

A Theoretical Framework of Sustainable Housing Renovation ---a system perspective and innovation approach

(Draft)

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1. Introduction

In recent years, housing renovation has become an urgent issue for the economic, social, and environmental sustainability of the Swedish society. The Swedish housing stock represents a considerable share of the country's capital stock and more than a third of the dwellings in Sweden are rental apartments (Statistics Sweden, 2016). At the same time, a large share of the existing stock of rental housing, such as the houses constructed during the Million Programme in the 1960s and 1970s, has now reached an age at which considerable renovation is needed. Renovation is a common concern both to owners/landlords and tenants and to society at large. The National Board of Housing, Building and Planning estimates the total cost at somewhere between 300 and 500 billion SEK (Boverket 2016). More importantly, besides of the high economic costs, the implementation of these renovations will have a long-term impact on the Swedish society and built environment at the same time. Therefore, renovation processes of rental housing are of great importance to the sustainable urban development in Sweden.

One of the greatest challenges to rental housing renovation, and the main focus of this paper, is how to address the two challenges of the conflicting sustainability-goals and the conflicting stakeholder-interests. First, the sustainability goals, as framed as the three-bottom-line (TBL) for sustainable development (Elkington 1994), are compatible in some circumstances. For example, reducing waste of construction material can reduce environmental impact and economic cost at the same time. However, in other situations these goals are conflicting. For example, the installation of electrochromic smart window glass will let in beams of sunlight in winter and block some of the sun radiation in summer thus saving energy without sacrificing indoor comfortableness. Unfortunately, such renovation will almost certainly increase the rent and consequently exclude the economically disadvantaged population, such as the single-parent families and the pensioners. Hence, environmental sustainability is in conflict with social sustainability. The possible conflicts between economic, environmental and social goals may fundamentally undermine the potential of sustainable urban development. Second, besides of the potential conflicts among the three aspects of sustainability goals, the complex relation among the different stakeholders' interests makes housing renovation more challenging. A renovation project involves a wide range of stakeholders, such as the owner/landlord, the tenants, the communities, the contractors, the government regulatory bodies, and so on so forth. They are interest groups with different preferences and priorities. The widely-discussed landlord-tenant dilemma (IEA 2007, Astmarsson et al. 2013) is a good example of such conflicts of stakeholder interest. For example, if the tenant bears the cost of heating and electricity, the landlord has not much incentive to invest in energy efficiency while the tenants want to lower the electricity bill. When the payer is not the direct beneficiary there occurs a dilemma of split incentives. Hence, in

this case, the economic benefit of the real estate company is in conflict with the economic benefit of the tenants.

We realise, of course, that such conflicts are not completely avoidable. What we can do is to reduce the conflicts and to expand the shared parts so as to create a healthier balance between conflicting goals and interests. However, conventional way of renovation cannot offer a solution. We need innovation. In this paper, we suggest a system perspective and innovation approach as one way forward.

Two points of departure of this paper are innovation and system thinking.

First, in order to analyse and understand the complexity of housing renovation process we apply an approach of *system thinking*. System thinking takes things as interrelated and interdependent parts---a system, in which the change of one parts affects other parts as well as the whole system. The outcome of a system does not depend on a single actor's effort and performance but the interaction of all the actors' actions and outputs. The actors do not act in a vacuum space but a systematic environment where rules and norms apply. Housing renovation is not only a set of technical activities conducted by a real estate company and their sub-contractors. It is a set of complicated social interactions among a wide range of heterogeneous stakeholders with enormous resources involved and complex rules applied. It runs the risk of overlooking some goals, particularly the long-term ones or the ones that are undertaken by economically and socially disadvantaged groups. The challenges of conflicting-sustainability-goals and conflicting-stakeholder-interests are system challenges rather than challenges only about technology or challenges only to a single organisation. Therefore, we claim that there is a need for a system framework that can be used to understand, evaluate and guide the renovation processes toward sustainability.

