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DRIVING SUSTAINABLE INNOVATION IN CONSTRUCTION COMPANIES

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Abstract

By adopting a theoretical framework from strategic niche management research (SNM) this paper presents an analysis of the innovation system of the Danish Construction industry. Theories within SNM look upon innovation in a sector as a socio-technical phenomenon and identify three levels of socio-technical interaction within which sectorial innovation can be explained. The analysis shows a multifaceted landscape of innovation around an existing regime, built in the existing ways of working and developed over generations. The regime is challenged from various niches and the socio-technical landscape through trends as globalization. Three niches (Lean Construction, BIM and System Deliveries) are subject to a detailed analysis showing partly incompatible rationales and various degrees of innovation potential. Based on the analysis, the paper further explores how companies can be introduced as drivers for innovation in the construction industry. By bridging SNM with business development activities through an adapted version of Ansoffs growth matrix, companies continuously and consciously can develop a competitive advantage by targeting new and existing markets with new or existing competencies/niches. The paper concludes with a discussion of how this approach can help to solve the challenge of retrofitting the existing building stock and thereby enabling the development a low energy consuming society.

Keywords: Innovation, Niche, SNM, Companies, Business development.

INTRODUCTION

The construction industry is often characterised as a tradition bound low innovation sector which struggles with low productivity. The constant comparison of the construction industry with other industries e.g. in relation to innovation is however problematic. The construction industry could be viewed as fundamentally different from many other industries by being project-oriented with a significant proportion of unique production. Construction is linked to a specific location and the design and production team is organized uniquely for each project. This dynamic frames the innovation process in contexts where continuous development is more or less impossible. Consequently many of the innovations are confined within the single project (Thuesen 2006).

The consequence is that numerous companies fail to evolve independently, but are subject to an industry development and regulation that fixates businesses in their existing working practices and institutional role.

Nevertheless, innovation processes *are* going on at all levels of the construction industry - from the builders at the construction site to the major development programs. Consequently a small but significant strand of Danish research has been conducted around innovation e.g. Clausen (2002), Simonsen (2007) and Vind and Thomassen (2009).

Despite the strong interest in stimulating innovation in Danish industry, the innovation programs are facing striking difficulties. Clausen (2002) concludes in his analysis of sectorial development programs that a mapping of innovation activity in construction industry is needed, focusing the interplay between strategically oriented and formalized activities and informal innovation processes on construction projects. (ibid: p. 13)

In this way it relevant to investigate how the construction industry capacity for innovation can be accelerated so that and how the industry can respond to new societal challenges such as the move towards CO2-neutral societies.

AMBITION

The ambition of the paper is to analyse the innovation system in the Danish construction industry (Thuesen et al 2011), and discuss by the use of innovation maps how companies can be introduced as vehicle for innovation driving towards a low energy consuming society.

THEORETICAL FRAMEWORK

The research of the innovation system of the Danish Construction industry draws upon a theoretical framework from strategic niche management research (SNM) (Schot and Geels 2008).

Theories within SNM look upon innovation in a sector as a socio-technical phenomenon and identify three levels of socio-technical interaction within which sectorial innovation can be explained (Schot and Geels 2008, p. 545). Illustrated in the following figure.

