Abstract

Energy use in buildings is a significant contributor to climate change. The purpose of this paper is to explore industrial changes towards sustainability in the Norwegian construction industry, adding to debates about transitions to sustainability and transition pathways in a traditional, low-tech sector. Empirically the paper reports a case of cumulative changes in the Norwegian construction industry over from 1998 – 2013. The case explores a complex innovation and diffusion process where technologies, visions, actors and policy co-evolve over time to transform an existing socio-technical regime. Findings indicate that the transition moved forward through interplay between innovations in niches, a growing constituency around green building and a string of regulative and market changes.

1 Introduction

In the past decade concerns about the environmental impact of the built environment have been raised. Green building has shifted from being a peripheral niche activity to having mainstream appeal. As a result building green is now considered strategically important to firms in the construction sector – a situation in stark contrast to prevailing industry attitudes ten – fifteen years ago. This promising change is the topic of this paper. There is a growing body of literature on transitions to sustainability in construction (Berry et al., 2013; Oneill and Gibbs, 2014; Rohracher, 2001; Smith et al., 2005). The literature on transitions is used to frame an investigation of innovation in green building in Norway. The aim is to explore the progress of industrial change and to answer the question: What are the main driving forces and characteristics of the transition towards green buildings in Norway?

The motives, development paths and possible consequences of this apparent shift have not been studied systematically. This is the main contribution of the paper. Understanding how the change towards sustainability has occurred can help create better policies for steering or scaling up change processes in a desirable direction. A series of regulatory changes, innovative demonstration projects and a shift in attitudes towards green buildings in combination were found to be the drivers of the transition.

The paper is structured as follows. Section 2 provides a theoretical perspective on transitions to sustainability and innovation in construction. Section 3 presents methods and data sources of the case study. Section 4 analyses the case by constructing a timeline of industrial change phases. Section 5 provides additional analysis and concludes the paper.

2 Theoretical framework

2.1 Transitions to sustainability

A transition can be conceptualized as the process of moving from one stable socio-technical regime to another. Transition studies have successfully described historical industry transformations, and increasingly describe industrial transitions to sustainability (Geels, 2005; Geels, 2006; Smith et al., 2010; Verbong and Geels, 2007). Studies of technological innovation systems have focused on the emergence of new industries - the formative phase and the difficulties new technologies meet when introduced (Bergek and Jacobsson, 2003; Bergek et al., 2008a; Hekkert et al., 2007; Suurs et al., 2010). The multi-level perspective (MLP) was adopted in this paper because focusing on the stabilizing forces in a regime fits with the aim to explore a wider industry transformation and not a specific technology. In the MLP framework, transitions are explained by dynamics between three analytical levels: niches, regimes and landscapes. The niche level denotes a place where alternative technologies are developed, such as R&D laboratories or subsidized demonstration projects. A socio-technical regime is understood as a relatively stable structure consisting of established practices and institutional arrangements. The landscape is thought of as exogenous factors that can influence the regime-niche interaction, such as global political events and global markets (Geels, 2011).

2.2 Innovation in niches

Niches are described as bubbles or protected spaces in which innovations can develop, a place where new technologies can grow, relatively free from market pressure and institutionalizing forces of the construction regime (Kemp et al., 1998; Smith and Raven, 2012). As construction is project based, niches are also referred to as niche projects or innovation projects in the following.

Green buildings may vary in technological complexity, but generally they consist of well-known components combined to a new whole. This kind of innovation is in line with Schumpeter's (1934) definition of innovation as "new combinations" of new or existing knowledge, resources, or equipment. Buildings are understood as complex product systems (Dubois and Gadde, 2002; Hobday et al., 2000), and changes in the links between product parts can be understood as architectural innovations (Henderson and Clark, 1990); newness lies in successfully recombining known components to form a new whole. Environmental innovation in construction is often conceptual in nature and connected to sustainable design and design management practices (Berry et al., 2013; Herazo and Lizarralde, 2015; Koch and Buhl, 2013; Reed, 2009). Capacity to innovate in building projects, therefore depends not only on protection from time and market pressures, but also on freedom from prevailing organizational practices in the construction industry.

2.3 Regime

A regime is understood as a dynamically stable structure consisting of established practices and institutional arrangements that legitimize regulation and financing mechanisms that in turn help preserve the regime. Regimes are results of path dependency and lock-in mechanisms to technologies, practices and institutions, and are consequently hard to change (Turnheim and Geels, 2013; Unruh, 2000). Regime actors have vested interests in regime preservation and can resist and fight back pressures to change (Geels, 2014; Orstavik, 2014). Regime is used here interchangeably with mainstream or established industry.

Market and policy structures are regime elements, and regulatory changes and market conditions are considered regime changes. In a study of transitions in the energy sector in Germany, Jacobsson and Lauber (2006) argued that industrial change was primarily driven by changes in the regulatory framework. Change ultimately comes down to a *battle over institutions* (p.260). Institutions refer to changes in policy and the formation of a market, more specifically policy supporting market formation or correcting market failures as well as the minimum requirements in the building codes. Policy impacting on the energy performance of buildings is essential for sustainable transition in construction (Greenwood, 2012; Oneill and Gibbs, 2014; Smith et al., 2005). However a transition cannot be dictated by policy alone. As Berry et al. (2013) show, regulatory changes are closely linked to innovative experiments because they legitimize the new technology and provide policy makers with the confidence to revise regulation.

