



Collaboration Models for Industrialised Renovation – Opportunities, Barriers and Risks

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Abstract

Facing the renovation demands of buildings constructed in the post-war period more efficient renovation methods are urgently needed. *The vision of the FP7 project E2ReBuild (2011-2014) is to transform the retrofitting construction sector from the current craft and resource based construction into an innovative, energy-efficient industrialised sector* [www.e2rebuild.eu].

The E2ReBuild project showed that a frictionless process chain and smooth workflow that is needed for industrialised renovation methods strongly depend on efficient collaboration among the involved actors. The seven E2ReBuild demo projects served as a source for the analysis and evaluation of applied processes and collaboration models. The analysis included two basic models: The *Design-Bid-Build* and the *Design-Build* model. In addition to five minor variations of these basic models, another two modified models were applied: The *Partnering Contracting* and a kind of *Main Contractor* model. The choice of the model depended on the policy and company structure of the owner and was determined by public procurement regulations and the common ways of building renovation. In every single model applied the stakeholders and actors struggled to achieve smooth and frictionless work flows and the fact that the teams were set-up by public tender did not necessarily promote the best-possible team set-up as far as skills and capabilities were concerned.

Workflow, optimization and the implementation strongly depended on:

- The quality of the collaboration amongst the involved actors and stakeholders. Inefficient coordination and communication, an unfavourable combination of team-members and poor know-how transfer between the individual phases led to unsatisfying results in terms of time, costs and quality.
- The communication management towards tenants. Well-informed tenants tolerated disturbances and accepted worse conditions much better and demanded fewer compensation measures. Their acceptance supported smooth work progress on-site. Especially “occupancy during renovation” is a challenge for all actors involved, On the other hand monetary compensation or relocation-measures could be saved if tenants remained in their apartments.

Summing up the experiences of all E2ReBuild demo projects, the application of industrialised renovation methods and prefabrication resulted in shorter renovation times on-site but the success

depended on a careful and serious planning, coordination and scheduling during the planning phase. Underestimated planning time led to failures and delays and significantly influenced workflow on-site.

Keywords: Energy-efficiency; Building Renovation; Industrialization; Prefabrication; Collaboration;

Introduction

Current renovation methods do not correspond with the renovation needs of buildings constructed between 1945 and 1980. The common way of renovation is based on crafts-oriented processes with high personal efforts. The traditionally chosen methods mostly offer only small and hardly predictable optimisation potential due to quality, costs and time. Facing the options given by industrialised methods and prefabrication there is a big potential for the application of innovative technologies in renovation. These methods are based on optimised technology use, such as highly insulated building envelopes free from any thermal bridge, highest airtightness and additionally integrated components for ventilation or energy generation. Therefore, the renovation result is beyond current standards in terms of energy efficiency, costs and time and meets all passive house standards. In various European countries first frontrunner projects using industrialised renovation methods have already been realised, but there is still further need for the implementation into more projects.

However, current collaboration models are not sufficient for industrialised renovation methods and prefabrication. While the technology has constantly been developed collaboration models, planning routines and process chains have yet to be changed. First feedbacks from demo projects showed inefficient communication, coordination and misunderstandings, which resulted in cost overruns, delays within on-site works, failures within component development and finally in a poorer implementation quality.

Objectives

Industrialised methods and prefabrication enable high quality, efficient building renovation in terms of energy, costs and time while providing added values for all stakeholders. The E2ReBuild project studied the role of collaboration models in practical implementation in order to facilitate their marketability. The analysis of different applied collaboration models aimed at the identification of causal motifs, related causes and different impacts related to industrialised renovation methods. Barriers and risks within collaboration blocking industrialized processes and prefabrication methods were to be identified. Finally, successful collaboration patterns amongst all involved actors and stakeholders facilitate industrialized renovation methods and prefabrication and should contribute to modify the common way of building renovation today.

Definitions

“A collaboration model describes coordinated and cooperative processes that enable an entire project team with all involved actors and stakeholders to achieve target-oriented concerted actions for the common goal of successful building renovation with industrialized methods and/ or prefabricated components. The structure of communication channels with defined interfaces and the definition of

clear responsibilities, rights and obligations are crucial for smooth process chains and successful collaboration". [Geier 2012]

In this definition of collaboration models developed in the E2ReBuild project any organizational and functional model approaches go far beyond common business models or process management.

