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Local strategies to promote energy retrofitting of single-family houses

Abstract

Energy retrofitting of existing buildings is a central challenge for local, national and international climate policies, and in several countries single-family houses represent a major energy-saving potential. Although many municipalities are implementing local climate policies with initiatives to promote energy retrofitting of buildings, little research has been done regarding the role of single-family houses in local climate policies. Thus, we have little knowledge about specific initiatives to promote energy retrofitting amongst owners of single-family houses, we know little about experience from such initiatives, and we lack knowledge about the extent to which national and EU policies support local initiatives directed at homeowners. This article provides insights into these issues from an explorative study on local climate strategies in Danish front-runner municipalities where single-family housing is the dominating building segment. Based on a study of local governance strategies in 12 municipalities targeting homeowners' engagement in energy retrofitting, the paper finds that these municipalities have developed promising local network-based ways to engage homeowners in energy retrofitting, but finds simultaneously that the national policy mix is only partly supporting these local initiatives. The paper also points out that the local and regional context for the programmes, including the local economic situation, is of great importance, and this context creates both potentials and challenges for the local programmes.

Keywords: Energy retrofitting, climate strategies, homeowners, single-family houses, local initiatives, networks, policy mixes

1. Introduction

An important precondition for reducing CO_2 emissions is the reduction of the total energy consumption. As the energy consumption for buildings accounts for approximately 40% of total energy consumption at EU level, the energy retrofitting of the existing building stock is at the core of international, national and local energy policies. In spite of national and European initiatives to regulate and promote energy retrofitting and energy savings (Mahapatra et al., 2013; Rosenow et al., 2016), evaluations and studies suggest that renovation activities regarding energy retrofitting are still not widespread (Bartiaux et al., 2014; Beillan et al., 2011). Although energy retrofitting of single-family houses has a large potential for reducing CO_2 emissions (Mahapatra et al., 2013), private initiatives to pursue this potential have been limited. However, an increasing number of municipalities are formulating and implementing climate strategies (Dent et al., 2016; Kern and Alber, 2009; Trencher et al., 2016) which might increase private retrofitting activities. More knowledge about the actual capacity and capability of cities' initiatives to increase homeowners' retrofitting is therefore needed (Webb et al., 2016). Furthermore, more knowledge is required about the conditions for operating under national and international regulation frameworks. Although many cities and local authorities are active in energy and climate planning, their formal power has declined due to market liberalization of the energy sector, and therefore municipalities need to develop new local governance instruments (Hodson and Marvin, 2012), including different modes of urban energy intermediation (Hodson et al., 2013). This calls for research into a more detailed understanding of the differences across cities and their ambitions regarding formulating climate policies and initiatives towards private homeowners, in order to grasp where motivations and competences come from. Much of recent research has focused on larger cities and hence there is a tendency to ignore less economically influential areas (Dent et al., 2016; Trencher et al., 2016). Moreover, not all municipal climate strategies include promoting initiatives towards local homeowners (Millard-Ball, 2012), and it is also uncertain if the municipalities gains the expected benefits from the initiatives, which include not just direct benefits gained through reduced GHG emissions, but also other co-benefits such as economic savings, local action and generating of local knowledge (Bulkeley and Betsill, 2003). To sum up, so far there has been little focus on local strategies initiated by municipalities and directed specifically towards retrofitting by homeowners, and therefore we have limited understanding of the drivers, challenges, and the potential of such local governance strategies, as well as their relation to national and international policies.

The aim of the paper is to identify, discuss and analyse different local municipal initiatives and policies for encouraging owners of single-family houses to energy retrofit their buildings, and to shed light on the limitations and solutions of the different efforts. The paper investigates conditions for municipalities to work with promoting energy efficiency in single-family houses, and discusses to which extent such initiatives are supported by national policies and which other factors might be decisive for municipalities to initiate them. Danish municipalities are used as a case for exploring these questions, as Denmark is often viewed as a front-runner country within policies for reducing energy use in buildings (Murphy, 2014). Further Denmark has a high share of single-family houses.

2. Review of existing literature: Retrofitting single family houses, policy mixes, and local climate initiatives

The theory and background in this project draw on two slightly different areas. One is research into understandings of how, why and why not owners of single-family houses retrofit and energy upgrade their homes. The other area is about policy approaches for this, especially on the interlinkage between national and international policies for energy retrofitting on one hand, and energy retrofitting initiatives targeting single-family houses promoted from a local municipality level on the other hand.

2.1 Retrofitting of single-family houses

For a long time, international research has assigned relatively little attention to retrofitting single-family housing, although the focus has increased recently with the renewed political interest generated by the claimed high potential for energy reductions in many countries (Gram-Hanssen, 2014). The following review focuses on the issue of energy retrofitting detached homes, although as also stated in several of the reviewed papers, it might be difficult to distinguish energy retrofitting from other types of retrofit. Some types of energy retrofitting, such as replacing old windows with new ones, might be done for aesthetical or practical reasons, though it also include energy efficiency. Current research has generally questioned policies and assumptions regarding homeowners' motivations for energy retrofitting their buildings (Murphy, 2016). For example, much policy builds on the contention that it is financially feasible for individual owner-occupiers to energy retrofit, which has been challenged by research, at least within the German context (Galvin, 2014).

Part of the problem is that many calculations on the potential savings build on theoretical assumptions of the energy consumption primarily relating to the theoretical energy efficiency of buildings, whereas research shows that people living in less efficient buildings consume much less energy than expected (Sunikka-Blank and Galvin, 2012) and thus the potential savings are considerably lower. The problem might also be that there are many different types of homeowners and their interest and resources for doing something with their home will thus vary significantly (Haines and Mitchell, 2014). Several studies have in different ways looked at how information and economy can explain energy-retrofitting activities (Christensen et al., 2014; Risholt and Berker, 2013; Zundel and Stieß, 2011). A general conclusion is that information campaigns have little effect and that the financial situation of the household in itself cannot explain why some people energy retrofit and others do not. However, in many ways, the financial situation of the household and the households' knowledge of types of solutions, can be important together with other factors such as more comfortable homes and different types of esthetical improvements (Maller et al., 2012). This also points towards energy retrofitting rarely being done for the sake of reducing energy consumption alone, but should be seen in combination with other interests the household have in their home and its renovation (Gram-Hanssen, 2014a). Research thus suggests that homeowners get involved in retrofitting projects for a number of other reasons than to save energy. Hence, major challenges for energy retrofitting are for instance the lack of a skilled workforce amongst the craftsmen and small and medium enterprises (SMEs) engaged in energy retrofitting, as well as an absence of public support schemes (Beillan et al., 2011).