Second, tackling the conflicting-sustainability-goals and conflicting-stakeholder-interest problem in housing renovation calls for new ways of thinking and new ways of managing. Thus *innovation* is needed. Addressing any of these two conflicts is not an easy task, say nothing to the situation when the two types of conflicts intertwist. To address the double challenges of conflicting-sustainability-goals and the conflicting-stakeholder-interest requires new processes of doing things, not only the engineering process of renovation per se but also the companies' management process and the government's administrative process. It requires new technologies and materials, not only for the building but also for connecting and engaging people. It requires new organisational design for coordination not only within the real estate company but also within the whole system that is involved. It requires new legislation for not only environment protection but also social integration. This paper will focus more on the organisational innovation.

Nevertheless, in the area of sustainability research, there is generally a lack of guidance by models and frameworks (Stirman 2012). Identifying models or frameworks for specific sustainability challenges is highly encouraged in the sustainability research community. The conventional project management tools, focusing on time, quality, and cost, do not offer effective measures to address the system challenge of conflicting-sustainable-goals and conflicting-stakeholder-interests. In the paper, we apply instead a broad system perspective on these complex relations and introduce a theoretical framework of housing renovation and innovation as a way to approach them.

The contribution of our theoretical framework is threefold: first, it adopts a system perspective combining the project processes, the sustainability goals, the stakeholders and the institutional

environment for understanding sustainable housing renovation. Second, it introduces an innovation approach to housing renovation for better addressing the challenges of conflicting sustainability-goals and conflicting stakeholder-interests. Third, the paper generates analytical tools and management implications to create and enhance innovation for sustainable housing renovation. The Swedish real estate industry is currently going through considerable structural change as a result of both fast market growth, rapid technological changes and increasing knowledge intensity of the production. In this transitional phase, the prerequisites are particularly favourable for our paper to contribute to new knowledge and better understanding for innovation and sustainability in real estate industry.

The paper consists of eight sections. The following section 2 defines sustainable housing renovation based on the discussion about the existing concepts and models of sustainability, as well as a discussion on the concept of housing renovations. Section 3 defines and elaborate the system of sustainable housing renovation. Section 4 identifies the key challenges in sustainable housing renovation. Section 5 introduces innovation as an approach to tackle the challenge. Section 6 summarise our theoretical framework toward sustainable housing renovation from a system perspective and with an innovation approach. Section 7 discussed several related issues of the application of the theoretical framework. Section 8 concludes the paper.

2. Defining sustainable housing renovation

Housing renovations can be seen as a spectrum of different types of measures, ranging from relatively simple replacement of surface materials to fundamentally changing both interior and exterior aspects of the house. There are also a number of different concepts used synonymously or in similar meanings, such as refurbishments, restoration or retrofitting. We will use the term renovations for describing relatively extensive changes of a building mainly used for housing. Housing can, compared to other types of buildings, be considered more complex since it affects people at a very personal level. Major renovations may result in tenants having to move out of the buildings for longer periods of times, which can be challenging especially in areas where there is a housing shortage. Technologically, buildings used for housing also need to suit quite demanding needs since people tend to spend a large part of the day. Renovation processes are a complicated complex. Comparing of the recognition of economic and technical values of renovation, there is a risk of underestimating architectural, cultural, and social values in housing renovation. Renovation should be considered a service-minded process rather than a merely technical one as often is the case in new construction (Thuvander, Femenías, Mjörnell, & Meiling, 2012).

Understanding sustainability as a multi-dimensional construct

Sustainability is a multi-dimensional construct. First, it is a multi-scale concept that can be applied on the organisational level, the industrial level and the societal level. Second, it is a multi-scope concept containing economic, environment and social aspects. Sustainability, as defined by both scholars (e.g. Hart and Milsten 2003) and international organisations (e.g. UN 1987), refers to the expectations of *improving the development performance of the present generation without compromising the ability of future generations to meet their needs*. The definition thus highlights the long-term aspects of present performance, economic as well as non-economic.

Due to its simplicity and universality, this definition has been widely used. Nevertheless, the definition does not offer any framework to monitoring the activities, generating new solutions,

and evaluating the performance of a company. It provides theoretical principles rather than practical guidelines. For understanding, e.g. how a real estate company can contribute to a sustainable urban development, the definition needs to be specified and operationalised into a theoretical framework to identify the content of activities, the criteria of evaluation and the direction in which to take action.