Social acceptance of technology, established practices and common frames of mind are important regime elements. Rohracher pointed out in 2001 that the main challenge with a transformation in construction is that it is social in nature, it is not primarily a technological problem, or even related to new technologies. Many sustainable building techniques exists, the major challenge is to persuade a risk-averse industry actors to try out green concepts.

2.4 Process of regime change

The MLP perspective has been criticized for not being sufficiently explicit about how niches and regimes interact (Smith, 2007). In historical examples, niches emerge on the outer margins of the established regime; subsequent niche-regime-landscape interaction patterns direct the process along different pathways. Four transition pathways are identified in the literature – *transformation, reconfiguration, substitution and de-alignment/ re-alignment* (Geels and Kemp, 2007; Geels et al., 2016; Geels and Schot, 2007). Transformation and reconfiguration describe evolutionary pathways of change, whereas substitution and re-alignment/de-alignment describe conflictual processes where new entrants substitute, or significantly destabilize the incumbent regime. As the analysis will show, the transition pathway of green buildings in Norway shifted from a reconfiguration pathway to a transformation pathway.

A reconfiguration pathway involves interaction between niches and regime actors through strategic alliances between incumbents and entrants (Geels et al., 2016). One example of a niche/regime interaction, or strategic alliance, is described by Smith (2007) in what he labels *intermediary projects*. Or what Berry et al. (2013) called *transformative niche events*. Intermediary projects are learning arenas, where regime and niche actors explore niche technologies face to face. Such alliances can act as stepping stones between niche and mainstream (p. 446). Intermediary projects are relatively easy to establish in construction because work is organized in projects People move between projects, and projects form, dismantle and reform with new and semi-new groupings of actors (DeFillippi and Arthur, 2002). Intermediary projects demonstrate possibilities, and can impact transition through learning, supply chain development and by giving policy makers the confidence to advance policy goals (Berry et al., 2013).

A transformation pathway can be described as an endogenous regime change; it is focused on interactions between the strategic choices and adaptive capability of regime actors, in response to institutional or landscape pressure. The transformation process is characterized by gradual regime reorientation (Geels et al., 2016; Geels and Schot, 2007). Transformation processes in mature industries have been described as *creative knowledge accumulation*, which refers to the incumbents' ability to absorb and utilize new technologies (Bergek et al., 2013; Berggren et al., 2015). A similar notion is developed by Bulkeley et al. (2014), which they label *regime experiments*, in which regime actors experiment with niche technologies.

Jacobsson and Lauber (2006) described how industries grow and change in different phases. They identified mechanisms that take place in a formative phase, in order for a new technology to move into a rapid growth phase. The formative phase includes a multitude of competing designs and lack of a dominant design (Utterback and Abernathy, 1975). The formation of a dominant design, as well as formulating visions and agreeing on what green building means is a precondition for the formative phase to proceed to a growth phase. Green building is a multifaceted phenomenon and a relative concept. Different actors have different assumptions about what it means to build green and the activity incorporates a multitude of practices (Oneill and Gibbs, 2014). Therefore the emergence of a dominant design is key in order to put pressure on an existing regime.

Kemp et al. (1998) emphasized the importance of building a *constituency* behind the new technology. The build up of a constituency involves entrepreneurial actors, or system builders, it involves the establishment of networks or advocacy coalitions and the entry of actors into the constituency (Markard et al., 2016). Entry of actors happens through intermediary projects, and through industry networks. The niche technology gains strength as new firms and other organizations join the constituency. Building a constituency is tightly connected to increasing the legitimacy and obtaining social acceptance of the new technology (Bergek et al., 2008b).

The concepts described above are used to structure the analysis. First, the extent to which there is a dominant design along with a coherent vision of sustainability is considered. This forms the basis of the division into specific phases. Second, the build up of a *constituency* includes attitudes to green building as well as recruitment of industry actors, either through participation in innovation projects or industry networks. Third, *regime change* is described through tracking market, policy and regulative changes as well as changes in attitude towards green building.

3 Research methods and data analysis

The research is based on a case-study strategy (Yin, 2011). Case studies are considered appropriate when the phenomenon is context-dependent (Eisenhardt, 1989). The case is longitudinal, in the sense that the intention is to provide a detailed empirical narrative of a change process. A single case design was deemed appropriate because the object of study was industry change over time (Dubois and Gadde, 2014).

Different data sources were combined to create a coherent narrative. The timeline constructed was primarily based on interviewee accounts. 30 interviews were conducted with industry professionals and institutional actors. Industry professionals include architects, consultants on energy and building physics, property developers, and builders. Institutional actors include policy makers, bureaucrats, professional and trade organizations and researchers. The interviews were semi-structured and lasted between 40 and 90 minutes. Interviews were recorded, transcribed, and coded in several stages using N'vivo software.

