4 Energy efficiency in French social housing renovations via Design-Build-Maintain

Explanatory note

The findings in the previous paper indicate that the project delivery method used by European social housing organisations for their energy renovations with the higher potential to deliver energy savings and to deliver higher process performance is Design-Build-Maintain. The following research paper seeks for evidence of the expected potential by analysing two social housing energy renovation projects carried out by two Shelter partners. The projects are among of the first Design-Build-Maintain experiences carried out by French social housing organisations.

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Abstract

The renovation of existing building stock is seen as one the most practical ways to achieve the high energy savings targets for the built environment defined by European authorities. In France, the Grenelle environmental legislation addresses the need to renovate the building stock and specifically stresses the key role of social housing organisations. In recent years, French procurement rules have been modified in order to allow social housing organisations to make use of integrated contracts such as Design-Build-Maintain. These contracts have a greater potential to deliver energy savings in renovation projects than do traditional project delivery methods, like Design-Bid-Build. This is because they facilitate collaboration between the various actors and boost their commitment to the achievement of project goals. In order to evaluate the estimated potential of such contracts to achieve energy savings, two renovation projects (carried out by two French social housing organisations) were analysed from their inception until the end of construction work. The analysis is based on written tender documents, technical evaluation reports, observations of the negotiation phase (in one of the cases) and interviews with the main actors involved. Findings show that Design-Build-Maintain contracts do indeed offer substantial energy savings. Both projects achieved higher energy targets than those initially required. Furthermore, the energy results are guaranteed by the contractor, through a system of bonuses and penalties. Other

results demonstrate that, compared to previous Design-bid-Build renovation projects, these projects were completed in less time (from project inception to completion of the work) and at virtually the same cost. There has also been a substantial improvement in cooperation between the actors involved.

Keywords: building renovation, Design-Build-Maintain, energy savings, integrated contracts, social housing.

§ 4.1 Introduction

The authorities in Europe consider the reduction of CO_2 emissions to be a top priority. Ambitious goals have been set at European level. These involve cutting CO_2 emissions by 20% (relative to the 1990 levels) by 2020, and by 50% by 2050 (CEC, 2007). There has been a particular focus on the potential for saving energy in the EU's building stock, as this is considered to be responsible for 40% of EU energy demand (Ekins and Lees, 2008).

In France the 2007 political debate, known as Grenelle de l'environnement, led to legislation in the form of the Grenelle I Act and the Grenelle II Act (Whiteside et al., 2010), which set out a more specific course of action to reduce CO_2 emissions. The Grenelle legislation covers a wide range of activities (e.g. agriculture, transport, education), the construction sector being one of the most important. Several of its proposals address the need to speed up the rate of renovation in the residential sector and to boost the energy savings achieved. Additionally, social housing organisations (SHOs) are identified as key players in the process of achieving the set targets.
The following objectives, presented in the plan bâtiment (buildings initiative of the Grenelle Acts), give an impression of the French government's ambitions in terms of renovating existing building stock (Plan bâtiment, 2013):

- Energy renovation of 400,000 dwellings annually, starting 2013.
- Energy renovation of 800,000 of the most energy-inefficient social housing dwellings until 2020.
- Start of energy renovation of all public buildings before 2013.
- Encourage energy renovation in the public and private service sectors between 2012 and 2020.

Social housing in France represents 17% of the total housing stock, accounting for over 3.1 million dwellings. A large proportion of social housing is provided by publicly and privately owned companies acting on a non-profit basis, which are known as HLM, Habitation à Loyer Moderé. Access to social housing in France is limited by income ceilings that vary between regions and according to household size. The level of these income ceilings ensures that a large proportion of the population is eligible. However, 35% of social housing tenants currently live below the poverty line (Pittini and Laino, 2012).

