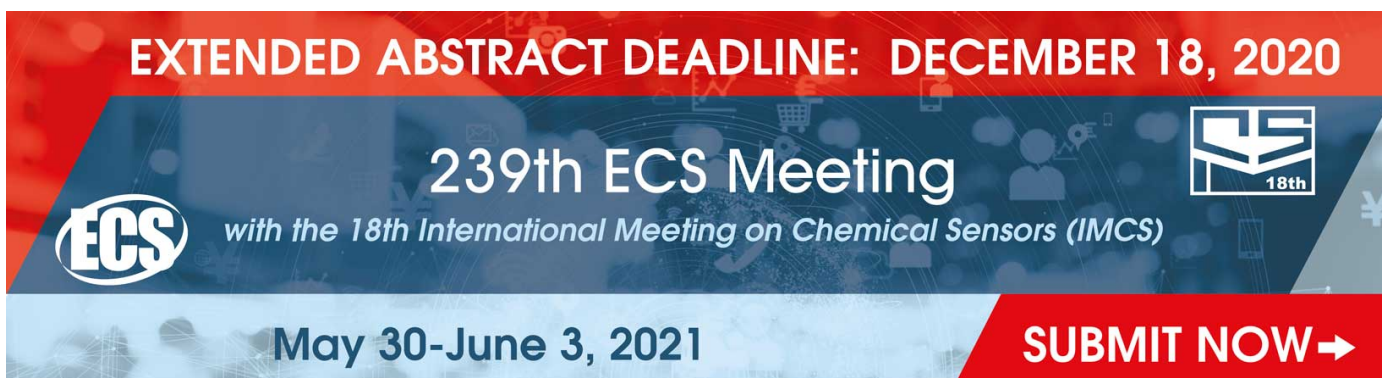


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Business Models in the context of carbon mitigation: New Questions and Approaches illustrated by the Example of Energy Performance Contracting in Germany.

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Abstract. The German government has set ambitious climate protection targets to limit global warming. The goal is to achieve an energy efficient and almost climate-neutral building stock by 2050. This will require, among other actions, a reduction of the primary energy demand of buildings by up to 95% by the end of 2050. In order to achieve an almost climate-neutral building stock, measures for deep energy retrofit are required. In addition to an existing financial demand, there are additional barriers to the expansion of activities to improve the energy performance and to reduce greenhouse gas (GHG) emissions of the existing building stock. One way to overcome these barriers are novel business models such as Energy Performance Contracting (EPC). The question arises as to whether and how the reduction of GHG emissions can be taken into account in the savings guarantees as they are typical for EPCs. This and other questions are addressed in the paper using conjoint analysis. Among other results, it is pointed out that specific approaches are required for different target groups such as the public sector and private homeowners. Finally, recommendations for further action are given. The presented partial results are drawn from the research work "Analysis of business models with regard to their potential for GHG reduction and energy efficiency of buildings".

1. Introduction

In order to achieve both the EU-wide and national targets for an almost climate-neutral building stock, an improvement of the energy performance of existing buildings and the switch to the use of renewable energies are necessary to reduce greenhouse gas (GHG) emissions during the use phase of buildings. However, current reports indicate that the number, pace and intensity of refurbishment measures must be drastically increased [1]. The implied necessary increase in the rate of deep energy retrofit, however, is hampered by barriers. Such barriers that arise in the decision-making process of specific actors for energy retrofit measures are, among others, lack of knowledge about technical possibilities, lack of trust in predicted saving effects, and lack of financing possibilities [2]. One possible way of overcoming such barriers is the development and provision of services by third parties. These can design business models (BM) that lead to energy savings and in parallel to an avoidance of GHG-emissions. The range of such BM in the context of energy efficiency in buildings contains a scope of services from the design, implementation and financing of measures to saving guarantees and the monitoring and verification of systems in operation. Although European Commission (EC) and International Energy Agency (IEA) consider these financial mechanisms to be very important, such BMs still occupy a comparatively small market share. With regard to the EU targets of a climate neutral building stock the research topic of BMs that guarantee a reduction in GHG emissions becomes highly relevant, even though such schemes have not been introduced in the market yet. Therefore, it is to be discussed whether and to what extent the guarantee to save energy can be extended to the mitigation of GHG emissions and further developed to a guaranteed climate neutrality. In this respect, the contribution supports the achievement of sustainability goals such as SDG 12 *Sustainable cities and communities* and SDG 13 *Climate action*