2.2 National policy interventions for promoting energy retrofitting of buildings

The question of how to address owners of single-family houses relates to the question of how national policies for energy retrofitting of buildings are formulated. There is a growing recognition that to achieve goals in policy formulation, single policies might not be sufficient, and instead a mix of policies will have larger effects (Kern et al., 2017; Mlecnik et al., 2012; Rosenow et al., 2016). The goals for a stronger "policy coherence" include a comprehensive strategy that aims to strengthen the connection between economic, social and environmental policy areas, and the need for smarter regulation (Nilsson et al., 2012). Policy instruments so far include national sustainable policies and national roadmaps, as well as

one-stop shops to promote integrated energy renovations, that go beyond single energy-saving measures (Mlecnik et al., 2012).

However, research on the outcomes is still limited as existing research has mainly focused on the outcomes of single policies related to energy retrofitting, e.g. energy audit programmes, energy performance certificates (EPCs) and energy performance regulation (Kern et al., 2017). Therefore, there is a limited understanding of the interlinking between policy formulation on retrofitting at international, national and local levels. Moreover, there is a need to understand how different types of benefits from energy retrofitting (carbon-emissions reduction, health/fuel benefits, employment/fiscal effects and energy security of supply) are actually being explicitly integrated into national and local policies (Kerr et al., 2017).

2.3 Local network-based policies

Across Europe and the US, a number of climate-oriented local municipal policies and initiatives have emerged, which have been labelled "local climate governance" initiatives (Kern and Alber, 2009), or new governance instruments which (in contradiction to traditional state-led direct regulatory interventions), allow broad inclusion of non-state stakeholders and approaches with newer voluntary mechanisms (Van der Heijden, 2016). As an alternative to traditional top-down regulation, local authorities are taking on new roles and promoting sustainable development at the local level, for example by acting as facilitators for local collaboration between different stakeholders regarding energy retrofitting, or acting as providers of frameworks that allow local collaboration (Alber & Kern, 2007). This approach thus focuses more on carrot-driven voluntary participation than mandatory top-down regulation, and a larger emphasis of public-private collaboration (Van der Heijden, 2016). These approaches refer to a shift from government to governance, based on collaboration involving multiple actors from different levels in networks rather than traditional hierarchical organisations (Sehested, 2003; Torfing and Sørensen, 2005). Today, municipalities worldwide promote energy retrofitting through establishing local reward schemes, improving educational activities for the local builders, communicating "best practices" for energy retrofitting, creating dialogue and partnerships with core actors in relation to energy retrofitting (e.g. local energy suppliers and local finance institutions), and thus act as intermediaries between multiple actors. Furthermore, municipalities can also be leading by example and focus on their own activities and changing them in a more sustainable direction (e.g. energy retrofitting of municipal buildings and disclosure of annual consumption through benchmarking). Moreover, municipalities can focus on a more area-based approach, for instance focusing on a specific village, and use different approaches in the same locality (Dowling et al., 2014). The shift from government to governance also relates to a regulation perspective, with increasing privatization and liberalization of energy systems, buildings and infrastructures, where the local authorities may struggle to constitute their power and legitimacy for intervening in energy systems (Webb et al., 2016). This means that climate planning, including retrofitting programmes, is often situated in other framings of urban development, and energy is likely to be framed as a source of "green economic growth" (Webb et al., 2016), thus combining the climate agenda with other municipal goals.

2.4 Options and challenges

Following the insight that homeowners and their energy-retrofitting activities cannot only be understood from an economic perspective, some researchers have pointed out how the energy-retrofitting activities can be understood in a practice theoretical perspective (Bartiaux et al., 2014). From a practice theoretical perspective, the individual is viewed as someone carrying out activities that are perceived as normal in their networks, and which are supported by structures around the homeowner. This practice theoretical perspective is thus in contrast to understandings of the individual as acting based on individual norms and beliefs, and this implies that the formation of collective processes and networks becomes more relevant. The practice theoretical perspective emphasises that promoting strategies towards energy-retrofitting activities among homeowners, should not so much focus on the individual households, but rather on the local communities and networks around the homeowners (Karvonen, 2013). Examples of networks around the homeowners include for instance professional building companies with specific energy-retrofitting knowledge (Horne et al., 2014). This line of shifting from focusing primarily on the individual household to including the local community and network around the homeowner indicates that network-based governance approaches might be interesting. This is supported by studies of specific energy-retrofit programmes showing that some local schemes basing their efforts on a combination of approaches (both socially and economically) at local level actually have led to substantial energy savings in the area (Gillich et al., 2017; Webber et al., 2015).

In spite of the promising opportunities, there are also substantial challenges related to network-based governance policies on a local scale. These include mobilising networks, identifying relevant participants, establishing legitimacy amongst the involved actors, resolving conflicts etc. (Torfing and Sørensen, 2005). From a planning perspective, a challenge in relation to single-family housing is the many units, many owners, and lack of shared organisation connecting

the homeowners, making it difficult for planners to reach these owners. Studies of local programmes to motivate building owners to increase energy efficiency in existing buildings (Gillich et al., 2017; Trencher et al., 2016; Van der Heijden, 2016) typically focus on other types of buildings than single-family houses, e.g. business buildings or multi-family homes (Trencher et al., 2016). The literature, which examines programmes directed towards larger buildings, include policy models such as cap-and-trade, mandatory retrofitting requirements and benchmarking, and as these are designed for large buildings in large cities they are not transferrable to single-family housing in semi-rural areas. Therefore, the instruments described in this literature cannot be directly transferrable to single-family houses. Finally, the classic challenges for energy efficiency - actual energy performance and residents' behaviour – are typically not included in the governance arrangements for promoting energy efficiency in existing single-family homes (Van der Heijden, 2016). Due to these challenges, new governance instruments, despite their promising potentials, might fall short in the same areas as traditional instruments (Van der Heijden, 2016).

Based on the understanding that network-based approaches from local authorities are promising, the paper will explore Danish examples of local policies, how they approach the owners of single-family houses, and to which extent the national policy mix for promoting energy retrofitting are supporting them.