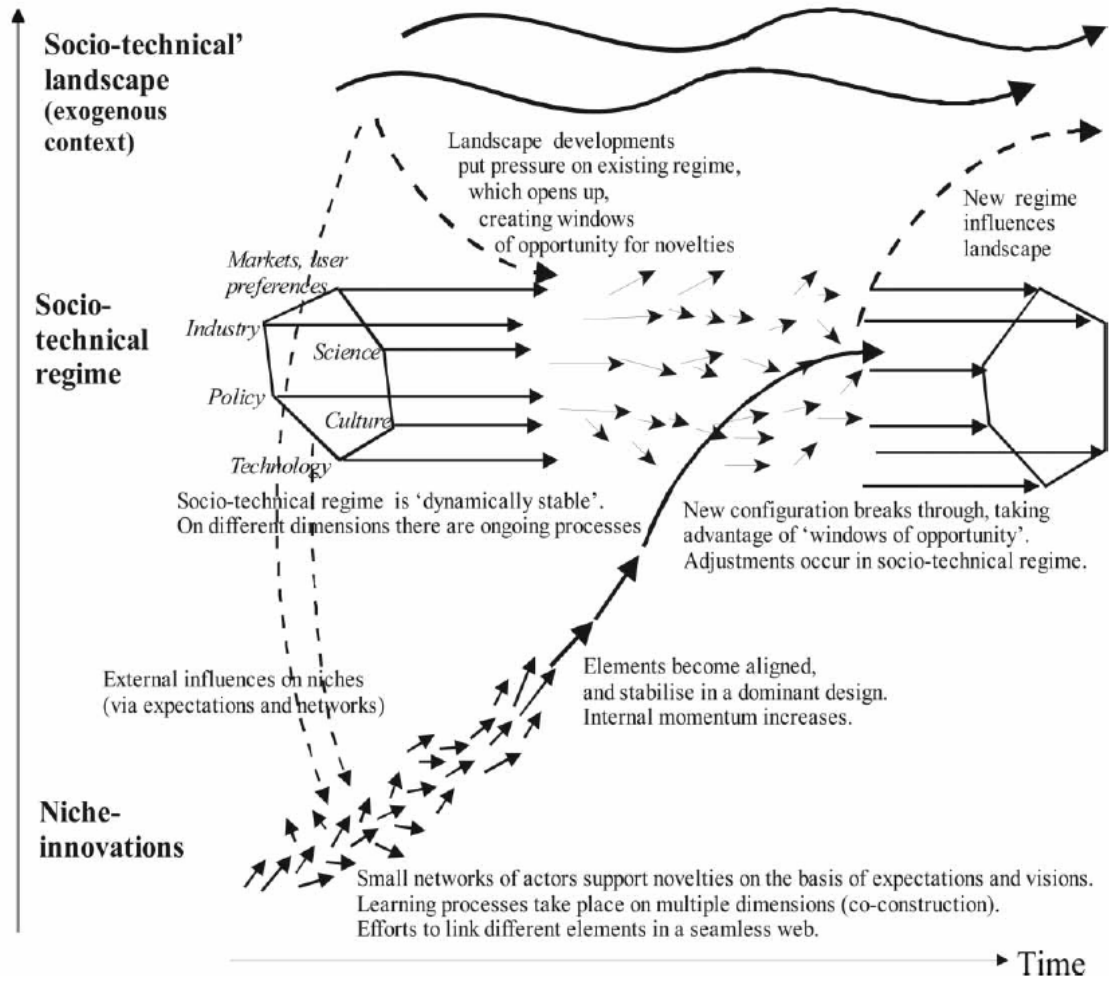


Figure 1: Innovation in a sector explained in three levels (e.g. Schot & Geels 2008, s. 546)

Niches form the micro-level where radical novelties emerge. The socio-technical regime forms the meso-level, which accounts for the dominating stabilized socio-technical pattern of interaction which is reproduced by institutionalised learning processes. The macro-level is formed by the socio-technical landscape, an exogenous environment beyond the direct influence of niche and regime actors (e.g. macro-economics, deep cultural patterns, macro-political developments).

According to Geels and Kemp (2007) researchers within sociology of technology and evolutionary economics have stressed the importance of niches as driver of innovations, from where new socio-technical regimes can be developed (Schot 1998, Levinthal 1998). Niches work as incubations environments for new ideas by being protected from the traditional selection mechanisms of the marketplace.

By distinguishing between market and technological niches Schot & Geels (2008) explains how innovation can be achieved through institutional learning processes linking technological niches to niche markets. These changes could potentially lead to regime shift as outlined in the following figure.