The energy saving ambitions of the French government have led to the use of integrated building contracts, which include design and construction work for the renovation of the social housing stock. The procurement rules for construction projects developed by public entities in France are based on legislation governing public contracting authorities, known as the MOP Act 85-704 (French Republic, 1985), and the public procurement code, or code des marchés publics (French Republic, 2006a). As far back as 1985, the MOP enabled the use of integrated contracts (known as conception-realisation in France). However, its use was restricted to particularly complex projects (Act 85-704; A.18). In the subsequent years, specific legislation in other sectors allowed the Ministries of Internal Affairs, Justice and Defence, as well as health institutions, to use integrated building contracts. The 2009-323 Act (French Republic, 2009) enabled the use of integrated contracts for the renovation of social housing (2009-323 Act; A.110). Modifications made to the public procurement code in 2008 allowed the use of competitive dialogue as a tendering procedure for integrated building contracts in the field of building renovations (Code des marchés publics; A.36, A.37 and A.67).

If maintaining the building in question is also included in the integrated contract (Design-Build-Maintain (DBM)), it is possible to guarantee a building's energy performance after the renovation work has been carried out (Chalançon et al., 2010). This is especially useful for SHOs that aim to optimise energy savings in their renovation projects. In research undertaken by Salcedo Rahola and Straub (2013), DBM was identified as the project delivery method with the greatest potential to deliver energy savings in social housing renovations. The reasons given were that it facilitates cooperation between the various actors and boosts their commitment to achieving the project's goals.

In this study, the use of Design-Build-Maintain contracts for the renovation of social housing is evaluated using two case studies of renovation projects procured by SHOs. Our research question was: how can the use of a Design-Build-Maintain contract improve collaborative working conditions for the actors involved while improving the project outcomes, particularly with regard to energy savings?

Section 4.2 gives details of our research methodology, while Section 4.3 describes the individual case studies. Our findings are set out in Section 4.4. Section 4.5 presents our conclusions and indicates this study's limitations. It also contains various managerial recommendations and suggestions for further research.

§ 4.2 Research methodology

For the purposes of this study, we conducted a literature review and two case studies. The literature review covers papers (published in international journals) dealing with integrated building contracts and with the renovation of residential buildings. More specific information about social housing and energy renovation in France, French national legislation, and French public procurement rules was obtained from reports produced by various French organisations and European research projects.

Our case studies were two social housing renovation projects, implemented by two French SHOs:

- the renovation of 14 dwellings in a three-storey apartment block in Nurieux-Volognat (in south-eastern France) by the Dynacité SHO; and
- the renovation of 231 dwellings in four apartment blocks (ranging from 6 to 10 storeys) in Vitry-sur-Seine (in the southern suburbs of Paris) by the Logirep SHO.

Dynacité is a public social housing organisation that operates in four administrative divisions in eastern France (Ain, Isère, Rhône and Saône et Loire). It owns 23,395 dwellings that are occupied by approximately 59,000 tenants. Logirep is a private social housing organisation operating in two regions in the north of France (Île-de-France and Haute-Normandie). It owns 36,000 dwellings that are occupied by approximately 108,000 tenants.

Both case studies were pilot projects within the Shelter project, funded by the Intelligent Energy Europe programme. The Shelter project aims to facilitate the use of new models of cooperation in the renovation of social housing. Data on the case studies was obtained from:

- the tender documents: call for offers, specifications and preliminary designs;
- observation of the negotiation phase, in the case of Dynacité;
- interviews, carried out after the construction work was finished, with the social housing renovations manager, the social housing project manager, the construction company, the architect office and the maintenance company involved in both cases;
- the evaluation reports produced by the SHOs' project managers.

