Multiple dynamics of sustainable housing concepts in Denmark – on the role of passive houses

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Abstract

The multilevel perspective of Geels (2005, 2011) outlines a number of dynamics of transition, yet after establishing pluralism what really remains from the analysis is a two sided competition between an existing regime and an upcoming technological niche.

Critically using Geels' conceptualization of a world of dynamics, the paper reviews institutional theory and actor network approaches to transition in an attempt to better account for contemporary developments, encompassing EU and governmental reforms and their role in transition in the building sector as well as multiple competing concepts. Referring to multiparadigmatic approaches (Goia & Pitre 1990) we argue that the combination of institutionalist and actor network theory can bring a fruitful understanding of this process. We use institutional theory to address emerging multiple competing institutions (Thornton et al 2012), and actor network to understand the heterogenous actor dynamics (Latour 2005, Pipan &Czarniawska 2010).

The emergence of 'passive houses' in Denmark is used as a case of transition dynamics. The concept was developed in Germany and imported into Denmark. In Geels' vocabulary it constitutes a technological niche, encompassing technologies, players, improvisation and early customers. Passive houses as future institutions have entered into fierce competition with other future institutions such as LEED, DGNB/green building council and active houses. Passive Houses was at the outset a well-developed upcoming institution with its own design principles, - software, certification and numerous material realizations, e.g. reference buildings, strong enough to be a challenger institution. Passive houses are promoted by a characteristic alliance of architects, consulting engineers, a few clients, and an architect school, whereas the other concepts exhibit their specific actor alliances. Yet passive houses experience barriers such as the reputation of being expensive and non-user friendly and are currently surpassed by the other concepts.

Keywords: passive houses, transition theory, Denmark, sustainable building

Introduction

Creating a sustainable society will demand major transitions implying social choices. Even setting the goals is demanding. Being able to define sustainability is about what to develop, what to sustain, and for how long. We characterize sustainability transition by relying on the large body of internationally negotiated consensus on development and environment. Here the focus isis on climate change mitigation in housing and building, encompassing sustainable housing concepts such as passive houses, active houses, energy class 1 and 2 . The paper analyses the passive house as upcoming institution and its competition with others concepts in the Danish context.

The theoretical framework departs from strategic niche management research (SNM) and Technological Innovation Systems (TIS) and uses institutional theory to address deinstitutionalization, emerging institutions and multiple competing institutions (Dover and Lawrence 2010, Meyer 2008, Suddaby 2010, Thornton et al 2012) of sustainable housing, and actor network theory (ANT) to understand the heterogenous actor dynamics (Pipan & Czarniawska 2010) in this domain. Combining these theories is unusual and not unproblematic. To underpin our endeavor we refer to multiparadigmatic approaches and argue that the combination of institutionalist and actor network theory can bring a fruitful understanding of the transition processes and to challenge our case of passive houses. This places our contribution in prolongation of previous institutional theory contributions to this conference (Fuenfschilling and Truffer 2011; Munoz 2011) as well as ANT contributions to transition theory (Garud R. and Gehman 2012).

In the analysis of the emerging sustainable buildings in Denmark, the paper places passive houses as one among several competing concepts, niches, actor alliances, institutions. In this perspective sustainable buildings are part of a multifaceted landscape of future institutions around an existing regime of built environment,. The dominant housing/building institutional regime is challenged from various niches- institutions to be- and from the socio-technical landscape through EU- initiatives. The future passive house institution is analysed showing the processes, experienced barriers and limited adoption. This is juxtaposed with other sustainable building upcoming institutions and their competition. Combining these dynamics leads to the view that sustainable housing concepts/institutions are only viable in windows of time; and that the contribution of the passive house institution is more of a stepping stone towards low carbon housing, than a final solution.

Method

The paper adopts an interpretive sociology framework. The theoretical position departs from two transition theory contributions: Science Technology and Society studies (SNM) and Evolutionary Economics (TIS) (Coenen and Lopez 2010, Markard and Truffer 2008) and proceeds to investigate the possible combination of institutionalism and ANT.

Our main contention about the merging of institutional theory and actor network theory is that they can supplement each other. Institutional theory has strength in understanding social structure, whereas ANT provides an interactional understanding of change processes agency as heterogeneous assemblages of human and non-human elements. The two types of theory are characterised by important differences in their ontology and epistemology. ANT does not accept structures of the type institutional theory proliferates and institutional theory would understand materiality as an object of social interpretation and assignment of meaning, not as active part as ANT would. Moreover institutionalist theory thinks in levels something ANT rejects. The combination carried out here however exploits that the two types theories have blind spots, grey areas where the combination does not "activate" the incommensurability their combination in principle would involve: ANT is used for the agency part of building transition alliances, whereas institutional theory is used for the structural elements in play and for enriching the range of possible elements and process features in the actor network building. ANT is quite open and multiple when it comes to conceptualise the processes and the heterogeneous assemblages. Referring to multiparadigmatic contributions (Gioia and Pitre 1990, Lewis and Grimes1999) presenting how the combination can be done by associating two theories in a sequential, parallel or synthesised manner. Gioia and Pitre (1990) argue for "transition zones" between paradigms, areas where they don't overlap and where it makes sense to use them in tandem. Thornton et al (2012) claim that institutionalist theory still, after recent years development of institutional entrepreneurship, lack a proper conceptualization of agency, which is where we use ANT. Garud and Gehman (2012) provide a meld between ANT and narratives in a conceptualization of sustainable transition.

