

PAPER • OPEN ACCESS

New business models to support sustainable development: The case of energy-efficiency measures in buildings

To cite this article: A Honold and T Lützkendorf 2019 *IOP Conf. Ser.: Earth Environ. Sci.* **323** 012166

View the [article online](#) for updates and enhancements.

New business models to support sustainable development: The case of energy-efficiency measures in buildings

Honold A¹, Lützkendorf T²

¹ Institute of Information Systems and Marketing, Karlsruhe Institute of Technology

² Centre for Real Estate, Karlsruhe Institute of Technology

anika.honold@kit.edu

Abstract. The German government has set ambitious climate-protection targets to limit global warming. The aim is to achieve an energy-efficient and almost climate-neutral building stock by 2050. This applies particularly to buildings, responsible for more than 20% of CO₂ emissions. The aim is to reduce the primary energy demand of buildings by 80% by the end of 2050. Achieving a nearly climate-neutral building stock requires targeted modernization measures that contribute to increasing energy efficiency. Barriers confronting the implementation of energy-efficient measures include lack of knowledge due to inadequate provision of information, lack of trust, and problems regarding financing possibilities. Therefore, solutions are needed for holistic concepts that make energy-efficient building and modernization more attractive. In addition to traditional business models (BM), measures that accelerate the implementation of energy-efficiency and BM that support the sustainable development of potential customers are sought. Expert knowledge must be shared to close information gaps; savings guarantees must be considered to build trust, and finally, financing possibilities must be available to support implementing sustainable measures. The research focuses on a modification of BM under the aspect of increasing energy efficiency in buildings for customers. This approach considers specific functions, effects, and benefits of BM. The aim of this extension is to create a basis for systematizing existing BM on the one hand, and on the other, to extend the proposed methodology. Finally, the developed guide supports startups designing new BM.

1. Introduction

Today, the development of strategies for sustainable development is based on generally accepted goals, specifically, the Sustainable Development Goals (SDGs) [1]. One essential goal is the protection of the climate in ways that contribute to the conservation of natural livelihoods (SDG 13). With the goal of influencing production and consumption patterns (SDG 12), a solution applicable in the area of construction and urban development (SDG 11) is presented. Several countries are currently developing national strategies to improve climate protection. In 2016, Germany presented the Climate Action Plan 2050 [2]. It establishes the principles and targets for conserving resources by saving primary energy and reducing greenhouse-gas (GHG) emissions. Proposed solutions include reducing energy demand, improving efficiency, increasing the use of renewable energy, optimizing operations, using new products and technologies, improving methods and tools for design, and questioning demand (sufficiency). In addition to identifying areas of action—Energy Sector, Transport, Industry, and Agriculture—the plan formulates reduction targets for GHG emissions particularly for the area of action designated as Buildings. By 2030, GHG emissions in buildings are to be reduced from 1990 levels by 67%. For this action area, a budget of 70 million metric tons of CO₂-equivalent will be available in 2030. For the year 2050,



Germany is targeting an almost climate-neutral building stock [2]. In order to achieve these medium- and long-term goals, the energy performance of existing buildings must be improved. Although an annual renovation rate of 2% is targeted, recent IPCC publications show that an average renovation rate of up to 5% is required to achieve the goal of limiting global warming to below 1.5 degrees [3]. In Germany, an annual renovation rate of less than 1% is currently being achieved in the field of energy-efficient modernization of residential buildings [4]. However, such data are controversial; clear definitions and survey methods for refurbishment and modernization rates are missing. Modernization rates for individual building components or parts of buildings are available in the literature [5]. It appears that current efforts are not sufficient to achieve the defined objectives, so possibilities must be sought to identify and overcome existing barriers to significantly improving energy efficiency in buildings. Private and institutional building owners currently do not have sufficient scope or willingness to take action that will speed up the modernization of existing buildings to improve energy efficiency. This raises the question of whether and to what extent additional incentives and/or complementary approaches should be pursued. One possible approach is the establishment and extension of new business models to improve energy efficiency in buildings. The authors of this contribution have undertaken a research project to investigate the potential for new business models, focusing on the following questions: (1) What is the condition of existing buildings in Germany with regard to their energy quality, and what is their ownership structure? (2) What barriers can be identified and assigned to actor groups? (3) What business model requirements can be formulated, and what approach to the systematization of business models can be derived from this (best needed)? (4) Which business models already exist, and how can their approaches be generalized or reused (best available)? Which hints and recommendations should business startups receive when they would like to contribute to the improvement of energy efficiency in the building sector with new business models? How can achievable economic effects be estimated? This article presents the first preliminary results in answer to these questions. Section 3 discusses major barriers; sections 4 and 5 present approaches for a typology and analyze existing BM. Section 6 provides information for startups. The basis for the article is a literature review, the authors' professional experience, and the results of discussions with experts.

