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Estimation of the Energy Performance Certificate of a housing stock characterised via qualitative variables through a typology-based approach model: A fuel poverty evaluation tool

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ABSTRACT

The European Union stresses the accent on the need of energy consumption and expenditure data related to housing stock (EP, 2010). Most of housing and living conditions databases of Member States investigate the housing status of a concerned region through a survey to be submitted to the sampled households. The assessment of energy performance then requires a simplified energy performance certification method, based on qualitative variables.

In this paper the French Enquête Nationale Logements (ENL) is considered. A conversion algorithm is elaborated to refer each of the ENL housing units to a reference building and a reference HVAC system of the European Typology Approach for Building Stock Energy Assessment database (TABULA–EPISCOPE, 2013) for France. The ENL housing stock is better specified in its technical and energetic features through a typological data crossing. As a result, an energy label and an energy performance index expressed in [(kWh, ep)/(m^2 year)] are issued for every single ENL row.

The calculation outcomes are assessed through a sensitivity analysis and compared to other national statistics; finally the distribution of energy labels is discussed. Many purposes of results exploitations are cited, concerning in particular the fuel poverty evaluation and the energy expenditure per household estimation.

1. Introduction and purposes

The elaboration of an efficient energy saving policy requires a more and more accurate estimation of the energy consumptions and expenditure related to building stocks. The European Union, with the publication of the EPBD Recast [1] stresses the accent on the need of an assessment procedure taking into account the energetic cost of buildings. The aim is to set "minimum energy performance requirements for buildings or building units with a view to achieving cost-optimal levels".

The present calculation process produces an Energy Performance Certificate (EPC), instructed by the international standard EN 15217 and transposed into the national legislations (see [3] for France). The energy performance indicators are issued as a result of a national evaluation method, with reference to a well-established European set of standards concerning the building envelope and equipment. This method underpins a complex range of technical variables to be collected by a professional or a qualified person. The amount of data required is complex to collect at national stocks scale. Usually this burden exceeds the data collection budget and purposes of a national statistic survey.

Most of housing and living conditions databases investigate the housing status of a concerned region through a survey to be submitted to the sampled households. The structure of this survey includes then a set of easy-to-answer questions, accessible and understandable to anyone, that does not need a professional support to be filled. The outcome is a qualitative characterisation of the building stock that makes it difficult to quantify the energy performance and compare it.

The present paper investigates an approach consisting in a simplified calculation procedure, which only focuses on the most characterising features of the building and associate them to default energy needs, but this would lack in accuracy. Otherwise an energy performance assessment could be committed but a smaller sample

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is then imposed. This is the case of the United Kingdom: the English Housing Survey consists of a first part including 13,300 interviews per year and a second part involving a physical inspection of a housing subsample (6200 households) [4]. Also France has a national housing enquiry (Enquête Nationale Logements) concerning almost 37,000 households and a more detailed energy performance survey (Phébus) based on 2500 rows [5].

The article 11 paragraph 7 of the EPBD Recast asserts that "certification for single-family houses may be based on the assessment of another representative building of similar design and size with a similar actual energy performance quality". Within this spirit, the aim of this paper is to experiment a data crossing between a national large-sampled housing survey (in this case the French Enquête Nationale Logements, ENL) and a residential typology database, the European Typology Approach for Building Stock Energy Assessment [2,6] for France. A specific algorithm is intended to associate a reference building from TABULA to each housing unit of the ENL in order to merge the gross qualitative characterisation provided by the household interview with a consolidated set of technical and geometrical features. In this way the building envelope and the HVAC system are defined in detail and in accordance with the European Standards. Energy needs and requirements are then estimated and an energy performance label is issued for each row of the whole ENL sample. The results are then compared to other national data distributions concerning energy use. The adoption of a European validated calculation tool allows the use of this dataset for international comparisons and analysis too. The conclusions of this paper present a possible further exploitation of this methodology and the related results.

2. Presentation of the data sources: ENL and TABULA

This section presents the structure of the chosen data sources to clarify the purposes of this paper. A detailed focus on the concerned variables is provided in the next section.