Methods

Within the FP7 project E2ReBuild (2011-2014) seven demo projects in Europe were used to develop and test technologies, processes and models for an innovative, energy-efficient industrialised building renovation. The experiences gained during the planning and implementation served as a source to set up and evaluate new perspectives that have not yet been described in literature. A dialogue between researchers and practitioners by means of questionnaires, interviews, stakeholder discussion panels and site-visits enabled an analysis and enhanced a better understanding of motives and causal relations.



Figure 1: E2ReBuild demo project Augsburg, Germany. Pictures show the building before, during and after renovation. Pictures: Frank Lattke.



Figure 2: E2ReBuild demo project Roosendaal, The Netherlands. Pictures show one of the buildings rows before, during and after renovation. Pictures: Trecodome/ HSLU



Figure 3: E2ReBuild demo project Munich, Germany. Pictures show the building before and after renovation. Pictures: Kaufmann.Lichtblau.Architekten./ SP

The study was conducted in two steps:

- In a first step two graphical representations were developed. The collaboration chart (Figure 4-7) shows the composition of the teams by displaying actors and their roles in the project. Different colours refer to groups of actors such as owners, designers, contractors, authorities, residents and neighbours. The action line diagram (Figure 10-11) shows the sequence of the entire planning, construction and operation phase. All collaboration models applied in the E2ReBuild project were aligned with this sequence.
- In a second step, the different collaboration approaches and process chains were analysed, compared and evaluated.

Findings

The analysis and comparison of the applied collaboration models showed that they were very inhomogeneous, concerning the various actors involved, their interfaces and their roles. Each project told its own story. However, the evaluation identified typical representative features and patterns that were generally relevant for the context of industrialised renovation methods.

Collaboration models

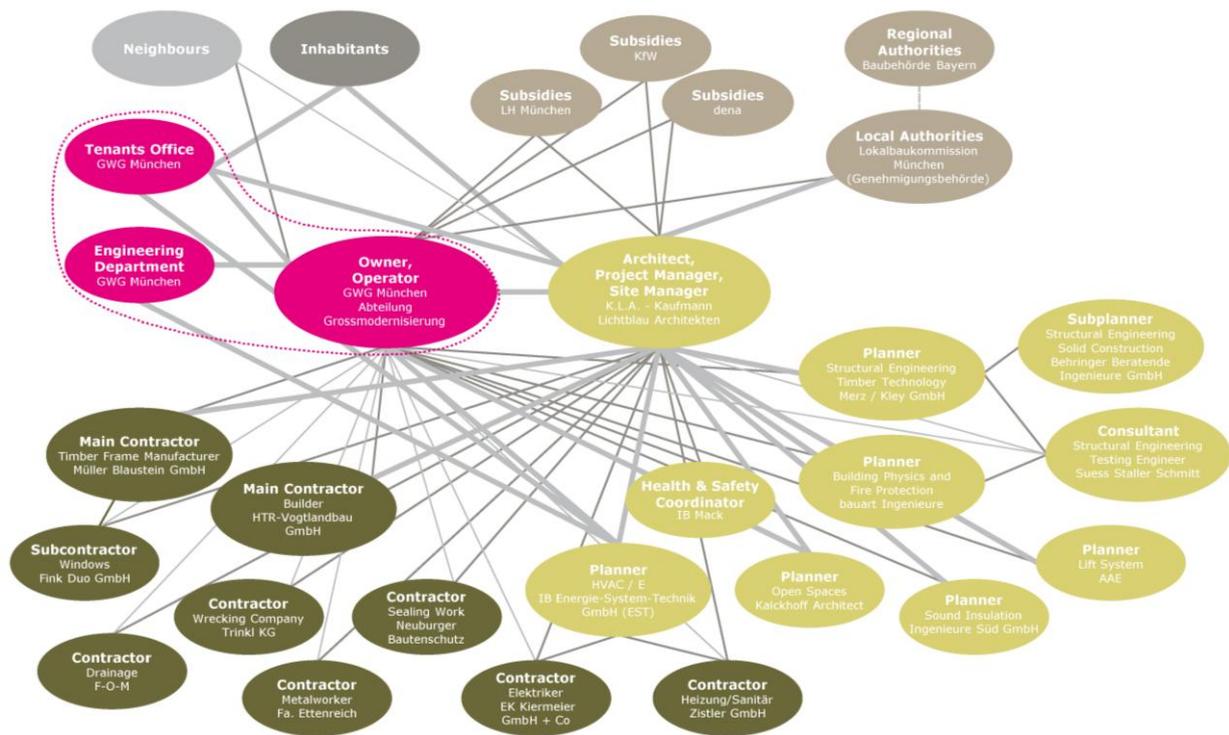


Figure 4: Collaboration chart. A *Design-Bid-Build* model, applied in the demo project Munich, Germany. [Geier, 2012] p. 17.

