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Jensen, Jesper Ole; Mechlenborg, Mette

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Ageing population in Danish single-family houses: Energy efficiency and other challenges illustrated by the “Single-family housing atlas” and home research

Abstract for ENHR 2019 in Athens: HOUSING FOR THE NEXT EUROPEAN SOCIAL MODEL

Jesper Ole Jensen and Mette Mechlenborg, Danish Building Research Institute, Aalborg University

**** Work in progress – please do not quote ****

ABSTRACT

The single-family house (SFH) is the most popular housing type in many western societies. In Denmark, more than 50% of the population is living here. The majority of the SFH-stock was built from the 1960ies to the 1980ies, in a period where the nuclear family was the predominant family type. Since then many things have changed: The residents have become older, the kids have moved away, many houses lack a physical upgrading etc. As a result, many municipalities are facing various challenges regarding the single-family houses; is there a need for other types of housing for the elderly? What is the energy standard of the SFH, how is the energy supply, and how bad are the houses in need for retrofitting? In order to illuminate and map the condition of the single-family housing stock, the Danish Building Research Institute (SBI) has developed an interactive GIS-map, that shows characteristics of the SFH-stock in small geographic areas (parishes). This include register-based data such as location, physical and economic data of the houses (year of construct, size, public valuation assessment, EPC label, energy consumption, energy supply etc.), and socio-economic data (number of residents, age, family type, income, education etc.). In this paper we relate this data to research on home - and place attachment, as the single-family house are said to promote many homemaking strategies especially over time. On this background, we develop three types of senior-SFH-owners: The free house owners, the homebound houses owners, and the unfree house owners. Secondly, research shows that elderly are more reluctant to invest in retrofitting their house compared to younger generations. This means that we also need to investigate private dwellers' motives for physical changes in their SFH. Using this map, we will illustrate some of the present and future challenges related to an ageing population in the SFH-stock, and how the municipality can formulate housing policies to meet these challenges.

Keywords: Single-family houses, ageing population, energy efficiency, GIS, home attachment

INTRODUCTION

In this paper we will address the aging of the residents in the single-family houses in general, using Denmark as a case. We aim to outline the challenges to both housing options for this group, the consequence in relation to energy efficiency in this housing type, and finally to sketch possible strategies for addressing these challenges. The single-family houses is a widely popular housing type in most western societies. The ageing of societies means that a gradual transformation of the single-family houses from families to empty-nesters and singles is taking place. Whereas this transformation has been scrutinized in terms of elderly care, living quality, service provision etc., there has been less attention to the sustainability aspect of this housing transformation. The main background is that there is an ageing of the residents all over the country, and also in the single-family houses. The group of 65-69 years old have grown with 30% since 2007, and the group of 70-74 years with 57%. At the same time we live longer; the new generation of elderly are re-defining ways to live their lives. When the single-family houses were built, it was mainly for the families from the post-ww2-generations who were establishing themselves in the new welfare state. Today the picture is different: In 1960 there were families living in 60% of all single-family houses, it is only 20% today (DST, 2019). The children-families (or nuclear families) are retreating from the single-family houses, and the seniors are taking over. This development means that today, the Danish single-family houses are mainly populated by people in their "third age". This is not only due to the demographic development, but also related to the policy of "staying longest time possible in your own home". This

“ageing in place” has been a policy for elderly care for several decades, not only in Denmark, but in many other western countries.

CRITICAL PERSPECTIVES ON AGEING IN THE SINGLE-FAMILY HOUSE

There are several challenges related to the current and future process on many residents in single-family houses getting older and shrinking in household sizes. When we focus on the single-family house as specific type of housing for seniors it has a double perspective: It is not only an individual challenge when so many elderly are living in a too large house that is not designed for their needs - it is also a societal challenge. From the perspective of the climate challenge, we question the distribution of our building- and housing stock; could a more equal distribution of housing space also lead to a decrease in energy use? And could this provide other benefits, e.g. in relation to elderly care? With the increasing amount of elderly persons living in single-family houses as empty-nesters and singles in houses that were built for families, there is a need to think about housing policies that might provide better options for the elderly, for the service care, and for reducing the climate impacts. In the following, we will present critical perspective on ageing in single-family houses, based on literature studies from different disciplines.

Ageing in place

Ageing in place is generally accepted as a desirable goal, for the elderly as well as for the government (Mechlenborg and Jensen, forthcoming; Judd et al, 2010) due to a higher degree of well-being and a reduced cost burden for governments (Miller et al, 2017). Older people enjoy greater independence and well-being through ageing in place and there is a reduced economic burden on government for institutionalized aged care. Although this policy is often regarded as the best, both from the users’ point of view (the elderly) and for the local authorities who are responsible for elderly care (in Denmark the municipalities), there are also critical view about this. Abramsson and Andersson (2016) argues that although ageing in place might be a desirable policy, it might not be the most appropriate or desired option for elderly; staying in the house may be a forced choice, e.g. if there is a lack of attractive housing alternatives nearby, or if the residents have economic restrictions. In contrast, provision of other types of housing might provide the elderly with more life quality, and could even be a way to provide better care, and to reduce costs for care (Abramsson and Andersson, 2016). However, peripheral municipalities who have the largest shares of the elderly population, also have the largest difficulties providing this type of housing (Abramsson and Andersson, 2016).

The single-family house is a type of house that we grow roots in which can make it difficult to leave it. Before we accept that the single-family houses is the preferred type of house for seniors, we should know the amount and consequences, and shed a critical light on alternatives. Both from a societal and from a home-ownership perspective there are reasons to consider, if alternatives should come into play. Older people are more reluctant to move. But when they move, it is often to a smaller dwelling, and to rented instead of owned accommodation (Abramsson and Andersson, 2016). This puts pressure on the welfare service in the municipalities. The social and demographic changes related to the single-family houses naturally challenges the municipalities’ public services to the residents, especially the elderly. Ageing in place requires more home-help and public service in the house, but at the same time public budgets are under pressure. The result is that the public expenses for service of the elderly is shrinking; over the last decade the public spendings on elderly service has been reduced by 26%, whereas the number of elderly over 80 years have increased by 14% (WA, 28 /12 July 2019). Moreover, the health of the older generation has not increased that much (as expected, and as the general perception is), making the lack of service even more problematic (Weekend Avisen, 28 /12 July 2019).

Geographic inequality: Changes in the urban pattern

The problems related to the ageing in single-family houses also concerns the neighborhood and the local facilities, taking place on the background of a changing geography and urban pattern. The single-family houses were built in a period with less urbanization and a more decentralized urban structure, where smaller towns and villages were more independent, having their own jobs, service functions, institutions and with far more families and children. Over recent decades, this picture has changed dramatically; there has been an increasing in-migration to the cities, especially amongst younger people, and an out-migration to the peripheral regions of low-income families and elderly. The nuclear families have moved to the cities, and the city-near suburbs have had an increasing share of empty-nesters and single-family households in the smaller towns and villages.

