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Energy Procedia 75 (2015) 2839 – 2845

Energy Procedia

The 7th International Conference on Applied Energy – ICAE2015

Categorizing barriers to energy efficiency in buildings

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Abstract

Introducing new technologies in buildings in Sweden have historically been connected with great portions of scepticism, hence influencing the speed of acceptance of new technologies. The speed is slow even though technologies are tested, evaluated, proven to make an impact, and economic efficient. In order to understand acceptance of energy efficient technologies in multifamily buildings and to identify the origin of barriers to energy efficiency this paper investigates barriers as consequences of the current *system structure* in the Swedish building sector. The study views the Swedish building sector as a sociotechnical system built from technical artefacts, institutions, and actors, thus often deeply embedded in our societies. The Swedish building sector is well structured, resulting in that innovation and development occurring outside of the existing sociotechnical regime might not be recognized as feasible investments. In order to identify the structures enabling barriers to energy efficiency adoption this paper aims at developing a framework for categorizing barriers depending on their structural origin. The categorization framework is inspired by theories of sustainable innovation journeys and of soft systems and distinguishes between three decision-levels for barriers to energy efficiency: Project level, Sector level and Contextual level. By implementing the proposed categorization framework it becomes obvious that problem areas in the building sector are not connected to any specific structural level. However, results in this study reveal that most barriers originate in the Contextual level, which implies that energy and sustainability are not yet key aspects when forming and transforming contextual preconditions on how to design and build multifamily buildings in Sweden.

Peer-review under responsibility of Applied Energy Innovation Institute

Keywords: Energy efficiency; barriers; categorizing; sociotechnical system; multifamily buildings; Sweden

1. Introduction

Introducing new technologies in buildings in Sweden is connected with great portions of scepticism, resulting in decreased speed of acceptance of new technologies. The speed of acceptance is slow even though technologies are tested, evaluated, proven to make an impact, and economic efficient [1]–[8]. In an interview study Anund Vogel et al [9] identified 38 barriers to implementing energy efficiency measures when building and refurbishing multifamily buildings in Sweden (see Table 1). However, the

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Peer-review under responsibility of Applied Energy Innovation Institute
doi:10.1016/j.egypro.2015.07.568

barriers are vastly different from each other, origin from different areas and structural complexity levels in the Swedish buildings sector. In order to understand acceptance of energy efficient technologies in multifamily buildings and to identify the origin of barriers to energy efficiency this paper investigates barriers as consequences of the current *system structure* in the Swedish building sector. In this study the Swedish building sector is viewed as a sociotechnical system [10]–[13], built from technical artefacts, institutions, and actors, thus often deeply embedded in our societies. The Swedish building sector is well structured, resulting in that innovation and development occurring outside of the existing sociotechnical regime might not be recognized as feasible investments. In order to identify the structures enabling barriers to energy efficiency adoption this paper aims at developing a framework for categorizing barriers depending on their structural origin. Inspired by Schot and Geels [12] theories of sustainable innovation journeys and Checklands [13] theories of soft systems this paper proposes a novel categorization framework for barriers to energy efficiency in buildings. The framework distinguishes between three decision-levels when building and refurbishing multifamily buildings: Project level, Sector level and Contextual level, each with their own sets of guiding principles, rules, and timeframes that have to be acknowledged when investigating barriers to energy efficiency.

2. Analytical levels for technology diffusion

In order to understand the actual acceptance (or movement) of technologies from single building projects to becoming a regular part of how multifamily buildings are produced in Sweden, this study is inspired by Schot and Geels [12] theories of sustainable innovation journeys. Schot and Geels distinguish between three analytical levels to understand diffusion of technologies: Technological niches, Sociotechnical regime, and Sociotechnical landscape.

The Niche level is derived from the idea that radical novelties (innovations) are developed in niches that enable cross-disciplinary experimentation. The niches enable specified interactions between issues and actors. Well-developed niches are suggested to act as building blocks for change; they are central for regime shifts. Niches are often subsidised to support as yet non-profitable innovations with the expectation of future societal benefits [12].

