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Assessing household energy uses: An online interactive tool dedicated to citizens and local stakeholders

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ABSTRACT

This paper presents the SOLEN integrated online tool, dedicated to citizens and local authorities. This methodology, developed to allow precise energy assessment (heating, cooling, ventilation, lighting, appliances, and cooking but also local production of renewable energy) of household energy uses, is firstly introduced. SOLEN uses a typological classification of buildings and thermal simulations. Many parameters are defined and taken into account to capture the specificities of numerous types of buildings exhaustively (e.g. type of buildings; number of floors; common ownership; orientation; thermal performances of the walls, floors, roofs, and windows; and ventilation type). These results related to building energy consumption are then crossed, in an integrated approach, with several indicators of urban sustainability, to take into account in the balance of the impact of the location of buildings on transportation energy consumption or the impact of the urban form on the production of solar renewable energy. This tool makes accessible to a large non-specialized audience the results of a three-year scientific research study in Wallonia (Belgium) and was awarded an Energy Globe Award (Belgium) in 2014. The first feedback from users is presented to conclude this contribution.

1. Introduction

There is an urgent need to reduce energy uses in our built environments, including cities, suburban areas, as well as rural settlements. In Europe, energy consumption in the building sector accounts for more than 40% of the final energy supplied to the customers [1], representing the most important sector, above transportation and industry. Buildings are thus considered as major contributors to climate change because of the release of carbon dioxide and others greenhouses gases, and promoting energy efficiency in buildings is often presented as a viable approach to the mitigation of climate change. Energy efficiency in the building sector has thus been the focus of extensive worldwide research over the past decades. Numerous research efforts have highlighted the need to produce more efficient buildings, but also to retrofit the existing building stock, especially in Europe where the renewal rate of buildings is quite low [2–4], thus the existing building stock should be the main target to significantly reduce energy consumption.

The use of mathematical models and simulation tools is often presented as the most credible approach to model the behaviour and to predict the energy consumption of a system [5,6]. Most of these existing models focus on the heating requirements of residential or tertiary buildings, at the individual building scale. More recently, the role that urban form plays in influencing the energy consumption of individuals buildings has also been studied extensively [7–9]; the importance of the location of a building and the characteristics of the neighbourhood in which it is located (density, diversity of function, access to amenities, etc.) on the generation of mobility patterns and quality of life has been highlighted. In fact, it seems counterproductive to produce or retrofit efficient buildings without any concern for the location of the building and its impact on the mobility of its inhabitants. Amongst their numerous advantages, the approaches based on mathematical models and simulation tools can account for a large number of parameters that are known to act upon the energy consumption of a system and can utilize parametric variations to test the impact of energy efficiency strategies.

Last but not least, several research and empirical results have demonstrated the significant impact of the lifestyles and behaviours of housing occupants on energy consumption [10,11]. Citizens and local authorities must be considered as the first actors that can concretely alter the energy consumption in buildings and

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in cities. The rate of private ownership in the residential building sector is high in most European regions (especially in Belgium where almost 70% of household occupants are owners of their own dwellings [12]). Private owners have a central role in the retrofitting of the building stock. Small adaptations to individual behaviours (e.g. thermostat, heated area, etc.) can help to reduce energy consumption drastically. However, research methods and tools that allow precise quantification of energy uses in buildings and energy savings related to various actions (insulating the roof, changing the glazing, behavioural changes, etc.) remain dedicated mostly to trained professional users [13–15], thus neglecting the huge potential energy savings linked to individual actions undertaken by citizens in their dwellings. Moreover, although an increasing number of household occupants are paying attention to their energy consumption and are motivated to undertake light or heavy renovation, they do not know what actions to undertake and are unaware of the impacts of renovation in terms of comfort, energy savings, costs, etc. Raising public awareness of the impact of citizens on energy efficiency is crucial and could quickly lead to significant reductions in the total energy consumption of a territory.

The dissemination of academic research to the public (citizens, local authorities, policy makers, etc.) is crucial to ensure more sustainable development of our territories and to reduce energy consumption in buildings. Thus, the main aim of this research was to encourage positive changes in the energy efficiency of the building stock, by providing an online interactive tool that will help citizens and local stakeholders to assess energy uses in their houses and neighbourhoods, starting at the individual scale. This tool was intended to transfer the main results of a three-year study to a non-specialized audience. The need for this type of research lies in the fact that its dissemination is for people that do not have specific knowledge in the energy field, but for them to have the necessary information to conduct themselves in their homes and neighbourhoods more energy efficiently.

