Energy efficiency in the residential sector: identification of promising policy instruments and private initiatives among selected European countries

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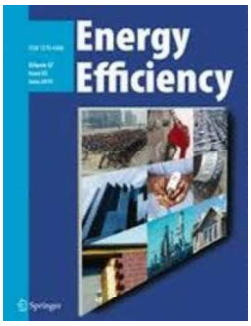
This is a pre-print of an article published in the *Energy Efficiency Journal.*



Please cite as follows:

Trotta, G., Spangenberg, J. & Lorek, S. (2018). Energy efficiency in the residential sector: identification of promising policy instruments and private initiatives among selected European countries. Energy Efficiency, 1-25. doi:10.1007/s12053-018-9739-0

The final authenticated version is available online at https://link.springer.com/article/10.1007/s12053-018-9739-0

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Abstract

Improving residential energy efficiency is widely recognized as one of the best strategies for reducing energy demand, combating climate change and increasing security of energy supply. However, progress has been slow to date due to a number of market and behavioural barriers that have not been adequately addressed by energy efficiency policies and programmes.

This study is based on updated findings of the European Futures for Energy Efficiency Project that responds to the EU Horizon 2020 Work Programme 2014-15 theme 'Secure, clean and efficient energy'. This article draws on five case studies from selected European countries - Finland, Italy, Hungary, Spain, and the UK - and evaluates recent energy efficiency developments in terms of indicators, private initiatives, and policy measures in the residential sector. Our analysis shows that the UK government has implemented a better range of policies, coupled with initiatives from the private sector, aimed at improving energy efficiency. However, its existing conditions appear to be more problematic than the other countries. On the other hand, the lack of effective and targeted policies in Finland resulted in increased energy consumption, while in Hungary, Spain and Italy some interesting initiatives, especially in terms of financial and fiscal incentives, have been found.

Keywords: energy efficiency policy; residential sector; European Union; NEEAPs; ESCOs

1. Introduction

Energy efficiency is widely considered as the most cost-effective way to enhance the security of energy supply and to reduce the emissions of greenhouse gases. In fact, the cheapest energy, the cleanest energy, the most secure energy is the energy that is not consumed at all (EC 2016a). Furthermore, energy efficiency improvements are thought to have the potential to support economic growth and social development, to improve occupant health and well-being, and to enhance competitiveness and investment opportunities (IEA 2014a).

In the last years, the European Commission has acknowledged these benefits in a series of directives and long-term strategy documents - such as the Energy Performance of Buildings Directive 2010/31/EU, the Energy Efficiency Directive 2012/27/EU, the Energy Roadmap 2050, etc. - by establishing a set of measures for improving the existing policy framework of measures and promoting energy efficiency within EU. In addition, the new 32.5% energy efficiency target for 2030 (with an upwards revision clause by 2023) agreed on 14 June 2018 by negotiators from the Commission, the European Parliament, and the Council[1] put the level of ambition of European energy efficiency policies into sharp focus. These regulations and policy documents have been mainly designed to meet the EU climate policy goals, i.e. an 80% reduction of CO_2 emissions by 2050, but they are still not in line with the commitments under the Paris climate treaty which would require even more efforts - so for the future stricter rather than relaxed regulations can be expected.

The residential sector is one of the most significant single sectors for energy consumption presenting high cost-efficient potentials for mitigation, and it is consequently vital to meeting the EU objectives towards a low-carbon economy and energy system. Nevertheless, recent years' experience has shown that there are considerable barriers to fully realise economically effective and technically feasible energy savings opportunities (Gillingham and Palmer 2014; Frederiks et al. 2015a; EC 2016b; Knoop and Lechtenböhmer 2017).

In compliance with the Energy End-Use Efficiency and Energy Services Directive 2006/32/EC (ESD) and Energy Efficiency Directive 2012/27/EU (EED), Member States are required to translate the energy savings objectives into domestic and effective measures in their National Energy Efficiency Action Plans (NEEAPs). But there exists a wide disparity in terms of content, level of detail in describing, and the level of ambition about the energy efficiency instruments in place and planned for the next years between Member States. At the same time, the energy share of residential sector strongly varies among countries due to different energy infrastructures, climate conditions, energy resource availability, income, economic structure (IEA 2014b),

[1] http://europa.eu/rapid/press-release_STATEMENT-18-3997_en.htm

dwellings' characteristics, household characteristics (Mills and Schleich 2012), lifestyles (Lorenzen 2012; Thøgersen 2017), household behaviour (Lopes et al. 2012; Frederiks et al. 2015a), and other country-specific conditions.

Therefore, the type of policy instrument suitable for driving energy efficiency depends on many country and sector specifics, and the circumstances determine which policy instruments are more appropriate than others.

Although policy makers have a decisive role to play in reducing energy consumption in the residential sector, there are many other players that can stimulate energy efficiency improvements:

- Energy utilities could provide advice and assistance to energy consumers, technology development, on-bill financing, etc.;
- Energy Service Companies (ESCOs), under an Energy Performance Contracting (EPC) arrangement, implement an energy efficiency project and use the stream of income from the cost savings to repay the costs of the project;
- National or local energy agencies promote training and information campaigns to help people to save energy and provide support to public administrations in the preparation, implementation and control of energy efficiency policies;
- National or regional banks, public or private, might develop specific packages for households to support energy efficiency improvements, renewable energy and broader green investments.
- Non-Governmental Organisations (NGOs) and consumer organisations promote energy efficiency through advice to and training of citizens, and by acting as political pressure groups.

A comprehensive review of all energy efficiency policies and private initiatives in the residential sector of the European Union is beyond the scope of this (and any other) paper, and given the diversity of local circumstances influencing the success of policy measures, the authors do not try to identify a "best practice", let alone search for silver bullets or no one-size-fits-all approach solutions. Nonetheless the authors assume that policy design matters, and try to identify some meta-level characteristics found by comparing promising recent residential energy efficiency policies and private initiatives in five case countries - Finland, Hungary, Italy, Spain and the United Kingdom.

Most of the literature focuses on the analysis of the energy efficiency policies by the type of instrument (regulatory, economic, informational, etc.) without considering (i) the underlying determinants driving the design of a specific policy and (ii) the coherence among policies creating synergies towards the achievement of

higher levels of energy efficiency. A recent review within the context of energy efficiency policies mix in buildings (Rosenow et al. 2016) supports this view. In addition, to the best of the authors' knowledge, the analysis of the role of the private sector in supporting the national government in stimulating energy efficiency investments in the residential sector has received little attention.

The remainder of the paper is organized as follows. Section 2 provides a brief literature review about energy efficiency policies and barriers; the identified barriers are used as basis for the subsequent analysis of policies. Section 3 describes the data and method used in this study; Section 4 illustrates data and information about the residential energy sector with indicators of energy efficiency; Section 5 analyses the main policy initiatives implemented in the European countries under investigation addressing the barrier identified in Section 2; Section 6 investigates the private initiatives that stimulate energy efficiency improvements; Section 7 offers some hints regarding the effectiveness of the policy packages implemented by presenting a cross-country comparison of energy efficiency progress; and Section 8 concludes by offering some explanations for obvious policy failures on the national level, and by deriving some meta-level success criteria for future European residential sector energy efficiency policy.

2. A brief literature overview

Despite the proven cost-effective energy efficiency opportunities for reducing energy consumption and related emissions in the residential sector, several studies consistently indicate that a large potential for the existing building stock remains untapped (see Gillingham and Palmer 2014 for an overview). In addition, improvements in energy efficiency do not regularly lead to one-to-one reductions in energy consumption (Galvin 2014), as energy efficiency gains alter the perceived cost of comfort and may thereby generate shifts in consumption patterns - a 'rebound effect' (Aydin et al. 2017). This discrepancy between the expected/realized energy savings and the optimal/actual investments in energy efficient technologies is often referred to as the 'energy efficiency gap' or 'energy efficiency paradox', which has been illustrated and examined in multiple articles (York et al. 1978; Stern 1992; Jaffe and Stavins 1994; Schleich and Gruber 2008; Chai and Yeo 2012; Allcott and Greenstone. 2012; Kallbekken et al. 2013; Ameli and Brandt 2015; Brown and Wang 2017; Gerarden et al. 2017). There is a substantial literature on the barriers to energy efficiency and on the importance of appropriate policy responses and actions in overcoming these impediments and stimulating investments (see Gillingham et al. 2009 for an overview). Low levels of investments in energy efficiency have long been associated with market failures, which are considered to be among the most important barriers to energy efficiency in the residential

sector, assuming 'rational' (i.e. utility maximising) behaviour. Commonly cited market failures include: (i) 'credit constraints' that prevent consumers from investing in energy efficiency solutions; (ii) 'imperfect information for consumers' about the energy savings from purchasing more energy efficient products, thus undermining incentives to invest in them; and (iii) 'landlord-tenant problem', that is when landlords have little incentive to invest in the energy efficiency of their properties, given that it is the tenant who benefits from lower energy bills (Allcott and Greenstone 2012). Thus, we analyse measures offering financial facilities to encourage private capital investments and fiscal incentives indirectly reducing the cost of investments, increasing consumer information, and measures addressing the landlord-tenant problem.

However, there can also be a state or policy failure in that plans, standards and regulations are either not ambitious enough or the enforcement is missing. To cover this aspect, we address the energy performance standards of new and existing buildings as a potential obstacle and their improvement as an efficiency opportunity.

More recently, several authors have supplemented the state and market failure approach with insights from behavioural economics and psychology. Behavioural barriers such as heuristic-decision making, status quo bias, loss and risk aversion, endowment effects, temporal and spatial discounting, and normative social influence, offer a more realistic view of the consumer decision-making process (Pollitt et al. 2011; Gillingham and Palmer 2014; Sallae 2014; Frederiks et al. 2015a). They are addressed by information promoting behavioural change, energy performance standards, and specific measures for vulnerable consumers and against fuel poverty.

