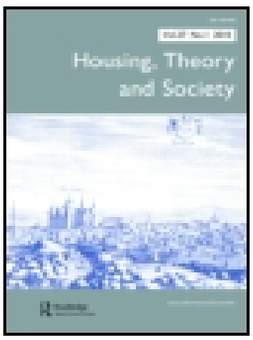

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Energy Efficient Housing through Organized Interactions? Conceptualizing the Roles of Householders and Providers in Housing Retrofitting in the Netherlands and China

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ABSTRACT

Energy saving is an explicit goal of housing retrofitting in both the Netherlands and China. Retrofit providers expect to achieve this goal by applying insulation to apartment buildings and improvements in heating, cooling and ventilation. The aim of this paper is to explore both conceptually and empirically the interactions between householders and retrofit providers. Interaction activities are conceptualized in a framework of overlapping practices of retrofitting and everyday life. Empirical material is derived from interviews with retrofit providers and householders in the Netherlands and China. This paper shows that full energy saving potential in housing retrofitting fails to be accomplished, due to a limited involvement of householders at the consumption junctions in retrofit processes. Central to this failure are the limited options for residents to share pre-retrofit living experiences, to test future housing equipment beforehand and to customize retrofit packages. Also post-retrofit educational support, evaluation and monitoring is falling short to engage householders in their appropriation of their retrofitted apartment.

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China; the Netherlands; housing retrofitting; providers-household interaction; householder participation; technology appropriation

1. Introduction

On a global level, one-third of carbon emissions originate from the built environment (UN Environment and International Energy Agency 2017). The majority of carbon emissions in the built environment are caused by energy consumption in existing residential housing. This phenomenon makes the energy performance of existing housing crucial in achieving national and international sustainability goals. Both in China and the Netherlands, emphasis in energy policies is on large-scale programmes of apartment building retrofitting and includes energy saving and standards of living and living affordability of housing for the urban poor. The retrofitting policy goals for China and the Netherlands aim for making fifty to sixty percent of the existing residential housing stock more energy efficient (Yang et al. 2013; Lijzenga et al. 2019)) towards a theoretical energy saving target of fifty to sixty-five percent in Chinese housing estates (Davoudi, Zhao, and Brooks 2014) and roughly fifty percent or more in Dutch social housing

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(Majcen, Itard, and Visscher 2013). Around the world, improving wall insulation, windows, window shades and energy efficient systems of heating and ventilation are covered in substantial financial contributions to programmes of housing retrofitting as strategic approaches for realizing low carbon cities (UN Habitat 2011).

Local governments, construction companies, housing associations and landlords are the main private and public stakeholders involved in the provisioning of apartment retrofitting to achieve energy saving. In provisioning, these stakeholders are responsible for organizing the process of investigation, redesign and actual implementation of retrofit projects and technologies. In both China and the Netherlands, retrofit providers recognize that housing retrofit projects with district heating and individual heating are of strategic importance to realize stringent sustainability goals (Xiong et al. 2015; Van Leeuwen, De Wit, and Smit 2017). However, studies in other countries show that retrofit providers conceive their role in the retrofit process primarily in terms of the installation of new technologies and building elements for heating, cooling, ventilating and insulation that are expected to lead to energy savings(Guy and Shove 2000). This illustrates that the provisioning stakeholders commonly use an instrumental approach in which organized activities to interact with households in the different stages of the retrofit process. Activities of introduction, visualization, consultation, construction, supervision and maintenance, are restricted to a largely top-down and limited one-way information provision (Karvonen 2013). The existing power structures in the organized interaction activities are often based on hierarchy and control, which has contributed to a reputation of conservatism and poor customer care (Owen and Mitchell 2015). The overall results of retrofit processes worldwide are reported to be less than expected in terms of realized domestic carbon reductions. This might be influenced by a narrowly top-down defined role for providers to facilitate householders' needs and desires in how activities in the retrofit process are set up (Dixon and Eames 2013; Winther and Wilhite 2015).

Reportedly, retrofit providers' assumption of complete energy efficient domestic behaviours after retrofitting is not realized (Sunikka-Blank and Galvin 2012). The observation that the domestic behaviours of households matter to realize low carbon energy consumption in the housing sector is well-documented in the academic literature. Gram-Hanssen (2010) shows a large variation in energy consumption between households living in identical housing, which may add up to 300%. Similarly, Diamond (1984) has shown major differences in energy consumption between identical apartments in moderate climates. This variation in energy consumption is caused by differences in the everyday activities and routines of households in the Netherlands and China (Santin, Itard, and Visscher 2009; Hu et al. 2017). All householders make use of energy for a range of energy intensive domestic practices, such as heating, cooling, ventilating, lighting the apartment, cooking, showering, watching TV and hosting guests (Naus et al. 2014). The differences in energy use implied in these routinised domestic practices are determined by a number of factors, including the nature of technological improvements, the competences of householders for working with these technologies, and the sociocultural standards of comfort, cleanliness and convenience (Shove 2003) the householders are accustomed to.

Building upon these studies, we take as a starting point that the energy saving results of the organized activities in housing retrofit processes depend upon the facilitation of

support for post-retrofit domestic practices. Particular performances of domestic practices co-determine the level of energy consumption and carbon reductions realized by retrofit projects (Maller, Horne, and Dalton 2012). When the new energy efficient housing improvements and behavioural options are considered from a householder point of view, they can either be ignored, adopted or adapted to make them fit their everyday life practices. The actual energy-use patterns of households before and after the retrofit processes are therefore of strategic relevance to providers in the organized interaction activities during the retrofit process. In line with Gabriel and Watson (2013), we acknowledge that better energy saving results are realized not just by top-down provisioning of energy efficient housing improvements but also by envisioning and helping to realize the new post-retrofit domestic practices that contribute to low carbon housing.

