Lessons learned on lessons learned: Gathering knowledge on energy-efficient rehabilitation of buildings

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Abstract

Sustainability and energy efficiency are topics that have gained much attention recently in many industries, including building and construction. Many national and international research projects have aimed at both developing technology and efficiently using existing technology over the course of last twenty years. Yet, the industry is lagging far behind other sectors with regards to putting available technology to good use. One important reason for this is the gulf that exists between the research as expressed in the scientific literature and the practice-oriented world of building construction and rehabilitation.

This paper describes an application of two methods for conducting literature review and collecting experiences from real-world application in order to efficiently synthesize knowledge from "both worlds". The methods are: structured literature review (SLR) of scientific articles and narrative literature review (NLR) of recommended, practical solutions. In this paper, (1) central characteristics of these methods are presented, (2) Usage of these methods is described, and (3) how these methods can be seen from the perspective of knowledge management / acquisition is discussed. As examples, few findings obtained from SLR and NLR are provided in order to complement the whole discussion.

This paper aims to make two major contributions to research and practice: The first contribution is that it addresses certain methodological issues related to gathering knowledge from both the scientific realm and practice. The other contribution is developing a knowledge base: The process through which the two literature review methods are applied, will result in a collection of knowledge / "best practices" regarding construction and renovation of energy efficient buildings. This knowledge will then be shared with others, and hence contribute to accomplish greater benefits. This paper looks at one of the aspects of "best practices" – namely, key performance indicators (KPIs).

This paper is connected to an EU-project called "Rezbuild", which focuses on developing decision and planning support for accomplishing near zero-emission in refurbishment of dwellings. One of the tasks in this project is to collect existing knowledge on better energy efficient solutions for near zero-emission buildings.

Keywords: Energy efficiency, Knowledge acquisition, Literature review, SECI model, Building refurbishment, Key performance indicator (KPI)

1 Introduction

Sustainability and energy efficiency are topics that have gained much attention recently in many industries, including building and construction. Referring to previous studies, Johansson et al. (2017) say that buildings are responsible for 30 – 40 % of global carbon emissions and that there is hence a significant improvement potential for energy saving in the building sector. This view is also reflected by Baumhof et al. (2018).

In addition to the existing buildings, there is new construction. New construction efforts are expected to increase the current stock at a rate of 1% per year (Vilches et al, 2017; Xing et al., 2011). In this context, what will be the status of building renovation? In this regard, it is relevant to look at a description provided by European Commission (2015, page 11):

> The biggest challenge when reducing energy use in buildings is to increase the rate, quality and effectiveness of building renovation (currently only at 1.2%/year). To do this, it is necessary to reduce renovation costs and also to increase the speed at which it can be carried out in order to minimise disturbance for occupiers. To achieve an ambitious increase of the renovation rate (up to 2-3% per year), effective solutions need to be widely demonstrated and replicated.

The above description not only points out the importance of building renovations in the future of the European building sector, but also sets the premise of this paper; that is, replicating effective solutions, learning from lessons learned.

Many national and international research projects have aimed at both developing technology and efficiently using existing technology over the course of last twenty years. Yet, the industry is lagging far behind other sectors with regards to putting available technology to good use. One important reason for this is the gulf that exists between the research as expressed in the scientific literature and the practice-oriented world of building construction and rehabilitation.

This paper describes an application of methods for conducting literature review and collecting experiences from real-world application in order to efficiently synthesize knowledge from "both worlds". The methods are: structured literature review (SLR) of scientific articles review and narrative literature review (NLR) of real-world applications. In this paper, (1) central characteristics of these methods are presented, (2) usage of these methods is described, and (3) how these methods can be seen from the perspective of knowledge management / acquisition is discussed. As examples, few findings obtained from SLR and NLR are provided in order to complement the whole discussion.

This paper aims primarily to make two major contributions to research and practice: The first contribution is that it addresses certain methodological issues related to gathering knowledge from both the scientific realm and practice. Methodological issues (such as how existing knowledge is identified / gathered) play a notable role in making knowledge management efforts effective. The other contribution is developing a knowledge base: The process through which the two literature review methods are applied will result in a collection of knowledge / "best practices" regarding construction and renovation of energy efficient buildings. Though there is growing interest in sustainability and energy efficient solutions, it is a challenge to gather relevant knowledge, sort it out and identify what is relevant for practice. Therefore, developing a knowledge base is important. The knowledge will then be shared with others, and hence contribute to accomplish greater benefits. In this paper, we look at one of the aspects of "best practices" – namely, key performance indicators (KPIs).

