Research Centre on
ZERO EMISSION
NEIGHBOURHOODS
IN SMART CITIES

GREEN PUBLIC PROCUREMENT AND ENERGY PERFORMANCE CONTRACTING

EXPLORING THE LINKAGE AND IMPROVEMENT OPPORTUNITIES

ZEN REPORT No. 29 – 2020

Hasan A. M. Hamdan, Luitzen De Boer, Mohamed Hamdy | NTNU

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Preface

Acknowledgements

This report has been written within the Research Centre on Zero Emission Neighbourhoods in Smart Cities (FME ZEN). The author gratefully acknowledge the support from the Research Council of Norway, the Norwegian University of Science and Technology (NTNU), SINTEF, the municipalities of Oslo, Bergen, Trondheim, Bodø, Bærum, Elverum and Steinkjer, Trøndelag county, Norwegian Directorate for Public Construction and Property Management, Norwegian Water Resources and Energy Directorate, Norwegian Building Authority, ByBo, Elverum Tomteselskap, TOBB, Snøhetta, Asplan Viak, Multiconsult, Sweco, Civitas, FutureBuilt, Hunton, Moelven, Norcem, Skanska, GK, Nord-Trøndelag Elektrisitetsverk - Energi, Smart Grid Services Cluster, Statkraft Varme, Energy Norway, Norsk Fjernvarme and AFRY.

The Research Centre on Zero Emission Neighbourhoods (ZEN) in Smart Cities

The ZEN Research Centre develops solutions for future buildings and neighbourhoods with no greenhouse gas emissions and thereby contributes to a low carbon society.

Researchers, municipalities, industry and governmental organizations work together in the ZEN Research Centre in order to plan, develop and run neighbourhoods with zero greenhouse gas emissions. The ZEN Centre has nine pilot projects spread over all of Norway that encompass an area of more than 1 million m^2 and more than 30 000 inhabitants in total.

In order to achieve its high ambitions, the Centre will, together with its partners:

- Develop neighbourhood design and planning instruments while integrating science-based knowledge on greenhouse gas emissions;
- Create new business models, roles, and services that address the lack of flexibility towards markets and catalyze the development of innovations for a broader public use; This includes studies of political instruments and market design;
- Create cost effective and resource and energy efficient buildings by developing low carbon technologies and construction systems based on lifecycle design strategies;
- Develop technologies and solutions for the design and operation of energy flexible neighbourhoods;
- Develop a decision-support tool for optimizing local energy systems and their interaction with the larger system;
- Create and manage a series of neighbourhood-scale living labs, which will act as innovation hubs and a testing ground for the solutions developed in the ZEN Research Centre. The pilot projects are Furuset in Oslo, Fornebu in Bærum, Sluppen and Campus NTNU in Trondheim, an NRK-site in Steinkjer, Ydalir in Elverum, Campus Evenstad, NyBy Bodø, and Zero Village Bergen.

The ZEN Research Centre will last eight years (2017-2024), and the budget is approximately NOK 380 million, funded by the Research Council of Norway, the research partners NTNU and SINTEF, and the user partners from the private and public sector. The Norwegian University of Science and Technology (NTNU) is the host and leads the Centre together with SINTEF.

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Norwegian Summary

Energisparekontrakt (EPC) er et virkemiddel som brukes for å finansiere investeringer i energieffektivisering fra energisparing i bygningen. I en EPC avtale initierer en ekstern organisasjon, kjent som energitjenesteselskaper (ESCO), prosjekt for å realisere energimål i bygget. Inntektsstrømmen som kommer fra energisparing brukes til å betale investeringene i energisparetiltakene. EPC regnes som en god mekanisme for å fange opp det kostnadseffektive potensialet for energieffektivisering.

I offentlige prosjekter fungerer offentlige anskaffelser og grønne offentlige anskaffelser som drivere for EPC. Offentlige byggherrer bruker en offentlig anskaffelsesprosess for å velge den beste leverandøren før de går videre med EPC-avtalen. Med andre ord er offentlig anskaffelse en forutsetning for EPC i offentlige byggeprosjekter. Selv om EPC har fått stor oppmerksomhet i offentlig sektor og regnes som en effektiv mekanisme for energisparing, finnes det få studier som ser på EPC og offentlige anskaffelser i sammenheng. Vi kan anta at vi fortsatt ikke har tilstrekkelig forståelse for hvordan EPC og offentlige anskaffelser fungerer sammen for bedre energisparing. Denne rapporten tar sikte på å utforske sammenhengen mellom grønne offentlige anskaffelser og EPC, og forslår forbedringsmuligheter for EPC i offentlige prosjekter basert på kunnskap og praksis i grønne offentlige anskaffelser.

I rapporten diskuterer vi EPCs tilstedeværelse i offentlig sektor, og foreslår forbedringspunkter, dvs. bedre utnyttelse av kunnskap og praksis i grønne offentlige anskaffelser, såkalt "bundling" og skalering strategier, og kontroll av kompleksitet. For det første ser vi at forankring av EPC i grønne offentlige anskaffelser generelt vil forbedre miljøprestasjoner og sikre valg av kvalifiserte ESCOs, spesielt siden Norge er i en fremskreden posisjon når det gjelder innovasjon og bærekraftighet. Som et resultat vil posisjonering av EPC som grønne offentlige anskaffelser ikke bare være til fordel for EPC, men kan også føre til økt bevissthet og aksept av ESCO blant offentlige og private kunder. For det andre kan større rehabiliteringsprosjekter gi større økonomiske fordeler ved bruk av EPC. Dette kan også gjøre at også prosjekter som ligger i mindre kommuner og fylker blir mer attraktive for ulike ESCO. Til slutt kan styring av kompleksitet omsettes til bedre samarbeid mellom de involverte parter, dvs. at å vite når og hvor kompleksiteten dukker opp kan hjelpe med styring av samarbeid i de forskjellige utviklingsfasene i prosjekter.

Summary

Energy Performance Contracting (EPC) is a method to finance energy efficiency investments from cost savings in the building sector. Under an EPC arrangement, an external organization, an Energy Service Company (ESCO), initiates a project to achieve energy efficiency in a building. It uses the stream of income from the cost savings to repay their investments. ESCOs and EPC are a desirable mechanism to capture cost-effective energy-efficiency potentials with the private sector's involvement.

In public projects, public procurement and green public procurement are the carrying vehicles of EPC where public clients use public procurement procedures and functionalities to select the right ESCO before landing on a suitable EPC agreement. In other words, public procurement is a prerequisite to EPC in public building projects. Though EPC has received much attention in the building sector and can probably be considered among the most effective mechanisms for energy efficiency in the public sector, very few studies have looked at EPC from a public procurement perspective. The current report aims to explore the link between green public procurement (GPP) and energy performance contracting (EPC) and propose improvement opportunities for EPC capitalizing on knowledge and practices derived from GPP.

In the current report, we discuss an approach to improve EPC presence in the public and residential sectors. That is, capitalizing on GPP practices, using bundling and scaling up strategies, and managing complexity. First, anchoring EPC projects in GPP will generally improve the project's environmental performance and ensure the selection of a qualified ESCO, especially since Norway is in an advanced position when it comes to implementing green solutions in public expenditures. Seeing EPC projects as part of the broader public procurement system may bring benefits to EPC's future in Norway. As a result, positioning EPCs as GPPs will not only benefit the EPCs, by may also lead to an increase in the awareness and acceptance of ESCOs among public and private clients. Second, pooling or bundling renovation efforts into larger blocks can be conducive to benefit from economies of scale. More extensive projects could be used to attract ESCOs in smaller municipalities. Lastly, managing complexity in EPC projects might translate to better collaboration between the involved parties. In other words, knowing when and where to let complexity emerge could probably improve collaboration throughout the stages of EPC projects.

