The Green House Effect:

the market creation of passive houses in Vienna

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Abstract:

Environmental innovations have the potential to transfer the society to more sustainable direction, and their success in the market is crucial for them to make a major impact on sustainability. The market creation of residential multi-storey passive houses in the housing market of Vienna can be seen as a relative success story. This thesis aimed to understand how this market creation has taken place and find out what could be learned from this development. By using the actor-network theory, the network of market creation of passive houses in Vienna was studied by making interviews and analyzing relevant documents. The results of the empirical research concluded on four actor sectors that have created the market of passive houses in Vienna: political will, knowledge and knowhow, idealism, and economic interest. Each of these main sectors included several more precise elements of the actor-network: actors, intermediaries, translations and motives of the market creations. These elements, which are further discussed in this study, made the successful market creation of passive houses possible. This study encourages to understand the market creation of an environmental innovation as an actor-network of linked actors and other network elements, and the importance of the coherence of this network for the success of the product.

Keywords: market creation, actor-network theory, passive houses, Vienna

The picture on the front cover: One of the passive houses of the Eurogate project in Vienna.

Contents

Preface

This study is a master thesis that was conducted during the fourth semester of the Environmental Management and Sustainability Sciences -master program of Aalborg University. The topic of the study was the market creation of passive houses in the city of Vienna in Austria, and the study was made during 1st February and 6th June 2013. The author of this study was located in Vienna for the whole study period and the thesis was conducted in cooperation with the Regional Centre of Expertise in Vienna (RCE Vienna). The study topic was determined together with the supervisor of the thesis, Kirsten Schmidt from Aalborg University. The author would like to warmly thank Kirsten for the immense support and constructive critique during the process of the thesis.

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Tuukka Mäkitie

1. Introduction

Problem formulation

Global environmental issues, such as climate change and natural resource depletion, are growing more urgent every year, as well as the public awareness of these issues. However, despite of this, the action towards overcoming the global environmental challenges is not yet convincing. For instance the global environmental politics have this far been unable to make decisive moves. Due to the failure of these large-scale solutions, the interest is diverted to the small-scale possibilities. Businesses and markets, some of the genuine superpowers of the world, have contributed in causing the environmental problems since the industrialism, but new optimism has been raised that they could also be some of the driving motors for the change towards sustainability (e.g. Larson 2000, Senge and Carstedt 2001, Cohen and Winn 2007, Ellis 2010). However, the change in the economy and business cannot only be shallow e.g. through Corporate Social Responsibility (CSR), but has to weave the sustainability to the very core of the society, and use the economy and markets as tools in solving global sustainability issues.

An important sector in the change towards more sustainable future is the housing sector. Green buildings (in this thesis understood as buildings that use minimal amount of energy) such as passive houses have been a growing sector in the housing market in Europe. These environmental innovations, or innovations with an essential environmental aim (van den Bergh et al 2011: 3), are expected to grow rapidly in near future, and due to the EU Directive 31 (2010), from 2021 onwards all new buildings built in EU must be "nearly zero-energy buildings". The passive house (PH) concept is one of the leading building types among the green buildings. However, the transitions towards sustainability are difficult processes in a major sector such as housing, as the conventional housing sector is often locked into the dominating mechanisms of the society. These mechanisms often support the *status quo* situation for instance through sunk investments, economical interests, fixed behavioral systems, existing policies and the political climate (Geels 2010: 495). However, in Vienna and Austria the PHs have been able to break these barriers: in 2012 about 25% of the construction projects in Vienna were PHs (IG Passivhaus Ost 2012). Understanding how come the housing sector has adopted the PH concept in Vienna poses an interesting study topic about how market creation of an environmental innovation has taken place. By understanding this market, new knowledge for understanding other transitions could be created, and perhaps enable to support the sustainability transition, a radical and large-scale socio-technical transition towards more sustainable society (van den Bergh 2011: 8), as a whole.

Vienna and passive houses

Vienna, the capital of Austria and home to slightly more than 1,7 million inhabitants, is located in the eastern part of Austria close to the borders of Czech Republic, Slovakia and Hungary. With history dating back to the Roman Empire, it was the capital of the Austrian empire peaking in influence at the turn of 19th and 20th century. After the fall of Austro-Hungarian Empire at the end of First World War the city turned to social-democratic direction which resulted in vast public housing projects which aimed to improve the living conditions of the people. This Red Vienna era in 1920s was the beginning of the renowned public housing program of the city of Vienna, which aims to offer affordable and quality housing for its population. This tradition has prospered during the 20th and early 21st century and today around 60% of the households in Vienna live in publicly subsidized apartments, and the city of Vienna itself rents out 220 000 apartments, making it one of the largest landlords in Europe (Förster s.a.). Vienna is expected to grow steadily during the next decades, and from 2011 to 2020 the population is expected to grow by almost 8% from 1 720 000 to 1 850 000 people (Statistics Austria 2012). This development will put challenges to the environmental impact of the housing development in Vienna, and the passive house (PH) concept has been seen as one of the possible solutions to improve environmental sustainability. The market for PHs has rapidly increased in the last 10 years or so in Vienna, and the framework of this development is the scientific interest of this thesis.

The housing market in Vienna is heavily influenced by regulations and policies (Maier 2013), a development that has started already in the Red Vienna period. Therefore the public and private sectors are not a clear-cut division in Vienna. For instance, several private property developers work on e.g. both subsidized social housing projects and non-subsidized private projects. This strong connection between public and private has also been used to integrate environmental issues to the housing sector. For instance, the Austrian building code has for several years regulated the energy-efficiency of housing by setting a limit for the heating energy demand of the new residential buildings. This value has been incrementally decreased to enforce more energy efficient houses. Currently the new residential houses can use maximum 54,4 kWh for heating per square meter in a year (kWh/m2/a) (OIB-Richtlinie 6, 2011). In addition to this, since 1996 the common public subsidies for residential buildings have had a requirement for low energy consumption. Meeting this energy efficiency is a condition for the developer being able to obtain the subsidy. Also this value has been gradually decreased, starting from 50kWh/m2/a in 1996 and currently being 36 kWh/m2/a

(Förster s.a., Neubauverordnung 2007, 2012). These issues have influenced the introduction of even more energy-efficient buildings, the passive houses, in the Viennese housing sector.

Passive house (PH) is a building which is designed to use as little energy for heating as possible. This is achieved by e.g. compact design of the house and effective insulation and air-tightness, which is achieved with thick (about 30 cm) insulation layers in the envelope of the building and the avoidance of thermal bridges (e.g. by insulating floor or roof pillars). Also windows have triple-glazing and the window frames are insulated. Ventilation is automated and controlled, and the heat from the exhaust air is recovered and fed back into the fresh air coming to the building. Therefore in an ideal PH there is no need for additional heating system. The heat produced by people and electronic appliances as well as e.g. the energy of the sun is used, and only the remaining heat demand is covered with external energy sources (ISOVER 2007: 16-19). Therefore it is possible to keep a comfortable temperature inside the building with very small energy demand while also having fresh air circulation inside the house. The PH is defined by its heating energy demand and total primary energy demand, where the latter stands for all energy consumed inside the house (such as warm water, electronic appliances, ventilation etc.). The maximal values for these two figures are 15 kWh/m2/a and 120 kWh/m2/a respectively, both which need to be fulfilled in order for the building to qualify as a PH (ISOVER 2007: 10-11). Lower energy demand logically also decreases the need and the CO2 emissions of energy production.

The focus of this study is on residential multi-storey PHs. The investment costs of this kind of PHs are slightly higher, around 5%, than buildings according to the minimum building code in Austria (ISOVER 2007: 12, Jedliczka 2013). However, it is argued that the low running costs pay back the higher investment costs during the lifetime of the building, especially as the price of energy is expected to increase in the near future. In promotional material the cost-savings of the energy demand of PHs are mentioned to be up to 1:8 in ratio compared to the minimum building code (ISOVER 2007: 11), or repaid in approximately 10 years, as in the case of a certain Viennese non-profit housing organization (Jedliczka 2013). However, in their study Hüttler et al. (2013) found out that while optimally planned, built and used PHs can achieve high cost-efficiency, on average the energy costs of PHs in Austria have not been as low as expected. Instead the anticipated 1:8 ratio, the real energy consumption of PHs has been only 1:2 smaller than in conventional houses (Hüttler et al. 2013). The reasons for this were suspected to be the rebound-effect in room temperature (when the heating cost of the apartment decreases, the tenant/owner can afford to have higher and more comfortable room temperature), suboptimal planning and construction, and higher

maintenance costs of PHs due to the controlled air-ventilation (Hüttler 2013). Also, in many PH projects a conventional heating system has been built parallel to the controlled ventilation system, which was considered unnecessary in the optimal PH, due to e.g. user demand, which again has increased the investment and maintenance costs (Hüttler 2013, Stude 2013).

However, the costs should be seen as only as one element of the market, which is a result of entangled collective actions of agents and actors (Kjellberg and Helgesson (2007: 156). These actors and the network that constitute the market creation of PHs are the research interest of this thesis.

Research focus

The increase of PHs in Vienna in recent years can be seen as a successful breakthrough of a environmental innovation into the mainstream practice, and this master thesis investigated this phenomenon. The market of PHs was seen as a social construction or a network of varied actors affecting the market creation. This construction was studied through the use of actor-network theory (ANT). The aim of the study is to uncover the relevant actor-network that has created the market for PHs. In order to contribute to the knowledge base of market creation of environmental innovations, most essential learning-points were drawn. The research questions defined this research focus.

- **What kind of actor-network has created the market of passive houses in Vienna?**
- **What can be learned from the market creation of passive houses in Vienna?**

Outline of the thesis

This thesis proceeds by introducing the research design and methodology of this study, which explains how the research proceeded. The third chapter introduces the actor-network theory, the concept of market and the relevant previous research related to the study topic, and their usage as a research method in this thesis. Further on, the empirical research and the results are presented. These results and the empirical research are discussed together with the theoretical framework in the Discussion-chapter. The last part of the thesis, the Conclusions-chapter, makes the final remarks about this study and answers the research questions.

2. Research design and methodology

The scientific knowledge of this thesis is based on the social constructivist view on reality. This theory of science argues that the human perception of reality is constructed in the social: in the interaction and relations with human and non-human entities. In other words, it is argued that our knowledge is based on our communication with the reality we observe. What we call knowledge is what we consider to be true in this observation and what we can consider possessing certain specific characteristics (Berger and Luckmann 1966: 13). Basing on this understanding, useful knowledge over various topics can be obtained through the study of their social structures. In the field of the technology and innovation studies, it has been argued that the social and technology cannot be seen as independent entities but as essentially being constructed from their various interactions (Bijker et al. 1987: 10). This social constructivist understanding of the reality sets the basic ontological foundation of this thesis: the thesis offers one perception of the network of actors (human and non-human) in the market creation of a technology (passive houses) in Vienna.

This research began with the problem formulation (see figure 1). The point of departure for this thesis was the acknowledgment of the role of the market and economy in the sustainability transition. In order to be able to support this development, it is necessary to understand the market element of the environmental innovations, and the passive house development in Vienna offered an appropriate study topic. The relatively successful market development of PHs in Vienna posed interesting study questions: how come has this happened and what could be learned from this? This process contributed to the development of the research questions and launched the next element of the research design: the literature review.

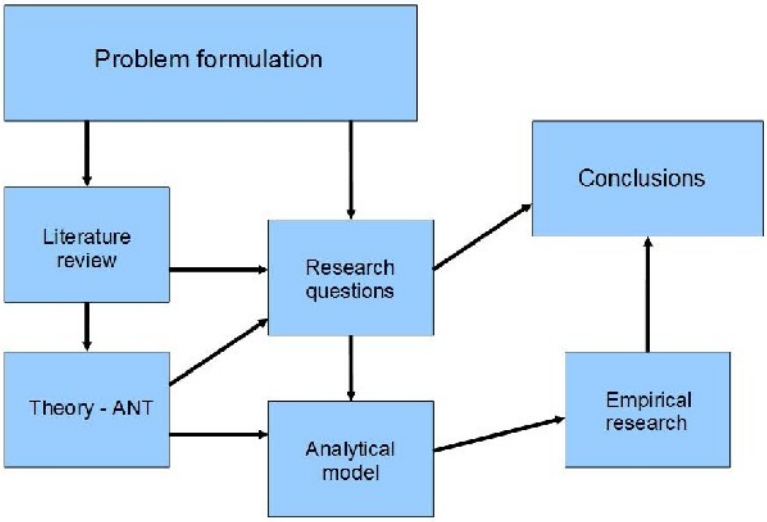

Figure 1. The research design of the thesis.

The literature review of the study topic studied the relevant background knowledge and possible theories. Factual knowledge about the PH development of Vienna was studied and theoretical literature on understanding market creation was read. These readings further contributed to the formulation of the research questions. Based on the literature review, the theoretical basis of the study was formed. The actor-network theory (ANT) was chosen as the main theory to be used in this thesis, as it was seen as a useful tool to understand the social constructions that shape the society. As e.g. Callon (1991) argues, ANT studies the relationships of actors that both constitute networks and are constructed by them, which is a fruitful approach to study social structures such as the sustainability transition and the market development of PHs. ANT crucially also acknowledges the relevance of both human and non-human actors equally, which is essential to be able to study the market creation of a certain technology – a topic that by definition is characterized by various elements, such as technical devices, money and human actors. ANT and its application to this study is further explained in the next chapter.