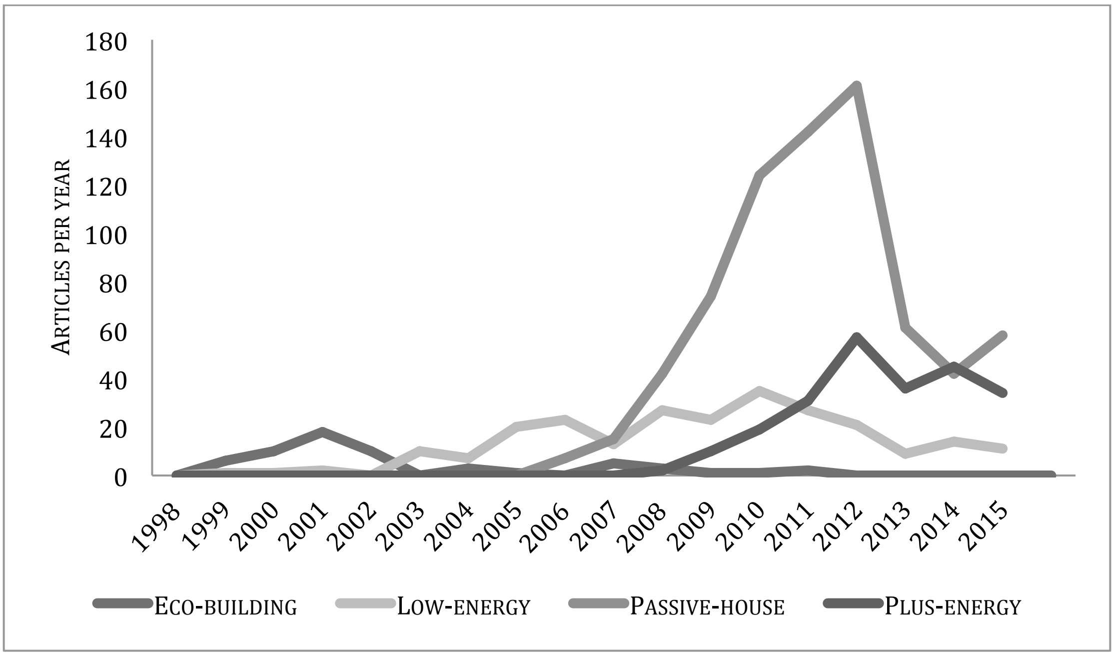
The Norwegian Association of Architects (NAL) maintains a database of notable building projects. The database contains a short description of the environmental targets and the responsible builders/developers. The types of actors involved in the different projects were classified according to the theoretical notions of niche project, intermediary alliance project or commercial mainstream project. The strategy for analysis was thus theoretically motivated. The Norwegian news archive Retriever was searched for keywords to monitor news coverage and public interest in green building over time. Key terms that describe green building over time, have been traced: from eco-building, to low-energy, to passive-house building, to plus energy building. These findings have been used to reinforce the timeline and periodization. Fig. 1 was constructed using the nine largest regional/national newspapers and a prominent weekly technical journal as sources. Content from the media archive has also been used to corroborate statements in interviews about key events such as introduction of EU legislation, building codes, and also landscape factors such as energy prices and political shifts. The case data includes written material such as government white papers and commissioned reports that have been useful to follow policy changes.

The strength of the approach lies in the number of industry actors interviewed and the variety of data sources. The stakeholders interviewed represent different parts of the industrial system, and cover activities over time, making it possible to discern shifts in attitudes. A considerable weakness is the lack of measurable data. Another limitation with the construction of a longitudinal narrative based on interview data is that it relies on the recollection of interviewees. The dependence on retrospective analysis is somewhat mediated by triangulation with other data sources, such as the project database and the media coverage.

4 Phases of development of green building

It is difficult to pinpoint an exact point in time when sustainability entered the agenda in construction. The analysis in this paper spans 1998 - 2013, acknowledging that there were sporadic experiments in the 1970s, 1980s and early 1990s. The periodization is pragmatic, but it reflects changes in the public debate and key events.

Figure 1: Media attention to green building concepts



The chart shows how different terms and concepts appear in the media during the period. The term "eco-building" appeared 1998 with a little peak around 2001 and disappeared by 2003. "Low-energy building" enters the public debate around 2003 but is surpassed by "passive-houses" in 2007. Passive-house is by far the most widely accepted concept, starting around 2008 and culminating in 2012. The massive spike in interest in passive houses coincides with the announcement of the policy strategy intending to demand energy performance on a "passive-house level" in 2015. By 2014 media interest in zero-energy and plus-energy building is slowly starting to replace passive-house building.