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1 Introduction

In Europe, buildings are the single largest energy consumer, with approximately 40% and 36% of energy consumption and CO2 emissions, respectively. According to (European Commission, 2020a), almost 75% of the EU's building stock is energy inefficient – of which only about 1% of the building stock is renovated each year. Due to the social and environmental risks associated with cities and urban areas, sustainable urban development is getting more attention from governments, businesses, researchers, and practitioners. At the same time, part of this attention can be traced back to the urban system's capacity to offer opportunities that could be exploited in the change towards a low carbon society.

Such a drastic change to our urban system is beyond the means of one organization or even one sector. Public-private collaboration is deemed pivotal for sustainable urban development projects to realize cross-sectoral solutions and zero-emission goals. Khare et al. (2011, p. 228) propose that cities' initiatives and programs responding to climate change "must be financially beneficial to all stakeholders." The collaboration between local governments, local businesses, and residents is a prerequisite to creating a win-win situation for all. For example, public-private partnership (PPP) and strong stakeholder involvement can be utilized to realize energy efficiency in social housing, see, i.e., (Copiello, 2015). However, risk-sharing emerges as an essential decisive factor in any collaboration-based work, where each sector deals with the risks it is best equipped to handle, especially when pooling together to perform a project that neither partner would be able to do on their own (Leruth, 2012; Makarevich, 2017).

Energy performance contracting had its origins in North America, where it snowballed in the 1980s (Brown, 1988). ESCOs[1] (Energy Service Companies) and EPC (Energy Performance Contracting) are a desirable mechanism to capture cost-effective energy-efficiency potentials with the involvement of the private sector, mainly because they do not involve either public expenditure or market intervention. EPC can probably be considered among the most effective mechanisms for energy efficiency in the public sector (World Energy Council, 2008).

The government in many European countries is a significant client of building and infrastructure projects, and usually, they use EU public procurement procedures to procure contracts of project development. The significant purchasing power of public clients positions public procurement as a powerful tool to drive and even transform the economy. Moreover, environmental and economic benefits could be obtained if environmental requirements/criteria are included in public tenders (Parikka-Alhola, 2008; Testa et al., 2016). Besides being on the EU agenda, green public procurement (GPP) becomes a popular tool among public clients to procure products and services with high environmental standards (Sparrevik et al., 2018; K Uttam et al., 2014; Varnäs et al., 2009). In the context of public projects, it is accurate to describe GPP as the carrying vehicle of EPC since public clients use GPP procedures and functionalities to select the right ESCO before landing on a suitable EPC agreement. In other words, public procurement is a prerequisite to EPC in public building projects.
Much research has focused on EPC from an engineering perspective, particularly at the intersection of energy and buildings. In contrast, very few studies, to the best of our knowledge, are found addressing EPC from a social science or management perspective. Here we see an opportunity to expand the

[1] An energy service company (ESCO) is "a company that is engaged in developing, installing and financing comprehensive, performance-based projects, typically 5–10 years in duration, centered around improving the energy efficiency or load reduction of facilities owned or operated by customers" (Vine, 2005, p. 691).

knowledge about public procurement and energy-efficiency, especially since this topic has not been approached systematically from procurement scholars in EPC projects. Thus, the current study, as shown in Figure 1, aims to understand the link between green public procurement (GPP) and energy performance contracting (EPC), and propose scaling up opportunities for EPC capitalizing on knowledge and practices derived from GPP.

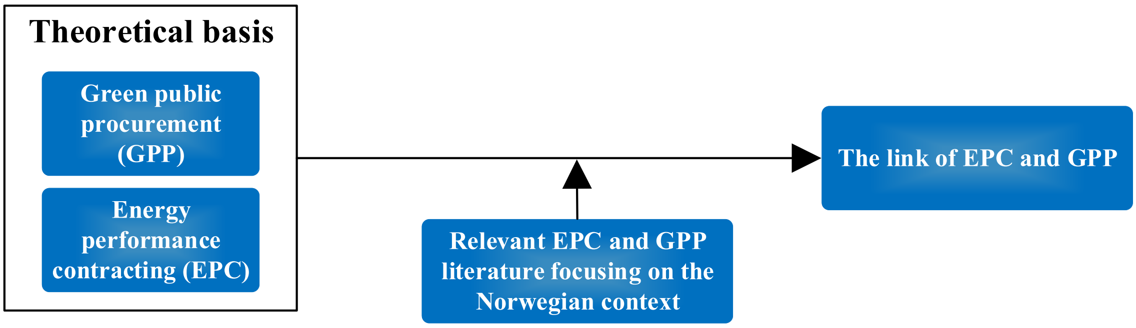

Figure 1. The study's scope

Our report provides a foundation to guide future empirical research on GPP in EPC projects and proposes an approach to improve EPC in the public and residential sectors. That is, capitalizing on GPP practices, using bundling and scaling up strategies, and managing complexity. The report is structured into six main parts. In parts two and three, we examine general literature and theory on GPP and EPC. Part four uses literature studies that either focused on the Norwegian context or used actual Norwegian case studies. Next, we attempt to conceptualize the link between GPP and EPC and discuss future possibilities. Lastly, part six summarizes the study's conclusions and provides suggestions for further research.

2 Green public procurement (GPP)

2.1 Public procurement

The Organization for Economic Co-operation and Development (OECD) defines public procurement as "the purchase by governments and state-owned enterprises of goods, services, and works" (OECD, 2020). EU member states, on average, spend around 14 % of their gross domestic product (GDP), over €1.8 trillion was spent in 2015 on purchasing goods, projects, and services (European Commission, 2020b). The latest EU directives on public procurement are Directive 2014/24/EU on public procurement and directive 2014/25/EU on procurement by entities operating in the water, energy, transport, and postal services sectors. The latest EU directives on public procurement made existing public procurement rules more flexible to benefit public purchasers and businesses, particularly small and medium-sized enterprises (SMEs). According to the European Commission, any public procurement must follow four basic principles: non-discrimination, equal treatment, transparency, and proportionality. Non-discrimination means that it is prohibited to discriminate against suppliers on the ground of nationality. The principle of equal treatment specifies the equal treatment of all tenderers during all tender stages of the purchasing process, ranging from formulation of specification, conditions, and selection criteria, to the stage of evaluation of offers and award. Transparency requires that tender opportunities are advertised widely enough to ensure competition. Proportionality means that the requirements must be both appropriate and necessary to achieve the contract.

The directives on public procurement include the following procedures: open procedure, restricted procedure, competitive procedure with negotiation, competitive dialogue, and innovation partnership. Figure 2 provides a comparison between these procedures. Public authorities are allowed to conduct market consultations before launching a procurement procedure. Initiating dialogue with the market at such an early stage could offer various benefits for both parties (public clients and suppliers), including needs mapping, improved specifications, access to supply market, market visibility, and market links creation (H. A. M. Hamdan & De Boer, 2019).

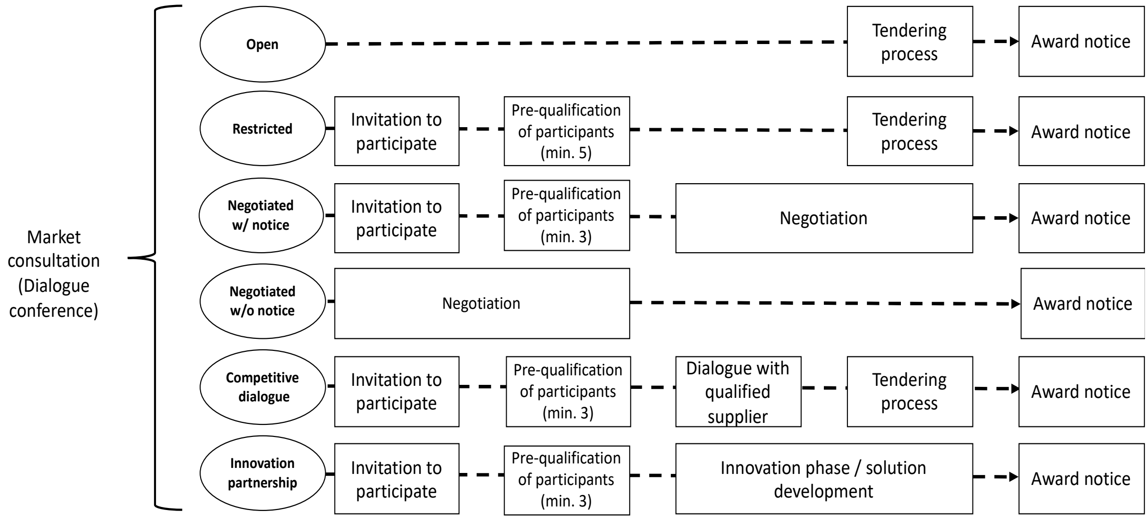

Figure 2. Procurement procedures in the EU/EEA (H. Hamdan, 2018)