A social network approach, as defined by Kenis and Oerlemans (2008), was used to gain insight into the actors' cooperation structure. This approach focuses on the characteristics of the relationships rather than the characteristics of the actors themselves. The relationship types defined for the purposes of this study are based on the citizen participation ladder defined by Arnstein (1969), including the alternatives proposed by Biggs (1989). They were adapted to comply with the specific circumstances of the construction sector. The five categories give an indication of the information flows between SHOs, designers, construction companies and maintenance companies:

- Informative: Information is offered without a specific request. One-way flow of information, no feedback.
- Contractual: A specific request is defined, an answer is offered. This answer is then either accepted or rejected.
- Consultative: A specific request is defined, several options are proposed and a choice is made.
- Collaborative: The objectives are mutually defined. The risk, however, is not shared.
- Partnership: The objectives are mutually defined and the risk is shared.

§ 4.3 Case studies

§ 4.3.1 Initial status of the buildings

Both the construction and the finishing materials of Dynacité's apartment block at Nurieux-Volognat were of good quality. All of the components and equipment used dated from the year of construction (1972). No major renovation had previously been carried out, except for the insulation of two of the building's façades (using 40mm polystyrene panels) during the 1980s. The windows had wooden frames and were single-glazed, while heating and hot water were supplied by a collective heating system running on fuel oil. The building made use of natural ventilation.

Logirep's four apartment blocks at Vitry-sur-Seine were constructed in 1966. The quality of the construction and that of the finishing materials was still good and no major refurbishments had been carried out previously. The building had prefabricated, non-insulated walls and single-glazed windows with wooden frames. The heating and hot water were supplied by a district heating system and the building made use of natural ventilation. A summary of the characteristics of the buildings prior to renovation is presented in Table 4.1.

	NURIEUX-VOLOGNAT, DYNACITÉ	VITRY-SUR-SEINE, LOGIREP
Year of construction	1972	1966
Type of building	Apartment block, 3 storeys	Apartment blocks, 6-10 storeys
Number of dwellings	14	231
Windows	Wooden frame, single-glazed	Wooden frame, single-glazed
HVAC	Collective fuel oil heater, natural ventilation	District heating, natural ventilation
Theoretical energy use	266 kWh/m²/year	168 kWh/m²/year
Actual energy use	256 kWh/m2/year	242 kWh/m²/year

TABLE 4.1 Initial characteristics of the buildings in question

At Nurieux-Volognat, actual energy use (energy consumption as measured by the meter) was close to the theoretical energy use (calculated using methods proposed by the Energy Performance Building Directive). At Vitry-sur-Seine, however, actual use exceeded theoretical use by a considerable margin. Accordingly, both cases conflicted with recent studies in which actual energy use in poorly insulated dwellings was shown to be considerably lower than the theoretical predictions (Majcen et al., 2013). Majcen's hypothesis is that people in poorly insulated buildings are well aware of their dwelling's energy performance and that they act accordingly, by not heating every room or by turning down the thermostat. The SHO managers interviewed expressed the view that neither of these hypotheses (which could be valid in dwellings with individual heating systems) apply in buildings with a collective heating system.

§ 4.3.2 Characteristics of the tenders

In both cases, the renovation projects were tendered as Design-Build-Maintain contracts. Dynacité tendered the contract using a reduced competitive dialogue, consisting of a single round of negotiations. Only three candidates responded to the call for tenders. This is the legal minimum for this type of procedure, as defined in Article 67 of the 2006-975 Decree (French Republic, 2006b). The three candidates were all consortia, two of which were led by national construction companies. The other consisted of local SMEs. The three candidates were invited to participate in the negotiation phase.

During the negotiation phase, the three candidates presented their renovation proposals to Dynacité individually, in separate meetings. They had the opportunity to ask questions and were given feedback. The consortia led by national construction companies proposed a preliminary design that largely reflected the requirements set by Dynacité. The consortium consisting of local SMEs failed to comply with all the requirements. During the course of the meeting, it became clear that this particular consortium had misunderstood some of the requirements involved.

After the negotiations had been completed, the candidates had two months to modify their proposals and submit their final offers. The best offer was selected on the basis of a set of award criteria, within which energy performance represented 20% of the total score (see Table 4.2). The SMEs' consortium achieved the highest score and was awarded with the contract.