The Sociotechnical regime can be expressed as the rule-set embedded in “engineering practices, production process technologies, product characteristics, skills and procedures, ways of handling relevant artefacts and persons, ways of defining problems; all of them imbedded in institutions and infrastructures” [14]. Sociotechnical regimes ensure stability in systems; i.e. they dictate guiding principles for products and processes.

The sociotechnical landscape is according to Schot and Geels [15] characterised by the set of rules that guide technical design, the rules that shape market development and rules for regulating these markets. The socio-technical landscape includes the institutional and market aspects required in order for lower levels to function.

These three analytical levels are central when investigating technology transfer. Is it possible to transfer these levels onto the Swedish building sector? In order to do so this paper chooses to view the Swedish building sector as a sociotechnical system, consisting of multiple sub-systems, a system boundary, and a surrounding environment.

3. The Swedish building sector viewed as a sociotechnical system

This study view the Swedish building sector as a sociotechnical system [10], [11], built from technical artefacts, institutions, and actors, thus often deeply embedded in our societies. The sociotechnical system “the Swedish building sector” is composed of different sub-systems which are defined using the concepts in Soft System Methodology (SSM) Checkland [13]. In SSM critical problems (barriers to energy efficiency implementation in this case) are viewed as parts of a system. A system can be defined as "interconnected sets of elements that are coherently organised in a way that achieves something" [16]. These systems are composed of sub-systems, which in turn might consist of yet another level of sub-sub-systems. Below all the system-levels there are system components, the building stones of the systems. Above the system level is the environment, consisting of the factors that influence the system but cannot be changed by the system. The system boundary separates the system from the environment [13].

This study proposes four levels of hierarchy when describing the Swedish building sector as a sociotechnical system (Figure 1):

- The *Component level,* consisting of specific technologies and their associated costs, for example heat pumps or vacuum insulation panels. This level could arguably be what Schot and Geels [12] call "Technological Niches". This level is characterized by singularity, leaving system benefits to the higher levels.
- The Project level, consisting of single building projects characterized by relatively low levels of freedom of interpreting the institutional frameworks governing the level. The process of building and refurbishing multifamily buildings is performed as projects, which can be defined as "a temporary endeavour undertaken to create a unique product of service" [17]. The term temporary means that the project has a definite beginning and end, and the term unique means that the product or service produced is to some extent different from all other products or services produced [17]. The Project level has a relatively short time frame, approximately 5 years, from the start of the planning process to the end of the construction works.
- The Sector level, consisting of companies, organizations, institutions etc. This level shows similarities with the sociotechnical regime described in section 2 in that it contains the institutional framework governing actions at this level and also strongly influencing lower levels. The Project level and the Sector level are in this study separated due to different timeframes and levels of freedom. Actions such as adding exterior insulation could be perceived as a barrier if having a narrow timeframe, but not accompanied with the same problem structures if extending the timeframe and scope. Areas perceived as barriers at the Project level could in the Sector level be tackled by strategies and long term planning in companies and organizations.
- The contextual level is the complex interrelated web, the framework needed in order for lower levels to function. This level can be viewed as the sociotechnical landscape as described in Section 2. This level is characterized by rules and regulations that influence technological design and market development, everything that can influence the lower levels but cannot be changed by them, within the lower levels timeframes.

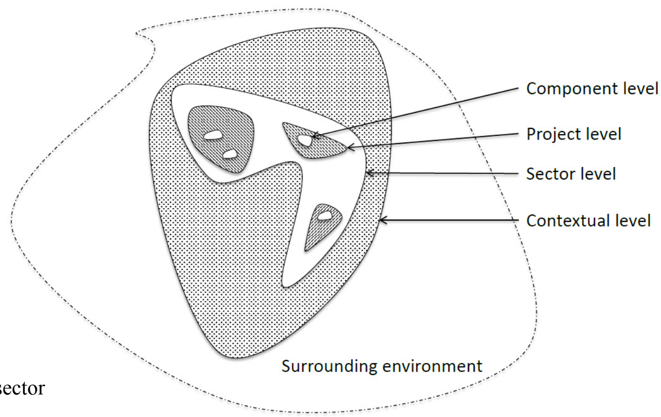

Figure 1 – Levels of hierarchy in the Swedish building sector

The hypothesis of this paper is that energy efficiency technologies exists, but are not used to the extent they could. How these innovative technologies develop and what barriers arise at Component level is due to that precondition of no actual concern in this study. The environment is also left outside the scope of this study due to the fact that it contains parts irrelevant to the purpose of the study. In order to investigate the structural complexity, the origins of barriers to energy efficiency, this paper further investigates three out of the four decision-levels described above; Project level, Sector level and Contextual level.