Within the E2ReBuild demon projects two basic collaboration models were applied which differ in their project delivery methods:

- The *Design-Bid-Build* model, applied in both German demo projects – Augsburg and Munich, and in The Netherlands and in France.
- The *Design-Build* model, applied in Great Britain, Finland and Sweden.

They differ in the delivery of planning and construction: In the *Design-Build* model both planning and construction were realized by one *Total Contractor*, who was responsible for the delivery of the entire package of building renovation. This model privileged big building companies, who were able to offer the entire package due to individual internal departments for planning, engineering and construction; but they were also able to commission subcontractors for further works. In contrary, in the *Design-Bid-Build* model planning and construction were delivered by different actors. First of all the design and planning team was designated in an early project phase. Through a subsequent tender process (“Bid”) individual professions were appointed based on detailed tender specifications.

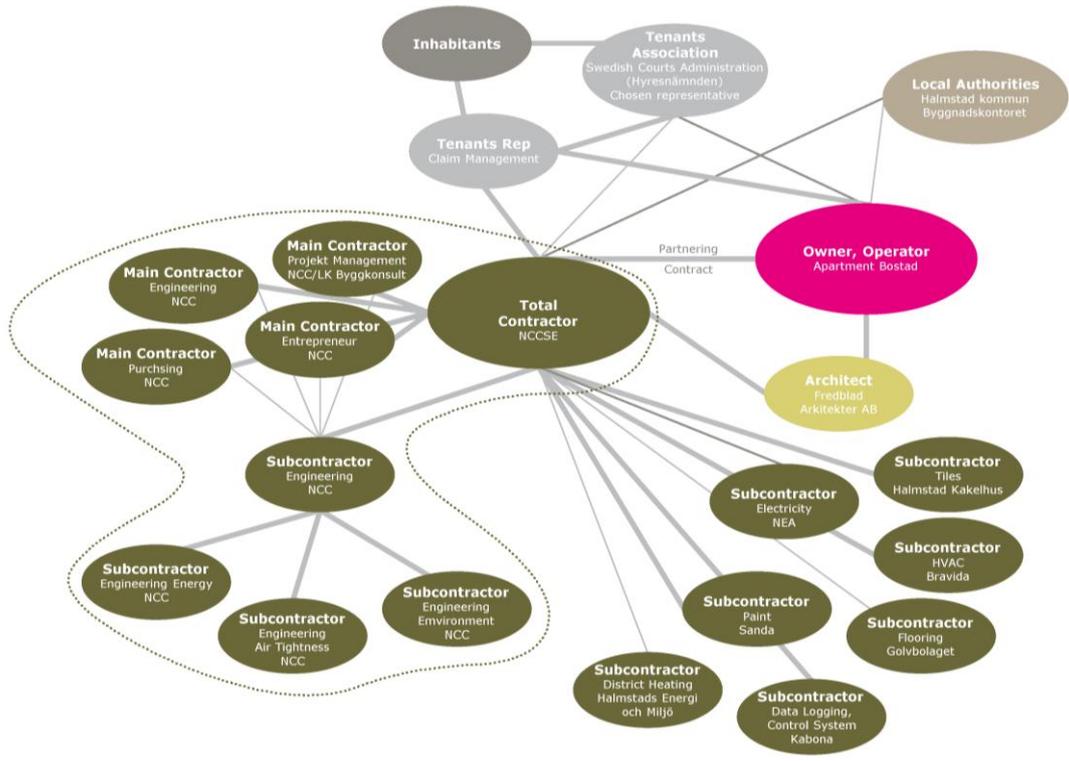


Figure 5: Collaboration chart. A *Design-Build* model following the so-called *Partnering Contracting*, applied in the demo project Halmstad, Sweden. [Geier, 2012] p. 25.