Consequently, householders' domestic practices and related energy use patterns are important considerations when organizing the various provider-household interaction activities during the housing retrofit process in both China and the Netherlands (Dixon and Eames 2013). The way in which policy makers, building regulators, technology designers and other institutional actors organize the interactions with householders in the retrofit process may influence the performance of post-retrofit domestic practices (Dowling, McGuirk, and Bulkeley 2013; Walker, Lowery, and Theobald 2014). The interaction between providers and householders can be organized in several ways (Fuller et al. 2010) depending on national and local rules and regulations and on the kind of technologies in housing. Interaction can be more or less structured, more or less frequent, more or less conflictual, and more or less fine-tuned to the needs and expectations of the participants. To understand the various possible interactions in retrofitting in a global context, there is need for cross-cultural and cross-jurisdictional research. To find out the consequences for the most prominent future visions in housing retrofitting (Karjalainen 2013) with either individual heating and district heating, it is strategic to analyse China and the Netherlands. Due to the prominence of district heating in public-sector led Chinese retrofit policy, we expect more emphasis on collectivized arrangements in the retrofit processes of low-income Chinese communities. In contrast, due to the prominence of individual heating in the private sector-led Dutch retrofit policy, we expect emphasis on individualized arrangements in the retrofit processes of Dutch social housing estates. If different ways of interacting between stakeholders determine how domestic practices may change after the retrofit process, the study of the varying organized interaction activities in both counties would be key for understanding how to achieve energy saving in housing retrofitting.

This paper intends to answer the question: *How can the organized interaction activities between householders and providers in Dutch and Chinese housing retrofitting projects for energy saving be conceptualized, understood and improved?* To answer this question, we analyse the expectations of householders and providers regarding the uptake of social and technical innovations determining the carbon performances of post-retrofit domestic practices. We analyse how householders and providers in systems of retrofit provision in both countries perceive the need for interactions and their views on the best possible ways to organize these interactions. In doing so, we investigate options to improve the interaction in different phases of the retrofit process. This paper concludes with the formulation of recommendations in retrofit processes to determine improvements for

alternative household-inclusive pathways of housing retrofitting leading to a better realization of energy savings.

In the next section, we present a conceptual framework to analyse the organized interaction activities between providers and householders in retrofit projects. Section three describes the research design and the methods used. A demonstration of the use of the overall research approach is presented in the section on the findings of selected Dutch and Chinese housing retrofitting projects. In the concluding section, we address the research questions and formulate general recommendations to improve the interaction between providers and householders in housing retrofit projects in both countries.

2. Investigating the Organized Interaction Activities between Retrofit Providers and Households

Since householders and their domestic practices are such important targets for retrofit interventions, we first discuss the concept of households (2.1). We then go on to specify retrofit as an intervention project that is organized and carried out primarily by actors and stakeholders within the systems of provision that are involved in the retrofit process (2.2). To investigate the interaction activities between providers as dominant organizers of the retrofit process and the households as important "targets" of retrofit interventions, we suggest using the theory of social practices and, in particular, retrofit practices of intermediation as representing the different forms of organized interaction activities between providers and households (2.3). The conceptual model and more specific research questions are formulated in section 2.4.

2.1 Conceptualizing Households as Conglomerates of Domestic Practices

Ulrich Beck has suggested that in its simplest form, the household as a social institution refers to a group of people sharing a kitchen table and a washing machine (Beck 1986). In most social science research, households are operationalized primarily in terms of the individuals making up the household. What occurs in the apartment is explained as resulting from the dispositions, preferences and more or less rational choices made by the inhabitants. Analyses of social change that make use of variables and indicators that "belong" to individuals are referred to in the literature as "individualist accounts of social change". Such individualist approaches fall short in considering the fact that individuals, to a considerable extent, act within the contexts of time, space and interactions (Shove 2003; Spaargaren 2003). As an alternative approach, social practices, instead of individuals, are taken as a focal point for theorizing and researching households. More specific units of analysis in this more contextual approach are made clear by this definition of a social practice:

> *A 'practice' is a routinised type of behaviour, which consists of several elements interconnected to one other; forms of bodily activities, forms of mental activities, 'things' and their use, a background knowledge in the form of understanding, know-how, states of emotion and motivational knowledge* (Reckwitz 2002, p. 249).

This definition includes the presence and usage of know-how with material things and also emphasizes the role of emotions and motivational knowledge as a structuring element "of the social" in a practice. The direction of domestic practices is guided by different motivational affectivities, such as thermal comfort, health, autonomy, economy, sustainability and safety (Shove 2003; Van Vliet, Chappels, and Shove 2005). When analysing the interconnected elements in domestic energy consumption, Naus et al. (2014) suggest focusing on a set of interconnected domestic practices that are of direct relevance to the overall energy consumption of the household. The way appliances, such as heating devices, air conditioning units, light bulbs, kitchen appliances and washing machines, are used all have an impact on the energy profile of the household. A prominent issue is how meanings and expectations of existing and emerging thermal comfort practices are entangled in housing retrofitting projects. The energy use in domestic practices can differ widely as a result of the efficient performances of energy intensive technology or adaptive strategies, such as wearing additional clothing in the winter (Valdorff 2017).