In the more city-near suburbs, the pattern was different as the suburbs were not planned as independent entities, but in a modernist manner with division of functions, meaning that the jobs were in the city, the dwelling in the suburb, and public and private services to some degree established in a local city center. In the 1960ies, the emergence of the postwar welfare state implied many changes, e.g. a growing public sector, women going out on the labor market, a growth in the economy meaning that people could afford to move out from to the larger cities, and into the suburb, becoming the owner of a single-family house with their own garden. Private car ownership and public transport made commuting possible between the suburb and the city.

There are quite different destinies for the suburbs, and for the single-family house. In general, the suburbs closest to the cities are doing fine, and keeping (if not increasing) their attraction to the market. In other cases however, the suburbs, in some cases villages, or just smaller conurbations, are too far from a city center or from a city center in decline, meaning that the market value of the suburbs and the villages are losing attraction.

Studies shows that for Danish families increasing income leads to a tendency of settling close to their jobs – typically in the cities – as a contrast to choosing a dwelling further away from the city (Gutiérrez-i-Puigarnau et al, 2014), which is often seen in the US. The larger cities in Denmark however have different design in relation to the amount of city-near suburbs, as well as different housing markets with different amounts of privately-owned housing, social housing, private renting and private co-ops, meaning the geographical pattern and attraction of the suburbs are different (Gutiérrez-i-Puigarnau et al, 2014). However, the overall pattern is the same: The suburbs closest to the cities are generally more attractive, with higher sales prices and public assessment values, larger shares of nuclear families and two-person incomes. In contrast, suburbs further away from the city centers are less attractive, with more singles and more elderly citizens, lower housing prices, and lower incomes. The local jobs have disappeared, so have the local services – private as public – and there are longer distances to schools, shops, doctors, restaurants, entertainment etc. Therefore, the general trends and challenges related to the single-family house has a strong component of geographical differentiation to it.

Energy use and poverty

The housing sector represents a huge part of the energy consumption and CO₂-emissions in today's societies. A large part of the consumption is related to the use of housing and housing space; although energy efficiency in buildings and housing has increased over recent years, floor space consumption has continued to increase, resulting in a status quo of the total energy consumption in Danish households (Gram-Hanssen et al, 2018). However, reducing the consumption of floor space has not yet found its way into policies on energy reductions or climate goals. Denmark has adapted an ambitious strategy for carbon neutrality in 2050, which implies severe energy conservations in the existing housing stock on at least 30%. Traditionally, energy regulation of the Danish housing stock has taken place through the building regulations, where demands for energy efficiency has gradually increased over the years. However, the increasing focus on reducing CO₂-emissions has gradually led the focus to the existing building stock, where the single-family house plays a dominant role. To support this, regulation demands house-owners to increase the use of energy-saving solutions when they retrofit their houses. However, research has shown that this only happens to a limited extent, as owners of single-family houses are not aware of this regulation, neither are the craftsmen that they normally use for the retrofitting (Christensen et al, 2013). Also, other initiatives to reduce energy consumption and energy retrofitting amongst owners of single-family houses have proven challenging, this might an argument for looking at ways to reduce the consumption of floor space as an element in the climate and housing policy.

There is another side to this, namely the risk of residents living in energy poverty. Several studies have focused on the links between housing quality, energy efficiency and the impacts of the health of the residents as related factors, and the risk of fuel poverty amongst elderly persons as a challenge. It is recognized that lack of energy efficiency (old houses and lack of upgrading), increasing energy prices, and economic poverty eventually might lead to fuel poverty when elderly remain in their dwelling – with negative impacts for the health of the elderly (see for instance Miller et al, 2007). Studies shows that many seniors in US experience fuel poverty (Kwon & Jang, 2017). A study found that comparing fuel poor seniors with non-fuel poor seniors, the first paid significantly higher heating costs while earning much less in income compared to those in the latter group (Kwon & Jang, 2017). Moreover, the fuel-poverty group were more likely to be older, females, widowed, comprising single-person households and in poorer health, compared to those in the non-poverty group. The fuel poverty group tend to live in older and smaller houses, and with worse building envelope

quality than the non-fuel poverty households. Many of the fuel poor households have income just above the limit for allowing aid from the energy support programs, and hence spend large share of their income on heating. Although Denmark overall scores low on indicators on energy poverty, there are several indications that this average covers large differences between the poor and the non-poor households. Moreover, research in declining housing markets in peripheral Danish regions also indicates that the structural conditions contains a combination of economy poor households, poor maintained houses and energy poverty. A survey on housing preferences amongst elderly in the municipality of Lolland showed that in many single-family houses, the heating costs of the house was the largest cost for the owners, and that larger energy retrofitting would be difficult to finance (Friis et al, 2014). Amongst the elderly, there was a widespread wish to move into something smaller, and more city-near, but a main barrier for this was the inability to sell the house to a decent price, i.e. a price that covers the debt in the house, corresponds to the price it was bought for, or the price for another dwelling in the vicinity. Although this municipality is renowned for it's large amount of vacant single-family houses, the survey showed that there was a lack of smaller row-houses, especially amongst social housing, which was the primary wish for the elderly to move on to (Friis et al, 2014).

RESEARCH AIM AND METHODOLOGY

This paper is a first attempt to shed light on the challenge of the many elderly families living in single-family houses, and especially the challenges related to the energy use in the buildings. Combining reflections and examples from ongoing debates, policies and research projects we will outline some of the problems related to the dominating household type in Denmark, the background for these present situation, and discuss possible policies for addressing these challenges. We will support the discussions with data and maps from the interactive GIS-map "Atlas on single-family houses", developed by the Danish Building Research Institute.

The aim of this paper is thus to present the present energy challenges in the existing stock of single-family houses in Denmark, seen in the light of the demographic changes until now, and in the future. Moreover, the aim to discuss potentials for new integrated housing policies to address this question.

DEVELOPMENT OF THE SINGLE-FAMILY HOUSE IN DENMARK

The construction of housing over the last 50 years has made Denmark a nation of homeowners in single-family houses. Single-family houses have been built over the last century, but especially became dominant in the beginning of the 1960ies, and reached a pace of around 30.000 new houses per year (see figure below). Since the 1980ies the construction of new homes has been more equally distributed between single-family houses, row-houses and flats, and recently the construction of flats in multi-story buildings has clearly taken the lead, reflecting the increasing urbanization in the larger cities. Still, 5-10.000 single-family houses are constructed per year at the moment.