3. Methodological approach

3.1 Data sources

This paper draws on research undertaken for the EU H2020 project EUFORIE (European Futures for Energy Efficiency), in particular on seven European country reports (Finland, Hungary, Italy, Latvia, Romania, Spain, and the United Kingdom)[2] covering a wide range of policies and private initiatives addressing energy efficiency in the residential sector (D5.1)[3] and their analysis (D5.2)[4]. Main EU laws, policies, and related documents (e.g., the Energy Efficiency Directive 2012/27/EU) were taken from public sources, mainly the EU law database[5]. The in-depth analysis of the third National Energy Efficiency Action Plans (NEEAPs) and other national policy

[2] http://www.utu.fi/en/units/euforie/Research/deliverables/country-reports/Pages/home.aspx
[3] http://www.utu.fi/en/units/euforie/Research/deliverables/Documents/Euforie-D5.1_revised-10012018.pdf
[4] http://www.utu.fi/en/units/euforie/Research/deliverables/Documents/EUFORIE-D5.2_revised-10012018.pdf
[5] http://eur-lex.europa.eu/homepage.html

documents is also based on D5.1 and supported by literature sources (Bertoldi and Economidou 2016; Economidou and Bertoldi 2018).

The country reports have been compiled with the help of national experts and are based on their country analyses. They had not only the language capabilities to analyse national language information material, but also the knowledge of where to find the appropriate information. Additionally, in some cases the collection of information has been supported by interviewing external stakeholder with expertise in the residential energy sector and energy efficiency.

An extensive use was made of the Odyssee database, which contains detailed data on energy consumption and related CO_2 emissions (Odyssee database 2017). Odyssee data on energy consumption are complemented with data on residential building stock taken from national statistics databases. This is because there exists a strong correlation between dwelling characteristics – age, tenure, type, size – and the energy consumption and thermal efficiency performance of buildings (Huebner et al. 2015; Trotta 2018a), in addition to household composition, income and behavioural traits (Danlami et al. 2015; Frederiks et al. 2015b; Trotta 2018b). To keep the sample size manageable, whilst ensuring a broad coverage of the European countries, in this study we focus our analysis on five countries: Finland, Hungary, Italy, Spain, and the UK.

3.2 Methodology

In order to provide a picture of the European Union and the countries under investigation, we first introduce a broadly accepted set of energy efficiency indicators used by the International Energy Agency (IEA 2014b; IEA 2014c). Then, we examine the residential energy efficiency policies in force by providing relevant information about the promising strategies adopted by the countries under investigation.

The promising strategies were selected from the country studies based on assessment if they addressed the key physical, social and behavioural obstacles to increasing domestic energy consumption known from the literature. As no detailed data about the effectiveness of certain instruments in specific contexts (legal, institutional, political majorities and traditions, or age, ownership and state of the building stock, etc.) are available, policy strategies intentionally addressing these objectives have been classified as “promising” (see EUFORIE Deliverable D5.2).

Since this paper is based on country data, we do not discuss *which obstacles should have been addressed by what means*, but describe *which obstacles have been addressed by which measures*. Moreover, we analyse the role of the private sector in stimulating the investments in energy efficiency and complementing European and

national public policies. In conclusion, we offer some hypotheses explaining obvious policy failures on the national level, indicating where there is room for improvement, and draw some conclusions – albeit on a meta-level – for EU residential energy policies.

4. The EU residential energy sector

The residential sector accounted for about a quarter of the total final energy consumption in Europe in 2015. This is only a EU average, and there exists a wide disparity of the share of the residential energy sector among countries due to climate condition, resource availability, energy infrastructure, economic structure and other country-specific conditions. For example, among the countries under investigation, in Spain the residential sector represented only 18.5% of the total energy consumption in 2015, while in Hungary and the UK it was 34.9% and 28.6%, respectively; in Finland it represented 20%, while in Italy it was 27.9% (Odyssee database 2017).

At EU level, the space heating consumption is assumed to hold the largest portion of households energy use representing 65% in 2015 (Odyssee database 2017), followed by the electricity consumption for electrical appliances and lighting (15.9%), water heating (13.7%) and cooking (5.4%). A similar composition of the energy consumption by end-use is found in Finland, Hungary, Italy, the UK, but not in Spain where the portion of space heating is lower and electricity consumption is higher than the other European countries.

For each end-use, we selected the indicators of energy efficiency suggested by the International Energy Agency (IEA 2014b; IEA 2014c), namely the final residential energy consumption per stock of permanently occupied dwellings (at normal climate)[6], the final residential space heating consumption per floor area 1990-2015 (at normal climate), and the final water heating, cooking, electrical appliances and lighting consumption per stock of permanently occupied dwellings.

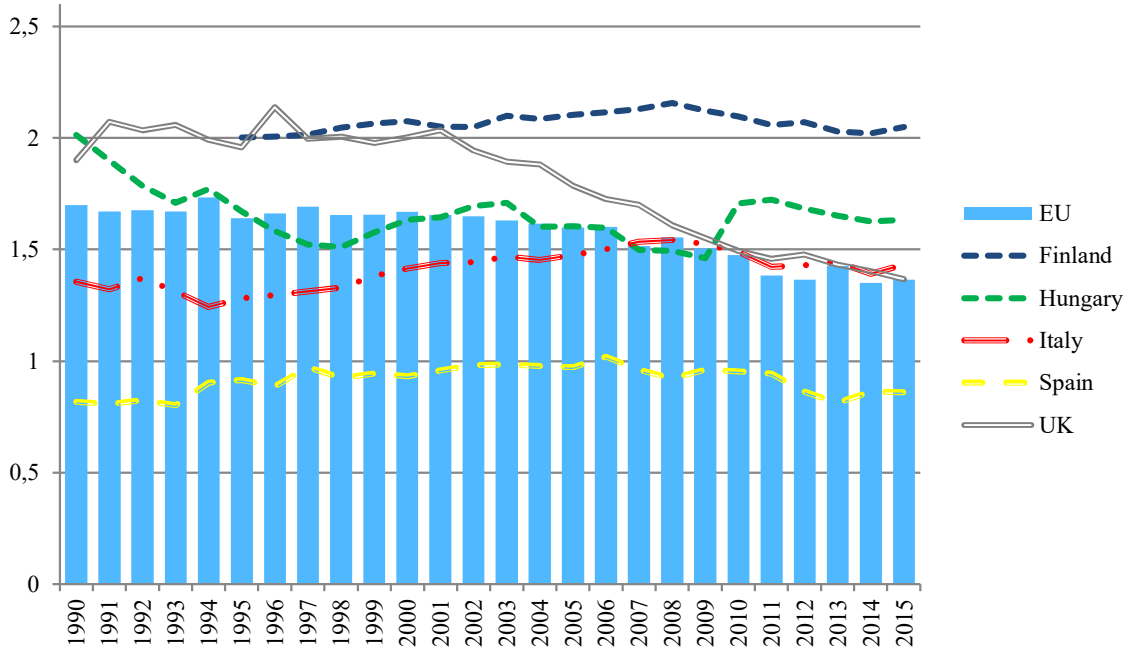
While these detailed indicators do not fully explain what is driving the changes in observed energy consumption, they provide indications about recent trends, and combined with implemented European and national policy and private instruments aimed at reducing energy consumption and CO_2 emissions, they can provide some guidance on the efficiency improvements achieved in the residential sector and allow for cross-country comparisons.

[6] 'Normal climate' or 'climate correction' is an adjustment to space heating and cooling energy consumption to normalise the consumption pattern over time by removing the impact of year-to-year temperature variations (IEA 2014b; IEA 2014c; Odyssee database 2017).

In order to compare the residential energy building performance of the European countries under investigation we use the final residential energy consumption per stock of permanently occupied dwellings 1990-2015 (at normal climate) as indicator (figure 1).

Finland had the highest residential energy consumption per stock of permanently occupied dwellings in 2015 followed by Hungary, Italy, the UK and Spain. Although Finland, Italy, and Spain did not decrease their consumption, in the European Union the final residential energy consumption per stock of permanently occupied dwellings decreased by 21.8% between 1990 and 2015.

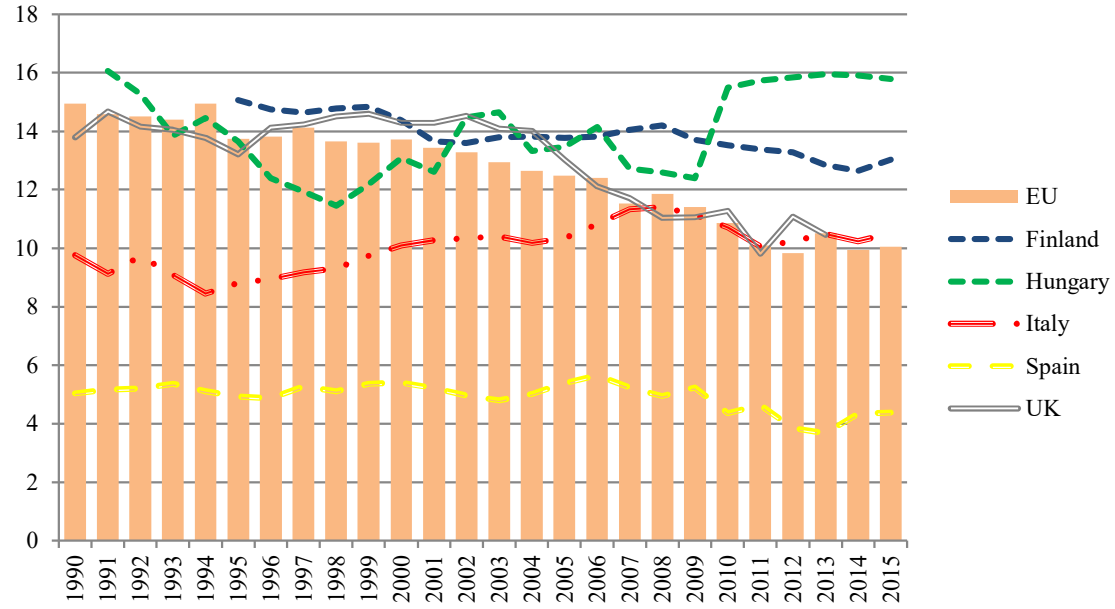
Figure 1. Final residential energy consumption per stock of dwelling permanently occupied 1990-2015 (at normal climate) for the European Union and selected countries (toe/dwellings)



To build more detailed indicators of energy efficiency it is necessary to disaggregate data further, and to understand which end-use has driven energy consumption in the last years. The energy end-use consumption data (e.g., space heating, lighting) are based on modelling or estimates (e.g. national surveys) as in large-scale assessment it is not possible to measure the distribution of residential energy consumption by end-use directly.

