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A global perspective on domestic energy deprivation: Overcoming the energy poverty–fuel poverty binary



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ABSTRACT

This paper offers an integrated conceptual framework for the research and amelioration of energy deprivation in the home. It starts from the premise that all forms of energy and fuel poverty – in developed and developing countries alike – are underpinned by a common condition: the inability to attain a socially and materially necessitated level of domestic energy services. We consider the functionalities provided by energy demand in the residential domain in order to advance two claims: first, that domestic energy deprivation in its different guises and forms is fundamentally tied to the ineffective operation of the socio-technical pathways that allow for the fulfilment of household energy needs, and as such is best analyzed by understanding the constitution of different energy services (heating, lighting, etc.) in the home. Second, we emphasize the ability of vulnerability thinking to encapsulate the driving forces of domestic energy deprivation via a comprehensive analytical matrix. The paper identifies the main components and implications of energy service and vulnerability approaches as they relate to domestic energy deprivation across the world.

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1. Introduction

When Boardman [1] published her seminal book on fuel poverty in the UK, this predicament was almost unknown within mainstream academic and policy-making domains. More than 20 years later, fuel poverty ‘has come of age’, as highlighted by the editors of a special section of the journal *Energy Policy* dedicated to the historical development and present state of the art of scientific work on the issue [2]. The plight of developed-world households suffering from inadequately heated homes has been widely publicized in the extensive amount of scholarly attention and advocacy work dedicated to such problems, including a number of papers published in this journal [3]. From an ‘occasional area of interest amongst a tiny group of demographers and survey statisticians’ [2] that failed to garner mainstream political acknowledgement for a long time, fuel poverty has gradually become a widely recognized societal challenge among key academic, practitioner and policy-making circles.

Problems of energy deprivation in the home are also commonly described via the term ‘energy poverty’. This concept has traditionally been used to capture problems of inadequate access to energy in developing countries, involving a host of economic,

infrastructural, social equity, education and health concerns [4,5]. Addressing the technological and economic aspects of energy poverty is otherwise a key component of the wider relationship between energy and development [6], in terms of both governance aspects and everyday life [5,7,8]. At the same time, a number of authors have been using energy poverty frameworks to encapsulate developed-world issues at the nexus of energy efficiency and affordability [9–12]. ‘Energy poverty’ is widely used to describe issues of domestic energy deprivation in many European countries, including Germany [13], Belgium [14], Greece [11], Spain [15], Poland [16] and Slovakia [17], while the notion of ‘energy precariousness’ has become enshrined in official policies and discourses in France [18]. The term ‘energy poverty’ is also incorporated in the European Union’s ‘Third Energy Package’ as well as a number of policy documents adopted by the various bodies of this organization [19]. It is being employed in contexts where domestic energy deprivation has not received scientific or policy attention to date, such as the US and Australia [9,10].

As a result of these developments, there is an increasing need for exploring the conceptual relationship between the energy and fuel poverty paradigms, and the governance implications of the emergent terminological diversity surrounding the lack of energy services in the home. Based on an extensive review of existing scholarship in the domains of energy, poverty, human geography, environmental policy and social practices, this paper investigates the possibility of cross-pollinating the fields of ‘energy poverty’ and

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‘fuel poverty’, as well as other ways of approaching domestic energy deprivation. Its overarching purpose is to contribute towards the formulation of a genuinely global and integrated perspective on the driving forces and systemic impacts of inadequate domestic energy delivery, in its multiple guises and forms. In the first instance, therefore, we aim to identify the commonalities that underpin existing approaches towards the study of domestic energy deprivation, and can help develop a more nuanced and inclusive framework. The paper then focuses on the material and social aspects of the relationship between ‘energy services’ [20,21] and poverty, as one of the entry points for articulating a global perspective on the issue. We subsequently move onto an exploration of this relationship via ‘vulnerability’ thinking, with the aim of introducing the wider systemic drivers of deprivation as they vary across time and space. The paper concludes by highlighting the implications of such approaches for policy and science.

2. Unpacking the dichotomy between fuel and energy poverty

The recognition of ‘fuel poverty’ as a significant systemic problem is best established in academic and policy discourses within the UK and Ireland – states that have developed the longest tradition in researching and addressing problems of cold and energy-inefficient homes in particular, with their associated impacts for well-being and health [22–31]. In the UK, fuel poor households were initially defined as needing to spend more than 10% of their income on energy in order to keep the home in a satisfactory condition (www.poverty.org.uk). A more recent definition, principally used in England, sees households as fuel poor if required energy costs are higher than those of the nation-wide median, while pushing them below the ‘official poverty line’ (www.gov.uk). In this geographical context, therefore, fuel poverty-related debates and discussion have principally been motivated by, and focused on, the poor affordability of energy for space heating (and other related domestic services) as a result of low household incomes or energy inefficient homes.