3. Danish policy mixes to promote energy retrofitting

The long-term energy policy goal in Denmark is that by 2050 the energy system should be carbon neutral (Klima-, Energi- og Bygningsministeriet, 2014). Energy demand from buildings represents a major part of achieving this, and a government committee dubbed "Network for energy renovation" has stated that in this context single-family houses represent a main challenge (Klima-, Energi- og Bygningsministeriet, 2014). Technical calculations show that, in 2011, the energy demand from single-family houses represented more than 50% of the total energy demand from the Danish building stock, and that they represent the part of the building sector with the greatest potential for reductions (Klima-, Energi- og Bygningsministeriet, 2014). Thus, single-family houses are generally recognised as one of the main targets of Danish policy for greenhouse gas (GHG) emission reductions.

3.1 International and national policy mixes for promoting energy retrofitting

The Danish national initiatives for pursuing these goals generally follow the EU regulations for the energy efficiency of buildings. Danish national energy policy has included various arrangements and tools to motivate private homeowners to energy retrofit their buildings, and these together constitute the overall national policy framework for local initiatives. (Oikonomou and Jepma, 2008) suggest four categories for policy interventions, which are useful to outline the main Danish policies for motivating energy-efficient retrofitting (for more details on these policies see (Gram-Hanssen, 2014b)):

1. *Financial measures*: In Denmark, there are no direct subsidies for energy retrofitting of buildings, but indirect subsidies in the form of tax deduction related to get renovation done by craftsmen (Håndværkerfradrag (artisan deduction)), as well as different types of support for renewable energy provision, including the use of heat pumps.

2. *Legal or regulatory instruments*: Refer to requirements set by the government. These include requirements in building regulations for energy efficiency initiatives when renovating buildings (since 2006). So far this has had limited effect on retrofitting practices for detached owner-occupied houses (Christensen et al., 2013). Lack of effect from this policy refers to limited knowledge about the regulations among homeowners as well as among builders. The effect is also weakened by the fact that some of the specific details of the regulations are open for interpretation and so far there have been no examples of prosecution (Christensen et al., 2013).

3. *Organizational measures*: Including negotiated and voluntary agreements. This includes energy-saving obligations for energy providers ('Energy saving agreement' established in 2009). This is an agreement between the Ministry for Climate and Energy and energy suppliers and distributers with the aim of achieving energy reductions amongst end-users. The savings are documented by a "standard value catalogue", which through a simple on-line calculation defines the theoretical amount of energy saved for different types of improvements to the building or replacements of old installations with new more efficient technologies. The

saving obligations create a market for energy savings, so that energy suppliers can trade energy savings, making energy-savings worth an investment. For an international comparison of the Danish energy-saving scheme related to other similar schemes, see (Rohde et al., 2015). Another organisational initiative is the establishment of the “Knowledge centre for energy savings in buildings”, a centre under the Danish Energy Agency. The centre was established in 2008 with the purpose of collecting and communicating knowledge on the practical possibilities of reducing the energy consumption in buildings. The centre offers consultancy, advice and training, especially for builders.

4. *Certificates or marketable (tradable) permits/quotas*. In relation to energy retrofitting of buildings the Energy Performance Certificate (EPC) can be seen as an example of such measures. The EPC aim to promote energy savings by ranking buildings according to a theoretical energy consumption based on calculations by an energy consultant after inspecting the building. The issuing of an EPC is mandatory when selling or renting out buildings. The scheme was established in Denmark in the 1980s, and since 2006, it is the transposition of an EU directive on the energy performance of buildings (the EPBD). Various evaluations have looked at the effects of the EPC scheme, and the general impression is that the scheme only to limited extent increases homeowners’ energy renovation (Christensen et al., 2014), though it may affect the sales price of the house (Jensen et al., 2016).

As the Danish national policy for pursuing these goals generally follows the EU regulations for energy efficiency of buildings, the Danish experience is in line with experience in other EU countries. In general, in Denmark as well as in other EU countries, the policy can be said to have had a limited impact so far, especially compared with the ambitions for this area (Gram-Hanssen et al., 2018; Visscher et al., 2016).

3.2 Local policies and the role of municipalities

There are 98 municipalities in Denmark, all acting as local authorities and with a high degree of autonomy. They are responsible for the overall planning and administration of the municipality, including provision of welfare services, planning and development, sustainable development etc., including spatial planning for heat provision, in the form of e.g. district heating or gas. How ambitious municipalities are regarding the sustainable development, however, varies. Thus, the extent to which municipalities engage in promoting energy retrofitting of single-family homes also varies. Some municipalities have set targets for CO_2 reductions, or in other ways formulated ambitious plans, and some municipalities have joined voluntary agreements with third parties such as the Danish Society for Nature Conservation.

Due to a large administrative reform in 2007 where a number of municipalities were merged, reducing the number from 275 to 98, the municipalities today typically consist of a mix of cities, towns, suburbs, villages and rural settings. Over the last decade, there has been a strong urbanization and a migration to the larger cities, leaving many municipalities in the western and southern part of Denmark in a challenged situation, with a high out-migration, loss of jobs, a changing demography, a reduced public service level, as well as with poor building conditions and hence large potentials for retrofitting.

4. Material and methods

4.1 Selected municipalities

The empirical material includes studies of 12 Danish municipalities. The selection was based on previous knowledge of how municipalities work decisively with strategies for motivating homeowners to energy retrofit, including network formation and village-oriented initiatives (Gram-Hanssen et al., 2015). We were specifically interested in front-runners in this field. Thus, the selected municipalities are not representative of all Danish municipalities. Using front-runners in a case study has the advantage of learning from the municipalities with the most experience in this area. Based on understandings of how to generalize on case studies (Flyvbjerg, 2006), these types of result can also be of general interest in relation to other municipalities which have not (yet) the same ambitions.

The geographical location of the 12 selected municipalities is shown in Figure 1. The selected municipalities are spread out in different parts of the country, with a few near the city centres of Copenhagen and Aarhus, representing the economic growth areas in Denmark, whereas more are located in less economically favourable areas.

