories of building research engineers is artificial, it says something about these engineers' self-image and about how their colleagues view them. As mentioned above, all of the researchers display elements of both perspectives, but everyone still prefers one of the two options and tries to promote one particular perspective. Due to the close communication typical of small research environments[56], both views have a real chance to be heard, and the negotiations have a good chance of resulting in a compromise everybody can tolerate. In the best case, the result of their collaboration in zero emission building research is co-management, along with the co-research that is already occurring. Regarding the learning process, learning to communicate with others and to see/accept/consider different angles for approaching the same task, if successful, could be one of the research group's most relevant achievements. The forms of cooperation developed by small groups (e.g., ZEB) can be then exported to larger environments.

The multiple roles of research engineers often bring them into interdisciplinary groups, where the given tasks cross the boundaries of more than one profession. When considering interdisciplinary work, the literature refers to work and collaboration between different engineers (e.g., Bucciarelli[57], Davis[58], Vinck[59],

[56] See also Guy and Shove, "The Sociology of Energy, Buildings and the Environment", 2000.

[57] Bucciarelli, *Designing Engineers*, 1996.

[58] Davis, Thinking Like an Engineer, 1998.

[59] Vinck, Everyday Engineering, 2003.

Trevelyan[60]). However, more research is needed for interdisciplinary work and collaboration between engineers and architects, for example. For instance, the creation of a dwelling, i.e., the creation of the virtual legal dwelling, is the result of work and collaboration of different experts, such as engineers, architects, and physicists, but also lawyers, policymakers and politicians. In such cases, the knowledge transfer between various professions relies on the participants' abilities to communicate and aggregate the existing knowledge. The scope of this paper does not extend to interdisciplinary collaboration. However, it is relevant to mention research engineers' tangential work and their ability to assimilate various approaches in the domestication of law process.

6 Concluding remarks

The interviewees do not dispute the necessity of law as a common intervention framework, as a norm and a tool. However, we have seen that research engineers perceive the way toward sustainable building differently. The "inside the box" and "outside the box" approaches frame in a metaphorical and suggestive way the two main approaches to sustainability. The three dimensions of domestication frame the most disputed topics of domestication, addressing prescriptive versus performance-based laws, incremental versus holistic development, and standards as the basis versus a barrier for creativity.

The tensions that accompany the legal dwelling's creation are evidence that building laws are not straightforward translations of supranational law and technological possibilities. The law's creation and mediation accounts for numerous aspects, as a simultaneously technological, cultural, political and legislative activity. The legal dwelling is not the best possible dwelling in laboratory conditions, but it is the best compromise. Irrespective of "inside the box" or "outside the box", the domestication of law is nothing less than the black-boxing of legal complexity.

[60] Trevelyan, "The Intertwined Threads of Work", 2008.

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Article 2:

Passive House at the Crossroads: The past and the present of a voluntary standard that managed to bridge the energy efficiency gap

Liana Müller and Thomas Berker

Abstract

Improving energy efficiency in dwellings is generally seen as the low-hanging fruit of climate change mitigation. In particular decreased heat loss through better insulation is suggested as one of the most cost-effective means to achieve the ambitious national and international goals of climate gas reduction. However, the literature shows that a profitable technological solution is not sufficient to reach the energy goals. Aspects such as a lack of information, unobserved costs, and heterogeneity among users can compromise the success of technical innovation. Still, there are successful concepts that drive the technological development in the construction sector. The Passive House is an example for such innovations that manage to bridge the energy efficiency gap. This paper addresses the Passive House concept and standard as a success story of technological innovation. With Bruno Latour's *Science in Action* (1987) as a starting point, we describe the conditions under which the standard was created, the role of the network built around the Passive House Institute, and the consequences of exporting the standard. We identify success factors that have supported the diffusion of the Passive House standard and concept and discuss its possible development in the current situation which is characterized by its wide-spread adoption.

Keywords: Passive House, technological innovation, immutable mobile

1 Introduction

Reducing buildings' energy consumption is generally seen as the low-hanging fruit of climate change mitigation (IPCC 2007). In particular decreased heat loss through better insulation is suggested as one of the most cost-effective means to achieve the ambitious national and international goals of climate gas reduction (McKinsey & Company 2009). However, that the large potential of these measures is still promoted today should suggest caution: the benefits of better insulation have existed and have been well understood for years (e.g., Perlman and Warren, 1977) but have apparently not lived up to their potential. The list of factors that are able to explain this classic case of an energy efficiency paradox is long, including the lack of information and private information costs, principal/agent slippage, unobserved costs, and heterogeneity among users (Jaffe and Stavins, 1994); sociocultural and psychological factors (Wilk and Wilhite, 1985); and the strategic postponing of costly investments (van Soest and Bulte, 2001).

Although all of these factors explaining the lack of energy efficiency investments apply to the case of buildings and building insulation, there is a counterexample of a building type that goes far beyond the usual measures to avoid heat loss: due to an innovative recombination of existing energy efficiency measures and the development of building elements, the Passive House concept allows a comfortable indoor temperature even without an active heating or cooling (hence the name "passive"). In practice, most Passive Houses have an active heating but still with radically reduced energy demand. At the end of 2010, there were approximately 27,600 certified Passive Houses in Europe, and it is estimated that there will be approximately 65,000 such houses by the end of 2012 (www.pass-net.net). The increase in the number of projects has been exponential since the first Passive House was built in Darmstadt, Germany, in 1991. Reducing the heating needs of buildings by a factor of ten, the Passive House requirements are considered by many experts today as a precondition to the "nearly zero energy building" that, according to the

EU directive on the energy performance of buildings (EPBD), must be implemented by all new buildings by the end of 2020 in the EU Member States.

This is a remarkable success story, given that the diffusion of the concept was initially mainly and is still mostly driven by enthusiastic individuals. The success is not only measurable in the number of dwellings built in accordance with the voluntary Passive House standard, but also in the attention that the Passive House enjoys in Europe and beyond.

In this paper, we describe how this voluntary standard could become so widespread. To identify the critical success factors in this history, we have analyzed insider accounts, observed a major Passive House conference and studied relevant documents. However, before we reconstruct the history from these sources, we will present a brief overview of what is known from the literature about barriers to otherwise rational energy efficiency measures. This overview will then guide us in the interpretation of success factors in the Passive House story.

2 Factors explaining the energy efficiency paradox

Explanations for the lack of seemingly rational investments in energy efficiency measures such as improved insulation each refers to its own general theory of human agency.

In this context, economic frameworks dominate. They introduce additional factors that influence the relationship between actors (potential investors) and their actions (investment energy efficiency) and thus help to make the outcome predictable. These "barriers" have been categorized along several axes, for instance, as being institutional, market related and behavioral (Weber, 1997). Jaffe and Stavins (1994) describe market failures such as the lack of information, principal/agent slippage (investments made by those who are not paying the energy bills, e.g., "landlords versus tenants"; see Phillips, 2012), and existing subsidies keeping energy prices artificially low. That these factors are described as "failures" implies that they should be corrected to create a perfect market. However, even if information about energy efficiency savings were perfectly transparent, if investors could withdraw the profits directly and if there were no distortion through subsidies, according to Jaffe and Stavins (1994), non-market failures would still interfere. The authors mention

private information costs (an individual's effort to learn new things) and heterogeneity among potential adopters (affecting the desirability of technological adoption, e.g., climatic variation). As a final non-market-related factor, they describe uncertainty about future energy prices. This point was generalized by van Soest and Bulte (2001), who demonstrated that the strategic postponement of costly and irreversible investments may be rational, given the problem that technological progress does not follow easily predictable linear paths (see also Sørensen et al., 2000).

A common motive in critiques of economic approaches to the energy efficiency paradox is that they hide or at least do not account for their own normative foundations (Weber, 1997). As early as 1985, Wilk and Wilhite described the rationality of *not* investing in home insulation that is revealed if competing normative goals that are particularly abundant only in domestic settings are taken seriously (see, e.g., Aune, 2007). Extending this perspective, Shove (1998) reminded us that the individuals involved in (not) making energy-efficient choices are creative social agents embedded in a broad variety of technical, social and cultural contexts that have to be accounted for if these (non) investments are studied.

In this paper, we assume that taken together, the economic, technical, social and cultural explanations for non-investments in energy efficiency all contribute to a better understanding of why people do not invest in energy efficiency. However, instead of trying to integrate these explanations into one all-encompassing system (as proposed by Chai and Yeo, 2012), we follow actors who have overcome most of these barriers and describe how they have dealt with them. As we will show in our description of the Passive House concept and standard, this is a story of a vigorous fight against consequences of market failures, lack of information, technological and economic uncertainty, and competing norms. We will argue further that in the current situation, in which the diffusion of Passive Houses reaches new quantitative dimensions, one of the challenges described in the literature, the heterogeneity among adopters will become crucial.

3 Method

This paper is the result of a structural analysis of in-depth interviews with key actors in the Passive House scene, participant observation at the 15th International Passive House Conference in 2011, and document analysis. This multi-method approach helped us to follow the key actors in various situations: being challenged to talk about their work and about Passive Houses generally, communicating with colleagues and promoting the technological solutions developed by industry partners, and presenting the concept through the World Wide Web to mobilise possible actors and convince possible customers. Moving between these situations, the actors adapt the language and the arguments to the listener. In all cases, they are promoting the Passive House as a robust concept, although the way they communicate the message is malleable.

The four in-depth interviews took place in Germany in June and July 2011 and lasted between 1.5 and 3 hours. The interviewees were key actors in the Passive House scene, and their answers offered a competent yet partial evaluation of the development of the concept. Two of the interviewees, a physicist (DB) and an architect (DA), were employed by the Passive House Institute (PHI), whereas the other two are involved in product development (DC) and in the design of Passive Houses and renovations of old buildings to Passive House standard (DD). The last two interviewees have been involved in Passive House projects from an early stage and have been active in developing new products, respectively new architectural solutions over the years.

The 4-day 15th International Conference held in Innsbruck, Austria, in 2011, offered a sample of how the Passive House concept and standard are communicated publicly. The thematic sessions of the conference were accompanied by exhibitions of certified components, poster sessions, and visits to Passive House projects. The social events allowed participants to meet and discuss the topic, strengthening the links between actors. The newcomers were presented to the audience, and their projects were publicly encouraged. The participation at the event offered the opportunity to follow the participants as actors in the network and to observe how they communicate and interact. The visits to Passive House projects in the region of

Vorarlberg allowed the architects to present their work as a success story and to talk about challenges and solutions when implementing the concept in practice.

The conference proceedings, the web sites of the PHI, relevant links to web sites, and the booklets made available by various actors are the documents that completed the picture of the Passive House development. These documents reflect the shared opinions, the research, the intentions and the targets of the actors and offer an official image of the Passive House as seen by its developers.

In this paper, we trace the most relevant moments of the Passive House concept by following the actors who have been involved in its development and who continue to support it. This is not to say that the concept did not have its critics and that these adversaries did not influence its diffusion. The exclusive focus on insider records can be seen as a limitation of the paper. However, our intention is to understand how key actors retrospectively see the development of the Passive House concept and standard and how they argue for the ways chosen at each crossroad. The specific controversies surrounding the Passive House concept are interesting in their own right and will be discussed in a separate paper. We are not taking sides but adding a third voice by proposing a theoretical perspective that contributes to an explanation to the success of this concept – in addition to and despite its intrinsic qualities or faults. Therefore, we use the *methodological* relativism (i.e., the deliberate use of relativism as a heuristic tool), as developed in anthropology and science studies, which is agnostic toward the value of the concept that is discussed – neither challenging nor supporting it. This does not mean that we are not committed to the truth of our account; if mistakes or omissions are present in the interviews, presentations and documents on which we base this study, these also form an important part of the analysis and are reported here.

4 The path to the Passive House concept and standard

The idea of a very low-energy house was not formed in a vacuum. At the time the Passive House concept was developed and tested, other low-energy dwelling projects had been realized. The interest in energy efficiency and in sustainable development had already reached the political arena,[I] and the extension of the broader political agenda to the construction sector was an implicit consequence

(Ornetzeder and Rohracher, 2009: 1535). The foundation for an innovative technical solution for the construction sector was present. However, the interviewees describe the beginnings of the development of the concept as an adventurous time, with clear ideas and a few enthusiastic supporters.

4.1 The Passive House from concept to standard

According to the interviewees, one beginning of the Passive House concept was the visit of the Swedish Professor Bo Adamson in China. In the southern part of the Yangtze River, because of scarce resources and a relatively mild climate, people are not permitted to heat their homes. However, in winter, the region can become uncomfortably cold (DB). In summer, however, the high temperatures would require active cooling to achieve a comfortable environment. Adamson was employed by the Chinese government to develop solutions that would enhance thermal comfort in these houses without using fuel. He called the resulting concept of houses that did not require heating "Passive Houses" (passipedia.passiv.de). Considering that the results could be applied further, his idea was "to transfer this principle to Europe using technical means (passipedia.passiv.de, historical review)." When he returned to Europe, Adamson met the German physicist Wolfgang Feist, and together they developed the Passive House concept and standard.

That travels are a source for knowledge transfer is a truism. At least as important as the travel itself was the creation of a centre of calculation (i.e. the place where the knowledge is stored, encoded and developed, see Latour 1987) represented by the working platform built by Bo Adamson and Wolfgang Feist. The knowledge brought to the center was combined with knowledge about European building traditions and the adaptation to local conditions and with existing projects of low-energy houses in Europe and the United States (passipedia.passiv.de).

A period of calculations followed, during which the information that was brought to the center was combined and developed further. The aim was to create an even more energy-efficient dwelling that combined the architectural means with the existing technology. According to our interviewees, the first calculations demonstrated that the compactness of the building was relevant for energy savings but also that the existing components were not in line with the requirements of the new concept. The

Passive House standard was the result of these first calculations transforming the concept into a standardized set of requirements. The interviewees repeatedly underlined the importance of the accurateness of the calculations at the beginning. Any failure or mistake could have compromised the concept. When the calculations were completed, the Passive House concept was stabilized as the Passive House standard. The standardization of the concept allowed it to multiply and to take various shapes, while still respecting the basic principles. The Passive House became through the process of standardization an "immutable mobile". By that Bruno Latour (1987) describes knowledge-objects that are able to "act at a distance on unfamiliar events, places and people" (Latour, 1987: 223). They become mobile, stable and combinable (Latour, 1987: 223), being able to move and recombine without distortion.

The five basic principles of the Passive House standard are simple: thermal insulation, Passive House windows, ventilation with heat recovery, airtightness, and a thermal-bridge-free design (passipedia.de). The thermal comfort in dwellings built in compliance with the Passive House standard "is achieved to a maximum extent through passive measures" (passipedia.passiv.de). More specifically, the standard allows for 10 W/m^2 specific annual heating load, while the total energy for space heating, domestic hot water and household appliances may not exceed 120 kWh/m^2a (CEPHEUS).

This simplicity is the consequence of a learning process made possible by a conceptual back and forth between centre (represented by the working platform created by Feist and Adamson) and periphery (the buildings where Passive House principles were implemented). In line with Bruno Latour's (1987) description of scientific knowledge production, these basic principles were the abstract result of combination and re-combination of the information that reached the center. The coding process that results in the Passive House (similar to the coding of the shapes of the land masses to form a map in Latour's example) allows construction materials, technological devices, thicknesses of walls and roofs, and U values of the components to become specifications of the standard.

From the beginning, it was clear that the developed standard should have a performance-based character. The aim was to reduce energy consumption in

dwellings, and the specific technical solutions that led to the target were left open. The essence of Passive House is encoded in the principles that remain at the foundation of the concept, but the performance of the dwelling is clearly coded in performance requirements.

From the drawing of the first Passive House plans, a critical role was played by a calculation tool. This Passive House Planning Package (PHPP) aims to cover all possible calculable details of a dwelling.[II] An advantage of this evaluation tool is that "it has been specifically created as a design and certification tool for Passive Houses and that it regularly incorporates new research results in its calculation procedures" (Mlecnik et al., 2010: 4598). In addition to the technical means, the tool also covers aspects related to funding and to specific details when building a Passive House (the Passive House construction manual) and includes an example project calculated in the PHPP (passipedia.passiv.de).