Recent years have seen the expansion of scholarship and policy on these topics onto the post-socialist countries of Eastern and Central Europe [12,32–38], as well as France [39–41], Germany [42–45], Spain [46–48], Austria [49], Italy [50,51], Greece [11,52–54], Australia [9,55], New Zealand [56] and even the US [10]. The diversity of this body of work means that it does not easily lend itself to cumulative summaries. Nevertheless, many such studies have sought to highlight the broad range of systemic circumstances that lead to the emergence of domestic energy deprivation: institutional factors, political economies, infrastructural legacies, housing structures, income differentials and changes in the affordability of utility services. With national-scale policy measures being developed in many of these national settings, transnational bodies such as the European Union have become increasingly interested in formulating agendas that can provide wider and more comprehensive frameworks to address the problem [57]. The diversity of geographical perspectives on developed-world energy deprivation has also been associated with a greater awareness on its health impacts and amelioration policies, with issues such as mental health and well-being becoming recognized as important in this context alongside the more traditional focus on respiratory and circulatory morbidity and ‘excess winter deaths’ [[29,58,59] also see Table 1].

At the same time, a number of international development organizations and scholars have been focusing on the persistent deficiency of energy infrastructure provision across large parts of Africa, Asia, and South America. Despite a long history of international involvement and high profile political attention, more than 1.2 billion people across the world still lack access to electricity,

Table 1
Principal elements of ‘energy poverty’ and ‘fuel poverty’ frameworks in traditional understandings of the two concepts.

Element	Developing world ‘energy poverty’	Developed-world ‘fuel poverty’
Recognition	Explicitly acknowledged in isolated documents during the early 1970s [95]. Subsequent debates mainly focused on technological expansion. More recent research addresses participation and governance challenges.	First mentions date back to the late 1970s and 1980s, principally referring to rising energy costs and ‘the right to fuel’ in countries like the UK [96,97]. Later research allowed for a wider understanding of the problem [1].
Driving forces	Primarily low levels of electrification and other forms of networked energy provision due to economic under-development and non-functional institutions.	High or rising energy prices vs. low household incomes. Inefficient housing, heating systems and appliance stocks.
Expression	Lack of access to adequate facilities for cooking, lighting and electric appliances, but also other services such as space cooling and heating.	Mainly inadequate heating in the home; importance of other services (particularly space cooling, lighting, appliances, IT) is increasingly recognized in recent years.
Consequences	Detrimental impacts on health, gender inequality, education and economic development more generally.	Long and short-term mental and physical health, inadequate participation in society.
Principal policies	Support for transitions to ‘modern’ energy fuels, investment in power grid expansion or micro-scale renewables; income support.	Combination of income support, provision of energy at lower costs, and energy efficiency investment.

while a further 2.8 billion have no choice other than traditional biomass for cooking and heating [60]. Termed ‘energy poverty’, this condition has received significant academic and policy attention [4,61,62], often as a result of its extensive impacts on well-being and health: the inability to access modern fuels in the home means that households are often forced to rely on open fires, which in leads in high levels of indoor air pollution. Thus, fumes and smoke from open cooking fires are estimated to contribute to the deaths of 1.5 million people per year, predominantly women and children [60]. Developed-world energy poverty also has significant impacts on issues such as personal safety, household time budgets, labour productivity and income [63]. It is a highly gendered problem, with women bearing the brunt of the consequences of inadequate energy access while suffering from systemic discrimination as well decreased access to resources and decision-making [64,65].

Traditionally, energy poverty research in the developing world has been mainly focused on supply-side issues, emphasizing the need for expanding electricity grids based on the experience of developed world countries [66,67]. Work undertaken by organizations such as the World Bank in particular has highlighted the benefits of extending the coverage of power grids into rural areas [68–71], as well as the economic, social and technical barriers to modern energy access [72] including the lack of adequate institutional infrastructures and financial capital [73–78]. This has been demonstrated in case studies from Africa, South America and Southeast Asia alike. The principal policies to address energy poverty have been largely driven by the ‘electrification for development’ imperative, as has been the mainstream identification of the driving forces and consequences of the problem.

In more recent years, scientific and policy attention has turned to the poverty-amelioration potential of micro-generation and renewable energy investment as an alternative to top-down power grid expansion [79,80]. There has been an increased awareness of the cultural and political determinants of household energy transitions towards the use of modern fuels in developing countries [81–84]. Also of relevance in this context is scholarship on the distributional and fiscal implications of state-led policies to address energy consumption [85–87], as well as the pathways through which increased access to modern fuels contributes to livelihood improvement and human development more generally [8,88–90]. Debates on the ‘other energy crisis’ [91], therefore, have gradually evolved from a supply-dominated logic underscoring the under-development of technical infrastructures to a more nuanced understanding of the multilayered political economies and relations of power that drive the emergence and persistence of energy poverty [92].

