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Energy poverty in Denmark?

Master Thesis
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Abstract

Energy poverty is the inability of households to afford adequate energy services in the home, which can have several impacts on health and well-being. Without an understanding of energy poverty, Danish energy policy might put vulnerable households at a disadvantage. The scope of the research was therefore first, to assess the energy poverty situation for Danish households, and second, to explain this situation by examining the drivers behind energy poverty (income, energy prices, energy efficiency, energy needs and available resources). Using objective, subjective and proxy indicators for energy poverty two societal categories were determined to be especially vulnerable in Denmark: single persons under 60 years on low incomes and pensioners in detached housing. The first category is very likely to contain energy poor households, because this group scores the worst on all the indicators. The main driver behind energy poverty for this category is low income, but additional drivers include the lower amount of available resources to improve the situation and for some groups also the poor energy efficiency of dwellings. The second category scores bad on objective indicators, but good on subjective and proxy indicators. The main driver behind energy poverty for this category is high equivalized energy expenditure, as this group lives in relatively large housing and uses more expensive liquid fuels. However, this has not lead to bad scores on the subjective and proxy indicators, probably because the Danish government currently reimburses a large part of the heating costs for pensioners.

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Chapter 1 Introduction

Having sufficient energy in the home is essential in order to meet basic Danish living standards. Energy is necessary for space heating, warm water, cooking, lighting and other electrical appliances. Energy poverty occurs when households are struggling to afford adequate energy services in the home, which can have several negative impacts on health and well-being. One of the fundamental goals of Danish energy policy should therefore be to provide every Danish household with sufficient energy. However, the energy agreement established by the Danish government in 2012 does not specifically address energy poverty, but instead concentrates on the green transition of the Danish energy sector. Of course, investments in renewable energy, energy efficiency and smart grids are expected to "make Danish (…) households less vulnerable to the increasing prices of fossil fuels caused by global population growth and diminishing resources" (Danish Ministry of Climate, Energy and Building 2012). In the same way, other goals of energy policy, such as security of supply and market liberalization, could potentially contribute positively to the ability of households to access and afford adequate energy services.

However, without a clear focus on energy poverty, the green transition could have a negative impact on vulnerable consumers, especially since household energy prices in Denmark are already high compared to other countries (Werner 2006; Eurostat 2013). Energy taxes and carbon taxes have been found to have regressive impacts, making energy more expensive for the poorest consumers (Feng et al. 2010; Hirth and Ueckerdt 2013). Taxes on solid and liquid fuels could have adverse consequences for households that do not have the means to switch to another fuel type. Regressive impacts have also been identified for surcharges on energy bills that finance renewable energy or energy efficiency initiatives (Neuhoff et al. 2013; Rosenow, Platt, and Flanagan 2013). Moreover, the implementation of district heating could force certain households to pay a sizable amount of their income for the costs associated with the construction of district heating (Just 2013).

In addition, the emphasis on cost-effective and market-based solutions limits the ability of vulnerable households to access funding for energy-efficiency and renewable energy. Investments in poor households that are under-consuming energy are often not cost-optimal from a carbon reduction perspective, because they are more likely to take up measures such as energy efficiency improvements as increased comfort (Boardman 2010). This means that absolute carbon reductions are not achieved, even though the well-being and carbon intensity of the household has improved. Vulnerable households could also be living in hard to treat homes, that are generally not cost-effective to renovate (Ástmarsson, Jensen, and Maslesa 2013). Moreover, vulnerable households likely lack the financial capacity to take out loans or to pre-finance part of the investments if necessary (G. Walker 2008; Guertler 2012). Altogether, there is a real possibility that vulnerable households are paying more for their energy through taxes and surcharges, but are not getting anything in return.

Against this background, it should be emphasized that the inability to afford adequate energy services can have multiple impacts on health and well-being. Low indoor temperatures have a strong relationship with cardio-vascular and respiratory diseases, as well as excess winter mortality (Healy 2003; Marmot Review Team 2011). Respiratory problems could also be exacerbated by the mold that develops in cold and damp housing. Children and elderly people seem to be especially affected by poor indoor climate conditions (Marmot Review Team 2011; Weitzman et al. 2013). In addition, mental health problems are significantly associated with issues to afford adequate energy, such as anxiety about the payment of energy bills (Liddell and Morris 2010; Gilbertson, Grimsley, and Green

2012). In some cases, the inability to pay the energy bills could even result in a choice between food and energy or "eat-or-heat" (Anderson, White, and Finney 2012; Beatty, Blow, and Crossley 2014). Furthermore, not being able to afford adequate energy could result in social isolation, as people might be ashamed to invite other people to their house. Conversely, helping households to afford adequate energy services has been found to have multiple rewards in terms of well-being (Howden-Chapman et al. 2012; Tanner et al. 2013).

Energy poverty should therefore be considered in Danish energy policy. Nonetheless, this inclusion is hampered by the fact that research on energy poverty is virtually non-existent in Denmark, so that there is little knowledge about the actual ability of Danish households to afford adequate energy services. Therefore, this master thesis aims to investigate the energy poverty situation in Denmark, based on the following research question: *to what extent are Danish households struggling to afford adequate energy services in the home, and why?*

First, chapter 2 further clarifies this research question by establishing the theoretical approach used in the thesis and delineating the field of research. Chapter 3 then addresses the first part of the research question by attempting to quantify energy poverty in Denmark using certain indicators and by identifying possible vulnerable households. Focusing on these households, chapter 4 and chapter 5 consider the second part of the research question by investigating which are the main drivers behind energy poverty and what are the characteristics of vulnerable categories. Chapter 6 summarizes and concludes the thesis.

Chapter 2 Theoretical approach

2.1 Introduction

This chapter further clarifies the scope of the research question by establishing the theoretical approach of the thesis. The analysis is based on a literature review, for which the methodology is described in section 2.2. Subsequently, section 2.3 explains some of the terminological issues surrounding energy poverty. Sections 2.4 - 2.8 then illustrate the theoretical context of energy poverty in Denmark by looking at the main drivers behind energy poverty: energy efficiency, energy prices, income, energy needs and available resources. Finally, section 2.9 uses the preceding theoretical analysis to formulate the scope of the research.

2.2 Methodology

The aim of the literature review was first to attain a general knowledge about the phenomenon of energy poverty and the different issues involved. Second, the objective was to obtain a solid understanding of the academic work on the measurement of energy poverty and the drivers behind energy poverty, both globally and in Denmark, in order to construct a strong research design. The literature on the drivers behind energy poverty is reviewed in this chapter and the research on the measurement of energy poverty is investigated in section 3.2.

The literature review used as the main search queries "fuel poverty" and "energy poverty", which are the most common terms in academic writing.[1] After scanning through the available documents on these subjects in the Aalborg University database called Primo, the Special Section in volume 49 of the journal Energy Policy was found entitled 'Fuel Poverty Comes of Age: Commemorating 21 Years of Research and Policy', as well as the most recent textbook on the subject by Brenda Boardman (Liddell 2012a; Boardman 2010). Furthermore, suggested articles on Science Direct related to the articles in the Special Section were explored. Then, search queries for 'fuel poverty' and 'energy poverty' were carried out in the ETDEWEB, PAIS International, Scopus and Academic Search Premier databases, focusing on articles published in the last five years if multiple articles on the same topic were found.

Subsequently, the literature review focused on the energy poverty situation in Denmark. First, "Denmark" was searched for in articles of the journal Energy Policy in order to obtain a general understanding of Danish energy policies. Publications of the Danish Building Research Institute were explored to understand the current state of the Danish building stock. Using references from these documents, more general articles on energy consumption in Denmark and distributional implications of Danish energy policy were explored. Then, the Danish equivalents of "energy poverty" and "fuel poverty", namely "energifattigdom" and "brændstoffattigdom", were searched for in general publications and newspaper articles on Google and Infomedia. However, the large majority of these documents did not pertain to energy poverty in Denmark, but related to either developing countries or other European countries, mainly the United Kingdom.

2.3 Terminology

The research on energy poverty has historically coalesced around investigations into 'fuel poverty' (Thomson and Snell 2013). Academic interest in fuel poverty commenced in 1991 in the United Kingdom with Brenda Boardman's 'Fuel Poverty: From Cold Homes to Affordable Warmth',

[1] The difference between the terms will be examined in more detail in section 2.3.

commonly referred to as the pioneering work on the subject (Boardman 1991). In the following years, the United Kingdom remained the main hub of fuel poverty research and policy, highlighted by the adoption of the UK Fuel Poverty Strategy in 2001 (Liddell 2012a). More recently, the topic has received attention in other countries in the European Union (EU). In this research, other terminology such as energy poverty, energy precariousness (from the French 'précarité énergétique') and energy deprivation have been used (Bouzarovski 2013). Although 'fuel poverty' also includes the use of all energy services, the term could be a source of confusion, as it seems to refer only to fuel sources used for space heating (Chester and Morris 2011). However, other authors argue that fuel poverty is a concept distinct from energy poverty: fuel poverty would concern energy affordability in developed countries, while energy poverty would pertain to energy availability in developing countries (Li et al. 2013).

In this thesis, the term 'energy poverty' is preferred, as it unequivocally incorporates all energy use in households (in particular the use of electrical appliances). Furthermore, it adequately captures the social complexities and the distributive injustice involved (G. Walker and Day 2012). In addition, the term 'energy poverty' seems to be the currently preferred terminology outside the United Kingdom, as EU documents refer to energy poverty instead of fuel poverty (Bouzarovski, Petrova, and Sarlamanov 2012). According to article 3(8) Directive 2009/72/EC "Member States shall take appropriate measures (…) to address energy poverty where identified" (European Parliament and the Council 2009). Nonetheless, energy poverty might not be the best wording in all contexts. Danish politicians and policymakers might not be inclined to talk about energy poverty; the words 'affordability' and 'energy affordability' seem to be more attractive for political purposes (Liddell 2012b). The usage of more neutral terms could also help to reduce the stigmatization usually associated with poverty and increase the acceptance of policies targeting energy poverty.

Households that are struggling to afford adequate energy services are principally referred to as 'vulnerable' households in this thesis. This also connects to terminology used in Directive 2009/72/EC that requires the protection of vulnerable customers. Article 3(7) states that "each Member State shall define the concept of vulnerable customers which may refer to energy poverty and, inter alia, to the prohibition of disconnection of electricity to such customers in critical times" (European Parliament and the Council 2009). It should be noted here that Denmark has not defined the concept of vulnerable customers, which is problematic from a legal perspective (Christensen 2012). In general, Denmark argues that the protection of vulnerable customers is sufficiently covered by the right of every Danish citizen to get connected to the electricity and gas grids and by the additional protection of the social security system (Klima- og Energiministeriet 2010; Christensen 2012). The approach is therefore to address energy poverty exclusively through social policy (Danish Energy Regulatory Authority 2013).

In this thesis, energy poverty denotes the inability of households to afford adequate energy services in the home.[2] The three main drivers behind energy poverty usually referred to in the literature are income, energy prices and energy-efficiency (Bouzarovski 2013). Taken together, these three factors show the ability of households to afford a certain level of energy services. Following the utilized definition of energy poverty, the energy needs of a household are identified as an additional driver that determines if this level of energy services is *adequate*. Finally, the financial, social and informational resources available to the household are an overarching driver behind energy poverty, because they determine the ability of a household to improve its situation. As energy poverty is thus

[2] This excludes energy used for transportation, because this has an own dynamic that does not easily lend itself to comparisons with housing-related energy expenses.

the product of the interaction between five factors (income, energy prices, energy efficiency, energy needs and available resources), energy poverty cannot prima facie be reduced to a social issue that aligns with income poverty (Hills 2012).

2.4 Energy efficiency

In the academic literature, energy efficiency is usually designated as one of the most important structural factors behind energy poverty. Vulnerable households are likely to spend more money for the same level of energy services due to older, energy inefficient housing and household equipment (Boardman 2010). In Denmark, poor maintenance of heating equipment was also reported to lead to overspending on energy (Knudsen and Form Nielsen 2014). Therefore, the most effective way to structurally reduce energy poverty is to promote energy efficiency measures. In particular, these measures lead to small, but significant improvements in health (Maidment et al. 2014), increase thermal comfort (Hong et al. 2009; Heyman et al. 2011) and lower stress (Gilbertson, Grimsley, and Green 2012). Moreover, these energy efficiency improvements reduce the carbon intensity of households (Boardman 2010). 'Deep' energy efficiency improvements could especially help vulnerable households to structurally afford adequate energy and prevent lock-in of carbon emissions (Ürge-Vorsatz and Tirado Herrero 2012; Jones, Lannon, and Patterson 2013).

Denmark has utilized multiple instruments to promote energy efficiency (Gram-Hanssen and Christensen 2012). Requirements for energy consumption were first introduced in Danish building regulations in 1979 and subsidies for energy renovations were implemented in 1980. In the 1990's norms for appliances' energy consumption and energy labels on buildings were introduced, as well as public campaigns and research on energy efficiency (Gram-Hanssen and Christensen 2012). More recently, utilities have been required to contribute to energy savings, and the concepts of Energy Performance Contracting and Energy Service Companies have been used to encourage the involvement of private companies in the renovation of the existing housing stock (AlmenNet 2011; Ástmarsson, Jensen, and Maslesa 2013).

These policies present considerable opportunities to reduce energy poverty, but they need to be implemented having the circumstances of vulnerable households in mind. For example, taxing houses based on the energy label or their CO_2 emissions could "spur energy renovation but it could also have adverse social effects for low income households unless it is linked with income taxes" (Ástmarsson, Jensen, and Maslesa 2013). Similarly, requiring electricity companies to participate in energy saving programs might ensure cost-effective investments, but it has also entailed that the main activities have been directed towards industry (Togeby et al. 2008). In particular, activities towards renovation of existing housing have been scarce (Gram-Hanssen and Christensen 2012). One solution could be to increase the compliance factor on non-profitable measures in buildings with the poorest energy performance (Ástmarsson, Jensen, and Maslesa 2013).

2.5 Energy prices

Energy prices are another basic driver behind energy poverty. In Denmark, the price level is significantly influenced by energy policy, because taxes form a substantial part of the energy price. For example, more than 50% of the Danish electricity price consists in VAT, taxes and levies (Eurostat 2013). Specific energy taxes were introduced already in 1977 and carbon taxes in 1992. On the one hand, these taxes have helped to curb Danish energy consumption and spur investments in renewable energy (Sovacool 2013). On the other hand, these taxes have had regressive impacts, as lower income consumers in Denmark bear a proportionally larger burden (Klinge Jacobsen, Birr-

Pedersen, and Wier 2003). In particular, carbon taxes imposed directly on households have tended to cause distributional effects (Wier et al. 2005). Moreover, taxes on certain fuels might be reasonable from an environmental perspective, but they could have adverse consequences for those households that do not have the means to switch to another fuel.

Similarly, surcharges on energy bills to finance renewable energy and energy efficiency could potentially have negative distributional consequences (Neuhoff et al. 2013). These surcharges can be imposed directly by the government or they can be a result of green obligations placed on energy companies, which pass the additional costs on to consumers. Nonetheless, the green transition could also present opportunities to reduce energy poverty if these two policy goals are connected (Jenkins 2010; Ürge-Vorsatz and Tirado Herrero 2012). For instance, local energy production from sun or wind could provide a cheap and secure energy supply, and bio-mass based district heating could allow households to decrease their dependence on expensive liquid fuels.

In addition to Danish energy policy, subsequent waves of EU legislation have impacted the Danish energy market through requirements on the unbundling of network operators and on market liberalization. Although there is no specific Danish research, the academic literature has been mixed on the effects of energy market reforms on energy poverty (Graham 2007; Miniaci, Scarpa, and Valbonesi 2008; Poggi and Florio 2010; Chester and Morris 2011). Even though enhanced competition might decrease average energy prices, energy suppliers in liberalized markets could have policies that disadvantage smaller households, for instance by offering reduced prices for bigger consumers. In Denmark, this seems to be the case for electricity, but not for natural gas (Grevisse and Brynart 2011). Moreover, suppliers could also have harmful policies on disconnection and billing, for instance by billing irregularly so that it is difficult for households to monitor their expenses. Besides, vulnerable households might not be able to take full advantage of liberalized markets because they lack the knowledge necessary to switch suppliers (Boardman 2010). Similarly, utilizing the potential of smart meters might require resources that are currently unavailable to these households (Darby 2012).

In this context, it should be noted that Denmark has no specific protection for vulnerable customers against disconnection of either the gas or the electricity supply (Grevisse and Brynart 2011). For electricity, the procedure in case of arrears is based on guidance documents of sector association Dansk Energi (Dansk Energi 2002), which are partially codified in § 72 (5) of the Electricity Law (Klima-, Energi- og Bygningsministeriet 2013b). For district heating the arrears procedure is similar, based on documents of sector association Dansk Fjernvarme (Dansk Fjernvarme 2007). The primary focus of these procedures is on obtaining payment quickly: in the regular procedure households are disconnected within three weeks after non-payment if they do not negotiate a payment plan with the energy supplier or provide financial assurance that future energy bills will be paid (Dansk Fjernvarme 2007). However, it is common practice to inform the municipality of disconnections, especially if there are children or animals in the house. Based on social legislation the municipalities are then the authorities responsible for supporting these households. In the near future this social legislation will remain separate from legislation on energy, although this might be reevaluated if deemed necessary (Klima-, Energi- og Bygningsministeriet 2013a).

2.6 Income

Income is another important factor in assessing energy poverty, as households with lower incomes tend to spend a higher share of their disposable income on energy services. After expenses on food, water and housing, energy is often the most essential spending priority (Anderson, White, and Finney

2012). Therefore, vulnerable households are usually found in low-income groups on state benefits, such as the unemployed, pensioners and the disabled. In Denmark, single-adult households are most likely to experience income poverty, which in the Danish context means living on an annual disposable income below 103,200 DKK (Bak and Larsen 2014; Faurholdt-Löfvall and Junker 2013). Social policy reforms by the Danish government could thus have consequences for energy poverty if they change employment rates or the amount and uptake of benefits. Moreover, the green transition could reduce energy poverty insofar as it provides green jobs to members of vulnerable households (Del Rio and Burguillo 2008).

Income policies could also be specifically targeted refunds of energy costs. In the United Kingdom, winter fuel payments distribute money to pensioners to cover winter fuel costs. A similar provision also exists in Danish law, which allows pensioners to get heating related expenses reimbursed if the costs are over 4,700 DKK for single households and 7,050 DKK for couples (Borger.dk 2014). This payment can cover up to 24,700 DKK per year of the heating costs. Nonetheless, it is argued that reducing energy poverty through these kinds of policies is relatively expensive and provides only a temporary solution (Boardman 2010).

2.7 Energy needs

A combination of energy efficiency, energy prices and income determines which share of income a household needs to spend to afford a certain level of energy services. The energy needs of the household then determines if a certain level of energy services is adequate.