Busch (2011) calls standardization "a form of trust (though likely not the only one) well suited for a world consisting largely of strangers acting in the marketplace" (Busch, 2011: 215). To fulfill this role, the processes leading to certification have to appear trustworthy. In this sense, it is important that the PHPP be promoted as scientifically superior: "The behaviour of buildings can be predicted very accurately using a simulation that is based on the fundamental laws of physics" (passipedia.de). Similarly, our informants focused extensively on the claim that the Passive House is based on physics and not on politics driven by lobby groups. As a consequence the Passive House is described as reliable (DA), and performance variations between identical dwellings in use are supposed to be smaller in the case of Passive Houses than in "normal" dwellings (DD).

The interviewees claim that the PHPP offers a more accurate statement regarding the energy efficiency of a building and that the national calculation tool prescribed by the official German building regulation (EnEV, DB) can be used "creatively" (DD), thus, it can offer different results because of the possibility to choose how to perform the measurements. The accurateness (or rigidity) of the Passive House calculation tool is presented by the interviewees as able to reduce the hazard of the results and can easily be used as policy tool if the target is to anticipate the outcomes. The interviewees claim that this accuracy can be achieved because the

concept of the Passive House was not new: it has always existed. The pioneers who developed the concept "found" it in the laws of physics. As a consequence, proponents of the Passive House standard maintain that the concept is stable and reliable because it is based on scientific knowledge: "The Passive House concept has not been invented/ made up, but rather discovered" (passipedia.de).

Thus, the interviewees and the web site of the PHI support the idea that the optimal solution to reduce energy consumption in all buildings exists "out there", "in nature", waiting to be found. Our sources claim that based on travels and calculations, they have discovered this one best solution that can be reduced to a set of simple principles because it is found in the fundamental laws of physics. In relation to key barriers against energy efficiency investments, this strong reference to scientific principles above all is relevant because of its ability to create certainty. Who would deny that the fundamental laws of physics will prevail in the end? The resulting standard reduces uncertainty as long as the trust in the standardization process to be able to remain true to the laws of physics is intact. At the same time, we observe that the standard eases information transfer ("five *simple* principles"), which was further supported by creating a "standardized package" (Fujimura, 1992) consisting mainly of the PHPP calculation tool that incorporates calculatory knowledge.

4.2 Pilot buildings and enthusiasm for the concept

In general terms the introduction of the concepts "immutable mobile" and "centre of calculation" (Latour 1987) changed the focus of research from theories and ideas as a monopoly of intellectual elites to the way in which knowledge is produced and disseminated (Stöckelova, 2012). The accurateness of a scientific result does not automatically lead the tested idea to success: the way this idea is formulated, circulates, has the ability to mobilize actors and to fight enemies, the way in which this idea prevails and wins recognition over other ideas, are as important as scientific acknowledgment. In this sense, after the first calculations proved the viability of the concept, the long and important work of enrolling allies had only just begun.

As early as 1991, the first Passive House was built in Darmstadt, Germany. This project is today celebrated as the beginning of the Passive House movement. Indeed,

this first dwelling can be considered a milestone in the development of the Passive House. However, as was shown in the previous chapter, the history of the concept and the standard actually began several years prior, when the idea of a very low-energy dwelling was born and the first calculations were performed. The first Passive House building was the proof of the idea. It visualized the existence and the viability of the concept, thus transforming the idea into reality.

From the first travels and calculations until the first project was realized, new actors had to be mobilized. The creation of the standard alone did not guarantee the success of the concept. However, the development of the standard was a precondition to the success of the concept.

The individual solutions that were developed to make the Passive House concept reality marked not necessarily a revolutionary departure from existing solutions. Combined into an integrated concept, however, they were a step towards the kind of integrated innovation that usually lacks in the building sector (Taylor & Levitt, 2004).

According to our interviewees, the difficulties at the beginning and the lack of trust of other experts transformed the step between performing calculations and the first Passive House built in Darmstadt into a real adventure. Only a limited number of enthusiasts believed in the concept. As an interviewee said:

"There were so many voices from everywhere. From the architects: 'The windows are ugly'; from the construction industry: 'This is not traditional. The house will collapse because it is based on insulation. How can you do that? This will not work'; from the manufacturers: 'The components they needed are too expensive'; from clients, 'I want to open the windows. I do not want to live in a house where I cannot open the windows'. But you can open the windows." (DA)

The pilot project proved that the standard can be applied with the expected results, and after the construction it served as feedback for possible improvement. This back and forth between the standard in paper form and its material solution was used over the years to improve both the calculation tool and the technical solutions and components.

The first pilot project was also the first exposure of the new concept to the consumers. As DD said, "There should be a house for the public to have hands on to

show people what is going on". The theoretical background could convince the experts, while the dwelling was the "exhibition piece" that took the form of a home/dwelling.

The interviewees presented the beginning of the development of the Passive House as a time of exploration, when the pioneers accepted the challenge to transform a "scientific finding" into reality. Two of the interviewees who were part of the development in its earliest phase confirmed that they were excited by the new concept and more than willing to participate.

The first supporters of the Passive House were enthusiasts. In this context, the demonstration project played an important role, as one interviewee said:

"I looked with wide open eyes at the first Passive House project in Darmstadt. I was very impressed by it, and since then I feel very connected with this mindset." (DD)

The interviewee had joined because he had "the same philosophy" and the Passive House provided a good scientific background for his work. It was "the most reasonable" concept. Then, he met like-minded people at the conferences and open days, and he enjoyed these meetings (DD). Similarly, another interviewee said:

"At the beginning there was a very enthusiastic architect, Folkmer Rasch, and his partner, Petra Grenz. They worked together with the manufacturers; they pushed them. They said, 'We want this window; we are not buying this ugly window', and they also got a good price. They were negotiating with them and said, 'Well, you cannot put all the costs of the development of something new into this project now; this does not work. There is a market, and you are the first ones on the market.' They were very good. And they built the first pilot projects." (DA)

As can be observed, the actors involved in the development of the Passive House concept engaged from the beginning in the promotion of the concept. They mobilized and involved possible developers by showing them the advantages (being the first on the market) and, at the same time, by imposing their conditions (technically robust and aesthetically attractive components).

In the beginning, the networks built around the researchers, developers, architects, consulting engineers and component makers were based on personal contact. The circle was closed, and the participants knew and trusted one another. They were "like-minded", and so there was a reduced danger of conflicts and

misunderstandings. The people involved called university colleagues and asked them to join (DB). The relationship was based on trust. The participants built around the Passive House an identity, and they shared this identity. People and things (e.g., pilot buildings) created a stable network. An interviewee spoke about a ventilation system with heat recovery as "the world champion" (DC). This implies that the ventilation system is seen as a result of a training process. Similar to people, the technological devices engage in a competition. Due to their qualities, these objects act as promotion agents.

The Darmstadt project was followed by a series of other pilot projects. From residential buildings, the interest moved to non-residential constructions in which the financial calculations prevailed over the emotional element. Being a "physico-technical concept, the Passive House does not appeal to people who approach the topics emotionally" (DD).

One of the most discussed issues is the architectural qualities of Passive Houses because the main principles of energy efficiency limit architectural freedom to a certain degree. The pilot projects in Germany and elsewhere also had as their stated mission to involve architects who developed attractive design. Architectural qualities were expected to give these buildings an identity and make them more attractive to the public (DD).

Especially early implementations of Passive Houses in Austria were successful in this respect. In the state of Vorarlberg where the first dwelling was built as early as 1996, the dwellings built to Passive House standard adopted the local architecture dominated by timber houses (Dangel, 2010). The technological concept matched the architectural ideals of the "Vorarlberg School of Architecture" that had developed since the 1960s and was grounded in the traditional regional architecture. This symbiosis between an established architecture school and the innovative standard turned out to be of decisive importance for the widespread diffusion of the Passive House (Dangel, 2010).

Early proponents of the Passive House standard presented themselves as being part of something important, even revolutionary. Although the concept was framed as a simple matter of the fundamental laws of physics, actually realising the concept generated a great deal of enthusiasm. The proof that the abstract principle could be

manifested physically added to the credibility that was initially based on the reference to scientific laws and a simple but consistent standard.

4.3 Creating a centre and controlling the margins

With pilot buildings, measurement and calculation tools, and committed individuals, the concept of the Passive House gained ground, but it was also in danger of losing its focus that would allow for a coordinated development.

In 1996, the Passive House Institute (PHI) was founded by Dr. Wolfgang Feist. This independent research institute allowed the concentration of all activities of the interdisciplinary team on the new concept. Additionally, its independence from other institutions conferred on the institute an image of impartiality and objectivity - that created trust among customers. The interviewees unanimously described the creation of the PHI as an important step in the development of the concept. According to them, Wolfgang Feist understood that "the concept is not going to develop by itself" (DA). The network had to be enlarged by involving new topics and new actors in the process. The extension occurred on the conceptual level as well: From the beginning, the Institute promoted cost effectiveness (not considered in the first demonstrations) in addition to the energy efficiency of buildings and component development. With time, new aspects completed the development, such as the aesthetics of the buildings and aspects related to their marketing.

The control of the PHI over the Passive House actors was ultimately maintained through certification, not only for the buildings and the building components but for people as well. The Institute organized courses by which one could become a "Certified Passive House Designer" "to show to the public that there is an extra knowledge available to this person, that he or she has extra experience with Passive Houses", as one interviewee (DB) described it. These certifications are not necessarily performed by the Institute itself. There are now approximately 15 partners that are connected to the PHI through a collaboration contract and annual meetings.

If the beginning of the Passive House development was dominated by enthusiasts, the next phases involved more strategic networking while close contact and trust remained valued aspects. Platforms were created in which these experts could meet

and talk. In these activities, the PHI was presented by the interviewees as an independent and impartial institution that guaranteed the quality of the products, performance, and experts. Through the certifications, the PHI had gained the reputation of an impartial third party that guaranteed the clients the quality of each service.

In addition to guarantees for the certified people and products, certifications clearly were also a way of excluding actors from the Passive House market (Busch, 2011, calls this "standardized differentiation"). Non-certified products could not enter the Passive House market, whereas the certified products would also have an advantage outside this market.[III] One of the interviewees stated that certain companies decided to certify some of their products because they could not sell them otherwise. Their products did not have the quality proof of an impartial authority (DB).

The PHI accompanies the actors of the network during the entire process of product development. The interviewees said that they do "consulting with architects and building companies to get a good overall design of the building" (DA) and that they collaborate with component makers to ensure cost effectiveness and good design (DB).

As "recipes of reality" (Busch, 2011), standards are able to order "people and things so as to produce outcomes desired by someone. As such, they are part of the technical, political, social, economic, and ethical infrastructure that constitutes human societies." (Busch, 2011: 13) Because of the elements that connect the center (i.e., the PHI) and a growing number of peripheral sites (e.g., Passive Houses), the standard increased the power of the center that controlled the Passive House development. Thus, the actors in the center had a "strategic position" because "they design networks that are tied together in a few obligatory passage points" (Latour, 1987: 245). The standardization of a concept and the procedure of certification helped companies to sell their products and to make the PHI a necessary point of passage in the acceptance of a component as suitable for Passive Houses.

With the creation of the PHI and its certification scheme, a technological niche was created that quickly developed into a commercial niche (Schot and Geels, 2008). Resting on its power to define what is inside and what is outside the market, entry into this niche was artificially restricted by the gatekeepers at the PHI. The basis for

this power depended on the Institute's ability to reduce uncertainty and to provide information. Moreover, the niche was held together on the inside through the PHI's training. Finally, principal/agent problems were reduced by ensuring that as many links in the chain as possible would have the same information and the necessary amount of motivation.

5 Quo vadis Passive House?

5.1 Spreading the word

Today, a high priority is given by the PHI to the presentation of the Passive House standard to prospective members and customers. This presentation is accomplished through the organization of "open days", conferences and workshops. Moreover, product developers organize courses in which experts can learn "extra knowledge", and open laboratory doors where customers and experts can view and experience the new technological devices and the Passive Houses built with different material, architectural and technological solutions.

There is even a Passive House village, called "Sonnenplatz Großschönau", in Austria that offers the possibility for anybody to experience living in a Passive House. The offer intends to introduce the concept of a new way of living to the public and to dissipate the inhibitions that might accompany such a decision. It is the difference between hearing about it and trying it, as the village described itself:

"The most pleasant and best way of learning about the advantages of passive-house living is to try one out. After all, visiting a show home on a traditional housing development and flicking through the brochures is one thing, but getting to know and generating a feeling for a house is something quite different (www.probewohnen.at)."

This is also the general message for both experts and lay-people: the concept is simple, it is based on physics (so it cannot fail), and it offers the full package of advantages, from low energy bills to comfort and architectural quality - a combination of objective and strict calculations before the product leaves the laboratory and the emotional factor in the promotion phase:

"The clients should not feel the Passive House as a technical pressure, but the topic has to be presented as sexy, exciting, comfortable, great architecture possible, these aspects are important." (DD)

Through the years, the promoters of Passive Houses have learned to improve their message. As an interviewee stated, most clients "would not come and say, 'Well, I want to have a Passive House'. This is what we had to learn – the hard way" (DB). Systematic surveys that were conducted among early customers indicated that the energy efficiency and the Passive House label might appeal to experts but were of less importance to clients (CEPHEUS.de). A consequence was the inclusion of non-technical aspects but also the principle that prospective clients should be given the sense that they are voluntarily participating in the implementation of a new form of home.

This focus on spreading the word and recruiting new volunteers continues the strategies that have been employed successfully since the beginnings of the Passive House movement. In Austria, the concept gained credibility quickly and was implemented with success in many regions. The region of Vorarlberg claims to have the highest number of Passive Houses per person. The lack of language barriers (DB and DA), the trust in German technology (DC) and the openness of Austrian architects, engineers and physicists toward new concepts (DB) appear to be the most relevant favourable conditions for acceptance.

Additionally, in the state of Vorarlberg, public authorities promoted Passive Houses actively through various strategies, supporting it financially or transforming it into legal requirement. Moreover, a number of intermediary organisations (e.g. IG Passivhaus, consultancy organisations, research programmes such as "building of tomorrow") acted as key actors in the planning process, in the promotion of Passive Houses and certifications, and in the knowledge transfer (Ornetzeder and Rohracher, 2009).

The mutual trust of actors and the more than average interest of all participants for energy efficiency in Vorarlberg represent a unique example of success. The cooperation of all actors in the network, from architects and craftspeople (also a traditional cooperation in the region that precedes the Passive House) to open-

minded clients and supportive local government played a decisive role on the implementation of Passive Houses (Dangel, 2009).

After the first successful projects in Germany and Austria, other European countries opened the doors to the new concept.

5.2 Spreading the standard

Today, the concept has extended beyond the Central European borders and has gained ground all over the world. However, the implementation of Passive Houses in different climate zones is accompanied by several problems. Whereas some countries have decided to implement the standard as given, other countries have imported the name and the basic principles but revised the calculation method, i.e., they imported the concept but not the standard.[IV] Norway, for instance, has adapted the Passive House concept but has developed a specific Norwegian standard (NS 3700 for residential and NS 3701 for non-residential buildings) that resulted from three years of controversial discussions of the requirements for energy supply, single-family homes (which are common in Norway), and to what extent climate change mitigation should be included. Reusing the calculation methods that are well established in Norway (e.g., NS 3031) while retaining the cornerstones of the original (e.g., annual heating demand 15 kWh/m^2), this standard changed primarily the values and methods used in the calculation certification, thereby breaking the link to the PHI that had existed, among other links, through the PHPP calculation tool.

Researchers involved in the development of the Norwegian standard argued that Norwegian conditions would incur excessive additional cost and thereby "hinder the market penetration of Passive Houses in Norway" (Dokka and Andresen, 2006: 227). The interviewees from the PHI opposed this view, expecting the newcomers to apply the standard as given. The simple definition and the clear basic principles should allow the export of the concept without distortion – after all, physics is the same regardless of the location. The standard prescribes the performance of the dwelling but leaves open the choice of solutions. The solution for countries with other climates and traditions should be a time-consuming development of components within the given standard (DA and DB). The interviewees conceded

that these components do not yet exist, but they also said that it is only natural that the development of such components would take time (DA). The interviewees would rather allow countries that implement the Passive House concept several years of development and "learning" than to insist on the immediate implementation of the concept in a modified or adapted form. As has been shown, this is opposed to the Norwegian (and e.g., Swedish) approach, in which the concept is adapted to provide "better consistency with existing values, past experiences and needs of potential adopters" (Mlecnik et al., 2010: 4597).

