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Household inclusion in the governance of housing retrofitting: Analysing Chinese and Dutch systems of energy retrofit provision

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**ABSTRACT**

One of the most important governance challenges in terms of energy saving is the physical upgrading of apartment buildings via housing retrofitting. In urban studies, little focus has been applied to the shape and character of the retrofit governance frameworks to realise inclusion of householders. Little is known about how these different frameworks, and the systems of provision they represent, impact on householders to achieve energy saving in their retrofitted houses. By recognising the importance of the relationship between provision and consumption, this study aims to analyse household inclusion in Chinese and Dutch systems of energy retrofit provision to suggest strategic improvements for intermediation. The empirical data is gathered in qualitative case studies of housing retrofitting in Amsterdam, Beijing and Mianyang (Sichuan province, China) by interviewing local retrofit providers, combined with site observations and reviews of policy documents. This paper shows how the formation of sustainable retrofit practices is co-constituted in shifting constellations of retrofit governance along the public-private-community divide. Public and private modes of housing retrofit provision seem to converge in Beijing, Mianyang and Amsterdam. The findings point to how regulations, processes and technical infrastructures should be adjusted to realise sustainable retrofit practices. The paper concludes that energy housing retrofitting in both Chinese and Dutch contexts requires co-management among householders and social intermediaries.

1. Introduction

One of the key challenges of sustainable development is effectively retrofitting existing old urban neighbourhoods [1]. Existing urban neighbourhoods and their buildings are particularly prioritized because they account for 32% of global carbon emissions [2]. To curtail urban carbon emissions, improving apartment buildings by means of retrofitting offers the most cost-effective way to reduce global building carbon emission by at least 25–30% at the end of the 2020s [2]. Especially, the energetic transformation of housing comes with substantial improvement of household’s quality of life and wellbeing of low-incomes [3].

Local governments, construction companies, private developers and housing associations are the main stakeholders provisioning large-scale urban retrofitting of housing estates. These stakeholders are responsible for the financing, production and distribution of retrofit improvements. Unfortunately, a series of governmental failures in China and market shortfalls in the Netherlands hinder exploiting the full prospective of retrofit provision [4,5]. The ambition is to make fifty to sixty percent of the existing residential housing stock energy efficient towards energy label B in Dutch social housing and a theoretical energy saving target of 50–65% in Chinese housing estates [6,7]. Retrofit providers in both countries have to deal with liberalisation, decentralisation and limited financial resources which problematizes the scope of retrofitting to tackle energy saving standards and householders’ demand for quality of life. Inclusive community participation and ways of democratising decision-making are restricted due to the current standardisation of limiting financial frameworks in retrofitting [8,9].

Currently, decision-making is largely based on pre-determined objectives after centralised decisions have been taken. Retrofit providers frame the management of supply chains as mainly linear with household-consumers only playing a role at the end of the chain [10]. This contributes to an exclusive orientation on ‘upstream’ systemic dynamics and an overall lack of attention for ‘downstream’ perspectives which strengthens the separation between retrofit provision and energy consumption. A study revealed that after energy retrofitting of housing complexes, the realised energy savings are 30–40% lower than theoretically estimated [11] which points to possible unused potential in
retrofit provision. Also in both China and the Netherlands, current retrofit providers ignore the fact that the institutional mechanisms, expert-led organisation of retrofit decision-making and the management responsibilities of retrofit packages influences the daily activities of householders after the retrofit [8,9,12]. The ignorance leads to a poor alignment between the technological and the social side of retrofitting which could lead to barriers in the use of retrofit packages. Little is known about how retrofit governance interferes in the ways of executing domestic routines like heating, cooling, ventilating and waste treatment [13,14]. Ultimately these domestic practices determine whether the home is environmentally sound and energy efficient or not [15].

The problematic division between the sphere of retrofit provision and the seemingly separate sphere of energy consumption in China and the Netherlands necessitates a re-shifting of roles between the government, market and consumers [16–18]. Conventional approaches fail to capture the diversity in forms and levels of housing systems. In academic studies, the blurring in the institutional order of purely market-based, public-based or community-based governance arrangements is not picked apart into dimensions of differentiation through retrofit supply chains. It is not just the fact that retrofit packages are generated by different institutional stakeholders but also that the variety of new institutional orders lead to different retrofit packages, responsibilities and relations between providers and consumers in many diverse ways. Here, the missing link is to retrofit housing not only materially in building elements and technologies, but to accommodate retrofit packages in domestic practices during the retrofit process and afterwards [19]. Retrofit governance in this study builds on Dowling et al. [20] who draw attention to the interplay between the development of policies, markets, technologies and participation activities to unravel the way energy consumption is co-constructed and co-managed in a multi-actor and multi-level context. Analysing the socio-technical systems of retrofitting is a prerequisite to bridge the governance implications of the sustainable city to householders’ everyday lives [21,22,58].

Building upon these studies, we take as starting point that the effectiveness of urban retrofitting arises from the different ways interactions are organised between retrofit providers and household-consumers. Environmental innovation, decentralisation and liberalisation in supply chains have led to hybrids of public, private and community governance arrangements in a variety of financial resources, retrofit packages, and decision making power vis-a-vis consumer roles. Beyond an artificial production-consumption division, the “system of provision” (SoP) approach [23] pinpoints to various vertical ways of interaction as connective tissue between production and consumption. By doing so, the SoP approach unites different forms of interaction by documenting a patchwork of structures, processes, agents/agencies and relations [24]. This framework does not isolate aspects of production and consumption. The structures in institutional settings for financing determine power in the organisation of decision-making [20]. This becomes visible in the distribution of responsibilities for retrofit improvements between provisioning and consuming agents. Retrofit practices in the organisation of decision-making and the distribution of responsibilities for retrofit improvements co-shape the well-being and energy saving in domestic practices [25].

To draw attention to the different ways in which production and consumption are linked, this paper offers an overview of emerging systems of retrofit provision using cross-national qualitative case studies [26]. Each of these systems of retrofit provision appears to represent a unique institutional and social configuration to embody different principles of demand management [27]. The main goal of this study is to bring householder-consumers back into view and to acknowledge their multiple roles for co-shaping sustainable transitions in the more public-led Chinese and the more private-led Dutch retrofitting of housing estates. Accordingly, this paper recognises that the different forms of interaction between providers and household-consumers in the management of infrastructures are fruitful points to analyse [12,28].

Such an integrated analysis of regulations, technologies, supportive organisational-institutional frameworks and social practices is required to begin designing the pathways towards a more sustainable energy consumption at the domestic level [29,30].

This paper aims to answer the question: How do interactions between providers and consumers in different systems of retrofit provision affect the formation of sustainable retrofit practices in China and the Netherlands? We assess how urban retrofitting is governed by whom, for what reason, and with which policy outcome at the level of householders. Using this assessment, we evaluate the systems of provision in Chinese and Dutch retrofitted housing estates for low-incomes. The social housing sector of Amsterdam is chosen as typical case study area in the Netherlands. The large size of China and differences between governance arrangement among provinces, however, make it necessary to focus on more than one city. For this reason, retrofit is studied in affordable former public housing in the stringent governmental organised and centrally heated megacity of Beijing (North-East China) and Mianyang (Sichuan province, South-West China) as smaller, and more experimental people-oriented city without central heating.