4.1 "Eco-building" period 1998 – 2003

The first period was labeled the eco-building period. Between 1998 and 2003 the beginnings of an environmental agenda appeared in the construction industry. The NAL database lists 33 projects in this period. The smallest was a wood fired sauna built exclusively from materials found on the property, while the largest project was a 1600 unit student-housing complex. The projects were heterogeneous in their approach to sustainability. The notion of urban ecology was prominent, and many project descriptions contain the phrase "built according to ecological principles". Closeness to nature, urban gardens and green roofs were also highlighted. The use of natural materials was emphasized; avoiding chemical and particulate emissions from building materials was a central concern in many projects. Water conservation techniques, including grey water recycling were tried out. Other measures mentioned in the project descriptions include facilitating for occupant recycling, compost systems and waste management. Utilizing natural daylight and solar irradiation as well as reducing the need for energy were considered important. The conceptual approach to green building was eclectic and reflected the different actors, although two categories of intermediary projects stand out. About half of the projects are public: schools, kindergartens, and nursing homes. Projects built by public clients or mainstream developers involved incremental improvements, particularly regarding choice of materials that fit in easily with the mainstream industry. The remaining projects were radical projects, initiated by enthusiasts on the outer margins of the established industry.

There was a distinctive aesthetic linked to the "eco-building movement". Particularly bale/straw-insulated buildings had thick walls and small windows. The eco-buildings were also at the time linked strongly to the idea of self-building and reuse of materials and waste, as well as autonomous (off grid) buildings. The notion of an "eco-lifestyle", living off grid and self-sufficiently, appealed to a particular, small group of people, and it never gained much mainstream attention. These environmental buildings and the ideas that went with them had closer ties to the environmental movement than to the construction industry.

A research group started to study energy efficiency in housing around this time at Norwegian University of Science and Technology. One researcher described the time period: *The winter in 2000 was very cold, that was when the increased focus started, I think. An International Energy Agency funded research project about low energy buildings was initiated. Up until then we had never talked about low-energy housing in Norway. There had been some experiments, but it never spread.* A professor in architecture described the situation as follows: *It used to be something very few were interested in. I tried to convince the students that energy was important, good for the environment and the world. I tried to convince developers they would save money on energy, but nothing worked, very few were interested.* The period was characterized by experimentation by fringe actors like self-builders and activists, as an industry consultant described: *The world wasn't all that interested. You know there were all* *these environmentalists, talking about mud-houses and the like. That was counterproductive.* The close links to radical environmentalists was described as counterproductive because it alienated the mainstream industry actors.

During this period green building entered the policy agenda. In 1997 a policy initiative called the “Eco-build program” was established aiming to increase awareness of eco-efficiency in the sector. Funding was split between industry and government, and the program ran from 1998 to 2002. The prime concerns were solutions for energy efficiency, material efficiency, waste, hazardous chemicals, and air quality. The program resulted in manuals for procurement of materials, manuals for technical installations, and waste and demolition management manuals. Even though the notion of eco-efficiency never quite succeeded, a group of people who worked with the Eco-Build program went on to establish the industry organization for property developers called the Green Building Alliance in 2003/2004. The Norwegian State housing bank granted inexpensive loans to housing projects with “environmental qualities”. In 2001 the Ministry of Oil and Energy established a subsidiary organization called Enova. Enova’s mission was to contribute to clean energy production and to energy efficiency in industry, buildings and households. In their two first years the main activity was to subsidize energy efficiency in households.

The years 1998 – 2003 were recognized by niche experimentation, the beginnings of institutional changes and a consistent lack of interest from the mainstream regime actors. There was considerable variety in the niches, but no unified vision about what “green building” was or meant. There was a lack of market and a lack of interest from commercial actors, in line with the early formative phase of a new technology. Niche projects appeared on the fringes of the mainstream industry, and in opposition to the dominant regime. Meanwhile on the landscape level climate change was entering the agenda. A Government White Paper from 2000 on climate policy identified area planning as important for energy saving. The third IPCC report came out in 2001, and it emphasized buildings as an important and cost efficient sector in which to reduce emissions. The EU directive (2002/91/EC) on the energy performance of buildings was adopted in 2002, which had a clear influence on national policy. Electricity prices in Norway had been low for a long time, practically cancelling arguments about saving money on energy efficiency. 2002/2003 saw a sharp rise in electricity prices – sparking some interest in alternative sources of space heating, however electricity prices stabilized again and it was short lived. Despite a growing awareness of green building in certain circles, neither companies nor customers were very interested in it, and thus the regime remained largely unaffected.

4.2 “Low-energy house” period 2004 – 2008

The period between 2004 and 2008 was labeled the “low energy” period because the majority of projects that were documented were identified as “low energy”. Low energy buildings were based on the same principles as the German passive houses, limiting heat loss by insulation and compact design as well as utilizing solar irradiation. The key aim was to conserve energy and therefore limit greenhouse gas emissions. Energy use became the fundamental definition of green building. The earlier focus on natural materials, closeness to nature, gray water recycling, compost, urban gardens etc. was gradually replaced by a focus on energy and passive design principles. There was some debate about how to achieve energy savings, and to what extent renewable energy sources should be included in building designs. Several projects from this period featured various heat pump technologies, as well as solar water heaters. Two high profile public buildings experimented with integrated photovoltaic elements. A prototype from 2005, which demonstrated the possibility of not having an active heating system in an arctic climate, was much publicized and gained interest. The first large-scale apartment blocks constructed as low-energy buildings/passive buildings attracted much attention in 2008. Commercial developers slowly started to consider it a strategic advantage to gain experience with green building. A majority of the projects from this time were intermediary bridging projects. They predominantly involved partners from the mainstream building industry, and they often formed alliances with universities or other expert actors.