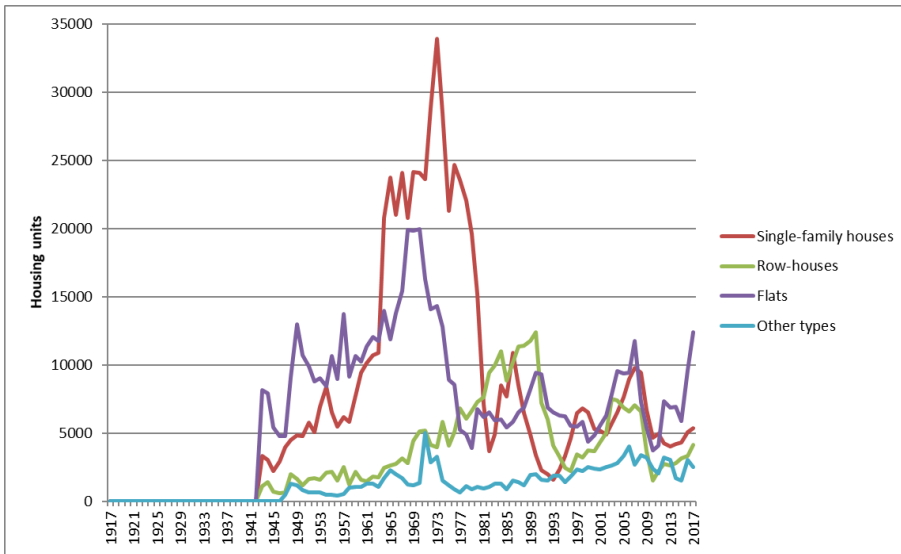


Figure 1. The building activity (number of dwelling) in Denmark, 1917-2013, distributed between different types of dwellings (single-family houses, row-houses, multistory buildings and others).

The size of the new single-family houses has been increasing over the years (see figure 2 below); in the period where the single-family house grew rapidly (beginning of the 1960ies), the average size was 120 sqm, but grew to around 150 sqm in the beginning of the 1970ies. Today the average size of a new-built single-family house is more than 200 sqm. Compared to that, other types of housing (row-houses and flats) has been more modest.

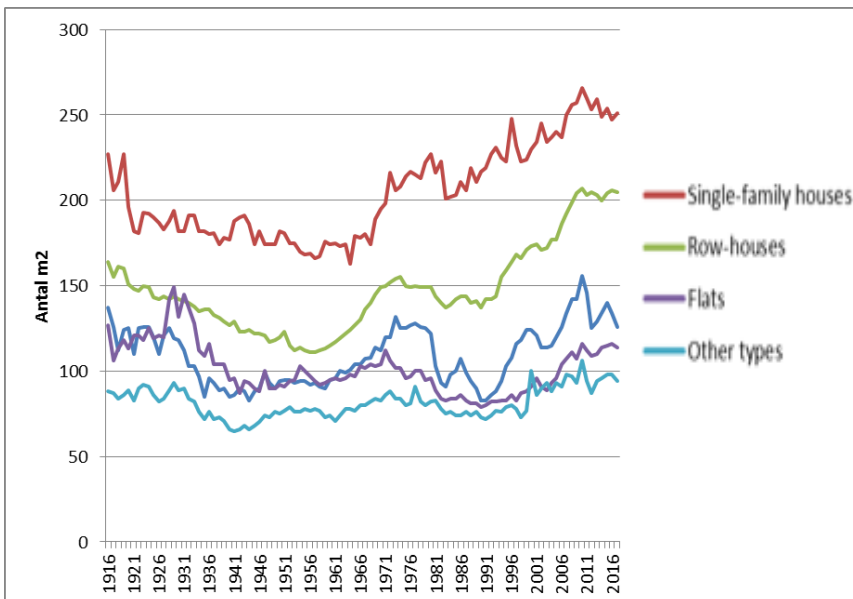


Figure 2. The development in average size of dwellings (m²) in Denmark (1916-2016), distributed between different types of dwellings (single-family houses, row houses, multi-story buildings and others).

The historic development means that we have a housing stock consisting of 44% single-family houses, 15% row-houses and 40% flats –and this distribution has only changed marginally over the last 10 years, in spite of relatively fewer new-built single-family houses.

Moreover, the demographic changes has implied that the number of "nuclear families", i.e. families with children, has decreased. Between 1986 and 2018 the share of single-person households has grown from 37% to 44%, whereas the

share of “merried couples” has dropped from 43% to 34%. This drop can only partially be explained by a growth in “non-merried couples” (from 10 to 13% in the same period). The development has also hit the single-family houses. According to Statistics Denmark, the number of houses with no children at all (below 18 years) amounts to 709.000, corresponding to 61% of all single-family houses in Denmark. And 20% of all single-family homes are occupied by just one person (in 11% a single men, in 9% a single woman). A majority of these residents are owners, but 20% are tenants – 17% among the single men, 23% among single women. See table below.

Table 1. Number of single-family houses (2019) with no children below 18 years, divided by family type, and percentage of all single-family houses (n = 1.163.788). Source: Own calculations based on Statistics Denmark, 2019.

Family type	Occupied by owner	Occupied by tenant	Total	% of all SFH
Single man	103.397	20.727	124.124	11%
Single woman	79.731	24.355	104.086	9%
Merried couple	336.536	15.872	352.408	30%
Other couples	57.010	10.323	67.333	6%
Other households consisting of several families	50.120	10.871	60.991	5%
Total	626.797	82.185	708.982	61%

Geographical inequalities

The geographical distribution of singles (man or woman) living in single-family houses is however very uneven. The map below shows the shares per municipality. The general picture is that the larger cities (Copenhagen, Aarhus, Aalborg, Odense) have the smallest shares of singles (12-16%), and the peripheral municipalities in the western, northern and southern parts of the countries have shares above 20%, somewhere around 30%, and in smaller islands up to 40% (see figure below).

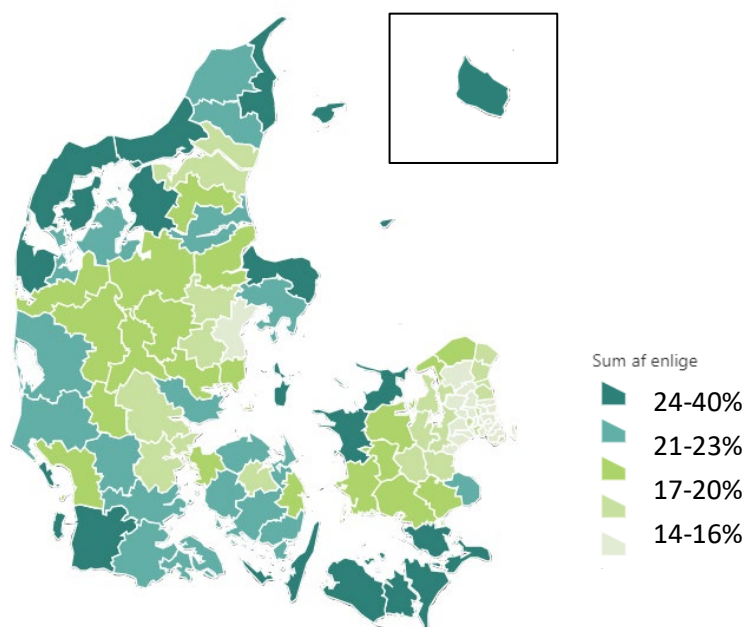


Figure 3. The share of single-person households in single-family houses distributed on municipalities. Source: Statistics Denmark (2019)

For empty-nesters the distribution is also geographically uneven, but less differentiated; around 25% in the metropolitan region, and typically around 35-40% in other municipalities.