As was pointed out above, global issues of energy equity have been historically considered within two relatively separate scientific and policy registers. While discussions and measures surrounding ‘fuel poverty’ have been largely seen within the context of unaffordable warmth in the home – and as such have mainly fallen under the remit of economists, sociologists, environmental scientists and engineers – perspectives on energy poverty in the global South have been closely articulated in relation to the interdisciplinary field of development studies, in addition to focusing on issues of access, equity and investment in socio-technical systems.

Most of the literature, therefore, displays a marked cleavage along developed–developing world lines – partly as a result of the specific historical and geographical trajectories in the scientific recognition of domestic energy deprivation (Table 1). Other areas of distinction include the conceptual understanding of the driving forces of energy and fuel poverty, as well as the policies to address them and their impacts on everyday life (where a clear division emerges the lack of heating vs. the lack of access to electricity – see the third row in Table 1). The health impacts of domestic energy deprivation are perhaps the only area in which similarities exist among dominant understandings, even if the energy poverty literature is predominantly preoccupied with indoor air pollution while fuel poverty is focused on cold air exposure (see the fourth row in Table 1). It should also be pointed out that the fuel-energy poverty binary is not universally applicable: in a limited number of cases, the term ‘fuel poverty’ has been used to capture the policies and measurement approaches that underpin access to non-traditional energy sources [93], while some authors use ‘fuel poverty’ and ‘energy poverty’ interchangeably to describe conditions in either developing [4,94] or developed [28] countries. But such studies have tended to gloss over – rather than directly engage with – the distinct intellectual and policy traditions that are associated with the public recognition and amelioration of the two sets of conditions.

The increasing globalization and marketization of energy flows, accompanied by the proliferation of research on developed world energy deprivation – in contexts where this condition previously received little public recognition – has started to challenge established understandings. Thus, ‘energy poverty’ is no longer confined to developing world debates, while the access-affordability binary is gradually being dismantled and challenged. As was pointed out above, policy and scholarship in many European countries – and even the European Union itself – uses the term ‘energy poverty’ to encompass questions of access, infrastructure, health and equity in addition to the more established issues of affordability and efficiency. And questions of security, justice, and socio-technical transition are jointly entering the vocabularies of energy and fuel poverty researchers across the world [98–100].

The destabilization of the traditional conceptual boundaries of fuel and energy poverty has created a need for exploring the relationship between these frameworks and the wider socio-spatial mechanisms that characterize the lack of adequate energy services in the home. But other than statements that the two terms have the same meaning in developed-world contexts [28,57,101] an explicit conceptual discussion of the relationship between energy and fuel poverty has been lacking for a long time. Li et al. [102] are among the limited number of authors who have ventured into this territory, by arguing that fuel and energy poverty are distinct problems that can be associated with accurate descriptors: access to electricity, education, health, and the International Energy Agency’s Energy Development Index (EDI) or Nussbaumer et al.’s [94] Multidimensional Energy Poverty Index (MEPI) in the case of energy poverty; and affordability, thermal comfort and Hills’ [103] Low Income High Cost (LIHC) measure in the case of fuel poverty. They elaborate such claims by insisting that ‘fuel poverty mostly occurs in relatively wealthy countries with cold climates’ (such as residents of the UK, Ireland and New Zealand), whereas ‘energy poverty occurs across all climates but mostly in poor countries’ (mainly Central South America sub-Saharan Africa and central Asia) [102]. The only people who may experience both fuel and energy poverty at the same time are those ‘living in a cold climate, and they have difficulty in getting access to electricity or modern cooking facilities, and with indoor heating at an appropriate cost’ [102]; they include ‘areas of northern rural China, Nepal, India and scattered instances of homeless people in developed countries’ [102].

However, it remains unclear how Li et al.’s [102] bracketing of the conceptual remit of energy poverty and fuel poverty would work in the case of households who experience domestic energy deprivation, while living in relatively affluent countries with warm climates. A wide range of authors – from Healy [104] to Tirado-Herrero et al. [48] – have found that relatively affluent countries in Southern Europe, such as Portugal, Greece, Spain, Cyprus, Malta and Italy, contain record numbers of households who lack adequate energy provision in the home. This concerns both suboptimal levels of space heating in winter and residential cooling in summer, and can be attributed to a combination of infrastructural, income and cultural factors. Also, what to make of middle-income states in regions like Central Asia or South America, where governments face parallel problems of energy access and affordability in, respectively, predominantly rural and urban areas? It is clear that the traditional pathways of scientific and policy thinking in the existing energy and fuel poverty literature become untenable when faced with the diversity of conditions and practices that capture energy demand across the world.