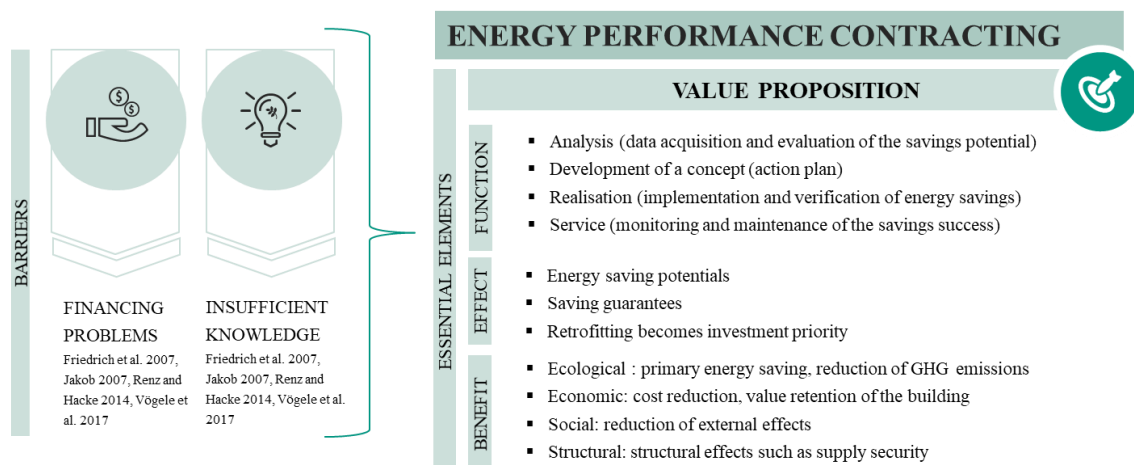
2. Business Models – basics and trends

A business model (BM) can be interpreted as the "rationale of how an organization creates, delivers, and captures value [3]. Network-centric approaches to BMs aim to link different types of stakeholders into a coherent system [4, 5]. Each BM is designed on the basis of the existing social, legal, technical and environmental framework. In its traditional way a BM is focused on the optimization of internal and organizational processes [e.g. 5, 6]. Two noteworthy trends are sustainable and service-oriented BMs: First, although companies are still uncertain about green strategies, studies show that sustainability implies technological and organisational innovation and thus has a positive effect on returns [7]. In addition, there are desirable side effects (for instance, less CO₂ emissions [8]). Sustainable BMs aim to go beyond the mere provision of economic values and take ecological and social factors into account for a broader circle of stakeholders [9]. Second, the focus on service-oriented BMs is changing the core of the business (e.g. from selling products to selling services that include the product). Therefore, BM can also provide a specific service to a customer. In this case, the motivation of a BM design process is customer-driven and customer-centric innovation aimed at developing a sustainable value proposition for the customer [10]. The combination of these two trends promises a rewarding approach [4, 8]. This may include new services, but also the restructuring of proven and modernised routes [8]. Examples of this type of BM in the real estate sector are energy performance contracting (EPC) and energy supply contracting (ESC), which have been developed over many years and will be analysed and further developed in this paper.

3. Energy Performance contracting – current state and new opportunities

The European Commission defines energy performance contracting as “a mechanism for organizing the energy efficiency financing”. The BM of an EPC involves an Energy Service Company (ESCO) which provides various services, such as finances and guaranteed energy savings [11]. In its simplest form and apart from the pure financing of actions to improve the energy performance of buildings, EPC involves the outsourcing of various services for such projects (e.g. basic energy assessment, design, installation services, maintenance and monitoring of installations, etc.) by a building owner to an ESCo. The technical scope of the EPC BM has been elevated in recent years in diverse areas, from building automation to the integration of renewable energies and the refurbishment of the thermal envelope of buildings. The value proposition of EPC is shown in Figure 1.

Figure 1 Energy performance contracting and its essential elements.



