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A new heat cost allocation method for social housing

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ABSTRACT

To promote energy saving in the residential sector Directive 2012/27/EU has set the obligation for buildings supplied by central heating sources to install individual heat metering and accounting systems. However, in social housing, bills based exclusively on individual consumption should be unfair due to some unfavourable situations, such as first and top floors, presence of unheated common spaces, north oriented dwellings. Nevertheless, fair heat accounting rules should be introduced especially in social housing buildings, which are often thermally underperforming with inefficient heating plants and tenants are commonly low-income people and elderly. On the other hand, common regulations for heat accounting providing compensation to avoid inequalities among tenants have not been set and different approaches on this topic are present among EU Member States. In this paper the authors present a new heat accounting method for social housing based on the estimation of extra-consumptions due to building inefficiencies. According to this method, extra-consumptions are charged to all tenants in order to encourage energy efficient retrofit interventions. Finally, the new method has been experimented in a typical social housing building in Italy and compared to other methods applicable in EU, evidencing some advantages and weaknesses.

1. Introduction

As widely known, residential energy consumption in Europe accounts for about 45% of the total energy demand, of which about 80% attributable to space heating and cooling [1]. With the aim to reduce energy consumption in residential sector, the Energy Efficiency Directive (EED) [2] has recently obliged in EU Member States (MS) the installation of heat accounting systems in multi-apartment buildings supplied by a common heating source, when technically feasible and economically efficient [3]. Despite EU requires the definition and introduction of clear consumption-based cost allocation methods and the frequent informative billing for heating, cooling and hot water production, not all EU MS introduced specific rules at national level. Even for cooling, only two MS (Denmark and Estonia) defined clear rules on this topic [4].

As also highlighted by Canale et al. [5], the impact of the installation of heat accounting systems and thermostatic radiator valves in residential buildings on national scales is strongly dependent on adopted energy policies. As a matter of fact, EU strongly promotes the definition of effective policy drivers to encourage energy efficient behaviours of final users [6,7]. However, defining fair methods for heat costs sharing among dwellings supplied by a centralized heating system is a complex task, due to legislative and regulatory issues involving political, social, economic and technical aspects.

Measuring or estimating the heat delivered to each apartment can be easily performed through Heat Meters (HM) or Heat Cost Allocators (HCA), respectively. However, the installation of such systems within a building introduces problems of fairness in allocating heat costs among tenants, even without considering the related issues in terms of accuracy and consumers' protection [8–10]. In fact, some of the apartments, such as the ones at first and top floors, the ones adjacent to unheated spaces or badly oriented, can even double their heat costs, though having the same energy behaviour and comfort level of their neighbours.

As a matter of fact, energy consumption for space heating is directly dependent on the users' behaviour (i.e. set point temperature, functioning hours of the heating plant, etc.) [11–13], on the climatic conditions (i.e. outdoor temperature, solar radiation etc.) but also on the morphological and constructive characteristics of buildings (e.g. thermal transmittances, air tightness, building envelope surface, shape factor) and heating systems (e.g. system efficiency), which greatly affect final consumption regardless of users' will. Thus, it is difficult to establish whether the heat measured is or not attributable to a given apartment.

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Nomenclature

Acronyms

AEEGSI	Italian Authority for Electrical Energy, Gas and Water System
Ap	Apartment
ATER	Territorial Agency for Social Housing
CTI	Italian Thermotechnical Committee
EED	Energy Efficiency Directive
ENEA	National Agency for new Technologies, Energy and Economic Sustainable Development
EU	European Union
HCA	Electronic heat cost allocator
HM	Direct heat meter
ITC	Insertion time counter
MID	Measuring Instrument Directive
MISE	Ministry of Economic Development
MS	Member State
SFOE	Swiss Federal Office of Energy
UNI	Italian Standardization Body

