

Original research article

## Renovating the retrofit process: People-centered business models and co-created partnerships for low-energy buildings in Norway

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## ABSTRACT

Building energy retrofit is not only an efficient approach to increase energy efficiency through technical installations, but also has great potential to improve social acceptance through co-creation. However, there are many existing residential buildings with low energy efficiency in need of retrofit, which is currently not being done. This paper aims to examine the barriers to conducting the residential building retrofit and co-created a suitable business model to overcome these challenges and improve social acceptance. Thirty-nine deep interviews and a workshop with representatives from people (residential building owners), public and private sectors were conducted. The results show that the barriers include lack of information sharing and consulting, limited resources and knowledge, and risks of not achieving the expected energy efficiency. Then a public-private-people partnerships (PPPP) business model is co-created to overcome the barriers by improving information sharing, making use of operational experience and financial resources from the private sector, as well as political and financial support from the public sector. Furthermore, the results illustrate the value of co-creating, by considering how the different sectors' wishes can be negotiated. It includes agility to adapt to the complex challenges by being open to ongoing suggestions instead of established planning and the scope to lead to new cooperation among the different sectors in the co-creation communication process. For further study, more workshops with participants from a wider range of backgrounds are needed to further refine the model and explore an efficient method to balance the power of different participants in the co-creation process.

### 1. Introduction

Building retrofit plays a key role in improving energy efficiency, living environment, and social acceptance [1-4]. In fact, the building sector represents about 40% of the final energy consumption in the European Union [5]. Research has proven that building retrofit can achieve energy savings in buildings of up to 80% [6] and that approximately 90% of the building stock in the world needs to be upgraded to transform existing buildings into nearly-zero energy buildings [7]. Therefore, building energy retrofit has the potential to play a vital role in energy saving. In addition, building retrofit can reduce electricity bills, maintenance costs, and achieve higher rent or sales prices from the financial aspect, as well as creating job opportunities, satisfying citizens' needs, and creating livable environmental space from the social aspect [8,9]. However, there is a considerable number of existing residential buildings that waste energy and require retrofit, which is currently not

being done on a large scale [10].

Building energy retrofit is influenced by different stakeholders, and they can be classified into three sectors: public (institution), private (commerce), and people (residents) [11]. Each sector has different concerns for conducting the retrofit. The public sector mainly focuses on the achievement of energy goals, and the efficiency of incentives, risk guarantees, and regulations [12], while the people tend to focus on information sharing about the benefits of conducting retrofit, access to consulting, the initial cost of investment, and financial support [13,14]. The private sector is often concerned with financial profits, risk guarantees, and payback time [15]. Therefore, the main barriers to conducting the retrofit will be explored from the perspectives of the people, public, and private sectors.

To cope with the complex challenges in the retrofit process, a wide range of knowledge and resources are needed from multiple sectors. At the same time, the challenges are ongoing and different in different

*Abbreviations:* PPPP, Public-private-people partnerships; EPC, energy performance contracting.

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regions, which requires co-creation among local communities [16]. Co-creation is an approach involving groups of diverse actors to create shared values, that can lead to overcoming the barriers, but also in defining problems and solutions [17,18]. There are several advantages to co-creation in the building retrofit. First, it has a high degree of adaptability due to the suggestions being co-created and tailored according to the background of the participants. Second, through sharing information, expressing concerns, and negotiating the different interests of each sector, co-creation has the potential to promote a balanced and sustainable social, environmental, and financial development [19]. Third, it facilitates information flows among different sectors, which forms shared value leading to increased social acceptance [20,21]. However, there are few cases and workshops on co-creation for building energy retrofit to guide further study in the field. This paper will figure out suitable solutions to overcome the barriers through co-creation, among local people, private, and public sectors.

In the co-creation process, it makes sense to engage the citizens before conducting any building refurbishment. Citizens living in the buildings have a deep understanding of their living environment, and their participation is crucial to guarantee that the real issues in the building are addressed. It is also vital to get support for the project from the community [22,23]. Satisfying citizens' needs, achieving optimal overall value, and sustainable development are critical, as they usually have profound and long-term effects on the lives of the general public [24]. Therefore, the paper will also pay attention to citizen participation in the co-creation process.

Co-creation is important to deal with the building energy retrofit. However, there is a lack of summaries of the typical partners concerning the choice of sectors for co-creation, as well as analyses and comparative studies among the various partnerships with different sectors, which makes it difficult to choose partners for a specific project [25,26]. Therefore, analyzing the strengths and weaknesses of different existing models, as well as proposing improvements, is crucial.

After identifying the main barriers, exploring a suitable business model to overcome these is crucial. A business model describes the rationale of how an organization creates, delivers, and captures value from an efficient and systematic approach, which can guide the whole process with a specific strategy to conduct the retrofit business [27]. In addition, the European Green Deal and several other researchers emphasize the need for new business models that can involve multiple stakeholders [28,29,30]. Therefore, the existing business models applied in building retrofit will be explored and analyzed, and a new suitable business model will be co-created.

Based on an analysis of the main identified barriers and existing business models, this paper proposes a novel public-private-people partnerships (PPPP) business model. The concept of public-private-people partnership is an emergent approach that highlights the need for sustainable development through the involvement of public administration, private actors, and citizens in a joint process [22]. "Public" means government departments, "private" refers to private for-profit enterprises, while "people" represent citizens [31]. This public-private-people partnership process framework embraces bottom-up participative strategies, making citizen engagement visible for the co-creation of projects [22]. It has the potential to both fully utilize the advantages of each partner and create a more open society through negotiation between different sectors. Furthermore, the PPPP business model will be co-created by the local public, private, and people to be more suitable to the market and achieve social acceptance.

To summarize, the main goal of this paper is to co-create a suitable business model to overcome challenges in building retrofit and improve the social acceptance for it.

The article is organized as follows: Part 1 demonstrates the aim of this paper; Part 2 introduces the concepts of co-creation, citizen participation, public-private partnership, public-private-people partnership, the business model and business model canvas, as well as a literature review about the existing business models for building retrofit;

Part 3 explains the methodology applied in the paper; Part 4 shows the results, including the main identified barriers for conducting the retrofit from the perspectives of people, private, and public, the proposed PPPP model, and the co-created PPPP model after the workshop discussions; Part 5 discusses the results; Part 6 contains the conclusion.

## 2. Background

### 2.1. Public-private partnership (PPP), citizen participation, and Public-private-people partnership (PPPP)

Public-private partnerships (PPP) was defined as "formal cooperation between enterprises, social leaders and local government officials to improve the city" by Perry Davis in 1986 [32]. Most often, the main applicable sectors are government agencies and private-sector companies. The private partners mainly participate in financing, planning, and managing the projects, while the public partners commonly focus on launching and monitoring the projects.

Public-private partnerships are well developed and have a wide range of applications internationally, including in the building energy retrofit, however, there is a lack of consideration of citizen participation [33]. In recent years, the participation of citizens has become an indispensable part of building retrofit as they can provide and discuss current issues and needs related to their living environment, which can lead to social sustainability through balancing community interests and creating shared value [34]. The participation of the people can also make the existing cooperation more diverse and realistic [35]. This led to the proposal of the public-private-people partnership (PPPP), which added people to increase transparency and engage citizens' knowledge to better satisfy their needs [36].

Compared with the PPP model, both the theory and the application of the PPPP model are less developed. This is not surprising since it is quite difficult to include people in the PPP models. The citizens usually have less impact on decision-making than the public and private sectors. Furthermore, ordinary citizens rarely have enough knowledge to participate in the discussions, and often fail to provide effective strategies. On the other hand, the PPPP can create added value, share risks within between participants, and minimize later conflicts through the cooperation of different resources [31,36].