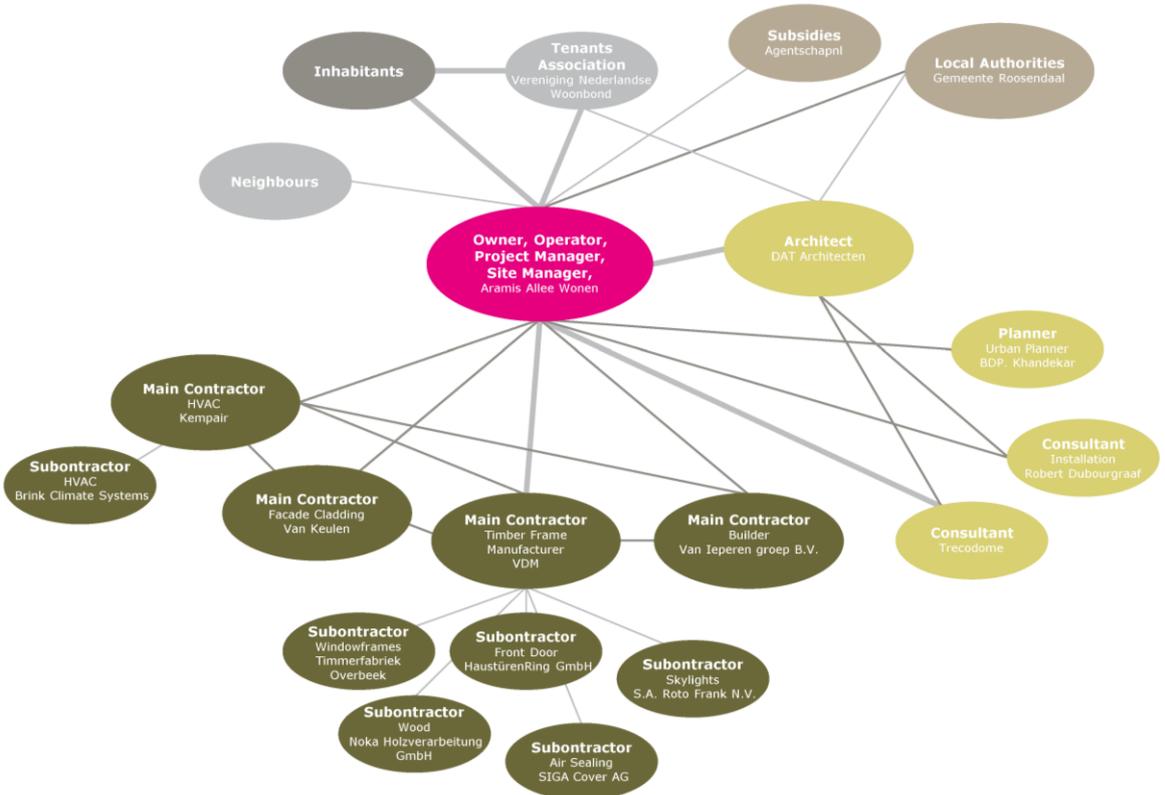


Figure 6: Collaboration chart. A *Design-Bid-Build* model where the four *Main Contractors* acted as a team, applied in the demo project Roosendaal, The Netherlands. [Geier 2012] p. 37.

Beside slight differences concerning specifics in project, ownership and country, two collaboration models with major modifications were applied for the first time:

- The *Partnering Contracting*
- A special kind of a *Main Contractor* model

The *Partnering Contracting* was applied in the Halmstad demo (Sweden, Figure 5). Based on the *Design-Build* model the owner and the *Total Contractor* acted as partners and jointly developed the renovation package. However, the client made the final decision regarding the renovation package. Nevertheless, the entire responsibility was transferred to the *Total Contractor* and risk and success were shared on a 50:50 basis. But the *Total Contractor* guaranteed savings of energy consumption for heating and DHW within the first two years.

The *Design-Bid-Build* model was applied in the Roosendaal demo (The Netherlands, Figure 6) but the housing association committed the four *Main Contractors* (HVAC, external façade cladding, timber manufacturer and builder) to collaborate as a team. Informally, the builder was in charge of the coordination, but no further formal rules or sanctions for any failure in coordination were given. This model was chosen to avoid higher costs for *Main* or *Total Contractors* and to develop the know-how for prefabrication in the Netherlands.

