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ORIGINAL ARTICLE

Energy performance contracting (EPC): a suitable mechanism for achieving energy savings in housing cooperatives? Results from a Norwegian pilot project

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Abstract The barriers to energy savings in institutions and private homes are well known and include people's lack of interest, awareness, knowledge and human and financial capacity. Experiences made in several countries show that EPC—energy performance contracting—may be used for overcoming many of these barriers. A typical EPC project is delivered by an energy service company (ESCO) and the contract is accompanied with a guarantee for energy savings. EPC is increasingly taken in use in the professional market (firms and the public sector), but is less common in the residential sector market. It has been suggested that there are several barriers for using EPC in the domestic sector such as the uncertainty involved in estimating forthcoming reductions in private consumption. In this paper, we present the results from a pilot project on the use of EPC in a housing cooperative in Oslo. The project was initiated and observed by the researchers. The research followed a transdisciplinary methodology in that it was conducted by both researcher and practitioner (co-authors) in close collaboration with members of the housing cooperative and the ESCOs, who also contributed to the interpretation of results. We document the process in terms of why the Board decided to join the EPC pilot, the call for offers from ESCOs who guaranteed that purchased annual energy would be reduced by one third, the responses to and negotiations of the offer from the ESCO who became contracted in the initial phase and up to the moment when the General Assembly finally decided to not invest in the proposed energy saving measures. We find that the residents not only had limited interest in energy savings but also lacked confidence in the EPC process. This contributed to the outcome. We discuss the findings in relation to the barriers to using EPC among housing cooperatives. We highlight the need for more knowledge about the client side for understanding how barriers may be overcome. Three specific recommendations for how EPC may successfully be employed among housing cooperatives are suggested as follows: (i) include refurbishment and not only energy savings in the EPC, (ii) identify the residents' needs in an early phase and (iii) communicate the EPC principle to the residents throughout the process.

Keywords Energy savings · Energy performance contracting (EPC) · Housing cooperatives · ESCO · Trust · Users' perspectives · Client perspective · Refurbishment

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Introduction

Performance contracting is said to have its roots in France in 1937 when a heating system in a hospital in Villiers-Saint-Denis suddenly broke down (Andersson et al. 2011:17). When the heating was restored, the hospital manager requested a contract for supply and operation of energy services that ensured a steady indoor temperature. The Dutch company Royal Dutch Shell soon exported the concept to the UK and the USA where contracts for shared benefits between contractor and customer were further developed (ibid.).

It would take another 50–60 years before energy performance contracting (EPC) became common in the form we know today: a market mechanism in which an energy service company (ESCO) provides a customer with a financially binding guarantee of the energy savings that will be achieved. According to the World Energy Outlook, 80 % of the economic potential of energy efficiency in buildings is still untapped (WEO 2012). Some of the barriers to energy savings are considered to be people's lack of awareness, knowledge and interest in prioritising energy efficiency measures, a lack of confidence in the profitability of energy efficiency measures and a lack of financial capacity to initiate such measures. Proponents of the model regard EPC as a particularly suitable tool for overcoming such barriers to cost-efficient energy savings.

Towards 2000 and in the following years, the USA experienced a rapid growth in the EPC market due to new policies, EPC standards, prequalified ESCOs, evidence of success in previous projects as well as new funding sources (Hoyle 2013). Also in European and Asian countries, the EPC market has been growing although at a slower rate and with great variation between countries (Bertoldi et al. 2006; Bleyl et al. 2013; Zhang et al. 2015; Nolden and Sorrell 2016; Labanca et al. 2015). Reflecting the increasing faith in EPC in the European Union, member states have since 2003 been required to implement performance-based energy regulations (European Commission, 2003 MB, found in Guerra-Santin and Itard 2012), and a Code of Conduct was launched in 2015.[1] In Norway, the EPC market has been denoted as 'preliminary' (Bertoldi et al. 2014:253) and 'intermediary' (EU/IEE 2013:8), but recently, more than 50 Norwegian municipalities have committed themselves to EPC projects. On average, these projects have the goal of saving approximately 30 % of overall energy use (Aasen et al. 2016). The introduction of a national EPC standard (NS6430-2014) is expected to facilitate further growth in this market.

[1] The role of the European Code of Conduct for EPC is 'to bring confidence to the EPC market in Europe and compliance with the Code of Conduct serves as a minimum guarantee of the quality of EPC projects implemented.' http://www.transparense.eu/eu/epc-code-of-conduct Accessed 31.05.2016.

In this paper, we present and discuss the results from an innovative Norwegian pilot project[2] in which EPC was tested out in a housing cooperative[3] in Oslo, Norway, in the period from 2013 to 2015. This type of contract had only rarely been used in the country's residential sector, and the pilot was the first attempt to employ EPCs in a comprehensive way in a Norwegian housing cooperative. In what follows, 'Definition and literature review' provides a definition of EPC through a review of the literature and discusses some of the observed barriers to using EPC in the housing sector. 'The pilot' presents the proposal and gives a detailed description of the process involving action research in which the research team initiated, planned and actively participated in the process. The methods used will be described as we account for the process. In 'Views expressed by members of the housing cooperative and the ESCO', we examine the perspectives and experiences of the Board and residents of the housing cooperative as well as the ESCO, and in 'Discussion and recommendations', we discuss the results and provide recommendations.

Definition and literature review

Generally, an energy service contract implies that a contractor has a long-term responsibility and incentive to maintain and improve equipment performance of a given physical structure (Sorrell 2007:508). Energy performance contracting (EPC) is a particular form of service contract in that the contractor pledges, through a binding commitment, that a specified amount of energy will be saved through the project. This implies that the contractor's compensation is directly linked to the performance of the project over time (Larsen et al. 2012:8, Hoyle 2013:5, see also Bertoldi et al. 2006; Nolden and Sorrell 2016).

There are two main schemes for EPC, one involving 'shared savings', which implies that the performance

[2] The pilot formed part of the research project ESPARR: Energy savings from regulation to realisation, led by CICERO, Oslo.

[3] The type of housing cooperative we refer to may also be called 'large housing estates' (e.g. Brattbakk and Hansen 2004). In Norway, most of these cooperatives, as the one under study, have private tenancy with each dwelling household being the owner of its flat. Each cooperative has a general assembly consisting of all residents who each have a vote when decisions are made. To reach a decision on major investments, a majority of at least 75 % is normally required.

risk (i.e. uncertainty of future energy use) is split between contractor and customer. The other, referred to as 'guaranteed savings', implies that the contractor assumes the entire performance risk (Bertoldi et al. 2006:1821–2). In funding arrangements for EPC, the customer assumes debt, the contractor assumes debt, or the financing is handled through third-party financing (TPF). The issue of financing is central to the potential spread of EPC, and is sometimes used by US observers as an indicator to denote various types of EPCs, but we agree with Sorrell (2007:510) that the financing model does not conceptually affect what EPC is about because there is always a certain degree of shared benefits involved. The choice of financing model should therefore be treated as a separate matter.

A common principle regarding the economics of an EPC project is that the investments in energy efficient technology will be covered by the saved future energy costs.[4] Together with the binding character of the offer from the ESCO, which includes fixed costs of investment and a guarantee that the goals for energy savings will be achieved, this principle of payback of investments through saved future costs constitutes the major argument for why end-users would benefit from using EPC. To the customer, EPC implies risk-free investments and guaranteed savings in the future. Figure 1 illustrates the financial principle of an EPC process, where the guaranteed savings over time equal the volume of investments in energy efficient measures. This implies that when the contract ends, all investments have been paid down, and, given that the energy price remains the same,[5] the running energy costs will be reduced.