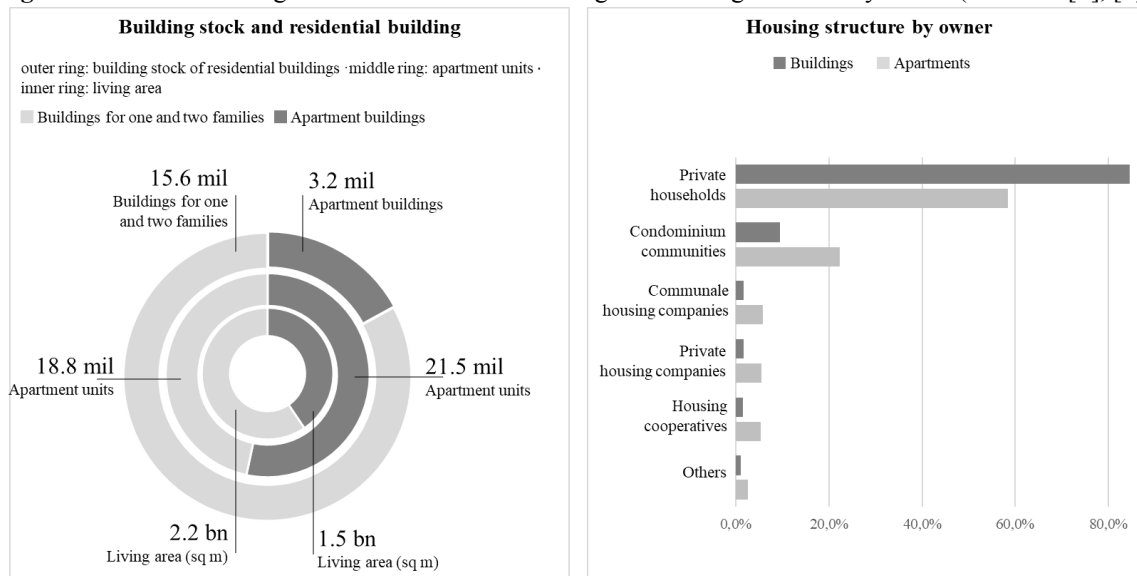
2. Overview of the building stock of residential buildings and ownership structure in Germany

In Germany, the building stock is divided into 18.8 million residential buildings and 2.7 million nonresidential buildings (excluding industry). Nonresidential buildings account for 37 percent of total building energy consumption, while residential buildings account for the remainder. Figure 1 (left) shows the building stock of residential buildings. Those built before 1979, when the 1st Thermal Insulation Ordinance came into force, are of special interest. In fact, this applies to 62 percent of residential buildings and 66 percent of residential units, whose share of final energy consumption is 68 percent [6]. The energy requirements of new and renovated residential buildings are significantly lower. The legal requirements for building construction before 1979 were significantly lower than after 1979. In addition, the current energy consumption of these buildings cannot be determined exactly, due to partial, complete, and multiple modernizations in the meantime. While the members of the organization *Bundesverband der Deutschen Wohnungs-Immobilien-gesellschaften* refurbished two-thirds of its building stock (28.9% partially, 37.3% completely) in terms of energy efficiency, the documentation of modernization measures for the private housing stock is fragmentary [7]. The progress in energetic retrofitting of individual building components also varies considerably [5], substantially complicating the analysis of the energy consumption of these buildings.

The “Destatis report” of the Federal Office of Statistics in Germany on the stock of buildings and apartments shows that the supply of housing in 2011 is predominantly in private ownership (Figure 1). More precisely, private households possess 84.6 percent of residential buildings and 58.4 percent of apartments [8]. Private households are grouped as *owner-occupiers*, who use their residential property for their own needs, and *private landlords* (also known in Germany as “amateurs”). The share of homeowners is the proportion of owner-occupied residential units to all residential units. In 2014, this share was around 46 percent in Germany. Conversely, 54 percent of private households own apartments that

they do not occupy, assigning this proportion to the group of private landlords. The second most common form of ownership is condominium communities (9.5 percent of buildings, 22.4 percent of apartments). These are owner-occupied properties and apartments eligible for allocation to the rental-housing market. Together, condominiums account for almost a quarter of the total housing stock. The remaining parts of the residential space fall into three forms of ownership: communal and private-sector housing companies and housing cooperatives (building share < 2 percent, residential share between 5 and 6 percent [4]).

