DELIVERING AND OPERATING LOW-ENERGY BUILDINGS IN FRANCE AND SWEDEN

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ABSTRACT

Purpose: The goal is to examine how high energy objectives are reached in building projects in France and Sweden and whether these energy objectives have modified the balance of power within the construction business system.
Background: France and Sweden belongs to two different national construction business systems. The organisation of project differs largely between the two countries in terms of responsibilities, expertise and roles when delivering low-energy buildings.
Approach/research limitations: The research includes a presentation of the concept of construction business system. Then, two case studies focusing on the construction and operation of low-energy buildings are exposed. This focus on two projects which are not representative is also the limit of the study.
Originality/value: The cases provide data on low-energy buildings in operation and try to explain the gap between real and expected energy consumption.
Results: Energy and sustainability objectives have led to changes in expertise provided by the actors of the projects and supported a change of power. In both cases the architect has less influence. It is counterbalanced by the emergence of design offices/consultants specialised in energy efficiency. Energy targets are not met at the operation stage after one year of operation. However, in the Swedish case, the performance-based contract provides strong incentives to find solutions in order to reach the energy target established at the design stage.
Practical implications: The cases indicate the need to integrate operators and users at the design stage of any building in order to reduce the discrepancies between expected and real energy performance and to satisfy the European Directive on the Energy Performance of Buildings.

Keywords

Low-energy buildings; construction business systems; energy performance;

1 INTRODUCTION

The decreases of energy use and greenhouse gas emission are among the main drivers for innovation and change in the building sector. As member of the European Union, France and Sweden are under the influence of European policy. For example, both countries had to implement the 2010 European Directive on the Energy Performance of Buildings which stipulates that "*it is necessary to lay down more concrete actions with a view to achieving the great unrealised potential for energy savings in buildings and reducing the large differences between Member States' results in this sector.*"

However, despite this common Directive, the way each country follows to reduce energy consumption of buildings cannot be similar since France and Sweden belong to two different national construction business systems.

Winch (2000) considered that there are two levels of analysis within construction business system: the national and the sectoral. At the national level, he identified three business systems: the *Anglo-Saxon*, the *corporatist* and the "*étatique*" systems.

At the sectoral level, the organisation of projects will differ in terms of:

- Conception which "*refers to the organization of the process of design on behalf of the client*";
- Construction which "*refers to the organisation of the process of execution on behalf of the client*";
- Control which "*refers to the organisation of third party actors ensuring that the client's requirements are met*".

One element can be added to these patterns identified by Winch: operation which refers to the organisation of the process of maintenance and operation on behalf of the user of the building.

There is collaboration between each actor of the system in order to achieve the goal of the client. However, at the same time, there is a competition since each actor tries to influence the system in order to strengthen his own position. Winch (2000, 91) indicates that there are factors "*that allow some actors in the system to become relatively powerful compared to others*". The "*ability to solve complex problems for the client*", "*the blessing of the state*" and the "*ability to manage risk for the client*" are three factors identified by Winch.

Based on this framework, the paper will firstly examine whether energy and sustainability objectives have modified the relationships between the actors and the power of each actor. The hypotheses of this paper are that energy and sustainability objectives have reinforced the complexity of building projects and that the actors who can help the client to solve these complex issues will reinforce their power. The second objective is to observe whether this move toward energy performance has been successful and has led to better performance for the building industry.

To answer to this question the paper will present the construction business system in France and Sweden in order to characterise the organisation of building projects in both countries in terms of responsibilities, expertise and roles when delivering high energy objectives. Lessons and practical implications will be based on the results of the two case studies.

2 CONSTRUCTION BUSINESS SYSTEM IN FRANCE AND SWEDEN

2.1. The French construction business systems

The State has a strong influence on the industry through the regulation concerning existing and new buildings. As such, France could represent the "*étatique*" system identified by Winch. For example, several standards have been developed since the oil crisis and the mid-1970s to reduce energy consumption in buildings. The requirements induced by this change in the regulatory framework led to a reduction of the average energy consumption in residential buildings. Between 1973 and 2005, it decreased from 364.8 kWh/m² to 215.6 kWh/m² (ADEME, 2007).