Sorrell (2007) observes that EPC arrangements differ in terms of 'scope', i.e. the number of energy streams and services that are included, and in 'depth', i.e. the number of activities required to provide these streams and services, and that both these dimensions influence the potential for energy savings, risks and transaction costs. Nolden and Sorrell (2016) distinguish between 'target bidding' on the one hand, which enhances competition between ESCOs but increases their costs and may limit ambitious goals, and 'partner bidding' on the other hand, which can foster innovation and help the clients to identify potential savings, but limit competition. Moreover, it has been pointed out that facilitators such as consultants and other intermediaries (e.g. public procurement frameworks) can play a vital role in helping clients identify EPC projects prior to going to tender (Bleyl et al. 2013; Nolden and Sorrell 2016). Observers have noted that EPC may also be suitable for projects that go beyond mere energy saving targets and involve comprehensive refurbishment (Bleyl-Androschin and Daniel 2008; Bleyl-Androschin et al. 2009; Milin and Bullier 2011; Grosser Lagos et al. 2015; Labanca et al. 2015). In such cases, the level of investment may exceed the saved energy costs that are possible to obtain within a project's lifetime, whereas long-term energy use may be reduced and other positive effects may be achieved (e.g. increased comfort, improved aesthetics, value of property increasing) and this model has been tried out in the public sector in Norway.[6] We therefore consider the principle of achieving payback during a project's lifetime as a possible, but not a compulsory, trait of EPC.

Main focus on the supply side

In the literature published in English and the Scandinavian languages, many EPC studies have focused on the regulatory, financial and supply side of EPCs, such as comparing the number of ESCOs in various countries and the total volume of contracts (e.g. Vine 2005; Goldman et al. 2005; Bertoldi et al. 2006, 2014; Marino et al. 2010; Hansen 2011; Xu et al. 2011; Guerra-Santin and Itard 2012). Industry and government sources also focus on the supply side, and they tend to highlight the win-win nature of such contracts where both customer and contractor are considered as beneficiaries. Together with her colleagues, Dr Shirley J. Hansen mapped the occurrence and views of ESCOs in 49 countries. In a summary produced

[4] The payback time is specified in the contract (for example, 6–10 years).

[5] As we account for below, the guarantee in the pilot project was linked to energy consumption (kWh/kW) and not costs. Hence, the risk of increasing energy price was similar to conventional energy saving projects, but with EPC, one keeps control of investments and future energy savings, which is not the case in conventional projects.

[6] In the Norwegian municipality Skjervøy, a recently signed EPC contract included a relatively high share of maintenance activities, which means that payback will not be achieved within the project's lifetime.

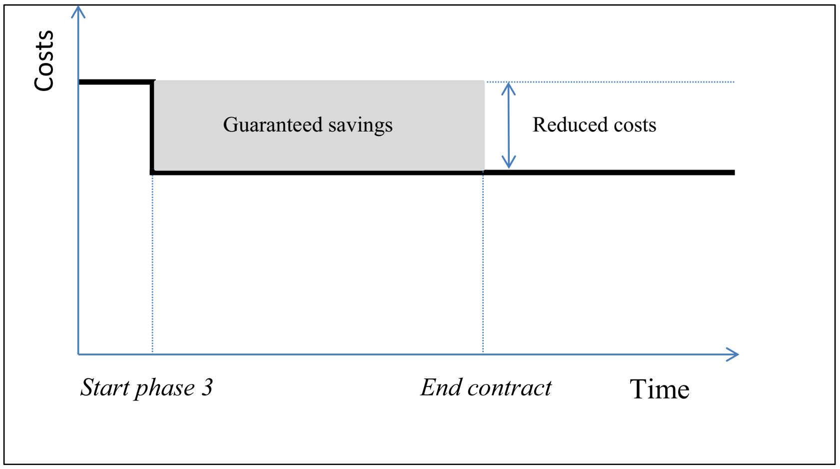

Fig. 1 Illustration of an EPC process (after Gurigard 2013)

for a newsletter, she rhetorically pointed to the economic benefits of EPC for both contractors and customers, as well as the wider society (Hansen 2011:9)[7]:

> Imagine an industry where 25–50 % return on investment is common … an industry that can cost-effectively reduce pollution and bring us closer to our sustainability goals … an industry where customers are offered reduced operating costs and new equipment without front-end capital expenses … an industry where the project costs are paid for out of avoided utility costs – guaranteed… The appeal is enormous, so it is not surprising that the energy performance contracting industry and the energy service companies (ESCOs), which offer all this, have been growing rapidly.

Other observers working from a sustainability perspective have emphasised the necessity to shift towards performance-based energy systems such as EPC. For example, in the context of the deregulated European energy sector, Steinberger et al. (2009:361) argue that only a performance-based energy economy will favour environmental and social goals. The turn to performance is necessary, the authors hold, because the energy market is 'based on profits through energy throughput' (see also Eikeland 1998). They make the call for fundamentally changing the economic structure so that most energy falls under performance arrangements.

Sorrell (2007) provides an economic analysis of EPC and points out that performance contracts may only be appropriate for a subset of energy services and users. The literature has paid limited empirical attention to the user side of EPC arrangements, so relatively little is known about end-users' various needs when it comes to this type of contract. There are numerous case studies available which sum up the projects' technical and financial characteristics, such as the obtained level of energy savings,[8] and market surveys also address the demand side (EEFIG 2015). However, though there are exceptions (Jensen et al. 2013; Rye Petersen 2010; Backlund and Eidenskog 2013; Aasen et al. 2016), there are few academic studies on how EPC is perceived and practised on the user side. Such endeavours seem required for understanding the demand side of EPC, as illustrated in the introductory story from France on how and why performance contracting was initiated. It appears as if the benefits of EPC to existing or potential customers are so obvious that there is no need to further scrutinise their situation.

Known barriers to EPC in the residential sector

The EPC arrangement has primarily been used in the public and commercial sectors and not among households (Vine 2005; Hoyle 2013:19, Satchwell et al. 2010; Bertoldi et al. 2014), though some case studies have been conducted (for a review, see Labanca et al. 2015). Observers have noted

[7] The study was published as a book, which also treats a range of barriers to EPC: *ESCOs around the world. Lessons learned in 49 countries*, by Hansen, Langlois and Bertoldi (eds.), 2009, Fairmont Press.

[8] See, for example, the EPC Help Desk for Sweden (European Energy Service Initiative) which includes a list of completed EPC projects among housing cooperatives (in Swedish): http://www.european-energy-service-initiative.net/se/epc-helpdesk.html Accessed 11 January 2016.

several reasons for the limited use of EPC and other types of services that include performance criteria such as Energy Efficiency Services (ESS) in the residential sector. Hoyle (2013:26) points out that 'residential consumers lack scale, both in per-unit consumption and in the number of readily identifiable homogenous units' … and they 'lack the necessary energy intensity to justify investment within the structure of present-day EPC business models' (ibid.). Similarly, Bertoldi et al. (2014:259) note that the decentralised structure of the residential sector and high transaction costs of face-to-face interaction hinder the uptake of EPC. Based on the review of several studies and cases, Labanca et al. (2015:285) propose 11 factors that may constitute barriers to using EPC (and EES in general) in the household sector:

1. High transaction costs, limited energy costs.
2. High fragmentation of market, need to look at each individual building; hinders standardisation.
3. The landlord/tenant dilemma: landlord does not have economic motivation to reduce electricity costs, which are paid by tenants.
4. Legal requirements, multi-apartment buildings: all tenants must agree before landlord can make investments in energy efficiency.
5. Decision making. Private flat owners must agree before decisions can be made about changes in building shell and technology.
6. Individual needs and behaviours vary and are difficult to control; meters are sometimes lacking.
7. Lack of information about existing offers and lack of understanding the EES/EPC concept, financing and contract.
8. Lack of credibility on EES/EPC providers due to lack of legal framework for their accreditation.
9. Fear of becoming dependent on the contractor.
10. Economic crisis and related uncertainty.
11. Lack of public subsidies and financing capital.