The BM provides numerous advantages for ESCos such as predictable long term customer relationships. For the building owners, energy cost savings are directly transferred into efficiency investments and allow to initiate building refurbishment even with no or scarce equity and limited access to third party financing. Also the ESCo takes two of the major risks (investment cost increase and underperformance of energy savings). In practice, an EPC is quite complex, since in addition to the stipulation of a functional construction contract also the performance based remuneration in a reliable way. The remuneration scheme of an EPC contract is always based on a performance guarantee for energy costs,

which, in certain cases can be extended to guaranteed savings of other life-cycle costs such as avoided maintenance costs etc. To enable a performance guarantee, the core scope of work to be provided by the ESCo has to be the design, implementation, monitoring and verification of the guaranteed savings of energy. This scope allows the ESCo to be able to readjust their design to the experience made in the monitoring and verification (m&v) process. The m&v processes which provide reliable information on the energy performance of an EPC project are standardized in the International Performance Monitoring and Verification Protocols [IPMVP, 12]. The protocols provide relevant algorithms in order to ensure that energy and energy cost savings are adjusted from impacts resulting from climate, usage and other influences. The use of the standards has increased acceptance of m&v in EPC projects from 80% up to 98% [13]. An EPC fulfils a number of requirements with regard to ecological, economic, social and, structural objectives (Figure 1). Although the EPC concept is a well-known BM to reduce energy consumption [14], the high expectations for an increasing use of this approach have so far only been met to a limited extent. For example, hardly any references for EPC projects in the non-public building sector could be identified, as EPC in non-public buildings is difficult to implement due to legal conditions [20].

However, it can be assumed that current initiatives towards a climate-neutral building stock will also increase the demand for BM to improve the energy performance of buildings. However, the authors consider it necessary that the reduction of GHG emissions be quantified, reported and, if necessary, guaranteed in the future.

4. Performance contracting for GHG mitigation - concept, typology and use cases

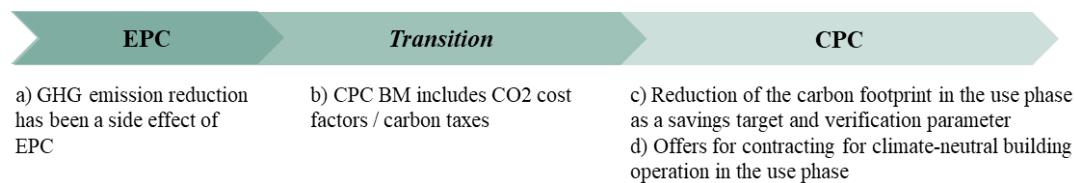
From the EPC BM and its end energy savings towards a BM with the main purpose of GHG emission reduction - here called Carbon Performance Contracting (CPC) - is from a theoretical point of view only a small step which links end energy savings with GHG emission factors. The value proposition of the CPC BM can be the “carbon neutral building in operation”, or “close to carbon neutral building in operation”. Both options include the basic assumption that the total GHG balance of the building is (nearly) zero or (nearly) balanced (net zero). Coming from the definitions of “net zero energy building” the “net zero carbon building” would imply that at least over the period of one year, the balance of GHG emissions caused by operation of a building or a building cluster can be considered to be totally or at least partly equalized. Currently, there are different opinions as to whether and to what extent exported energy and emissions avoided by third parties may be included in the balance. The energy needed to operate an existing building will be reduced by energy efficiency measures, the remaining energy demand will be provided by building integrated (e.g. BIPV) or on site/local production and storage sources and, if necessary, by regional carbon neutral energy sources. The remuneration scheme of the CPC BM would imply for existing buildings the compensation of the first investment and the operative costs (carried by the ESCo) as a reduction of energy costs (i.e. kWh saved), calculated on the basis of the end energy savings and the relevant CO₂ savings factor.

Typology of option of the integration of GHG mitigation into contracting. There are different starting points and options to support the intention of enhancing EPC to CPC - a carbon reduction performance contracting.

