Chapter 3
German Retrofit Policy in Context

Abstract EU member states are committed to the Energy Performance of Buildings Directive (EPBD) and the Energy Efficiency Directive (EED), including a 20% energy efficiency target by 2020. Most European countries have adopted market-led policies to meet these targets, relying on voluntary take-up by homeowners. Some impose taxes on energy inefficiency, but there is reluctance to do this due to issues of inspection, control, unpredictability, the vulnerability of low-income households, and political sensitivity. Most EU countries offer subsidies for thermal retrofits, though research suggests a weak relationship between subsidies and the diffusion of thermal efficiency technologies. Germany and Finland, for example, rely heavily on technical fixes and deep retrofits, though there are technical and economic difficulties with the depth of thermal improvement demanded. All European policies seem to lack tools to address the energy saving potential of behavioral change, although based on evidence to date occupant behavior can have important implications for the effectiveness of policy instruments.

Keywords Thermal retrofits · Sustainable building · European Union policy · Housing stock · Energy use behavior

3.1 Introduction

Chapter 2 outlined the development of the key elements of Germany's thermal retrofit policy. As Germany is one of the few countries with mandatory thermal requirements for the existing stock and demanding standards for new construction, it is often seen as a global leader in implementing energy efficiency in the building sector (e.g. Sunikka 2006; Pasquier and Saussay 2012; IEA 2008). This chapter sets the German retrofit policy in a wider context, focusing mostly on EU initiatives, and on EU member states with similar economies and climates to Germany (for a wider, global perspective see e.g. de T'Serclaes 2007).

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In Sect. 3.2, we consider the two key EU Directives that aim to influence national legislation and policy on thermal retrofitting. In Sect. 3.3, we discuss regulatory approaches to raising thermal standards, compared with market-led, positive, and negative financial incentives in Sect. 3.4. Section 3.5 focuses on the advantages and disadvantages of deep versus incremental retrofits. Section 3.6 discusses household behavior influences on heating energy consumption, including a case study in Cambridge, United Kingdom. Conclusions are drawn in Sect. 3.7.

3.2 European Directives

In March 2007, the EU member states agreed on a 20% energy efficiency target by 2020. This aims to improve energy efficiency by 20%, increase the share of energy from renewable sources to 20%, and reduce EU-wide CO_2 emissions by 20% compared to 1990 levels. This '20-20-20' target aims to integrate climate and energy policy, enhance energy security, and ensure European competitiveness and an increase in jobs. The 20% energy efficiency target is mainly addressed in the implementation of the Energy Efficiency Directive (EED), supported by the Energy Performance of Buildings Directive (EPBD).

3.2.1 Energy Efficiency Directive

The EU reached agreement of the Energy Efficiency Directive (EED) in June 2012. This sets four key requirements for member states to improve their energy efficiency, supporting the EU's 20% target, although in the final negotiation stage the legally binding target was set at 17%. First, energy supply companies (ESCOs) have to reduce their energy sales to industrial and household clients by 1.5% or more each year. This involves introducing clients to energy efficiency measures and encouraging their implementation. A similar type of policy has already been place in some countries. In Finland, since January 2010 a law imposes obligations upon energy companies to provide information to customers on their energy use and on suggested energy efficiency measures. The UK was the first country to introduce a 'Supplier Obligation' (SO) on ESCOs, to save energy at the customer end, in 1994. The policy has been cost-effective, for example in comparison to the German KfW program (see Chap. 2). According to Rosenow (2011), the KfW program and the SO have produced comparable energy savings, but while under the SO about 2 billion euros were spent by energy suppliers between 2002 and 2008, in the same period the KfW spent twice as much, at around 4.5 billion euros of public funds. The difference may partly be due to the higher energy-efficiency standards demanded in the German scheme, which increase the marginal cost of each kWh saved.

Second, the EED sets a target of a 3% annual retrofit rate for public buildings. However, during the lengthy negotiations on the EED's implementation this requirement was weakened, so that it only applies to public buildings that are central government-owned and occupied, for example excluding regional and state-owned properties in Germany. Although this means that only around 30% of Germany's public buildings need to comply, a number of states and municipalities already have their own programmes for thermally upgrading their buildings. Munich, Freiburg, and the city-state of Hamburg are leading examples.

