Adapting an English methodology to assess health cost benefits of upgrading energy inefficient French dwellings

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Abstract

There is a growing bank of evidence on the health and well-being gains from alleviating energy inefficiency in housing. The gains are strongest for vulnerable groups such as those on low income, and, in particular, the elderly, children and those with existing respiratory illness. To date, the health costs attributable to energy inefficiency and energy precariousness have not been calculated in France where more than 5 million households (12.5 million people) are estimated to be energy vulnerable. However, the health costs associated with energy inefficient dwellings have been estimated in England based on the Housing Health & Safety Rating System (HHSRS) a health-based risk assessment system, incorporated into English law in 2006, and unique in Europe.

Our objective was to adapt the English methodology based on the HHSRS to provide a means to estimate the health costs associated with energy inefficient dwellings and energy vulnerability in France, and then compare this with cost benefits of thermal improvement.

Adapting this methodology, and focusing on energy inefficiency and vulnerability involved the following steps –

1. Using an energy efficiency indicator inspired from the UK Standard Assessment Procedure (SAP) to determine the number of energy inefficient dwellings where the risk to health could be deemed totally unacceptable.
2. Relating the energy inefficient dwellings to the probability of exposure to low indoor temperatures and an occurrence resulting in negative health outcomes to residents, making it possible to estimate the cost to the health sector associated with such exposure.
3. Comparing the cost to the health sector with the cost of works to upgrade energy efficiency to an acceptable level.

This paper shows that it is feasible to adapt an English methodology to enable the health costs of French energy inefficient housing to be calculated, and compared with the cost benefits of improving that housing.

Introduction

The relationship between poor housing conditions and health is well established[1] . Health outcomes linked, to a greater or lesser extent, to housing conditions range from relatively minor physical injuries, respiratory conditions, serious long-term disabilities, stress and depression, life-threatening cardiovascular conditions, and even death.

A major health-related housing problem is that of energy efficiency. Energy inefficient dwellings allow heat to escape to such an extent that reaching and maintaining reasonable and safe inside temperatures during the colder seasons is expensive. Not only is energy inefficiency wasteful, it increases the possibility of exposure to low indoor temperatures, particular for those households on low income, with limited financial resources. And the exposure to low indoor temperatures is an

1. See for example – Commission on Social Determinants of Health. CSDH Final Report: Closing the Gap in a Generation: Health Equity Through Action on the Social Determinant of Health. Geneva, Switzerland: World Health Organization; 2008; Broader determinant of health. The King's Fund. Available at: http://www.kingsfund.org.uk/time-to-think-differently/ trends/broader-determinants-health.

acknowledged serious threat to health, especially for the elderly, children, and those with existing respiratory illness and cardio-vascular conditions[2]. The potential health outcomes from periods of such exposure include heart attacks and other cardiovascular conditions, asthma and respiratory conditions, and mental ill-health. As with other health outcomes associated with poor housing, these have various consequences. As well as the suffering caused to the individual, there are demands on the health sector (diagnosis and treatment), days-off-work (which may affect household income), and days-off-school (affecting educational development). These all have negative implications for society affecting the household, the local, and the national economy, both currently and in the future.

There is now a growing bank of evidence on the benefits, particularly to health and well-being, from alleviating housing energy inefficiency[3]. Such positive gains will be the greatest for particular groups of the population; principally those that are on low incomes, and those physically or mentally vulnerable.

The costs to the health sector linked to energy inefficient dwellings have been estimated in England. This was achieved through the development of a methodology based on the Housing Health & Safety Rating System (HHSRS), a health-based risk assessment approach to evaluation of housing adopted as the prescribed statutory for assessing housing conditions in England and Wales in 2006. Up to now, these costs have not been published in France where more than 5 million households (12.5 million people) are estimated to be energy precarious[4].

Terms such as 'fuel poverty', and 'energy precariousness' ('précarité énergétique' in French) are widely used, but often defined or intepreted differently. Here, **energy vulnerable** and **energy vulnerability** have been adopted (unless the context requires otherwise). This is to recognise that while energy inefficient dwellings are a potential threat to health, it is when such dwellings are occupied by low-income households that the threat becomes a reality. Those households that can afford to heat an energy inefficient dwellings to 'safe' temperatures (i.e., included in the WHO thermal comfort range of 18-24 °C[5]), while wasting energy, can avoid the risk. Low-income households, however, may not be able to afford the energy needed to achieve safe temperatures, and so unable to avoid being exposed to a serious threat to health from low temperatures. It is these households that are the energy vulnerable.