2.2 Green public procurement (GPP)

According to the European Commission, green public procurement (GPP) can be defined as "a process whereby public authority seeks to procure goods, services and works with a reduced environmental impact throughout their life cycle when compared to goods, services and works with the same primary function that would otherwise be procured" (European Commission, 2019a). Thus, compared to conventional public procurement, GPP uses green criteria to achieve green (or greener) results. The procurement process usually consists of several separate, yet interdependent stages, see, i.e., (Cheng et al., 2018).

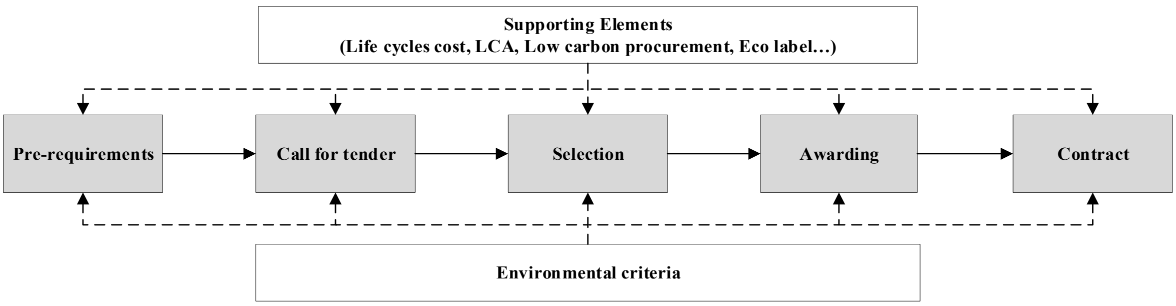

Figure 3 GPP process (Cheng et al., 2018)

GPP process usually incorporates product-related (e.g., technical specifications) and organization-related (e.g., suppliers' competencies) environmental criteria (Cheng et al., 2018). In which environmental requirements and criteria can be included at different stages of the procurement process: specification requirements, selection (qualification), awarding (award criteria), and contracting (contract clauses) (European Commission, 2016; Igarashi et al., 2015). GPP is increasingly playing a significant role in the area of the sustainable built environment, including building projects, see, i.e., (Sparrevik et al., 2018), and infrastructure projects, see, i.e., (Kedar Uttam & Le Lann Roos, 2015). For example, it empowers the purchasers to make better decisions and prioritize environmental needs (Igarashi et al., 2015). However, "environmental requirements associated with procurement increase the complexity of the process and reduce qualified bids" (Cheng et al., 2018, p. 780), as purchasers need to collect more information about their potential bidders and invest more time in the selection process (Igarashi et al., 2015).

The green supplier selection (GSS) process is an integral part of the GPP process, and it is a core procurement activity in both the private and public sectors (Igarashi et al., 2015). However, GSS and GPP mean nearly the same meaning in public sector projects. This means models fall under GSS can also be employed for the use of public authorities in public procurement. Igarashi et al. (2013) suggested a conceptual model of GSS (Figure 4) built upon four key dimensions of the GSS process: the alignment of supplier selection with an organization's overall green strategy, the role of decision-making tools and models in GSS, GSS as a series of interrelated decisions and information processing activities, and the wider supply chain context in which GSS takes place.

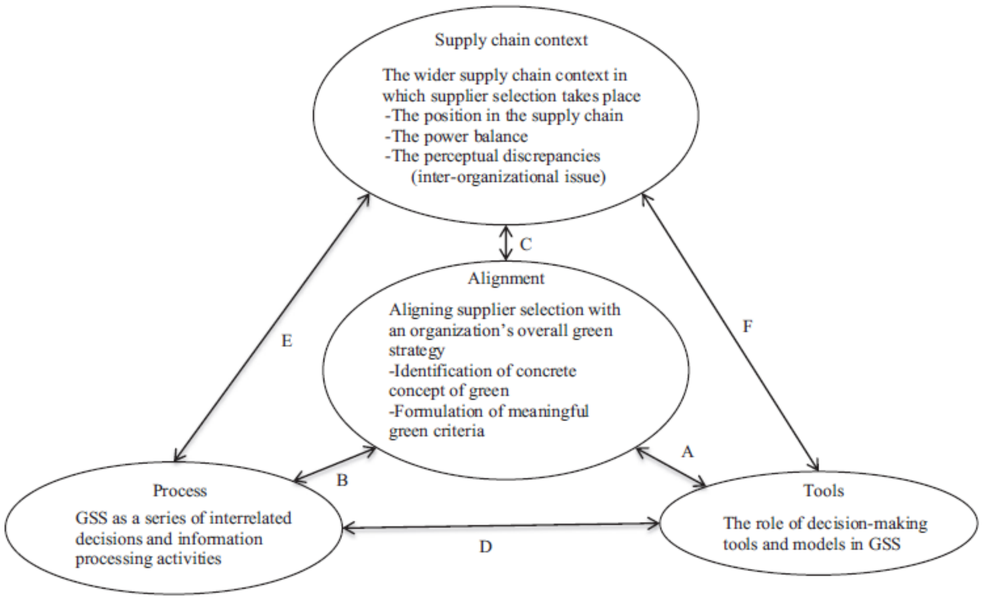

Figure 4 Conceptual model of GSS (Igarashi et al., 2013)

The first dimension (alignment) concerns the development of a meaningful understanding of what 'green' means concerning the organization's overall strategy. Without such understanding, the organization will be left with an endless list of environmental criteria that might complicate the decision process when it comes to supplier selection, and consequentially degrading the value of green procurement. To be useful, the environmental criteria cannot be chosen randomly without relation to the organization's long-term goals, for example, stimulate product innovation or cost-efficiency. The second dimension (tools) deals with the role of decision-making tools and models since different supplier selection situations will require different decision-making tools and models.

The third dimension highlights (process) GSS as a series of interrelated decisions and information processing activities. It also addresses the fragmented nature of the supplier selection process and how a more coherent GSS can be achieved. As previously mentioned, environmental criteria can be included in different stages of the supplier selection process, which means different stages might require different criteria. However, "it seems important to make sure that the various green criteria applied in the different phases, taken together, constitute a coherent set aligned with the overall green strategy" (Igarashi et al., 2013, p. 256). The fourth and last dimension deals with GSS as part of a broader supply chain context, as most organizations are both suppliers and customers, and therefore addressing environmental requirements through supplier selection can occur on the broader supply chain context of each organization.

3 Energy performance contracting (EPC)

Energy performance contracting means "the packaging together of both technical aid and the necessary funding for energy cost saving investments by an outside company (outside to the energy user), using the energy cost savings themselves to pay for that investment" (Brown, 1988, p. 297). In other words, EPC is an arrangement where "an external organization (ESCO) implements a project to deliver energy efficiency, or a renewable energy project, and uses the stream of income from the cost savings, or the renewable energy produced, to repay the costs of the project, including the costs of the investment" (Paolo Bertoldi et al., 2006, p. 1821). The approach is based on the transfer of technical risks from the energy client to the ESCO based on performance guarantees given by the ESCO.

