A blind spot of European policy? Energy efficiency policies for low-income households

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Keywords

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Abstract

To reach the target of an almost carbon neutral building stock in the European Union by 2050, as proposed by the low-carbon roadmap, it is crucial to include all residential buildings into these efforts. However, at the moment, only few energy efficiency (EE) policies in Europe focus on or actively include low-income households (LIH), which represent about 17 % of households in the EU (as defined by earning less than 60 % of their respective national median equivalised disposable income). Social policies to alleviate the precarity of fuel poverty exist in nearly all Member States. Though these policies may be successful in alleviating fuel poverty, they can actually counteract the incentive for investing in EE.

This paper stems from research performed by the authors for the ITRE Committee on EE policies for LIH (EP, 2016). In this paper, we analyse the current EE policy landscape in the EU and its Member States with regard to how they address LIH. After presenting barriers to efficiency in households, we refer to the capability of EE policies to remove specific barriers for EE investments in LIH, as well as their environmental, economic, and social benefits. These benefits are often discussed as "multiple benefits" of EE and include, beyond their contribution to the achievement of energy and climate targets, positive impacts on employment, GDP, competitiveness or energy security and beneficial social impacts as e.g. alleviation of fuel poverty, better health and well being or an improved living comfort. We then give recommendations for future policy design in the EU Member States and the recast of important EU Directives (EED, EPBD, Eco-Design and Energy Labelling Directives), while considering special design elements for LIH without neglecting rebound effects and other counter-productive effects.

Introduction

The Eco-Design Directive, the Energy Labelling Directive as well as the Energy Efficiency Directive (EED) and the Energy Performance for Buildings Directive (EBPD) comprise the four main pillars of energy efficiency policy in the European Union. The latest progress report towards the implementation of the EED and the 20 % national energy efficiency (EE) reduction targets for 2020 by the European Commission (EC) stresses the importance of Member States further improving the investment conditions for private consumers to accelerate the currently very low renovation rates. It specifically emphasizes the need for targeted measures in the household sector due to its lower responsiveness to increasing energy prices (as compared to industrial consumers) as well as the need for focused measures targeting vulnerable consumers to address fuel poverty and improve living standards (EC, 2015). Meeting the EU's greenhouse gas (GHG) emission reduction targets requires that nearly zero emission levels are achieved in all new and existing buildings, including LIH, by 2050 (EC, 2012). Considering the potential of EE to both alleviate fuel poverty in millions of households within the EU and incorporate LIH in EE efforts to reach EU-targets, this paper analyses the current EE policy landscape in the EU and its Member States with regard to how they address LIH, thereby referring to the policies' capability to

remove specific barriers for EE investments. The paper stems from research recently conducted for the ITRE[1]-Committee of the European Parliament to examine if EE policies should be extended to actively include LIH in the context of the revision of the EED and EPBD (EP, 2016).

The importance of the inclusion of low-income households in EE efforts to reach the EU's greenhouse gas (GHG) emission reduction targets becomes clear when outlining the order of magnitude of the problem: Residential buildings account for 75 % of the European building stock, from which more than 40 % was built before 1960 and more than 90 % before 1990 (EP, b, 2016). LIH[2] represent about 17 % of households in the EU (Eurostat, 2014), while estimates of EU-inhabitants suffering from fuel poverty ranging between 50-160 million inhabitants, corresponding to roughly 6–21 % of the total EU-population (Bird et al., 2010, Bouzarovski, 2013 and BPIE, 2014). Next to the metrics used in the studies, a reason for the wide range of the estimates is the lack of a common definition for fuel poverty[3]. The link between EE and fuel poverty lies in the very causes for fuel poverty, which is commonly depicted to originate as the combination of three factors; low-incomes, high energy bills and low EE of household's insulation and devices, as outlined in Figure 1 (left side) (INSIGHT-E, 2015). Hence, policies to alleviate fuel poverty can address any of these factors, such as lowering the electricity bills through energy subsidies or income assistance through social security payments (social policies). These policies, while favourable for the beneficiaries, not only discourage EE improvements, but cannot solve the precarity of fuel poverty in the long-term, as opposed to improving a household's EE. Improving EE not only alleviates the root causes for fuel poverty, but additionally induce the *multiple benefits* of EE, such as improving human health, lowering energy subsidies through social policies, increased the value of properties, local spending and employment, reduced emissions, etc. (Figure 1 right side) (selection after IEA, 2014).

In view of the large potential of EE of both alleviating fuel poverty in millions of households within the EU and incorporating LIH in EE efforts to reach EU-targets, this paper analyses the current EE policy landscape in the EU and its Member States with regard to how they address LIH, thereby referring to the policies' capability to remove specific barriers for EE investments[4]. The analysis is based on a review of the scientific literature and policy reports, semi-structured interviews with selected stakeholders pertinent to the policy environment of residential EE (overview in Table 5), as well as an analysis of the policy landscape of EE based on the MURE database on energy efficiency policies[5]. The paper is structured as follows: section 2 presents barriers to EE in the residential sector by analyzing the vast literature dealing with the topic and extracting the most important barriers in the low-income sector. Based on the largest database for EE policies within the EU, ODYSSEE-MURE, section 3 of the paper illustrates the EE policy landscape in the EU. Section 4 analyzes how generic policy topics remove the barriers to EE in the low-income household sector and presents examples of concrete measures removing numerous barriers. Section 5 presents the multiple benefits from EE and outlines how the low-income sector might benefit from these. Section 6 summarizes and concludes, while presenting policy recommendations.

Barriers to EE in LIH

BARRIERS TO EE IN THE SCIENTIFIC LITERATURE

Barriers to EE can generally be defined as inhibiting factors that explain the reluctance of persons, households, firms or other institutions to adopt cost-effective EE measures as derived from mainstream economics, organizational economics or organizational behavioural theories (Thollander 2010, IEA 2007, IEA 2012). Barriers as such are not observable; they are *notions* with their origin in the discipline chosen to analyze them. The existence of barriers to EE is the reason for the existence of the *energy paradox on* or *energy gap* between the cost-effective EE level as derived from technical and economic models and the level actually implemented by market participants (early noted by Brown and Hist 1990 followed by, among others Sorell 2004, IEA 2007). Extensive scientific literature deals with barriers to EE, proposing taxonomies and categorizations of barriers' types. In what follows, an overview of previous scientific approaches to deal with barriers to EE is provided: Brown and Hist (1990) is one of the earliest publications proposing a taxonomy of barriers to EE by dividing them in structural barriers, which are beyond the control of the individual end-user, and behavioural barriers, which relate to the end-users decision-making process. The authors propose several policy interventions to remove the barriers in place. Jaffe and Stavins (1994), while not explicitly referring to "barriers", analyze factors for the existence of the *energy paradox* from a technology diffusion perspective and categorizing these *inhibiting factors* (i.e. barriers) in market failures and non-market failures. This logic is followed by Brown (2001), also using these categories to classify barriers. Weber (1997) uses 4 categories to classify barriers, namely institutional, market-based, organizational and behavioural barriers. Prominently, Sorell et al. (2000) provide an extensive literature review on barriers to EE and proposes a taxonomy three broad categories, in economic[6], behavioural and organizational barriers. More recently, the IEA's World Energy Outlook 2012 presents barriers divided in visibility, priority, economic, capacity and fragmentation, while also proposing remedial policy tools to alleviate them. Finally, Fraunhofer ISE et al. (2012) analyze barriers to energy efficiency investments in the residential sector, dividing barriers in financial, informational, behavioural, legal/administrative and technical barriers.

Noted by Weber (1997), the categories used in taxonomies are not unambiguous, i.e. each barrier has institutional, eco-

1. ITRE refers to the European Parliament Committee on Industry, Research and Energy.

2. As defined by earning less than 60 % of their respective national median equivalised disposable income.

3. Extensive overviews on official definitions of fuel poverty by Member States for selected EU-countries as well as in scientific literature are provided by EP (2015) and EC (2016).