Figure 1. German building stock and residential building and housing structure by owner (based on [6], [8]).



3. Overview of the barriers related to energy retrofit

Barriers are unwanted factors that slow down, hinder, or block a decision-making process. Various studies have already investigated the circumstances of the matter, subjecting influencing factors to refurbishment decisions and removing barriers that arise during energy-related refurbishment (cf. [9-17]). Table 1 shows the identified barriers (see lines A-K), whereas columns 3-10 check whether a barrier could be confirmed in the literature [10-17]. The most frequently occurring obstructions are explained as examples here. Often, financial factors (barrier type A) prevent an energetic refurbishment. For example, those affected by an alleged refurbishment measure may encounter limited financial possibilities [9], insufficient financial support, or an uneconomical refurbishment [10]. Limited financial possibilities imply a postponement of measures to improve energy efficiency [11,12]. Insufficient knowledge (barrier type B) results in those affected, on the one hand, not knowing about the need for renovation of their property [9,13]; and, on the other hand, being insufficiently informed about possible savings (e.g., heating costs, energy, CO₂) after a refurbishment. This is usually due to a lack of consciousness with regard to the issue of environmental protection, which often has the consequence that other aspects (e.g., economic efficiency, aesthetics, living area) have a greater impact on refurbishment design than energy-related aspects [13]. Time-related factors (barrier type E) also have an influence, whether because of the long period of un-inhabitability of the property [14] or the complexity and associated strain of various time aspects on the design and coordination effort [15]. The principle of the landlord/tenant dilemma (barrier type K) describes the interest of landlords in protecting their investments over the long term, but possible unwillingness to finance short-term costs. In addition, the tenant is reluctant to bear short-term costs, despite benefiting directly from the refurbishment and lower energy costs [11,12,18]. However, the investor could levy a modernization charge and a rent increase after an energetic retrofit, a potential disadvantage for the tenant if a disproportionate increase in rental costs to offset the additional expenditure is significantly higher than the energy costs saved.

Different strategies for select appropriate solutions to address the barriers may include government incentives, counseling programs, and regulations, as well as new technologies, which can be used to overcome them. Another approach is either existing or newly developed business models. This research paper examines business models as a solution to identified problems. Prospective business models could possibly contribute to achieving a modernization rate of more than 2 percent per year.

Table 1. Barriers confirmed in literature.

Barriers	confirmed in literature							
	Friedrich et al. (2007)	Jakob (2007)	Kesternich (2010)	Stieß et al. (2010)	Beilan et al. (2011)	Meyer et al. (2014)	Renz/Hack e (2014)	Vögele et al. (2017)
A Financing problems (e.g. no money, no monetary incentives, uneconomical)	✓	✓	✓	✓			✓	✓
B Insufficient knowledge (e.g. about possible savings and energetic condition)	✓	✓	✓	✓	✓	✓	✓	✓
C No discussion of the topic of energetic refurbishment (e.g. lack of knowledge about possible solutions)			✓	✓	✓	✓	✓	✓
D Lack of knowledge in the operating phase and operational optimization (lack of problem awareness, no need to refurbish)	✓	✓		✓	✓		✓	
E Time factors (uninhabitability of the apartment, lack of time for planning and coordination, etc.)	✓	✓	✓	✓	✓		✓	✓
F Underestimation or doubt of savings potential	✓						✓	
G Missing technical and satisfactory solution (e.g. loss of comfort, no holistic solution)							✓	
H Missing planning tools								
I Lack of reason for renovation (e.g. low price level of fossil energies)		✓		✓			✓	✓
J Architectural and constructional reasons (e.g. restriction by monument protection and other technical factors)		✓	✓	✓			✓	
K Investor-user-dilemma	✓	✓	✓	✓		✓	✓	✓

It is now possible to apply this table to the identified actors in the housing sector (see section 2). Then the question can be answered: which stakeholders are affected by which barriers? In essence, private households (amateur landlords, owner-occupiers) and communities of homeowners provide the most reasons for a lack of modernization measures and have major deficits in knowledge, financing, and trust.

4. Business Model—Basics, trends and typology

4.1. Basics and scientific trends of business models

The term “business model” is not clearly defined in literature. Where Osterwalder and Pigneur [19] describe a business model as the “rationale of how an organization creates, delivers, and captures values,” Margretta [20] combines business models with the fundamental questions of a company (i.e., how a company can earn money with its business). Bieger and Reinhold [21] see a business model as the result of an analysis of existing and new combinations of business-model elements. Network-centric approaches to business models aim to link different types of stakeholders into a coherent system. This includes all types of stakeholders (e. g., customers, investors, employees, suppliers, partners) and, in particular, society and the environment [22,23].