First of all, the size and type of the household is important for the energy needs. It has been established in Denmark that it is relatively more energy efficient to live together (Gram-Hanssen 2012). Even though the energy consumption increases according to the number of persons in the household, the energy consumption per person decreases for larger households. In combination with the recent trend in Denmark that more people live alone and households are getting smaller, this means that households have relatively more floor space to heat and require more household equipment (Gram-Hanssen 2003). Under occupancy – where the dwelling is too big for the household in energy terms – can therefore contribute to energy poverty. Furthermore, some vulnerable households could have relatively higher energy needs than other households. The unemployed might be at home a larger proportion of the day. Pensioner households might require higher indoor temperatures, because of changes in their physiological systems responsible for thermoregulation (Tod et al. 2013). Indeed, Danish research has found that pensioners prefer somewhat higher room temperatures (Gram-Hanssen 2003). Disabled and sick persons are also more likely to be bedridden at home. Housing policy could aim to target these drivers, for example by moving single pensioners from larger detached housing to smaller apartments, but this might be controversial.

Additionally, the weather has a significant influence on energy needs, as annual temperature differences impact on the necessity for heating. A particularly harsh winter could temporarily cause more households to struggle to afford adequate energy services. Although average temperatures do not vary widely across Denmark, local differences might explain part of the energy needs of households. For instance, the urban heat island effect leads to lower heating requirements in urban areas compared to rural areas.

Finally, energy needs are determined by the energy consumption behavior of households. This includes the frequency of taking showers, the room temperature and the number of electric equipment on standby (Gram-Hanssen 2003). For instance, research in Denmark has found that

higher income households take more weekly showers (Gram-Hanssen 2003). Moreover, energy efficiency improvements are to some extent counterbalanced by the 'rebound effect', whereby better efficiency causes households to have more equipment, use equipment more intensively and heat more floor space. These developments have also been identified in Denmark (Gram-Hanssen 2012). Households might also have energy practices that are wasteful, for instance by heating with the windows open. Danish policy has attempted to influence energy consumption behavior by campaigns, advertisements and brochures (Haunstrup Christensen et al. 2007).

Nonetheless, it should be kept in mind that certain vulnerable households could be under-consuming energy, which means that their current level of energy services is inadequate. These households have little possibility of cutting back on energy consumption through changes in behavior. Conversely, if these households use energy efficiency improvements to increase their comfort level, it would be somewhat deceptive to attribute this to the rebound effect. This could give the negative impression that the increased comfort is the result of higher norms and expectations: that the higher level of energy services is a matter of luxury, while in fact for these vulnerable households it is a matter of necessity. This issue is especially problematic if subsidies for energy efficiency are paid for through lower energy bills (Booth and Choudhary 2013). Academic publications in Denmark seem to overlook these complications sometimes (Gram-Hanssen 2003; Gram-Hanssen, Christensen, and Petersen 2012).

2.8 Financial, social and informational resources

Finally, energy poverty is produced and aggravated by a lack of financial, social and informational resources (Nierop 2014). In terms of financial resources, vulnerable households might not have the option to invest in energy efficiency or renewable energy in order to improve their situation, because they do not have enough capital to fund these measures (G. Walker 2008). Moreover, they might not own enough assets to obtain loans on the private market, since they rent their dwelling or the value of their house is too low for a mortgage-backed loan. In this case, governmental assistance adapted to the capability of the household is necessary to overcome these barriers. For some home-owners, providing low-interest loans might be sufficient to enable energy renovations (Guertler 2012). However, subsidies should be available for those vulnerable households that avoid borrowing altogether since they already have accumulated debts (Anderson, White, and Finney 2012). Governmental assistance should also consider extra funding for hard to treat homes that are not cost effective to renovate.

A special approach is necessary for vulnerable households that rent their dwellings, because of the landlord-tenant dilemma (Bird and Hernández 2012; Ástmarsson, Jensen, and Maslesa 2013). Vulnerable tenants are disadvantaged because they cannot access mortgage-based loans and because investments in energy improvements accrue to the value of the home belonging to the landlord. What is more, landlords in the private sector have no behavioral incentive to invest in renovations as they do not live in the energy inefficient housing themselves, and even when landlords are willing to invest, renovations that increase the rent are unlikely to be acceptable for households that are struggling to afford adequate energy. A combination of economic incentives and legal reforms might be necessary in Denmark to overcome these problems (CONCITO 2011). In the social housing sector the landlord-tenant dilemma might be less acute, but even housing policy that aims to renovate social housing might be counterproductive if this forces vulnerable households to move due to higher rents (Rask Sønderborg 2014).

Vulnerable households could also lack the social resources to improve their situation. Being unable to afford adequate energy can lead to social exclusion and stigmatization, making it more likely that households are unable or unwilling to seek assistance (Anderson, White, and Finney 2012; Brunner, Spitzer, and Christanell 2012). These social complexities involved in energy poverty need to be kept in mind when policies are developed. Instead of fixating on the 'poor', programs might be more accepted if they focus on the appearance of the home and environmental sustainability (Scott, Jones, and Webb 2014). Moreover, it might be beneficial if programs target local communities, so that socially isolated people can be more easily assisted (Nierop 2014). Community-based projects could also utilize and expand the resources available in social networks (McMichael and Shipworth 2013).

Finally, vulnerable households might not possess the necessary informational resources. This includes information on how to switch energy suppliers (Lorenc et al. 2013), how to obtain the state benefits they are entitled to, how they can access financial resources to fund energy renovations and how they could install decentralized energy (G. Walker 2008; Owen, Mitchell, and Unsworth 2013). Therefore, policy could aim to educate vulnerable households about the possibilities they have to improve their situation. However, information campaigns might need to take into account that certain vulnerable households could lack access to modern communication systems such as the internet.

2.9 Scope of the research

Building upon the previous sections, the theoretical framework of this thesis is graphically summarized in diagram 1. This framework allows the research question to be further clarified and to delineate the scope of the research. The first part of the research question (*to what extent are Danish households struggling to afford adequate energy service in the home?)* focuses on assessing the energy poverty situation for Danish households. In the diagram, this is the quantification of the box 'energy poverty'. This first part will be mainly investigated in chapter 3. The second part of the research question (*and why?)* focuses on which drivers behind energy poverty explain the energy poverty situation in Denmark. These drivers are energy efficiency, energy prices, income, energy needs and available resources. The available resources can be considered as a driver that affects energy poverty through the other drivers, because a lack of resources affects the ability of households to improve their situation, for example by constraining investments in energy efficiency. The scope of the second part of the research question is depicted as the area within the red box in diagram 1. This second part will be mainly examined in chapters 4 and 5.

Therefore, this thesis does not investigate how the various Danish policies and actors influence and interact with the drivers behind energy poverty. For instance, it falls outside the scope of this research to identify if the liberalization of the energy market has had a negative impact on energy poverty in Denmark. Nonetheless, this thesis could serve as a building block for future research that investigates the effects of past policy on the energy poverty situation and which type of programs would be most effective to support vulnerable households.

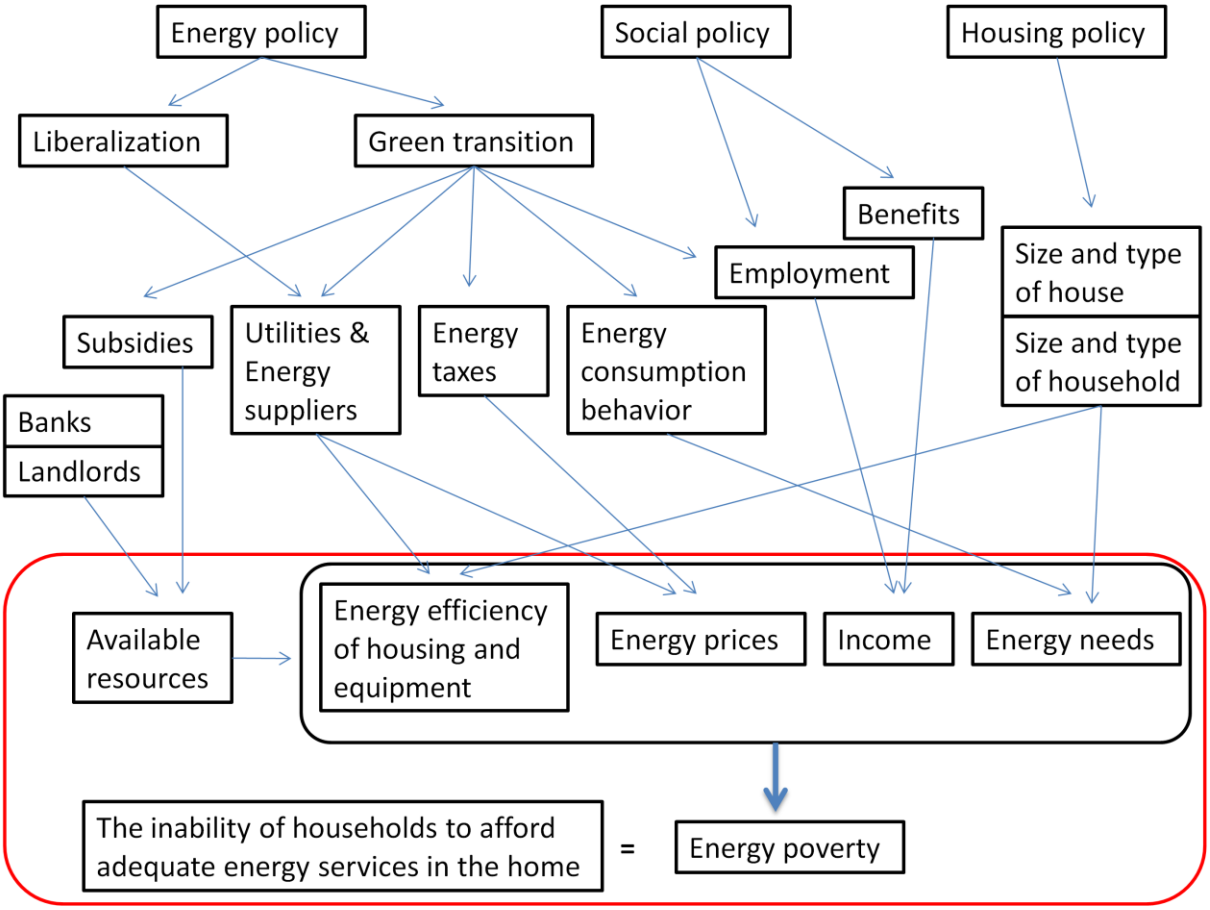

Diagram 1: Interaction of policies, actors and drivers related to energy poverty. The scope of the first part of the research is to assess the energy poverty situation for Danish households, which is the quantification of the box 'energy poverty'. The second part of the research focuses on which drivers behind energy poverty (energy efficiency, energy prices, income, energy needs and available resources) explain the energy poverty situation in Denmark, which is depicted as the area within the red box. Therefore, this thesis does not investigate how the various Danish policies and actors influence and interact with the drivers behind energy poverty.

Chapter 3 Quantifying energy poverty

3.1 Introduction

This chapter investigates the first part of the research question (*to what extent are Danish households struggling to afford adequate energy service in the home?).* It attempts to quantify the energy poverty situation for Danish households using energy poverty indicators and identify which groups are the most vulnerable to energy poverty in Denmark. Section 3.2 starts with an overview of the theoretical considerations involved in the measurement of energy poverty, based on the literature review described in section 2.2. Subsequently, section 3.3 outlines the methodology and indicators used in this research. The results are presented in section 3.4 (for the objective indicator) and in section 3.5 (for the subjective and proxy indicators). Both these sections end with small subsections that summarize which societal groups in Denmark are the most vulnerable according to these indicators. The explanation of the results by analyzing the drivers behind energy poverty is done in chapters 4 and 5.

3.2 Theoretical considerations

3.2.1 Indicators of energy poverty

The academic literature contains many different proposals on how to quantify energy poverty. The most common approach is to investigate the share of energy expenditure in the household income, so-called 'objective' indicators (Waddams Price, Brazier, and Wang 2012). In 1991, Boardman proposed the first of these indicators, defining a household as energy poor if it would need to spend more than 10% of its income to have adequate energy services (Boardman 1991). This 10%-income indicator continues to be one of the most prevalent definitions in the academic literature. Importantly, Boardman based her definition on hypothetical, not actual expenditure. This means that a household that is currently spending less than 10% of its income on energy services could be considered energy poor if it would need to spend more than 10% to obtain adequate energy services. In other words, this definition tries to incorporate those households that are currently forced to underspend on energy services due to budgetary constraints.

However, there arise multiple complexities when one attempts to operationalize this definition. First, multiple definitions of income can be used based on the exclusion of housing costs and the equivalization of income, which can have large consequences for the demographic groups that are assessed to be energy poor (Moore 2012). Second, using an absolute threshold of 10% might lead to arbitrary inclusion and exclusion of households that are close to the threshold. As the threshold was based by Boardman on UK household data from 1988, it might be inconsistent with situations in other time periods and in other countries (Liddell et al. 2012). One alternative is to construct a relative indicator that compares the energy expenditure share of a household to the median energy expenditure share (Liddell et al. 2012). However, it is argued that such a relative indicator is not suitable because a sharp increase in energy prices would lead to more energy poverty, but little change in the median indicator as all households would need to spend more (Moore 2012). Therefore, indicators have been proposed that examine if the residual income after subtraction of the required fuel costs would be sufficient to cover the minimum living expenses (Moore 2012). Recently, a highly anticipated review of UK fuel poverty policy proposed a similar indicator based on a comparison of the residual income after fuel expenses with the official poverty line (Hills 2012).

Still, these indicators do not solve another essential complication: that it is difficult to determine what *adequate* energy services are. Taking the example of space heating, it is commonly assumed

that the room temperature should be within a certain range to achieve thermal comfort (Ormandy and Ezratty 2012). However, temperature preferences differ between persons, so that the adequacy of energy services is also dependent on the preferences of the specific household (Hong et al. 2009). Similarly, personal preferences determine if energy services have to be considered inadequate when a household can only heat a house partially. Therefore, even direct measurements of the room temperature can only partly indicate energy poverty, because they have to be compared to a standard that is difficult to establish (Bouzarovski 2013). Besides, it is often not feasible to carry out these direct measurements on a large scale.

Avoiding the inherent issues of objective indicators, subjective indicators ask households directly to assess whether they can afford adequate energy services. Subjective indicators do not necessarily point to the same vulnerable households as objective indicators (Waddams Price, Brazier, and Wang 2012). Nevertheless, reliability could be an issue for subjective indicators, as social and cultural factors might play an important role in the self-assessment of energy poverty.

Finally, one could move away from direct indicators of energy poverty and focus on proxy indicators, which suggest that the household might be struggling to afford adequate energy services. Possible proxy indicators are arrears on utility bills, disconnections of energy provision and the presence of mold (Thomson and Snell 2013; Bouzarovski 2013) These proxies can also be combined in a compound indicator (R. Walker et al. 2013).

3.2.2 Vulnerable households

Academic research using the different indicators outlined above has demonstrated that vulnerable households are not characterized by a uniform set of socio-economic characteristics. In the United Kingdom, energy poverty is especially prevalent "amongst private rental and local authority tenants, amongst single people, single older people and lone parent households, amongst the unemployed and economically inactive, amongst low income households and benefits recipients, and amongst households containing one or more persons with a long-term illness or disability" (Fahmy, Gordon, and Patsios 2011). Energy poverty is also especially prevalent in "thermally inefficient dwellings, in under-occupied and rural dwellings and in older dwellings (especially those built before 1945) or lacking central heating" (Fahmy, Gordon, and Patsios 2011). Complicating the issue is that vulnerable households do not constitute the majority in most of the socio-economic groups they belong to (Boardman 2010). For example, in the United Kingdom "50 percent of the fuel poor are pensioners, but these pensioner households only represent 19 percent of all pensioners" (Boardman 2010, 231).

As mentioned before, choices in the construction of the indicators have important consequences for which groups are deemed most vulnerable (Moore 2012). For instance, taking the income after subtraction of housing costs results in more renting households being classified as vulnerable, because they have less income left after they pay their rent. Therefore, choices on the indicators used for policy development can partially reflect political decisions on which groups should be targeted principally (Dubois 2012).

3.2.3 International comparison

An international comparison of the scores on the described energy poverty indicators can give an impression of the energy poverty situation in Denmark. Objective indicators show that the share of energy expenditure in household budgets is relatively large in Denmark. The lowest income quintile in Denmark spends more than 8% on energy, which is more than Belgium and France (6%), and the United Kingdom and Spain (around 4%) (Grevisse and Brynart 2011). This is the result of relatively

high energy prices and of comparably high energy consumption. The higher energy consumption can be attributed partially to lower winter temperatures in Denmark, so that more heating is required. Another factor is that Danish households live on average in larger dwellings with more occupied surface area to heat (Grevisse and Brynart 2011).

Nonetheless, comparative studies have generally found that the Danish scores on subjective and proxy indicators are among the best in Europe (Healy and Clinch 2002; Grevisse and Brynart 2011; Thomson and Snell 2013). Danish households are relatively unlikely to report arrears on utility bills or the presence of leaks, damp or rot in their dwelling (Thomson and Snell 2013). Moreover, Danish households are relatively unlikely to report that they are unable to heat their home adequately or that they lack adequate heating facilities (Healy and Clinch 2002). Finally, domestic thermal efficiency in Denmark is high compared to other European countries, although not as high as in the other Scandinavian countries (Healy 2003).

3.3 Methodology

Objective, subjective and proxy indicators were investigated in order to quantify the energy poverty situation for Danish households and identify which groups are the most vulnerable to energy poverty in Denmark. As an objective indicator for energy poverty, the share of energy expenditure in the income of households was examined based on data available from the website of Statistics Denmark (Danmarks Statistik 2014a; Danmarks Statistik 2014b). These statistics are based on yearly surveys of approximately 2500 households and computed for an average of three years. Data of these three-year periods (e.g. 1996:1998) can in practice be assigned to the middle year (e.g. 1997) (Danmarks Statistik 2013). Data on income and energy expenditure was available from the period 1993:1995 until 2010:2012. Nominal energy prices are used in this thesis, unless stated otherwise.

As indicated in section 3.2, the definition of income could matter for the results of energy poverty assessments. First of all, calculations were made based on disposable income and on total income. Total income includes all the income originating from work, capital and public transfers (in Danish: 'samlet indkomst'). Disposable income is the total income minus interest payments and taxes, plus payments from capital pensions (called the 'disposable amount' on the website of Statistics Denmark, in Danish: beløb til rådighed). For the purpose of this thesis, the results for both incomes were comparable (cf. figures 7 and 8). Moreover, the results were calculated for incomes after deduction of the rent, but this likewise did not change the results significantly (cf. figures 7 and 9). In addition, the computations for energy expenditure share could be carried out with equivalized incomes, using data from Statistics Denmark based on the modified OECD-scale.[3] However, the available data did not allow the computation of the hypothetical energy expenditure that households should spend in order to obtain adequate energy services (see section 3.2). Because actual energy expenditure was used, it is not correct to calculate the energy expenditure share with equivalized incomes: if one equivalizes incomes, then one should also equivalize the energy expenditure, since both income and energy expenditure need to increase in accordance with the size of the household (Moore 2012). Nonetheless, it should be noted that using actual energy expenditure could underestimate energy poverty if households are underspending on energy. Altogether, figures on the energy expenditure share are thus based on non-equivalized disposable income including rent, unless stated otherwise.