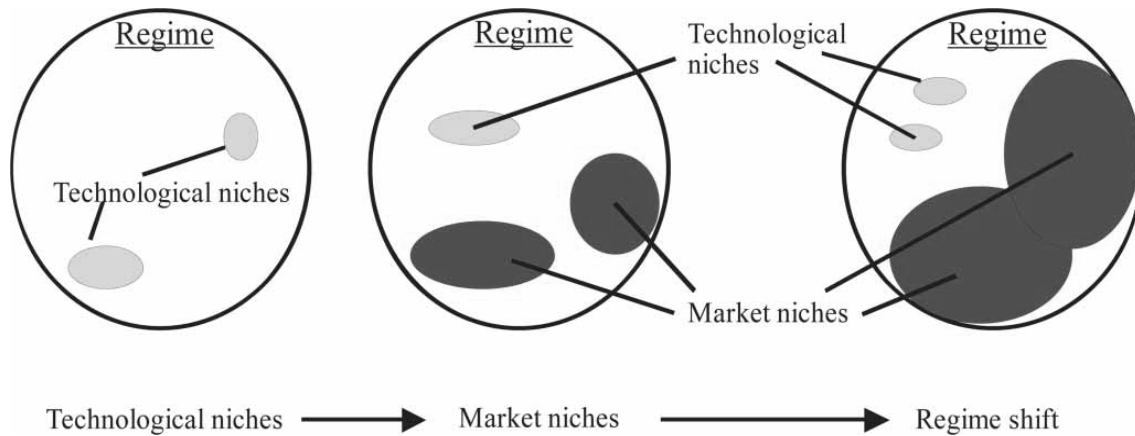


Figure 2: Regime shifts from niche development (Schot & Geels 2008, 540)

The regime is challenged as (1) technology matures in some closed technological niches (2) these technical solutions addresses a limited market need (3) and through the growth of the markets the technologies further matures and win wider acceptance in the entire regime. An important premise for the development and maturation of ideas in the form of niches are learning processes and the building of social networks that support new innovations and investments (Schot et al 1994, Kemp et al 1998 & 2001 and Hoogma et al 2002). The development of niches through these activities is achieved through ongoing project-based learning processes which over time provides a certain direction / rationality as outlined in the following figure.

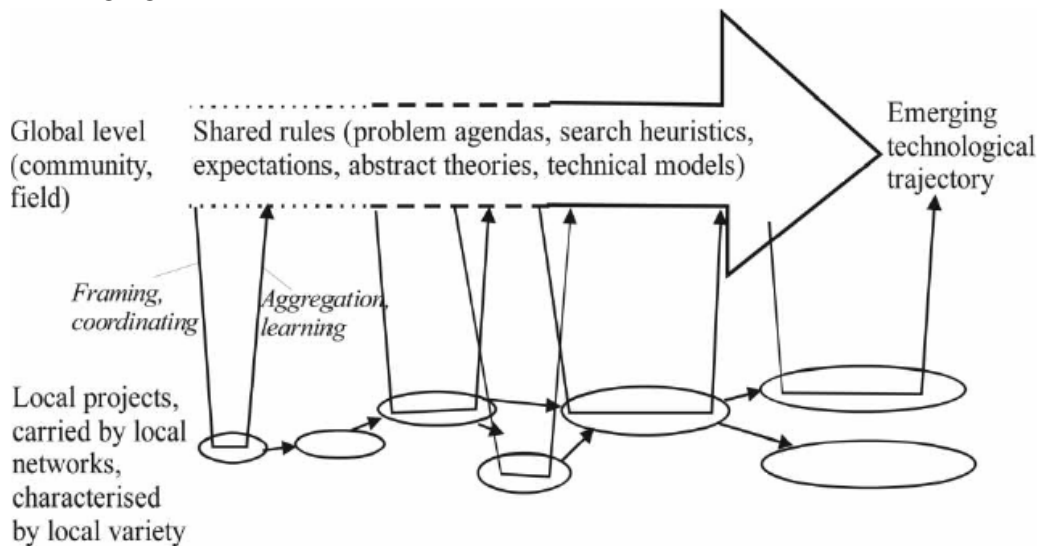


Figure 1: Niche learning processes (Schot & Geels 2008, p. 544)

It is precisely this common sense making which integrates the niches and develop its own sense of identity - a rationality that legitimizes the stakeholders' actions even though they may be in opposition to the dominant regime. Jensen et al (forthcoming) explain the rationality based on three mutually constitutive concepts an interpretive resource, a sector representation and a strategic orientation. Thus, they want to explain how a "tool" (the interpretive resource), forms a certain image of the existing regime (sector representation) and develops corresponding practices (strategic orientation). Rationality in the niche can thus

be explained by using a key metaphor in which a set of problems (the sectorial representation) can be unlocked with a corresponding solution (strategic orientation) by the key (the interpretive resource).

METHOD

Based on the theoretical concept, the collection of empirical material for analysing the innovation system draws on multiple sources like qualitative workshops, semistructured interviews, existing analysis and analysis of central texts.