Companies still have some uncertainties with regard to environmentally friendly strategies. However, research shows that the sustainability factor implies technological and organizational innovations that positively influence sales and profits [24]. In addition, there are positive side effects, such as environmentally friendly production, less use of resources, less CO₂ emissions, and more innovations [25]. The current literature contains numerous papers dealing with business models in the context of sustainable development [25-37]. An excerpt from that discussion can be found in Nidumolu et al. (2009), who describe the path to business models that support sustainable development. They outline in five steps the challenges a company faces on the way to a holistic sustainable strategy. Sustainable business models are the result of exploring new paths that can include ecological services, but also the restructuring of established paths that require modernization [25-27]. Concretely, concepts such as *Green Economy*

or *Green Growth* emphasize the sustainable use of resources [28]. A similar aspect is taken up by the *Green* [29,30] or *Sustainability Business Model* [22,31]. Such models include the establishment of lower environmental impacts and a promising platform for innovation. Their focal point is a change of core business strategy (e.g., from selling products to selling service systems containing the product). Somewhat less specific but still relevant are general recommendations for business models on redesigning systems (e.g., minimizing consumption, maximizing the society's benefits, and avoiding waste, cf. [32]). These aspects are considered and classified into so-called archetypes. Different archetypes include different approaches (e.g., maximizing material/energy efficiency; adding value from waste; replacing renewable energy and natural processes; and providing functionality instead of ownership. Detailed descriptions can be found in [29,30,33,34]).

Economically successful technological innovation requires business-model design and implementation combined with careful strategic analysis [26]. Canvas—a business model by Osterwalder and Pigneur [19]—takes this aspect into account. It provides every business with a simple tool to describe and think through its processes. This architecture of business models typically contains and connects different dimensions—for example, in relation to customers, benefits, added value, partners, and finances. While previous research has generated concepts that include the ecological aspect in Canvas (e.g. [30] or *Value Mapping Tool* [34]), the *Triple Layered Business Model Canvas* (TLBMC) is a specific tool that is an extension of Canvas, combining topics such as innovation of business models, as well as sustainable and green business models [33, 35-37]. This extension adds an ecological and a social dimension to the model, the ecological extension of the TLBMC based on a life-cycle perspective on environmental impacts and benefits of products and services. Environmental impacts contain ecological costs based on performance indicators (e.g., GHG emission). Environmental benefits extend the aspect of value creation. Essentially, innovations are sought that reduce (increase) negative (positive) environmental and social impacts [30,33,37].

Although the current literature aims to integrate sustainable development into business models, it is essentially focused on the optimization of internal and organizational processes. Therefore, an approach is sought that aims to optimize customers' processes in order to create added value for customers, ecology, and welfare. A first approach links the sustainable business model to user-driven innovation. The development of a sustainable value proposition constitutes the core of a sustainable business model [38]. However, to this aspect, the externality of the business models can be added. The research approach in this paper follows one that defines business models in the context of supporting sustainable development (in this specific case, an energy-efficiency strategy) for the customer.

4.2. Functions, effects, benefits of business models to improve energy efficiency in buildings (EEiB)

The main function of an EEiB-business model (as defined by the authors) is to increase the energy efficiency of a building. Hence, in order to eliminate barriers that arise during energetic refurbishment, a business model requires certain functions that imply effects and benefits for the customer and for society. Table 2 shows the identified functions (A), effects (B), and benefits (C).

Functions of business models represent their basis. This could be the provision of innovative products and services, but also the development of concepts for the design and implementation of renovation measures, or approaches for the optimization of existing HVAC systems. The effect describes the result a business model can produce. With regard to a potential refurbishment investment, this characteristic represents the time-related advantage of an investment, the identification of savings potentials or guarantees, or the provision of knowledge. The benefit of a business model refers to ecological circumstances that the business model causes (e.g., saving GHG emissions or primary energy and the associated costs). The benefits essentially reflect environmental circumstances. The conceptual step that follows is the development of benefits around social and economic aspects (e.g., reduction of externalities, creation of jobs and partnerships, or integration of companies with different interest groups). Thus, a business model can be evaluated from environmental, social, and economic points of view. Together, these components represent the future value proposition of a company's range of products and services to its customers.

4.3. Introduction of specific business models

The range of business models that contribute to the improvement of energy efficiency in the housing and real-estate sector is constantly increasing. In fact, a recent evaluation of the accompanying research "Energiewendebauen" commissioned by Project Management Jülich indicates that the number of projects (PRJs) dealing with business models has more than doubled from 2018 to 2019. Accompanying research includes projects on contracting (28 PRJs), prosumer models (16 PRJs), and leasing (8 PRJs), but also on approaches such as crowdfunding or sharing economy (in total, 9 PRJs). In Table 2, five business models (partly based on the mentioned projects) are presented.