The low energy and passive houses that were built at the time were still somewhat tied to fringe actors, activists and a few dedicated architects. Low-energy buildings were considered the domain of engineers rather than architects. A professor in architecture described: *Part of the story is that it (energy efficiency) was very technical and the architects didn't really get it. The buildings were quite ugly - or at least very distinct. And I am sure it held progress back a lot because it was not what people wanted, neither for offices nor to live in.* Energy efficiency was also described in interviews as a niche for architects who were not very 'aesthetically gifted', not something 'normal' architects would do. Mainstream attitudes to green building were still rather negative, although attitudes seemed to change somewhat towards the end of the period. By now, green buildings no longer looked so different due to supply chain developments in windows enabling larger glass areas. A prevalent concern for the industry at the time was that there was no identified market for green building, and very little willingness to pay a premium for sustainability. The saying was that the only way to sell low energy houses was by promoting qualities like thermal comfort and healthy indoor climate. One developer said: *It has to be a nice place to live, and make economic sense to buy it. And if you save some money on electricity, then that's a bonus for now. If we were to sell 80 apartments to environmental activists – they would still be empty.* Ambitious industry actors were at that point calling for stricter regulation in order to correct the market failure, because they wanted to build greener, but saw the lack of regulation as creating an unfair playing field. Other mainstream actors were still reluctant, and wanted a slower introduction of energy performance regulation.

In 2005 a red-green[1] alliance won the Parliamentary elections. While energy performance regulation was underway, the new government took it a step further and declared all new buildings should be low-energy. One policy interviewee recalled: *I remember there was one sentence in the new government platform probably put there by the socialist party and then forgotten about – about low energy buildings becoming standard. Nobody thought much about it, but the environmental movement picked up on it and suddenly the 2007 building codes demanded low-energy. We were all a bit surprised when they were introduced.* By 2007 the building codes had not been updated in 10 years, and previously they had said little about buildings' energy performance. While it had taken ten years to revise the previous building codes, these were to be revised at regular intervals from then on. The updated building codes were met with resistance when they were introduced. It seems the industry came to terms with energy efficiency demands relatively quickly. In the words of one industry informant: *The industry has changed, and one could wonder if it is due to pressure from the new building codes. Every time the building codes are revised there is some controversy – the industry has been stalling and they have fought and fought to avoid it. Until a few years ago when it seemed they suddenly gave up more or less, and accepted that it is the future and they would have to accept it.*

Some of the innovative projects from this period went on to become very visible demonstration projects in the sense that they were communicated widely to the industry and held up as examples by policy makers in the years to come. Several demonstration projects were realized in this period through a program called Norwegian Wood, which ran from 2005 until 2008. Norwegian Wood was set up as collaboration between industry actors, municipalities, policy actors such as the Norwegian Housing Bank, Innovation Norway, Enova, actors from the lumber industry and the Norwegian Association of Architects (NAL). Seven demonstration projects were built and the goal was to demonstrate modern environmentally sound solid wood architecture. Another industry network, the previously mentioned Green Building Alliance, started working on establishing an environmental certification system in Norway around the same time. The organization developed into a formal network, arranging seminars and courses for their members, as well as acting as a consultative body for policymakers. The network introduced property developers to ideas of green building.

In the research domain, the establishment of the Zero Emission Building Center (ZEB) in 2008 saw powerful actors enter the constituency. ZEB was established as a collaborative effort involving research, industry and public agency partners. The objective was to stimulate innovation among partners and to provide research useful to industry. The research groups involved in ZEB came from the applied research institute SINTEF as well as the Norwegian University of Science and Technology.

[1] The red–green coalition was a centre-left coalition of parties in Norway, constituting the Labour Party (Ap), the Socialist Left Party (SV), and the agrarian Centre Party (Sp).

They had been doing research on energy and buildings for a number of years, highlighting the importance of earlier efforts. The founder explained: *It is not something that suddenly materialized from nothing, we've been planning and building it for years. We have been doing research in this field since the 1970s. We have had IEA projects for the past 12 years. We have the publications and the merits, which made it obvious we were going to get the funding if there was going to be a center on buildings.* The research center established alliances with large industry actors and has been credited with providing consultancy services, calculations, definitions and methods to innovative industry actors.

During this time a dominant design emerged and "green building" took on a specific meaning. Previous interest in urban ecology, gray water recycling and avoiding chemical emissions from materials was replaced by a narrower focus on measureable energy saving and passive house principles. Demonstration projects were increasingly competing in the regular market helped by financial policy instruments, such as subsidies and favorable loans from the Norwegian State Housing Bank. Enova established a support scheme to cover up to 50% of costs associated with building to low energy or passive house levels. Both the emergence of a dominant design and the existence of instruments to help the technology in the marketplace bore witness of a growing niche influence. Concrete niche-regime interaction happened through intermediary projects, which were proliferating at the time. The intermediary projects acted as learning arenas for the involved organizations. The experimental projects were important for policy makers who felt more confident implementing the new building codes. The EU directive on the energy performance of buildings, which was adopted in Norway in 2005 influenced the new building codes.. The winter 2006/2007 was very cold, coinciding with a sharp rise in electricity price. In the national media it was called a power crisis. Although electricity prices stabilized at a low level again, it acted as a reminder that inexpensive electricity might not last. In 2007 the IPCC and Al Gore were awarded the Nobel Peace Prize, and climate change entered the agenda full-scale in Norway