Symbols

$A_{com,\,j}$	surface of the *j*th common building element, m^2
AU	Allocation Unit, dimensionless
AUc	Compensated Allocation Unit, dimensionless
b_j	correction factor due to heat dispersions of unheated spaces, dimensionless
$EQ_{inv,\,i}$	Involuntary extra-consumption of the *i*th dwelling, kW h
$EQ_{inv,\,tot}$	Total Involuntary extra-consumption of the building, kW h
$EQ_{v,\,i}$	Voluntary extra-consumption of the *i*th dwelling, kW h
$EQ_{v,\,tot}$	Total Voluntary extra-consumption of the building, kW h
f_i	Correction factor (Greek method), dimensionless
$f_{ext,\,i}$	Correction factor (proposed method), dimensionless
HDD	Heating Degree Days, K
k_{inv}	Coefficient for involuntary consumption, dimensionless
m_i	Percentage of heated gross volume of the *i*th dwelling, dimensionless
$Q_{H,\,ls,\,i}$	total heat loss for transmission and ventilation of the *i*th dwelling, kW h
$Q_{com,\,v,\,i}$	Voluntary Consumption of common parts of the *i*th dwelling, kW h
$Q_{com,\,inv,\,i}$	Involuntary Consumption of common parts of the *i*th dwelling, kW h
$Q_{inv,\,i}$	Involuntary consumption of the *i*th dwelling, kW h
$Q_{v,\,i}$	Voluntary consumption of the *i*th dwelling, kW h
$U_{com,\,j}$	actual thermal transmittance of the *j*th common building element, W m^{-2} K^{-1}
U_{com}^{ref}	reference thermal transmittance of the *j*th common building element, W m^{-2} K^{-1}

This issue has been addressed by different authors in the scientific literature. Siggelsten [14] developed a method for estimating heat transfers between adjacent apartments in multi-apartment buildings in order to allocate the related heat costs. By applying the method to an existing multi-apartment building with 16 apartments, he demonstrated the possibility to use correction factors in a fairly cost-efficient manner. Michnikowski [15] presented a variation of the method proposed by Siggelsten for correcting errors in the allocation of heat costs in multi-family buildings. His method is based on the determination of the average internal temperature with the use of special HCA and on the analytical determination of the energy required for heating with the aim to correct the participation of individual apartments in the total energy consumption of a building. Davariu [16] proposed a method to correct the heat costs through the measured difference between the indoor comfort temperature and the outdoor one. However, as also highlighted by Liu et al. [17], all the cited papers emphasize the issue of "fairness" of heat cost allocation, but do not address the problem from a wider point of view, that is heat metering based on individual consumption should drive towards energy efficient behaviours in buildings.

The adoption of responsible behaviours aimed to achieve energy savings/efficiency has to be promoted through adequate regulatory drivers, especially in social housing, where economic constraints [18] and building characteristics should be carefully considered. In fact, social housing apartments are often randomly assigned, tenants pay for the surface and independently from the dwelling's energy need, first and top floors (generally the more unfavourable positions) not always have further advantages especially in cases of absence of lifts, yards or similar [19].

As a matter of fact, the improvement of energy efficiency of multi-family buildings is not always easily achievable. In fact, the decision to improve the insulation of building envelope components (such as the roof) does not solely depend on the will of individual tenants and landlords, but it should be agreed by the condominium meeting. Common properties determine a singular situation: it is up to all landlords to decide whether or not to improve building energy performance (i.e. through boiler replacement, insulation of common surfaces), while inefficiencies mostly affect only few dwellings. This often represents an obstacle for the approval of energy retrofits in residential buildings, because not all landlords are at the same time potential direct beneficiaries of the intervention. Such situation is even more complex when tenants are not the owner of the apartment, as often occur in social housing. Furthermore, the lack of transparency and simplicity of several heat cost allocation methods does not encourage virtuous behaviours and may lead to a perception of iniquity and to increasing disputes.

In this paper, the authors propose a heat cost allocation method for social housing aimed to address the above described issues and representing a driver for improving building energy efficiency without leading to discomfort conditions and to imbalances of the heating system. This method has been also proposed as a standard method to the Thermotechnical Committee for Energy and Environment associated with the Italian Standardization Body (UNI) and to the competent Italian Authority MISE, the Ministry of Economic Development. The proposed method is based on the estimation of the consumption due to the building's inefficiency, hereinafter called "extra-consumption". These latter represent in particular the consumption exceeding those that would occur if legal limits related to thermal transmittances were respected. It is proposed that extra-costs due to building inefficiency are temporary allocated to all tenants until a retrofit intervention is carried out and this should represent a driver for energy retrofits implementation. The main peculiarities of the proposed method are the following: *(i)* the allocation of energy consumption of common parts of the building is proportional to the reference building energy performance (i.e. the minimum thermal transmittance provided by the current regulation) and it is not a pure correction of the consumption data; *(ii)* all tenants are charged for common areas' inefficiency and, consequently, landlords should be encouraged to perform energy retrofits; *(iii)* once performed the energy retrofit, landlords/tenants start paying only for their individual consumption without any compensation. Unlike methods already proposed in scientific literature, which mainly approach the problem with