The non-selected candidates were awarded a sum of €12,000. Dynacité set the minimum requirements to be met in relation to energy performance: a minimum of French Energy Performance Certificate level B, below a theoretical 90 kWh/ m^2/year, and a minimum reduction of 40% in real energy consumption for heating and hot water.

In the case of Logirep, the contract was tendered using the restricted procedure. Five candidates from a total of eight, the legal minimum for this type of procedure (as stipulated in Article 61 of the 2001-210 Decree; French Republic, 2001), were pre-selected and invited to submit their proposals. The five candidates were all consortia, each of which was headed by a national construction company. The selection was based on a set of award criteria in which energy performance represented 30% of the total score (see Table 4.2). Candidates who had submitted a proposal but who had not been selected were awarded a sum of €15,000. Logirep defined the following minimum requirements to be achieved in relation to the energy performance: a minimum of French Energy Performance Certificate label BBC "low consumption building label" (equivalent to less than a theoretical 104 kWh/m^2/year) and a minimum reduction of 30% in the actual energy consumption for heating and hot water.

NURIEUX-VOLOGNAT, DYNACITÉ		VITRY-SUR-SEINE, LOGIREP	
Price	45%	Price	30%
Energy performance objective	20%	Energy savings proposed	10%
Works methodology	14%	Energy saving measures proposed	15%
Quality of the maintenance	14%	Obtaining BBC certificate	5%
Tenant's guidance	7%	Technical report	25%
		Architectural quality of the project	15%

TABLE 4.2 Award criteria and distribution used

§ 4.3.3 Nature of the construction work

The renovation project in Nurieux-Volognat, with a budget of €39,000 per apartment, included the renovation of kitchens, bathrooms, floors and electric systems in the apartments and repainting work, the renewal of garbage facilities and floors in the common spaces. Moreover, a set of energy-saving measures representing 45% of the total budget was implemented:

- wall insulation (14 cm polystyrene panels);
- roof insulation (30 cm glass wool);
- replacement of windows (PVC frame, double glazing 4/16/4 low emissive argon, Uw< 1.4 Wm^2K);
- installation of hygrosensitive mechanical ventilation;
- replacement of heating boiler and hot water supply (high efficiency gas boiler).

In Vitry-sur-Seine, the renovation project had a budget of €40,174 per apartment. This project involved the renewal of kitchens, bathrooms, floors and electric systems in the apartment, repainting work, the restructuring of green areas and renewal of garbage facilities in the communal spaces. In this project, the energy-saving measures represented 48% of the total budget and included:

- wall insulation (12 cm polystyrene panels R=3.75 m^2K/W);
- roof insulation (13 cm polyurethane panels);
- replacement of windows (PVC frame, double glazing 4/16/4 low emissive argon, Uw< 1.4 Wm^2K);
- installation of hygrosensitive mechanical ventilation;
- replacement of the district heating system heat exchanger;
- installation of energy monitoring system in each dwelling.

Nurieux-Volognat project after renovation

Vitry-sur-Seine project after renovation

§ 4.3.4 Energy performance

In both cases, an energy performance certificate was issued based on the official theoretical calculation method. Both projects also involved maintenance contracts that included a guarantee of performance, in terms of actual energy consumption. It was the consortia themselves that proposed the figure for guaranteed actual energy consumption (see Table 4.3).

The energy consumption guarantee has the same period of validity as the respective maintenance contracts (8 years for Nurieux-Volognat and 4 years in the case of Vitry-sur-Seine). According to the terms of the contracts, no penalties may be imposed during the first year in the event of under-performance. From the second year onwards, if the reduction in energy consumption is higher than the level specified in the contract, the gains are to be shared equally between the consortium and the tenants. In the event of underperformance, however, 100% of the amount involved is to be covered by the consortium. The difference between theoretical energy use and guaranteed energy use results from the uncertainties involved in predicting user behaviour. Indeed, the consortium members interviewed indicated that this is particularly applicable to buildings with a collective heating system.