The selected examples show the approaches to complementary research mentioned above and set different priorities. While in Case 1, the EEiB business model focuses on a financing concept, other business models are based on product service systems or prosumer approaches. Finally, these business models are classified according to the systematization described in Chapter 4.2.

Table 2. Examples of EEiB business models

Case 1 EPC [39]: Energy performance contracting is based on a contract between an owner of a building and a service provider, which contains a guaranteed savings goal in relation to energy consumption or energy costs before the contract is concluded. The service provider receives a regular payment that the client can often finance from the saved energy costs. The contractor controls, optimizes, and maintains the systems with regard to the highest possible energy efficiency. Planning and operational optimization for lighting, cooling, ventilation, and/or heating installations remain in the contractor's hands.
Case 2 RRA [40]: The leasing of roof areas with simultaneous roof renovation is an example of sharing concepts. This model enables a refurbishment measure with a significant increase in the value of the property. The operator of the photovoltaic system receives possible subsidies and the current feed-in tariff by feeding the generated electricity into the grid of the local grid operator. In exchange, the owner of the roof area receives the agreed-upon payment from the operator. The amount of the payment for the roof is determined individually. In addition, a complete renovation of the roof is carried out for owners of large roof areas, such as large production halls and warehouses, commercial enterprises, and public facilities.
Case 3 SW [41,42]: The leasing of software includes the aspect that the supplier often retains ownership of the physical product. This is a subscription-based service that, depending on the rate, offers services in addition to basic applications. Software for operating and building technology may enable energy management of buildings. Efficiency potentials in highly complex building operation can be identified, and energy-saving measures can be implemented and controlled. Corresponding software service packages also provide online diagnostics, updates, cloud applications, or maintenance.
Case 4 FSM [43]: Full-service renovation packages include consulting, design, energy testing, renovation, quality control, commissioning, and financing. The concept of serial modernization of buildings differs fundamentally from previous refurbishment offers, in terms of lower costs, short refurbishment duration, attractive design, and functional and savings guarantees. This is implemented with elements such as 3D scans of the building, pre-assembly of all components, and quality control to achieve the Net-Zero standard.
Case 5 MS [44]: The decentralized generation of electricity from renewable sources or in a combined heat and power plant, often in combination with a tenantable-electricity approach (<i>Mieterstrom</i>), is based on a prosumer approach (i.e., an energy consumer like a building also acts as an energy producer). Energy is preferably fed into the house network of the building and either directly covers the current energy consumption of the tenants living in it or charges a battery store. Only when the energy produced on site cannot be consumed is the excess electricity fed into the public grid. For owners of apartment buildings, these models offer the opportunity to reduce ancillary costs, become less dependent on electricity price trends, increase property value, and generate additional revenue. Tenant savings of energy costs is another advantage.

5. Classification and analysis

The classification and analysis aims to identify business models that increase energy efficiency in the construction sector and contribute to the reduction of greenhouse-gas emissions. The developed systematization refers to the identified barriers. The evaluation in Table 3 regarding functions, effects, and

ecological benefits is based on the personal assessment of the authors. Development of the systematization with regard to further functions, effects, and benefits shown in Table 3 is possible. In the future, the list should be extended in both horizontal and vertical directions, with the aim of clustering similar models and uncovering future potential for new business models.

Table 3. Systematization of business models

	1) EPC	2) RRA	3) SW	4) FSM	5) MS	Addressed barriers*
A) Function	✓	✓		✓	✓	B, C, E, F
A1 Building inspection and energy audit	✓	✓		✓	✓	B, C, E, F
A2 Approvals from local authorities and applications for grants and subsidies		✓		✓	✓	A, B, J
A3 Analysis and diagnosis (energetic analysis)	✓	✓	✓	✓	✓	B, C, H, I, F
A4 Consulting, development, and selection of solutions and energy concepts			✓	✓		B, G, I, J
A5 Economic efficiency calculations	✓			✓	✓	A, B, F, K
A6 Financing concepts and aids	✓	✓		✓	✓	A, B
A7 Project planning				✓	✓	E, J
A7 Project implementation and renovation work	✓		✓	✓	✓	E, J
A8 Project management				✓	✓	E, J
A9 Quality control	✓		✓	✓	✓	B, D, F
A10 Operating the plant/facilities	✓	✓	✓		✓	B, D
B) Effect						
B1 Energy saving potentials	✓	✓	✓	✓	✓	
B2 Savings guarantees	✓		✓	✓	✓	
B4 Investment priority	✓	✓		✓	✓	
B4 Provision of information	✓	✓	✓	✓	✓	
C) Ecological benefits						
C1 Primary energy saving	✓	✓	✓	✓	✓	
C2 Reduction of greenhouse gas emissions	✓	✓	✓	✓	✓	
C3 Comfort gains for customers		✓		✓		
C4 Cost saving for customers	✓	✓	✓	✓	✓	
C5 Reduction of resource consumption	✓	✓	✓	✓	✓	
C6 Motivation to deal with the life cycle of a product/service	✓	✓			✓	
C7 Improved longevity and durability of products (upgradeability and repairability)	✓		✓			
C8 Recycling of materials						
C9 Change in consumer behaviour			✓			
C10 Active development and maintenance of existing value creation networks				✓		
C11 Promotion of efficiency	✓		✓	✓	✓	