Figure 2 shows the final residential space heating consumption per floor area 1990-2015 (at normal climate) for the European Union and selected countries (Kgoe/m^2).

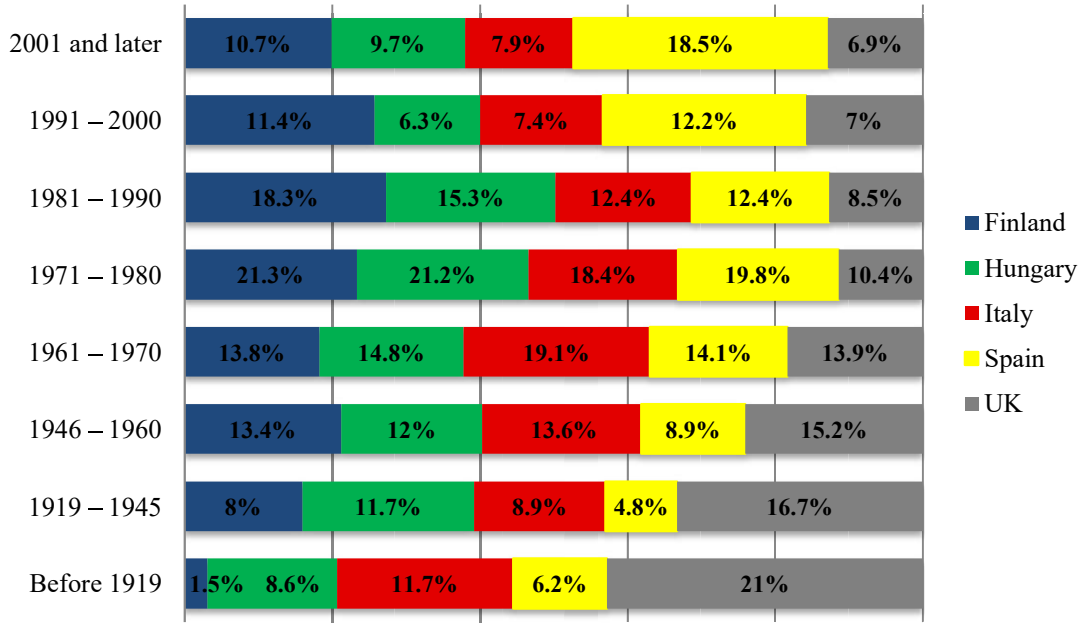
Figure 2. Final residential space heating consumption per floor area 1990-2015 (at normal climate) for the European Union and selected countries (Kgoe/m^2)



Space heating consumption per floor area decreased in all Member States (on average) between 1990 and 2015 (Odyssee database 2017). The lower space heating consumption per floor area could be explained by more stringent energy efficiency requirements for buildings, appliances and heating technologies, partly due to the progressive implementation of the Energy Performance of Buildings Directive in 2002 (2002/91/EC) and 2010 (2010/31/EU). With the exception of the United Kingdom where high potential for reducing space heating consumption exists, no or small improvements have been found in the other countries during the period under consideration.

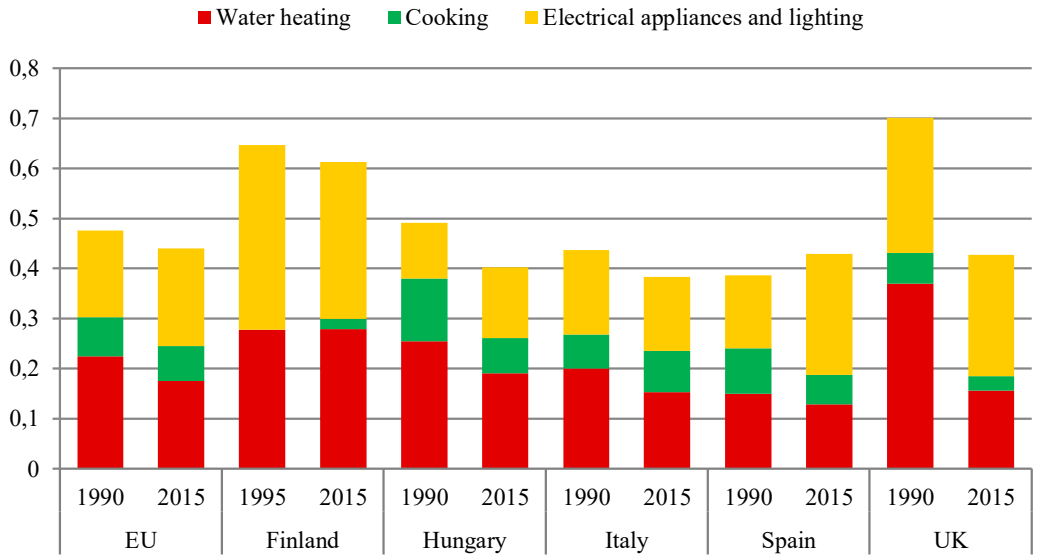
However, it is important to note that this indicator of energy efficiency for space heating do not provide any information about the infrastructural components of energy consumption, such as for instance the construction year of the dwellings. In fact, the age of a dwelling usually affects its energy efficiency, and older homes typically have poorer insulation than modern homes. For example, as shown in figure 3, in the UK approximately 70% of the existing residential dwelling stock was built before the first national Building regulations in 1965 that set up minimum standard for insulation entered in force. Before this time, solid walls, un-filled cavity walls, single glazing, un-insulated roofs and un-insulated floors were common construction features (Dowson et al. 2012). On the other hand, Spain has experienced a strong boom in construction in the last years: approximately 30% of the existing dwelling stock was built after 2000.

Figure 3. Percentage of the dwelling stock by period of construction in selected countries



With regard to the others residential end-use efficiency, on average the combined final energy consumption of water heating and cooking (per stock of permanently occupied dwellings) decreased in the European Union, Italy, Spain, the UK, and Hungary between 1990 and 2015 (figure 4), while the electricity consumption for household appliances (and lighting) increased in the European Union on average, in Hungary and Spain.

Figure 4. Final water heating, cooking, electrical appliances and lighting consumption per stock of dwelling permanently occupied in 1990 and 2015 for the European Union and selected countries (toe/dwellings)



5. Policies and measures to remove energy efficiency barriers in the residential sector

In the next paragraphs, we analyse the energy efficiency policies that have been recently implemented in the residential sector of Finland, Hungary, Italy, Spain, and the UK, with reference to the barrier and/or specific target addressed, as follows:

- Improving the energy performance standards of buildings and energy-related products;
- Financial facilities to encourage private capital investments;
- Fiscal incentives that indirectly reduce the cost of investments;
- Measures addressing vulnerable consumers and fuel poverty;
- Measures addressing the landlord-tenant problem;
- Increasing consumer information and promoting behavioural change.

The chapter shows that whereas there are quite a number of informational efforts (5.6) and incentives for energy efficiency (5.2, 5.3), hardly any country has thoroughly analysed the obstacles and none had comprehensive policies to overcome them. To the contrary: often other public policies are directly counterproductive to residential housing efficiency improvements (e.g. policies to keep energy prices as low as possible to stimulate economic growth). While standard setting dominates (5.1), social aspects play a minor role (5.4). This chapter addresses the policy initiatives as identified in the country studies directed at the obstacles identified in the literature analysis, but does not discuss the missing policies that should be in place to eliminate these hindrances. An overview of the policies discussed in the next sections is provided in table 1.

Table 1. Overview of the energy efficiency policies in the residential sector

	Finland	Hungary	Italy	Spain	UK
Improving the energy performance standards of buildings and energy-related products	• EPBD • ErP	• EPBD • ErP	• EPBD • ErP	• EPBD • ErP	• EPBD • ErP
Financial facilities to encourage private capital investments		• The Warmth of the Home Programme	• Thermal Account • Thermal Account 2.0	• State Housing Plan • PAREER-CRECE Programme	
Fiscal incentives that indirectly reduce the cost of investments	• A general tax reduction for any household services		• Tax deductions for the energy upgrading of buildings		
Measures addressing vulnerable consumers and fuel poverty			• (Social bonus)	• (Social bonus)	• Energy Company Obligation • Warm Home Discount
Measures addressing the landlord-tenant problem			• Regional Law 13/12/2013		• Landlord's Energy Saving Allowance • Green Deal • New Minimum energy efficiency standards
Increasing consumer information and promoting behavioural change	• Completed roll out of smart meters • Motiva	• Energy and Climate Awareness-Raising Action Plan • No smart meters • Energy Saving Trust	• Completed roll out of smart meters • Italian National Agency for New Technologies, Energy and Sustainable Economic Development	• Roll out of Smart meters by 2018 • Institute for the Diversification and Saving of Energy	• Roll out of Smart meters by 2020 • National Environmental Protection and Energy Center Nonprofit

5.1 Improving the energy performance standards of buildings and energy-related products

Standards for buildings and energy-related products ensure that the desirable energy performance of e.g. building components and (especially) heating equipment is achieved even when its purchaser does not show interest in obtaining more efficient products due to either credit constraints or lack of incentives (IEA 2011).

Reviews of the literature on energy efficiency policy shows that instruments such as energy efficiency standards have been one of the main drivers of innovation (Noailly 2012), and the preferred policy option in the European Union to address barriers to energy efficiency (Bleischwitz et al. 2009). Broin et al. (2015) by using a panel of 14 EU countries to estimate the impact of efficiency policies affecting space heating demand in the residential sector, have found that regulatory policies had a greater success than financial or informative instruments in the period 1990-2010. These findings are in line with results from previous studies of Saussay et al. (2012) and Filippini et al. (2014).