Following the *Grenelle de l'Environnement* (a French multi-party debate on the environment involving several bodies) the national energy policy was modified. A new thermal regulation was implemented stating that buildings have to consume more or less than 50 kWh/m²/year (primary energy) in 2013 depending on the climatic conditions that prevail in French regions.

However, this vision of an "étatique" system is mitigated by the influence of three French contractors (VINCI, BOUYGUES and EIFFAGE) which are among the largest construction companies in the world. On the other side, firms with less than 10 employees represent about 93% of the contractors while they concentrate only half of the turnover (CGDD, 2009).

Moreover, the law towards public private partnership (PPP), enacted in June 2004, has brought about renewed interest in PPP. Under this new scheme, design, build, finance and operation are transferred to private sector partners. Despite this law, the vast majority of investments (more than 95%) in the French public service is still procured through conventional means.

In public procurement, the separation between design and construction is the most prevalent framework. Design and Build (D&B), Design or Build and Operate (DB&O) are still exceptions. D&B is possible in case of technical complexity. DB&O is possible since 2012, if it leads to better energy performance.

2.2. The Swedish construction business system

The Swedish construction business system cannot be classified in the aforementioned categories defined by Winch.

2.2.1. The domination of Design and Build

The Swedish construction industry is mainly local and national with a few internationally operating actors. On the production side, the sector is dominated by three large actors. Together they controlled 20% of the Swedish market in 2012 (Sveriges Byggindustrier, 2013). A change process during the 20th century has seen the contractor gaining in power on expense of other actors (Grange 2010). The architect industry reflects the production side with a few large consultancies, a larger number of small consultancies and very few in the segment between these two groups. Compared to other countries, architects and engineers are in a weaker position in being consultants without precise professional responsibilities (Kadefors, 2004). Bröchner et al (2002) describe the Swedish culture in construction as low power distance and low respect for authorities which allows for a strong respect for rationality to be reconciled with a weak role of the experts. The culture is based on a belief in egalitarianism where common sense tends to be valued higher than expertise. The actual power relation is usually perceived as a problematic among architects (Grange, 2010).

Traditional contracts of the type design-bid-build are becoming less common and are often replaced by D&B contracts. D&B contracts are dominating in housing production but less common in civil works and infrastructure projects, project with higher complexity (Nilsson, 2008). Between 1980 and 1999 the share of D&B contracts in the production of multi-residential buildings increased from 24% to 93% then falling back to 75% in 2007 (SCB, 2010). DB&O contracts have only been tried out in a few projects (Nilsson, 2008).

Public clients are subject to follow agreements on public procurement. A study from 2001 show that 80% of the building projects purchased through public procurement was chosen on the lowest bid. Qualitative differences between architect consultancies and different proposed solutions did not seem to have been given attention by the client in these cases (Lindqvist, 2001).

2.2.2. The introduction of energy objectives in the construction sector

Sweden has thermal requirements of buildings since the 1950s. Since 2006, these regulations have been increasingly strengthened. The last up-dates came into legal force in January 2013 demanding a maximum of 90 kWh/m2/year delivered energy (including heating, hot water, electricity for operation) for housing and depending on the climate conditions.

Last years, Sweden has seen a rapid development of low-energy construction. In 2010, 24% of all new multi-residential buildings in Western Sweden were considered as low-energy i.e. having an energy performance of 25% less energy use than is required by the national building regulations (Wahlström et al, 2011). This progress has been pushed by local environmental policy which often set higher requirements than the national (around 60 kWh/m^2/year).. The intensified focus on energy and environmental objectives has pushed all categories of actors in the construction industry to develop competence in this field (Gluch et al, 2013).

3 METHODOLOGY

The first objective is to examine whether energy and sustainability targets have modified the relationships between the actors and the power of each actor. The second objective is to observe whether this move toward energy performance has been successful and has led to better performance for the building industry.

