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Building synergies between climate change mitigation and energy poverty alleviation

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ABSTRACT

Even though energy poverty alleviation and climate change mitigation are inextricably linked policy goals, they have remained as relatively disconnected fields of research inquiry and policy development. Acknowledging this gap, this paper explores the mainstream academic and policy literatures to provide a taxonomy of interactions and identify synergies and trade-offs between them. The most important trade-off identified is the potential increase in energy poverty levels as a result of strong climate change action if the internalisation of the external costs of carbon emissions is not offset by efficiency gains. The most significant synergy was found in deep energy efficiency in buildings. The paper argues that neither of the two problems – deep reductions in GHG emissions by mid-century, and energy poverty eradication – is likely to be solved fully on their own merit, while joining the two policy goals may provide a very solid case for deep efficiency improvements. Thus, the paper calls for a strong integration of these two policy goals (plus other key related benefits like energy security or employment), in order to provide sufficient policy motivation to mobilise a wide-scale implementation of deep energy efficiency standards.

1. Introduction and aims

Fighting climate change has become one of the most accepted and celebrated environmental policy priorities, resulting in the re-contextualisation of many seemingly unrelated subjects, which are now often presented from this new perspective. However, sometimes the link may be or seems somewhat artificial. And for a lay audience, forging the link between energy poverty alleviation and climate change mitigation may also seem like trying to sell a less *sexy* subject in a more popular packaging.

This happens at a time when large challenges lie in front of national and global decision-makers as a massive decarbonisation of the world economy (i.e., a 50–85% reduction in the year 2000 global carbonCO_2 emissions by 2050, as suggested by IPCC, 2007) needs to be achieved while improving the life standards of the global population. These challenges are especially difficult in those world regions or societal segments that have less benefited from the developments that have resulted in current GHG atmospheric concentrations. Complex policy frameworks are thus needed to reach a delicate balance between a better satisfaction of the needs of present generations and an effective protection of the rights of future generations to enjoy a stable and safe climate. Additionally, in less affluent geographic and social areas where immediate economic priorities override environmental concerns, climate change alone is often not a sufficient policy goal to be able to mobilise enough political will or adequate action.

Typically, alleviating poverty is not the most obvious area for policy integration with climate change because these two rank high on rather different local political agendas. Nevertheless, this paper argues that alleviating one particular type of poverty – energy poverty – offers strong synergies with climate change mitigation agendas, for two reasons. First, the buildings end-use sector offers the largest and most cost-effective mitigation potential according to global and regional estimates (IPCC, 2007; Ürge-Vorsatz and Novikova, 2008; Eichhammer et al., 2009). Second, a key mitigation strategy to capture these potentials in buildings can also alleviate, or even fully eradicate fuel poverty, providing the ground for successfully aligning shorter-term social and longer-term environmental priorities. Otherwise, as Boardman (2010, p. 17) has put it, "there is a risk [...] of seeing fuel poverty as a peripheral side issue that can be tackled by social and fuel pricing policy. This is incorrect and has failed for the last 30 years [in the UK]. The obligations to the present generation must not be obscured by our commitment to future generations and they do not have to be."

In this context, the co-benefits or ancillary benefits of mitigation policies may provide the key entry points to policy-making.

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If, as argued by the co-benefits literature, emission reduction measures also have substantial positive effects on the welfare of present generations (Pearce, 2000; Markandya and Rübbelke, 2004; IPCC, 2007), these will provide additional – or sometimes the main – incentives for decision-makers to engage in more resolute climate action. Conversely, other policy goals may also not score sufficiently high on political agendas in order to mobilise adequate resources for tackling them alone. Either way, the integration of multiple policy goals may tip the balance in the cost-benefit considerations towards action (Lafferty and Hovden, 2003; EEA, 2005). Therefore, exploring and assessing the co-benefits and forging policy synergies offer important avenues into achieving policy goals that otherwise may not seem weighty enough for sufficient societal investments. In fact, as we argue in subsequent sections, it may be difficult to address both the climate and poverty challenges without a concerted effort at establishing the policy link between the two areas.

A main purpose of this paper is to map the taxonomy of interactions between the climate change mitigation and energy poverty alleviation policy areas and to identify the main synergies between the two fields of policy action. This way, it also aims at addressing a certain gap in the energy/fuel poverty literature, which has focused mostly on its social and human health aspects but has not consistently explored its climate change implications, with some exceptions (e.g., Pett, 2009; Boardman, 2010). Additionally, given the policy relevance of these elements, policy approaches are discussed in order to support some main arguments of this paper, though the aim is not to provide a proper analysis of policies implemented in developed and transition economies.

For that, we first make a short review of the fuel/energy poverty concept in the context of this paper (Section 2) and then explore the typology of the general interactions between these two fields of enquiry (Section 3). We later focus on deep energy efficiency retrofits as a win–win long-term solution to both the energy poverty and climate change challenges (Section 4). Finally, Section 5 provides a summary of the main conclusions of this analytical review.

2. Energy poverty—the concept

2.1. An energy affordability issue

The authors are aware of the apparent terminological confusion existing between the terms of energy and fuel poverty: on the one hand, *fuel poverty* is the without doubt the favoured wording in English-speaking nations such as the UK (e.g., Boardman, 1991; BERR, 2001), where the concept originated, and Ireland (e.g., MacAvoy, 2007), On the other hand, key references for Central and Eastern Europe (Buzar, 2007a, 2007b, 2007c) and other EU-level institutional sources like Morgan (2008) and EUFORES (2008) refer to the same phenomenon as *energy poverty*. However, other authors speak of *energy poverty* when referring to the lack of access of quality energy carriers, mostly in developing countries (Birol, 2007; Sagar, 2005). The latter is an issue that, though related, falls out of the scope of this paper (see Section 2.3).