Forecasts for the single-family houses

Looking at prospects, the future for the single-family houses looks even more divergent; prognosis predicts that on a national level, the share of +65 citizens will raise from the present 20% to 25% in 2040. The consequences for the housing market has been investigated in a recent study (DREAM, 2016), using a micro-simulation of the housing careers. The study shows that the baby-boom generation (post WW2) is ageing, and will cause age to be raising throughout the country. However, the age will raise more in the peripheral regions and municipalities, and the differences to the larger cities, where many young people are moving, will be larger. The share of elderly people (+65 years) in peripheral municipalities will raise from 35% to 45% in 2040. This will also lead to a change in the family structure, as the number of single-person households will increase. Normally, the number of singles used to be highest in the city centers, and lower in the suburbs. As there is not sufficient supply of houses for the elderly – e.g. smaller flats or row-houses in the nearby towns - and as the prices of their houses might have been reduced and won't allow them to buy another home - they might be forced to stay in their single-family house. Although the number and share of singles will increase, the age of the singles in the peripheral regions will be higher than in the cities. These older singles will demand other types of housing than the existing housing stock – more rented apartments, smaller flats, homes in the local towns instead of single-family houses and farm houses. But it is uncertain whether the housing supply is able to follow this demand. Another question is, whether the lack of demand on single-family houses will reduce the prices so much that it will attract new population segments that are willing to commute over longer distances – this question is not answered in the model. However, in some regions the prices on single-family houses have already fallen drastically, without have any effect on attracting new buyers (except for speculation reasons). This indicates that there will be no demand for a large amount of the single-family houses in the peripheral regions, where many elderly are still living, and lack of demand will lead to falling prices, which again will give the homeowners in these regions less options to move somewhere else. And eventually this will mean that many elderly singles will be living in large houses, of which many are of poor energy quality (not physically updated regarding insulation, energy supply etc.). The energy costs might become a large economic burden, and as many might be living on pensions, it might lead to energy poverty.

The question is, what does this situation mean for the energy consumption in the houses, that the elderly people are forced to stay in a too large house, which might not be properly isolated, and might not be supplied with collective heating (district heating, gas)? – but based on individually energy forms such as oil, electricity, stoves

EXAMPLES ON THE LOCAL SCALE

The challenges outlined so far often gets more obvious on a smaller geographic scale; on the municipal level, there is a mix of larger towns and cities, along with suburbs, villages and rural areas. To improve the statistic overview on a local scale, and to support the municipalities planning in relation to the single-family house the Danish Building Research Institute has developed the interactive GIS-map "Atlas on single-family houses". This displays the geographical distribution of single-family houses, where they are located, the age-distribution and the family types, the size and value of the houses, the energy consumption, the EPC label, energy supply, the income of the households and many other data as well. Data are aggregated on parish level (the smallest geographical unit in the Danish system) for each municipality.

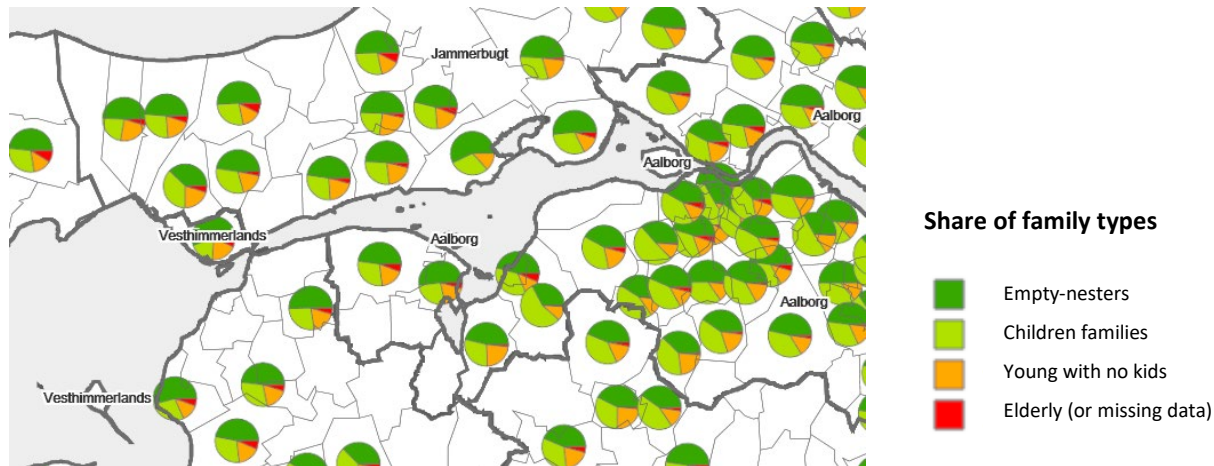
In the following, we will use examples from this map to illustrate characteristics and challenges on a smaller geographical scale. The themes we will address is demography, energy and economy.

Demography

On the map section below from the municipalities Aalborg (third-largest city in Denmark) and the more peripheral municipalities Jammerbugt and Vesthimmerland, there is a tendency that the child-families in single-family houses are living in, or closer to the cities, whereas the empty-nesters are more dominating the longer you move from the cities.

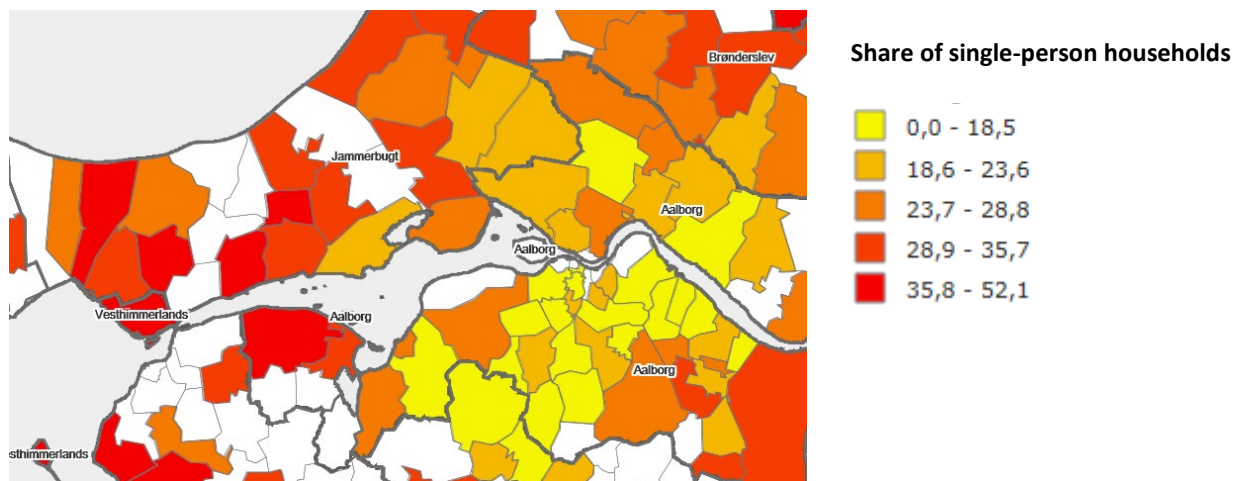
Generally, the amount of empty-nesters is the dominating type family in the single-family houses, compared to children-families, younger families without children, and elderly. However, in single-family houses close to larger cities