Together with the problem formulation and the literature review, ANT formed the final research questions. The research questions acted as the key to the empirical study, as they settled the precise focus and the final study topic of the thesis. They also clarified the research aim, which the conclusion element of the study ventured to answer. Together with the theory element, the research questions enabled the definition of the analytical model of the study. The purpose of this element was to make use of the theory element in the empirical research of the study. The analytical model (further explained later in this study) enabled to design the empirical research according to the theory, thus allowing the production of useful knowledge about the study topic at hand. Basing on the results of the empirical research element (see the corresponding chapter of this thesis), finally the conclusions of the study could be made, and research questions answered.

In the next part of the thesis, the relevant theoretical framework of this study is presented: the actor-network theory, the market and the previous research of using these concepts in the environmental innovation and housing studies.

3. Theoretical framework

Actor-network theory

John Law (1991) argues that technology should be understood in the framework of social relations. In other words: it is not, or at least should not be, possible to treat people and technology as totally separate entities. The value of technology is manifested through its usefulness for humans, and all humans constantly need various technologies in their daily lives. Some necessary technologies are simple, such as a blanket to keep one warm during the night, while others are more complex, such as a computer which enables one to perform various tasks, such as studying, more efficiently. Technology, after all, is developed to meet human needs, and humans wouldn't survive without technology.

Law (1991: 10) further argues that the development of technology should be seen in the context of various networks, which extend to fields such as the economy, politics, science and social. These different fields constitute a seamless web, which is inherently interwoven (Callon 1987: 84). Law (1991) uses the example of Thomas Edison (basing his analysis on the work of Thomas Hughes), who not only worked with physical materials to develop the necessary technology to yield the powers of electricity, but had to extend his work to texts, appliances, people, political institutions, infrastructure etc. in order to construct the necessary socio-technical sphere to make his invention work in the society. For instance, without certain elements, such as infrastructures (e.g. electrical grid), laws (electrical standards), people (users), logistics (availability of fuels), economy (revenue from electricity production) and so on, electricity wouldn't be a success story in the modern world as we know it. Therefore it is essential to understand that technology is depended on various networks and actors in which it is embedded in (Callon 1987: 84). This connection between technical and social worlds sets the fundamental theoretical starting-point for this thesis. This issue is further investigated in the actor-network theory (ANT).

A central argument in ANT is that society or social networks do not consist solely from people, but also from various other materials. As Law (1992: 381) argues, the actor-network theory suggests that *"the social is nothing other than patterned networks of heterogeneous materials"*. What is meant by this is that, besides humans, all networks are composed of machines, money, design, texts, natural resources and so on. Even some of the simplest human interaction use intermediaries which are not human *per se*, such as words transferred in air, texts or technical equipment. The point made

is that various materials are necessary for any interaction or a network to shape. Therefore, in the ANT perspective, people are seen as materials of the network, and not only interacting with other people in the network, but constantly also interacting with an endlessly large amount of other materials. These other materials could be for instance physical or more abstract elements. All materials of the network, such as people, machines, texts, institutions and so on, are equally necessary for a particular network to exist as it is. Seen in this light, a human is ”reduced” only as one building block of the network. Therefore, a central argument in ANT is that the social is not only human, and if these non-human materials of networks would seize to exist, the networks would lose their existence, or its social order (Law 1992: 381-383). However, it should be noted, that treating people on an equal basis to any physical elements is merely an analytical stance to study networks, not an ethical statement (Law 1992: 383).

The key concepts in ANT are actors, intermediaries and networks, and the use of these concepts in this thesis is largely based on the work of Michel Callon (1991). As previously described, networks consist of materials, which can be human and non-human. In principle all of these materials can be actors or intermediaries. As Callon (1991: 134-135, 140) explains, the difference between an actor and intermediary is that actor puts intermediaries into action – an actor delivers and receives a message via an intermediary. An actor is *”an author”* (Callon 1991: 140), or as Kera and Tuters (2011: 4) puts it: *”anything and anyone who has a propensity to act, connect, perform, resist, and translate”.* On the other hand, an intermediary is a medium of actors, or *”anything passing between actors”* (Callon 1991: 134). For example, scientist A suggests her student to read about the work of scientist B regarding theory X. In this case, the scientist A could be seen as both an actor and an intermediary. The scientist A is an actor as she uses the work of B as an intermediary in order to push the student towards a desired direction, the theory X. On the other hand, A is also merely an intermediary between the scientist B and the student in their own academic interaction over the theory X. Further on, both scientists A and B could end up being intermediaries between the student and the theory X. Callon (1991: 135) further argues that ”*actors define one another in interaction – in the intermediaries that they put into circulation”.* For instance, a scientist as an actor in a scientific community is defined by the immense number of intermediaries, such as her experiences, talks, colleagues, research papers, books, seminars, education etc. that one has received, produced and transmitted in the academic network. All actors are also networks – a result of interactions between other actors through intermediaries – thus the name actor-network (Callon 1991: 142). Therefore, the social world is formed from extremely complex web of networks. However, as Law (1992: 385) notes, these networks are often invisible to us. When networks act as a coherent unit,

only the action is seen, and the network disappears. To give a simplified example, when a computer functions as hoped, no attention is normally given to how complex web of minerals and other resources it actually is. However, when a hard drive breaks down, it is revealed how depended the computer, or the network of a computer, is on its various parts (or actors), this time the hard drive, in order to work as a whole. Without this important actor, the network of a computer doesn't work as a coherent unit, and is solely a useless heap of metals, plastics and minerals. This *coherence* of a network is depended on its translations and coordination, as explained in the following paragraphs.

The interaction between actors through intermediaries describe the network: *"they identify and define other groups, actors, and intermediaries, together with the relationships that bring these together*" (Callon 1991: 142). In order for a network to successfully form, the materials need to translate more or less similarly between actors. The actors have to understand, or to translate, the topic similarly so that communication is possible. The translation can be seen as a definition, and the necessity of similar translation equals to the need of having a relatively common definition for a topic that is being transferred. Translations can also change over time, and actors have to constantly agree on the translations (Callon 1991: 143-146). Therefore also the network itself is evolving and reproducing itself and is constantly in process (Law 1991: 385-386). As Law (1992: 385) puts it: *"social structure is not a noun but a verb"*. Therefore the network is never complete or final. A successful translation between actors creates space for a network, and *aligns* actors and their intermediaries together. A failed translation, or a situation where actors do not understand each other, leads to a deterioration of the network. As an example, a person C wants to start eating healthier and sends the person D to supermarket in order to buy healthy food. However, in D's opinion, C is too thin, and thinks that it would be healthy for C to eat food that is rich in nutrition values. Therefore, while person C is thinking of apples and carrots, the person D buys sausages and whole milk. As a consequence, the network of healthy food between C and D falls apart, as they don't share the same view about what is healthy for person C.

As Kera and Tuters (2011: 4) identify, the central goal of ANT is *"to understand the connections of heterogeneous actors in hybrid networks across scales"*. The purpose of ANT is not to study technical networks (e.g. how a computer works as a whole), nor is it a tool to investigate mere social networks, in other words the study of only social interaction of humans and networks of individual people. Instead, it studies the actors and intermediaries (both human and non-human) of larger entities that actively shape a network, their connections, distributions and transformations (Latour 1996: 373). One such kind of network is arguably the market.

The market and the actor-network

This section discusses the concept of market and its connection to ANT. As Vail (2010) defines it, a market is ”*a relatively stable network of institutions or organizations that enable the exchange of goods and services among producers and consumers, usually (but not always) on commercial and monetary terms”.* This definition stresses the multiplicity of different actors in the market, such as institutions, organizations, producers, consumers etc. This attention to actors is further discussed by Callon (1998a: 3), who underlines the importance of calculative agencies to the market. The calculative agencies consist from agents who pursue their interests. To Callon (1998a: 32), a market is *”a process where calculative agencies compete and/or co-operate with one other”*. He accepts the existence of the neo-classical *homo economicus*, but argues that the characteristics of agents in the market go beyond that view of exclusively rational and narrowly self-interested agents (1998a: 22, 51). As Callon (1998a: 8) argue: *”The agents, their dimensions, and what they are and do, all depend on the morphology of the relations in which they are involved”*. This definition is very similar to the ANT term ”actor”, but with the difference that ”agents” are essentially human, while ”actors” could refer to both human and non-human materials.

Stressing the importance of the social dimension of markets, Callon calls upon the *”anthropology of markets”* that can uncover the agents with their framing characteristics, or things that have shaped the actor to become what it is (Callon 1998a: 15, 51). The agents have been produced by their relations and connections, and are thus networks themselves (Callon 1998a: 8). The market is not only driven by the *invisible hand* but by actor-networks, who actively shape and negotiate the market, and vice versa (Callon 1998a: 51, Callon 1998b: 266, Granovetter and McGuire 1998: 166-167, Sarasvathy and Dew 2005: 558, Kjellberg and Helgesson 2007). *”Far from* being *the economy, markets have to be made 'economic', through a complex interplay of cultural, legal, political and institutional arrangements”* (Smith et al. 2006: 95). Markets are thus social creations, and therefore the study of markets should focus on actors and agents that produce the market and the networks. As Gabriel and Jacobs (2008: 534) point out, methods such as ANT are suitable for ”*unpacking”* economic models / social constructions such as the housing markets and find out the various relevant actors working in these entities. Therefore an analysis based on ANT might be a fruitful venture also to understand the creation of the PH market in Vienna.

Lovell (2005) argues in her study about low energy houses in UK that the housing market is affected by various socio-technical issues that shape the market. This statements underline the

crucial role of different actors in the network, which operate in e.g. cultural, political and economic fields. Also, as the housing market is a social production, it can also be changed. Markets result from intertwined collective actions, and therefore the development of the market is a joint effort of several agents (Kjellberg and Helgesson 2007: 156). Rather than being solely an outcome of purely technical and economic rationality, the market is (re-)negotiated, (re-)framed, and (re-)mobilized by the actors in their interaction (Granovetter and McGuire 1998: 167). In Sarasvathy and Dew's (2005: 543) view a new market starts to emerge when the capabilities of the agents and the interaction between them are capable to produce common goals, which in ANT could be seen as translations. In order to reach this point, effective communication and commitment have to take place between other relevant agents and stakeholders, e.g. in order to gather the necessary funding. Still, several constraints can hamper the whole process, and these constraints could include e.g. financing, demand and competition issues. In order for the venture to be successful and a new market to be born, the market has to overcome these constraints. This process is continuous, and the established markets are also constantly challenged. Therefore also the ”laws” of the market, or the patterns of how the exchanges are taking place, are only temporary (Callon 1998a: 47). This view also underlines the notion that the *”abstract demand”*, as called by Sarasvathy and Dew (2005: 559), is not the only driver of new markets and innovations, but they rather emerge as a product of actor-networks (Colarelli O'Connor and Rice 2013: 213).

Even though the agents actively shape the market, it necessarily doesn't mean that they do it consciously or according to some specific plan. As Colarelli O'Connor and Rice (2013: 210) point out, the new market creation as a process is often not systemically managed, but rather *”firms rely on the market to ready itself”*. This seems like a paradoxical statement after pointing out how agents shape the market themselves, but actually only strengthens the point that was made previously in this chapter. Several issues and agents affect the market creation, such as competition, regulations, policies, resources and so on. In other words, companies or the customers are not the only kind of actors in the market. Therefore the market creation is by far not a simple process and for instance Colarelli O'Connor and Rice (2013: 225) argue that the market creation of an innovation might require as much time and resources as the actual technical creation of the innovation. As Callon (1998a: 9-10) describe, intermediaries are necessary in order for the agents to interact, and in order for the market to be possible. Therefore issues such as good communication and promotion about the innovation can be essential for the product's successful market creation (Colarelli O'Connor and Rice 2013: 225).

In housing sector, Jensen (2012) has studied the regimes and actors in the transition towards green buildings in Denmark. The key actors were for instance certain institutions (e.g. the Housing Ministry), dominant companies (e.g. component manufacturers), interest groups and philanthropic foundations, but also ideas such as the need for internationalization and development of the housing sector. Also Smith (2007: 447) identified the importance of ideologies as starting agents for sustainability transitions, but argues that their roles decrease when the transition matures. On the role of policy-makers, Lovell (2005: 825) argues that these actors might easily be inefficient in advancing green buildings, as they might not be able to create policies that are tailored for the specific needs of the green building sector. In the case of Danish housing sector, Jensen (2012: 60) found out that there was no single translation for green buildings, or in his words, no ”*single unifying representation of the sector”* which has, according to Jensen, resulted in *”uncoordinated sector development strategies”*. He also concluded, that despite of engaging in transition towards sustainable development, several relevant actors were merely motivated by their own interests (Jensen 2012: 60). Smith (2007: 447) also pointed out the possible differences of translations between regime and niche actors e.g. in the green building sector. For instance, the translation of green buildings and sustainability among the established institutions, such as large property developers and ministries, is likely to be a product of long term development, while for newer actors, such as sustainability-driven companies at the niche-level, it might be easier to have a ”fresh start” to sustainability issues.

Analytical framework

In this thesis, the ANT is used to understand the phenomenon of the breakthrough of PHs into the housing market in Vienna. For this purpose the actor-network in the market creation of PHs in Vienna is mapped. This aim is approached by studying the relevant actors of the market creation. The intermediaries, translations of PHs and the motivations of the actors were also studied and reported. These supporting issues helped to understand the methods of market creation (intermediaries), the meanings of PHs (translations) and the purposes of the action (motives). For the sake of simplicity and more effective analysis, the case of PHs in Vienna is seen as a single network. The possible actors could be for instance companies involved in the construction sector, active individuals, the city of Vienna, research programs, policies, ideologies, money and so on.

As the summary to this chapter, an analytical model for how the actor-network theory is used in the analysis of the market creation of PHs in Vienna is proposed. In order to be able to answer the

research questions, the interviews and analysis is based on four questions in the study of the successful market creation of PHs in Vienna: who, how, what, and why?