The Ecodesign Directive 2009/125/EC for Energy Related Products (ErP) and the 2010 recast Directive on Energy Performance of Buildings (recast EPBD, 2010/31/EU) are the main legislative instruments affecting energy use and efficiency of energy-related products and buildings in the EU, respectively. Both looked at energy efficiency beyond the immediate point of consumption, and entered into the design and lifelong energy use of household appliances, equipment, and new buildings. As integral part of the EPBD, the Energy Performance Certificates (EPCs) are an important tool to enhance the energy performance of buildings. They include a report that assesses the energy efficiency of a property and recommendations for cost-effective improvements. These certificates enable consumers to obtain information about the energy consumption of the dwelling they are going to buy or rent and are mandatory in EU countries each time there is a change of occupant or a sale. While new buildings can be constructed to be very efficient, the existing stock is predominantly of poor energy performance, having mostly been built before legal requirements concerning the use of energy were introduced and when there were very different expectations of thermal comfort. Furthermore, building components and technical systems are subject to deterioration over time, resulting in increased energy use to provide the same level of energy service.

By law, EPCs can only be produced by an accredited Energy Assessor. The accreditation schemes protect builders, owners, landlords and tenants by making sure Energy Assessors have the appropriate skills to carry out energy assessments, and that EPCs are always of the same high quality. Nevertheless, the EPC schemes are not yet fully implemented in all Member States nor sufficiently enforced. Therefore, the EPCs' quality, credibility

and usefulness vary largely among Member States, and there is still a need to further support and set guidelines for the implementation of the EPC schemes at national level (Arcipowska et al. 2014). Today, performance certificates may be understood in different ways from one European country to the next, and definitions and certificate types can vary widely even within countries.

In a recent study commissioned by the DG Energy, the ICF Consulting Group analysed the national frameworks and systems put in place by Member States to help deliver and achieve compliance with the Energy Performance of Buildings Directive (EPBD) in relation to the EPCs and the minimum energy performance (MEP) requirements for buildings, building elements, and technical building systems (EC 2015). Among the countries under investigation, Italy received a higher score in terms of compliance rate with the application of MEP requirements and production and use of EPCs placing fifth in the EU Member States' ranking, followed by the UK (seventh position), Finland (tenth position), Spain (thirteenth position), and Hungary (fifteenth position). Most of the Member States reported a high compliance rate for MEP requirements. Spain and Hungary failed to comply with the production of EPCs in rented buildings, while Italy has not produced EPCs for public buildings.

5.2 Financial facilities to encourage private capital investments

Financial incentives can take many forms - grants, subsidies, soft loan, etc. - and are commonly used to encourage energy efficiency improvements by lowering inhibitive up-front costs faced by households.

In Hungary, the main financial instrument managed by the central government to promote investments aimed at furthering energy efficiency in households is a grant scheme called the 'Warmth of the Home Programme'. The Warmth of the Home Programme was launched in September 2014 and till date there have been five sub-programmes implemented focusing on the following aspects: 1. the modernisation of heating systems (replacement of inefficient heating boilers – HUF 1.2 billion (c.a. € 3.85 million); 2. support to the complex energetic refurbishment of blocks of flats 2015 - HUF 11.8 billion (c.a. € 37.9 million); 3. the replacement of energetically obsolete facade doors and windows 2014 - HUF 876 million (c.a. € 2.8 million); 4. the replacement of inefficient refrigerators and freezers with new efficient ones 2014 - HUF 780 million (c.a. € 2.5 million) - and 2016 - HUF 1.5 billion (c.a. € 4.8 million); 5. the replacement of inefficient washing machines with new efficient ones HUF 1.2 billion (c.a. € 3.85 million). All of them provided co-financing up to a maximum of 40% or 50% of the total expenses incurred by the households (Hungary's NEEAP 2014; UNFCCC 2016).

Due to overwhelming interest on the part of households, the sub-programme funds have been sourced out fully after announcement, either within hours, or after a few days the latest (Slezák et al. 2015). Over 85,000 households benefitted from these programmes, but the allocated government budget (HUF 17.3 billion, c.a. € 55.7 million) did not satisfy all the requests from households. To meet the high demand, the Hungarian government has recently announced that from the spring of 2018 the Warmth of the Home Programme will be refinanced. Households can receive a reimbursement of up to 40% or 90% of the total expenses incurred, and in some cases (e.g., vulnerable households) they can claim a reimbursement of up to 100%.

The Thermal Account, introduced by the Ministerial Decree of 28 December 2012 'Renewable Energy for Heating & Cooling Supporting Scheme' (Legislative Decree No 28/2011), is the first nationwide and the youngest direct incentive scheme in Italy for projects of energy efficiency improvements and the generation of small-scale renewable thermal energy in buildings. The Thermal Account supports the following projects:

- Energy efficiency improvements in existing building envelopes (thermal insulation of walls, roofs and floors, replacement of doors, windows and shutters, installation of solar screens);
- Replacement of existing systems for winter heating with more efficient ones (condensing boilers);
- Replacement and, in some cases, construction of new renewable-energy systems (heat pumps, biomass boilers, heaters and fireplaces, solar thermal systems, including those based on the solar cooling technology).

The scheme is addressed to both public administrations and private parties (i.e. individuals, apartment block owners, and parties with business or agricultural income). The incentive covers part of the costs incurred and is paid out in annual instalments for a period from 2 to 5 years according to the actions implemented. Since its implementation in July 2013 until December 2015, eligible private beneficiaries submitted around 17,407 applications, among which approximately 8,000 in 2015 (GSE 2015; GSE 2016). Approximately 0.54 Mtoe/y savings by 2020 are expected to come from the implementation of the Thermal Account in the residential sector (Italy's NEEAP 2014).

With the Ministerial Decree of 16 February 2016, the new Thermal Account 2.0 entered into force the 31st of May 2016. It provides incentives for € 900 million per year, of which 700 for private sector and 200 for public entities, over the next five years. The new Thermal Account 2.0 introduced simplified access mechanisms, included the housing cooperatives in the list of private eligible beneficiaries, introduced new types of improvements subject to the incentives, and increased the reimbursement limits of the projects (65% of the total

expense incurred). In addition, it states that private entities should receive reimbursement of up to € 5,000 (instead of € 600) in one single instalment within two months from the request submission.

In Spain, the Royal Decree 233/2013 of 5 April 2013 of the Ministry of Development approved the State Housing Plan aimed at promoting the energy renovation of residential buildings. The main functions of the State Plan 2013-2016 were underlined in its preamble: "to adapt the aid system to the current social needs and to the scarcity of resources available, concentrating them on two issues: the promotion of tenancy and the promotion of rehabilitation and urban regeneration and renewal." The plan was funded by the Directorate General of Architecture, Housing and Land (€ 2.311 million) and the Autonomous Regions (€ 216 million). Measures eligible for subsidy include: improving the thermal envelope of buildings to reduce energy demand for heating and cooling; installing heating, cooling, domestic hot water and ventilation systems and common building facilities such as lifts and lighting. To qualify for subsidies, the building's total annual energy demand in terms of heating and cooling must be reduced by at least 30% compared to the levels taken before implementation of the measures, as demonstrated by the energy certificate. Up to 35% or 50% of the eligible costs of the action, with a maximum of up to € 11,000 per house or 100 m^2 of the premises useful surface could be claimed. Beneficiaries of assistance from this programme include owners' associations, groups of owners' associations or individual owners of residential buildings as well as public administrations and public-law entities.

Despite a general positive valuation of the government about the results obtained by the State Plan in driving efficient renovation in buildings, many points of criticism have been raised by different stakeholders. In particular, a slow implementation of the Plan combined with problems of communication and the lack of widespread publicity dissuaded many potential applicants from applying.

In combination with the State Plan, but more specifically targeted to energy efficient retrofit measures in the residential sector, the Ministry of Industry, Energy and Tourism through the Institute for Energy Diversification and Saving (IDAE) has recently launched the PAREER-CRECE Programme 'Aid programme for integral energy efficiency and saving projects in residential buildings'. It is a specific aid and financing programme amounting to € 207 million that encouraged and promoted the (i) upgrade of the energy efficiency in the thermal envelope, (ii) upgrade of energy efficiency in thermal and lighting installations, (iii) replacement of conventional energy by thermal biomass or geothermal energy in building thermal installations. Eligible beneficiaries of the aids from this Programme are: natural and legal persons, owners of residential and hotel buildings; owners of single-family houses or sole owners of residential buildings; associations of property owners or Associations of residential-building property owners; ESCOs. All types and beneficiaries were

entitled to receive a money allowance without consideration, supplemented with a refundable loan, varying from 20% to 30% of the total investment costs. Aid could be requested from the 5th of May 2015 to the 31st of December 2016.

5.3 Fiscal incentives that indirectly reduce the cost of investments

Fiscal incentives for the energy efficiency in buildings include several measures to lower the taxes paid by consumers and are one of the instruments that can be used by Member States to promote and facilitate efficient use of energy among domestic costumers (EED, article 12 (2a)).

Fiscal incentives have been traditionally common in Italy and Finland. Tax deductions for the energy upgrading of buildings were introduced in Italy by the Budget Law 2007 and are still in force. They consist of reductions of IRPEF (personal income tax) and IRES (corporate income tax) in respect of actions to improve the energy efficiency of existing buildings, in particular for expenses incurred to:

- Reduce heating demand by means of overall upgrading of the building's energy performance;
- Improve the building's thermal insulation (replacement of windows, including blinds and fittings, and insulation of roofs, walls and floors);
- Install solar thermal panels;
- Replace winter heating systems (with condensing boilers or heat pumps);
- Replace electrical water heaters with heat pump water heaters.

The total deductible amount is then distributed over a period of ten years. These deductions have been key drivers of energy efficiency improvements in the housing sector helping to achieve final energy savings of 1.066 Mtoe between 2011 and 2015 and are expected to be the largest contributor of the final residential energy savings in 2020 (Italy's NEEAP 2014). In total, from 2007 to 2013, the intervention that benefited more from tax deductions has been the replacement of windows (including blinds and fittings), representing 56.2% of the total incentive; it was followed by intervention for efficient heating system (27.4%), replacement water boiler (12.2%), multiple selection (2.6%) and overall renovation (1.3%).