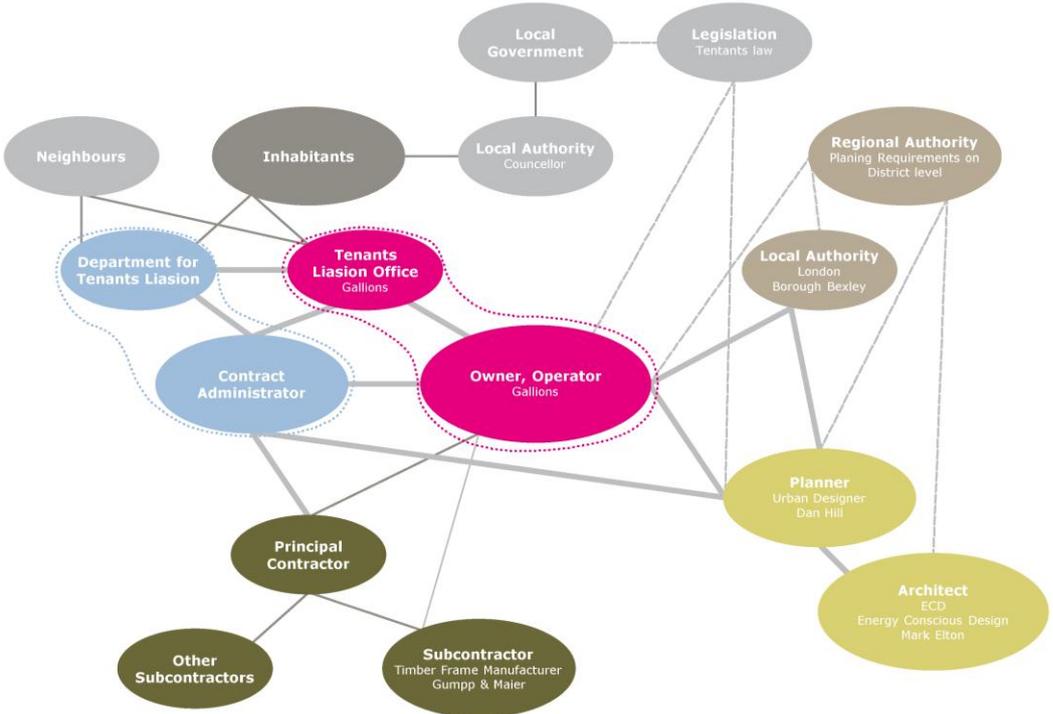


Figure 7: Collaboration chart. A *Design-Build* model where the *Contract Administrator* established and supervised the compliance with contractual and legal conditions, applied in the demo project London, UK. [Geier, 2012] p. 42.

Summing up the experiences of the E2ReBuild demo projects, the choice of the collaboration model was based on the policy and structure of the building owner and influenced by the legal framework conditions such as procurement requirements or building legislation. But the model itself did not influence the implementation of industrialised renovation methods as strong as communication management and frictionless knowledge chains.

Communication and claim management

The building owners interviewed in the E2ReBuild project emphasised the importance of the communication with tenants. However, following his own policy, everyone had a different approach to handle it. Some took over the responsibility for their tenants and handled communication and claim management themselves (such as Munich, Figure 4). In other projects responsibilities and risks were transferred to the *Total Contractors* who also handled communication and claim management (such as Halmstad, Figure 5). The demo in London (Figure 7) followed the *Design-Build* model, where the owner was very active in informing the tenants, when he needed the tenants' and neighbours' agreement for renovation in the *True Design Phase*¹. The effort to establish a project team was kept very low within this first phase, because in case of failure the project would have come to an end. Hence, a directly assigned urban designer (consultant) developed the building design in close cooperation with the city.

Formal tenant meetings were useful for initial information but experience in the E2ReBuild projects showed low participation (for example Voiron stated that only about 10-15% of residents attended such a meeting). The issue was not so much rejection but ignorance (people are used to their situation and do not like changes) or fear (of infeasible rent increase and eviction). In contrary, communication strategies on a personal level were more successful. For example, the “weekly open desk” in Voiron ([Geier 2012] p. 32) turned out to be a meeting point for residents to overcome the anonymity and to contribute to an atmosphere of trust ([Geier 2012] p. 52). Beside personal and formal communication activities, a lot of information was exchanged through informal channels. Especially residents in bigger residential areas shared both good and bad experiences in their daily chatter on the street, at the bakery or grocer, etc. In order to avoid this gossip among residents the owner of the demo in London aimed at informing all residents simultaneously, preferably on a personal level face to face. However, a good word of mouth helped the owner in Augsburg to promote renovation measures in subsequent building renovations – residents had already heard from their neighbours about procedures and experiences.