	NURIEUX-VOLOGNAT, DYNACITÉ	VITRY-SUR-SEINE, LOGIREP
Theoretical energy consumption	89 kWh/m^2/year	65 kWh/m^2/year
Guaranteed energy consumption	166 kWh/m^2/year	145 kWh/m^2/year

TABLE 4.3 Energy use after renovation

§ 4.3.5 Characteristics of the relationships

The common project delivery system used by Dynacité for major renovations is the traditional Design-Bid-Build (DbB) model. The design services are tendered in a single contract, which in France is called maître d'œuvre (project manager). The maître d'œuvre is usually a group of design companies led by an architectural firm. Using the technical documents produced by the design companies, the construction work is tendered by Dynacité in the form of multiple contracts. Dynacité usually divides the work into lots to facilitate the involvement of local small and medium-sized enterprises (SMEs). The maintenance services are contracted, per service, for a part of the entire building portfolio. Of the various maintenance services contracted, the energy services contract is the largest. The energy services company is responsible for maintaining the energy systems as well as for the supply of energy. The design companies have a consultative role. During the design process, they propose a range of design options in response to requests from the SHO. The relationships between the SHO and the other contracted parties are purely contractual in nature, as the SHO is free to accept or reject the answer to its specific request. The relationship between the design companies and the specialised contractors is purely informative in nature, being restricted to a one-way flow of information (see Figure 4.3).

While common project delivery system used by Logirep is also based on the traditional DBB model, there are two major differences in terms of the renovation processes used. Since Logirep is a private SHO, if the total price of a bid is below a certain threshold, it does not need to comply with French public procurement rules. However, it must comply with its own procurement code, which requires a minimum number of offers rather than a public call. The amounts involved when contracting out design services often fall below this threshold. As a result, candidates are chosen from among a restricted number of design companies that the SHO has worked with in the past. This is why their relationship is considered 'collaborative' rather than 'consultative' (see Figure 4.1). The second difference is that Logirep usually tenders the construction work in a single contract, so the successful companies tend to be general contractors.

In both Design-Build-Maintain projects, the various companies contracted directly by the SHO were all consortia. The relationship between the various companies in a consortium can be seen as a partnership, as the consortium's objectives are mutually defined. For Logirep, the specialised contractors were not part of the consortium, since they were contracted by the general contractor.

The two cases studied involved quite different relationships between the SHO and the consortium. In the case of Logirep, the relationship is contractual. Logirep tendered the contract according to a restricted procedure. Accordingly, the pre-selected candidates immediately presented a preliminary design in response to a request from the SHO. In the case of Dynacité, this relationship can be considered consultative. Dynacité tendered the contract using a reduced competitive dialogue, consisting of a single round of negotiations. During these negotiations, the candidates participating in the competitive dialogue each presented a preliminary design to the SHO, together with a limited range of alternative options. Each candidate had an individual meeting with the SHO, which then provided feedback on the design proposal and its alternatives. In this course of this meeting, the SHO did not make a definitive choice from among the alternatives, however it was able to indicate its preferences. Following this meeting, the candidates each submitted a modified preliminary design.