### 2.2. Co-creation

To achieve efficient cooperation among the people, private, and public sectors, co-creation is an ongoing and reflexive method that can be applied to encourage different actors to interact and collaborate and create new products, services, and shared value [16]. The European Union also regards co-creation as an approach that can create higher quality in public services and social sustainability [17]. Co-creation suggests that jointly creating innovations across organizational boundaries is mutually beneficial for the participants [17]. It is also highly relevant in the PPPP model. For the private sectors, co-creation can lead to more efficient goods and services to maintain competitiveness in global markets [37]. For the public, it can help improve the effectiveness and satisfaction with public services through solutions tailored to meet the wishes and values of its users [38]. For the people, co-creation with public and private sectors can provide opportunities to express their needs and receive resources from other sectors to satisfy their needs. Citizen participation in the co-creation process is not only involved citizens as test subjects who can react to the suggestions proposed by a designer, but rather as people with insiders' knowledge of how suggestions should be developed to fit their own needs [17].

### 2.3. Business model and business model canvas

The concept of a business model has been explained by researchers from many different angles. Al-Debei and Avison [39] consider the

business model a tool for conducting business through analyzing, designing, and applying a set of business strategies. A business model is also widely accepted as a way to describe the rationale of how an organization creates, delivers, and captures value [27]. In addition, the development of new business models is regarded as an efficient method to promote the diffusion of sustainable development [40-43].

As urban space develops, new requirements are needed for sustainable business models to replace the traditional business models. In the past, the financing for building refurbishments strongly relied on limited budgets in the public sector. Now, new business models with innovative revenue models and financing schemes, developed to promote market investment instead of burdening the public sector, are needed to achieve sustainability [15]. Furthermore, the participants are different. The traditional business models are customer and market-oriented, whereas sustainable business models consider the values of all the stakeholders, including investors, designers, and customers [40]. Finally, the sustainable business models aim to achieve balanced sustainable development, emphasizing the environmental and social value in addition to the financial value [44].

To develop a new business model that is taken in a sustainable outlook in this paper, the business model canvas method was chosen because it provides a structured way to focus on the fundamental elements for building a business model. Fundamental elements focus on the basic information at play in a business model, such as what resources are needed, what is the core value for each partner, what kind of relationship could be built, and the financial input and output [27]. Furthermore, business model canvas has a universal application, which is easily understood by lots of related research [45]. Finally, the standardized elements of the business model canvas provides an easy approach for partners to co-create.

The development of a business model for sustainable development relies on a good Business Model Canvas. The Business Model Canvas proposed by Osterwalder [27] has been widely applied for analyzing and designing business models by many researchers through four pillars and a basic nine-block model [10,15,46], which are illustrated in Fig. 1.

The infrastructure management pillar consists of three blocks: key partners, key resources, and key activities. This pillar describes the partners, the human and physical resources they can offer, and the activities needed to deliver value to the consumers [47,48]. The product pillar has only a value proposition block, which is the core of the business model. It defines what types of value the stakeholders will provide

to the consumers, and explores the customers' problems and needs [48]. The customer interface pillar comprises customer segments, channels, and customer relationships. This section defines the target consumers, the channels for communicating, distributing, and selling products or services, as well as establishing and maintaining relationships with consumers [27]. The financial aspects pillar includes cost structure and revenue streams, which describe how the finances are spent and the return on revenue. [49].

2.3.1. The existing business models for building energy retrofit

In the section, the existing business models, namely, host-owned, energy performance contracting, and community shared business model will be introduced.

The most widely used model is the host-owned business model, where the initial cost is paid mainly by the host. Projects using this model are often strongly dependent on public funding, which typically covers 20%-40%. Furthermore, retrofit services such as design, construction, and materials are typically supplied by separate providers, which requires the building owners to spend a lot of time and effort on communication and coordination [15].

For the energy performance contracting (EPC) business model, the energy-saving companies finance the initial investment and get payback from the building owners based on the attained energy performance [15,50]. EPC models tend to be driven by energy-saving companies and typically have better access to financial capital than the host-owned model. The risk of investing in energy retrofits is reduced for building owners because they pay for the attained energy performance. However, the energy-saving companies usually cannot receive the predicted payback because the predicted energy performance does not match the actual energy performance. This is often due to changes to building design during the construction stage or the impact of the user's behavior on the energy load not being captured during lifecycle assessment [51,52].

In the community shared business model, the investment is mainly financed by a large number of citizens [53]. They form a community group, who co-invests in a project and shares the benefits. In the community shared model, the residents are important actors, as they not only invest in the project but also provide the needs and information about problems related to the building environment. However, it is not easy to engage the citizens, and there are other barriers such as lack of industrial resources and connections, issues of trust among citizens, and

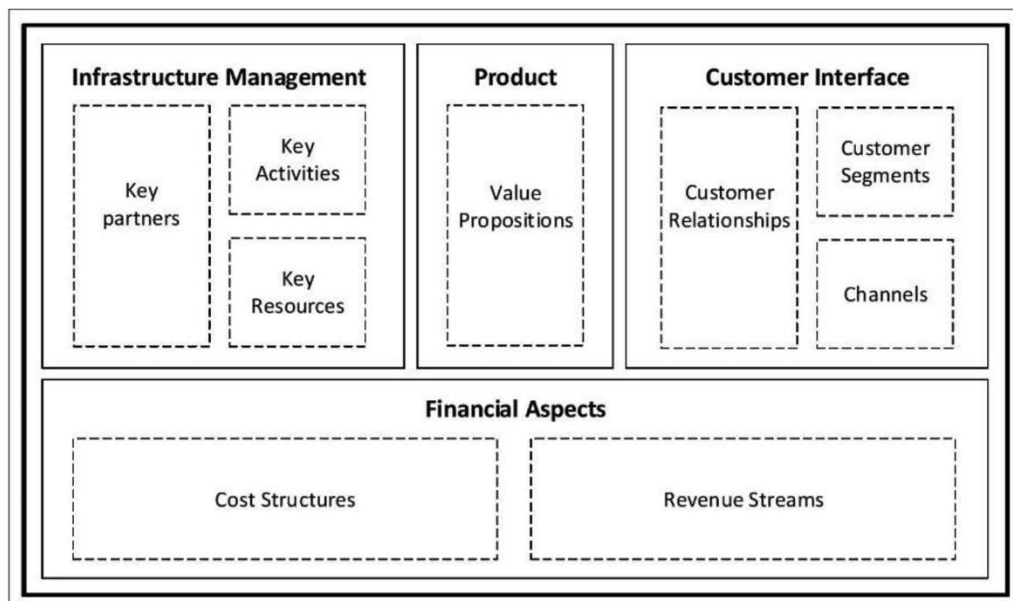


Fig. 1. General business model canvas, adapted from [47].

limited skills in community engagement [54].

#### 2.4. Co-creation approaches for sustainability in Norway

Norway was selected as the regional study background because a large number of its citizens care about energy sustainability. According to a country ranking of public environmental concern conducted by Franzen and Vogl [55], Norwegians pay much attention to sustainable environmental development. This increased the likelihood of engaging the citizens in the building refurbishment partnerships, which is needed to achieve social sustainability. In addition, many stakeholders in the energy sector such as research groups, private companies, and municipalities collaborate through energy clusters in Norway [56]. This makes it easier to both identify the building refurbishment-related partners for interviews and workshops through the energy cluster and to understand how the different sectors cooperate. Furthermore, co-creation is already present in the energy sector, most notably through the prosumer scheme offered by the Norwegian Energy Regulatory Authority [57]. It is a set of regulations supporting cooperation between people, private industry, and public sectors [58]. Although the interviews and the workshop were organized in Norway, it has significance for other countries with a similar background, particularly those with high interest in the environment and high levels of citizen participation.

### 3. Methodology

The methods have been designed according to the goal of the paper, which can be achieved in three steps:

- Understand the barriers for conducting the building energy retrofit from the perspectives of people, private, and the public through interviews
- Propose a suitable business model to overcome these barriers to promote the residential building retrofit market
- Assess the potential feasibility of the business model and develop it to be more suitable for practical application through a workshop

Interviews were chosen to understand the barriers and figure out the potential solutions, as well as testing the possibility to apply the potential models with interviewees who have empirical experience. The interviews can provide narrative and explorative data that explain the barriers clearer and provide detailed suggestions on how to overcome the barriers and adjust the potential model. Furthermore, the interviews produce empirical data specific to the Norwegian context. Finally, the interview can be used to identify interviewees with resources and high interest in the proposed model, which can be chosen as participants for the workshop in the next stage.

