# A co-creative method for mapping and improving energy use and management in non-residential buildings

To cite this article: E Verhulst *et al* 2023 *IOP Conf. Ser.: Earth Environ. Sci.* **1176** 012025

# A co-creative method for mapping and improving energy use and management in non-residential buildings

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**Abstract**. The built environment has a significant role to play to support a transition towards sustainability. A critical point is the energy use and management of non-residential buildings, where the operational phase has been identified as the largest contributor to energy use over a building's lifecycle. To achieve performance in line with ambitions, there is a strong need to address interactions between architecture, technology and the people who use and maintain non-residential buildings, and to foster collaboration between different stakeholders. This article introduces a co-creative method that offers the opportunity to gather insights on how energy management and use happen on a day-to-day basis in the building, as experienced by the different stakeholder groups. The main goals of the presented method are to gather insights into the perspectives of different stakeholder groups on a systemic level and to offer innovative ways to search for opportunities to improve the energy performance of the building. Stakeholders include users or tenants, building operators, facility managers, and building owners. The article presents the method, examples from user-testing in Norwegian school and office buildings and reflects on how co-creation principles can add value to improving energy use and management in non-residential buildings.

## 1. Introduction

Globally, buildings are responsible for more than 40 % of the energy use and one third of the greenhouse gas emissions [1]. The pressure on the energy system is still increasing, resulting from global population growth and improvements in economic developments and living standards, which lead to a rise in energy use in the building sector [2]. The building sector has a high responsibility for diminishing this pressure, and it simultaneously also has the largest potential to deliver long-term, significant, and cost-effective cuts in energy use and related emissions [3]. Previously, research on increasing energy efficiency aimed to link technical and commercial approaches in facility management, with the main goal to save energy and reduce operation costs [4]. In recent years, the focus has changed towards awareness of climate change. One of the main goals is to reduce emissions and replace non-renewable energy sources.

Advances in technological solutions, as well as a raising awareness of the need for a more energy efficient building stock – both supported by regulations and fluctuations in the energy pricing market – are leading to a growing number of new and retrofitted non-residential buildings with a high energy

efficiency potential. However, there is increasing evidence that buildings often do not live up to the energy efficiency standards they were originally designed for [5]. This gap between the building's estimated energy performance as it is designed and its actual performance in daily use is commonly known as the energy performance gap [6,7].

A lack of knowledge regarding how buildings perform during the use-phase has been highlighted as one of the driving forces behind the energy performance gap, next to causes rooted in the design, construction, or commissioning phase [6,8,9]. Moreover, several studies indicate factors related to human behaviour such as building operation and maintenance, occupant activities and behaviour as having a significant impact on the building energy consumption [1,10-12]. In this article, building use forms the starting point for gathering more profound insights on how energy management and use take place in practice. Different scholars advocate the need for better understanding the use and management of energy in buildings through addressing the complex interactions between architecture, technology and the people who use and maintain the buildings [13]. This incorporates collaboration between different stakeholders between and within the design and operation stages of a building [10,14-17]. Next to that, literature asks for practical approaches and methods that make it possible to study the interplay between humans and the built environment, which can offer an interdisciplinary and systemic view on how technologies for energy efficiency get linked with e.g., business processes, end user behaviour, the social context of buildings operation and use. Such practical approaches and methods can facilitate development of interventions for change [18] and help to bridge different fields by concretizing theoretical frameworks. However, up to now, there are no methods available that focus on the interaction between building managers, occupants, and the technology used in the field of energy use and management [19].

This article presents a new method that brings the perspectives of different stakeholders of non-residential buildings together through a systemic, co-creative approach. The main goals of this method are a) to gather insights into the perspectives of different stakeholder groups and b) to offer innovative ways to collaboratively search for opportunities to improve the energy performance of the building. The article first introduces co-creation principles and how these have been integrated in the method, followed by a presentation of the co-creative method itself and some examples that result from testing the method in practice in a school building in Norway. This testing was a crucial part of the iterative design process through which the method was developed. Finally, in the discussion section, the authors reflect on the validity of the method and discuss its potential impact on the field of energy use and management in practice and in research.