- **Who:** Who were the main actors of the market creation of passive houses in Vienna?
- **How:** What were the main intermediaries of the market creation?
- **What:** What were the main translations of passive houses?
- **Why:** What were the main motivations in the market creation? (See figure 3)

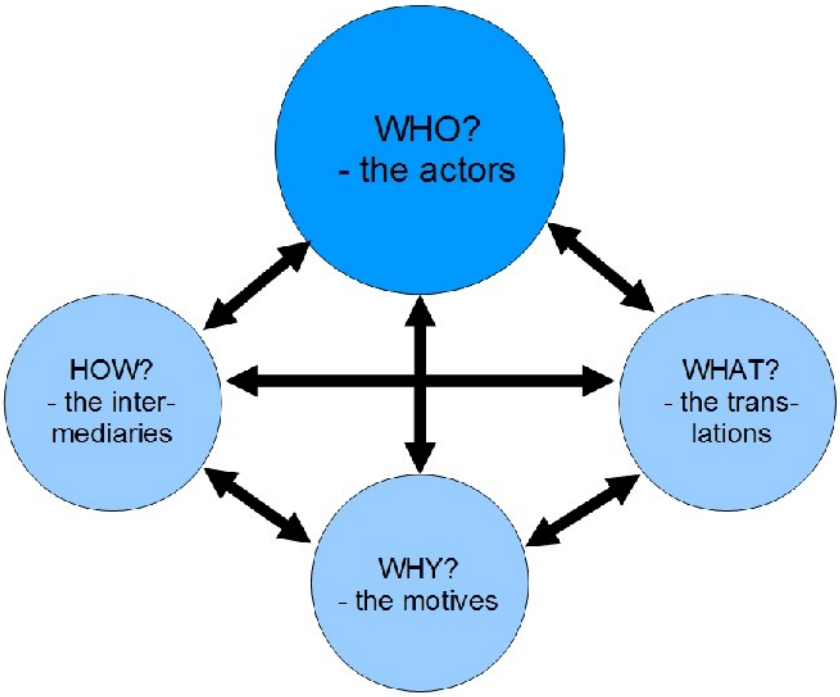

Figure 3. The analytical model of the thesis.

This analytical model crucially attempted to find connections that these actor-network elements had to each other, represented as arrows in figure 3. Based on the analysis of the actors and their intermediaries, translations and motives, the analytical model of the thesis allowed making remarks about what have been the success factors in the market creation of PHs in Vienna. It was not possible to create a perfect representation the actual actor-network of the market creation. Instead, the thesis labored to identify the key actors, intermediaries, translations and motives of the network. The result was an illustration of the actor-network that has managed to succeed in bringing an important environmental innovation, a passive house, successfully into the housing market. It is not expected that the result of this analysis would be applicable as such in other market contexts, nor should it be seen as nothing else than one way of representing the case of PHs in Vienna.

4. Empirical research

This chapter describes the empirical research of this thesis. The chapter begins by explaining the data collection methods and the method of data analysis used in this thesis. Then the chronological overview of the market creation of passive houses (PHs) in Vienna is introduced, and after this part, the main results of the analysis are reported.

Data collection

This thesis used qualitative methods. As Callon (1991: 152) point out, they are the most logical choice of methods in the actor-network analysis. According to him, networks can rarely be reliably cut into quantifiable frameworks, and the qualitative means are more likely to produce the sufficient multi-vocal narrative that can cover all relevant details about the research topic in ANT. In this thesis the narrative was collected in semi-structured expert interviews and analysis of relevant documents. A semi-structured interview follows a pre-determined set of questions over a specific theme(s) (see the interview questions used in this thesis in the Appendix). However, the researcher is allowed to choose the sequence of the questions and ask the interviewee more specific questions regarding their answers if he sees fit (Tuomi and Sarajärvi 2009: 75). In this thesis, the same set of questions was used in all of the interviews with usually some additional questions if seen useful for answering the research questions of this study.

Due to the limited amount of time available, the selection of interviewees tried to rely on quality rather than quantity. The key persons in the PH development in Vienna were identified based on three means: independent background research, consultation from peer-researchers and snowballing through the selected interviewees. The last method means that each of the interviewees was asked to suggest another interview partner, and some of these suggestions were realized with an interview. This way of finding relevant interviewees can be highly beneficial to map the relevant actor-network, as the suggestions may reflect the actual actor-networks that also have affected the market creation itself. Prior to the interviews, a pilot interview was conducted with a person employed with a professional in energy-efficiency issues. This pilot interview proved to be very useful and helped to sharpen the interview questions further. Excluding the pilot interview, 10 semi-structured interviews and one open discussion with an academic expert was conducted. The interviews lasted approximately an hour on average and were mostly held in the interviewee's office. During the last interviews, a sense of saturation in the interview statements was perceived and to some extent the

interviews started to repeat each other, hinting that main issues about the study topic were found. All interviews were recorded and transcribed. English was used as the interview language, which posed some problems for a few respondents, as the native language of all interviewees was German. However, according to the author's perception, even though in some interviews the language barrier seemed to hinder the interviewee's reflections to some extent, the language issue did not pose major problems for communication.

In addition to the interviews, relevant policy document and regulations, such as subsidy schemes and building code documents were analyzed. Due to the time restrictions, only the policies and schemes that, according to the information gained from the interviews, seemed most important were analyzed. With more time, it would have been useful to make more extensive literature review regarding policies and regulations. For instance, there are several sustainable housing schemes in place which support green buildings in the country. Also PHs are promoted in some of these programs, but due to the time restrictions, their relevance to the market creation remained ambiguous for the author. Also, as it was not possible to interview any representatives of the political field, secondary sources had to be used. Therefore the notes from the political debates from the city council of Vienna regarding PHs over the recent years were analyzed.

Data analysis

In order to make sense of the qualitative data produced by the interviews and document analysis, coding was performed. This means condensing *"extensive data sets into smaller analyzable units through the creation of categories and concepts derived from the data"* (Lockyer 2007). The codes enable the identification of the linkages and their common properties between different parts of the qualitative data. The codes were categorized according to the analytical model into four categories, each answering respectively to the analytical questions proposed in the analytical model of this thesis: Who? How? What? and Why? The categories of codifications represented the relevant actors, intermediaries, translations and motives that have been present in the market creation of PHs in Vienna. The intermediaries, translations and motives were also tied to the actors who have been using them to allow more precise analysis. Also, each of these codes was set to a coarse timeline in order to be able to track the temporal development of the market creation. Many of the codes were active in several phases of the development, while some were significant only in certain phases. Further on, the codes were categorized according to the type of their impact: either to be positive,

neutral or negative to the market creation of PHs in Vienna. Identifying these three characteristics for each of the code enabled to study their contexts.

The coding included three rounds. During the first round, the author identified and listed the elements of the actor-network: the actors, intermediaries, translations and motives, as well as their contexts as described above, on a table combined with representative excerpts from the data. This first round of coding produced 36 actors, 24 intermediaries, 28 translations and 4 motivations. Second coding round was needed as the results of the first round of coding were somewhat overlapping. The purpose of this second round of coding was to group together the overlapping codes and achieve higher certainty by discarding codes that appeared only once or twice in the data set. This second round of coding reduced the number of actors to 16, intermediaries and translations to 11 while the number of motives remained in 4. Also, the interactions between different actors, intermediaries, translations and motives codes were taken to the core of the analysis. This setting was the starting-point for the third round of coding performed with support from the supervisor of this thesis. This round resulted in a visual illustration of the varied elements of the actor-network and their connections (figure 7). This final phase of data analysis interpreted four main actor sector of the actor-network. The results are presented later in this chapter.

In the next part, the chronological development of the market of PHs in Vienna is explained. This market creation of the PHs was divided into three main phases: niche, breakthrough and maturation. These phases are briefly described through their most characteristic elements: important events, milestones and their main actor-network elements. After this sub-chapter, the actor-network of the market creation of PHs is analyzed in more detail.

The passive house development in Vienna

The development of PHs in Vienna was seen to have three phases: niche, breakthrough and maturation phases (compare with Geels 2006: 1005-1006). The niche-phase, dating roughly to the years between 1997 and 2005, describes the period when the first PHs were introduced in Vienna. The PH concept itself was originally developed in Germany by Wolfgang Feist in 1991. The first PH in Austria was built in the state of Vorarlberg in 1996, and the first one in Vienna was completed in the following year. At this time the residential PHs were single-family houses. In 2000, a research and technology program of the federal government Haus der Zukunft (Building of Tomorrow) was formed, which since then has supported the development of green building

concepts such as the PH (Haus der Zukunft 2013). The role of this research program has been described to be crucial in the early market creation of PHs as it coordinated and funded e.g. early research and demonstration projects and their monitoring and evaluation (Fechner 2013, Geissler 2013, Hüttler 2013). Around 2005 a significant milestone was achieved when some of the first multi-storey houses in PH standard were finished, such as the student dormitory of ÖAD Housing in the second district close to the city center (Jedliczka 2013) (See figure 4). These early good experiences encouraged other property developers, and the PH segment started to increase rapidly, a phase that is described as the breakthrough phase.

Figure 4. The student dormitory of ÖAD Housing at Molkereistrasse, one of the first residential multi-storey passive houses in Vienna (picture: Iulia Marginean).

The breakthrough phase of PHs in Vienna dates roughly to 2006-2010. In this period the construction and planning of a significant number of multi-storey houses was started and 14 subsidized projects with 792 apartments were completed (see figures 5 and 6). Several property developers, both for-profit and non-profit, had started their own PH experiments. By 2009 there were 25 multi-storey PHs in Vienna and in them about 1820 apartments (Lang 2010). The development was similar also elsewhere in Austria, and by 2010 there were around 5000 PHs in the country, most of which were single family houses (Lang Consulting 2013). In 2009, the construction of the Eurogate project started. Eurogate is a new residential area in the third district of

Vienna. It will consist completely of multi-storey PHs making it one of the largest PH neighborhoods in the world with its 1600-2000 apartments at the time of estimated completion in 2019 (Stadt Wien 2013a). The Eurogate project can be seen as the culminatum of the breakthrough phase. During the breakthrough phase also the PH interest group, IG Passivhaus, was highly active and promoting constantly the PH concept (Lang 2013). The breakthrough phase of PHs was partly pushed by subsidies of the city of Vienna. This subsidy was established in 2007 and it funds the building of multi-storey residential PHs by 60€ per m2 (Neubauverordnung 2007), which covers approximately half of the estimated extra investment costs compared to minimum building code (Hüttler 2013). According to the calculations of the author based on the data received from the department of the subsidies for new buildings in the city of Vienna (Magistratsabteilung 50, 2013), the city has granted about 7,6 million Euros as these PH subsidies since 2007. Despite of this subsidy, after the first decade of the 21st century, the growth of the PH sector started to stabilize.

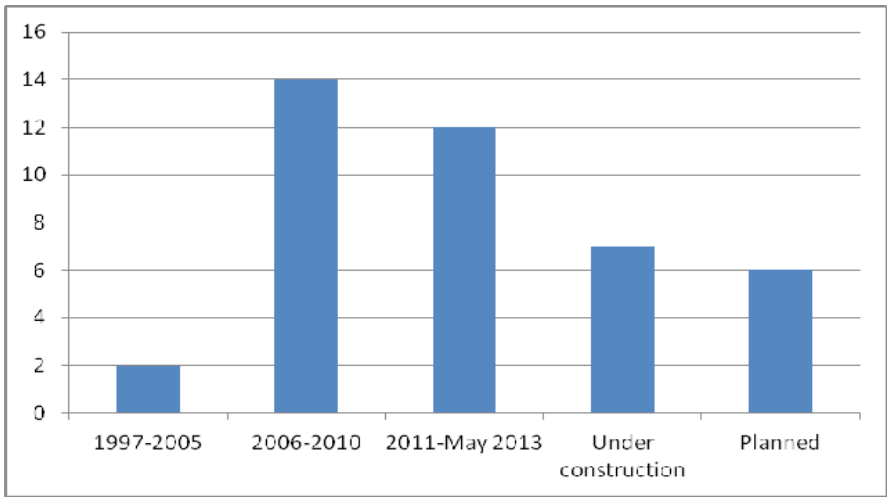

Figure 5. The completed multi-storey residential passive houses subsidized by the city of Vienna (Magistratsabteilung 50, 2013).

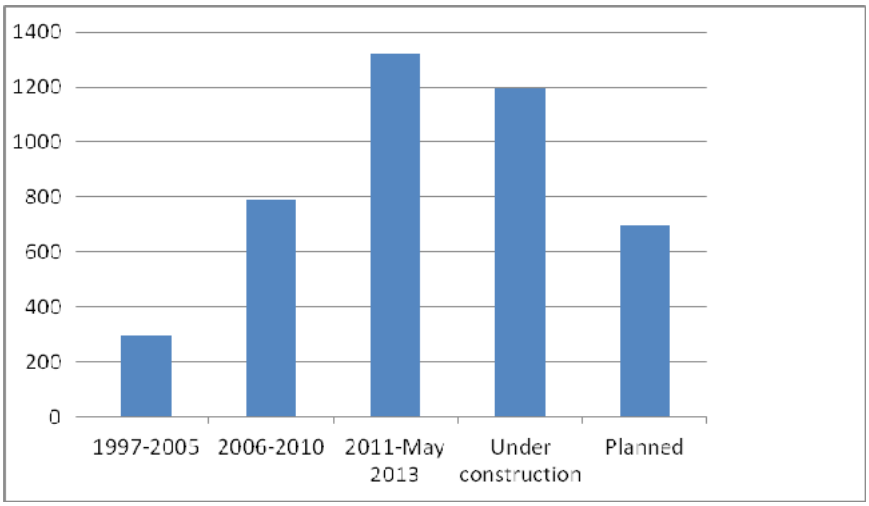

Figure 6. The completed apartments in multi-storey passive houses subsidized by the city of Vienna (Magistratsabteilung 50, 2013).