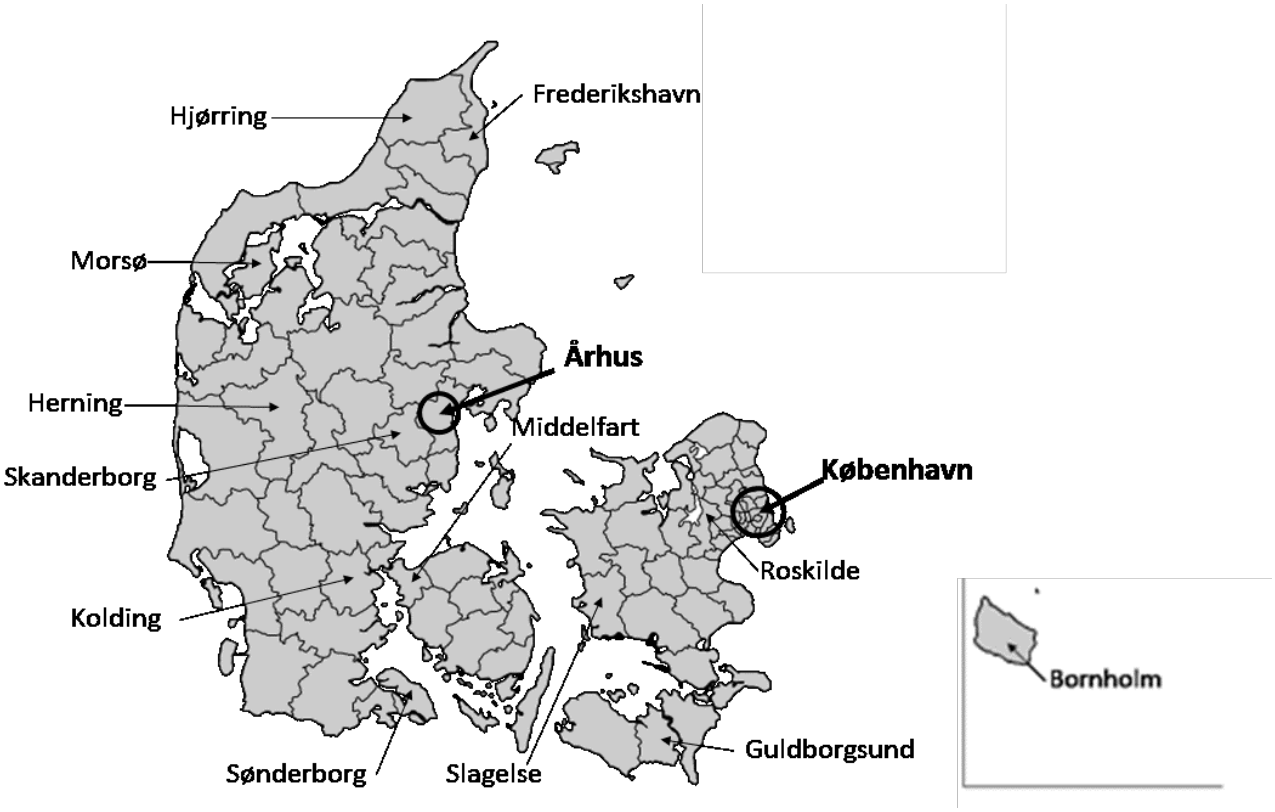

Figure 1: Map of Denmark showing the geographical location of the 12 selected municipalities out of 98 Danish municipalities. The Danish capital, Copenhagen (København) as well as the second largest city, Århus, is also shown at the map, to indicate the location of the economic growth areas.

Characteristics of the 12 selected municipalities are shown in table 2, which summarizes key figures for each municipality, compared with the national average for the same parameters.

Municipalities	Size (sq km)	Population	No of SFH	% SFH of residential buildings	Average household income (DKK)	Voluntary climate Agreements (year of signing)
Bornholm	588	39,695	11,634	62%	425,129	Climate Municipality (2008)
Frederikshavn	651	60,356	18,044	77%	461,786	Climate Municipality (2007) Covenant of Mayors (2011)
Guldborgssund	901	61,257	18,163	76%	425,487	Covenant of Mayors (2009)
Herning	1,321	88,386	19,820	72%	498,724	Climate Municipality (2009)
Hjørring	927	65,307	18,861	76%	509,448	Climate Municipality (2010) Covenant of Mayors (2013)
Kolding	604	92,282	20,364	71%	530,442	Climate Municipality (2008)
Middelfart	299	38,093	10,327	71%	444,802	Climate Municipality Plus (2008)
Morsø	366	20,665	6,628	73%	569,742	Climate Municipality (2009)
Roskilde	212	87,015	15,761	73%	607,789	Climate Municipality (2008) Covenant of Mayors (2009)
Skanderborg	417	60,401	14,220	72%	449,906	Climate Municipality (2009)
Slagelse	568	78,828	15,211	67%	474,561	Covenant of Mayors (2009)
Sønderborg	497	74,801	19,555	77%	425,129	Climate Municipality (2008) Covenant of Mayors (2012)
National average	***438***	***58,480***	***11,278***	***70%***	***500,550***	71 municipalities (72% of all) have signed up as "Climate Municipality", and 36 municipalities (37% of all) have signed the Covenant of Mayors

Table 1: Key characteristics of the 12 selected municipalities as regard single-family housing (SFH), as well as the national average for the same figures. Source: Statistics Denmark (2017); The Danish Society for Nature Conservation (http://www.dn.dk); Covenant of Mayors (http://www.covenantofmayors.eu/index_en.html)

As seen in table 1, all the selected municipalities have signed up for either or both of the two voluntary agreements of respectively the Danish Society for Nature Conservation (Klima-kommune (Climate Municipality)) and the EU voluntary climate agreement (Covenant of Mayors). Besides this type of voluntary agreements with a third party, some municipalities have formulated overarching climate plans or energy plans that embrace interactions between energy efficiency, CO_2 neutrality, local job creation, more attractive housing stock, branding of the municipality etc. Examples of this are ProjectZero, a public-private collaboration in Sønderborg, the EnergyCity in the municipality of Frederikshavn and the Green Growth Programme in the municipality of Middelfart. The initiatives and programmes for promoting energy retrofitting amongst single-family owners are typically a part of these overarching policies. Such policies typically provide a platform for the initiatives to reach homeowners, and strengthen their credibility as well as their links with other initiatives in the municipality.