The outline of the paper is as follows: the second section introduces the system of provision approach resulting in an analytical framework. Methods are discussed in the third section. The fourth section gives an overview of retrofit governance in systems of retrofit provision in Mianyang, Beijing and Amsterdam. The fifth section provides the main conclusions with regard to the governance in systems of provision and discusses retrofit policy recommendations.

2. Investigating systems of retrofit provision

To be able to conceptualise complexities and dynamics of specific supply chains, the SoP approach was introduced by Fine and Leopold [23] and developed further in Fine et al. [24] as a methodologically and theoretically open approach. As an analytical tool to map provider-consumer interaction, the categories of this comprehensive framework partly overlap because they hang together in a system as “complex wholes” that cannot easily be reduced to component parts. To assemble the elements and linkages to configure particularly decisive sub-aspects for SoP functioning, the specificities of historical, economic, socio-cultural, geographical and material dimensions need to be followed across structures, processes, agents/agencies and relations.

By operationalizing the SoP approach to housing retrofitting in different governance contexts, the characteristics of institutional structures are employed with respect to retrofit financing in 2.1. In 2.2 we specify how these institutional structures determine power in decision-making processes. The next section focuses on the dealings between agents/agencies in the responsibility for retrofit improvements (2.3). The way relations between the organisation of decision-making and responsibilities for retrofit improvements co-shape the formation of sustainable retrofit practices is addressed in 2.4. The four categories are brought together in the paper’s analytical framework in Section 2.5.

2.1. Structures – institutional setting for financing

Structures in a SoP approach intercede in numerous institutional ways through the chain of provision by creating program standards, resources and regulatory frameworks. These social and economic interventions structure financing, production, distribution and consumption. Structural divisions have originated among public and private supply and also on public and private demand, not at least in patterns of ownership, control and delivery. Structures of provision are part of historically-progressed and socially-particular constructions with differing public-led or private-led dominance. The SoP approach views markets as organised to a significant extent by the state in contexts that are ceaselessly developing [31].

In the structures of housing retrofit, the institutional settings to
financing have become especially decisive because arrangements of the market and community are becoming more prominent which also changes the role of the state in retrofitting. The rules and resources can confirm certain patterns but structures are never fixed-for-ever [20]. State intervention in retrofit provisioning has historically been justified by the role of housing as a basic human necessity and place of shelter [32]. Liberalisation requires a different but not a diminished role for government stakeholders [33]. More concretely, the privatization of social housing and increasing housing homeownership make financial settings, such as financial burden sharing patterns and responsibilities between participating stakeholders, increasingly prominent [29]. Privatization in the housing sector commonly refers to ownership of economic and financial assets, which easily leads to issues around distribution of costs and benefits in retrofitting. Retrofit governance is changing to project-driven collaborative modes of provision in either more autonomous, universal, simple, integrated or marketised arrangements [29]. This urges the call to balance the roles of householders and providers in the institutional setting for financing, consisting of regulatory arrangements, funding frameworks, financial burden-sharing patterns, consumer incentive structures and consumer inclusion methods.

2.2. Processes – organisation of decision-making

Processes in a SoP approach consist of various modes of financing, production, distribution and marketing at the providers’ end of the chain which interact with certain modes of access and use at the consumer’s end of the chain. Processes are decisive with specific organizational mechanisms for consulting, resident representation and power distribution [34-36]. There are distinct sets of governing procedures with specific power dynamics between state, market and community in each stage of the process cycle from production to consumption. The SoP approach argues that within the institutional structures certain processes unite a specific pattern of production with a specific pattern of consumption [23].

The process organisation in retrofit decision-making is especially decisive due to differing power dynamics of public, private and community stakeholders in subsequent phases. The main phases in the retrofit process are technical audit, design of plan options, construction, commissioning and occupancy or use [35]. Providers’ interference in these phases are complicated because the process interferes with existing inhabited buildings by householders who need to give a majority approval. This interference is specified in technological change as a more or less one-way process of technology transfer or as a two-way process of technical learning and spillover [10,36]. To understand dynamics in the socio-cultural process-cycles, which form chains of retrofit provision, focus is needed on the opportunities for creative dialogues with householders [37]. Involving householders in retrofit design can be a solution to overcome problems of pre-bound and re-bound effects, non-acceptation, sabotage or misuse of technology [38]. The organisation of decision-making between providers and consumers is indicated by core procedures of the retrofit, project timelines, consulting mechanisms, delegated powers to consumers and models of consumer demand management.

2.3. Agents/agencies – responsibilities for material improvements

Different agents/agencies in a SoP approach have different responsibilities in the configuration of materials, post-consumption feedback, control and conservation [39,34]. Agents/agencies compete and distribute control to manage material attributes of technology networks along the chain of provision. The SoP approach focuses on emerging responsibility outcomes from settlements between internal groupings of agents/agencies in three domains: citizens, the private sector and the state [31]. This leads to differing symbolic meanings for the physical supply chain items [23].

With regard to public, private and community agents/agencies, the specific scope of retrofit improvements is especially decisive due to differing responsibilities and roles for participating stakeholders. The management about the distribution and the use of retrofit innovations are determined between construction companies, local governments, housing associations and household-consumers [40] to realise energy saving targets. Technology is not universal, neutral and independent but inherently social and part of societal dynamics by balancing energy saving and the quality of life [41]. Some retrofit projects focus only on the “inside” of the housing and the painting and adding of exterior walls, bathroom retiling, new heating- and ventilation equipment while others give more attention to improving “outdoor” facilities in security, parking, garbage cans and sport facilities. Choices for technical control in retrofit packages interfere with existing and emerging domestic practices [12,28], and determine the specific roles householders have in controlling and maintaining their homes. The distribution of responsibilities for material improvements between providers and consumers depends on who are the key players; the scope of material interventions and problems in post-reetrofit material control, and lastly, consumer needs in retrofit products and the technical representation of consumers roles.

2.4. Relations – formation of sustainable retrofit practices

In a SoP approach, relations between social structures, processes and agents/agencies are shaping and being shaped by the retrofit practices of steering and empowering. Domestic practices are co-shaped by organised interactions during retrofit processes. Both socio-cultural and material aspects constitute stakeholders’ practices among the public, private and community domain. By locating consumption in the context of a chain of processes and structures brought together by relating practices of agents and agencies, the SoP approach opens the way to a more grounded interpretation of consumption [24]. This stresses the importance of exploring retrofit practices co-shaping everyday consumption practices and the degree to which they are supporting or obstructing sustainable consumption.