*Barriers: A) Financing problem, B) Insufficient knowledge, C) No discussion of the topic of energetic refurbishment, D) Lack of knowledge in the operating phase and operational optimization, E) Time factors, F) Underestimation or doubt of savings potential, G) Missing technical solution, H) Missing planning tools, I) Lack of reason for renovation, J) Architectural and constructional reasons, K) Effort without direct benefit

6. Guide for Startups: Turning an Idea into a Business Model

If the development of business models seems complicated and ambiguous at first sight, a guide serves to develop and help in business-model selection. The path from an idea to a business model that improves the customer's sustainable process includes the key points summarized in Table 4. Ideally, when searching for and selecting a suitable business model, startups must consider four steps. In step 1, ecological, technological, and social developments result from the named techniques. These trends call for business models that support the energetic-refurbishment measures. Step 2 analyses the market and its participants. The focus includes identification of a suitable target group. For example, using the building

and ownership structure from Chapter 2 for this study enables identifying the target group of private landlords. Subsequently, assessing for the focal target group the barriers confronting customers becomes possible (cf. chap. 3). Essentially, private landlords and owner-occupiers show considerable deficits in terms of knowledge, financing, and trust (e.g., [11]). A potential business model must take this into account. After designing a business model with the tools of Canvas or TLBMC, the business model must be specified (step 3). In addition, the functions, effects, and benefits of business models (see chapter 5) must be considered in order to counteract the barriers identified in Step 2. After identifying potential business opportunities, the business model with the greatest potential for overcoming the barriers must be selected. Finally, further steps (such as the preparation of a business plan and its implementation) must be initiated [45].

Table 4. Turning an Idea into a Business Model.

	To do	In detail
1	Have an idea or search for upcoming trends	Generate ideas using creativity techniques (e.g. brainstorming, mindmapping) and trend analyses regarding current developments in society, culture, state, law, politics, economy, technology, and ecology
2	Analyze all conditions and elaborate the idea	Analysis regarding market, competition, market potential, market trends; customers as well as their needs and barriers; strength-weakness analysis of all market participants
3	Identify potential business models	Model a business model using Canvas and TLBMC; take into account the functions, effects and benefits of business model
4	Select business models	Select a suitable business model and initiate the next steps (business plan, implementation, controlling, monitoring, and, if necessary, adaptation of the business model)

7. Discussion and outlook

Through the proposed systematization of business models, this paper offers an approach to linking the theoretical concept of (sustainable) business models with the problem of the barriers that arise during the energetic refurbishment. In addition, the identified functions, effects, and benefits have the potential to represent future value-proposition formulations for the customer. Companies and startups can use combinations of the identified systematization to design their own business model. A guideline for startups is also provided, to help startups on their way from an idea to an economical and ecological business model. Business models that focus on sustainable process improvement for the customer contribute to improving the energy efficiency of existing buildings. In addition, supporting overall solutions (e.g., a combination of consulting, design, and financing concepts) instead of individual solutions ensures a holistic approach to the barriers that homeowners face. The proposed systematization has its limits in terms of completeness. Therefore, carrying out studies that identify barriers by type of building owner and building (chap. 2-3) can extend this conceptual research. It is also important to broaden the systematization in chapter 5 to find patterns and gaps in business models. Future research may also address broad changes in political, social, environmental, and economic aspects. In addition, the aspect of potential conflicts of objectives that may arise among initiators must be examined. Intellectual property is protected knowledge and is only available to society at high cost. For example, to integrate analytical and diagnostic software into building services as a standard would require government intervention. With the help of patent races (e.g., an award system), the government has the opportunity to announce project goals, winners of these competitions receive a reward, and at the same time, the innovation becomes a public good. Furthermore, the state can offer training programs for startups. The systematization and guideline developed in this paper can inspire and help prospective companies to develop new sustainable business-model ideas.