The analysis of the existing regime draws upon a Foucauldian analysis of the development of the Danish construction industry (Gottlieb 2010) combined with an analysis of the past 25 years of development of construction based on the driving myths of construction (Thuesen et al 2009). This is supplemented by the IT element, based on Berard (2006) and Jensen (2011).

The three analysed niches in Thuesen et al (2011) have been selected from an initial larger sample of 'candidates' according to their innovation potential and the main drivers of the development being either the governmental or sectorial driven. The niches are the concepts around Lean Construction (Last Planner System LPS), BIM (Building Information Modelling) as a part of a general digitalization of the Danish construction industry and an emerging niche around new industrialization termed "system deliverances". The empirical material for analysing the niches consists of two qualitative workshops, eight qualitative interviews combined the central texts and theories of the niches. The material was collected in the period from the autumn of 2009 to the spring of 2010 starting with execution of the two workshops in communities around the niches followed by semi-structured interviews (Kvale, 1996) of persons in playing different roles the niche development. By asking the persons similar and different question based on their role it was subsequently possible to identify coherency and differences in their understanding of the niche and its relation to other niches and the existing regime. The material from Thuesen et al (2011) is supplemented by material on BIM from Berard (2006) and Jensen (2011).

ANALYSIS

The analysis of the innovation system is structured in three sections, firstly focusing on establishing an understanding of the predominant regime, secondly juxtaposes the three niches and finally analyzing the niches up against the existing regime.

The construction regime - developed through generations

The existing regime is developed through generations in a process characterised by periods of more and less stability and moments of radical changes in the construction practices. Although the moments of change encapsulates periods of fundamental different construction practices as between the premodern (-1945), modern (1960-70) and postmodern (1980-) construction the historical practices are to some extent sedimented in the present postmodern construction practices. Based on a historical analysis (Gottlieb 2010) the postmodern construction regime is identified as having the following characteristics according to the theoretical dimensions Technology, Industry, Market /customers, Policy, Culture, Education and research.

Dimension	Characteristics
Technology	Building materials: many different materials are in play all though there has been a preference around concrete elements since the introduction in the 60'ties. Processes: Phase models, in-situ production, planning tools based on Critical Path Method (CPM) wide spread, but “islanded” use of information technology, project management as the predominant management philosophy.
Industry	The organization of the industry is characterized by strong interest organizations representing many different professions like crafts, engineers, architects, contractors, and material producers. The value-chain is fragmented with a strong separation of design and production.
Market and customers	The market is heterogeneous and characterized by fluctuation. The customers are addressed by the architects, who tailor unique projects specifically to the customers' individual needs.
Policy	The sector is regulated around competitive bidding, tendering systems, shared standards and general conditions for work and supply. The development of the regulation happens in close collaboration between the interests organizations and the governmental anchoring (Danish Enterprise and Construction Authority, EBST), but also increasing EU.
Culture	The cultural organization of the industry is based on professions which are sustaining craft differentiated education institutions with a strong element of apprenticeship learning processes. The building organization has over time developed a strong separation between design and production favouring the development of cultures around problem solving. The institutional learning processes have the past 30 years, been centred on the myth about the unique building, make the actors perceive the nature of the build process as complex or even chaotic. Final there is a strong focus on collaboration rethorics among actors in the future development of the industry.
R&D	The organization and division of labour is mirrored and reproduced by the educational system. This system spans a wide way of cultural knowledge's from tacit and embodied situated in crafts to explicit and scientific in the academic professions. The central management practice is Project management, which is inscribed in the educational system and is influencing the research agendas.

Table 1: *overview of the building regime*

The regime is situated within a broader societal context which challenges it and creates new possibilities of innovation. Trends like globalization, climate change, an aging population, new technological breakthroughs partly destabilize the regime making it vulnerable to niche innovations and other dynamics. When this happens it can be understood as windows of opportunities for change of the existing regime.

Niches represent different sources of innovation

This window of opportunity might be addressed by different niches. We will here look closer to the niches around the Lean Construction, BIM and System deliveries illustrated in the following figures.