Several differences distinguish EPC from other mainstream energy-saving approaches (Paolo Bertoldi et al., 2006; Brown, 1988). First, the client contracts with only one ESCO in the case of an EPC, instead of coordinating with several suppliers under separate contracts. Second, the energy savings are seen as a 'stream of income' to repay the cost of the investment. Third, ESCOs differ from other energy service providers. They guarantee the energy savings and can finance the operation of the energy system. Fourth, ESCOs accept some degree of risk for the achievement of improved energy efficiency; their payments hinge upon the level of energy efficiency achieved. Furthermore, in EPC, the focus is on reducing final energy consumption through demand-side energy efficiency measures (Suhonen & Okkonen, 2013), including the supply and installation of energy-efficient equipment, building refurbishment, maintenance and operation, facility management, the supply of energy (including heat), and/or user behavior.

3.1 EPC Business models

The EPC Business Model (EPCBM) refers to the agreement between clients and ESCOs required to ensure successful implementation of the EPC project (Shang et al., 2017). The most common kinds of EPCBM are the shared savings model, guaranteed savings model, and Chaffee model (see Figure 5).

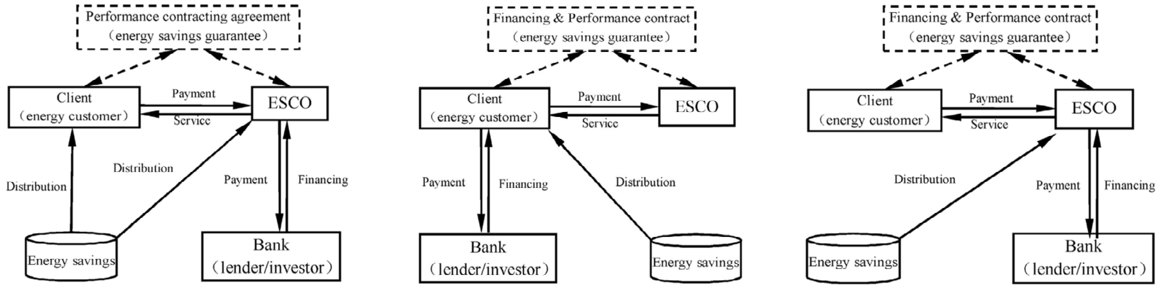

Figure 5. Three main kinds of EPCBMs (Shang et al., 2017)**.**

- *Shared saving model*. The ESCO gets the responsibility for designing, financing, and implementing an EPC project. The ESCO must also verify the energy savings during the contract period. The cost savings obtained through the investments are shared between the ESCO and the client and are used to pay for energy-saving investments covered by the ESCO.

- *Guaranteed saving model*. In contrast to the shared saving model, the client bears all costs, including hiring the ESCO and financing, while the ESCO designs and implements the EPC project. The ESCO guarantees the client a certain amount of savings for a longer period – sufficient to cover debt service payments. In other words, this model is related to the percentage of energy cost savings, and the ESCO is freed from any credit or financial risks.

- *Chaffee model*. Here the ESCO manages and transforms the energy system for energy clients by self-financing according to targets in the contract. If targets are achieved, the ESCO gets to keep all energy savings. Otherwise, the ESCO needs to compensate energy clients for the amount of shortage. For further information about the differences between the three models (Table 1).

Table 1. Comparison of the three models (Shang et al., 2017)**.**

	Shared saving	**Guaranteed saving**	**Chaffe**
Application frequency	Low	High	Low
Financing approach	ESCO	Client	ESCO self-financing
Financing cost	High	Low	Low
Payback period	3 years	5 years	Generally longer
Project scale	Generally small	Generally large	Generally large
Risk sharing - credit	ESCO/Financing institution	Client/Financing institution	ESCO
Risk sharing - performance	ESCO and client	ESCO	ESCO
Risk sharing - technique	ESCO	ESCO	ESCO

3.2 Barriers for EPC projects

There are numerous barriers that hinder the adoption of EPC and ESCO models. Barriers include, but are not limited to, lack of trust, lack of financing, low client confidence, lack of understanding, complicated procurement, lack of model contracts, low energy prices, negative experiences (projects that failed), small market, small projects, and lack of awareness. In the following, we will unfold some of these barriers.

- *The lack of information and understanding of the ESCO and EPC*

Lack of understanding about EPC and its opportunities for potential clients was reported as a barrier to the diffusion of EPC projects (Kiss et al., 2007). According to (Paolo; Bertoldi et al., 2007), the lack of awareness between potential clients hinders the evolution of ESCOs – their attention is on their core business (private actors) or primary mission (public actors), and energy constitutes a small part of their expenses. Demonstration projects and success stories are deemed an essential means to develop an understanding of and trust in ESCOs and EPC. Moreover, capacity building (through training and information sharing) is also seen necessary, not only to develop trust with potential clients but also with the financial sector – as some conservative banks might not perceive the energy efficiency business as a sufficiently promising market niche.

- *Public procurement and regulatory barriers*

Another major barrier hindrance to the ESCO industry's development is regulations and impeding public procurement rules (Paolo; Bertoldi et al., 2007; Kiss et al., 2007). Non-supportive public procurement rules and other legal and regulatory frameworks were found incompatible with energy efficiency investments in many countries. "It is necessary to change related procedures in order to carry out green procurement, also in the form of EPC" (Kiss et al., 2007). However, some countries are more progressive than others in terms of the public procurement system. Also, public budgeting practices and rules can be a barrier to EPC's application in the public sector since these induce a lack of interest in energy cost saving (Paolo; Bertoldi et al., 2007). Local decision-makers tend to spend rather than save to avoid budget reduction in the following year.

- *Administrative hurdles and high transaction costs*

Administrative hurdles and high transaction costs limit willingness to participate, mainly, and keep the ESCOs away (Paolo; Bertoldi et al., 2007). Several barriers are facing the ESCO model in the public and residential sector, including high relative transaction costs and lack of interest in the ESCO models and mistrust. Many countries have started to pool projects to decrease risk and transaction costs coming from small projects. In their case study, (Suhonen & Okkonen, 2013) tested ESCO as a business model for biomass-based heat entrepreneurship in 26 housing associations. Their results indicate that the ESCO model is challenging in the residential sector due to the low level of cash flow (savings per customer and the profit-sharing between the ESCO and the customer), in which the model would require economies of scale. The interests of the clients and the ESCO may differ in the ESCO model. That is, customers prefer long-term service periods and lower prices from the beginning, while ESCO interests are more in shorter contracts and faster investment paybacks.

Furthermore, defining a consumption baseline in the residential sector can be challenging since the energy consumption in this sector is much more dependent on individual needs and behaviors than other sectors (Labanca et al., 2015). This, in turn, might increase the risk level when setting energy-saving guarantees.

- *Tenant-owner dilemma*

The issue of splitting incentives is still fundamental in the building and the public sector (Paolo; Bertoldi et al., 2007; Labanca et al., 2015). An example is the "tenant-owner" dilemma. Neither side has the incentive to invest in energy efficiency measures. The owner would have to bear the investment costs since he is responsible for renovations. However, the owner typically receives no benefits from these investments or can hardly pass on investment costs to the energy bills paid by the tenants. On the other hand, although the tenant has an interest in reaching savings, it is improbable for the tenant to invest in energy efficiency measures and equipment since he can never be sure whether he will use the property long enough to recover the investment.

3.3 Risks in EPC projects

Based on a literature review, (Lee et al., 2015) summarized the risks associated with EPC projects into seven categories.

- *Economic risks*

Economic risks can result from variations in energy costs, demand charges, material costs, equipment costs, and labor costs. In the shared saving model, both the energy client and the ESCO bear the risk of variations in energy costs and demand charges. However, in the guaranteed saving model, only the ESCO bears those risks. For the risk of variations in material costs, equipment costs, and labor costs, it is expected that the ESCO fully bears the risks associated with increases in those costs.