Using the TBL model as an evaluation framework and practical guideline for sustainability

The triple bottom line, also known as the TBL model (economic line, environmental line, social line) or 3Ps (profit, planet, people) model (Elkington 1994), is a sustainability-related framework for evaluating a company's performance (Goel 2010) as well as a practice guideline for sustainability (Roger and Hudson 2011). It goes beyond the conventional corporate evaluation criteria, such as profit and revenue---long-term to be economically sustainable --- by including measures concerning environmental and social impacts (Elkington 2004). Such impacts lie both inside and outside of the organisational boundary and they fundamentally affect the wider settings of the society in which the company operates and will operate. The TBL model has been widely and increasingly used as an accounting framework and practical guideline for not only companies but also NGOs and government agencies. The triple pillars are considered as three independent but interrelated goals of sustainability.

The *economic aspect* of the TBL model is related to the activities that are conducted, e.g. by a firm, in order to add economic value to the surrounding system (Elkington 1997) in which the organisation operates and grows. The economic sustainability of a firm is a precondition for the firm's support to the future generations by means of generating employment, training human resources, etc. A firm's economic goals of sustainability may well be about profitability, growth rate, economic efficiency, etc., but in order to contribute to economic sustainability the outcome must not compromise the ability of future generations to meet their needs.

The *environmental aspect* of the TBL model is related to the practices of a firm (or other actors) to reduce environmental impact and to create environmental benefit. The environmental sustainability of a firm is to ensure a liveable environment for the future generation. A firm's environmental goals of sustainability may be the goals about energy consumption, water efficiency, toxic waste prevention, etc. In terms of sustainable renovations, many previous studies focus on the environmental aspects such as reducing energy use (Ástmarsson et al., 2013; Hauge, Thomsen, & Löfström, 2013; Pombo, Rivela, & Neila, 2016)

The *social aspect* of the TBL model is related to the practices that are beneficial and fair to the workers in the company and to people in the community (Elkington 1997). The social sustainability of a firm, within the company as well as in the wider society, is an important part of the efforts of the whole society to promote social well-being, such as equality, justice, social capital, health, quality of life, within the company as well as in the wider society. A firm's social goals of sustainability can be the goals about culture heritage protection, fair access to resources, personal security, community integration, equality, democracy, health, etc..

Defining sustainability of housing renovation and sustainable housing renovation

Housing renovation is a crucial field for sustainability. On one hand, housing in general is quite special as a market commodity. Both in theory and in practice, housing markets differ in many respects from the textbook standard competitive market for homogeneous goods (e.g. Quigley 2002; O'Sullivan & Gibb 2006; Fallis 2014). Arnott presents a long list of 'peculiarities of housing as a good', with eleven entries: necessity; importance; durability; spatial fixity; indivisibility;

complexity and multidimensional heterogeneity; thinness of the market; non-convexities in production; importance of informational asymmetries; importance of transaction costs; and near-absence of relevant insurance and futures markets (Arnott 1987:960; cf. also Stahl 1985:3–13; Hårsman & Quigley 1991). The importance of the transaction and attachment costs in the housing market is put on edge in renovation processes where long-term ambitions of the estate owner and the municipality regarding a certain estate or housing block are confronted with the needs and preferences of sitting residents.

On the other hand, we may also expect a comparatively long-term perspective in the housing sector, where investments in estates and buildings typically have a life-time of 50 years or more. At least to serious professional landlords with a long-term perspective on their management, residents' responses to the renovation of their homes and neighbourhoods should represent an important post in the investment calculus. Thus, an efficient renovation process has to address society's ambition e.g. to build socially mixed and attractive cities as well as the need for a functioning dialogue between the company and the current and potential residents of the estate that is renovated. This would make economic, social and environmental sustainability a more complex issue in housing renovation than in many other fields of industry, but it would also motivate an expectation that matters of sustainability would be easier to integrate in the generally long-term perspective of housing construction and management.

Based on the existing definition of sustainability and the TBL model, we define sustainability of housing renovation, as the expectations of improving the outcomes of housing renovation for the present inhabitants without comprising the ability of future generations to meet their needs. Therefore, sustainable housing renovation is defined as housing renovation that simultaneously takes into consideration of economic, environmental and social aspect of long-term development.