Regarding the nature of private consumption (point 6 in the list), Hoyle (2013:26) notes that '[c]onsumption in the residential sector is driven by different factors than in other sectors.' The commercial and public entities tend to operate on set schedules with reasonably consistent consumption patterns, which simplify the estimation of potential energy savings. Residences, in contrast,

> … may contain a wide variety of energy-consuming appliances and devices, numerous types of lighting fixtures, have unknown building characteristics that may negatively impact the effectiveness of energy efficiency upgrades … consume energy based on the behaviour of occupants, and – most importantly – energy consumption patterns may vary widely from one household to another and among individual members of the same household. (Hoyle 2013:18)

In sum, as seen from an ESCO perspective, both structural/technical factors and the particular nature of private consumption may limit a residential project's feasibility and profitability. Compared to other sectors, this spurs a considerable level of uncertainty, which increases the performance risk (and transaction costs) assumed by ESCOs that become involved in the residential sector. In 'Discussion and recommendations', we discuss to what extent and how these factors came into play in the pilot under study.

As solutions to these barriers to EPC in the residential sector, it has been suggested to focus on information, technology and motivation to change consumption patterns (Hoyle 2013), introduce policy measures that increase people's trust in EPC and ESCOs (Labanca et al. 2015) and focus on the role of project facilitators (Bleyl et al. 2013; Nolden and Sorrell 2016). Moreover, Bleyl-Androschin et al. (2009:996), focusing on the German market, propose that energy savings in the residential sector can most effectively be reached through projects that include refurbishment: 'Additional efficiency potentials of typically 20-50 % can only be tapped, if building technologies, building envelope (building insulation, improved glazing) and targeting user behaviour are integrated into energy service schemes.' According to Labanca et al. (2015:294), two types of models for energy efficiency services (including EPC) may suit the residential sector particularly well: First, the community-based model (social housing, multi-apartment buildings such as the pilot under study) may ensure an economy of scale and help reduce transaction costs. Second, the household model may suit energy suppliers who wish to attract loyal customers (ibid.).

A report by the EEFIG (2015:16) sought to identify drivers of demand for energy efficiency in buildings in general and arrived at the conclusion that the following factors are the most important drivers among owner occupied residences: (i) payment capacity, (ii) transaction costs/simplicity, (iii) behavioural economics/personal priorities, (iv) fiscal support and (v) tailored financial product availability, hence, indicating that people's financial capacity and concern for simplicity are crucial motivational factors for undertaking energy efficiency measures. The report ranks 'awareness of appropriate timing for energy efficiency measures within the traditional building cycle' as relatively unimportant (number 18 of 25 suggested drivers).

Sociological and anthropological research (e.g. Wilhite et al. 2000; Shove 2004; Aune 2007) has shown that domestic energy use, understood as cultural practices, tends to be socially conditioned and motivated by people's concerns for comfort and convenience rather than costs and savings alone. Domestic energy use is also resistant to change due to the habitual, non-reflexive character of such practices (Røpke 2009; Wilhite 2008). Thus, in addition to the 11 barriers to EPC noted above, households are not necessarily interested in obtaining energy savings, and in Norway, the interest in energy savings is particularly low (Winther and de Lesdain Bouly 2013; Westskog and Winther 2014). If habits are hard to change and attitudes are insignificant, the question is what would make them invest in energy efficient measures. Ethnographic studies in Norway and Sweden provide some interesting insights: In many circles, investments that are socially legitimate are those which are perceived to be 'useful' in an economical sense and thus, profitable (Henning 2000). 'Being clever' or 'smart' in the sense of making the right decisions constitutes an important Norwegian cultural value (Norgaard 2011). In this light, the EPC model is particularly interesting for the residential sector, such as in a housing cooperative because the process involves documentation in advance of a project's profitability. Moreover, through the guarantee provided by the ESCO, it involves low financial risk on the users' part. In combination, this appears to have the potential to produce the image of a 'useful project' initiated by 'smart' protagonists and thereby providing legitimacy for making investments in energy efficiency (see Aasen et al. 2016 who found this aspect to be important for why Norwegian municipalities have embraced the EPC model). On this background, we were motivated to try out the EPC model in a Norwegian housing cooperative.

The pilot

Initiation

When this interdisciplinary[9] research was planned in June 2011, we wished to study a couple of promising energy-saving measures in Norway and investigate such initiatives both from a policy and practice perspective.[10] We had learned about the increasing use of EPC among Norwegian municipalities and decided to focus on this market mechanism. A committee had been established at Standards Norway at that time to help prepare a national standard for EPC (which resulted in the standard NS6430-2014). One of the committee members, Mr. Eyvind Kvaale who was employed by the Norwegian State Housing Bank at that time, was working closely with housing cooperatives and expressed a keen interest in trying out EPC in the residential sector through a research project. The advantages of EPC for housing cooperatives are obvious, he told us. Not only is there a minimal level of risk involved to the user, but EPC also has the advantage that throughout the process the customer relates to one single contractor who has all the knowledge needed to suggest and accomplish suitable energy efficiency measures. Kvaale's confidence in the idea and the arguments that an EPC process is low risk, profitable, simple and maintained by a highly knowledgeable actor (the ESCO) triggered our motivation to test out whether and how EPC could be used by housing cooperatives. The existing literature had not highlighted the customers' wish for simplicity (but see EEFIG 2015), and this appeared as a particularly interesting aspect of EPC.[11] The pilot thus set out to examine if and how EPC might contribute to realising energy savings among housing cooperatives in a simple and profitable way.

Finding partners

As a next step, the researchers invited a practitioner (engineer) who had been central in the initiation of EPC activities in Norway to join the project. This EPC

[9] The disciplines included in the research team were political science, economics, social anthropology and engineering.

[10] In addition to EPC, the project focused on policies, regulations and practices surrounding smart meters and in-home displays.

[11] Bertoldi et al. (2006:1827) treated the EPC situation in Ireland and found three categories of companies in the Irish energy efficiency business. When touching on the possible motivation of customers for engaging in EPC, the issue of convenience and simplicity is mentioned: 'However, the companies that contract ESCO-type work in Ireland are interested in saving hassle and time, not in energy efficiency'. This observation may correspond to the interest of many potential EPC customers. As long as they save energy by engaging in EPC, their initial motivation (to save time and hassle) seems just as good as any other kind of motivation—and vital for understanding how to approach them and develop contracts that suit their concerns.

consultant (one of the co-authors) has negotiated almost all the more than 50 EPCs that have been contracted by Norwegian municipalities, and is thereby an experienced 'facilitator' (Bleyl et al. 2013). He had also been engaged by the Norwegian Association of Local and Regional Authorities (Kommunenes Sentralforbund) to develop standardised EPC templates and manuals which were employed in the projects, and he was a member of the national committee for the new national EPC standard. The EPC consultant participated in the research project and also acted as the housing cooperative's consultant vis-à-vis the ESCOs throughout the process. The role of the researcher was to plan and obtain funding for the pilot project, lead and facilitate the first part of the EPC process together with the consultant and document the process, the experiences of the actors involved and the results.[12]

Finding a suitable housing cooperative for collaboration was an important step in the process. The EPC consultant had been in contact with Mr. Stig Hvoslef in the Akershus County Council Administration who was working with energy and environmental issues, including EPC. Hvoslef was interested in using EPC within his own housing cooperative, Nedre Silkestrå Borettslag (Fig. 2), where he was a member of the Board. The Board had already decided that it was time to maintain the buildings and improve energy efficiency as well.[13] The apartment buildings (146 flats, a kindergarten and some common areas) were about 30 years old and had not been subjected to renovation apart from minor repairs. The Board felt that the opportunity to collaborate on a pilot project had come at an expedient time and made the suggestion to the General Assembly (the owners of the flats), who supported the idea to join the pilot project. It was understood that the members of the housing cooperative alone (not the researcher/consultant) would decide if they wanted to engage in a binding contract with an ESCO after the initial phase. They would also be solely responsible for deciding what the contract should include.