Summing up the E2ReBuild experiences, residents tolerated disturbances and worse conditions more and raised fewer claims if they felt well informed, taken seriously and as part of the decision and renovation process. Hence, fewer compensation measures were necessary and work on-site was less interfered. A good word of mouth was the best promotion campaign for the renovation.

Knowledge chains

In the E2ReBuild project some experienced architects and designers already had a profound knowledge, but generally the level of knowledge and experience was rather little. Knowledge sharing was important in order to promote joint development from the beginning. In most cases manufacturers were involved in early stages in order to guarantee proper design. In some cases, their know-how was essential to develop tender specifications. However, if public procurement was necessary, it led to a change of manufacturers and required a significant re-design after the tender due to changed manufacturing methods. This change of actors influenced the overall renovation

¹ In Great Britain two steps are necessary to grant building permission: A “*Planning Permission*” aims at the compliance with legal requirements and regulations without any technical specification (“*True Design Phase*”). The “*Building Regulation Approval*” aims to achieve a properly constructed building the construction fit for purpose.

schedule, increased the effort for the owner and planning team and partially (or once entirely) changed the already developed renovation solution.

Moreover, owners focused on the communication with tenants, while efficient communication among professionals as a tool for mutual know-how exchange was underestimated. Communication was very important concerning efficient joint development and reduction of time and costs. One-sided communication or the total lack of communication - especially within unequal partners - led to incomplete information within the project team. This resulted in failures at interfaces between project phases, alterations of planned elements, delays in subsequent project stages and finally in minor implementation quality. Interruptions in the knowledge chain were responsible for inefficient process chains, as well as a change of actors or insufficient communication.

Opportunities

Upgrading entire city districts

The feedback from the E2ReBuild demo projects showed the advantages of renovation perspectives on portfolio or district level. Industrialised methods and prefabrication needed a certain initial effort in design and planning, logistics, establishment of routines, etc. Hence, a certain project size contributes to the economic viability of the applied technology.



Figure 8: Residential area De Kroeven, demo Roosendaal, The Netherlands.
Picture: Trecodome



Figure 9: Residential area in Sendling, demo Munich, Germany.
Picture: Kaufmann.Lichtblau.Architekten

A close collaboration with the city or single city departments provided opportunities for additional investments (for example in the infrastructure and external spaces in Roosendaal). Renovation plans on district level and the integration of the city into the project enhanced the development of social stability in certain city districts and helped to avoid a social downgrading of that area.

Occupied building sites

A relocation of residents allowed generally a more in-depth renovation. For example, the demo in Munich reshaped the inner apartment layout completely, only the initial structure was kept. On the one hand, the flooring and the entire building services were renewed and new ventilation installed. These were measures that significantly improved the building value in terms of living quality, energy efficiency and building physics. On the other hand, the opportunity to allow residents to remain in

their apartments during the construction work was a big advantage for the demos in Halmstad, Voiron, Augsburg, Roosendaal and London. All profited from the reduced costs and lower risks that residents would not move back, Roosendaal and London saved pay-offs for the residents. However, staying in the apartments during renovation was a huge burden for residents. Provisional cooking and sanitary facilities, workers in front of or in the apartments at any time, a lot of dust and dirt, reduced or no access to elevators or staircases – the list of disturbances was long. Despite the stressful situation, the residents honoured this way of renovation as “worthwhile” ([Geier 2012] p. 55) and recommended it to neighbours in the district. The owner of the Augsburg demo expressed the secret of success. *“It is necessary to provide the information on what to expect truly and without ‘sugar-coating’ to the residents”* ([Geier 2012] p.55). In addition, it has to be considered that the entire team has to react to this situation and has to use (and not only intend to use) efficient and appropriate communication methods.

Easier liability handling

Today multiple areas of responsibilities cause a series of uncertainties about liability issues at interfaces between components such as windows and walls, roof and walls, roof and doors. The timespan for liability varies among different countries and national framework conditions. A commission combined with a final on-site inspection helps to identify remaining work or failures. Subsequently various warranty frameworks should protect the owner from undetected malfunctions or failures. In France, for example, there is a three-step approach: Within the first year the contractor is fully liable (“well-done work”). Within two years after completion, the contractor is only liable for technical equipment and the insurance company with external experts has to be informed and the correction work becomes more difficult for the owner. 10 years after completion the contractor is only liable for failures at the primary structure.

Summing up the E2ReBuild interviews, owners expressed their hope that large-scale prefabricated components would reduce interfaces and facilitate liability handling. They expect a high quality result and in case of failures an easy allocation of responsibility and prompt and satisfying corrective action. Hence reducing interfaces or responsibilities by industrialised methods and prefabrication could facilitate liability issues.