4.2 Study methods

The study methods include document analysis, a telephone-based survey of the municipalities and in-depth follow-up telephone interviews with the planners in charge of local climate policy in the 12 municipalities. Interviews were

performed in 2013. The in-depth telephone interviews were based on a semi-structured interview guide that focused on describing the activities of the municipalities directed towards retrofitting of single-family housing, mapping the networks and the cooperation partners as well as the background for the initiatives, and asked about the experience so far. Detailed notes from interviews were taken (but no transcription of the interviews) and the written case descriptions were afterwards approved by the municipalities.

5. Results: Local climate governance in front-runner municipalities

Analysis of what Danish front-runner municipalities are doing to promote more energy-efficient retrofitting among single-family housing reveals many similarities and a few differences in the approaches taken. Much of their work is about establishing networks with different actors who have contact to homeowners. Figure 2 illustrates in principle the network of these groups of actors. The actors enrolled might include craftsmen in local SMEs, e.g. electricians, plumbers and carpenters, as well as actors such as energy consultants, energy suppliers, financial institutions, real estate agents, and educational centres for craftsmen and builders. These networks are supported by parts of the national policy mixes, including the energy-saving obligations for the energy providers, motivating them to obtain energy savings amongst end-users, e.g. through co-financing an energy consultant. The energy consultant reports the energy savings achieved by reporting the implemented energy improvements through the standard-value catalogue that converts these improvements into specific annual energy savings.

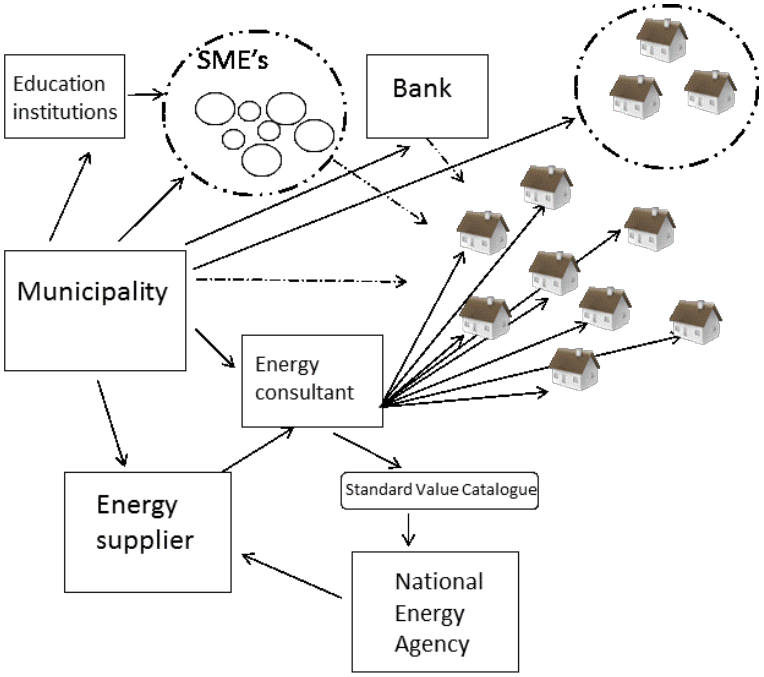

Figure 2: Illustration of how municipalities enrol different actors and policies in their efforts to persuade single-family homeowners to energy retrofit. The figure also illustrate that single-family homeowners can be approached both individually and through village approaches.

The types of activities used by the municipalities are summarised in Table 2. Results show that the interviewed municipalities used various types of communication (e.g. websites; special events; commercials) in their efforts to inform and market their initiatives to homeowners. Besides, the activities can be distinguished into two other types of contacts towards homeowners, either direct contact to homeowners, or a collective approach of village contact. Activities related to craftsmen/builders typically include establishing networks and retraining, and finally the table shows which municipalities that involve other collaborative initiatives towards either energy suppliers or financial institutions. In Table 2, the different approaches and included initiatives in the 12 municipalities are summarized.

Initiatives	Towards citizens			Towards builders		Other collaborative initiatives	
Municipalities	General communi-cation	Energy audits	Village contact	Establishing networks	Retraining	Energy suppliers	Financial institutions
Frederikshavn	X	X	X	X	X	X	X
Herning	X		X			X	
Hjørring	X			X		X	
Kolding	X	X	X	X	X	X	X
Middelfart	X	X	X	X	X	X	X
Morsø	X	X	X	X	X	X	X
Skanderborg	X				X		
Sønderborg	X	X	X	X	X	X	X
Guldborgssund	X	X	X	X	X	X	X
Roskilde	X	X	X	X	X	X	
Slagelse	X	X	X	X	X		
Bornholm	X	X		X	X	X	X

Table 2: Overview of the 12 studied municipalities and the initiatives included to promote energy retrofitting of single-family houses.

The following sections describe in more detail examples how the municipalities work with these approaches.

5.1 Energy audits: Establishing direct contact to homeowners

A core effort among the front-runner municipality cases is the use of energy consultants, especially for outreaching efforts towards homeowners, as illustrated in Figure 2. Typically, municipalities offer the homeowners an energy survey of their house, which is either free or at a reduced price. In most municipalities, this subsidy is co-financed by the municipality and one or several local energy suppliers. Municipalities thus utilise part of the national policies according to the saving obligations imposed on the utilities. As mentioned previously, the 'Energy saving agreement' implies saving obligations for the energy suppliers and thereby creates a market among energy suppliers for energy savings achieved from the end-user level. This enables energy suppliers to pay for the energy savings obtained through homeowners' energy retrofitting. Therefore, some municipalities use this mechanism by collaborating with energy suppliers, so that the energy consultant is financed partly or fully by the energy supplier from the energy savings derived from the energy consultants' visits. These energy savings can then help the energy company to reach its saving obligations. The energy consultant reviews the energy saving potential of the house, and writes a report with suggestions for improvements and for financing of the various retrofitting initiatives. In general, the municipality states that the results mainly rely on the energy consultancy giving the homeowners personal, professional, and independent advice, as well as holistic solutions, instead of single solutions.