This paper is connected to an EU-project called "Rezbuild" (https://rezbuildproject.eu/), which focuses on developing decision and planning support for accomplishing near zero-emission in refurbishment of dwellings. One of the tasks in this project is to collect existing knowledge on better energy efficient solutions for near zero-emission buildings within the context of renovation.

It is to be noted that we use the terms "rehabilitation", "renovation", "retrofit" and "refurbishment" interchangeably in this paper.

The structure of the paper is as follows: Following the introduction, Chapter 2 describes some key characteristics of systematic and narrative literature review methods and their usage in this study. Chapter 3 presents few

results from the two types of literature review methods. Chapter 4 looks at these two review methods from the perspective of knowledge acquisition. In this regard, a model developed by Nonaka and Takeuchi (1995) is sued. Finally, concluding remarks winds up the whole discussion.

2 Literature reviews

Hart (1998, page 13) provides the following definition of literature review:

> The selection of available documents (both published and unpublished) on the topic, which contain information, ideas, data and evidence written from a particular standpoint to fulfil certain aims or express certain views on the nature of the topic and how it is to be investigated, and the effective evaluation of these documents in relation to the research being proposed.

When defining the term literature review, Ridley (2012) points out that the term can be considered in two parts; namely, as a product – a completed description (result) of a literature review, and as a process through which the review is done. In the following sections of this paper, we will focus on the process-part of literature review. In this regard, we will look at two different methods / approaches:

- Systematic literature review
- Narrative literature review

2.1 Systematic literature review

Aarseth et al. (2017, page 1073) say that systematic literature review "is generally considered to be superior to in terms of transparency as other researchers can more easily verify the findings of the study by replicating the research setup". This means that the steps related to the review process, specially search for relevant literature, adheres to a set of clearly defined selection criteria.

Now, we will look at how we did our systematic literature study. First, few sample articles that had been published in a relevant scientific journal were studied in order to identify search terms that were to be used in the literature search. As a result, the following terms were identified: (1) Renovation (2) Refurbishment (3) Renovation (4) Rehabilitation (5) Energy efficient (6) Sustainability (7) Building (8) Construction

We selected certain scientific journals to look for relevant articles that had been published between 2016-2018. Based on the theme and focus-area of the journals, we combined the search terms differently in order to ensure obtaining as many relevant articles as possible. Table 1 presents names of the journals and the search terms that were applied.

Table 1: Identification of relevant articles

Name of the journal	Combination of the search terms	Number of articles obtained
Building and Environment	(retrofit OR rehabilitation OR refurbishment OR renovation) AND (sustainability OR "energy efficient")	08
Construction Innovation	(retrofit OR rehabilitation OR refurbishment OR renovation) AND (sustainability OR "energy efficient")	04
Construction Management and Economics	(retrofit OR rehabilitation OR refurbishment OR renovation) AND (sustainability OR "energy efficient")	13
Energy and Building	(retrofit OR rehabilitation OR refurbishment OR renovation) AND (sustainability OR "energy efficient") AND (building OR construction)	58
Facility	(retrofit OR rehabilitation OR refurbishment OR renovation) AND (sustainability OR "energy efficient")	15
International Journal of Project Management	(retrofit OR rehabilitation OR refurbishment OR renovation) AND (sustainability OR "energy efficient") AND (building OR construction)	20
Sustainability	(retrofit OR rehabilitation OR refurbishment OR renovation) AND (building OR construction)	28
Cleaner Production	(retrofit OR rehabilitation OR refurbishment OR renovation) AND (building OR construction)	20

In total, we obtained 168 articles through the search process.

We chose to use the search terms in the full texts of articles published in the above journals, but with two exceptions: When it comes to the journals, "Building and Environment" and "Energy and Buildings", we applied the search terms only in the title, abstract and keywords, since there were several hundreds of articles (all of which are not necessarily providing the degree of detail that we aim to obtain in our research) , and hence we had to narrow down the search and selection of relevant articles.

The identified articles can be considered as a knowledge-base in which we can learn about various case studies and best practices. As we mentioned earlier, in this paper, we look at one of the aspects of "best practices" – namely, key performance indicators (KPIs).

When it comes to identifying KPIs in the selected articles, we used the search terms, "KPI", "indicator" and "performance". If we did not find any results in an article, then we read abstract and other parts of the article to find out whether the article had any relevant information that could serve our purpose.