The empirical design is a case study of the development of passive house in Denmark using a mixed method approach combining quantitative and qualitative data. . The qualitative analysis of competing concepts included the content of the concepts, how they differentiate from each other, the role of materiality, and the actor alliances. Quantitatively a mapping of the development over time of sustainable housing concepts and their emergence is carried out using desk research, Google, Infomedia (Danish Newspaper database) and other press articles. The Google search of the presence of the concept covers a period from 2000 to 2012 in Denmark. Search words was found in an iterative manner as some search words created hits that was overly polluted with other data. ". For example "energi klasse 1 huse" and "lavenergiklasse 1 huse" ("energy class 1 houses" in Danish) was used followed by manual subtraction of hits of product classes of household appliances which continued to pollute the hits. Similar strategies were applied for the other concepts. Nevertheless we consider the Google count as merely indicative with low validity.

A range of other material has been used to underpin the analysis including university research and publication, consultancy reports, students' work and master theses supervised by the authors. First hand data collection includes participation in architects and engineers' workshops on the topic. The trustworthiness of results is achieved through triangulation, by the comparison of information collected through different channels (Bryman and Bell, 2007). A lot of the material used is in Danish and it has been chosen not to reference it here.

It is recognised as a limitation of the paper that the competition of the concepts are no thoroughly mapped. Moreover the further implications of combining institutional theory and ANT on a background of strategic niche management and technological innovation systems are not discussed here.

Theoretical framework: Transition theory

The transition theory literature is currently being developed as a response to the societal challenges of climate change (Markard et al 2012). It encompasses looking at the drivers, emerging actor constellations, technologies and barriers in play.

This section develops our transition theoretic framework referring to two types of transition theories. Those which are using this label namely Geels (2005,2011) , Strategic Niche Management SNM and Multi level perspective MLP as well as the Technological Innovation System (TIS) (Jacobsson & Bergek 2011). And those which possess theories for understanding the transition paths in contemporary society, yet is not using the Institutional theory label (Greenwood et al 2002, Scott 2001, Røvik 1996, Thornton et al 2012 a.o.) and Actor Network Theory (Akrich et al 2002 Latour 1993, 1996, 2005 a.o.).

Multilevel framework and strategic niche management

The SNM view approaches innovation in a sector as a socio-technical phenomenon. Three levels of socio-technical interaction are identified: Niches form the micro-level where innovations emerge; The socio-technical regime forms the meso-level, which accounts for the dominating stabilized socio-technical pattern of interaction that are reproduced by institutionalised learning processes; and Finally the macro-level which is shaped by the socio-technical landscape, an exogenous environment beyond the direct influence of niche and regime actors (Geels, 2005). Schot and Geels (2008:545) note:

"The core notion of the multi-level perspective (MLP) is that transitions come about through interactions between processes at different levels: (a) niche innovations build up internal momentum; (b) changes at the landscape level create pressure on the regime; (c) destabilisation of the regime creates windows of opportunity for niche innovations".

This suggestion that regime shifts would (predominantly) come about through bottom–up processes of niche expansion is however combined with multiple levels of possible explanations. Niche innovations are still important, but these innovations would probably diffuse more widely if they link up with ongoing processes at regime and landscape levels. The strategic niche management perspective allows for a range of actors to be included in the conceptualisation. It should be noted that the strategic niche management perspective does not encompass processes of legitimation. As

such it does not give a central role to the public audience, processes of public communication and other elements of legitimation processes. Even if such social processes are not counter or alien to the dynamics outlined.

Technological Innovation systems

The technological innovation system (TIS) approach focuses on the dynamics of the systems both in terms of structural growth and key innovation-related processes. Carlsson and Stankiewicz (1991:93) define a technological system as:

"a dynamic network of agents interacting in a specific economic/industrial area under a specific institutional infrastructure and involved in the generation, diffusion, and utilization of technology."

According to Bergek et al. (2008) a TIS is made up of: (i) firms and other organisations; (ii) networks; and (iii) institutions. Firms refer to firms within the entire value chain and organisations include universities, research institutions, industry- and other professional organisations. TIS as championed by amongst others (Bergek et al., 2008; Carlsson and Stankiewicz, 1991; Jacobsson and Bergek, 2011) views the 'functions' of the innovation system as central. The eight key functions are (Bergek et al. 2008): Development of formal knowledge, Entrepreneurial experimentation, materialisation, influence on the direction of search, market formation, resource mobilisation, legitimation, and development of positive externalities.The interplay between these functions is multiple, complex and cannot be reduced to a linear progression. *Formal knowledge* is the explicit research-based knowledge. The TIS develops if it manages to expand the breadth and depth of its knowledge base and diffuse and combine it into the system. *Entrepreneurial experimentation* on the other hand is development of tacit, explorative, and applied knowledge. *Materialisation* involves the development of (and investment in) artefacts such as products, production plants and physical infrastructure within the technological innovation system. The *influence on the direction of search* is about actors being able to orchestrate the assembled effort and direct it in a particular direction and thereby strengthening the TIS development. This dimension is one of the more agency oriented elements in the TIS model. *Market formation* relates to articulation of demand and market development in terms of demonstration projects, nursing or niche markets (Schot and Geels, 2008), bridging markets and, eventually, larger markets and large-scale diffusion. *Resource mobilisation* is about the TIS having to mobilize human capital, financial capital and complementary assets. The socio-political process of *legitimacy* forms through actions by various organisations and individuals. Central features are the formation of expectations and visions as well as regulative alignment. *Development*

of positive externalities reflects the strength of the collective dimension of the innovation and diffusion process.