5.2 Village contact: Collaboration on local bottom-up initiatives in villages

One option that municipalities have, in contrast to national policies, is to address the climate initiatives in specific geographic areas. Most of the interviewed municipalities have initiatives directed towards entire villages, typically on shifting the energy supply of the village from individual oil boilers to Combined Heat and Power supply (CHP), but also in relation to promoting energy retrofitting for homeowners. The initiatives might consist of meetings collecting the homeowners in the village, with participating actors from the municipality, energy suppliers, local builders, and local banks, where different types of retrofitting models are presented and promoted. Sometimes also offering a free energy consulting for the homeowners. In other cases, more longstanding efforts are carried out, e.g. by profiling the village as an "energy village". A number of municipalities, implying a long-term collaboration between the people living in the village, the municipality, energy suppliers and possibly other actors as well, has used this concept. The nature of these initiatives and the selection of the participating villages can be a result of bottom-up initiatives where active villagers contact the municipality, or the inverse initiated by a top-down selection, where, in collaboration with the energy suppliers, the municipality identifies possible villages for collaboration. However, most municipalities acknowledge that the village-based initiatives on energy retrofitting and change in energy supply should start with interest and engagement from the residents. This is in line with the findings of other studies, emphasising the importance of embedding projects

locally (Beillan et al., 2011). The initiatives in the villages are intended to encourage homeowners to share knowledge, instead of informing each homeowner individually. This also helps strengthen local networks and social capital in the village. However, according to the municipalities, one of the challenges is that in many rural villages, the houses are in a rather poor condition, meaning that energy refurbishment is rather costly. Furthermore, the residents are often DIY (Do It Yourself)-oriented, meaning that they might have listened to the advice from the energy consultant, but decided to carry out the energy retrofit themselves. In this case, the retrofit and the savings are not registered in the "standard value catalogue", and therefore not documented.

5.3 Establishing networks of SMEs and retraining craftsmen and builders

Retraining of local craftsmen and builders is an important element in most municipalities' efforts, as it will give the craftsmen more competences in guiding homeowners towards energy retrofitting and thereby generate more renovation projects and create more local jobs. Several municipalities encourage local craftsmen to join the energy consultant programme; a three-day course offered by the Danish Technological Institute as a part of the national initiative "Knowledge Centre for Energy Renovation of Buildings" (as previously described). This will qualify the craftsmen as approved "Energy Guides". This retraining has allowed the craftsmen to perform the final approval of the energy savings, calculated through the standard value catalogue. Other municipalities offer retraining programmes at local education centres. As an example, the municipality of Sønderborg cooperates with the local trade training centres (EUC Syd) through "Projekt ZeroByg", which aims to promote development and sale of energy-efficient solutions and to create market-based concepts aimed at exports. The main tasks are to establish and run programmes to qualify craftsmen, to go from single solutions to system solutions, and to emphasise the collaboration between different types of skills. The retraining efforts are often supported by ambitious municipal demands regarding energy efficiency in new buildings and retrofitting of public buildings. In the Sønderborg region, 65% of craftsmen and builders have now completed an energy-guide training programme. According to the municipality, the increased number of housing renovation projects has further encouraged craftsmen to take the course. As a part of the retraining, some municipalities have helped to create local networks amongst craftsmen and builders with different skills, in order to strengthen knowledge-sharing and collaboration competences. On a national scale, four different local and regional networks of builders have been established (Strandgaard, 2012). Some of the experience reported by the municipalities is that homeowners are convinced by documentation of payback times for different energy solutions, which the craftsmen learn at the programme, as well as by hearing about "success" stories from other renovation projects.

5.4 Collaborative initiatives with financial Institutions

Financial actors such as credit institutions and banks can play an important role in financing energy retrofitting, but many municipalities have the impression that knowledge about energy retrofitting and the value it creates for the houses is rather limited amongst banks and credit institutions. Therefore, several municipalities have tried to establish collaboration with these actors to make them aware of the benefits related to energy retrofitting, and to make homeowners aware of the possibility for energy retrofitting when they go to the bank for loans to buy or rebuild their home. Several municipalities invite financial institutions to an annual energy exhibition, or other types of public events held by the municipality as part of their climate strategy, and generally the municipalities describe the banks as being increasingly proactive and open in relation to financing energy retrofitting. There are several examples of banks and credit institutions that on their own initiative establish favourable loans for energy retrofitting to private homeowners, arrange courses to increase "energy knowledge" for their staff, or promote energy retrofitting towards local homeowners. In Sønderborg, the municipality has addressed all local banks and offered them courses on payback times for different energy-retrofitting solutions, or the increased value obtained by energy retrofitting a home. In the municipality of Morsø, the four local banks have been presented for the energy survey offered by the energy consultant, which has made them aware of the financial benefits of the solutions presented in the survey. This has reportedly increased the banks' willingness to lend money to private householders for energy retrofitting. Moreover, local real-estate agents have been involved in some municipal strategies, although to a smaller degree, and several municipalities emphasize the need for greater involvement of these actors. Research has shown that public display of the energy performance rating influences the market price of houses (Jensen et al., 2016), and the rationale from the municipalities is that real-estate agents can convince banks as well as homeowners of the value of a higher energy rating, especially for houses in peripheral regions. Low sales prices and poor physical condition of the houses might make heating costs the largest item in the household budget, and therefore energy retrofitting will potentially have a larger effect on the households' total economy, as compared with the larger cities, where sales prices are typically much higher and energy costs are most likely proportionally lower.

6. Discussion

Based on these findings from front-runner municipalities and their governance activities towards owners of single-family houses, more general learnings in relation to the literature presented previously are discussed below: also in relation to national policy in a multilevel governance perspective.

6.1 Assessment of the influence of national policy mixes on local retrofitting initiatives

Our results related to the various municipal initiatives for promoting energy retrofitting of single-family houses shows that, to varying degrees, the national policy mixes supports these initiatives. Energy saving obligations for energy suppliers in particular have been an important element in several local programmes in motivating local energy suppliers to collaborate and thereby establishing co-finance for the direct contact to the house-owners. Moreover, several municipalities have used the national knowledge centre for energy savings to train local craftsmen and builders.

It is, however, noteworthy that neither the building regulations, outlining the requirements for energy improvements when buildings are renovated, nor the Energy Performance Certificates (EPCs) have been utilised in the local programmes and policies we have studied. Ideally, the EPCs could have functioned as a guideline for building owners on how to approach future energy retrofitting of their house, and therefore theoretically supporting or substituting the reports made by the energy consultants. The limited uptake might be because that not necessarily all buildings have been certified, or that the EPCs have a reputation for being too imprecise to be used for actual retrofitting initiatives.