- a) GHG emission reduction has been a side effect of EPC: From the holistic perspective, the reduction of fossil fuels and the emission reduction have been per se stable side effects of the so far existing EPC schemes. In some of the decision-making schemes in the public procurement processes, GHG emission reduction has been an evaluation factor, however so far only with a small impact on the mostly economically based decision-making process of an EPC procurement process. Taking GHG emission reduction up as a part of the CPC stipulation can be integrated under the premise, that the measured and verified end energy savings can be linked to GHG emission factors per unit of end energy. The relevance of the measurement and verification process for the end energy savings performance can be used as a solid fundament to calculate the avoided amount of GHG emissions.
- b) CPC BM is supported by CO₂ cost factors / carbon taxes: The introduction of a CO₂ levy in 2020 in Germany provides an excellent structural basis for a CPC BM. Besides the energy prices, a CO₂ levy will contribute to increase the cost effectiveness. As of today, EPC already takes into account the end energy saved, the compensation is independent of the amount of CO₂ saved. In the future, additional saving effects will result from the value of the avoided CO₂. This value will be

- accountable by matching end energy savings with CO₂ emission factors and the CO₂- cost factors. The benefits are of relevance for the building owner and for the ESCo: the increased cost effectiveness will contribute to reduce pay-back period and contract time periods for both sides.
- c) Reduction of the carbon footprint in the use phase as a savings target and verification parameter. In this variant proposed by the authors, the defined and guaranteed reduction of GHG emissions during the use phase of the buildings becomes the actual design and verification parameter and thus the object of the promised savings. ISO 16745-1 [15] and ISO 16745-2 [16] provide a basis for the recording of corresponding emissions and their reduction. The cost-effectiveness of the measures is reflected in the amount of energy sources saved and thus the energy costs avoided, typically represented by the use of energy prices that include a CO₂ tax.
 - d) Offers for contracting for climate-neutral building operation in the use phase. From the authors' point of view, new BMs that guarantee a climate-neutral operation of buildings in the use phase are a viable option. The term "climate-neutral" has not yet been defined in a legally secure manner. As a rule, it is understood to mean a building whose operation either does not produce any GHG emissions or which is offset or compensated for. The use of ISO 16745-1 [15] must be used to define which proportions of the energy input and thus the causes of energy-related GHG emissions are taken into account during the use phase. It must be regulated how an equalized emissions balance is to be proven or which possibilities of compensation are recognized. Likewise, it must be defined whether a contractual reduction success is only weather-adjusted or generally owed. In the latter case, flexible options for offsetting GHG emissions must be provided and taken into account, if necessary.

Figure 2 Starting points to support the intention of enhancing EPC to CPC.



An overview of the four mentioned possibilities of considering savings targets in contracting can be found in Figure 2. In order to develop special BMs that focus on the reduction or compensation of GHG emissions, an adaptation to the needs and motives of selected target groups is necessary.

Use case: Public buildings and non-residential buildings

The strongest market penetration of EPC in Germany can currently be found in hotels, hospitals, nursing homes and the energy-intensive industry. The real estate sector (e.g. property funds and housing companies) is also a growing demand group [17]. The main reason for the implementation remains the reduction of energy consumption so far. Companies in the housing and real estate sector, companies in industry and trade, and public-sector institutions at federal, state and local government level are also currently developing an additional interest in reducing the GHG emissions that arise from the use of their building stock. Drivers are the publication of sustainability reports on the building portfolio and the sustainability certification "in use" of individual buildings. Achieving climate neutrality in operations is a prerequisite for the successful implementation of goals such as "Climate Neutral State Administration" or "Climate Neutral Campus". These groups of stakeholders are therefore also target groups for a CPC.