The limits of MLP/SNM and TIS

At present transition is faced with effects of the financial crises, which even stronger than previously underline the need to conceptualise the competing dynamics in transition. In our view MLP/SNM and TIS feature some important limits that need to be better conceptualised. We claim that there are four main limitations:

- Illusions on levels in transitions
- So many dynamics that a cacophony is the result
- SNM and TIS share a relatively weak and unclear concept of agency. This includes a lack of conceptualisation of (active) materiality
- The scope of the theories is only one cycle of transition

First both models implicitly and explicitly operate with different levels of aggregation. Geels (2011) claims that these levels can be appropriated to concrete contexts (as a response to Genus and Coles 2008). Markard and Truffer (2008) suggest that a technological innovation system and the niche/regime level are at the same aggregation. The idea of levels risks to give rise to illusions on separate worlds with different dynamics. According to Geels (2005) niches are protected from forces of competition and the landscape level is beyond the influence of the players. Such division of dynamics are however refuted by many of the Geels and Scoot (2008) reported studies. The notion of a landscape beyond influence is parallel to Latour (2005) critique of sociology for inventing overarching concepts that mystify social processes unnecessarily.

Second even at the outset the two theories encompassed a relatively high number of recognized dynamic in transitions. Something that can be seen as a necessary response to the complexity of transition As the two theories have matured, more dynamics have been added (Geels 2011, Jacobsson & Bergek 2011, Schott and Geels 2008). For example at the niche level both SNM and TIS conceptualise a large number of possible dynamics at least five of the so called functions in TIS, innovation processes overlap heavily with the niche dynamics described in Schot and Geels (2008).

Third even if (human) agency and materiality is recognised in SNM and TIS, it still remains unclear what the distinct contribution of agency is. For example in TIS The *influence on the direction of search* is one of the more agency oriented elements). Markard and Truffer (2008) in their review argue that the functions in TIS can be substituted with activities in appreciating a more agency oriented conceptualisation of an innovation system. There are also elements of (human) agency in SNM and MLP. When it comes to role of materiality both approaches assume human manipulate materiality into technologies and products, but disregards that opposite dynamic from hybrid associations of human and non-human elements (Latour 1993)

Fourth there is a tendency in SNM and TIS to view transition as a modification of a linear process, and focus on singular change. The question occurs, what happens after a niche technology has changed the previous incumbent regime (cf. Geels and Schoot 2008) and once the eight functions of TIS is established? In other terms transition theory lack meta cycle concepts.

It is on this background we find it fruitful to turn to other types of social scientific contributions in an attempt to conceptualise transition towards a sustainable society as agency changing and establishing institutions.

Developing a new transition theoretic framework

Institutionalist theory advocates non rational, cultural socially constructed explanations of societal order and change. Scott (2001:48) defines institutions as ”social structures that have attained a high degree of resilience…[institutions] provide stability and meaning to social life….. Institutions are transmitted by various types of carriers, including symbolic systems, relational systems, routines, and artifacts. Institutions operate at different levels of jurisdiction, from the world system to localized interpersonal relationships. Institutions by definition connote stability but are subject to change processes, both incremental and discontinuous…”. Scott (2001) and others (Thornton et al 2012) conceptualise institutions as consisting of three types of elements; cultural cognitive, normative, and regulative. Even if institutionalist theory depart from explaining organisational homogeneity and stability (Dimaggio & Powell 1983), most recent contributions are interested in institutional change, including the discourse on institutional entrepreneurs (Garud et al 2007, Munoz 2011), and also to some extent deinstitutionalisation, diversity of institutions and societal and other non-organisational change (Thornton et al 2012).

The contributions to understanding institutional change provide concepts for how an existing institution would be deinstitutionalised, delegitimised, and how a future institution would develop

through gaining legitimacy and more (Greenwood et al 2002). Legitimacy is not given but has to be formed through conscious actions by various organisations and individuals in a socio-political process. Gaining legitimacy would involve cognitive, normative as well as regulative aspects. The most commonly described strategy for obtaining legitimation is to conform to established institutions. However, deinstitutionalisation and reinstutionalisation, as described by Greenwood et al. (2002), is another means of attaining it. If legitimacy is attained for a technological innovation this would support obtaining resources for its further development, and it would generate demand and give actors in the institution political strength. For example, Bergek and Jacobsson (2008) argue that attaining legitimacy is a prerequisite if new industries are to be formed around renewable technologies, as the incumbent energy production regimes might otherwise actively counter them. Greenwood et al. (2002) point at several steps in gaining legitimacy. They assign early legitimacy as being value oriented 'moral' legitimacy. If the emerging products and practices cannot be referred to existing institutions, functional superiority has to be established, labelled 'pragmatic' legitimacy. At a later stage the legitimation might solidify and become cognitive (Greenwood et al., 2002).

As touched upon above institutionalist theory also go beyond the single stabilisation of a new institution, through the discussion on concept cycles and deinstitutionalisation. Røvik (1996) raised issue with the assumptions of evolutionary economics claiming the selection and adaption assumes that a given concept/institution will be substituted only by one which is technically superior. Røvik points out that the decay of concepts would also occur through other mechanisms. For example, concepts that become institutionalized and therefore widespread, would lose their social differentiation element, and become 'normal'. As a result, leading players would lose interest. Røvik (1996) points out that a process of obsolescence would occur where actors through reinterpretation create a socially constructed impression of the concept as "passé". He describes it as a social contagion leading to trickle down effects. This leads to a gradual fading of obsolete institutions/concepts as a compromise between rationality and fashionableness.

As argued by institutional entrepreneur contributions (Garud et al 2007 a.o.) institutional theory is in need of conceptualising agency. According to Thornton et al (2012)'s version of institutional logics perspective this could be done in a Giddens like structure agency dualism. Thornton et al (2012) are critical towards the institutional entrepreneurship contributions for trying to, yet not being able to, solve the agency problem.

Institutionalist theory tends, as Geels in early versions, to understand transition as a competition between a dominant and a challenger social dynamic (Dimaggio and Powel 1983). Some contributors to institutional theory do however extent this original dualism (Dover and Lawrence 2010, Scott 2004). Scott(2004) demonstrates competition between professionalism, managerialism and two different state regulation approaches to healthcare. Scott (2004) distinguishes between powerful rhetoric's of market and equal access to healthcare and their after all limited implementation as the professional institutions of the doctors prevail. Meyer and Höllerer (2010) contend that many competing label in an institutional environment enable negotiation of meaning and thereby shaping of future institutions. The institutional logics perspective extends these approaches and argues for

multiple orders of institutions and multiple dynamics driving their changes (Thornton et al 2012). This approach proceeds to argue for an inter-institutional system of multiple orders of institutions and with a loose coupling between them.