Workshops are a good choice to assess the potential feasibility of the proposed model and are considered an efficient approach for future-oriented study [59]. The workshop has its advantages from the following aspects. First, it can gather the opinions, knowledge, and needs from the public sector, private sector, and residents, which provides a basic understanding. Second, during the process, participants in the workshop can expose potential problems earlier, which can help make strategies for alternative scenarios [60]. Finally, different stakeholders can express their opinions in the process, helping them understand each other, and negotiate the detailed application of the business model. This can also enhance relations and communications, as well as promote the practice and acceptance of the decisions [61].

#### 3.1. Interviews

Interviews were used to determine the barriers to conducting the building energy retrofit from the perspective of people, private, and public. All participants had to satisfy a set of criteria to participate. First, the interviewees from the public sector and private sector had to work in

a field related to building retrofit, to ensure a good understanding of the area. Second, interviewees needed to have a good understanding of the retrofit market. This is critical to gather empirical data that can contribute to a more accurate analysis of the current state of building energy retrofits.

The study took the form of semi-structured interviews on an individual level. Each interview lasted for about 50 min. The interviewees were provided with an interview guide at least two days in advance, for them to prepare appropriately. All the interviews were conducted by video meeting, the majority during a three-month period. During the interview, the participants were asked about their thoughts on barriers for public, private, and people to conduct the building energy retrofit, considering technical, economic, regulatory, and social factors. The respondents were then allowed to steer the conversation within the topic. The interviews were all captured through a combination of recording and transcription.

After the completion of the interviews, the data analysis process began. The interviews were transcribed, and the answers were summarized according to the questions and sector the participant belonged to. To make the best use of the space available, similar opinions were grouped for analysis and counted. This made it easier to find the information receiving the most attention and see if there were any substantial differences between different sectors. Due to the qualitative nature of the data, many quotes were used in the publication and were paraphrased where appropriate. Where there was agreement amongst respondents, detailed summaries were given to ensure that such commonalities were made clear.

According to the results of the analysis, a business model was proposed with the potential to overcome the main barriers.

#### 3.2. The workshop

After the interviews were conducted, the interviewees were invited to participate in a workshop to discuss the feasibility of the proposed model and co-create the detailed application to be more practical. There were participants from the public sector, private sector, and residents, as well as some professional experts. Participants from the public sector included members of a municipal institution for promoting energy sustainable development, the state housing bank, and the municipal government. The private sectors included representatives from the property, construction, and design companies, as well as engineering consulting companies, facility management companies, companies for organizing multiple stakeholders, and energy performance contracting (EPC) companies. They can provide expertise in multiple areas related to building retrofit, as well as a mixture of experiences from various projects in Norway. The residents were mainly people living in apartment buildings, which have great potential for building energy retrofit. They can provide information about the buildings and surrounding environment, as well as their needs.

During the workshop, there was no set speaking order, allowing participants to express their thoughts and ideas freely. At the same time, knowledge from different sectors was shared, which facilitated further discussion. Based on the needs and resources of each sector, participants provided their opinions on how to overcome the barriers, use the resources, and apply the PPPP business model. They analyzed the feasibility of each aspect of the business model canvas and together decided which element to add or remove. Finally, a revised version of the originally proposed business model was created. The whole process is shown in Table 1.

The information was collected through different stages. In the interview stage, the barriers for public, private, and people to conduct the building retrofit from a real-life context were identified. For the workshop, there were three stages: brainstorming, presenting ideas, and negotiating the model. The participants first came up with suggestions to overcome the barriers, without considering the limitations of the method, implementation, and feasibility. The different ideas were then

**Table 1**  
The schedule of the interviews and the workshop.

| Stage                            | Time                                     | Methods                             | Participants | Focus                                 |
|----------------------------------|--|-------------------------------------|--------------|---------------------------------------|
| Interviewee selection 1          | 1 <sup>st</sup> August-30th October 2019 | Email, online searching, conference | 23           | Choosing interviewees retrofit        |
| Interviewee selection 2          | 1st November-30th December 2019          | A snowballing method                | 48           | Figure out more interviewees retrofit |
| Conducting the interview         | 1st January-30th April 2020              | Interview                           | 39           | Barriers of retrofit                  |
| Propose a suitable model         | 1st May-30th June 2020                   | Data analysis                       | 9            | Propose a suitable model              |
| Preparing the stage for workshop | 1st August-30th August 2020              | Meeting presentation                | 22           | Presentations                         |
| Workshop                         | 1st September-30th September 2020        | Brainstorming                       | 15           | Brainstorming                         |
| Workshop                         | 1st October-30th October 2020            | Present and discuss                 | 15           | Present and discuss                   |
| Workshop                         | 1st November-30th November 2020          | Negotiating                         | 15           | Negotiating                           |

collected and shared with the other participants in the presenting stage. Then, the feasibility and implementation of the ideas were discussed. Finally, the participants negotiated the detailed application of the business model canvas. By developing a model agreed upon by all three sectors, most of their needs would be satisfied, which could increase its likelihood of success. Thirty-nine people participated in the interviews, and from this sample, 15 participated in the workshop. The number decreased for two reasons. One is that the people needed to satisfy more criteria, such as a complex background and empirical experience in a similar project. Another reason is the lack of time and interest for workshop discussions.

There are some limitations to the methods. One is the sample size. Although the sample was chosen based on strict criteria, which offers important potential for richer and higher quality data, the small sample size might negatively impact the validity of the data by introducing bias. On the other hand, this has allowed for the use of interviews, which can lead to higher quality answers than for example surveys. Another advantage is that it can lead to a deeper discussion about the topic. The other limitation is the country focus, as the interviewees in this study mainly consisted of those based in Norway. The model has the most potential to be applied in Norway and countries with similar backgrounds, as the interviewees have a good understanding of the policies and residents here. The validity of the model from an international perspective could have been improved with the inclusion of more countries.

## 4. Results

### 4.1. Public, private and people's concerns for doing retrofit

The interviewees in the study are referred to by numbers as participants 1–39, among which participants 1–19 represent the residents, participants 20–32 represent the private sector, and participants 33–39

represent the public sector. The majority of the participants are highly educated and between ages 30–50, with representatives from all three sectors.

The results of the interviews shown in Fig. 2, the main concerns are:

#### (1) Financial barriers

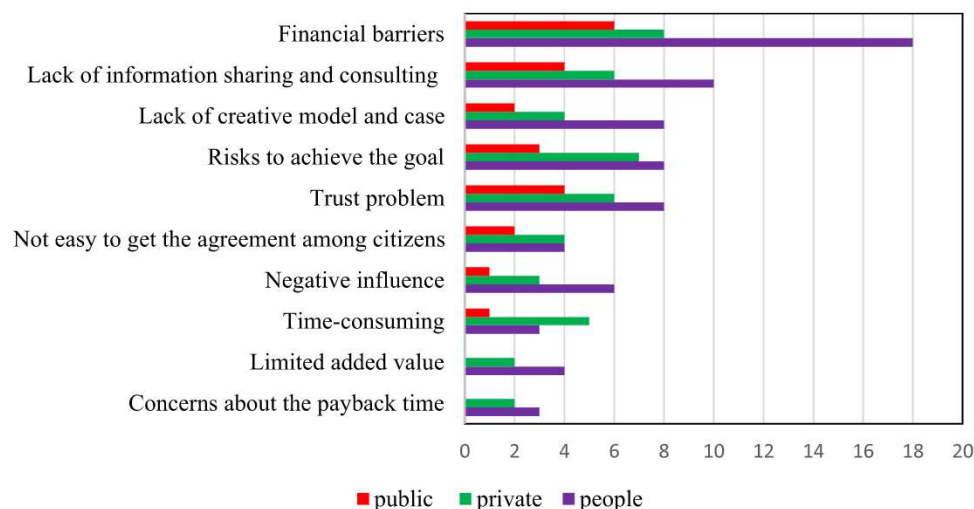
Eighteen people representing the residential perspective expressed financial concerns when investing in retrofit, which can be classified into three categories. The first is lack of money to invest at the moment, and unwillingness to increase current loans. The second is difficulty applying for financial support from the public sector, which also is quite limited, and the third is that many prefer prioritizing spending elsewhere. As people participant 2 said “*I need make smart investments. If I invest in the building retrofit, I cannot buy a new car or switch for a bigger apartment.*”

Eight private company representatives had concerns primarily based on the financial barriers. Private participant 23 mentioned that their company is interested in investing in energy retrofit, but that they lack the financing to do so. There are also private companies that believe the return on investment is too low, as participant 25 said “*We have invested in some building retrofit, but most of them are official buildings, we are not investing in the residents' buildings, they're small and it's not easy to get the money back.*”

All the interviewees from the public sector think their main concern is low interest among residents to invest in building energy retrofit, and that this is due to financial barriers.