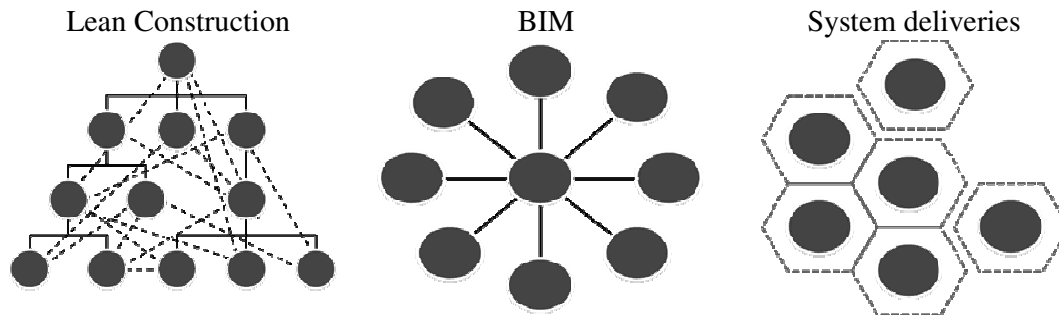


Figure 4: Illustration of niches

While the niches all try to address the regime, they represent different logics for building developments that are more or less compatible. The table below summarizes some of the key differences in rationality between the three niches.

	Lean Construction	BIM	System deliveries
Key (Logic)	Process planning tools around LPS	The object oriented 3D model / BIM	Mass-customization
Understanding of the existing regime (Sectorial representation)	The complex and chaotic building process makes long-term planning impossible.	The construction industry as a series of inconsistent and uncoordinated information flows	The construction industry as an under-modularized mode of production characterized by project-specific problem solving and short term collaboration, which hinders innovation and specialization
Solution (Strategic orientation)	Development of tools and processes for optimizing value and flow based on short term planning and involvement of crafts	The development of a shared object-oriented classification and infrastructure able to ensure unequivocal information capable to coordinate the complexity of the construction process	Project independent design and production of modular and customizable products and services through product platforms, strategy partnerships and value-chain integration

Table 2: Different rationalities of the niches

The three niches perceive the existing regime from various perspectives and are consequently formulating different problems and solutions. In LC is the building process considered as complex and even chaotic, which prevents long-term planning. As a result is LC developing tools and processes for optimizing value and flow based on short term planning and involvement of crafts symbolised in the Last Planner 'System LPS. The perspectives offered by the BIM and System deliveries niche is different as they claim that the building process can be tamed and standardized so that information flows and processes can be coordinated. System deliveries also notes that the short-term collaborative constellations often prevents the development of the industry, and thus seeks to create a better process understanding across the actors enabling value-chain integration. As the different niches don't have identical

understandings of the regime their diagnosis of the regimes problems are different. Their different diagnoses and keys (logics) also allow different strategic development directions. While LC is trying to handle the complexity of the building process through short-term planning, the BIM concept is trying to manage complexity through common systems and standards for information exchange (interoperability) and final are System Deliveries strategy to reduce complexity through modularization.

While the niches have different rationalities, they are also major differences in terms of radicalism. While Lean Construction tries to change the regime from within reproducing the existing building practices (*reproduction*) system deliverances fundamentally tries to reorganize the regime from outside (*transition*). In between these BIM is trying to digitalize the existing regime while not fundamentally changing the organisation of the industry (*transformation*). The niches are thus having different innovation potential as summarized in the following table

	Lean Construction	BIM	System deliveries
Potential	Can strengthen the effectiveness and value-creation within the existing regime Short ROI – can be implemented at project level	Enables a more efficient exchange of information between building partners. Enables a greater complexity in construction	Addresses productivity challenge Delivers product of high quality, faster and cheaper
Barriers	Can't facilitate cross-project optimization – pursuing economy of scale. Requires change a in cultures	Hard to get all parties to agree => implementation is difficult. Can't optimize across the value chain – pursuing economy of scale. Long ROI	Long ROI Can't be realized at the project level, but requires a market of a certain size and extensive knowledge of customer needs Requires reorganization of the division of labour in regime.

Table 3: *Barriers and potentials of the niches*

The conflicting rationalities among the niches internally and towards the regime put emphasis on strategy development in the companies. Thus is it important to develop strategies which will be able to handle these differences and navigating in the innovation system.

DISCUSSION: COMPANIES A INNOVATION DRIVERS

Companies present innovation practices

Thuesen, Koch and Nielsen (2010) show how SME's is navigating in the innovation system today. They identify that companies have a reactive practice towards development, where companies try to follow the development in the market rather than shaping their own market in strategy processes which are characterized by being unstructured, undocumented and non-reflexive.