We embrace the emergent terminological messiness developing around the two concepts to argue that the blurring of conventional definitions offers opportunities for advancing scientific and policy debates on the fundamental relationships among energy access, affordability and state policy. Our claim is based upon the premise that that all forms of household-scale energy deprivation share the same consequence: a lack of adequate energy services in the home, with its associated discomfort and difficulty. When cross-referenced with the most widely acceptable definition of relative income poverty (a condition with a global definition – see [105]) fuel and energy poverty alike can be considered under the same conceptual umbrella: as a set of domestic energy circumstances that do not allow for participating in the lifestyles, customs and activities that define membership of society [32].

3. Unpacking energy services

If there is one common thread that connects both developed and developing world countries with respect to the underconsumption

of energy in the home, it is the pivotal role of 'energy services'. Commonly understood as the 'benefits that energy carriers produce for human well being' [106], energy services allow for shifting the perspective away from 'fuels' such as 'coal, oil, natural gas, and uranium, and even... sunlight and wind, along with complex technologies such as hydrogen fuel cells, carbon capture and storage, advanced nuclear reactors, and superconducting transmission lines, to name a few' [107] onto the notion that 'people do not demand energy per se but energy services like mobility, washing, heating, cooking, cooling and lighting' [108]. As a result, policy goals can start to revolve around issues such as achieving 'adequate levels of light rather than delivering kWh of electricity' [107]. This opens the path for approaching the insecurity of demand-side energy services as a distinct societal challenge, allowing for an 'integrated approach to gauge the resilience of a society to meet the needs of its population... over longer timescales ahead from various interrelated perspectives' [20].

Energy service approaches also highlight the inadequacy of existing measurement frameworks for understanding and monitoring energy delivery in the home, which is mainly captured by the number of energy units consumed by the carrier, or the effect that the conversion process has on affected spaces (such as levels of temperature or illumination). Neither of these metrics properly describe the utility and satisfaction received by the final user, partly because the effect of the energy service on his or her requirements – principally a comfortable and well-functioning home – is largely dependent on subjective variables [12,109]. It thus becomes important to consider the individual, household and community-level determinants of energy dynamics in the residential environment, by taking into account environmental, cultural, technical and architectural factors in influencing [110–112].

Thinking about energy in terms of the domestic functions that it affords also allows for considering the wider technologies and dynamics involved in the operation of modern homes. The relatively simple (and somewhat out of date) classification of energy services provided by authors such as Reister and Devine [113] and further enshrined in the 'energy ladder' and 'fuel stacking' models [107,107,114–116] – space heating, water heating, space cooling, refrigeration, cooking, drying, lighting, electronic services, and appliance services – quickly starts to break down when the relevance of other processes in the home is considered within this context. The inherently multifunctional nature of energy services means that carriers with one primary purpose often serve a range of secondary roles, many of which are not explicitly linked to energy. Thus, a wood-burning stove can provide space heating, hot water, cooking, drying and light, as well as a feeling of coziness, comfort and a focal point in the home [117–119]. At the same time, a single energy service can be supplied by a range of different fuels: 'illumination, for example, can come from candles, kerosene lamps, or electricity' [21].

Further testifying to the multifaceted nature of energy services is their complex composition, which entails 'different inputs of energy, technology, human and physical capital, and environment (including natural resources)' [108]. This means that energy services cannot be understood in solely technological or social terms, but rather represent hybrid 'assemblages' [120,121] operating across a multitude of scales and sites, beyond the confines of the home. As such, they consist of 'composite accomplishments generating and sustaining certain conditions and experiences' [122] that are deeply embedded in the 'orchestration of devices, systems, expectations and conventions' [122]. Energy services embody social practices that are 'configured by the "hanging together" of institutional arrangements, shared cultural meanings and norms, knowledges and skills and varied material technologies and infrastructures' [123]. The routines that coalesce around systems of provision can thus be studied via a social practice approach that

requires 'stepping back from energy itself' [123] and moving beyond issues of technological or behavioural efficiency in the series of transformations that lead to the production of useful energy – however important these may be – onto the manner in which end-use energy demand is articulated in time and space [123–125].

At a more fundamental level, energy services are driven by needs, which reflect what the recipients of this system of provision effectively require: 'a cooked meal, a well lit room, a fast computer with an internet connection, a cold beer, a warm bed, mechanical power for pumping or grinding' [21]. As such, the fulfilment of energy needs is a crucial component of the functionings that enable individuals to perform their everyday life and achieve well-being [126–128]. But needs are themselves closely conditioned by the social practices that inform the social expectations and settings in which energy use takes place. This is particularly obvious in the case of electricity, whose technical versatility and flexibility [129] has often prompted actors on the supply side to actively manage and produce energy demand. Despite its intractability and vastness, therefore, the entire electricity system can be seen 'as an element of electricity-consuming social practices, informing what makes sense for householders to do during (and outside) peak periods' [130].