The consequence of these conditions is that the PHI loses at least partially the control of the development of the Passive House standard: it cannot unconditionally and directly "act at distance" (Latour, 1987: 228) in countries such as Norway. In these situations, the certification is performed by new actors under new premises, relieving the PHI of its responsibility but also of its ability to control and learn through direct feedback. The implications weaken the position of the PHI as an actor in Norway. Another way of describing this development is that in the moment when the concept is exported and a new standard is adapted, a new center of calculation is created. In our case, the private research institution SINTEF is one of the central Norwegian institutions that have the competence to certify the products, the dwellings and the actors involved, and to train professionals and develop the concept – possibly in another direction from the PHI (Müller, 2012). However, the communication with the original centre of calculation and control is not completely broken. A large Norwegian delegation was present at the conference in Innsbruck, proving that the connections between the two centres remain strong. Thus, the communication still exists, but the border is only conditionally permeable, indicating that the PHI is no longer an obligatory point of passage.

6 Conclusion: Success factors

Our analysis of the Passive House development as told by its protagonists demonstrates that the success of the concept and the standard was not made possible through enforcement by (supra) national regulation or through the backing of powerful commercial actors. Rather, success was achieved through a combination of a fervent belief in the scientific basis of the fundamental principles of the standard, a

rigid certification scheme (which involves a required certification tool), demonstration through good examples (from pilot buildings to the Passive House village), the creation of a protected market niche, extensive training activities and an increasingly professional marketing of the concept, standard, components and technologies. These success factors have created synergies that enabled the Passive House concept and standard to overcome the barriers to energy efficiency that are reported in the literature. More specifically, we have observed that

- the scientific foundation that remained at the core of the transformation of the concept into a performance-based standard has reduced uncertainty and instilled trust,
- the unambiguous simplicity of the standard has facilitated information transfer,
- a tool required for certification has further contributed to the reduction of uncertainty and created a standardized package that is easily employed,
- demonstrations through pilot buildings mobilized early supporters and acted as convincing proof for the viability of the concept and standard,
- a devoted community of like-minded proponents was formed that shared the same norms and values,
- a protected market niche was created through the certification scheme,
- strict quality assurance in training experts reduced principal/agent problems, and finally,
- lessons learned throughout the history led to a professionalization of the propagation of the concept and standard.

Currently, two factors – the climatic variation and the competing normative goals - are likely to gain prominence. Both are related to the fact that the heterogeneity of adopters has been growing rapidly over the course of the last few years. As described above, the history of Passive Houses over 20 years has occurred primarily in Germany and Austria. These two countries have a common language and a similar climate and technical infrastructure. Moreover, early adopters of the concept were likely to be interested in prioritizing energy saving to a more than average extent. In the current situation, the Norwegian case, among others, illustrates that for

the rapid implementation of the concept, much is to be gained from modifying and thereby multifying the standard and weakening the connection to the original centre of calculations, the PHI. The Austrian case of the state of Vorarlberg is instructive in this respect: unique cultural and social conditions that predate the Passive House have created an extraordinarily fertile ground for a creative development of the concept and standard. Cultural norms and values as described by Wilk and Wilhite (1985) vary geographically and have already influenced established calculation standards and associated methods. However, above all, climatic variations create barriers that are able to slow the diffusion of the standard.

Given the success of the Passive House to this point, a possible future scenario may be that such construction becomes a matter of course. This option is described by one informant as follows: "In the beginning I was a crackpot or a visionary, then I was a visionary who was in great demand, and today, Wolfgang [Feist] and many others, we are normality […]" (DD). The transformation from vision to normality changes the character of the certification from a tool of change to a tool of solidifying the status quo. The informant continues: "Today, audiences get excited when someone talks about plus-energy buildings" (DD). Indeed, we now observe the emergence of competing concepts and standards all over the world. Their different names, methods and philosophies inspire ambitious environmental goals. However, these concepts and standards may also produce confusion among otherwise willing adopters. In this situation, the tension between rigid control and flexible adaptability becomes the central moment defining the future of highly effective energy efficiency concepts and standards in the building sector.

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Endnotes

[I] See also the Brundtland Report (1987) which defines sustainable development as "paths of progress which meet the needs and aspirations of the present generation without compromising the ability of future generations to meet their needs".

[II] Since 2003, attention has been drawn toward the existing building stock. Overcoming the difficulties to force a rigid standard into another building concept, a special tool was adapted for renovations, EnerPHit (Quality Approved Energy Retrofit with Passive House Components), which follows the same criteria as for new buildings but with less freedom in the choice of solutions.

[III] The same idea is supported by Mlecnik et al. (2010): "Market actors consider the label to be an advantage. For companies to be recognized as market leaders – whether local, regional, national or international – the aim is to demonstrate that their product differs from that of their competitors. Labels of Passive House projects that have been completed provide credentials for companies. Some specialized networks provide databases of labeled Passive House projects with project files with references to the actors involved, thereby providing a promotional tool for market actors".

[IV] For example, Sweden and Norway. In the U.S., the Passive House Institute U.S. (PHIUS) partnered with the Residential Energy Services Network (RESNET) in 2011, offering its own certification system, PHIUS+, which includes elements of the so-called HERS index used by RESNET.

Article 3:
The way towards zero-emission buildings: The Passive House controversy in Norway

Abstract

The Norwegian Passive House standard enjoys political support as a necessary step towards the sustainable development of both buildings and the construction sector. However, the implementation of the standard as a technical requirement for all new buildings is still disputed in various environments.

This paper follows the Norwegian Passive House controversy among experts. Focussing on the tensions between various actors regarding the robustness of the sociotechnical artefact, the controversy analysis tracks concerns regarding the consequences that the volume production of passive houses may have on law, policy, research and education. The disputed content and the context of the Norwegian Passive House standard as a sustainable path for development in the building sector is seen as a specific form of controversy, enabled by semi-public information and communication technologies and situated between a scientific controversy and a public controversy about matters of science and technology.

Keywords: Passive House, controversy, sustainable transition

1 Introduction

Compared with other sectors (e.g., industry and transportation), the building sector is seen as the best suited for a transition towards greater energy efficiency. The member states of the European Union see reducing buildings' energy consumption and greenhouse gas emissions as a way to fulfil the building directive of the European Commission and to respect international agreements, such as the Kyoto Protocol. Since the Brundtland Report of 1987 encouraged sustainable development in all industrial sectors, concepts such as Passive House, low energy house, active house and green house have been developed and competed for subsidies, promotion and a place in building legislation.

In April 2012, Norwegian Prime Minister Jens Stoltenberg presented the government's "Norwegian Climate Policy", which announced future measures to reduce greenhouse gas emissions and promote technological development. For the building sector, the white paper foresees sharpening the technical requirements for new buildings to the "Passive House level" by 2015 and to nearly zero-energy buildings by 2020. Component requirements are proposed for renovations of existing buildings. In this way, the Norwegian Passive House standard has taken one more step towards becoming the future of Norwegian buildings. However, the proposal met and still meets resistance in various expert arenas.

In 2008, when a climate agreement proposed the Norwegian Passive House standard as a technical requirement for all new buildings, a Passive House controversy stirred among experts in various fields. Several actors, such as architects Frederica Miller and Anne Sigrid Nordby (Architecture N, May 26, 2010) and physician Jan Vilhelm Bakke (Technical Weekly Magazine from October 11, 2010) used the media to contest the fitness of this sociotechnical concept, labeling it a form of limitation rather than a reasonable innovation and warned the public of possible indoor climate deterioration. This paper analyses a central episode in the Norwegian Passive House controversy: the semi-public email exchange that took place in 2010 between leading experts in Norway.

Given what we know now, this exchange was one of the battlegrounds in which alternatives to Passive House approaches were defeated. The controversy analysis

follows the disputed contents and contexts of Norwegian Passive House implementation and discusses the use of (initially private) emails as the data set. Thus, stepping back from the question of whether the Passive House is a good solution and whether it should be discussed publicly before becoming the law, the paper analyses a form of controversy neglected in Science and Technology Studies (STS) that usually takes place behind closed doors. The paper contributes to the understanding of the negotiations in expert arenas that preceded the legislation. For a better understanding of the controversy analysis, I will briefly introduce the Passive House standard as advocated or contested in Europe.

2 The Passive House in the European and Norwegian context

Developed by Swedish professor Bo Adamson and German physicist Wolfgang Feist the Passive House standard is "a building in which a comfortable interior climate can be maintained without active heating and cooling systems. The house heats and cools itself, hence *passive*" (PHI). The first pilot project was launched in Darmstadt (Germany) in 1991. Since then, the Passive House standard has been introduced as a voluntary standard, especially in central European countries. The standard had a remarkable success: Europe had approximately 27,600 certified Passive Houses by 2010 and approximately 65,000 by the end of 2012. The number of projects in Europe has increased exponentially since 1991 (Müller & Berker, 2013).

Due to its energy saving potential, the Passive House standard won the attention of policymakers, politicians and building experts. Reducing heating needs by a factor of ten, the standard is preferred by construction engineers as a rational step towards the nearly zero-energy building that, according to the EU directive on the energy performance of buildings (EPBD), must be implemented by 2020 in all new buildings in EU member states, Norway and Switzerland.

Despite being a voluntary standard, the Passive House standard has been and still is met with criticism across Europe. The most problematic aspects mentioned in the literature, media and scientific reports are the increased costs compared with

dwellings built in accordance with national technical requirements, the problematic indoor climate due to increased insulation (media debate in Fastighetshjälpen, 2009), user-related aspects (Diskussion "Wohnen im Passivhaus"; Brunklaus et. al., 2010: 276; Passivhaus der Zukunft-Akademie), the robustness of the technology, the focus on technical solutions at the expense of the dwellings' architectural qualities (Meyrhöfer, 2008: 12; Forster & Junker, 2008: 45; media debate in Fastighetshjälpen, 2009; Marsh & Lauring, 2008) and the increased focus on the dwellings' energy efficiency at the expense of a holistic perspective that views buildings as components of larger systems (Interview with Fisch in Aface, 2011: 14; Kohoutek & Pirhofer, 2007). The literature also suggests that the environmental impact of passive houses may not actually be lower than the impact of conventional dwellings (Brunklaus et. al., 2010: 265; media debate in Fastighetshjälpen, 2009). Additionally, when considering the life cycle analysis of dwellings and materials, it is still unclear whether passive houses score better than conventional dwellings (media debate in Fastighetshjälpen, 2009; Brunklaus et. al., 2010).

Moreover, reduced space heating does not automatically reduce the primary energy consumption (Marsh & Lauring, 2008), and reducing environmental solutions to the Passive House technology is seen as problematic (Brunklaus et. al., 2010: 276). Additionally, technological concepts (e.g., the Passive House standard) require the development of new forms of cooperation among actors (Brunsgaard et. al., 2009; Passivhaus der Zukunft-Akademie). Other studies suggest that the performance of energy efficient buildings is not exclusively an expert's task, as users can become innovative in accordance with or against the initial use design (Ornetzeder & Roracher, 2006; Hyysalo et. al., 2013).

In spite of the critique, the Passive House standard became a widely accepted energy efficiency reference point. With the increase in interest, the heterogeneity of adopters also increased. Climatic variations, competing normative goals and various building traditions impede further diffusion of the standard (Müller & Berker, 2013). Norway, Sweden and Finland adapted the Passive House standard to the Nordic climate, creating alternative calculation tools to the initial Passive House Planning Package (PHPP) calculation tool. However, each country has its own standard, irrespective of the other Nordic standards, and uses the original German standard as

reference. The Nordic climate's cold winters with short daylight, the high humidity (along the Norwegian coastline) and extreme low temperatures in some regions (Finland and Norwegian and Swedish inland areas) challenged the standard proposed by the Passive House Institute. Although it is possible to build passive houses in Nordic countries using the PHPP (Kreutzer, 2011), the increased construction costs would impede the standard's market penetration (Dokka & Andresen, 2006). The Norwegian and Finnish standards adapted to the Nordic climate allow for more than 15 kWh/m^2 for annual heating and cooling demand. The Finnish standard allows for 130 kWh/m^2, while the Swedish standard does not have requirements for total primary energy consumption. The differences between the standards aim to cover the climatic and the cultural specificities of these Nordic countries. Moreover, the new standards refer to previous technical requirements and building codes in the Nordic Countries, thus offering a certain continuity in the legislative framework.

In Norway, the first dwelling that fulfilled the Passive House standard was built in 2005. A political compromise on Norway's environmental and climate policy, a climate agreement was signed on 17 January 2008 and proposed the Passive House standard as a technical requirement for all new buildings by 2020. In June 2009, the Low Energy Committee appointed by the Ministry of Oil and Energy had already proposed 2017 as the year for the mandatory introduction of the Passive House standard for new buildings. As specified in the introduction, the new recommended deadline is 2015. Thus, the Passive House standard became a political target, a passage point towards zero-energy or even zero-emission buildings.

When the email controversy that is analysed here took place, the Norwegian Passive House standard for residential buildings (NS 3700) had already been developed, and the standard for non-residential buildings (NS 3701) was under development. The Norwegian Passive House standard had been proposed as a technical requirement, but a final political decision had not yet been made. The email controversy is one of the many forms of communication and negotiation that took place around this time, in addition to official meetings, reports, lobby work, and incentive development.

While the Passive House standard is voluntary in other countries, Norwegian white papers propose introducing its version of the standard as the technical requirement

for all new buildings. As a voluntary standard, it has been accepted, even if not encouraged, by all actors. In Norway, the controversy started when the Passive House standard was proposed as a technical requirement for all new buildings. Some topics that have been or are still controversial in other European countries are echoed in the Norwegian controversy. Country- and climate-specific discussions are also part of the dispute.

3 Scientific controversies in STS

Venturini (2010) encapsulates controversy as follows:

"Controversies begin when actors discover that they cannot ignore each other and controversies end when actors manage to work out a solid compromise to live together. Anything between these two extremes can be called a controversy" (Venturini, 2010: 4).

Technological and scientific controversies have concerned STS scholars for decades (e.g., Collins, 1981; Nelkin, 1992; Callon et. al., 2009). The complexity of the scientific knowledge, increased public awareness about the possible risks that science and technology present, and controversies' high potential to clarify tensions that might appear opened the door towards detailed analyses of controversial matters. The controversies studied in STS are often framed as scientific controversies, where the "scientific truth" is disputed, or as public engagement, where the science meets the public.

Writing about the scientific controversies, Pinch and Leuenberger (2006) distinguish between the long-standing disputes (e.g., the dispute between science and religion) and the localised disputes (i.e., "hot spot" controversies). Scientific controversies escape democratic scrutiny and remain at the expert level. The research behind experts' scientific arguments claims to be immune to political manipulation (Nelkin, 1992: XVIII-XIX). However, the "scientific truth" is not just a singular given: it is complex and ambivalent. A scientific truth is given priority over alternatives in a certain trade cycle. In this vein, Jasanoff (1990) discusses the role of scientific advisory committees in policymaking and in the closure of technical disputes. She concludes that the scientific advisors do not limit their advice to purely scientific

issues, but "the advisory process seems increasingly important as a locus for negotiating scientific differences that carry political weight" (Jasanoff, 1990: 249).

Dismissing technological determinism and the direct causality and anticipation of technological innovation, scientific controversies presented in the STS literature showed that innovation and progress might produce unexpected consequences. Dramatic events, such as the power plant explosion in Chernobyl, proved that knowledge that grounds decisions is limited and incomplete, and risks cannot always be foreseen and avoided (Nelkin, 1992: xix). The techno-scientific controversies addressed in the STS literature are thus often framed as a problem of democracy and scrutinise the public participation (Wynne, 1992; Latour, 2004a; Bijker, 1995; Irwin, 2001).

In this vein, Jasanoff pleads for active public empowerment through "*social* technologies (that) would give combined attention to substance and process, and stress deliberation as well as analysis" (Jasanoff, 2003:243). In addition, the philosophy of science focuses on public participation as sub-politics and empowers the public over the institutional pathways of development (De Vries, 2007). Latour changes the focus from "matters of facts" to "matters of concern" (Latour, 2004b) thus signalling that scientific controversies about facts are always about more than just facts. Moreover, Star and Griesemer (1989) describe how tensions among actors can remain unresolved and still be non-controversial through boundary objects—different communities use information in different ways.

More recent STS studies turn their attention towards "issue-oriented" perspectives on public involvement in politics (Marres, 2004 and 2007). This shift extends STS by making the creation and development of political "issues" an object of research. Marres asks how citizens become concerned about "issues" in the first place. She opens the black box of public participation in techno-scientific controversies whose desirability has been previously taken for granted in many STS studies.