Looking at international examples of programmes, there are both similarities and differences. For instance, the US Better Buildings Neighborhood program (BBNP) included (1) programme design, (2) marketing and outreach, (3) workforce engagement, (4) financial incentives and (5) data and evaluation (Gillich et al., 2017). Van Der Heijden in his work on the new governance on low-carbon buildings identifies a number of regulation mechanisms, including instruments for (1) certification and classification, (2) information generation and dissemination, (3) financing, and (4) accelerators and bridging instruments (Van der Heijden, 2016). Compared to the international literature and experiences, there are a number of possible policy interventions that have not been included in either a national or a local scale in Denmark, and these could be relevant to discuss:

- *Financial measures:* The Danish policy intervention mixes have not included any fiscal means for promoting energy retrofitting. However, on a local scale, mobilising banks and financial institutions might pave the way for easier access to financing energy retrofitting activities. Therefore, local programmes demonstrate a knowledge-gap in this sector, and a need for such initiatives to meet this challenge.
- *Outreach:* Information campaigns and exhibitions are often integrated parts of the initiatives for reaching owners of single-family homes. Outreach is an important way to disseminate knowledge about; the local initiatives, retrofitting options, local craftsmen and builders, local producers, and other users having retrofitted their homes etc. At national level, there have been various degrees of information available to support such local initiatives, however, this is an area where the national policy mixes could be further strengthened.
- *Sustainability labelling schemes*: In contrast to international programmes on city scale for promoting energy efficiency in the existing building stock (Van der Heijden, 2016), there has been no use of sustainability labelling schemes (e.g. BREEAM (Building Research Establishment Environmental Assessment Method), DGNB (Deutsche Gesellschaft für nachhaltiges Bauen e.V. - German Sustainable Building etc.)) in the Danish cases. This relates mainly to the building segment in this study (single-family houses), where potentials for using labelling schemes are very limited, but also in relation to the limited market penetration these programmes have had so far in Denmark (Larsen et al., 2017).
- *Benchmarking and rating of buildings and municipalities:* This instrument has also been absent in the Danish cases. A few municipalities have calculated the amounts of CO_2 saved through the programmes, but no benchmarks with other municipalities or benchmarks at building level have been recognised. However, as a political legitimization, the programmes have often focussed on measuring and monitoring the effects locally in terms of number of households reached, the amount (theoretically) of energy savings, or the amount of jobs created.
- *Actual energy performance and residents' behaviour*: This has been pointed out as a possible element in local programmes (Van der Heijden, 2016) and the issue is highly central in the literature on energy retrofitting in general, but we have found no indications that this issue has been a part of local programmes for promoting energy retrofitting. However, by not doing so, it might be difficult to convince other house-owners about the actual benefits of doing an energy retrofit of their house.

Seen in relations to this, there are several ways to improve the national policy mixes. However, it is clear that the national policies have not been designed to support local initiatives, like those studied in this paper, based on networks between municipalities, energy suppliers, craftsmen, financial institutions, homeowners etc. Rather, national policies have been designed as context-free tools, not designed especially to support local initiatives. In general, when designing national policies and policy mixes, more focus on the experience from local programmes could be a valuable source of possible inputs and inspiration. This could be a step in the direction of better co-ordination between national goals and local initiatives for energy planning and efficiency, as many researchers are calling for (Sperling et al., 2011). Inspiration could also be gained from the various studies giving suggestions on how to manage and design effective policy mixes (Kern et al., 2017). For instance, Nilsson et al (2012) develops a three-step analytical approach, consisting of an inventory of policy objectives, a screening of existing policies and an in-depth analysis of key interactions, including focus on both vertical / horizontal as well as internal / external interactions (Nilsson et al., 2012). Using insights from such frameworks might help design a more efficient national policy mix that might to a larger extent support local policies for energy retrofitting.

6.2 Regional dimensions in the uptake of local policies

Results demonstrate that in order to understand how and why local programmes and initiatives for promoting energy retrofitting in single-family houses are being launched, it is also necessary to understand the local conditions in the municipalities.

The municipal initiatives reported in our case studies are often embedded in, or related to, voluntary climate agreements, climate goals and policies for sustainable urban development defined at a municipal level, including benefits of job creation, developing local competences, creating more attractive settlements, attracting residents to the region, branding the city etc. Thus, this corresponds to what has been described internationally about retrofitting programmes to be framed as a source of “green economic growth” (Webb et al., 2016). Several of the selected front-runner municipalities in this study are located outside the growth areas in Denmark, which is probably not a coincidence, as these municipalities have a special inclination to be innovative in their search for possible initiatives to boost the local economy. The present migration from smaller to larger cities leaves many peripheral municipalities with declining population rates, an ageing population, old housing stocks, and falling housing prices. This in turn gives certain conditions for municipal initiatives: housing prices in these areas are generally low, compared with other parts of the country, and energy costs take up a large proportion of housing expenses, making energy retrofitting more attractive, in theory. On the other hand, the low housing prices and the uncertain future for peripheral regions makes it difficult to borrow money to finance energy retrofitting. According to several peripheral municipalities in our study, there are villages and settlements where finance institutions are not willing to lend money to buy houses or renovate them, as they see a large risk in continuously decreasing housing prices. Part of this reluctance from the local financial institutions is a limited understanding of the value of energy-reducing initiatives. Therefore, initiatives to inform banks and financing institutions about the value of energy retrofitting, e.g. through collaboration with the municipality, might prove valuable. This in turn underlines the important role that the municipality can play in order to improve the local framework for local homeowners to energy retrofit. Furthermore it underlines the importance of including studies from different regions with different economic conditions, thus understanding the different context for local governance strategies, which is also emphasised in an international context (Dent et al., 2016). In a multi-level governance perspective, this furthermore raises the question of how national policy can include the different economic conditions and possibilities in various regions of the country; an issue which has not yet been included in any national energy policy formulations regarding energy-efficient retrofitting (Seyfang and Haxeltine, 2012).

6.3 Costs of achieving energy savings

Direct contact to house-owners has been a crucial element in the local strategies. This corresponds to findings from other studies, e.g. the US BBNP programme, where the ‘energy advisor’ serving as an intermediary between contractors and building owners proved to be successful (Gillich et al., 2017). However, in the context of single-family houses, this is a resource-demanding strategy. Especially for the energy suppliers, involvement in initiatives towards homeowners can be an uncertain business case, and we have seen some examples of initiatives where the design of the initiatives has been changed due to this. As the regulation does not say anything about how the savings amongst end-users should be gained, the energy suppliers use very mixed strategies (CM analyse, 2010). This includes the question of whether the energy suppliers at all focus on homeowners as a segment for energy reductions, as many suppliers prefer to focus on larger building owners in order to reduce transaction costs in relation to the persuasion and documentation process.