The case study approach appears appropriate since little is known about this phenomenon (Eisenhardt, 1989). As mentioned by Tellis (1997) and Eisenhardt (1989) the selection of the case is one of the most important issues in case study approach. Low-energy building will be a standard in the future. However, in France, the market is still in its infancy and the first projects were launched about five years ago. In Sweden, low energy projects started in the 1970s and since the early 2000s they are becoming dominant. For the comparison, it was necessary to select a modern Swedish example which represents and reflects how the industry deals with actual requirements. For France, it was necessary to select a case among the first low-energy buildings projects in order to get data and feedbacks on the buildings in operation.

The French case study is based on face-to-face interviews with the client, the architect, the design office, the environmental consultant, the operator and the two people who are following the contracts and representing the users of the building. A report completed after one year of operation was also used as complementary source of information.

The Swedish case study is based on a combination of face-to-face interviews with representatives from the client (also the operational unit) and telephone interviews, due to long distances, with the contractor, the architect, and the engineer having the role of energy coordinator. Some key actors have been interviewed at several occasions. Two earlier reports (not including the operation phase) were also sources of information.

The interviews mainly focused on the organisation of the projects, their origins and goals (mainly energy and environmental issues), the characteristics and impacts of main innovative solutions on the operating costs, the competencies of the different stakeholders, the nature of the contractual agreements, the responsibilities in case of poor performance, the performance of the building in operation and users' involvement during design / construction / operation.

4 FRANCE: THE CONSTRUCTION OF IGN AND MÉTÉO FRANCE HEADQUARTER

4.1 Characteristics of the project

The construction of the new headquarters of IGN (National Geographic Institute) and METEO France was decided in 2007 by the Ministry of Ecology, Housing and Transport. The aim was to gather several services scattered everywhere in Paris and its suburbs. The construction was carried out under a public management contract (law n°85.704 laid down the 12th of July 1985). The Ministry, as client, delegated the supervision of the project to its regional division. He was assisted by an environmental consultant who is also in charge of auditing the energy performance of the building after the first and second year of operation.

When the Ministry launched the contest to select the architect, the building was not supposed to be certified and low energy. However, the national multi-party debate on the environmental policy modified the position of the Ministry. During the auditions, the client asked the design team who was finally selected, to modify slightly its project in order to be certified for its environmental performance and to get the label "low energy building".

The HQE (High Environmental Quality – French environmental assessment system) certification is issued after three audits carried out during key periods (programming, design and construction) in the construction period. The certification relates to the operation management system and the environmental quality of the building. The client must hierarchically define 14 targets in order to create a profile of the environmental quality of the building.

The Ministry decided to focus on four targets which had to reach the level "high performance":

1. Low site nuisance (environmental management of the building site);
2. Energy management (reduction of energy and greenhouse gas emissions);
3. Maintenance and sustainable environmental performance (the aim is to develop solutions that take into account maintenance issues);
4. Hygrometric comfort.

The cost of the building works reached 30 million Euros for14 900 m² (and 180 parking places).

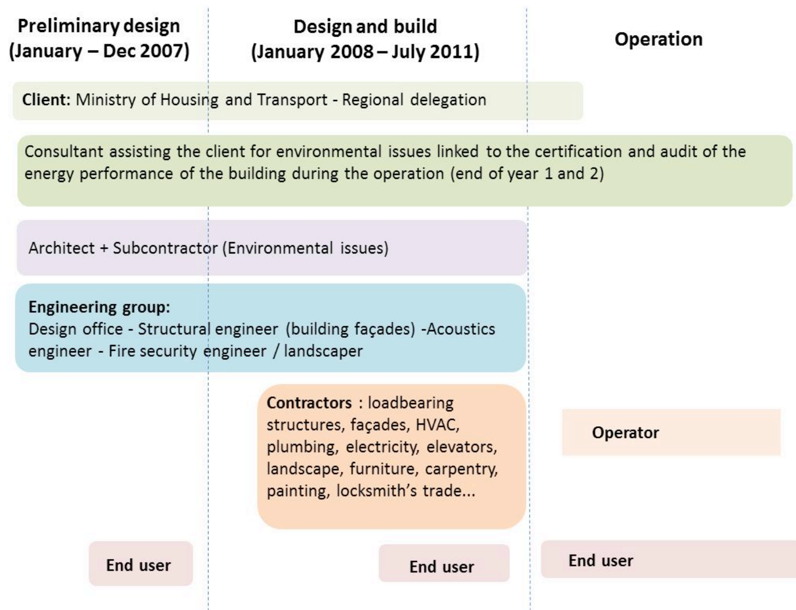
4.2. Organisation of the construction process