The tax deduction scheme has been renewed on a yearly basis. Also, the Decree Law No 63/2013 (converted by Law No 90/2013) increased the tax deduction rate from 55% to 65%. This led to an increase of more than one third of requests of tax deductions compared to the year 2012 (when the rate was 55%).

The International Energy Agency mentioned this measure as a best practice at international level (IEA 2014c), with specific reference to its role in spreading energy efficiency culture at local level. Indeed, between 2007 and

2014, more than 2 million of interventions have been realized, and in 2013 households had invested € 22 billion, with a cost of € 13 billion in terms of foregone fiscal revenue (Concerted Action Energy Efficiency Directive 2016).

A tax deduction for the labour costs incurred in replacing, upgrading and repairing the heating and electricity systems of residential houses has been available in Finland since 2000. The maximum amount of household deduction varied according to the year it has been claimed. The house owner bears the first €100 of the labour costs and the deduction is available for the taxation of both spouses. In 2017, the maximum credit that can be deducted is € 2,400 per person, and it available during the year when the claimer has to pay an invoice to a service-provider company or to pay wages to someone he employs.

5.4 Measures addressing vulnerable consumers and fuel poverty

The EED article 7 (7a) allows EU Member States to include requirements with social aims in their Energy Efficiency Obligation Schemes[7], as for example to prioritise households in energy poverty or social housing. However, most of the Member States have not translated this requirement into national legislation, if not through one-off measures. The United Kingdom is one of the few EU Member States where this problem is both recognized and systematically addressed by means of household support policies and energy efficiency investments (Bouzarovski 2014). The Energy Company Obligation (ECO), which started in 2013, is a government scheme for Great Britain that placed legal obligations on larger energy companies to deliver energy efficiency measures to domestic premises targeted at low-income and vulnerable households, and homes in low-income areas. In particular, ECO has three distinct targets:

- The Carbon Emissions Reduction Obligation (CERO) which focuses primarily on the installation of insulation measures in hard-to-treat properties;
- The Carbon Saving Community Obligation (CSCO) which focuses on the provision of insulation measures and connections to district heating systems to domestic energy users that live within an area of low-income;
- The Home Heating Cost Reduction Obligation (HHCRO) - 'Affordable Warmth Group' - under which suppliers provide measures that improve the ability of low-income and vulnerable households to affordably heat their homes.

[7] Under the Energy Efficiency Directive, EU countries should set up an energy efficiency obligation scheme. This scheme requires energy companies to achieve yearly energy savings of 1.5% of annual sales to final consumers.

The first phase of ECO, known as ECO1, ran from January 2013 to March 2015, and the second (ECO2) from April 2015 until March 2017; recently, the government announced that from the first of April 2017 the scheme will be replaced with a new supplier obligation (ECO3) that will run for five years.

Before the ECO scheme, several others obligation schemes such as the Energy Efficiency Standards of Performance (1994), the Energy Efficiency Commitment (2002), the Carbon Emissions Reduction Target (2008), and the Community Energy Saving Programme (2009) were implemented in the UK for tackling fuel poverty and lowering the pressure placed by energy prices on low-income households (Rosenow 2012; Rosenow et al. 2013). Alongside the obligation scheme, the UK government introduced in 2011 the 'Warm Home Discount' programme. It is a five-year scheme, in which the government, in collaboration with the electricity suppliers, offers a one-off discount of £ 140 on the electricity bill, usually between September and March, to private eligible customers (low-income and vulnerable customers who met their individual eligibility criteria and successfully applied, and people in receipt of Pension Credit Guarantee Credit). Since 2011, the Warm Home Discount has helped around 2 million low-income and vulnerable households (Department of Energy and Climate Change 2016a). That is why the UK government has committed to continuing this scheme until 2021 at current levels of spending - £ 320 million per year rising with inflation.

Similarly to the Warm Home Discount, a 'social bonus' - that is a discount of the electricity bill each year, dependent upon the use and number of people in the family - is offered by the governments of Italy and Spain to help people struggling to pay their energy bills.

5.5 Measures addressing the landlord-tenant problem

According to the article 19 of the EED, Member States should take appropriate measures to overcome misaligned incentives between landlords and tenants. The landlord-tenant problem occurs when landlords have little incentive to invest in the energy efficiency of their properties, given that it is the tenant who benefits from lower energy bills (Allcott and Greenstone 2012). As a consequence, rental properties tend to be less energy efficient than owner occupied houses. This split incentive between owners and renters is one of the greatest barriers hindering the development of sustainable renovation of residential buildings in Europe, but it has hardly been an objective of policy-making. In 2015, on average in the European Union, 69.5% of the dwellings were owner-occupied (own it outright and mortgagors), while the remaining were privately or social rented (Eurostat 2017). Significant differences exist among Member States: for example, in Hungary 86.3% of the dwellings, while in the UK only 63.5%, were owner occupied in 2015. In particular, the private rented sector has been

growing in recent years in the UK, and is at its highest level since the early 1990s. In 2014-15, 19% (4.3 million) of households were renting privately, while 17% (3.9 million) of households lived in the social rented sector (Department for Communities and Local Government 2015). Thus, a significant portion of rented properties in the UK leaves a considerable room for energy efficiency policies to addressing the split-incentive barrier. As result, in the United Kingdom a combination of regulatory and economic instruments has been established to tackle this issue.

In particular, the Landlord's Energy Saving Allowance (LESA) was a tax allowance introduced in 2004, which let landlords claim on their tax return against the cost of buying and installing energy efficient retrofit measures such as cavity wall and loft insulation, solid insulation, draught-proofing, hot water system insulation, floor insulation. Tax relief was for a maximum of £ 1,500 per property. This aid scheme applied until the first of April 2015.

With the Green Deal (GD), the UK has been the first European country that adopted an on-bill finance scheme, designed to address, interalia, the split incentive barrier. The GD, which came into force in the beginning of 2013, allowed owners to install energy efficient retrofits at no upfront costs and enabled repayments to be made through a charge on the occupants' utility bills - 'Golden rule' (Economidou 2014). However, due to low take up and concerns over industry standards, the government announced the end of funding for the GD in June 2015.

On the other hand, the first of April 2016 the new 'Tenant's Energy Efficiency Improvement Regulations' entered into force. While it is still the responsibility of the tenant to ensure that the energy efficiency improvements are funded and that no upfront costs should fall on the landlord (unless he agrees to contribute), now the landlord cannot simply refuse the permission for any energy efficiency improvements requested by the tenant without motivating its decision.

However, the situations in which a landlord can reasonable refuse the consent to the proposed interventions are many (Department of Energy and Climate Change 2016b); initial evidence suggests that 58% of tenants surveyed by letting agent PropertyLetByUs have had requests for energy efficiency improvements refused (Climate Change Committee 2016).

Starting from the first of April 2018, the new Minimum energy efficiency standards (MEES) makes unlawful to let buildings (both commercial and domestic) in England and Wales which do not achieve a minimum Energy Performance Certificate (EPC) rating of 'E'. The landlord will need to ensure a property complies with MEES before the lease is granted. But in certain circumstances the landlord will have six months after the lease is

granted to comply. From 1 April 2023 MEES will be extended to cover all leases, including existing leases but only if the property has a valid EPC on the relevant date.

In Italy, an interesting policy measure similar to the UK GD has been implemented at regional level. The Emilia Romagna region approved a legislative reform in 2013 (Regional Law 13/12/2013) that promotes energy efficiency improvements in the social housing sector and provides savings to the tenants at no upfront cost. This policy has the double objective to both address the split-incentive problem and to help households living in fuel poverty. The tenants renounce to part of the savings to pay back the energy efficiency investment and the ESCO (not a bank) is responsible for the energy efficiency improvements. In this way, the energy efficiency measures become economically sustainable and it is possible to involve private investors. The contract between the company social housing and the ESCO lasts 12 years and it is renegotiable in case of further improvement interventions. The ESCO guarantees minimum results and provides the report to the monitoring of individual consumptions.

5.6 Increasing consumer information and promoting behavioural change

Information and educational programs typically aim to induce change of the consumer's behaviour by providing information about potential energy savings from energy efficient products or investments and by including programs to give feedback to consumers about their energy consumption. The intention is that through the provision of greater and more reliable information, issues of uncertain future returns and asymmetric information may be lessened (Gillingham et al. 2009). However, this reliance on the concept of 'rational decisions', considering negative responses as irrational and interpreting them as a result of information deficits leads to neglect other factors such as habits, routines, social constrains etc., and thus minimises the impact of information provision by misguiding its focus.

According to articles 12 and 17 of the EED, Member States shall take appropriate measures to promote and facilitate an efficient use of energy by small energy customers, including domestic customers. Furthermore, Member States shall, with the participation of stakeholders, including local and regional authorities, promote suitable information, awareness-raising and training initiatives to inform citizens of the benefits and practicalities of taking on energy efficiency improvement measures (Concerted Action Energy Efficiency Directive 2014).

With the aim of guiding consumers to be more concerned of energy efficiency in their purchasing decisions, governments and energy agencies[8] have introduced in the last years a number of different mechanisms, ranging from energy labels and energy performance certificates to pure publication of information in brochures and mass media campaigns via internet or TV, respectively. Their effectiveness vary depending on the objective pursued, the obstacles present, and the way they are integrated with measures addressing routines, social norms and values, etc., and of course the technical feasibility.

Of particular importance is the Energy and Climate Awareness-Raising Action Plan (ECARAP) endorsed by the Hungarian government in September 2015. The plan identifies the main areas of action for the government in the short term to foster a major change in the awareness, attitudes and values of stakeholders concerning the use of energy and related to climate change, as well as towards the necessary change of related consumption patterns. The ones with the most relevance to the household sector are (i) the promotion of energy efficiency and energy conservation and (ii) the realisation of new social and economic structures according to the principles of resource efficiency and low carbon-intensity. The intended main 'messages' of the ECARAP are differentiated according to specific target group based on age and level of income. Target groups are selected so that activities can be specifically set for the behavioural changes that are requested for a specific group, rather than following a scattergun approach.