This work is connected to a larger, interdisciplinary research project named MINDER - Methodologies for Improvement of Non-residential buildings' Daily Energy Efficiency Reliability. The project mapped energy management and use and proposed solutions for more energy efficient use of operational energy in non-residential buildings. The study encompassed school and office buildings with high energy ambitions in Norway. Insights resulting from the application of the co-creative method are presented in other articles related to the MINDER project, whereas this article focuses on the presentation of the method, its development and testing process.

## 2. Using co-creation principles in methods for energy use and management

Co-creation is the practice of collaboratively developing products, services, and solutions. It is understood in different ways but originates from a business context, focusing on the interaction between companies and their customers. In co-creation, the distinction between the roles of a company on the production side and a consumer on the consumption side diminishes, and consumers and other stakeholders get more actively engaged in the processes of defining and creating value [20]. Sanders and Simons define co-creation more generally as "any act of collective creativity that is experienced jointly by two or more people" [21, n.p.]. It includes collaborative creation of ideas, knowledge, and approaches. The authors define different application types, targeting value creation within communities, companies and organisations, co-creation between companies and their business partners, and co-creation between companies and their customers [21]. Value forms a central element of co-creation and

refers to "one or more form(s) of value(s) produced through the collective creativity of people" [21, n.p.]. It can refer to material or monetary worth, one's judgement of what gives meaning in life, experiences, knowledge, social or societal improvements, etc.

There are two core steps in a co-creation process: the contribution of ideas and novel concepts, and the selection of which specific concepts and ideas should be pursued [22]. Prahalad and Ramaswamy suggest four building blocks as being fundamental for a co-creation experience to be successful [20]. These building blocks are dialogue, access, risk-benefit, and transparency. *Dialogue* enables stakeholders to interact with each other through a two-way connection. *Access to data* for all stakeholders offers the opportunity for all participants in the process to come up with ideas and improvements that can create value and meaning. Monitoring *risk and gaps* between different stakeholders and an organisation opens the way to assess personal and societal risks of products, services, processes, and knowledge. It also encourages participants to search for solutions or improvements that can help closing monitored gaps. *Transparency* relates to information symmetry, in contrast to the information asymmetry that has often been present between organisations and other stakeholders. This is a question about information about products, technologies, business systems, performance, and knowledge becoming more accessible. Combining these four building blocks makes value creation for both the organisation and the stakeholders possible [23]. Moreover, the co-creation experience itself also provides value towards all participants through their interactions in the process, by creating meaning, raising understanding, and offering insights from the different perspectives of all stakeholders involved. The presented co-creation principles and building blocks have been the backbone for the development of the co-creative method for energy use and management.

## 3. Methodology: development and testing of the co-creative method

In developing the co-creative method, an iterative design process was followed, consisting of different phases of convergence and divergence. Such processes often start rather chaotically, but iteratively evolve towards clarity. Throughout the development process, emphasis moves from finding and discovering in the analytical phases towards invention and making in the synthesis phases, whereby the level of insight and learning increases [24]. Knowledge from different fields has been used as a foundation for the development process of the method, including results from research and insights from the practical fields of facility management, energy management, co-creation and design processes. These insights have been incorporated into different conceptual versions of the method – each with a growing level of detail - throughout the development process.