4. As noted by Shove (2009), while the barriers and drivers framework is as a popular and predominant paradigm in the scientific literature addressing environmental externalities, other approaches stemming from transition theories and social theory and can also be used to approach this topic.

5. http://www.measures-odyssee-mure.eu/

6. For the first category of barriers in his proposed taxonomy, Sorell at el. (2000) use the terms *economic barriers* and *neo-classical barriers* in an exchangeable way.

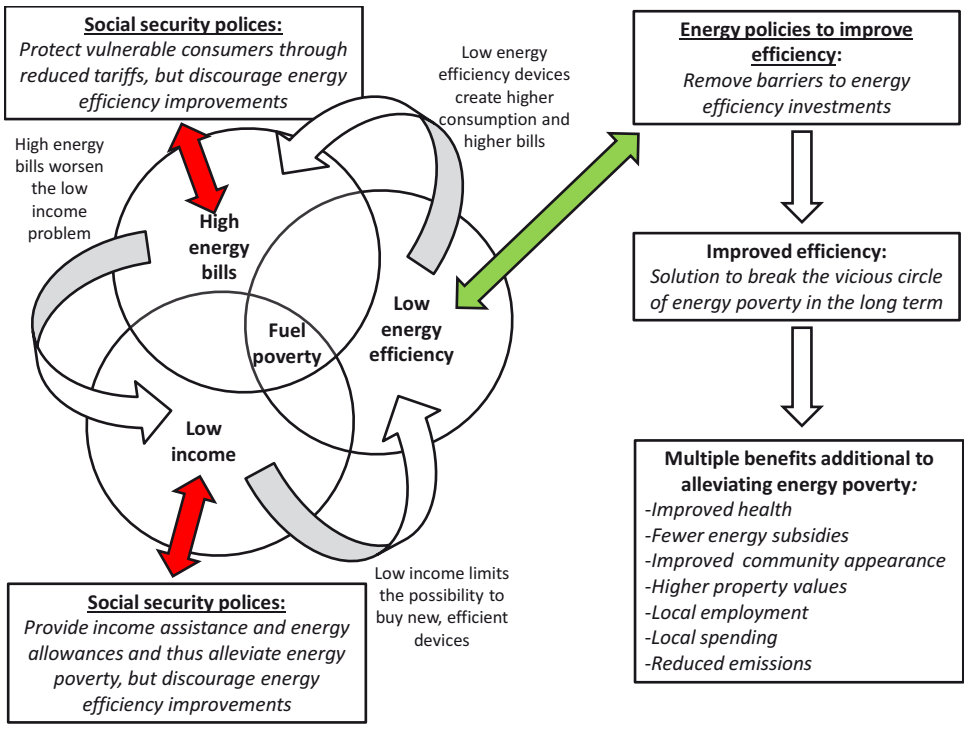

Figure 1. Fuel poverty as a combination of high energy bills, low income and low efficiency (left side) and its relationship to EE policies, barriers to EE investments and multiple benefits (right side) (Own elaboration after EP (2016), INSIGHT-E (2015), IEA (2014)).

nomic, behavioural and other components. Table 1 presents an overview of the categories used by studies dealing with barriers with the aim of depicting overlapping categories among them. It becomes visible that *behavioural barriers*, *organizational barriers* and *economic barriers* are consistently used within most of the studies.

Of relevance within the literature on economic barriers is the question whether barriers to EE correspond to *market failures.* Market failures originate when market participants do not behave as profit maximisers (bounded rationality), lack of perfect information, when markets are not perfectly competitive and in presence of externalities (Perman et al. (2003). The question whether barriers to EE correspond to market failures has been subject to analysis by numerous studies (Brown (2001), Weber (1997), Jaffe and Stavins (1994), Sorell et. al (2000), IEA (2007), among others). The relevance of this debate is twofold; On the one hand, as noted by Brown (2001), market imperfections are common in many markets; market failures in energy markets are however of great relevance because of the widespread environmental, macroeconomic and national security implications of energy markets. On the other hand, the relevance of market failures in the context of EE emerges from the perspective of legitimating policy interventions aiming at promoting EE investments. From a welfare economics, neoclassical perspective, policy interventions are legitimate to correct inefficient market outcomes and increase welfare in dysfunctional markets (Sorell et. al, 2000). While climate change represents a global, inter-temporal externality (Stern, 2006) and might therefore justify policy interventions relating to EE on a general basis, further legitimation to public policy intervention emerges if energy markets as well fail to provide the optimal level on EE.

BARRIERS TO EE FOR LIH

Table 2 presents a compilation of barriers to EE in the residential sector based on existing literature[7]. A total of 27 barriers was collected, using the categories 1) behavioural 2) informational 3) economic and 4) regulatory/administrative to present and analyze them. The proposed taxonomy follows previous literature by utilizing the most common categories being behavioural and economic barriers. Since 12 out of 27 barriers found in the residential sector are related to knowledge and information, it seems appropriate to incorporate this category in the taxonomy. Finally, the category regulatory/administrative is adopted following Fraunhofer ISE et al. (2012) given the fact that the barriers comprised by the category are of particular relevance in the low-income sector. All barriers listed in Table 1 are inhibiting to EE improvements in the residential sector. Of note, determining with certainty the most inhibiting barriers in the LIH would be subject to empirical investigation by behavioural and causal-inference economic techniques. In lack of such empirical studies, the next section presents the sub-set of barriers that is a-priory expected to be of higher relevance for LIH as compared to the remainder of households[8]

Behavioural, knowledge and informational barriers: Affirmed by Eurostat (2013) "the education level is one of the most important individual factors for adults in reducing the risk of poverty and being able to secure acceptable living conditions for themselves and their families". While it cannot be

7. Table 2 of the paper corresponds to table 14 in Annex 2 of EP (2017).

8. To the knowledge of the authors, limited scientific studies have dealt with barriers in the context of low income households; i.e. Charlier (2015), Bird and Hernández (2012), dealing with the split-incentives barrier or in France and USA or EPC (2013), proving an overview of barriers to energy efficiency in multifamily housing.

Table 1. Overview of barrier's taxonomies in previous literature (own illustration).

Studies (left) and proposed barrier's taxonomies							
Brown and Hist (1990)	behavioural				structural		
Jaffe and Stavins (1994)			market failures	non-market failures			
Weber (1997)	behavioural	organizational	market based		institutional		
Sorell et. Al (2000)	behavioural	organizational	economic				
Brown (2001)			market failures	non-market failures			
Fraunhofer-ISE et al. (2012)	behavioural	informational	financial			legal/administrative	technical
IEA 2012	priority	visibility	economic			fragmentation	capacity

generalized that of LIH are in their totality less educated than high-income households, in the EU ISCED[9] levels below 3, i.e. an education level below higher secondary, result in a median equalised net income 44 % lower than ISCED 5 to 8 and 20 % less compared to ISCED levels 3 and 4 (Eurostat 2017a). Thus, a considerable subset of the total LIH will have lower educational degrees as compared to high-income households. LIH suffering from low levels of education are expected to be more strongly inhibited by behavioural and informational barriers (No. 1–14). For instance, less educated households might be less aware of the benefits of EE, about the (non-visible) energy consumption and saving potentials of their dwelling (No. 6) or about the difference between the maintenance costs of energy devices and efficiency improvements (No. 8). The fact that EE benefits are heterogeneous and depend on consumption patterns, devices and appliances in place further aggravates the inhibiting effect of informational barriers[10] (availability of individual-specific, targeted information, information on targeted support programmes, etc., barriers No. 9–14).

Economic financial barriers: LIH have by definition less savings compared to high income households and thus the upfront costs of EE investments represent a fundamental obstacle to them (No. 15). Further, LIH might have less access to capital (No. 16) as a result of lower creditworthiness than high income households[11], thereby facing (in absence of targeted policies in place) lack of potential to financing EE investments through loans.