This paper details the methodology involved to adapt the approach developed and validated in England to provide a means to calculate and analyse the cost benefits to the health sector of alleviating energy inefficiency in French dwellings. The English approach has been used to this end and has shown the benefits of investing in domestic energy upgrades. As the data on energy assessments systems in the two countries are very different, this paper gives a clear and transparent explanation of the processes needed to ensure a firm foundation for the French project.

Method

THE ENGLISH METHODOLOGY

This is based on the Housing Health and Safety Rating System (HHSRS), which relates health outcomes to potential housing **Hazards**. The HHSRS was developed between 1996 and 2006 and included reviews of the current literature, and analyses of housing and health data sets for 1996 to 1999[6]. This development work identified 29 potential housing Hazards, one of which, **Excess Cold**, corresponds to energy inefficiency resulting in exposure to low indoor temperatures, and gave the possible associated health outcomes as ranging from death to severe coughs and colds. This linking of health outcomes with particular housing conditions made it possible to put a cost to the health sector against each of those outcomes. This, uniquely, allows for a total health cost to be estimated for a particular Hazard – for the purposes of this study, the health costs associated with exposure to low indoor temperatures.

- The HHSRS categorised the possible health outcomes attributable to periods of exposure to low indoor temperatures as **Classes of Harm** based on the degree of incapacity suffered. Examples of the outcomes of each Class of Harm were given as –
- **Class I –** Heart attack or respiratory conditions resulting in death.
- **Class II –** Cardio-respiratory diseases; Severe Asthma; Non-malignant respiratory diseases; Myocardial infarction; Stroke; Chronic confusion; Regular severe fever.
- **Class III –** Rhinitis; Hypertension; Sleep disturbance; Neuropyschological impairment; Sick building syndrome; Chronic severe stress; Mild heart attack; Regular and severe migraine; Asthma; Psycho-physiological effects; Hypertension.
- **Class IV –** Occasional severe discomfort; Occasional mild pneumonia; Regular serious coughs or colds; Chronic obstructive lung disease (COPD); Respiratory disease; Ischaemic heart disease; Mild stroke; Psycho-physiological effects; Hypertension.

For practical purposes, a proxy has been adopted in England to ascertain whether a dwelling is energy inefficient such that occupiers are liable to be exposed to low indoor temperatures, i.e., the dwelling presents the HHSRS Hazard of Excess Cold. This proxy is the Standard Assessment Procedure (SAP), originally developed in 1992 and revised in 2012[7]. The SAP uses assumptions of occupancy and behaviour to estimate the energy used for the provision of space heating, domestic hot water, lighting, ventilation, and use of appliances, giving a relative rating on a

2. Marmot Review Team (2011) The Health Impacts of Cold Homes and Fuel Poverty. Friends of the Earth and Marmot Review Team, London, UK.

3. Pearson AL, et al (2014) Housing quality and resilience in New Zealand, Building Research & Information, 42:2, 182–190. Wilson J, et al (2016) The Health Benefits of Home Performance: A review of the current evidence. US Department of Energy.

4. Ambriosio G, et al (2015) Analyse de la précarité énergétique à la lumière de l'enquête PHEBUS . Available at http://www.onpe.org/sites/default/files/pdf/documents/rapports_onpe/onpe_cstb_phebus_onpe.pdf

5. Ezratty, V and Ormandy, D. Thermal discomfort and health – A threat to health (part 1) Environnement Risque & Santé 2015, 14 (3): 215–220.

6. Explanation of the HHSRS and its development are given in ODPM (2006) Housing Health and Safety Rating System: Operating Guidance. Office of the Deputy Prime Minister, London. See also – https://www.gov.uk/government/collections/housing-health-and-safety-rating-system-hhsrs-guidance.

7. See – https://www.gov.uk/guidance/standard-assessment-procedure.

HHSRS Definitions	
Excess Cold	The condition of a dwelling that poses a threat of harm to health from sub-optimal indoor temperatures (i.e., temperatures below 18 °C).
Harm and Classes of Harm	An adverse physical or mental effect on the health of a person. It includes, for example, physical injury, and illness, condition, or symptom whether physical or mental. It also includes both permanent and temporary harm. Possible Harms that may result from an occurrence are categorised according to their perceived severity into four Classes of Harm. These are harms of sufficient severity that they will either prove fatal or require medical attention.
Hazard	Any risk of harm to the health or safety of an actual or potential occupier that arises from a deficiency.
Likelihood	The probability of an occurrence during the next twelve months that could cause harm.
Occurrence or Hazardous Occurrence	An event or a period of time exposing an individual to a hazard.
Spread of Harm	The range of possible harm outcomes (i.e., Classes of Harm) that could result from an occurrence, expressed as a set of percentages indicating the relative possibility of each Class of Harm as assessed from data sources.