In this work, the method was further tested in different phases throughout the development process in order to improve its effectiveness and efficiency. Ilevbare, Dusch et al. propose three criteria for assessing and testing: feasibility - is one able to apply the tool as described? -, usability - how well are the steps organised and is it easy to use? -, and utility or functionality - is it useful and reaching its goals? [18] Firstly, and with these criteria in mind, the method was assessed and tested by experienced practitioners and potential users. This offered valuable feedback on the concept, and was used to further refine it. Subsequently, the co-creative method was utilised in a preliminary test interview in a building that was under study in the MINDER project, followed by a more elaborate round of user testing as part of the iterative design process. This offered additional insights and ideas for minor changes and improvements of the method. The user tests of the co-creative method took place in eight Norwegian school and office buildings with high energy ambitions. In total, 36 interviews have been completed with different building user types, including building owner representative, facility manager, energy manager, building operator and end users of the building. These were selected as they represent the most relevant stakeholders in energy management and use in the two building types in focus. The co-creative method was used in all interviews, which had an average length of 45 minutes. A stepwise analysis of the interview data was further performed. First, interviews were transcribed and coded using qualitative data analysis (QDA) software. Preliminary (sub-)themes from the interview approach (Table 1) provided a starting point for an inductive analysis process, and provided valuable feedback on how the co-creative

method performed and managed to collect insights on different energy management and use practices in the building, as perceived in everyday life by different actors.

## 4. Results: a co-creative method for energy management and use

In this section, the co-creative method is presented. To improve the energy performance of a building, it is important to first find out where improvements can be made, by understanding how energy is being used and managed in that building. Often, this is done through collecting and analysing data on the energy use in the different technical building systems, such as ventilation, heating, and lighting. However, energy use and management usually happen in a combination of different practices [25], including *understanding the building, communicating on energy issues, reaching comfort, managing energy systems*, etc. Each of these practices consists of different elements – materials, meanings, and practical competencies – and connections between them [26]. The co-creative method for energy use and management presented in this article was developed to gather insights on the different elements and connections of practices related to energy use and management using a participatory interview approach. The approach gives the participants the possibility to create a systemic overview of the interactions between architecture, technology and the people who use, manage and maintain the energy in the building. These stakeholders are occupants, energy managers, building operators and building owners. The following paragraphs present how the co-creative method is structured, its content, process, and the diverse elements of the method.

**Table 1.** Themes and their corresponding aims in the interview.

| Theme | Aim |
|---|---|
| **Ambitions** | Gather respondent insights on ambitions related to energy use and management in the different life cycle stages of the building: design, commissioning and current use stage, as well as future ambitions. |
| **People** | Establish an overview of which stakeholders or actors the respondent sees as having an impact on building energy management and use, as well as their relative impact. |
| **Activities – overview** | Establish an overview of the activities and processes the respondent sees as having an impact on building energy management and use, as well as their relative impact. |
| **Activities – mapping top activities** | Map the 1-2 activities the respondent considers to have the largest impact on building energy management and use. This step goes more in depth on the performance of the activity (meaningfulness, frequency, etc.), who is involved (people), which methods and tools are used, and what competences and skills are used and/or needed to for it to support energy management and use. The mapping encourages the respondent to think about and express how the different elements and factors are connected, thus offering a systemic view of the activity. |
| **Strengths and weaknesses** | Gather insights on which factors form strengths or weaknesses within the energy use and management system of the building. |
| **Time dimension** | Link the insights from the previous steps to the time dimension, to encourage the respondent to reflect on the different aspects of energy management and use in the past and present, and formulate possible opportunities for the future. |

### *4.1 Main themes*

The participatory interview is structured around six main themes: ambitions, people, activities, strengths and weaknesses, and a time dimension (Table 1). The selection of these generic themes is based on a framework for effective development and implementation of energy management strategies [27]. These are combined with basic components from strategic roadmapping processes that focus on the current state, future ambitions and the road to get there [28]. The six themes structure and focus the interview

on specific topics. At the same time the topics are kept generic in order to give the respondents the opportunity to talk about what they consider most important, e.g. technologies for energy efficiency, relevant managerial processes, specific user behaviour and occupancy of the building. As part of the co-creative method, templates and cards are used during the interview to go more into detail on specific methods and tools, stakeholder or actor groups, competences and skills.