Third, the EED requires each EU member state to draw up a roadmap to make the building sector more energy efficient by 2050, including strategic plans for commercial, public and private households. The roadmaps are intended to provide continuity and security for long-term investment. The commitment to these roadmaps is the responsibility of each national state, but as a positive measure the requirement emphasizes the building sector as one key stakeholder of the policy.

Fourth, the EED includes encouraging additional measures such as energy audits and energy management for large firms, and cost-benefit analysis for the deployment of combined heat and power generation (CHP).

The EED entered into force in November 2012. The member states had to present their national programs for its implementation, together with their national indicative targets, by April 2013. In countries like Germany, which is likely to implement the Directive correctly and in detail, it is likely to have direct impact on energy suppliers, while the national EED roadmap will provoke clarification of the contribution of the Energy Saving Regulations (EnEV), and other policy instruments, to the target of a 20% gain in energy efficiency by 2020.

3.2.2 Energy Performance of Buildings Directive

In early 2003, the European Parliament accepted Directive 2002/91/EC on the Energy Performance of Buildings (EC 2003). One of the four key elements described in the Directive was the introduction of energy certificates for the existing building stock. The directive required that, by January 2006, an Energy Performance Certificate (EPC), not more than 10 years old, must be shown to prospective purchasers or tenants when a new or existing building is sold or let, including recommendations for improvements in energy performance. The directive requires energy certificates to be issued for the existing buildings, but leaves it for each member state to decide whether certain minimum energy criteria should be met, and whether to combine the energy certificate with economic policy instruments (Beerepoot and Sunikka 2005). The UK Government, for example, has announced that it aims to set a requirement that from April 2018 it will be illegal for landlords to rent out homes or business premises with an energy efficiency rating less than 'E', as verified in the EPC. According to the UK Government, at least 682,000 properties are currently below this standard (House of Commons 2011).

The effectiveness of these EU initiatives in stimulating thermal retrofits has been criticized. Aware of these criticisms, the European Commission proposed a recast of the 2002 EPBD as part of its Second Strategic Energy Review in

November 2008. According to the Commission's own estimates, the recast of the EPBD is expected to bring EU energy consumption down by 5–6% and reduce CO_2 emissions by 5% by 2020, all contributing to the 20% energy efficiency target described above. Further, the 2002 EBPD required that building retrofits meet minimum national thermal standards if their floor area exceeds 1,000 m^2—which excludes most housing projects. One of the key changes introduced in 2008 was the elimination of the 1,000 m^2 threshold, implying that all existing buildings undergoing major retrofits would have to meet minimum thermal efficiency levels. It was also suggested that all member states should set target percentages for a minimum percentage of the existing buildings to become energy neutral in 2015 and 2020, and that smart meters to be installed in all new buildings and retrofits.

However, after long negotiations with all member states in 2009, it was decided that the recast of the EPBD would not set obligations or thermal standards for the existing buildings. This was due to the strong resistance from member states that judged the draft proposal as over ambitious and administratively burdensome, especially considering economic challenges and austerity programs. The Directive suggests instead that major retrofits must improve energy efficiency but only if doing so is technically, functionally, and—not surprisingly—economically feasible. For new construction, the consensus was easier to achieve. It was agreed that all new buildings would have to comply with tough energy-performance standards and supply a significant share of their energy requirements from renewables after 2020.

The difficulty in introducing more binding targets for the existing stock in the recast of the EPBD illustrates that there is still a question of the extent to which the EU should intervene in member states' legislation on housing and energy, which have hitherto been purely national policy areas. EU Directives would seem to be an effective catalyst for national action on building regulation, but while they may produce new administrative initiatives, legislation based on Directives will not necessarily be effective in reducing environmental load. The energy performance of the current housing stock varies among EU countries, as do climate and economic conditions, and the member states are at different stages regarding the energy performance of their housing stocks, making uniform requirements across member states difficult. It seems to be left open for each member state to decide whether to adopt mandatory policies (as in Germany) or leave it to the market and stimulate efficiency with fiscal incentives (as in the UK). This leads to a discussion of issues involved in regulating for energy efficiency in the existing stock, and why this may be unpopular in many countries.