The controversies analysed in the STS literature show that innovation is no longer just a scientific concern. Due to the dramatic societal implications of science and technology, innovation has become a highly political matter. The circle of actors involved in the innovation process extends from scientists and industry to policymakers, politicians, users, interest groups, and even animals, plants and the

general climate. It is difficult to draw borders around a controversy, given the multiple implications that successful innovation might have. In this vein, Pinch refers to the "porous boundaries between science, technology, politics, the media, and the citizenry" (Pinch, 2002: 13723).

Nevertheless, most of the mentioned studies treat scientific and technological controversies from the perspective of public participation. Scientific controversies among experts are also analysed from outside, as they are communicated in the public sphere by interested actors.

However, the Norwegian Passive House controversy presents disputes that take place behind closed doors, where the public is not explicitly excluded but is not invited. It is not a purely scientific controversy, but it is not a controversy with public participation either. This study contributes to a better understanding of negotiated knowledge production and path formation among experts. The email exchange data reveals multiple aspects of the Passive House standard as sociotechnical innovation—enriching the meaning of the situation (paraphrasing Callon et. al., 2009: 30)—but at the same time, it is also about priorities and exclusion. Moreover, the controversy touches relevant legislative and political matters, as a "question of political control" (Nelkin, 1992: x).

4 Method

The empirical data consist of 50 emails sent between 30 April and 31 August 2010. The exchange started as a private email sent from Gaia (an architectural firm) to Ecobox (a task-financed part of the National Association of Norwegian Architects) with copies to FutureBuilt (a ten-year programme (2010-2020) - a partnership between several municipalities, Enova (i.e., the Norwegian energy fund), the Norwegian State Housing Bank, the Green Building Association, the Norwegian Building Authority, Transnova, the National Association of Norwegian Architects and the Ministry of Local Government and Modernization), Hambra (a consultant office) and Civitas (an independent group of consultants). Using the snowball technique, the first participants in the email exchange re-sent the entire text to other experts with an interest in the controversy. The circle of participants increased rapidly—for example, increasing from 18 to 25 recipients on 7 May 2010 and

reaching 32 recipients the next day. The email exchange slowed in June and July, and the last recipients were included on the list as late as 25 August 2010. Within a short period of time, 25 of the 76 experts that received the emails participated actively in the discussion.

The most active Passive House supporters were the experts from SINTEF, a private research institution that was leading the development of the Norwegian Passive House standard and supported its implementation (eleven emails). Experts from Civitas (one email) and FutureBuilt (three emails) also supported its implementation. The latter is part of Cities of the Future, a collaboration between the state and the 13 largest Norwegian cities that seeks to reduce the greenhouse gas emissions.

Opposition to the Norwegian Passive House standard as a technical requirement for all new buildings came from the Gaia architectural firm (eleven emails), the Norwegian Labour Inspection Authority (two emails), the Norwegian Trekking Association (three emails) and the Norwegian University of Science and Technology (NTNU, two emails).

The actors who discussed the arguments without being explicitly for or against the Norwegian Passive House standard as a technical requirement came from the Green Building Association, a network of building owners (two emails), Hambra, (one email), Ecobox/the National Association of Norwegian Architects (two emails), the Norwegian Building Authority (one email) and the BGM architectural firm (one email).

As we can see, participants' affiliations are difficult to follow because some of the named organisations/institutions are part of larger groups. When email exchange participants belong to more than one institution, the email address of the participant was considered.

The non-Norwegian institutions represented in the controversy are from Sweden (nine emails) and from Denmark (one email). These emails connect the Norwegian controversy to controversies in other Nordic countries.

Even if it started as a private email exchange, this form of communication developed into a broad arena of negotiations that was voluntarily shared by a large number of participants. The email exchange offers a unique chance to follow the patterns of work, collaboration and negotiation at the expert level without intervening in the

conversation. I did not participate in the controversy. All participants that are quoted directly or indirectly have agreed to the publication of this paper by allowing me to use the email controversy as research data. At one point, a participant also made the email exchange accessible to the media and was quoted by the journalist Joachim Seehusen in a newspaper article on 11 October 2010 in the Technical Weekly Magazine. Moreover, one of the participants has already provided a short summary about the debated topics in an email that was part of the exchange.

The data analysis followed steps proposed by the grounded theory (Charmaz, 2006). After initial coding, I selected representative quotations and wrote the first memos. Returning to the data, I grouped the codes into larger categories and followed the way they were linked together. After formulating the narrative, I answered the research questions by going back and forth between data, codes and memos. I gave the participants fictive names, and I translated the quotations from Norwegian to English. The framework of the grounded theory allowed a flexible methodological pathway.

5 Controversy analysis

The first email referred to a dispute that began in a seminar and included the most controversial aspects of the Passive House: the indoor climate, the questionable robustness, the "human-ecological" aspects and the climate gains (Mats). The author mentioned a Swedish study that showed that passive houses with electric radiators scored worse than conventional dwellings when the environmental costs were calculated. One of the co-receivers re-sent the email to several experts who could comment on the study. In the answer, the study was discredited as "too little transparent" (Vegard), such that the reader could not evaluate the results of the calculations. The emails were again re-sent to experts with possible interests in the topics. More participants and topics thus became increasingly involved. The participants gradually transformed the email exchange into an arena of communication and negotiation, with the Norwegian Passive House standard as the main actor.

5.1 Controversy actors

What began as a private email soon became an open expert arena. The email exchange involved 25 active participants representing 20 institutions. Additionally, the imagined actors played a significant role through representation.

5.1.1 Who is "we"?

The selection of actors in the controversy developed as a snowball effect; i.e., participants freely invited new experts. Therefore, the mobilisation of new actors did not happen arbitrarily: the inclusion of new experts was a mobilisation of allies. When a new topic or argument was brought into discussion, a new group of experts became involved in the controversy. With various formulations, e.g., "We allow ourselves to link the discussion to one of the authors of the named study, together with some others who might be interested" (Jon and Mats), "I continuously include new participants who I think may benefit from the email discussion" (Vegard) or "I invited (names) to comment on the debate from their perspective" (Ellen), participants signalled to others that the number of readers had increased.

Despite the controversial topics, participants created a lively work atmosphere. The language used was informal, adorned with anecdotes and personal stories, but the use of technical jargon was also a matter of course:

"I came to believe in the Passive House after traveling to Austria many times and visiting some of them (the oldest are 12 – 14 years old now, and they still stand) and after staying in my own for half a year…even if the ventilation system froze in winter, one of the engines and the remote control panel fell to pieces, and the solar collector continuously splashed glycol in the washroom! What is OK is that the house works even if the ventilation stays… What I actually wanted to say is that we do not have to construct antagonisms here. I hope and believe that the Passive House will "take off" and that all who participate in the debate agree that the Passive House has to be developed in the direction of a holistic and climate efficient concept that also focuses on materials used and robustness" (Frode).

This informal language strengthened the self-image of the group of experts and allowed professional collaboration while simultaneously avoiding the implications and formalism of a meeting. This form of organisation and communication reminds

us of Jørgensen and Sørensen's (2002) development arenas, as spaces where topics are negotiated. The Internet, as a virtual meeting place, is a modern arena that eliminates the constraints of location and time.

This peer arena is less official than a formal meeting and allows the participants to deepen selected topics without the constraint of covering an agenda or reaching an official conclusion at the end of the meeting. In addition to the discussed topics, the email exchange is a sample of a work in process when experts assume that they are among their peers.

The email exchange participants can be classified into three groups: supporters, opponents and mediators of the Norwegian Passive House standard. However, the unofficial arena also allows the actors that mainly support or oppose the standard to form temporary and fragile alliances on a certain topic and to change the alliance when another matter of concern is discussed. In general, the SINTEF experts argued in favour of the Passive House as a technical requirement, while experts from Gaia, Norwegian architectural firm, highlighted possible risks. However, most of experts were in-between, balancing the advantages and the risks of the Passive House for volume production.

A third group did not advocate for or against the Passive House but acted as mediators. They mobilised new actors, named reports, asked for research results and redirected the conversation when it seemed to stumble onto an overly disputed matter, thus encouraging participants to continue the dialogue. This group appeared to be interested in identifying elements of agreement and driving the conversation towards a compromise and an end to the controversy. The disputed terms were discredited as "unnecessary barriers on the way towards energy efficiency" that can be avoided because "everybody agrees on the target" (Ingrid).

Especially the mediating group argued in favour of a *techno-economic network* (TEN) (Callon, 1991), to be able to fulfil a political agenda. The Passive House supporters were also interested in avoiding conflict and following a manageable path, while its opponents were interested in breaking the status quo and allowing for more fluidity. There are the three TEN models that exclude each other. In this fragile network, the mediators take on the role of (political) translation.

The mediators strengthened common identity and kept the dialogue open. They articulated the common coordinates in the discussion and stayed impartial whenever possible, with conciliatory expressions, e.g., "I am a fan of both clubs" (Frode). The building experts were cast as the designers of tomorrow, having the competence "to make possible what most people considered impossible just years ago" (Frode). This border between experts and "most people" remains intact throughout the email exchange. Experts from Gaia proposed public scrutiny through media involvement, but Vegard discredited such involvement as "pearls for pigs" because the requisite simplifications made the discussion boring.

The written dialogues show that participants see the design of buildings' sustainable pathways as an expert task. However, peer allegiance deepened the gap between experts and other actors. Non-participants were ignored or were present in the discussion through representation.

5.1.2 The others

Two groups did not participate but were mentioned often: construction workers and end users. They have agency through imaginaries: they are created/imagined and participate in the controversy through these representations (for imagined lay people, see Akrich, 1995). They cannot be ignored because they transform the laboratory into a dwelling and the dwelling into a home, respectively. They are also partially responsible for the success or failure of implemented research results. Controversy participants ascribe to these two groups qualities that support or contest the robustness of the Passive House standard in climatic, social and cultural Norwegian conditions.

5.1.2.1 The construction worker

One concern of the Passive House critique is that even if one could accept the Passive House as a robust laboratory solution, the building in use might not be robust. Especially for the first dwellings built to the Passive House standard, some aspects might be overlooked, such as high indoor temperatures during the summer. In addition, construction workers might not have the necessary skills and knowledge to build a Passive House without failures. The failures are not always visible in a Passive House but are "built in", and the possible damages increase both energy

consumption and environmental costs (Mats and Erik). Most participants in the email exchange shared the mistrust in the workers' competence. Norwegian workers would "not [be] prepared to build a Rolls Royce and may not be willing either in the petroleum-dominated Norway" (Daniel). Another participant stated that with the "construction sector and the documentation on quality we have, in my opinion this will not hold through the life of a building" (Erik). The introduction of the Norwegian Passive House standard as a technical requirement should thus not precede the requalification of workers. In this way, the cultural aspect of the sustainable development is extended to Norwegian work culture.

The defence of construction workers came in a rather indirect form and did not improve their image: "There will be mistakes, people are people" (Marie), but the Passive House standard is robust even if some mistakes are made (Vegard). Moreover, it is claimed that execution quality and control have increased over the past few years, and if there are clear specifications for quality and control, the construction workers will deliver higher quality. The Passive House as a technical requirement would thus force the construction industry to improve. Therefore, construction laws and technical requirements are seen as drivers towards an improved construction sector because "the Passive House requirement can lead to more careful planning and construction of buildings" (Marie). In this way, the construction workers' image oscillates between indifference, which can be avoided through control, and incompetence, which can be corrected through learning.

The workers' competence was questioned and problematised. Workers are expected to learn and improve their skills, but at varying rates. The Passive House supporters stated that the standard's introduction as a technical requirement would improve the planning and execution of buildings and thus would soon force the construction industry to improve. The Passive House sceptics warned that a technical requirement could be changed only when the construction industry had the necessary competence to build such dwellings. Both parties agreed that the construction workers tend to stick to the building methods that they have already mastered and passively resist proposed technological innovations.

The experts distanced themselves from building workers. One participant stated that he could build a Passive House "anytime" and with the same resources needed for

the TEK 10 (the technical requirement at that time) (Vegard). This answer strengthens the position of researchers who argue that a pilot project planned and built by an expert will certainly fulfil the exigencies. However, the laws are made for the construction industry, and it may be more difficult to train, motivate and control workers.

The building experts involved in building construction (not mainly in research and consultancy) praise the researchers' work and join the actors that favour clear legal requirements. The following quotation supports this argument:

"We who have to cope every day with the building code and technical requirements value the technologists/technocrats that in a realistic way evaluate, plan and conduct solutions with backgrounds in known research and technology and at the same time test the new and innovative technologies and ideas. These people propose regulations and law on which our society is so dependent in order to function properly" (Tore).

This quotation also shows that practitioners want a clear line of legal and technological development. The construction sector values the recipe form of technological requirements and standards (Bush, 2011) that research and university arenas so often criticize. However, this quotation does not signal that each proposal is accepted but that practitioners need a clear law as the recipe for their work.

5.1.2.2 The end user

If the construction worker transforms the laboratory into a dwelling, the user is transforming the dwelling into a home. The discussions regarding the user did not touch upon the cosiness of the place but instead focused on the user's ability to master the building and how the dwelling influenced the user's health.

The most disputed user-related aspects are the indoor climate and comfort in Passive Houses. Passive House proponents claimed to offer the users a good indoor climate and increased comfort. When participants commented that the user might not master the technological devices, the answer was that the Passive House is "stone age technology" compared with cars and computers. The chosen solutions are so simple that "even father can manage" the building (Vegard). Moreover, "there will be even more technology". The unavoidability of technological devices in homes leads to

two proposed solutions: the user has to learn to master the building, or the building maintenance has to be delegated to a janitor.

The Passive House sceptics underlined the risks that the Norwegian Passive House standard as a mandatory technological requirement might bring. In addition to the possible construction failures already named, the Passive House concept alone is a matter of concern: the super insulation does not allow the building "to breathe", so the humidity could compromise indoor air quality and comfort, causing health problems for users; the ventilation system with heat recovery is at best unnecessary and disruptive, and users might find it difficult to maintain (Jon and Mats); in addition, comfort understood as a constant temperature throughout the year might cause obesity, and adequate clothing adapted for seasons and various temperatures is better for the users' health. The stress and burden connected with the difficulty of using and maintaining such buildings and the expectancy that the users will master their homes may endanger their psychical health. "People's psychology, physiology, health and needs" are at stake (Erik). It may be that an expert could build and use a passive house correctly, but "Ola and Kari" (an expression that means the typical Norwegian) would not understand this concept (Erik). The users should have the right to manage their lives, "which means having complete information, insight/knowledge and influence on all circumstances and the coverage of basic needs" (Eric). As an ally, the cultural dimension brings the controversy from technological innovation back to the locality of implementation. In an attempt to domesticate their homes, users might become the victims of their shelter.

Two scenarios are drawn. In the first one, the user has to learn and adapt to the new unavoidable standard (or delegate the responsibility). In this case, the quality of the building is a technical challenge, and more research is needed, along with improved planning and execution. The second scenario sees the Passive House as a sociotechnical concept, where the user's health might be physically and psychically endangered due to stress, incompetence and failures (of users and construction workers). In this case, the user needs protection. All scenarios have a common line: they disempower the user and legitimise the experts to decide what is better or what is dangerous and what can be expected from users.

The unavoidable presence of building workers and users in the lifetime of a dwelling cannot be ignored in the controversy. These two categories have agency through imaginaries, but they do not really have a voice. The workers and users are treated in a symmetric way to the other concerns: as objects of dispute. At least in the analysed moment in the controversy, the construction workers and end users are not an active part of the TEN (Callon, 1991).

The experts try to foresee and co-determine what will happen with the building in use after they lose their influence. One form of not completely losing their influence and preventing the performance of a building is to guarantee a certain level of performance of the building in use. This approach is mostly empowered through the Planning and Building Act and the technical requirements (TEK).

6 The law

Given the context of the controversy, it is not surprising that the question of the law's relationship to sustainable innovation is at the centre of the controversy. The Norwegian Passive House standard became a controversial topic when it was proposed as a technical requirement for all new buildings. Choosing a standard as a technical requirement has broad implications, as the controversy suggests. Following the literature on socio-technical transitions (Kemp & Loorbach, 2006: 105; Markard et. al., 2012), the Passive House is about to leave its niche and enter the regime level.