Also, the relatively large expenses for saving energy in households, compared to saving energy in industries, has been pinpointed in national evaluations of the energy-saving obligations (Deloitte og Grontmij, 2015; Ea Energianalyse, Niras, RUC and 4-Fact, 2008), making it uncertain whether energy savings in single-family housing are profitable, in relation to the relatively large resources used for establishing contact and maintaining dialogue with the house-owners. These challenges might be managed in different ways, e.g. by focusing on villages and more collective homeowner groups, using social media to communicate etc., or by changing the institutional arrangement, and leaving it for "traditional" actors, for instance to let craftsmen take care of contact with the house-owners (Jensen, 2016). Interviews amongst energy-suppliers, however, reveal that there are large differences in strategies and views on the energy-saving obligations (Gram-Hanssen et al., 2015). For some energy suppliers, the local attachment and local collaboration hardly exists, and they achieve their energy savings through collaboration on a national scale. However, other energy suppliers have a much more local approach, and prioritize local initiatives (e.g. by promoting energy retrofitting amongst local house-owners), and are less focused on the financial benefit of their efforts. This also implies differences in relations between the municipality and the energy suppliers; the most progressive municipalities typically have quite good relations to the local energy suppliers, who also give local initiatives a high priority – which again is related to the ownership structure of the energy supplier. Therefore, the local energy supplier's local attachment and relations to the municipality make a large difference regarding its interest in pursuing energy saving obligations in local households.

6.4 Outcomes: Do local energy retrofitting policies deliver energy reductions?

The achievement of the energy suppliers' energy saving obligations is documented by calculations in the "standard value catalogue", where certain physical energy improvements in the building (e.g. new low-energy windows) are calculated as a certain amount of energy saved per year. This has proved to be an important element in strategies for promoting energy retrofitting - however, this also includes some challenges. There is often a large difference between the calculated energy reductions and the actual energy savings for the homeowner, as also discussed in the theoretical section and reported both in Danish and international studies (Gram-Hanssen and Hansen, 2016; Visscher et al., 2016). There can be many reasons for this: Primarily, the calculations only serve the technical purpose of driving the energy efficiency of the buildings, but they are frequently also used as measures for the actual energy savings. Homeowners often include many other changes in the home together with the energy-saving devices, e.g. expanding the house and adding more space that might affect the heating bill negatively, as well as changing the householder's comfort practices after the energy retrofitting. The question is whether this will affect the homeowner's post-assessment of the energy retrofitting, and whether that may possibly affect other homeowners' decisions. The economic rationales of the energy retrofit in particular, including the involvement from banks and financial institutions, are challenged by these issues. Although these issues have not yet appeared as problems in the case studies, it seems as if both municipalities and the actors they enrol think that their efforts are producing actual savings. More emphasis on this aspect in national policy might, however, be relevant to prevent homeowners, and those funding the homeowners, from ending in financial difficulty if the expected energy savings turn out not to be achieved. Negative stories on savings not achieved can work against the goals, so realistic assumptions are important. Also, this might affect the municipal climate strategies, as the calculated energy reductions might not be followed by a real decrease in the energy consumption of homeowners. However, the opposite argument is also often heard: that the initiatives actually lead to more energy retrofitting projects than what can be seen in the reports. This is because residents complete the ideas through DIY or by using the craftsmen/builders that they normally use (and not the craftsmen with an energy certificate), which means that the energy saving projects that are actually completed are not documented by the standard value catalogue, and not reported to the authorities.

7. Conclusions

The Danish municipalities' initiarives for promoting energy retrofitting in single-family houses seem to be filling a gap on how to reach the owners of single-family houses. These houses represent more than 50% of the energy use in the Danish building stock. Our study has examined these local initiatives, the means of reaching the building owners, and to which extent the national policy mixes supports energy retrofitting. These local initiatives address many of the so-called barriers to energy retrofitting outlined in research studies, including the direct contact to the homeowner, independent assessment of retrofitting solutions, qualified craftsmen to carry out the retrofit as well as pursuing more neighbourhood-oriented approaches in the contact with homeowners. We conclude that the municipal initiatives have to some extent been supported by the national policy mixes. The energy savings obligations that motivate local energy providers to collaborate with municipalities on energy savings in single-family houses has been particularly important for the local programmes, but the National Knowledge Centre for Energy Savings in Buildings has also been important for training

craftsmen. In contrast, other elements in the national policy mix have not been utilized, including the requirements in the building codes for energy improvements in relation to renovation activities, and the EPC certificate for energy efficiency.

This emphasizes that, although in many cases national policies on energy reduction in private households might not have directly measurable effects, they might provide an important framework for the formulation and implementation of local climate policies. Thus, we argue that in many cases the main achievement of these national policies has been to frame and support local climate policies.

An important precondition for the local programmes is that they are often embedded in ambitious climate plans and regional development strategies, as well as being located in peripheral regions. In these regions, the local housing market is dominated by low housing prices, where energy costs take up a much larger proportion of the household budget compared with the housing market in growth areas, thereby making energy retrofitting more attractive, but also more difficult to finance. Therefore, the municipalities' ability to involve different actors (energy suppliers, craftsmen, financing organizations etc.) and establish local partnerships is crucial for the success of the programmes. Nevertheless, the initiatives remain fragile, partly because the business case for municipalities and energy suppliers remains uncertain due to the high costs of contacting the homeowners. Therefore, we will probably see a continuous development and adaptation of these initiatives in the future. Approaching homeowners and encouraging energy retrofit as part of the municipalities' climate plans and governance strategies is a new and large challenge, but as single-family houses represent a large energy consumer in many countries, this is an important field to be engaged in for municipalities. Acknowledging the interplay between national and local climate policies, and the relative success of local initiatives towards local house-owners, we suggest a stronger national emphasis on providing room for local actions, and facilitating such actions. This could include more explicit policy formulations of local initiatives, and a continuous compilation of experience gained from establishing local networks and strategies for promoting local energy retrofitting activities. This would also include an acknowledgement and interest in the very different economic situations which are the reality in different parts of the country, and which strongly influence possibilities for retrofitting single-family houses in different regions, and thus lay very different foundations for the climate strategies in different types of municipalities.

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