3.3 Regulations Versus Market Led Approach

Direct regulation means policy instruments that seek to impose environmentally benign behavior by imposing legal standards. In EU countries, thermal regulations for new builds have been tightened in recent years to support energy-saving strategies, and revised to conform to EU requirements, such as the EPBD described above. Environmental legislation related to the building industry in EU countries tends to focus primarily on energy, indoor air quality, waste, and emissions of hazardous substances. Direct regulation of energy use in the existing buildings has been initiated relatively recently, and only in some EU member states. In 2002, England and Wales imposed minimum insulation levels for replacement of windows and doors, and efficiency standards for boilers, in the existing buildings, controlled by means of self- certification schemes. Germany first required thermal upgrade measures to be included in retrofits in the same year, but these were unique in that they also covered wall, roof, and ground floor insulation (as outlined in Chap. 2). Some countries like Finland are now in the process of introducing mandatory thermal regulations for those retrofits that require building permission, although exceptions can be made depending on the function of the building, its heritage status—and economic viability of thermal measures (YM 2013).

Direct regulation on the existing buildings can operate by means of standards for singular measures, such as minimum insulation levels for building components, or standards for general energy performance of a building, as now required by the EPBD. In most EU countries, minimum insulation levels in new builds were the first type of energy regulation, introduced in the 1970s. These were gradually transformed into integrative approaches, in which the overall energy demand or consumption of buildings was calculated (Beerepoot 2002). Whole building performance standards, as distinct from standards for individual components, can overcome some of the disadvantages of direct regulation as they enable planners to choose the most economically efficient combination of measures to meet the energy performance goal.

Regulations appear to be effective where there are market failures, such as insufficient demand for energy improvements, a constant shortage of affordable housing in high demand areas, and the split incentive dilemma where a landlord invests in energy upgrades and a tenant reaps the benefits. However, the disadvantages of direct regulation, especially regarding existing housing, include: high administrative costs (if the compliance with the regulations is actually inspected or enforced); possible tolerance of noncompliance by local governments as a result of this administrative burden; and economic implications of trying to force costly improvements on private households, especially when housing is considered to be a basic human right.

These issues might lie behind the German Government's choice not to inspect thermal retrofits or enforce the implementation of the EnEV in practice. The UK Government will face these ethical issues in its ambitious and straightforward-sounding plan to make renting EPC 'E' level property, with the existing occupants, illegal in 2018. Further, it is often considered that as a result of a regulatory approach, innovation will be limited as there are no incentives for performance that exceeds the regulations. Germany has addressed this issue with its KfW subsidy program, which applies only to projects that do exceed the regulations.

The question of control is very important, as homeowners do not usually require building permission to carry out retrofit activities in their own property, unless it is listed or in a heritage area. The issue of control for the existing buildings arises in Directive 2002/91/EC, which demands that EPCs are mandatory. However, the energy certificate only proposes energy efficiency improvements and does not require their implementation. Even so, in Denmark, for example, where energy certificates for buildings were first introduced in 1979 and later considered as a prototype for EPCs, only 50–60% of potential buildings had been registered in the scheme by 2005, despite EPCs being mandatory and not requiring any improvement actions (Beerepoot and Sunikka 2005). There were no inspections and no sanctions for noncompliance. A policy assessment saw the cost-effectiveness of labeling of buildings very poor, and no significant difference between houses with or without the energy label (Togeby et al. 2009).

German thermal retrofit policy stands out from that of other European countries by counting on regulation instead of a free market. This could be due to a different political culture, education, the influence of the Green Party (which was a governing coalition partner when the EnEV was devised), or a long established environmental policy. The first Environmental Programme in Germany dates back to 1971, and in 1994 the principle of sustainable development was laid down in the German Constitution in terms of 'bearing responsibility for future generations'. The National Climate Protection Programme (NCPP) identified the retrofit of existing buildings as a priority (BMU 2000).

Apart from new-build regulations, most EU countries have adopted voluntary and market-led policies for building energy efficiency, relying heavily on the environmental conscience of market parties. Policy in the Netherlands and Finland falls between the two extremes of Germany (regulatory) and the UK (market-led), using very few regulatory measures but involving strong leadership from the government. In the Netherlands the government can influence practice, for example through subsidy criteria in the social housing sector, or draw market parties into voluntary agreements. Predicting the impact of a market-led policy can be difficult, and so far there is little evidence of these approaches' success in achieving policy targets. Leaving the encouragement of thermal retrofits to market parties is also an easy option for the government with little political risk.