Use case: Residential buildings

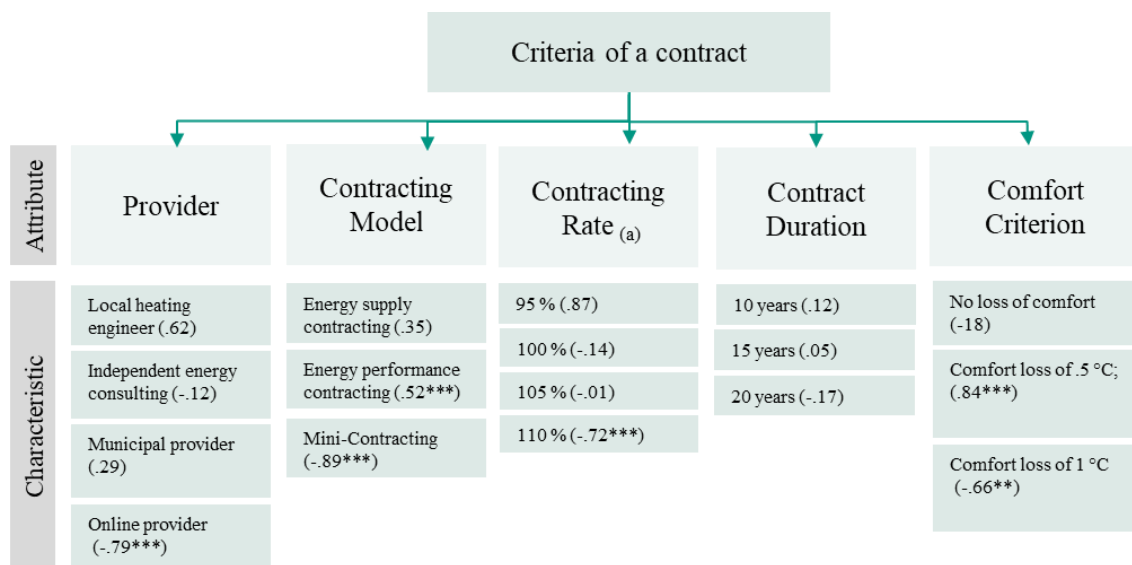
Building owners, private landlords and housing companies have so far - if at all - predominantly used energy supply contracting or direct service for energy supply. Reasons were and are the modernization of heating systems (in the case of all named groups of actors) and an intended transition to direct billing of heating costs (in the case of private landlords and housing companies). Another contracting possibility is mini contracting, which is mainly interesting in the residential building sector for individual actors or smaller non-residential buildings. Mini contracting promotes the modernisation of heating systems in the output range up to about 50 kW. Common mini contracting mainly involves energy supply contracting, where no guarantee is given for a specific saving and the output is not refinanced by energy

cost savings [18]. This special form of contracting is therefore mainly of interest to individual actors in the residential building sector. However, expected subsidy programmes, greater consideration of environmental performance in the appraisal process to assess the market value of buildings (in Germany, the energy performance must already be taken into account in the economic valuation) as well as a general change in values in society suggest that interest in reducing GHG emissions is also growing among these stakeholder groups and a market for contracting offers is emerging which may also contain elements of a CPC. Even if the supply of energy is at the forefront of these business models, there are opportunities to integrate the switch to the use of renewable energies and the reduction of GHG emissions into the business model and to realize them as important side effects.

Clients’ Needs (residential market) – using conjoint analysis to elicit preferences for contracting

The presented partial results are drawn from the research work "analysis of BM with regard to their potential for GHG reduction and energy efficiency improvement of buildings" of the funding initiative EnEff.Gebäude.2050 [19]. The goal of the specific analysis in this part of the overall project was to understand the preferences of clients regarding energy performance contracting. To achieve this, a two-step approach was implemented: In a first step, a general survey of the participants was implemented. Different categories of questions were asked such as demographic data (e.g. age, marital status, educational background), questions regarding the characteristics of the residential building (type, age and size of the building) and regarding the incidental expenses and the state of refurbishment of the building. The participants were also asked about contracting and GHG emission related issues. In a second step a conjoint analysis was conducted to analyse the needs of the target groups for contracting in the actor group of private owners of residential buildings. A conjoint analysis is a market research technique. The question of the survey was, which attributes and characteristics does contracting need in order to provide a maximum benefit for the client. Numerous attributes are in the focus of contracting (e.g. type of heating, scope of refurbishment, type of supplier, amount of contracting rate, duration of contract, credit conditions, etc.). Within the framework of this conjoint survey, the focus was on the potential advantages of contracting that these features can offer a survey participant. In the main part of the survey, all selected attributes and characteristics were first explained to the participants in detail so that they could make a well-founded decision. Participants had to choose between four contracting alternatives (option A, B, C, D), 12 times in total. The attributes and characteristics are shown in Figure 3. In all, 36 questionnaires were completed, the sample contains 432 observations. In this context, it should be noted that the results are hardly representative due to the small number of respondents.