The Passive House would not merely be a standard among others but instead would become the "normal" dwelling, a starting point, and a lowest technical level. According to one participant, this closes the way for all other concepts that do not fulfil the minimum technical requirements:

"We most likely do not fully believe in Passive House, but we are not interested in stopping it. We just want to actively act against a development where laws and regulations force the construction sector into such a narrow trail. The milieu is known for a much brighter approach and a large variety in focus. There are more answers that are most likely unknown to us today" (Mats).

Such claims capture the essence of the controversy: the choice of a standard as a technical requirement would be difficult to legitimise and, as the opponents claim,

would bring unnecessary risks. As quoted above, such arguments against prescriptive technical requirements support the fluidity of (technological and architectural) solutions and openness to alternative solutions. Architects especially see sustainable transition in buildings as a multitude of locally adapted solutions.

One participant suggested that it would most likely be easier to negotiate if the term "Passive House" were avoided because "We all agree about the target, but we still discuss the way to get there" (Ingrid). There is a clear signal that the policymakers want to have a determined target and to act to reach that target. However, during the written discussion, it became evident that the means of reaching the target *and* the target itself are negotiable. The Passive House is promoted as the most robust and successful solution for energy efficiency in buildings (e.g., Vegard), because the opponents claim that a holistic architectural approach for the intervention would increase the climate profile of buildings (e.g., Mats and Nora).

Even the proponents of the Norwegian Passive House saw the standard's introduction as a technical requirement only as one step towards sustainability. One participant wrote that "We assume that all agree on the target: reduction of greenhouse gas emissions", yet even this partial target was contested: "It is not certain that the zero-emission building is a reasonable target. The experiences from the '70s and '80s with the autonomous house show that some problems can be more easily solved in a broader context" (Mats and Jon). The target is thus moved even further—to "sustainable society" and to "zero emission society". It soon became clear that the experts did not only disagree about the approach, they could not even agree on the target. They did not even have a common question: "Sooner or later we have to ask what the real question is and make policies around that" (Daniel).

Both parties claimed to encourage and support a holistic perspective in the sustainable transition. The quotations below suggest that even the proponents of the Norwegian Passive House see a need for future development towards sustainable buildings and a sustainable construction sector. The disagreement seems to reside in the ways to reach the projected goal:

"The way towards zero-emission buildings and a zero-emission society (including zero emissions from transportation, building and industry) will imply dwellings with extreme degrees of energy efficiency; all the rest is a stupid use of money and

resources…Passive House is a rational and necessary step towards the target…The discussion has to be rather how to go from the Passive House to the zero-emission building (Vegard)."

"We know enough to give the authorities a tool, a direction to go in that is clear, demanding, and that gives concrete results, that are on principle producing buildings that are physically good, that are comfortable, that give a robust and good indoor climate and that are as simple as possible but not simpler" (Vegard).

In the quotations above, the Passive House is presented as a reasonable step towards achieving ambitious sustainability goals. The concept is still open to improvement, and holistic development resides within the choice of materials and the introduction of renewable energy sources. Still, the dwellings' energy efficiency is seen in these quotations as a necessary and affordable measure. The holistic perspective is driven even further, towards the "zero-emission society": "We have to work more to make such solutions industrialised, standardised, robust, and easy to install and use" (Vegard).

The researchers who oppose the introduction of the Passive House standard as a technical requirement for all new buildings see the standard's adoption as an unnecessary and risky restriction of alternatives. They claim that architectural means are ignored through the adoption of restrictive technical requirements and that the building's impact on the environment can be minimised by means other than just a unidirectional focus on energy efficiency. The introduction of restrictive standards is disqualified as a political target:

"The laws and regulations have to promote intelligent solutions adapted to the real situation and not a standard or the need of the political authority for easy supervision… It is risky to gamble on one card" (Ellen).

This quotation refers to policy and political tasks, while the following quotation refers to the construction industry:

"The new technical requirements unify the whole construction industry and exclude in praxis all other possibilities and approaches other than increased insulation and balanced ventilation with heat recovery" (Petter).

These discussions suggest a conflict of interest: while the Passive House proponents see the law as an intervention tool against bad practices and towards energy

efficiency in buildings, the opponents criticise implementing the law for political purposes. The quotations also indicate that the technical solutions are more easily employed in policy because of their apparent manageability. The architecturally fluid solutions that are adapted to local conditions do not seem to appeal to legislators and policymakers because they do not offer strategies that are easy to translate into legal texts (Mats and Jon). The fluid approach (as proposed among others by Guy, 2010 and 2011) is difficult to capture in numbers. Or as one participant expressed, "How else [than in numbers] would you formulate the requirements?" (Vegard).

Indeed, the law is not just a reflection of the research but is an amalgam of various factors. As we have seen in the quotations, the ability of the construction industry to adapt to the new standards also has to be considered. Additionally, Norway must respect international agreements, such as the EU Directives and the Kyoto Protocol. The legislators can favour a certain path or technology (David, 1985) that might transform the sustainable development of buildings in an irreversible path (Callon, 1991). The choice of a solution has advantages but also its costs.

7 Resources

Another central theme—besides the boundary work between "us" and "them" and the law—involved resources. What is usually presented as a "cost" in Passive House promotion, i.e., the additional (financial) costs for the users, is problematised to only a small degree in the email exchange. Instead, the experts refer to "environmental costs" and "state and society costs". Additionally, the redirection of research funds is seen as a problematic consequence of the introduction of restrictive technical requirements.

Proposed primarily by architects, the holistic and fluid approaches favour the development of multiple and local solutions. Adopting a standard as a minimum technical requirement was seen as restricting the variety of alternatives. However, the supporters of the Norwegian Passive House standard did not see the standard as a restriction but as a chance to improve the concept and develop it "towards a holistic and climate-effective concept" with a focus on material development and robustness (Frode). In the same vein, a mediator proposed that "If somebody wishes

to develop Passive Houses without a balanced ventilation system, this solution is also welcome" (Agnes). In these approaches, the holism is seen as continuously improving and adapting the standard, while a minimum building performance is assured.

The standard would increase the manageability of the transition towards sustainability. The quotation above suggests that step-by-step development is encouraged and favoured by the legislators and policymakers. The improvements are expected to occur within the given legal frameworks. However, the proponents of fluid solutions warned about the consequences for research: the redirection of funds and education on a rather narrow path.

The openness, curiosity and plurality of research as "*the precondition for a healthy society*" (emphasis his) are at stake (Daniel). Being given an official trajectory, deviations would be treated as hobbies rather than as competitive alternatives. Even if not forbidden, other solutions are deprived of research funds and would not enjoy political credit:

"Alternative voices have to snuggle up in the evening until late in the night with volunteer contributions. It is stupid, undemocratic, and scientifically unacceptable" (Daniel).

"It seems that it is expected that research for alternative solutions can be done after work, at the kitchen table, and free of charge by enthusiasts" (Nora).

The redirection of research funds at the expense of the development of alternative solutions has thus been presented as an additional cost of the Passive House. Alternative solutions to the official "normality" do not benefit from comparable resources. This cost suggests that the experts do not see the development of construction law as a direct consequence of scientific truth but rather as a product of negotiations and compromise. Research is a way to improve knowledge, while the right and the truth are not absolute but negotiable values.

The quotations draw the discussion on the concentration of resources towards a common goal (the alternative being presented as an ill-advised use of money and resources) versus political decisions limiting diversity by adhering to one standard/recipe (Bush, 2011). This situation resembles the *path dependency* described in economic science (David, 1985), where a technical solution gains

terrain not because of the technical superiority, but because of external circumstances (e.g., the success stories of Passive House projects in Austria and Germany, and the Norwegian government's desire to find an immediate response to Kyoto Protocol expectations and EU Directives specifications for GHG reduction). The consequences would be a component price decrease and the possibility that future technology would be developed to be compatible with the existing regime (David, 1985: 335-336). The irreversibility of the process after choosing a solution becomes the highest concern (Callon, 1991: 150). Without support and resources, alternative solutions would die out or be subordinated to the winner.

Moreover, the email exchange contributions show that the choice of the Norwegian Passive House standard as a minimum requirement for all new buildings would build up asymmetries (Callon, 1991) in the research environment because the "winner" will have a stronger position when negotiating with other actors (i.e., the building industry, component developers, users, universities, and not least policymakers).

8 Discussion

The Passive House controversy in Norway presents the tensions that appear when a niche development is extended to a technological regime through a legislative change. Even if successful at the niche level, the Passive House as the "norm" meets new challenges, involves new actors and increases risk. Usually a new actor proposes a niche technology (Geels, 2002). However, the Norwegian Passive House standard is advocated by established actors (e.g., SINTEF) and encouraged and broadly supported by policymakers.

The necessity and potential of the intervention of a more sustainable building development are commonly shared opinions in the controversy. However, the controversial email exchange shows that buildings are parts of larger systems, and technological innovation alone cannot solve the complexity of the buildings' development. Divergence between various groups is not about if the intervention is necessary, but how to design an irreversible path dependence process (David, 1985). The three participants groups (i.e., supporters, opponents and mediators) claim to describe pathways towards sustainable building development. However, the

difference resides in the strategy employed: from offering a recipe for a minimum building performance to an allowance of messy and fluid solutions towards environmental futures to the mediation of a negotiation arena where the actors stay in dialogue and eventually reach an agreement. The three approaches offer at the same time alternatives of techno-economic models (Callon, 1991), where the network's power relation varies from subordination to the given path to irreversibility of the process as research in dialogue and compromise to fluid and loose regulated relations (i.e., fluid architecture).

The creation of two categories of actors, "we" the experts and "they" the construction workers and the users, establishes a clear power relation above the divergences connected to a standard. The creation of "the other" (for imagined user see, e.g., Akrich, 1995) fastens the boundaries between experts. The "imagined other" might become a powerful actor through representation if the negotiations regarding science and technology manage to avoid the public scrutiny.

Moreover, the controversy goes beyond the intrinsic properties of the technological Passive House concept and reaches broader implications that the standard's introduction as a technical requirement might have at other levels, e.g., society, health, culture, research and education. The adoption of a technological pathway determines the paths of social, economic and educational environments. Moreover, the email exchange shows that redirecting research to follow the adoption of one strategy has a considerable impact on the development of future philosophies and discourses regarding building sustainability.

We see also that the controversy is not about rejecting or accepting technology but rather which technology is desired, where to set the boundaries and how to organise the transition. Technology is not seen merely as an artefact but also as the knowledge and practices that precede and follow the artefact (Guy, 2010: 25). As Feenberg puts it, instead of splitting technology and meaning, the focus should be on the "struggle between different types of actors differently engaged with technology and meaning" (Feenberg, 1999: xiii; Guy, 2010). This claim is supported by discussions regarding cultural aspects and the effort to make technology and the process domestic (Lie & Sørensen, 1996).

The Passive House controversy did not conclude and continues in other arenas. In the media, at conferences organised by various actors (e.g., The Nordic Passive House Conference), and in scientific reports (Klinski et. al., 2012) and books (Butters & Leland, 2012), the arguments and counterarguments of the political decision are highly debated. However, the email exchange analysed in this paper is a unique and dynamic arena that allowed the actors to meet in a virtual space and to react immediately to any arguments. It was a way to mobilise allies and to fight enemies, to define and legitimise one's position, and to challenge existing power relations.

9 Conclusions

Participants in the email controversy negotiated the adoption of the Norwegian Passive House standard as a minimum technical requirement for all new buildings. Although policymaking requires a decision, a boundary of what it is considered a sustainable building and what paths should be followed (Eriksson, 2013), the experts are still disputing the conditions of sustainability in buildings. Returning to the controversy definitions offered by Venturini (2010) and Pinch and Leuenberger (2006) and to the ways participants see the email exchange, the Passive House debate can be defined as a "hot-spot" controversy. Experts from different fields actively participate to create building laws and regulations and to develop pathways with the policymakers.

The Passive House controversy brought the actors together and allowed them to interact (Brante & Elzinga, 1990: 36). The results of the data analysis and the way that participants approached the email exchange signal that the Norwegian Passive House debate is a controversy, not just a "rapidly passing disunity" among experts (Brante & Elzinga, 1990: 36). The controversy can be classified as a "regulation versus freedom of choice" type (Nelkin, 1987; Brante & Elzinga, 1990). This controversy analysis shows that scientific controversies where the "best scientific evidence" (Nelkin, 1987: 283) is disputed are not just relevant for science and technology studies. There are different knowledge claims that are disputed, including technological, architectural and medical knowledge claims, but their implications in the society and in the research environment are also disputed. The

scientific knowledge is contested, along with the applied knowledge or the knowledge in context; as Brante and Elzinga put it, the controversy has a *political-contextual approach*.

The same controversy in other arenas addresses different axes of divergence, due to the different auditors and participants. The content of the socio-technological artefact is identical, and the involved actors are often the same. However, the context determines the direction of the discussions and decides the matters of concern.

The most controversies analysed in the STS literature are either scientific controversies or controversies in an arena where science meets the public. The analysis of the Norwegian Passive House controversy is presenting another arena of negotiation, less accessible to the public and to social scientists. The heated negotiations about the right and the truth in designing sustainable pathways involved scientists, consultants, architects, physicians, practitioners and policymakers. This arena has thus far been neglected in STS studies because it is something that falls between a purely scientific controversy and a controversy with public participation. Drawing on the analysis, the Norwegian Passive House controversy can be seen as a path dependency controversy.

Along with the scientific and technological robustness of the Norwegian Passive House standard, the participants create imaginaries of the absent actors. The imagined building workers and users may be typical for this type of expert exchange. The design of the sustainable pathway is seen as an expert's task. "The others" cannot be ignored, but their involvement in the discussion is not desired either. In addition, the discussions about law, policy and costs situate the controversy somewhere between science and the public, in a path dependency dispute where one has to choose between multiple "scientific truths", while the public is not invited yet is felt at the negotiation table.

The special controversy analysed in this paper (i.e., not a public controversy but not a private one either) is a result of the Internet. The experts created a new working arena through an email exchange. The analysis of the email controversy also shows that the ways of communicating at the expert level adapt to the facilities offered by electronic media. It may also suggest that the easy email exchange might replace

traditional forms of communication and negotiation. The new medium might influence the rules that govern communication: while experts' access to negotiations increases, public participation is limited. If the involved experts agree to avoid public participation, this agreement might challenge the democratic scrutiny.

The limitation of the paper is that it exclusively analyses the experts' email exchange over a relative short period of time. However, the data offer a valuable pattern of work that is usually unavailable to social scientists and thus is of relevance for STS research. For a better understanding of the Norwegian Passive House controversy further research is needed. An analysis of the negotiations that occur in other arenas would complete the understanding of pre-legislative negotiation processes. A future end to the controversy would also complete the current analysis.

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Article 4:
Conspicuous Domestication: Expert-Based Media Coverage of Low-Energy Buildings in Norway (2005-12)

Liana Müller and Thomas Berker

Abstract

The implementation of low-energy standards for buildings is promoted as an efficient and relatively unintrusive intervention towards sustainability. However, building codes enforcing the scientific knowledge developed in research environments are alien interventions in the private sphere of homes. Media have the potential to popularise low-energy buildings. However, media depend on experts' willingness to provide input.

Through the qualitative and quantitative analysis of 1774 news articles that appeared in print media in Norway between 2005 and 2012, it is observed the interaction between media and building experts; media engagement was a part of experts' practices. Three types of mutual engagement between media and experts can be distinguished: during public controversies, experts took sides and actively intervened; in a limited number of local controversies, experts were more cautious, using the newspapers' "kronikk" section as a forum that preserved the control over the published text; and experts portrayed as heroes in "home-stories"—experts shown living in low-energy buildings pioneering a sustainable domestic life.

Although engagement in controversies—whether proactive or cautious—is a more general pattern of mutual engagement between media and experts, the "home-story"

should be seen as a specific type of performance of expertise in which unfamiliar technology is conspicuously domesticated.