This leads to a discussion of fiscal policy instruments. These can be both positive (e.g. subsidies) and negative (e.g. taxes), and can be used both in a market-led and a regulatory approach to support thermal retrofits policies.

3.4 Economic Instruments

Financial incentives are an alternative to command-and-control policy instruments such as thermal regulations. Economic instruments in general aim to influence the economic attractiveness of environmentally benign behavior (both investment-related and operational) and, because the environment can be considered a public good for which insufficient market demand exists, they try to overcome market imperfections (Beerepoot and Sunikka 2005).

3.4.1 Negative Fiscal Instruments

Taxes are often assumed to be the least cost policy instrument to encourage energy efficiency and to provide continuous incentive to the industry's search for more cost-effective technologies (Hasegawa 2002; Siebert 1995). Higher taxes on energy may seem relatively effective in reducing a household's consumption and they also reduce the payback times of energy investments. Environmental taxes that aim to shift taxes away from labor and onto the environment have been implemented, to some extent, in several European countries (Andersen 1994; NOVEM 2002; Sunikka 2003). In Germany, the Ecological Tax Reform was introduced in 1999 to encourage energy saving and promote renewable energy sources, for which a portion of the revenue is used (IEA 2000). This supports the objective of German environmental policy to internalize the external costs of environmental protection: applying the polluter-pays principle would thus require energy-related costs to be fully integrated in home owners' and occupiers' expenses.

In 1996, the Federal Environment Agency in Germany studied energy-induced environmental damage related to habitation, and concluded that energy-related costs amounted to €7.7 billion per year, or roughly €2.5 per m^2 of the housing stock per year (Lintz 2000). However, with the current market price of CO_2 abatement at €7 per tonne, paying for one's CO_2 emissions would have added only 1.4% to the cost of one's heating energy bill, assuming CO_2 emissions of 0.0002 tonnes/kWh of heating energy consumed, and a current retail cost of heating energy of €0.10/kWh. The customer was therefore already paying €500 for every tonne of CO_2 emitted, so an extra €7 would have increased this by 1.4%.

Energy taxes are unpopular with the electorate in general and with industry in particular (Beerepoot and Sunikka 2005). Sinn (2008) maintains that Germany's environmental taxes do not cause any net reductions in GHG emissions but merely export these to less environmentally conscious countries. By reducing demand for fossil fuels in Germany, he argues, they reduce the marginal price on the global market, enabling other countries to buy more. To be environmentally effective, he suggests, negative financial instruments need to be imposed in all countries simultaneously, but in practice this is very difficult.

A further problem with using taxes as a policy instrument is that in order to create more sustainable practice and behavioral change, the price incentive needs to be relatively high. But the total environmental costs for industry and households, including both abatement costs and tax payments, are also likely to be high, and this may induce the government to set the tax at a level too low to be effective. The Regulator Energy Tax (REB), for example, was applied to Dutch households in 2001 (and abolished in 2004). Although this increased energy bills by a third, research shows that only half of the population was aware of it, and only 2% took it into account in their electricity use (Van der Waals 2001).

Further, the tax was partly used to subsidise Energy Performance Advice (EPA), introduced in 2000, which led to an increase in the number of energy-labeled houses. However, 75% of EPA assessments were on rented houses, typically owned by professional housing associations rather than private owners. A contradiction existed in that the approach aimed to perform assessments at 'natural moments', such as when a dwelling was being renovated or a central-heating boiler being replaced (Jeeninga et al. 2001). Hence, the EPA subsidy was often used for investments that would have been made anyway. The average cost of the EPA program was 300 euros per tonne of CO_2 reduction, over 20 times the commercial rate. The administrative costs were high, but applications led to relatively small energy savings, with almost three-quarters of customers indicating that the EPA advice had not changed their planned investments in the energy performance of their home (Harmelink et al. 2005).

The question remains as to how taxation on energy can be increased without penalising low-income households, often in energy inefficient housing, with higher energy prices. Despite assistance from government programs such as the Affordable Warmth Obligation in the UK, these households have fewer financial resources to invest in energy-saving measures. It has been argued, therefore, that imposing energy taxes on households causes greater inequality between rich and poor (Anker-Nilssen 2003), so heavy taxation of end-user energy may be neither an advisable nor politically viable option.