The table below compares the results from Thuesen, Koch and Nielsen (2010) with a similar study of SME in the general industry (DI 2011), showing that strategy processes among construction firms are not nearly as formalized and deliberate as in the industry.

Companies with ...	Industry companies	Construction companies
no strategy	19%	39%
a strategy	81%	61%
a strategy which is implemented	27%	17%

Table 4: Differences between industrial and construction companies' business development processes

The non-reflexive strategy combined with the fact that the input to the strategy direction does not differ significantly from competitors' input makes the companies move in the same direction as the competitors. Consequently will they reproduce the existing division of labour in the industry.

This development has resulted in that most businesses operate from a Cost+ model, making the companies compete on their overhead rather than their core processes (Nicolini et al 2001). In this sense the market place is characterised as a typical red ocean environment, where the companies in the absence of core competencies compete on their overhead rather than their ability to reduce production cost and create value – as described by Kim and Mauborgne (2004, 81):

Red ocean strategy	Blue ocean strategy
Compete in existing market space	Create uncontested market space
Beat the competition	Make the competition irrelevant
Exploit existing demand	Create and capture new demand
Make the value/cost trade-off	Break the value/cost trade-off
Align the whole system of a company's activities with its strategic choice of differentiation or low cost	Align the whole system of a company's activities in pursuit of differentiation and low cost

Table 5: Characteristic of red and blue oceans

Companies as innovation drivers – combining markets and competences

Thuesen, Koch and Nielsen (2010) stress that although the red ocean market puts pressure on margins in each company making them struggle for survival it also represents an opportunity for creating an uncontested market space pursuing a blue ocean strategy.

A premise for the development of a blue sea strategy, however, requires a conscious approach for business development. This is supported by the DI study which identifies that 48% of companies that have a formulated strategy expect growth in the coming years, while only 12% of those who do not have a strategy expect growth (DI 2011, p 3). So there is a connection between conscious business development and growth.

By upgrading business development skills of managers of construction companies, while at the same time providing them with an overview of the societal challenges which should be addressed and what potential tools and competences they can apply, we could potential realize an untapped potential for innovation in the industry's.

One of the classical approaches to strategy development is how company can combine competences and markets. The following figure, which is inspired by Ansoff growth matrix (Ansoff 1957), formulate strategy choices as a matter of combining new and existing competences and new / existing markets. In this way it can help to translate the concepts around niches and markets to the classic strategic tools.