Economic risks barriers: LIH have difficulties coping with everyday expenditures. EE investments involve direct and certain upfront costs and less certain future benefits. Risk-associated barriers are therefore expected to be particularly inhibiting, such as risk aversion due to long amortization time (No. 20). With LIH having a higher propensity to live as tenants (Eurostat, 2014), risk aversion due to a long amortization time might be as well enhanced by uncertainty regarding the duration of their stay in the rented dwellings. Finally, with external capital being associated with costs for capital, LIH are expected to be more reluctant to the higher costs and risk of acquiring external capital as opposed to using their own savings (which are, if existent, very limited) (No. 24).

Economic incentives barriers: A further, widely discussed and well known economic barrier that is particularly inhibiting in the low-income household sector is the split-incentives barrier (No. 17); it is present where the costs and benefits of economic transactions are not incurred and appropriated by the same agent. A common example is the landlord-tenant dilemma[12], where neither one has the incentive to invest in EE because the other party will also appropriate benefits from the investment. The landlord-tenant dilemma plays a crucial role in the low-income household sector when considering the following two facts: firstly, in view of 220 million inhabitants or approx. 30 % of the EU's population living as tenants and secondly, bearing in mind that LIH are, in all EU-countries, more likely to be tenants and are therefore more exposed to this barrier (Eurostat, 2014).

A further barrier originating from misaligned incentives are subsidies to energy prices. In competitive markets, prices are the result of supply and demand. They are a signal of scarcity and incentivize participants in their market behaviour. Energy cost subsidies represent a distortion of markets and incentivize higher consumption of energy. They make investments in energy conservation technologies less attractive by prolonging their amortization time. Energy cost subsidies explicitly conceived for LIH exist in nearly all Member States via their social security systems (MISSOC a, b, 2016)

Regulatory/Administrative: Lastly, barrier No. 27, complex owner structures in multifamily housing, is of particular relevance in the low-income sector. In the European Union 46.8% of people earning less than 60 % of the median equalised income live as tenants in apartment buildings, as compared to 42 % of the total population (Eurostat, 2017b), which emphasises the importance of this kind of barrier for LIH. Multifamily houses in general, which are expected to represent a higher share of social-dwellings, are strongly affected by the split-incentives barrier given the complex ownership structures. Administrative procedures are more complex pass-through regulations of refurbishment costs to tenants create a strongly hindering factor to EE investments.

9. International Standard Classification of Education (ISCED 2011): levels 0–2: Less than primary, primary and lower secondary education; levels 3 and 4: Upper secondary and post-secondary non-tertiary education; levels 5–8: Tertiary education.

10. As reported by Caritas-Stromsparcheck (2016) in the interview performed on the Caritas' appliances and devices replacement program (see acknowledgment section), in which the crucial importance of face to face counseling as a requisite to overcome the heterogeneity of EE benefits was outlined.

11. See Sorell et al. (2000) for an overview on how the lack of access to capital has been presented in the barrier's literature.

12. Notably, split incentives can exist in other constellations than landlord-tenants, for instance as an inter-temporal split-incentives dilemma between building/housing constructors and operators, where the agent responsible for energy efficiency in the building is not the agent responsible for its operation.

Table 2. Barriers to EE (EP (2016), with barriers compiled from Sorell et.al (2000), Fraunhofer-ISE et al. (2012), IEA (2012), Thollander et al. (2010).

Type	Subtype	#	Barrier	Market failure	Higher relevance for low-income segment
Behavioural	Behavioural & priority	1	Lack of general awareness of benefits of EE measures	Yes	Yes
		2	Preference for visible (or other) improvements of the dwelling		
	Behavioural comfort	3	Behavioural inertia and bounded rationality	Yes	
		4	Comfort loss and dissatisfaction during refurbishment phase (noise, dirt, etc.)		
		5	Concerns on dispute with tenant/landlord (behavioural dimension of split-incentives problem)		
Information	Knowledge	6	Lack of knowledge on energy consumption/ saving potential of the dwelling	Yes	Yes
		7	Misperception on known consumption / lack of knowledge on saving potentials	Yes	Yes
		8	Lack of understanding between general maintenance costs (i.e. of boiler) and energetic improvements through new investments	Yes	Yes
	Information availability	9	Lack of availability of general information related to energy consumption, energy saving potentials, economic and environmental benefits, etc.	Yes	
		10	Lack of availability of credible information	Yes	
		11	Lack of availability of understandable information (complexity of information, form of information)	Yes	Yes
		12	Lack of availability of individual-specific information due to heterogeneity of individual benefits	Yes	Yes
		13	Lack of availability of specific information on individual support programs providing loans/grants	Yes	Yes
		14	Lack of availability of information on consultancy and advisory services	Yes	Yes
Economic	Economic financial	15	Lack of access to internal capital (i.e. lack of equity due to low savings or prioritisation of other investments)		**Yes**
		16	Lack of access to external capital		**Yes**
	Economic incentives	17	Split Incentives	**Yes**	**Yes**
		18	Subsidies to energy prices	**Yes**	**Yes**
	Economic risks	19	Risk aversion due to hidden costs (Decision-related costs, information-related costs, new technology adaptation costs, etc.)		
		20	Risk aversion due to long amortisation time		**Yes**
		21	Risk aversion due to uncertainty on own future economic situation		**Yes**
		22	Risk aversion due to overall economic situation		
		23	Risk aversion due to uncertainty on energy prices		
		24	Risk aversion due to general preference for equity over debt	**Yes**	**Yes**
		25	Risk aversion due to technological risk		
Regulatory/ Administrative	Regulatory/ Administrative	26	Regulations to pass-through refurbishment costs to tenants		
		27	Complex owner structures in multifamily housing	**Yes**	

EE Policy Landscape in the European Union

The analysis of the EE policies in the residential sector is mainly based on the MURE database, which was developed within the EU ODYSSEE-MURE project[13], as well as research on regional and national policy documents by Member States. The ODYSSEE-MURE project gathers representatives from the 28 EU Member States plus Norway and Switzerland and aims at monitoring EE policies, their impacts and as well as general efficiency trends in Europe. To our best knowledge, the MURE database is the most comprehensive database on EE policies in the EU[14]. About 470 national and regional measures regarding EE in the residential sectors were implemented by EU Member

13. http://www.odyssee-mure.eu/

14. While the MURE database is extensive, recently implemented or small energy efficiency measures policies might be omitted for the database. Other databases to be mentioned here are the IEA database on energy efficiency policies & measures and the EEA database on climate change mitigation policies and measures.

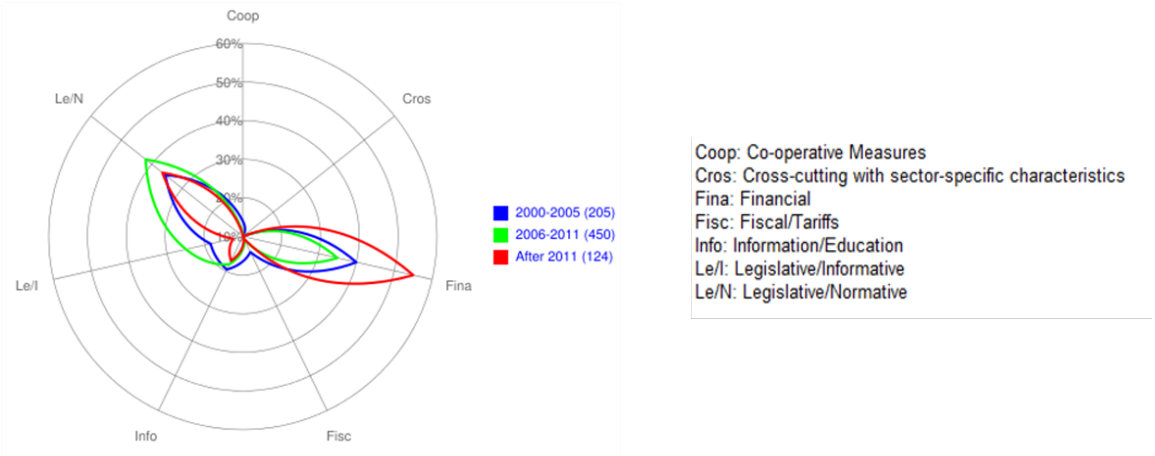

Figure 2. Distribution of EE measures relative to the total number of measures by type in the EU (ODYSSEE-MURE (a) 2016).