3.4.2 Positive Fiscal Instruments

A number of European countries have introduced financial incentives, of various kinds, for improving energy efficiency in buildings (de T'Serclaes 2007; IEA 2008; NOVEM 2002; Sunikka 2003). In most cases, the use of subsidies as a policy instrument aims to create market transformation for energy efficient improvements (see Gillich and Sunikka-Blank 2013).

The French Government's 2007 environmental and energy sustainability initiative, *Grenelle de l'environnement,* spawned a policy for improving the energy efficiency of buildings, the *Plan Bâtiment.* This is a consensus commitment of government and industry to reduce the energy consumption of buildings by 38% by 2020. It includes demonstration projects, and offers an interest-free loan of up to €30,000 for energy upgrades on existing homes, the *Éco-prêt à taux zéro.* Loans have to be repaid within 10 years (principle only) and cover thermal upgrade measures such as insulation, new windows, heat pumps and heat recovery ventilation systems, plus labor, and on-site supervision (Ecocitoyens 2012). Further, under the 2009 Finance Law interest-free loans are offered for the purchase of new or existing homes, with the size of the loan increased if the thermal quality of the home exceeds current building code requirements. Also, tax credits for interest paid on home loans have been modified to incentivise high thermal standards (Pasquier and Saussay 2012).

In 2012, as promised by incoming President Hollande, the French Government announced its aim to encourage an annual retrofit of one million homes. The costs of these retrofit projects will partly be financed by income from the auctioning of CO_2 allowances under the Emissions Trading System (ETS). Further, the French Government wants to introduce progressive energy tariffs aimed at reducing utility bills for energy efficient households, and extend lower social rates for natural gas and electricity for four million low-income households. The costs of a more complex tariff system would need to be met by energy providers.

A strategy for making positive fiscal instruments more effective, and their effects more measurable, is to connect them to the energy reduction targets of voluntary agreements. This policy has been adopted for example in relation to the social housing sector in the Netherlands (see Sunikka and Boon 2004). In Finland's National Climate Strategy and its associated Energy Conservation Programme, voluntary energy conservation agreements play a central role in the implementation of energy policy. Energy conservation agreements are framework agreements made between the Ministry of Trade and Industry (KTM) and various sector organizations, including the real estate sector, though excluding private households. The agreements are voluntary but financially supported and monitored by the government. Participating companies receive 40% financial support for energy audit costs, 15–20% for energy improvement investments and for expenses in setting up an environmental management system under international standard ISO 14001, and up to 40% for new technology investments.

Between 1996 and 2003 the government invested 16.1 million euros in the agreements. Heikkilä et al. (2005) estimate a return of five euros for each euro of public investment. In the real-estate sector, the target was to reduce heating energy consumption by 10% by 2005 compared to 1990 levels and 15% by 2010 but this proved to be over ambitious. Between 2000 and 2004, heating energy consumption per square metre of floor area (kWh/m^2) was reduced by 3.4% compared to 2000 levels, and the heat index (kWh/m^3) by 7% (Hekkilä et al. 2005). Average electricity consumption had stabilized in 2004 to the 2000 level, and the aim was to turn the trend to decline in 2005.

Nevertheless, financial support in the estate sector was mostly given for energy audits, whereas the implementation of the improvements suggested by the audits has been very slow. Again this reflects the problem of moving from energy certificates to actually implementing the recommended measures. Another problem is labor intensity: the real-estate sector required the largest rate of investment to energy efficiency gain: the expenses of the scheme compared to the energy saved were estimated to be around €37.60 per MWh/a.

A difficulty with subsidized voluntary incentive programs is that they can lead to the 'free rider effect', where recipients receive funding for upgrades they would have done anyway. For example, in 1978 the Dutch Government established a large investment subsidy program, the National Insulation Programme (NIP), for improving energy efficiency in the existing housing stock. Kemp (1995) showed that there was only a weak positive relationship between the subsidy for thermal home improvement and the diffusion of thermal insulation technologies. The program mainly provided receivers with a 'windfall gain', helping them in the direction they were already planning to take (Beumer et al. 1993). This effect has been found with other environmental subsidies (Tweede Kamer der Staten Generaal 1987; Vermeulen 1992).