Fig. 2 Nedre Silkestrå Borettslag, Oslo, the housing cooperative under study. Photo: Kristin Helena Amundsen

The partners acknowledged that the outcome of the pilot was highly uncertain. In particular, we wondered if any ESCOs would be willing to provide offers to the housing cooperative. As noted in the literature, it may be difficult to estimate the development in private consumption, and this uncertainty increases the risk of the ESCOs providing guarantees on reductions. ESCO representatives in the project's reference group had expressed similar concerns.

Inviting ESCOs to make offers

In April 2013, the project invited energy contractors in Norway and energy consultancy firms located in the Oslo area to a meeting about the EPC pilot. Nine energy contractors (with or without experience from EPC in the public sector) were represented, and in total, there were 22 participants,[14] including a representative from Enova[15] who also gave a presentation. We explained the purpose of the pilot and the premises for the competition, including a special arrangement in which the contractors would need to be prequalified before submitting their offers. The reason for this unusual step in an EPC process was that in order to trigger interest from ESCOs, the project would give compensation of approximately 3000 Euros (25 000 NOK) to each of the

[12] The methods included participation in two General Assemblies and two Board meetings, individual interviews with all the Board members, and several meetings, email exchanges and telephone conversations with individual Board members. The researcher and the EPC consultant also participated in meetings with ESCOs and attended an inspection on the premises as part of the EPC process ahead of the tender. In September 2013, a brief web-based survey was conducted among residents of the housing cooperative, asking about indoor climate, heating comfort and ventilation habits. The survey was answered by 20 of the 144 residents/owners, thus 14 %. Finally, the researcher followed the residents' exchanges of viewpoints on Facebook where the housing cooperative has created a group.

[13] Before the pilot was initiated, the Board had developed a plan for maintenance and repairs.

[14] We did not manage to attract building contractors on this occasion.

[15] Enova SF is a public enterprise owned by the Norwegian Ministry of Petroleum and Energy which allocates funds to energy efficiency and renewable energy initiatives.

contractors who provided EPC offers.[16] We therefore had to ensure in advance that the contractors providing offers (and receiving compensation) had relevant experience.

Four contractors applied for prequalification and all were approved. In July 2013, the chair of the Board sent out a formal EPC invitation to the qualified contractors. This invitation, which followed the principle of target bidding (Nolden and Sorrell 2016), constituted a crucial step in the process in that the client defined the tasks at hand and the competition criteria and provided information about the buildings.[17] The invitation also contained templates for the different contracts to be signed in forthcoming phases of the EPC project. In the pilot, these were based on the templates developed and used by municipalities, though they were modified to match the situation of a housing cooperative. The most important modification was a simplified description of purchasing procedures, as these are regulated and rather rigid for the public sector but not for the private sector. As the housing cooperative intended to finance the project themselves,[18] the ESCOs were not invited to offer loans.

What kind of consumption should be included in the guarantee?

It took careful consideration to decide on what kind of energy use should be included in the EPC competition. This choice would determine what would later be included in the guarantee for energy savings, and thus, ideally, it should include a high proportion of the total energy consumption. At the same time, the included energy consumption should be relatively simple to monitor and not induce too much risk for the ESCO.

The housing cooperative used district heating for space heating (radiators) as well as hot water consumption (showers, etc.). This water-carried energy was jointly metered, and each household paid a monthly fee based on the size of the dwelling (number of rooms). District heating was also used in the cooperative's common areas such as entrances, two laundry rooms and a kindergarten. In total, the buildings included 12.500 m^2 of heated space. It was decided that the EPC should include space heating and hot water consumption because this constituted a large proportion of people's energy use and because the administration of the metering would be simple. Uncertainty remained, however, about the agreement with the district heating supplier regarding the cost if the housing cooperative were to terminate this service and switch to other energy sources for producing heat. As we discuss, this issue turned out to be a major obstacle to realising EPC in the way proposed by the ESCOs.

Every apartment had an electric meter, but individual electricity consumption was excluded from the EPC project because this was considered to be relatively unpredictable and difficult to control, thus increasing the ESCO's performance risk. Furthermore, accessing data on private electricity consumption would have posed a major challenge due to privacy regulations.[19] The cooperative had 24 electric meters for common use (light in entrances and outdoors, garage, kindergarten, laundry rooms), which were included in the EPC project. In sum, due to these practical, contractual and legal issues, only 68 % of the total consumption was included in the EPC project (referred to as 'basis consumption'), which the ESCOs were invited to reduce. Table 1 provides an overview of the cooperative's total annual energy consumption prior to the pilot and the volume and types of energy consumption that were excluded from and included in the competition, respectively. To ensure that the offers would be comparable, it was decided that the call for offers should not include refurbishment, maintenance or other measures which were not directly linked to energy consumption. It was understood that such aspects could instead be considered in a later phase of the EPC process.

[16] Maximum of five ESCOs would be prequalified and invited to provide an offer. When we later asked the three ESCOs who made it to the final phase of the competition if the compensation had been important in terms of making them provide offers on EPC, they said no.

[17] Various attachments followed the invitation, such as the cooperative's historical data on energy use (temperature adjusted) as well as maps, a description of energy systems, the number and types of flats, the age and condition of the building construction and other things.

[18] Favourable public lending arrangements are available for housing cooperatives in Norway.

[19] In Norway, the consent of a private household is needed before electricity data can be shared. Other projects in housing cooperatives have shown that it may be difficult to obtain consent from all households. Households that do not give their consent would have to be excluded from an EPC project, which lasts for several years. This uncertainty would complicate the process and reduce the volume included in the guarantee.

Table 1 Energy consumption in the housing cooperative prior to the EPC pilot, showing the volumes and types of consumption that were excluded from and included in the project

Type of consumption	Energy (GWh)	Share of total consumption (%)
Total annual energy consumption	2.58	100
Consumption excluded from the EPC (individually measured electricity)	0.83	32
Basis consumption included in the EPC (energy for space heating, hot water and common electricity consumption)	1.75	68

Criteria for competition

Having established what types of consumption to include in the competition, the invitation also stated the desired payback time (10 years) and further specified the criteria for competition which concerned all the three common phases of an EPC project:

Phase 1Analysis and project development
Phase 2Implementation of energy efficiency measures
Phase 3Guarantee period (monitor and follow-up energy consumption)

The ESCOs were informed that they would be evaluated on the basis of the profitability of their offers, using the following criteria found in Table 2.

To calculate the present value of the project, the following dummy values were provided in the call for offers: 15 years technical-economic life, 5 % interest rate and energy price 10 Eurocents (85 øre) per kilowatt hour. Note that the dummy price of energy was only used to calculate profitability. The ESCO would guarantee savings on the amount of purchased energy (kWh), not energy costs.

To limit the risk of ESCOs and encourage them to provide binding offers to the housing cooperative, the following condition for exception handling (over- and under-performance) was specified: If the realised savings (kWh) achieve at least 70 % of the identified goal, the contract will be regarded as fulfilled.[20] If the realised amount of savings is less than 70 %, the ESCO must financially compensate the housing cooperative. If the realised energy savings reach more than 110 % of the identified goal, the ESCO and the cooperative will share the gain equally. The prospect of benefit sharing is common in EPC and intended to motivate both parties to achieve a high level of energy savings.