In the original definitions that are currently prevalent in the UK (Boardman, 1991, 2010; BERR, 2001), fuel poverty is described as a household's inability to ensure an adequate thermal regime in its living space. These sources usually rely on objectively measured fuel poverty rates based on expenditure, income and indoor temperatures, and have been criticised because they fail "to capture the wider elements of fuel poverty" and are "based on arbitrary calculations and estimations" (Healy, 2004, p. 36). An alternative set of indicators that favours a more subjective approach based on households' self-reported measurements has been thus proposed (Healy and Clinch, 2002, 2004). Other authors have stressed the role of societal norms in setting the thresholds beyond which a household is in fuel poverty (Buzar, 2007a) and the relevance of energy prices (EPEE, 2009). However, all of them emphasise the affordability of heating as a key energy service for a household's well-being and somehow downplay the importance of other domestic end-uses of energy. And many are motivated by the defined policy response, i.e., they are directed at identifying the population sub-segments that can be defined to be in energy poverty and therefore needing special policy attention, and they are thus linked to specific measurement systems or indicators.

Based on the assessment of the literature and experience of the authors, we define *energy poverty* as a broader concept encompassing the various sorts of affordability-related challenges of the provision of adequate energy services to the domestic space. These typically represent situations in which households with access to modern energy carriers cannot comfortably satisfy their energy service needs, be it because of their inability to afford sufficient energy services and/or because of the disproportional costs they have to bear for those energy services (see an example of the latter in Tirado Herrero and Ürge-Vorsatz (this issue). By choosing to refer to this phenomenon as energy poverty – and not as fuel poverty – the papers aims at a larger scope of the conventional fuel poverty notion: not only the space heating needs of a household have to be met for ensuring its well-being, but also other energy service demands such as space cooling, lighting and powering appliances (many of which require electricity, not a fuel itself). In that sense, for instance, the paper emphasises the summertime, cooling-related energy poverty first defined by Healy (2004), which is likely to be enhanced by the foreseen increase in summer temperatures induced by climate change.

2.2. Poverty and energy poverty

The concept of energy poverty has become important recently in several developed countries, where deep general poverty has been more or less eradicated (as compared to developing nations) while some specific inequalities in the living conditions of the population still prevail. In this sense, particularly important is the definition of relative poverty by Townsend (1979, p. 31), according to which

> individuals, families and groups in the population can be said to be in poverty when they lack the resources to obtain the types of diet, participate in the activities, and have the living conditions and amenities which are customary, or are at least widely encouraged and approved, in the societies in which they belong.

and upon which some later energy poverty definitions (e.g., Healy, 2004; Buzar, 2007a) have been grounded. It stresses the conditions that a *decent life* should fulfil and identifies a list of items (e.g., diet, clothing, shelter, environment, etc.) that define the necessities that are recognised as such in a society (European Communities, 2009). Thus enjoying an adequate provision of domestic energy services is one of those basic needs that a household is expected to meet. In that sense, energy poverty is one component of a multi-faceted deprivation notion that encompasses the various aspects of human life.

Why then discuss energy poverty as a distinct concept from just being a face of poverty? Even though solving the energy poverty challenge contributes to solve only one specific aspect of a complex deprivation picture, this goal has a justification in itself especially because of the comfort and human health gains that derive from it, i.e., it is known that energy poverty is a cause of excess winter mortality and of a number of physical and mental diseases (The Eurowinter Group, 1997; Healy, 2004; Liddell and Morris, 2010). That way, the UK – the most advanced country in this policy field – has made it a legal obligation the eradication of fuel poverty by 2016, though the ability of the government to reach its self-imposed target is seriously questioned (Boardman, 2010). In addition, energy poverty is narrowly connected to the climate challenge through the energy performance of the residential stock. As argued in this paper, this provides a second, key argument to prioritise energy poverty alleviation as a policy target.

2.3. Geographical scope

Though energy poverty is mostly a European subject (Boardman, 1991; Healy, 2004; Buzar, 2007a; Morgan, 2008; EPEE project, 2009; EC, 2010), domestic energy affordability issues are likely to be equally relevant in other large industrial and transition nations and large carbon emitters like the USA, China and the Russian Federation. The geographical context for aspects discussed in this paper is thus the transition and developed economies of Eurasia, the Pacific and America, where the existing infrastructure practically guarantees an universal access to energy services but a combination high energy prices, low incomes and poor energy efficiency of the residential stock prevents a certain segments of the population comfortably satisfy their energy service needs.

However, energy poverty can be also regarded as a broader notion not only referring to the affordability of energy (particularly heating) but also related to more complex issues such as access to modern energy services. This is very relevant for developing countries even though traditionally the poverty, energy access and environmental agendas and thus research have been largely disconnected, with some exceptions (e.g., Pachauri and Spreng, 2003; Sagar, 2005; Birol, 2007). Though these aspects are acknowledged they are not discussed in this paper as they would require their own in-depth analysis.

3. Exploring the energy poverty and climate change connection

3.1. Taxonomy of interactions

Climate change and energy poverty are two largely different phenomena both often partially rooted in the inefficient use of energy in buildings. Depending on their mid- and long-term evolution and on the policy responses provided, a number of different outcomes can be expected in terms of the mitigation of climate change and the alleviation of energy poverty.

Acknowledging that not all policy responses are equally fit to tackle both challenges simultaneously, Table 1 presents a taxonomy of interactions between these two policy areas, with two main typologies suggested. Synergies are identified when the effect on both the energy poverty alleviation and climate change mitigation goals point into the same direction (be it negative or positive), and trade-offs are found in the opposite case. By definition, all trade-offs are regarded as undesirable because they allow advancing on a policy field only at the expense of the other (e.g., letting emissions grow unabated results in a warmer climate but reduces energy poverty levels), but some synergies are not desirable either (e.g., a warmer climate enhances summertime energy poverty). Thus only desirable synergies which are beneficial to both goals are identified as policy levers that allow advancing simultaneously in the energy poverty alleviation and climate change mitigation agendas.