Acknowledgement

This research has been supported by the Research College EnEff.Gebäude.2050, which is part of the project “EnEff.2050.Begleit” (FKZ 03EGB0006B) and financed by the Federal Ministry for Economic Affairs and Energy (BMWi). The authors would like to thank all members of the research college and Project Management Jülich for the support, and the BMWi for the encouragement. Additional thanks to Ingo Halbauer for his support.

References

- [1] Nam U V 2015 *Transforming our world: The 2030 agenda for sustainable development Division for Sustainable Development Goals* (New York)
- [2] Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety 2016 *Climate Action Plan 2050 Principles and goals of the German government's climate policy* (Berlin)
- [3] Intergovernmental Panel on Climate Change 2018 *Global warming of 1.5°C Special Report* (Switzerland)
- [4] Lange J 2018 *Die Neuordnung der energetischen Modernisierung im Recht der Wohnraummiete: Zur Umsetzung klima- und umweltpolitischer Ziele mit den Mitteln des privaten Vertragsrechts* Lit Verlag **58**
- [5] Diefenbach N, Clausnitze K D 2010 *Datenbasis Gebäudebestand. Datenerhebung zur energetischen Qualität und zu den Modernisierungstrends im deutschen Wohngebäudebestand* Institut Wohnen und Umwelt Bremer Energie-Institut (Darmstadt, Bremen)
- [6] Bigalke U, Zhang Y, Kunde J, Schmitt M, Zeng Y, Discher H, Bensmann K and Stolte C 2018 *Gebäudereport Kompakt 2018* Deutsche Energie-Agentur GmbH (Berlin)
- [7] Bundesverband deutscher Wohnungs- und Immobilienunternehmen e.V. (GdW) 2017 *11 Fakten zum Klimaschutz* (Berlin)
- [8] Statistische Ämter des Bundes und der Länder 2011 Wohngebäude und darin befindliche Wohnungen in Deutschland im Jahr 2011 nach Eigentümer In *Statista: Das Statistik-Portal*
- [9] Hauge Å L, Thomsen J, and Löffström E 2013 How to get residents/owners in housing cooperatives to agree on sustainable renovation *Energy Efficiency* **6**(2) 315-328
- [10] Friedrich M, Becker D, Grondey A, Laskowski F, Erhorn H, Erhorn-Kluttig H and Weber H 2007 *CO₂-Gebäudereport 2007* Bundesministerium für Verkehr, Bau und Stadtentwicklung (Berlin)
- [11] Renz I and Hacke U 2016 *Einflussfaktoren auf die Sanierung im deutschen Wohngebäudebestand Ergebnisse einer qualitativen Studie zu Sanierungsanreizen und-hemmnissen privater und institutioneller Eigentümer* Studie des Instituts für Wohnen und Umwelt (Darmstadt)
- [12] Vögele S, Matthies E, Kastner I, Buchgeister J, Kleemann M, Ohlhorst D and Nast M 2017 Reduktion des gebäuderelevanten Energiebedarfs als Herausforderung für die Energiewende Sechs Thesen zu unterschätzten Barrieren und Potenzialen *Die Energiewende verstehen-orientieren-gestalten* Nomos Verlagsgesellschaft mbH & Co. KG 513-530
- [13] Beillan V, Battaglini E, Goater A, Huber A, Mayer I and Trotignon R 2011 Barriers and drivers to energy-efficient renovation in the residential sector: Empirical findings from five European countries *ECEEE Report*
- [14] Kesternich M 2010 Einflussfaktoren auf die Zahlungsbereitschaft für energieeffizientes Wohnen: Ergebnisse eines diskreten Entscheidungsmodells *Soziale, ökologische und ökonomische Dimensionen eines nachhaltigen Energiekonsums in Wohngebäuden* (Mannheim)
- [15] Stieß I, van der Land V, Birzle-Harder B and Deffner J 2010 Handlungsmotive,-hemmnisse und Zielgruppen für eine energetische Gebäudesanierung: Ergebnisse einer standardisierten Befragung von Eigenheimsanierern *ENEF Haus* (Frankfurt am Main)
- [16] Jakob M 2007 The drivers of and barriers to energy efficiency in renovation decisions of single-family home-owners *Center for Energy Policy and Economics CEPE, Department of Management, Technology and Economics, ETH Zurich, Switzerland*
- [17] Meyer N I, Mathiesen B V and Hvelplund F 2014 Barriers and potential solutions for energy renovation of buildings in Denmark *International Journal of Sustainable Energy Planning and Management* **1** 59-66
- [18] CEPI and UIPI 2010 Landlord/Tenant Dilemma *European Council of Real Estate Professionals and the International Union of Property Owners* (Brussels)
- [19] Osterwalder A and Pigneur Y 2010 *Business model generation: a handbook for visionaries, game changers, and challengers* John Wiley & Sons