The shift in consumer behaviour towards energy conservation measures can be also supported by the installation of smart meters and more accurate billing information (articles 9, 10 and 11 of the EED). By providing real time feedback, smart meters allow consumers to take control of the energy bill, and to become more aware of their actual energy consumption. Consumers are then able to compare this feedback to previous consumption periods or benchmark values to detect and implement energy efficiency options. The early actor of the smart meters roll out has been Italy (completed in 2011), followed by Finland (completed in 2013); in Spain and in the UK the complete roll out of the smart meters is expected to be by the end of 2018 and 2020, respectively, while in Hungary pilot projects are still on-going.

6. Private initiatives supporting public activities towards energy efficiency

Beyond public programs and policy instruments, energy efficiency improvements in the residential sector are supported by the private sector in a variety of ways:

[8] Motiva in Finland, Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA) in Italy, the National Environmental Protection and Energy Center Nonprofit (NKEK) in Hungary, Institute for the Diversification and Saving of Energy (IDEA) in Spain, the Energy Saving Trust (EST) in the UK.

- Initiating and implementing concrete actions, e.g. through providing loans, investment and implementing demonstration programs, alternative solutions to low-energy buildings;
- Organizing awareness raising and information exchange programs;
- Providing input to policies, analysing policies, and initiating discussion.

Mobilising investments and actions from the private sector is therefore essential to complement public activities and to contribute meeting the energy efficiency and climate change goals. What motivates the private sector is the possibility for profit. Shareholders tend to request maximal dividends (institutional shareholders all the more), and tend to reject 'climate motivated' actions. Politics must make sure that the environmentally necessary is also the economically desirable - that is the justification for economic instruments and should be our yardstick for their efficacy.

6.1 Energy service companies (ESCOs)

Traditional utilities, start-ups, or cooperatives can all become Energy Service Companies (ESCOs), be it as the business model of a new market agent or the new business model of an old market agent. They all face certain obstacles, but different ones due to their size, history and corporate structure. The task of politics is to remove such obstacles, even grant 'launch platforms' supporting the start into unchartered territory during the pre-competitive phase.

The ESCO can be a natural or legal person that delivers energy services and/or other energy efficiency improvement measures in a user's facility or premises - such as project finance, engineering, project management, equipment maintenance, monitoring and evaluation - and accepts some degree of financial risk in so doing (ESD). These are usually made through Energy Performance Contracts (EPCs), which are self-reimbursing loans (i.e. that are repaid through savings). The EPC is a contractual arrangement between the beneficiary and the provider of an energy efficiency improvement measure, where investments are paid for in relation to a contractually agreed level of energy efficiency improvement. Energy performance contracting takes several different forms but all such projects share the characteristic that the technical risk is transferred from the client to the ESCO and that the ESCO will not receive its payment unless the project delivers energy savings as expected.

Despite the large economic energy saving potential, the ESCO market in the residential sector is much less developed compared to the industry, tertiary and public sectors in the European Union, as indicated in several reports and studies (e.g., Marino et al. 2011; Bertoldi et al. 2014; Bertoldi and Boza-Kiss 2017).

Irrek et al. (2013) and Labanca et al. (2015) provide a comprehensive overview of the barriers preventing a large scale application of the ESCO concept in the residential sector: (i) the particularly high transaction costs for ESCOs relative to the small amount of energy costs and thus potential cost savings per single energy efficiency service supplied; (ii) the landlord/tenant problem and the decision-making processes existing in multi-apartment buildings; (iii) the perception of the ESCO as not a trustworthy organisation and the fear of households to become too much dependent on the ESCO; and (iv) the difficulties for residential customers to understand the ESCO model and the EPC financing and contract and lack of information on the availability of ESCO services.

The number of ESCOs, their market size and the type of services provided varies a lot among Member States. Recently, Bertoldi and Boza-Kiss (2017) have analysed the market development of the ESCO industry in EU Member States and neighbouring countries between 2010 and 2013. From their analysis, it emerged that with the exception of Hungary (and according to some experts also Sweden and the Netherlands), all the EU MSs' market grew during the period under investigation, or remained stable as in the case of Finland. Although the residential buildings were still not very attractive for ESCOs, compared to 2010 more activities were targeted to this sector.

In Italy there were about 272 ESCOs in 2016, with a market size of € 836 million, corresponding to approximately 14% market share of the total energy efficiency investments (Polytechnic University of Milan 2017). Here, not many ESCOs couple energy services with other functions. Within the 'energy services' area, the most commonly offered service is the energy audit, followed by concluded EPC contracts. Excluding energy services, the three principal functions of Italian ESCOs are: technologies for the generation and use of thermal energy, CHP and CCHP systems, and efficient buildings. The sectors covered by these businesses are commercial, services, and partially residential, which generate together the 76.7% of their total turnover; the remaining share comes from the industrial sector (23.2%), and a negligible portion from the agricultural sector (Italy's NEEAP 2014). According to the latest Energy Efficiency Report of the Polytechnic University of Milan (2017), although the total energy efficiency investments in 2016 have been driven by the residential sector (53%), the support of the ESCOs has been marginal. In fact, only 3.4% of the total energy efficiency investments in the residential sector have been financed by ESCOs. This means that the residential sector

covered by ESCOs accounted for € 110 million, representing 13.4% of the total investments made by ESCOs in 2016.

In the United Kingdom, despite the fact that the ESCO market is one of the most developed in Europe, ESCOs activities have been mostly concentrated in the commercial and industrial sector (Labanca et al. 2015; ENSPOL 2015a). There are about 30-50 ESCOs active on the UK market with an estimated market size of more than € 400 million: the major players are large international manufacturers of building automation & control systems but a growing number of construction and property companies, smaller consultancies and dedicated ESCO firms started to populate the market in recent years. New ESCO entrants and in particular utilities see it reasonable to engage in the field of energy savings as they see a serious national commitment to a low-carbon transition (Hannon et al. 2013) - framed by the Climate Change Act 2008 - and an increased attention towards energy efficiency in the residential sector. Alongside ECO, which encouraged large energy suppliers to team up with ESCOs in order to deliver energy efficiency measures to vulnerable households, the GD was expected to set the necessary framework to open up the residential market to ESCOs, but failed to achieve its purpose.

In Spain, the profile of the ESCOs is essentially that of engineering, installation, and assembly companies, some of which are associated with building heating system maintenance companies, as well as with subsidiaries of building companies and electricity suppliers, primarily. There is no agreement about the number of ESCOs in Spain amongst local experts. The most likely range of available companies is 20-60 with a market size of over € 300 million (Bertoldi and Boza-Kiss 2017). About 80% of the registered companies provide services in industrial activities and service buildings, 70% in residential sector, 65% in outdoor lighting and just 50% in cogeneration. 93% of these companies are SMEs, that is, they have fewer than 250 employees and annual revenue of less than € 50 million, while 7% are large enterprises (Spain's NEEAP 2014). In the last years, the ESCO market for the residential sector has benefited from the support of the IDAE-managed programmes, BIOMCASA II, GEOTCASA, SOLCASA and GIT. However, the main aim of these programmes is to promote renewable energy investments such as heating and cooling systems powered by biomass, solar power or geothermal energy, and only to limited extent energy efficiency investments.

In Hungary, the complex refurbishment of residential block houses has been a fast emerging market area for ESCOs mainly due to state and municipal grants available for panel blockhouse refurbishment (Irrek et al. 2013). More recently, the market has experienced a strong decline due to the instability of funding programs, financial crisis, and the collapse of the construction sector. As a result, the 20-30 active companies were reduced to 6 in 2013. Some ESCOs disappeared because of lack of business or decline of profits, while other firms that

had been active in construction or consultancy before entered the market and succeeded with providing new products in the form of ESCO projects (Bertoldi et al. 2014).

In Finland, only 5-8 are actually active companies, with a market size of € 10 million. Pätäri and Sinkkonen (2014), by following a two-round Delphi study analysed the reasons for the limited ESCO market in Finland. The findings of this study indicate that the generally weak knowledge about ESCOs and their offerings is among the key reasons for the immaterialised volume of activity in Finland. Like other countries, the residential sector constitutes a minor share of ESCO operations. Customers may regard ESCO projects as complicated and time-consuming, and potentially not 'worth the trouble'.

6.2 Energy providers

The principal driver of the energy providers to deliver energy saving activities is induced by regulatory mechanisms created by the 'Energy Efficiency Obligation Scheme' (EEOS, article 7, EED) which calls on each Member State to ensure that energy providers achieve new savings each year from 1 January 2014 to 31 December 2020 of 1.5% of the annual energy sales to final customers of all energy distributors. In the transposition of the EEOS into national law, the government of Finland decided to adopt the 'alternative approach', meaning that it opted to take other policy measures such as energy or CO_2 taxes, financing schemes and fiscal incentives, voluntary agreements, etc., in order to achieve an equivalent energy saving target, while Italy, Spain and the UK adopted a combination of both EEOS and alternative measures (Bertoldi et al. 2015). In Hungary, the EEOS was initially planned but then it has been withdrawn (Fawcett et al. 2018).

Differently from Spain, the Italian and the UK governments placed legal obligation on larger energy suppliers or distributors to deliver energy efficiency measures before the ones set by the EEOS. In the UK, the Energy Company Obligation that ran from 2013 (see Section 5.4) was introduced as a successor to the Carbon Emissions Reduction Target (CERT) and Community Energy Savings Programme (CESP) schemes which ran from April 2008 to December 2012 and October 2009 to December 2012, respectively. Within the Carbon Emissions Reduction Target (CERT) energy suppliers were required to achieve an overall target of 293 million lifetime tonnes of carbon dioxide ($MtCO_2$) by 31 December 2012, while the Community Energy Saving Programme (CESP) required gas and electricity suppliers and electricity generators to deliver energy saving measures to domestic consumers in specific low-income areas of Britain (for a comprehensive overview please see Rosenow 2012; Rosenow and Eyre 2013; Rosenow et al. 2013; Rosenow and Eyre 2015). In Italy, the White Certificate scheme entered into force in 2005 and was imposed on electricity and gas distributors (DSOs) with

more than 100,000 users connected to their grid (from 2008 the obligated parties' threshold was 50,000 users). These parties are required to deliver yearly quantitative primary energy-saving targets through the White Certificates attesting the energy savings claims of market actors as a consequence of energy efficiency measures. All type of energy efficiency measures, apart from the improvement of energy efficiency in power plants, and all sectors are covered (ENSPOL 2015b). From 2005 to 2015 the White Certificates contributed to save 1.7 Mtoe in the residential sector, corresponding to 38.8% of the total final energy saved through this scheme (ENEA 2016).