- *Financial risks*

There are two types of financing approaches in EPC projects: self-financing and third-party financing. In self-financing, the client pays the upfront investment for project implementation, and the ESCO bears the performance risk by a guarantee on the energy savings. With third-party financing, the ESCO or the client may obtain a loan from a third-party financial institution. To ensure the repayment ability, the financial institution may require the ESCO's guarantee on the achievable energy savings or some forms of financial security from the borrower.

- *Project design risks*

The success of EPC projects depends on performing an accurate estimation of the energy saving of the proposed energy conservation measures. The availability of building operational data plays an important role when predicting energy performance and evaluating the project risk of expected energy savings. That is, the low quality of system operating data increases uncertainties in estimating energy savings. In practice, before both parties commit themselves to an EPC contract, the ESCO will carry out a detailed energy audit to evaluate the room for saving and the feasibility of proposed solutions in achieving it.

- *Installation risks*

EPC projects often involve the replacement of existing energy setups with new ones. To minimize the amount of disruption to occupants, the removal and installation works are only allowed in specific hours. As a result, a project delay may occur, resulting in a delay in materializing the actual energy savings.

- *Technology risks*

Inaccurate sizing, improper system selection, and unexpected deterioration may cause variations in equipment performance and lifetime. The ESCO fully bears any technology risks during the contract period. In some cases, the installation of additional measures is allowed during the post-retrofit period to improve the system energy performance and achieve the expected energy savings at its own cost.

- *Operational risks*

Operational risks mean variations in energy savings due to changes in the agreed system operation schedule. Contracting parties often negotiate on the allocation of operational risks. In most EPC contracts, the ESCO would not be liable to the shortfall in savings when the client does not operate the system following the agreed strategy and procedures. Other operational risks that affect the actual energy savings include uncertainties in weather and occupancy conditions. EPC contracts usually incorporate an adjustment mechanism to address the impact arising from changes in the agreed schedule; however, it is difficult to determine these impacts, resulting in uncertainties in actual savings.

- *Measurement and verification risks*

Measurement and verification risks include modeling errors, low data quality, and imprecise measurements. These risks are all intrinsic, and both parties (the client and ESCO) should equally bear them. Model validation, proper metering, and implementation of recommended plans can be used to manage these risks better.

4 The Norwegian context

4.1 GPP in Norway

In Norway, public clients procure products and services for around 58 billion Euros every year, and they are obliged to take the environmental performance of products and services. However, research shows that including environmental demands in the procurement and selection processes complicates purchasers' decision-making (Igarashi et al., 2015). As a result, public clients may choose to ignore green products or recognize them partially in the procurement process. This result has motivated several procurement scholars to investigate GPP practices seeking information and suggesting improvements in many European countries, including Norway.

Michelsen & de Boer (2009) investigated to what degree GPP is implemented in Norwegian municipalities and counties and which capabilities are critical for a successful procurement process. Their findings show that the practice of GPP is significantly more established in large public clients than in small ones. That is, larger clients have more resources at their disposal for establishing a purchasing department and developing purchasing strategies and environmental-related knowledge. (Igarashi et al., 2015) studied the inclusion of environmental requirements/criteria in several procurements in the Norwegian public sector to find out to what degree the environmental criteria are presented in the selection process. Based on data from 41 procurement projects, public purchasers seem to follow four strategies (Figure 6) for tackling the increased complexity arises from the inclusion of environmental demands. Purchasers seem to avoid a direct trade-off strategy (integrate) between green performance and other classical criteria such as quality and price – as environmental award criteria seem to have little influence on the final decision made by purchasers.

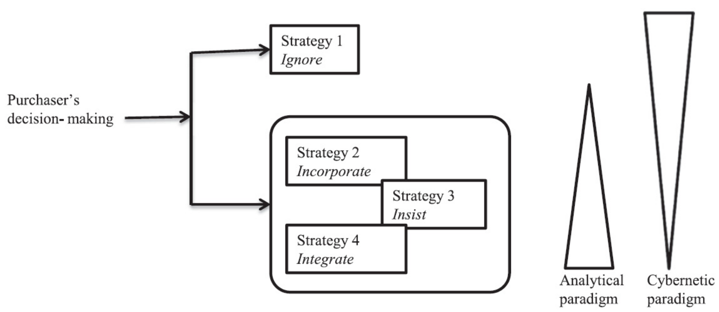

Figure 6. Strategies for dealing with the complexity in GPP (Igarashi et al., 2015)

Wondimu et al. (2016) explored the success factors for early contractor involvement (ECI) in infrastructure projects' public procurement. Six essential success factors were identified based on data from 11 Norwegian infrastructure projects: timing of involvement, risk distribution, proper compensation, establishing trust, clients' competencies, and contractors' qualifications. Moreover, the study proposed several approaches for public clients wishing to implement ECI in future projects without violating the public procurement rules, including information meetings, partnering phase, design-build contracts, competitive dialogue and negotiated procedures, idea competition, and alliancing. In a study by (H. A. M. Hamdan & De Boer, 2019), early dialogue with suppliers and innovative public procurement were discussed in light of sustainable neighborhood-scale projects' complexity. Their findings suggest that conducting a dialogue with the market players (i.e., contractors and suppliers) before the formal tendering process offers various benefits that could potentially be used to reduce some of the structural complexity and uncertainty imposed on complex projects.

According to Sparrevik et al. (2018), bridging the gap between policy requirements and formal governance improves the progress of GPP efforts. The case study, the procurement of an innovative building project in the Norwegian public sector, shows that the integration of policy requirements directly into the formal governance of the project allowed for successful implementation of GPP compared to the traditional GPP process (Figure 7). The integration of the policy requirements in the procurement process was achieved through contextual activities (the horizontal arrows in the figure). First, the incorporation of definable targets (i.e., low or zero energy demands) from government into agencies allows the incorporation of tangible matters (i.e., Life cycle assessment (LCA)) in the procurement process. Second, functional requirements are more effective than predefined solutions in stimulating new solutions and encourage improved environmental performance, mostly since there were no' zero energy solutions' available on the market.

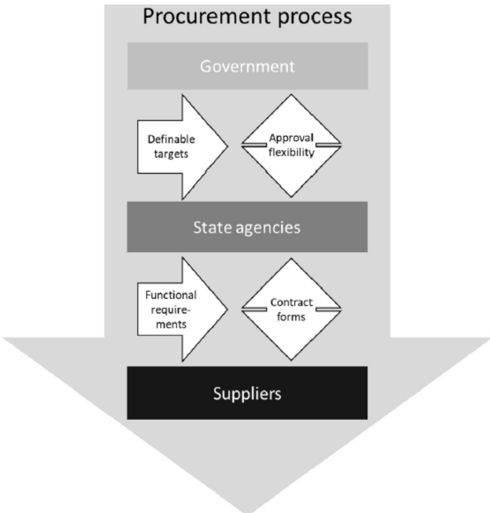

Figure 7. Integrating policy and formal requirements in procurement (Sparrevik et al., 2018)

Furthermore, green projects attempting to implement higher environmental standards will need more social learning and improvement than other traditional projects. This was captured through processual activities (the vertical arrows in the figure) — the increased interactivity between actors during the formal procurement process allowed for more flexibility. For example, a hybrid-turnkey contract was applied during the construction phase to motivate suppliers to achieve environmental improvements. Though costly and complicated, the hybrid-turnkey model contributed to both effective solutions and sound implementation.