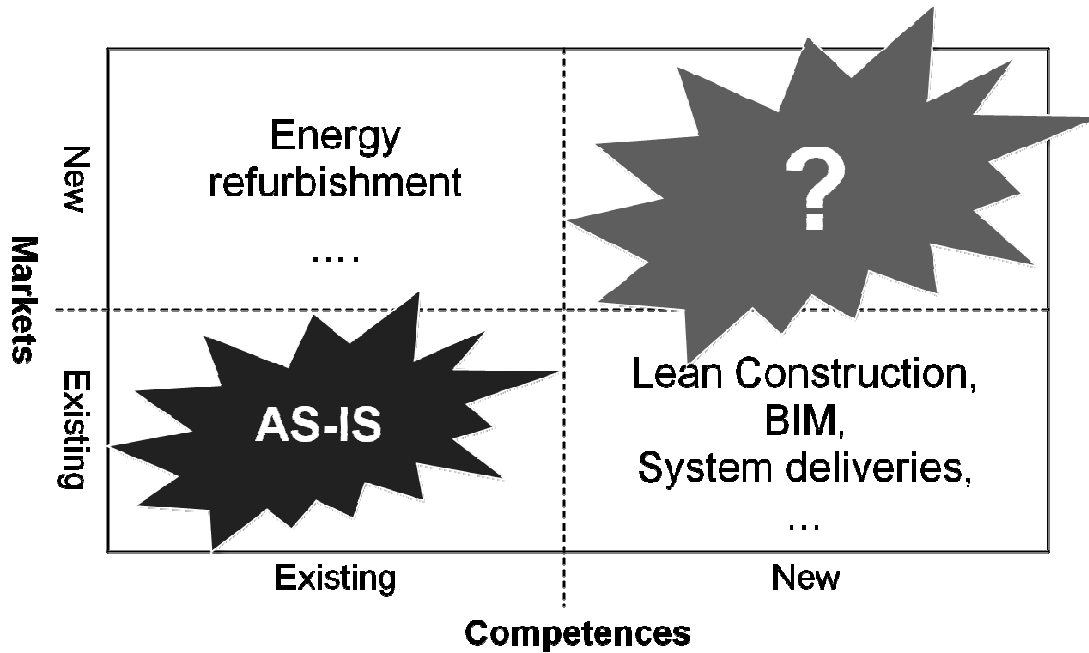


Figure 5: Strategy as a combination of market and competences

The companies which have to drive the innovation forward is neither large nor small, but a combination of different types and sizes, across sectors and roles. This means that companies do not have the same setup and hence not be able to make the same strategic choices. As an example it will be difficult for a small company to implement System deliveries because of the requirement to invested capital.

While the local strategic position of the company influences the possible strategic choices so do the internal compatibility of niches and markets. Not all the technologies/competences and markets that are well-matched. E.g. can the general market for energy renovations be addressed by System deliveries, LC and BIM, but if one have to build a one-of-a-kind opera houses, system deliveries would not be as relevant as LC and BIM. Conversely, will a project of energy refurbishment of an opera house not be suitable for system deliveries. It may therefore be beneficial to help businesses to assess which technologies can be applied to which markets as outlined in the following table.

Market	Energy refurbishment								
	Dwellings		Apartment blocks		Offices	Simple		Complex	
Submarket/-complexity	Small	Large	Small	Large		Small	Large	Small	Large
Size									
Niches / competence									
Lean Construction	-	-	+	+	+	-	-	+	+
System deliveries (component)	-	+	-	+	+	-	+	-	+
System deliveries (concept)	+	+	+	+	-	+	+	-	-
BIM	-	+	+	+	+	-	+	+	+

Table 6: Possible combinations of markets and competences

The table shows the possible good and bad matches between technological niches and market niches exemplified by markets around the energy refurbishment. As an example will it not be very wise to renovate single-family homes based on LC, as these type of projects typically are small are therefore not sufficient large to bear the costs of implementing the LC on each project. Conversely, will it be obvious to address a big market around the renovation of single family houses with System deliveries (e.g. the ones build in the 60-70'ies) since the size of the market easily could cover the development costs across projects.

This analysis is of course a gross simplification, but is nevertheless trying to describe what constitutes good combinations. Therefore it may be appropriate to subdivide "niches" like it have been done around System deliveries since the applicability of these is very different if they focus on building components or concepts for entire buildings.

The flexibility in which companies can experiment with linking various technical competences with potential markets will ensure the testing of various combinations of markets and competencies. By the different strategic choices the companies will drive the innovation and since some combinations will be more successful than others the level of innovation in the industry can be strengthened.

Innovation map

In order to make the companies capable of navigating in the innovation system – their strategic direction can be supported by a map.

A central premise for the facilitation of innovation through in this perspective is the development of a "language" through which the industry can understand and articulate innovation and strategies. Here it is appropriate to draw on the theories presented in this paper. Through concepts as niches, regimes, etc. these theories offers a typology which can be ordered in a map. Such a map could provide an overview and orientation points for navigating in the innovation system. Moreover, the map could clarify the interfaces of key players such as the different interest organizations and governmental institutions. Consistency and transparency in the innovation activities can be developed internally among government agencies and between public and private players including construction companies.

By combining the past, present and possible futures in an innovation map, companies can orient and position themselves strategically and thus be the basis for the launching development initiatives in the individual company. By creating an overview of innovation in

the industry, companies can reflect on where they want to go. Will/can we focus on the short or long term? Will we take the risks needed to invest in System Deliveries or should we just choose to deploy LC ... or should not do anything. In this way, the map will be a tool for a more focused and deliberate business development where leaders do not just subscribe to every existing development agenda, but work with a limited, compatible and consistent number of elements ... in relation to the company's existing competencies, the industry's current regimen, technological niches and potential markets.

From a company perspective two elements are necessary in such a map – information about niches and markets.

The analysis of the niches can be inspired by the methodology one presented in this paper focusing on rationality and the potential and barriers with the niche. Furthermore can information about the niche relation to the existing regime, involved actors, possible networks and funding possibilities.

The analysis of the market can build on existing market analysis. These analyses which traditionally include quantification of existing markets could be expanded to include future niche markets. Furthermore could the analysis be added extra dimensions such as; sustainability impact, addressability, return on investment, market homogeneity. The figure below illustrates such a market analysis of the market for energy refurbishment of the existing building stock in Denmark (Thuesen 2011).