2.2 Systems of Retrofit Provision

Most of the control to direct social practices inside the apartment is at the consumer end of the chain, but substantial changes in energy use are also shaped by the "upstream" activities of actors and organizations responsible for the technological systems their apartments are plugged into. This phenomenon connects to the simplest definition for systems of provision as: "*an inclusive chain of activity that attaches consumption to the production that makes it possible*" (Fine 2002, p. 79). Fully understanding domestic energy use requires analysis on the way in which social practices in an apartment are materially furnished in historically developed infrastructures of technological systems. From a consumer point of view, technological systems, such as district heating in large parts of China and individual heating in the Netherlands, are an outcome of the ways in which city authorities, energy suppliers, and landlords have performed their conventional tasks in relation to their systems of provision (Fine, Bayliss, and Robertson 2018; De Feijter, Van Vliet, and Chen 2019). Over the past decades, inhabitants of Chinese and Dutch housing estates have been confronted with a wide range of policies, rating systems and regulations to target the energy dimension of domestic life. In the context of apartment, improvements like double glazing, wall insulation, new window types, new window shades, energy efficient appliances and smart energy metres are becoming normal items to consider in retrofitting. The technical rationality that dominates the provisioning networks may conflict with the life-world rationalities of how households organize their daily lives. The places where on the one hand the technological instrumental logics of the retrofit provision systems (Bayliss, Fine, and Robertson 2013) run into the logics of everyday life energy consumption in domestic practices on the other hand, are called consumption junctions (Schwartz-Cowan 1987). These consumption junctions relate to the sites and settings for communication, decision and maintenance of technical equipment within networks of household-consumers and networks of providers. At these sites of intermediation, Fine, Bayliss, and Robertson (2018) proposes a "vertical" analysis to look at different access points in the process that energy consumption passes across the chain of provision. Each access point reveals different power relations between providers and household-consumers.

2.3 Sites of Intermediation as Retrofit Practices

To unravel sites of intermediation in systems of retrofit provision, more attention is needed to the access points within networks of providers and household-consumers. In different phases of intermediation, the scope for, and the use and expectations of retrofit improvements are co-determined. The process of retrofitting apartment buildings is divided in a pre-retrofit phase and a post-retrofit phase (Owen and Mitchell 2015). The pre-retrofit phase comprises identifying the retrofit opportunities and options, followed by the selection of options. The post-retrofit phase starts with the subsequent retrofit construction activities and the commissioning of retrofit measures, followed by the use and maintenance of the retrofitted home. Since the rise of user centred design approaches (Norman 1986), design decision making (Hansen and Andreasen 2004) and innovation management (Hidalgo and Albors 2008), there is increasing emphasis on the importance of users' needs and requirements as subject for technology design. Also, Ornetzeder and Rohracher (2006) emphasize the importance of organized negotiation activities with householders in the *pre-retrofit phase*, to make the improvements fit to their dynamic everyday lives. Others (Way and Bordass 2005; Brown, Swan, and Chahal 2014) highlight that activities with householders in the often-neglected *post-retrofit phase* are essential for the fit to retrofit adoption. Building on this research, we propose to focus on both the organized activities in the pre-retrofit phase as well as the post-retrofit phase. In the following, we describe the strategic negotiation activities in the pre-retrofit phase as *retrofit recruitment* and the strategic adoption activities in the post-retrofit phase as *retrofit appropriation*. The organized activities of retrofit recruitment can be divided into: 1) retrofit plan making, 2) visual demonstration of retrofit possibilities and 3) retrofit participation approval. Retrofit appropriation can be divided into: 4) retrofit evaluation 5) education in retrofitted housing equipment usage, and 6) energy monitoring of retrofitted housing equipment. These different contact moments of recruitment and appropriation have become institutionalized through stable procedures in routine treatment by policy protocols, manuals and standards (Judson and Maller 2014; Palm and Reindl 2016). We propose to determine these contact moments of recruitment and appropriation as social practices of retrofit intermediation to put institutional, technical and social settings into context (Macrorie, Foulds, and Hargreaves 2015). These social practices of retrofit intermediation comprise of a recognizable set of routinized interaction activities between retrofit providers and householders on the retrofit, including know-how, rules and conventions about the planning and management of retrofit resources (Shove et al. 2007; Judson, Iyer-Raniga, and Horne 2012).

2.4 Conceptual Model and Specific Research Questions

The previous sections explain that social practices of retrofitting need to be taken into account for the complete realization of Dutch and Chinese government targets around energy conservation in the built environment. The application of rules and resources for insulation and improvement of the technical infrastructure for heating, cooling and ventilation is organized into *systems of retrofit provision* (left side of Figure 1) by local and (sub)district governments, construction companies, housing associations and

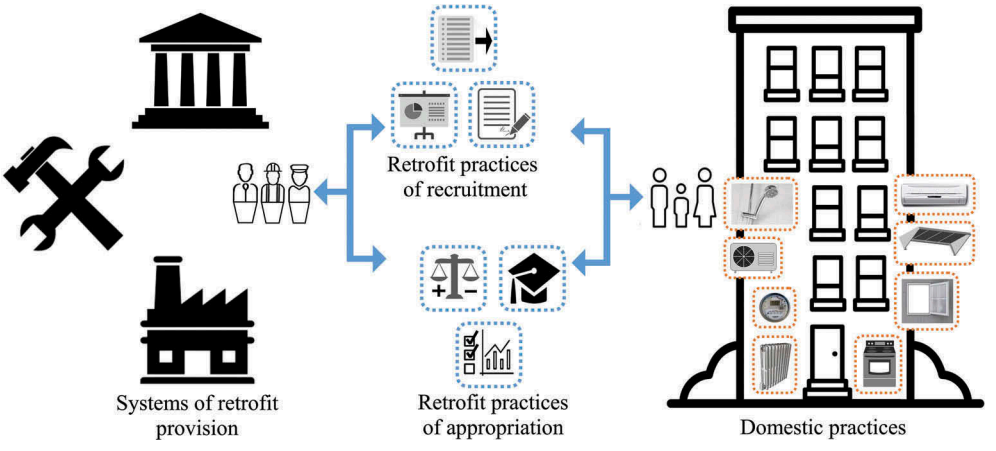

Figure 1. Conceptual framework for studying housing retrofit interventions.

landlords. To achieve the expected energy savings, retrofit providers are dependent on the ways in which the *domestic practices* (right side of Figure 1) of heating, cooling, ventilating, cooking, showering, washing and hosting guests are executed before the retrofit. We postulate that the retrofit practices of intermediation during the process of retrofitting are crucial for how post-retrofit domestic practices will be performed after the retrofitting. In retrofit practices of intermediation, utilization of knowledge, reflexive learning and technology assessment can potentially lead to more energy efficient post-retrofit domestic practices. Figure 1 shows that systems of retrofit provision and householders affect the energy efficiency of domestic practices primarily through the *retrofit practices of recruitment* (top side in the middle of Figure 1): plan making, demonstration and participation; and the *retrofit practices of appropriation* (bottom side in the middle of Figure 1): evaluation, education and monitoring.