scale from 0 (very inefficient) to 100 (extremely efficient). SAP is now used in England to calculate the Energy Performance Certificate (EPC)[8], and a dwelling having a SAP of 38 or less (i.e., an EPC of Band F or G) is officially considered to be energy inefficient[9]. Such dwellings are deemed to pose an unacceptable threat to health because of the possibility of exposure to low indoor temperatures.

Analysing statistical evidence on housing conditions (from the English House Condition Survey and other housing-related datasets) and matching it with health data (including from GP visits, hospital attendance), the **Likelihood** of a **Hazardous Occurrence** and of the possible outcomes (**Harms**) from such an occurrence was calculated[10] [9]. The results gave a **Likelihood** of an individual suffering harm over a twelve-month period that was 1 in 18; that is one event and harmful outcome for every 18 energy inefficient dwellings (those with a SAP of 38 or less).

While the possibility of an outcome from a Harmful Occurrence (the period of exposure to low indoor temperatures) is given as 1 in 18, that nature and severity of the outcome would vary, but would be one of the four **Classes of Harm**. This **Spread of Harm** based on analyses of pre-2000 data gave the following results – 34 % of victims would suffer a Class I Harm, 6 % a Class II harm, 18 % a Class III harm, and 42 % a Class IV harm. And, as each of these outcomes would be sufficiently serious to warrant medical attention, there would be a cost to the health sector that could be calculated.

ADAPTING THE METHODOLOGY TO FRANCE

To convert the approach developed in England would necessitate the following:

- Identifying energy inefficient dwellings in the French housing stock.
- Estimating the costs to the health sector attributable to occupation of energy inefficient dwellings.
- Estimating the cost of energy improvement measures.
- Carrying out cost benefit analyses, and assessing the repayment or pay-back period.

To Identify Energy Inefficient Dwellings

In 2012/13, the Statistical Office (SOeS) of the French Ministry for Environment, Energy and Sea[11] carried out a survey of the 28 million principle residences in France. This survey, PHEBUS, was in two parts – a face-to-face interview of residents (13,074 individuals) of 5,405 representative dwellings. It also included information on a sub-sample of 2,389 dwellings to give a picture of the energy performance of the principal residences, and on energy vulnerability by comparing income and the share of energy expenses, as well as the subjective satisfaction with the heating.

PHEBUS also included an assessment of energy consumption and performance of the dwelling carried out by a qualified official, together with recommendations for improving the energy performance. The energy consumption and performance was calculated following the Conventional Consumption Calculation developed for the Diagnostic de Performance Energétique (3CL-DPE)[12].

Adopting the equivalent of the English proxy of a SAP of 38 or less to identify the energy inefficient dwellings involved converting the French 3CL-DPE scale to match SAP. A standard-

8. As required by EU *Directive* 2002/91/EC (EPBD, 2003), updated 2010.

9. A Decent Home: Definition and guidance for implementation (2006) Department for Communities and Local Government. Originally given as SAP 35 at paras 5.27, and 7.1, now taken as SAP 38 as the upper limit of EPC Band F.

10. sODPM (2003) Statistical Evidence to Support the Housing Health and Safety Rating System: Vols I, II and III. Office of the Deputy Prime Minister, London.

11. Service de l'Observation et des Statistiques, Ministère de l'Environnement, de l'Énergie et de la Mer.

12. Decree of 17 October 2012 amending the 3CL-DPE calculation method introduced by the decree of 9 November 2006 approving several calculation methods related to the energy assessment in continental France. – http://www.rt-batiment.fr/batiments-existants/dpe/outils-et-guides-pour-le-dpe.html; http://www.rt-batiment.fr/fileadmin/documents/RT_existant/DPE/DPE_outils/Annexe_methode_de_calcul_3CL-DPE_V1.3.pdf

ised theoretical energy consumption (final energy) was calculated using the 3CL-DPE method for space and water heating, to which were added standardised theoretical consumptions for the three other end uses included in the SAP method (lighting, and, if present, mechanical ventilation and air conditioning). The SAP scale runs from 0 (inefficient) to 100 (efficient), while the normative energy consumption calculated using 3CL-DPE for the PHEBUS sample dwellings is the inverse, running from very low consumption (efficient) to very high (very inefficient). The normative consumption of the PHEBUS sample dwellings was re-scaled to give the equivalent of SAP, a 0–100 (bad to good) scale. To avoid confusion, this was named Indice de Performance Energétique du Logement (IPEL). This meant that the higher the IPEL, the better the energy efficiency.