4.2 EPC in Norway

According to (Lindseth, 2015), there were very few EPC projects in Norway before 2008. Low energy prices in Norway from hydropower (which accounts for 96% of the country's electricity production) have reduced the interest in developing energy measures in general. However, with a target to reduce emissions with at least 50 %, and towards 55 % by 2030, Norway has introduced many policies and plans on both the national, regional, and local levels to alleviate its built environment's poor performance. For example, under the Planning and Building Act, Norwegian municipalities have been required to develop a 'Climate and Energy Plan' for improving their environmental performance (Aasen et al., 2016). The Norwegian Association of Local and Regional Authorities, KS2, and the national energy agency, Enova, have played an important role in spreading information about the EPC model and developing model documents. Particularly, Enova has played an active role in promoting EPC and arranging information events (Lindseth, 2015). The agency has since 2002 had a grant scheme for energy efficiency measures in buildings. In Norway, ESCOs have targeted the building and residential sectors, focusing on heat recovery, HVAC systems, lighting, control systems, heat pumps, and local heat production (Kiss et al., 2007). EPC has performed better than other energy efficiency projects in Norway in terms of building coverage, implementation certainty, saving, and speed (Lindseth, 2015). Furthermore, a Norwegian Standard for EPC was launched in April 2014. Having an official standard is important in the promotion of EPC as it counteracts many of the barriers related to trust, public procurement, and 'outsourcing' (Lindseth, 2015).

4.2.1 Drivers and barriers for EPC (Lindseth, 2015; Mørk, 2013)

The European Commission has initiated several projects to improve energy efficiency and promote EPC knowledge, including Eurocontract, Transparense, and EESI. Being part of the European Economic Area (EEA), Norway has benefited from these projects. In a study supported by the EU Transparense project (Mørk, 2013) summarizes the drivers and barriers for EPC in Norway. The main barrier identified in her report is the lack of incentives for energy efficiency in general and EPC. Lack of awareness about EPC and lack of capacity in some municipalities have also been identified as barriers to EPC development in Norway. Moreover, there are few success stories. This might not sound surprising considering that EPC is still in its emerging phase in Norway. The report has also included barriers for public building clients, including budgeting issues, the fear of losing control, profits vanish, and low energy prices. Regarding drivers, the report mentioned several, including training of actors and standard tendering and contract documents, and promotion of EPC by the authorities. In another study by the Nordic council of ministers, Lindseth (2015) has also summarized the drivers and barriers that influence EPC's spread in the Nordic countries. Table 2 summarizes the results from the two studies.

[2] Kommunenes Sentralforbund (KS)

Table 2. Drivers and barriers of EPC in Norway (Lindseth, 2015; Mørk, 2013)**.**

Drivers	Barriers
Involvement and promotion of EPC by the authorities (e.g. Enova)	Lack of incentives to implement energy efficiency measures (low energy prices, no regulations)
Financial grant scheme for energy efficiency measures	Lack of experienced project facilitators
Marketing and training seminars for EPC	Lack of available and experienced ESCOs
Success stories – promotion of good practice examples	Complicated tendering and contracting process (legal/procurement, technical issues)
Active project facilitators	Insecurity about legislation and framework (decreasing with new standard)
Standard contract documents and guidelines tested and adapted for many years.	Lack of documented experiences and success stories (decreasing but still important)
Increased climate focus	Lack of capacity among municipalities (time and knowledge)
Successful financing model. Public building owners relies on KBN with "green interest rates" for energy efficiency investments rather than ESCOs	Low energy prices in Norway leads to longer payback times and less interest in energy saving measures
	Building owners are conservative and not used to buying services. Fear of losing control and responsibilities.

4.2.2 EPC in the municipal sector (Aasen et al., 2016)

EPC has received much attention in the Norwegian public sector. It has been implemented in various public buildings, including schools, offices, and health care institutions. Almost all known EPC projects in Norway have been in the public sector, and mainly in municipalities. This is not surprising since many public buildings need both upgrading and energy efficiency improvements. KS states that 15-20 % of Norwegian municipalities' budgets are used to run and maintain municipal buildings (Aasen et al., 2016).

In the EPC model used in the municipal sector, an ESCO provides the municipality with a set of energy efficiency measures accompanied by a guarantee of the EPC's energy savings. EPC's scope usually covers the improvement of the building envelope, energy management systems, HVAC, and heating and lighting. Municipalities in Norway use the guaranteed saving model, where municipalities are guaranteed 90 % of the EPC's estimated energy savings. If the savings gained are less than 90%, then the ESCO has to pay the remaining 10%. To achieve 110% of the estimated energy savings, the gain is split between the ESCO and the municipality. Municipalities finance their investment either through their funds or through a Norwegian bank called BKommunalbanken (KBN) (the largest credit provider to local authorities in Norway). Besides, municipalities might receive grants from Enova when applying energy efficiency measures.

Aasen et al. (2016) described the development stages of the EPC process in Norway (Figure 8). The EPC model develops through four stages. The first stage, termed as 'stage 0', covers the establishment of the EPC project in the municipality, calculating the potential of energy efficiency (energy audit), call for tenders, ESCO selection process, and contract signing. During stage 0, the interested ESCOs receive background data on energy use for a few selected buildings and use such data in developing their proposals. The municipality selects one ESCO based on the received proposals. The selected ESCO and the municipality then negotiate and enter into an EPC agreement. In the next stage, stage 1, detailed analysis and calculation of all buildings are conducted by the ESCO, identifying what measures and conditions to include in the EPC contract. In stage 2, the ESCO takes over as project manager and implements the energy-saving measures. The last stage, stage 3, covers activities related to monitoring and optimization, which is the period when guaranteed energy savings are attained.

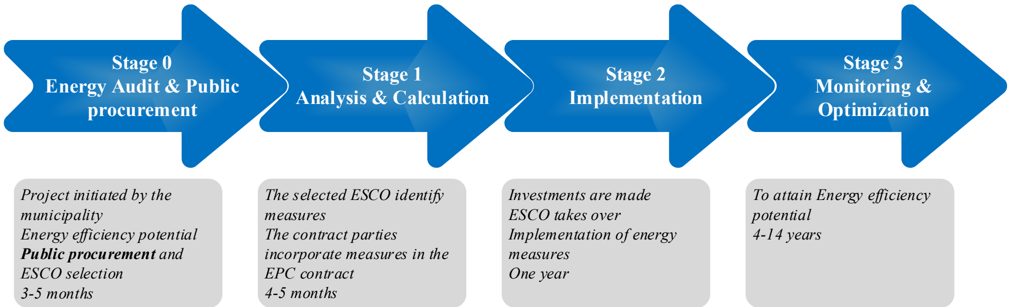

Figure 8. EPC development stages in public projects.

The study also investigated the factors affecting EPC's uptake in the Norwegian municipal sector, including the municipal size, the presence of an administrative entrepreneur, the guarantee offered by the EPC, trust creation, and flexible contracts. Their findings show that the municipality size is not a decisive factor for the uptake of EPCs. However, the municipality's size might be significant to the ESCO since ESCOs might perceive smaller municipalities as unattractive due to their contracts' size. The study also highlighted the importance of committed individuals at administrative or political levels for the adoption of an EPC. These individuals can see the potential for energy savings and have sufficient capacity to understand the communication and decision channels necessary to realize EPC. The guarantee offered by the EPC is essential to receive support and approval at the political level. For politicians to support investment decisions in energy-saving measures, the risk of failure must be perceived as low. Something the guarantee provided with the EPC can assure – and thus be attractive within a political sense.

Moreover, the study points out how the governmental institutions' activities related to EPCs, such as courses for municipalities on the EPC model and practical support to facilitate the EPC process, build trust in the EPC model. In other words, EPCs can play a crucial role in achieving national energy targets if augmented with an active public policy. Lastly, having flexible contracts incorporating ordinary maintenance measures into the EPC agreement seems essential for municipalities since including cost-efficient energy measures allows the municipalities to cut their backlog in maintenance activities.

4.2.3 EPC in housing cooperatives (Winther & Gurigard, 2017)

(Winther & Gurigard, 2017) present the results and experiences from a pilot project in which EPC was attempted to be employed in a Norwegian housing cooperative. The study confirms some of the known challenges to achieving energy savings and EPC in the residential sector. As the pilot developed, it concealed its EPC elements partly and took the form of a conventional rehabilitation project. The failed project seems to be linked to the particular organizational culture and decision-making processes in the housing cooperative, especially that EPC projects have experienced a successful expansion in the municipal sector. Thus, housing cooperatives need to spend more time and resources on project design, assisted by a facilitator familiar with such organizational form, before proceeding with the tendering process. The EPC model in the pilot project followed the same development process described previously in Figure 8 with only one exception; the procurement did not follow public procurement rules since this is a housing cooperative owned and run by a group of residents.