*4.2 Process flow*

A process flow forms a visual guideline for the interviewer and participants by offering a clear structure and overview of the main themes in Table 1. The flow shows the order in which the themes are to be discussed, notifications and specific questions per theme, estimated time slot per theme, and which templates and cards to use in each step of the interview. Next to offering guidance to the person conducting the interview, the interview flow makes the process reproducible for students, practitioners, and researchers to use in collecting data on energy use and management in different non-residential building. The complete process flow can be obtained by request to the authors.

*4.3 Templates and cards*

The co-creative method contains different templates and cards that are used as part of the interview. They inform the respondents about specific topics within the different themes and inspire them to reflect upon and express their own experiences, feelings, attitudes and ideas on those topics [29]. The templates and cards enable the interviewer to gather insights on and to record the respondent's perception and personal context [30]. There are two templates and six different types of cards, each with their own specific objective within the overall aims of the participatory approach. The process flow indicates when to use which templates and cards.

*4.3.1 Templates*. The templates (see Appendix A) provide a way to visualise and record the respondent's insights, perceptions and thoughts on the different themes discussed. They enable researchers and respondents to create an overview of the different components of energy management and use (such as people involved, methods used) and mutual connections between the components.

*4.3.2 Cards*. Different types of cards facilitate the process of mapping the elements of practices related to energy management and use. They also support recording input from the participant in a visual manner. Three of the card types have pre-defined features; these are the people, activities and tools & methods cards. The predefined groups make it possible to clarify or exemplify the subject of the conversation to the respondent.


**Figure 1.** Six different types of cards highlighting different aspects related to energy management and use in non-residential buildings.

For the **people cards**, actors are based on literature that looks at the different sides of the energy performance gap – design, commissioning and operation and on results from a survey on the implementation of facility management approaches in Norway. Actor groups included in the approach

are: facilities manager, building operator, building user, building owner, project leader, energy consultant/specialist, project champion, amongst others [27,31].

The **activity cards** include 24 predefined activities on the strategic, tactical and operational level, such as: *metering strategy, communication strategy on stakeholder engagement* (strategic level); *feasibility studies, implementation of energy efficiency standards, maintenance of building systems, occupant satisfaction, training provision* (tactical level)*; system commissioning and fine tuning, manipulation of ventilation, lighting, heating, appliances, etc.* (operational level) [27,32,33].

The **method and tool cards** give an overview of possible hardware, software and management tools and methods to support the energy management of a building. These include *thermostat, light switches, windows, appliances* (hardware), *technology for detailed energy metering, fault detection and diagnosis* (hardware and software), *tailored energy guidelines, briefings, reports, newsletters, energy workshops and focus groups* (management tools), amongst others [27,34,35].

Extra space on each of the cards makes it possible to record input and examples provided by the respondent. Table 2 gives an overview of the objectives of each of the card types, whereas Figure 1 shows the different card types with their respective colour to raise recognisability and ease-of-use.

**Table 2.** Six different card types and their corresponding objective.

| Card type | Objective |
|---|---|
| **People** | *Map and visualize relevant stakeholders* or actors that have an active role in the energy management and use of the building, and their relative impact. |
| **Activities** | *Map and visualize activities* at the strategic, tactical and operational levels that have an impact on the energy management and use of the building.<br>*Map the relative impact of the different activities* to detect the top two activities with highest perceived impact according to the respondent. |
| **Tools & methods** | *Map and visualize relevant tools and methods* that support or hamper each of the 1-2 main activities selected by the respondent. |
| **Competences & skills** | *Map and visualize used and needed competences and skills* that support or hamper each of the 1-2 main activities selected by the respondent. |
| **Strength/success factor** | Help the respondent *reflect on and visualize which activity elements* (people, activities, tools & methods, and competences & skills) *strengthen* efficient energy management and use. |
| **Weakness/barrier** | Help the respondent *reflect on and visualize which activity elements* (people, activities, tools & methods, and competences & skills) *hinder* efficient energy management and use. |

## 5. Examples from user-testing the co-creative method in school and office buildings

This section provides examples from the elaborate round of user-testing of the co-creative method in Norwegian school and office buildings. The examples illustrate how the method is used in practice and how data is collected.