Figure 3 Contracting criteria - attributes and characteristics of the conjoint analysis.



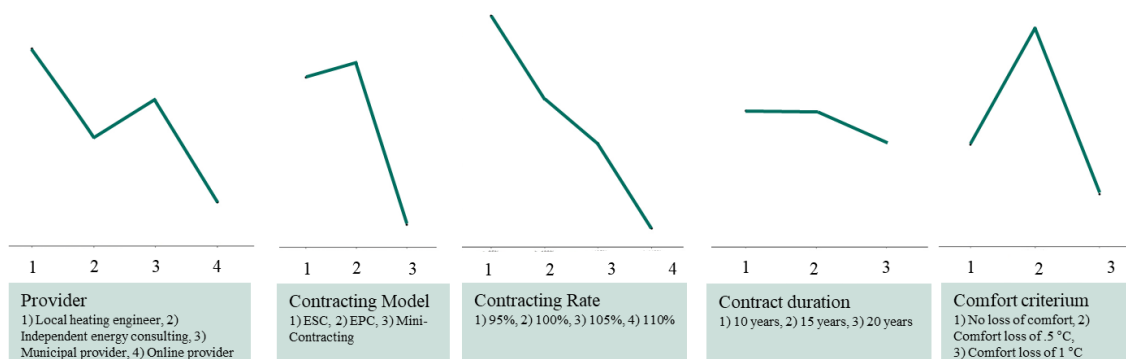
a) The percentage contracting rate reflects the monthly incidental and puts these in relation to the incidental costs incurred for heating and hot water before the refurbishment measure.
 Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

However, the results of the conjoint analysis are considered reliable. This is because if only the observations of the building owners are taken into account, the direction of the coefficients does not change.

Results of the survey: 75% of the respondents stated that they owned at least one residential building. More specific, 44% of the survey participants are owners of a residential building, 31% are owners of more than one residential building, the rest belong to the group of tenants. The participants were asked to characterize their typical buildings. In most cases the buildings were built before 1977 (44%). In 31% (17%) of the cases the buildings were built between 1978 and 1995 (resp. after 1995). In most cases oil heating (42%) and gas heating (39%) are in operation. On average, the respondents are only moderately satisfied with the incidental costs for heating (47%) and hot water (50%). Rather less frequently, the respondents are (very) satisfied with the incidental costs for heating (27%) and hot water (25%). In addition, only 20% of the participants were familiar with the business model of contracting. Finally, 44% (28%) of respondents stated that it is important (very important) to reduce the CO₂ emissions of the building. In total, 72% of the participants are interested in this topic.

Results of the conjoint analysis: It is of interest which choice set a participant prefers. The survey results can then be used to determine the part worth for each characteristic (see Figure 3, values and significance level in parentheses) and relative importance per attribute. The relative importance of an attribute indicates how great the influence of the attribute is on the overall preference if the attribute is changed from the "best" to the "worst" state of expression. With regard to the attributes selected in this survey, the following priorities emerge: Type of provider 21.31%, type of contracting model 22.19%, comfort criterion: 22.97%. The most important attribute is the contracting rate which was identified at 29.2%, the least important attribute in this survey is the contract duration at 4.33%.

Figure 4 Part worth for each contracting criteria.



The part worth indicates to what extent each attribute and each characteristic has influenced the customer's decision to make this choice (see Figure 4). The evaluation of the analysis shows that in the type of contracting provider, local heating engineers and municipal providers such as public utilities are preferred to other providers such as online providers and independent energy consultants. EPC also offers greater benefits than the other contracting models (ESC, mini contracting). Given the coefficients of the contracting rate (Figure 4), the linear, negative trend is not surprising; the price sensitivity of the survey participants for all forms of contracting was confirmed due to the high investments. In terms of contract duration, contracts with a duration of 10 or 15 years were preferred; a contract duration of 20 years tended to be perceived as worse. Finally, clients do not want to lose any comfort or were only accepted to a limited extent. Losses of comfort, i.e. temperature renunciation in the living space above 0.5 degrees is largely rejected.