Given the pivotal role of energy services in understanding the underlying dynamics that lead to poverty, it is remarkable how little systemic attention they have received outside the familiar tropes of engineering or economic evaluation. While studies of consumption and sustainability have often explored how particular patterns of energy use are normalized via social practices and everyday routines [130,131], there has been little work on the levels of domestic energy services that households require for the full participation in society within different geographical and cultural settings. Nevertheless, the suggestion that energy consumers throughout the world require service standards that would allow them to have 'effective opportunities to undertake the actions and activities that they want to engage in, and be whom they want to be' [131] provides a starting point for moving beyond some of the conceptual quandaries at the access–affordability nexus, as described above. In the first instance, this suggests that thinking about fuel or energy poverty in terms of 'basic needs' [132,133] does not adequately capture the full array of household requirements and functionings. Moreover, the fact that energy services are themselves the outcomes of a complex set of conversions and networks implies that the driving forces of domestic energy deprivation are multidimensional and hybrid, while extending beyond the developed–developing country distinctions that some authors have attempted to make.

At this point, it should be emphasized that the literature on developing world energy poverty generally offers a more sophisticated understanding of the relationship between energy services and household needs [see, for example, [107]]. While much of this work lacks an explicit theorization of the everyday grain of energy needs and services, it does offer an invigorated perspective on the importance of human security, democratic participation and social cohesion for the development of energy systems as they relate to individual household requirements. Thus, van Els et al. [90] highlight that market mechanisms have not been sufficient to guarantee the economic sustainability of rural electrification projects in the Amazon, underlining the need for a paradigm shift towards local mobilization and organization via development initiatives so as to partnership between local new actors in the electricity sector and governmental bodies. At the same time, arguments about the importance of 'just grids' and 'good governance' [134] have been accompanied by an increased awareness of the importance of political, institutional and cultural factors in influencing energy poverty [72] beyond more conventional economic, financial and technical

considerations. Energy service approaches have also underlined the importance of moving beyond electrification onto the provision of heating and cooking services in the home [135], as well as the need for considering broader issues of geopolitical risk and uncertainty in the governance of systems of provision [20,136].

Such concerns have also started to permeate the work of policy-making organizations at different scales. In response to the omission of energy in the UN Millennium Development Goals, work undertaken by the UN Development Programme report proposed practical steps towards ‘scaled-up investments in health, education, and infrastructure, alongside efforts to promote gender equality and environmental sustainability’ [106]. In 2012, the Sustainable Energy for All initiative gave prominence to the impact of international and local policies on the provision of energy services at the local scale, while foregrounding the need for integrated thinking to address concerns of climate change, natural resource scarcity, and global income inequality [137]. Also of note is the UK Department For International Development’s statement that ‘energy in a development context is not about technology provision first... but about understanding the role that energy services play within people’s lives’ [138] calling for a ‘people-centred approach, reaching beyond the technical issues, to deliver energy services that meet peoples’ needs and priorities’ [138].

A shift of perspective away from the supply of fuels onto end-use services in conceptualizations of fuel and energy poverty opens the path for considering domestic energy deprivation issues via a joint framework (see Table 2). This approach identifies the need for meeting household energy needs – diverse and socially contingent as they are – as a global challenge. At the same time, the developed–developing country binary starts to break down as the commonalities that characterize the absence of socially and materially necessitated levels of energy services come to the fore. Both fuel and energy poverty can be encased within the broader notion of ‘energy service poverty’. Such an approach allows for the entire range of circumstances that describe the experience of domestic energy deprivation to be integrated into a single conceptual approach.

4. Energy vulnerability: exploring the drivers of deprivation via systems of provision

Identifying a shared set of energy services required by households in both developed and developing countries can only provide an initial step towards the formulation of a planetary approach towards domestic energy deprivation. It is also necessary to highlight any commonalities in the driving forces of energy poverty throughout the supply chain that leads to the delivery of the final service. In developing a common framework for this purpose (see Fig. 1) we have relied on two approaches.

The first is the ‘systems and infrastructures of provision’ paradigm [152–155] which, put briefly, describes, the institutional dynamics and material cultures surrounding the rise of commodity-specific chains that connect production, distribution and consumption activities. By assigning a ‘vertical’ logic [156] to the circulation of commodities and services, systems of provision approaches affirm the multiple interdependencies and standardizations that allow for the delivery of specific goods and services to the final consumer. In the case of energy, they bring to light the complex concatenation of activities, infrastructures and resources necessary to provide households with energy. It also becomes apparent that the energy chain [157] extends well into the home, involving multiple conversions from fuel carriers into end-use services. A household’s energy needs are at the final point of this system while driving its emergence.