States and Norway since year 2000 (MURE, 2016). The vast majority of these measures correspond to the implementation of the EED and EPBD. Every three years, EU Member States must submit their National Energy Efficiency Action Plans (NEEAP) to the European Commission, describing the set of planned national EE measures to reach the targets set by the EED. This database contains by now 228 measures regarding EE addressed to households, which represents about half of all existing measures[15]. Figure 2 shows the distribution of measures according to their type from 2000 to 2016. Most of the measures in the residential sector are financial measures (i.e. loans and grants), followed by legislative/normative measures (building and appliances performance standards as well as labelling and buildings certificates) and informative measures (audits and information campaigns). In view of the large amount of measures in place and their heterogeneity, the further analysis of policies in the EU and how these work against barriers to EE investments must rely on a policy categorization with a rather high level of aggregation. The types as presented in Figure 2 are the most aggregated categorization following ODYSSSE-MURE, with five categories relevant in the residential sector namely 1) financial 2) fiscal 3) legislative[16] 4) information/education 5) market-based instruments.[17] For our analysis, these *policy types* are further subdivided in subcategories, referred as *policy topics* and presented in Table 3. Table 3 shows EU-Member States[18] with respective measures implemented for each policy topic, while depicting which member states have EE measures specifically targeting LIH, i.e. tackling fuel poverty. This is the case for *energy audits*, *incentives for energy efficient buildings renovations*, *income tax credit reductions*, *energy audits*, *information campaigns* and *EE obligations*.

Additionally, Table 3[19] presents the share of EU-Member States plus Switzerland and Norway that have implemented EE measures for all households (left row) or for LIH specifically (right row).

As for households in general, financial and legislative instruments are the most widespread instruments in the EU: Consequential to the EED, EPBD and Labelling Directive, nearly all countries have appliance labelling and performance standards, as well as EE certificates and performance standards for buildings. Further, a high share of the countries (87 %) has incentives for energy-efficient building renovations and incentives promoting renewables. Informative instruments are widespread but less common, with 73 % of EU countries having information campaigns and 43 % having energy audits. Market based instruments such as Energy Efficiency Obligations (EEOs) are present in half of EU countries.

The share of countries with EE policy measures specifically targeting LIH is substantially lower. As for financial instruments, such as *incentives for energy efficient building* renovations, only 7 out of 30 EU countries (23 %) have policies that target LIH. Similarly, 4 out of 30 countries (13 %) have incentives for appliance replacement programs (of note, this policy measure is only implemented targeting LIH, while all households might bear potential). Energy audits are present in 7 and information centres are present in 8 out of 30 countries, corresponding to shares of 20 % and 27 %, respectively. Finally, EEOs specifically targeting LIH comprise 13 % of EU countries.

Capacity of policies on EE to remove barriers

GENERAL CONSIDERATIONS

Table 4 shows the policy topics as presented in the previous chapter, while conceptually depicting which barriers to EE investments by private households are removed by each policy topic. Concrete policy measures differ from these conceptual and generic policy topics as presented in Table 4 insofar as

15. The database also contains altogether 125 measures in the residential sector reported in the first NEEAPs (2008), extended to 212 measures reported in the second NEEAPs (2011).

16. Legislative instruments can further be divided in legislative normative (i.e. appliance's/ building's standards) and legislative informative (i.e. labeling requirements or building's performance certificates).

17. Co-operative measures mainly refer to voluntary agreements with manufacturers or energy suppliers. Cross-cutting measures with sector-specific characteristics here refer to eco-tax policies in general.

18. Including Switzerland and Norway.

19. Energy audits might also be classified as financial instruments: Most of the energy audits in place are not only highly subsidized, but are also part of programs offering loans and grants for energy-efficient building renovations or appliance replacement programs.

Table 3. EE policies in the residential sector in the EU (including Switzerland and Norway) by policy type and policy topics, presenting selected examples of concrete policy measures (own elaboration based on MURE database).

Policy topic by instrument used	EU-Member States implementing EE measures for households in general*	EU-Member States implementing EE measures for LIH**	Share of EU-countries implementing		Selected examples of specific measures	
			general EE policies	EE policies targeting LIH	* targeting LIH	** targeting all households
Incentives promoting renewable	**AT, BE, BG, HR, CY, CZ, DK, FI, FR, DE, EL, HU, IE, IT, LV, LT, LU, MT, NL, NO, PL, PT, RO, SI, ES, SE**	**none**	87 %	0 %	AT: Sanierungscheck* LT: Special programme for climate change* DE: Market Incentive Programme for Renewable Energies*	
Incentives for energy-efficient building renovations	**AT, BE, BG, HR, CZ, EE, FI, FR, DE, EL, HU, IE, IT, LV, LT, LU, MT, NL, NO, PL, RO, SK, SI, ES, SE, UK**	**BE, DE, FR, IE, LV, SI, UK**	87 %	23 %	DE: CO_2-Gebäudesanierungsprogramm* DE: Energieeffizientes Bauen (KfW)* AT: Sanierungs-check* FR: Habiter Mieux** Scotland: Home energy efficiency programmes**	
Investments in new buildings exceeding building regulations	**AT, BE, HR, CZ, FR, DE, IE, LV, LU, NL, NO, PL, SI, ES, SE, UK**	**none**	53 %	0 %	FR: Prêt à taux zéro (PTZ)*	
Incentives for appliance replacement		**AT, BE, DE, HU**	0 %	20 %	HU: Replacement of Household Appliances programme** DE: Caritas Stromspar-Check**	
Fiscal instruments						
Income tax credits or reduction	**BE, EE, FI, FR, IT, SE**	**EL, FR, IT**	26 %	9 %	FR: Crédit d'Impôt Transition Energétique (CITE)* Eststonia: Eesti eluasemevaldkonna arengukava*	
Legislative instruments						
Energy efficiency certificates for buildings	**AT, BE, BG, HR, CY, CZ, EE, FI, FR, DE, EL, HU, IE, IT, LV, LU, NL, NO, PL, PT, RO, SK, ES, SE, UK**	**none**	83 %	0 %	Spain: CER (Energy Performance Certificate for Buildings): FR: Diagnostic de performance énergétique (DPE)	
Energy performance standards for buildings	**BE, BG, HR, CY, CZ, DK, EE, FI, FR, DE, EL, HU, IE, IT, LV, LT, LU, MT, NL, NO, PL, PT, RO, SK, SI, ES, SE, UK**	**none**	93 %	0 %	FR: Réglementation thermique	
Energy performance standards for appliances	**AT, BE, BG, HR, CY, CZ, DK, EE, FI, FR, DE, EL, HU, IE, IT, LV, LT, LU, MT, NL, NO, PL, PT, RO, SK, SI, ES, SE, CH, UK**	**none**	100 %	0 %	DE: Energiebetriebene-Produkte-Gesetz – EBPG	
Energy labelling of household appliances	**AT, BE, BG, HR, CY, CZ, DK, EE, FI, FR, DE, EL, HU, IE, IT, LV, LT, LU, MT, NL, NO, PL, PT, RO, SK, SI, ES, SE, CH, UK**	**none**	100 %	0 %	DE: Energieverbrauchskennzeichnungs-verordnung:	
Smart metering and detailed energy billing	**AT, DE, IE, LV, NL, UK**	**none**	20 %	0 %	NL: Uitrol slimme meters* UK: Smart metering and billing*	