The initial offer from the ESCO

After a joint inspection of the premises, three ESCOs submitted their offers, which were treated confidentially. A round of negotiations with each company followed, whereupon they revised and refined their offers. In December 2013, a contract for phase 1 was signed with the company offering the most profitable solution (Boligenergi AS). The proposed changes/investments included shifting from district to geothermal heating,[21] implementing automatic regulation of the water temperature, introducing individual metering of hot water consumption, controlling and exchanging various light sources in common areas such as building entrances and the garage and other measures. The offer also included a system for monitoring energy consumption which would be undertaken by the ESCO. The goal for energy savings set by the ESCO was 1.193 GWh per year, which implied a 46 % reduction in the total amount of purchased energy; i.e. a reduction from 200 to 111 kWh/m^2 (Table 3). When taking the agreement on under-performance into account, this meant that the ESCO provided a financial guarantee that the cooperative would reduce the amount of purchased energy by 32 % and obtain 140 kWh/m^2. This level of guaranteed savings by one third compared to initial energy consumption corresponds to the binding goals for savings achieved through EPC in the Norwegian public sector (Aasen et al. 2016). Table 3 sums up the details in this ‘initial offer’ as well as subsequent offers, which we will discuss.

[20] Among Norwegian municipalities, where the performance risk of the ESCO is perceived to be lower, the corresponding level of required fulfilment is set at 90 %.

[21] In their offers to the housing cooperative, all the three ESCOs included installing geothermal heating (heat pumps extracting heat from the ground, carried through water).

Table 2 Criteria for the EPC competition, housing cooperative pilot project

Criteria	Measurement	Weight
Costs (lowest possible)	Costs of phase 1 (50 %) Costs of energy labelling of the buildings (50 %)	30 %
Customer profitability (highest possible)	Present value (50 %) Expected energy savings, kWh (50 %)	70 %

Heat pump out and refurbishment included, then project reduced and terminated

During a process of repeated meetings and communication in phase 1, which lasted for one and a half years, the ESCO representative, the consultant, and the Board discussed what measures to implement. On one occasion, a spokesperson from the authorities (Enova) participated in a Board meeting (ahead of the preparation of offer 2) to share knowledge about energy savings and refurbishment, arguing for the benefit of balanced ventilation systems in terms of energy efficiency and indoor climate.

An important obstacle to realising the plans in the initial offer was soon observed. The supplier of district heating (Hafslund Fjernvarme) put strict conditions on the cooperative's request to only use district heating for peak periods and not as their main source of heating.[22] As a result, the suggestion to introduce geothermal heating was abandoned. This was the single most important energy saving measure included in the initial offer. Furthermore, the Board now wished to expand the list of measures by also including refurbishment (e.g. change windows, upgrade the facade). This initiated a lengthy negotiation process in which the ESCO provided several revised offers, and in the present discussion, we only highlight the most crucial steps. A central element of discussion was the issue of introducing balanced ventilation, which the ESCO and the consultant advised, but which several Board members were hesitant about due to the increased costs involved and the inconveniences caused by installing ventilation.

The ESCO looked further into the ventilation issue, and in February 2015, the Board decided to present a revised offer (offer 2) to an Extraordinary General Assembly with approximately 100 attendees including the ESCO, various suppliers of equipment as well as the researcher who observed the event. The Board asked the Assembly to vote either for or against offer 2, which included changing windows and a less comprehensive solution for ventilation where existing tubes would be used with distributed heat recovery through passive ceramic elements in order to keep costs down and avoid having to make significant changes in the structure of each flat. Other measures that had initially been suggested were maintained in offer 2, such as introducing individual metering and automatic regulation of hot water, energy saving showers and various changes in lighting in common areas. The resulting effect, thus the goal for energy savings in offer 2, was now 534.000 kWh, approximately half of the saving volume initially offered (Table 3).[23]

During this Assembly which lasted for about 2.5 hours, the residents commented on the proposal and asked a total of 79 questions about the 18 measures included in the package. In addition, during the days leading up to the meeting, some residents shared their opinions of the housing cooperative's Facebook site. In short, many people were critical of the alleged need for these measures (and their costs), and others questioned the chosen technical solutions. On Facebook and during the meeting, the chair of the Board responded to each question and repeated that nothing had been decided yet, and his neutral rather than emotional description of the elements in offer 2 was probably why the discussion never became

[22] A rumour reached the researchers that the supplier of district heating was worried that other cooperatives would also want to end or change their contract of delivery. The pilot project received attention in the Norwegian press and during a national conference (Enova) in January 2014 and also produced a brochure in 2014 which had the title: 'EPC in housing cooperatives: How they managed in Nedre Silkestrå' (translated from Norwegian by author), which was based on the pilot's experiences up to the signing of the contract for phase 1.

[23] Correspondingly, due to exclusion of heat pump and inclusion of refurbishment, the financial profitability was also considerably reduced compared to the Initial offer. The investment costs in both offers were approximately the same; 2.9 million Euros excluding VAT, thus ca 20.000 Euros per household.

Table 3 Goals for energy savings and resulting annual consumption offered by the ESCO

	Annual energy consumption / annual savings	Energy (GWh)	kWh/m^2	Share of total consumption (%)	Share of basis consumption (%)
Prior to competition	Energy consumption	2.58	200	100	
	Excluded from EPC	0.830		32	
	Basis consumption	1.750		68	100
Initial offer (heat pump)	Goal savings	1.193		46	68
	Goal consumption	1.387	111		
	Guaranteed savings	0.835		32	48
	Guaranteed max consumption	1.745	140		
Offer 2 (rehab.)	Goal savings	0.534		21	30
	Goal consumption	2.046	164		
	Guaranteed savings	0.374		14	21
	Guaranteed max consumption	2.206	176		
Offer 3 (reduced)	Goal savings	0.354		14	20
	Goal consumption	2.226	178		
	Guaranteed savings	0.248		10	14
	Guaranteed max consumption	2.332	187		

heated despite the many questions and objections that were forwarded. Through a written voting procedure, the Extraordinary General Assembly voted against the Board's proposal, and offer 2 was rejected. The Board and the ESCO successively reduced the ambitions (avoiding new windows, balanced ventilation and energy efficient showers) which resulted in offer 3,[24] which was presented to the General Assembly in May 2015, when the composition of the Board was routinely changed. The meeting gave the new Board a mandate to follow up offer 3 with the contractor while defining an upper limit for investments. However, on September 3, 2015, the Board concluded that due to declining electricity prices, which were expected to continue, the project's financial framework would not be viable. The EPC project was terminated before any investments in energy efficiency measures had been made. In this process, the proposed measures changed from first including heat pumps, which would have reduced the amount of purchased energy considerably. This idea was abandoned because the cooperative felt forced to continue purchasing district heating from the existing supplier who put strict conditions on the prospect of only supplying peak load. In the next step (offer 2), the share of energy efficiency measures was reduced while major rehabilitation tasks were added, which increased the costs and reduced project profitability. In the last round (offer 3), the rehabilitation measures were also reduced and the ESCO's guarantee for savings decreased to 10 %. Finally, the plans were terminated.

[24] The investment cost in offer 3 was 650,000 Euros excluding VAT, thus 4.452 Euros per household. Of this amount, it was expected that authorities would provide about 100,000 Euros as subsidy. The housing cooperative would cover the rest through their joint bank savings and a loan.

Views expressed by members of the housing cooperative and the ESCO

We now examine more in depth some of the viewpoints expressed by members of the housing cooperative and the Board during the course of the pilot project. As we will show, the residents' opinions ranged from a concern with the aesthetics and functionality of the suggested measures to uncertainty regarding the need for investment in both energy efficiency and refurbishment. The effects on their monthly costs and the value of the properties also became a heated issue. Moreover, some questioned the position and loyalty of actors involved, which implied that a lack of trust became a crucial issue.

Decision making: from desire for simplicity to complex realities

In the initial phase, Board members said they regarded the EPC procedure as attractive because they could start the process, get binding offers from ESCOs, get the analysis done by a committed ESCO and, at a later stage, decide if they wanted to go on to phase 2, which implies investments. This step-by-step process also appeared to make it acceptable for residents to let the Board manage the EPC preparations and the call for offers up to the time when decisions on investments were to be made, when residents would be brought back into the process. Board members also said they were content that it was a professional, trustworthy ESCO that suggested the various measures and that the Board could have an informed dialogue with the ESCO about costs, savings and other aspects. The guarantee for savings and the fixed cost of investment were believed to enhance effective decision making in the General Assembly. In a conventional process, the housing cooperative would first engage a consultancy firm which would analyse the situation and suggest measures, then select what measures to implement through internal discussion and finally, hire a company (or several) to do the job. The prospect of a simpler procedure for internal decision making, together with the guarantee for savings, were important reasons why this type of contract seemed attractive to the Board.