The design team (architect and design office) coordinates the firms in charge of the different batches: loadbearing structure, façades, HVAC, plumbing, electricity, elevators, landscape, furniture, carpentry, painting, locksmith's trade.

The environmental approach modified the organisation of the building process. Preliminary studies were more developed and strongly focused on energy issues. This approach which was not very usual for most actors was considered as positive since most issues were raised before the launch of building works. However, the administrative tasks were considered as a burden.

The environmental consultant was a subcontractor of the architect. As such, he was not responsible for the final decision and he tended to propose very innovative solutions. Thus, the architect who was not competent for energy issues was not in a comfortable position between the consultant and the design office that preferred to favour traditional solutions.

Figure 1: the actors of the project from design to operation



Several delays were registered at the beginning of the building works. Indeed, the company in charge of the preliminary works was not competent. Moreover, several solutions were quite innovative (the geothermic system, the heating system - capillary tubes for radiant ceilings) and required permanent adjustments. Despite this situation, the building was delivered on time to avoid strong penalties[1].

The users were not involved during the design process. The people in charge of logistics and representing the users discussed with the architect at the design stage about access control, electrical current and transfer of technical equipment.

4.3. The building in operation: the energy issue[2]

The facility manager is in charge of the maintenance of the building and the follow-up of the energy consumptions. However, his contract is not performance-based. It is more a duty-based contract. In case of poor maintenance, he is not penalised. The facility manager was involved in the project six months after the delivery period since the client forgot to launch a call for tender on time. Moreover, he was not allowed to optimise the systems for several months since the acceptance of work was not completed.

[1] Météo France had sold its former headquarter to a Russian property company and it was forced to leave it on time. Otherwise, it had to pay a monthly penalty of 300 000 euros.

[2] More information linked to the operation stage was obtained. Issues such as the performance of equipment in operation, the satisfaction of the users, the communication towards the users of the building, were raised during interviews. However, the paper focuses on the energy issue.

The building is equipped with a centralised control station that allows the operator to watch over the performance, to optimise the technical installations and to control all energy consumption units. However, the strong thermal inertia of the building makes daily adjustments complex.

After one year of operation, energy consumptions are much higher than expected (table 1). This was due to the inadequacy of the hypothesis retained for dynamic simulations, dysfunctions of the geothermic system and the gap between the theoretical and real use of the building.

Table 1: Comparison between energy objectives and consumptions in operation
May 2012 to April 2013

Uses	Objectives (kWh/year)	%	Consumptions in operation (kWh/year)	%	Gap
Heating	56 428	7.39	327 014	21.32	+ 479,5%
Air conditioning	63 812	8.36	287 017	18.72	+349.79%
Hot water	2 933	0.38	-	-	-
Lighting, office automation	573 461	75.1	743 234	48.46	+29.6%
Ventilation and auxiliaries	66 949	8.77	176 332	11.5	+163.38%
Total without PV	**763 583**	**100**	**1 533 597**	**100**	**+100.84%**
Photovoltaic	17 652		12 047		-31.75%
Total	**745 931**		**1 521 550**		**+103.98%**

Source: BEHI (2013)

The geothermic system worked only two months during the first year. Consequently, it was the gas heating system which was the back-up system which was used for the first year. Moreover, when the system was in operation, its energy efficiency was much lower than expected since the pumps that are used for the geothermic system, consume energy.