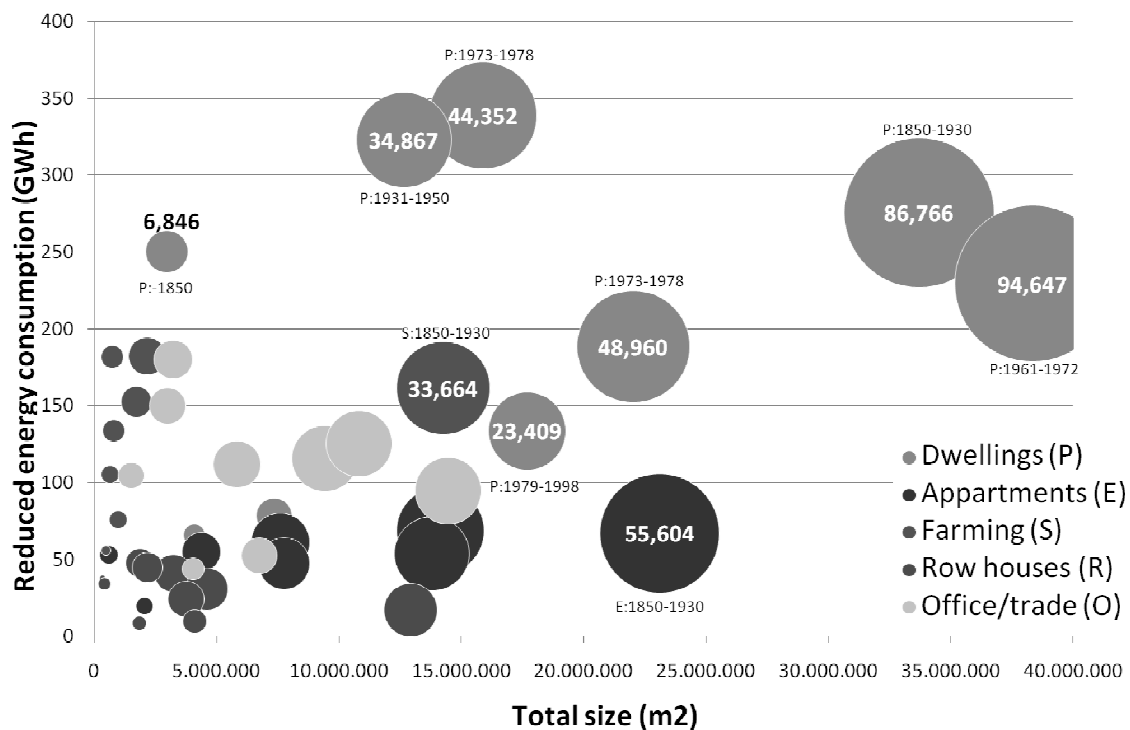


Figure 6: Quantification of market for energy refurbishment of the existing building stock (the size of the circles represents the market size in Billion DKK)

By adding different dimensions to the market analysis certain innovation agendas such as sustainability can be facilitated as it informs the company's strategic choices. In this way can the innovation map combined with aligned policy initiatives help to solve the challenge of

retrofitting the existing building stock and thereby enabling the development a low energy consuming society.

CONCLUSION

Based on the theoretical framework from strategic niche management research (SNM) the paper presents an analysis of three niches and a strategy for understanding and facilitating innovation activities in the sector by mapping the predominant regime, overall societal trends and different niches.

The analysis shows a multifaceted landscape of innovations around an existing regime, built in the existing ways of working and developed through generations. This regime is challenged from various niches and the socio-technical landscape through micro and macro trends. The detailed analysis of the three niches Lean Construction/Last Planner System, BIM, and System Deliveries, and their compatibility with the existing regime, show how they represent partly incompatible rationales and various degrees of innovation potential.

The conflicting rationalities among the niches internally and towards the regime put emphasis on reflexive strategy development in the companies. Thus is it important to develop strategies which will enable handling these differences in order to navigate in the innovation system.

By mapping some of the most influential trends and promising niche innovations and relate these to the existing paradigm, an innovation map can act as a medium in which policymakers, interest organization and companies can develop and coordinate future innovation activities.

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