In this context, this paper presents the SOLEN tool, a novel integrated urban tool, developed within the "Solutions for Low Energy Neighbourhoods" project and dedicated to citizens and local authorities. The aim of this tool is to address the previously highlighted main challenges, in an integrated approach, by allowing the user to perform an entire assessment of energy uses from residential buildings and daily mobility, as well as to quantify the energy efficiency of several types of retrofits and changes in daily habits. This tool is based on a previous version, developed to assess only suburban houses and neighbourhoods [16]. Major updates and complements were developed to strongly improve and enrich the first version and are presented, especially:

- The methodology to assess energy uses in buildings was strongly improved to also consider lighting, appliances, and cooking;
- The updated version of the tool allows the local production of renewable energy, such as PV panels, solar heating, etc. to be taken into account;
- The impact of the neighbourhood in which the building is located is taken into account;
- The methodology used to assess transportation energy uses was modified to include all types of travel, including chained trips;
- Several sustainability indicators were developed and crossed with energy consumption in buildings; and
- It is now also possible to obtain financial gains related to energy consumptions and potential energy savings.

The SOLEN interactive tool was built upon numerous methods, tools, and data that cannot be presented extensively in a single paper. As this paper focuses on the presentation of the interactive tool, enabling the transfer of scientific methods and results to a non-specialized audience, the interested reader can refer to several previous scientific papers in which all parts of the methods and related assumptions have been extensively presented [10,16–18,29,33–36]. The methods that have been developed to build the SOLEN tool are summarized in the two following sections. Section 2 briefly presents the methodology that enables a precise assessment of energy uses in buildings (heating, cooling, ventilation, lighting, appliances, cooking, and production of local renewable energy). This methodology was applied to the Walloon (Belgium) building stock and a huge database including more than 250,000 individual results was produced. Then, Section 3 presents several indicators of urban sustainability that were developed to be taken into account in the online interactive tool, including the impact of the location or urban form on energy production and consumption. In Section 4, the SOLEN online integrated urban tool, developed based on previous methodologies and their application, is presented. This tool, especially dedicated to citizens and local

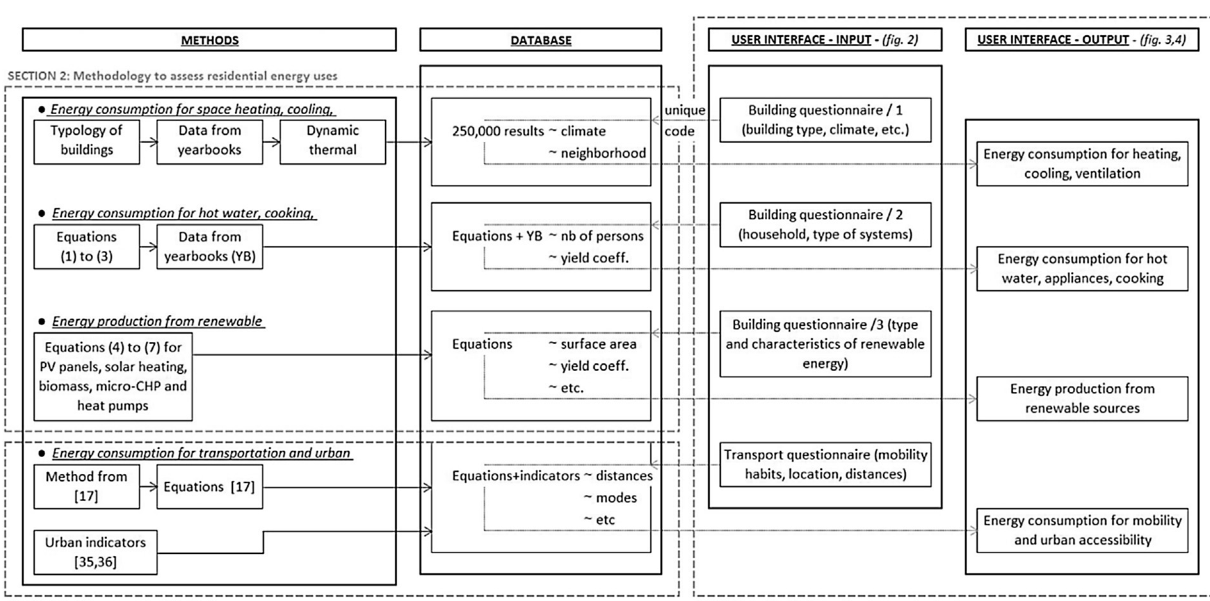

Fig. 1. Articulation between the components of the research (methods – database – user interface).