Relations between providers and consumers in different private, public or community governance contexts result from the specific organisation of decision-making and the distribution of agents’ responsibilities for material improvements. The specifics of these economic, institutional, technological contexts co-shape what householders do in their everyday lives in different forms of retrofit steering. In this light, it becomes clear that the differing visualisation and education methods by which retrofit providers accommodate householders’ practices in organising retrofit processes can either barricade or enable householders on the road to sustainable consumption [42,39,57]. Finally, the problems and solutions in housing retrofitting do not only derive top-down but also arrive from the organised intermediation support and the everyday experiences of householders [44]. The embedded nature of energy in the home requires a smooth formation of retrofit practices to capture collective routine behaviour of domestic tasks in heating, cooling, ventilating, cooking, washing and treating waste [45]. The formation of sustainable retrofit practices is constituted by retrofit steering in visualisation tools and education services, consumer communication designs and consumer conflict management.

2.5. Analytical framework

Building on the theoretical inspiration in the work of Fine & Leopold [23] and Fine et al. [24], we distinguish the following elements of focus for this paper on provider-householder interactions in retrofitting SoPs (Table 1). In the table below we present how we operationalise the general SoP categories, by specifying determinants of retrofit systems of provision. The latter will be used as headings to organise the empirical sections.
Table 1
Analytical dimensions in framework for studying governance in Dutch and Chinese systems of retrofit provision.

| Category          | Descriptions in retrofit SoPs |
|-------------------|--------------------------------|
| Structures        | Decisive aspect in the institutional structures for providers and household-consumers is the institutional setting for financing. |
| Processes         | Decisive aspect in processes from production to consumption is the socio-cultural organisation of decision-making. |
| Agents/ agencies  | Decisive aspect in the role of providers and householders are responsibilities for material improvements. |
| Relations         | Decisive aspect in relations between agents’ practices of provision and consumption is the formation of sustainable retrofit practices. |

3. Methods

This research examines housing complexes, which have been retrofitted to meet higher energy- and life quality standards, as starting point to explore household-provider interactions. New household-provider interactions in housing retrofitting arise as a result of liberalisation and decentralisation leading to hybrid partnerships across the traditional state-market-society divisions. By acknowledging the broad variety of possible hybrid partnerships and to avoid a bias towards the traditional state-market-society divisions. The Amsterdam metropolitan region (roughly 1.3 million inhabitants) offers the embodiment of different retrofit projects with active citizen-involvement. Public social housing has mainly been developed during the last century and especially in Amsterdam. Today 30% of its housing stock is owned by semi-private housing associations, who are privatised in 1994 but still have a public goal to provide housing for low-incomes [47]. To contrast the Dutch retrofit project cases, the decision is made to focus on China with the largest building energy consumption and residential retrofit challenges of the world [48]. Today approximately 19% of its housing stock consists of affordable former public housing as a result of different housing reforms in the 1990s [49]. Retrofit projects in Beijing, a city with more than 20 million inhabitants, are illustrative for its top-down public-private leadership [50] as the city hosts the government. However, to obtain better insight in the differences in Chinese housing retrofitting governance [7] it was necessary to choose additional retrofitting project cases outside Beijing. We choose to include retrofitting projects in Mianyang (Sichuan province), a smaller city with roughly 1.3 million inhabitants. This is a unique so-called Science and Technology city in the Chinese Torch program [51] and a representation of Chinese experimental people-oriented public governance.

After selecting the three cities, a quick scan was executed into the specifics of different ways of retrofit governance to make sure the cities are comparable to the extent of our variables (Table 2). Similarities between the three cities are that the financing of retrofitting is institutionally set in regulatory arrangements around apartment building programs. Decision-making is organised in terms of core procedures around technical audits; resident committees and legislation about obligatory majority approvals concerning planned retrofit projects. Also the responsibilities for material improvements are mainly governed by the institutional stakeholders as key players. In the formation of sustainable retrofit practices there is organised support for intermediation in retrofit steering.

Apart from these similarities the three cities differ in:

- The funding frameworks and financial burden-sharing patterns.
- The project timelines and consulting mechanisms.
- The scope of the material interventions and problems in post-retrofit material control.
- The visualisation tools and education services.

We realised that all cities have a significant contribution to make to the research as they are located on a different angle of the institutional triangle in sustainable development governance [52]. The analysed projects in the three cities represent three typical models of housing retrofit provisioning for housing estates (Fig. 1).

The overall methodological framework is based on guidelines (cf. [46]) for case studies of specific geographical disclosed neighbourhoods (Table 3). This paper is primarily based on 45 expert interviews with 15 interviews executed in each city. Using semi-structured interview techniques, data was gathered from local government officials, housing association officials, construction companies, and private developers. These interviews of around sixty minutes were directed on the one hand to describe and to understand the governance of retrofit projects, and on the other hand to identify broader trends of urban retrofitting in the three cities. Specifically, topics of the interviews have been: 1) general questions about the institutional structure, financial burden sharing and specific regulations, etc.; 2) questions targeting at the planning- and decision-making process, such as who initiates the project, who are mainly involved and what is the role of end-users; 3) questions aiming at design and construction, such as the objective and scale of the retrofitting housing project, and which distribution of responsibility for retrofit improvements is in place, etc.; 4) questions aiming about the intermediation for the use of the retrofitted house, including who is in charge of the apartment management and maintenance and how do the occupants evaluate the retrofitted apartments. The interviews were transcribed, and along with the notes, coded and analysed by identifying key themes, concepts and specific phrases, with reference to the conceptual framework. The interview findings have been triangulated with site observations of visited retrofitted neighbourhoods, which helped to understand the physical retrofit improvements and the practices of providers and householders. Occasionally observing interactions between retrofit providers and householders has helped to analyse not only their sayings but also their doings. These findings have been triangulated with reviews of policy documents to strengthen the validity of the generated data.

4. Empirical results: systems of retrofit provision

4.1. Mianyang – public social partnerships

In the public social partnerships of Mianyang, the limited public financial support reveals the boundaries of what engaged collective householders can achieve by themselves in simple fixed retrofit packages for energy saving. However, the lack of financial sources may also contribute to a larger role of resident committees in long-term governance and supervision.