Table 1 shows, that even though most connections between climate and energy poverty issues are drawn on the mitigation side, adaptation aspects may become increasingly important: milder winters in temperate regions will have positive energy poverty alleviation effects and the increase of temperatures in the warm season could make the so far unexplored summertime energy poverty (Healy, 2004) a more relevant aspect of the energy deprivation challenge. Cooling-related energy poverty is thus expected to have trade-offs and synergies with climate change mitigation depending on the route of the solution. If the main adaptation method is increased air conditioning, this will have detrimental effects on both energy poverty and climate change mitigation. On the contrary cooling-related energy poverty can be better prevented through climate action (e.g., climate-resilient building design, eradication of heat islands, etc.).

3.2. Energy poverty perspective: three contributing factors

Understanding the roots of energy poverty offers further key opportunities for alleviating both the energy services affordability and the climate change mitigation challenges, and places the energy poverty problem on the energy radar screens. From that perspective, three elements usually regarded as main contributing factors to the energy poverty phenomenon are considered: household income, energy prices and energy efficiency of the dwelling (BERR, 2001; OECD/IEA, 2011). These underlying factors of energy poverty provide the analytical framework for this review and offer a ground for key entry points into policy-making.

First, low incomes have been usually regarded as an important cause of energy poverty as less affluent household often live in poorer-quality housing and have more restricted budgets to spend on energy (as well as on other goods and services). Its analysis has long belonged to a more general field of inquiry such as the study of poverty and deprivation and policy action is restricted because the income level of a household largely depends upon factors beyond the sphere of influence of an energy poverty alleviation policy (e.g., overall performance of the national economy, educational attainment of the household's members, etc.) However, although the literature and thus the documented evidence on this are scarce, this paper argues that providing a long-term solution to the energy poverty problem via households' income (e.g., through subsidies to energy costs or fuel payments) is often difficult because extra income may not be used by households for covering their unmet energy service needs or for improving the energy efficiency of their dwellings (Healy, 2004; Boardman, 2010). They have been also criticised because they are often poorly targeted and become a burden in public budgets (Scott, 1996; Tirado Herrero and Ürge-Vorsatz, 2010), thus making income support schemes dependant on the availability of funds or the willingness of decision-makers.

Energy prices are a second level through which energy poverty has been traditionally addressed. Many countries and jurisdictions have attempted to address energy poverty and spur development through subsidised energy prices or social tariff policies. Nevertheless, this is a double-edged sword, and subsidised energy prices need to be very carefully used in addressing energy poverty. Though they offer a temporary solution to energy poverty (ideally, during the transition to a low-carbon residential stock), if provided in absence of energy efficiency measures they can be counterproductive for solving the problem, potentially locking the more vulnerable households in energy poverty because they remove incentives to invest in energy efficiency at the household level. This is because lower-than-real energy prices provide wrong economic signals and thus result in a capital stock whose efficiency is lower than that justified by economic rationality considerations. Finally, when the subsidies are weaned, the

Table 1
Taxonomy of interactions between energy poverty (EP) and climate change (CC): its problem areas and measures for their alleviation.
Source: Own elaboration.

Link between energy poverty and climate change	Impact on energy poverty	Impact on climate change-related emissions	Nature of the interaction between the two policy areas	Potential policy leverage
PROBLEM AREAS OF CLIMATE CHANGE (CC) AND ENERGY POVERTY (EP)				
Warming climate	Reduces wintertime heating-related energy poverty ↓		Trade-off	CC is not a right lever to reduce heating-related EP
	Increases summertime cooling-related energy poverty ↑		Synergy, but undesirable	A desirable synergy is the mitigated CC, which also reduces cooling-related EP
Energy poverty		Reduces emissions ↓	Trade-off	No policy leverage: CC should not be mitigated by letting EP levels increase
MEASURES TO COMBAT ONE OF THE PROBLEM AREAS				
Fuel payments or social subsidies to help with income poverty	Reduces it—temporarily ↓	Increases emissions through increased energy consumption ↑	Trade-off	Not the optimal policy response: they don't provide a long-term solution to the EP challenge nor contribute to mitigate CC. Better alternatives exist (domestic energy efficiency)
Energy price subsidies	Reduces it—temporarily ↓	Increases emissions through increased energy consumption and resulting energy inefficiency ↑	Trade-off	
Improved efficiency of energy—using equipment, buildings and infrastructure	Reduces it and could eliminate energy poverty completely in some areas ↓	Reduces emissions through improved efficiency as compared to baseline (accounting for all energy services), despite potential increases in service levels ↓	Synergy	Strong policy synergy, though take-back or rebound effects need to be considered (see Section 3.3)
Carbon pricing	Increases energy poverty ↑	Reduces emissions ↓	Trade-off	Price signals are a key policy tool to reduce emissions but the energy poor must be protected (e.g., by being the first to benefit benefiting from domestic energy efficiency)
Reduced heat islands	Increased winter heating-related energy poverty ↑	Increased heating-related emissions because of colder temperatures in the winter. ↑	Synergy, but undesirable	No policy leverage: EP and CC should not be alleviated through heat islands
	Decreased summertime cooling-related energy poverty ↓	Reduced cooling emissions ↓	Synergy	Strong policy synergy
Climate (heat) resilient architecture	Decreases summertime cooling-related energy poverty ↓	Reduces emissions ↓	Synergy	Strong policy synergy
Increased cooling to adapt to warming climate	Increases summertime cooling-related energy poverty ↑	Increases emissions ↑	Synergy, but undesirable	Poor response to climate warming. Better alternatives than cooling as an adaptation measure exist

low-efficiency equipment and infrastructure results in energy costs that are far higher on a lifecycle basis than if they were optimised at the time of investment, forcing households into unnecessarily high energy expenditures. In the case of long lifetime energy-using equipment and infrastructure (e.g., a house or apartment), this can lock households into unnecessarily high expenditures for as long as decades.