[3] Equivalization corrects for the fact that larger households need a higher disposable income to fulfill their (energy) needs. The modified OECD-scale assigns a weighting to additional household members: 0.5 to the second and each further person aged 14 and over, and 0.3 to each child aged under 14. For example, a household with 2 adults and one 5-year old child would have a total equivalization score of 1.8. The household income is then divided by this score to yield a representative income.

Data on the energy expenditure share was disaggregated for total household income, household type, socioeconomic status, type of dwelling and geographical location. Since no information on standard deviation was available, only the average score of groups could be calculated. This means that it was impossible to identify the amount of energy poor households within the groups by comparing the energy expenditure share with a certain absolute (e.g. more than 10%-income) or relative (e.g. more than twice the median) threshold. Besides, such a procedure would also have serious methodological caveats, which were explained in section 3.2.1. Therefore, the main approach was to identify vulnerable groups that have relative difficulty to afford adequate energy services.

As heating presents a large part of energy expenses, the average outdoor temperature in winter will likely influence the energy needs of households. Based on monthly temperature measurements from the Danish Meteorological Institute, the average winter temperature was computed by combining data from five Danish weather stations and calculating an average temperature for the four coldest months of a year (January, February, March and December) (DMI 2013). In order to subsequently adjust the energy expenditure for the outdoor temperature, heating degree days can be used (figure 3).[4] Based on data from the Odyssee database about heating degree days in Denmark, the energy expenditure for a given year can be corrected by dividing the energy expenditure by the number of heating degree days for that year and then normalized by multiplying with the average number of heating degree days for the period 1994 – 2011 for which energy expenditure data was available (Enerdata 2014). The effect of degree day correction can be seen by comparing figure 1 with figure 2. However, in this chapter all other figures displaying the share of energy expenditure in the disposable income will be shown without degree day correction. The first and most important reason is that temperature variations are significant to consider in energy poverty, as harsh winters might be especially challenging for vulnerable households. Second, as degree day corrections affect the energy expenditure share of every Danish household, they do not change the relative vulnerability of societal groups and are therefore not conducive to identifying groups more vulnerable to energy poverty.

Subjective and proxy indicators of energy poverty were explored based on the EU-Statistics on Income and Living Conditions (EU-SILC) survey (Eurostat 2014). The minimum effective sample size for Denmark was 4250 households in cross-sectional terms and 3250 households in longitudinal terms. Data was available for the period 2003-2012. Two indicators were utilized: the self-declared inability to keep the home adequately warm (called the 'adequate warming' indicator' for short) and the self-declared arrears on utility bills (called the 'arrears' indicator for short). The adequate warming indicator is a subjective indicator as it directly asks if households can keep their home adequately warm. The arrears indicator is a proxy indicator, as it is interrelated with an inability to afford adequate energy. The two indicators were disaggregated for income level and household composition. The income level distinguished between households below and above 60% of median equivalized income, which according to the EU definition is effectively a distinction between income poor and non-income poor households. For household composition, categories were differentiated depending on the age and number of the adults and the number of children. In turn, relatively vulnerable groups were identified similar to the approach used with the objective indicator. Finally, another proxy indicator used was annual data on the amount of electricity disconnections, provided by the energy sector organization Dansk Energi through contact via e-mail (Dansk Energi 2014).

[4] Heating degree days are a measure for the amount of heating necessary, defined in relation to a base temperature. For example, if the outside temperature for 2 days was 10°C and the base temperature is 15°C, then the amount of heating degree days over that period is 5 degrees * 2 days = 10 degree days.

Both the datasets from Statistics Denmark and Eurostat contain some anomalies that are likely due to statistical problems. For the data of Statistics Denmark, these anomalies are likely caused by sampling errors, such as the small sample size of certain household categories (Danmarks Statistik 2014c). In particular, the categories of rented room and unemployed contained less than 50 households in the period 2006:2008-2010:2012. Similarly, the categories of receiving education and other not economically active contained less than 100 households in this period. For the Eurostat data, the question posed for the adequate warming dataset changed from 2007 to 2008 (Danmarks Statistik 2014h). In the year 2007 and before, the question posed was if the household had problems to keep the dwelling pleasantly warm in a normal winter. This phrasing could be somewhat inaccurate for energy poverty purposes, because these problems could also occur for non-vulnerable households if there are issues with drafty windows for example. In 2008 and after, the question posed was if the household could afford to keep their dwelling adequately warm if they would like, which more accurately asks about the ability of households to afford heating services. Therefore, for the adequate warming indicator only data of 2008 and later was used. Finally, one very probable outlier was removed from the adequate warming dataset, namely the figure of 14.4% in 2012 for three or more adults with dependent children.

The results are limited by the fact that the datasets were only disaggregated for certain types of societal differentiations. For instance, it would have been interesting to investigate the energy poverty situation for households that include disabled persons, but this data was not available. Also, a disaggregation by income quintiles instead of absolute income differentiations would have been useful to explore.

3.4 Objective indicator

3.4.1 Average energy expenditure share

The average share of disposable income spent on energy in Denmark has been quite stable around 6 percent (figure 1). The average nominal energy expenditure of Danish households has been steadily rising in the last twenty years, but inflation has kept pace with this increase: real energy expenditure has been approximately constant during the period. The peak in energy expenditure in 2009:2011 was due to the exceptionally cold winter, as the average winter temperature for that year was about three degrees below the average of the 1994-2012 period (figure 3). Figure 2 shows the energy expenditure corrected using heating degree days, where the peak in energy expenditure in 2009:2011 has indeed disappeared. However, in this chapter all other figures displaying the share of energy expenditure in the disposable income will be shown without degree day correction, because this correction does not change the relative vulnerability of societal groups and temperature variations are significant to consider in energy poverty (section 3.3). The remaining peak in energy expenditure share in 2001:2003 was mainly due to stagnating disposable incomes (figure 4).

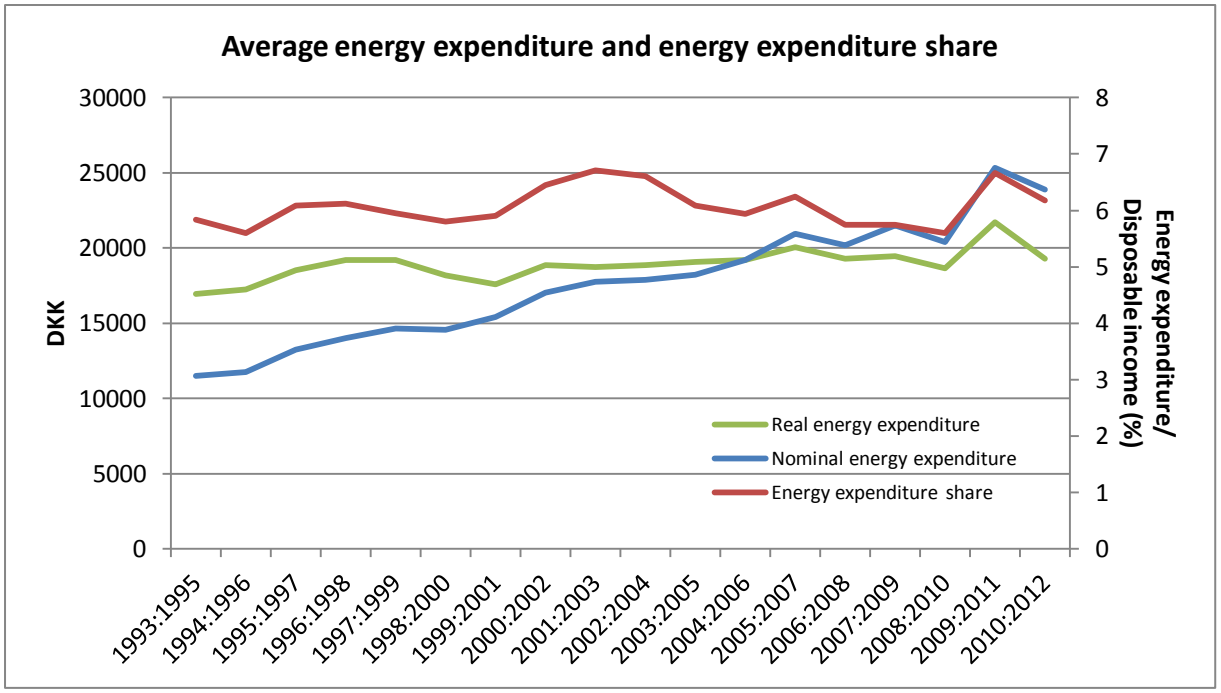

Figure 1: Average energy expenditure and average share of energy expenditure in disposable income for Danish households (Danmarks Statistik 2014a; Danmarks Statistik 2014b). The average share of disposable income spent on energy and the real energy expenditure in Denmark have been quite stable. The peak in expenditure in 2009:2011 was due to the exceptionally cold winter (cf. figure 2).

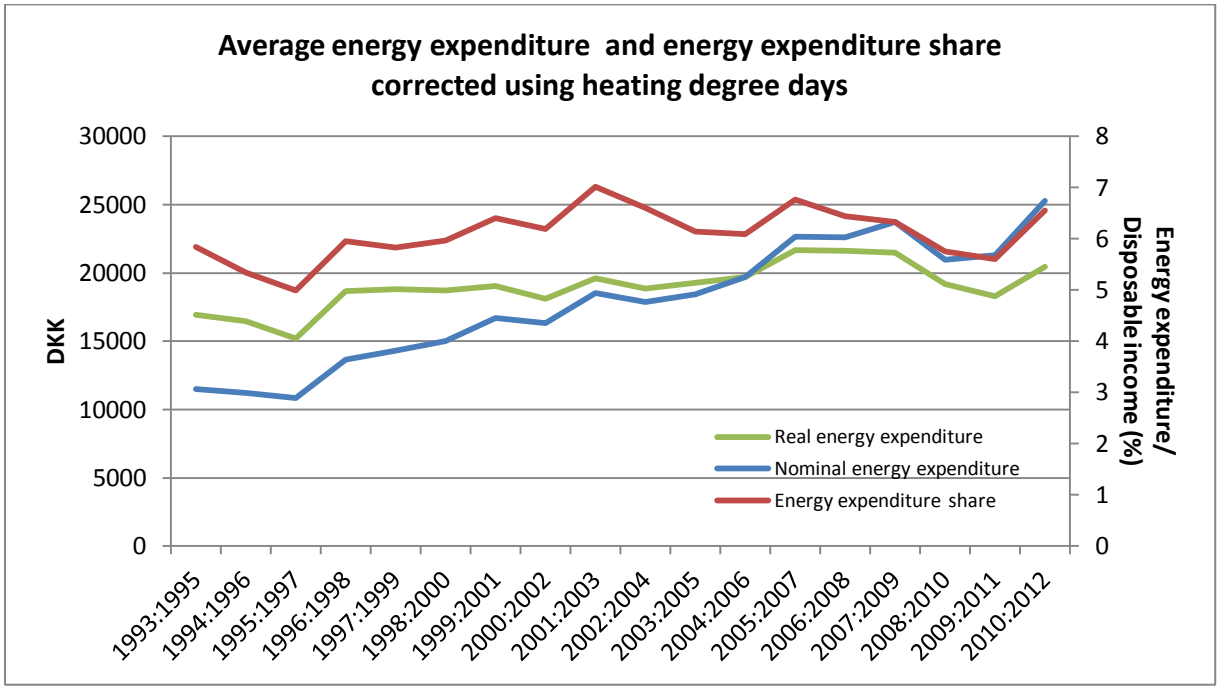

Figure 2: Average energy expenditure and average share of energy expenditure in disposable income for Danish households corrected using heating degree days (Danmarks Statistik 2014a; Danmarks Statistik 2014b; Enerdata 2014). The peak in energy expenditure in 2009:2011 in figure 1 disappears when energy expenditure is corrected for temperature using heating degree days. However, in this chapter all other figures displaying the energy expenditure share are shown without degree day correction, because this correction does not change the relative vulnerability of groups and temperature variations are significant to consider in energy poverty (section 3.3). The remaining peak in energy expenditure share in 2001:2003 was mainly due to stagnating disposable incomes (figure 4).

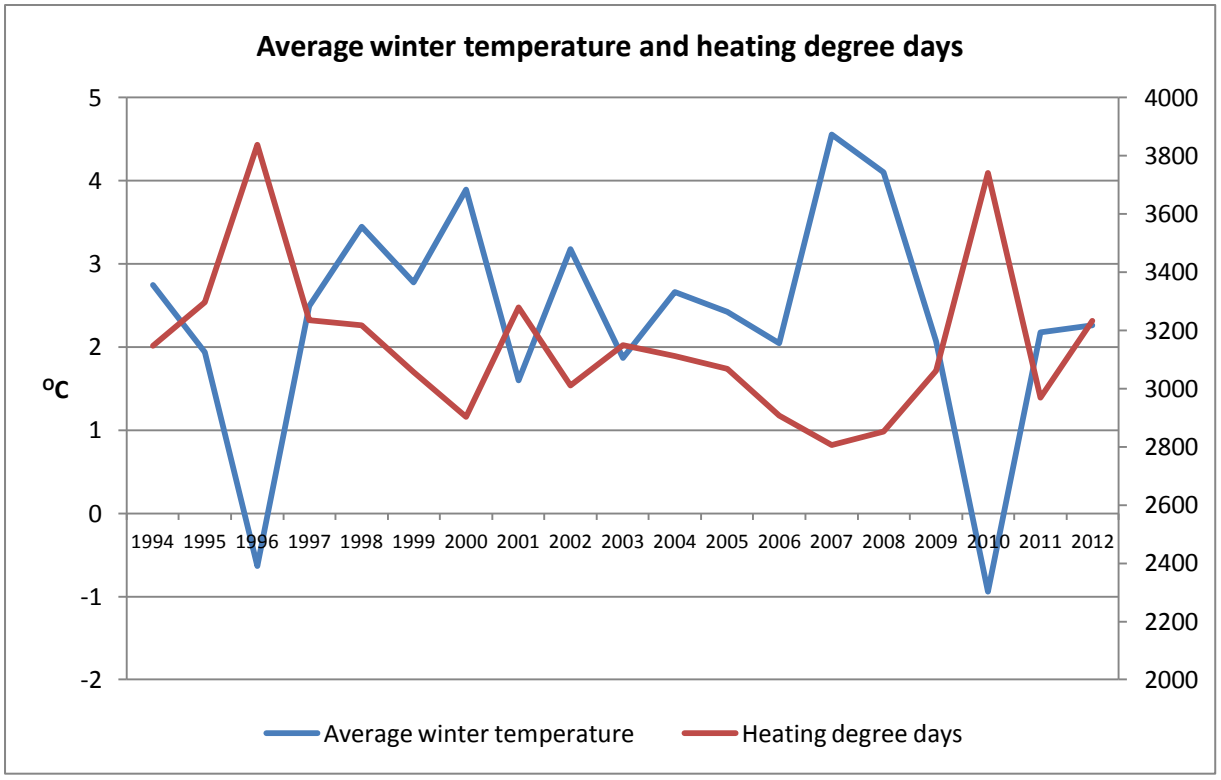

Figure 3: Average temperature for the months January, February, March and December of a given year (DMI 2013) and heating degree days (Enerdata 2014). The average winter temperature influences the heating needs of households. Heating degree days are a measure for the amount of heating necessary that can be used to correct energy expenditure for annual temperature variations (section 3.3).

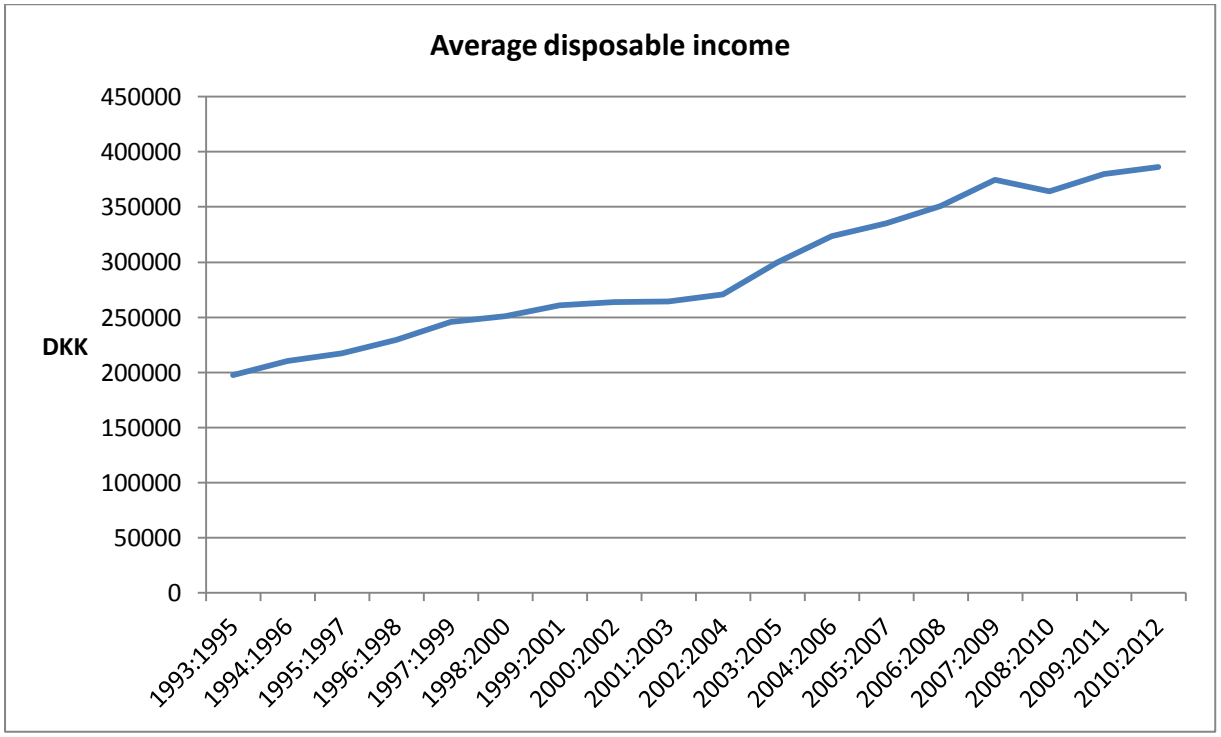

Figure 4: Average disposable income of Danish households (Danmarks Statistik 2014b). The average disposable income shows a general increasing trend, but stagnates in the periods 2000:2002-2002:2004 and 2007:2009-2010:2012.

3.4.2 Total household income

Figure 5 shows energy expenditure as a share of disposable income disaggregated for different ranges of total household income. In line with results in other countries, lower income groups spend a larger share of their disposable income on energy. The income group under 150,000 DKK and the income group 150,000-299,999 DKK can therefore be considered vulnerable. Since 2004:2006 there has been a rising trend in energy expenditure share for the income group under 150,000 DKK. This increase can be mainly attributed to a decrease in disposable income: before 2005:2007 this group had on average more than 80,000 DKK of disposable income, while it was below 76,000 DKK in the following years. For 2008:2010 and 2009:2011 their disposable income was even below 60,000 DKK. More detailed investigations into the drivers behind energy poverty for this disaggregation are carried out in section 4.3.