The table continues on the next page. →

Table 3. Continuation …

Policy topic by instrument used	EU-Member States implementing EE measures for households in general*	EU-Member States implementing EE measures for LIH**	Share of EU-countries implementing		Selected examples of specific measures	
			general EE policies	EE policies targeting LIH	* targeting LIH	** targeting all households
Informative/Education instruments						
Energy audits	**BE, CZ, EE, FI, FR, DE, EL, LV, LU, MT, NL, NO, ES**	**BE, DE, FR, IE, LV, SI, UK**	43 %	21 %	DE: BAFA Onsite Consultancy* DE: Caritas Stromspar-Check** IE: Better Homes Schemes** Scotland: Home energy efficiency programmes**	
Information campaigns and information centres	**AT, BE, CY, CZ, DK, EE, EU, FI, FR, DE, EL, HU, IE, LV, MT, NL, NO, PT, SK, ES, SE, UK**	**AT, DE, FR, IE, HU, MT, SI, UK**	73 %	27 %	DK: BedreBolig* DE: Caritas Stromspar-Check** IE: Better Energy Warmer Homes** UK: The Heating Cost Reduction Obligation*	
Voluntary labelling of buildings/ components	**AT, BE, CZ, DK, FI, FR, DE, IT, NO, SE, UK**	**none**	36 %	0 %	FR: Label haute performance énergétique (HPE)* AT: Klimaaktiv* *	
Market based instruments						
Energy efficiency obligations	**UK, FR, PL, AT, BG, LU, SI, ES, BE, IT, DK, LT, EE, MT, IE**	**AT, FR, IE, UK**	50 %	13 %	AT: Energy efficiency obligation for energy suppliers IE: Energy efficiency obligation scheme* UK: The Heating Cost Reduction Obligation*	

concrete policy measures contain components from different policy topics, i.e. it is common that loans *and grants for energy efficient building renovations* are combined *loans and grants promoting renewables* as well as *information campaigns* or *energy audits*. Nevertheless, the generic policy topics as used in Table 3 and Table 4 allow analyzing which barriers to EE are removed by the different specific policy topics:

Financial instruments: Policy topics within the financial instruments such as *incentives promoting renewable*, *incentives for EE building regulations* and *investments in new buildings exceeding building regulations* merely tackle the barrier *lack of access to external capital* by providing either loans or investment grants to promote energy-efficient construction. With households having a general preference for equity over debt[20] and low LIH having a lower creditworthiness than higher income households (Sorell et al.), policy measures within this policy topics might, if not specifically targeted to LIH, not be sufficient to entirely remove the lack of access to capital for EE investments which is characteristic to LIH.

Fiscal instruments: Tax credits of are applied to the purchase price of energy efficient materials and equipment, usually excluding installation costs. The interest paid on loans for thermal refurbishment of households is commonly also income tax-free. Considering that LIH by definition pay a less significant insignificant amount of income tax, income tax credits or are not expected to considerably alleviate the *lack of access to capital barriers*.

Legislative instruments: Legislative instruments can be subdivided in two categories, 1) legislative informative instruments, which comprise *EE certificates for buildings* and *energy labelling for appliances* as well as 2) legislative normative instruments which comprise *energy performance standards for buildings* and *energy performance standards for appliances*. As for the *legislative-informative* instruments, the policy measures within this category counteract the informative barrier *lack of knowledge on energy consumption*. Considering that there are numerous other behavioural and informative barriers (Table 2), it remains questionable if the information provided by labels and certificates is substantial to counteract all the informational barriers in the low-income sector. As for the legislative normative instruments, i.e. energy performance standards for buildings and energy performance standards for appliances, the barriers-to-investment framework do not apply: Performance standards force high EE of buildings, appliances and devices independently from market participant's decisions.

Informative/Education instruments: Information campaigns and information centres aim to raise awareness of market participants by informing about energy saving possibilities, energy cost reduction potentials, available financing programs, etc. Not only private households might be the target group of informational campaigns, but also stakeholders in energy markets such as contractors, architects, engineers, building industry stakeholders, workmen, landlords, house-owners, landlords, tenants, etc. Information and educational measures can alleviate numerous barriers, notably not only the informational ones, but also behavioural, economic and administrative barriers. For instance, information not only informs about energy consumption of the dwelling, saving potentials, difference be-

20.As reported by Fraunhofer ISE et al (2013).

tween general maintenance costs and energetic improvements, but also removes behavioural inertia by enhancing awareness of benefits of EE measures. Information on loans and grants can remove the lack of access to capital barriers as well as risk aversion barriers by enabling to asses with precision the costs and benefits of EE investments. Finally, information on administrative issues and regulations can also help to reduce administrative and regulatory barriers such as those present in multifamily housing. Instruments removing informative barriers are expected to benefit all households, disregarding their income level.

A further type of information provision is given through *energy audits*. *Energy audits* remove the same barriers as information campaigns, but provide individual-specific information on cost and benefits, i.e. thereby removing also the *lack of availability of individual-specific information due to heterogeneity of individual benefits* as well as the *lack of availability of specific information on individual financial support programs providing loans/grant.* Audits are therefore superior to general information campaigns for households through other channels such as information centres, seminars, brochures, etc. As reported by Caritas-Stromsparcheck (interview – 2016), energy audits with face to face counseling are of crucial importance of face to face counseling as a requisite to overcome the barrier resulting from individual-specific benefits attached to EE improvements.

Market based instruments: EEOs function by forcing the "obliged entities" to deliver a set of energy savings by incentivizing energy consumers to install EE measures. Article 7 of the EED requires Member States to introduce EEOs, by which energy companies must fund EE projects with 1.5 percent of their annual sales. Generally spoken, EEOs force EE improvements independently from market participant's decisions on energy investments. If obliged entities are required to induce energy savings in LIH, this segment might also strongly benefit from EEOs.

BEST CASE EXAMPLES POLICY MEASURES WITH CROSS CUTTING CHARACTERISTICS REMOVING BARRIERS FOR LIH

Scotland – Combining financing and informative measures

As mentioned, policy measures differ from conceptual and generic policy topics as previously presented by combining several components from different policy topics. The Scottish *home energy efficiency programmes for Scotland (HEEPS)* is an exemplary for program removing different barriers to EE investment by combining targeted financial instruments with informative instruments**.** The program is the Scottish government's main programme to deal with fuel poverty. Its holistic approach origins from the fact that it is a follow-up program bounding the preceding Boiler Scrappage Scheme (BSS), the Home Insulation Scheme (HIS), the Universal Home Insulation Scheme (UHIS) and the Energy Assistance Package (EAP), which delivered over 230,000 EE measures to Scottish households since 2009/10 (MURE (b) (2016)). The program combines *information provision* through the internet and through a hotline, followed by *energy audits* to determine the most beneficial individual-specific measures. Once determined, *financing is provided*. Finance for the most cost-effective measures is provided by the Scottish government and interest-free loans are available to meet costs of further, not subsidized measures (EST (2016)). The HEEPS program also includes different *area based schemes* (HEEPS:ABS), for which the Scottish Government made available £65 millions of grant funding in 2015/2016. This funding goes to local authorities to develop and deliver fuel poverty programs (mainly solid wall insulation) in parts of their council area with high levels of fuel poverty.

Germany – Combining informative measures with appliance replacement programs

The Caritas Stromspar-Check was initiated in Germany in 2008 with the initial scope to create employment for unemployed, while raising awareness on energy savings and sustainability in LIH (EP, 2016). Unemployed people were trained as energy counsellors with the aim to advice LIH on energy savings. During the pilot phase in 2009–2010, households were advised and instructed how to save energy, but not assisted with finance or effective devices. This approach didn't work: low-income households were reluctant to invest even small amounts of money to improve their energy consumption. From a **barriers-to-energy-efficiency** perspective, it became visible that the informational barrier was indeed present and had to be removed firstly, but removing this barrier through the audit was not enough to trigger efficiency investments. The behavioural inertia and the lack of finance were still strongly limiting. The program was adapted and started not only to provide audits and behavioural training, but also the new, more efficient appliances. Some days after the audit, new, fully subsidized highly-efficient devices are delivered and installed to the dwelling. On average, a household benefits with electricity savings of approx. 16 % per year from appliance replacements with a market value of (on average) €70.