Barriers and risks

In the E2ReBuild project three main barriers and risks were identified: Know-how losses at interfaces, limited cooperation possibilities and inefficient time management.

Know-how losses

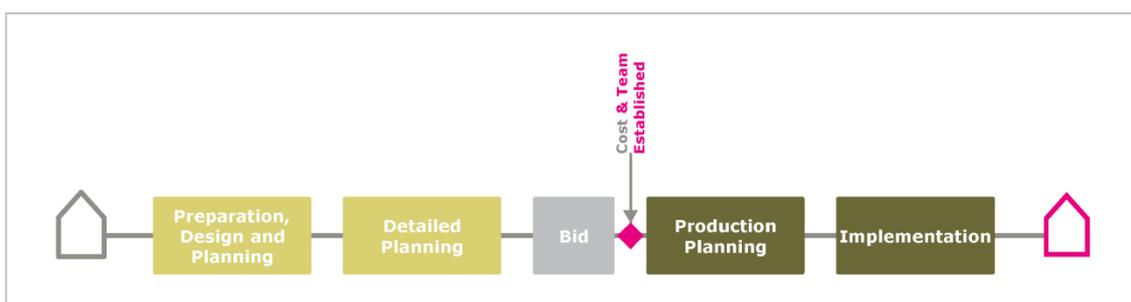


Figure 10: Simplified action line diagram. A *Design-Bid-Build* process following the common way of renovation process. The project team was established after the tender (“Bid”). The manufacturer is not able to influence design and planning in order to optimize the solution. [Geier, 2012] p.45.

Know-how losses and frictions within the process chain appeared at interfaces, especially between the planning phase and the production planning of the manufacturer. If there was a cut or gap between the design and construction team or if actors were exchanged, know-how got lost, a re-design became necessary and a lot of planning had to be redone. Thus, the full potential of industrialised methods could not be exploited. Some of the stakeholders of the E2ReBuild demos had to go the common way of tender and public procurement (Figure 10), which limited options for designers, planners and contractors to work together in early planning stages.

Limited cooperation possibilities

The E2ReBuild demos showed limited options to realise joint development and optimization until a team consisting of all relevant actors was finally established. Figure 10 shows the point of time when the team was set-up. In most cases this was too late. As design and planning have already been finalised, the detailed planning has been finished as well. In order to optimise or adapt prefabricated modules to the manufacturing set-up and facilities changes were necessary before production planning and led to significant changes. In one demo project an entire re-design after the appointment of the manufacturer was necessary.

Inefficient time management

Today, industrialised renovation methods and prefabrication indicate efficient and frictionless workflows that save time. However, this is only true for renovation times on-site. No demo project in the E2ReBuild project was able to reduce the entire renovation time. On the one hand, a lot of development work had to be done and a lot of barriers such as lacking know-how and experience had to be overcome. On the other hand, the complex nature of industrialised renovation methods or prefabrication required intensive preparation, planning and coordination phases. In reality there was a shift in time, phase and priority: The better the preparation and planning was, the shorter the work on-site. Feedback from the demos showed that the planning phase must not be under-estimated. In-depth coordination among structural engineers, prefabrication manufacturer and energy planners were crucial for the quality of planning and implementation: Beside the aesthetical and technical design, the development of 3D nodes, the approach of airtightness targets or the elimination of thermal bridges needed adequate attention.

Conclusions

The implementation of industrialised methods and prefabrication within the E2ReBuild project showed that stakeholders and actors struggled to achieve smooth and frictionless workflows, efficient in time and cost, no matter what model they chose. Furthermore, impacts were related to a very active driving force - the owner, the architect or the *Total Contractor*. However, the set-up of teams by public tender processes did not promote optimised team-building according to skills and capabilities. In the *Design-Build* models, the set-up of a team with subcontractors in relevant fields, under the pressure of keeping costs low led to insufficient information management in the project team.

It was obvious that smooth workflows, efficient in terms of quality, time and costs, depended strongly on the quality of the collaboration amongst the involved actors and stakeholders. Inefficient coordination and communication, missing know-how transfer between the planning and construction phase and underestimated team set-up led to unsatisfying results in terms of time, costs and quality.