Germany's Federal subsidy system is also based on voluntary thermal improvements, but only for those that go beyond the legal requirements (see Chap. 2). This has the effect that only the least economically efficient aspects of thermal upgrades are being subsidized. The marginal cost of upgrading a building to a standard 20% better than the minimum thermal standard can be in the order of €0.20/kWh of energy saved over the technical lifetime of the retrofit measures, equivalent to €825 per tonne of CO_2 saved (Beecken and Schulze 2011).

An essential question related to both regulatory and market-led retrofit policy approach is: what kind of thermal retrofit measures should be demanded and/or subsidized? The following section explores this issue.

3.5 Deep Versus Incremental Retrofits

A question frequently asked regarding thermal retrofits is should we go deeper, or should we go broader? Deep retrofits are technically demanding and expensive, not only in absolute terms but also in euros spent per kWh of energy saved. Shallower or incremental retrofits are less difficult technically, cheaper to implement, save more energy per euro invested, and can be rolled out quickly to a larger constituency. Despite the common European Directives (Sect. 3.2), retrofit strategies can differ between European countries not only in their implementation strategy (see Sects. 3.3 and 3.4) but also by the choice and depth of technical measures that are encouraged.

Germany's thermal retrofit policy can be described as a deep retrofit approach. The commitment to deep cuts in household heating energy is reinforced by the policy target of 80% GHG emission reduction by 2050, which has been directly translated into the building sector (see Chap. 2). The limitations of this approach are beginning to be recognized. Increasing criticism from homeowners and the building industry is evidenced in recent television reports and a spate of press articles. Academic criticism has come from recent peer-reviewed articles in Germany's highly technical building physics periodical, *Bauphysik* (Beecken and Schulze 2011; Greller et al. 2010; Schröder et al. 2010, 2011). Meanwhile a government-commissioned report authored by some of Germany's leading building physicists concluded that a further tightening of thermal standards would violate the economic viability criterion (Hauser et al. 2012). Despite Germany's ambitious CO_2-reduction goals and high confidence in its technical ability, the German Government has now recognized that its thermal policies for both new builds and retrofits were going too far too fast. The plan to tighten new build thermal standards by a further 30% in 2012 has been replaced by a 12.5% tightening now scheduled for 2014 and possibly a further 12.5% in 2016. The plan to tighten thermal retrofit standards by 30% in 2012 has been shelved, with no timetable for future updates. Ironically, Germany is again proving to be a world leader: while others such as the UK remain committed to making all new homes 'nearly zero energy' by 2016, Germany has effectively stepped back from this goal.

The main reason for this slowdown is that the depth of thermal quality required by the EnEV is proving too difficult to achieve economically for new builds, and too difficult both technically and economically for retrofits. This makes new homes unaffordable and dissuades homeowners from retrofitting, thus reducing national fuel savings. Meanwhile, many homeowners simply ignore the regulations and retrofit to whatever standard suits them (Galvin 2012). It also pushes the cost of saving CO_2, through retrofits, to hundreds of euros per tonne, compared with €10–€30 per tonne for energy-efficiency upgrades in other sectors (Sinn 2008).

In Finland, a similar strategy of deep retrofits and high insulation levels has been encouraged, and the retrofit of state-subsidized housing aims to bring dwellings up to new build standards. Aside from difficulties of economic viability (cf. Chap. 4), research indicates that complaints of mould and poor indoor air quality can be associated with increased insulation and insufficient ventilation. This is partly due to the speed of tightening of the thermal regulations, without considering whether the building industry has been able to adapt its standard construction solutions to changes in building physics that occur as a result of excessive extra insulation (Vinha 2011).

Similar complaints, though to a lesser extent, are heard in Germany, where natural ventilation accounts for nearly 100% of the residential stock. In Finland, France and the Netherlands the share is approximately 30, 40 and 60%, respectively (Meijer et al. 2009).

In France, by contrast, the trend has been toward small retrofits and improvements requested by tenants, supported by the holistic High Environmental Quality (*Haute Qualité Environnementale*) concept (Sunikka 2001). In the Netherlands, the focus of sustainable retrofits has been more on seeing energy efficiency improvements in the context of comprehensive urban renewal projects, including social sustainability targets, although this has recently changed (see e.g. Sunikka and Boon 2004). A number of local schemes in the UK also focus on small incremental upgrades, such as free loft insulation and filling cavity walls.