However, as the project changed from primarily including a technological/institutional change in the production of hot water (replacing district heating with geothermal heat pumps) in offer 1 to the emphasis on refurbishment together with energy saving measures in offer 2, which would imply making considerable changes in each apartment (changing windows, introducing balanced ventilation), the decision-making process turned out to be more complex than anticipated. During the year it took to develop offer 2, the Board held several meetings in which the discussions at times became quite intense. Some of the issues brought up by individual Board members were later reflected in the discussion during the Extraordinary Assembly, when it was not fully clear whether all Board members supported the proposal or not. Below, we convey people's responses to two proposed and interconnected measures in offer 2: changing windows and installing balanced ventilation.

The Board had asked the ESCO to include new windows because the existing ones were more than 30 years old and cases of punctures had been observed. Consequently, the ESCO advised that balanced ventilation would be needed to obtain energy efficiency and a good indoor climate, and the consultant supported this argument as the new windows would be more concealed than the old ones, which had valves for regulating fresh air. To avoid the need for opening windows to obtain fresh air (energy loss), a solution for balanced ventilation with heat recovery was suggested which would ensure energy efficiency while minimising the required changes in each apartment.

At the Extraordinary Assembly, the questions about the ventilation system concerned aesthetics, user flexibility, indoor climate and the appropriateness of the technical solution. For example, participants in the meeting asked if the fans would make a lot of noise, what they look like and how many there would be in each apartment. They also wondered if the balanced ventilation system would require the windows to be kept closed and if they would be able to open them at all, one participant declaring that 'I need to sleep with an open window!' Others asked about the temperature and whether individual regulation would be possible. The residents' focus on the indoor climate in their private homes is not surprising, but the emphasis in the meeting (protests against the new fans) overshadowed a potential discussion of the existing indoor air quality. In an initial web-based survey of the residents (though only answered by 20 of the 144 residents), five respondents had complained about the existing indoor air quality, but this issue (and thus, a possible need to improve air quality) did not receive much attention during the meeting compared to the many questions expressing scepticism regarding the proposed system for balanced ventilation. This indicates that residents were more concerned with possible drawbacks of the new fans than the possibility that they might have a positive effect on indoor climate.

Some residents had investigated the particular type of fan on the Internet in advance of the meeting, claiming that it had rarely been in use in Norway, which made its suitability an open question. There was considerable technical competence among participants, and some seriously questioned the functionality and appropriateness of the technical solution. In this way, a lack of confidence in the choice of solution arose.

Finally, there were complaints about the inconvenience residents would experience during the period of installing the balanced ventilation (and changing the windows). The residents' input to the suggested balanced ventilation system may be summed up in this way: If it is a hassle to install, ugly and noisy when performing, if it provides us with less flexibility than before and we do not even know if it works well, why should we get it?

Lack of trust in the ESCO

As to the other central component in the proposal, changing windows, residents did not question the technology itself, but rather the timing, the selection of supplier and the cost. 'My windows are perfectly fine; there is no need to change them, so why should we incur those costs now?' Another meeting participant commented: 'I changed my windows five years ago; how will that be handled?' To this, the chair of the Board said that such differences would be addressed, but the issue of cost sharing was not detailed during the meeting. To the issue of timing, Board members referred to the ESCO's recommendation and 'standard knowledge' which says that windows have a typical lifetime of 30–40 years and that problems with the old windows in the cooperative had already been observed. Given that the windows were now about 35 years old, the window issue would likely become pressing within the next 5 years, Board members argued, and the EPC process should therefore accommodate this need in the near future.

Another topic of the window debate was the selection of supplier: 'Given that the Board has not received incoming offers from several window suppliers, how do we know that the included offer is the best? I think it looks rather expensive.' This quote is important because it concerns the issue of trust and indicates that the EPC model had not been fully accepted by the residents. Commonly, when an ESCO with the most profitable offer has been selected in competition with others, the achievement of the goals is supposed to be ensured through collaboration between the ESCO and customer, both of whom have economic incentives for doing so. Thus, after signing the first contract, the ESCO and the customer have a mutual interest in energy savings, which is likely to strengthen the customer's trust in the ESCO's suggested solutions (but see Backlund and Eidenskog 2013 for a treatment of firms and how the issue of trust in the ESCO changed over time). In this case, however, the expansion of the project after selecting the ESCO (in phase 1) appears to have contributed to the residents' scepticism towards the proposed solutions and reduced their confidence in the ESCO. In the meeting, participants seemed to regard the ESCO as their foe and not as their alley. As mentioned, refurbishment was not included in the initial phase in which three ESCOs competed on measures that dealt solely with energy and savings. This target-bidding process and limitation at the competition stage was set to ensure that incoming offers would be comparable. As the project was expanded to include refurbishment, the EPC principle was followed in that the contracting ESCO took responsibility for negotiating and bringing in offers from sub-contractors. To the people questioning whether the price of windows was in fact the best possible, this was a crucial step, as they did not trust that the ESCO had secured the best offer. Instead, they expressed that the investments in refurbishment should have been subject to a competition process controlled by the Board and not the ESCO.

Economy counts—but how?

The residents expressed concern for the project's economic aspects in a particular way. The figures for projected savings were shown in the documentation that was handed out,[25] but the home owners did not seem preoccupied with the potential benefit of saving energy (and costs) over time. Almost none of the questions raised during the meeting addressed a need for energy efficiency, which was the rationale for several of the proposed measures such as introducing balanced ventilation. In informal conversations, Board members supported this impression and said this is a well-off area in Oslo where people are more concerned with comfort than keeping energy costs down. This shows an important discrepancy in the perceptions of the ESCO (and the

[25] In the documents presented to the residents, each of the 18 measures was specified according to their investment cost and expected/guaranteed energy savings, e.g. new windows and balcony doors: 13 million NOK investment and 105 000 kWh saved per year. Also, total investments and total savings were shown. However, the documentation did not provide a summary of investment in energy measures on the one hand and investment in other measures on the other. In the example of windows, the energy savings over 8 years would be 840 000 NOK (assuming 1 NOK/kWh), thus 6.4 % of the investment cost, assuming a payback time of 8 years. A presentation of the total investments and savings for all energy-related measures could have better clarified the economy of the energy-saving measures to the residents.

consultant and some of the Board members) and the residents regarding the project's overall goal.

However, critics of the proposal emphasised that the effects of the EPC investment would imply a higher monthly rent (specified in the proposal) and that these project costs would far exceed the saved energy costs. Here, the chair of the Board agreed and explained that this was because refurbishment/windows are not purely energy measures and that they constitute a large proportion of the investment. The critique continued with some arguing that the increased monthly rent would negatively affect the market value of the flats.[26] Individuals who argued this point did not mention that the increased rent would be a financial burden on them, which could be linked to a feeling of embarrassment from admitting in public to a tight budget. But according the Board's impression, most people in this housing cooperative do not have severe financial constraints. Whatever the case, despite Board members' suggestions that the new windows might increase the value of the properties, this view point was overridden by the argument that a rise in rent would have a negative effect on property value. This issue was highlighted towards the end of the Extraordinary Assembly before the voting took place, and the proposal was turned down.

A final point about the way residents spoke of the EPC offer concerns how they perceived their own consultant and to what extent they trusted his advice. When offer 2 had been rejected, several Board members said upon reflection that the consultant had seemed very motivated to introduce energy-saving measures but less informed or concerned about their situation as a housing cooperative.[27] They did not doubt his capacity as a skilled EPC advisor for municipalities, but stressed that the residential sector is very different than the professional sphere (cf. Bleyl et al. 2013).