Based on this conceptual model, we are now able to formulate more detailed research questions for this paper:

- How are retrofit practices of recruitment being shaped and performed in housing retrofitting processes in China and the Netherlands?
- How are retrofit practices of appropriation being shaped and performed in housing retrofitting processes in China and the Netherlands?
- How and to what extent can insights in retrofit practices of intermediation contribute to energy efficient post-retrofit domestic practices in China and the Netherlands?

3. Research Design

To better understand how systems of retrofit provision can influence domestic practices, we investigate the organized social practices of retrofit intermediation between providers and householders. A case study approach is used, employing qualitative methods of data gathering. Qualitative methods are specifically designed to clarify the meanings of social relations and to focus on the way different people experience, interpret and

structure their lives. Understanding the performance of social practices benefits from a comparison between different performances that are spatially distributed. As such, the differences between the chains of retrofit practices, where the domestic practices are settled in, can be addressed, providing better insight into the subtleties of the interplay between practices and practitioners. We have chosen the Netherlands because of its recently initiated extensive programmes for apartment retrofitting in social housing, which have been strategically set up to boost energy saving retrofit programmes in all other sorts of housing (Oorschot et al. 2018). The global abundance of housing apartments and retrofitting programmes made it evident to focus on multiple countries in our study. While acknowledging the major differences in cultural, political and economic respects, comparing the case of the Netherlands with China is relevant because both countries have large institutional programs for apartment retrofitting. Besides that China has the largest potential for energy saving in housing worldwide (Berardi 2016). While in the Netherlands both collective and individual arrangements exist, the emphasis in Amsterdam is expected to be on individual arrangements, because of the prominence of individual heating systems over district heating in Amsterdam. Because of the widely spread district heating systems in Beijing, the latter is chosen to analyse collective arrangements in China, while the city of Mianyang may exemplify the Chinese individual arrangements because of its widely applied individual heating systems in housing. In analysing the cities, this paper is based on a selection of retrofit projects (Table 1) that are distributed over them, 6 retrofit projects in Amsterdam, 3 retrofit projects in Beijing and 3 retrofit projects in Mianyang.

Analysing at least three retrofit project cases in each city makes it possible to compare the similarities and differences of the project cases to obtain cross-case and cross-country insights. The researched retrofit projects are large-scale multi-story residential apartment blocks, with a primary focus on wall insulation and windows in relation to heating, cooling and ventilation strategies, built before the era in which energy saving became a common prerequisite in Dutch and Chinese urban planning and building regulation. In addition, another criterion for the selection of these cases is that the processes for retrofitted apartment buildings are governed by institutional actors (local government, housing association, constructors and architectural design companies) rather than by individual householders. Along with the site visits to the different retrofit projects, 80 semi-structured interviews were conducted with different stakeholders of the retrofit projects. The semi-structured interviews allow interviewees

Table 1. Researched retrofit projects in the three cities.

Name	Building year	Retrofit construction period
Het Breed (Amsterdam)	1968	2013–2016
Karel Klinkenberg (Amsterdam)	1958	2015–2017
Plesman (Amsterdam)	1958	2014–2015
Knijtijzerpanden (Amsterdam)	1955	2014–2015
Koningsvrouwen van Landlust (Amsterdam)	1936	2009–2012
Olympia (Amsterdam)	1926	2010–2014
Muzongchang (Mianyang)	1997	2015–2016
Lishan (Mianyang)	1993	2015–2016
Gong'an (Mianyang)	1988	2015–2016
Chezhan (Beijing)	1990	2015–2016
Fuchenglu (Beijing)	1986	2016–2017
Ling Tong Guan (Beijing)	1970	2015–2016

Table 2. Interviews in the three cities.

Interviews	Amsterdam	Beijing	Mianyang
Householders	17	14	14
Constructors and architects	9	3	3
Representatives of governmental agencies	3	4	4
Citizen organizations	2	0	0
Scientific experts	1	3	3

the freedom to express their views in their own terms and to solve misunderstanding directly. The focus in the interviews was directed to the different organized interaction activities "before" and "after" the retrofit process, provider/householder relations and the broader retrofit policy context. The interviews were both recorded, transcribed,

anonymized and coded by the researchers. Selection of interviewees was based on their relevance for needed information, diversity between interviewees and accessibility (Table 2). The interview findings are triangulated with observations of retrofit projects and with findings from the literature to strengthen the validity of the collected data.

4. Empirical Results: Practices of Retrofit Intermediation and Everyday Life in the Netherlands and China

To obtain a social-scientific understanding of housing retrofitting processes and their intersection with domestic practices, we explore both the organized activities in retrofit practices of recruitment prior to the retrofit (4.1) and in retrofit practices of appropriation after the retrofit (4.2) and related domestic practices in the Netherlands and China.

4.1 Retrofit Practices of Recruitment

4.1.1 Plan Making

The process to define retrofit plans is largely structured by governmental regulation and available financial resources of housing associations in the Netherlands and (sub-)district governments in China. The development of retrofit plans is extensively pre-determined by a routinely conducted technical building assessment, combined with detailed estimations of budget and staff availability. For example, the budget for a unified basic retrofit of €35,000 for one apartment in Amsterdam and ¥300,000 (€40,000) for 56 apartments in Mianyang is determined by technical building assessments only. A constructor in Amsterdam shares: "*We analyse the heat leakages of the housing estates to define the retrofit plan. This is also the basis of evaluating our company's performance after the retrofit*" (30-04-2017; Karel Klinkenberg). Characteristically, the plan making only offers space for householders to decide about some minor issues, such as the colour of the walls in shared entrances and staircases in a resident questionnaire, which is one of the few ways for residents to express their views on the retrofit. In our fieldwork, we have encountered a resident questionnaire in Mianyang with only one open-ended question for free expression, while an example from Amsterdam has no open-ended questions. Such a resident questionnaire has been completely absent in one case in Beijing. The routine performance of pre-determined resident questionnaires typically frames householders as a "passive barrier". Or, as a Chinese retrofit provider expresses:

"*We have a clear retrofit plan [. . .] Some householders are very difficult to persuade. They are very selfish*" (20-10-2016; Lishan). As brought forward in different interviews, the purpose of plan making is to comply with unified energy efficiency targets and, in the case of China, earthquake protection and cultural heritage. For conventional providers, these goals are pursued on the basis of technical building assessments without the involvement of residents.