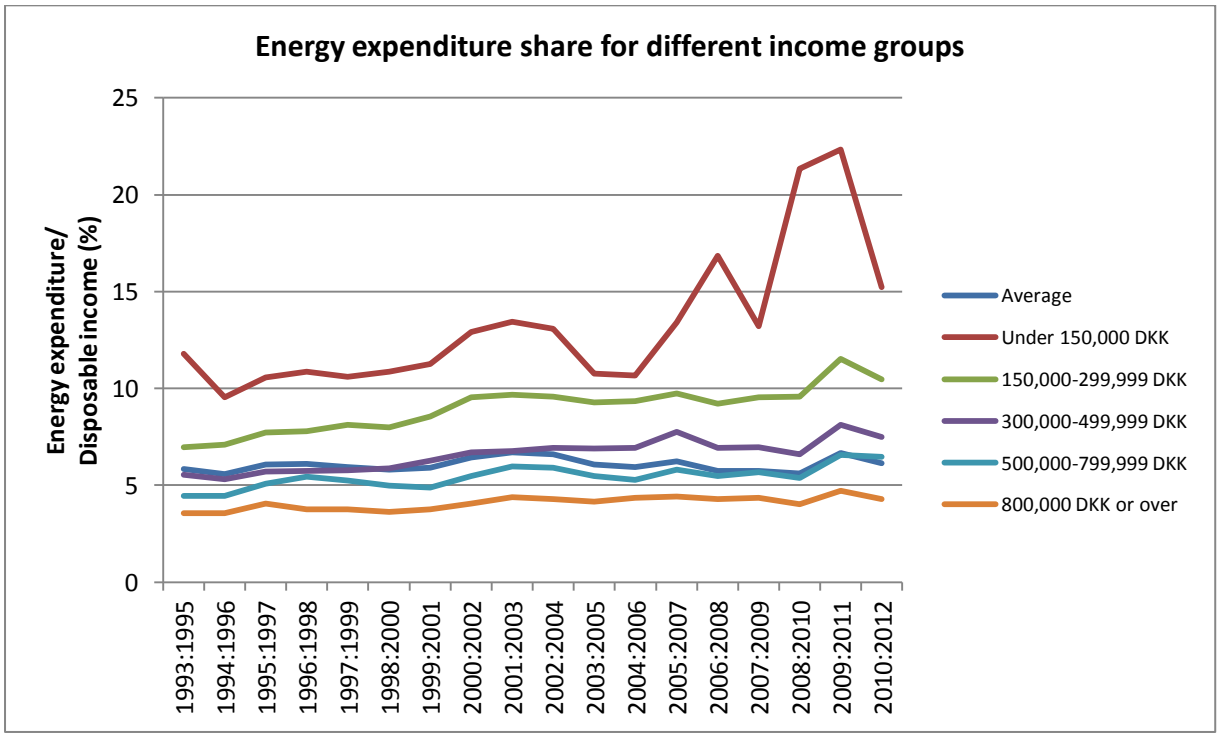

Figure 5: Energy expenditure as a share of disposable income for different income groups (Danmarks Statistik 2014a; Danmarks Statistik 2014b). Lower income groups spend a larger share of their disposable income on energy. The income group under 150,000 DKK and the income group 150,000-299,999 DKK can therefore be considered vulnerable. The recent increase in energy expenditure share for the income group under 150,000 DKK is mainly due to a decrease in disposable income. More detailed analysis is carried out in section 4.3.

3.4.3 Household type

Figure 6 shows the energy expenditure as a share of disposable income disaggregated for different household types. Single persons seem to be more vulnerable to energy poverty. Since 2008:2010, single persons over 60 years old without children and single parents have had the highest energy expenditure shares and can therefore be considered vulnerable groups. Generally, these groups have lower disposable incomes than non-vulnerable groups. Furthermore, the energy expenditure of single persons over 60 years without children is relatively high. More detailed investigations into the drivers behind energy poverty for different household types are carried out in section 4.4.

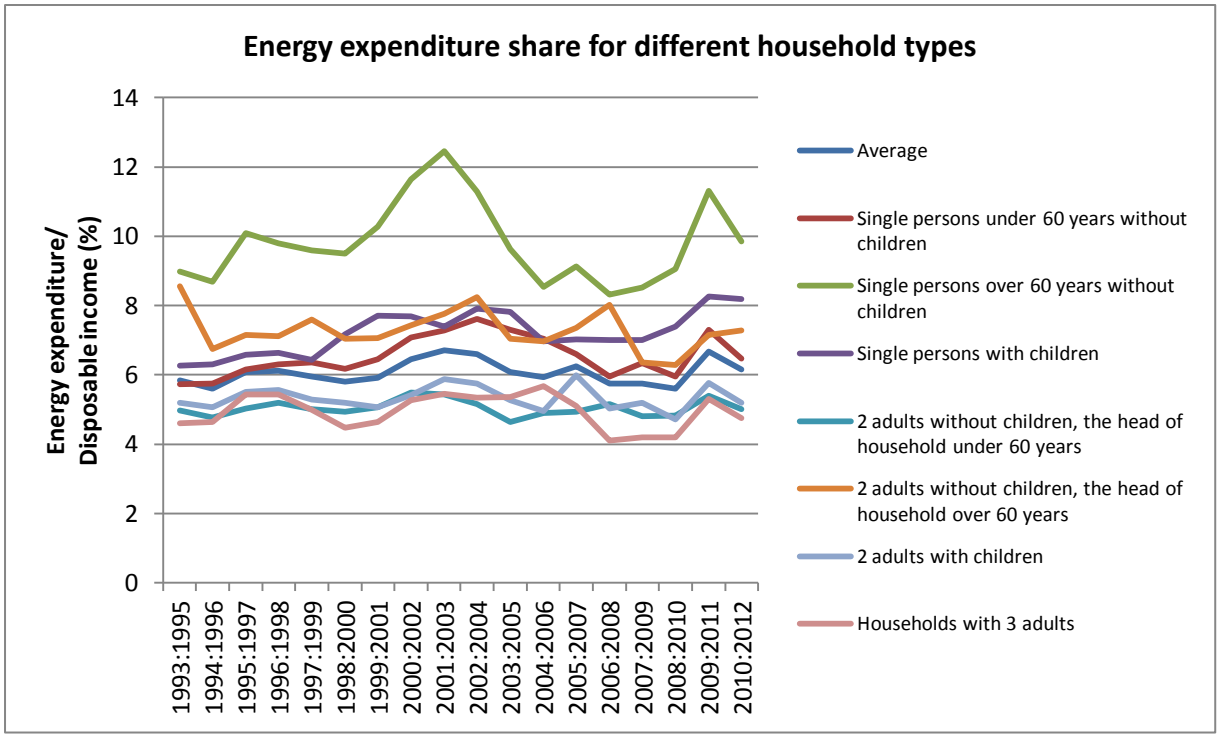

Figure 6: Energy expenditure as a share of disposable income for different household types (Danmarks Statistik 2014a; Danmarks Statistik 2014b). Since 2008:2010, single persons over 60 years old without children and single parents have had the highest energy expenditure shares and can therefore be considered vulnerable groups. The peak in energy expenditure share for single persons over 60 years in the first years of the century is due to a stagnation of their income during that period. The peak in 2009:2011 for most groups is due to the exceptionally cold winter (figure 3). More detailed analysis is carried out in section 4.4.

3.4.4 Socioeconomic status

Figure 7 depicts the energy expenditure as a share of disposable income disaggregated for socioeconomic status. Pensioners, unemployed, receiving education and other not economically active are found to have higher shares of energy expenditure than other groups and can therefore be considered vulnerable. Other not economically active is a rest category that contains among others those that receive state benefits called 'kontanthjælp' (Danmarks Statistik 2012). The regular unemployed category contains those that have received unemployment benefits ('arbejdsløshedsdagpenge') for more than half a year. All the vulnerable groups in this category have a disposable income below average. More detailed investigations in the drivers behind energy poverty for different socioeconomic status are carried out in section 4.5.

This disaggregation is used to illustrate the effect of using total incomes and incomes after deduction of the rent (figures 8 and 9). Using total income, the unemployed have a relatively smaller energy expenditure share compared to other vulnerable groups (figure 8). If incomes after deduction of the rent are utilized, those receiving education have relatively higher energy expenditure shares (figure 9). However, in general these different income bases do not significantly change which groups are most vulnerable. This was the same for other disaggregations, so that only figures using disposable income are shown in this chapter.

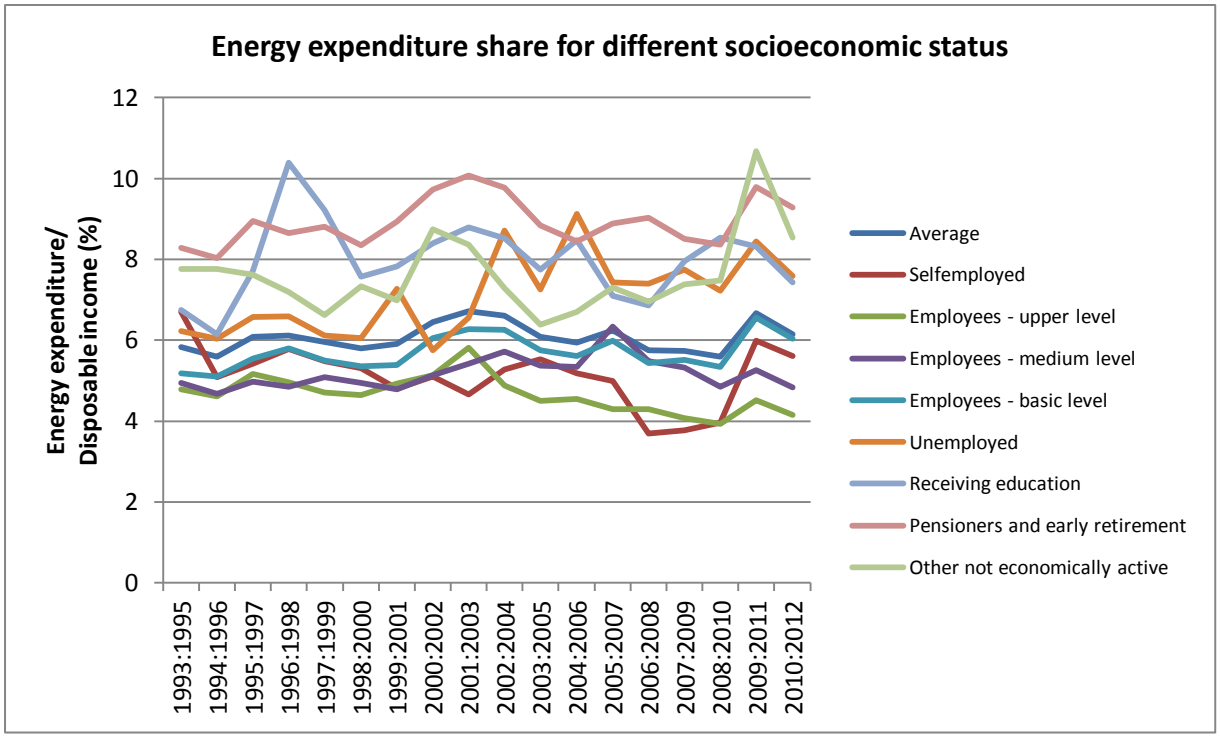

Figure 7: Energy expenditure as a share of disposable income for different socioeconomic status (Danmarks Statistik 2014a; Danmarks Statistik 2014b). Pensioners, unemployed, receiving education and others not economically active are found to have higher shares of energy expenditure than other groups, and can therefore be considered vulnerable. The peak in 2009:2011 for most groups is due to the exceptionally cold winter (figure 3). Some of the fluctuations in the graphs for the unemployed, receiving education, other not economically active and selfemployed are likely due to the small sample size (section 3.3). More detailed analysis is carried out in section 4.5.

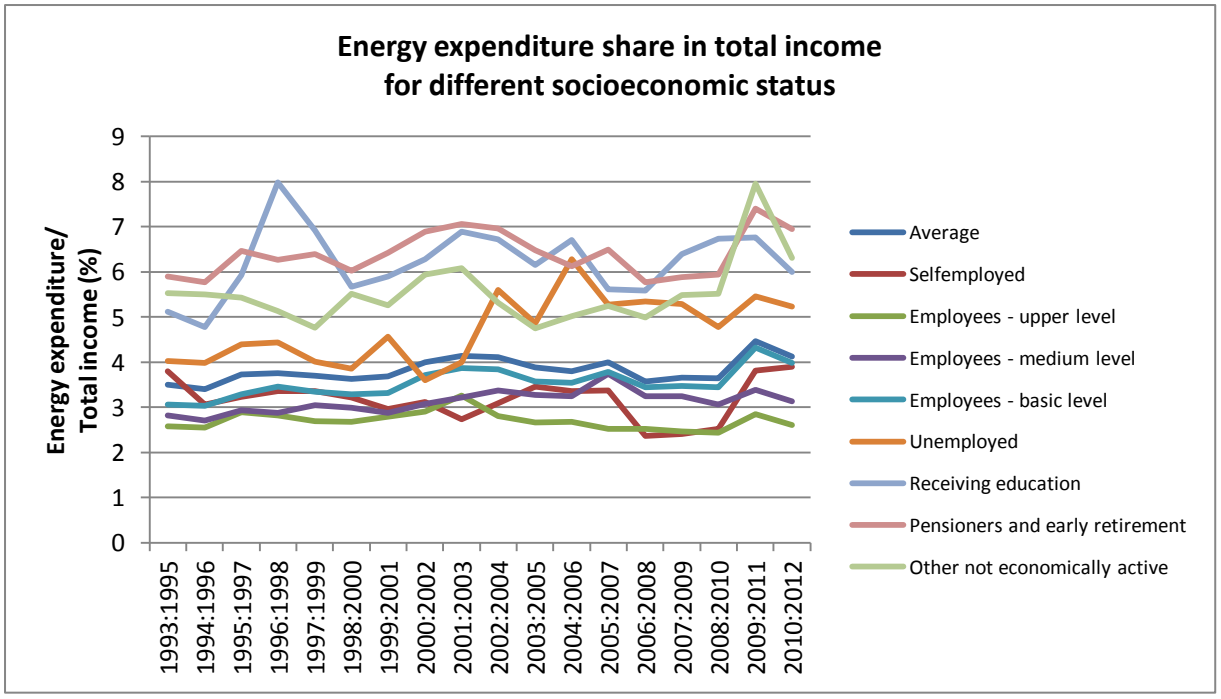

Figure 8: Energy expenditure as a share of total income for different socioeconomic status (Danmarks Statistik 2014a; Danmarks Statistik 2014b). Using total income, the unemployed have a relatively smaller energy expenditure share compared to other vulnerable groups than when disposable

income is used (cf. figure 7). However, the groups that are vulnerable do not change. This was the same for other disaggregations, so that only figures using disposable income are shown in this chapter. Some of the fluctuations in the graphs for the unemployed, receiving education, other not economically active and selfemployed are likely due to the small sample size (section 3.3).

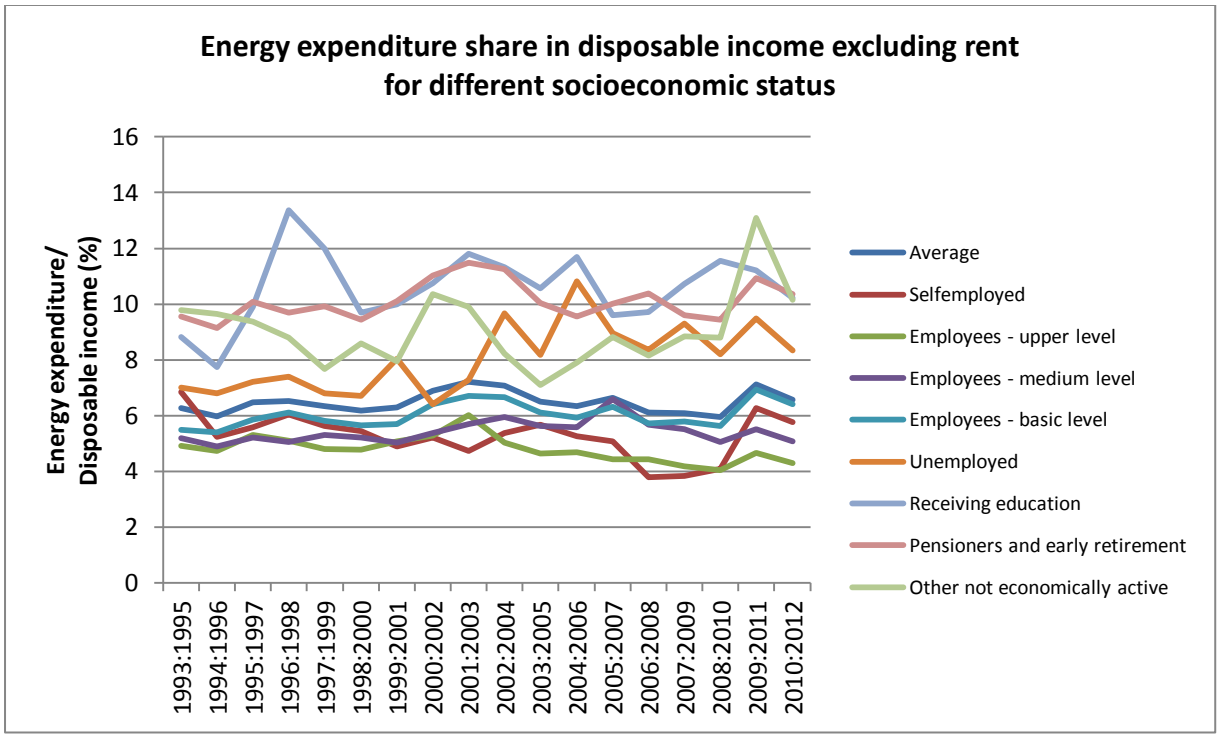

Figure 9: Energy expenditure as a share of disposable income after deduction of rent for different socioeconomic status (Danmarks Statistik 2014a; Danmarks Statistik 2014b). If disposable incomes after deduction of the rent are utilized, those receiving education have relatively higher energy expenditure shares (cf. figure 7). However, the groups that are vulnerable do not change. This was the same for other disaggregations, so that only figures using disposable income including rent are shown in this chapter. Some of the fluctuations for the unemployed, receiving education, other not economically active and selfemployed are due to the small sample size (section 3.3).

3.4.5 Type of dwelling

Figure 10 shows the energy expenditure as a share of disposable income for different types of dwelling. In general, households in rented properties have the highest energy expenditure share. Since 2008:2010, households living in rented detached housing and rented rooms have had the highest energy expenditure share, so that they can be considered vulnerable. Detailed investigations in the drivers behind energy poverty for the different types of dwellings are carried out in section 4.6.

3.4.6 Geographical variation

Figure 11 shows the energy expenditure as a share of disposable income for different Danish regions. For this disaggregation only the last five years of the dataset were available. There is a rising trend in the energy expenditure share in Nordjylland for these years, so that Nordjylland now spends considerably more than other regions and can therefore be considered vulnerable. This rising energy expenditure share is mainly due to an increase in energy expenditure in Nordjylland. More detailed investigations in the drivers behind energy poverty are carried out in section 4.7.