2.2 Narrative literature review

Narrative literature review looks at various studies of a topic, and allows the reviewer to obtain an understanding of various views associated with the topic, and to make a holistic interpretation of the studies by using his / her experience as well as existing theories and models (Campbell Collaboration, 2001; Kirkevold, 1997).

Another description of narrative literature review is as follows:

> It can inspire research ideas by identifying gaps or inconsistencies in a body of knowledge, thus helping the researcher to determine or define research questions or hypotheses. […] It can also be helpful in developing conceptual or theoretical frameworks (Cronin et al., 2008, page 1).

Jahan et al. (2016), referring to previous studies, point out that the narrative literature review is more informal compare to systematic literature review, and it does not necessarily require to report more rigorous aspects that characterize structured literature review – aspects such as research methodology, search term, database that was used, and inclusion as well as exclusion criteria.

Another characteristic related to this narrative literature review could be the subjective nature of the study. Hence, the study could be colored by the researcher's professional background and experiences. However, it is important to note – as we mentioned earlier – that the narrative literature review allows the researcher to make a holistic interpretation of the studies by using his / her experience as well as existing theories and models (Campbell Collaboration, 2001; Kirkevold, 1997).

As a result, narrative literature review does not follow the extent of structured approach that the systematic literature review adopts. The search starts normally from one or more known sources of knowledge, and then based on the available knowledge and information from the previous search-results, further sources of knowledge are identified and relevant knowledge is obtained.

We started our search for other research and development (R&D) projects that have similar thematic focus as our R&D project "Rezbuild", by first going through projects that our research institution has been involved in. And then, we use Google search to find out other R&D projects in Europe and other parts of the world. Our initial search resulted in forty-seven R&D projects. Once we have obtained information on these projects, we search for KPIs in these projects by using search terms, such as "KPI", "indicator", and "performance".

3 Summary of the results

As it is mentioned earlier, one of the contributions of this paper (in addition to discussing knowledge search and other methodological issues) is developing a knowledge base: The process through which the two literature review methods are applied will result in a collection of knowledge / "best practices" regarding energy efficient buildings. In this paper, we looked at one of the aspects of "best practices" – namely, key performance indicators (KPIs).

The main aim of this paper is to describe and discuss the literature review methods that we adopt in order to find KPIs connected to near zero-emission in refurbishment of dwellings. In this regard, presenting the results (all identified KPIs) is not the primary focus of this paper. However, we will briefly present some results as examples (cf. Table 2). We consider that the results that we present here are a kind of a snap-shot, and we hope that these examples complement our main discussion.

Table 2: Some results - KPIs

Systematic literature review	Narrative literature review
Heat transfer	Energy use for space heating
Percentage of discomfort hours	Energy use for cooling and dehumidifcation
Primary energy consumption	Payback period
Global cost	GHG indicator
Polluting emissions	Energy use for lighting
Energy saving for lighting	Energy use by energy carrier
A pay-back period	Grid interaction
Compliance with national standards	Life Cycle Cost

Preliminary study on the results that we have obtained from the literature study so far point out that most of the cases represent Northern European countries. The "Rezbuild" project will continue to study the results further and actively publish the results in near future.

4 Reflection and discussion

As it was mentioned earlier, systematic literature review and narrative literature review have their own characteristics. Some of these characteristics are compared and summarized below (cf. Table 3).

Table 3: Comparison of few characteristics of systematic literature review and narrative literature review (based on Green et al., 2006 and Ferrari, 2015)

Systematic literature review	Narrative literature review
Clearly defined criteria for the selection of articles from the literature.	Describe and appraise published articles but the methods used to select the articles may not be described.
Comprehensive research to find all the relevant studies within a set of clearly defined boundary / criteria. Identify, assess and synthesize the literature gathered in response to a specific query.	General debates, appraisal of previous studies and the current lack of knowledge. Often describe the history and development of a problem or its management.
Comprehensive report with explicit processes so that rational, assumptions and methods are open to examination by external organizations	Helpful in presenting a broad perspective on a topic. Do not have the degree of comprehensiveness that characterizes systematic literature reviews.

Different characteristics of these two review methods complement each other and strengthen the study. To study a topic from two approaches generally provides a better understanding of the topic. A wider knowledge can thus be created through applying different approaches. As it is mentioned earlier, the study which this paper is based on, focuses on identifying key performance indicators (KPIs) related to energy efficient solutions in buildings, both in the scientific publications and in the R&D projects. And, the aim here is to increase the knowledge of contemporary KPIs in this field. In addition to increase knowledge on the subject area, the study that this paper represents, also looks at the process through which the knowledge is obtained; that is, applying two different approaches – systematic and narrative literature reviews – to search for and identify relevant sources of knowledge and obtain the required knowledge.