This period from about 2011 to the present day is seen as the maturation phase of PHs in Vienna. Since the turn of the last decade, the growth rate of PHs has stabilized and PHs no longer seemed to experience an explosive growth (Lang 2013). This change can be seen from the number of the granted subsidies of the city of Vienna to residential multi-storey PHs (see figure 5). During this period, 12 PH projects built with the city subsidy were finished and only 7 more are under construction and 6 in the planning phase. However it should be noted that the PHs built in the maturation phase have been bigger than before, and the number of apartments in subsidized PHs has remained to grow (see figure 6), and from 2011 to the present day 1320 PH apartments were finished, from which 545 were in the Eurogate project (Magistratsabteilung 50, 2013). Due to the large size of the project, the PHs built in this project spread to a long time period. Thus the number of projects and apartments completed during the maturation period over-estimates the willingness to build according to the PH concept during the last few years.

In any case, the PHs have established themselves in a strong position among the housing techniques, and currently about 25% of the new buildings in Vienna are built in PH standard (IG Passivhaus Ost 2012). PHs are nowadays considered rather common in the housing sector, as many property developers already have experience from PHs (Haertl 2013, Jedliczka 2013), and therefore not considered as innovative and attractive as in the breakthrough phase. Also the growing political discourse about affordable living and the rapid growth of the city of Vienna has discouraged the building of PHs, and has created more demand for cheaper apartments (Jedliczka 2013, Hüttler 2013, Kislinger 2013a, Stude 2013). This has been seen e.g. in the case of aspern Seestadt, which will be a major new residential area of about 20 000 inhabitants in North-Eastern Vienna by the time of its completion in 2028 (Stadt Wien 2013b). This residential area was planned to be built in energy plus concept (basically PH with additional small-scaled renewable energy production in the building facilities) but this target was canceled to reduce the building costs, and now mostly conventional building techniques are applied (Stieldorf 2013).

Also after first experiences with PHs, some of the property developers and non-profit housing organizations have grown skeptical on the cost-efficiency and the value of the PH concept. Some have stepped back from the PH standard to ease the energy-efficiency targets of their buildings (Hüttler 2013, Haertl 2013, Stude 2013). One reason for this has been the technology that is required for PHs, such as the controlled air ventilation. These necessary devices not only raise the investments and maintenance prices, but are also considered unnecessarily complicated, and there has been a tendency to return to simpler building techniques (Stude 2013, Haertl 2013). There are

also competing green building types in the market, such as the so called Sonnenhaus or active houses which have lower levels of insulation but compensate the energy-efficiency with renewable energy production, such as photo-voltaic panels placed on the roof of the building. The competition between the PH concept and these other concepts has been described as fierce at times, and the concepts have their own competing lobbies (Fechner 2013, Döll 2013, Lang 2013).

Even though the PH has effectively broken through from the niche phase to maturation in just around 10 years in Vienna, it remains to be seen if the PH standard will rise as the dominant building concept in the city or if it will remain only as one technique among others. However, the PH as an environmental innovation can already be seen as a success story in Vienna, and the next sub-chapter will further investigate the actor-network that has created the current situation.

The actor-network of market creation of passive houses in Vienna

The actor-network that has realized the market creation of PHs in Vienna is illustrated in figure 7. In the analysis, four main actors in the market creation of PHs were identified: Political will, Knowledge & knowhow, Idealism and Economic interest. According to the analysis performed in the coding rounds, these actors were seen to summarize the actor-network of PHs in Vienna. These four denominating actors are illustrated as sectors in the figure 7. In these sectors there are several elements – actors, intermediaries, translations and motives – that define each of the actor sectors. The borders of the four actor sectors are represented as lines in the figure 7. In reality such borders are not as clear-cut, and are here represented only for communicational purposes. The elements of the actor-network are linked to each other, which is represented with arrows. These linkages are essential in understanding the actor-network. As Callon (1991: 135) argues, the actors are aligned and defined in their interaction, and without these links, the efforts of actors would be useless, and the market creation would not be possible. Therefore the actor-network should be seen as a whole: the market creation of PHs in Vienna was possible through the interactions of the actor-network. The actor-network thus sums up more than the number of its elements, and none of the elements would have been able to produce the market creation of PHs by themselves. Also, it should be noted that the illustrated connections are not exclusive: only the ones that were analyzed as most important are represented in the figure 7. The illustration presented in the thesis is two dimensional, but better illustration would be a four dimensional actor-network. In reality, the connections between elements are numerous and cross-cutting through the different sectors, thus adding the third dimension. Also, as the networks are dynamic, they have been changing over time, adding the

temporal fourth dimension. However, as will be further argued in the Discussion-chapter of this thesis, the main goal of this analysis was not to try to represent a perfect picture of the actor-network. Instead the main purpose was to encourage understanding the market creation as an actor-network, making the current two dimensional representation adequate for this purpose.

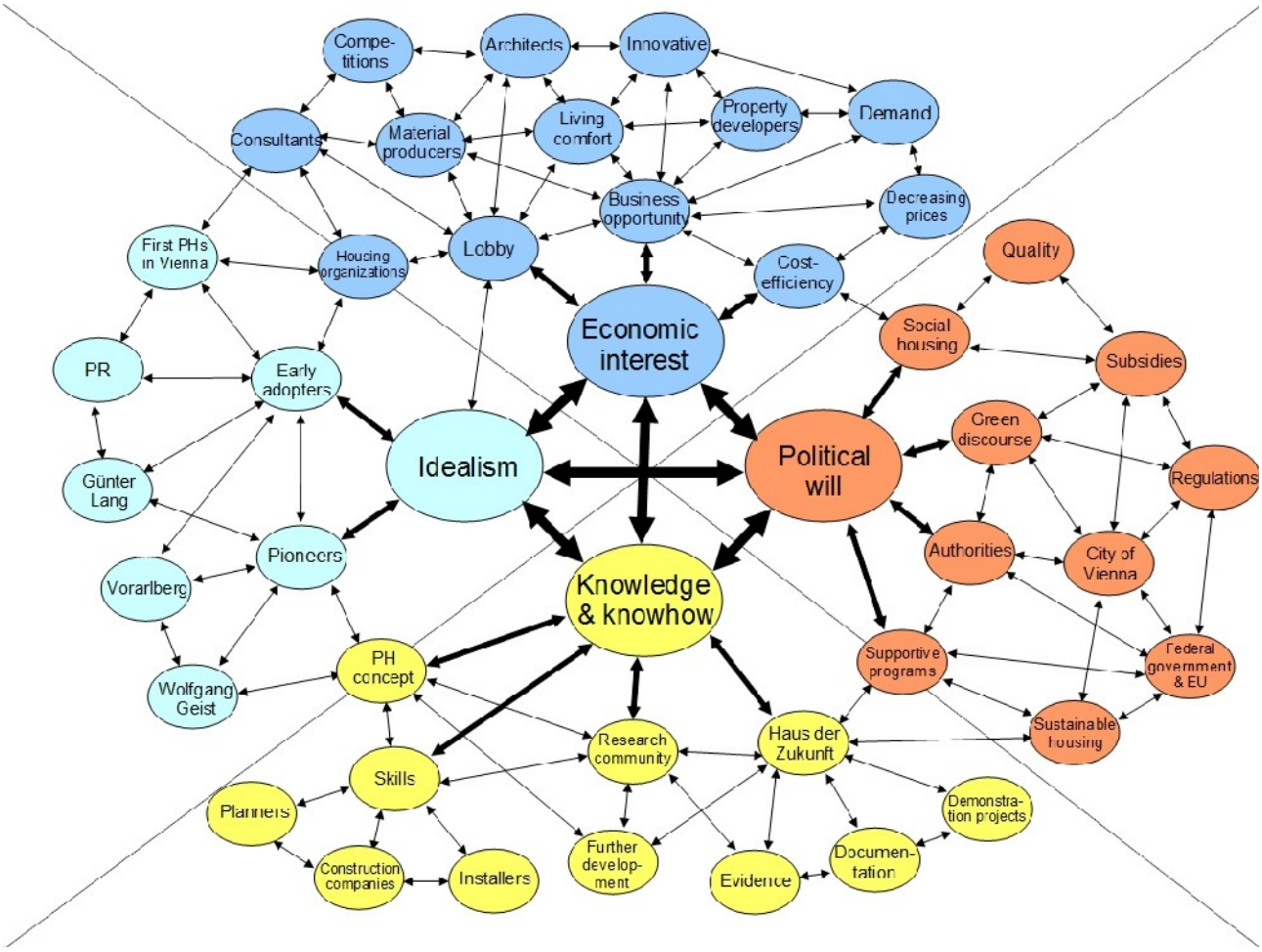

Figure 7. Actor-network of the market creation of passive houses in Vienna.

The main interactions between the four denominating actors are marked with the thickest arrows in the center. These central arrows describe the argument that the sum of the interlinked actors is larger than its parts: the definition of the actor sectors is in their interactions with other actor-network elements. Each of the denominating actors has 2-4 main elements, which are linked with medium-sized arrows to the summarizing actor. The rest of the links are demonstrated with the thinnest arrows. However, it should be noted that even though the represented structure with inner and outer position of the elements, and with different levels arrow thickness in figure 7 would suggest hierarchy, it is important to understand that this not necessarily the case. The elements closer to center of the figure are considered to summarize the sector as a whole, but the actor-network is constructed from all of the elements and their interactions. However, the amount of

arrows is an indicator about the significance of the elements: the more interactions, the more crucial the element has been for the whole actor-network due to the defining element of the interactions. However, not all elements and interactions have been possible to illustrate here, but this figure is designed to show the most important characteristics of the actor-network as could be analyzed from the source data. Finally it should be noted, that the elements in the illustrated actor-network are not necessarily exclusive, and some of them might overlap with each other but represented separately to enable more robust description. In the next part, the four sectors are introduced. The analysis starts from the Political will, and advances in clock-wise direction through each of the elements.

Political will

One of the defining sectors of the actor-network of the market creation of PHs in Vienna has been the political will to support more energy-efficient housing and PHs specifically. This can be seen in the relation of political will with other actor sectors: it makes clear economic sense to reduce energy consumption, and thus costs. The political will has been reinforced by the increasing knowledge about environmental issues and new building innovations, and the ideological drive to pursuit these issues. The political will that has supported the market creation of PHs in Vienna has been manifested through several elements, which have been presented in its sector in the figure 7. This actor of political will is in central importance in the case of Vienna because the housing sector in general can be described to be strongly influenced by several policies and schemes which to large extent direct the housing development (Maier 2013). This influence of political bodies on the housing sector in Vienna originates already from the 1920s and the Red Vienna period, which began the large-scale construction of social housing for the city residents. This social housing was essentially of good quality, which has created a tradition for technically advanced social housing sector, which on the other hand has been described as one of the reasons why the social housing sector has been interested in green buildings (Jedliczka 2013). Therefore social housing has acted as an actor in the market creation of PHs, and quality being one of its main translations in this process (See figure 8).

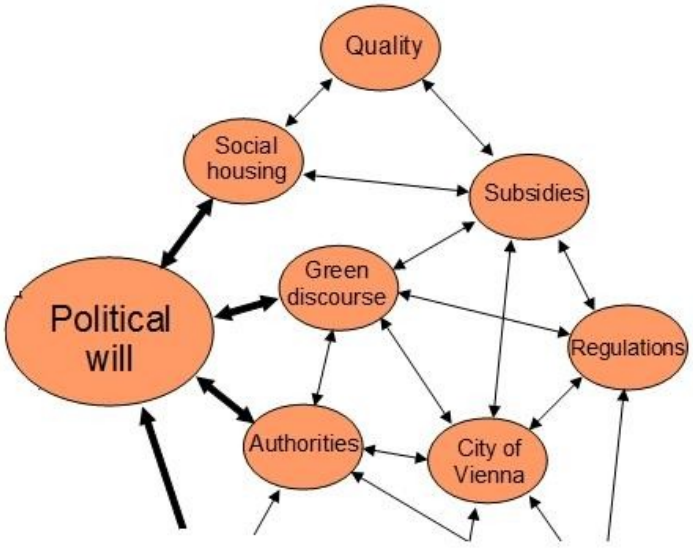

Figure 8. Social housing, green discourse and subsidies.

Another important element related to the political will is the green discourse that has been present. This green discourse equals to the awareness of the need to take action to combat environmental challenges such as climate change and natural resource depletion, and housing has been seen as a sector where the city can make a difference (Chorherr 2007). There has been a political will to implement the green discourse into the housing sector of Vienna (Geissler 2013, Jedliczka 2013). This green discourse is both an actor and a translation of PHs, and is strongly established in the housing sector of Vienna, and the need to gradually reduce the energy demand and emissions of the housing did not seem to be questioned in the actor-network of PHs. As an actor the green discourse was not a visible argument for PHs, but operated on the background of the whole development towards more sustainable housing.

> **J**. **Fechner, 17&4.** *This script you have in your mind, that you should do something to this direction [of climate protection] of course, so if we would not have any climate problems, it would be not so easy: "why should we do that huh?"* (Fechner 2013).

This green discourse has manifested through its intermediaries such as incentives for better energy-efficiency and especially for PHs in the subsidy schemes of the city of Vienna (Neubauverordrung 2007). The main authority to give out these subsidies in Vienna has been the city hall and its departments. The PH subsidy has been directed to all residential multi-storey PH projects in Vienna (Schneider 2013), but there has also been another PH subsidy for high-volume social housing, which has recently been canceled (Kislinger 2013b). These special subsidies have been reported to be highly important for the builders to overcome the higher investment costs of PHs.