Moreover, it appears that one floor dedicated to METEO France is in operation 24/7 while the air processing system was supposed to work only five days a week from 8 am to 7 pm. However, the seven floors are inter-dependant. Thus, the air processing system is in operation 24/7 for the part of the building owned by METEO France.

Finally, the large gap for heating is due to the entrance hall. It was supposed to be heated at 17°C. This temperature is fine for employees who cross the hall but not for receptionists who work there. Thus, most of the energy used to heat the building is used for the entrance hall.

5 SWEDEN

5.1. Characteristics of the project

The Swedish Fortifications Agency (SFA) is publicly owned and one of the largest real estate owners in Sweden. Their main role is to supply and operate the Swedish defence estate and their property ranges from statuary protected national heritage buildings to modern purpose built facilities such as airports, naval bases and housing.

SFA has no history of engaging in projects with a sustainability profile. In 2010, two pilot projects for low-energy construction were initiated. The projects are a student accommodation for the training of soldiers, and a rescue station for the military including an administrative part and a depot. The student accommodation was carried out as a D&B contract due to the simplicity of the project while the more complex rescue station was carried out as a traditional design-bid-build contract. This description focuses on the student accommodation for which a penalty was amended the contractor on the energy performance.

The student accommodation consists of two longer building volumes in two levels with individual rooms for 160 soldiers and common areas with smaller kitchens. Stairs and corridors that connect the different parts are not heated but will be heated by surrounding heated space to more than 10 ˚C and are thus included in the total heated area which is calculated to 4590 m².

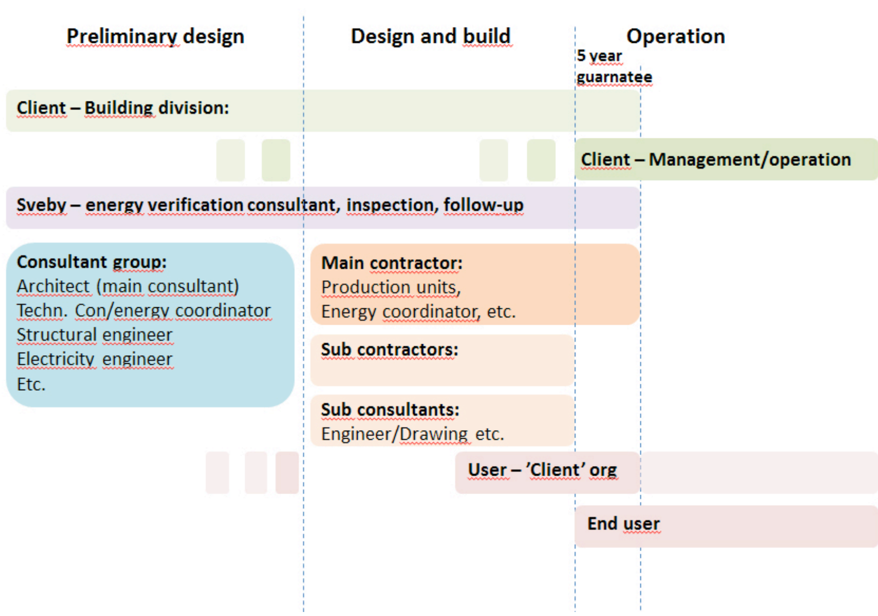
The SFA tried out a new method called Sveby in both pilot projects in order to verify the energy demands during the whole process. Sveby stands for 'Standardise and verify energy performance in buildings' (www.sveby.org). This method was developed by the Swedish building industry to interpret and guide functional demands on energy saving in the national building regulation. SFA has an agreement with the Swedish Energy Agency to participate in the development of Sveby.

5.2. The preliminary design

In the preparation of the preliminary design, a specific document was prepared for the energy programme. This was central to the project and also a novelty for the client.