### *5.1 Ambitions on energy use and management*

The method focuses first on the energy ambitions of the building in the design and use stage (Figure 2). Future ambitions come back later in the process.

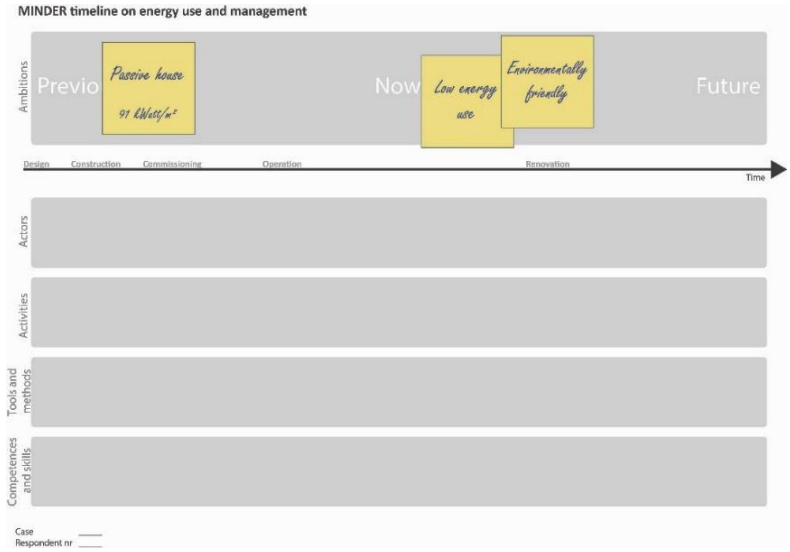



**Figure 2.** Example of previous and current ambitions on energy use and management (office building).

*5.2 Relevant actors in energy use and management of the building*

This section of the method provides insights on the perceived impact of different actor groups seen from their respective perspectives, as presented in Figure 3. It also offers insights on the different roles of the various actor groups in the building.

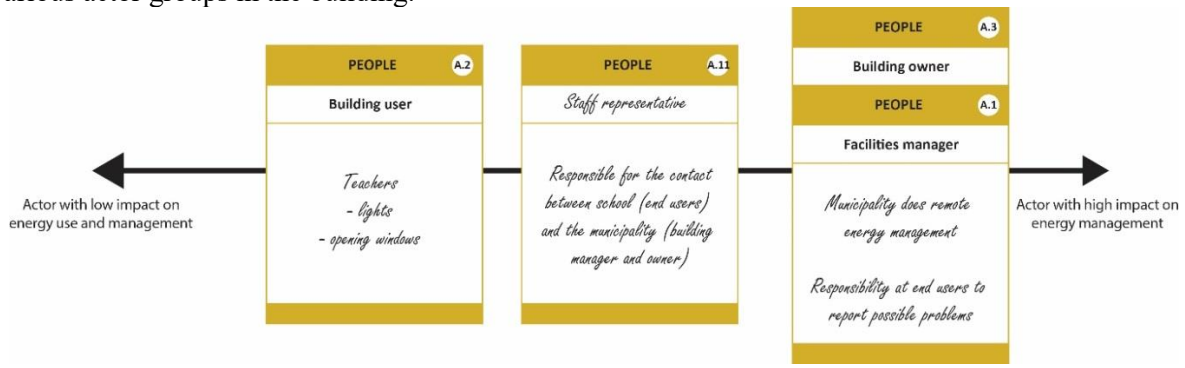



**Figure 3.** Example of interview data on actors and their impact on energy use and management.

*5.3 Activities with impact on energy use and management of building*

This part of the interview offers insights into which activities the different actors consider to have an impact on the energy use and management of the building (Figure 4). After mapping all activities, the respondent is asked to arrange the activities from having a low to having a high perceived impact on energy use and management.