To sum up the experiences of the housing cooperative in this study and their reasons for rejecting the EPC proposal, they doubted the need for and benefits of the measurements and thought the costs were too high. In effect, they also doubted the competence of the ESCO, the Board and the consultant. After the vote in the Extraordinary Assembly, several residents nonetheless expressed their appreciations for the Board's efforts and said that the cooperative would benefit from this work in the future.

The ESCO's viewpoints and the communication of EPC

The ESCO side admitted that this EPC process had been challenging. The project had been more resource demanding than anticipated due to the many changes requested by the Board and Extraordinary General Assembly, which led to extra hours planning new measures. The contract for phase 1 did not specify that the ESCO's extra resource use would be compensated, and this was based on experiences with EPC in the municipal sector where relatively few individuals are involved in the process of elaborating the details and where the final decisions are made by politicians who consider the needs of the public and not private homes. Another question that the ESCO and consultant put much effort into was considering what kinds of energy-saving measures should be included in the guarantee for savings, and thus, the monitoring period, and which would not. Moreover, the principals of the EPC model were explained to residents in the initial phase. However, at the time when the decision about investments was to be made, a similar clarification of the model was not provided. Nor did the residents receive an overall calculation of which costs and future energy savings belonged to the EPC part of the project and which were simply refurbishments and upgrading of the premises. This made the proposal gradually resemble a conventional refurbishment project. If the energy-saving measures and their payback time had been clearly conveyed during the General Assembly (e.g. as in Fig. 1), and thus, separately from refurbishment, it might not have changed the outcome in terms of rejecting the project, but it might have clarified for the residents what the EPC aspect of this pilot in fact implied.

Discussion and recommendations

The experiences from this pilot project in which energy performance contracting (EPC) was attempted to be employed in a Norwegian housing cooperative confirm

[26] The monthly rent is included in the announcements when properties are put out on the market for sale.

[27] Some Board members said that they felt that the project had been too ambitious and that the consultant appeared at times to be representing the ESCO rather than the cooperative. Consequently, he was not invited to attend the two mentioned General Assemblies. All Board members were asked by the researcher in the aftermath if they had felt pushed to join and proceed with the pilot by the research project. Everybody said that they had not felt pushed, but this reaction vis-à-vis the consultant might indicate some sense of pressure.

some of the observed challenges to achieving energy savings in the residential sector in general and the barriers to EPC in particular. First of all, the residents neither expressed a deep concern for saving energy nor did they appear motivated to change their own routines. The ECSO acknowledged the latter aspect when accounting for the proposed measures which all concerned technical/physical changes and not behavioural change: 'We expect people to continue using energy as they did before.' The low expectations for behavioural change and the strong habitual element of energy consumption have support in the mentioned social practice literature. Second, the pilot failed to produce sufficient trust in the process. Although residents expressed an interest in rehabilitation (e.g. at the outset of the pilot), this aspect only became included in the project at a later stage when progress was jeopardised through people's lack of trust in the ESCO, the EPC process and the solutions suggested. Because rehabilitation, comfort and aesthetics were important to the residents, we concur with one of the Board members who said when the process had been terminated: "We would have been more likely to succeed had we presented this to the residents as 'a refurbishment project with an EPC component' rather than an EPC project". Comprehensive refurbishment, thus projects which are broad in scope, is also what may ensure the highest outcomes in terms of energy savings (Bleyl-Androschin et al. 2009), as shown in successful EPC projects in multi-apartment buildings that have renovated the building structure, improved indoor air quality and so forth (Milin and Bullier 2011; Grosser Lagos et al. 2015; Labanca et al. 2015) In hindsight, it is clear that the pilot's strict competition criteria which solely focused on energy savings did not serve the overall process well. The tender bidding did enhance competition, but the expectation that this would also enhance simplicity and allow the ESCO to help develop and expand the project further was not realised.

Rather, as the pilot developed, it partly lost and partly concealed its EPC aspects, and instead took the form of a conventional rehabilitation project, but at this stage lacking the important competitive element. In contrast, the gradual expansion of EPC projects has been realised with success among Norwegian municipalities; thus, the failed project in the housing cooperative appears to be linked to the particular culture and decision-making processes. The central lesson from this is that ahead of an EPC tender, housing cooperatives need to spend more time and resources on project design, assisted by a facilitator who is familiar with EPC and refurbishment in this kind of organisation and culture (Bleyl et al. 2013, see also Backlund and Eidenskog 2013).

To summarise the experiences and lessons learned in this pilot, Table 4 provides an overview of the observed characteristics of the residential sector and potential barriers to EPC, where points marked with * have been retrieved directly from Labanca et al. (2015) though also often mentioned in the general literature ('Known barriers to EPC in the residential sector'). Text marked in italics indicates additional barriers/factors discovered in this pilot study. To indicate how various actors (e.g. boards of housing cooperatives, ESCOs and authorities) may contribute to mitigating the barriers, we group them according to their relevance at various levels: client, ESCO and framework conditions.

Table 4 also shows that some of the common problems with using EPC in the residential sector did not appear as barriers in pilot, such as residential consumers' lack of scale, energy intensity and readily identifiable homogeneous units. The incoming, binding offers from three ESCOs in the pilot reflected that they perceived the project to be commercially interesting and viable. As one of them said, 'When we have seen one flat, we know approximately what to expect in the others'. Their engagement also indicates that they did not think the prospect of residents' shifting and different consumption patterns increased uncertainty to an unacceptable level so they would not assume the risk of providing guarantees for savings. Also, because the studied housing cooperative is located in the Norwegian capital of Oslo and included 144 flats concentrated in one area, the issue that EPC may be hindered by a decentralised structure of the residential sector did not apply in this case, though it might very well be relevant in other places.

Based on these experiences, we have the following three main recommendations:

1. Refurbishment through EPC.

The use of EPC in housing cooperatives is more likely to succeed when the project includes comprehensive refurbishment and not only energy measures. This is so because householders tend to be more interested in comfort and aesthetics than energy savings. Projects that include comprehensive refurbishment also have the highest outcomes in terms of energy savings.

Table 4 Barriers to EPC in the residential sector, the way and extent they came into play in the pilot, and suggestions to how the barriers may be mitigated

	Barriers for EPC, residential sector	Experiences from the pilot project (housing cooperative)	Suggestions for how to mitigate barriers
Client perspective, general			
1	Lack of interest in energy savings	Was an underlying, major barrier.	Shape and promote EPC project as comprehensive refurbishment project with EPC component. Start process by examining and discussing the potential need for refurbishment (and energy savings). Suited timing: when refurbishment is required.
2	Lack of willingness to change practices and reduce user flexibility (Henning 2005)	Initial offer: was not a barrier because proposed changes did not affect/ dictate energy use. Later stage: became a barrier (protests against balanced ventilation).	To be taken into account in initial discussion and project design.
3	Main focus: comfort, convenience and aesthetics	Became a barrier. Flat owners contested effects of EPC measures on comfort: noise from ventilation, indoor temperature and air quality, disturbances during installation.	To be taken into account in initial discussion and project design.
4	Decision making: private flat owners must agree before decisions can be made about changes in building shell and technology*	Became a major barrier. Would probably have been enhanced if the owners had been more actively involved in the initial stage including thorough mapping of their needs and those of the building structure.	A general challenge during energy and refurbishment projects in self-owned, multi-apartment buildings.
5	High transaction costs, limited energy costs*	Was not a barrier. An attempt was made to keep the process simple, and let the selected ESCO suggest measures to expand the project (including refurbishment), but this failed. Higher transaction costs in the design phase would have been necessary.	Community model (housing cooperatives) is likely to bring down transaction costs.* Sufficient investment (time, efforts, resources) in project design appears as condition for successful result.
6	Lack of information about existing offers and lack of understanding the EPC concept, financing and contract*	Became a barrier. Initial phase: one Board member had experiences with EPC, and Board was approached by pilot and research team who explained EPC principle. As the project progressed (taken over by the Board), there was less focus on the EPC aspect of the project which was not clearly communicated to the owners at the time of decision making.	Strengthen the capacity of EPC consultants/ facilitators. This is a role that could be taken by umbrella organisations that represent housing cooperatives. In concrete projects: communicate the EPC principle throughout the project and show the distribution of costs and benefits on energy savings and refurbishment, respectively.
7	Lack of trust, fear of becoming dependent on the ESCO*	Became a major barrier. Before decision on investments: project failed due to a lack of trust in the ESCO and EPC process.	On the basis of a thorough project design, invite ESCOs to compete on offers for comprehensive refurbishment and energy savings.
8	Lack of financing capital*	Not a barrier as the housing cooperative had access to favourable loans and received a modest, standard subsidy from Enova. Research project contributed to covering parts of client's transaction costs.	Norway: Enova has introduced a new subsidy scheme tailored for the design phase of EPC. Standard criteria apply for support to investment in energy efficiency.
Client perspective, technical			
9	Lack of meters* *and lack of consumption data*	Not a barrier. Installation of individual metering of hot water was included in EPC offer as an energy saving	Access to historical and future consumption data is required. Metering can be done on collective or individual basis. Higher risk of wasting