> **Author:** *So this subsidy [of the city] was an important reason to support that [the building of a PH]?*
> **S. Haertl, Heimat Österreich:** *Yeah. That's the, sorry, but to build a passive house, [the lower energy costs], that's not in the same range as the higher [investment] costs* (Haertl 2013).

> **W. Hüttler, e7 Energie Markt Analyse:** *This additional subsidy: we asked the housing companies what was the main reason for going to the passive houses, yeah and they said "it was this special subsidy I got"* (Hüttler 2013).

K. Stieldorf, Technische Universität Wien: *Well I think subsidies were very important, I think without subsidies [the passive house development in Vienna] would not have been started well* (Stieldorf 2013).

The city of Vienna can therefore be seen as an important actor in the Political will sector due its encouraging subsidy programs. Vienna has also some influence through regulations, but the more important authorities in the regulative field have been the federal government of Austria and the European Union. The building code of Austria has been gradually tightening the allowed energy demand of new houses (OIB-Richtlinie 6, 2011) and thus acting as an intermediary of the government of Austria (See figure 9). Together with the subsidies, the regulations have been an important intermediary in pushing the housing development towards more energy-efficient houses.

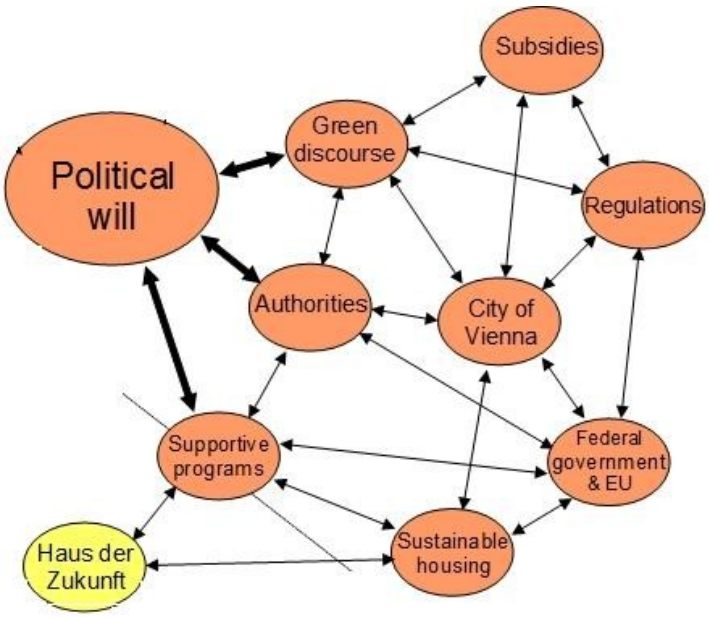

Figure 9. The authorities, regulations and supportive programs.

S. Geissler, ÖGNB: *In fact, the social subsidy system goes ahead, prepares the market for let's say a demand to come, and then the building regulation is tightened towards which is, what people already know from their social subsidy scheme* (Geissler 2013).

Another important political driver for the market creation of PHs was the EU Directive 31 (2010) that requires all new buildings inside the Union from 2021 onwards to be built as ”nearly zero-energy buildings” (NZEB), a concept that has been left for national governments to define. Due to this regulation the trend towards more energy-efficient houses in Europe is clear, which has influenced positively to the market creation of PHs (Döll 2013). However, the change towards NZEBs has been described as too slow this far.

J. Kislinger, ah3 Architekten / IG Passivhaus Ost. *Nobody realizes that 2020 is not somewhere in a light age. It is in 7 years time and nobody realizes that. --- We have to meet these [targets], it’s a regulation, its not something we might achieve, we have to* (Kislinger 2013).

However, the process of this Directive and the definition of NZEBs is yet unfinished. Therefore the Directive is not directly promoting PHs, but has set the trend towards greener buildings.

Highly important intermediaries where this translation of sustainable housing is further supported by the authorities are the supportive programs for PHs and other green buildings. There are several such programs and platforms in Austria which offer e.g. certificates and assessment tools, such as Austrian Sustainable Building Council (ÖGNB) and the federal climate protection program klima: aktiv (Geissler 2013). These programs are supporting the sustainable housing sector, but are not exclusively focused on PHs. Many of the public programs are also aiming to support knowledge and knowhow in the sustainable housing sector, and perhaps the most crucial of these for the market creation of PH has been the research program Haus der Zukunft (Building of Tomorrow).

Knowledge and knowhow

Another actor sector in the actor-network of PHs in Vienna has been the knowledge and knowhow. As the design, the construction and the use of PHs differ from conventional houses, new knowledge and knowhow had to be created. Due to the political will, economic interest and idealism to create the market of PHs the knowledge and knowhow has been able to form as there was willingness to fund and study the concept of PH. On the other hand, without proper knowledge and knowhow regarding the PHs, the market creation of this building concept could never have been possible.

Haus der Zukunft, the mentioned federally funded research project, has been perhaps the most important actor in the knowledge and knowhow sector (see figure 10). It has supported the concept of PH by funding and coordinating both theoretical and practical projects.

J. Fechner, 17 & 4: *Very important factor in Austria of course was Haus der Zukunft, --- what Feist* [the founder of the PH concept] *made in the beginning, it was taken over to Austria by Haus der Zukunft* (Fechner 2013).

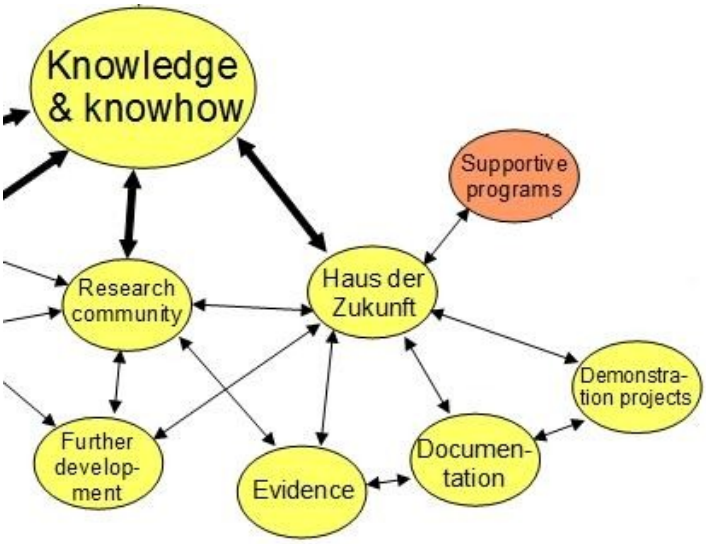

Figure 10. Haus der Zukunft and research community.

> **S. Geissler, ÖGNB:** *I think that the development is very much influenced by Haus der Zukunft, because they are the research stream and they bring the new products and they funded the demonstration projects (*Geissler 2013).

These practical demonstration projects of PHs, which were funded and coordinated by Haus der Zukuft and realized by external companies and organizations, were important as intermediaries in showing in practice that the PH concept was a feasible and viable option.

> **W. Hüttler, e7 Energie Markt Analyse:** *Maybe there was some people at the beginning questioning the practical feasibility* [of the PH] *but this was clear after a few projects that the concept is working and it is also working in practice and people* [the persons living in the PH] *are happy on the average. --- I would say in this innovation story first of all you need something that triggers single projects* (Hüttler 2013).

In the case of Austria and Vienna, Haus der Zukunft was essential in triggering these early experiments, and this research program was involved in realizing some of the very first multi-storey passive houses in Vienna (Haertl 2013, Stude 2013). Another important intermediaries of Haus der Zukunft was their documentation and monitoring activities. The funded projects were well documented and the results were made publicly available in Internet creating a valuable database for professionals in the housing sector (Kislinger 2013). This clear documentation of the Haus der Zukunft projects created, together with the research community, the needed evidence about the PH concept in both theoretical and practical terms. Academic field was also important in this development. For instance in the field of architecture, the faculty of architecture in the Technical University of Vienna (TU Wien) has been studying the concept of PH already since the 1990s and training some of the first PH architects in Austria and Vienna (Stieldorf 2013).

The research community has also an important role in the further development of the PH concept, and e.g. Haus der Zukunft has already moved on to support more advanced concepts, such as the so called plus-energy houses (Haus der Zukunft 2013). It was suggested that the PH as a concept should not stay stagnant and it has further opportunities e.g. in combining PH with the production of renewable energies (Döll 2013, Geissler 2013, Stude 2013). This could also help in keeping the concept attractive for builders who seek evermore innovative building solutions.

B. Stude, BAI. *Passive house is not new anymore, it's kind of standard, so people try - we try - to find out if there's an opportunity to go even further, [to do] something really new again, like we did in 2004* [their first PH]*, and start a zero-energy or even plus-energy building* (Stude 2013).

Another important actor in knowledge and knowhow sector is the skill level of e.g. planners, construction companies, installers and other professionals involved in PHs (figure 11). Designing and constructing a cost-efficient and well-functioning PH requires specific knowhow (Hüttler 2013). This knowhow is offered by formal training programs in the PH techniques both on national and European level (Fechner 2013). The quality and amount of the available training and information regarding PH concept was described to be relatively high (Hüttler 2013). However, there were controversial evaluations of the current skill level among the professionals of the housing sector, and as PH is still rather new concept, especially the construction companies were said to have most to improve (Geissler 2013, Hüttler 2013). The importance of the skill level was nevertheless underlined throughout the interviews, and for instance builders seemed to put special emphasis on the skill level of the companies and individuals that are hired for the planning and construction of PHs (Haertl 2013, Stude 2013). The skill level of planners, construction workers and installers was particularly important actor when evaluating the cost-efficiency of PHs. As earlier mentioned, a recent study has questioned the claimed cost-efficiency of the PH concept, and has pointed that the skills in designing and realizing a PH in a cost-optimal manner are essential in order to achieve good cost-efficiency (Hüttler et al. 2013, Hüttler 2013). Also horizontal learning and communication e.g. between planners on the one hand and also with the construction companies was mentioned to be a notable intermediary in improving the skills and the outcome of the PH projects (Stieldorf 2013, Hüttler 2013).

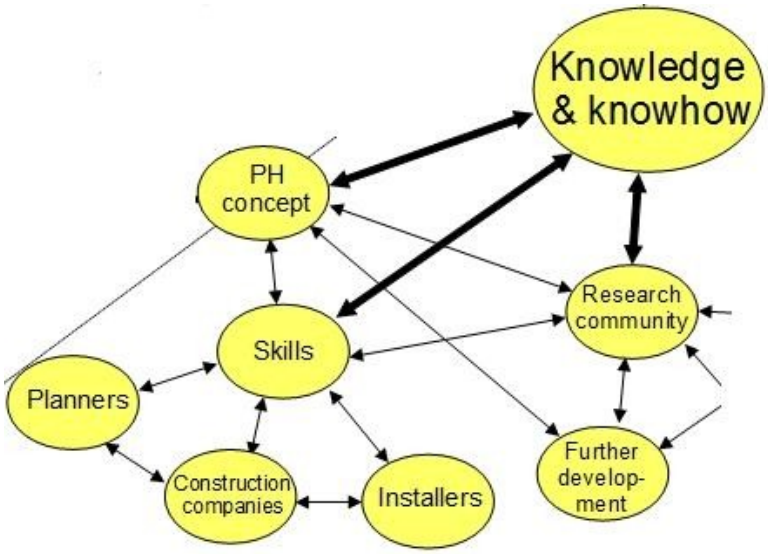

Figure 11. Further development and skills.

Idealism

PHs, as probably any innovations, would not have been realized without a touch of idealism. Even with appropriate political will, knowledge and knowhow, and economic interest, a vast personal commitment and effort from some individuals was needed that the PHs would break through in Vienna. Therefore idealism, a personal drive for some cause, was an essential actor in the market creation of PHs. The early pioneers and developers of the PH concept, such as the founder Wolfgang Geist and his Passive House Institute in Darmstadt, Germany, were obviously essential actors in the process (See figure 12). In Austria, the PH concept was first adopted from Darmstadt in the state of Vorarlberg, and the expertise from this area was important also for the actor-network of Vienna (Stieldorf 2013): for instance some of the first multi-storey PHs in Vienna were designed by architects from Vorarlberg (Jedliczka 2013).

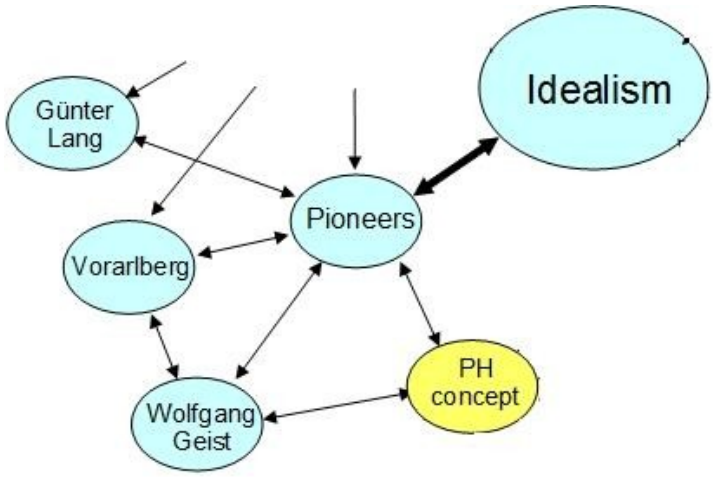

Figure 12. Pioneers.