3. Sustainable housing renovation as a system construct

In this paper, we construct sustainable housing renovation as a system with system characteristics manifested in 1) the triple goals of sustainability; 2) the complicated dynamic process and procedures established to carry out specific activities; 3) the wide participation and interaction of diverse stakeholders; and 4) the sophisticated institutional environment where various rules, regulations, and routines apply (see Figure 1).

The *goals* of sustainable housing renovation are the triple goals of sustainability, namely the economic, environmental and social goals. The economic goals for the firms involved are, for example, efficiency and required yield. For the tenant is the importance of economic sustainable condition of the rent. Environmental goals are energy consumption, water consumptions and waste management, but also material and transportation of materials used during the renovations. Social goals could be to preserve cultural heritage, integration of tenants, safety and democracy. Noticeably, these goals need to be seen from a holistic perspective and from the perspective of the different stakeholders involved. Sometimes the goals are compatible and sometimes conflicting. The goals can be set before, during and after the renovation process. The goals can also be set specifically for one building/property or generally to a wider range of buildings as well as the area in between the buildings and the cluster of buildings. Such diverse ways of goal-setting are common in the public housing companies.

The *process* of sustainable housing renovation refers to the project process from initiating to closing that are undertaken with long-term economic concerns for the company and

environmental and social concerns for the wider society. Typically, the process includes pre-study, design, procurement, construction and closing, but the details can vary from project to project. Even though process is the focus of the framework, our framework exclude neither the resources used in housing renovation, such as the materials, equipment and tools, nor the buildings that are worked on during the renovation process. The reason is that usually the process and the resources are interrelated. The framework also includes the after-renovation stage, which is usually forgotten in research and practice, as part of the processes in question.

The *actors* of sustainable rental housing renovation include a wide range of stakeholders including the owner/real estate company, the construction companies, the consultant companies, the sub-contractors, the tenants (and their family and relatives), the neighbourhood residents, the service providers to the buildings, the government regulatory bodies, the city planning authorities, etc. In this paper, for simplicity, we categorise the stakeholders as belonging to one of the three groups. They are the owner/*real estate company*, the *tenants* and the *wider society* including the community, the NGOs, the local and national authorities etc. These actors are directly and indirectly involved to different extent in different stages of the renovation processes. They form an actor network where different actor owns different strength and weakness, bears different interests and plays different roles. Noticeably the actor network is a dynamic network during the whole process of housing renovation. The entry and exit of actors may change the dynamics of the network and result in different outcomes in the housing renovation projects. (The renovation of non-rental housing also include a large number of stakeholders, the main difference being that there is nothing corresponding to the long-term contractual relation between an owner/real estate company and a number of individual tenants. In this paper we focus on rental housing renovation, but part of our argument may also have some relevance to other housing tenures.)

The *institutional environment* of sustainable housing renovation refers to the formal rules (constitutions, laws, regulations and standards among others) and informal norms (such as conventions, customs, values and beliefs) that enable and constrain social interactions in the renovation process. This paper perceives institution as rules-of-the-game (Johnson 1992; Edquist 2004; Asheim & Gertler 2005; Lundvall 2010). Institutional theory suggests that institution as rules of the game can be identified as three categories, namely regulative, normative and cognitive (Scott 2008). Regulative institution refers to formal rules, such as laws, regulations, standards and sanctions, contracts and their enforcement through mediation, arbitration or litigation. In many countries, housing is regulated e.g. through land use policies and construction regulations, as well as the more specific rent regulations and tenant protection laws. Normative institution refers to informal rules, such as work roles, social norms and routines, shared expectations of appropriate behaviour, social exchange processes, etc. For example, in Sweden it is the tradition for the head of the real estate company to announce the renovation plan to the tenants not even his deputy nor project manager. Otherwise it will be considered to be improper. Cognitive institution refers to perceptions of reality, such as shared identities, values, interests, beliefs and assumptions etc. For example, in Sweden it is commonly shared value that the buildings and the people living in the buildings should be respected when renovating. One should not make the tenant big trouble and the original design of the architecture should not be dramatically changed.