#### (2) Lack of information sharing and consulting

Ten people expressed that limited information and knowledge are key factors hindering them. For example, some citizens are worried about the regulations for retrofitting. Some also wanted more



**Fig. 2.** The barriers for conducting retrofit from people, private, and public.

information about technical problems that may arise during the process.

Six private company representatives also believed lack of information to be a major problem. Participant 27 mentioned that *“Because there is a lack of information sharing, different sectors do not know what resources they can get from the others, especially the residents do not know how to get support.”* Participant 28 added that *“There are barriers related to our ability to provide the people with good information, for example, which kind of retrofit they should do, how to do it, and how much they can benefit”*.

Four representatives from the public sector believed there were barriers related to information-sharing. Participant 36 pointed out that the building owners usually do not have enough knowledge about the buildings and business, and that they believe that it will take a lot of time to find the information needed.

### (3) Risk of not achieving desired benefits

Eight people had concerns about the risk of not achieving the desired benefits, especially financial ones. First of all, the investment might not pay off and has a long payback period. Participant 5 expressed that: *“Selling the apartment might not be worth it for a while, because after I invest in the retrofit, I cannot get a good return on investment in a short time”*. Others pointed out that refurbishing might not be better than simply buying a new apartment. Participant 8 stated that *“There are a lot of things that need repairing in old buildings, it also takes a lot of time, and sometimes they are still not as comfortable compared to new houses”*. Furthermore, the value of the house might not increase to expected values after the energy retrofit, and it is more difficult to sell when the loan attached to the building is high.

Four private companies mentioned this problem. It is not easy to achieve the energy goal from the construction aspect, and perhaps more importantly, it is not feasible to control the behavior of the residents for good energy performance. Participant 29 expressed that *“It is very difficult for us to promise a reduction when we need to control the way of living and action. People’s behavior changes, and it is very difficult for us to make contracts with citizens for residential buildings”*.

### (4) Limited resources, knowledge, and experience

Eight residents, four representatives from the private sector, and two from the public sector believed the main barrier to be limited resources, knowledge, and experience. Among the residents, People participants 12 and 15 expressed that they were interested in retrofit but did not know how to get technical support from the public sector and did not have any related experience. From the private sector, Private participant 32 said that *“We want to test the new business model for energy sustainability, however, our main role is construction, we do not have the necessary connections with the bank, so it is difficult for us to invest”*.

### (5) Lack of trust

Eight residents, six representatives from the private sector, and two from the public sector thought that one of the barriers was lack of trust. Some residents did not believe that the data from other cases were suitable for their cases. Participant 16 said: *“Sometimes I cannot believe that the data from other cases can also be applied to my apartment, I do not really trust the data from the providers, they just care about their profits”*. The sentiment was shared by participant 18, who said *“I am not so trusting of the advertisements because I am worried that they will cheat me. I would like to hear from people I know”*.

There are also other barriers, such as concerns about the payback time, limited added value, time spent on the retrofit, possible negative side effects, and difficulty getting an agreement among the citizens. However, these were mentioned by only a few of the interviewees, and the paper will focus on solving the main barriers. The five concerns were mentioned by all the sectors, while the others were only mentioned by one or two interviewees and were therefore not considered a common

concern.

## 4.2. The PPPP business model was proposed

The interviews suggest that the current business models are insufficient in providing a good way to finance building retrofit and that there are problems with lack of knowledge, risk of investment, limited resources, and lack of trust. Furthermore, there is a need for a partnership with qualities from the public and private sectors as well as a residential sector (people) that will increase retrofit in residential buildings. With this in mind, a public, private, and people partnership (PPPP) business model is proposed, which provides a new way to conduct energy retrofit through a deep cooperation between the public, private, and people (see Fig. 3).

In this model, the public sector, private sector, and the residents compose a partnership for building energy retrofit. First, all partners share their needs and resources for the building retrofit. Specifically, the public sector provides political consulting and investment, the private sector provides investment, construction experience, and knowledge, and the residents provide investment and information about their needs. The different sectors then negotiate the details around the application of the business model and how the building retrofit will be carried out—it is this negotiation that is important for building trust as the outcome should be an agreement of terms on how the retrofit should proceed. Once the building is complete, the investment is recouped through the saving of energy in which the public sector, the private sector, and residents will share the profits and risks according to the initial investment and the agreement between them.

## 4.3. Co-create the PPPP business model canvas through the workshop

After the PPPP business model was proposed and introduced to the interviewees, 32 of them believed that the PPPP business model had a high value in terms of solving the existing barriers and expressed interest in developing the model. Eventually, 15 participants attended a focus group meeting and formed the expert panel separated into three groups. The panel was comprised of a wide spectrum of retrofit professionals, with 3 participants from the public sector and government support organizations, 6 from the private sector, and 6 from the residents (Table 2).

To develop the PPPP model, the participants co-created the detailed application of the model through the dimensions of the business model canvas. The result of the discussions was a PPPP business model canvas, co-created according to the opinions and ideas of the participants (Table 3).

### (1) Key partners

For the people, the citizen board is regarded as a necessary key partner, because they can share relevant information with the residents in the building, collect their opinions, and represent them in decision-making processes. In addition, it was argued that both residents with and without interest in investing should be encouraged to participate in this model. As private participant 3 mentioned, *“it is better to add citizens who are not interested in investment, then we can know the practical obstacles we have in such a project”*. As for key partners from the private sector, facility management companies for building energy sustainable buildings are considered useful, because facility management companies can play really important roles for the building retrofit, such as financing, building relationships with the public, and knowledge sharing. The consulting, design, construction, and maintenance companies are needed because they have good experience with building retrofit. From the public sector, the public support energy institutions are necessary, because they can make or influence policies to a certain degree, create strategies, and provide financial support.

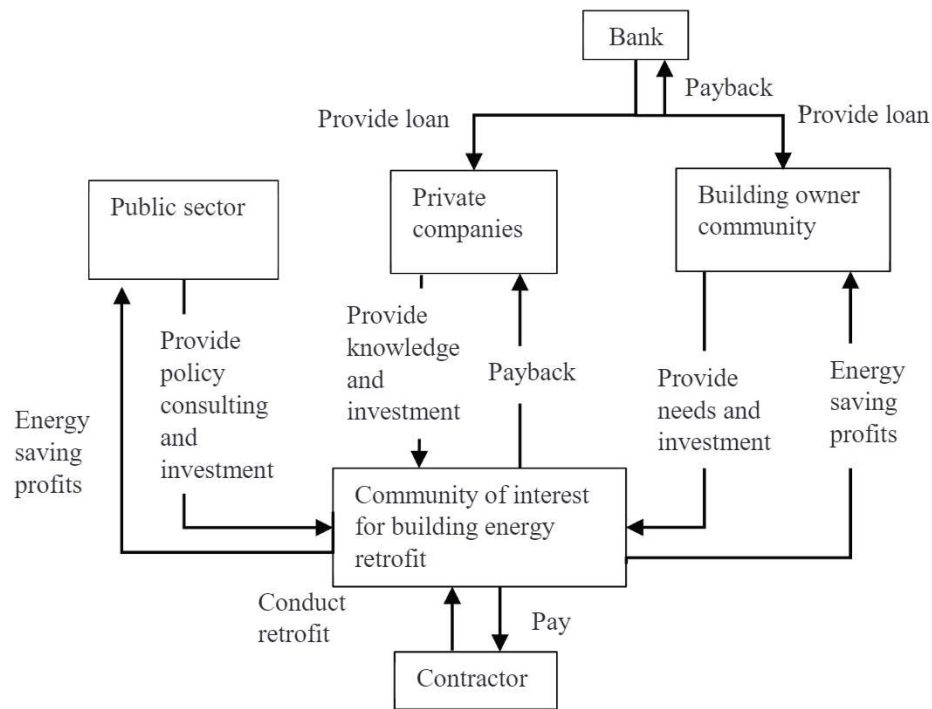


Fig. 3. PPP Business model for building energy retrofit.