Summarising institutionalist theory offers conceptualisations of central dynamics of transitions. This includes regulatory, normative and symbolic aspects and spans from the multinational phenomena to the individual. There is an appreciation of a possible role for agency and concepts for change processes. Moreover there is some understanding of institutions in competitions. However institutional theory also possesses weaknesses. Even if some contributions operate with multiplicity our particular contribution would be to view the process of institutional change (transition) as a competition and coexistence of multiple emerging institutions. This also involves taking distance to the ideas of interinstitutional systems and leaving it for empirical analysis to investigate whether there is one or more institutions in play and if and how far they are interrelated.

The institutional logic perspective operates with a level thinking close to Geels (2005, 2011). Moreover the opening for agency in our contribution should not mean a fall back to a belief in the knowledgeable individual alone (re. Giddens 1984), as transition does span the abovementioned areas and narrowing agency down to individuals is too limited, We therefore turn to Actor Network Theory (ANT).

Actor Network Theory (ANT)

Actor-network theory is a social constructivist approach in which change/transition is understood as a process (Akrich et al 2002, Latour 2005). ANT would view the emergence of a sustainable building concept as the building of a heterogeneous assemblage of material and immaterial elements over a series of negotiations enrolling actors and materiality (Latour 1987, 2005). The concept would interest (attract) actors and they would impact on the concept in a mutual shaping process. This process would go through obligatory points of passages where certain features would come to be obligatory for the further development. Below, we first carry out a review of ANT contributions before continuing on to present the main concepts of sociology of translation (Callon, 1986)

ANT has been used in a variety of areas. At least three contributions discuss transition towards sustainability Callon (1986), Garud and Gehman (2012) and Pohl et al (2009). Other important areas are innovation studies (Akrich et al., 2002; Pohl et al., 2009), organisation studies (Alcadipani and Hassard, 2010; Harrison and Laberge, 2002), and public policy and management (Pipan and Czarniawska 2010,; Young et al., 2010). Actually all these are relevant here, since focus is on transition processes, the active role of devices/actants and networked concepts, in a process where public regulation is enacted as actor as well. In the classical ANT studies of innovation processes, such as Law and Callon (1992), emphasis is on the emergent processes of associating human and material elements and the lack of ex ante importance of resources or other features. Moreover, devices and materiality of various kinds are assigned an active role, signalised through the notion of actant (Christensen and Skærbæk, 2007, 2010; Latour, 1993). In this ANT view, the interest centres

on how actors strive to stabilise a concept. Concepts used here include fact building and purification (Christensen and Skærbæk, 2010). Similar concepts would apply to the design of a sustainable house.

ANT studies of public sector change would view government and regulation as merely an element in the emergent actor network (Young et al 2010: 1209, Wessels 2007), in contrast to political science approaches. Wessels (2007) advocates a need for a multiactor, multimodal perspective on governance, which ANT is responding to (Wessel 2007:353,355, see also Arnaboldi and Azzone 2010). Pipan and Czarniawska (2010) in their study juxtapose central government processes with local ones, find local translations and do assign law reforms a certain framesetting role (Pipan and Czarniawska 2010:250). Similarly Christensen & Skærbæk (2010) find an important central alliance between a government commission and consultants in the networking processes of local government bodies.

Basic concepts of translation

As our interest here is a process of change/ transition, we use sociology of translation (Callon, 1986) as the basic framework for analysing the process (as Alcouffe et al 2008 and Harrison and Laberge, 2002). According to Callon (1986), there are four main moments of translation:

- Problematisation
- Interessement
- Enrolment
- Mobilisation

Problematisation involves construction of the problem, i.e. formulating the problem and proposing solutions (Harrison and Laberge, 2002). At the same time, this also involves "interdefinition of actors" (Callon, 1986a). The actors and the problematisation – "a double movement" – evoke actors and define their identity in such a way as to establish themselves as part of the emerging network of relationships they are building (Callon, 1986a).

The mechanisms of *interessement* are defined as a set of actions through which the already involved actors and materials (hybrids denoted actants (Latour, 1993)) impose and stabilise the identity of other actors in an effort to promote the pursuit of the objectives and goals that have been attributed to them (Harrison and Laberge, 2002).) The invited new actor may submit or may define his identity, aims, projects and interests differently. This involves negotiation and may be done through coercion. In this way, the emerging network is trying to build alliances and destroy competing associations (Harrison and Laberge, 2002). *Enrolment* consists of defining a role and ensuring that it is played by the actor to whom it is proposed (Harrison and Laberge, 2002). It is concerned with the distribution and assignment of roles in the network involving human, material

and hybrid elements. *Enrolment* can be viewed as the result of successful *interessement* (Callon, 1986a; Harrison and Laberge, 2002It designates the device by which a set of interrelated roles is defined and attributed to actors who accept them (Callon, 1986).

Mobilisation of allies is the stage in which ordering takes place (Harrison and Laberge, 2002). The actants of the network are ordered in a way that makes it possible for a spokesman, i.e. somebody/something that represents the network, to be established (Akrich et al., 2002). Innovation might become irreversible or the opposite, the network begins to fall apart (Harrison and Laberge, 2002). The further strengthening involves a range of intermediaries: meetings, contracts, education information, privileged status, etc. (Harrison and Laberge,2002). The actors are enabled and constrained in a network of links whose consensus limits each actor (Alcouffe et al 2008, Callon, 1986a; Harrison and Laberge, 2002).