Table 2
Deprivation issues as they relate to different types of domestic energy services.

Type of energy service	Relevance for domestic energy deprivation
Space heating	Principally a problem for households in cold climates – in developed-world countries this includes low income groups, as well as those living in inefficient homes. Access to more effective, comfortable or efficient methods of domestic heating is associated with the situation in developing countries [139]. The two problems may combine in countries with relatively mild winters where households do not have adequate heating systems in their homes—in Europe, the highest numbers of excess winter deaths are found in countries like Cyprus and Portugal [140]. Poverty implications mainly discussed in relation to developing-world contexts [141], although this service is a significant component of energy consumption in developed-world countries [142].
Water heating	An-energy related problem for households living in climates with unbearably hot summers, and urban areas in particular. Climate change-related heatwaves have exacerbated the issue [9]. Both the inadequacy and access to the service may be an issue. Research on developing-world contexts is lacking beyond large-scale models [143,144].
Space cooling	A global domestic energy deprivation-related challenge. Mainly researched in developing world context in connection with the lack of electricity access [145,146], although the reduction of indoor lit spaces in relation to affordability issues has also been observed [32].
Lighting	Most of the literature explores this service in relation to developing world energy poverty, where the lack of access to electricity is a major obstacle towards economic development and well-being [147,148]. Rarely connected to energy deprivation, although the lack of adequate facilities for this service in colder climates (whether provided by networked infrastructures or not) has been connected with adverse health impacts [149,150].
Cooking	These services are directly linked to the affordability and availability of electricity infrastructures, and as such can be found across the world. Levels of consumption are culturally and socially conditioned [151], which means that deprivation ‘thresholds’ are highly context-specific [7].
Drying	
Refrigeration/appliances/IT	

Energy vulnerability thinking provides the second lynchpin of our framework. This approach helps draw a distinction between energy or fuel poverty as a descriptor of a state within a certain temporal frame, on the one hand, and vulnerability as a set of conditions leading to such circumstances, on the other [158,159]. One of the departure points for the vulnerability approach is the realization that households who are described as ‘energy service poor’ at a given point in time may exit the condition in the future by changing some of their circumstances; and vice versa, fuel or energy poverty may affect households who are not described as such at the moment of consideration [160]. In essence, therefore, energy vulnerability thinking is probabilistic: it highlights the factors that affect the likelihood of becoming poor. When combined with the systems of provision approach, energy vulnerability identifies the role of ‘horizontal’ factors within different components of the energy chain. These extend beyond the affordability–access binary to encompass the nature and structure of the built environment of the home, as well as the articulation of social practices and energy needs.

In the mainstream literature on developed world ‘fuel poverty’, the dynamics that underpin the condition are mainly identified within the narrow triad of low household incomes, high energy prices, and inadequate levels of energy efficiency. But these are only part of the factors that describe the likelihood of experiencing a socially and materially inadequate level of energy services in the home. The interplay between built environment flexibility and

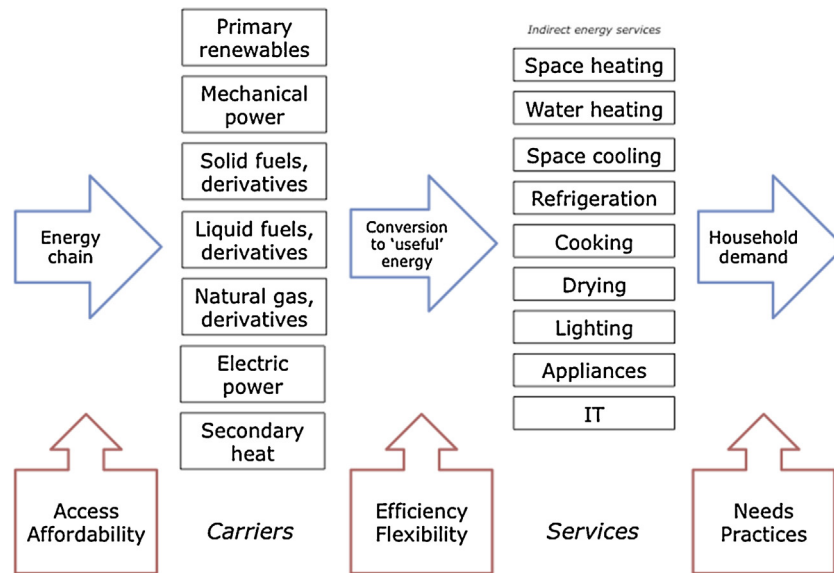


Fig. 1. Dimensions influencing the delivery of energy services to the home, and the emergence of domestic energy deprivation.

energy-related social practices means that domestic energy deprivation may arise as a result of a mismatch between the heating or cooling system installed in the dwelling, on the one hand, and the energy service needed by the occupant household, on the other. For example, electric night storage heating is not the most economic option for households who only use the home in the evenings [97,161,162]; and district heating systems that do not have individual controls or thermostats may prove unaffordable for residents who end up 'trapped in the heat' at undesirable times of the day [38].