Keywords: controversy, innovation, low-energy building, mediatisation

1 Introduction

Experts involved in sustainable innovation routinely observe that completely reasonable and beneficial innovations are not adopted by society. For example, although buildings that produce clean energy have been possible for some time, they remain a fringe phenomenon and their diffusion is slow despite considerable political support. This non-adoption is part of a much larger phenomenon: the link between an invention that has proven its value in models, trials and well-received pilot projects on the one hand and its widespread implementation on the other is less straightforward than the "waterfall logic" of linear "science and technology push" thinking would have it. A common reaction to this observation is the search for "barriers," which has catalogued the factors that interfere with the adoption potential of innovations (e.g., Lovins, 1992; Lomas, 2009; Sheffer & Levitt 2010; Häkkinen & Belloni, 2011). Instead of listing additional barriers to this "conventional view" (Shove, 1998) that ignores some thirty years of research into the non-linear nature of innovation (e.g., Kline & Rosenberg, 1986; Sørensen et al., 2000, Misa, 2004), in this paper, we reverse the perspective and analyse one of the productive links between invention and successful implementation: building scientists' and other building experts' involvement in efforts to popularise low-energy buildings through mass media outlets—or the lack thereof.

Media have the undisputed potential to bring concepts produced by experts to the public. However, agreement about media's relation to science and innovation ends there. The idea that mass media could educate the public about and democratise science and technology originated in the early years of public television (Hartley, 2002). At the same time, television and other mass media have attracted criticism for their detrimental influences on consumers, a phenomenon that can actually be traced back to the early days of the printing press (Löwenthal, 1960). Avoiding these two

extreme positions—mass media either dumbing down otherwise responsible citizens or raising the masses out of ignorance—in this paper, we draw on recent theoretical developments in media studies and science and technology studies to analyse how low-energy building experts have engaged with Norwegian newspapers over an eight-year period.

In analysing both media representations of the experts and their mediatised statements about low-energy buildings, we have two aims.

First, we want to shed light on the question of how newspapers and low-energy building expertise have interacted in a specific space (Norway) and during a specific period of time (2005-12). Media coverage of low-energy buildings has increased considerably in Norway during this period, as has the number of low-energy buildings. As we will show, experts were not only involved in the construction of the buildings but were also extensively involved in the media reporting. Based on this observation, the main question that we will answer is how this expert-based newspaper coverage was related to the actual diffusion of the buildings. More specifically, we describe and analyse three types of expert engagement: experts as pioneer users, experts intervening cautiously in safe spaces, and experts' engagement in political controversies.

In addition to the analysis of the mutual engagement between experts and newspapers— how often and how does it happen—a second goal of this paper is to offer guidance for both experts who seek and those who avoid media appearances. The three types of engagement with media described in depth here are found within a relatively small geographical and temporal frame. Consequently, the list cannot be exhaustive. However, we hope that readers recognise our descriptions as opportunities for engagement in their own practice as well.

2 From Science Distorted by Media to Active Engagement with Media as Part of Scientific Practice

Whether and how scientists and engineers should engage with media to promote the application of their results has been discussed extensively in studies of science and technology. At stake here is nothing less than how the societal roles of science,

technology and media are conceived. At the same time, there is a notion that media influence (not only on science and technology but in other areas as well) increased during the 20th century, a phenomenon termed "mediatisation" in media studies. With Väliverronnen (2001), Couldry (2004) and Driessens et al. (2010), we propose a synthesis of both approaches in which the performance of scientific practices involving media is studied.

2.1 Media, Audiences, and Experts: Effects, Irritations, and Resonances

The underlying assumption of studies that look at media's effects on science and technology is that media representations of science and technology somehow interfere with these fields. In their most basic form, "media effects" are constructed as causal relations between positive or negative images of science and technology in the media and the distribution of these images among media consumers (Gerbner et al., 1981; Nisbet et al., 2002; Ricci, 2009; Dudo et al., 2011; Metag & Marcinkowski, 2014). Empirical studies of these "effects" typically acknowledge complexity and indeterminacy in the media-audience relationship but then move on to studying the framing of a certain scientific or technological field in the media assuming that these representations surely have *some* relevance (e.g., Stephens, 2005; Kjærgaard, 2010).

Weingart and his colleagues take a step back, looking at the distinction between media and science. Modern societies, they argue based on Luhmann (1995), are differentiated in distinct social systems that are "autonomous in the sense that they are defined by their respective operating codes, in the case of science it is *truth*" (Weingart, 2012, p. 25). Media, it follows, make up another system with another operating code, which, according to Luhmann (2000), is "information/noninformation." Once this difference is stated, the "resonances" and "irritations" between the different "codes" can be studied. Put into a historical frame, this perspective expects resonance and irritation to grow along with the impact of media on society. Consequently, Rödder and Schäfer (2010, p. 251) refer to Weingart's (2002) diagnosis of a "loss of distance" between science and society that is visible in the degree of mediatisation of scientists' work. Historically, they argue, there was a

protective layer of science journalists who both related and kept apart these two areas. With direct and indirect pressure mounting on scientists to account for their deeds to society, this mediation is increasingly enacted by scientists themselves. Based on this trend, Rödder and Schäfer studied particle physics and genome research based on interviews with scientists and content analyses. They found that, particularly during phases of routine operation, the formative influence of the media on science is weak and restricted to a small number of highly visible scientists.

2.2 Mediatisation

In media studies, the process of increasing media saturation in modern societies is termed mediatisation (Lundby, 2009). The definition of this term and even the term itself—whether it is mediation or mediatisation or even medialisation—are still unresolved (Couldry, 2008; Livingstone, 2009). However, a consensus appears to exist that the most specific use of the term is to describe what happens when processes and structures are enacted through technical media instead of face-to-face interactions. In this sense, it describes "communication via medium, the intervention of which can affect both the message and the relationship between sender and receiver" (Hjarvard, 2008: 114). However, the term is also used more broadly to refer to the general influence of media over society and media's role in society. This is the mediatisation that is described by Hepp et al. (2010, p. 233) as "long-term inter-relation processes between media change on the one hand and social and cultural change on the other." The step from the individual act of mediation to a secular process of mediatisation is based on the observation that "[in] our present media-saturated society media are *inside* society" (Hepp, Hjarvard & Lundby, 2010, our emphasis). Mediatisation in this latter sense is an attempt to consider this new situation in the context of other fundamental developments such as globalisation and individualisation (Schulz, 2004; Krotz, 2008). Consistent with the descriptions put forward by Weingart, this notion of mediatisation presupposes that media is at least a "semi-independent institution" (Hjarvard, 2013, p. 21) and can be meaningfully described as distinct from other institutions, for example, belonging to science and technology. Radicalising the metaphor of media being "inside" society, however, Driessens et al. (2010), based on Couldry (2004), depart explicitly from the interest

in what the media and their increasing presence "do to" society and culture. Instead, these researchers propose to analyse how mediatisation is enacted in its everyday contexts and study mediatisation as a practice that is embedded in other practices. Important to this shift is abandoning the idea that there is an inherent "logic" (Altheide & Snow, 1979) that describes "media as such" and prompts the question asked by Strömbäck (2008) of who influences whom more: political media or media politics. Instead, Driessens et al. (2010) describe how media are specifically involved, for example, in image building or defining "the private" by Belgian politicians.

2.3 Media as Part of Experts' Practice

A corresponding move away from the question of what media and science "do" to each other is proposed by Väliverronnen (2001) in her study of the practices of researchers in relation to media. Opposing findings that view mediatisation as mainly at work in exceptional circumstances, she describes different media-related roles for scientists, namely as populariser, interpreter, adviser/advocate, promoter/manager and critic. These roles, she maintains, are not to be understood as media phenomena trespassing on the domain of actual science but rather as part of science as social activity, activity that is diverse and that is (among many other arenas) also enacted in a mediated fashion.

One obvious difference between Rödder and Schäfer on the one hand and Väliverronnen on the other is the empirical field. Väliverronnen studies environmental research, which has arguably always been engaged in hybrid fora where concerned groups meet science (Yearley, 1991; Callon et al., 2011) by destabilising the boundaries between science and non-science. Rödder and Schäfer's particle physicians and genome researchers and their doings are traditionally much less visible to journalists and the general public—at least during routine phases of scientific work.

However, the difference between these studies is not only one of what is studied but also a difference in more fundamental conceptions of the science-society nexus as it was discussed, for example, in the classic mode 1 and mode 2 distinction (Gibbons et al., 1994; Nowotny et al., 2003; Hessels & van Lente, 2008). Seen from the

perspective of mode 1 science, the routine science of Weingart, Rödder and Schäfer will suffer "irritations" and "resonances" from engaging with media and mode 2 science will gain robustness. In even more fundamental terms, the difference between the two approaches can be compared to what Taschwer (1996) has described as the incommensurate difference between system approaches and those approaches that presuppose a more fundamental embeddedness of science in society. Returning to media studies' concept of mediatisation, Väliverronnen's research corresponds to the renunciation of mediatisation as a process that "does something" to its objects—here, science, researchers and scientific research. Instead, Väliverronnen's research is consistent with the mediatisation studied by Driessens et al., in which media-related practices are addressed as part of other non-mediated practices—in other words, media as part of everyday life and, in this case, of scientists' everyday work lives.

This latter perspective on mediatisation adds to the study of media representations of science and technology by encouraging a turn away from questions of "distortion" and "influence" and towards questions of "enactment" and "performance". Moreover, it avoids a common, naive approach that takes media writings at face value, assuming that media frames are worth studying in their own right because they will *somehow* influence the public perception of the subjects that are framed. Instead, the objects of the study of this type of mediatisation are specific activities of researchers, scientists and other experts within media that leave traces in newspaper articles, radio and television interviews and features, and other media outlets.

3 Method

The articles used in our analysis were published in Norwegian newspapers between 2005 and 2012 and were collected through the online database *Retriever*. In addition to media monitoring, media analysis, social media and business information, *Retriever* indexes an online news archive comprising all the major Scandinavian daily newspapers, provincial newspapers and most magazines, journals and periodicals. We used the online archive to search the articles that address concepts of low-energy building in all the daily newspapers, regional newspapers, periodicals, and specialised publications that appeared in Norway between 2005 and 2012.

Our search terms were *low-energy building, passive house, active house, plus-energy house, zero-energy building, zero-emission building, and BREEAM*. These are the concepts found in the main discourses connected with low-energy buildings in Norway; they were extracted from experts' reports, policymakers' strategic plans and political programs. They cover not only the Norwegian innovation strategy towards more sustainable buildings but also the European trend. We omitted other concepts such as *green building* or *ecological building* that do not enjoy equally broad political support in Norway.

For representative coverage of the concepts in the media, we did not select specific newspapers because we wanted to look at the full picture. In this way, we included mass appeal of the large audience newspapers (e.g., Dagbladet), the more specific focus of specialised publications (such as publications circulated among professional organisations, e.g., Teknisk Ukeblad), and local reporting in regional newspapers (e.g., Adressavisen). We searched all the above-mentioned terms in the full text of the articles.

From the initial 2338 articles, we deleted those that were obviously irrelevant (such as advertisements). We then manually coded the remaining 1774 articles, employing an open coding strategy, and grouped the codes into larger categories. The codes were developed during the analysis, and in this way, the topics were identified as they appear in the articles. Next, we analysed the relationships among the codes by examining their proximity to each other within articles and paragraphs. Employing qualitative data analysis (using the tool QDA Miner), the link between the code and the actual text was maintained at all times so that we could move back and forth between these two levels.

In relation to the theoretical approach outlined above, this study has two empirical restrictions. First, we only study print media, and second, we analyse products (the articles) as opposed to the processes leading to these products (for example by interviewing experts or journalists).

The first restriction introduces a bias towards textual representation that is common in studies of media; however, this bias is somewhat moderated by our decision to include all the types of Norwegian print media—from specialised newspapers with more technically inclined audiences that are open to long texts to the popular press

with its characteristic focus on images and short texts consisting of short sentences. Still, like in many studies of public representations of science (Schäfer, 2012), the bias exists and is reinforced by our mode of analysis that at least in its quantitative aspects only accounts for the textual information.

The second restriction—the focus on the product instead of the process—does not introduce a bias but restricts the scope of our account of the process of mediatisation. We have neither information about how the texts came to be nor information on how the texts are read and what they then "do". What remains is a focus on the texts themselves—the low-energy buildings and their experts, existing as stories, descriptions and images in Norwegian print media between 2005 and 2012. We address this particular bias by being careful to restrict our assumptions about process (and impact) to the immediate contents of the analysed media product—i.e., the newspaper articles.

4 Findings

4.1 Background

Consistent with research priorities and political discourse, some low-energy building concepts gain media attention at a certain moment to be gradually replaced by competing and often technologically improved building concepts.

Figure 1 shows that low-energy building prevailed in the first years after 2005, gradually giving way to the Passive House concept as the dominant way of framing low-energy buildings. The year 2005 also coincides with the first passive house being built in Norway. Soon thereafter, the Passive House standard caught the attention of building experts and policy makers as a solution to achieving the energy efficiency proposed by the European Commission and the reduction of greenhouse gas emissions stipulated in the Kyoto Protocol. However, due to different climate and cultural conditions, new calculations resulted in two Norwegian Passive House standards, NS 3700 for residential buildings and NS 3701 for non-residential buildings (Müller & Berker, 2013). As early as January 2008, the so-called "climate agreement"—a white paper supported by (almost) all the parties represented in the

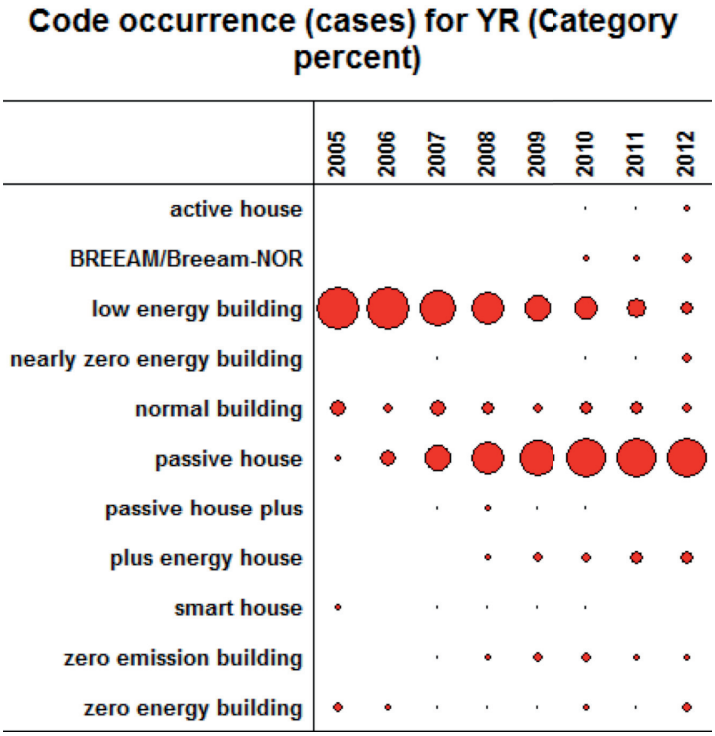

Figure 1: Code occurrence: sustainable building concepts in the Norwegian print media.

Norwegian parliament—proposed to make the Passive House standard the technical requirement for new dwellings by 2020, and in June 2009, the government's Low-Energy Committee suggested an even earlier date of 2017. However, the focus on Passive House, which neglected other solutions and partially excluded different approaches from the negotiating table, ended in a heated debate targeting both the robustness of the Passive House concept and the impact of the single standard for all new buildings in Norway. In April 2012, the white paper "Norwegian Climate Policy" foresaw the raising of technical requirements to Passive House-level by as early as 2015 and to nearly zero-energy building by 2020. The white paper in this way encouraged the early introduction of Passive House as a technical requirement but at the same time made concessions to the opponents of the Passive House as a unique solution by specifying that the "level" should be reached and not the "standard" (so that alternative energy-efficient solutions are still possible) and by

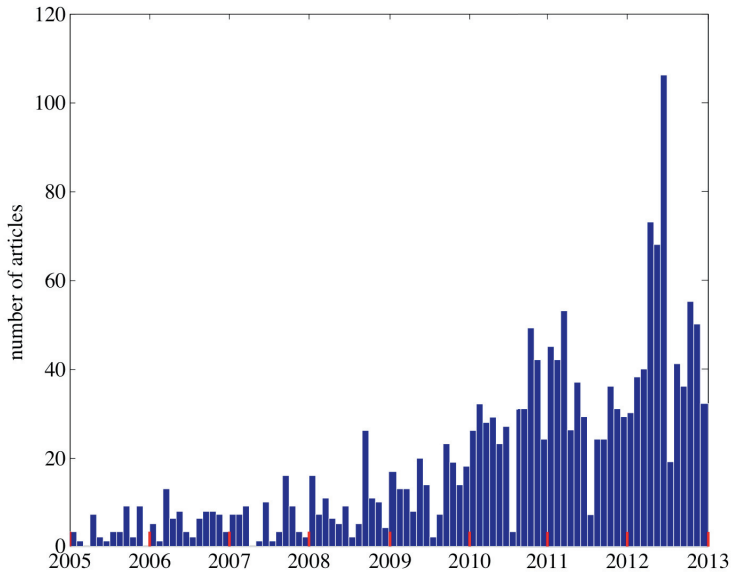

Figure 2: Number of articles per month returned by the full text search for low energy building related terms.

viewing the Passive House level as a step towards nearly zero-energy building (imposed through the European Directive on energy efficiency in buildings, EPBD). Concepts related to low-energy buildings were almost absent from pre-2005 media but increased continuously in number in media produced after that year. Because of the increased political attention to Passive House and the increased media interest in low-energy buildings generally, we decided to begin our analysis with newspaper articles since 2005.