4.1.1. Institutional setting for financing

Public-led retrofitting of housing estates for urban low-incomes is at an early stage in the city of Mianyang. In 2015, the local government launched the first four-year program of “Urban Old Community Governance and Work Guidance for Retrofit” to target existing residential communities consisting of approximately 50–200 households and which were built before 2000. These housing communities were built for employees of specific companies, many of which have now been closed and therefore not liable for any financial contribution to the retrofit. Financing retrofitting is largely dependent on public funding from governments. The city government of Mianyang invested ¥130 million (€18 million) in the new four-year program aiming to retrofit
Table 2
Quick scan: Similarities and differences in dimensions of provider-householder interaction in the systems of retrofit provision from Mianyang, Beijing and Amsterdam.

| Analytical dimensions                  | Indicator                                    | Retrofit case projects in Mianyang                                      | Retrofit case projects in Beijing                                      | Retrofit case projects in Amsterdam                                      |
|---------------------------------------|----------------------------------------------|-------------------------------------------------------------------------|-------------------------------------------------------------------------|---------------------------------------------------------------------------|
| Institutional setting for financing   | Regulatory arrangements                       | Financial programs for apartment buildings retrofit                      | Financial programs for apartment buildings retrofit                      | Financial programs for apartment buildings retrofit                        |
|                                       | Funding frameworks                            | Limited funding abilities by governments                                | Medium funding abilities by governments                                  | High funding abilities by housing associations                             |
|                                       | Financial burden-sharing patterns             | Almost no payment for the private home owners                          | Small payment for the private home owners                                | Often a rent-increase for the renting householders                         |
| Organisation of decision-making       | Core procedures                               | Technical audit, resident committees and 2/3 majority approval          | Technical audit, resident committees and 2/3 majority approval          | Technical audit, resident committees and 70% majority approval             |
|                                       | Project timelines                             | Project duration: 12 months                                            | Project duration: 7 – 12 months                                         | Project duration: > 24 months                                             |
|                                       | Consulting mechanisms                         | Emphasis on householders in long term governance                       | Emphasis on work unit / former employer who founded the building       | Emphasis on household right organisations                                  |
| Responsibilities for material         | Key players                                  | Governed by institutional actors: local governments, construction companies | Governed by institutional actors: local governments, construction companies | Governed by institutional actors: housing associations, construction companies |
| improvements                           | Scope of material interventions              | Quality of public space and limited energy saving                      | Quality of public space and (optional) energy saving                    | Energy saving and limited quality of public space                         |
|                                       | Problems in post-retrofit material control   | Poorly adjustable windows and window shades                            | Non-adjustable district heating systems and old air-conditionings       | Difficult adjustable heating- and ventilation systems                     |
| Formation of sustainable retrofit     | Retrofit steering                            | Organised support for intermediation                                   | Organised support for intermediation                                   | Organised support for intermediation                                       |
| practices                              | Visualization tools                           | Poster in the public space                                             | Visiting neighbouring community                                         | Model apartment                                                           |
|                                       | Education services                           | Institutional role of resident committees                              | Informal role of householder as retrofit ambassadors                   | Institutional role of householder energy coaches                          |

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300 ¥/m² (10.30 €/m²) to a general maintenance fund is obligatory4. In one of the 12 urban districts the district government is exploring whether householders can contribute 20% of the total project costs in the next batch of retrofitting.

4.1.2. Organisation of decision-making
A common timeframe for retrofitting processes in Mianyang includes six months for establishing a resident committee and getting householder agreement and three months for executing the construction of retrofitting. The district government created a provisional program of requirements based on an influential techno-economic examination of old buildings suitable for retrofitting (Fig. 2). The first step to be taken by the householders is to represent themselves in a resident committee of 5, 7 or 9 residents. The resident committee together with the sub-district government officials informed householders via introductory meetings and through posters about the retrofit. All householders are requested to fill in an open-ended survey to give their recommendations and suggestions for the retrofit project to initiate an application to the district government. The approval by at least 2/3 of the householders is compulsory for application of the retrofit project. After householders’ application, the district government decided on reasonability and made a specified retrofit plan. Also the specified retrofit plan needed approval from 2/3 of the householders. The retrofit construction had to be carried out by a qualified construction company carefully chosen via an open tender within specified financial limits. Retrofit construction works needed to be verified in detail, ratified by a supervision company and monitored by the resident committee. When the retrofit construction was finished the district government evaluated the used budgets. The district government used the resident committee as a “representative bridge” towards the householders. The last step for

Table 3

| Case                     | Building Year | Building specificalities | Retrofit construction | Market | Household | Public-Private Partnerships |
|-------------------------|---------------|-------------------------|-----------------------|--------|-----------|-----------------------------|
| Lishan (Mianyang)       | 1993          | 2 apartment building block of 8 floors | 2015 - 2016          | Public-social partnerships | 46       | 105                |
| Gongzhong (Mianyang)    | 1988          | 1 apartment building block of 7 floors | 2015 - 2016          | Public-private partnerships | 48       | 190                |
| Ling Tong Guan (Beijing)| 1986          | 2 apartment building block of 13 floors | 2013 - 2014          | Public-private partnerships | 650      | 1490               |
| Fangzhuang (Beijing)    | 1970          | 3 apartment building block of 6 floors and 3 multi-layered buildings of 6 floors | 2016 - 2017          | Public-private partnerships | 1176     | 535                |
| Fuchenglu (Beijing)     | 1986          | 5 multi-layered buildings of 3 floors | 2016 - 2017          | Public-private partnerships | 224      | 1176               |
| Olympia (Amsterdam)     | 1926          | 5 multi-layered buildings of 3-4 floors | 2010 - 2014          | Private-social partnerships | 555      | 555                |
| Karel Klinkenberg (Amsterdam) | 1958 | 4 apartment building block of 5 floors | 2015 - 2017          | Private-social partnerships | 224      | 1176               |
| Het Breed (Amsterdam)   | 1968          | 11 multi-layered building block of 5 floors | 2013 - 2016          | Private-social partnerships | 224      | 1176               |

1 Interview with several officials of the city level government Housing and Construction Bureau and Urban Planning Bureau of Mianyang and local researcher energy saving, 15-10-2015.
2 Interview with an official of the city level Housing and Construction Bureau and Urban Planning Bureau of Mianyang, 15-10-2015.
3 Interview with urban planners sub-district during site visit Lishan community, 20-10-2016.
4 Interview with a deputy director of Urban Planning Bureau at City level during site visit Muzongchang community, 20-10-2016.
the householders in the procedure was to encourage the resident committee to set up their own funding for a limited form of long term “self-governance”. Evaluation of the project is planned after one year.

4.1.3. Responsibilities for material improvements

The government takes responsibility for integrated urban retrofitting. Table 4 illustrates that priority is given to improving basic quality of life and repairing earthquake damage, not to environment. This is combined with improving the environment and preserving cultural heritage. An example of fixed products to enhance cultural values is the retrofit of a community gate in traditional style. The beautification of outdoor spaces and communal facilities has often been neglected because of lack of investment power in the past, resulting in a low basic quality of the apartments, especially windows and window shades. Nowadays, the district government emphasised the most urgent collective needs of householders. These highest needs, as mentioned in the questionnaires (unpublished report, sub-district government with Lishan, 20-10-2016), are leaking and dilapidating of their sewage systems and roof leakages. In many cases the retrofitting projects in this city with a hot-summer-cold-winter climate without central heating focused only on one superficial environmental measure, like sockets for e-bikes, also because energy saving standards are not so strict. Regarding the energy saving, target setting is based on the level of theoretical energy efficiency in the 1980s (the baseline). The local governments obliged the construction company to advance the buildings to 50% energy reduction in relation to the theoretical energy use of the 1980s while the reduction target of Beijing is recently changed to 75%.