Initially, the project invited energy contractors in Norway and consultancy firms to an information meeting about the EPC pilot. The project presented the pilot's purpose and the grounds for the competition, including a special arrangement to conduct the prequalification process before the competition. The project wanted to trigger interest from ESCOs, and ensure in advance that the contractors providing offers (and receiving compensation) had relevant experience. Next, a formal EPC invitation was sent to qualified contractors. The client described the current energy consumption and the competition criteria (Table 3) and provided information about the buildings. Deciding on what kind of information about energy use to be included in the EPC competition is critical since this decides what to include to guarantee energy savings. The project used templates from the municipal sector for the different contracts to be signed in the forthcoming EPC project stages. These templates were modified to match the situation of a housing cooperative, especially the purchasing procedures.

Further, the invitation also stated the desired payback time (10 years). The ESCOs were evaluated based on their offers' profitability, using the criteria shown in Table 3. After the ESCOs submitted their proposals, a round of negotiations with each ESCO followed. They revised and refined their offers. Then, a contract for stage 1 was signed with the ESCO offering the most profitable solution.

Table 3. Competition criteria for the EPC pilot project (Winther & Gurigard, 2017)**.**

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

The board of the cooperative wanted to expand the project by including refurbishment measures. This initiated a lengthy negotiation process in which the ESCO provided several revised offers. The proposed measures changed from first, including heat pumps, which would significantly reduce the amount of purchased energy. However, this proposal was abandoned due to disagreements between the existing supplier of district heating and the cooperative. In the next round of negotiation, energy efficiency measures were reduced while major rehabilitation tasks were added. This, in turn, increased costs and decreased profitability. In the last round, the rehabilitation plans were also reduced, and the ESCO's guarantee for savings reduced to 10%. Finally, the project was terminated before any investments had been made.

The study provides three main recommendations to encourage the uptake of EPC projects among housing cooperatives. First, the use of EPC projects in housing cooperatives is more likely to succeed when the project includes refurbishment plans and not only energy-saving measures. This serves to attract residents who are interested in comfort and aesthetics than energy efficiency. Second, to identify the residents' needs and involve them in an early phase. Understanding the potential needs for refurbishment and energy saving plans before the EPC project is launched improves the predictability. It increases the likelihood that ESCOs will be interested in providing offers. Lastly, it is conducive to communicate the EPC principle to decision-makers and residents throughout the process. This points to the importance of the client's perspective to the EPC projects implemented in the residential sector – it helps to understand how EPC could become attractive and fulfill their needs.

5 Discussion

This report attempted to explore the link between GPP and EPC in the context of public projects and the implications to the development process of EPC projects. We examined general literature and theory on GPP and EPC, and then relevant literature focusing on the Norwegian context or Norwegian case studies. This approach was conducive to understand how these concepts, GPP and EPC, are used in practical settings. In what follows, we discuss how EPC can be improved in public projects (Figure 9).

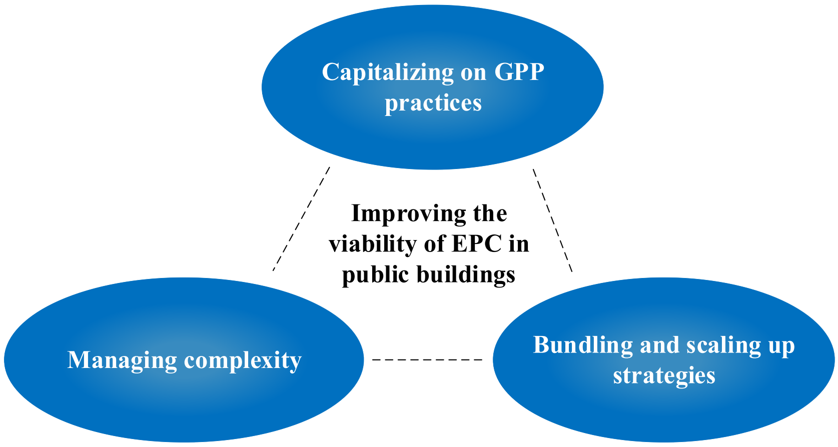

Figure 9. Improving EPC in public projects

5.1 Capitalizing on GPP practices

Our preliminary investigation of the current literature on EPC, including case studies from the public sector, does not seem to provide an adequate picture of GPP in EPC projects. Therefore, we have a strong reason to believe that EPC projects do not seem to take advantage of the GPP features and functionalities. Therefore, we speculate that there has been a lack of attention given by procurement scholars to EPC projects. Since public procurement and GPP are the EPC's carrying vehicles, we believe that procurement research should thus play a more prominent role in EPC research. In turn, as a practical field, EPC projects can help the advancement of GPP practices. Based on the GPP model described in (Cheng et al., 2018), we tried to assemble one model integrating EPC elements under a general model for GPP (Figure 10).

It is noticed that the GPP process covers mostly the first two stages in the EPC process, where the remaining steps are concerned with implementation, monitoring, and optimization of the energy-saving measures and equipment. In what follows, we will discuss how environmental criteria and supporting elements translate to the various procurement stages in EPC projects. Regarding the environmental requirements and criteria, purchasers in EPC projects rely on different information about the building and current energy consumption to devise relevant competition criteria. This step is mainly found critical since it decides what to include in the guarantee for energy savings. What distinguishes the GPP implemented in EPC projects is that the last round of environmental criteria (what goes into the EPC contract) is mainly dependent on the ESCO's analysis and evaluation (Figure 10). Simultaneously, environmental requirements/criteria used in the stages of supplier selection (up to awarding) are primarily formulated and managed by the public purchasers. This could be the reason behind the municipalities' dependence on external EPC facilitators. Facilitators help municipalities to draw a clear picture of the building's current state. Thus, sharpening specifications and criteria and make them meaningful to the ESCO companies. Successful GPP needs to incorporate and adapt to appropriate and available supporting elements and tools. Supporting elements could include, for example, life cycle assessment (LCA) and life cycle cost (LCC).

Regarding LCA, Jenssen and de Boer (2019) presented a conceptual model for strategic LCA-implementation in purchasing. LCA's use may depend on a combination of capabilities, level of implementation, and purchaser's ambition(s). It would be interesting to see how LCA is planned and performed in an EPC context. Especially that "when GPP is applied, incorporating LCA-based information in and applying a life cycle perspective to management processes is likely to help the green strategy based on a procedure of environmental assessment approach that aligns its overall green strategy and contributes to a shift towards more sustainable and green paradigms." (Cheng et al., 2018, p. 781). EPC also has its specific tool, such as energy audits implemented at the outset of the project. It would also be beneficial to map the supporting elements used in EPC projects and see how it related to the GPP process.