Compliance with European or national regulations is not the only way to mobilize energy providers to take on energy saving activities: market mechanisms, financial incentives, funding opportunities, business retention and development, and voluntary agreements are also needed to stimulate energy providers to delivery energy efficiency investments in the residential sector. Governments turn to energy providers to deliver energy efficiency for several reasons. Energy providers have long-standing commercial relationships with the end-use customers, allowing them to influence energy saving activities in diffuse markets; they have the technical capacity and infrastructure for delivering services in their area of operations and they possess detailed information on the energy consumption habits of their energy consumers. However, revenues and profits of the energy providers are directly linked to the volume of energy they sell: this creates a powerful disincentive to deliver energy efficiency solutions.

Even though in almost all jurisdictions we find energy providers active in some form of demand-side management or other types of programmes, this energy efficiency activity seems to be only a window dressing or driven by legal requirements. On the other hand, in some cases energy suppliers seem to be genuinely attempting to develop and implement new business models that incorporate energy efficiency, driven by a non-traditional profit motive and a belief that it is the right thing to do (Fawkes 2016).

In a study carried out in 2013, the International Energy Agency identified several distinct types of energy saving activities that energy providers engaged in (42 case studies in 19 countries). While advice and assistance to energy consumers was the most common energy saving activity, in about one-third of the case studies energy providers offered or helped access financial incentives and in almost half of the case studies energy providers disseminated information, educated consumers, and promoted energy saving measures. Other energy saving activities included comprehensive implementation, direct installations, replacing equipment, on-bill financing, and technology development. For example, in Spain the Iberdrola's Integrated Energy Management initiative utilizes an ESCO model to upgrade and manage centralized heating and hot-water systems in residential

apartment buildings. Through this activity, Iberdrola finds and replaces older fuel-oil or coal-burning boilers with more efficient natural-gas installations, facilitating financing and then maintenance over a 10-year contract period.

In Italy, the Energy@home association funded by Enel Energia (the biggest national electricity provider), in collaboration with Electrolux, Indesit Company and Telecom Italia, has the mission of developing and promoting technologies and services for energy efficiency in smart homes based upon the interaction between user devices and the energy infrastructure. Its goal is to promote the development and widespread of products and services based on the interoperability and collaboration of the appliances within the household.

In Hungary, E.ON Hungária organized in 2015 for the second time the 'Energy Experience' that is a large-scale educational program aimed at increasing energy awareness and knowledge of citizens with a special focus to children and young people. Similarly, the provider ELMÜ-ÉMÁSZ offers two incentives and programmes, namely 'Energiapersely' and 'GREEN and GEO tariffs', both intended to increase household energy efficiency and awareness. The former provides tips and advice for daily energy-saving behaviours and allows households to borrow energy meters; the latter offers interest-free loans to households for installation of solar energy systems.

7. Cross-country comparison of energy efficiency progress

Figure 5. Cumulative and year-to-year % variation of energy efficiency trends 1990-2015

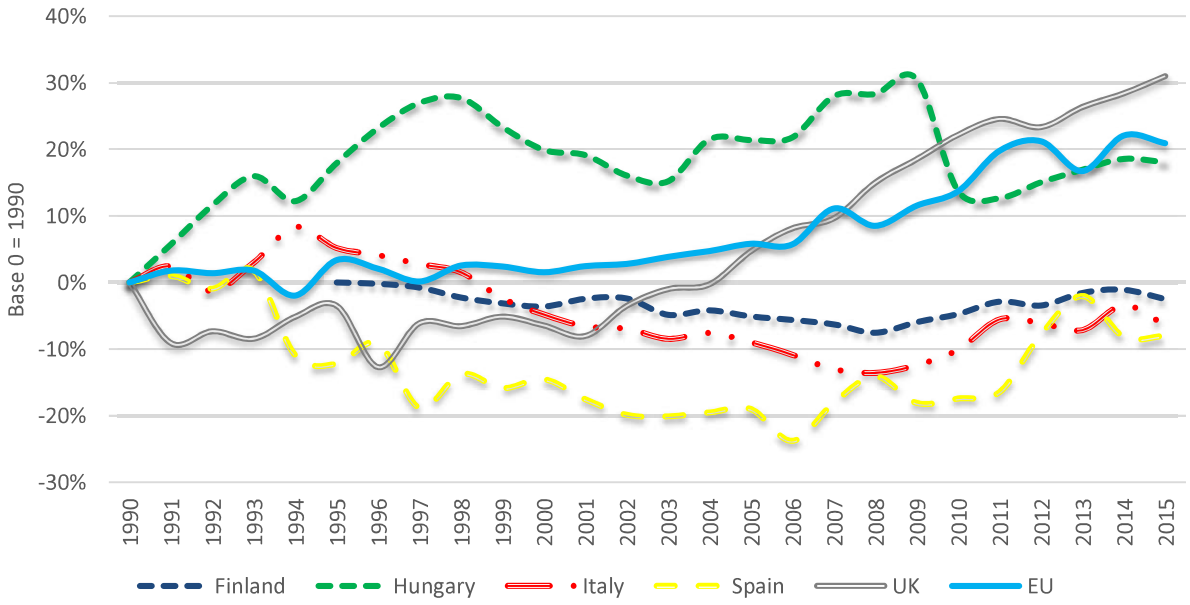


Figure 5 illustrates the energy efficiency trends in the residential sector of Finland, Hungary, Italy, Spain, the UK, and European Union over the period 1990-2015. Energy efficiency is calculated as the ratio of final residential energy consumption and the stock of permanently occupied dwellings. Differently from Figure 1 (Section 4), the cumulative percentage variation from 1990 to 2015 and year-to-year percentage changes are represented. The cumulative percentage variation is the sum of the positive and negative percentage changes of energy efficiency improvements from 1990 to 2015 using 1990 as the baseline year (with the exception of Finland that is from 1995 to 2015), while the year-to-year percentage changes represent the positive or negative percentage variation of energy efficiency in comparison to the previous year.

In order to improve the readability of the graph we converted positive values to negative values and vice versa. In this way, an upward trend represents an increase in energy efficiency (otherwise, a negative value would indicate an increase in energy efficiency).

The implementation of policies and other measures to improve energy efficiency in the residential sector does not happen into an 'empty' economic, political, and social context. In addition, several other factors can affect energy efficiency variations over time such as energy prices, climate conditions, changing household composition, behaviours, and lifestyles, larger homes (average), more people living in urban areas, and rebound effects (e.g., Sudarshan 2013; Filippini et al, 2014; Ameli and Brandt 2014). Therefore, measuring the direct causal effect of a policy or a range of policies on energy efficiency improvements and what the outcome would have been in the absence of interventions can be very challenging (Ferraro 2009; Rosenow et al. 2016) and not accurate (Sorrell 2015). Thus, we simply provide some indication of energy efficiency trends in relation to the measures previously analysed. It is important to interpret these results with caution, given the reliance on a macro energy efficiency indicator.

It can be noted from Figure 5 that the energy efficiency trends of the residential sector among countries are very diverse. While some countries show an upward and quite linear trend (the UK, and the EU as a whole), others show variable results (Finland, Italy, Spain, and Hungary).

In the UK from 1990 to 2015 energy efficiency in the residential sector improved by 31%, in total. In other words, from 1990 to 2015 energy efficiency improvements produced energy savings of 1.19% on average per year. While from 1990 to 2001 energy efficiency improvements have not been able to offset increasing demand of energy, from 2001 to 2015 there has been significant progress. The Energy Company Obligation that ran from 2013 and some of its predecessors - the Carbon Emissions Reduction Target (2008) and the Community Energy Savings Programme schemes (2009) - combined with measures addressing the landlord-tenant problem

and fuel poverty, certainly contributed to this positive trend. In fact, half of the total energy efficiency improvements has been achieved from 2008 to 2015. Compared to the period 1990-2007, from 2008 to 2015 households in the UK consumed in total 16% less energy for satisfying their needs for energy services, such as electrical appliances, lighting, water heating, cooking, and space heating.

Finland, Italy, and Spain show a non-linear but similar trend. Whereas a downward trend is observed before 2006-2007, a slightly positive trend is observed after 2006-2007. This result may reflect the increasing efforts of Member States to translate EU requirements (e.g., Directive 2006/32/EC) into national energy efficiency policies and investment opportunities for households. In absolute values, compared to Finland and Spain, the energy efficiency improvements in Italy contributed to higher savings; tax deductions (since 2007), financial incentives (Thermal Account of 2012), compliance rate with the application of MEP requirements, and ESCOs activities might have influenced this result. Despite progress in the last years, the total effect of energy savings provided by energy efficiency improvements on energy consumption is still negative and far from the EU average.

In Hungary, from 1990 to 2015 the final household energy consumption per dwelling varied from 2.01 (toe/dwellings) to 1.63 (toe/dwellings). The policies and measures analysed that have been implemented in the last years do not support any conclusion in this regard. However, the intuition here is that reduction of energy consumption might have mainly been driven by other factors rather than actual energy efficiency investments. Energy bills are a fundamental component of personal finance of Hungarian households and a considerable number of the population live in a fuel poverty condition - and thus being unable to finance energy efficiency investments (Fellegi and Fülöp 2012; Team and Baffer, 2015). In addition, one-fourth of households accumulated debt towards energy utility companies due to steadily increasing price of imported natural gas (Fülöp and Kun 2014; Slezák et al. 2015). On the other hand, there is also evidence suggesting an increasing attention of households to energy efficiency solutions. For example, the 2014 edition of the Energy efficiency barometer (Fülöp and Kun 2014) found that from 2004 to 2014 about 64% of the households performed some kind of energy efficiency investment such as insulation, update of the heating system, and replacement of windows. Also, the rapid end of funds allocated by the Warmth of the Home Programme confirms the willingness of households to improve their energy use and living standards.