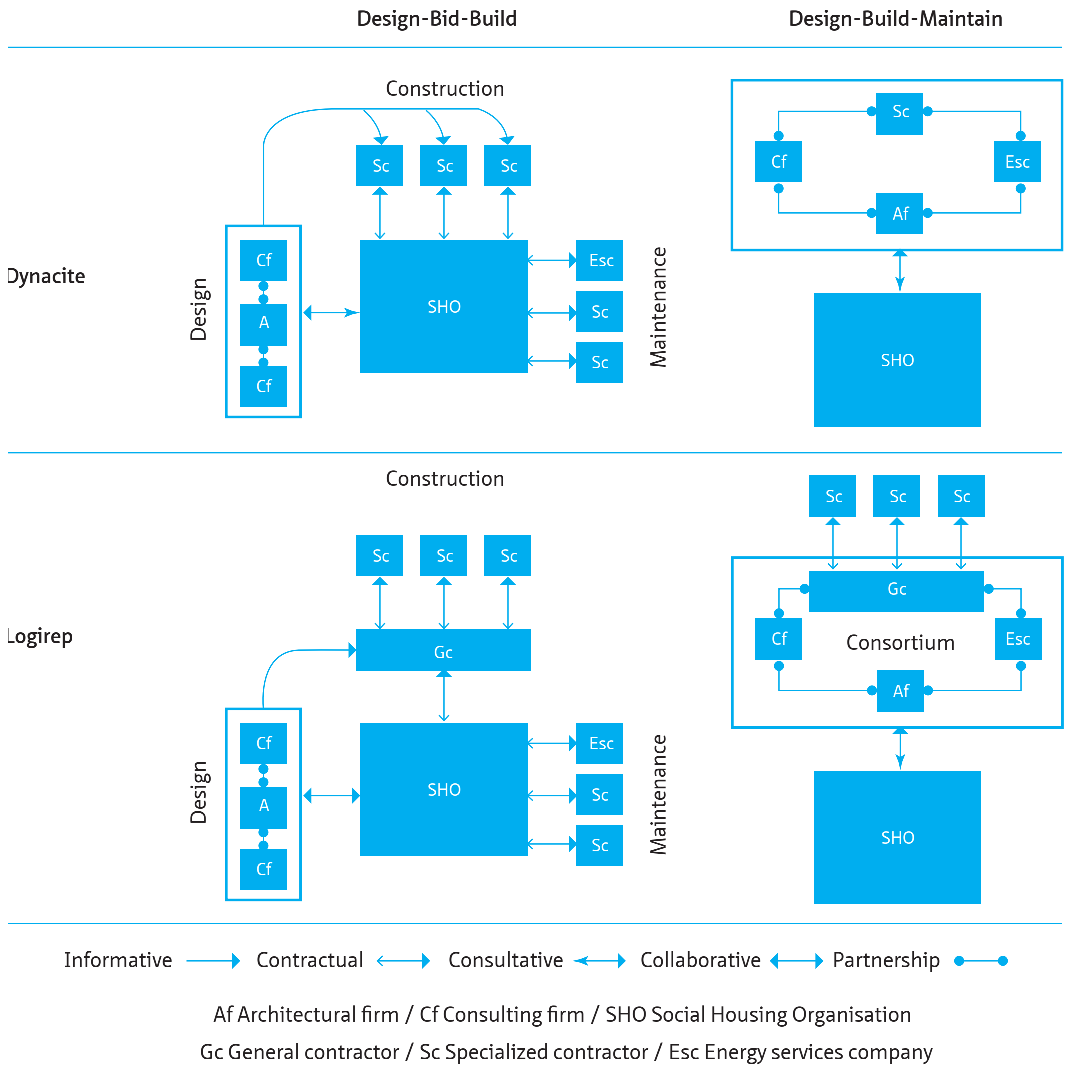

FIGURE 4.1 Common relations among actors in Design-Bid-Build and Design-Build-Maintain contracts of Dynacité and Logirep

§ 4.4 Findings

Both DBM projects achieved their energy savings targets and even surpassed the minimum requirements. These projects were completed in less time (from project inception to completion of construction) and at virtually the same cost (in terms of design and construction) as other, similar, DbB projects. Moreover, the general perception among the actors involved was that communication had been improved and mutual conflicts reduced. Previous studies on integrated contracts in other construction sectors delivered similar findings in terms of time-use, costs, and the relationships between individual actors (Hale et al., 2006; Koppinen and Lahdenperä, 2007; Molenaar et al., 2010; Palaneeswaran et al., 2003; Pietroforte and Miller, 2002).