4.3 Passive-house period 2009 – 2013

Passive houses dominated the debate in this period. A national passive house standard was meant to be released in June 2009. It was delayed several times because of internal debate and disagreement in the committee. The national Passive House Standard (NS 3700) was finally released in 2012. The standard included two categorizations of low-energy buildings, based on the same principles, but with less stringent parameters. 39 passive house projects were initiated and built during this period. The largest projects in terms of costs were also the most ambitious in terms of environmental profile. Municipalities were responsible for some of the projects in this period; schools and kindergartens were built according to passive house standard. One of the largest house building associations (OBOS) initiated a project with 17 passive detached houses in 2010. The headquarters for the environmental organization Bellona were built in 2010, and for a while, the building was considered state of the art. It was also the first manifestation of an ongoing debate over the need for more versus less technology integrated in the buildings. While passive houses are about reducing demand for space heating to a minimum, the Bellona building was based on the passive principles, but prioritized energy production arguing that at some point it is more cost effective to produce energy than to conserve. Towards the end of the period several approaches to green building coexisted. New concepts emerged – zero emission buildings and plus energy buildings were frequently talked about in industry media, although the first plus energy building was not realized until 2014. A pragmatic goal of building to a *passive house level* became widely accepted, and it could be reached through certification such as BREEAM, energy labeling, or the passive house standard.

The shift in focus from energy saving to energy production had what interviewees called a psychological impact on the industry. The idea of producing energy was seen as a lot more appealing than not using or conserving energy and reached a much broader audience. One architect explained: *It is a response to the rather sad passive house debate, it is about making sure that people who build these kinds of buildings feel positive about it, more than doing less of something negative. There is a psychological difference between a surplus of something positive – and electricity is positive, people see that – and reaching zero, of something you should not have in the first place. It might be more accurate in academic terms, but it is really hard to sell. Plus energy on the other hand is easy.*

As environment and energy concerns slowly became legitimized in the industry, it was no longer the work of energy consultants but top management. The following quote from a property developer explains the shift: *I was at a conference in 2009 where it struck me that the speakers used to be environmental consultants and enthusiasts; the speakers now are business leaders and top management. Now that's a big change, environment is no longer on the passion-agenda it is on the business-agenda.*

The efforts of the Green Building Alliance (GBA) also contributed to the shift in attitudes. At the time they were working to establish a certification scheme paid off in October 2011, when BREEAM-Nor was launched. BREAAM-Nor was a voluntary environmental certification scheme where projects score points along several dimensions. A property developer expressed: *BREEAM-Nor was a game changer, not primarily because of the energy focus, but in the sense that it made sustainability a legitimate goal.* BREEAM-Nor was positively received in the industry partly due to its flexibility. It was flexible in terms of incorporating other certification and management systems, for example the mandatory government building classification scheme. Many informants also suggested that it became popular because it introduced an element of competition to the industry by constituting a very visible and marketable sign of quality to potential building owners and tenants. A GBA representative summarized: *If you ask developers why they jumped on the Breeam* *bandwagon, almost before they knew what it was, they'll tell you it's because it is fun to compete – and to compete about something as tangible as "BREEAM excellent"*. A third success factor was that it was grounded in the industry through the Norwegian Green Building Council (NGBC). Industry actors thus had a feeling of ownership and control because they had a say throughout the process.

In 2009[2] a commission to The Ministry of Petroleum and Energy pointed to the construction sector as key to energy efficiency, and recommended that building codes should include net energy frame values that would eventually cut energy use in half. In 2010[3] an independent commission reporting to The Ministry of Local Government and Regional Development recommended that all new buildings should conform to a passive house standard by 2015. Both ministries recommended to Parliament in 2012[4] that building codes should be updated in 2015 to passive house level and to "zero emission" by 2020. From that point on the policy strategy was very clearly communicated, that the energy requirements would reflect that goal.

Meanwhile much policy focus was on incentivizing the industry to experiment with building beyond the minimum standards pending the new codes. One such incentivizing program called Futurebuilt was established in 2010, and by 2013 9 demonstration projects were built. Futurebuilt was said to be the legacy of the Norwegian Wood program. It was designed to encourage sustainable architecture in collaboration between several municipalities and policy organizations and industry organizations like the Green Building Alliance and the National Association of Architects. Several interviewees accredited Futurebuilt as a driving force for pushing boundaries and creating examples and demonstration projects. Both agencies providing financial incentives continue to do. At this point many interviewees explain they were getting concerned with the growing gap between the innovative projects and the building codes, which created high expectations for the 2015 update.