Table 2  
The background of the participants in the workshop.

| Group | Participants          | Sector  | Background                             | Gender |
|-------|-----------------------|---------|--|--------|
| 1     | Public participant 1  | public  | public support institution             | male   |
|       | Private participant 1 | private | property company                       | male   |
|       | Private participant 2 | private | consulting company                     | male   |
|       | People participant 1  | people  | residents                              | female |
|       | People participant 2  | people  | residents                              | female |
| 2     | Public participant 2  | public  | public support bank                    | male   |
|       | Private participant 3 | private | multi-stakeholder organizing companies | male   |
|       | Private participant 4 | private | construction company                   | male   |
|       | People participant 3  | people  | residents                              | male   |
|       | People participant 4  | people  | residents                              | male   |
| 3     | Public participant 3  | public  | municipality                           | female |
|       | Private participant 5 | private | consulting company                     | male   |
|       | Private participant 6 | private | facility management                    | male   |
|       | People participant 5  | people  | residents                              | female |
|       | People participant 5  | people  | residents                              | female |
|       | People participant 6  | people  | residents                              | female |

(2) Key resources

The public can provide consulting services on existing policies and can create new policies and regulations for building retrofit. Public participant 1 said, “Now we have quite strict energy regulations when building the new house, but there are no rules when you refurbish older houses, this is an opportunity to create the regulations with people and

private”. They can also provide information and consulting to answer the questions from the residents. All participants from the public sector also expressed willingness to provide financial support, as long as the retrofit could improve energy efficiency. The private can provide information sharing and consulting, financial support, and knowledge and experience. Almost all the private sectors can provide related knowledge and experiences for the cooperation. Most private companies mentioned that they would not provide financial support, as they thought the money should come from the public sector and green banks, and only a small part of private companies would consider contributing with a limited amount. The key resources from the people are information about their needs and financial investment. Private participant 5 thought that the opinions of people were quite important to consider and that engaging people was crucial.

(3) Key activities

The main activities include understanding the barriers and resources from different sectors, presenting the findings, engaging people, building an open innovation platform, and conducting workshops. Determining the barriers and the resources of the different sectors before the co-creation process is crucial, which can give a better understanding of how to use the resources to satisfy the needs. For understanding the barriers of people, public participant 3 mentioned: “a starting activity should be a dialogue with the citizen board, so they can be facilitators to the communities”. People participant 3 also believed that convincing people of the value of the investment was an important activity. In addition, information can be provided by building an open innovation platform, where different partners can share information and provide consulting. People participant 4 thought a presentation would be needed to explain the costs, benefits, and business model canvas, as well as statistical analysis of the costs and savings. The final activity was for the partners to discuss the detailed application of the PPP model in a workshop.

(4) Value proposition

The value for the people includes financing support, energy-saving, getting a comfortable living environment, and easy access to updated

**Table 3**  
The revised PPPP business model canvas for building energy retrofit.

| Category          | People   | Private   | Public  |
|-------------------|--|---|---|
| Key partners      | Community board<br>Citizens (with interest and without interest) in building retrofit  | Facility management companies<br>Consulting, design, operation, construction, and maintenance companies                         | Public support energy institutions  |
| Key resources     | Opinion<br>Investment capital  | Investment capital<br>Knowledge and experience<br>Information sharing   | Policy consulting services<br>Investment capital and support<br>Information sharing |
| Key activities    | Understand barriers and necessary resources from different sectors<br>Presenting the findings of the previous activity<br>Engaging people<br>Build an open innovation platform<br>Conducting a workshop for negotiating of the nine aspects of the business model canvas |   |   |
| Value proposition | Financial supports<br>Energy-saving and comfortable living environment<br>Efficient information updating and easy access to related consultants  | More opportunities to interact with and build good relationships with local municipalities<br>Increase the product sales volume | Contributes to achieving the energy reduction goal by 2050<br>Social sustainability |
| Relationships     | Information sharing, co-investment, as well as co-benefit  |   |   |
| Channels          | For raising awareness: (1) meeting (2) documents from experts (3) familiar people (4) good example demonstrations<br>For evaluating value: (1) technical report (2) consulting   |   |   |
| Revenue streams   | Lower electricity bill<br>Revenue from feeding excess energy into the grid<br>Potential increase in house value  | Energy products or services sales   |   |
| Cost structures   | Build the relationship between different partners<br>Build the online platform for information sharing and consulting  |   |   |

information and related consultants. The co-investment in the PPPP business model can solve the financial barriers by dividing the financial investment between different sectors, and energy-saving lead to lower electricity bills and a higher energy rating for the building. Another value for the citizens is getting a more comfortable living environment, such as heating, stillness, spaciousness, and low electricity use. People participant 4 thought that frequently updated information and easy access to related consultants were important, “It will save lots of time checking different knowledge from different places, in the PPPP model, we can easily access to this information”. The value for the private sector mainly comes from building relations with people and the public sector and increasing the product sales volume. Building relations is important for private companies, as it can lead to more contracts with the government and residents. Private participant 5 mentioned that “People are more willing to buy the apartment, which is developed through the cooperation of the public and private sector, as the public sector always receives more trust, leading to a higher profit for the private”. The value for the public sector is to get closer to achieving their energy goals as well as social sustainability. Public participant 2 also pointed out that “the retrofit can create jobs, which is good for the community. By giving people more contracts, they create more work, which generates more taxes, which is good for the entire the community”.

## (5) Relationship

All the participants agreed that the PPPP cooperation can promote building relationships between the sectors. The types of relationships include information sharing, co-investment, and benefits sharing. Information sharing between private and people can involve residents, as private participant 4 said “If the private sector works for the people to present themselves as green developers and give information related to the retrofit, the residents will more willing to cooperate with the private”. Information sharing between the private and public sectors can promote more opportunities for cooperation. Private participant 3 and people participant 4 both expressed that co-investment is the core relationship for the model. The co-investment relationship leads to the benefit-sharing relationship and using the model, all three sectors can benefit. For people, it is easier to get relevant information and financial support from the public with cooperation. Public participant 3 mentioned “we want to assist all the building owners. We can hold several information meetings for people. In addition, we conduct many one-on-one meetings with building owners, consultants, architects and planning authorities each year to try to provide help”. For the private sector, private participant 1 believed the relationship between private and public could be quite useful and expressed that a good relationship with the public would likely get them more contracts. For the public, they can get social sustainability, the cooperation can create more job opportunities, which increases the tax revenues and is good for the community.

## (6) Channel

The channels for raising awareness are meetings, documents from experts, acquaintances, and demonstrations of good examples. People participants 2, 4, and 5 thought the meetings were an especially important channel. On the other hand, People participants 3 and 6 believed that presenting documents from experts was the best way because they could just focus on the data they were interested in, without it requiring a lot of knowledge and time to understand. People participants 1, 2, and 4 stated that if people they knew had successfully conducted the retrofit, they would be more interested in doing it themselves. Private participants 1, 2, and 5 believed that showing good examples of past projects could be an effective method. Private participant 1 mentioned, “we need show residents good examples and show what happened in each example and the scenarios, give them ideas about how can we learn from this case and how the lessons can be applied in our cases.”.

For evaluating the value of the retrofit, the main channels are technical reports, consulting, and meetings. People participant 2, 3, 4, and 6 expressed that a technical report could help them evaluate the value of investing in retrofit, as participant 6 mentioned: “If you make a detailed calculation of the expected investment and profit in a technical report, I can see more clearly what I am investing in”. People participants 1 and 5 thought the consulting platform would be useful. While meetings and reports can provide a general overview, consulting is needed for case-specific problems. In addition, people can seek help from experts on the platform that they trust.