A prime example how an attempt to guarantee widespread access to low-cost energy services through subsidised prices can result in long-term energy poverty even after general poverty is alleviated is the case of the former communist countries of Central and Eastern Europe. In this region, low energy prices during sustained periods of time have resulted in the construction of buildings and infrastructure with poor energy performances. As a result, their per capita energy consumption had become one of the highest in the world at the end of the 1980s (EIA, 2004). In this way, the current carbon emission (in the buildings sector) and energy poverty rates in this region can be at least partially attributed to the subsidised energy prices that were characteristic of communist regimes until the 1980s. The subsequent liberalisation of the energy sector, which brought residential tariffs close to full recovery costs at a time when household incomes were shrinking as a result of the economic slowdown, are equally important factors that explain the higher energy poverty levels reported in Central and Eastern Europe (World Bank, 2000; Ürge-Vorsatz et al., 2006; Buzar, 2007a; Boardman, 2010).

The third contributing factor to energy poverty, identified also as a lever for its solution, is the efficiency of the households' energy-using capital stock, namely residential buildings. However, as discussed in the following section, for this lever to make a marked difference in energy poverty levels, the efficiency levels achieved must be state-of-the-art and the improvement in the equipment or stock in use needs to be substantial. Besides, in warmer regions where energy use is dominated by equipment such as electricity-using appliances, improving the efficiency of the built stock is still important but perhaps cannot be considered as the single lever to address energy poverty.

The energy performance of the dwelling is thus identified as the key factor to take or keep households permanently out of energy poverty while contributing simultaneously to reducing GHG emissions. But other co-benefits can be accrued as well, as there is evidence of the significant net employment creation and energy dependency reduction effects of investing in buildings energy efficiency (Wade et al., 2000; Li, 2008; Pollin et al., 2009; Tirado Herrero et al., 2011). These are presented in Fig. 1 along with a summary of the key messages of this section.

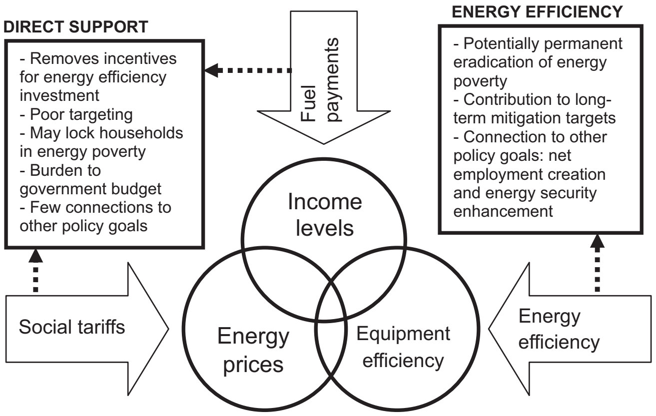

Fig. 1. Contributing factors and policy entry points to fuel poverty and their relation to climate change mitigation.
Source: Own elaboration after OECD/IEA (2011).

3.3. *Potential conflicts and trade-offs*

Even though key synergies has been identified between climate change mitigation and energy poverty alleviation as policy goals, two cases of potential conflicts or trade-offs between both policy goals have been identified: the rebound (or takeback) effect and carbon pricing.

The rebound effect is an undesirable side-effect of improving the energy efficiency in end-use sectors. It is the result of a shift in the demand, which rises following a drop in energy prices triggered by the efficiency gain (price effect), and of the of the additional income obtained as energy savings (income effect), which increases the consumption of other energy-consuming goods and services different than energy services (Greening et al., 2000; Nässén and Holmberg, 2009). In the residential sector, reviews indicate a rebound effect of 10–30% for space heating, around 10–40% for water heating and 5–12% for lighting (Greening et al., 2000).

The rebound effect is a case of potential conflict because in energy poor households the efficiency gains may be realised as comfort improvements (i.e., increased indoor temperature or fraction of floor area heated) rather than as reduced energy consumption. As Milne and Boardman (2000, p. 411) put it, "if the dual goals of energy conservation and affordable warmth for low-income households are to be attained, the nature of [the] takeback must be more thoroughly understood so that the full benefit of energy efficiency measures can be assessed along with the carbon/energy savings". In that regard, the evidence collected by these authors from monitored residential energy efficiency projects implemented in the UK in the 1980s and the 1990s found out that pre-retrofit indoor temperatures were the main indicator of the rebound effect. According to their estimates: (i) at 14 °C of indoor temperature, half of the potential energy savings will be achieved and the other half will be taken as increased comfort; (ii) at 16.5 °C of indoor temperature, 70% of the energy efficiency benefit will be obtained as lower energy consumption; and (iii) at 20 °C of indoor temperature it is more likely that all energy efficiency improvements will reach the full energy saving possibilities (Milne and Boardman, 2000). On the other hand, a recent assessment of 30 households recipient of energy efficiency measures provided under local authorities funding schemes in Eastern UK found a very low rebound effect following the implementation of the measures (Pett, 2009).

It is, however, debatable whether the predicted reduction in the potential energy savings can be labelled as a rebound effect. On the contrary, it may be argued that potential savings are estimated following the unrealistic assumption that households living in energy poverty will not increase their energy consumption following an improvement in the energy performance of their dwelling. As argued in Section 3.1, climate change cannot be mitigated at the expense of the energy poverty priorities.