An earlier set-up of the team or the integration of engineers and the manufacturer in earlier planning stages would help to solve the problem. Basically, the cooperation of planners and contractors in early stages is given but law excludes these contractors from participating in the subsequent tender [EU 2004] and thus discourages prospective planners and contractors to cooperate before official tender. Today, legal requirements and the common ways of building renovation makes it difficult to combine know-how and actors of planning and construction phase together.

The E2ReBuild project showed two options for the future of industrialised renovation methods and prefabrication:

- Tendering must be done at an earlier stage, i.e. before detailed planning or designing of modules has started. However, this option of tendering does not guarantee a team set-up according to know-how, skills and manufacturing capabilities.
- Design and construction consortiums must be encouraged to offer and realise design and implementation of renovation solutions as a team. Even if this makes detailed specifications for tender impossible, it provides room for different solution approaches and negotiations. Current functional descriptions for tender show an option for its realisation but further development is necessary. In future, such a project would be tendered at an earlier stage and different consortiums may compete with different (tailor-made) solution approaches (Figure 11) offered to the client.

Today, both options lack the legal background and the acceptance of clients and contractors. The lack of legal background could be overcome – the example of the “Bauteam Mainz Großberg” ([AK Baden-Württemberg 2010], p. 75-125), addressed so-called “Competition Consortia” of design and construction teams within public tender.

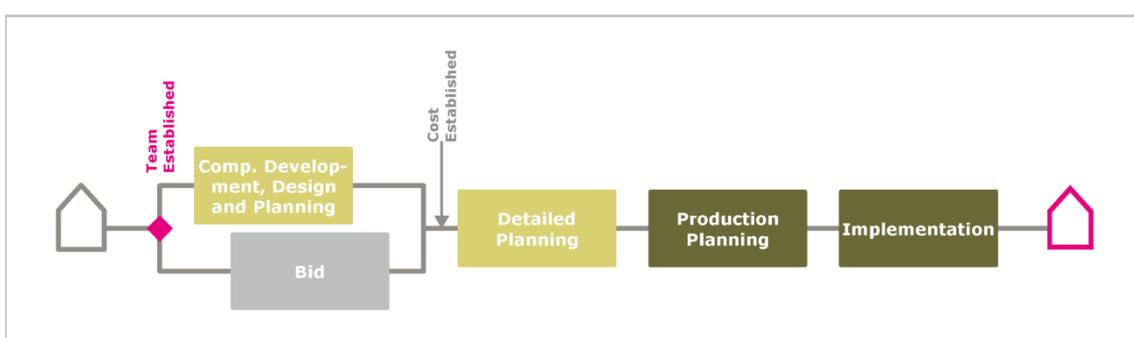


Figure 11: Simplified action line diagram. A *Team* model. The project team is established before the planning starts. [Geier, 2012]

As a feedback from the E2ReBuild projects, it can be stated that teams or partners working together effectively (in early stages and later on) enabled joint development and therefore industrialised methods and prefabrication. Successful patterns were identified with the involvement of a key actor as coordinator, who made all loose ends meet.

Further-on the focus was on the awareness for design and planning quality. The E2ReBuild project showed: the better the design and planning phases, the shorter the building time. Hence, the complexity of industrialised methods and prefabrication needed a shift in time, phase and priority. A better coordination of planning activities and scheduling of subsequent workflows promoted reliability of renovation time and costs.

In future a clearly empowered “project coordinator” should lead the project team. There is no need for a further role. Moreover, the definition of responsibilities and the empowerment to act appropriately are important.

As the E2ReBuild project showed, there are many future challenges and many gaps from legislation that have to be filled in. At the beginning of the E2ReBuild project all demo building owners were encouraged to try new models and methods from the technological and the organisational point of view. During demo projects, leaving traditional paths and experiencing new ways meant to overcome various obstacles during planning and implementation. Now the involved designers and contractors look forward to using the experienced methods, technologies and processes further-on. Parallel to all demo project stakeholders became aware of the replication potential within the processes and the advantages of collaboration. Despite a lot of setbacks and challenges, each of them stated a big *replication* potential of the applied models and processes, within the same district, area or portfolio.

Further information

This paper reports the opportunities, barriers and risks identified and evaluated within the Work Package “Innovation in Planning and Design” in the E2ReBuild project. Further aspects are shown in the paper “Collaboration Models for Industrialised Renovation – Experiences on legal and organizational frame conditions” [Geier 2013]. The detailed report “Evaluation of Collaboration Models” [Geier 2012] is available at the E2ReBuild website: www.e2rebuild.eu

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