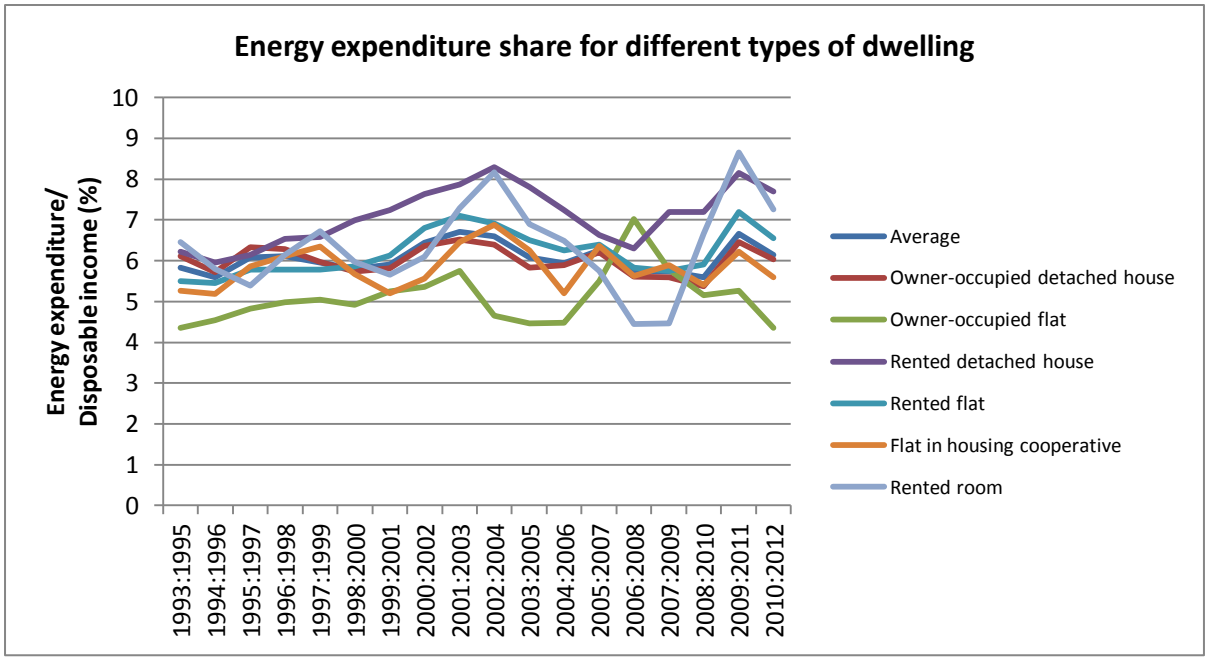

Figure 10: Energy expenditure as a share of disposable income for different types of dwelling (Danmarks Statistik 2014a; Danmarks Statistik 2014b). Since 2008:2010, households living in rented detached housing and rented rooms have had the highest energy expenditure share, so that they can be considered vulnerable. The peak in 2009:2011 for most groups is due to the exceptionally cold winter (figure 3). The rapid fluctuations in energy expenditure share for rented rooms and owner-occupied flats are likely a statistical anomaly because of the small sample size of these groups (section 3.3). More detailed analysis is carried out in section 4.6.

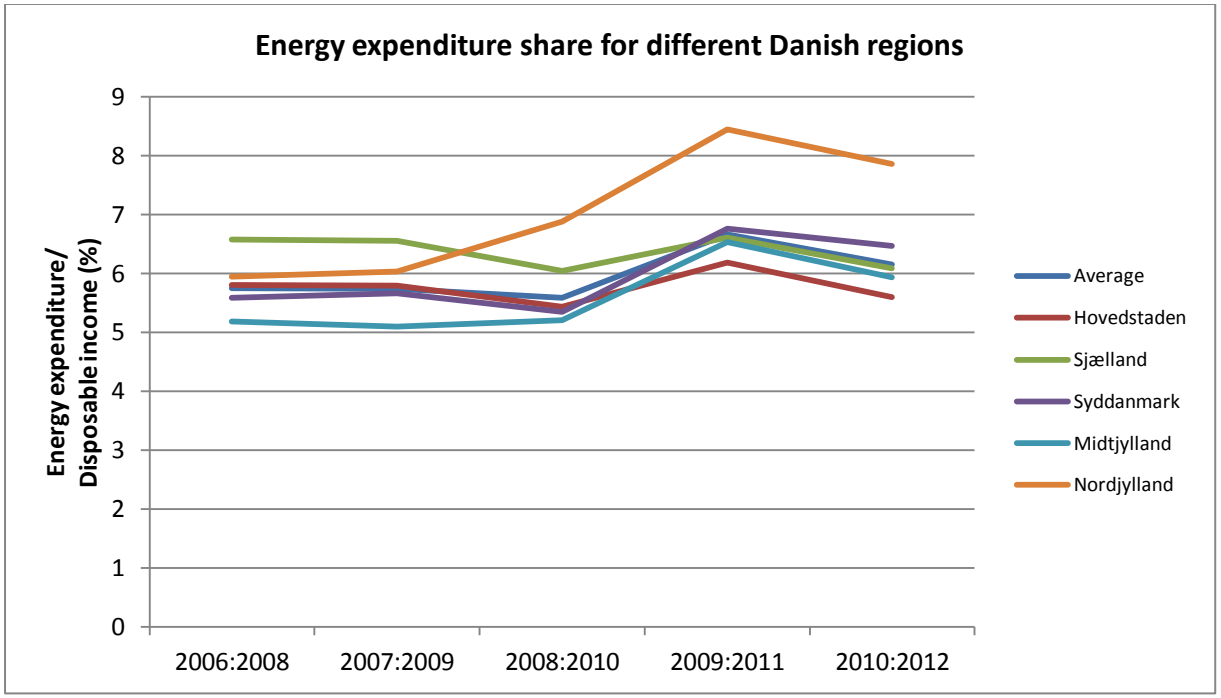

Figure 11: Energy expenditure as a share of disposable income for different Danish regions (Danmarks Statistik 2014a; Danmarks Statistik 2014b). Since 2008:2010 the energy expenditure share in Nordjylland has been higher than other regions, so that Nordjylland can be considered vulnerable. The rising trend for Nordjylland is mainly due to an increase in energy expenditure. More detailed analysis is carried out in section 4.7.

3.4.7 Vulnerable households

In the previous sections, certain socioeconomic and geographic groups had higher energy expenditure shares in recent years, so that these groups could be considered vulnerable to energy poverty. The vulnerable groups are:

- Total household income
  - Under 150,000 DKK
  - 150,000 DKK – 299,999 DKK
- Household type
  - Single persons over 60 years without children
  - Single parents
- Socioeconomic status
  - Pensioners
  - Unemployed
  - Receiving education
  - Others not economically active
- Type of dwelling
  - Rented room
  - Rented detached housing
- Geographical variation
  - In Nordjylland

3.5 Subjective and proxy indicators

3.5.1 Overview

Figure 12 shows the number of private households in Denmark that were disconnected from the electricity grid due to arrears in the years 2007 – 2013. There is an upward trend in the number of household disconnections for these years. The 30,865 disconnections in 2013 amount to around 1% of the household customers in Denmark.

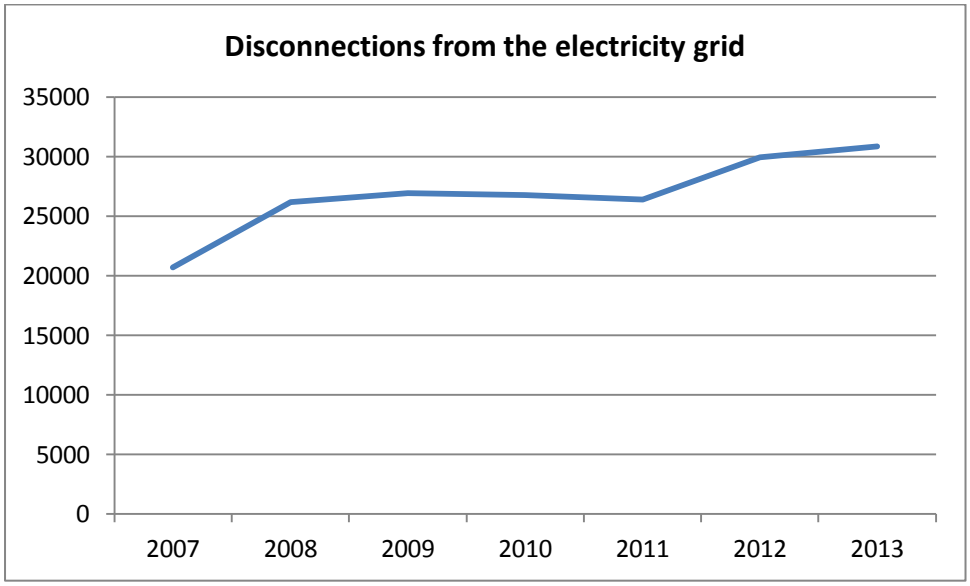

Figure 12: Private households that were disconnected from the electricity grid due to arrears (Dansk Energi 2014). There has been an upward trend in the number of household disconnections since 2007.

The general development of the two indicators in the EU-SILC survey is displayed in figure 13. The increasing trend in the number of disconnections since 2007 (figure 12) has been accompanied by an average rise in arrears on utility bills, as one could expect. The indicators are additionally disaggregated for income level, distinguishing income poor households (below 60% of median equivalized income) and all other households (above 60% of median equivalized income). Figure 13 demonstrates that on average relatively few Danish households have problems with paying their utility bills or keeping their home adequately warm. Nonetheless, income poor households score considerably worse on both indicators: 7.1% of low income households could not afford to keep their home adequately warm in 2012, compared to 1.9% of other households. For arrears on utility bills this difference was 5.5% compared to 3.4%.

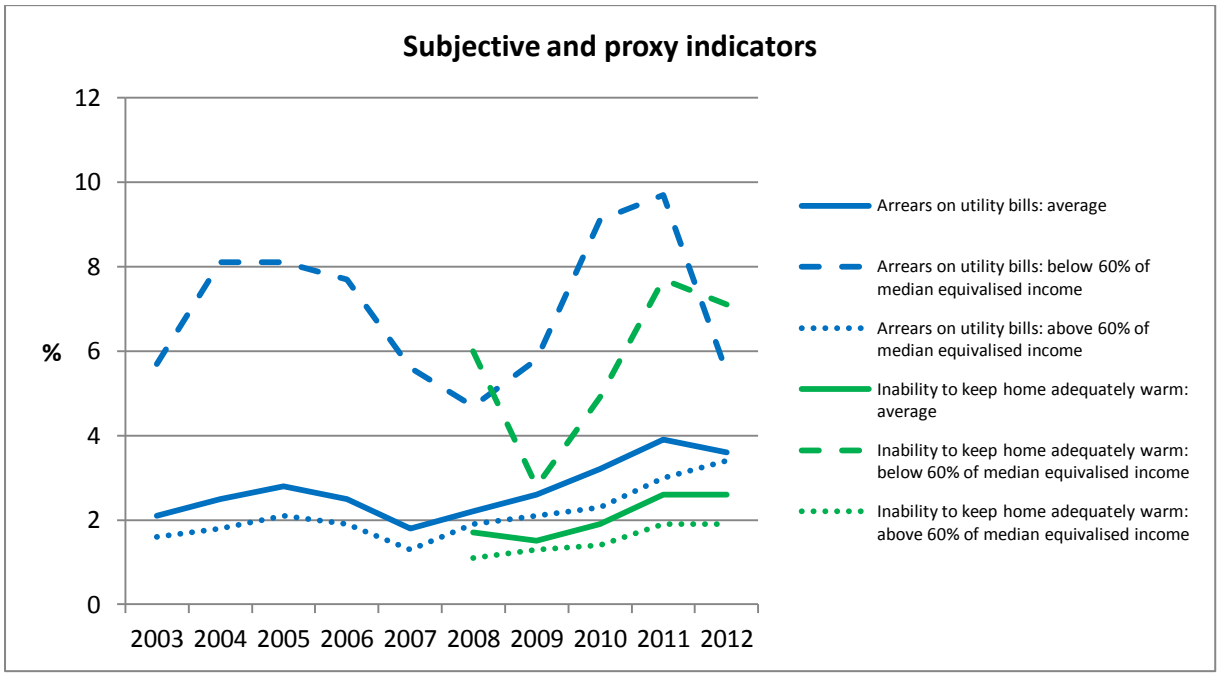

Figure 13: Subjective and proxy indicators of energy poverty for different income groups (Eurostat 2014). Relatively few Danish households have problems with paying their utility bills or keeping their home adequately warm, but income poor households score considerably worse on both indicators. Data before 2008 for the adequate warming indicator was not used, since the question posed during that period was not accurate enough for the purpose of this research (section 3.3).

3.5.2 Household type

Figure 14 shows the average score on the adequate warming indicator over the period 2008-2012 for all household types. An average was taken in order to present the differences more clearly. Single households with dependent children and single persons younger than 65 years are most likely to be unable to afford to keep the home adequately warm and can therefore be considered vulnerable households. It is also noteworthy that single adults younger than 65 years have relatively more financial trouble to keep their home warm than single adults 65 years and over.

The results are similar for the arrears indicator, as the two indicators are highly correlated (linear $R^2 = 0.70$). Single persons with dependent children and single adults younger than 65 years have the highest percentage of arrears on utility bills and can therefore be considered vulnerable households (figure 15). The difference between households with adults younger than 65 years and households with adults 65 years and over is especially striking for this indicator.

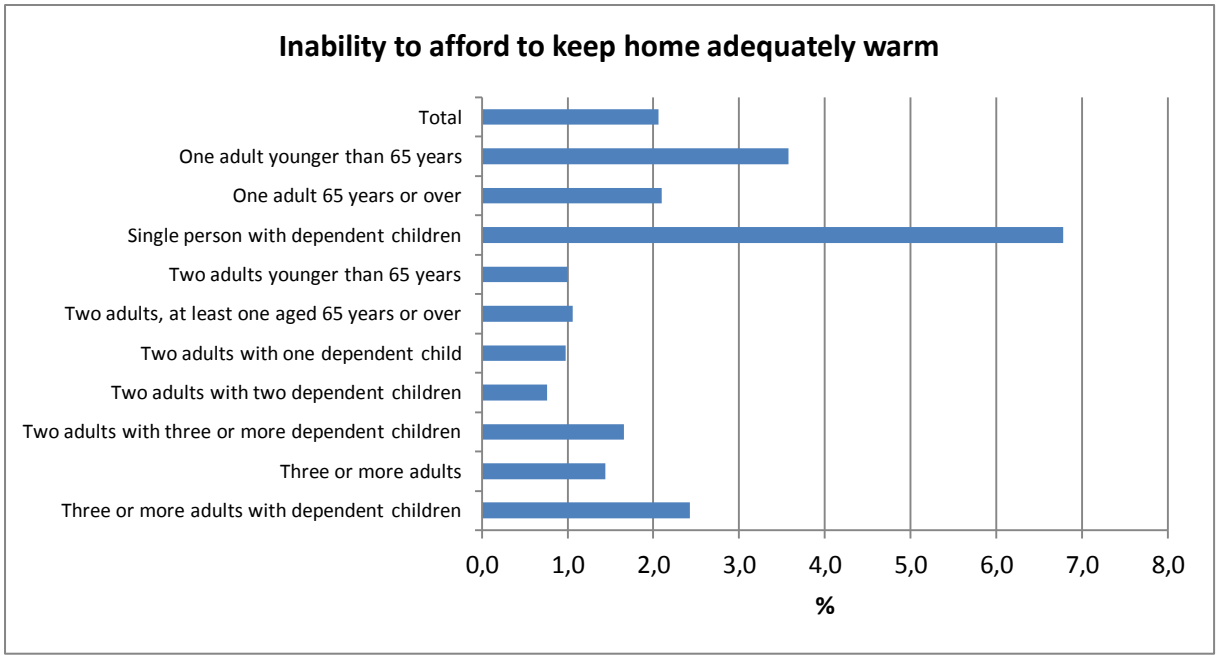

Figure 14: Inability to afford to keep the home adequately warm averaged over the period 2008-2012 for different household types in Denmark (Eurostat 2014). Single households with dependent children and single persons younger than 65 years are most likely to be unable to afford to keep the home adequately warm and can therefore be considered vulnerable households.

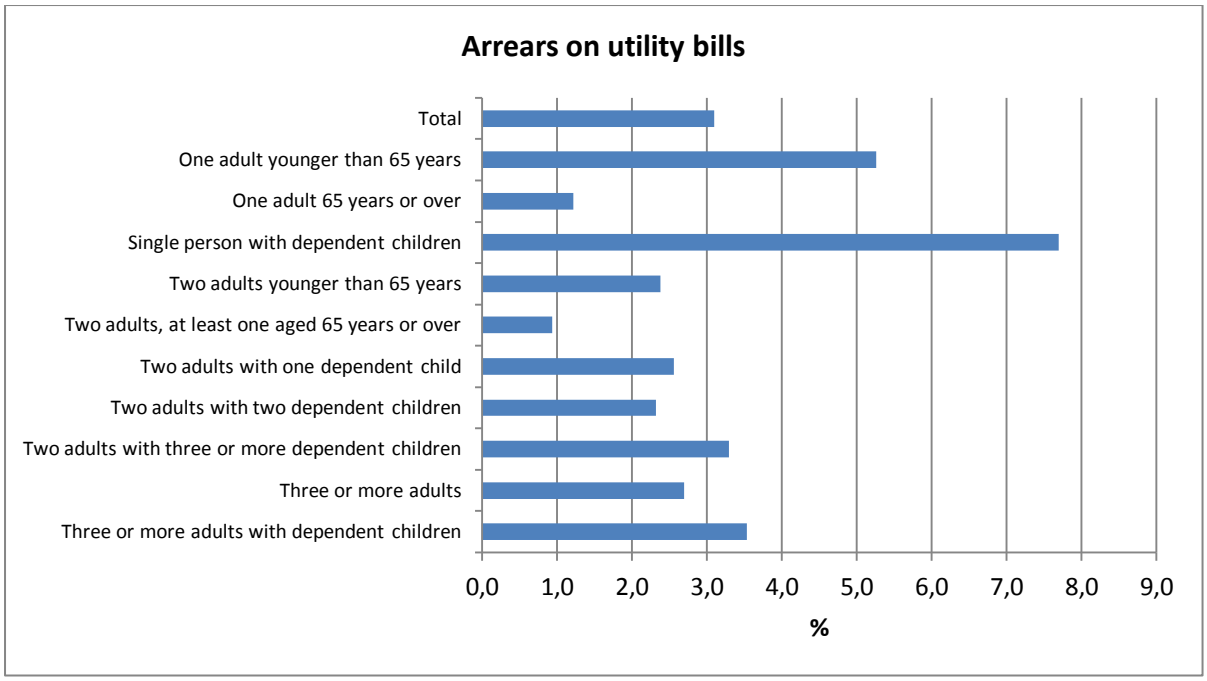

Figure 15: Arrears on utility bills averaged over the period 2008-2012 for different household types in Denmark (Eurostat 2014). Single persons with dependent children and single adults younger than 65 years have the highest percentage of arrears on utility bills and can therefore be considered vulnerable households. There is a large difference between households with adults younger than 65 years and households with adults 65 years and over.