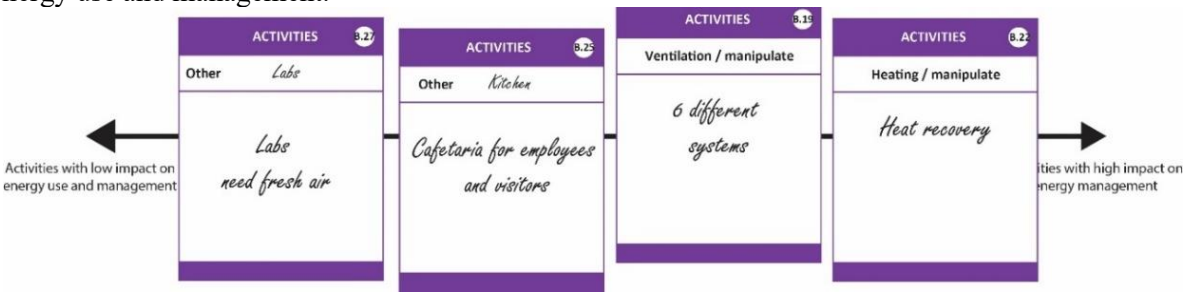



**Figure 4.** Example of interview data on activities and their impact on energy use and management.

*5.4 Systemic view of main activities*

This section of the method focuses on mapping two activities that are considered having the largest impact on energy use and management of the building. It brings together insights on actors, methods and tools, competences and skills that are linked to the activity in focus. An example of the outcome of this step is illustrated in Figure 5 with the results from an activity. It shows how a staff representative of a school building sees the role of the building users (mostly limited to opening or closing windows), the building operator and the energy manager (understanding and steering the ventilation system when changes are needed, maintenance when required). In addition to actors and roles, the data also indicate which physical tools and methods are being used by whom (such as air quality sensors, automatically controlled windows) and which competences and skills are being used or required by the different actors (e.g., no need for end users to understand the feedback on the boxes with air quality sensors). This step is followed with a reflection on strengths and weaknesses related to the mapped activity.