ANT celebrates a possible symmetry between failure and success (Akrich 2002: 123),. It is thus impossible to predict in advance whether a change process will succeed or not or partially stabilised.

Moreover Latour (2005) emphasises the importance of staying flat in his critique of context, , meaning that one should stay close to the immediate processes of translation of actants, rather than look for abstractions such as context or hierarchy. As concept for links between such parallel domains of flat analysis, Latour (2005: 174) suggests the notion of 'clamps'.

In sum, ANT views a sustainable housing actor network as a heterogeneous association of devices actors, intermediaries, companies, technologies and more. A range of concepts for analysing this process is offered of which we will use some but not all.

Synthesis of the two main contributions, ANT and institutional theory

As argued above the transition theories allows us to understand and conceptualise central, and multiple dynamics in the transition towards zero carbon buildings and society. Here MLP/SNM and TIS are used as a background domain conceptualisation allowing us to use ANT and institutional theory to understand the rise and possible fall of sustainable housing concepts, focusing on passive houses. More specifically institutionalist theory provides a series of dynamics involving regulatory, normative and symbolic aspects and the role of legitimacy. Moreover it provides us with an understanding of the interplay between old and new institutions. Finally we add the multiple institutions understanding. ANT is used to understand the building of alliances around the concepts and the role of materiality. Here ANT would emphasise the interaction between human actors and materiality and the social construction of the market. It would also help thinking of materialisation as a more dynamic process. We include the building of legitimacy in our actor network building concept of future institutions aiming at institutionalisation.

Case: First Passive Houses, then competing future institutions in Denmark

Below the case of passive houses develops as a future institution within sustainable housing with an emerging heterogeneous alliance of companies, architects, and materialised houses followed by a presentation of the competitors.

The central European development of passive houses

The early development towards passive houses, i.e. with such a low energy that it does not require active warming, can be traced back to the period 1975-1990 in a number of countries, e.g. Austria, US, Sweden, Denmark, Germany, . From the early 1990's the development around Institut Wohnen und Umwelt, Darmstadt, took precedence. The first batch of houses built according to Darmstadt standards, such as those in Dörpe and Kranichstein (Hinz, 1994), were used to develop a standard for passive houses, incorporating specific design parameters, energy consumption calculation software (PHPP) and tests. By the year 2000 around 100 passive houses had been built according to these standards (passivhausinstitute.de, 2012). The Darmstadt institute database portfolio of passive houses as of early 2012 encompasses 1753 projects. 1586 of these are in Germany, 33 in Austria, 12 in Denmark, and 10 in Switzerland. The vast majority of these projects are single family houses.

A passive house according to the Darmstadt criteria (Passivhaus Institute, 2012) encompasses four central technical properties: (i) The specific space heating demand should be lower or equal to 15 kWh per m2 per year; (ii) the heating load should be ≤ 10 W/m; (iii) the tightness of the building envelope should be tested with a pressure test showing air changes of ≤ 0.6/h; (iv) the specific cooling demand should be ≤ 15 kWh per m2 per year and the total specific primary energy demand ≤ 120 kWh per m² per year.

The context of Danish building

Following the oil crises in 1974 the Danish building sector started coordinating path of improving insulation and reducing the energy consumption (Marsh et al., 2010). In the period 1975- 2000 a 19 percent reduction of heat consumption was realized, an improvement that was mitigated by a 69 percent growth in energy consumption due to more intensive use of household appliances and IT (Marsh et al., 2010). A range of planning, fiscal, and regulatory policy initiatives were taken in this period. As a result energy planning in Denmark changed from oil to natural gas and district heating, produced by centralized combined heat and power plants (Marsh et al., 2010). Until around 2002 Danish regulation were ahead of those from EU. Since then new building regulations have been implemented in Denmark largely following EU directives and have substantially tightened the demands on energy consumption. The EU directive EUBP 2002 was implemented in 2006, introducing two energy classes; 1 and 2, also called 2015 and 2010 referring to the years they become obligatory. The building regulation BR10, from august 2011 installs a third class 'BR 2020' with even stricter demands. These reforms have been accompanied by a range of initiatives such as

Directive No 2010/31/EU on the energy performance of buildings, and the directive No 2009/28/EC demanding national renewable energy plans, initiatives of developing sustainable skills amongst construction workforce, financial and fiscal arrangements. In summary, between1974-2002, Denmark as a national state had a broad alliance of actors pushing for energy savings and accompanying technologies; whereas from 2002 and onwards the initiative shifted to the EU. The reform tempo has been quicker over the past ten years than previously. Alike many countries the Danish housing sector, had a serious bubble that burst in 2008 as shown in the building volume 2007-2011 below

	2007	2008	2009	2010	2011
Commenced new build in mio m2	10,6	9,15	6,30	5,15	4,75
Commenced Housing Buildings	26000	17000	10000	10500	11500

Figure 1: Building activity 2007-2011 (source: Denmark Statistics)

The story of passive houses in Denmark

The interest for passive houses occurs in the above sketched context.There has been a strong tendency in Danish building to gather around one common solution supported by law with occasional subsidies (Marsh et al. 2010). This continued even after the EU taking over the initiative, but now with implementation of EU legislation as the key driver. The passive house community is a niche environment that distinguishes itself from other parts of the industry. Especially the architectural community in Denmark second largest city, Aarhus, has been important in constituting this early interested group ashe architect school, local architects and alliances of architects, consulting engineers and contractors commenced following the German development from around 2000. In 2005 the consultancy Ellehauge and Kildemoes obtained funding for the EU-project "Promotion of European Passive Houses" together with a range of European partners. . Promoting passive houses as a well-documented sustainable solution Ellehauge and Kildemoes created a website, commenced educational activities, and arranged study visits to Germany and Austria,. The project was finalized in 2007,.The website transferred to a new association for passive houses in Denmark. One active person in this niche community, the architect Olav Langenkamp, designed and built his own villa according to passive house criteria and got it certified. The house was completed in 2008 as the first passive house in Denmark. When building the house Langenkamp had to use German suppliers to get components that would be certifiable. The contractor was therefore a German company, Ökologischer Holzbau Sellstedt (Langenkamp.dk, Passivhus.dk).