Adopting an IPEL of 38 as a threshold provided a simple means to categorise those dwellings in France that could be regarded as energy inefficient. Using the PHEBUS data, it is estimated that 3.65 million (13 % of the total stock) have an IPEL of 38 or less and so can be considered a threat to health because of the risk of exposure to low indoor temperatures, a risk only avoidable by those households able to afford to compensate for the poor energy efficiency.

To Estimate the Potential Cost to the Health Sector

As noted above, by linking health outcomes with potential housing hazards, the HHSRS made it possible to estimate the cost to the health sector attributable to those outcomes. Following this approach, the costs to the French health sector for each of the HHSRS Classes of Harm can be calculated. These included the health costs (both the reimbursed and direct medical costs) associated with each of these outcomes and were based on information from the French national claims database for the period 2007–2011, the Hospital Cost Database (ENCC survey) for 2013, and the Patients Classification System (GHM).

As noted above, the Spread of Harm for the HHSRS had been calculated based on pre-2000 data, and there is evidence that, over the last 15 years and for various reasons including medical advances, there has been a reduction in the more serious health conditions, in particular cardio-vascular mortality. To take account of this, and based on data from INSERM[13], the percentages were revised for this study to give Class I as 3 %, Class II as 17 %, Class III as 30 %, and Class IV as 50 %.

Without improving or upgrading of energy inefficient dwellings, it can be considered that the potential annual cost to the health sector will recur in subsequent years.

To Estimate the costs to Improve Energy Efficiency

The average IPEL of the French housing stock is estimated to be 63.5, and various combination of upgrade measures have been investigated that would improve the energy inefficient dwellings, those with an IPEL of 38 or less, to at least the average IPEL or above. The measures involved:

- The provision of thermal insulation of the fabric to the roof, external walls, floors, and windows.
- The replacement of the technically efficient equipment for space heating and domestic hot water, using where appropriate air source heat pumps.
- The installation of a controlled mechanical ventilation system (CMV).

Using a combination of these measures, three scenarios were considered involving different combinations of these upgrades depending on the dwelling.

The first scenario included eight different packages of the improvements made up of a mixture of the measures. For this scenario, the space and water heating systems were replaced with systems using the same energy (whether using gas, electricity, oil, or wood as fuel, or a district heating system); additional thermal insulation of the walls, roof, and floor was provided and the windows were replaced with double glazed units; and a CMV was installed. It was estimated that this scenario would increase the energy performance by raising the IPEL to 72.

For the second, the heating systems would be replaced with air source heat pumps in all cases. For a small minority of cases, this would not be enough to raise the energy efficiency above an IPEL of 63, so for these, additional insulation would need to be provided to the walls and/or roof. The result for this scenario was estimated to have raised the IPEL to 81.4.

The third scenario, giving an estimated IPEL of 73, was a hybrid of the other two. In this case:

- Where dwellings were heated by a gas fired boiler, this heating source would be retained.
- For those dwellings heated by an oil fired boiler, this would be replaced with gas condensing boiler (or a heat pump where a piped gas supply was not available).
- For those dwellings heated by wood or electricity, heat pumps would be fitted.

For each of these options, as well as considering the energy performance achieved, an annualised investment cost was estimated including the cost implications from the prospective life-span of the equipment/material involved in the upgrade.

Discussion

This methodolocal paper is intended to detail the development used to adapt the English approach to provide a necessary foundation to enable the cost to the health sector of energy inefficiency in France to be calculated and analysed.

The ultimate objective of the project is to estimate the cost benefits to the French health sector that can result from alleviating residential energy inefficiency.

In France there has not been estimations of the costs of energy inefficiency for the health system while it has been estimated in England. Our aim has been to investigate the feasibility of adapting and adopting the English approach to estimate those costs to the health sector in France. Underlying the approach was the intention to utilise, wherever possible, existing and accepted methods and resources. The English methodology was founded on the Housing Health and Safety Rating System (HHSRS), which was evidence-based, and had been introduced into the statutory canon in 2006 and since then used on a daily basis throughout England and Wales. The HHSRS has also

13. http://www.inserm.fr/thematiques/physiopathologie-metabolisme-nutrition/dossiers-d-information

been shown to be transferable, and was adopted (unchanged) in 2010 by the US Department for Housing and Urban Development as the Health Homes Rating System[14].