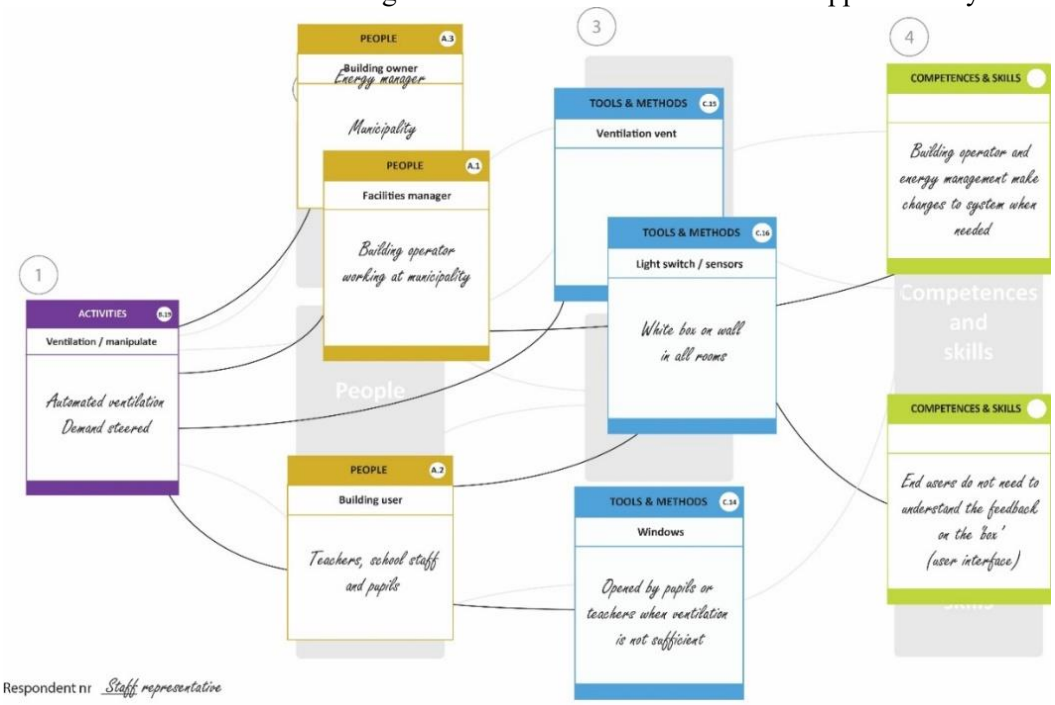



**Figure 5.** Illustration on mapping main activity *'ventilation'* from a *school staff representative.*

## 6. Discussion and conclusion

*6.1 Reflections on the co-creative method*

The method presented in this article was developed based on co-creation principles. This was done to give the stakeholder groups the opportunity to collaboratively create meaning and value by drafting the current energy system and coming up with opportunities for improvement related to energy management and use. The aim was to build a feeling of shared ownership, (re)formulate stakeholder roles and spread responsibility related to energy use and management of the building. More specifically, the four building blocks of co-creation [20] were applied: *dialogue*, *transparency*, *accessibility* and *gaps and possible risks*. These principles are used to reflect on the validity of the co-creative method. In the interviews, *dialogue* took place between the interviewer and each stakeholder representative separately. Moreover, results from the user-testing indicate that the method helped to gather available building information, performance data and insights on practices from the different stakeholder groups in a structured manner that was similar for all participants, thereby leaning on the principles of *transparency* and *accessibility*. Through dialogue and access to data, participants got the opportunity to monitor performance *gaps and possible risks* and come up with ideas and improvements related to energy use and management. When

testing the method insights were however gathered on an individual level, and interaction and collaboration between the different stakeholders was not included. It is therefore recommended to combine the co-creative method with a co-creative workshop with all stakeholders, to provide space for discussing insights about the current practices for energy use and management and collaboratively formulate future-oriented improvements and solutions for better energy-efficiency in the building. This combination can provide methodological support to strengthen collaboration between different stakeholders within and between different life cycle stages of a building [10,16].

Results from the user-testing also showed that the used visualisation tools greatly supported the respondents in reflecting on and communicating their ideas and perspective on different aspects of energy use and management in the building. Next to that, the use of templates and cards helped making the respondents evoke responses and make them think and talk about energy use and management from a systemic view: they managed to connect the different elements rather than think of them separately. From the perspective of the interviewers, the templates and cards helped record the respondents' perception and personal context [30]. One of the challenges experienced when testing the co-creative method was its strict structure. This structure helped securing that the same topics were discussed with the different actor groups. However, this turned out to not be that easy: the interest in certain topics was relatively low within specific stakeholder groups, and other wordings were needed to make sure that the participant understood the topic. An example of this is the use of the timeline, which did not always offer relevant input. When a respondent – e.g., a user of the building – was not involved in the design and construction stage of the building, that person could not give any input on those phases. Another challenge that came up from the testing related to the ability to go sufficiently in depth on certain topics. As Warde states, it is easier to make people talk about what they do than to talk about why they do what they do and how they do it [36]. A practical hurdle turned out to be time availability, as each interview is planned to take 45 min. This can become demanding for interviewers, depending on the number of stakeholders to involve. On the other hand, the interviewer needs to follow the proposed timing to complete the interview within the planned time frame. This limitation proved to make it difficult to go in depth into specific aspects of the interview. For future use, adaptations can focus on specific themes.