Commonly, plan making practices do not connect to understandings of pre-retrofit domestic practices of Chinese and Dutch householders, although biographies of historically developed practices, such as heating, cooling and ventilating, could be valuable experiences to include in plan making. Apart from utilizing the technical know-how of occasional householders, these experiences could potentially lead to the generation of better problem definitions and potential retrofit solutions. As this Dutch householder explains: "*I had argued for a complete insulation of the outside walls from the beginning. Initially, the retrofit provider did not agree [. . .] I know how difficult it is to keep the living room warm when using the heater [. . .] After months, they had to come back on their initial bad decision*" (27-11-2017; Karel Klinkenberg). Another example shows the potential to connect plan making practices with norms of safety in pre-retrofit domestic practices, as illustrated by this Chinese householder: "*First, we heard our housing estates would be demolished. I think this would have been the best option for our old apartments. Later, they decided to retrofit [. . .] I am not satisfied with the lack of attention to the security of the buildings and its surroundings*" (26-10-2016; Ling Tong Guan). How easily pre-retrofit domestic practices can be connected to plan making is illustrated in Mianyang by the creation of a public facility for e-bikes, where pre-retrofit storing and charging was done inside the apartments with narrow staircases. A Dutch householder suggested to renew sensor-based lighting in the storage area, to insert a clothing line and to add a coat hook at the back of the door. When these suggestions are not taken into account in largely top-down decided retrofit plans, householders report that it disturbs their trust in retrofit providers.

4.1.2 Demonstration

Both in China and the Netherlands we observe that physical configurations of housing retrofitting are demonstrated to residents before the retrofit. Demonstration entailed putting large billboards in the neighbourhood or organizing collective or individual visits to a model apartment or an already retrofitted neighbourhood nearby. The visited retrofit projects in Mianyang solely use large demonstration billboards with limited information on the physical housing equipment. In the visited retrofit projects in Beijing and Amsterdam, demonstration spaces are solely used to prepare residents for the retrofit intervention. A Dutch retrofit provider admits: "*I mainly use the model apartment to show the uniform impact of the retrofit plan. I also mark the indoor working spaces we need during the retrofitting [. . .] I could imagine additionally presenting a short movie about energy saving next time*" (12-01-2017; Karel Klinkenberg). Current demonstration practices prioritize passive visualization of housing equipment, without the possibility for householders to test future heating, ventilation devices and new windows, which make the current organized activities hardly fit to show future efficient use. According to a Chinese retrofit provider in Beijing: "*Designing a retrofit sample is a common way to show householders the new housing equipment. Additionally, in this*

project, it was quite helpful. Almost all the residents visited our model apartment. This is the first step of visualization" (01-11-2016; Fuchenglu). The common goal in demonstration practices of retrofit providers is showing standardized technical visualizations of housing equipment. By no means it offers householders opportunities to test an energy efficient model apartment.

Demonstration practices hardly align with the shared motivational affectivities of everyday life of Chinese and Dutch householders. Such motivational affectivities include aesthetics, autonomy, health, daily living comfort ("keeping warm feet", "coziness", indicated by the occurrence of drafts, or moisture). These are the key motivations for residents to engage in a retrofit, rather than the technical aspects, which are typically exemplified in the model apartments (installations, insulation values and energy labelling). Or, as a Dutch householder explains: "*The future use of housing equipment should be considered more. I should have known earlier that the radiators take more space [. . .] and the colour of the painted balconies becomes dirty easily [. . .] Additionally, the paving stones to prevent slipping [. . .] and the new air vents are very difficult to clean*" (27-11-2016; Het Breed). When zooming in, the anticipated impact on future domestic practices is difficult to oversee because of the current non-inhabited nature of the model apartment as well as differences between the model apartment and resident's own apartment. According to most householders in our case studies, demonstration activities do not fit with householders' perspectives on the future use of the retrofit products in their domestic lives. In one of the Dutch cases for example, the windows in the model apartment kitchen appear to be opened inwards, blocking the space normally reserved for a refrigerator. The anticipation of future domestic routines is even more difficult when there is no model apartment, as in the case of Mianyang. One householder mentions why, for him, this has problematic consequences: "*I think I want a central heating system such as the people have in the North of China, but I have never experienced it. I do not exactly know what it is and how it works*" (06-10-2017; Muzongchang). From the perspective of householders more information exchange, advice and transparency in demonstration activities could help to connect to their domestic life and contribute to a better understanding of the retrofit packages.

4.1.3 Participation

Participation practices in both China and the Netherlands are shaped by organized meetings with residents' representative bodies and by explicit formal regulations, such as the rule to obtain a consent of a majority of residents before the retrofit commences. To act in accordance with the rule of a resident approval rate of 70% in the Netherlands and a resident approval rate of 66% in China, retrofit providers have a shared understanding of "what works" to get the material consent forms signed by householders. During large-scale resident meetings it is advocated that governmental targets should be met, just for reasons of process efficiency. Interviewed retrofit providers in China emphasize that the governmental pressure, together with pressure from the closely tied householders, make the retrofit processes relatively short (seven to twelve months), as compared to Netherlands, where it usually takes at least two years and occasionally as long as ten years. A Chinese retrofit provider in Mianyang states: "*Together with the employer of most residents, we organized a meeting for all the householders [. . .] We have a limited budget and regular plan. We cannot include everything the householders want*"

(21-10-2016; Gong'an). Another disadvantage of the limited budgets in Beijing is that it may lead to offering energy efficient windows only as an optional choice, making the energy saving objective unattainable. In contrast to such collective modes of communication in China, a more individual approach is taken in Amsterdam: "*We have met all householders individually in their apartment to carefully explain our uniform retrofit plans. We also asked personal questions such as whether the residents have a pet*" (Dutch constructor Karel Klinkenberg; 03-04-2017). Yet, the current objective of participation practices in both China and the Netherlands is to win householders' support for a mostly technological standardized retrofit intervention, instead of exploring the various wishes on future ways of living as suggested by householders.