like Aalborg, the share of children-families is larger, often around 1/3, whereas in parishes further away from the city, the children-families are fewer (typically less than 25%), and the empty-nesters the dominating family type. In several parishes in the above municipalities empty-nesters represents more than 40% of the households.



Figur 4: The spatial distribution of family types inhabiting the single-family houses in an area between the municipality of Aalborg and two neighbouring municipalities, Vesterhimmerlands Municipality and Jammerbugt Municipality. Data is divided on parish level

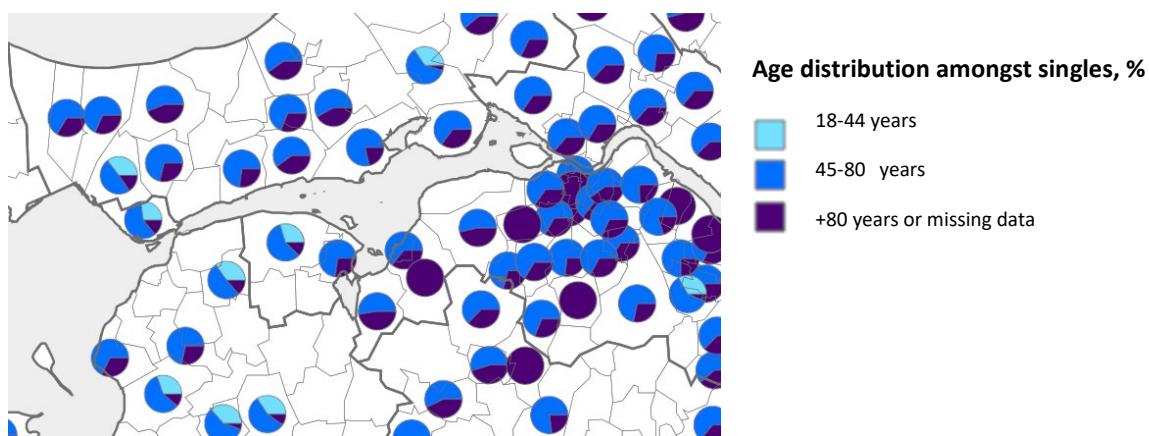
The same geographical inequality is present when looking at the number of singles living in single-family houses; in the peripheral municipalities and parishes there is a larger share of singles (see figure below), compared to the larger cities. As illustrated below, the peripheral parishes often hold between 36% and 52% of singles in the single-family households, whereas in Aalborg municipality the number is typically between 0 and 19% (yellow colour).



Figur 5: Map section showing the share of single person households in single-family houses in parts of the municipalities of Aalborg, Jammerbugt and Vesterhimmerland. The map shows large differences with many singles living outside the city (Aalborg) and a high proportion in the vicinities.

A large proportion of the singles, often more than 25%, are elderly over 80 years. For this group, the single-family houses might not be the ideal type of home, in relation to the amount of space, the maintenance of the house and the garden, the services available nearby etc.

As indicated in the figure below there does not seem to be a distinctive difference between cities and rural areas when it comes to the share of elderly over 80 years. Actually, there are many younger house owners outside the cities, probably because the prices are lower here, and therefore more economic accessible for the younger generations.



Figur 6: The share of +80 years residents in single-family households is in many parishes 25% or more.

Energy consumption

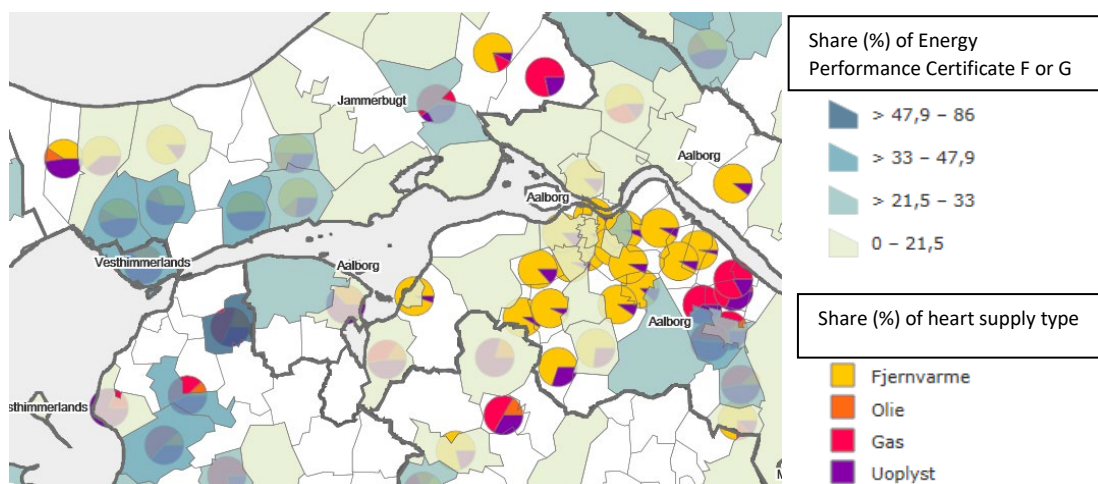
Calculations based on the numbers in the map shows that the singles and empty-nesters per capita have a significantly higher heat consumption per person, compared to other family types – and that this is correlated to the amount of heated floor space per resident - see table below.

Table 2. Heat consumption in single-family houses, distributed between different family types. Source: Source: Calculations made by Anders Rhiger Hansen and Majsa Stina Grosen, based on Statistics Denmark.

Family type	Size of house (m2)	Consumption of floor space (m2 / person)	Heat consumption, kWh/m2	Heat consumption per person, MWh / year
Singles	122	107,0	65,9	7.05
Empty-nesters	138	80,2	57,2	4.59
Nuclear families	150	37,8	56,0	2.11
Others (younger with no children + elderly +80)	142	51,4	59,3	3.05

This shows one of the consequences of staying in the single-family houses when the children have left, and the potential of making singles and couples to a smaller dwelling. Moreover, as a relatively smaller proportion of the houses in the periphery are connected to the district heating, but instead are based on individual oil-boilers, electricity panels and others, their CO₂-emissions per energy unit are probably higher, compared to single-family houses closer to the cities. This is illustrated in the figure below. The figure also shows that many single-family houses in parishes outside the cities have a poor EPC label (category F or G), reflecting a poor standard of the buildings in terms of insulation, making it more expensive to heat. In several parishes outside the city of Aalborg, the share of F and G-labels amounts to almost half of the houses; in the central parts of Aalborg, most parishes have shares below 20% of EPC labels F and G.