## (7) Revenue streams

For the people, the revenue can come from lower electricity bills, revenue from selling excess energy into the grid, and a potential increase in the value of the apartment. The first and direct revenue is the decline of the energy cost, which leads to the lower electricity bill. Another revenue from selling excess energy back to the grid or to the neighbor, as people participant 4 mentioned “I will add the PV panel for an energy retrofit, we have really big roofs, we could actually get enough energy, if we can sell the extra energy to the grid or the neighbor, I will get more money”. Some participants mentioned that the increased high energy performance would increase the value of the apartment.

For the private, the main revenue comes from the sales of energy



products or services during the project. In addition, discussions with the consumers can improve customer relations and give a better understanding of their needs, which in turn could increase the sales volume even further. The public sector cannot get revenue directly but can promote building energy projects, which can lead to long-term energy efficiency.

#### (8) Cost structures

In addition to the costs of the building energy retrofit itself, the main costs come from building the information-sharing platform and building the relationship between the different sectors. Private participant 3 and public participant 2 believed that getting the consulting work done would cost a lot of money, because it would require many experts within a wide range of subjects, as private participant 3 mentioned: *“the most costly one is to get all consulting work done, due to there being different sectors that need to prepare all the related project documentation”*. Private participants 2 and 4 expressed that building relationships also would require a lot of money and time and is sometimes not easy.

### 5. Discussion

The main goal of this paper is to co-create a suitable business model to overcome challenges in building retrofit and improve the social acceptance for it. 39 deep interviews were conducted to determine the main barriers. The financial barriers and information sharing barriers account for most of the answers, and these two barriers were mentioned by all the sectors. This result provides a clear direction for which barriers should be the main focus when developing the business model. The findings are also consistent with existing research, as the problems related to financing, information sharing, and concerns of risk guarantees are all mentioned in existing research [13–15]. However, this result also brings new insight about the barriers from the perspectives of different sectors, which can give a deeper understanding of the issue.

For (1) financial barriers, the co-investment from public, private, and people can divide the high initial costs into more affordable sums, which will increase the likelihood of getting investment from more partners and reduce the individual risks, as different sectors have different sources of financing [62]. In contrast, the host-owned model can get some financial support from the public sector to cover 20–30% of the costs, the cost is still very high [55]. The EPC model can solve the high initial cost problem, however, relying on the private sector in Norway is not as suitable [55]. This is because few pilot cases, lower profitability due to cheap hydropower, and long payback times make it risky for third-party companies to invest in residential buildings [65]. Co-investment and co-creation can solve (4) limited resources, knowledge, and experience by sharing each sector’s unique resources and knowledge with each other.

For (2) limited information, building an information-sharing platform among public, private, and people can be useful. On the platform, all partners share their needs, resources, information, and can ask questions and seek to consult. The platform should have a wide range of up-to-date information on building retrofit and be easily accessible for the residents to save them time. It should also facilitate the information flow across different sectors, which can improve both the knowledge and the relationship between the sectors [34]. The information from all three sectors can give a more complete picture for building retrofit than the existing models. The host-owned model does little to spread awareness about available policies and incentives, and the building owners need to find the information by themselves. The energy company in the EPC can take the role of an educator to help citizens understand the benefits. However, the energy company is often regarded as an “outsider” and often needs to first establish a trust to lend credibility to their information [81].

For (3) risks about the achievement of the expected energy efficiency, the PPPP can reduce the risk for each stakeholder by dividing the

costs between the three sectors. More importantly, it can also reduce the overall risks by allowing participants to make better-informed decisions based on knowledge from three different sectors [63]. Furthermore, the cooperation of three sectors often has a better ability to overcome unforeseen events in the installation process, because each sector has different types of experiences and resources, leading to better flexibility [31,62,64,65]. The host-owned model has the highest risks among all the models, as the building owners themselves have to fund the main portion of the high initial costs. In the EPC model, citizens pay a renting fee to the energy company, which takes the main risks for the citizens and takes responsibility for maintenance. However, this only shifts the risks from the people to the private sector [87].

Fifteen participants discussed the business model canvas in detail and co-created it by applying their knowledge and experience in building retrofit. The co-creation process facilitated the most knowledge and suggestions, which led to a joint understanding of the different sectors. The co-created PPPP business model canvas is likely more suitable to the market, because it is not purely theoretical but also based on the participants’ experiences and understanding of the market.

The co-creation process among the people, private, and public sectors has the potential not only to co-create a PPPP model to face the barriers in the residential building retrofit but also improve the social acceptance for it. The final PPPP business model takes into consideration the needs, suggestions, and resources from people, private, and public sectors, especially focusing on the needs of local people, which could lead to improved social satisfaction. All the participants from the different sectors were satisfied with the model and expressed a high likelihood of participating if a real case was organized. In addition, it involves the suggestions from a real-life context in different stages instead of pre-established planning. The final model is made through three rounds of discussion through brainstorming, presenting, discussion, and negotiation, by participants with rich experience. This iterative process makes it better suited to face the complex challenges in building retrofit. Furthermore, it has the potential to establish new cooperation among the different sectors through communication during the co-creation process. Finally, the co-creation process can increase the awareness for building energy retrofit. Instead of relying on show, it leads to a more hands-on approach, which can be effective in educating the participants.

There are also other limitations to the co-creation of the PPPP business model. The first barrier is engaging the citizens. Government departments can provide corresponding institutional guarantees and enforcement rights, and private companies can provide investment capital and operational management experience, but citizens have neither the authority nor the money, making it difficult for them to have an equal position. Moreover, ordinary citizens rarely have enough knowledge to participate in the discussions, and often fail to provide effective strategies. This is mainly due to lack of the time and incentives to participate, lack of knowledge and skill to co-create with others, and lack of confidence to get an agreement. The second barrier is the communication barrier due to the different levels of knowledge in each sector [66]. To communicate and participate in discussions, a basic understanding of the topic is needed amongst all partners. The third barrier is the time and investment it takes to reach an agreement for all partners during the process of co-creation and co-implementation of the new business model [22]. There are many aspects that need to be discussed and negotiated, as the participants likely have different goals and concerns. It will require a large investment to co-create a new business model that engages many different partners. The main costs will be the costs of building relationships between public, private, and people through meetings and workshops, building the online platform for information sharing and consulting, and organizing activities such as surveys and interviews.

With that being said, there are still opportunities to apply the PPPP model. In recent years, many different types of partnerships involving citizens, such as community engagement, multi-stakeholder

partnership, and public-private-people partnership, have been gradually receiving more attention for their use in sustainable development [67]. In addition, there has been increased awareness on the importance of balancing financial, environmental, and social development, and achieving this requires co-creation between the sectors, making the PPPP model a suitable candidate. The awareness of balanced development of financial, environmental, and social development under the building retrofit, will promote the cooperation of different sectors [41].

The PPPP business model for building retrofit has the most potential in countries or regions that meet some basic conditions. First, it requires a large number of citizens with a high interest in energy sustainability, as people in these areas are more willing to participate and express related opinions. Second, there should exist some building energy clusters, including public bodies, industries, and private businesses, and citizens, to achieve efficient innovative cooperation with joint partners [68]. Finally, it is beneficial if there already exist regulations supporting cooperation between people, private industry, and public sectors [58].

**6. Conclusion**

Building energy retrofit is not only an efficient approach to increase energy efficiency through technical installations, but also has great potential to improve social acceptance through co-creation. Hence, the main goal of this paper is to co-create a suitable business model to overcome challenges in building retrofit and improve the social acceptance for it.

The most important contribution of this paper is the proposal of the public-private-people partnership (PPPP) business model as a potential model to promote the building refurbishment market, based on the identified barriers and solutions, as well as the analysis of the differences among different models. It can divide the high initial costs into more affordable sums, facilitate the information flow among different sectors, and involve all three sectors to receive different resources, knowledge, and experiences to better handle unforeseen events. Another main contribution is that the paper for the first time identified the barriers for building refurbishment from the angle of public, private, and people, which provides a full picture of the barriers. This is important because all three sectors play a significant role in building retrofit. It extended

existing research which only focused on the barriers from one or two of the sectors.