In Vienna, the actor-network was also characterized by certain individuals, such as Günter Lang, the former CEO of the PH lobby group IG Passivhaus. Lang has pushed the PH concept forward intensively during the niche and breakthrough periods (Döll 2013, Jedliczka 2013). This can be seen for instance in the events leading to the Eurogate project:

> **G. Lang, Lang Consulting:** O*ne person from the third district, [said to me] that there will start --- a competition for a whole area, and he asked if one of these buildings we can start in passivhaus standard, and I said "oh wonderful idea but why only one, why not the whole area in passivhaus standard?". He was from the Green party, I said "where are the green visions?". He said "oh that's not possible, we could not bring it so that all parties will say ok". I said "Let's do it, let's start it!" I wrote the paper, he brought it into the discussion --- They said ok from the district and then comes to the Viennese government to say ok, and so I go three weeks to all meetings of this minister and always asking about passivhaus standard or ask people if they can make a question to him, so that he sees that passivhaus standard is very much in discussion --- he's also*

positive about this, and so on and they will say ok, and then they make the whole competition, architecture competition in passivhaus standard, and this was worldwide the first [residence] area completely with passive houses (Lang 2013).

Besides lobbying, an important intermediary for PH pioneers like Günter Lang was the public relations (PR) work that would create the necessary media attention which would help in creating awareness of the PH concept (figure 13). It was also stated that the way of communicating the PHs in public is important. As the PH in its basics is rather technical concept, it was considered important to communicate the subject in an understandable manner, and to focus on issues such as the improvements to the quality of life that the PH can bring to the user (Döll 2013, Lang 2013). The quantity of promotion has also been extensive.

G. Lang, Lang Consulting: *In this time, I think I had in minimum each month one PR conference or press relation so, and then often sometimes weekly, so we can have a time when each day you have between 5 or 30 press writings about passive house so each day you can read about passive house. --- This time in reality its not 1% of the building sector but you can read every day of that, so the people think "Oh that's very important, maybe we are the only who wasn't active in this sector so we have to start also" So this helps to bring it up* (Lang 2013).

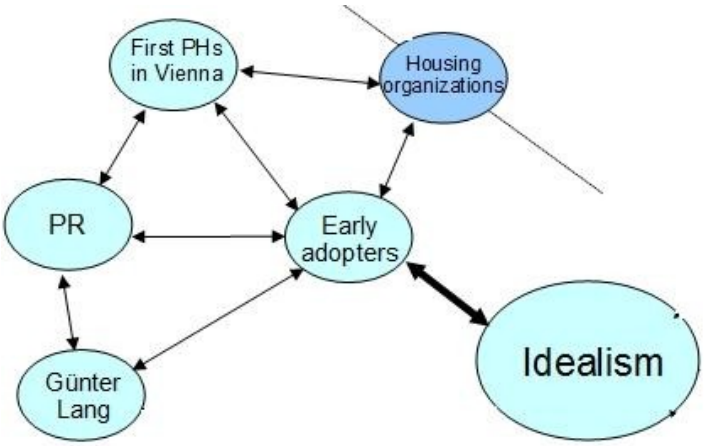

Figure 13. Early adopters and PR.

This media and reputation element was also a remarkable motive for some of the early adopters of the PH concept to start these first projects. PH as a new and environmental innovation offered a possibility to improve the brand of the organization (Jedliczka 2013, Stude 2013). This was true also for the city of Vienna, to whom the developed PH sector has been described as a matter of international reputation and pride (Ludwig 2009). However, regardless of the motives, early adopters of the PH concept were important actors in the market creation of PHs in Vienna. As mentioned earlier, the early demonstration projects played a major role in convincing larger audiences of the viability of the PH concept. Therefore these early adopters, especially non-profit housing organizations, who ordered the first PHs with e.g. the support of Haus der Zukunft, were

important in bringing the market creation from the niche phase to the breakthrough phase. These organizations in general have been some of the first builders to adopt PHs. One reason which has been offered as a reason for this phenomenon is the public funding e.g. through subsidies, and the smaller financial risk due to the lack of need to be profitable (Haertl 2013). Nevertheless, these early purchases helped to create the early market for PHs.

> **J. Kislinger, ah3 Architekten / IG Passivhaus Ost.** *You have come across the ÖAD --- a client who orders, like Günther Jedliczka has told you, he orders passive houses, so there was an epic chance to get a client on the table --- He's a driving factor in ordering, and exclusively ordering passive houses. So these are the factors and reasons why it has been pushed, or big housing companies ordering that* (Kislinger 2013).

These large housing organizations bring us to the last key actor of the market creation of PHs: the economic interest.

Economic interest

The economic interest, the possibility of making profit or cost-savings, is the last actor sector that completes the picture of the market creation of PHs in Vienna. PHs makes clear economic sense for certain actors, such as building material producers for whom the PHs create more demand for their products and the non-profit housing organizations, who seek to reduce the energy costs of their properties. Combined with the political will, appropriate knowledge and knowhow to realize the PHs and with the drive of idealism, the economic interest imbedded in PHs has been the final driver that has made the market creation of PHs possible. One of the most visible actors in the market creation of PHs has been the mentioned PH lobby group IG Passivhaus (See figure

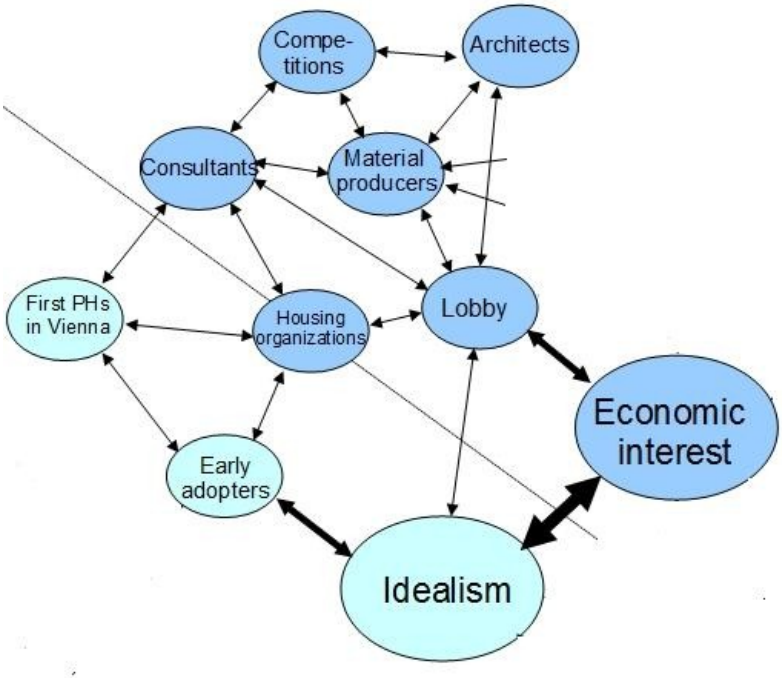

Figure 14. The PH lobby.

14) (Fechner 2013, Hüttler 2013), which can be seen to be driven by the economic interest of its members but also the idealism of some of its key persons, as described in the previous part. IG Passivhaus has been active in involving various organizations from the different fields of housing sector, such as building material producers, architects, housing organizations and consultants (with term "consultants" in this context is meant especially private engineering experts such as building physicists who are essential in planning the actual PHs). The lobby has been involved e.g. in training and lobbying and through these means disseminating the idea of PH (Kislinger 2013).

One of the main groups in the PH lobby is the building material producers. Companies such as multinational insulation material company ISOVER has been promoting PH concept already for more than a decade. One example of their intermediaries in the market creation of PHs has been architecture competitions in PH techniques which ISOVER has sponsored. These events have also been important opportunities in improving communication between varied actors in the housing actors, such as architects (Döll 2013, Stieldorf 2013). Also the communication and social networks between different actors in the building sector was valuable for the market creation, and platforms such as IG Passivhaus are in key position to improve this communication (Lang 2013, Döll 2013, Geissler 2013). Even though obviously present and having importance throughout the actor-network, these social networks seemed to play a key role in the realizations of some of the first multi-storey PHs in Vienna.

> **S. Haertl, Heimat Österreich:** *And we had one research project with Schöberl and Pöll* [building physics company]--- *then they are searching some partner to make it* [a PH project] *real --- I know Helmut Schöberl and then Heimat Österreich came together, they searched for a place where we can build it* (Haertl 2013).

Another important actor group in both the passive house lobby and in the overall market creation of PHs has been the architects (Döll 2013, Fechner 2013, Lang 2013). They have been capable of producing the practical combination of design and energy-efficiency, which is in the core of PH concept (Kislinger 2013, Stieldorf 2013). Austrian PH architects were also credited for being capable of combining the original idea of PH with aesthetic values – an issue which was described to be lacking from the early German PH prototypes (Lang 2013). PH architecture opens up a possibility to combine environmental issues and design in new and innovating ways thus optimizing the building concept (Kislinger 2013). However, more used translation of PH than "innovative" has been the living comfort, which is reached through the comfortable indoor climate due to the

controlled air ventilation and effective insulation (Lang 2013, Stude 2013). Also the end users have been reported to be highly satisfied with their PHs (Hüttler 2013, Stude 2013). The living comfort has therefore risen as a key selling and marketing translation of PH for several actors, and e.g. ISOVER uses the term "multi-comfort house" parallel to PH when marketing the concept (Döll 2013, ISOVER 2007).

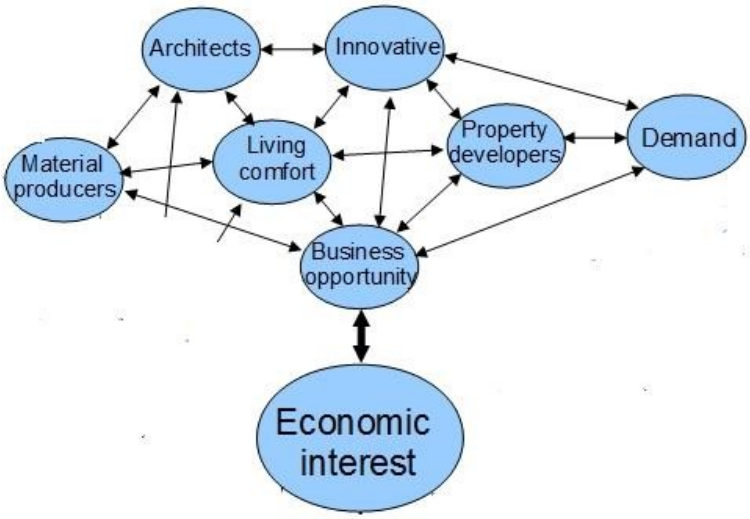

Figure 15. Business opportunity.

This translation of living comfort is an example of the possible business opportunities that the PH has been produced for economic actors such as building material producers and property developers (see figure 15). Not only is a PH energy-efficient, but it is considered to possess qualities that can improve the quality of life, which can be an attractive selling argument (Lang 2013, Stude 2013). The business opportunity that the PH concept creates is in itself an important motive in the economic interest sector. For sectors such as building material industry it is a possibility to sell more of their products (Döll 2013, Geissler 2013) and for private property developers PH is a chance to produce more valuable houses while appearing innovative and forward-looking (Stude 2013). However, private property developers are depended on the demand in the housing market, and recently the trend in Vienna has been towards affordable housing, which the PH concept in the terms of short-term investment costs is not (Döll 2013, Hüttler 2013, Kislinger 2013). However, if the customer demand for PHs and other green buildings would increase, this would pose also an incentive for property developers to build more PHs.

> **B. Stude, BAI:** *With a demand from the customers for certain housing standards, e.g. passive house or solar energy, especially in the high-price sector, developers would act accordingly to keep up with their competitors* (Stude 2013).

However, due to the steadily increasing demand for PHs, the prices of building materials and PH techniques, such as ventilation systems, have been decreasing (Stude 2013) (See figure 16). The development of the building material sector has been seen as remarkable importance for the whole development of the PH concept (Kislinger 2013).

Cost-efficiency is another essential aspect in the economic interest sector. Some supporters of the PH concept argue that the life-cycle costs, or cost calculation that involves also the running costs of PHs in a long-term timeline, make the PH a cost-efficient building solution (Döll 2013, Kislinger 2013). Even though the claimed cost-optimality of PHs in practice has been challenged (Hüttler 2013), PH concept has been attractive for some non-profit housing organizations, such as those operating in the social housing sector (Jedliczka 2013). Due to the cost-efficiency, there might be a business opportunity in the social housing sector. If the cost-optimal level of PHs is reached in planning and construction, and the investment costs of PHs are decreasing due to cheaper materials, the low long-term energy costs might become more attractive for some organizations. E.g. social housing organizations build houses for their own use and they manage their properties for decades, and therefore benefit from low running costs during the lifetime of the PH. Therefore the particularly strong social housing sector in Vienna might be a key actor in the future market creation of PHs in Vienna, assuming that it becomes more economically attractive housing option.

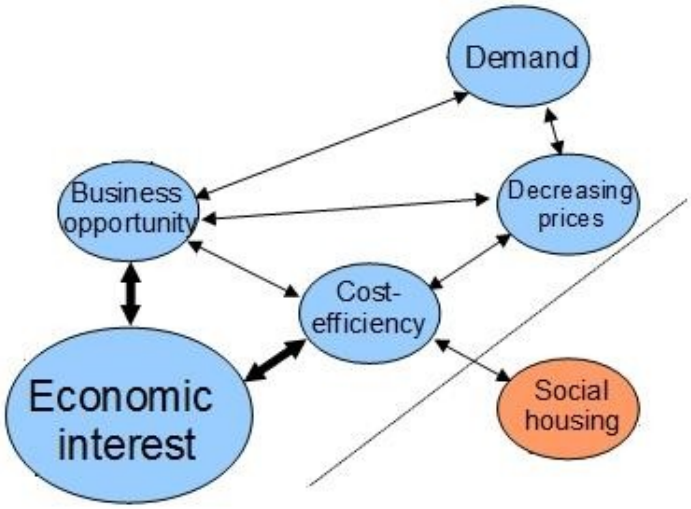

Figure 16. Decreasing prices and cost-efficiency.