Carbon prices are a component of energy prices that, if properly managed, are a powerful tool of demand-side climate policies (Matthew, 2007; Dellink et al., 2010). They are expected to increase in real terms as we progress towards a carbon-constrained (and possibly also fossil fuel supply-constrained) economy and therefore may become an important driver of energy poverty rates in the future. A trade-off between climate change mitigation and energy poverty alleviation goals is then expected (see Table 1), and a potential conflict between the welfare of future vs. present generations will arise unless energy poverty is addressed through other levers (preferably energy efficiency).

This potential conflict has been identified since the early stages of the energy poverty research field. In the 1990s, Boardman (1991) already warned about the potential negative consequences on the welfare of energy-poor households of imposing a carbon tax in the UK and alerted about environmental policies increasing the deprivation of worse-off families. The solution may pass by ensuring high levels of insulation in the houses of the energy poor, which should also be a priority for the installation of low- or zero-carbon measures (e.g. solar thermal, solar photovoltaics, etc.); the latter, when combined with a feed-in tariff, may become a source of income for these families (Boardman, 2010). Other authors have requested that in order to avid carbon taxes becoming regressive (i.e., hitting hard on the energy poor), they should be carefully implemented (if at all) in the domestic sector and only aimed at the high-income strata (Healy, 2003).

4. Making the case for deep efficiency: avoiding the *lock-in* risk

This section focuses on the strong policy synergy between climate change mitigation and energy poverty alleviation identified in the implementation of energy efficiency measures in residential buildings of developed and transition economies requiring significant heating services in the cold season.

Today's state-of-the-art design, know-how and technologies (e.g., the passive house standard—a maximum annual heating demand of 15 kWh m^{-2} year^{-1} irrespective of climate) ensure reductions in heating energy use by a factor of four to five as compared to new buildings, and by a factor of 15–25 as compared to existing buildings (Harvey, 2010). In those buildings, heating costs can be minimal and only small backup heating systems are required. Such very high-efficiency new construction and retrofitting standards can potentially eliminate energy poverty: for instance, the SOLANOVA project, a pilot passive house-like retrofit of a low-quality prefabricated block in Hungary, reduced the per dwelling monthly heating expenses from €96 to €16 (Hermelink, 2007),[1] demonstrating that heating energy services can be affordable even for the lowest-income Hungarian households. This proves that residential buildings can be effectively *energy poverty-proofed* (DTI, 2006), thus showing the way to a potential full eradication of energy poverty in the long-term.

At the same time, since in temperate climates heating and cooling constitute a large fraction of the residential energy consumption, such buildings also can save a significant amount

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[1] Furthermore, these large energy cost savings were achieved with a heating demand after retrofit of around 40 k Wh m^{-2} year^{-1} (Hermelink, 2006), which is clearly above the passive house standard.

Table 2
Energy saving potential of the application of state-of-the-art standards in new and existing buildings of selected world regions until 2050. *Lock-in* risk of the application of sub-optimal standards in new and existing buildings of selected world regions. [Both are measured as a percentage of the 2005 final heating and cooling demand of each region.]
Source: Ürge-Vorsatz et al., 2012.

	North America (%)	Western Europe (%)	Eastern Europe (%)	Former Soviet Union (%)	Centrally Planned Asia (%)	Pacific OECD (%)
Energy saving potential	75	72	67	66	54	66
***Lock-in* risk**	50	46	75	72	76	41

The percentage of *lock-in risk* can be larger than the potential because the model forecasts in some cases a net increase in total heating and cooling demand for the sub-optimal scenario (see Figure 10.2 in Urge-Vorsatz et al., 2012).

of GHG emissions. For instance, according the Global Energy Assessment (GEA) estimates between 66% and 75% of the 2005 final heating and cooling energy use of the transition and developed economies of North America, Europe and Asia can be eliminated by 2050 through the widescale adoption of such state-of-the-art standards in new and existing buildings,[2] as shown in Table 2.

Recognising the link between building efficiency, social welfare and climate change mitigation, policy efforts have accelerated in many countries to ensure energy-efficient new construction (such as the Energy Performance of Buildings Directive, or EPBD, in the EU) as well as the implementation of energy-efficient building refurbishments. However, many of these efforts mandate or aim at reaching thermal efficiency levels that are far from the state-of-the-art. This leads to the *lock-in* effect or *lock-in* risk, which is defined as the unrealised energy and carbon saving potentials that result of the installation of below state-of-the-art energy efficiency technologies in buildings. This is a critical notion from the perspective of the capital investments needed in the buildings sector because since space heating and cooling in buildings are an important source of carbon emissions, and their related emissions are difficult to mitigate in other ways than addressing them in the buildings themselves, applying sub-optimal[3] retrofits may force to revisit once retrofitted buildings after a few years in order to capture the remaining potential (which may be technically difficult or uneconomic) or consider other more expensive mitigation options (e.g., renewables or CCS) at later stages (Korytarova and Ürge-Vorsatz, 2010; Tirado Herrero et al., 2011; Ürge-Vorsatz et al., 2012).

In the case of the developed and transition economies of North America, Europe and Asia, the GEA has estimated that between 41% and 76% of the 2005 final heating and cooling demand will be *locked-in* if sub-optimal technologies are applied instead of state-of-the-art (see Table 2). Given the scale of the climate challenge – up to 85% reduction in 2000 global CO_2 emissions by 2050 in order to avoid a global temperature increase beyond the 2.0–2.4 °C –, that most mitigation will be done in developed and transition economies, and that buildings are the end-use sector with the largest cost-effective mitigation potential (IPCC, 2007), the application of sub-optimal technologies to the building stocks of these nations may severely threaten the ability to reach the required mitigation target.