3.5.3 Vulnerable households

Income poor, single parents and single adults younger than 65 years seem to be the most vulnerable households based on the subjective and proxy indicators. These groups are related since single-adult households are most likely to experience income poverty in Denmark (Bak and Larsen 2014). The considerable difference between single adults younger than 65 years and older than 65 years could be explained by the reimbursement of heating expenses that pensioners are eligible for, which covers a large amount of their heating costs (see section 2.6).

Chapter 4 Drivers behind energy poverty

4.1 Introduction

In order to understand why the Danish households identified in sections 3.4.7 and 3.5.3 are relatively more vulnerable than others, the drivers behind energy poverty need to be investigated in more detail. First, the methodological approach is described in section 4.2. Thereafter, sections 4.3 to 4.8 focus on explaining the patterns uncovered in the previous chapter for the different disaggregations (total household income, household type, socioeconomic status, type of dwelling and geographical variation). Explanatory variables are principally income, energy expenditure and the type of energy carriers used by households. Additional variables include climatic differences, the available financial resources for renovations and the year of construction of housing.

4.2 Methodology

Family budget surveys from Statistics Denmark were used to assess which factors could explain the disparities between vulnerable and non-vulnerable groups (Danmarks Statistik 2014a; Danmarks Statistik 2014b). These statistics are based on yearly surveys of approximately 2500 households, available for the period 1993:1995-2010:2012. The 13 explanatory variables extracted from this dataset are numbered throughout this methodology.

The selection of vulnerable groups based on the energy expenditure share does not indicate if it is income or energy expenditure that is the main contributor to developments in energy poverty. Therefore, data on (1) equivalized disposable income and (2) equivalized energy expenditure were used to assess their respective importance. Furthermore, the (3) equivalized size of dwellings was used to investigate the relative energy needs of households. Income, energy expenditure and the size of the dwelling need to be equivalized since bigger households generally need a higher income, more energy and a larger dwelling. Moreover, the equivalized energy expenditure was corrected for annual temperature differences using heating degree days (Enerdata 2014).

In addition, the type of energy carriers that households use could affect energy poverty. The consumer price index for energy services has increased in the last 15 years (figure 16). The index for most energy services was above the overall consumer price index. In particular, liquid fuels have become considerably more expensive since 2010. Therefore, the expenditure share of disposable income was analyzed for the different energy carriers ((4) district heating, (5) electricity, (6) natural gas, (7) solid fuels, (8) liquid fuels and (9) bottled gas). Solid fuels are coal, coke, briquettes, firewood, charcoal, peat and the like; liquid fuels are domestic heating and lighting oils (Danmarks Statistik 2014d).

In section 2.4 it was established that the energy efficiency of housing and equipment is an important factor behind energy poverty. However, no statistics were available on the energy efficiency of housing that could be used to examine if vulnerable groups live in less efficient housing. Energy labels of housing only exist for a small portion of the Danish housing stock and were not available in the family budget survey (Gram-Hanssen and Christensen 2012). However, the (10) year of construction of housing can be used as a proxy for energy efficiency. Since the energy efficiency of housing has been improving in the last 150 years, older housing is generally less energy efficient (Wittchen 2009).

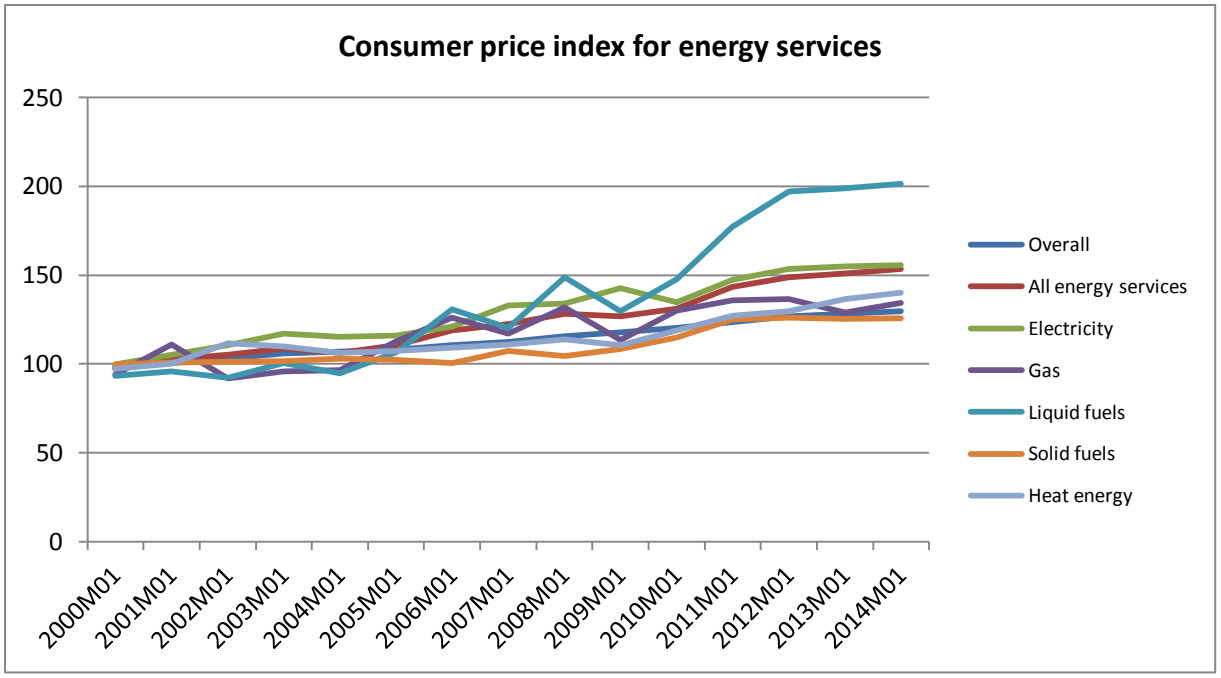

Figure 16: Consumer price index for energy services (Danmarks Statistik 2014e). The index for most energy services was above the overall consumer price index. In particular, liquid fuels have become considerably more expensive since 2010.

Factors that could affect the ability of households to carry out energy-efficiency improvements are home-ownership and the value of owner-occupied dwellings. If a household owns their house, it might be easier and more lucrative to renovate the house (see section 2.8). Ownership of dwellings was investigated by looking at the (11) percentage of adults in households that are homeowners averaged over the years from 2006:2008 to 2010:2012. An average was taken because the available data on homeownership was rounded to one decimal so that small fluctuations between years were not visible. For those households that own their home, the value of housing might additionally influence their ability to obtain financing for renovations because their house might not have enough value to support a mortgage loan. To investigate the value of housing, the (12) rental value of owner-occupied dwellings was used as a proxy. This is the approximate annual amount the dwelling could be rented for (Danmarks Statistik 2012). The average rental value for specific groups was divided by the average number of homeowners in the group, in order to get an indication of the rental value among the home-owners in the group. Again, an average was taken over the years 2006:2008-2010:2012.

Finally, (13) regional climatic differences could impact on variations in heating requirements between the Danish regions. The coldness of the climate was estimated by using data from the Danish Meteorological Institute (DMI 2013). For four weather stations in different parts of Denmark, the temperature averaged over the four coldest months of the year (January, February, March and December) was calculated.

4.3 Total household income

Two vulnerable groups were identified for this disaggregation: households with total household income under 150,000 DKK (the lowest income households) and those with income 150,000 DKK – 299,999 DKK (section 3.4.2). The higher energy expenditure share of these groups is mainly due to a lower equivalized disposable income. As indicated in section 3.4.2, the recent rising trend in the

energy expenditure share for the income group under 150,000 DKK can be attributed in particular to a decrease in equivalized disposable income. Indeed, other research also shows that the poorest 10% in Denmark are the only group that experienced a decrease in disposable income in the period 2002-2011 (Pihl and Sabiers 2013).

In relation to energy expenditure, a conspicuous development is displayed in figure 17. This figure shows that the equivalized energy expenditure of the lowest income group has been significantly below the other income groups since 2002:2004. In theory, this could mean that this group lives in more energy efficient housing, which is however highly unlikely since they do not live in newer dwellings. More plausible explanations are that they live in housing with lower energy needs, such as rented rooms (section 4.6), or that they are not obtaining the same level of energy services as the average Danish household. The latter option would mean that this group is probably energy poor, since it was already spending more than 13% of disposable income on energy in the period 2006:2008-2010:2012. Indeed, if the lowest income households would have an equivalized energy expenditure in 2010:2012 of 17,000 DKK similar to other income groups, this would constitute 25% of their disposable income.

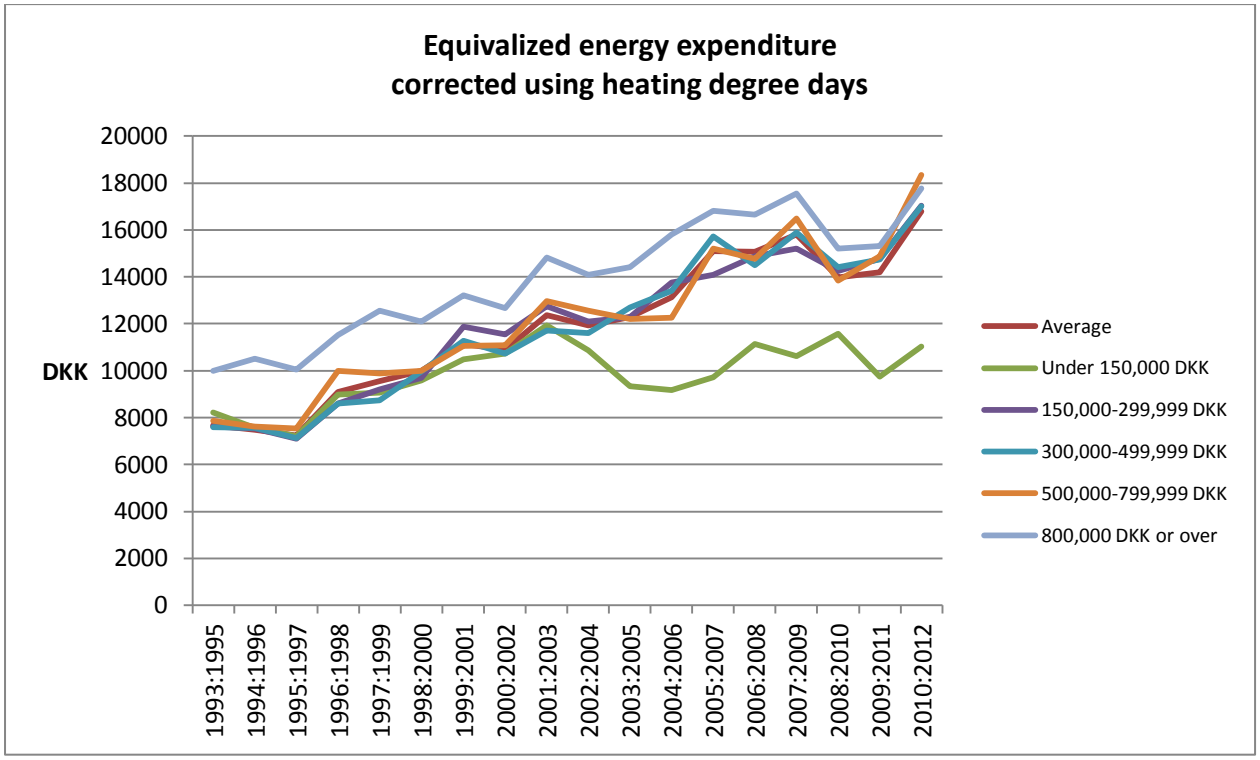

Figure 17: Equivalized energy expenditure for different income groups corrected using heating degree days (Danmarks Statistik 2014a; Enerdata 2014). The equivalized energy expenditure of the lowest income group has been significantly below the other income groups since 2002:2004. This could be because they live in housing with lower energy needs, such as rented rooms, or because they are not obtaining the same level of energy services as the average Danish household. The latter option would mean that this group is probably energy poor.

Lower income groups spend a higher percentage of their income on district heating and electricity. The lowest income group spent more than 10% of disposable income on district heating alone in the years 2008:2010 and 2009:2011. Besides these years, district heating presented about 6-8% of the disposable income for the lowest income group in the last decade, while electricity was around 4-6%.

The income group 150,000-299,999 DKK uses around 5-6% of disposable income on district heating and around 3% for electricity. In comparison, the highest income group spends less than 2% of disposable income on district heating and less than 2% on electricity. The energy expenditure shares on natural gas, solid fuels, liquid fuels and bottled gas do not display a clear relation with total household income.

The percentage of homeowners decreases with income: averaged over the period 2006:2008-2010:2012, there were 10% homeowners in the lowest income group and 20% in the income group 150,000-299,999 DKK, compared to around 90% in the highest income group. However, among the home-owners the rental value is similar across all the income groups, except for a higher rental value for the highest income group. There is no clear relationship between the year of construction of the dwelling and the total household income.

4.4 Household type

For this disaggregation, the vulnerable groups identified by the objective indicator were single persons over 60 years without children and single parents (section 3.4.3), while the subjective indicator pointed to single parents and single adults younger than 65 years (section 3.5.2). Generally, these groups have lower equivalized disposable incomes than non-vulnerable groups: in 2010:2012 vulnerable households had an equivalized disposable income below 230,000 DKK compared to an equivalized disposable income above 270,000 DKK for other groups.

Concerning the equivalized energy expenditure, single persons over 60 years without children and the non-vulnerable group 2 adults without children, the head of household over 60 years, spend more than all other groups: in 2010:2012 they spent around 21,000 DKK compared to an equivalized energy expenditure below 17,000 DKK for all other groups. This is likely due to the fact that these groups live in bigger housing which have higher energy needs: the equivalized size of their dwellings in 2009:2011 was around 90m^2 compared to an equivalized dwelling size less than 80m^2 for all other groups. Moreover, these households use more liquid fuels (1% of disposable income in 2010:2012 compared to less than 0.5% for all other groups), which are relatively more expensive. However, they generally do not live in older housing.

On the other hand, single persons under 60 years without children generally live in older housing. Furthermore, single persons under 60 year without children, as well as single parents, are least likely to own their house, as on average more than 75% rent their dwelling in the period 2006:2008 to 2010:2012, compared to a Danish average of 50%. This indicates that this group might not have the resources to renovate their house.

All the vulnerable households for this disaggregation spend more of their disposable income on district heating than non-vulnerable groups. Vulnerable households spent more than 4% of disposable income on district heating in 2009:2011, compared to less than 3% for non-vulnerable households. For electricity expenditure, vulnerable households spend more than average, but only single parents and single persons over 60 years without children spent more than non-vulnerable groups in 2009:2011. The energy expenditure shares on natural gas, solid fuels and bottled gas do not display a clear relation with household type.

4.5 Socioeconomic status

The vulnerable groups according to socioeconomic status were pensioners, unemployed, receiving education and other not economically active (section 3.4.4). These groups all have an equivalized disposable income below average: compared to an average equivalized disposable income of around

250,000 DKK in 2010:2012, pensioners have around 210,000 DKK, other not economically active around 175,000 DKK and those receiving education around 100,000 DKK. They are also lacking in other financial resources: except pensioners, on average less than 30% of the vulnerable groups owned their dwelling in the period 2006:2008 to 2010:2012. Excluding pensioners, the rental value for the home-owners in vulnerable groups is also considerably below other groups (around 40,000 DKK for vulnerable households compared to more than 50,000 DKK for other groups).

The group receiving education spends significantly less on energy than all other groups in this category (in 2010:2012 an equivalized energy expenditure around 7500 DKK compared to more than 15,000 DKK for all other groups). This is probably because they predominantly live in rented rooms with lower energy needs (section 4.6). On the other hand, pensioners consistently have a somewhat higher equivalized energy expenditure, which is likely due to the fact that they live in relatively large housing and use more liquid fuels. Nonetheless, they also live in newer housing: the average year of construction for this group has been around 1955 since 1999:2001, compared to an average year of construction below 1950 for all other groups in this category.

All vulnerable groups in this category spend more of their disposable income on district heating and electricity than non-vulnerable groups. Pensioners, receiving education and others not economically active spent more than 4% on district heating and around 3% on electricity in 2010:2012. Conversely, the unemployed spent almost 3% on district heating and 4% on electricity in this year. This could be a statistical issue because of the small sample size of the unemployed (section 3.3), but it could also indicate the usage of expensive electric heating. Non-vulnerable households spent less than 2.5% of their disposable income on district heating and around 2% on electricity in 2010:2012. The energy expenditure shares on natural gas, solid fuels and bottled gas do not explain the differences between vulnerable and non-vulnerable groups.

4.6 Type of dwelling

Types of dwelling more vulnerable to energy poverty were rented rooms and rented detached housing (section 3.4.5). The equivalized disposable income for those households living in rented rooms (around 90,000 DKK in 2010:2012) is significantly below the other groups (all above 190,000 DKK in 2010:2012), while the income of households in rented detached housing is – though below average – not below non-vulnerable types of dwellings.

Rented rooms have an equivalized energy expenditure significantly below all other types of dwellings: in 2010:2012 this was around 7000 DKK for rented rooms compared to more than 13,000 DKK for all other types of dwellings. This is likely due to the lower energy needs of single rooms, as there is less outside surface area through which heat is lost and it is likely that equipment such as washing machines is shared. On the other hand, the equivalized energy expenditure for detached housing (both rented and owner-occupied) was more than 18,000 DKK in 2010:2012 with the other types of dwellings below 14,500 DKK. This might be because they use a significant amount of expensive liquid fuels, with detached housing spending more than 0.5% of their disposable income on liquid fuels, compared to less than 0.1% for other types of dwellings. Nonetheless, rented detached housing is significantly newer than other types of dwellings: since 2008:2010 the average year of construction has been around 1965 for rented detached housing, compared to around or below 1950 for all other groups.

Rented rooms and rented detached housing do not consistently spend more on district heating than other types of dwellings, but they do spend a higher percentage of disposable income on electricity (more than 2.5% in 2010:2012 compared to around 2% for other groups). The energy

expenditure shares on natural gas, solid fuels and bottled gas do not explain the differences between vulnerable and non-vulnerable groups.

4.7 Geographical variation

The region in Denmark that was identified as being most vulnerable to energy poverty was Nordjylland (section 3.4.6). Nordjylland is the most Northern region in Denmark. The equivalized disposable income in Nordjylland has been below all other regions since 2007:2009, but not significantly. For instance, in 2009:2011 the equivalized disposable income was around 242,000 DKK for Nordjylland compared to 245,000 DKK in the second-lowest region.

The vulnerability of Nordjylland since 2008:2010 therefore stems from a higher equivalized energy expenditure: in 2010:2012 this was around 20,000 DKK compared to less than 17,500 DKK for the other regions. A first reason for this could be climatic differences due to the geographical location of Nordjylland. However, the four weather stations located in the different regions of Denmark do not show major differences in average winter temperatures (figure 18). The weather station situated in Nordjylland, Vestervig, did record a particularly cold winter in 2010 compared to other regions, which coincided with the increased energy expenditure in that year in Nordjylland, but the average winter temperatures cannot explain the energy expenditure difference among the Danish regions in 2009 and 2011, as average winter temperatures were similar across Denmark in that year.