5. Discussion

This chapter discusses the findings of this study with the theoretical framework presented earlier in this thesis. The chapter begins by discussing the ANT and the market and reflects the use of these theories in the study of passive houses (PHs) in Vienna. After this part, some of the results are compared with the previous knowledge regarding the housing markets. The chapter ends with some reflections about the limitations of the study.

Actor-network theory (ANT) is said to be effective in understanding the connection between varied actors in networks (Kera and Tuters 2011) and in unpacking economic constructions (Gabriel and Jacobs 2008). As could be seen in the previous chapter, the market creation of an environmental innovation such as a PH was hardly a pure and clear-cut economic process, but a complex web of varied social elements, both human and non-human actors (Smith et al 2006, Lovell 2005). Therefore by applying a theory such as ANT as the analytical method, relatively comprehensive picture of the market creation of such innovation has been possible to produce. ANT's emphasis on both non-human and human actors was essential in understanding the diversity of materials working in the market creation of PHs (compare with Callon 1987 and Law 1992). For instance, the information collected in this study to answer the research questions revealed that materials such as history (tradition of quality social housing), ideas (the green discourse), public spending (subsidies), communities (the city of Vienna), research programs (Haus der Zukunft), buildings (demonstration projects), professionalism (skills), enthusiastic individuals (PH pioneers), interest groups (lobbies), money (business opportunities), companies (property developers) and many other elements have played a role in the market development of PHs in Vienna. Without a broad and tolerant analytical framework essential knowledge that might help in understanding sustainable transitions would have been lost. For instance, focusing only on economic incentives or human actors, the analysis would have been strongly biased and only explaining one part of the complex system of the market network. However, by following the linkages between actors in the research data, but also through the method of snowballing from an interviewee to another, these same linkages between varied types of actors became more visible and open for analysis.

ANT puts great emphasis on the interactions of the actors and claims that the actors and the networks are defined in the interactions between actors and in the intermediaries that they put into motion (Callon 1991: 135) – in other words – in their framing characteristics (Callon 1998a: 15, 51). The importance of these interactions can easily be seen from the figure 7 which represents the

actor-network of the market creation of PHs in Vienna. Even though this study at best could find and report only the part of these interactions which were most visible and crucial for the development to take place, the complex and crucial linkages between different elements of the actor-network and their defining nature of the actors in question is imminent. For example, the city of Vienna could be seen as a supporter of PHs due to the PH subsidy, an intermediary, it has offered. Also building material producer such as ISOVER could be seen important for the market creation of PHs due to its multiple activities in this field. For instance, ISOVER has been actively involved in the activities of another actor, the passive house lobby IG Passivhaus, arranging intermediaries such as architecture competitions in PH standard and promoting significant translations of the PH standard, such as the living comfort.

In order for the network to work effectively, it has to be coherent, which is achieved e.g. through common translations (Callon 1991: 143-146, Law 1992: 385). In the case at hand, the translation of PHs has not been totally harmonious, which can be seen as one of the reasons why the growth of the PH sector has slightly stagnated. For instance, PH was argued to be cost-efficient by some of the supporters of the concept, but this was challenged by other voices. Therefore the translation of cost-efficiency dissolves due to the lack of common agreement, which partly decreases the coherence and viability of the actor-network of the PH concept in Vienna. Also, sustainable housing does not automatically translate as PHs in Vienna due to the presence of competing green building concepts, such as the Sonnenhaus or active house, in the market. Further on, the translations are in constant change, as well as networks in general (Law 1992: 385). This was evident in the remarks that after a decade of PH development in Vienna, the PH does no longer translate as innovative, as it used to in the niche and breakthrough phases of the development. This notion underlines the need of the PH concept to constantly develop and evolve, in case it wants to be considered as exciting and innovative also in the future.

As Colarelli O'Connor and Rice (2013) point out, the market creation of an innovation can take time, but once the necessary actors, intermediaries and translations are in place, the development can advance rapidly, as could be seen in the breakthrough phase of the PH development in Vienna. In the case of PHs in Vienna, the most important actor sectors were the political will, knowledge and knowhow, idealism and economic interest. The actors in these sectors used intermediaries such as supportive programs, demonstration projects and subsidies, and translations such as sustainable housing, innovation and living comfort. When comparing the results of this study with Jensen (2012), one can see that the housing sectors are strongly tied to the local conditions. Even though

there are some similarities with the Danish context, e.g. in the role of interest groups and building material producers and the translations of need for development and innovativeness, these notions strengthen the earlier assumption that the market creation of PHs or other green buildings in a certain city cannot be exported as such to another context. Having said this, Smith's (2007: 447) remark on the possible slowness of regime actors, such as in this case the large property developers, to adopt new innovations held true to some extent. While some large private property developers in Vienna, such as BAI, built their first PH already early in the breakthrough phase, the non-profit housing organizations, such as ÖAD, were the first-movers to adopt the PH concept. Therefore the study at hand would suggest directing the market entry strategy of PHs in other cities to e.g. social housing organizations that are not operating solely on economic grounds.

This thesis has taken on to the study call of Callon (1998a) on investigating *"the anthropology of markets"*. The market of PHs and its creation has been seen as a social construction, and this actor-network of the PH market has been studied according to the method defined by the ANT. In the light of ANT, the market of PHs has not only been driven by the actors (compare with Callon 1998a: 51, Sarasvathy and Dew 2005: 558, Lovell 2005, Kjellberg and Helgesson 2007) but partly formed *of* them. For instance, without the work of the PH pioneers in developing and diffusing the PH concept, or without the capabilities of architects in creating them, or without the trend towards energy efficiency imbedded in the green discourse, there most likely would not be a product of PH for which to create the market. From the view point of ANT, the PH itself is an actor-network which constitutes from varied actors, intermediaries and translations, many of which are the same as in its market creation. Important in seeing the PH and its market as actor-networks is to understand their dependency on their actors, intermediaries and translations. As can be seen in the case of PHs in Vienna, the good and working links between actors through effective intermediaries, such as subsidies, regulations, research programs, demonstration projects, PR etc. have been capable of creating the market. Understanding the market of PH as an actor-network opens it up for critical examination, which can be used for further advancing this innovation. As a conclusion to this part of the Discussion chapter, it is argued that in the study of dynamic constructions, such as the markets (Callon 1998a: 47), the ANT serves best as way of understanding the network, but perhaps not as a historical research method. Therefore also the results of this study should be seen as an inspiration to see the market creation and an environmental innovation such as the PH as an actor-network rather than as a clear and accurate picture of the actual actor-network that has been in place in Vienna. This issue is further discussed in the next sub-chapter on the limitations of this study.

Limitations of the study

As argued earlier in this thesis, ANT understands networks as dynamic constructions. However, this thesis has to some extent had a historical approach: it has wanted to understand how the market creation PHs has taken place in Vienna, a process which has been spread for at least 10 years time span. In the understanding of ANT this network of PHs has been in constant change during this time. As the data used in this study was collected only on a certain time period, spring of 2013, the empirical research of this study is biased with the view that has been present in that given time period. Therefore by the own definition of ANT about the dynamism of networks, the method based on the ANT cannot reproduce an exact *a priori* picture of a historical process. This possible bias could have been perhaps avoided by undergoing more extensive analysis of e.g. contemporary newspaper articles, political debates etc. from each of the phases of the PH development. However, it was seen that focusing on these kinds of methods would have compromised the ability to find the crucial links between the actors and other actor-network elements, which are at the core of ANT. By reading secondary sources rather than interviewing some of the actors directly with questions designed to uncover the actor-network, the research method would have risked missing some of the essential interactions that are more likely to open up in personal communication. Therefore the choice of using ANT as the main theory of this thesis and choosing interviews as main data collection method posed a methodological tradeoff: having in-depth knowledge but with a temporal bias. However, as the market creation is constantly on-going, the focus of this thesis has never been purely historical, but has also regarded current and future aspects. Therefore the results of this thesis are an overview of the market creation of PHs in Vienna, combining the historical, present and future perspectives.

This thesis took on a big topic: trying to uncover a vast network of a well-established innovation which has been active in several temporal phases in a big housing market of a major European capital, without prior personal contacts in the city, in a country and culture that was practically unknown to the author, partly in a language that the author did not master (German), with a topic and sector where the author was inexperienced in (PHs and building sector) and by using a theory that was completely unknown to the author (ANT) before the thesis, and all this in a timescale less than four months. These conditions put obvious limits to the reliability of the results of this thesis. Due to the time constraints, also thorough analysis of e.g. all of the multiple housing policies and schemes, as well as their internal connections, which have been present in the housing market in Vienna have been lacking from the empirical research of this thesis. Therefore the view on the

policy and regulative field was left vague. Also the number of interviews could have been larger. Even though the narrative of the PHs in Vienna began to saturate during the last interviews, more interviews could have given more depth to the analysis. For instance only one private property developer and one building material producer were interviewed in this thesis, and therefore the view of the private sector was left somewhat thin.

Despite the limitations, the thesis is seen successful in meeting the study objectives. As mentioned, this thesis should be seen as an inspiration to understand the market creation of environmental innovations as a network. Even though the empirical research can be seen to uncover some of the main aspects of the actual market creation of PHs in Vienna, this picture should not be seen as the perfect representation. These and other main lessons to be learned in this thesis are further presented in the following Conclusions-chapter of this thesis.

6. Conclusions

This thesis was based on an argument that market and economy can be used as mechanisms to support the sustainability transition of the society. In order to be able to support these processes, better understanding about the market creation of environmental innovations was seen necessary. This problem formulation set out to study a Viennese example of a successful environmental innovation, the passive house (PH) development, and its breakthrough to the housing market of the city. Research questions of this thesis were designed to find out about this case of PHs and to learn about the market creation of environmental innovations. Through applying actor-network theory, empirical research regarding this topic was commenced to be able to answer these research questions. These answers and results are presented in the next part.

The actor-network of the market creation of PHs in Vienna has been consisted of four main actor sectors and their interactions: political will, knowledge and knowhow, idealism and economic interest. These summarizing actors consisted of multiple actors, intermediaries, motives and their linkages that define these sectors. For instance, the political will to implement the green discourse in the housing sector has enabled authorities such as the city of Vienna or the state of Austria to introduce subsidies and regulations that have been involved in the market creation of PHs. Through e.g. support from publicly funded initiatives such as the research program Haus der Zukunft, the knowledge and knowhow base in PH concept has been able to improve. In order for the PH technology to take off, well documented and coordinated demonstration projects were seen important to provide practical evidence of the feasibility and viability of the PH concept in the local context. Also adequate skill-level in PH techniques and its continuous improvement in the housing sector was seen necessary, and the early knowhow in PH was imported from early pioneers such as from the Passive house Institute of Wolfgang Feist and the state of Vorarlberg in Western Austria. Also idealism and personal commitment to drive the PH concept was needed to push it through to the housing market. Early adopters such as non-profit housing organizations were important in the early phases of the market creation in introducing the concept in practice to the housing market, an effort that acted as an encouragement for other similar organizations as well as private property developers. The completing actor in the market creation was the economic opportunities the PH concept possessed for certain agents such as building material producers, whose businesses benefited from the PH concept e.g. through increasing sales. These interest groups as well as other interested actors were collected under an umbrella of a lobby organization, which has also been an

active element in the market creation. PH also had certain qualities, such as cost-efficiency, which would translate as an economic interest for e.g. non-profit housing organizations.

The main lesson to be learned from this thesis is the relevance of the actor-networks for the market creation of environmental innovations. By understanding the innovations and their markets as an actor-network in their given contexts, one can pay attention to the crucial interactions and relations that enable the market creation. This has been the case of PHs in Vienna. Like in the example of Thomas Edison earlier in this thesis, the market creation of innovations cannot be realized by only focusing on one single or a few sectors of the innovation, such as technical issues, but has to understand the whole actor-network as equally relevant for the success of the innovation, and develop all sectors simultaneously. Therefore the market creation of environmental innovations calls for managerial approach that would take the whole picture of the relevant actor-network into account. This managerial approach would need to take care that the crucial connections between actor-network elements exists and support each other, so that the market creation will proceed as a coherent and aligned unit, as a single and well-connected network. In the case of Vienna, the PH lobby IG Passivhaus has to some extent acted as the managerial body who has been able collect different agents together and to establish connections between the actor sectors.

The four actor sectors presented in this thesis are rather generic and probably relevant also in other market creation cases of major environmental innovations. However, the actor-network of PHs in Vienna should not be seen as a model to be applied elsewhere. Having said this, there are some parts of the actor-network dynamics which are worth noticing as learning-points. For instance the subsidy system present in Vienna was seen important for the growth of the PHs, and especially in combination to the tightening building code. This double effect from regulation and incentive could be seen as an effective tool of the local and national governments to steer the market towards more sustainable housing. In addition to this, the effective research and demonstration scheme, Haus der Zukunft, further advanced the market. This versatile approach to housing policies by the local and national governments where different policies support and complement each other has been proven to be effective in supporting the market creation of PHs. This could be a valuable learning-point for policy-makers.