4.1 From the perspective of knowledge management

Though there are several differences between a systematic literature review and a narrative literature review, we will look at some of their major aspects from the point of view of knowledge acquisition in detail in this paper. In this regard, we will first present a model.

A process of obtaining knowledge can be described in various models. For our purpose, we can look at the following self-explainable model for knowledge acquisition (cf. Figure 1):
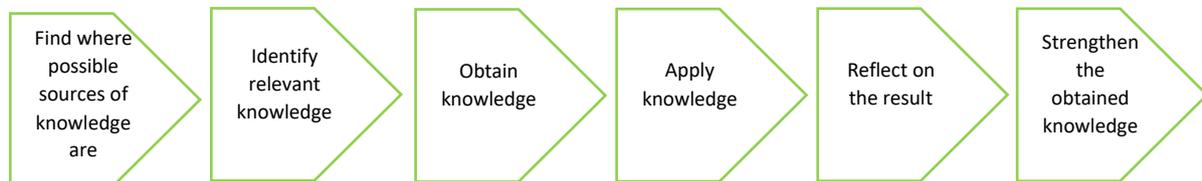
Figure: 1: A model for knowledge acquisition

Having this model on one side, we will now look at major steps that are associated with systematic literature review through the lens of knowledge acquisition.
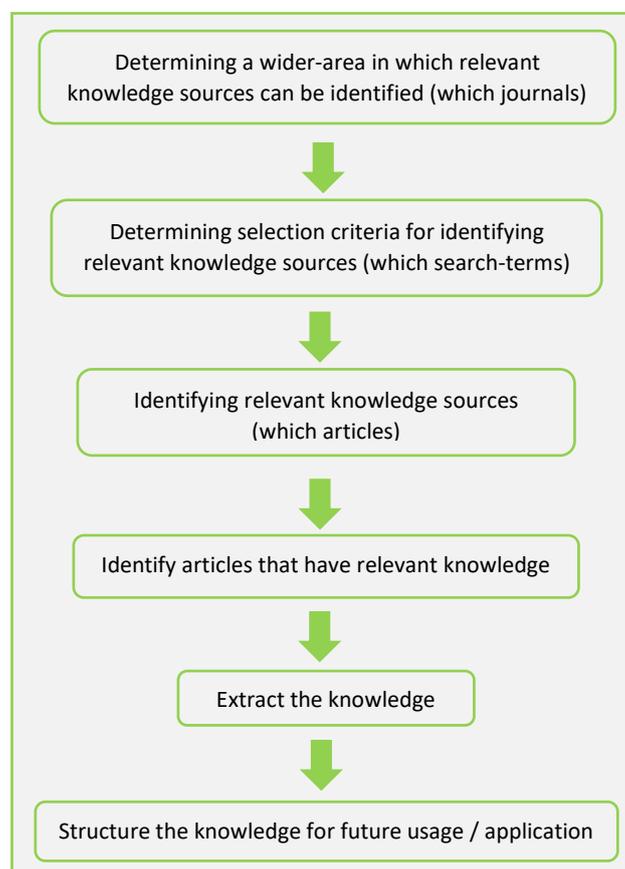
Figure 2: Learning and knowledge sharing steps involved in this paper

Figure 2, in a way, elaborate the first three activities mentioned in Figure 1.

An explicit description of the process through which sources of knowledge are identified, can strengthen the future knowledge sharing processes. This kind of systematic approach not only makes it easy for a knowledge-seeker to search for and obtain the required knowledge, but also contribute to strengthen the reliability of the results that were obtained initially. In this regard, it is relevant to refer a definition of reliability within the context of knowledge acquisition and development: "Reliability refers to whether the data collection techniques and

analytic procedures would produce consistent findings if they were repeated on another occasion or if a different researcher replicated them" (Zidane, 2018, page 57; Saunders et al., 2012). This reliability contributes to increase not only the usability of the knowledge, but also the legitimacy of the knowledge. This legitimacy stems from the fact that the knowledge accompanies a systematic description of the context in which the knowledge is developed. Contextual information that is associated with knowledge is important to take into consideration, when it comes to sharing / transferring the knowledge (Ekambaram, 2008). In the case of conducting a systematic literature review, information about both criteria for selecting relevant articles and the content of the selected articles act as contextual background, and can thus justify the relevance of the results (of the systematic literature study) within the well-defined context. This can have two major implications:

- Product: Since the knowledge that is presented also provides the conditions that framed and structured the knowledge acquisition process, it will lead to better understanding of the knowledge.
- Process: The process through which the knowledge is created is made explicit. This can help another person to make use of this processual knowledge.