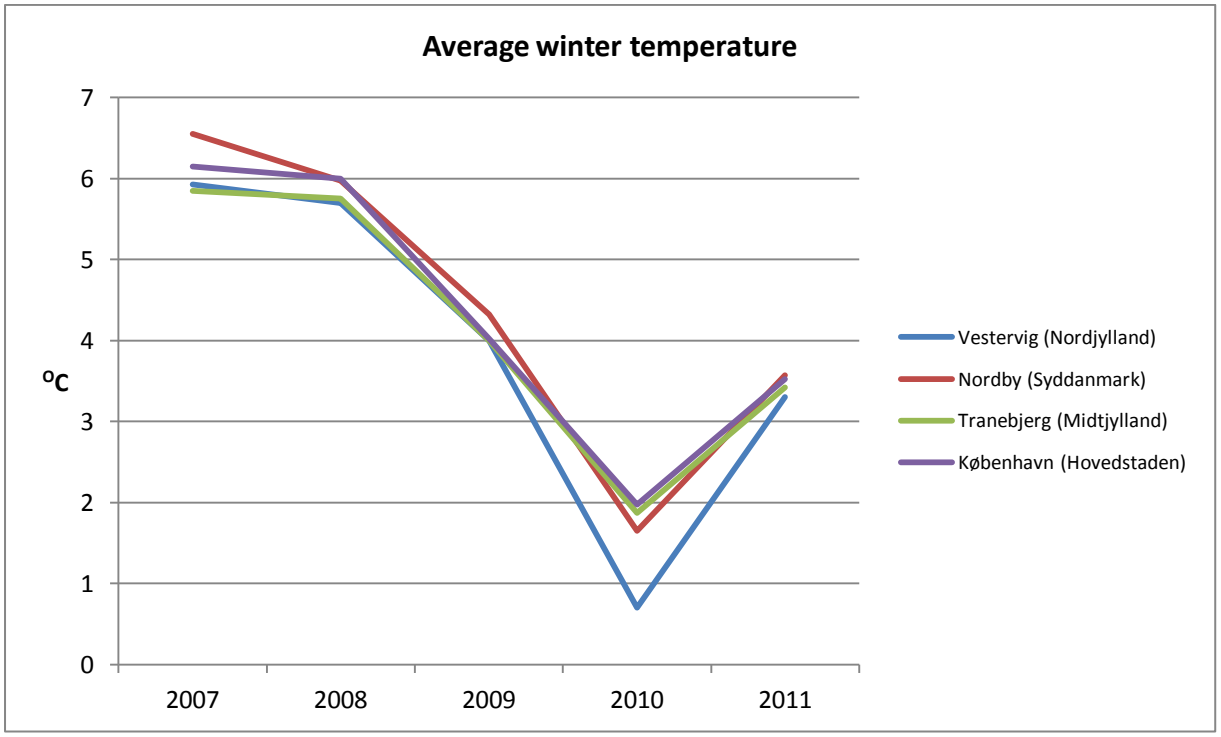

Figure 18: Average temperature for the months January, February, March and December of a given year (DMI 2013). Differences in average winter temperatures between regions cannot explain the trends in energy expenditure share, although the particularly cold winter in 2010 might have contributed to the increased energy expenditure in that year in Nordjylland.

One contributing factor to the higher energy expenses could be that the equivalized size of housing is somewhat larger in Nordjylland than in other regions (124m^2 in 2009:2011 compared to less than

120m^2 in all other regions), which means that there is more floor space to heat. The year of construction of the housing stock in Nordjylland is around the average, so the higher energy expenses might not be due to older inefficient housing.

In terms of energy carriers, households in Nordjylland pay more for district heating: in 2010:2012 around 3,5% of disposable income compared to less than 3% for all other regions. Another region, Sjælland, had the highest expenditure share on electricity in this year, with around 2.6% compared to an average of 2.2% with Nordjylland around 2.3%. An important reason for the recent increase in energy expenditure in Nordjylland is that the use of both solid and liquid fuels has increased dramatically. The share of solid fuel expenditure in disposable income increased from 0.3% in 2007:2009 to 0.9% in 2010:2012, compared to a solid fuel share of less than 0.5% in 2010:2012 for all other regions. The liquid fuel share increased from 0.2% in 2006:2008 to 0.7% in 2010:2012, compared to a liquid fuel share in that year below 0.4% for all other regions except Sjælland. Furthermore, even though bottled gas presents on average a tiny percentage of households' energy expenditure, there is a clear increase in Nordjylland compared to other regions, so that in 2010:2012 households in Nordjylland spent about twice as much on bottled gas. As the use of natural gas is low in Nordjylland, these developments could indicate that households resort to other means of heating their house, which might suggest that they are struggling to afford adequate energy services.

Chapter 5 Categorizing vulnerable households

5.1 Introduction

The analysis in the previous chapter showed the main drivers behind energy poverty for the different statistical disaggregations. However, it is to be expected that some of the identified vulnerable households overlap demographically and socio-economically. For example, the vulnerable group 'single persons over 60 years old without children' is likely to intersect with the vulnerable group 'pensioners'. Moreover, the drivers behind energy poverty could also be similar for these groups. In order to have a complete picture of the energy poverty situation in Denmark, this chapter therefore aims to combine multiple disaggregations to identify general categories of vulnerable households with common demographic and socioeconomic characteristics.

The dataset and variables used are the same as in the previous chapter (section 4.2). In addition, the relative share of energy carriers in the overall energy expenditure was investigated. First, the general characteristics of vulnerable households in terms of demography are presented in section 5.2. The next sections (5.3-5.5) demonstrate similarities in the energy expenditure patterns of vulnerable households, as well as similarities in the energy needs, the energy-efficiency of housing and homeownership. Section 5.6 synthesizes the previous sections to present two general categories of vulnerable households.

5.2 Demographics

The amount of households in vulnerable groups has been more or less constant since 1993:1995 (figure 19). Only the numbers of households in the lowest income and the 150,000-299,999 DKK categories have decreased significantly, which is probably due to the overall increase in average disposable income (figure 4).

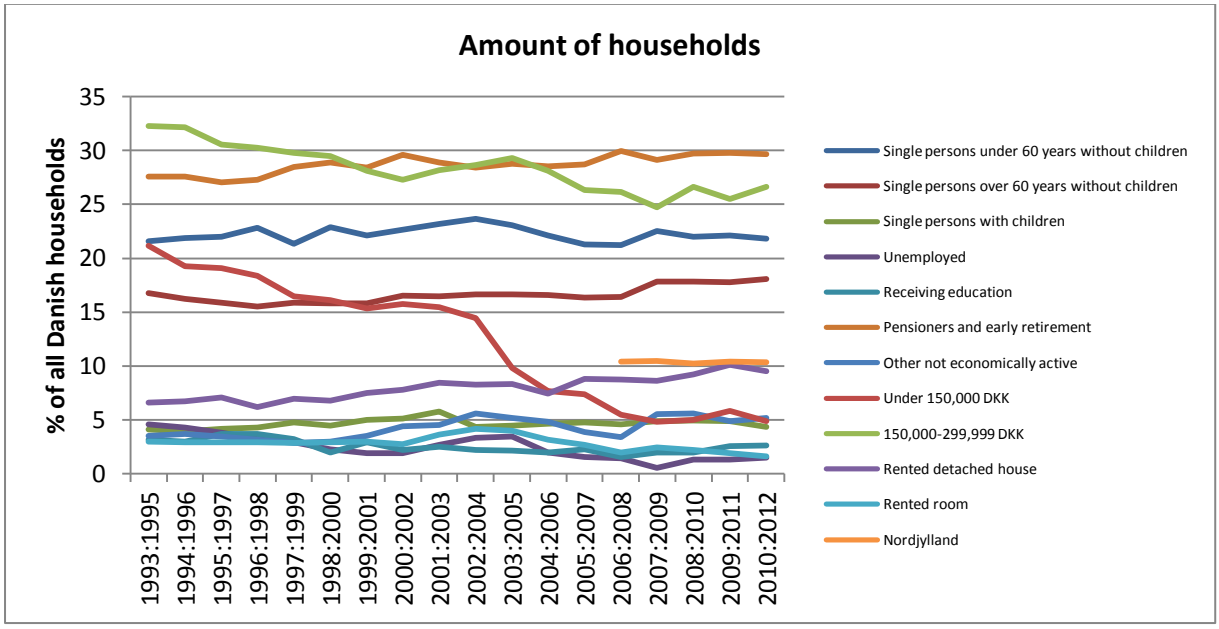

Figure 19: Amount of households in vulnerable groups as a share of all 2.6 million Danish households (Danmarks Statistik 2014a). The amount of vulnerable households has been more or less constant since 1993:1995, except for the lowest income and the 150,000-299,999 DKK categories which is probably due to the overall increase in average disposable income (figure 4).

Figure 20 shows the average age of vulnerable households. The figure suggests that the category pensioners overlaps demographically with single persons over 60 years without children. Similarly, rented room seems to overlap demographically with those receiving education. An interesting development is that those on the lowest income have become younger since 2000:2002. This suggests that they might align now more with other not economically active, single persons under 60 years without children and single parents, instead of pensioners before.

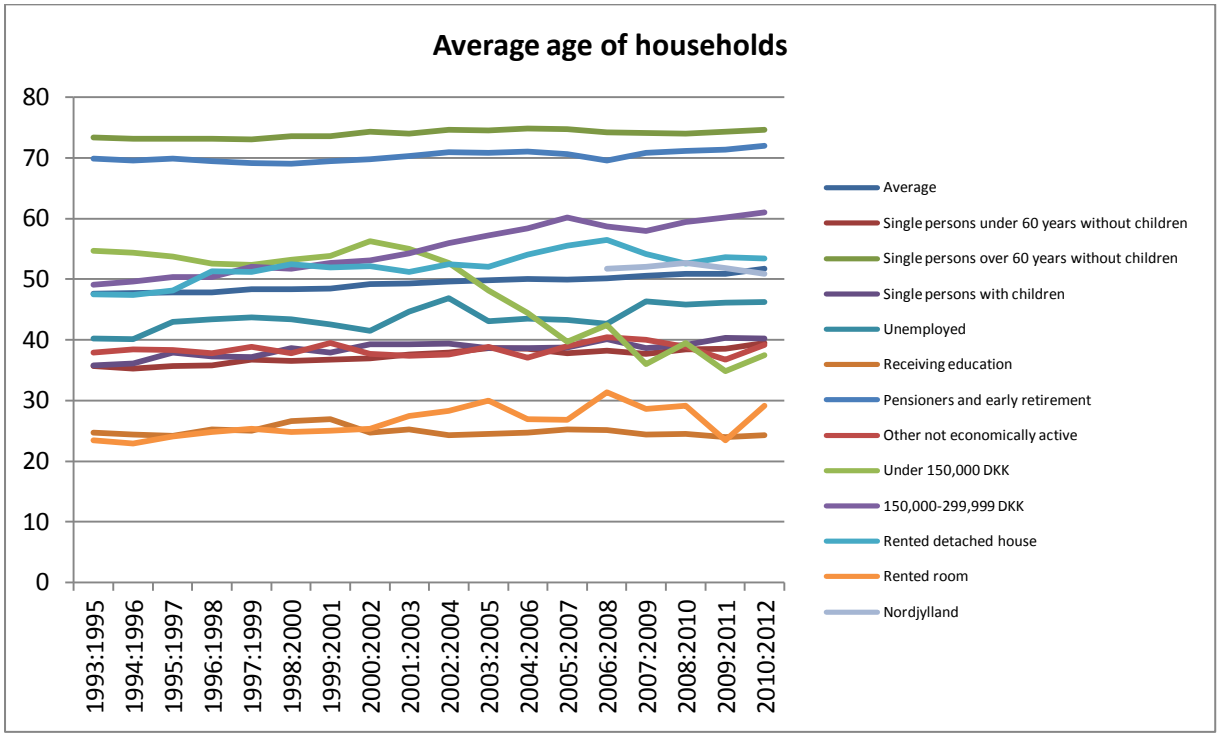

Figure 20: Average age of households in vulnerable groups (Danmarks Statistik 2014a). Some vulnerable households are likely to overlap demographically, since they have a similar average age. For example, demographic overlaps seem plausible for pensioners together with single persons over 60 years without children, and for rented room together with receiving education. The decrease in average age for the lowest income group suggests that they might align now more with other not economically active and single persons under 60 years, instead of pensioners before.

5.3 Energy expenditure

Figure 21 shows the equivalized energy expenditure corrected using heating degree days. Pensioners, single persons over 60 years without children and households in Nordjylland spend consistently more than other households, suggesting that they might have similar drivers behind energy poverty. Likewise, those receiving education, in rented rooms and on the lowest incomes spend considerably less than average, indicating possible similarities related to their vulnerability.

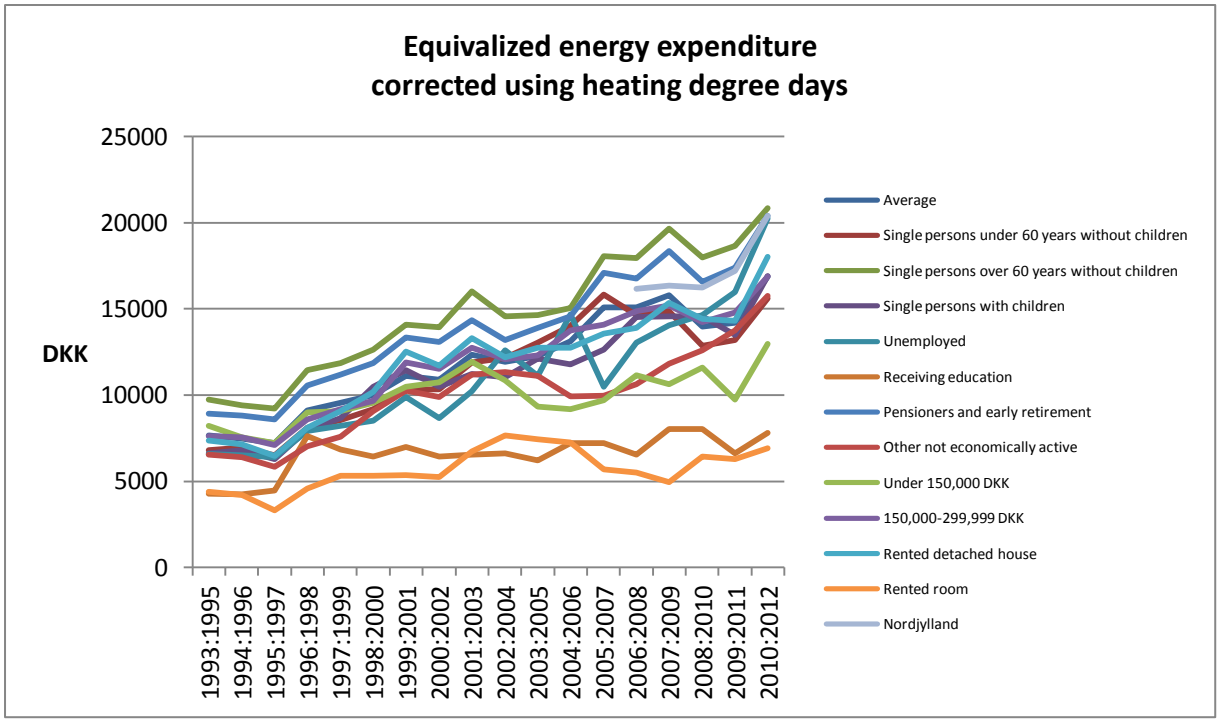

Figure 21: Equivalized energy expenditure for vulnerable groups corrected using heating degree days (Danmarks Statistik 2014a; Enerdata 2014) Pensioners, single persons over 60 years without children and households in Nordjylland spend consistently more than other households, while those receiving education, in rented rooms and on the lowest incomes spend considerably less than average. Therefore these two groups might belong to separate categories with different drivers behind energy poverty. The fluctuations for the unemployed are likely due to statistical errors (section 3.3).

On average, district heating is the biggest part of a Danish energy bill, with a share around 42%. Almost all vulnerable groups spend a larger than average share of their energy bill on district heating. In 2010:2012, vulnerable groups with a particularly high district heating expenditure (more than 55% of their energy expenses) were single persons with children, other not economically active, the lowest income group, receiving education and rented rooms, indicating that they might have similar energy expenditure patterns. On the other hand, pensioners, rented detached housing and households in Nordjylland spent less on district heating (around 45% of energy expenses in 2010:2012) than other vulnerable groups.

Electricity and natural gas are the second and third most important energy carriers in the energy costs of Danish households with respective shares in the energy bill of around 35% and 10%, but there are no clear patterns within the vulnerable groups in terms of expenditure on these energy carriers.

Both solid and liquid fuels represented around 6% of energy expenditure of Danish households in 2010:2012. There were a few vulnerable groups that spent more - around 8-9% - on liquid fuels: rented detached housing, pensioners, single persons over 60 years without children and households in Nordjylland. This is similar for solid fuels, with pensioners, single persons over 60 years without children and households in Nordjylland spending more than other vulnerable groups on solid fuels in 2010:2012.

Finally, bottled gas has a very small share in household energy expenditure for all vulnerable households (less than 0.3% of the energy bill in 2010:2012) without a clear pattern distinguishing vulnerable groups.

5.4 Energy efficiency and energy needs

Figure 22 depicts the age of housing for the vulnerable groups. In the years 2009:2011-2010:2012 pensioners, single persons over 60 year without children and rented detached housing lived in somewhat newer housing (year of construction around 1960), while single persons under 60 years without children, the lowest income group, others not economically active and the unemployed lived in somewhat older housing (year of construction around 1945). This suggests that these groups might belong to two distinct vulnerable categories.

Figure 23 shows that pensioners and single persons over 60 years without children are more likely to live in dwellings that are relatively large, so that under occupancy might be a driver behind energy poverty for these groups.

5.5 Homeownership

Figure 24 shows that only a considerable share of households in Nordjylland, pensioners and single persons over 60 years without children own the homes they live in over the period 2006:2008-2010:2012. Among the other vulnerable groups, more than 70% live in rented dwellings.