4. A hierarchical framework for categorizing barriers

Barriers to energy efficiency can, and have been, categorised in several different ways. Sorrell et al [18] introduces the classification market failures, organisational failures, and non-failures, and Weber [19] classifies the barriers as institutional, obstacle conditioned by the market, organisational, and behavioural. However, this study aims at investigating barriers that inhibit energy efficiency adoption in building projects in Sweden, more precisely when building and refurbishing multifamily buildings in Sweden. The hypothesis of this paper is that there are multiple techniques for lowering the energy usage in multifamily buildings that are not being used, even though they are economically feasible. The Swedish building sector is well structured, resulting in that innovation and development occurring outside of the existing sociotechnical regime might not be recognized as feasible investments [20], [21]. In order to identify the structures enabling barriers to energy efficiency adoption this paper proposes a framework for categorizing barriers based on the structural origin of barriers. Barriers are categorized into three analytical decision-levels:

1. Project level (Singular building projects):
2. Sector level (Swedish building industry):
3. Contextual level (Institutional framework for the two lower levels, rules and regulations, geography etc.)

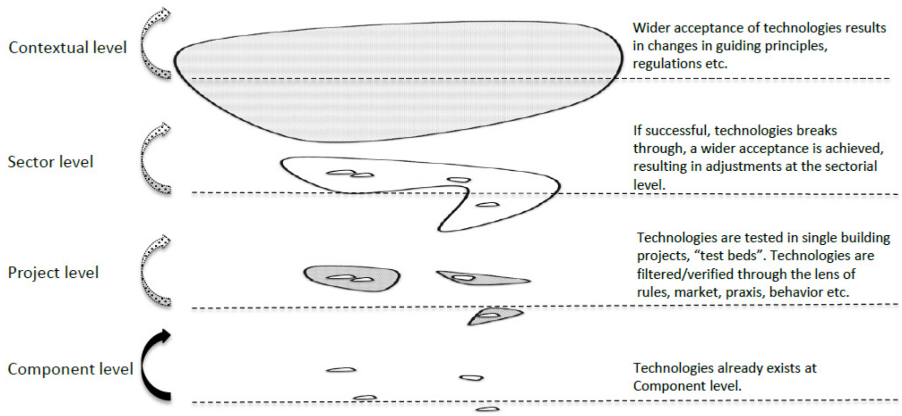

Figure 2 – Hierarchical level framework for categorizing barriers to energy efficiency

5. Results – categorizing the barriers

Barriers identified by Anund Vogel et al [9] are categorized using the framework described in section 4. Barriers are categorized from the developers point of view and also by taking the different timeframes of the levels into account. Each barrier is categorized by asking the questions "Can I do anything about it?" and "Does it matter relative to the objectives?"[22]. If the answer is "Yes" to both questions, then the barrier is categorized as belonging in the "Project level"; if "No" to the first question and "Yes" to the second question, then the barrier is categorized as belonging in either the "Sector level" or the "Contextual level". A third question is then asked "Can I do anything about it if expanding the timeframe and widening the scope, including also future building projects and new strategies?". If the answer is "Yes" then the barrier is categorized as belonging in the "Sector level", otherwise the "Contextual level".

The first barrier presented by Anund Vogel et al [9] will here serve as an example. The barrier "1.1 - Lacking project goals and objectives" is further described as follows: "Lacking project objectives and goals when refurbishing multifamily buildings is according to the interviewees a barrier for implementing energy efficiency measures. Without early-adopted energy related project objectives and goals, the possibility of reaching lower energy usage and sustainability in projects decreases" [9]. The answer to the first question "Can I do anything about it?" is "Yes", taking both the developers point of view as well as the project time frame into consideration. The answer to the second question, "Does it matter relative to the objectives?" is "Yes". This results in that the specific barrier is categorized into the Project level. By following this method, the 38 barriers presented by Anund Vogel et al [9] were categorized as presented in Table 1.