Narrative literature review provides a general and wider understanding of a topic since the knowledge is obtained from various relevant arenas that can represent various time periods. The extent of the search for relevant knowledge sources (in our case, relevant literature) is guided by the researcher's subjectivity to a greater extent, compared to systematic literature review. The degree of freedom can allow the researcher to find very interesting information and / or view-points that can elaborate the topic of consideration more. The activities mentioned in Figure 1 are relevant for narrative literature review too.

4.2 The SECI model

Now, we will look at the learning process behind the literature review that we adopt in this paper with respect to a model that Nonaka and Takeuchi (1995) describe. Nonaka and Takeuchi (1995) present a model for knowledge creation in companies. This model is widely called as the SECI model. This model describes mechanisms that are involved in knowledge creation: Socialization, Externalization, Combination, and Internalization (SECI). Figure 3 illustrates this.
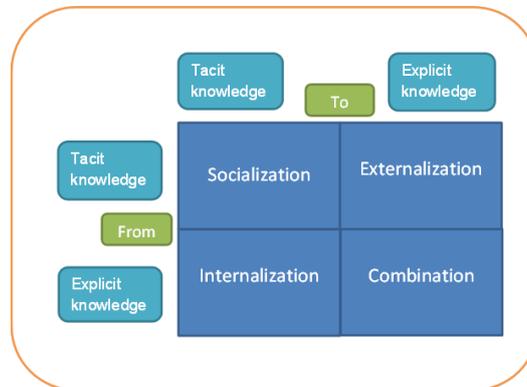
Figure 3: SECI model (Nonaka & Takeuchi, 1995)

As the SECI model describes, socialization is a process that contributes to transfer tacit knowledge. Externalization is to make the tacit knowledge explicit with words and expressions. Combination is a process that contributes to combine the externalized knowledge with relevant existing (explicit) knowledge. Institutionalization is about making the newly created knowledge as an integral part of the work practice.

We can consider the SECI model with respect to our literature review in three dimensions:

- The search process involved in narrative literature reviews is more of tacit nature. Even though a researcher uses various (explicit) search-terms in this process, the choice of the search terms and the search process can be based on (at least, partly) the researcher's gut feeling or intuition. One the other hand, systematic literature review makes the search process explicit, since, for instance, there are well-defined search terms, exclusion-inclusion criteria, and knowledge sources. In other words, systematic

literature review contributes to transforming tacit knowledge to explicit knowledge. The transformation (for instance, from a tacit search process to an explicit one) happens through discussion between the researchers who are involved in this study and collective reflection. Boud et al. (1996) suggest that reflective skills are needed in order to turn an experience into learning. When reflection is considered in connection with a professional action that an organizational member participates, then it can be viewed as reflection-on-action and reflection-in-action (Schön, 1998). Reflection-on-action is a process in which the individual reflects on his or her past experience or on a future act deliberately or unintentionally. Reflection-in-action is a process in which the individual reflects on what he or she is experiencing while he or she is engaging in the activity. These two processes play a notable role in making the tacit knowledge explicit in our study.

- Our literature study is to find published ("externalized") knowledge with respect to our research topic, structure the results that we have obtained from various sources of knowledge and present them in a structured, coherent manner so that it can be easily "combined" and then applied in new work-settings.

- The SECI model, and specially the tacit dimension of knowledge mentioned in the model, point out the importance of paying adequate attention on (1) understanding KPIs and best practices identified in the literature review within their respective contexts, and (2) making appropriate transformation of the obtained knowledge, if necessary, before applying it in other contexts.

5 Concluding remarks

The overall aim of the study – from which this paper was developed as one of the outcomes – is to gather existing knowledge ("best practices") on construction and renovation of energy efficient buildings, with the aim of sharing the "best practices" with others. This paper looks at one of the aspects of "best practices" – namely, key performance indicators (KPIs).

Sharing knowledge is of primary concern for research and development. It is essential to understand how relevant existing knowledge is identified and gathered. This will provide the necessary contextual information that can be useful for modifying / transforming the original (existing) knowledge before applying it in a new setting. The required modification will ensure the positive impact of the knowledge.