The presented results cannot be directly compared to other studies due to the uniqueness of the research question. However, a study by Winter and Gurigard [20] reveals barriers to EPC in the private building sector. Winter and Gurigard implemented a pilot project on EPC in a housing cooperative in Oslo and subsequently identified starting points for overcoming barriers in EPC in the future. They concluded that residents neither have a deep concern about energy savings nor are they particularly motivated to change their usual routines. They concluded that "householders tend to be more interested in comfort

and aesthetics than energy savings" [20]. The current results do not confirm these findings, but this is related to the scope of the study, while the results presented here are based on a survey, the study by Winter and Gurigard is based on a real life EPC pilot project.

5. Discussion

The following factors are important for the further development of contracting models with the aim of increasing the use of renewable energies and reducing GHG emissions:

- a) Contracting (EPC and – in a limited way – ESC) is a possibility to evolve buildings in the direction of reducing energy-related greenhouse gas emissions and thereby achieving a nearly climate-neutral building stock in use.
- b) By orientating the savings target towards greenhouse gas emissions, concepts with a conversion to renewable energy gain in importance; this is enhanced by the highest possible tax or levy on CO₂.
- c) In the future, energy suppliers have to publish and guarantee not only specific primary energy factors but also emission factors.
- d) The decarbonisation of energy supply (especially in the electricity market) leads to a reduction of reduction potentials for greenhouse gas emissions and thus complicates the economic efficiency (i.e. for each Euro investment less kg CO₂ are saved than before). This effect is compensated by increasing taxes or prices for greenhouse gas emissions. However, concrete simulations are required to estimate the effects of opposing trends.
- e) It is necessary to analyse other effects on the local environment besides the reduction of greenhouse gas emissions in order to avoid undesired side effects. A shift in environmental impacts (global greenhouse gas emissions versus local particulate matter emissions) has to be avoided.
- f) In the future, the planned measures must be analysed in terms of the amount of material resources, primary energy, non-renewable energy and greenhouse gas emissions that will be required to implement them. Preferably, a life cycle analysis should be carried out. In the ideal case, the reduction effect in the use phase should also compensate for the costs of production, maintenance and disposal.
- g) The interest in reducing greenhouse gas emissions is mainly in the public sector, the housing and real estate industry as well as in industry and trade. In the case of private homeowners, the focus continues to be on guaranteed reductions in energy costs, the financing of modernisation measures without the use of equity or borrowed capital, and the problem-free implementation of the measures. However, both the level of the CO₂ tax and possible subsidy programmes for "climate-neutral" buildings, as well as the consideration of ecological quality in the valuation (previously the energy quality) can also arouse interest in the subject of greenhouse gas emissions among this target group. The results of the Conjoint confirm in particular that there is a fundamental interest in contracting to save CO₂ emissions.

6. Summary and outlook

The uptake of contracting, specifically in the German Efficiency Strategy [21], indicates that the German government is aiming to increase the position of EPC and energy services in the building sectors.

The EPC BM is based on a performance- based remuneration system, which refers to the guaranteed and actually achieved energy performance provided by the energy service company (ESCO). The precondition for the execution of this remuneration scheme is so far a baseline for energy consumption and cost, which refers to the status of a building or a building cluster before energy retrofit. The design, financing, implementation of the measures, as well as the monitoring and verification is provided by the ESCo (Section 3).

One possibility to contribute to the mitigation of GHG emissions is the transformation of existing EPCs into CPC BMs (see Section 4). Although EPC already implies a CO₂ reduction indirectly, there is the possibility of integrating aspects proposed by the authors (Chapter 4 c-d) for the assessment of GHG emission reductions. The starting point remains the measured and verified final energy savings. In addition, the authors have identified three approaches for the further development of EPC: First, the CO₂ levy introduced in 2020 increases the cost-effectiveness of many investments by increasing the economic benefit of a saved kWh (while considering primary energy and CO₂ emission factors).

results from the amount of energy sources saved. Finally, a definition of not yet defined - but contractually essential - terms, the establishment of emission balances and the regulation of possibilities for CO₂ / GHG emissions compensation are needed. Finally, the aspects proposed by the authors in Chapter 5 for the further development of contracting should be considered.