From this, we can assume that the energy costs per person are much higher in the peripheral areas, and as the residents also have much lower income (see later), there is a risk of fuel poverty in these peripheral areas. So, the problem with the many singles and couples in single-family houses is not just a climate issue, but also a poverty issue.



Figur 7: Map section of Jammerbugt, Aalborg and Vesthimmerlands municipalities showing the share of single-family houses with categories of EPC labels F and G together with the type of heat supply.

Economy

In the table below, data shows for different family types the median value for their single-family house, and the annual of the household income after tax. It shows that the housing value for the singles and empty-nesters is considerable lower compared to the values of the houses that the nuclear families live in. If we compare the size of the house from table 1, we can see that it's not because the houses are larger (nuclear families live in houses in 150 m², empty-nesters on 138 m², and singles in houses on 122 m²) – the reason is, as illustrated in figure 3, that they decided to liver closer to the cities, where housing prices are higher.

Table 3. Housing values for single-family houses and household incomes distributed on family types. Source: Calculations made by Anders Rhiger Hansen and Maja Stina Grosen, based on Statistics Denmark.

Family type	Value of house (public assessment), DKK	Households income after tax (median), DKK
Singles	1.100.000	233.016
Empty-nesters	2.200.000	370.689
Nuclear families	6.000.000	604.154
Others (younger with no children and elderly +80)	3.600.000	570.175
Total	3.200.000	471.046

The demographic distributions is reflected in the values of the single-family houses in the respective parishes and municipalities; closest to the city of Aalborg the public assessment of the single-family houses are typically in the range of 2-4 mill. DKK (app. 300.000-600.000€), but further away from the city considerably smaller, typically in the range of 400.000-1.000.000 DKK (app. 50.000-150.000€).

Parishes dominated by empty-nesters have smaller values of their houses: 1.000.000 DKR for houses in areas with empty-nesters, compared to 1.750.000 DKK as median value in parishes dominated by children families.

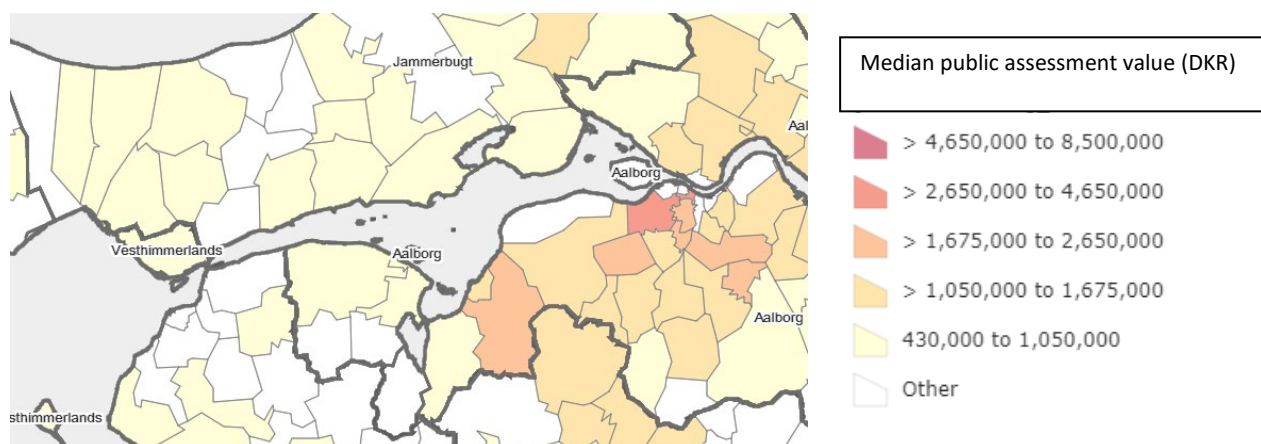


Figure 8. Map section showing median real-estate values (public assessment) of parishes in the municipalities of Aalborg, Jammerbugt and Vesthimmerland.

Not surprisingly, the value of the houses is reflected in the household income, as shown in the map below.

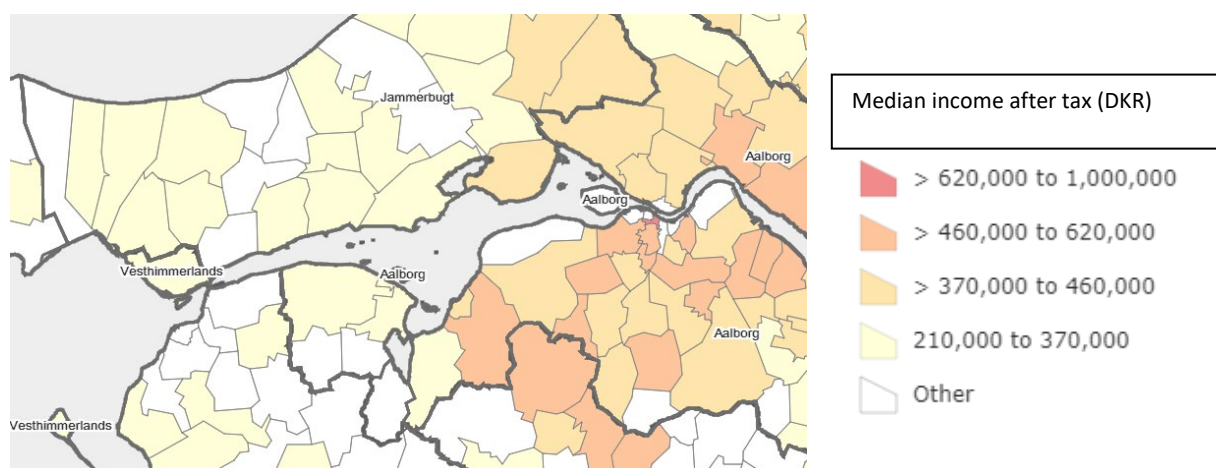


Figure 9. Map section showing median household income after tax in selected parishes in the municipalities of Aalborg, Jammerbugt and Vesthimmerland

Therefore it seems quite reasonable to ask, if the elderly singles and empty-nesters might not want to look for another, smaller and more suitable place to live in their seniority? One of the main challenges is the economic aspects; for many people living in the periphery, demographic changes have meant that their house has lost significant value over the last decades, meaning that the residents might get a very high value for their house, which might keep them from moving.