While the *lock-in* effect is the most concerning for climate change mitigation because of the urgency of reducing emissions, it also applies to energy poverty eradication: if only suboptimal retrofits are applied, energy poverty will be partially alleviated but not eliminated. It is also hypothesised that the energy poverty alleviation potential of sub-optimal technologies is below their energy saving potential. This is because domestic energy costs often have a certain fixed cost component (such as standing fees, or metering costs), and thus energy savings may reduce energy costs by a less than proportional amount. In contrast, if heating systems are virtually eliminated in deep retrofits, these fixed costs may almost disappear, potentially making heating costs negligible. For instance, Behr (2009, in Harvey, 2010) suggests that since the energy use in passive house apartments is so small, individual metering and billing is not worthwhile and could be substituted by a billing system based on either floor area or number of occupants.

An additional advantage of state-of-the-art solutions is that the rebound effect can be avoided to some extent because the high efficiency buildings ensure the satisfaction of the thermal comfort needs is achieved with a very low energy consumption (e.g., the 15 $kWh\,m^{-2}\,year^{-1}$ standard of the passive house). However, it can also be argued that additional energy will be consumed in the form of goods and services (other than domestic energy) purchased with the additional income provided by the energy savings.

However, delivering deep efficiency in buildings is associated with significant investment needs that make the task challenging from a policy perspective, even though very substantial energy cost savings can be also accrued. In that way, estimates from the Global Energy Assessment indicate that a worldwide adoption of state-of-the-art buildings will require undiscounted cumulative investments of approximately US$14 trillion by 2050 and will deliver approximately US$58 trillion in undiscounted energy cost savings during the same period (Ürge-Vorsatz et al., 2012). However, due to a number of barriers – relatively long payback times, restricted access to credit, lack of appropriate financing schemes, low awareness of decision-makers about the existence of deep efficiency alternatives, split incentives between tenants and owners, etc. – deep efficiency is often not applied on a private investor or market basis in spite of its larger societal benefits. This calls for the incorporation of monetised co-benefits different from the energy cost savings – such as the value of avoided GHG and non-GHG emissions and of the comfort and human health gains – in assessment tools like cost-benefit analysis (see Clinch and Healy, 2001).

In summary, because of the *lock-in* effect, it is important to very carefully consider the strategy to retrofit the building stock—i.e., the depth (targeted specific energy consumption level after retrofit or for the new dwelling) and breadth (fraction of the stock to be acted on) of it. Lower depth and larger breadth may sound politically more attractive, and the challenges of the large individual investment needs are also significantly lower, but such strategies result in substantial *locked-in* emissions as well energy poverty levels. Therefore, under certain circumstances (i.e., demonstrated technical and economic feasibility of the state-of-the-art solution alternatives), the sustainable solution may be to *wait out* until a complex, deep retrofit can be performed on a building rather than force large-scale, superficial renovations. A negative effect of this strategy is that it lets current or increased emissions and energy poverty levels go on unabated for

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[2] These estimates incorporate the increases in floor area as well as improvement in service levels projected for the same period (Ürge-Vorsatz et al., 2012).

[3] Suboptimal in the sense that these technologies, which are not as advanced as state-of-the-art, do not fully realise the total energy and carbon savings potential of the building stock.

a number of years until the political decision for deep efficiency is taken.

This leads us to the crucial importance of policy integration. Because substantial investment costs and policy efforts are required for a large-scale implementation of deep efficiency in new and existing buildings, neither energy poverty eradication nor climate change mitigation goals alone may be enough to mobilise sufficient policy effort for making it happen. In contrast, if several of these policy goals are considered together, and the political and financial resources for several policy fields are merged, this might tip the expenditure-benefit[4] balance in favour of action. Following this approach, it is more likely that one of the most promising measures to fight climate change and energy poverty – deep efficiency – will take place if their synergy (and perhaps further synergies such as with energy security and net employment creation) is forged through strong policy integration. For such an integration to be effective, however, progress is also needed in research and methodologies. Today, cost-benefit assessments on which policy decisions are based typically consider direct costs and benefits only for single policy fields. In ideal policy-preparatory assessments, full costs and benefits, going beyond the single policy fields and just direct impacts, need to be considered. This requires a major advance in presently used methodologies to quantify and monetise co-benefits (e.g., for some key co-benefits like net employment creation and energy dependency reduction no economic valuation techniques are yet available) and co-costs (e.g., transaction costs, policy implementation costs, risks, etc.), as well as to their summation accounting for all synergies and trade-offs.

5. Conclusions

This paper has explored the functional and policy interactions between fighting climate change and alleviating energy poverty. For that, it has reviewed a number of selected mainstream scientific literature and policy-relevant literature in both domains in order to identify trends, key elements, synergies, trade-offs and potential conflicts, and to provide a taxonomy of these interactions. The conclusions reached refer primarily to residential energy users and buildings in developed and transition economies, where a considerably large potential for cost-effective mitigation lies, and where the inability of some households to afford an adequate level of energy services (energy poverty) has distinct public health and social welfare implications.

The most important trade-off identified in the paper is the potential increase in energy poverty levels as a result of strong climate change action increasing energy prices through carbon pricing, which points at an impending conflict between the welfare of present and future generations. If the internalisation of the external costs of carbon emissions is not offset by efficiency gains, the burden of mitigation will be disproportionately felt by those worse-off members of society who are still unable to provide enough energy services to their households. The rebound or takeback effect, another case of potential conflict between energy poverty and climate goals, is thought to be not as relevant and perhaps not even applicable to the case of energy poor households, where energy services needs are inadequately covered in the first place.

The most significant synergy is offered by the improved energy efficiency of buildings. As argued in Section 4, ensuring high efficiency standards is the only option for aligning strong energy poverty alleviation and climate change mitigation goals. In comparison, direct support measures implemented as fuel allowances or social tariffs do not provide a long term solution to the energy deprivation challenge – in fact, they may *lock-in* households in energy poverty if implemented on their own because they remove incentives to invest in energy efficiency at the household level – and do not reduce carbon emissions either.