In theory, we can only reach a national 80% reduction goal by deeply retrofitting every home by an average of 80% savings. While some therefore argue that deep retrofits are the only way forward, others point out that in countries where only deep retrofits are permitted, the rate of retrofits is very low and the actual savings achieved per retrofit are far less than 80% (cf. Tuominen et al. 2012).

But if technical retrofit measures can only partly improve the energy efficiency of the existing housing stock, a further option to consider is behavioral change. Some key elements of this issue are introduced in the next section.

3.6 Technical Measures Versus Behaviour

Occupant behavior and household characteristics are important contributors to domestic energy consumption (Faber and Schroten 2012; Guerra-Santin 2010). Heating energy savings achieved through retrofit measures can be remarkably lower than calculated (Haas and Biermayr 2000), often less than 50% of the expected savings (Simons 2012). Yet current policies in European countries, including Germany, have yet to harness the potential of user behavior to energy savings.

Insights into the effects of behavior on energy use were illustrated in a recent UK study. Sunikka-Blank et al. (2012) describe a thermal retrofit in a Council housing estate in Trumpington, Cambridge. Prior to the retrofit the home was monitored using data loggers and comfort surveys. Temperature measurements were taken in all rooms, at 10-min intervals for 24 h during a 7-day period in March, when the outdoor temperature averaged approximately 2.5 °C. The occupants were an unemployed couple and their three sons. They were using pre-pay meters for their energy costs, as their economic situation disqualified them from contract schemes. This made their heating energy more expensive than for most householders.

Although the couple spent most of the time at home, they said they turned the heating on in winter for only 5.5 h a day at 20 °C. The recordings showed large indoor temperature variations, tracking 10–15 °C above the outdoor temperature, with evening peaks of 25 °C in bedrooms and early morning troughs of 16 °C in the hallway and kitchen. Questionnaires, completed by the occupants three times a day, showed that the children had less tolerance of temperature change, had the highest mean comfort temperature, and wore less clothing than the parents at home.

In order to better understand the characteristics of the case study household compared to other households in the area, a behavioral survey was conducted in 13 identical Council owned properties. Over 39 individuals in 13 households responded to the questionnaire on heating, the use of appliances, occupancy time, level of clothing and heating habits. Households' reported thermostat settings ranged from 16 to 25 °C, the case study being toward the higher end of this scale. The number of heating hours also showed a wide range, from 5 to 24 h per day. Further, the household with the highest energy demand in the survey heated their house more than three times longer than the family with the lowest energy demand.

While it is not possible to generalize behavioral patterns from such a small sample, the findings concur with those of other recent studies. In a study in Denmark, Gram-Hanssen (2010) found households using three or more times as much energy for heating as their neighbors living in identical homes. In studies in the Netherlands, Guerra Santin (2010) found that the quality of building construction plays only a limited role in determining actual energy performance in domestic buildings. As we show in Chap. 5, it is not unusual to find differences of 600% in energy consumption in homes with identical energy ratings.

The large range of differences in energy consumption habits in similar houses suggests two things. First, it is very hard to estimate standard energy consumption for even identical buildings, in simulations related to retrofit. Lifestyle changes have been found to be more effective in saving energy than increasing the thickness of thermal insulation (Shimoda et al. 2003). Information about the thermal properties of buildings can be a very poor predictor of actual consumption in homes. There is also the possibility that occupants may opt for higher indoor temperatures after a building's thermal properties are improved, resulting in significantly less energy saving than expected.

Second, retrofits should allow sufficient deviation in comfort temperatures, more than conventional comfort theory may indicate. People tend to be more tolerant in their comfort zones if they know they can control the temperature and ventilation, so retrofit strategies should offer adaptive opportunities and not be over-engineered.

In the Trumpington case study, despite being a fuel-poor household and pre-pay meter clients, who were paying more than average for their energy, the tenants' energy use was characterized by high indoor temperatures (reaching 25° during the heating season) and a significant number of entertainment appliances. Every member of the family had a TV set; children had their own mini-fridge. Despite economic constraints, there appeared to be an acceptance of energy wasting behavior. In the case study area, households topped up their meters with around £20 weekly during the heating season, regardless of shifts in energy prices. These actions do not reflect 'rational' economic behavior of seeking the lowest price for the most benefit. 12% of all the UK energy customers (mostly low-income or in debt) are on pre-pay meters and pay higher energy prices than if they were on a contract. Data from Brutscher (2010) indicate that such households like to make frequent and small top-ups regardless of the increased energy tariffs or income level, possibly due to liquidity constraints and loss aversion.