Based on the discussion above, the paper therefore forms a system model of sustainable housing renovation as shown in Figure 1. The core of the model is the renovation processes containing the stages of before-renovation, renovation and after-renovation. The actors (firm, tenant and society) interactively participate into the renovation processes in different stages and to different extent. The renovation processes are guided and evaluated by the triple goals of sustainability

(environmental, social and economic). All these processes are supported or hindered by the institutional environment including regulative, normative and cognitive aspects.

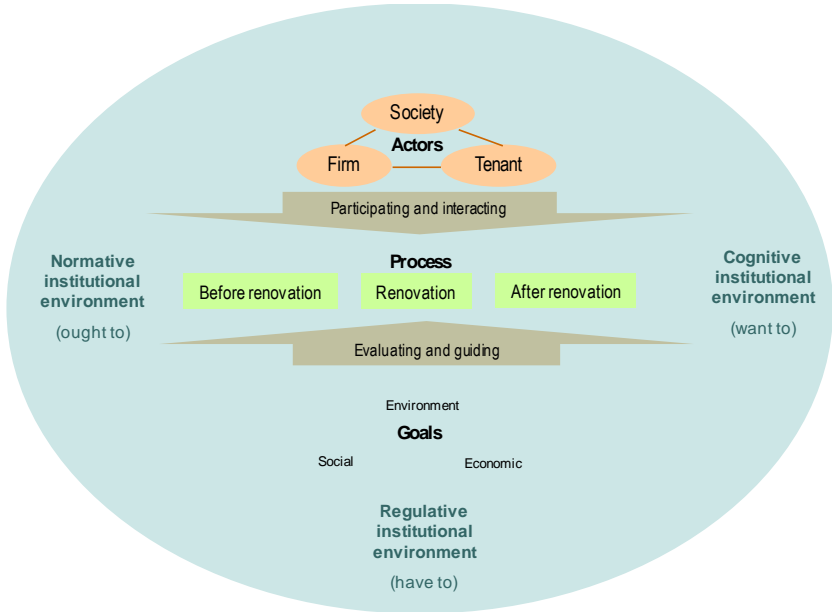


Figure 1. A system model of sustainable housing renovation

4. Identifying the key challenges of sustainable housing renovation

The challenge of conflicting sustainability-goals

The economic, environmental and social aspects of sustainability are logically independent but also systematically interconnected factors at different levels that firms are expected to address at the same time (Hahn 2014). Sustainable housing renovation simultaneously targets economic, environmental and social goals (see Figure 2). A solution for reaching one goal may be beneficial but sometimes also be detrimental to that of another goal(Newton 2002). For example, the increasing use of environmental friendly construction materials may in some cases harm the profitability of a real estate company. In this case, there is a conflict between the economic and environmental goals. It creates dilemma for company’s decision making.

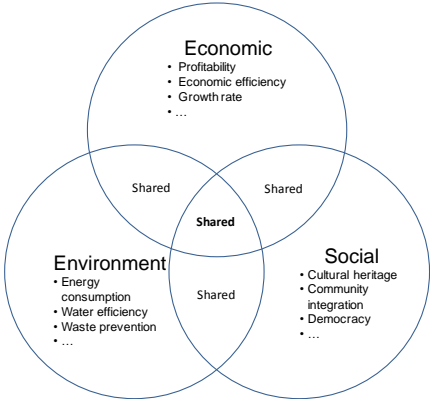


Figure 2. Stylized model of shared and conflicting goals of sustainable housing renovation

In reality, companies tend to prioritise the economic goals over environmental and social goals. The prioritisation of economic aspect of sustainability clearly implies that the economic aspect of sustainability conflicts with the environmental and social aspect in certain occasions. When there is a conflict, economic goals usually win. The reasons are twofold. First, profit motive is the main motive, if not the only motive, of the existence of a firm. Mainstream economic and management theory posits that the ultimate goal of an enterprise is to make money. A firm, as an economic agency, is the very organisation has the legitimacy to maximising profit and pursuing what is in their own best interests. Corporate social responsibility (CSR) came into see in much later years of industrial history. Companies just started to recognise CSR as one of the important task under external pressure from consumers, NGOs and government agencies. Most companies have not institutionalised CSR into their daily operation more than producing a pretty CSR annual report. Second, the survival and existence of a firm, which is based on its economic profitability, is the precondition of any environment friendly and/or social responsible conducts. A bankrupted firm does not have the capacity nor opportunity to do anything good to the environment and society. Therefore, economic goals cannot be removed from a firm's strategic agenda when talking about sustainability. Third, actualisation of economic goals are the goals of a company itself that usually happens in the business sphere while environmental and social goals are societal level goals of which the actualisation depends on a much broader range of engagement of the stakeholders. Operationally it is more difficult to reach. Such operational difficulty is a commonly observed obstacle in housing renovation.