This analytical review has explored in more detail the strongest synergy that is offered by these two areas of policy action: large reductions in GHG emissions and the elimination of energy poverty through deep energy efficiency. The paper suggests that in the developed and transition economics of North America, Eurasia and the Pacific this synergy is so strong that neither of the two problems is likely to be solved in such countries fully on their own merit; while the integration of these policy goals, with the potential addition of other key related policy goals such as energy security or employment, is likely to tip the cost-benefit balance and provide sufficient policy motivation to mobilise wide-scale resources and commitments. Thus, an essential message carried by this review is the importance of integrating seemingly unrelated policy goals and sharing the resources for their solution.

The paper has also identified critical gaps in knowledge and methodology that presently prevent such informed decisions to be integrated in policy-making, in order to forge this synergy on the ground. Only by ensuring that the various co-benefits are appropriately integrated into policy assessment methods and decision support tools, and thus making policy-makers aware of the synergistic economic and social benefits of reaching these various policy goals simultaneously through ambitious energy efficiency programmes, will the needed transformation be realised.

References

Behr, I., 2009. Utility bills in passive houses—doing away with metering bills. In: Proceedings of the 13th International Passive House Conference 2009, April 17–18. Frankfurt-am-Main. Passive House Institute, Darmstadt, Germany, pp. 377–382.

Birol, F., 2007. Energy economics: a place for energy poverty in the agenda? The Energy Journal 28 (3), 1–6.

Boardman, B., 1991. Fuel Poverty: From Cold Homes to Affordable Warmth. Belhaven Press, London.

Boardman, B., 2010. Fixing Fuel Poverty. Challenges and Solutions, Earthscan, London.

Buzar, S., 2007c. When homes become prisons: the relational spaces of post-socialist energy poverty. Environment and Planning A 39, 1908–1925.

Buzar, S., 2007b. The ‘hidden’ geographies of energy poverty in post-socialism: between institutions and households. Geoforum 38, 224–240.

Buzar, S., 2007a. Energy poverty in Eastern Europe. Ashgate, Aldershot.

Clinch, J.P., Healy, J.D., 2001. Cost-benefit analysis of domestic energy efficiency. Energy Policy 29, 113–124.

Dellink, R.B., Jamet, S., Chateau, J., Duval, R., 2010. Towards Global Carbon Pricing: Direct and Indirect Linking of Carbon Markets. OECD Environmental Working Paper No. 20, OECD.

Department for Business Enterprise and Regulatory Reform (BERR), 2001. UK Fuel Poverty Strategy, UK.

DTI, 2006. Energy—Its Impact on the Environment and Society. Department of Transport and Industry, UK.

EC, 2010. An Energy Policy for Consumers. Commission Staff Working Paper. SEC(2010) 1407 final. Brussels, 11.11.2010.

EEA, European Environment Agency, 2005. Environmental policy integration in Europe. State of play and an evaluation framework. EEA Technical report No 2/2005, Copenhagen.

EIA, Energy Information Administration (EIA), US Department of Energy, 2004. World Energy Use and carbon Dioxide Emissions, 1980–2001.

Eichhammer, W., Fleiter, T., Schlomann, B., Faberi, S., Fioretto, M., Piccioni, N., Lechtenböhmer, S., Schüring, A., Resch, G., 2009. Study on the Energy Savings Potentials in EU Member States, Candidate Countries and EEA Countries. Final Report for the European Commission. Directorate-General Energy and Transport. EC Service Contract Number TREN/D1/239-2006/S07.66640, Karlsruhe/Grenoble/Rome/Vienna/Wuppertal.

EUFORES (European Forum for Renewable Energy Sources), 2008. Declaration of Budapest 2008 on the future of Europe’s energy supply. In: Proceedings of the 8th Inter-Parliamentary Meeting on Renewable Energy and Energy Efficiency, November 7, Budapest.

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[4] By expenditure it is not only financial costs that are considered, but political, policy and other resources that are required for such a widescale deep efficiency path to be implemented.

European Communities, 2009. What can be Learned from Deprivation Indicators in Europe Eurostat. Office for Official Publications of the European Communities, Luxembourg.

European fuel Poverty and Energy Efficiency (EPEE) project, 2009. Evaluation of fuel poverty in Belgium, Spain, France, Italy and the United Kingdom. WP2—Deliverable 6. Intelligent Energy Europe (contract EIE/06/158/SI2.447367).

Greening, L.A., Grene, D.L., Difiglio, C., 2000. Energy efficiency and consumption – the rebound effect – a survey. Energy Policy 28, 389–401.

Harvey, L.D.D., 2010. Energy and the New Reality 1, Energy Efficiency and the Demand for Energy Services. Earthscan, London.

Healy, J.D., 2003. Fuel poverty and policy in Ireland and the European Union. Studies in Public Policy. 12 (The Policy Institute at Trinity College in association with the Combat Poverty Agency).

Healy, J.D., 2004. Housing, Fuel Poverty, and Health: A Pan-European Analysis. Ashgate Publishing, Aldershot.

Healy, J.D., Clinch, J.P., 2002. Fuel poverty, thermal comfort and occupancy: results of a national household-survey in Ireland. Applied Energy 73, 329–343.

Healy, J.D., Clinch, J.P., 2004. Quantifying the severity of fuel poverty, its relationship with poor housing and reasons for non-investment in energy-saving measures in Ireland. Energy Policy 32, 207–220.

Hermelink, A. 2006. Reality check: the example SOLANOVA, Hungary. In: Proceedings of the European Conference and Cooperation Exchange 2006. Sustainable Energy Systems for Buildings—Challenges and Chances. November 15–17, Vienna, Austria.