Although the current retrofit interventions can positively affect bad air-quality, noise, draft and mould issues in apartments, it is perceived as overdue maintenance and in most cases it does not comply with householders' broader life-world rationalities (Spaargaren 2003). Motivational affectivities around comfort, cleanliness and convenience result in different goal expectations regarding the retrofit, such as having more space or less noise, avoiding moisture or enhancing safety from burglars and fire. These expectations lead to requests for new kitchens, bathrooms, or windows to be accommodated in the retrofit intervention. A Dutch householder reflects how the housing retrofitting falls short in offering additional options: "*The retrofitting was a simple make-over instead of a complete apartment improvement [. . .] I had to organize and pay the new bathroom tilings, kitchen closets, wall plastering and floor lamination by myself, separately from the collective retrofitting*" (10-01-2018; Knijtijzerpanden). The specific preferences that result from the anticipation of future domestic practices make large-scale resident meetings in both countries not the most efficient participation practice: "*During resident meetings, usually, negative residents express their complaints about details [. . .] For example the intended retrofit would destroy their own decoration in the toilet without compensation*" (Chinese householder Fuchenglu; 01-11-2016). Usually, residential meetings happen to be one-directional promotion activities without opportunities for learning from householder perspectives. Retrofitting projects will not be change based on expressed opinions of only a few householders. Also communication falls short in explaining the duration of the construction period. Effective communication is hindered by a lack of openness from retrofit providers and a lack of possibilities for personal mediation. This issue makes several householders in the Netherlands and China feel forced to accept the more or less standard retrofit intervention that is not customized to householders' preferences.

4.2 Retrofit Practices of Appropriation

4.2.1 Evaluation

Retrofit evaluation practices are often performed in temporary walk-in offices during and shortly after the retrofit construction. Such walk-in offices as a collection point to gather feedback are helpful because in most retrofit projects, households are still in their apartment during the retrofit construction. It appears that in most retrofit projects residents are not required to move out. Some residents complain about everything during meetings, in writing or during visits at walk-in offices while others never report any disruption, noise, or other inconveniences and never visit the walk-in

office. Usually, the performance of the retrofit evaluation is largely left to the initiative of householders, and its outcomes hardly have a long-term impact on the maintenance of retrofitted apartments by the retrofit providers. As one Dutch retrofit provider states: "*After the retrofit, we get some feedback about the heating system, which does not work as quickly as before. We investigate and determine whether it might have to be de-aerated [. . .] However, there is a group of residents who never contacts us. We are mostly worried about them. We will never know what they think, as they do not notify us*" (12-01-2017; Karel Klinkenberg). In contrast to such experiences in Amsterdam, in China evaluation standards and feedback roles for householders have been intensified, sometimes also using WeChat communication. Collectives of householders in Mianyang and property management units in Beijing are given responsibility with regard to the cleaning, noise counselling, garbage monitoring and safekeeping. Householders are also actively contributing to the quality of the retrofit construction in other ways. As a Chinese retrofit provider states: *"We give the resident committee a role in the selection of the supervision company and the evaluation of the construction [. . .] Informal supervision by householders helped [. . .] We have a plan for an evaluation after a year, but we did not achieve this (yet)"* (21-10-2016; Gong'an). Retrofit providers agree that further evaluation activities are scarce in both Chinese and Dutch retrofit provisions.

Evaluation practices do not take post-retrofit domestic practices into account, which lead to criticism from Chinese and Dutch residents. The quality of the construction and the used material is often poor. Due to insufficient communication typical problems are not solved once the apartment was domesticated, like experiences of cold drafts, heat leakages caused by warped walls, malfunctioning of heating and ventilation adjustment systems, and wrongly installed windows and window-shades. Or, the retrofit destroys aesthetics as a Dutch householder states: *"They had to remove a timber object of mine. In contrast to agreements to put it back, it was thrown away as scrap wood [. . .] After this, I forbade them to enter my apartment [. . .] Additionally, a window and door were damaged. It took two months for them to finally solve this" (*13-12-2017; Het Breed). Furthermore, inhabiting the apartment during the inconvenience of the retrofitting activities is critically evaluated by especially older householders and young parents (because construction activities are often delayed). As a Chinese householder in Beijing states: "*The retrofit construction was much harder than expected. We could not use our toilet for a long time. The final result was disappointing and the aftercare was limited [. . .] There is a lot of dust in the staircases and the apartment. Also the new windows do not open and close easily*" (01-11-2016; Fuchenglu). Interviewed householders in Mianyang value the agreements made to change the windows in half a day; this appointment was carefully fulfiled within the reserved timeline. As observed in China, property management units and a resident caretaker team play an important role in checking the performance of retrofitted apartment blocks, like reporting unusual sounds of the heater. Additionally, Dutch householders want a stronger role of resident caretakers they know personally and who are keeping an eye on the neighbourhood, as occasionally is provided. Evaluation moments often stand alone as they are not replicated over a longer period, although this potentially could lead to rich and diverse insights about living in retrofitted apartments from a householder perspective.