This paper focused on application of two literature review methods, namely systematic literature review (of scientific articles) and narrative literature review (of real-world applications). In this paper, some key characteristics of these methods were presented; usage of these methods was described; and, how these methods could be seen from the perspective of knowledge acquisition was discussed. Few findings obtained from these two review methods were provided as examples in order to complement the whole discussion.

With this background, the contribution of this paper can be described as follows:
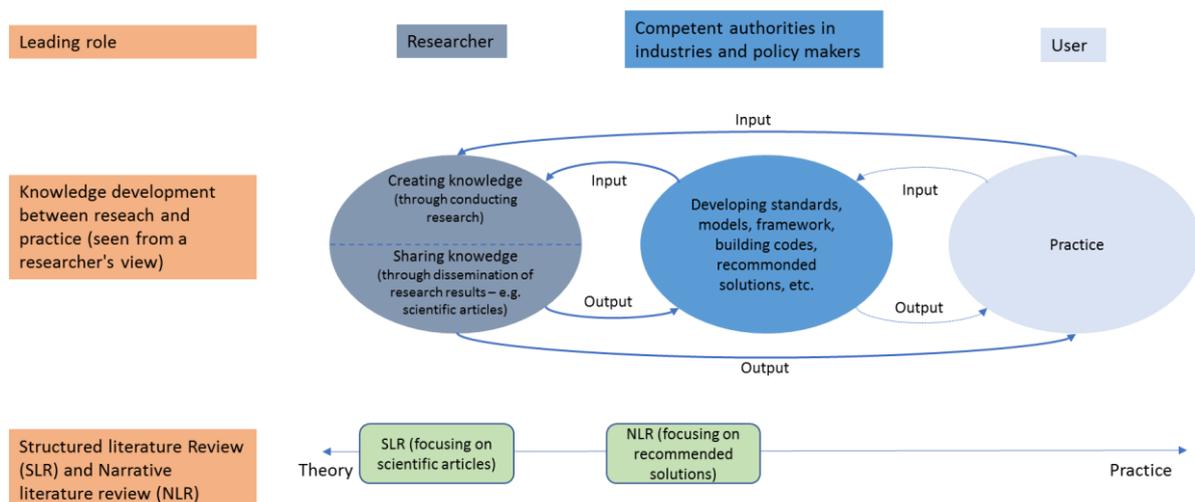
Figure 4: Contribution of the paper

Figure 4 describes knowledge development between research and practice from a researcher's perspective. One of the ways to develop knowledge through research projects is to gather relevant information directly from individual practitioners on their actual practice and from competent authorities in industries on standards and recommended solutions, analyze the information and present results. The results can be shared with the practitioners and / or the competent authorities in industries in order to improve work-performance. As Figure 4 illustrates, identifying best practices and KPIs through narrative literature review (of standards and recommended solutions) is at least one step closer to practice, compared to structured literature review (of scientific articles). In other words, the study that this paper is based on (identifying KPIs related to the application of energy efficient solutions) considers two different stages of the theory-practice-spectrum. Consideration on these two stages also point out the contribution / implication of the study for the academia and the industry.

There are varying view-points on standardizing knowledge. Certain types of knowledge can be standardized in order to generate more benefits. But, certain other types of knowledge cannot be standardized. They are, for example, of fluid or tacit nature, and hence do not susceptible for standardization (formalization). As in the case of knowledge, standardization also varies with regard to the process of identifying / acquiring knowledge. Systematic literature review, in a way, represent the standardization, or at least it makes an attempt to standardize the knowledge acquisition process. Narrative literature review is, on the other hand, more free and fluid. As standard and non-standard knowledge complement each other, systematic and narrative literature review methods too complement each other, and strengthen the research study. Applying these two review methods in this study to find out "best practices" and KPIs is therefore expected to produce a positive effect; a synthesis of the results can be very useful for the building construction industry.

In summary, in this study, systematic literature review was applied for scientific articles and narrative literature review was applied for practical results from R&D projects. Acquiring knowledge and information from these two different (but relevant) arenas by using two different knowledge acquisition approaches (two different literature review methods) can enrich the research study as well as the results.

Further study: Preliminary study on the results that we have obtained from the literature study so far point out that most of the cases represent Northern European countries. It will be interesting to explore underlying reasons behind it. In addition, presenting a complete set of results of the literature study and making a comprehensive analysis of the results can also be further study, since this part was not covered in this paper.

Acknowledgement

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