EPCs are already established in the case of public buildings and non-residential buildings. The establishment of a CPC to reduce GHG emissions could enable drivers such as mandatory sustainability reports and sustainability certificates. In contrast, EPC is not considered established in the housing sector. However, the current change in social and ecological values could sensitise private actors to GHG emission reduction in the future and thus represent the beginning of an interesting market for contracting in the housing sector. The conducted conjoint analysis gives qualitative hints of which criteria owners of residential buildings prefer when choosing a suitable contracting model. The seriousness and expertise of contracting providers is important for the clients, especially when considering the price sensitivity of building owners. A focus on differentiated contracting offers (including potential CO₂ / GHG avoidance) as well as the minimization of amortization time and contract periods are also criteria that future contracting providers should consider. The present conjoint analysis has its limitations, which indicate that research needs to be and will be extended in various ways. First of all, it should be noted that the results should be evaluated with regard to the small sample size. However, it is assumed that the most important results will hold if the sample size is increased.

Obviously, it is possible in principle to extend contracting models to include a guarantee of reductions in GHG emissions. The target groups are, in particular, housing companies, real estate funds, industrial and commercial enterprises and the public sector. In the future, the needs of private homeowners in particular will have to be analysed more intensively in order to be able to offer them suitable options for reducing energy consumption and GHG emissions by using contracting models.

Acknowledgements

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References

- [1] Abergel T, Dean B, Dulac J and Hamilton I 2018 Global Status Report. Towards zero-emission efficient and resilient buildings and construction sector, International Energy Agency (IEA) and United Nations Environment Programme
- [2] Honold A and Lützkendorf T 2019 New business models to support sustainable development: The case of energy-efficiency measures in buildings. In IOP Conference Series: Earth and Environmental Science 323(1)
- [3] Osterwalder A and Pigneur Y 2010 Business model generation: a handbook for visionaries, game changers, and challengers John Wiley & Sons.
- [4] Zott C and Amit R 2010 Business model design: an activity system perspective Long range planning 43(2-3) 216-226
- [5] 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
- [6] Stubbs W and Cocklin C 2008 Conceptualizing a “sustainability business model” Organization & Environment 21(2) 103-127
- [7] 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
- [8] 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
- [9] 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
- [10] 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
- [11] European Commission 2019 Energy Performance Contracting,
URL: <https://ec.europa.eu/energy/en/content/energy-performance-contracting>
- [12] IPMVP 2005 International Performance Monitoring and Verification Protocols
URL: www.ipmvp.org
- [13] KEA Klimaschutz- und Energieagentur Baden-Württemberg GmbH 2019 Evaluation of the ESC projects initiated by KEA in the period 2000-2018: Effort of the accounting procedure *Internal Report KEA*
- [14] Sorrell S 2007 The economics of energy service contracts. Energy policy 35(1) 507-521
- [15] ISO 16745-1 2017 Sustainability in buildings and civil engineering works - Carbon metric of an existing building during use stage. Part 1: Calculation, reporting and communication
- [16] ISO 16745-2 2017 Sustainability in buildings and civil engineering works - Carbon metric of an existing building during use stage. Part 2: Verification
- [17] Geissler J 2017 Contracting: Marktentwicklung und Trends in Deutschland. Bundesstelle für Energieeffizienz (BfEE) / Bundesamt für Wirtschaft und Ausfuhrkontrolle (BAFA) Contracting Forum Hamburg 2017: Neue Impluse für energie- und ressourceneffizientes Bauen
- [18] Clausnitzer K D and von Hebel E 2011 Mini-Contracting: Weiterentwicklung von Contractingdienstleistungen für Einfamilienhäuser unter Einbindung Regenerativer Energien und mit Effizienzversprechen Bremer Energie-Institut
- [19] Wissenschaftliche Begleitforschung EnEff.Gebäude.2050 Berlin
URL: <https://projektinfos.energiewendebauen.de/forschung/begleitforschung/>
- [20] Winther T and Gurigard K 2017 Energy performance contracting (EPC): A suitable mechanism for achieving energy savings in housing cooperatives? Results from a Norwegian pilot project. Energy Efficiency, 10(3), 577-596
- [21] Bundesministerium für Wirtschaft und Energie 2019 Energieeffizienzstrategie 2050 Berlin