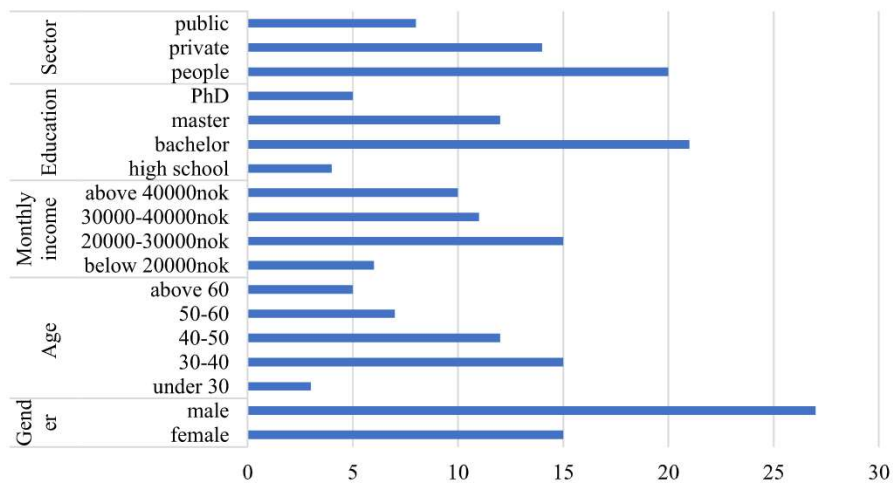
To make the model more suitable for practical use, fifteen participants from the public, private, and people with rich experience in building retrofit participated in a workshop detailed discussed and co-created the PPPP business model canvas, which can provide a systematic method to apply the PPPP business model. The final PPPP business model canvas was designed and supported by theory and empirical experience, which makes it better suited for real-life application. The PPPP business model has the most potential in countries and regions with citizens with high interest in energy sustainability, and barriers in building retrofit similar to the ones discussed in this paper. If successfully applied, the model may be used to stimulate the market for building retrofit, which could contribute significantly to reducing carbon emissions from building sectors and promote energy sustainable development.

Still, there are some limitations to this research. Although the participants of the interviews and workshops were chosen based on strict criteria, the small sample size might negatively impact the validity of the data. In addition, citizens in the co-creation process still tend to have less impact on decision-making than their counterparts in the public and private sectors and reaching a final decision can be time-consuming. For further research, more workshops with participants from a wider range of backgrounds and different countries are needed to obtain more accurate results. In addition, case studies applying the model should be conducted in different countries to further refine the business model canvas. The model should be refined continuously and iteratively through workshops and case studies, as new insight can always be gained from previous iterations of the model and potential case studies. To increase the citizens' participation, as well as improve their role in decision-making, more research is needed on managing relationships in PPPP.

**Declaration of Competing Interest**

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

**Appendix**



The background of the interviewees.