It also seemed obvious that the PH sector would not be what it is today without a great dedication of certain individuals. This personal drive behind an environmental innovation should not be undermined. Therefore this dedication should be supported where possible, e.g. through supportive

programs such as arranging alliances with other actors both inside and over the borders of a specific product actor-network and try to align the specific products to the overarching whole. For instance, as also Fechner (2013) argued, PHs are most effective in improving sustainability only when joined together e.g. with sustainable urban planning with dense and effective public transport systems. In the market creation of PHs these connections to other fields, such as to urban planning or to public transport systems, did not seem to play a large role, even though the concept could have had clear synergies with parallel developments in neighboring segments, such as public transportation or renewable energy production, of the urban context. More extensive cross-sectoral integration could bring more leverage power to an otherwise rather isolated environmental innovation such as a PH. Combining the visions of several complementary environmental pioneers might result in more comprehensive sustainability transition. Also social and economic sustainability should not be forgotten – energy-efficiency cannot be the only interest of housing policies. The admirable tradition of quality social housing in Vienna should be cherished, and the PH poses potential for long-term cost-savings and improvement to living standards in the social housing sector.

Therefore, highly energy-efficient buildings pose a great opportunity to improve the sustainability in the housing sector. This Green House Effect is worth supporting by further studies. This thesis has mainly focused on the market creation of PH as new buildings. However, the existing conventional housing stock poses even greater opportunity to increase the energy-efficiency and to reduce emissions. Even though in many cases technically possible, the energy refurbishment of the existing buildings to PH level is not advancing as well as hoped. Therefore more effort should be directed to this sector of energy refurbishment in order to enable faster transition towards sustainability. For instance, the possibilities of introducing alternative funding mechanisms for energy refurbishments, such as energy contracting, could pose an exciting opportunity to advance the energy-efficiency of the existing housing stock. These possibilities to open the actor-network of PHs to more actors in order to advance the market would be an interesting further research topic.

References

Berger, L. P. and T. Luckmann. 1966. *The Social Construction of Reality. A Treatise in the Sociology of Knowledge.* Penguin Books: London.

van den Bergh, J.C.J.M, Bernhard Truffer and Giorgos Kallis. 2011. Environmental innovation and societal transitions: Introduction and overview. *Environmental Innovation and Societal Transitions 1.* pp 1-23.

Bijker, W. E., T. P. Hughes and T. J. Pinch (Eds.). 1987. *The Social Construction of Technological Systems. New Directions in the Sociology and History of Technology.* The MIT Press: Cambridge, Massachusetts.

Callon, M. 1987. Society in the Making: The study of Technology as a Tool for Sociological Analysis. In W. E. Bijker, T. P. Hughes and T. J. Pinch (Eds.). *The Social Construction of Technological Systems. New Directions in the Sociology and History of Technology.* The MIT Press: Cambridge, Massachusetts.

Callon, M.. 1991. Techno-economic networks and irreversibility. In J. Law (ed.). *A Sociology of Monsters: Essays on Power, Technology and Domination.* Routledge: London and New York.

Callon, M. 1998a. Introduction: the embeddedness of economic markets in economics. In M. Callon (Ed.). *The Laws of the Markets.* Blackwell Publishers/The Sociological Review: UK.

Callon, M. 1998b. An essay on framing and overflowing: economic externalities revisited by sociology. In M. Callon (Ed.). *The Laws of the Markets.* Blackwell Publishers/The Sociological Review: UK.

Chorherr, C. 2007. Statement in a public debate about green buildings in the city council of Wien. Member of the city council of Vienna. The Green party. 25th May 2007. <http://www.wien.gv.at/mdb/gr/2007/gr-021-w-2007-05-25-077.htm>

Cohen, B. and M. I. Winn. 2007. Market imperfections, opportunity and sustainable entrepreneurship. *Journal of Business Venturing 22.* pp. 29-49.

Colarelli O'Connor, G. and M. P. Rice. 2013. New Market Creation for Breakthrough Innovations: Enabling and Constraining Mechanisms. *The Journal of Product Innovation Management 30:2.* pp 209-227.

Döll, M. 2013. Semi-structured interview. Saint-Gobain ISOVER. 16th April 2013.

Ellis, T. 2010. *The new pioneers. Sustainable business success through social innovation and social entrepreneurship.* John Wiley & Sons: UK.

EU Directive 31. 2010. Directive 2010/31/EU of the European Parliament and the Council of 19 May 2010 on the energy performance of buildings. *Official Journal of the European Union L 153/13.*

Fechner, J. 2013. Semi-structured interview. 17 & 4 Organisationsberatung. 3rd of May 2013.

Förster, W. *80 Years of Social Housing in Vienna.* Vienna Housing Subsidies Department. <http://www.wien.gv.at/english/housing/promotion/pdf/socialhous.pdf> 14th May 2013. Original date of publication unknown.

Gabriel, M. and K. Jacobs. 2008. The Post-Social Turn: Challenges for Housing Research. *Housing Studies 23:4.* pp. 527-540.

Geels, F.W. 2006. Co-evolutionary ad multi-level dynamics in transitions: The transformation of aviation systems and the shift from propeller to turbojet (1930-1970). *Technovation 26.* pp. 999-1016.

Geels, F. W. 2010. Ontologies, socio-technical transtitions (to sustainability), and the multi-level perspective. *Research Policy 39.* pp. 495-510.

Geissler, S. 2013. Semi-structured interview. Österreichische Gesellschaft für nachhaltiges Bauen (ÖGNB). 9th April 2013.

Granovetter, M. and P. McGuire. 1998. The making of an industry: electricity in the United States. In M. Callon (Ed.). *The Laws of the Markets.* Blackwell Publishers/The Sociological Review: UK.
Haertl, S. 2013. Semi-structured interview. Heimat Österreich. 29th April 2013.
Haus der Zukunft. 2013. English version. Building of Tomorrow. <http://www.hausderzukunft.at/english.htm> 17th May 2013.
Hüttler, W. 2013. Semi-structured interview. e7 Energie Markt Analyse. 25th April 2013.
Hüttler, W., Rammerstorfer and Tudiwer. 2013. *InnoCost – Cost-effectiveness of innovative multi-family-residential buildings in Austria.* e7. Preliminary report.
ISOVER 2007. *Built for the future: The ISOVER Multi-Comfort House. Live comfortably – Save natural resources.* Saint-Gobain Insulation: France.
IG Passivhaus Ost. 2012. *So fühlt sich wohnen besser an!* Brochure about passive houses.
Jedliczka, G. 2013. Semi-structured interview. ÖAD Housing. 4th April 2013.
Jensen, J. S. 2012. Framing of regimes and transition strategies: An application to housing construction in Denmark. *Environmental Innovation and Societal Transitions 4.* pp. 51-62
Kera, D. and M. Tuters. 2011. Actor-Network Theory. In Mulvaney, D. and P. Robbins (eds.). *Green Technology: An A-to-Z Guide.* SAGE knowledge. <http://knowledge.sagepub.com.zorac.aub.aau.dk/view/greentechnology/n1.xml> 30th March 2013.
Kislinger, J. 2013a. Semi-structured interview. ah3 Architekten / IG-Passivhaus Ost. 10th April 2013.
Kislinger, J. 2013b. A personal e-mail. ah3 Architekten / IG-Passivhaus Ost. 17th May 2013.
Kjellberg, H. and C-F. Helgesson. 2007. On the nature of markets and their practices. *Marketing Theory 2007 7:2.* pp. 137-162.
Lang, G. 2010. 1000 Passivhäuser in Österreich. Passivhaus Objektdatenbank: Interaktives Dokumentations-Netzwerk Passivhaus, 3. Dokumentationsperiode 2006-2009. *Berichte aus Energie- und Umweltforschung 85/2010.* Bundesministerium für Verkehr, Innovation und Technologie.
Lang, G. 2013. Semi-structured interview. Lang Consulting. 5th April 2013.
Lang Consulting. 2013. *Geschichte des Passivhaus.* <http://www.langconsulting.at/index.php/de/das-passivhaus/geschichte-des-passivhaus> 17th May 2013.
Larson, A. L. 2000. Sustainable innovation through an entrepreneurial lens. *Business Strategy and the Environment 9.* pp. 304-317.
Latour, B. 1996. On actor-network theory: A few clarifications. *Soziale Welt 47:4.* pp. 369-381.
Law, J. 1991. Introduction: monsters, machines and sociotechnical relations. In J. Law (ed.). *A Sociology of Monsters: Essays on Power, Technology and Domination.* Routledge: London and New York.
Law, J. 1992. Notes on the Theory of the Actor-Network: Ordering, Strategy, and Heterogeneity. *Systems Practice 5:4.*
Lockyer, Sharon. 2007. Coding Qualitative Data. In Lewis-Beck, M. S., A. Bryman and T. F. Liao (Eds.). *Encyclopedia of Social Science Research Methods.* SAGE Knowledge. <http://knowledge.sagepub.com.zorac.aub.aau.dk/view/socialscience/n130.xml> 19th November 2012.
Lovell, H. 2005. Supply and Demand for Low Energy Housing in the UK: Insights from a Science and Technology Studies Approach. *Housing Studies 20:5.* pp. 815-829.
Ludwig, M. 2009. Statement in a debate at the city council of Vienna. Executive city councillor for housing, housing construction and urban renewal, city of Vienna. 24th November 2009. <http://www.wien.gv.at/mdb/gr/2009/gr-053-w-2009-11-24-020.htm>

Magistratsabteilung 50. 2013. *Subsidized residential multi-storey passive houses in Vienna.* An Excel-sheet compiled by the MA 50 of the city of Vienna.
Maier, G. 2013. Discussion. Head of the Research Institute for Spatial and Real Estate Economics. Wirtschaftsuniversität Wien. 7th May 2013.
Neubauverordnung 2007. 2007. *Verordnung der Wiener Landesregierung über die Förderung der Errichtung von Wohnungen, Geschäftsräumen, Heimplätzen, Eigenheimen, Kleingartenwohnhäusern und Einrichtungen der kommunalen Infrastruktur im Rahmen des Wiener Wohnbauförderungs- und Wohnhaussanierungsgesetzes - WWFSG 1989 (Neubauverordnung 2007). Landesgesetzblatt für Wien 27/2007.* City of Vienna.
Neubauverordnung 2007. 2012. *Verordnung der Wiener Landesregierung über die Förderung der Errichtung von Wohnungen, Geschäftsräumen, Heimplätzen, Eigenheimen, Kleingartenwohnhäusern und Einrichtungen der kommunalen Infrastruktur im Rahmen des Wiener Wohnbauförderungs- und Wohnhaussanierungsgesetzes – WWFSG 1989 (Neubauverordnung 2007). B 630-060. 2012/18.* City of Vienna. 14th May 2013.
OIB-Richtlinie 6. 2011. *Energieeinsparung und Wärmeschutz.* Österreichisches Institut für Bautechnik. <http://www.oib.or.at/RL6_061011.pdf> 1st May 2013.
Sarasvathy, S. D. and N. Dew. 2005. New market creation through transformation. *Journal of Evolutionary Economics 15.* pp. 533-565.
Schneider, B. 2013. Personal e-mail. Department of subsidies for new buildings, city of Vienna. 8th May 2013.
Senge, P. M. and G. Carstedt. 2001. Innovating Our Way to the Next Industrial Revolution. *MIT Sloan Management Review 42: 2.* pp. 24-38.
Smith, A. 2007. Translating Sustainabilities between Green Niches and Socio-Technical Regimes. *Technology Analysis & Strategic Management 19:4.* pp. 427-450.
Smith, S.J., M. Munro and H. Christie. 2006. Performing (Housing) Markets. *Urban Studies 43:1.* pp. 81-98.
Stadt Wien. 2013a. *Aspanggründe/Eurogate im Zielgebiet Hauptbahnhof Wien – Erdberger Mais.* <http://www.wien.gv.at/stadtentwicklung/projekte/zielgebiete/erdbergermais/teilgebiete/aspanggruende-eurogate/> 17th May 2013.
Stadt Wien. 2013b. *aspern Die Seestadt Wiens.* <http://www.wien.gv.at/stadtentwicklung/projekte/aspern-seestadt/> 17th May 2013.
Statistik Austria 2012. Population forecast 2012. <http://www.statistik.at/web_en/statistics/index.html> 4th March 2013.
Stieldorf, K. 2013. Semi-structured interview. Technische Universität Wien. 11th April 2013.
Stude, B. 2013. Semi-structured interview. Bauträger Austria Immobilien (BAI). 2nd May 2013.
Tuomi, J. and A. Sarajärvi. 2009. *Laadullinen tutkimus ja sisällönanalyysi.* 5th Edition. Kustannusosakeyhtiö Tammi: Helsinki.
Vail, M. 2010. Market. In M. Bevir (Ed.). *Encyclopedia of Political Theory.* SAGE knowledge <http://knowledge.sagepub.com.zorac.aub.aau.dk/view/politicaltheory/n271.xml> 18th April 2013.

Appendix

Interview questions used

Introduction

1. Please introduce yourself and your organization.
2. How did you personally end up working in the green buildings sector?
3. How long have you and your organization been involved in this field?

The development of passive houses and the actor-network in Vienna

4. Please describe the history of passive houses in Vienna. Has the development been market or policy-driven? What were the important decision etc. ?
5. How has your organization been involved in the field of passive houses in Vienna?
6. Who have been talking in favor of passive houses?
7. What have been the drivers for the construction of passive houses in Vienna? E.g. Political, economical, environmental...
8. In your opinion, what are the advantages of passive houses?
9. What have been the main barriers for passive houses? Why?
10. What kind of disputes there have been in the field of passive houses, e.g. political, economical etc.?
11. Who or what have been against passive houses? Why do you think this was?
12. Have you been cooperating with other people or organizations involved in the passive house sector, e.g. through common projects? How would you describe this cooperation?
13. What are the benefits of this kind of cooperation?
14. What are the lessons to be learned from the passive house sector?

Epilogue

15. How do you see the future of passive houses in Vienna?
16. What are the challenges of the passive house market? What are the opportunities?
17. Who should I interview next?