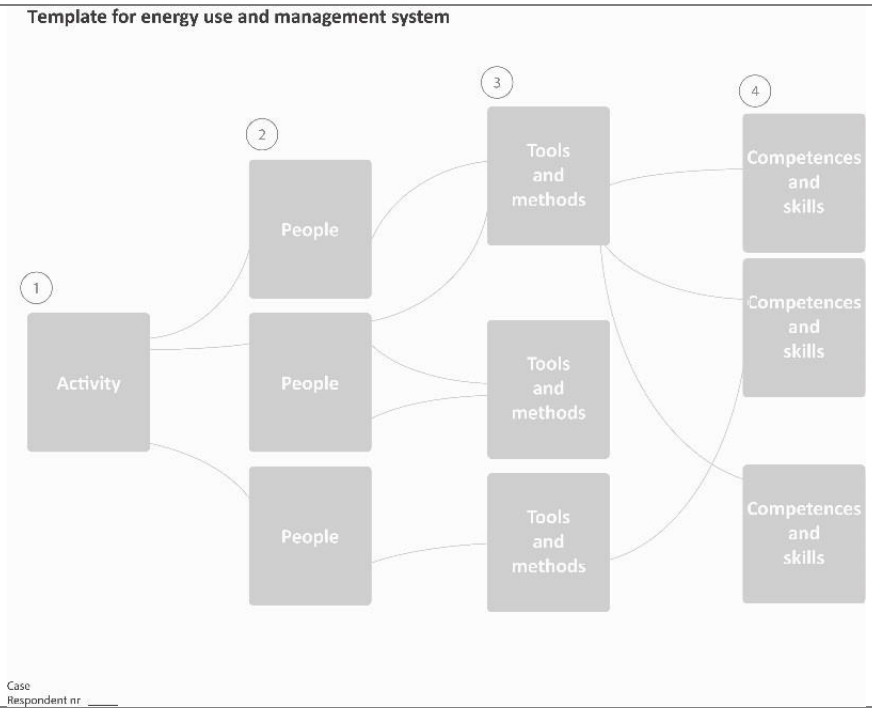
### *6.2 Potential impact in the energy use and management field*

This article presents a new method to the field of energy use and management, bringing the perspectives of different stakeholders in non-residential buildings together through a systemic, co-creative approach. Testing of the method showed that it helps create a systemic overview of energy use and management in non-residential buildings, more specifically in school and office buildings. It supports mapping activities and practices performed in everyday life, shaped by a combination of technologies, activities, competences and skills, ambitions and perceptions as performed, perceived and delivered by different stakeholders and technologies. In that way, this work contributes to the body of knowledge within the field of energy use and management with a method that helps answer the need for better understanding of interactions between end users and the built environment [10,13]. Using the method, researchers can gather valuable insights into the energy performance gap in non-residential buildings.

For the method to become attractive and applicable also for energy management practitioners, it needs further refinement into a format that is less time-consuming and adapted to an adequate level of interview skills. Further developments also include the connection to a follow-up workshop that aims at improving energy use and management in the building collectively. Conducting the interviews then happens as part of a preparatory phase in which insights are gathered from the different stakeholders.
Future research should focus on how the use of the method changes practices of energy use and management in buildings. Research could also focus on studying the way co-creative methods can support connections between different stakeholder perspectives and the aim to improve energy-efficiency in non-residential buildings, thereby contributing to a transition towards sustainability.

**Acknowledgments**
This research has been funded by the Norwegian Research Council, project 228642.

**Appendix A.** Two templates and their corresponding objectives.

| Template | Preview |
|---|---|
| **Energy use and management system** |  |
| **Objectives** | Enable *visualisation* of the perceived system centred on the 1-2 main activities with the largest impact on energy management and use in the building, its components (people, tools & methods, competences & skills, and strengths & weaknesses), and their mutual connections. |
| **Timeline on energy use and management** |  |
| **Objectives** | Enable *visualisation of the time dimension* by assembling insights on ambitions, components of energy management and use, and linking these to *changes in time.* Encourage respondent to reflect on insights and perceptions presented in interviews and turn these into proposals for *future opportunities* and improvements. |

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