ISOVER, the insulation manufacturer initiated a project of 10 passive houses “komforthusene”. The idea was to let building sector actors tender for the various houses to obtain as much experience with passive houses as possible. Another goal of the project was to experiment with indoor climate

and develop documentation, involving Aalborg University in a three year long measurement program. By September 2008 eight out of the ten planned passive houses, Komforthusene, were inaugurated by the Minister of climate. The two last houses participating to "Komforthusene" did not obtain the label passive houses once their construction was achieved. Through these early projects the passive houses got the reputation of being expensive. A later evaluation report (Isover, 2010) shows that the Komfort houses were indeed more expensive to build with an additional cost of 6-12 % but it also demonstrates that these extra expenses are compensated for within fifteen years thanks to their low energy consumption. Besides being expensive these early trials all share the dependence on German suppliers .

These considerations also applie to the 2009 dormitory project "H2 College" (Bertelsen and Koch, 2011). The dormitory encompasses 66 apartments, in two blocks built as passive houses, with a hydrogen conversion installation and thermal (earth) heating. A building association Fruehøjgaard is the client and Aarhus Arkitekterne, NIRAS, and Ökologischer Holzbau Sellstedt were respectively the architects, consulting engineers and contractor. Over 2009-2010 various component suppliers start engaging in passive house projects. In 2010 for example the Danish window manufacturer Rational was part of a vocational training school, built as a passive house.

By the summer 2012, they are hundred engineers and architects certified passive house designers meaning they took a specific education and are able to design passive houses and one consultant company "passivhus.dk" accredited to certify the buildings.

In summary, the development of passive houses mobilized both small grassroot players as well as larger players in the industry. Most of the Danish passive house projects occur as part of publically financed demonstration and/or innovation projects with the intention of first communicating the values and qualities of passive houses to a wider audience of possible future clients; second to underpin this by supporting the legitimization process by providing formalized knowledge about the design, the costs, the building process etc. A less controllable part of the communication is that the passive houses appear expensive and difficult to live in as the indoor climate is controlled with complex equipment.

The concepts competing with passive houses

From 2005 and onwards an increasing number of sustainable housing concepts have emerged. An European survey from 2009 has identified 17 different terms in use to describe such buildings used across Europe, among which the terms low energy house, high-performance house, zero carbon house, zero energy house, energy savings house, energy positive house, 3-litre house etc (EU 2009). All are focusing on different scopes, calculation methods and norms for low energy. In Denmark in particular, the preparation activities before the United Nations Climate Summit, COP 15 in 2009 seems to have initiated a number of projects attempting to exploit the marketing options related to the summit. Figure 2 depicts the attention to the various concepts on the Danish part of the internet:

Figure 2 hits in Danish on the internet of selected competing concepts

	2001	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Concepts												
Passive house	107	64	51	125	207	411	661	1694	2577	3302	4830	2792
Active House		2	0	0	0	4	11	39	90	173	322	253
Energy C II				4	145	157	387	659	1230	5010	7520	11200
Energy C I	108	39	44	126	337	311	540	925	1810	5980	8979	12294
DGNB							6	7	68	143	713	741
LEED						8	27	90	216	214	401	258
BREEAM						7	26	89	227	259	605	329

Figure 3 below provides a list of concepts materialised in housing found in Denmark. The year of introduction, as provided the left hand column, is given as when the first realised building occurs. The list is not exhaustive but gives an impression of a veritable cacophony of concepts and indicates a limited breakthrough of sustainable building concepts compared to the overall building activity in the same period (re figure 1).

The following the year of introduction of concept is counted for the year where the first building is finished. Obviously press coverage and emerging actor network would commence long before and some concepts will never materialize.

Figure 3: Sustainable Building concepts 2005-2012 materialised buildings (source: desk research).

Concept/Year of introduction in DK	**Found** **Estimated number of projects**	**Actors** **(examples)**	**Examples**
Passive house, Darmstadt criteria/ 2008	20		H2 College (dormitory) Komforthusene
Active House (Velux group)/2009	3	Velux	Lystrup, Cph.
DGNB (Deutsche Gesellschaft für Nachhaltiges Bauen)/2012	2	Green Building Council Danmark Ramboll Ålborg University	Ramboll HQ Company house NCC KPMG Domicil
Svanemærket (Nordic Ecolabel)/ 2011	2	Odense Kommune, pluskontoret, Køge kommune, Det grønne hus (Agenda 21)	2 kindergartens Fremtidens Parcelhuse Køge
BREEAM (Building Research Establishment Environmental Assessment Method)/2010	>6 large Projects	Grontmij DK	Vestas HQ, Sillebroen shopping center, Grontmij HQ
LEED (Leadership in Energy and Environmental Design)/2010	>7 larger projects	COWI,KPC, Sjælsø	FN-byen, UL Intern. Demko HQ
EU Green House/2008	7	NCC	Skejby Company House I-III (also BREEAM)
Energy Class II (EUBD 2002)/ 2010	>4 large projects		KPMG, Flintholm City Court Kolding Christian Union HQ Industriens Hus,
Energy Class I (EUBD 2002)/2006	9 large and small projects and 7 under construction	Arkitema, KAB, Ramboll, Pihl, Lind og Risør, a.m.o	Stenløse Syd Multimediehus Navitas
Other concepts Sabro, ZERO+, lavenergi, BR 2020	8		Sabroe Sønderborg Zero plus Vordingborg

Energy class 1 was announced by the EU in 2002. Several years before the passive houses were first built in Denmark, the first energy class 1 buildings, the Stenløse Syd project, was erected (2005-2008) encompassing 400 hundred dwellings including housing and villas as well as a kindergarten and an elderly home. Designed as show case by EU program Concerto, a range of small players in the villa market was mobilized to the project, also involving the local municipality and a social housing company. The blower door testing of airtightness received extra joint attention, resulting in reported and documented good results assembled by a participating university. The project scale has been downsized following the last economic crisis but it still undergoing. In 2010-2012 several large office and institutional building were designed according to energy class 1, which continue to grow on all market segments parallel to the passive houses.