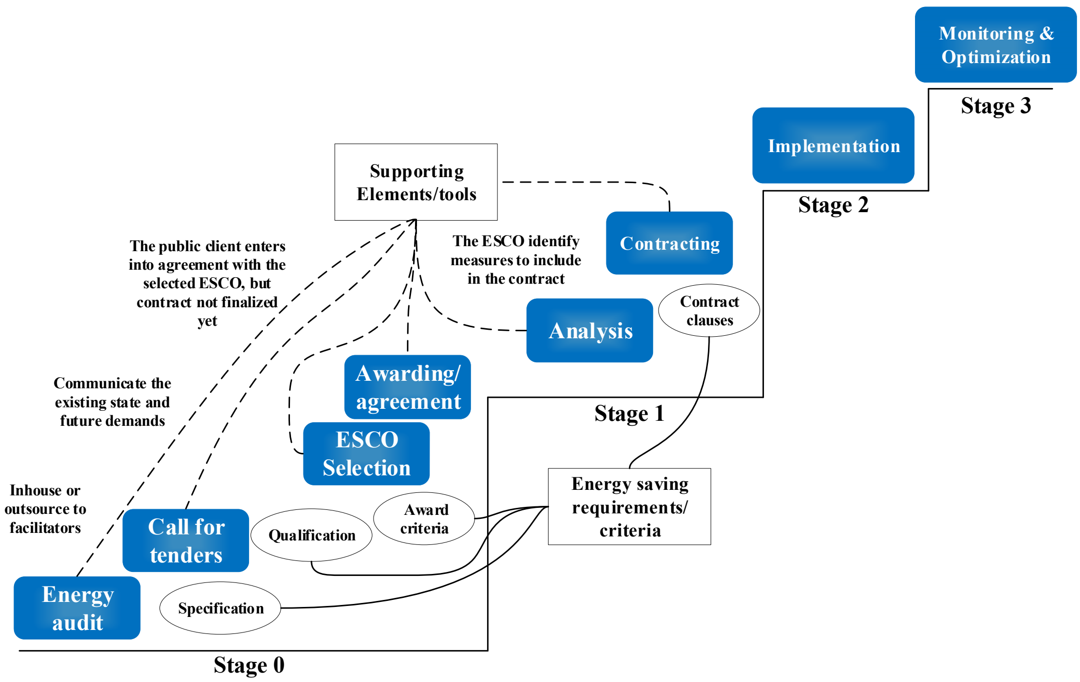

Figure 10. GPP process for the EPC project.

Furthermore, we find the case of housing cooperatives presented in (Winther and Gurigard, 2017) interesting. However, it is not technically a public procurement case. However, the project has copied some procurement practices and routines from projects implemented in the municipal sector, such as prequalification of suppliers, early information meetings, and contract templates. The experiences derived from the study can be conducive to public clients owning and running social blocks to anticipate and mitigate the 'tenant-owner dilemma.' Understanding the residents' needs and involve them early in the process was emphasized as a significant success factor to sustainable urban development projects, see, i.e., (Oliver & Pearl, 2018; Purtik et al., 2016). This underlines the importance of the residents' perspective on the EPC projects implemented in the residential sector – it helps to understand how EPC could become attractive and fulfill their needs. However, in public building projects, resident involvement might be challenged due to the rigid rules of public procurement. Currently, few studies have discussed the role of end-users or residents in public building projects, see, i.e., (Majamaa et al., 2008).

5.2 Bundling and scaling up strategy

Part of their efforts to make the EU's economy sustainable, the European Commission introduced the European green deal. It provides an action plan to boost the efficient use of resources and restore biodiversity and cut pollution. Building and renovating are among the action areas to implement the European green deal. According to the European Commission (2019b), the current renovation rates (both public and private) should at least double. Pooling or bundling renovation efforts into large blocks when implementing energy efficiency measures can be conducive to benefit from economies of scale (European Commission, 2019b). A good example for bundled EPC strategy can be found in the STEPPING project (Auvergne-Rhône-Alpes Energie, 2019). It aims to develop and test bundled models of EPC for the renovation of public buildings in rural communities or small municipalities.

Forming an effective scaling-up strategy depends to a large extent on the capabilities of the public client. Although results from (Aasen et al., 2016) show that the municipality size is not a decisive factor for the uptake of EPCs, the size of the municipality might be significant to the ESCO. Especially that some ESCOs are interested in preparing for the future and growing their business. In other words, bigger municipalities are more likely to offer more profitable projects than smaller ones. However, small clients might still attract ESCO companies if they managed to initiate more significant projects, ranging from multi-apartment building to neighborhood development. For example, a neighborhood-scale or large renovation project might be perceived as attractive to the ESCO, considering the economies of scale involved.

Nevertheless, we believe it is hard to proceed with the above discussion apart from procurement. In public procurement, the municipality size seems to be a decisive factor (Michelsen & de Boer, 2009). That is, larger clients have more resources at their disposal for establishing a purchasing department and developing environmental-related strategies. This illustrates the importance of the size of municipalities or their organizational capability. More evidence about the importance of capabilities for the procurement and supplier selection processes can be found in Jenssen & de Boer (2019). Thus, we argue that smaller municipalities can still perform complex EPC projects in the presence of two conditions: a good business case for the ESCO and a capable purchasing department. On these bases, municipalities, regardless of their size, can devise attractive bundling strategies to improve project attractiveness and economies of scale.

5.3 Managing complexity

EPC projects are complex undertakings, considering the number of details and coordination it takes during the EPC process. While expanding towards larger projects sounds like a good strategy, such an approach may cause the complexity to spike considerably – due to the increased number of participating organizations and the interactions expected to happen (Simon, 1962). The added complexity has substantial implications for the features and design of the procurement process. For example, Clement et al. (2012) discuss a Finnish case whereby a competitive dialogue procedure was used to procure the EPC project targeting energy savings and energy-efficient refurbishments in buildings. The study recommends this procedure for large, complex EPC projects, where the tender evaluation should focus on the expertise of the ESCO's personnel. The selection criteria included aspects such as the quality of the proposed project plan, the suggested method of cooperation between the contractor and the authority, the energy savings guarantee, the comprehensiveness of the proposed measures and their effects on indoor climate, and the use of the buildings and the operational costs.

Moreover, measures to handle complexity in EPC public procurement are not limited to the choice of the procurement procedure. For example, in a neighborhood-scale development comprising several EPC projects, purchasers can coordinate the inclusion of energy-saving requirements in the EPC procurement process by employing a mix of various strategies (Igarashi et al., 2015). Another approach is to initiate stakeholder engagement activities with the market, or residents in the case of residential projects, at an early stage. This can be achieved through information meetings and technical consultations without the violation of public procurement rules. Lastly, it is vital to bear in mind that what is argued for here is managing complexity rather than reducing it. If reducing complexity was the right call, then the number of interactions has to go down by logic. However, evidence shows that increased interactivity between actors during the procurement process could allow for more flexibility and enable project success (Sparrevik et al., 2018).

5.4 Impact on future EPCs

We should note that measuring the above model's impact is beyond the scope of the study and requires empirical investigation and validation. However, our intention here is to discuss some of the expected benefits of the suggested model. First, anchoring EPC projects in GPP will generally improve the project's environmental performance and ensure the selection of a qualified ESCO, especially since Norway is in an advanced position when it comes to implementing green solutions in public expenditures. Seeing EPC projects as part of the broader public procurement system may bring benefits to EPC's future in Norway. As a result, positioning EPCs as GPPs will not only benefit the EPCs, but may also lead to an increase in the awareness and acceptance of ESCOs among public and private clients. Second, pooling or bundling renovation efforts into larger blocks can be conducive to benefit from economies of scale. More extensive projects could be used to attract ESCOs in smaller municipalities. Lastly, managing complexity in EPC projects might translate to better collaboration between the involved parties. In other words, knowing when and where to let complexity emerge could probably improve collaboration throughout the stages of EPC projects.

6 Conclusions

We began our study with the observation that the current literature has not addressed EPC from a public procurement perspective sufficiently and stressed the need to explore in greater depth GPP to understand its potential in improving EPC projects. This study contributes to the literature on GPP and EPC. In particular, we see an opportunity to expand the knowledge on EPC and provide insights to improve ESCO selection and tendering practices. First, we provide a preliminary conceptualization of the link between GPP and EPC (Figures 9 and 10). Second, the study proposes an approach to improve EPC in the public and residential sectors. That is, capitalizing on GPP practices, using bundling and scaling up strategies, and managing complexity.

Furthermore, the current study hints at the underutilization in the current EPC research at the intersection between engineering and management fields. This study serves as a precursor for future empirical research on GPP and EPC projects. Shedding light on the ability of GPP to improve EPC can be of great value. More research on specific features and procedures of GPP based on the elements of EPC should be carried out. For example, the mechanics of the procurement stage and the interface points between GPP and EPC. The impact of stakeholder engagement should also be considered in the context of EPC projects, especially in the residential sector.

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