Hermelink, A., 2007. SOLANOVA. The Real Social Housing. Presented at the EU Sustainable Energy Week. February 1, Brussels, Belgium.

Intergovernmental Panel on Climate Change (IPCC), 2007. Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. In: B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (Eds.), Cambridge University Press, Cambridge and New York.

Korytarova, K., Ürge-Vorsatz, D., 2010. Energy savings potential in the Hungarian public buildings for space heating. Presented at IEECB'10: Improving Energy Efficiency in Commercial Buildings. Frankfurt, 13–14 April.

Lafferty, W.M., Hovden, E., 2003. Environmental policy integration: towards an analytical framework. Environmental Politics 12 (3), 1–22.

Li, J., 2008. Towards a low-carbon future in China's building sector—a review of energy and climate models forecast. Energy Policy 36, 1736–1747.

Liddell, C., Morris, C., 2010. Fuel poverty and human health: a review of recent evidence. Energy Policy 38, 2987–2997.

Markandya, A., Rübbelke, D.T.G., 2004. Ancillary benefits of climate policy. Jahrbücher für Nationalökonomie und Statistik 224, 488–503.

Matthew, J., 2007. Seven steps to curb global warming. Energy Policy 35 (8), 4247–4259.

McAvoy, H., 2007. All-Ireland Policy Paper on Fuel Poverty and Health. Institute of Public Health in Ireland, Dublin.

Milne, G., Boardman, B., 2000. Making cold homes warmer: the effect of energy efficiency improvements in low-income homes. A report to the Energy Action Grants Agency Charitable Trust. Energy Policy 28 (6–7), 411–424.

Morgan, E., 2008. Energy poverty in the EU. Socialist Group in the European Parliament.

Nässén, J., Holmberg, J., 2009. Quantifying the rebound effects of energy efficiency improvements and energy conserving behaviour in Sweden. Energy Efficiency 2, 221–231.

OECD/IEA, International Energy Agency, 2011. Evaluating the co-benefits of low-income energy-efficiency programmes. Workshop report (Grayson Heffner, Nina Campbell (Eds.)). Results of the Dublin Workshop, 27–28 January, Paris.

Pachauri, S., Spreng, D., 2003. Energy use and energy access in relation to poverty. CEPE Working Paper Nr. 25. Centre for Energy Policies and Economics. Swiss Federal Institutes of Technology, Zürich.

Pearce, D., 2000. Policy Frameworks for the Ancillary Benefits of Climate Change Policies. Workshop on Assessing the Ancillary Benefits and Costs of Greenhouse Gas Mitigation Strategies, (Washington DC, 27–29 March 2000), OECD.

Pett, J., 2009. Carbon footprints of low income households; does addressing fuel poverty conflict with carbon saving? In: Proceedings of the ECEEE 2009 Summer Study. La Colle sur Loup, France.

Pollin, R., Heintz, R., Garrett-Peltier, H., 2009. The Economic Benefits of Investing in Clean Energy. How the economic stimulus program and new legislation can boost U.S. economic growth and employment, Department of Economics and Political Economy Research Institute (PERI). University of Massachusetts, Amherst. Center for American Progress. University of Massachusetts, Amherst. Center for American Progress.

Sagar, A.D., 2005. Alleviating energy poverty for the world's poor. Energy Policy 33 (11), 1367–1372.

Scott, S., 1996. Social welfare fuel allowances… to heat the sky? Working Paper no. 74. The Economic and Social Research Institute (ESRI), Dublin.

The Eurowinter Group, 1997. Cold exposure and winter mortality from ischaemic heart disease, cerebrovascular disease, respiratory disease, and all causes in warm and cold regions of Europe. The Lancet 349, 1341–1346.

Tirado Herrero, S., Ürge-Vorsatz, D., 2010. Fuel poverty in Hungary. A first assessment. Report prepared for Védegylet—Protect the Future Society. Center for Climate Change and Sustainable Energy Policy (3CSEP), Budapest.

Tirado Herrero, S., Ürge-Vorsatz, D., Arena, D., Telegdy, A., 2011. Co-benefits quantified: employment, energy security and fuel poverty implications of the large-scale, deep retrofitting of the Hungarian building stock. In: Proceedings of the ECEEE Summer Study 2011. 6–11 June, Belambra Presqu'île de Giens, France.

Tirado Herrero, S., Ürge-Vorsatz, D. Trapped in the heat: a post-communist type of fuel poverty. Energy Policy, doi:10.1016/j.enpol.2011.08.067, this issue.

Townsend, P., 1979. Poverty in the United Kingdom. Penguin, London.

Ürge-Vorsatz, D., Miladinova, G., Paizs, L., 2006. Energy in transition: from the iron curtain to the European Union. Energy Policy 34, 2279–2297.

Ürge-Vorsatz, D., Eyre, N., Graham, P., Harvey, D., Hertwich, E., Kornevall, C., Majumdar, M., McMahon, J., Mirasgedis, S., Murakami, S., Novikova, A., Yi, J., 2012. Energy end-use: buildings. In: The Global Energy Assessment: Toward a more Sustainable Future. IIASA, Laxenburg, Austria and Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Ürge-Vorsatz, D., Novikova, A., 2008. Potentials and costs of carbon dioxide mitigation in the world's buildings. Energy Policy 36 (2), 642–661.

Wade, J., Wiltshire, W., Scrase, I., 2000. National and Local Employment Impacts of Energy Efficiency Investment Programmes. Volume 1: Summary Report. SAVE contract XVII/4.1031/D/97-032.

World Bank, 2000. Maintaining Utility Services for the Poor. Policies and Practices in Central and Eastern Europe and the Former Soviet Union. The World Bank Group, Washington.