In situations where the structural fabric of the building, housing tenure and other legal obstacles do not allow for switching to a more suitable heating system, the household affected by the situation may find itself suffering from inadequate energy services even if it is otherwise able to afford the energy that it consumes, while living in a home that is well insulated [32,163]. Moreover, bringing needs into the equation leads, inter alia, to the conclusion that individuals who spend a greater degree of the day at home (such as pensioners or unemployed people) or have specific energy requirements (including disability or the presence of small children) are more likely to suffer from domestic energy deprivation than the rest of the population, as their socio-demographic circumstances mean that such households demand above-average amounts of end-use energy [34,164–166]. This situation can transpire irrespective of the affordability of energy prices, or the lack of residential energy efficiency.

Vulnerability thinking can also destabilize dominant understandings of the driving forces of this condition in developing countries. A recognition of the need for energy as a socially necessitated phenomenon above basic biological requirements problematizes the idea that minimum standards can provide for adequate individual functionings. Given the multiple socio-technical trajectories through which any given service can be procured, this suggests that the reduction of energy poverty measurement and indicator frameworks to particular carriers [in contributions such as [167]] cannot capture the entirety of household needs and situations across the world. Of particular importance here are claims that the households primarily desire an energy supply that is reliable, affordable and accessible [107] whereby 'the use and security of energy services is not ingrained but rather conditioned strongly by income and relative wealth within societies' [107]. The linear logic of the energy ladder model

– which implies that households move towards more technologically sophisticated energy services as their incomes increase and higher levels of national economic development are reached [107,114,115] is also destabilized by the multiple functions enabled by energy services, ranging from domestic comfort to personal identity. For example, the use of traditional biomass is predicated upon 'active decision making on the part of individual households according to their preferences and broader lifestyle considerations' [168] in developing and developed countries alike.

Alongside issues of access to infrastructure (located at the left side of the energy chain) the affordability of energy is a key underpinning of energy vulnerability. This is because the manner in which state bodies and utilities choose to price energy or support particular groups plays a powerful role in determining whether a household is likely to live in conditions of domestic energy deprivation. Injustices of distribution, procedure and recognition [169] become important factors in driving fuel or energy poverty before even considering income, price or efficiency. Indirect subsidies embedded in the energy tariffs, for example, have a significant impact in determining patterns of deprivation [37,170]. Also of relevance in this case are fiscal or pricing measures targeting particular types of fuel; while taxes on diesel and petrol—and even natural gas—are generally less harmful to the poor, it has been demonstrated that placing the tax burden onto electric bills often disproportionately affects poor households (see, for example, [171]). In addition, it should be pointed out that 'schemes that put a price on carbon emissions further upstream ... have an effect not only on downstream energy prices but also on all other goods and services owing to the higher price of the energy used in their production' [172]. In some cases, fuel or energy poverty assistance programmes can structurally exacerbate the very condition that they are meant to target by privileging particular groups over others. Regulatory obstacles, information scarcity and socio-cultural factors often prevent socially excluded groups from accessing support [28].

Moving towards a global understanding of energy vulnerability factors (Table 3) also helps highlight the manner in which the driving forces of deprivation can belong to circumstances that are either internal or external to the household. It becomes apparent that external spheres of action tend to be located at the far ends of the provision system – this also includes the domains of needs and practices. Such thinking is not only useful in identifying groups

Table 3
A typology of energy vulnerability factors and their constituent elements.

Factor	Driving force	Sphere of action
Access	Poor availability of energy carriers appropriate to meet household needs.	External/internal
Affordability	High ratio between cost of fuels and household incomes, including role of tax systems or assistance schemes. Inability to invest in the construction of new energy infrastructures.	External/internal
Flexibility	Inability to move to a form of energy service provision that is appropriate to household needs.	Internal/external
Energy efficiency	Disproportionately high loss of useful energy during energy conversions in the home.	Internal
Needs	Mismatch between household energy requirements and available energy services; for social, cultural, economic or health reasons.	Internal/external
Practices	Lack of knowledge about support programmes or ways of using energy efficiently in the home.	Internal/external

that may be at risk of falling into energy poverty in the future, but can also help place the combination of social, economic, political and infrastructural factors that have contributed to the position of households who are facing the predicament in the present. This is particularly true in the case of developed-world urban households living in transitory housing arrangements – mainly young people, tenants in private rental housing, and residents of informal settlements—which are difficult to detect and target via conventional policy frameworks [173–175]. In developing country contexts, the framework highlights the crucial importance of ensuring that the technical and financial availability of energy carriers is matched with socially necessitated household needs.