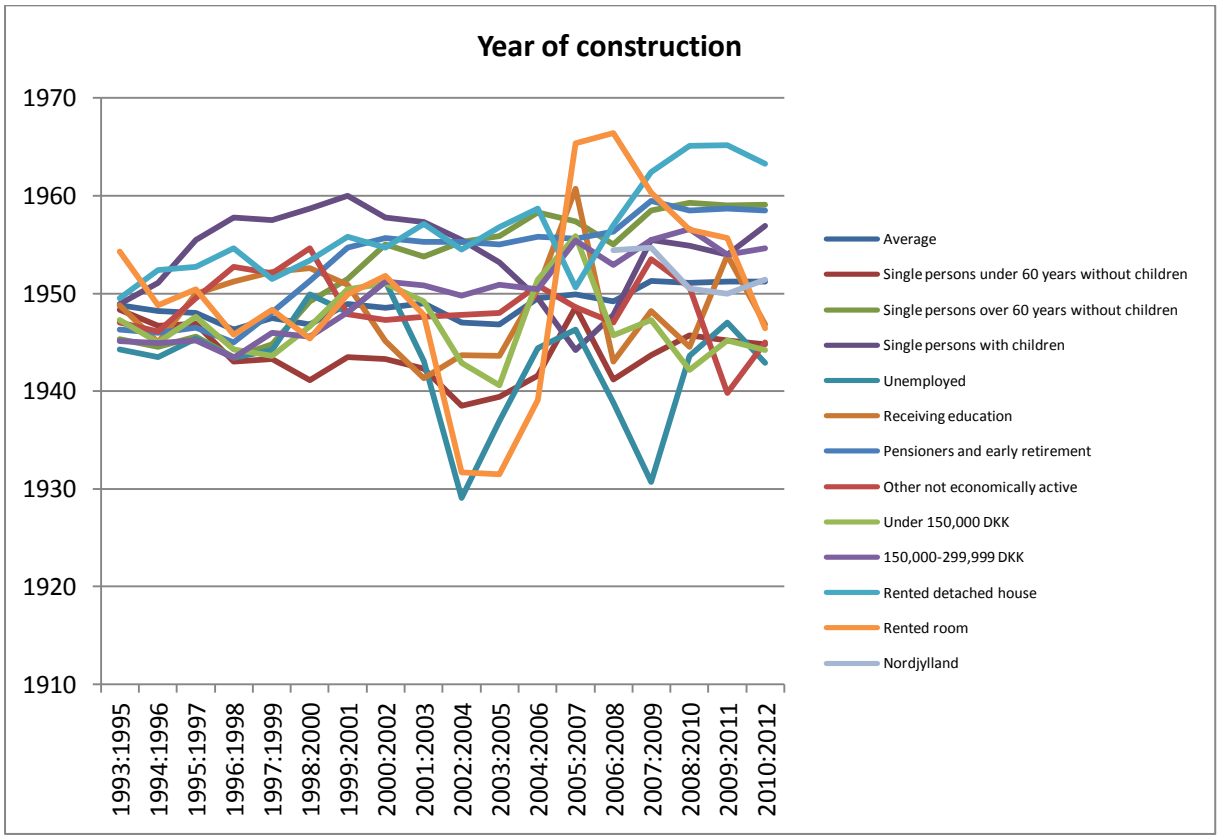

Figure 22: Year of construction of housing for vulnerable groups (Danmarks Statistik 2014a). In the years 2009:2011-2010:2012, certain vulnerable groups lived in housing around the same age, suggesting that these groups might belong to similar vulnerable categories. The fluctuations in the curve for rented rooms, receiving education and the unemployed are likely due to the small sample size (section 3.3).

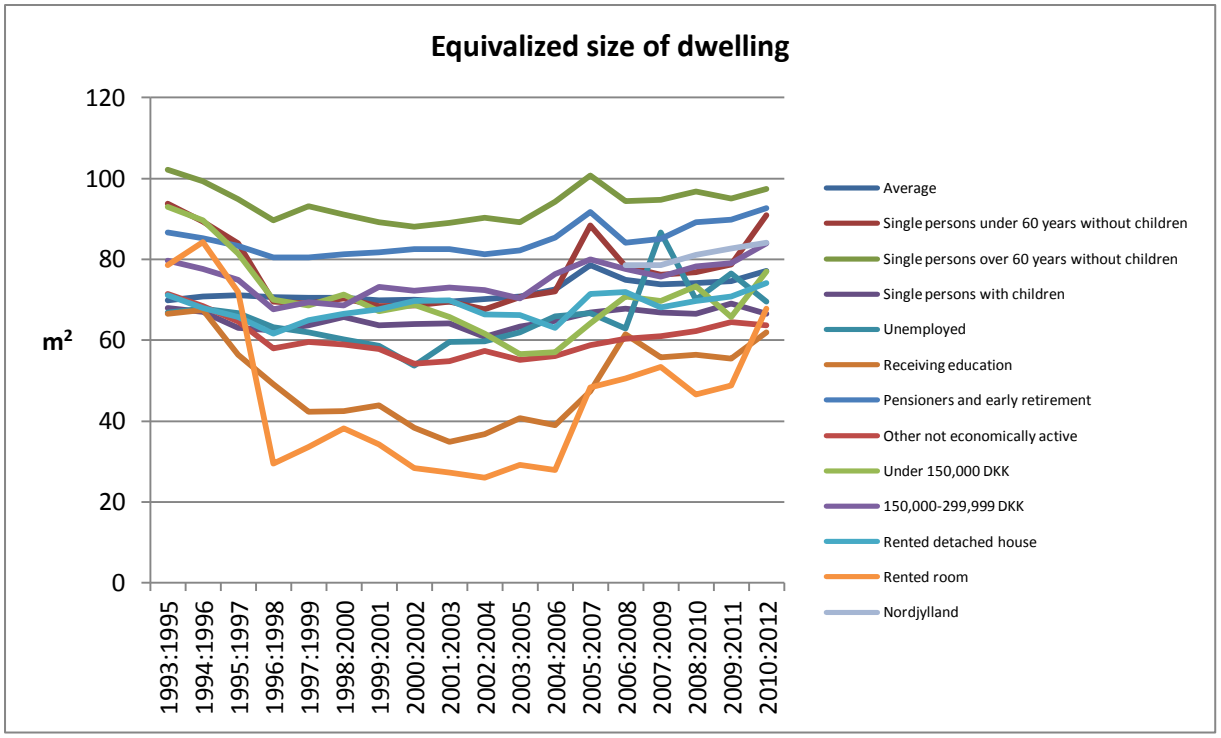

Figure 23: Equivalized size of dwellings for vulnerable households (Danmarks Statistik 2014a). Pensioners and single persons over 60 years without children are more likely to live in dwellings that are relatively large so that their energy needs are comparatively high. The fluctuations in the curve for rented rooms, receiving education and the unemployed are likely due to the small sample size (section 3.3).

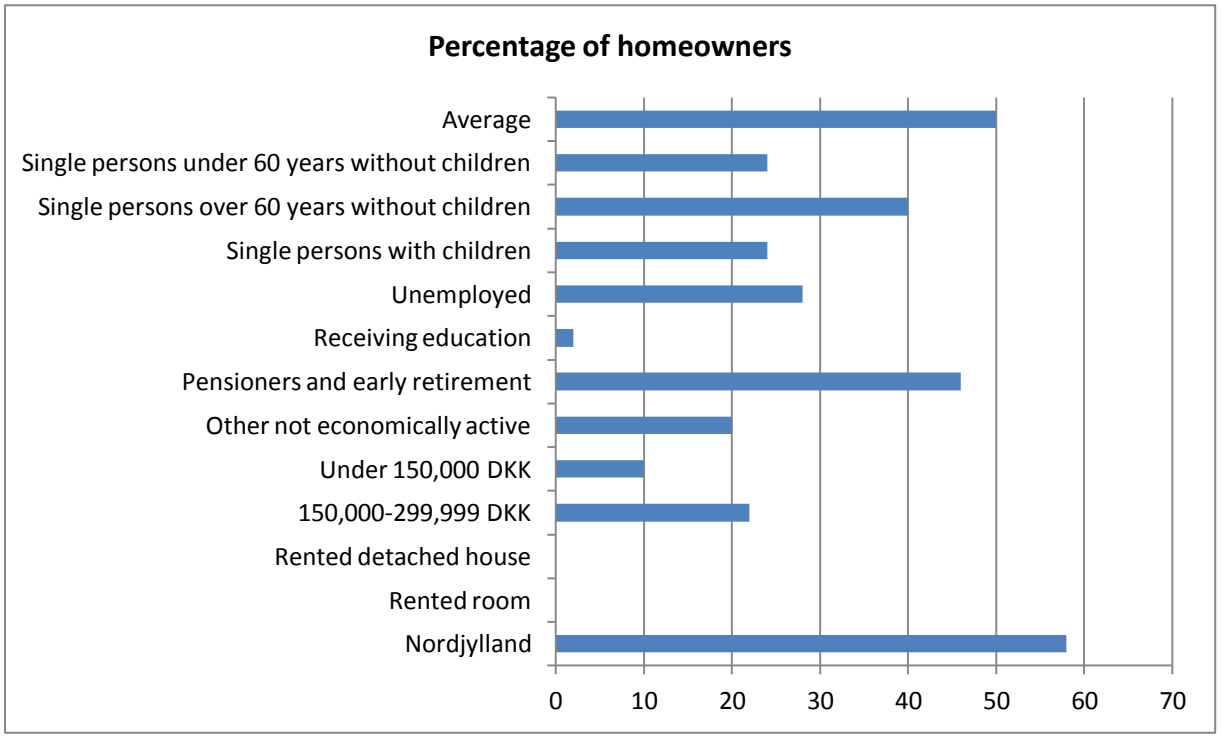

Figure 24: Average percentage of homeowners among vulnerable households from 2006:2008 to 2010:2012 (Danmarks Statistik 2014a). Most vulnerable households are unlikely to own the home they live in, except for households in Nordjylland, pensioners and single persons over 60 years without children.

5.6 Categories of vulnerable households

The results in the previous sections can be synthesized to suggest two general categories of households that might be struggling to afford adequate energy and to identify the main drivers behind energy poverty for these households. The relation of policy with the energy poverty situation in these groups is also briefly discussed.

5.6.1 Single persons under 60 years on low incomes

The first vulnerable category contains households on an income below 150,000 DKK, single persons under 60 year without children, single parents, unemployed, other not economically active, receiving education and rented rooms.

Certainly, the households on the lowest income seem to be the most vulnerable group in Denmark, as their energy expenditure share in the period 2006:2008 to 2010:2012 was above 13%. In addition, they might be underspending on energy since their equivalized energy expenditure has been significantly below the other income groups since 2002:2004. In section 4.3 it was suggested that a first reason for this could be that they have lower energy needs, because they live in rented rooms. This indeed seems plausible, since other characteristics of the lowest income group, rented rooms and receiving education overlap in the period 2006:2008 to 2010:2012. All these groups are relatively young, live alone, have a low equivalized disposable income and low equivalized energy expenditure. Since rented rooms might have comparatively lower energy needs than other types of housing, those in the lowest income groups that live in these dwellings might have a smaller chance to actually be energy poor. Furthermore, those in the lowest income groups that are receiving education might be less vulnerable to energy poverty, since their education provides them with informational resources and with better prospects to future employment, although this does not necessarily mean that they cannot experience temporary poverty (Sorgenfri Kjær 2012). Nonetheless, students do not provide a full explanation for the vulnerability of the lowest income group, because this group is larger (5% of population in 2010:2012) than the receiving education and rented room groups (respectively around 2.5% and 1.5% of the population in 2010:2012).

The lowest income group also shares some characteristics with single persons under 60 year without children, the unemployed and other not economically active, as they all are around the same age and they all lived in somewhat older housing in the period 2008:2010 to 2010:2012. Moreover, most households in these groups rent their dwellings, and for those that own the house, the rental value is significantly below average. This means that these groups likely do not have the financial resources to improve the ageing dwellings they live in. Similar to these groups, single parents also have an average age around 40, receive a below average income and mostly rent their dwelling. However, they lived in somewhat newer housing in the period 2008:2010 to 2010:2012.

For all vulnerable groups in this category, district heating presented more than 50% of the energy bill in 2010:2012, compared to an average of around 42%. Consequently, these groups also spend a higher percentage of their income on district heating than non-vulnerable households. This most likely means that the majority of vulnerable households in this category live in urban areas with access to district heating.

Overall, it seems that for this category energy poverty largely coincides with income poverty, as students, unemployed, other not economically active and single parents are also most likely to experience income poverty in Denmark (Danmarks Statistik 2012). The low scores on the adequate warming and arrears indicators for single parents and single adults younger than 65 years are therefore probably because a significant amount of these households lives on a disposable income

below the poverty line. More general social policies that either increase income or help with the payment of energy bills might therefore be sufficient to prevent energy poverty. Nonetheless, since 2008:2010 some vulnerable groups in this category have also lived in older dwellings which might not be very energy-efficient, while these households do not have the financial resources to renovate their dwelling. Therefore, policies could also aim at improving the energy-efficiency of rented dwellings in urban areas with a high percentage of income poor, without increasing the rent.

5.6.2 Pensioners in detached housing

The second vulnerable category of households includes pensioners, single persons over 60 years without children, households in Nordjylland, rented detached housing and the income group 150,000 DKK – 299,999 DKK. All these groups are on average older than 50 years and they generally have an income above the poverty line, as evidenced by the inclusion of the income group 150,000 DKK – 299,999 DKK. Indeed, pensioners only represent a small percentage of the income poor in Denmark (Frandsen and Engmann 2013). In 2014, a single pensioner receives around 160,000 DKK of annual total income (corresponding to approximately 115,000 DKK of disposable income), which includes the basic pension and an additional sum for lower income pensioners (the so called ældrecheck) (Ældre Sagen 2014). Their relatively larger financial resources are also demonstrated by the higher percentage of home-ownership among these groups. Nonetheless, the rental value of their dwellings is below the Danish average. It should also be kept in mind that there are large and growing income and capital inequalities among pensioners in Denmark (Schytz Juul and Baadsgaard 2010).

The equivalized energy expenditure of the households in this category is above the average Danish household. The first reason for the higher expenditure is that the households in this category live in bigger housing (larger equivalized size of their dwellings), which have higher energy needs. The second reason is the extended usage of solid and liquid fuels in these households. They spent more than 10% of their energy bill on solid and liquid fuels in 2010:2012, with households in Nordjylland spending almost 20%. The share of liquid fuel expenditure in particular is above the average Danish household.

Solid fuels and liquid fuels are mostly utilized in detached housing, both rented and owner-occupied, as detached houses comprise more than 80% of the housing stock with oil-based central heating and almost 95% of the houses with central heating without oil or gas (Danmarks Statistik 2014f). Because the consumer price index of liquid fuels is rising considerably since 2010, this dependency on liquid fuels could make it difficult to afford adequate energy services. With an old oil-fired boiler it costs around 20,000 DKK to heat a 100m^2 detached house with a heating oil consumption of 1,800 liter (Bolius 2013). This would be around 17% of the disposable income of a single pensioner. However, the vulnerable groups in this category seem to generally live in newer housing, so that their dwellings are not necessarily poorly insulated or energy inefficient, but this might be because part of the pensioners live in newly established senior living communities. Indeed, Danish houses that use liquid fuels have been found to be generally older and poorly insulated (COWI 2011).

Combining the different groups in this category, it seems likely that especially vulnerable households will be found among single pensioners in Nordjylland that live in detached housing. Almost 100,000 people above 60 years old live in detached housing in Nordjylland (Danmarks Statistik 2014g). Furthermore, almost 85,000 people above 60 years old live in detached housing that was constructed before 1980, when requirements for energy consumption were implemented in the

building regulations. More than 20% of the detached housing in Nordjylland built before 1980 uses central heating with oil (Danmarks Statistik 2014f).

At the moment, there seems to be already policy in place to support this vulnerable category. First, the Danish government reimburses a large part of the heating costs of pensioners. This might be an important reason for the better scores of households over 65 years on the subjective and proxy indicators than households under 65 years. Second, there are some subsidies available to replace or improve liquid fuel fired heating, for example from DONG energy (DONG energy 2014). This funding remains necessary as more efficient alternatives, such as heat pumps, are not currently cost-effective for a majority of the houses that use liquid fuels (COWI 2011). Moreover, the households in this category might lack the financial resources to carry out energy renovations. Policy could therefore focus on supporting efficiency improvements for these households, in particular for single pensioner households in Nordjylland using liquid fuels. Such financial support might also be cheaper in the long term than reimbursing the expenses for inefficient oil-fired heating.

Chapter 6 Conclusion

Having sufficient energy is essential in order to meet basic Danish living standards. Energy poverty occurs when households are struggling to afford adequate energy services in the home, which is caused by an interaction between low incomes, high energy prices, low energy efficiency, high energy needs and a lack of financial, social and informational resources. Without an understanding of energy poverty, recent developments in Danish energy policy, such as the liberalization of the energy market and the green transition, might put vulnerable households at a disadvantage. However, there is currently little knowledge about the ability of Danish households to afford adequate energy services. This master thesis therefore aimed to assess the energy poverty situation in Denmark, based on the research question: *to what extent are Danish households struggling to afford adequate energy services in the home, and why?* Accordingly, the scope of the research was first, to quantify the energy poverty issue for Danish households, and second, to explain the situation by examining the drivers behind energy poverty (energy efficiency, energy prices, income, energy needs and available resources).

In order to evaluate the situation in Denmark, objective, subjective and proxy indicators for energy poverty were utilized. The objective indicator used was the share of energy expenditure in the disposable income of households and the subjective indicator was the response of households to the question if they are unable to afford to keep the home adequately warm. Two proxy indicators were used: the amount of disconnections of electricity supply and if households stated they had arrears on utility bills. Based on these indicators, two societal categories were determined to be vulnerable to energy poverty: single persons under 60 years on low incomes and pensioners in detached housing.

The first identified vulnerable category, single persons under 60 years on low incomes, is very likely to contain households that are struggling to afford adequate energy services in the home, because this group scores the worst on all objective, subjective and proxy indicators. This category contains students, unemployed and not economically active, as well as single parents. The majority of these households likely lives in urban areas, with district heating presenting a large part of the energy bill. The main driver behind energy poverty for this category is low income, with a significant amount of households living on a disposable income below the income poverty line. In addition, since 2008:2010 some vulnerable groups in this category have also lived in older dwellings that might not be very energy-efficient. As most of these groups rent their housing, they likely do not have the financial resources to renovate their ageing dwellings. Students might be less vulnerable to energy poverty because they live in rented rooms and have better informational resources.

The second identified vulnerable category, persons over 60 years in detached housing, is less likely to contain households that are struggling to afford adequate energy services in the home, because this group scores bad on the objective indicator, but good on subjective and proxy indicators. The main driver behind their bad score on the objective indicator is an equivalized energy expenditure above the average Danish household. This is due to the fact that they live in relatively large housing which has higher energy needs and due to the extended usage of solid and liquid fuels in these households. With the consumer price index of liquid fuels rising considerably since 2010, this dependency on liquid fuels could present issues for energy poverty. Especially vulnerable households in this category might be found among single pensioners in Nordjylland that live in detached housing. However, the relatively high energy expenditure has not lead to bad scores on the subjective and

proxy indicators, which is probably because the Danish government currently reimburses a large part of the heating costs for pensioners.

Due to certain limitations of the datasets used, these conclusions only provide an indication of the energy poverty situation in Denmark. Since only averages were available for the objective indicator, certain households in the vulnerable categories might be struggling to afford adequate energy service even more than the statistics reveal, while other vulnerable households could have no issues whatsoever. Conversely, certain households in non-vulnerable groups might be struggling to afford adequate energy services. Averages used for other parameters, such as the year of construction of dwellings and disposable incomes, also likely hide large differences within the groups. Moreover, the results are limited by the fact that the datasets were only disaggregated for certain types of societal differentiations. Furthermore, the utilized datasets contained some anomalies that are likely due to statistical problems. Finally, certain drivers, such as the informational resources of households, could not be evaluated or, in the case of energy-efficiency, not be evaluated accurately. Nonetheless, this thesis presents a good starting point for future research that could use more elaborate and detailed data.

In addition, it was established in the theoretical approach of this thesis that energy policy, social policy and housing policy could have a significant influence on energy poverty. In particular, it was suggested that the green transition and the liberalization of the energy market could have a profound impact on vulnerable households, but it was outside the scope of this thesis to investigate this further. Future research could therefore also focus on how Danish policy affects the energy poverty situation and which type of programs would be most beneficial to vulnerable households.

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