In a housing renovation project, the challenge of simultaneously addressing the three aspects of sustainability does not lie in the shared part of the triple goals where economic benefit can be combined with environmental and/or social benefits. Instead, the challenge lies in the field where economic benefit is in conflict with the environmental and/or social concerns.

Therefore, we identify one of the key issues of sustainable housing renovation is not how to achieve economic, environmental and social goals respectively but how to address the conflicts among them. In other words, the key issue of sustainable housing renovation is how to enlarge the shared parts and to reduce the conflicting parts of the triple sustainability goals. Obviously, if a certain practice can simultaneously lead to economic, environmental and/or social benefit, the company will have motivation to implement it. The enlargement of shared sustainable goals and the reduction of the conflicting ones are the key for sustainable housing renovation.

The challenge of conflicting stakeholder-interests

Sustainability of housing renovation, like many other business processes, needs the simultaneous recognition of various, often conflicting demands of different stakeholders (Clarkson 1995, Maon et al, 2008, Astmarsson et al 2013) who tend to apply different decision logics and preferences than the company managers (Hahn 2012). The economic, environmental and social interests of a housing renovation project are carried and influenced by a wide range of stakeholders beyond the organisational boundary of the real estate company. Within one aspect of sustainability, there exists conflicts between different stakeholders' interests. For example, the economic benefit of a renovation project can be distributed to the real estate company and the tenants that live in the building. Sometimes it is a zero-sum game. Then there comes the conflict between the economic interest of the renovation project owner and the user. The environmental impact of the renovation process can harm the inhabitants living close by the renovation site during the renovation but benefit the tenants living in the building after the renovation. Then there is a

conflict between the environmental interests of the people who live in the building and the people who live nearby.

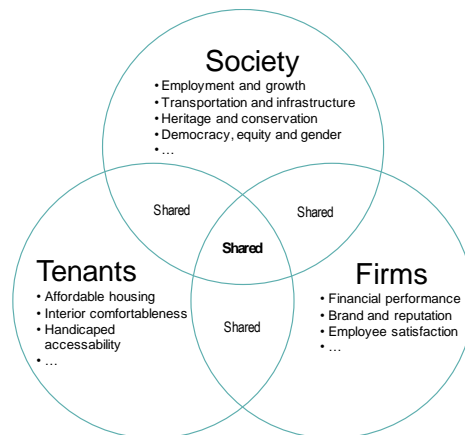


Figure 3. Stylized model of shared and conflicting interests of stakeholders

Researchers argued that firms can benefit economically while they address environmental and/or social challenges (Dentchev 2004, Husted and de Jesus Salazar 2006). The alignment of stakeholder-interests is also possible ([literature is needed here](#)). However, such conflicting goals among different aspects of sustainability and conflicting pressures from different stakeholders cannot be reconciled through traditional business practices (Hall and Martin 2005). Addressing the double challenges of conflicting sustainability-goals and conflicting stakeholder-interests calls for innovation.

5. Innovation as an approach for addressing the key challenges

Housing renovation is a set of processes happening in a system where different actors interact and different aspects of institutions restrict. Understanding how innovation can address the key challenges in sustainable housing renovation should first answer the questions about what types of innovation can happen, how innovation happens and how to make innovation happen.

Product innovation and process innovation in housing renovation

This paper mainly focuses on product innovation and process innovation which addresses the key challenges in sustainable housing renovation. The adoption of the product-versus-process innovation typology in our framework is to give space for further identification of different types of innovation which, on the one hand, occur in the production and process of housing renovation, and on the other hand, are specifically related to technology, organisational structure, organisational methods, business model, or social means, etc. The product-process innovation typology suits better to a general model for housing renovation system rather than other innovation typologies, such as incremental-versus-radical, technological-versus-organisational, business-versus-social, etc.