5. Conclusion: implications for research and policy

This paper has spoken to on-going debates about the definitions, driving forces and extent of domestic energy deprivation across developed and developing countries. We have argued that the inability to secure adequate energy services lies at the heart of this condition, as opposed to the focus on fuel, energy efficiency, and affordability that dominates most scientific and policy discussions. While thinking in terms of energy services allows for all of these factors to be included into a single framework, it also emphasizes that deprivation in the home is deeply embedded in ‘not only the resources (energies) necessary for its upkeep, but also the appliances, infrastructures, social norms and human action’ [176] within which the residential environment of the home is ‘bound and reproduced’. At the same time, this approach has helped us identify the pathways through which households become unable to attain socio-materially sufficient levels of domestic energy functioning, while highlighting the importance of considering more complex and nuanced questions of need and social practice in the understanding of such processes.

The arguments presented here hint at the theoretical obsolescence of the notion of ‘fuel poverty’, even if the concept is widely recognized in policy and scientific circles. In purely discursive terms, fuel poverty incorrectly places an emphasis on the supply of energy carriers to the home, despite the fact that conceptual debates on the subject have significantly advanced past such understandings. We would also argue in favour of the need for considering energy service poverty as a planetary problem, which is just as much a question of ensuring an adequate match between energy resources, technical infrastructures and household needs,

as it is about access, incomes and energy efficiency. This needs to transpire alongside the continued need for context-specific research and advocacy on questions of energy access and deprivation, underlining the specific political circumstances that underpin the sheer absence of adequate infrastructures in some cases, and their inefficient operation in others. The conceptual commonalities highlighted in the paper are not aimed at reincarnating the much criticized ‘one size fits all’ approaches previously promoted by some international donors and multilateral organizations; rather we have sought to underline the binding together of services, needs and practices in driving domestic energy deprivation as a planetary problem.

At the same time, the paper has emphasized the need for integrating temporal dynamics [123] with understandings of energy services. Of particular importance in this context is the framework of ‘energy vulnerability’, which provides an encapsulation of the risk factors that contribute to the precariousness of particular spaces and groups of people. Energy vulnerability thinking can help challenge the predominantly socio-demographic approaches that pervade much of the literature and policy on ‘vulnerable consumers’ in the UK and the EU [for an example, see [177]]. This is because defining vulnerability in terms of purely social categories such as ‘households on very low incomes, including pensioners, female single parent, and benefit recipients’ [178] neglects the role of housing and socio-technical factors in conditioning the propensity of a household to become unable of meeting its energy needs, while extending the debate to groups who may not necessarily face precarious household energy circumstances.

Policy-wise, moving the focus of state programmes towards energy services can lead towards the implementation of strategic measures aimed at ensuring that the needs and functionings of vulnerable households are satisfied, thus supplementing existing efforts to supply raw fuels to particular groups and places [21]. A widening of energy poverty amelioration frameworks towards the notion of ‘services’ also brings to the attention issues of public engagement, democracy and politics [179], potentially allowing affected publics to have a voice over the kinds of services and forms of utility provision that they need. Overall, it emphasizes the importance of access, reliability and built environment efficiency, by helping devise policies that address energy as a broader issue of demand-side energy security. This, in turn, can help generate a wider awareness of energy poverty as a global challenge, rather than a predicament specific to particular geographic settings.

Energy services and vulnerability approaches allow for a more explicit focus on the geographic aspects of domestic energy deprivation, as dimensions such as energy access, flexibility, efficiency and needs are unevenly distributed across space. This implies that planning frameworks need to be mobilized so as to ensure that some of the broader structural problems surrounding energy service poverty can be dealt with in a systematic and comprehensive manner, alongside fiscal policies to support the low carbon transition. Specific measures may include supporting neighbourhoods, cities and regions to address domestic energy deprivation via affordable and locally sourced low carbon energy, as well as ensuring the pooling of household resources via various informal or formal networks so as to reduce individual energy needs. In the policy and regulatory domains, associated actions can include the formulation of governance processes and practices that can support fuel and supplier switching and facilitate energy efficiency investment: particularly in the private rented sector, housing in multiple occupancy, and apartment blocks. Developed-country contexts in particular may benefit from the implementation of area-based approaches, while building the capacity of community organizations and local authorities to address retrofits in ‘hard-to-treat’ properties.

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