At this stage it was not possible to verify the building's actual post-renovation energy consumption, given the limited amount of time that had elapsed since the work had been completed. The guarantee of energy consumption defined in the maintenance contract can be used as a performance indicator for energy efficiency. Dynacité required a 40% reduction in energy consumption, and the winning consortium provided a contractually guaranteed cut of 42.5%. Logirep required a 30% reduction in energy consumption, and the winning consortium provided a contractually guaranteed cut of 40%.

The total duration of the project was reduced in both cases. There were also changes to the length of individual project phases. In the case of Dynacité, the total duration of the project (from inception until the end of construction work) was cut by 3 months (relative to a conventional DBB renovation project with similar characteristics), which is equivalent to an 11% reduction in time. The corresponding figures for Logirep were 1 month, and 2.5%. In the case of Logirep, the project remained on stand-by for five months at the end of the design phase, as various internal financial agreements were not completed on time. Without this delay, the reduction involved would have been 15% (see Table 4.4). The SHOs believe that future projects involving DBM contracts could probably reduce this time by a further one or two months. This is because the design work on the new process is now complete, and the new contract documents have already been created, so no more time will need to be devoted to these aspects during the pre-tender phase.

DYNACITE	DBM	Pre-tender	Tender	Design	Construction	
	DBB	De-sign T	Design	Works Tender.	Construction	
LOGIREP	DBM	Pre-ten-der	Tender	Design		Construction
	DBB	De-sign T	Design	Works T.	Construction	
		1 2 3 4 5 6 7 8 9 10 11 12	13 14 15 16 17 18 19 20 21 22 23 24	25 26 27 28 29 30 31 32 33 34 35 36	37 38 39 40	

Design T.: Design Tender

TABLE 4.4 Project phases from inception until the end of construction work

The interviews revealed that the design phase has been completed more quickly (see Table 4.4). By the time that the design phase started, the main design decisions had already been taken. This was because the candidates needed to present a preliminary design at the end of the tender phase. Moreover, when the design team is working on the final design, less time is required to choose between the possible design alternatives. This is because the consortium includes a construction company, so it is possible to get immediate answers to questions about prices and feasibility of implementation. Improved preparation, together with better coordination between design and implementation, produced time savings during the construction phase. DBB projects often require extra design decisions to be taken during this phase, but this was not the case here. With regard to the tender phase, Logirep saved some additional time as they only needed to tender one contract rather than two. This was not the case with Dynacité. As a result of the competitive dialogue involved, Dynacité's tender phase took two months longer than a DBB project.

For both renovation projects, the SHOs calculated that the cost of the work involved was just 1% to 2% higher than in similar DBB projects. This was in spite of the fact that the tender procedure was considerably more expensive, partly because the evaluation required the involvement of external consultants but more particularly because of the requirement to compensate non-selected candidates. For Dynacité, the compensation of non-selected candidates represented 4.2% of the total cost. The corresponding figure for Logirep was 0.7%. The difference in these percentages arises from the enormous disparity in total project costs (€570,000 for Dynacité and €9 million for Logirep).

The general view of all the actors interviewed was that the relationships between the actors involved were better than in similar DBB projects. In addition, the majority indicated that they trusted all of the actors involved and that fewer conflicts had occurred.

The flow of information was reported to be higher during the initial stages of the project (the tender and design phases) and lower during the construction phase. It was also stated that the meetings were less formal.