From the urban planners’ point of view the “inside” of their individual apartments is the householders’ own responsibility. This made energy saving measures, like efficient solutions for heating and ventilation, in new windows and window shades largely dependent on the engagement of householders.

4.1.4. Formation of sustainable retrofit practices

Retrofitting in Mianyang is only recently introduced and has a simple chain of provision and limited financial resources. The simple character is expressed in the substantial limitations in available technical, financial and managerial resources. The current house-ownership structures give only limited opportunities to district governments to organise activities in the retrofit process and to interfere in private properties. From an energetic point of view, urban retrofitting in Mianyang is largely restricted by the exclusion of energy saving improvements “inside” the apartments to accomplish the relatively low energy standards within the existing regime. Householders complain about still jamming windows, and because flexible window shades have not been introduced, there is a higher use of air-conditioning after the retrofit. As retrofit packages only target the outer parts of apartment buildings, and not the “inside” of the apartments, there is obviously no need for example houses to visualise retrofit improvements as posters are considered as satisfactory. In terms of organised activities, the district and sub-district governments focused on technical audits, resident questionnaires with some open questions, resolving consumer conflicts and occasionally organising meetings to educate residents in energy saving and waste treatment. The public space improvements can be destroyed easily by householders without perspective on long term maintenance. The main strategy of the urban planners of Lishan and Muzongchang (20-10-2016) was to stimulate new resident committees to cultivate pro-environment volunteerism and investments via self-governance of the community. This strategy came without strong incentives to innovate. The possibilities to invest in their apartment differ between householders. The resident committees organised and encouraged residents to behave more environmentally friendly. An example of the steering role for the resident committee in their daily practices was to check whether all garbage is put in the correct garbage can. They played parental and pastoral roles at the grassroots level, intervening and mediating domestic cooperation and regulating individuals’ life in relation to building improvement. The volunteers of the resident committee, who know all householders well because of shared working history, organised a collective purchase of unified solar-protecting shades in the Lishan community.

4.2. Beijing – public private partnerships

The public-private partnerships in retrofitting projects of Beijing have, compared to those in Mianyang, more public financial support available for retrofit packages. The lack of individual fine-tuning in the retrofit packages makes householders rather passive. However, the fact that there are still strong ties between householders as former employees and their former employers, who founded the apartment building, make the former employees willing to act as informal retrofit ambassadors. Their contribution could potentially be a way to unburden all householders in the retrofit process.

4.2.1. Institutional settings for financing

The Beijing government is active to combine both retrofit and renewal projects in large residential communities of former state-owned or enterprise-assigned public housing through a program launched in 2011. The program, named “Comprehensive Treatment of Anti-Earthquake and Energy-saving for Old Housing Areas” is led by the deputy vice-mayor who decided to make community retrofitting the responsibility of the district governments. In case the community is related to a still existing work unit institution, the affiliated employer is sometimes able to contribute financially. Yet, retrofits in Beijing rely to

Table 4

| Retrofit plan                      | Availability in projects | Category         |
|-----------------------------------|--------------------------|-----------------|
| Road pavement                     | In all 3 case projects   | Quality of life |
| Roof improvements                 | In all 3 case projects   | Quality of life |
| Painting of outdoor walls         | In all 3 case projects   | Quality of life |
| Security system                   | In all 3 case projects   | Quality of life |
| Garbage cans                      |                          | Environment     |
| Sport facilities                  | In 2 case projects       | Quality of life |
| Sewage system                     | In 2 case projects       | Quality of life |
| Indoor public space LED-lighting  | In 2 case projects       | Environment     |
| Replacement of the gate           | In 1 case project        | Quality of life |
| Outer wall insulation             | In 1 case project        | Environment     |
| Replacement of window frame and   | In 1 case project        | Environment     |
| glazing                          |                          |                 |
| Sockets for E-bikes               | In 1 case project        | Environment     |
| Smart gas meter                   |                          |                 |
a large extent on public funding from national to local level to meet the energy performance requirements. Besides the ¥4.6 billion (€0.6 billion) of subsidies from the central government to retrofit 400 million m² in the cold climate zones arranged during the 11th Fifth Year Plan period (from 2006 to 2010), the local government and districts of Beijing invested ¥30 billion m² (€4.2 billion) of subsidy in retrofitting in three years⁷. The local government contributed at least ¥100 for every retrofitted m² in Beijing. The subsidy of the local government is higher compared to other areas in China. The costs for retrofitting in Beijing⁸ is on average between 250–2250 ¥/m² (35–315 €/m²). Householders had to pay a small amount as a contribution, in one additionally, a very small personal investment is required from the residents of more than 1000 households, inhabiting high-rise buildings. Additionally, a very small personal investment is required from the residents for the optional new windows and wall decorations. Other financial costs are the removal of illegal constructions, like self-built shades. In most cases the householders could stay living in their apartment during the retrofit. Easy expropriation is counteracted with the new Property Law of 2007 with more reasonable compensations for removal or expropriation⁹.

4.2.2. Organisation of decision-making

The most common timeframe for a retrofit process consists of a pre-retrofit phase of 4–7 months and retrofit construction phase of 3–5 months. The district government created a provisional program of requirement using qualified technical companies to make an influential techno-economic examination of old buildings suitable for retrofit (Fig. 3). After this, the district and sub-district government organised meetings in the community house with the former work unit and sometimes appointed building representatives. In contrast to Mianyang there are in many cases no bottom-up organised resident committees. To draw the attention of householders announcement posters were put near the building entrances. The sub-district government organised a demonstration visit to neighbouring projects in some of the cases or occasionally created an on-site example house with samples of retrofit packages. After this, the governmental sub-district officials used questionnaires as consultation mechanism to ask for suggestions, recommendations from householders and approval for application. Compulsory application for the retrofit project to the district government is an approval rate of at least 2/3 of the householders and 100% agreement for the introduction of elevators or sewerage improvements. However, householders had to decide individually on whether or not to approve the replacement of the current windows by efficient air-conditioning are not introduced. For the passive householders, comfort reasons are the main motive to appreciate the retrofit, rather than a lower energy bill. The latter is already rather low in relation to living costs, as a result of high prices of apartments and a heating bill which is still based on the level of theoretical energy efficiency in the 1980s (the baseline). Since 2015, the local governments obliged the construction company to advance the buildings to a 65%, very lately even 75% energy reduction as compared to the theoretical energy use of the 1980s. Besides energy saving, occasional objectives from the householders are included. A shift of objectives is made in the district governments from economy first to people first in the retrofit of old housing projects. This directed to more integrated strategies and objectives across many aspects. However, adjustable central heating, or programs for more energy efficient air-conditioning are not introduced. For the passive householders, comfort reasons are the main motive to appreciate the retrofit, rather than a lower energy bill. The latter is already rather low in relation to living costs, as a result of high prices of apartments and a heating bill which is still based on the floor size of the apartment instead of actual consumption of heat.