While the illustrated Scottish *Home Energy Efficiency Programmes for Scotland* and the German *Caritas Stromspar-Check* are presented in depth within the previous section, a number of EU-wide and international best practices to deliver EE to LIH are presented by EP (2016). Particularly relevant are USA's *Weatherisation Assistance Program* (WAP), New Zealand's *Warm Up New Zealand* program, Mexico's *Cash for Coolers*, the Irish *Better Homes Scheme,* France's *Habiter Mieu* and Austrias *Sanierungs-check.*

Multiple benefits of energy efficiency in low-income households

The evaluation of costs and benefits of EE investments might differ widely depending on the benefits considered in the analysis. When merely accounting monetary energy savings as benefits, a large share of EE investment options would not be considered to be cost-effective. When including further aspects in the analysis, the benefits can significantly over-compensate the cost of EE investments (Zhang et al. 2016). Vast recent scientific literature[21] points to the fact that EE measures in households produce many other direct or indirect benefits than merely energy savings – the so called multiple benefits of EE, which

21. With IEA 2014 and Ryan and Campbell, 2012 providing overviews on the extensive literature related to the topic.

Table 4. Overview on EE policy topics in the EU and specific barriers removed by the topics.

Policy topics by instrument used	Barriers categories removed	Specific barrier's removed
Financial instruments*		
Incentives promoting renewables	**Economic (1)**	**– Lack of access to external capital**
Incentives for energy-efficient building renovations	**Economic (1)**	**– Lack of access to external capital**
Investments in new buildings exceeding building regulations	**Economic (1)**	**– Lack of access to external capital**
Fiscal instruments*		
Income tax credits or reduction	**Economic (1)**	**– Lack of access to external capital**
Legislative instruments*		
Energy efficiency certificates for buildings	**Information (1)**	**– Lack of knowledge on energy consumption**
Energy performance standards for buildings	not applicable	*Forces high energy efficiency of buildings independently from market participant´s decisions.*
Energy performance standards for appliances	not applicable	*Forces high energy efficiency of appliances independently from market participant´s decisions.*
Energy labelling of household appliances	**Information (1)**	**– Lack of knowledge on energy consumption**
Smart metering and detailed energy billing	**Information (2)**	**– Lack of knowledge on energy consumption** **– Lack of availability of individual-specific information**
Informative/Education instruments*		
Information campaigns and information centres	**Behavioural (2)** **Information (7)** **Economic (3)** **Administrative (1)** **Total= 13**	**– Lack of general awareness of benefits of energy efficiency measures** **– Behavioural inertia and bounded rationality** **– Lack of knowledge on energy consumption/ saving potential of the dwelling** **– Misperception on known consumption / lack of knowledge on saving potentials** **– Lack of availability of general information related to energy consumption, energy saving** **– Lack of availability of understandable information (complexity of information, form of information** **– Lack of availability of individual-specific information due to heterogeneity of individual benefits** **– Lack of availability of specific information on individual support programs providing loans/grants** **– Lack of availability of information on consultancy and advisory services** **– Risk aversion due to long amortisation time** **– Risk aversion due to preference for equity over debt** **– Risk aversion due to preference to technological risk** **– Complex owner structures in multi-family housing**
Voluntary labelling of buildings/ components	**Information (1)**	**– Lack of knowledge on energy consumption**
Energy audits	**Behavioural (2)** **Information (9)** **Economic (3)** **Administrative (1)** **Total= 16**	Same as *information campaigns and information centers* but additionally removing the individual-specific barriers **– Lack of availability of individual-specific information due to heterogeneity of individual benefits** **– Lack of availability of specific information on individual support programs providing loans/grants**
Market based instruments*		
Energy efficiency obligations	not applicable	*Obligated parties are forced to improve energy efficiency.*

can be classified in *environmental*, *economic* and *social benefits* (Ryan and Campbell, 2012):

Environmental Benefits: The instantaneous benefits of increased efficiency, which result on primary and final energy consumption savings, less fossil fuels use, as well as the reduction of local pollutants and GHG emissions related to energy conversion, are self-evident.

Economic Benefits: *Economic benefits* go beyond the pure cost savings induced by energy efficiency investments. On an individual base, the cost savings materialize by *increasing disposable income*, while also *increasing asset values* due to their higher energy performance. From a macroeconomic perspective, increasing energy productivity can have substantial *effect on employment*, *economic growth* and *competitiveness*. BPIE (2011) reports an approximate net impact of 17–19 jobs per million Euros spent on energy efficiency. IEA (2014) reports a wider range of 8 to 27 job years per EUR 1 million invested, while the range of estimates can vary to a great extent. Similarly, Ryan and Campbell (2012) report that estimates regarding GDP effects due to increased energy efficiency are small but positive.

Further, increased EE can have an *effect on public budgets*. IEA (2014) describes several channels of interaction, in particular the effects on public budgets by reducing government expenditures on energy, by increasing tax revenues due to 1) increased economic activity or 2) spending on energy efficiency-related and other goods and services. In the context LIH a further effect on public budgets can be noted. As depicted in Figure 1 in, fuel poverty can be tackled either through social policies or through EE policies. Both approaches have the potential to reduce the deprivation caused by fuel poverty. In consequence, investing in cost-effective EE improvements trades off in a reduction of spending for social security payments related to energy subsidies.

Social benefits: The *social benefits*, i.e. benefits on living conditions of households, have lately been subject to analysis by an increasing number of studies, with a particular focus to health impacts of increased EE: Willand et al. (2015) gives several examples of health benefits from EE measures in household including respiratory health, cardiovascular diseases, general health and mortality, mental health, autonomy and social status of residents. Especially LIH see significant improvements in health following EE measures (Maidment et al. 2014). This again emphasises the importance of EE measures as part of a strategy to tackle social issues like health inequity. Other health benefits are strongly related to (local) emissions from power plants, district heating and local residential heating systems, as well as emissions from transport, agriculture and industry. Fossil fuel based electricity and heat generation lead to increased concentrations of local air pollutant such as NO_x, SO_2, small particle matters (PM2.5[22]) as well as GHG such as CO_2. Reducing energy consumption in turn implies a partial reduction of pollution. Lelieveld et al. (2015) estimate that outdoor air pollution, mostly by PM2.5, lead to 3.3 million premature deaths per year worldwide.

22. Fine airborne particulate matter with a diameter <2.5 µm, which is linked to respiratory diseases and cardiovascular diseases (Dockery et al. 1993).

Alleviation of poverty in general as well as fuel poverty represents a further social benefit from improved EE. Energy affordability represents both a cause and a symptom of poverty (Ryan and Campbell (2012)). Poverty and fuel poverty are alleviated by EE through increasing disposable incomes. However, the higher disposable incomes can lead to increased heating and to acquire and use of more energy consuming appliances. For this reason, savings can be less pronounced and even non-existent due to rebound effects and sometimes rising energy prices can also outweigh savings (Willand et al., 2015). The re-investment of increased disposable income to heat more space or to acquire and use energy consuming appliances entails an increase in the living standards and conditions of deprived households. In this light, the rebound effects can be associated with a positive overall social outcome (Ryan and Campbell (2012)).

Investments in measures regarding energy efficiency of buildings have, as regarded within the *economic benefits*, net positive impacts on employment. With the majority of the direct jobs created expected to be created in the construction sector (e.g. IWU; Fraunhofer IFAM (2016)) and requiring low levels of education, LIH might thus benefit through additional employment opportunities. In this light, the job effects not only represent *economic benefits* but can also be classified to be *social benefits*.