Longest possible time the house? – as seen from the residents point of view

Why do people not move away from the single-family house when the children have left the nest? There are more explanations to this; an obvious explanation is that there is a lack of suited elderly-friendly houses nearby. Therefore we often see a high interest from the empty-nesters living in single-family homes when new housing projects with alternative housing types is presented, e.g. senior co-housing, social housing, smaller row houses etc. However, the market seems to under-provide this type of housing, especially in the peripheral regions. Another explanation is it's a

general welfare perception that one should “stay as long as possible in one’s own home”, meaning that for the residents and for the society as a whole the residents should not move into special elderly-houses with service facilities, but preferably stay home, and get the public service (nurses , doctors etc.) delivered there. This idea has historically been supported by the state-support for establishing single-family houses after ww2, and also generally being promoted as “the preferred housing type”. Also the perception of “the family” as the basic household in throughout public welfare regulation has supported the perception of the single-family houses as being a life-long housing type (Mechlenborg and Jensen, upcoming). Thirdly, research in single-family houses and the suburban lifestyle shows that the single-family houses possesses a number of the qualities needed for residents to “root”: The option for forming one’s own home inside and outside, a well-defined private life (the hedge, fences), where one can be safe from work and the outer world, safety (also economically), social status and personal and collective identification with the house etc. Recent research also has pointed out that Danish people are more tied to the bricks in their house than to their marriage. For many, the single-family house is an oasis in the world – this created a local connectivity which makes it difficult to think about alternatives.

Most of the seniors living as empty-nesters have probably lived in the house for a couple of decades; they have had kids, seen them grow and move away from home. They have fixed the house, taken care of it, socialized with neighbors and been through smaller and larger events of life here. For many, the house is a container of memories. Along with the economic advantages, the local network built up through years it’s difficult to see other types of homes as an alternative. Therefore, to move from one’s home is a big mentally challenge, to sort the belongings and say goodbye to a home that one has lived in for a long time. For most people moving out is forced, and often happens in relation to a tragic event such as death or divorce; few people choose willingly, for most people it just happens as a result of circumstances. Those people are likely to be found on waiting lists for senior co-housing, row houses, smaller flats in the towns and cities etc. However, this is probably a minority of resourceful residents who have managed to take decisions on how to live their seniority; for the majority this changes doesn’t take place –many elderly living in single-family houses don’t have the resources for making this choice and have to stay in their house in spite of the loneliness, isolation, stress and economic burden that also can be a part of living as elderly in a single-family house.

HOUSING POLICIES AND HOUSING SEGMENTS

The challenges discussed above should lead to rethink housing policies and strategies on a national and a local scale, and to challenge the view of the single-family house as a preferred place to grow older. A general notion in the paper is that the homebound culture of the SFH needs to be considered as an important factor of housing politics and strategies for a sustainable energy transition. In other words, we need to look at empty-nesters’ capacity to react upon their life situation. The Polish sociologist Zygmunt Bauman presents a more nuanced understanding of capacity to move. Bauman looks critically at the consequences of globalization both in relation to the polarization between rich and poor countries and internally in individual societies and local places (Bauman 1996). Instead of talking about globalization as an abstract concept in which everything is mutually defined, Bauman uses the concept of 'globalization' to emphasize that new global development has resulted in a greater division between those, who have many opportunities and those with no or few opportunities for life. According to Bauman, peoples can be divided into the globalized and the localized. Some live all over the globe, they are free, detached and independent while others are chained to a specific place, with only few opportunities. The world's peoples live in different dimensions. In a world of choice, not everyone has a real choice.

Based on the above presentation of the Danish single-family house and Bauman’s arguments, we can roughly make a distinction between three groups of owners of single-family houses:

1. The free houseowners:

This group of senior SFH-owners have houses of high value, most of them located near the cities or popular residential areas. They are willing to leave their house, maybe they are already about to move, e.g. to co-housing other an apartment in the city. They have resources in terms of economy, knowledge and physical and mental health. Most importantly, they perceive their dwelling as a functional unit that should fit their contemporary needs and dreams; their life situation. This group is similar to Zygmunt Bauman’s ‘tourist’.

2. The homebound houseowners:

This group of SFH-owners have houses of varied values, but often these houses are well-maintained and they have lived in them for many years.

They have the capacity to move, but are not willing to or –most likely - do not consider moving as an option, as they have rooted themselves in their home, which they consider to be permanent. They are truly ‘empty-nesters’ in character, keeping the house as a container of memories; as the childhood house of their children.

3. The unfree houseowners

This group of people is mainly living in the periphery of Denmark in a private owned house where prices have declined, and often the house is in poor condition. They have limited resources to move, as debt might be higher than possible sales-price. They could be motivated for finding another dwelling or maybe they strongly wish to move, but they have few resources, little knowledge on how to get rid of the house, and how to enter another housing segment (e.g. social housing). This group can be perceived as the aging members of the precariat of the housing market; the house owns them not the other way around. Similar to Zygmunt Bauman’s vagabond.

Table 4. Three types of single-family residents, their characteristics and possible local initiatives towards them.

Name	Characteristics	Local policy / initiative
The free	House of high value, located near the cities. Are willing to move, e.g. to co-housing, and have the resources in terms of economy, knowledge and health	Provide new types of housing to, e.g. co-housing for seniors
The homebound	House of varied values, but well-maintained, have lived there for many years. Have the capacity to move, but are not willing to, as they have rooted in place. Empty-nesters in character, keeping the house as a container of memories	Provide knowledge and information about options for alternative housing options Campaigns and support for energy optimization of the existing family house, as well as for alternative energy supply Local clustering or concentration of functions through planning, keeping local community alive
The un-free	Living in a house where prices have fallen, have limited resources to move, as debt is higher than possible sales-price. Are motivated for finding another dwelling, but have few resources, little knowledge on how to get rid of the house, and how to enter another housing segment (e.g. social housing)	Social out-reach to residents Help to sell house or to remove it, and to re-locate in more suitable home

As suggested, the three types have different approaches to staying and going. In short, there are indications that the “free” are potentially interested in finding other places to age, e.g. in senior co-housing, and they also have the economic resources. For the group of “un-free” residents there are several indications that they stay in their single-family house because they are not able to find suited alternatives. Paradoxically, in many peripheral regions there are well-kept social housing departments with vacant flats, and at the same time residents in single-family houses of poor quality who are not capable of moving to social housing, because they cannot sell their house, or have limited knowledge of how to enter the social housing sector.