UK policy instruments such as Smart Meters are also based on the rational choice models that assume people make decisions based on rational processing of information. In practice, however, energy behavior does not seem to fit this model. In the Trumpington case study, for example, the occupants did not engage with the smart meter provided. Hargreaves et al. (2010), Shove (2003) and Gram-Hanssen (2010) are pioneering research on household energy behavior that seeks to explain people's choices in terms of routinized practices and habits, rather than rational, economically based decisions. Galvin (2013) applies this approach to a study of household ventilation practices in Aachen, Germany, again finding that indoor routines and habits dominate over economically 'rational' behavior. Uitdenbogerd et al. (2007) also suggest energy relevant household behavior seems to be of habitual character rather than based on economic rationality. This can limit the effectiveness of economic instruments (Sect. 3.4), and leads us to explore quite different approaches to changing energy use behavior.

3.7 Conclusions and Implications

The EU member states have agreed on a 20% energy efficiency target by 2020. The main policy instruments of the EU to stimulate thermal retrofits are the recast Energy Performance of Buildings Directive (EPBD) and the Energy Efficiency Directive (EED), although both Directives were weakened in the negotiation stages. As a part of the EED, each member state is required to draw up a roadmap to make the building sector more energy efficient by 2050. Nevertheless, Germany has halted its drive to continually tighten thermal retrofit regulations, and delayed and reduced its next step in tightening new build thermal standards. Our analysis (see Chap. 4) suggests it will fall far short of the 20% target, in the residential building sector, by 2020.

Most EU countries have to a large extent adopted voluntary and market-led policies for promoting thermal retrofits, relying heavily on the environmental conscience of market parties. Where fiscal incentives are used, taxes are often seen as the least cost policy instrument, but high energy taxes are unpopular with the electorate in general and with industry in particular, including in Germany, and it is difficult to impose a level high enough to bring desired results without penalising lower income households. Subsidies are used to promote thermal retrofits, for example the interest-free tax in France and KfW subsidies in Germany. Some research indicates a free-rider effect and a weak positive relationship between subsidies and the diffusion of thermal insulation technologies, but free loft insulation in the UK does seem to be reaching households that would otherwise not insulate their homes.

German belief in technical fixes and deep retrofits could be rooted in the ambitious policy target of an 80% reduction by 2050, and the fact that most post-war apartment housing has solid, plain, thermally inefficient walls that lend themselves to external wall insulation. Ironically, however, this sector is one of the slowest to undertake retrofitting. There is also a backlash against deep retrofit regulations in Germany among homeowners, the building industry and some academics and research institutes, for reasons ranging from excessive marginal costs and technical difficulties, to complaints of indoor mould and discomfort after retrofitting. Excessive insulation levels in countries like Finland have also brought complaints of mould and indoor quality risks.

EU countries appear to share a consensus on the energy-focused concept of thermal retrofit and carbon emissions targets, usually by 60–80% by 2050, for example in the Netherlands, Germany, and the UK (MVROM 1999; BMU 2000; DTI 2003). The strongest driving forces to make vague aims more specific have been the Kyoto Protocol and the European Union Directives, which put pressure on governments to achieve measurable energy savings. Quantitative targets, however, are still set over a very long time frame and the measures required to achieve them are not necessary defined. Some policy targets seem to be overoptimistic, with policymakers tending to overestimate outcomes when under pressure to deliver overall targets (Wagner et al. 2005). There may need to be a rethink of how to reach goals of 60–80% reduction in home heating energy consumption by 2050.

An avenue yet to be systematically explored is the potential energy savings in household behaviour change. The EU Commission is now promoting this as a significant source of large, untapped energy savings (Faber and Schroten 2012). The case study of low-income households in Trumpington illustrates the large range of heating energy consumption patterns among apparently similar households in identical dwellings. As in many other studies, these consumers' energy choices do not seem to be based on classical models of economic rationality, a possible reason why policy instruments based on such models are failing to bring effective change. Research in this area is moving beyond rational choice theory to explore how habitual and routinized behavior locks consumers into high consumption patterns. If energy efficient, exemplar household routines can be identified, they may then be able to be taught to or copied by others.

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