A product innovation refers to the introduction of a good or service that is new or significantly improved to the market (OECD 2005). Product innovation in housing renovation includes significant improvements in technical specifications, components and materials, incorporate software, user-friendliness or other functional characteristics of the buildings. Noticeably,

product innovation can be both the creation of a new product or service and the new use of an existing product or service. (example of product innovation in housing renovation needed)

A process innovation is the implementation of a new or significantly improved production or delivery method which includes significant changes in techniques, equipment and/or software (OECD 2005). The process of housing renovation is a combination of facilities, skills and technologies that are used to renovate the buildings and provide services. Process innovation initiatives in housing renovation can result from the introduction of new construction materials, new construction machineries and technologies, new project management software. It can also come from the re-design of the organisation, the introduction of new management methods and way of delivering service. Process innovation in housing renovation can be intended to decrease unit costs of production or delivery of renovation projects, to increase quality or to produce or deliver new or significantly improved renovation process and results. (example of process innovation in housing renovation needed)

The combination of product and process innovation may have great potential to address the key challenges in sustainable housing renovation. (to be elaborated)

The process of innovation in housing renovation

The process of innovation refers to a set of activities from the development and selection of ideas for innovation and the transformation of these ideas into innovation (Jacobs and Snkjders 2008). There are two different innovation process models, namely linear model and organic model.

The linear models take innovation process as a planned and controlled process, for example, the technology push model and the market pull model (see Godin 2006 for a review). In these two models, the product or service concept is frozen and criteria are set at the early stage the process and gatekeepers decide the continuity or exit of the process. The innovation process is tightly controlled and planned by the actors and guided by the desired goals that are set in advance. The linear models suit better to the situation where the change in the environment is slow and the time for innovation is sufficiently long. We expect that the linear models apply to the incremental innovation with less actors involved and clear short-term goals set in a relatively certain environment of a housing renovation project.

The organic models take innovation process as an open, learning based, trial-and-error process, such as the cyclic model (Gomory 1989), the funnel model (Wheelwright and Clark 1992), neural network model (Zeeman 1991). In the open and flexible innovation process, no concept is frozen and no design is fixed at the early phase, phases can be repeated and actors can enter and exit at any time. The process is continuously driven by customer needs or needs from other part of the system. Diverse actors are involved. The process is orchestrated by different actors over different stages of the process. Thanks to the ambiguity and uncertainty of the process, the organic model of innovation process may lead to unexpected chaotic results. Nevertheless, it is argued that the organic models are more open and flexible with more divers actors involved and in a more complicated, ambiguous and uncertain environment.

Innovation process, which aims to address the challenges of conflicting sustainability-goals and the conflicting stakeholder-interests in sustainable housing renovation, is a complex process involving different actors who hold different goals and bear different interests. Research shows that innovation comes from the interaction of different actors and the heterogeneity of divers

actors is critical to the generation of innovation. Different from conventional housing renovation, sustainable housing renovation calls for innovation targeting not only economic goals but also social and environmental goals. The triple goals of housing renovation are carried by different actors or stakeholders. Consequently, the generation of innovation in sustainable housing renovation is expected to involve more actors in the innovation process than the conventional housing renovation. Thus, the well-planned and controlled linear models may not work. We expect the innovation process in the sustainable housing renovation is more an organic process than an linear process.

The drivers and binders of innovation in housing renovation system

Innovation processes are conducted by the interrelated actors in the housing renovation system and are embedded in the institutional environment. The drivers and binders can be identified in different aspect, namely the actor aspect and the institution aspect. (to be elaborated)

6. A theoretical framework toward sustainable housing renovation
 (We may give a name to the model, such as challenge driven model, or innovation-system model, or something that is easy to remember)

Employing innovation approach to address the key challenges in the sustainable housing renovation system, the paper forms a theoretical framework as shown in Figure 2. In the centre of the framework is the sustainable housing renovation system (see Figure 1 for its components and relations) of which the triple goals (economic, environment and social) are the expected outcomes and the conflicting sustainability-goals and conflicting stakeholder-interests are the key challenges. Innovation, including product and process innovation, is used as tools to address the key challenges in the system. Innovation is led and guided by the triple sustainability goals. Innovation is driven or hindered by the system’s process, actors and institutional environment.