The EU energy classes were introduced in Danish law in 2006. From 2006 to 2010 using *Energy class 2* would imply going ahead of regulatory demands. A Danish investigation indicates that 10% of all new houses did so in 2007-2009.

In 2008, NCC introduced an office house following the *EU green building standard*. EU originally launched this program for non-residential housing in 2004. The idea being to introduce a standard ahead of regulation as the main content is that the building should consume 25% less energy that legislation demand at any time. NCC decided to market the office building following the EU standard in a context of crisis on the market. Their concept, company house, was building on renting out to several businesses and after the first erection in 2008, more followed.

In 2009 the large windows manufacturer Velux introduced a new concept in Europe, the 'active house'. This concept directly targeted the legitimacy of passive house claiming that low energy consumption was not ambitious enough, the houses should actively produce energy. Velux allied with architects engineers, contractors and universities to realize five houses before the COP 15 meeting in Copenhagen. However the concept became more than a stunt as a new association 'Active House Alliance' was inaugurated in June 2010. Velux however has recently renamed their concept advertised now as Model Home 2020 still based on active house principles.

From 2009-2010 *Energy Class 2*, part of the 2002 EU regulation, received attention in Denmark reinforcing the legal demands for the energy performance of new buildings. Several large projects such as Sorcer in Hillerod associating the municipality, Cowi and the Danish Technical University under the umbrella of Concerto, were part of this new wave. The project was realized one year before the before the class became obligatory.. Ørsted School for example realized as an PPP is Green building certified.

In 2010, the Green Building Council Denmark was formed.involving consultancy companies such as Ramboll and Ålborg University. The council first carried out a comparison of different concepts, , and later became proponents of an accommodated version of the German concept DGNB. This modified

certification was launched in 2012 introduced in pilot building projects involving ATP Ejendomme (Estate player), MT Højgaard (contractor) and Velux again . Nine auditors and seven certificates have already been attributedIn 2010 The American *BREEAM* and British *LEED* concepts were introduced in Denmark targeting the larger projects. These concepts do not only focus on energy consumption but assess the environmental performance of the totality of the building, from construction to maintenance Over 2010-2012 a series of project have been launched referring to those two standards with heavy weight players such as COWI, Carl Bro/Grontmij, Sjælsø, KPC on board. Vestas head quarter and Sillebroen shopping center are highly profiled projects.

Also in 2010 the preparations for BR 2020 a voluntary energy class beyond the two previously implemented started. This involved all the central players in Danish construction and the new norm was introduced in October 2011. When BR 2020 will become law in 2020 it will mean a reduction of 75% compared to 2006 rules.

The description above is not exhaustive but gives an impression of a veritable proliferation of concepts even if several haven't been accounted for here (such as Svanemærket and ZERO+). It also indicates a limited breakthrough compared to the overall building activity in the same period (entered above in figure 1). Besides the choice of one concept is not disqualifying the others; some of the projects are subscribing to more than one concept such as the Green Lighthouse in Copenhagen, or the Nordhuset in Kastrup which are both LEED and DGNB certified.

Discussion

Below we first discuss the emerging of a possible future institution of passive houses in Denmark and then move on to the dynamics of the competing future institutions.

The built environment regime in Denmark has continued over the last ten years to be relative conservative in “following the rules”. As a discourse passive houses interesting a handful of architects and consulting engineers around 2000 developed as a contesting future institution . This early community shares features with other grassroot developments of renewable energy, such as wind turbines (Steen et al. in Foxon et al. (2008). Obligatory point of passage was an accommodation of the design principles from Germany to Danish building standards. An important actant here is the PHPP calculation program that had to be negotiated versus the Danish BR06 software. The alliance developed based on accumulating knowledge of the concept and the EU project obtained by Ellehauge and Kildemose solidified the alliance in the absence of actual building projects. The study trips to Germany revealed the cost as barrier since the German houses were subsidised. So even if the German passive house institution possessed moral and cognitive legitimacy the alliance did not materialise, even if 2005-2007 was a peak of building activity in Denmark (see figure 1). Instead education as certified passive house designer was central for the network. It is characteristic that s a fiery soul architect, building his own house commenced the materialisation. Olav Langenkamps house materialised as the first realisation in 2008. Soon after followed the ISOVER initiated comfort

houses. Here the intended 10 houses were reduced to 8 as the two last did not comply with the Darmstadt criteria. Besides through media coverage and building sector word of mouth the houses got the reputation of being too expensive, to be untight, to use more energy than calculated and suffer from poor indoor climate. By spring 2012 these issues were documented by the evaluation project carried out by Ålborg University: only six of the original ten complies with Darmstadt criteria. This evaluation meant to contribute to the legitimation of the concept, thus end up contributing to the contestation of the concept and underlining need for improvement. Passive houses both private houses and public institutions continue to be built in 2009- 2011 , however it is 5-10 projects per year. From 2009 the alliances are stabilised and the interest is growing with research and funding, an annual Nordic passive house conference as well as more educated designers. This stabilisation is also indicated by the internet hits in figure 2. However by 2012 it appears to be a decrease in finalised houses. Over 2011 and 2012 we found three finalised passive house buildings, compared to six in each of the years 2009 and 2010.There continue to be considerable distance between rhetoric in and materialisation. There is no Danish realisation before 2008 and then only a handful is realised. . The continued economic crisis and a stand still on the housing market, the loss of moral and cognitive legitimacy due to indoor climate issues and price probably created reverse salience in the network building as the attention turns to the competing sustainable housing concept.