A consultant group directed by an architect was procured for preparing the preliminary design. After a first qualification, the client complemented the tendering process with interviews in a bid to ensure that consultants had the right expertise to reach the energy objectives. The winning architect had a sub-consultant, a technical consultant, as energy coordinator. The energy coordinator had been last in ranking after the first qualification but was granted the project after the interview. The client was satisfied with the interview procedure and found the energy coordinator to be dynamic managing the whole consultant group through a creative process.

Figure 2: the actors of the project from design to operation



Early in the process a specialist from Sveby was contacted to join the consultant group. Initially he provided support as a discussion partner and held training. Later he gave direct input to specifications of requirements in the D&B tender and provided support for control, documentation, and inspection. In the end the Sveby consultant was also contracted to carry out the inspection as it was difficult to find somebody who could do this kind of inspection.

In the early calculations and in discussions with the consultants, the client understood that a higher energy goal than first defined could be reached without larger efforts: 50% instead of 75% of the national regulation. While the initial objective could have been reached by smaller adjustments to a conventional building, the new objective provided a positive challenge for all involved.

5.3. Design and build – contract and production

A direct consequence of the specific framework programme for energy objectives was that the energy performance must be part of the inspection of the building. Energy performance as a juridical part of a contract is not the normality in Swedish construction projects. Further, the D&B contract was designed with a penalty on the energy performance but without a reward, as public clients are not entitled to give rewards. The main contractor is also responsible to follow-up the energy performance during five years from the inspection. The penalty was defined as:

> *A penalty will be demanded at the 2-year inspection if objective of not increasing the energy use by 50% of the building regulation (55 kWh/m²/year) has been fulfilled.*
>
> *The contractor is given the opportunity to within 3 month from the 2-year inspection declare performed actions, if not a penalty is demanded as of 1 SEK (~0,10 €) per increase of 1 kWh/m²/year multiplied with 30 years (theoretical life time of the building).*

Because of the crisis on the construction market and the prestige to win the bid of this low-energy project, the client received offers that were lower than expected. He selected the lowest bid. The contractor engaged an engineering company to make the final design and had an employee from the technical department of their HQ as the energy coordinator.

The high energy performance required a very air-tight construction. This was a challenge for the contractor. The final tests show that they managed to construct one of the air-tightest buildings in Sweden and that the calculated energy demand was about 44 kWh/m²/year. The client credited the committed site manager of the main contractor for the good technical quality.

5.4. The building in operation

The buildings are operated by a local division of the SFA operation department, while the user is the Swedish Defence. SFA is also responsible for the monitoring of the buildings. The buildings are fitted with many measuring points, on each flow, and for example on each radiator. The buildings are monitored in real time. No changes can be made to the operation of the building without the agreement of both partners (client and main contractor).

During the delivery the contractor made a review of the systems and their operation with the operational personal. An optimization of the systems was also made at the delivery. All checklists and other documents were transferred from the contractor to the operation. Special instructions were written for the operation. Routines and a handbook were produced.

Early indications of energy use were very good but after the first year of operation a higher energy use was detected. This was partly due to the energy used the first year to dry out the concrete construction – and considered as normal. However, there are also indications that the building does not function optimally[3]. The client and the contractor have gone through the contract and revised all contractual temperatures and flows and calibrated the building. After that a new monitoring period was initiated. It will end in April 2014.

Despite the lack of information, there are some indications that the building has not been used as planned. Some additional energy use included after the completion of the building (e.g. operational electricity for a newly installed solar heating system) and erroneous use of the building (weapon cleaning machine being left on for longer periods of use) has been deduced from the total use. However, according to the contractor, the users have kept doors open to individual rooms thus interrupting the automatic presence regulation for temperatures and ventilation and changing the energy balance of the building. This possible malfunction of the system was predicted by the consultant group in the preliminary design. It seemed obvious that the users would keep their rooms open onto common areas as a means to increase social interaction. A system with automatic door closers was ruled out due to costs and a note was made that users were supposed to close the doors. This incident could point at a problem and solutions which are not inscribed in the preliminary design, not documented and not transferred to actors in later stages of the process and maybe not even made known to the client.