At EU level, the trend is linear and positive. Most of the energy efficiency progress have been achieved after 2006. One explanation for this positive trend is the increasing role of energy efficiency in shaping the EU strategic objectives and policy agenda. It was in 2006 that the European Union implemented the first major

wide-reaching piece of legislation on energy efficiency, commonly referred to as the Energy Services Directive (Directive 2006/32/EC). This directive was followed by the Ecodesign Directive in 2009, the Energy Labelling Directive in 2010, the recast Energy Performance of Building Directive in 2010, and the new Energy Efficiency Directive of 2012 that is still the most important legislation currently in force establishing a common framework of measures for the promotion of energy efficiency within the European Union.

8. Conclusion and implications for energy policy

This study builds on the EU Horizon 2020 project 'European Futures for Energy Efficiency' and provides insights on the different energy efficiency strategies adopted by some EU Member States to remove barriers and stimulate energy efficiency investments in the residential sector.

In particular, we analysed private initiatives and policies implemented in the residential sector over the last years in Finland, Hungary, Italy, Spain and the UK. Since it is not possible to show a causal relation between energy efficiency trends and differences on the basis of indicators (our means of assessment), we conducted an analysis of the policies implemented, combined with private measures targeting energy efficiency in the residential sector. While not indicating mechanical causalities, this analysis further improves the understanding of the country-specific conditions and actions. With the development of a framework taking into account multiple actors and both quantitative and qualitative information in the evaluation process, we contribute to a comprehensive analysis and enhanced comparability among case studies.

8.1 Country level insights

When compared to what has been achieved in the last years in Finland, Spain, Italy, and Hungary, the UK government's set of energy efficiency policies targeted at the residential sector appears to be more effective. We argue that its more balanced character, together with the participation of and obligations for private actors have been decisive for this relative success. In particular, the legal obligations placed on energy suppliers to deliver domestic energy efficiency programmes are part of a holistic policy package with a medium-term framework addressing many aspects of energy efficiency in the residential sector. The motivation for this rather ambitious approach appears to be a domestic one: the UK residential energy sector is more problematic than the European average. In particular, the prevalence of older dwellings in the national stock, built to lower standards of energy efficiency, combined with a high share house ownership amongst the less affluent sectors of society and the

dominant role of the private sector in the housing rental market leaves larger untapped potential for improvements than in the other countries under investigation. Due to the significant energy efficiency improvements at a faster pace than the EU average since 2007, in 2015 the energy use by households in the UK was in line with the EU average.

It is currently unclear how Brexit will influence future energy efficiency policies in the UK. The importance of energy efficiency improvements in the residential sector will probably prevail, as reducing household emissions is an important means contributing to meeting the national emission reduction targets codified in the 2008 Climate Change Act. On the other hand, assuming that the UK leaves the common market after Brexit, the UK will not be obliged to transpose the EU Winter Package into national legislation, in particular not the extension for the period 2021-2030 in article 7 of the proposed new Energy Efficiency Directive. This means that progress will slow unless a strong national energy efficiency strategy replaces the EU legislation as a driver of efficiency improvements.

In Finland, improvements of energy efficiency in the residential sector seem not to have been a priority for policymakers, although Finland has the highest energy consumption per capita and the highest space heating demand per dwelling in Europe. Beyond a general tax reduction for any household services, no real economic incentives have been provided to stimulate energy efficiency investments in the last years. Issues like fuel poverty and the landlord-tenant problem have not been taken into account in the national energy efficiency strategy, and the private sector remains a marginal player. Therefore, it comes as no surprise that the residential energy consumption per stock of permanently occupied dwellings did not decrease within the period 1995-2015. One possible explanation for the lack of political commitment is the policy makers' focus on the energy-intensive industries representing almost half of the energy consumed in the national energy sector.

Also in Spain the residential energy sector seems not to have been at the top of the energy saving agenda; instead, the attention has been focused on the transport sector representing about 40% of the energy consumption. But as opposed to Finland, in Spain the residential energy sector is one of the most efficient in Europe, mainly because of the modern building stock and the low level of space heating demand (however, due to the economic crisis a significant share of the modern buildings is standing idle). In addition, with the State Housing Plan 2013-2016 and the PAREER-CRECE Programme, both the national and local governments have recently allocated a significant share of the budget for energy efficiency and saving projects to inhabited residential buildings.

In Hungary, with the Warmth of the Home Programme, the government provided financial incentives to households ranging from the replacement of inefficient appliances or obsolete facade doors and windows, to complex energetic refurbishment of blocks of flats. The success of this policy measure has been witnessed by the rapid exhaustion of funds allocated (in other words: the program was underfunded as compared to demand). In order to increase energy awareness, large-scale educational programmes targeted to specific groups have been provided by both the government (ECARAP) and the energy providers E.ON and ELMÜ-ÉMÁSZ. However, there is still room for improvement: implementing policies incentivising energy efficiency investments could reduce domestic energy consumption, alleviate fuel poverty, and improve health and thermal comfort (Poortinga et al. 2017), while reducing the dependence on Russian gas.

Italy offers some interesting policy initiatives in terms of fiscal and financial incentives. The tax deduction scheme (in force since 2007) has proven to be very effective in attracting more investments than what it actually cost in terms of foregone fiscal revenue. In addition, since 2012 the Thermal Account has provided substantial incentives for energy efficiency (and also renewable energy) investments. Subsidies covering part of the expenses for renovation will be available until 2021. Benefits from these policy measures are partially exploited by ESCOs. These measures and activities, and the resulting energy efficiency improvements since 2007-2008 may have contributed to curb the negative trend of energy savings. However, these measures have not been developed into a comprehensive policy package addressing all the aspects of the residential energy sector.

8.2 European Perspectives

It may be surprising that the EU member states analysed, despite a shared ambitious EU residential energy policy, have highly different levels of per capita or per dwelling household energy consumption. The reasons revealed by our study show that this is to a large degree influenced by policies of the last decades, as the housing stock is a lasting legacy of such decisions. For instance, governmental preferences for large uniform housing blocks in the socialist countries led to settlement structures different from e.g. the UK where the 1980s policies supporting house ownership still shape the dwelling landscape and the occurrence of energy poverty to a significant degree. More recent policies were found in Spain and Finland – in both countries governments focussed their climate mitigation efforts on other, more dominant sectors, transport in Spain and industry in Finland. Furthermore, economic dynamics play a role: the recent construction boom in Spain led to a significant share of the housing stock built according to advanced energy standards, unlike in the UK or in Finland.

Finally, answering our research question, policy design matters, if only in terms of meta-level criteria: an optimal policy strategy aiming at improving energy efficiency in the residential sector should seek to impact different barriers and target segments through a holistic approach pursuing multiple goals coherently, mutually supporting each other. However, as the barriers are diffuse and policy mechanisms rarely operate effectively in isolation (Sovacool 2009), a holistic approach must be based on a thorough analysis of the local and national situation. Only then the hope for synergies (IEA 2005), making the combined impact larger than the sum of isolated effects, may be realised. This implies that a comprehensive energy efficiency policy strategy is determined by the degree to which the design of policy mixes address the barriers identified. Our study has provided some examples for such relatively successful strategies. We could also illustrate that an energy efficiency policy package tends to be more effective if it is maintained over the long-term. Therefore, the 2021-2030 Integrated National Energy and Climate Plans (EC 2016c) which will replace the National Energy Efficiency Action Plans (NEEAPs) and the National Renewable Energy Action Plans (NREAPs) provide an opportunity for Member States to think up new energy efficiency policies with a longer perspective.

In addition to policy packages, engaging the private sector is acknowledged as being central to ensuring long-lasting impact. As such, private initiatives do not duplicate governmental energy efficiency measures in the residential sector, but rather augment and strengthen them (Haney et al. 2010). A long-term policy horizon is a necessary, but not sufficient condition for mobilising private investments in energy efficiency in the residential sector. While it could strengthen the confidence that there will be money to be made through efficiency in the longer run, justifying investments and a rethinking of business models, the latter is still challenging. The cliché "the cheapest energy is the energy not consumed at all" may be attractive to residents, but is a deterrence to business: there appears to be nothing to sell, and thus no profit to make (Fawkes 2016). In their current business model, energy providers cannot decouple utility profits from energy volumes and energy service companies do benefit from economies of scale when selling energy efficiency solutions to households.

While coherent public policies and business investment are indispensable, the reductions in household energy consumption needed to reach the Paris climate goals are unlikely to be achieved from interventions designed to retrofit buildings alone. Studies on household energy use have found a high variability in energy consumption across identical houses, implying that the occupants are the third decisive agent and their behaviour can be as important as building physics (Santin et al. 2009). Beyond efficiency, including sufficiency principles into policy design for a good quality of life could contribute to reducing energy consumption: energy efficiency and energy sufficiency are complementary approaches to energy saving (Thomas et al. 2015; Bertoldi 2017; Samadi

et al. 2017). Given the different obstacles in different circumstances, any approach of standardisation or transferability of approaches would be futile: there are no "best solutions". Instead, the lists of instruments and their design which have been promising under specific circumstances in the countries analysed can be read as a toolbox to get inspiration from for a suitable design of policies and policy mixes in the respective socio-political context.

Acknowledgements

This work has been supported by the European Commission under the project grant EUFORIE/H2020-EE-2014-2015- RIA/649342. The authors would like to thank József Slezák and Edina Vadovics for the information provided about Hungary, and the participants of the '3rd RSEP Multidisciplinary Conference' (April 5-7, 2017) in Vienna and the 'Biennial International Workshop Advances in Energy Studies' (September 25-28, 2017) in Naples for their comments. We are also thankful to the anonymous reviewers for their valuable comments on the earlier version of this paper.

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