4.2.2 Education

Education activities are frequently performed with a brief verbal explanation about the retrofit improvements during the handover of the apartment to the householders. This is common in both the Netherlands and in China. Such handovers usually follow expert-derived guidelines to target the performance of housing equipment with only a manufacturer's manual as reference material. Protocols with technical knowledge on housing equipment and energy saving are usually not translated or communicated in adapted instruction sheets to encourage "ownership" of the new housing equipment. The current organizational settings are explained by a retrofit provider in China as follows: "*We sometimes educate householders regarding water saving and garbage collection. Further education on the use of housing equipment and energy saving is not a priority in this round of retrofitting. Maybe we can do more in the future*" (20-10-2016; Muzongchang). Education activities, such as public learning programmes and information sessions, do sometimes occur, as illustrated by this occasional Dutch retrofit constructor who states: "*We have to educate the residents on how to use the mechanical ventilation system technically. We also go door to door to give householders flyers to teach them about comfort behaviours. A few months later, we give them an energy saving light bulb"* (03-04-2017; Karel Klinkenberg). Some Dutch housing associations transfer the responsibility for education to voluntary energy coaches, who instruct on health, well-being and financial positioning in domestic practices, like lowering the indoor temperature, shortening shower durations and turning off the lights when leaving home. In sum, the current aftercare by retrofit providers is rather technical and mostly takes place during the handover, except for some instructions on efficient energy use in housing equipment over a longer period after the retrofit.

More frequent education practices would better fit to let new domestic practices emerge and may promote the appropriation of new housing equipment. While experimental routines of testing new housing equipment could result in an understanding that it is 'easy', also negative use experiences could arise from the sparse and difficult-to-comprehend instructions. More explicit education is needed, as expressed by this Chinese householder: "*There are multiple factors influencing electricity use, which is related to the whole dimension of living. Education about energy saving to the next generation is quite important, especially in relation to their specific choices in cooling*" (17-06-2017; Chezhan). Moreover, current dealings of post-retrofit domestic practices contribute to an understanding that it is important to make the use of housing equipment for everyday life simple and to provide explanation in person. For householders, the current dealings with the retrofit provider are perceived as impersonal, and the handover is seen as the end point of the retrofit process: "*We are not considered people; we are pawns on a chess board*" (Dutch resident Het Breed; 13-12-2017). This highlights householders' perceived lack of power and control, which limits their autonomy in making their home comfortable. Highly developed practical understandings such as how to maintain technologies or change a smoke detector battery are rarely available. As a Dutch householder admits: "*The explanation of the new mechanical ventilation is limited for certain householders. Many householders do not know how to use and maintain, for example, the valves […] I think an energy coach or professional could be helpful for support*" (10-01-2018; Knijtijzerpanden). The primary feedback from several householders is that the retrofit providers who execute the handover are not available or friendly enough to

address questions in later stages. In the end most householders do not achieve adequate practical understandings of housing equipment for heating, cooling and ventilation after the retrofit.

4.2.3 Monitoring

An important measure of retrofit monitoring is the signing of a benchmark checklist, which is a routinised practice in both China and the Netherlands. The obligated benchmark checklists consist of a simple questionnaire about levels of satisfaction concerning the technical installations and usually do not question the actual energy consumption. The preference of retrofit providers to monitor building energy performance only by theoretical models makes any other means of energy monitoring redundant. As a Dutch retrofit provider states: "*We are focused on a better energy label. Due to privacy regulation, we have no insight into the energy consumption of individual householders. In this retrofit project, we asked some residents to report back on their energy bill [. . .] Maybe in the future, we can give them a monitoring dash-board or an App*" (12-01-2017; Karel Klinkenberg). Smart metre displays are occasionally installed in Amsterdam by an independent intermediate organization, who started a pilot to monitor energy use post-retrofit, because the retrofit providers themselves do not take on this responsibility. Home visits and interviews in Beijing have made clear that there are no in-depth monitoring practices because individual heating metres are absent in systems that lack the options to individually adjust the temperature, and where the heating bill still relates to the size of the apartment. Householders in Mianyang, however, were invited to take responsibility for energy monitoring by themselves: "*Specific focus on energy monitoring is rare in the current stage of retrofitting. In the future, we expect the resident committee to take more responsibility in organizing, monitoring and maintaining the neighbourhood and retrofit process*" (21-10-2016; Gong'an). The current method of post-retrofit energy monitoring is largely conceived by retrofit providers as a task for householders themselves, bounded by simple technical monitoring of housing equipment. Neither householders nor retrofit providers seem to have learned from feedback on the actual energy performance after the retrofit.

Conventional monitoring practices usually do not align with post-retrofit domestic practices to provide insight into the energy demand of the new housing equipment, which was repeatedly mentioned by both the Chinese and the Dutch householders. Instead of using clear feedback from technical monitoring tools, sense of heating (noise) and sense of touch (warmth) are utilized to check whether technical systems are turned on. Feedback from energy bills is delayed and complicated and does not directly link to the performance of individual housing equipment. As a Chinese householder in Beijing states: "*I think the retrofit has not led to a difference in energy use, but I do not know exactly. I want to have a heating energy metre, or a heating bill based on real usage from the perspective of fairness and costs*" (18-06-2017; Chezhan). The desired monitoring routines of householders are anticipated by an affectivity to control and understand practice-specific energy usage patterns around thermal comfort, cooking and washing. In Amsterdam, an interviewed woman kept a daily log file on the date, the temperature and the energy consumption since the retrofit. Having insight into specific energy consumption and indoor air-quality is so attractive that sometimes householders purchase the monitoring devices by themselves. As a Dutch householder stated: "*The*

current smart energy metre devices are smart for the energy provider but not for me. They save all my energy data. I would prefer to have a device that shows how much electricity, for example, a lamp or other specific device at home, consumes" (10-01-2018; Knijtijzerpanden). In the eyes of householders, retrofit providers miss the attention on delivering monitoring technologies that give reliable, clear and accessible feedback on the actual energy consumption of housing equipment.