4.2.3. Responsibilities for material improvements

The responsibility of the district government is to stimulate energy saving, to make the buildings earthquake-resistant and increase low-income citizens’ living conditions (Table 5). In contrast to Mianyang, reducing energy consumption by retrofitting existing building stock is conceived as a priority in Beijing. Due to the cold climate and central heating system, the use of mass products to improve wall insulation is seen as easy win. Before the retrofit, condensation problems were common and householders described the temperature inside the apartments after the retrofit often as too cold or too hot due to imbalance in the heating systems. Regarding the energy saving, target setting is based on the level of theoretical energy efficiency in the 1980s (the baseline). Since 2015, the local governments obliged the construction company to advance the buildings to a 65%, very lately even 75% energy reduction as compared to the theoretical energy use of the 1980s. Besides energy saving, occasional objectives from the householders are included. A shift of objectives is made in the district governments from economy first to people first in the retrofit of old housing projects. This directed to more integrated strategies and objectives across many aspects. However, adjustable central heating, or programs for more energy efficient air-conditioning are not introduced. For the passive householders, comfort reasons are the main motive to appreciate the retrofit, rather than a lower energy bill. The latter is already rather low in relation to living costs, as a result of high prices of apartments and a heating bill which is still based on the floor size of the apartment instead of actual consumption of heat.

4.2.4. Formation of sustainable retrofit practices

The large scale of retrofit communities in Beijing, with normally more than 300 residents in high-rise apartment buildings leads to a largely universal provision chain and hampers the establishment of sustainable retrofit practices. Instead of focusing on the varying needs

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⁷ Interview with a leading designer/architect involved in retrofitting projects in Beijing, 14-10-2015.
⁸ Interviews with experts of an institute under MOHURD (Ministry of Housing and Urban-Rural Development), 14-10-2015.
⁹ Interview with an academic expert in community construction, 26-10-2015.
in different apartments, householder needs are largely considered as a universal given and met by standardised products that must be used in all projects at all costs. Financial limitations restricted a more far reaching retrofit and led to a situation in which heating is still centrally controlled on the building block level. So some householders still need to open their windows when it is too hot in the apartment while others still need to heat with their air-conditioning devices. Post-retrofit information about the poor performance of individual apartments is often inaccurately managed. Heating company managers pursue their own utility rather than paying for the public interest and continue to make householders dependent. This shows the different perception of economic or technical efficiency. Consumer roles in retrofitting have always been largely captive, meaning that the range of alternatives to choose from is limited. This led to resistance from residents who felt that the public interventions would invade their “private” spaces and rights. Nowadays, retrofit providers and former employers who founded the buildings still define the goals as well as the problems and put only limited effort in collecting feedback from the public. Participative policy-making focused on environmental behaviour is still at an early stage. Conscious steering of everyday practices was not observed in Beijing retrofitting, although the visit to neighbouring community or the use of walk-in houses to demonstrate the new windows and ceramic tiles did occur. Members of the resident committees are not in the proximity of communities because often they commonly live elsewhere. Above this, they largely need to stand for the government which makes it difficult to represent the differing interests of the large number of householders. Supervision companies and property management companies occasionally represented the householders in bringing in their needs but they also have their own private interests. Based on shared information, television, WeChat and internet, active householders are slowly organising themselves as informal retrofit ambassadors, especially around health issues, like elevators for elderly. This is also shown in the rise of homeowner organisations. The voice of the differentiated community is badly listened to because of the absence of real bottom-up community-based organisations.

4.3. Amsterdam – private social partnerships

In the private social partnerships in Amsterdam we observed high funding abilities, leading to multiple retrofit packages for energy saving. The multiple options lead to complex negotiations on finances and technologies which are only understood by well-informed technology-minded householders. However, social housing in Amsterdam embraces many householders rights organisations and voluntary energy coaches. Their contribution can potentially counterweight the economic and technical reasoning behind retrofit programs.

4.3.1. Institutional settings for financing

Since the 1970s housing associations in Amsterdam have been involved in the improvement of energy efficiency in housing estates using national government-tied targets and regulations. Recently, the national government concluded agreements with housing associations of Amsterdam to raise the minimum energy standard of all 190,000 properties before 2020. The local government obliged the housing associations of Amsterdam to a large scale efficiency improvement of 16,000 houses15 with low energy performance between 2015-2018. Housing associations are used to retrofit serial dwellings of 50–250 apartments, like gallery entrance flats and apartment blocks built in the 1970s or before. The resources for financing the retrofit of these apartment blocks are provided by housing associations supplemented with subsidies from the national government and the local government. The national government subsidises between €1.500-4.900 and the local government €2.000–14.00010 for every retrofitted apartment depending on the scale of improvements. The retrofit costs are mostly around €30.000 for every apartment and in occasional cases around €100.00011. Due to the private structure of housing associations they cannot gain more subsidies from the government, making it rather hard for housing associations to balance large amounts of investment capital at once. To provide a stable financial position for themselves, the housing associations sometimes need to sell units of the retrofitted apartments. Some householders are disturbed by the regulation for temporary re-housing. Although in most cases householders can stay in their houses during the retrofit, in case householders need to move out, they can receive approximately €5.000 as a compensation. Typically, the broad community participation in retrofitting leads to lengthy procedures to reach consensus with and between the residents.

4.3.2. Organisation of decision-making

The duration of retrofit processes in Amsterdam is approximately two years until more than five years in complicated projects. The processes of retrofitting start with a provisional program of requirements and an influential techno-economic examination of housing qualities (see Fig. 4). The responsible housing association decides on the scheduling of the extensive maintenance and appoints a project team. A legal commitment is that a residents’ committee must be formed as representation of the householders. The resident committee is the discussion partner of the housing association with the help of non-profit tenant right organisations as qualified bridging partners. Small demonstration visits are organised for the householders as part of the retrofit communication plan. Householders are invited to a demonstration visit of a showcase-house, are informed via leaflets, advertisements and are asked to fill in a public questionnaire with their suggestions. Housing associations decide on the basis of suggestions from householders and of a techno-economic examination to a qualified advice on the preferred scenario of the retrofit plan. A legal approval rate of at least 70% of the tenants in every building block is needed to proceed with the proposed retrofit plan. The agreement is personalised to an individual retrofitting proposal for every household. In most cases householders can choose between basic packages and more ambitious retrofitting measures with financial consequences for the rent. After this, the housing associations start a tender selection process to select the constructor. In case of conflict about the implementation of the agreements, the housing association and the residents committee have the option to go to the conciliation committee with representatives from the local government, social housing sector and organisations for householders rights.

4.3.3. Responsibilities for material improvements

The housing associations take responsibility to improve the energy performance of their real estate properties. Their retrofit plans to improve their apartments focus predominantly on technical energy performance and improving comfort and to a lesser extent on liveability and quality of life (Table 6) in the moderate sea-climate. Due to agreements on national level, the aim of housing associations is to upgrade all their dwellings via multiple products to an average energy performance label B or improve at least by two energy performance label classes. This improvement is roughly half of the theoretical energy-use (see also [5]). The priorities of the housing association and the well-informed householders are often conflicting. Representatives of housing associations need to ensure the long-term theoretical energetic sustainability of the real estate properties in a cost-efficient way while residents are often quite focused on their own comfort and

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9 Interview with a senior and mediator advisor of the Amsterdam Municipality department Sustainable building and housing, 03-10-2017.