The English methodology for estimating the health costs attributable to unhealthy housing was developed by the UK Building Research Establishment in 2010, based on the HHSRS. The findings from the BRE's studies have been validated and acknowledged by a wide range of bodies including Public Health England (a government agency), and the UK National Health Service and gave the inspiration for the French project. .

It has been officially accepted in England that dwellings should be considered energy inefficient where, using the UK Standard Assessment Procedure (SAP), the energy performance was calculated to be 38 or less on the 0-100 scale (100 being very efficient). It was decided that, for this project, rather than invent or formulate an arbitrary definition, this threshold would be adopted, and a French equivalent of the English SAP scale would be computed – the Indice de Performance Energétique du Logement (IPEL).

While the project focuses on health costs associated with exposure to low indoor temperatures, there are several direct and indirect health consequences that were not included. One reason for not including these is that it is difficult, if not impossible, to apportion the health outcomes that could be ascribed to those threats when not linked to low temperatures. One of the direct threats to health is associated with dampness and mould which can occur irrespective of the indoor temperature. However, cold indoor surfaces and high levels of relative humidity increase probability of dampness (in the form of condensation) and associated mould growth. Such dampness is an indicator of an unhealthy indoor environment, and the spores from mould growth can be potent allergens[15]. Furthermore, accidental fall injuries can occur in any dwelling, but the incidence of accidental falls and the severity of any related injury are linked to cold homes, particularly so for elderly residents.

Other possible indirect outcomes of low indoor temperatures not included in the project are injuries from fires (from the use of candles and oil lamps), respiratory conditions associated with poor indoor air quality (from the restriction of ventilation and use of inappropriate means of space heating), food spoilage and contamination, low quality meals (leading to obesity), and a negative impact on personal and domestic hygiene (related to the lack of hot water).

It is established that occupying an energy inefficient dwelling increases the likelihood of social isolation, stress, depression, and related Common Mental Disorders (CMDs). However, when the HHSRS was developed there was only relatively weak data on the potential impact of exposure to low temperatures on mental health, and this means that the HHSRS under-estimated costs that should be attributed to mental ill health. This is compounded as it appears that less than 50 % of those suffering from mental ill health seek medical attention (in England it is around 25-30 %)[16]. The population group vulnerable to, and most likely to suffer from, CMDs are mainly those of working age. Employed individuals suffering from CMDs will be likely to take days off work and be under-productive when at work, and this will have a negative impact on Gross Domestic Product (GDP).

In addition, as the project focuses only on the costs to the health sector, related costs to society associated with the occupation of cold homes have not been taken into account but should be recognised. These include, for example, economic costs attributable to educational under-achievement, and factors contributing to the GDP generally.

This means that the estimated costs associated with energy inefficient dwellings produced by this project will be conservative.

To date, studies in England have looked at the cost benefit of domestic energy upgrades in removing the threat to health from energy inefficient dwellings. It is intended that this project will take at least one further step. This will be to calculate the health costs associated with those energy inefficient dwellings that are occupied by energy vulnerable households. These households are those occupying energy inefficient dwellings, with meagre financial resources, such that they are unable to afford the energy necessary to heat the dwelling to safe temperatures (avoiding exposure to low indoor temperatures), to provide for hot water, and to use other fundamental equipment (eg, cookers). The first stage gives the health cost associated with the threat from all energy inefficient dwellings, this is a potential cost as some households will be able to afford to raise indoor temperatures to safe levels. The additional step of this project will give a more realistic cost as it will focus on those most at risk.

Conclusion

This paper has shown the feasibility of adapting the methodology developed in England based on the HHSRS to enable the cost to the health sector of energy inefficient housing in France to be estimated. It has also shown that a cost benefit can be carried out, comparing *this cost with the cost of energy improvements.*

The English methodology has been in use and validated for some time, to utilise this as the basis for developing a first such estimation in France seems practical and rational.

14. https://portal.hud.gov/hudportal/HUD?src=/program_offices/healthy_homes/hhrs

15. WHO guidelines for indoor air quality: dampness and mould (2009) WHO Europe – http://www.who.int/indoorair/publications/7989289041683/en/.

16. http://cep.lse.ac.uk/_new/research/wellbeing/mental_health.asp