## References

- [1] F. Pardo-Bosch, C. Cervera, T. Ysa, Key aspects of building retrofitting: Strategizing sustainable cities, *J. Environ. Manage.* 248 (2019), 109247.
- [2] J. Li, M. Colombier, Managing carbon emissions in China through building energy efficiency, *J. Environ. Manage.* 90 (8) (2009) 2436–2447.
- [3] G. Li, C. Kou, H. Wang, Estimating city-level energy consumption of residential buildings: A life-cycle dynamic simulation model, *J. Environ. Manage.* 240 (2019) 451–462.
- [4] U. Ali, et al., A data-driven approach to optimize urban scale energy retrofit decisions for residential buildings, *Appl. Energy* 267 (2020), 114861.
- [5] K. Mahapatra, et al., Business models for full service energy renovation of single-family houses in Nordic countries, *Appl. Energy* 112 (2013) 1558–1565.
- [6] A. Khadra, M. Hugosson, J. Akander, J.A. Myhren, Economic performance assessment of three renovated multi-family buildings with different HVAC systems, *Energy Build.* 224 (2020), 110275.
- [7] A. Hamburg, K. Kuusk, A. Mikola, T. Kalamees, Realisation of energy performance targets of an old apartment building renovated to nZEB, *Energy* 194 (2020), 116874.
- [8] M. Krarti, M. Aldubyan, E. Williams, Residential building stock model for evaluating energy retrofit programs in Saudi Arabia, *Energy* 195 (2020), 116980.
- [9] P. Moran, J. O'Connell, J. Goggins, Sustainable energy efficiency retrofits as residential buildings move towards nearly zero energy building (NZEB) standards, *Energy Build.* 211 (2020), 109816.
- [10] X. Zhao, B.G. Hwang, Q. Lu, Typology of business model innovations for delivering zero carbon buildings, *J. Cleaner Prod.* 196 (2018) 1213–1226.
- [11] D.N. Yin Mah, G. Wang, K. Lo, M.K.H. Leung, P. Hills, A.Y. Lo, Barriers and policy enablers for solar photovoltaics (PV) in cities: Perspectives of potential adopters in Hong Kong, *Renew. Sustain. Energy Rev.*, 92 (2018) 921–936.
- [12] S. Azizi, G. Nair, T. Olofsson, Analysing the house-owners' perceptions on benefits and barriers of energy renovation in Swedish single-family houses, *Energy Build.* 198 (2019) 187–196.
- [13] M. M. Sesana, G. Salvalai, A review on Building Renovation Passport: Potentialities and barriers on current initiatives, *Energy Build.*, 173 (2018) 195–205.
- [14] C. Baek, S. Park, Policy measures to overcome barriers to energy renovation of existing buildings, *Renew. Sustain. Energy Rev.*, 16(6) (2012) 3939–3947, Pergamon.
- [15] R. Moschetti, H. Brattebø, Sustainable Business models for deep energy retrofitting of buildings: state-of-the-art and methodological approach, *Energy Procedia* 96 (2016) 435–445.
- [16] S. Sillak, K. Borch, K. Sperling, Assessing co-creation in strategic planning for urban energy transitions, *Energy Res. Social Sci.* 74 (2021), 101952.
- [17] L. Gjørtter Elkjær, M. Horst, S. Nyborg, Identities, innovation, and governance: A systematic review of co-creation in wind energy transitions, *Energy Res. Soc. Sci.*, 71 (2021) 101834.
- [18] V. Ramaswamy, K. Ozcan, The co-creation paradigm, *The Co-Creation Paradigm* (2020).
- [19] C. Booth, T. Richardson, Placing the public in integrated transport planning, *Transp. Policy* 8 (2) (2001) 141–149.
- [20] H. Overholm, Collectively created opportunities in emerging ecosystems: The case of solar service ventures, *Technovation* 39–40 (1) (2015) 14–25.
- [21] N. Mouter, R.M. Shortall, S.L. Spruit, A.V. Itten, Including young people, cutting time and producing useful outcomes: Participatory value evaluation as a new practice of public participation in the Dutch energy transition, *Energy Res. Social Sci.* 75 (2021), 101965.
- [22] S.T. Ng, J.M.W. Wong, K.K.W. Wong, A public private people partnerships (P4) process framework for infrastructure development in Hong Kong, *Cities* 31 (2013) 370–381.
- [23] S.G. Bagaen, Redeveloping former military sites: Competitiveness, urban sustainability and public participation, *Cities* 23 (5) (2006) 339–352.
- [24] J. Zhang, W. Zou, M. Kumaraswamy, Developing public private people partnership (4P) for post disaster infrastructure procurement, *Int. J. Disaster Resil. Built Environ.* 6 (4) (2015) 468–484.
- [25] L. Sanderink, N. Nasiritousi, How institutional interactions can strengthen effectiveness: The case of multi-stakeholder partnerships for renewable energy, *Energy Policy* 141 (2020), 111447.
- [26] C. Knoeri, J.K. Steinberger, K. Roelich, End-user centred infrastructure operation: towards integrated end-use service delivery, *J. Cleaner Prod.* 132 (2016) 229–239.
- [27] A. Osterwalder, Y. Pigneur, A. Smith, T. Movement, *Definition of business models*, 30 (5377) (2010).
- [28] M. Hafner, P.P. Raimondi, Priorities and challenges of the EU energy transition: From the European Green Package to the new Green Deal, *Russ. J. Econ.* 6 (4) (2021) 374–389.
- [29] M.G. Dilger, T. Jovanović, K.-I. Voigt, Upcrowding energy co-operatives – Evaluating the potential of crowdfunding for business model innovation of energy co-operatives, *J. Environ. Manage.* 198 (2017) 50–62.
- [30] C.J. Chiappetta Jabbour, et al., Stakeholders, innovative business models for the circular economy and sustainable performance of firms in an emerging economy facing institutional voids, *J. Environ. Manage.* 264 (2020), 110416.
- [31] P. Marana, L. Labaka, J.M. Sarriegi, A framework for public-private-people partnerships in the city resilience-building process, *Saf. Sci.* 110 (2018) 39–50.
- [32] P. Davis, Why partnerships? Why now? Published by: The Academy of Political Science Why Partnerships? Why Now?, 36(2) (2016) 1–3.
- [33] Y. Xue, A. Temeljotov-Salaj, A. Engebø, J. Lohne, Multi-sector partnerships in the urban development context: A scoping review, *J. Cleaner Prod.* 268 (2020), 122291.
- [34] P. Maraña, L. Labaka, J.M. Sarriegi, We need them all: development of a public private people partnership to support a city resilience building process, *Technol. Forecast. Soc. Chang.* 154 (2020), 119954.
- [35] T. Brauhnoltz-Speight, et al., The long term future for community energy in Great Britain: A co-created vision of a thriving sector and steps towards realising it, *Energy Res. Soc. Sci.* 78 (2021), 102044.
- [36] L. Perjo, C. Fredricsson, S. Costa, Public-private-people partnerships in Urban Planning, *Baltic Urban Lab* (2016).
- [37] V. Ramaswamy, Co-opting Customer Competence.
- [38] W.H. Voorberg, V.J.J.M. Bekkers, L.G. Tummers, A systematic review of co-creation and co-production: embarking on the social innovation journey, 17 (9) (2014) 1333–1357, <https://doi.org/10.1080/14719037.2014.930505>.
- [39] M.M. Al-Debei, D. Avison, Developing a unified framework of the business model concept, *Eur. J. Inf. Syst.* 19 (3) (2010) 359–376.
- [40] F. Boons, F. Lüdeke-Freund, Business models for sustainable innovation: State-of-the-art and steps towards a research agenda, *J. Cleaner Prod.* 45 (2013) 9–19.
- [41] I. Oskam, B. Bossink, A.-P. de Man, The interaction between network ties and business modeling: Case studies of sustainability-oriented innovations, *J. Cleaner Prod.* 177 (2018) 555–566.
- [42] B. Baldassarre, G. Calabretta, N.M.P. Bocken, T. Jaskiewicz, Bridging sustainable business model innovation and user-driven innovation: A process for sustainable value proposition design, *J. Cleaner Prod.* 147 (2017) 175–186.
- [43] M. Yang, S. Evans, D. Vladimirova, P. Rana, Value uncaptured perspective for sustainable business model innovation, *J. Cleaner Prod.* 140 (2017) 1794–1804.
- [44] R. Moschetti, H. Brattebø, K.S. Skeie, A.G. Lien, Performing quantitative analyses sustainable business models in building energy renovation projects: Analytic process and case study, *J. Cleaner Prod.* 199 (2018) 1092–1106.
- [45] C. Wu, Z. Wei, H. Han, G. Xue, H. Huang, A. Fu, Research on source-grid-load-energy storage collaborative service business model based on business model canvas approach, *Asia-Pacific Power Energy Eng. Conf., APPEEC*, vol. 2020-September, Sep. 2020.
- [46] M. Hora, S. Hankammer, S. Gahrens, E. Zurich, V. Electronics, S. Gomez, Designing business models for sustainable mass customization: a framework proposal-sustainable mass customization-mass customization for sustainability view project designing business models for sustainable mass customization: a framework proposal Sultan, *Int. J. Ind. Eng. Manage. (IJEM)* 7 (4) (2016) 143–152.
- [47] C.-A. Gabriel, J. Kirkwood, Business models for model businesses: Lessons from renewable energy entrepreneurs in developing countries, *Energy Policy* 95 (2016) 336–349.
- [48] A. Osterwalder, The business model ontology a proposition in a design science approach (2004).
- [49] A. Leitão, P. Cunha, F. Valente, P. Marques, Roadmap for business models definition in manufacturing companies, *Procedia CIRP* 7 (2013) 383–388.
- [50] J.W. Bleyl-Androschin, Competitive energy services comprehensive refurbishment of buildings through energy performance contracting (2010).
- [51] M. Fouquet et al., Illustration of methodological challenges in energy and environmental assessment of buildings (2014).
- [52] K.L. Soroye, L.J. Nilsson, Building a business to close the efficiency gap: The Swedish ESCO experience, *Energy Effic. 3* (3) (2010) 237–256.
- [53] A. Stauch, P. Vuichard, Community solar as an innovative business model for building-integrated photovoltaics: An experimental analysis with Swiss electricity consumers, *Energy Build.* 204 (2019) 109526.
- [54] M. Gordon, J. Schirmer, M. Lockwood, F. Vanclay, D. Hanson, Being good neighbours: Current practices, barriers, and opportunities for community engagement in Australian plantation forestry, *Land Use Policy* 34 (2013) 62–71.
- [55] A. Franzen, D. Vogl, Two decades of measuring environmental attitudes: A comparative analysis of 33 countries, *Global Environ. Change* 23 (5) (2013) 1001–1008.
- [56] Norwegian Innovation Clusters, Overview over the Norwegian Innovation Clusters.
- [57] The Norwegian Water Resources and Energy Directorate, Plusskundeordningen (English: The plus customer scheme), *The Norwegian Water Resources and Energy Directorate*, 2020.
- [58] The Norwegian Water Resources and Energy Directorate, Plus customers, *The Norwegian Water Resources and Energy Directorate*.
- [59] H.-Y. Wu, Imagination workshops: An empirical exploration of SFP for technology-based business innovation, *Futures* 50 (2013) 44–55.
- [60] N.A. Nygrén, Scenario workshops as a tool for participatory planning in a case of lake management, *Futures* 107 (2019) 29–44.
- [61] M. Geissdoerfer, N.M.P. Bocken, E.J. Hultink, Design thinking to enhance the sustainable business modelling process – A workshop based on a value mapping process, *J. Cleaner Prod.* 135 (2016) 1218–1232.
- [62] L. Sihombing, A.J. Santos Adiwijaya, A. Wibowo, L.B. Sihombing, A.J. Santos, Public-private-people partnership as a new financing model for infrastructure development: A CONCEPTUAL FRAMEWORK, in: *The 7th Engineering International Conference*, 2018, pp. 2–4.

- [63] M.T. Masonta, A. Kliks, M. Mzyece, Unlocking the potential of unoccupied spectrum in developing countries: Southern African Development Community – case study, *Dev. S. Afr.* 34 (2) (2017) 224–244.
- [64] S. Barile, M. Saviano, Resource integration and value co-creation in cultural heritage management (2015).
- [65] T.C. Fontainha, A. Leiras, R.A.d.M. Bandeira, L.F. Scavarda, Public-Private-People Relationship Stakeholder Model for disaster and humanitarian operations, *Int. J. Disaster Risk Reduct.* 22 (2017) 371–386.
- [66] W. Mauser et al., Transdisciplinary global change research: The co-creation of knowledge for sustainability, *Curr. Opin. Environ. Sustain.*, 5(3–4) (2013) 420–431.
- [67] Y. Xue, A. Temeljotov-Salaj, A. Engebo, J. Lohne, Multi-sector partnerships in the urban development context: A scoping review, *J. Cleaner Prod.* 268 (2020), 122291.
- [68] D. Ahlers, P. Driscoll, H. Wibe, A. Wyckmans, Co-creation of positive energy blocks, *IOP Conf. Series: Earth Environ. Sci.* 352 (2019) 012060, <https://doi.org/10.1088/1755-1315/352/1/012060>.