Table 5 presents an overview on the previously presented multiple benefits, while depicting the time frame for the effect (short vs. long term), the level at which the outcome takes effect (individual vs. national), the dependency of the benefit on energy savings (yes vs. no) and if a rebound effect is expected. As previously outlined, some of the multiple benefits of energy efficiency are particularly relevant to the context of LIH, such as the *increased disposable income* along with most of the *social benefits,* such as *increased health*, *job creation*, *poverty alleviation*, etc. Notably, these benefits set a clear incentive to increase energy consumption thus represent drivers of the rebound effect. While the rebound effect is counterproductive to reaching energy reduction or GHG emission targets as such, many benefits such as improved health, job creation, increased asset values, will expected to remain even in presence of a rebound effect. For this reason, the rebound effect associated with many of these benefits can generally be associated with a positive overall social outcome, disregarding its counterproductive effect in terms of increasing GHG emissions (Ryan and Campbell (2012)).

Concluding, a holistic approach to evaluate EE-investment options should, to the best possible extents, consider the wide range of possible benefits presented in this section. The exact evaluation of multiple benefits of EE remains subject to empirical analysis. However, in view of the multiple benefits attached to EE measures, EE measures might be evaluated as a more attractive policy options to assist LIH than social policies – such as income assistance or energy subsides.

Conclusions and policy recommendations

Fuel poverty is a widespread problem in the European Union. It can be alleviated through income assistance or through improving EE of households. While income assistance or energy allowances are beneficial for their recipients, improving effi-

Table 5. Multiple benefits of energy efficiency (adapted from Ryan and Campbell (2012).

Benefits	Time-frame for effect		Level at which outcome takes effect		Depends on energy saving?	Rebound effect
	Short	Long	Individual	National		Impact on energy consumption?
Environmental benefits						
Reduced greenhouse gas emissions	X			X	yes	no
Enhanced resource management	X		X	X	yes	no
Reduced air/water pollutants	X		X	X	yes	no
Economic benefits						
Increased asset values	X		X	X	no	no
Increased disposable income	X		X	X	yes	yes
Industrial productivity	X		X	X	no	yes
Energy provider benefits and infrastructure	X	X	X	X	yes	no
Energy prices	X	X		X	yes	yes
Public budgets		X		X	yes	yes
Energy security		X		X	yes	no
Macro-economic effects		X		X	no	yes
Social benefits						
Health	X		X	X	no	yes
Energy affordability/poverty alleviation	X		X		yes	yes
Energy access		X	X	X	no	yes
Development	X			X	no	yes
Job creation	X		X	X	no	yes

ciency can not only alleviate fuel poverty, but also induce the multiple benefits of EE, such as improved health, increased jobs and lead to a reduction in energy subsidies.

Barriers to EE are inhibiting factors to investments in EE by private households. Behavioural, informational, economic and administrative barriers hinder participants from improving EE. LIH face a subset of different barriers to EE than high-income households. In particular, lack of information and lack of finance are crucial barriers for them to improve the EE of the dwellings they live in. Removing barriers to EE is not only legitimated by climate change representing a market failure in terms of a global inter-temporal externality, but also by the fact that many of the barriers to EE also represent market failures. Energy markets thus do not provide the optimal level of EE, thereby causing the *energy paradox, i.e.* the gap between the theoretical optimal level of EE and the observed one. Policy measures can remove numerous barriers to EE investments in the residential sector. With exception of EEOs and performance standards for buildings and appliances, EE policies in the residential sector function by removing specific barriers to EE investments by market participants. However, only a limited share of EU countries have EE policies implemented specifically targeting LIH. Concrete policy measures to increase EE in LIH might combine different type of policy types (e.g. financial instruments, informational/educational instruments, etc.) and thereby remove the different barrier's types which are present in LIH, such as behavioral, informational, economic and administrative barriers. Selected examples of concrete policy measures tackling different barriers are, among others[23], the *Home Energy Efficiency Programme of Scotland* or the *Caritas appliance replacement programme in Germany*. Informational/educational instruments, in particular energy audits, are not only good to remove informational barriers, but can also remove behavioural, economic, and administrative barriers. Combining informational measures such as energy audits with financial measures such as subsidies, loans and grants can be very effective in improving EE in LIH.

Following the presented analysis and in-line with EP (2016), we provide the following recommendations to specifically address EE improvements in LIH[24]:

1. **Common Definition**: 'To support and incentivize design of EE policies that effectively address *vulnerable consumers*, a common definition of *vulnerable consumers* and *fuel poverty* at EU level is required. It is thus recommendable to deline-

23. A number of further EU-wide and international best practices to deliver EE to LIH are presented by EP (2016).

24. Of note, EP (2016) presents specific recommendations to individual articles of the EED, EPBD.

ate an EU-wide definition, but simultaneously accounting for the heterogeneity at European level by leaving the Member States the freedom to further adapt these definitions.

2. **EU Climate Targets**: Long-term targets on energy savings in the European building sector require that all types of end-users are addressed, including vulnerable households[25] among others. Active monitoring the achievements by end users can ensure that Member States achieve their targets among all types of end-users.
3. **Multiple benefits of EE:** With vast recent scientific research outlining the fact that the benefits of EE are beyond energy savings, costs savings and environmental benefits, EE measures should be designed in such a way that they support these additional benefits. In particular, when considering that many of the multiple benefits of EE are particularly relevant to the context of LIH, such as the increased disposable income along with most of the social benefits, such as increased health, job creation, poverty alleviation, etc. These benefits set a clear incentive to increase energy consumption thus represent drivers of increased energy consumption, i.e. generating a rebound effect. While the rebound effect is counterproductive in reaching energy reduction or GHG emission targets as such, the multiple benefits associated with increased EE can generally be associated with a positive overall social outcome.
4. **Specific barriers:** In view of the subset of specific barriers to EE investments present in LIH (such as lack of capital, lack of information, etc.), policy measures should be customized to integrate measures that address specific barriers or monitoring requirements for these end-users.
5. **Strategy towards fuel poverty**: Fuel poverty can be reduced either through social policies (such as income assistance, reduced tariffs, tolerance for non-payment) or through EE policies. Only a limited amount of EU-countries have targeted EE policies towards LIH. EE policies to reduce fuel poverty should be considered instead of limiting the policy approach to social policies. The choice of targeted policies is best left to the Member States.
6. **Financing**: In view of the multiple benefits of EE, financing EE policies could partly stem from infrastructure funds from other sectors that positively benefit from the impacts of increased EE, as for example health or social welfare funds.

List of Acronyms

BSS	Boiler Scrappage Scheme
EAP	Energy Assistance Package
EC	European Commission
EE	Energy Efficiency
EED	Energy Efficiency Directive
EEO	Energy Efficiency Obligations
EP	European Parliament
EPBD	Energy Performance for Buildings Directive
EU	European Union
GHG	Greenhouse Gas
HEEPS	Home Energy Efficiency Programmes for Scotland
HIS	Home Insulation Scheme
IEA	International Energy Agency
ISCED	International Standard Classification of Education
ITRE	Industry, Research and Energy
LIH	Low Income Households
UHIS	Universal Home Insulation Scheme

25. Of note, this argumentation is valid for different type of end-users, from which different barriers to the implementation of energy efficiency are expected, such as elderly population, rural households etc. (*EP, 2016*).

References

Bird J., R. Campbell and K. Lawton, (2010), *The Long Cold Winter: Beating Fuel Poverty*, IPPR (Institute for Public Policy Research) and NEA (National Energy Action), London, 2010, available at www.energy-uk.org.uk/publication/finish/6/284.html.

Bird, S., Hernández, D., (2012) P*olicy options for the split incentive: Increasing energy efficiency for low-income renters*, Energy Policy, Volume 48, September 2012, Pages 506–514.

Bouzarovski, S., (2013), *Social justice and climate change: addressing energy poverty at the European scale. Social platform*, 2013, available at http://www.socialplatform.org/documents/article-social-justice-and-climate-change-addressing-energy-poverty-at-the-european-scale/.