As shown in Figure 2, the 2008 white paper coincides with an increase in media attention; however, a dramatic peak in news coverage appears simultaneously with the experts' Passive House controversy in Norway after 2009, through 2010 and culminating in 2012, when the government released the white paper announcing further changes towards a "passive house level" in future technical requirements. The Norwegian newspapers manifested an increasing interest in low-energy buildings over the years. Although, there were forty articles referring to low-energy

buildings (and related search terms) in 2005, the number increased to 588 articles in 2012.

Following the development of the media reaction to these political decisions, we observed that they are interconnected: the greater the interest shown in low-energy buildings at both the national and international levels, the more these concepts are mediatised. Moreover, there are several peaks where the media interest in low-energy buildings increased, such as after the climate agreement or the Low-Energy Committee declaration and before the political elections. The Government's 2012 White Paper was particularly mediatised, and the political decision mobilised experts, policymakers and other interest groups that used the media as an arena for communication. We observed that the mediatisation of low-energy buildings did not occur in a vacuum but was a part of an increased interest in these concepts at all levels: policy, research, and the construction industry.

These findings give us clear indications of the factors influencing the number of instances in which low-energy buildings are covered in newspapers. Next, we look at the role of experts in these instances.

4.2 Building Experts in the Media

The first noteworthy characteristic of experts' engagement in the material is that they are introduced with their respective affiliations. We know when we meet an architect from a particular firm or a research engineer from a certain research institution. Research and education institutions such as Sintef (473 occurrences), The Norwegian University of Science and Technology (NTNU) (178) and The Research Centre on Zero Emission Buildings (ZEB) (102) are particularly well represented; however, experts from architecture firms and various interest organisations, such as ZERO (176) and the Norwegian Society for the Conservation of Nature (70, as well as 53 occurrences of its sub-unit Green Daily Life), are also referenced. In addition to such institutions, the industry is largely represented through experts. In this case, the discussions are not theoretical debates (as in the case of research institutions) but rather concrete, often entailing the presentation of plans for low-energy dwellings or realised pilot projects.

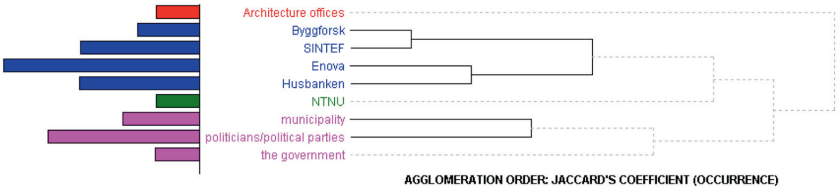

Figure 3: Jaccard's coefficient of co-occurrences within newspaper articles (institutions appearing in 100 or more articles).

As shown in Figure 3, in their newspaper representations (co-occurrence within articles), the different actor groups fall roughly into two clusters: on the one hand, a political cluster encompassing municipalities, the government, and political parties/politicians and on the other, a cluster of applied research (Sintef Byggforsk) and implementation/support through governmental bodies (Enova and the state housing bank "Husbanken"). The technical university of Norway (NTNU) and architecture firms are mentioned with roughly the same frequency as the government but do not belong to either cluster. This clustering of occurrences corresponds to the structure of the Norwegian low-energy building innovation sector. Norway, with a population of just above five million, provides the frame for what Guy and Shove (2000, p. 19-22) have called a "close community" of researchers and industry. Similarly, a closer look at the newspaper articles reveals the difficulty in drawing borders between different professions or other actor types because of the multiple roles that many individuals play, sometimes simultaneously and sometimes sequentially over the course of their careers. Often, architects and engineers are portrayed as users/pioneers building dwellings to low-energy standards for their own families—blending the role of expert and user. A second overlap encountered frequently is due to the revolving door between research and industry for architects and engineers, who additionally take part in the policymaking process when they serve on advisory boards and similar bodies. These multiple roles constitute two different types of engagement with media. We start with experts as users (4.3) before looking at experts who become involved in political controversies (4.4).

4.3 Experts as Pioneering Users

The material analysed here extends over eight years, and most of the technological solutions have even longer histories (e.g., the first Passive House was built in 1991 in Germany). However, in the analysed newspapers, the solutions are exclusively presented as very new, even revolutionary. Individual building projects, even those that might be considered to use mature technology in the European context, are labelled "engines of sustainable development", "lighthouses" or "flagships".

A series of newspapers, for example, report on a building constructed near Stavanger in 2011 using headlines describing it as "The building of the future that has already arrived." Based on a feature article from the national press agency NTB (8 September 2012), these reports emphasise that the building "can produce 17% of its energy consumption" and that the "energy that the family does not use is sent directly on the open energy market to be sold." As technical claims, in 2011, these achievements were not extraordinary. However, it is evident that the feature of selling energy has greater novelty value than the more accurate claim that relatively little of the energy needed for the building will likely be supplied through on-site production. Viewed from the perspective of the vast majority of media consumers who live in ordinary homes, the possibility of selling energy is interesting. However, from experts' perspective, the representation of this "building of the future" overstates the technical achievement. As an expression of media logic, the strong wording is due to the aim of creating a specific "news effect" (Altheide, 2004) and can be seen as an example of the type of irritation Weingart (2012) has described. In this case, the technically more correct evaluation of the project is distorted by the "news effect" inherent in media reporting.

A closer look at the articles, however, adds more nuances to the picture of one-sided distortion. The articles bear traits of a "home-story", a genre common in the yellow press reporting about celebrities and their private lives. They present a regular family consisting of Oluf Langhelle, Trude Hammer Langhelle and their teenage children and the futuristic building. As such, the mundane world of everyday domesticity, in which the energy consumption is so much less apparent than in the immediate experience of a long, hot shower (Berker, 2013), is contrasted with the

fantastic technology in which the Langhelle family lives. According to the articles, the connection between “everyday home” and “ground-breaking innovation” is also made directly in a quote by one of the occupants of the innovative home: “We are very interested in questions related to the environment and we wanted to reduce our use of fossil energy. However, we do not have to give up something to live here.” In fact, this speaker, Oluf Langhelle, is not only interested, being a professor at the University of Stavanger with sustainable development as one of his main research topics, he also qualifies as an expert—even though he is presented in this “home-story” exclusively as a regular, albeit pioneering, homeowner.

If we look at reports of other low-energy buildings, the presentation of experts in “home-stories” as regular users is common, for instance the architect Stein Stoknes's heroic fight to build a passive house is featured several times in national press. In these “home-stories” experts are typically presented with their entire families, active and expressing emotions. The comfort and the cosiness of low-energy homes, as well as the reduced maintenance costs, are a common thread of the stories, which often feature images of the experts sitting on their sofas enjoying the comfort of their homes.

Users of the new buildings are not always presented in this upbeat way; there is also a sub-genre of disgruntled and disappointed victims of empty promises. If, however, the users are engineers, architects, sustainability experts or individuals who work in the building industry, the pioneering aspect dominates the presentation. These experts are presented as pioneers who enjoy the challenges of living with the new technology and who are able to master their homes.

The mediatisation of users and user experiences with the various concepts of low-energy buildings normalises the new home—the home of the future—presenting the concepts as already tested and already existing. In these cases, the concepts are neither cryptic technical standards supported or contested by experts—more on this later—nor parts of a political program. The dwellings become homes with occupants who are willing to share their personal reasons and personal experiences.

4.4 Episodes of Engagement

Despite the image created so far, in which experts as pioneering users evoke a largely unproblematic image of an exciting new technology, the materials analysed in this study also contain voices that do not trust the impact of the pilot projects, claiming that the increased investments do not lead to the expected results.

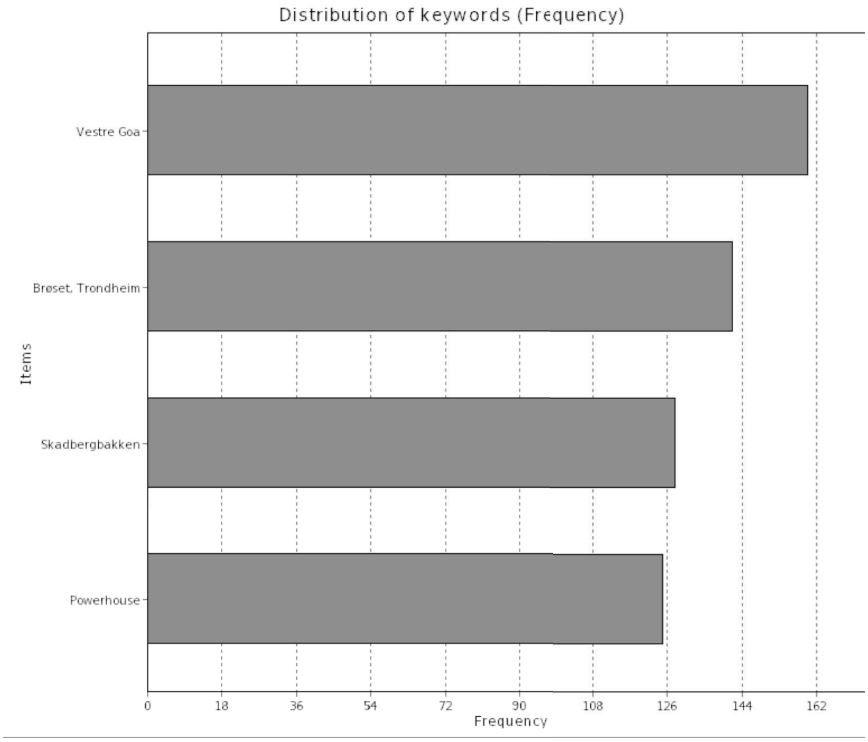

Figure 4: Building projects appearing in more than 100 newspaper articles.

These stories in which experts intervene in controversies fall into two categories: resistance to specific construction projects and general resistance to passive houses as part of Norway's energy and climate policy. All four projects (Figure 4) that feature prominently in the newspaper coverage touch both specific and more general questions related to their implementation.

4.4.1 Specific Projects

Experts involving themselves in specific construction projects can expect to be drawn into larger public debates around architecture and urban planning—which are not uncommon in large, highly visible projects (Yaneva, 2009)—and also into discussions of environmental aims and measures. Two of the most widely reported projects, Vestre Goa and Skadbergbakken, are located near Stavanger. Although the coverage of Vestre Goa is due to a political quarrel that is not directly related to Vestre Goa's passive house ambitions, Skadbergbakken is an example of a development project involving low-energy buildings that has received bad press because of technical errors and the subsequent bankruptcy of the developer. Notably, no individual expert on passive houses is quoted in the comprehensive coverage of Skadbergbakken, possibly indicating that no expert was involved in the planning—which would explain the mistakes and failures but is highly unlikely. More likely, the reservations were due to this project being a disaster on the whole, which would make experts hesitant to associate themselves with it. The two other widely mediatised projects in the materials analysed here are Powerhouse One and the Brøset residential area, both located in Trondheim. Both projects involved researchers from NTNU and Sintef in central roles, and both generated public (and widely mediatised) controversy.

Powerhouse One was planned as the world's northernmost energy-positive building. Despite backing by a new partnering initiative, involving, among others, a large public property owner (Entra), Norway's most prominent architecture office (Snøhetta), a large construction firm (Skanska), an influential environmental organisation (Zero) and the central research institutions in Norway, the project was terminated by the municipality in 2013 in response to growing political resistance to the shape of the building, its location (potentially blocking the view of the fjord) and particularly the fact that it was to exceed local height restrictions. The second case is the development of a low-energy neighbourhood, the broadly mediatised Brøset project. Facilitated by a close collaboration between the municipality and a research project (Gansmo, 2012), Brøset was to involve low-energy buildings, increased public transport, and experiments in sustainable lifestyles. This project too, however, met broad resistance, with politicians and real estate agents arguing that

the (urgently needed) development of new buildings was being unnecessarily burdened by unrealistic goals.

It is a clear characteristic of experts' involvement in these cases that experts intervene sparingly and that if they do engage with the media, they prefer the genre of "kronikk," an open space reserved for a longer text often written by experts about their topic of expertise, found in many Scandinavian newspapers. A "kronikk" has traits of both the American op-ed and the feature story. It is longer than the op-ed; however, like the op-ed, it is often written by a person who is not a member of the newspaper's staff. A "kronikk" is expected to address a topic of current societal relevance and has to illustrate the different sides of an issue. Accordingly, in our case, the interventions are not necessarily always in favour of the projects. With Powerhouse One, for example, a professor serving argued cautiously for using the site for an art museum instead (Adresseavisen 27 April 2012). Equally cautiously defending lofty environmental goals for the Brøset area, three other researchers wrote a "kronikk" that directly addressed the critics of the project (Adresseavisen 9 November 2011).

4.4.2 Public Disputes

With a second type of controversy that is less bound to a specific controversial project and more general in nature, we find that experts also take sides outside the protected space of a "kronikk." Two representative examples of this type of expert involvement from the material are discussions around the use and extension of district heating networks, particularly in and around Stavanger, and the debate about whether passive houses are a good way forward in the Norwegian climate.

The arguments in favour of or against district heating show a fight over resources and legitimacy based on the question of who is "really" environmentally friendly. Researchers with expertise in energy-efficient building doubt that a forced extension of district heating matches the strongly reduced energy demand of future buildings. Unsurprisingly, this argument is opposed by representatives of those who operate and build these district heating networks. Much of this particular discussion is conducted by two researchers. In 2006, a researcher, Marit Thyholt, published a PhD thesis that cast doubt on the need for district heating in the near future. However, her

message did not reach the media until 2010, by which point she had moved into the private sector, representing a construction firm heavily invested in energy efficient construction. Then, five newspapers took up the case, quoting her and noting the conflict between public subsidies for district heating and the public commitment to energy efficiency in buildings. Her former colleague at Sintef, Tor Helge Dokka, also an engineer, is, with 78 articles to his name, one of the most quoted experts in Norwegian media. In 2012, he was quoted widely, first by regional and then by national press, arguing with Thyholt against district heating.

The second widely mediatised case of experts in Norwegian media has its roots in an expert discussion that was not originally public but rather conducted through a series of emails, which were later compiled into a document and widely circulated. Near the time of this exchange (April to August 2010), two of the participants published an article criticising passive houses and their tightly insulated building envelopes. They argued that a more holistic approach might show that many small improvements to traditional methods are superior in terms of the overall environmental impact than rolling out passive houses on a grand scale (Miller & Nordby, 2010). This text was originally published in the journal of the National Association of Norwegian Architects and three months later republished in abbreviated form as a "kronikk" in the weekly periodical Morgenbladet, which addresses a broad (although mostly academic) public. Another participant in the email exchange, a physician from the Norwegian Labour Inspection Authority (Arbeidstilsynet), Jan Vilhelm Bakke, first appeared prominently as a passive house critic in an article published by Teknisk Ukeblad, the leading Norwegian technical weekly magazine, and has since been widely cited by regional and national press. His critique is less architectural and more directed towards the unknown health effects of tight building envelopes—especially if moisture becomes a problem due to errors by Norwegian craftsmen. The original article sparking this part of the debate, which was published on 11 October 2010, was written by journalist Joachim Seehusen, who referred to the aforementioned semi-public email exchange as a source. Among the defenders of the passive house concept, once again, the engineer Tor Helge Dokka took the lead; he was first quoted in Teknisk Ukeblad and then in almost every newspaper article that took up the topic.