6 DISCUSSION AND PRACTICAL IMPLICATIONS

This paper raised two questions:

1/ Did energy and sustainability objectives modify the relationships between the actors of a building project?

2/ How successful is this move toward energy performance?

In France, architects are not engineers by training. Those with an engineering background represent the minority. Consequently, the move towards energy efficiency mainly benefited to design offices that are staffed with engineers specialised in thermal simulations. However, in public procurement, the architect is still at the head of the design team and in charge of coordinating the construction project. Thus, the power of the architect is still strong despite the increasing role of the design office.

In the Swedish case, the architect did not have any specialist knowledge in low energy building (some architect consultancies have that competence in-house). As the energy programme was set before all other documents, the energy coordinator had the key role during the preliminary design and in directing the team of consultants although not officially being the main consultant. The architect was then given a sub-ordered role and in the D&B phase no architect was involved. The architect has a weakened role in the Swedish construction industry and this case might point to an evolution in which the strong energy focus leads to an even weaker role for architects. The weak role of the architect seems to be accentuated by the increasing use of D&B contracts. It is interesting to note the sub ordered role of the architect in the Swedish project despite that the public client, SFA has an explicit Governmental directive to work for achieving national

[3] At this point it is not clear why and due to the penalty mechanism, no detailed information can be given.

objectives for architecture and design. SFA are satisfied with the result of the project and find no contradiction between architecture and low energy construction while the architect is disappointed with the final expression of the building.

In the French case, neither the operator, nor the users were involved at the design stage. The power appears to be still in the hand of the design and construction team while the performance of the buildings on the long run relies mainly on the competencies of the operator and the behaviour of the users.

In the Swedish case, it seems that the role of the contractor was reinforced since he has to monitor the energy performance during the five years following the inspection. Like in France, the behaviours of the users were not fully integrated at the design stage. However, the operator was more involved during design and build. As shown by figures 1 and 2, stages overlap in Sweden while stages are separated in France. In the French case, this inability to integrate the operator and the users upstream partly explains why the expected energy performance is not reached despite a building with good intrinsic performance (the airtightness is much higher than in most buildings because the actors modified their practices at the design and build phases). There was also a lack of commissioning. Most clients, such as the Ministry of Ecology, Housing and Transport, are not aware of the advantage of this systematic process assuring that a building performs in accordance with the design intent and the user's operational needs. Thus, they are not ready to pay for this activity.

Similarly in Sweden, the complexity of the projects and the inability of the actors to integrate the behaviour of the users at the design stage explain a higher energy use than expected. However, the performance-based contract provides strong incentives to find solutions in order to reach the energy target established at the design stage.

7 CONCLUSION

Both cases are examples of new national ambitions regarding energy performance. They also illustrate a shift of power within the project team. Architects are at the head of the design team in both cases. However, engineers specialised in energy performance become relatively more powerful with new objectives and regulations focusing on energy efficiency in buildings.

Despite progress in low energy design and airtightness of buildings, there is still a gap between theoretical and real energy performance. There are on-going investigations in different groups nationally looking into the calculation methods to try to understand these errors. This gap appeared to be due to the difficulties to integrate occupants' behaviour and the performance in use of equipment.

The cases could also be examples of a rebound effect where the user behaviour challenges the technical and theoretical energy performance. This could point to a risk in making a building into a one-issue task – to reach a good energy performance – and thus neglecting other functions of a building which in the end might contribute to the failure of the energy objectives.

One of the limits of the research is linked to the case study approach which has limited the analysis to two stories. Moreover, the feedback is still very short. One year of operation is too restricted to make definitive conclusions. Indeed, after delivery it usually takes the operator about two years to learn how to optimise the building according to the behaviour of the users. Similarly, users need time to take over their building interior. Thus, more research is necessary in this field. More data on building in operation also needs to be gathered.

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