10 Interview with a senior technical experts of housing association De Key, 12-01-2017.

11 Interview with a senior technical expert of housing association Eigenhaard, 09-03-2017.
Four of the biggest challenges to establish sustainable retrofit practices in Amsterdam is the semi-private role of housing associations, market fragmentation and the search for an incentivisation which leads to a largely marketised provision chain. The material improvements of retrofitting are framed by ideas about what is good from a theoretical energy use perspective, as legitimised in energy label steps, instead of real consumption patterns. As a result, the targeted improvements are trapped in technical audits and evaluations and interfere only occasionally with householders’ everyday practices. Householders commonly misuse their retrofitted heating and ventilation installations, which leads to increased energy consumption, despite the occasional personal home visits, model apartment, public education, technology tours, and information sessions to visualise the retrofit plans and bring them closer to the residents’ perspective. Housing associations partly outsource the retrofit steering of sustainable consumption to voluntary householder energy coaches to motivate and instruct tenants about the use and meaning of energy facilities in their retrofitted homes. Tailor-made instructions concern the best ways to adjust the indoor temperature and air-quality for health, well-being and financial positioning. Energy coaches are important in social housing because energy use and energy saving are abstract phenomena to many tenants and sustainable use of the retrofitted apartments is not ensured without proper training.

5. Conclusion and discussion

5.1. Conclusion

In this paper we asked the question: How do interactions between providers and consumers in different systems of retrofit provision affect the formation of sustainable retrofit practices in China and the Netherlands? Empirical evidence from China and the Netherlands shows the implications of institutional, social and technical arrangements for the relationships between consumers and providers. Our results reveal that the formation of sustainable retrofit practices is constituted in shifting constellations of retrofit governance along the public-private-community divide. We distinguish three different supply chains: public-social, public-private and private-social governance hybrids. The findings concerning householder-provider interactions in the SoP are displayed in Table 7 below.

Our findings on the governance of retrofit projects in Beijing, Mianyang and Amsterdam point us to the relevance of the organisational and technical voids between provision and consumption in the retrofit process. Ignoring these action spaces leads to householders being stowed with post-retrofitted housing equipment for heating, cooling and ventilation, which they do not use efficiently in their domestic practices. These new forms of dependency are the result of simply “rolling out” of standard retrofit packages. Clearly in all three case cities, the objectives on what a retrofit entails are driven by financial incentives which are earmarked to certain predetermined retrofit packages. These provision-based retrofit programs define “the rules of the game” by enabling how retrofit processes are organised in terms of visibility of products, conflict mediation, communication and further instrumentation.

The ways in which the retrofit is made available to residents varies widely in terms of possibilities of consultation and responsiveness of retrofit providers. Differences in financing arrangements of governance modes, along the public-private-community divide, lead to different organisational support for intermediation in the formation of sustainable retrofit practices. By doing so, each of the systems of provision has generated a specific kind of householder inclusion in the retrofit. In general, householders, as end-users of the retrofitted apartments, turn out to be scarcely involved in the decision-making on retrofit interventions. Most retrofit providers decide about retrofit packages upfront, instead of allowing householders to participate in the pre-retrofit analysis and the maintenance of the retrofit intervention. The findings of the study show a governance gap in regulatory frameworks, participation mechanisms and retrofit packages to embrace specificities of

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Table 6

| Retrofit plan                  | Availability in projects | Category       |
|-------------------------------|--------------------------|----------------|
| Outer wall insulation         | In all 3 case projects   | Environment    |
| Replacement of window frame and glazing | In all 3 case projects   | Environment    |
| Balanced mechanical ventilation | In 3 case projects       | Environment    |
| Floor insulation              | In 3 case projects       | Environment    |
| Roof insulation               | In 3 case project        | Environment    |
| Improved heating system       | In 2 case projects       | Environment    |
| Indoor public space LED-lighting | In 2 case projects       | Quality of life|
| Repairing public staircases   | In 2 case project        | Quality of life|
| Floor alterations             | In 1 case project        | Quality of life|
| New bathroom or kitchen       |                          |                |

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beautification of indoor improvements, like a new kitchen or bathroom. Also the expectation about how to use the retrofit improvements of complex individual heating- and ventilation systems is not always clear. This results in polarized confrontations and imbalance in urban retrofitting projects due to unbridled social differentiation and uncertainty. In the eyes of householders the major improvements in retrofitting can be framed as overdue maintenance. Some householders have been living in their apartments for a long period of time and therefore feel like being experts of their living situation.

4.3.4. Formation of sustainable retrofit practices

One of the biggest challenges to establish sustainable retrofit practices in Amsterdam is the semi-private role of housing associations, market fragmentation and the search for an efficient use of financial resources which leads to a largely marketised provision chain. The market character becomes visible in financial negotiations between the housing association and multiple construction companies about technical solutions. These technical solutions do not always match with present demands for comfort, cleanliness and convenience. The needs in householders’ demand to facilitate domestic practices are highly negotiable in contrast to retrofit providers’ attempts to manipulate and manage passive buildings or smart homes. In the eyes of caretakers from housing associations made the tension of a rent-increase retrofit plans subject to contestation and resistance by the tenants in retrofit processes. A non-profit householder right organisation is made available to householders to support them in their struggles with retrofit providers. There are hardly any post-occupancy evaluations to monitor the “real” energy effects of the retrofit in consumption patterns. The material improvements of retrofitting are framed by ideas about what is good from a theoretical energy use perspective, as legitimised in energy label steps, instead of real consumption patterns. As a result, the targeted improvements are trapped in technical audits and evaluations and interfere only occasionally with householders’ everyday practices. Householders commonly misuse their retrofitted heating and ventilation installations, which leads to increased energy consumption, despite the occasional personal home visits, model apartment, public education, technology tours, and information sessions to visualise the retrofit plans and bring them closer to the residents’ perspective. Housing associations partly outsource the retrofit steering of sustainable consumption to voluntary householder energy coaches to motivate and instruct tenants about the use and meaning of energy facilities in their retrofitted homes. Tailor-made instructions concern the best ways to adjust the indoor temperature and air-quality for health, well-being and financial positioning. Energy coaches are important in social housing because energy use and energy saving are abstract phenomena to many tenants and sustainable use of the retrofitted apartments is not ensured without proper training.