- [20] Magretta J 2002 Why business models matter *Harvard Business Review Reprint* r0205f
- [21] Bieger T and Reinhold S 2011 Das wertbasierte Geschäftsmodell: Ein aktualisierter Strukturierungsansatz *Innovative Geschäftsmodelle* Springer (Berlin, Heidelberg) 13-70
- [22] Zott C and Amit R 2010 Business model design: an activity system perspective *Long range planning* **43**(2-3) 216-226
- [23] Donaldson T and Preston L E 1995 The stakeholder theory of the corporation: Concepts, evidence, and implications *Academy of management Review* **20**(1) 65-91
- [24] Sharma S 2002 Research in corporate sustainability: What really matters *Research in corporate sustainability: The evolving theory and practice of organizations in the natural environment*, 1-29
- [25] Nidumolu R, Prahalad C K and Rangaswami M R 2009 Why sustainability is now the key driver of innovation *Harvard business review* **87**(9) 56-64
- [26] Teece D J 2010 Business models, business strategy and innovation *Long range planning* **43**(2-3) 172-194
- [27] Lüdeke-Freund F 2010 Towards a conceptual framework of 'business models for sustainability' *Knowledge collaboration & learning for sustainable innovation*, R Wever, J Quist, A Tukker, J Woudstra, F Boons, N Beute, eds, Delft
- [28] Schaltegger S, Hansen E G and Lüdeke-Freund F 2016 Business models for sustainability: Origins, present research, and future avenues *Organization & Environment* **29**(1) 3-10
- [29] FORA 2010 *Green Business Models in the Nordic Region A Key to Promote Sustainable Growth* FORA (Denmark)
- [30] Bisgaard T, Henriksen K and Bjerre M 2014 Green Business Model Innovation: Conceptualisation, Next Practice and Policy *Nordic Innovation Report 20012:12* (Oslo)
- [31] Stubbs W and Cocklin C 2008 Conceptualizing a "sustainability business model" *Organization & Environment* **21**(2) 103-127
- [32] Jackson T 2009 Prosperity without Growth: Economics for a Finite Planet Earthscan (London)
- [33] Bocken N M, Short S W, Rana P and Evans S 2014 A literature and practice review to develop sustainable business model archetypes *Journal of cleaner production* **65** 42-56
- [34] Bocken N M, Short S, Rana P and Evans S 2013 A value mapping tool for sustainable business modelling *Corporate Governance* **13**(5) 482-497
- [35] Zott C, Amit R and Massa L 2011 The business model: recent developments and future research *Journal of management* **37**(4) 1019-1042
- [36] Hahn R, Spieth P and Ince I 2018 Business model design in sustainable entrepreneurship: Illuminating the commercial logic of hybrid businesses *Journal of Cleaner Production* **176** 439-451
- [37] Joyce A and Paquin R L 2016 The triple layered business model canvas: A tool to design more sustainable business models *Journal of Cleaner Production* **135** 1474-1486
- [38] Baldassarre B, Calabretta G, Bocken N M P and Jaskiewicz T 2017 Bridging sustainable business model innovation and user-driven innovation: A process for sustainable value proposition design *Journal of Cleaner Production* **147** 175-186
- [39] Deutsche Energie-Agentur 2018 Energiesparcontracting *Deutsche Energie-Agentur* (Berlin)
- [40] Dachverpachtung.com 2019 *Dachverpachtung* (Seehausen)
- [41] Kieback&Peter 2019 Qanteon Das integrierte System für Energie- und Gebäudemanagement *Kieback&Peter GmbH & Co KG* (Berlin)
- [42] Goedkoop M J, Van Halen C J, Te Riele H R and Rommens P J 1999 Product service systems, ecological and economic basics *Report for Dutch Ministries of environment (VROM) and economic affairs (EZ)* **36**(1) 1-122
- [43] DENA 2018 Serielles Sanieren von Mehrfamilienhäusern *Deutsche Energie-Agentur* (Berlin)
- [44] Polarstern 2019 Mehr Wert für Immobilien: Wirklich Mieterstrom *Polarstern GmbH* (München)
- [45] Bundesministerium für Wirtschaft und Energie 2019 „Roter Faden“ der Gründungsplanung *Bundesministerium für Wirtschaft und Energie* (Berlin)