The other voluntary sustainable housing concepts (Active House, LEED, BREEAM, DGNB a.o.) suffers from the same marginalisation vis-à-vis the built environment regime, even if large players such as NCC, MTH, Ramboll, COWI, CF Møller, Arkitema and Velux contributed. This is also indicated by the internet hits in figure 2. Only a few buildings have materialised. The moral legitimacy has not sufficed even if supported by cognitive and functional arguments of cost effective energy consumption.

However the institutions carried by regulatory dynamics are in stark contrast to the voluntary. “energy class 1” was early a strong brand on the internet (see figure 2) and the future institution encompasses early materialisation in Denmark in the Stenløse project. Also “energy class 2” enjoyed attention especially by 2006 when announced as future legislation. As energy class 2 became obligatory and energy class 1 is to be so by 2015. Several of these concepts have been harsh competitors for the passive houses, but the most important factor seems to be the impact of the legislation.

The voluntary (normative) and regulatory types of sustainable building institutions do carry a number of similarities both in their technical content and in their actor alliances. There is overlap of design demands, overlap of actors and the common obligatory physical tests such as the demands for airtightness.

It appears to be the contours of a constellation within sustainable building. This constellation is however not so similar that it can be viewed as one institution of sustainable houses. Neither do we

interpret it as a interinstitutional system (Thornton et al 2012) as the relations between the future institutions are too vague.

Common for many of the concepts is the alliance of public institutions and public founding at least partially, large companies showing support, universities either participating in the design or the assessment of the project. It does not appear to cause problems for many actors to support several institutions at a time. Thornton et al (2012) argue that this support to more institutions simultaneous is a more general phenomenon of actors vis a vis institutions.

Also slight changes of content and labelling involving adaption to BR 2020 now perceived as the future legislation occurs. Velux for example changed “active house” into “home model 2020”, involving a similar principle but new name besides being part of various certification projects at the same time.

The multiple embarking could be seen as a marketing stunts towards new markets for the large companies be it architect, consulting engineers, contractors or suppliers. It does underline a weakness in a combined institutional ANT analysis as they tend to downplay the commodity feature of future institutions and concepts. Knowledge on sustainable housing should be understood as a commodity on a market as well. Even of its clear that also this sustainable market is characterised hybrid aspublic subsidies playing a major role.

The passive house niche analysis shows slow and hesitant processes, involving public support as the lever for development. It took 16 years from the first realised passive house outside Darmstadt in 1994, to realise the roughly 20 Danish projects in our sample. Indeed, all were built after 2006. As the niche commenced to produce material results a key experienced barrier turned out to be the initial price of the houses. As a direct result the passive house concept has experienced limited adoption, keeping it on the niche level. This is despite of its German origin and backup, which provides well established knowledge, legitimate institutions, design procedures and more. When the passive house development is juxtaposed with other sustainable building niches and their competition is mapped it becomes clear how voluntary concepts that go beyond what is specified in the legislation have been introduced in succession over time, e.g. passive, active, DGNB. But it is also clear that the early compliance with future legislation, especially energy class 1, has tended to dominate these voluntary steps. There are tendencies of segmentation, where LEED, BREEAM, DGNB a.o. are used for office buildings, whereas passive house, active house, Svanemærket and ZERO+ mostly are used for single family houses and smaller buildings such as kindergartens.

Stepping back to a TIS and SNM point, both TIS and SNM highlight the importance of a dominant design. Our study shows that none of the future institutions has obtained this. Instead they continue to exist in parallel. Passive houses represent a well stabilised design with an institutional set up in Germany. Nevertheless this does not render the concept sufficiently strong as concept in what is a growing and active part of the construction market.

We have seen how the EU processes create regime dynamics that are more prevalent for the development of sustainable buildings than the future voluntary institutions. Usually it is expected that regime driven institutions would conserve existing ways of working (Geels, 2005; Markard and Truffer, 2008). This is evidenced by the far bigger number of projects built according to the required levels set out in the official regulations during the investigated period. In the Danish setting the restructuring of government responsibilities into a ministry of climate, energy and building can even be viewed as the more important dynamics in 2011 apart from the central EU initiatives discussed above. Seen from a grass root perspective the commodification of a type of house, using a certificate is less interesting than promoting sustainable buildings in a broader sense. There will therefore be a tendency for grassroot engagement to move from one promising future institution to the next, especially if the approaches get too commercial.

Conclusion

This paper set out to investigate the introduction of Passive houses onto the Danish arena, viewing passive houses as a possible future institution within the built environment. The analysis showed a slow process, cost and technology barriers, limited adoption and recently an apparent decrease. Roughly 20 projects over the last six years have been realised. The institution has not been able to exploit its basis in formalised knowledge and cognitive legitimisation to become a contester institution. When juxtaposed with other future sustainable building institutions, it appears that all the voluntary normatively bases are small. Rather than just being about niche technologies it is the voluntary early adoption of future regulatory demands that is prevalent as energy class 1 proliferates as a strong contester of the existing built environment institution. Therefore government policymaking as the "regime internal" dynamic contributes more convincing in institutional change than contesting small future institutions does. Compliant with the theoretical framework there are multiple dynamics in play. These combined dynamics between sustainable housing institutions, the regime internal dynamic through EU-regulation leads to the conclusion that sustainable housing concepts are only viable in fairly confined windows of time, and that the contribution of passive house trajectory probably is more of a stepping stone towards low carbon housing, than a final solution.

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