Using this distinction between going and staying, one line of the housing policies should focus on remaining and ageing in place, and improving the existing building stock – as the most common housing choice as elderly is to stay put (Abramsson & Andersson, 2016). Initiatives could comprise campaigns for upgrading and adapting the house to the future, including energy improvements of the building, conversion of the energy supply to more sustainable energy sources, and a space management with focus on reducing space for heating. For densification of the single-family houses, there are international examples on programs promoting this, e.g. “Rehabitat” (Austria) and “MetamorphHouse” (Switzerland) (Fischer and Stiens, 2019). The basic idea is that improvements on energy efficiency should be seen in connection to making the houses more elderly-friendly. There are various international examples on this. In the US, there are various care-programs to support elderly to stay in their own home, for instance “Program of All-Inclusive Care for the Elderly (PACE)” and “Money Follows the Person”, where home modifications are included in the services (Pyynos, 2018). Another example is the “CAPABLE (Community Aging in Place Advancing Better Living for Elders)” program, based on a team concept where a nurse, occupational therapist, and a handyman visit the home and, with input from the resident, recommend changes to the home environment. This has demonstrated that with a limited investment (in average \$1,300) it can improve functioning and significantly reduce health care expenditures (Pyynos, 2018). Other

countries (like UK and Japan) have such policies as well (Pynoos, 2018). In Denmark, there is a policy for social housing where renovations schemes over recent years have focused on making the flats “elderly-friendly” and thereby “future-proof”. This include establishing elevators, adapting the flats to potential wheelchairs (e.g. broad door openings, dimensioning turning space for wheelchairs), handlebars etc. This is mandatory whenever the social housing departments are renovated with the support from the “National Trust”. However, such program does not exist for the single-family houses.

Another line of the housing policies should explore options for motivating the elderly in single-family houses to move to other locations, using less space, and being more suited for elderly care¹. Recent years there has been an increasing attention towards co-housing as a re-emerging housing trend (Beck, 2019; Tummers, 2015), and towards senior co-housing. Several municipalities have experienced a high interest in co-housing for elderly when the present ideas for developing such new housing areas. The philanthropic foundation Realdania has launched a campaign where they help municipalities to establish senior-co-housing. This comes as a way to solve the paradox that the private market for senior co-housing has more or less stopped, in spite of the increasing interest. Surveys made by RealDania indicated that 91% of the residents in senior-cohousing experience increased life quality, and 75% better social relations when moving into senior co-housing. Today, there are app. 7.000 dwellings for senior-co housing, of which the majority was established between 1993 and 2004. There are, however, 80.000 elderly who consider moving into to senior-cohousing, so apparently there is an in-balance between demand and supply. The amount of seniors wanting to move into co-housing seems high in relation to the existing capacity, but represents a small share (7%) of the present number of seniors (1.074.000 older than 65 years, representing 20% of the entire population). However, moving from a single-family house to co-housing would imply obvious energy benefits. The size of the new senior co-housing dwellings are between 50-100 m², and the shared spaces ranges from 200 to 1.000 m²

(<https://realdania.dk/tema/seniorbofaelleskaber>). Singles and empty-nesters have today an average house on 122 and 138 m², so moving to a co-housing dwelling could reduce the heated space per capital down to around 50%. This means that the majority of the residents will be living in less housing space, compared to living in a single-family house, and in a more energy-efficient house, but they will have access to more facilities (shared with other), compared to living in a single-family house. For the German housing market calculations shows that a reduction by only 2 m² per person in heated space would lead to a reduction of 4,5% in energy use (Fischer and Stiebs, 2019).

We see several examples municipalities starting new development projects e.g. on co-housing, many elderly shows up, expressing wishes for leaving their old single-family house, and moving into a new type of houses. The project “Living Space” in the Steinfurt district in Germany is an interesting example on an initiative to establish new housing solutions for elderly in single-family houses living with too much space. Here, different options were presented to the elderly, including re-locating, renting out space on their house, energy refurbishment and other options (Fischer and Stiebs, 2019). The program is running now, so the outcome of the initiative is yet to be seen.

Several municipalities have started to paid certain attention to the “un-free” families. Initiatives in the municipalities include the use of urban regeneration programs to help the families to find another home, and renovate or demolish the house they lived in. In Mariagerfjord municipality, an urban regeneration program focused on targeting vulnerable households in poor quality buildings, and re-housing these families to better houses of better standard (Andersen, 2015). Since then, other municipalities have made similar efforts, and established “social coordinators” across municipal departments, aiming to strengthen efforts towards vulnerable households, including an active out-reach to the households, who typically live in single-family houses, and whose problems are often “under the radar” of the authorities. There is however no overview on the size of this problem. In the municipality of Lolland, one of the municipalities with largest amount of vacant houses and for many years an in-migrating municipality for low-income households, an estimate on app. 1.000 vulnerable households living in single-family houses has been made (Oxford Research og Naboskab, 2017), out of app 16.000 houses in the municipality. The challenge in these regions is that the

¹ The “traditional” option is “elderly-friendly homes”, of which there are 77.000 dwellings in Denmark, operated by social housing associations. Amongst there are a number of “care-dwellings” with care personnel and care facilities to meet the needs of the elderly. The municipalities accommodate the citizens to these dwellings (TBST, 2019). However, these elderly homes are typically for the “late” age, and not attractive for most seniors above 65 years. Therefore, municipalities needs to find other ways to think of alternatives.

housing market is declining in many areas, making it difficult to generate investments amongst developers for new housing projects.

CONCLUDING REMARKS

The present paper is an attempt to shed light on the various challenges related to elderly ageing in place in their single-family house. As shown by the collection of data from the GIS-atlas of single-family houses, this has a number of negative consequences for the energy consumption in the housing sector, resulting in a per-capita energy consumption amongst empty-nesters that is approx. 3 times as high as for nuclear families. Moreover, prognoses show that this tendency will only get worse in the coming decades. The problem is rooted in a high share of single-family houses in Denmark, most of them built in the period 1960-1980, and many presumably suited for retrofitting and energy improvements. Another major issue is the question whether the single-family house is suited for ageing. There are a number of problems living as empty-nesters and singles in single-family houses

These problems are accentuated when the house is located in peripheral regions, with shrinking cities, job losses, municipal service cuts, and lack of private services disappearing. Who will take the risk of providing new houses? And can the elderly afford buying new? We see many projects in city-near locations, but in the smaller towns there is little building activity. In many peripheral regions, however, the process of “double urbanization” makes people from rural districts and smaller villages move to larger towns and cities on a local scale, which gives opportunities for establishing new housing types to combat excessive space use, less social isolation, and better public and private services. One of the great barriers for this development is that many elderly are rooted in their home (Abramsson & Andersson, 2012; Mechlenborg & Jensen, forthcoming), and in spite of the many advantages of moving decide to stay put.

Therefore, the question is whether local policies for new housing supply can make “old singles” and “old couples” move to a new residence? Or, if they will not move, what can be done to make up for the excessive use of energy per capita, and at the same time make the houses more suited for “aging in place”? There are several international examples on various policies for facilitating elderly on moving to another and more suited location, and on making changes in their existing home – policies that should be of inspiration for the Danish local authorities.

We need more knowledge about the motives for elderly to move, and to which extent local initiatives, policies and strategies on housing is able to change the perception of elderly about what a suitable home is for aging.

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