Buildings performance Institute Europe (BPIE) (2011), *Europe's Buildings Under the Microscope*, BPIE, Brussels, available online: www.bpie.eu/eu_buildings_under_microscope.html.

Buildings performance Institute Europe BPIE (2014), *Alleviating Fuel Poverty in the EU. Investing in home renovation, a sustainable and inclusive solution*, available online: http://bpie.eu/wp-content/uploads/2015/10/Alleviating-fuel-poverty.pdf.

Brown, M.A. (2001). *Market failures and barriers as a basis for clean energy policies*. Energy Policy, 29, 14, 1197–1207, ISSN 0301-4215.

Charlier, D. (2015) *Energy efficiency investments in the context of split incentives among French households*, Energy Policy, Volume 87, December 2015, Pages 465–479.

Dockery, D. W.; Pope, C. A. 3rd; Xu, X.; Spengler, J. D.; Ware, J. H.; Fay, M. E. et al. (1993): *An association between air pollution and mortality in six U.S. cities*. In The New England journal of medicine 329 (24), pp. 1753–1759. DOI: 10.1056/NEJM199312093292401.

EP (2015), *How to end Energy Poverty? Scrutiny of Current EU and Member States Instruments*, available online: http://www.europarl.europa.eu/RegData/etudes/STUD/2015/563472/IPOL_STU%282015%29563472_EN.pdf.

EP (2015), Boosting Building Renovation: What potential and value for Europe? available online: http://www.europarl.europa.eu/RegData/etudes/STUD/2016/587326/IPOL_STU%282016%29587326_EN.pdf

EP, (2016), *Energy Efficiency for Low-Income Households*, available online http://www.europarl.europa.eu/committees/en/itre/supporting-analyses.html.

EC (2010), *DIRECTIVE 2010/31/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 19 May 2010 on the energy performance of buildings (recast),* 2010.

EC (2012), *DIRECTIVE 2012/27/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC*, 2012.

EC (2012) Low-Carbon Efficiency Roadmap, available online: https://ec.europa.eu/clima/policies/strategies/2050_en.

EC (2016), DG Energy, *Selecting Indicators to Measure Energy Poverty,* available online: https://ec.europa.eu/energy/sites/ener/files/documents/Selecting%20Indicators%20to%20Measure%20Energy%20Poverty.pdf.

Eurostat (2013) *Is the likelihood of poverty inherited*? – Issue number 27/2013, available online: http://ec.europa.eu/eurostat/web/products-statistics-in-focus/-/KS-SF-13-027.

Eurostat, *EU Statistics on Income and Living Conditions (EU-SILC)*, Brussels, 2015, available online: http://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:EU_statistics_on_income_and_living_conditions_%28EU-SILC%29/de

Eurostat (2017a) *Mean and median income by educational attainment level* – EU-SILC survey. Available online at http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=ilc_di08.

Eurostat (2017b) *Distribution of population by degree of urbanisation, dwelling type and income group – EU-SILC survey (ilc_lvho01). Available online http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=ilc_lvho01*.

Energy Saving Trust – EST (2016): Website of the energy saving trust, available online: http://www.energysavingtrust.org.uk/scotland/grants-loans/heeps/heeps-warmer-homes-scotland-scheme.

Fraunhofer ISE et al., *Erarbeitung einer Integrierten Wärme- und Kältestrategie*, available upon request at the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, Referat KI III 2, 2012.

International Energy Agency (IEA) (2003), *Creating Markets for Energy Technologies*. International Energy Agency, Paris: OECD Publishing, 2003.

International Energy Agency (IEA) (2007), *Mind the Gap*. International Energy Agency, Paris: OECD Publishing, 2007.

International Energy Agency (IEA) (2012), *World Energy Outlook*. International Energy Agency, Paris: OECD Publishing, 2012.

International Energy Agency (IEA) (2014): C*apturing the Multiple Benefits of Energy Efficiency. A Guide to Quantifying the Value Added*. Paris: OECD Publishing, 2014.

IWU; Fraunhofer IFAM (2016): Monitoring der KfW-Programme „Energieeffizient Sanieren" und „Energieeffizient Bauen" 2015. KfW. Available online at https://www.kfw.de/PDF/Download-Center/Konzernthemen/Research/PDF-Dokumente-alle-Evaluationen/Monitoringbericht_EBS_2015.pdf.

INSIGH-E (2015), *Energy poverty and vulnerable consumers in the energy sector across the EU: analysis of policies and measures*, 2015.

Lelieveld, J.; Evans, J. S.; Fnais, M.; Giannadaki, D.; Pozzer, A. (2015): *The contribution of outdoor air pollution sources to premature mortality on a global scale*. In Nature 525 (7569), pp. 367–371. DOI: 10.1038/nature15371.

MISSOC (a) (2016), *Your social security rights in each Member State* (standardized reports for all EU-Member States), 2016.

MISSOC (b) (2016), *Comparative Tables Database*, available online: http://www.missoc.org.

ODYSSEE-MURE (a) (2016) Online Database, available online: http://www.odyssee-mure.eu/.

ODYSSEE-MURE (b) (2016) Online Database UK33 Policy Measure's Assessment, available online: http://www.measures-odyssee-mure.eu/public/mure_pdf/general/UK33.PDF.

Perman et al, *Natural Resource and Environmental Economics*, third edition 2003 Pearson Education Limited 2003.

Ryan, Lisa; Campbell, Nina (2012): Spreading the net. *The multiple benefits of energy efficiency improvements*. IEA. Available online at https://www.iea.org/publications/insights/insightpublications/Spreading_the_Net.pdf.

Shove, Elisabeth (2009): *Beyond the ABC: climate change policy and theories of social change,* in Environment and Planning A 2010, volume 42, pages 1273–1285, available online: https://blog.itu.dk/hest/files/2012/10/shove_abc.pdf.

Sorrell et al., *Reducing Barriers to Energy Efficiency in Public and Private Organizations,* Study funded in part by THE EUROPEAN COMMISSION in the framework of the Non Nuclear Energy Programme, 2000.

Stern, N. H., & Great Britain. (2007). *The economics of climate change: The Stern review*. Cambridge, UK: Cambridge University Press.

Thollander P, Palm J, Rohdin P, (2010), *Categorizing barriers to energy efficiency – an interdisciplinary perspective*, 2010.

Willand, Nicola; Ridley, Ian; Maller, Cecily (2015): *Towards explaining the health impacts of residential energy efficiency interventions – A realist review*. Part 1: Pathways. In Social science & medicine *(1982)* 133, pp. 191–201. DOI: 10.1016/j.socscimed.2015.02.005.

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Table 6. Interviews performed during research.

Organization/Country	Main topics discussed
Bo-Ex – Housing Association of Utrecht, The Netherlands	Bo-Ex experience in renovating old households without increasing rent
Caritas, Germany	Caritas appliance replacement program
CONUEE – National Energy Efficiency Commission, Mexico	Targeted energy efficiency programs as a replacement of non-discriminatory subsidies
CURE – Centre for Urban Resilience and Energy, University of Manchester, United Kingdom	Barriers and best practices in the United Kingdom and in Eastern Europe
Energieheld, Germany	Barriers to efficiency in thermal renovation
Euroace, Belgium	Policy options to address low-income households
ICAEN Institut Català de l'Energia, Spain	Financial barriers to retrofit of buildings and household appliances
KfW-Bank, Germany	Loans, grants and financing for household's refurbishment
Municipality of Rubí, Catalonia, Spain	Overcoming informational and financial barriers in Southern Europe
Municipality of Utrecht, The Netherlands	Financing of energy efficiency measures in social housing
Policy Advisor, United Kingdom	Policy options to address low-income households, best practices from UK
Volgroen, The Netherlands	Barriers and access to finance for energy efficiency projects
WSP,Sweden	Energy poverty, Energy Efficiency and Social Security Systems in Sweden