2.1. Enquête Nationale Logements, ENL 2006

The French Enquête Nationale Logements (ENL) purpose is to describe housing conditions of households and their spending in housing at a national scale. It is one of the most important surveys of the national statistical institute (INSEE), by its age (since 1955), its frequency (every 4/5 years) and the size of its sample (roughly 40,000 households). The survey gives lots of details both on housing units (size, number of rooms, age, comfort, equipment, surroundings and urban position, rent, loan, charges, energy spending, etc.) and on households' characteristics (number and ages of people, education, professional activity and distance from work, incomes and social benefits, etc.). In this condition, the thermal quality of the dwelling is not a central subject, but a lot of information can be used to make estimations (see below).

2.2. Typology Approach for Building Stock Energy Assessment, TABULA 2011

Firstly the IEE project DATAMINE (2006–2008) collected 19,000 Energy Performance Certificates across the European partners and transferred them to a common database by use of commonly defined data fields. For different age and size groups "average buildings" were defined which are representative for the respective sample subsets. During the following IEE project TABULA (2009–2012) residential building typologies have been developed for 13 European countries. Each national typology consists of a classification scheme grouping buildings according to their size, age and further parameters and a set of exemplary buildings representing the building types. A selection of HVAC (heating, ventilation and air-conditioning) systems is also provided to be associated together with the building types. Each "reference building" is then characterised with typical energy consumption values and an estimation of the possible energy savings through the implementation of different refurbishment measures.

The method is focused on the energy use for space heating and domestic hot water of residential buildings. Cooling, air conditioning, lighting, electric appliances are until now not considered in the concept but can of course be supplemented later. The results of this process have been published by the project partners in national "Building Typology Brochures", written in their respective languages and enclosed with statistical data for buildings and supply systems.

Each building type in TABULA is identified through a code which resumes its main features, in particular: the national and regional relevance (e.g.: according to climate zones), the housing size (single family house, terraced house, multifamily house, apartment blocks), the building age (in 10 classes, from 1800 to 2000), the reference type (real example building, real average building, theoretical statistical model) and the increasing refurbishment package code (001–003). The reference HVAC system as well is defined by a national code and by three components related to the concerned heating, DHW and ventilation system. More details can be found in the TABULA final report [6]: an outline of the code composition is presented in Fig. 1.

3. Variables employed in the calculation process

The ENL 2006 survey provides a set of variables that can be exploited for an energetic characterisation of the concerned buildings. As can be remarked, most of them state a broad qualitative description of the building, with banded values. Three variables (SOURCE, SOURCEECS and MODE) were designed on purpose to resume the output of several other variables. Even if these data are not detailed enough to attempt an energy performance evaluation, they can be used to select a reference building from the TABULA database. In fact, the features listed in Table 1 are comparable with the ones outlined in Fig. 1. A conversion algorithm described in the following sections of this paper links each row of ENL to a reference building (Fig. 2) and a reference HVAC system (Table 2) of TABULA. This is done by the use of the TABULA code structure, according to the variables listed in Table 1.

4. ENL to TABULA algorithm description

4.1. First step: associating each housing unit of ENL with a reference building in TABULA

With reference to Fig. 1, the TABULA code is assumed as a standard to identify every row of ENL. The aim of the described algorithm is then to assign a TABULA code to each of the 36.955 ENL housing units and pair them to a specific reference building equipped with different reference HVAC systems. This process can be easily automated and it returned 1.1% of uncertainties at this stage.

As a first step, the number of the department which hosts the housing unit (variable DEP in ENL) is related to a climatic zone according to a ministerial table [7]. Three climatic zones are settled in France: H1, H2, and H3 (colder to warmer).

The second point focuses on the building construction achievement date. It identifies the technologic typology of the building, as well as the usually employed materials. This information is contained in variable IAAT of ENL, grouped by classes. The ENL housing units, gathered in ten classes from "before 1871" to "1999 and beyond", are re-organised in ten classes as well from "1800–1900" to "1990–2000", according to the TABULA classification.