The period was characterized by internal regime changes. At the landscape level, the recast of EU directive on the energy performance of buildings (2010/31/EU) clearly affected the decision to reach for "nearly zero" energy buildings across Europe by 2020. In 2012, the launch of the passive-house standard coincided with much talk of upgrading the building codes to demand a "passive house level" by 2015. The ongoing efforts in the ZEB center confirmed the importance of green building in the

[2] "Lavenergiutvalget" Low-energy Commission
https://www.regjeringen.no/globalassets/upload/oed/rapporter/oed_energieffektivisering_lavopp.pdf

[3] "Arnstadutvalget"
https://www.regjeringen.no/globalassets/upload/KRD/Vedlegg/BOBY/rapporter/energieffektivisering_av_bygg_rapport_2010.pdf

[4] Government white paper on climate policy 2011-2012
https://www.regjeringen.no/en/dokumenter/report-no.-21-2011-2012/id679374/

research community and enlisted some of the most powerful actors in the industry to the cause. Finally the launch of the BREEAM-Nor certification scheme was important for anchoring green building in industry. In addition to institutional changes, there was a serious shift in attitudes towards green building, clearly helped along by a now strong constituency formed around it. Green building was no longer a niche, but a growing part of the regime. Most developers, consultancies and contractors consider green building to be important strategically. This period also witnessed interaction between previously diverging efforts, such as passive house standard buildings, obtaining BREEAM certification, and becoming a demonstration project at the same time. The launch of BREEAM-Nor and the ZEB center were two relatively independent processes. They came into contact with each other through personal relationships because individuals had been involved with both of them, through companies who participated in the new certification scheme and the research center. BREEAM also utilized calculations coming out of ZEB research.

Considering the period beyond 2013, focus has shifted beyond passive-houses towards plus-energy and zero-energy concepts. Buildings have become part of the energy policy, and consequently debates focus more on if and how energy produced in buildings can be delivered to the net. The building code, in effect from January 2016 requires all buildings to conform to a “passive house level”.

Table 1: Summary of analysis

Time	Build-up of constituency	Regime change	Landscape factors
Eco-building period 1998- 2003	• No dominant design • Few mainstream actors • Academic attention • Mostly fringe actors in opposition to regime	• Weak regulation • Information-based policy instruments (guidelines developed by eco-build program) • Financial policy instruments emerging (State housing bank financing low energy projects, Enova established in 2001) • Lack of market	• EU directive on the energy performance of buildings (2002/91/EC) • Third IPCC report – growing acceptance of climate change • Spike in electricity prices 2002/2003
Low-energy period 2004-2008	• Emerging dominant design • Buildings start to look 'normal' • Networks such as NGBC and GBA growing • Demonstration projects interact with academia • ZEB Research center with industry partners	• New building codes introduced (TEK07) • Financial policy instruments (subsidies for extra cost associated with exceeding minimum requirements) • Demonstration projects through Norwegian Wood program • Direct subsidies for alternative technologies such as heat pumps • Emerging market	• Government change 2005 • Stern report in 2005 • EU directive implemented in Norway after 2005 • Spike in electricity prices 2006/2007 • Fourth IPCC assessment report • Al Gore and IPCC win Nobel peace prize
Passive-house period 2009- 2013	• Dominant design • Commercial projects - increasing strategic importance of green building	• Building code updates (TEK 10) • Expectations for "passive house level" in 2015 update • Continued economic incentives for innovation projects through Enova • Continued focus on demonstration projects through Futurebuilt program • BREEAM-Nor launched	• Recast of the EU directive on the energy performance of buildings (2010/31/EU) • Fifth IPCC report 2013

5 Discussion and conclusions

The article analyses changes in the Norwegian construction industry, covering the period from 1998 – 2003, in order to identify driving forces and characteristics of an apparent transition towards green building. Such a transition can occur when there is simultaneous pressure on a dominant regime from a niche technology and from the exogenous factors at the landscape level (Geels, 2002; Geels, 2004). In the green construction case, multilevel interaction processes constitute a transition pathway for the regime influenced alternately by pressure from niches and landscape developments.

As expected in the early formative period, green building technologies emerged in niches on the outer margins of the regime and in opposition to the mainstream. Niche activity was observed primarily in the form of innovative green building projects, but also in the form of R&D activity as well as industry and policy network formation. The early niche projects varied in their approach to green building; there was no unified understanding of what green building meant, or how sustainability should be understood. Disagreement about the relative virtue of different approaches to green building and competition between niche technologies subsided with the emergence of a dominant design (Abernathy and Utterback, 1978; Jacobsson and Lauber, 2006). By 2007/2008 low-energy building based on passive house principles of compactness and minimizing need for space heating had become the de facto dominant design. The increasing agreement among the different niche projects helped the mainstream industry view green building as a valid option rather than as isolated experiments. Establishing a dominant design that was suitably aligned with regime practices helped the diffusion of green building concepts, speeding up the pace of the transition process. The build-up of a constituency around the new technology – a process by which mainstream actors endorsed green building practices – contributed to legitimization and social acceptance and eased collaboration with regime actors.