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12 Interview junior social expert of housing association De Key, 20-02-2017.
Table 7
Similarities and differences in dimensions of provider-householder interaction in the systems of provision from Mianyang, Beijing and Amsterdam.

| Analytical dimensions                  | Indicator                                      | Public-Social partnerships in Mianyang cases                        | Public-Private partnerships in Beijing cases                        | Private-Social partnerships in Amsterdam cases                        |
|--------------------------------------|-----------------------------------------------|---------------------------------------------------------------------|---------------------------------------------------------------------|-----------------------------------------------------------------------|
| **Institutional setting for financing** | Regulatory arrangements                       | Financial programs for apartment buildings retrofits                 | Financial programs for apartment buildings retrofits                 | Financial programs for apartment buildings retrofits                 |
| - Regulatory arrangements            |                                               |                                                                     |                                                                     |                                                                      |
| - Funding frameworks                 | Limited funding abilities by governments      |                                                                     |                                                                     |                                                                      |
| - Financial burden-sharing patterns  | Almost no payment for the private home owners |                                                                     |                                                                     |                                                                      |
| - Consumer incentive structures      | Tailored offerings to householders who have    |                                                                     |                                                                     |                                                                      |
| - Consumer inclusion methods         | an intent for collective energy saving         |                                                                     |                                                                     |                                                                      |
| - Simple chain: consumer defined need is considered as an incremental invitation |                                                                      |                                                                     |                                                                     |                                                                      |
| **Organisation of decision-making**  | Core procedures                               | Technical audit, resident committees and 2/3 majority approval      | Technical audit, resident committees and 2/3 majority approval      | Technical audit, resident committees and 70% majority approval       |
| - Project timelines                 | Project duration: 12 months                   |                                                                     |                                                                     |                                                                      |
| - Consulting mechanisms              | Emphasis on householders in long term governance |                                                                     |                                                                     |                                                                      |
| - Delegated powers to consumers      | Self-organised co-decision / consulting and engaging |                                                                     |                                                                     |                                                                      |
| - Models of consumer demand management | Invite, respond and develop                   |                                                                     |                                                                     |                                                                      |
| **Responsibilities for material improvements** | Key players                                   | Governed by institutional actors: local governments, construction companies | Governed by institutional actors: local governments, construction companies | Governed by institutional actors: housing associations, construction companies |
| - Quality of public space and limited energy saving |                                                                     |                                                                     |                                                                     |                                                                      |
| - Poorly adjustable windows and window shades |                                                                     |                                                                     |                                                                     |                                                                      |
| - Fixed products to meet with simple needs |                                                                     |                                                                     |                                                                     |                                                                      |
| - Engaged resident collectives closely coupled by inviting providers |                                                                     |                                                                     |                                                                     |                                                                      |
| **Formation of sustainable retrofit practices** | Retrofit steering                            | Organised support for intermediation                                | Organised support for intermediation                                | Organised support for intermediation                                |
| - Poster in the public space         | Visiting neighbouring community                |                                                                     |                                                                     |                                                                      |
| - Institutional role of resident committees |                                                                     |                                                                     |                                                                     |                                                                      |
| - Resident questionnaire with some open-ended questions |                                                                     |                                                                     |                                                                     |                                                                      |
| - Sub-district officials              | Supervision companies                          |                                                                     |                                                                     |                                                                      |
| - Model apartment                    | Institutional role of household energy coaches |                                                                     |                                                                     |                                                                      |
| - Informal role of householders as retrofit ambassadors |                                                                     |                                                                     |                                                                     |                                                                      |
| - WeChat                             | Home visit                                     |                                                                     |                                                                     |                                                                      |
| - Supervision companies              | Caretakers of housing association             |                                                                     |                                                                     |                                                                      |
existing domestic practices and to orchestrate support for new domestic practices. To identify new provider-consumer relations and social practices that can contribute to services for energy efficiency at the household level retrofit interventions must be viewed more broadly than as only a set of traditional financial incentives and information dissemination.

Public, private and community modes of provision to housing retrofitting co-exist in all three cities, but they do seem to converge. From the different governance hybrids across the public, private and community domain specific challenges for domestic practices arise. In the public-social partnerships of Mianyang, the boundaries of what collective householders can achieve by themselves in retrofit packages for energy saving are set by the available public financial support. In the public-private partnerships of Beijing, the lack of individual fine-tuning in standardised retrofit packages for energy saving is an important limitation, although compared to Mianyang more public financial support is available. Lastly in the private-social partnerships of Amsterdam only well-informed technology-minded householders can oversee the retrofit packages for energy saving, as a consequence of the complex negotiations on finances and technologies. In all three case cities, these challenges lead to a lock-in of householders’ practices into their retrofitted homes.

5.2. Discussion

Understanding that retrofit packages do not only entail material interventions, but also have social and political implications in the energy efficiency of domestic practices, points to a need for enhanced consumer involvement [18]. The fact that many of our findings are similar for the diverse contexts in the Netherlands and China suggests that they may also apply to retrofit cases of apartment buildings in other countries.

The elaboration on what retrofit governance is and what it can ‘do’ leans on the underlying theorisation of societal dynamics and sustainability perspectives. On a theoretical level, this paper offers a comprehensive, non-functionalist, open account of the ways in which retrofit practices are shaping and being shaped by systems of retrofit provision [20]. The analytical framework has proved beneficial in analysing the different contexts of housing retrofit in China and the Netherlands. This paper also helps to move away from the image of practice research as being exclusively micro-situated, ethnographic, ad-hoc and a-historic [53]. Instead this study engages with the analysis of wider practice-arrangement bundles and networks in the supply chain. In this perspective, the material, social, institutional and legal conditions in systems of provision are finally shaping – and are being shaped by – consumption practices [43]. Systems of provision approaches are especially strong in characterising the messy relationships of situated practices by householders and providers in wider configurations of retrofit provision to explain how competition for crucial resources can result in power inequality. Their final contribution is in the presentation of promising legitimate institutional arrangements within the supply chain.

Existing knowledge, policies and instruments in retrofitting for energy efficiency at the domestic level do not seem to be up to the task. This points to new approaches in terms of both understanding and organising retrofit programs. In terms of inclusive retrofit governance, this paper points towards the need to complement top-down, technologically oriented forms of retrofit governance with bottom-up, socio-technical and life-world oriented forms of retrofit governance [54]. This would mean to allow householders at least to further co-determine the retrofit plan and to facilitate the embedding of domestic practices into the proposed retrofit packages (see also [37]). This makes the social-inclusive visualisation tools, communication designs, education services and consumer conflict management increasingly prominent. In an intermediate approach, consumer roles in retrofitting could change from only captive, to co-designer or co-decision maker [55,38]. This would mean less power for vested interests in housing and less reliance on generic regime-preserving solutions. Finally, in all three contexts voluntary householders and household organisations are motivated to be involved in the co-management of their neighbourhood, which can be seen as an in-kind financial contribution. To align key domestic practices towards sustainability, acknowledgement is needed for the grassroots role of resident committees like we have seen in Mianyang for long term governance; voluntary energy coaches and intermediating organisations like in Amsterdam; and householder-to-householder contacts like in Beijing. Environmental innovation processes in retrofit production-consumption chains offer potential for consumer inclusion. Rather than replacing traditional modes of retrofitting, perspectives on householders’ everyday lives should be built in to processes leading to a more sustainable housing retrofit.

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