DYNACITÉ	SHO		DC		CC		MC		LOGIREP	SHO		DC		CC		MC	
SHO	IF	M	-	-	-	=			SHO	IF	M	+	=	+	+	+	+
	C	T	=	=	-	+				C	T	-	+	-	=	-	=
Dc	=	-	IF	M	=	=			Dc	=	+	IF	M	+	=	=	=
	=	+	C	T	-	+				-	+	C	T	-	=	=	=
Cc	+	+	+	+	IF	M			Cc	+	+	=	=	IF	M	+	+
	=	+	-	+	C	T				-	+	-	=	C	T	-	+
Mc	+	+			+	+	IF	M	Mc	=	+	+	+	+	+	IF	M
	-	+			-	+	C	T		=	=	=	+	-	+	C	T

Dc: Design companies/ Cc: Construction companies/ Mc: maintenance companies
If: Information flow / M: Meetings / C: Conflicts / T: Trust / +: more / =: equal / -: less

TABLE 4.5 Actor relationship evaluation compared to previous experiences of Design-Bid-Build

However, a deeper analysis of the relationship between the actors did yield some specific details. In the interviews, every actor was requested to evaluate their relationship with each of the other actors involved in the project. They had to indicate whether this was better, unchanged or worse, relative to their previous experiences of DBB, and to give reasons for this view. The evaluation of the relationship was based on four parameters: flow of information, meetings, conflicts and trust (see Table 4.5). In the case of Dynacité, there was reduced information flow and there were fewer meetings with contractors than in previous projects. This is because, in the past, a number of specialized contractors had to be commissioned directly. Using the present approach, the coordination role is transferred to the consortium. Dynacité found that reduced communication did not impact the trust that they had in their contractors.

In both cases the maintenance companies participated less in the process than the other actors. One unusual aspect of the Dynacité project was that the maintenance company contact person was switched during the process. This had the effect of reducing the company's presence at the regular team meetings. As a result, the relationship with the maintenance company was not evaluated. In the Logirep project, the maintenance company did participate in the regular meetings, but the other actors felt that it only played a minor part, and that its involvement was mainly limited to the design phase. On the other hand, in both cases, the maintenance companies believed that even making a minor contribution during the design phase represented a major step forward. They had gone from a situation in which they had no influence at all in the design to one in which they could be sure that the installations they would have to maintain, would meet all their requirements perfectly.

§ 4.5 Conclusions

We analysed two French social housing renovation projects (from inception to the end of construction work) that used the DBM project delivery method rather than the usual DBB method. We demonstrated that it is possible to engage the design companies, construction companies and maintenance companies to achieve energy savings that exceed those stipulated by the SHO and to obtain a guarantee of results. This approach also made it possible to reduce the duration of a project, while keeping the costs involved approximately equivalent to those incurred by DbB renovation projects. The collaborative set-up defined by the DBM process also resulted in improved relationships between the actors involved. However, our analysis of these relationships indicated that there is still room for improvement, particularly with regard to the maintenance company.

The case studies demonstrate that the use of Design-Build-Maintain project delivery in the renovation of social housing is a good strategy for improving energy savings. If such savings are to be achieved, it is necessary to define:

- realistic but ambitious minimum requirements;
- clear and measurable award criteria that stress the importance of achieving high energy savings; and
- a guarantee mechanism that is fair and robust.

However, in order to profit from these potential benefits, the following conditions need to be taken into consideration:

- the scale of the contract must be large enough to ensure that any compensation paid to non-selected candidates does not adversely affect the total cost of the project;
- the SHO's maintenance strategy needs to be flexible enough to handle maintenance contracts that are project-related as well as maintenance stock-related contracts.

The study involved two pilot projects in France. This sample size is too small to support any general conclusions. However, this study's conclusions could be of benefit to SHOs in France and other European states, given their common objective of achieving substantial energy savings in renovation projects. The scope for potential energy savings clearly depends on the initial consumption figures. Moreover, project results can vary considerably depending on whether the dwellings in question have individual or collective heating systems.

The social network approach used in this study has helped to identify the changes in relationships between the main actors involved. Further research is needed to extend the analysis to every one of the actors involved and to evaluate the changes in their relationships in greater detail.

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