Regime change is the essence of this transition. Changes in the regime were observed through policy and regulatory changes, market development and a significant shift in attitudes towards green buildings. The formulation of clear policy goals combined with a stepwise tightening of regulation provided predictability for the regime to work towards reducing the gap between the niche innovation projects and the industry as a whole. When energy performance regulation became stricter, demonstration projects from previous years were used actively to legitimize the new building codes. The existence of successful demonstration projects gave policy makers the confidence to demand a higher energy standard. The most elusive indication of regime change was the shift in attitudes towards green buildings. Increasingly positive perception of green building practices may be seen as both cause and effect, contributing to positive feedbacks and cumulative changes in the industry. The buildup of a strong constituency and successful demonstration projects strengthened the shift in attitudes, and the positive perceptions of green buildings recruited new actors to the constituency.

Landscape factors such as increasing concern for the environment and obligations to international climate agreement commitments influenced policy in the regime. The 2002 EU directive on buildings' energy performance (EPBD)[5] put pressure on the government to facilitate green building. The adoption of the directive coincided with a government change in 2005, and by 2007 the new building codes were introduced. In The 2007 Nobel peace price to the IPCC and Al Gore increased awareness of climate

[5] (2002/91/EC) http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32002L0091

change issues in Norway, again energizing the growing niches. In 2010 the EU recast of the EPBD[6] emerged, which prompted the policy strategy to reach a passive-house level by 2015, and nearly zero by 2020.

In the early stages the transition followed a *reconfiguration pathway* (Geels and Schot, 2007). Reconfiguration in this case meant testing green building concepts in cooperation with niche actors. Interaction and alliances were formed between niche and regime actors in *intermediary projects* where regime actors could experiment with green building (Smith, 2007), that is innovative building projects involving collaborations between regime and niche actors. Because of the project-based nature of construction, regime actors were able to simultaneously participate in regular non-innovative projects and in niche projects.

A shift to a *transformation pathway*, characterized by strategic exploration of niche technologies by incumbent actors (Geels and Schot, 2007), transpired around 2012 as attitudes towards the value and worthwhileness of sustainability gradually changed. Major regime actors strategically explored opportunities previously developed in niches. The rationale for green building was no longer social consciousness or environmentalism, but rather business strategy. The analysis indicates that the shift in attitudes preceded strategic appropriation of niche technologies to mainstream projects. The intermediary projects acted as learning arenas for regime actors, who went on to incorporate practices from these activities in their next projects, thus contributing to endogenous regime change. Alliances between academic institutions and industry proved to be an effective driver of transformational change because it attracted powerful mainstream actors to green building projects. Green building thus became incorporated in the regime, and the current pathway is one of *endogenous regime change*.

In the ongoing transition in the Norwegian construction industry, green building is a moving target. The case study has identified significant changes in attitudes towards green building and analysed how green building practices entered into the mainstream market. This was largely due to interplay between increasingly demanding building codes, and incentives for innovation and green building experiments. The minimum requirements in the building codes, effective from January 2016 demands building to a passive-house level, which means that the legal minimum requirements are now approximately where the most innovative demonstration projects were 15 years ago; the innovative demonstration projects have themselves moved beyond energy efficiency towards energy production. This is interpreted as a strong indication that a transition is underway. It can hardly be interpreted as a complete transition, as the industry continues to evolve and as the "frontier" of green building moves beyond energy efficiency towards energy production. Two major barriers still warrant attention – the observed changes do not apply to the existing building stock, apart

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[6] (2010/31/EU) http://www.eceee.org/policy-areas/buildings/EPBD_Recast

from major refurbishments that are subject to building codes. Secondly, the majority of innovative projects are high-end office buildings, which could mean that the housing segment of the industry is lagging behind in innovative projects.

The multilevel perspective on transitions has proven a useful concept to study the greening of industries to sustainability; however it often juxtaposes incumbents and new entrants (Bergek et al., 2013; Berggren et al., 2015; Geels and Kemp, 2007; Geels and Schot, 2007). This paper contributes to nuancing the discussion of different types of transition pathways in an established industry, where incumbent actors simultaneously contribute to regime preservation and participate in niche projects. Later investigations may want to explore other project-based industries to confirm if similar patterns may be detected there. Further research could also explore how different combinations and sequences of policy instruments interact and reinforce each other.

Although policy has had an impact on the green building transition, such a transition concerns a multitude of actors and cannot be completely steered by instruments and regulation alone. Still, the observed changes in the industry can be strongly tied to long-term and coordinated policy efforts. Policy in the field has been based on a long-term strategy with stepwise introduction of a variety of policy instruments as a main approach. Increasingly strict regulation and simultaneous support for niche projects turned out to be a powerful combination in order to prompt regime change. Interaction between research and industry resulted in innovative demonstration projects, which again contributed to the legitimization of stricter regulation. The formulation of clear policy goals along with a stepwise regulatory tightening provided predictability for the industry to work towards diminishing the gap between the innovation projects and the minimum requirements specified by regulation. A stepwise approach and policies that form a link between innovative projects and industry standards may be relevant approaches also in other industries.

The project-based nature of construction nevertheless means that incumbent firms in the mainstream industry can simultaneously contribute to regime preservation and participate in niche projects. Projects allowed powerful regime actors to experiment with green technologies without committing the whole organization to the technology. Participation in intermediary projects and alliances in order to experiment with green building technologies was identified as a central driver of change. Policy instruments designed to encourage regime actors to experiment with niche technologies could be a way to move forward with a transition in other countries and industry sectors.

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