5. Discussion and Conclusion

The primary question of this paper is: *How can the organized interaction activities between householders and providers in Dutch and Chinese housing retrofitting projects for energy saving be conceptualized, understood and improved?* Conventionally, the success of housing retrofitting for energy saving is being assessed with technical indicators for energy efficiency in buildings, without taking into account how houses are actually being used or how a retrofit would impact domestic energy-related practices. In contrast to this conventional view, this paper shows that the failure of retrofitting processes to accomplish the full energy saving potential is actually determined in the consumption junctions where retrofit provision and consumption intersect. These intersections produce the misfit or fit between retrofit provision and consumption through organized activities about the meaning, the choice and the use of new housing equipment. Consumption junctions have been conceptualized as overlapping bundles of retrofit practices on recruitment and appropriation. This idea enabled us to characterize the systems of retrofit provision with the inclusion of domestic practices. The sites of intermediation where the two retrofit practice bundles overlap bring vulnerabilities to light, which can help enact environmental socio-technical change into everyday life. By doing so, this article not only describes why the full energy saving potential in Chinese and Dutch housing retrofitting fails to be accomplished, but also points to possible improvements and how they may be achieved.

The findings show that Chinese and Dutch housing retrofitting usually fails to accomplish the full energy saving potential because a dominant engineering perspective on housing retrofit mismatches with the conventions and competences of comfort-making in domestic practices. We illustrated mismatches between retrofit practices and domestic practices in relation to meanings of thermal comfort, cleaningness and convenience but also control, safety and autonomy. In retrofit practices of recruitment, the misfit between housing retrofit provision and consumption is manifested in a narrow view on technical building assessments and standardized retrofit interventions, while a connection with the dynamics, variety and local specifics from householders' point of view is missed. Additionally, the pre-retrofit model apartments in the Netherlands are only used as a showroom to visualize housing equipment instead of providing options to test its contribution to conventions of thermal comfort, such as warm feet and the avoidance of drafts and moistures. Such an approach underlines the dominance of a technically isolated view and a passive way of dealing with what householders do and say. The empirical results on both Chinese and Dutch retrofitting show that technical perspectives dominate in practices of recruitment, while everyday life perspectives are dominant in practices of appropriation. When focusing on the retrofit practices of appropriation, we observed a misfit between consumption and retrofit provision in

the involvement of domestic tasks at the household level, as well as a limited access to knowledge and competences to employ retrofit equipment energy-efficiently. In the absence of appropriate monitoring tools to show the energy use of individual appliances, post-retrofit energy efficiency in domestic practices, such as heating, cooling, ventilating, washing and cooking, could not be assessed. This issue accentuates the lack of post-retrofit backing at the household level to organize energy-efficiency in domestic practices.

We observed a theoretical challenge for the fields of design theory, psychology and sociology related to issues of householder inclusion in retrofit processes. The theoretical innovation of our study builds on the notion of "retrofit practices of intermediation" in relation to "domestic practices", which contributes to conceptualizing engaged roles of householders in retrofit processes. In this approach knowledgeable household-consumers, instead of being passive subjects who need "to be worked upon", are conceived as active co-creators of "retrofit practices of intermediation" that are fundamentally social, political and contextual. By using practice theory, we show that the interrelations between "retrofit practices of intermediation" and "domestic practices" in everyday life are structured and routinized in particular ways by a number of elements (amongst others: material objects, ideas, competences and conventions) that can be specified with the help of empirical research. This helps to understand that householders may only be called upon to "do their bit" when retrofit practices of intermediation are organized in ways that fit their domestic practices. Retrofit recruitment can be included in retrofit plans by inviting householders to bring in suggestions derived from their pre-retrofit domestic practices as was the case in the building of bicycle sheds as part of the retrofit. Retrofit appropriation can be realized to by taking householder feedback into account to unfold construction errors, like in the case of irregular heater noise. By showing the relevance of practice theory for retrofit policies in conceptualizing the social embedding of householder- and provider-roles in new ways, this paper adds new insights to existing approaches of design theory and social psychology dealing with technology design and adoption in housing retrofitting.

To learn how to improve retrofit housing for energy savings, the empirical analysis in China and the Netherlands shows that provision-consumption interactions need to be considered in their specific retrofit settings. For example, because of the complex systems for heating and mechanical ventilation in the Netherlands, demonstration in retrofit practices of recruitment is more emphasized here while the fast pace of housing retrofitting in China result in more emphasis on evaluation in retrofit practices of appropriation. Reflecting on our expectations about strict dichotomies of China as mainly collectively organized and the Netherlands as mainly individually focused, our results sketch a much more nuanced picture. The fact that a considerable number of outcomes are comparable for the various settings in China and Netherlands suggests that they may likewise apply to apartment buildings retrofitting in other countries as well. To find points for improvement in retrofit recruitment stages, this study firstly suggests to analyse the *retrofit practices of recruitment* to assess how retrofit design fits with the engagement of residents and how different retrofit settings can learn from each other. Secondly, for retrofit providers it is essential to ensure a consistent scope of retrofit packages while taking into account what householders see as problems and solutions in their housing. It is, thirdly, recommended to conduct resident questionnaires

with open-ended questions in the pre-retrofit phase, such as in the Chinese example, and to offer optional retrofit packages similar to what has been done in Amsterdam. Lastly, model apartments can be a useful tool to mobilize residents' engagement and adaptation, especially if they offer more than just a display of the equipment. Essential in *retrofit practices of appropriation* is the fit between the empowerment of residents and the retrofit validation. Firstly, taking householders seriously as co-shapers of retrofit futures means avoiding uncertainties in retrofit expectations and offering transparency and credibility of retrofit packages via post-retrofit certification and temporary services during the retrofit, like toilets. It is, secondly, recommended to give resident collectives a prominent role in the evaluation of retrofit, such as what we have seen in China, and to educate and employ energy coaches, as has been the case in Dutch retrofit projects. Thirdly, the success of the energetic post-retrofit performances depends on the reliability, predictability and feedback mechanisms of retrofit packages. Finally, we suggest developing social and technical monitoring tools to bridge everyday life domestic practices with retrofit interventions.

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