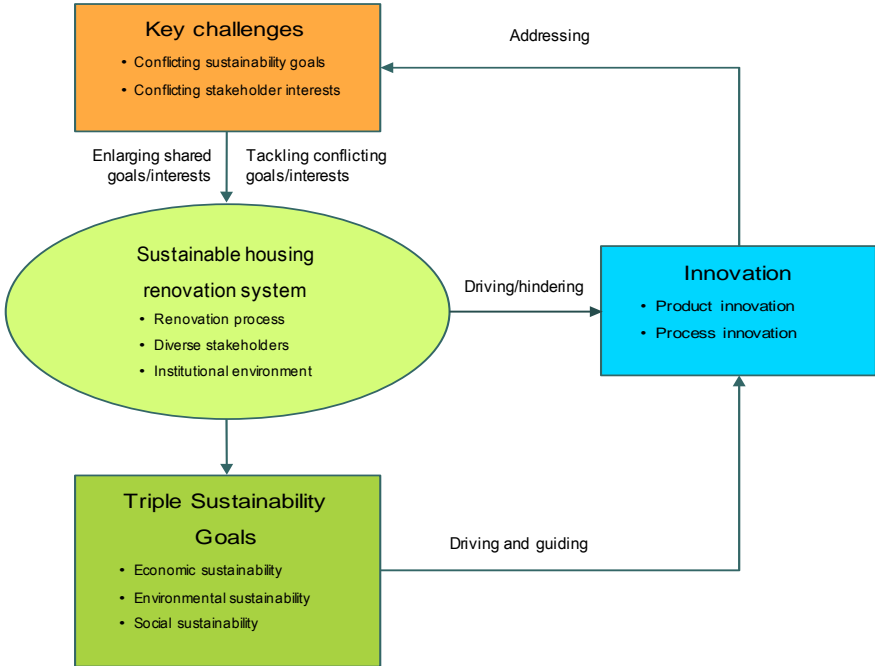


Figure 3. A theoretical framework toward sustainable housing renovation

7. Discussion

This paper develops a system model of sustainable housing renovation and a theoretical framework to address the key challenges of sustainable renovation. The model and framework adopts a system perspective and an innovation approach. It does not take a stand of a real estate company nor of a municipality authority nor of a general public society. Instead, it takes a general view over the sustainable housing renovation processes, the actors that processes involve and the institutional environment that the processes are embedded. All the different stakeholders can find their own positions in the model and framework. The model and framework can be used by firm managers, city planners, regulators, and also tenants and citizens to understand the complicated system of sustainable housing renovation and to find innovative solutions to address its key challenges.

This model contributes to sustainability literature with a focus on the TBL model in several ways.

First, the model introduces *systematic thinking* into the application of TBL model by taking housing renovation as a system in which different groups of stakeholders are engaged at different level in different phases of the process, and institutional environment as driving and hindering power of the system. One of the criticism to the TBL model is that it is in lack of systematic thinking (Doppelt 2003). The introduction of systematic thinking into the application of TBL entails the ability of understanding the complicated relations, interactions and situations in housing renovation that can hardly be explained by simple cause-and-effect relations.

Second, the model introduces *integration focus* into the application of the TBL model. The TBL model pay more attention to the co-existence of the three aspects while somehow ignores their dynamic interdependence. Such ignorance may lead to “a tendency to ignore the profound interdependence of these factors, and to see them as likely to be conflicting rather than potentially complementary (Sridhar and Jones 2013). It also leads to a static perspective which assume that sustainability is about balancing the three aspect with a given size of benefit. The integration of the three aspect of the TBL model has two meanings. On the one hand, it is to enlarge the shared parts or to realise the potential of possible synergy among different goals; on the other hand, it is to reduce the conflicting parts or to minimise the negative impact of the conflicts. Provided an integration focus, can the model be used to achieve mutual supporting advices on all aspects of sustainability.

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