Table 1 – Categorized barriers to energy efficiency, identified by Anund Vogel et al [9]

System structure	Barrier to energy efficiency implementation
Contextual level	2.1 - Weak national energy regulations when refurbishing buildings 2.2 - Incoherent national and municipal energy regulations 2.3 - Ambiguous energy related rules and regulations 2.4 - Unclear incentives for the market to reach energy targets 2.5 - Regulations or certifications, or both? No common way forward when planning multifamily 2.6 - Weak national R&D inhibit regulation development 2.8 - Certifications and geography 3.1 - Cut up planning process 3.2 - Broken Agency - different incentives for different actors 3.3 - Lack of contact areas between energy user and energy producer 3.4 - Agreement structure do not promote innovation or the use of emergent technologies 4.3 - Altering energy agreements 4.4 - Low transparency of energy pricing models 4.5 - Innovation and technology advancements not in line with the planning process 4.6 - Vague or non-existing incentives for distributed energy production 4.7 - Buildings as part of the energy system
Sector level	1.2 - Weak or lacking feedback structures 1.3 - Resistance to change 1.7 - Weak communication structures between companies, organizations, and academia 2.7 - Lacking system view, leading to lost opportunities 3.5 - Lacking comprehension of system benefits 5.2 - Technology lock-ins 5.3 - Extensive feedback cycle time 5.4 - Research & development only at company levels constrain progress 5.5 – Weak or non-existing incentives for using latest technology 6.5 - Innovation budgets coupled to project budgets 6.6 – Technical accounting rules not in line with life spans of the products
Project level	1.1 - Lacking project goals and objectives 1.4 - Lacking knowledge of details in projects 1.5 - Time dependent knowledge 1.6 - Actor dependent knowledge 4.1 - Lacking knowledge of and interest in energy related topics 4.2 - Low interest of future energy related topics 5.1 - Lacking transparency weakens system benefits 6.1 - Perceived increase of operation costs and risks with introduction of new technology 6.2 - Insufficient and inconsistent calculation methods 6.3 - Lacking knowledge about investment horizons, risks, and life spans 6.4 - Lacking transparency in numbers

6. Concluding remarks

This paper creates a novel framework for categorizing barriers depending on their structural origin, this in order to understand where barriers arise in the current system structure of the Swedish building sector. By implementing the proposed categorization framework on barriers to energy efficiency it becomes obvious that problem areas in the building sector are not connected to any specific structural level; 18 of the 38 identified barriers have their origin in the Contextual level, 11 in the Sector level, and 11 in the Project level. This means that most of the areas hindering change in buildings origin at levels of hierarchy unreachable for actors in single buildings projects, once the projects have started. Moreover, the largest parts of the barriers have their origin in the Contextual level, the hierarchical level furthest away and hence hardest to influence for the building owner/developer. During the last years, investments have increased in pilot projects and arenas for innovation connected to buildings and sustainability. However, results in this study reveal that most barriers originate in the Contextual level, which implies that energy and sustainability are not yet key aspects when forming and transforming contextual preconditions on how to design and build multifamily buildings in Sweden. The outcomes of pilot projects are apparently still to be further evaluated before having any substantial impact on design principles and regulations in the Swedish building sector.

So how can we eliminate these identified barriers? This paper does not give the answers but the means to further investigate the problem situation. The way buildings are designed and the way new technologies are accepted is deeply embedded in the structure of the building sector. In order to reach substantial change there is a need not only to address specific practices and technologies, but also to address wider cultural and institutional structures. Future research will further investigate the conditions in the different levels of hierarchy that enables barriers to energy efficiency in Swedish multifamily buildings.

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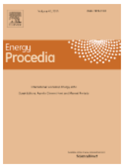

Biography

Jonas Anund Vogel, Ph.D candidate at Royal Institute of Technology in Sweden since 2011. Investigating barriers to energy efficiency in multifamily buildings. Focusing on how the system structure in the Swedish building sector creates opportunities for barriers to arise, this in order to identify how to eliminate the barriers.