In both incidents—the discussion around district heating and the passive house controversy—a dispute between experts begins in a publication read mostly by experts from one discipline (e.g., the members of a professional association) and is then carried to a broader audience. For the second, even more broadly mediatised instance, additionally, a combination of the crystallisation of the scientific dispute in a semi-public forum (e-mail discussion) in which sustainable buildings became a relatively major news story present in virtually "all" media outlets. The original article beginning this process, written by Seehusen (Teknisk Ukeblad, 10 November 2010), is titled "Passive house is technological hubris" and begins, "It is maintained that passive houses are both bad for the occupants' health and that they do not reduce CO2 emissions. New rules are criticised heavily. [our translation]" Most of the articles relating to this case were similarly framed to show that the background of "new rules," which alludes to "passive house levels" as part of new building codes, creates an image of the arrival of "the building of the future" as less easily controlled than was suggested in the reports of expert-users.

5 Discussion

We began and ended the presentation of our empirical findings with the observation that low-energy buildings became a media topic at the stage of actual implementation through building codes. Both overly positive and negative representations and the engagement of experts increased at this time, and sustainable buildings approached, a major news story launched by critics of the Passive House standard, which threatened to become part of the next building code. This type of engagement with the media comes closest to the descriptions of Rödder and Schäfer (2010) and can be called a point of "irritation" and "resonance" (Weingart, 2012) in exceptional circumstances that deviate from routine scientific operations.

Between these observations, however, we observed two distinct additional forms of engagement with the media.

First, there was what could be called a "fictive implementation" in "home stories" in which experts were featured as pioneering users. Here, we encountered experts as popularisers and interpreters in the sense of Väliverronnen (2001). Experts and their expertise played a key role in almost all newspaper representations of low-energy

buildings. When they were presented as users, however, their role gained additional attributes (as father, husband, and design lover) that were not directly related to their primary expertise. Media representations in these cases transformed these experts into peers of the audience. They were no longer the scientists in the ivory tower but "one of us," transforming low-energy buildings from the unknown to the familiar. The literature on domestication of technology (Silverstone & Haddon, 1996; Lie & Sørensen, 1996; Berker, Hartmann, Punie, & Ward, 2005) has described processes of the embedding of new facts and artefacts in everyday life, which were typically performed in private. The by definition public instances of introductions of new building concepts that are observed here, however, cannot hide the intention behind these concepts to change public perception. In turn, it is reasonable to assume that by being persuaded to talk to the public, experts are also forced to reformulate the topics of their research and practices—even adapting their definitions—and that, in this way, they come closer to the reader. In cases where such a mutual learning process among the audience, media and experts occurs, links are established that are productive for all three of the parties.

A second role for experts emerged in the cases of actual building of low energy buildings. Here, it became apparent that the normality of the "home stories" is in fact fictive. The absence of engagement (in the case of Skadbergbakken) and the prevalence of a specific style of engagement—the "kronikk"—show that in these cases, the wish for control was particularly strong. When experts were drawn into specific controversies, they preferred to take part on their own terms. This finding is consistent with Dudo's (2013) biomedical researchers, whose engagement with the media was strongly related to the construct of perceived behavioural control. Here, we find a specific form of engagement that is performed within a third space between the arenas for scientists' publications and the newspapers' other sections. Although affording writers more space and complete control over the text, a "kronikk" also demands that experts are able to describe their concerns to a larger audience; further, a "kronikk" reader is prepared to invest somewhat more effort in this section than in other parts of the newspaper. Again, a successful encounter between expert and reader in these cases ideally fosters mutual learning.

The three modes of engagement allow for the performance of different aspects of being an expert. Interventions in public debates portray the expert as an ally in a (political) disagreement, the “home story” showcases experts using their expertise in their own everyday lives, and finally, the “kronikk” allows experts to demonstrate their pedagogical ability to convey more or less complex facts.

6 Concluding Remarks

In this study of low-energy building experts and newspapers, we found an impressive amount of mutual engagement. Whenever newspapers covered energy-efficient buildings, experts and experts’ opinions, descriptions and explanations were quoted. The fact that experts and research institutions were broadly mediatised indicates that newspapers acknowledge and do not question experts’ claim to have a privileged voice.

Most significantly, we observed three types of mutual engagement: engagement at the side of other stakeholders in times of increased public attention to the topic (e.g., because of discussions of plans for a new building code), engagement in experts’ “home stories” and engagement in specific implementation projects within the safe confines of a “kronikk.” With even the space provided by the “kronikk” section in Scandinavian newspapers demanding from the authors to express their expert knowledge in a way that is accessible to the general public, the engagement between experts and newspapers observed here was always based on what we, together with Väliverronnen, have called multiple roles performed by the expert. Although the engagement in times of general or specific controversy—be it when researchers actively take sides or do so cautiously within a "kronikk"—can be seen as a general trait of expertise performed in relation to media, "home-stories" acquire a double meaning in building research. In principle, we could think of experts showing their "human side" in everyday contexts in any other area as well; however, showing how experts live in the very buildings their expertise has helped create adds a new dimension: by conspicuously connecting everyday life and technological innovation, they create a powerful image of the compatibility of the new with everyday life.

In conclusion and returning to the frustration felt by the expert involved in sustainable innovation, the type of conspicuous domestication of a new technology

observed here is arguably a more powerful way of popularising new and better technologies than the identification of barriers (outside the experts' reach) and perhaps even more effective than experts' sometimes heavy, sometimes cautious and hesitant engagement in controversies.

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Appendix: Interview guides

1 The legal dwelling: How Norwegian research engineers domesticate construction law

1.1 In-depth interview questions (Norwegian)

Utdanning og erfaring:

Kan du fortelle meg om utdannelsen din? Hva gjør du nå? Hva har du eventuelt jobbet med tidligere? Hvordan er du tilknyttet ZEB?

Energi – lovverk:

Norge er ett av de landene i Europa som har de strengeste reguleringene i forhold til energi. Har du noen oppfatning av når energi ble til et fokusområde i bygningssektoren? Kan du fortelle om hvordan dette har utviklet seg?

Reduksjonen av CO2 utslipp er et aktuelt tema nasjonalt og internasjonalt. Tror du at problemet kan løses nasjonalt eller internasjonalt? Hvorfor? Hvordan? I hvor stor utstrekning? Hva med reguleringer og standarder – bør de besluttes på et nasjonalt eller internasjonalt nivå?

Norge har oversett EU Direktivet om energi i byggesektoren i nasjonal lov, som kalles "Plan- og bygningsloven". Synes du at reguleringer støtter utviklingen i Norge eller er det til et hinder? Hvor bredt?

Reguleringer på arbeidsplassen:

I hvor stor grad forholder du deg til bygg - reguleringer i en vanlig arbeidsdag? Hvilken innvirkning har normer og reguleringer på din kreativitet? Hvordan blander/kombinerer du behov/nødvendighet med funksjonalitet og energi effektivitet når du designer bygninger? Hva prioriterer du? Hvorfor? Føler du at du har frihet til å komme med egne ideer? I hvor stor grad?

Kommunikasjon og tilbakemelding:

Hvordan kommuniserer du med andre arkitekter? Og med andre eksperter? I hvilken fase av prosjektet er du involvert? (fra begynnelse til bruk?) Hvordan følger du med på prestasjonen av bygninger i bruk? Hvor mye mener du brukere kan påvirke planleggingen/byggingen/bruken av bygninger? Forventer du tilbakemelding fra brukere?

Har du kontakt med personer som bor/jobber i ZEB eller bygninger med lav CO2 utslipp? Hva sier de om hjemmet/arbeidsplassen? Hva slags vanskeligheter har de? Hva slags forventninger/ønsker uttrykker de?

Hvordan organiseres kommunikasjonen med eksperter i utlandet? Hvilke kontakter har du i utlandet? Hvordan utviklet de seg – hvordan bygger du nettverket? Har du fulgt med på prestasjoner av null utslippsbygninger i utlandet? Er det likheter/forskjeller fra norske bygninger? Hvor kommer forskjellene fra? I hvilken grad er lover og reguleringer ansvarlige for suksessen/fiaskoen av slike prosjekter?

Innovasjon – din mening

Hva tror du er de beste løsninger for å virkeliggjøre energimålene i Norge? Hvordan påvirker bygging av passivhus prosessen med å nå målene? Hvilke andre løsninger kan være aktuelle? Hvilken strategi er best for Norge? I hvilken grad respekterer de politiske bestemmelser (EU og nasjonale reguleringer) lokale vilkår?

Eksperter rolle i lovgivning:

Hvordan støtter de nasjonale reguleringene utviklingen i bygebransjen? Hvor mye påvirkning har arkitektene/ingeniørene på lovgivning – hvordan bidrar de inn mot endringer i regelverket? Hvor mye fleksibilitet har du når du skal velge løsninger? Hva slags vanskeligheter ser du når energilovene anvendes?

Renovering av bygninger:

EU direktivet definerer ikke mål for renovering av gamle bygninger. Hva synes du om det? Finnes det politikk i Norge som supplerer denne utelatelsen? Hvordan renoveres gamle bygg? Hvordan informeres brukere om muligheter/begrensninger? Kan de velge mellom flere muligheter? Hvilke alternativer tilbys?

Vil du si noe mer om ZEB hva angår reguleringer og definisjoner?

1.2 In-depth interview questions (English)

Professional background:

Could you tell me something about your education? What is your current job? How are you connected to ZEB?

Energy, national and global: laws and regulations

Norway is one of the countries with very restrictive requirements regarding energy. When did energy become an issue in the construction sector? How has it developed? Do you think that the aim to reduce CO2 emissions is a national or an international problem? Why? To what extend? What about regulations and standards: should they be decided at national or international level?

Norway implemented the EU directive on energy performance of buildings, translating the requirements in national law, named The Planning and Building Act. Do you think that the EU regulations encourage the development in Norway or rather restrict/break it? To what extend?

The impact of regulations at workplace

How much do you have to deal with regulations in a "normal" working day? What impact have the requirements regarding energy on your creativity? How do you combine necessity with functionality and energy efficiency when designing dwellings? What are the priorities? Why? How much freedom is left for one's ideas?

Communication and feed-back

What are the forms of communication with architects? What about other experts' groups? In what phase of the project are you involved? (from planning to the turnkey?) How do you follow the performance of dwellings in use? How much can users influence the plans/building process/use of dwellings? Do you expect feed-back from end-users/owners/companies?

Do you have contact with people living/working in ZEB or law emission buildings? What do they like? What problems they have? What are the main requirements of users?

How is the communication with experts from abroad organized? What contacts do you have? How did they develop? Did you follow the performance of low energy dwellings abroad? What are the similarities/differences from the dwellings built in

Norway? Where do the differences come from? To what extend are the laws/regulations responsible for the success/failure of such projects?

Optimizing innovation – personal opinion

What do you think are the best solutions for achieving the energy goals in Norway? How is the building of passive houses influencing the process? What other solutions can be considered? What form of achieving the goals is best for Norwegian conditions? To what extend are the political decisions (EU and national level) respecting the local conditions?

The role of experts in law giving

How are the national regulations supporting the development? How much influence have the architects/engineers in law giving and regulations? How much flexibility do you have to choose the solutions? What difficulties you see in implementing the requirements regarding energy?

Refurbishment of dwellings

There are no specific targets in the EU Directive for renovation of existing dwellings. What do you think about it? Are there policies in Norway that complete the omission? How does refurbishment of dwellings work in practice? How are the users informed about possibilities? May they choose between offers? What incentives are offered?

What else would you like to tell me about ZEB with regard to regulations and definitions?

Contacts in Germany!

2 Passive House at the crossroads: the past and the present of a voluntary standard that managed to bridge the energy efficiency gap

2.1 In-depth interview questions (English)

Professional background:

Could you tell me something about your education? What is your current job?

How long have you worked in PHI/in PH projects?

The concept:

Why this name? How did you choose the name of your concept? Did you think about other names?

Since when it is used this name for the concept?

How long it took from the idea to the construction of the first Passive House?

How do you explain that the concept of Passive House is so broadly accepted?

Why is the concept more used now than several years ago?

The history of Passive House:

In Passipedia there are many examples of houses build in the last centuries that can be considered Passive Houses. What is new in your concept?

How was the beginning of the process of implementation of the concept in practice? Did you meet obstacles? What kind of obstacles?

How did you succeed to mobilize engineers and architects to join you and further develop the concept of PH? Were the engineers or the architects easier to convince? Why?

Which role played the creation of the PH Institute in the success of the concept?

How many employees had the Institute at the beginning? How many employees it has now? If the difference is considerable, when was the break through? Why? (Some special event?)

How did you convince the first clients to build their house on Passive House standard?

What role it was played by the financial incentives? When were the first incentives offered and by what institution? Is there a connection between the financial incentives and the success of the concept?

The PH concept has a large political support in the whole Europe. When it began? How? Why?

Did you expect that your concept will become legal requirement in such a short time?

How did you manage to make your concept known all over the world? Did you meet resistance? In what countries? Why?

How do you explain that the concept was so successful in Austria?

How did the market for PH components developed? Do you see a connection between the success of the concept in the last years and the availability of such products?

Implementation:

How do the engineers and architects work together in a project? Are there usually different opinions about how to plan and how to builds a dwelling as Passive House?

How are the dwellings in use followed? Do you have feed-back from users? What do they say? What kind of problems they report?

What are the main requirements of clients when they want to build/renovate?

Is the design an important issue? Do the clients prefer traditional design?

How is the communication with experts from abroad organized? What contacts do you have? How did they develop? Did you follow the performance of Passive House dwellings abroad?

What are the similarities/differences from the dwellings built in Germany? Where do the differences come from? To what extend are the laws/regulations responsible for the success/failure of such projects?

Are the engineers/architects/craftspeople educated/trained to construct Passive Houses? How is the education/training organized?

Law giving/advisory groups:

Are there employees of the Passive House Institute involved in law giving/advisory groups?

Discussions:

Is it possible that the procedure of certification would shadow alternative solutions?

What is the key for success?

Is there something else you consider relevant regarding the history of the Passive House?

2.2 In-depth interview questions (German):

Persönliche Informationen:

Können sie mir ein paar Worte über ihre Ausbildung sagen?

Was ist ihre heutige Beschäftigung?

Geschichte:

Sie haben die Firma 1994 gegründet. Wie haben sie angefangen?

Was hat sich geändert im Laufe der Zeit?

Welche Bereiche deckt die Firma ab?

Seit wann bieten sie Produkte oder Dienstleistungen für Passivhäuser an?

Was ist Ihre Meinung zum Passivhauskonzept?

Warum haben sie sich entschieden Passivhauskomponenten zu produzieren?

Welche Bedeutung hat das Passivhausgeschäft für Ihre Firma?

Wie ist die Zusammenarbeit mit dem PH-Institut?

Dienstleistung:

In welcher Phase des Baus werden Sie kontaktiert?

Arbeiten sie mit Ingenieuren und Architekten zusammen?

Interessieren sich auch Privatpersonen für Ihre Produkte?

Welche Serviceleistungen bieten Sie an?

Wie haben sich die Dienstleistungen im Laufe der Zeit entwickelt?

Arbeiten sie mit anderen Dienstleistungsfirmen? Nach welchen Kriterien wählen Sie diese aus? Warum?

Wie hat sich der Markt angepasst? Wie war es am Anfang? Was hat sich geändert?

Fachleute:

Wie bilden sie die Teams?

Wie viele Fachleute sind in einem Projekt involviert? Wie arbeiten sie zusammen?

Hat sich etwas geändert seit dem ersten PH bis heute? Inwiefern?

Ihre Firma hat heute 60 Mitarbeiter. Wie viele Mitarbeiter hatte die Firm am Anfang?

Welche Kompetenzen müssen die Handwerker/Ingenieure haben um bei Ihnen angestellt zu werden?

Wie werden die Fachleute ausgebildet?

Feedback/Evaluierung:

Welche Erwartungen haben die Klienten?

Welche Qualitäten Ihrer Produkte sind entscheidend?

Ist Energieeffektivität ein entscheidender Punkt?

Welche Evaluierungsmethoden gibt es?

Sind die Produkte so energieeffektive wie geplant?

Sind Sie in Kontakt mit den Benutzern?

Was sagen die Benutzer über ihr Zuhause?

Was für Probleme gibt es?

Falls es Probleme gibt, wenden sie sich an Sie? Wie werden die Probleme gelöst?

PH-Institut:

Arbeiten sie mit dem PH-Institut zusammen?

Falls ja, wann hat die Kooperation begonnen? Wie hat sie sich entwickelt?

Welche Rolle spielt das PH-Institut für den Erfolg des Passivhauses?

Was sonst könnten sie mir zum Thema Passivhaus sagen?