Table 4 (continued)

Barriers for EPC, residential sector	Experiences from the pilot project (housing cooperative)	Suggestions for how to mitigate barriers
	measure. Individual electricity consumption not included in EPC.	practices if consumption is not metered and paid individually.
10 *Existing contracts with energy suppliers*	Became a major barrier because existing supplier of district heating put strict conditions on the proposed change from ordinary supply to peak load supply.	Examine existing contracts and criteria for changing them. In Norway, housing cooperatives in areas with district heating are obliged to be connected but not to purchase district heating.
ESCO perspective		
11 Individual needs and behaviours vary and are difficult to control*	The ESCO did not calculate with changed behaviour.	Fair to expect that residents will not want to change their daily routines in significant ways, but expect that they wish to ensure comfort, convenience and flexibility.
12 High fragmentation of market, need to look at each individual building/flat. Hinders standardisation*	Competition stage: Flats considered to being relatively similar, which enhanced the preparation of offers on energy savings, but when later planning for ventilation and windows i.e. changes in the physical structure of each flat: individual variation became a challenge.	Refurbishment in general: need to look at individual buildings/flats.
13 High transaction costs, limited energy costs*	Phase 1: high transaction costs (many revisions of offer, many meetings with Board, the consultant and sub-contractors). Extra work was not compensated, but competition criteria were less strict than in the municipal sector and qualified ESCOs received a minor compensation when handing in offers.	Contract for phase 1: specify a limited number of meetings and hours covered in the contract and how unexpected need for extra time will be compensated.
Framework conditions		
14 *Legal requirements, ban on data sharing of individual electricity consumption*	This legislation resulted in the need to exclude individual electricity consumption from the EPC. A major share of the cooperative's energy consumption was included in the EPC because electricity was not used for space and water heating.	This legislation implies that when electricity is metered individually, such consumption is unsuitable for EPC projects unless the metering is done jointly. When electricity is used for space and water heating which constitute a high share of energy consumption (common in Norway), this legislation reduces the applicability of EPC. A proposal for a new regulation in Norway is likely to put a ban on joint metering of electricity consumption among housing cooperatives. This is likely to further hinder the development of EPC in this sector.
15 Lack of facilitators who are familiar with EPC in the residential sector	Pilot provided a facilitator (experienced with EPC in the municipal sector), arranged a process of prequalification of ESCOs, and adapted a standardised contract that has been used among municipalities. Both the facilitator and the contracted ESCO did not have previous experience with EPC in multi-apartment flats, and this may have jeopardised residents' trust.	Offer training to consultants/facilitators in the housing sector who can support and represent the building owners vis-à-vis ESCOS during the EPC project's life time. Create a system for accreditation of EPC consultants/facilitators in the residential sector. Run more case studies and share the experiences of clients, not solely technical and economic outcomes.
16 Lack of credibility on EPC providers due to lack of legal framework for their accreditation*		Offer training to ESCOs in the housing sector including building constructors as well as energy entrepreneurs (Grim 2005). Promote EPC through authorities and policy measures* Create a system for accreditation of ESCOs in the residential sector

Table 4 (continued)

	Barriers for EPC, residential sector	Experiences from the pilot project (housing cooperative)	Suggestions for how to mitigate barriers
			where conditions and culture differ from public sector.
17	Legal requirements, all tenants must agree before landlord can make investments in energy efficiency*	Not applicable (self-owned).	
18	Economic crisis and related uncertainty*	Not relevant, but expectations for declining/low energy prices became a major issue.	
19	Lack of public subsidies and financing capital*	Was not a barrier as the housing cooperative had access to favourable loans. Received a modest, standard subsidy from Enova.	Norway: Enova has introduced a new subsidy scheme tailored for the design phase of EPC. Standard criteria apply with regard to support for investment in energy efficiency.

Text marked in italics indicates additional barriers/factors discovered in this pilot study

*Retrieved directly from Labanca et al. (2015) though also often mentioned in the general literature ('Known barriers to EPC in the residential sector')

2. Identify the client's needs and involve them in an early phase.

The pilot project did not include an initial and thorough discussion among the residents regarding the potential need for refurbishment and energy savings before the EPC project was launched. To enhance predictability and increase the likelihood that ESCOs will be interested in providing offers, this discussion should be informed by a project design and preferably culminate in a voting procedure during the General Assembly (e.g. simple majority) about the intention to embark on an EPC project either with or without refurbishment (including a list of the main refurbishment measures needed). In terms of energy measures, it is up to the ESCOs to suggest measures as they compete for the offer, but prior to the EPC project, the housing cooperative can discuss their ambitions in terms of goals for energy use per square meter (cf. 'passive house standard').

3. Communicate the EPC principle throughout the process.

To trigger residents' willingness to invest in energy savings through EPC, we highlight the importance of communicating to decision makers throughout the process what the EPC principle implies in terms of investments and energy savings. In the pilot, this was done initially, but not repeated or shown for the concrete project during decision making. The specification of investments that fall 'in between' refurbishment and energy savings (e.g. windows) is challenging but possible to handle, and the total investments in and guarantees for energy savings should be presented in a clear manner, preferably through graphic visualisation.

As a final remark, the EPC literature has largely overlooked the issue of convenience and simplicity (but see EEFIG 2015), which appear as crucial concerns to the resident group we worked with as they decided to get engaged in an EPC project. More studies focused on the perspectives of the clients are needed to further understand how EPC could become attractive to them and fulfil their needs. Currently, a lot of resources are being spent on meeting requirements to label buildings. As one of the co-authors has suggested, such initiatives have similarities with going to the dentist, discovering cavities and not having your teeth fixed. EPC, in contrast, also includes the step of ensuring action. However, as the presented pilot study indicates, some barriers persist, of which the most central concerned the issue of trust and the general challenge of decision-making processes in housing cooperatives. EPC is not a silver bullet, but it could be a mechanism that encourages protagonists to want to see their dentist at all. While not ignoring potential rebound effects, we think that the focus on energy technology and physical structure, economic viability and guarantees and the monitoring of consumption over time constitute the major advantages of the EPC model. We also think this type of contract has great potential in projects that include installation of solar PV and other visible forms of energy production, which may serve to socially legitimise investments in important ways (Henning 2000). Ultimately, it is people who decide what measures to initiate or not, and decision making on energy consumption in household co-operatives remains a complex field. More knowledge is needed about how energy savings could be realised through EPC in this sector.

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