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Energy consumption and efficiency in buildings: current status and future trends

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ABSTRACT

The building sector is considered as the biggest single contributor to world energy consumption and greenhouse gas emissions. Therefore, a good understanding of the nature and structure of energy use in buildings is crucial for establishing the adequate future energy and climate change policies. Availability of the updated data is becoming increasingly important in order to allow a rigorous analysis. In this paper, recent data on the world energy consumption in both residential and commercial buildings are reported. Past situation, current status and future trends are discussed and analyzed for selected countries. A breakdown of buildings energy consumption is realized in order to determine the influencing key parameters. A whole section of this paper is dedicated to give an overview of measures and policies adopted by different countries, allowing the monitoring, management and reduction of the energy consumption in buildings. Critical aspects of these policies are discussed based on the feedback of the early adopters.

1. Introduction

The sustainability challenges concerning energy saving and environment protection are enormous (Dovì et al., 2009; Diedrich et al., 2011; Van Vuuren et al., 2012; Allouhi et al., 2015) and will require major changes, not only in the way that energy is supplied but in the way that it is consumed. On the other hand, the close relationship between energy and economic development gives rise to the necessity of a good understanding and a continuous monitoring of energy consumption (Asafu-Adjaye, 2000; Lee, 2005; Shahbaz et al., 2013), something that cannot be achieved without its quantification and categorization by sector and end-use. Even if great efforts are undertaken by many organizations to supply sufficient information of energy consumption worldwide, the clear screen related to this target cannot be drawn without a global cooperation between nations, international organizations and agencies. A special focus should be given to the characteristics of the building sector due to its significant amount of the energy consumption and the associated CO_2 emissions (Lukas and Ugursal, 2009; Santoyo-Castelazo and Azapagic, 2014; Mattinen et al., 2014).

In a previous interesting work, Lombard et al. (2008) presented an analysis, based on available information relative to 2004 period, about energy use in residential and commercial buildings with a detailed breakdown and special focus on HVAC systems. In the regard of obtaining more recent data on this topic, the present study aims at surrounding energy consumption in the building sector by giving updated information of energy indicators. Many countries are considered as references according to the illegibility of official data. Furthermore, resulting strategies and measures adopted by the reviewed countries along with their successful achievements are discussed. The remainder of this paper is organized as follows: After presenting briefly the methodology adopted in the current study in Section 2, we describe the world evolution of energy use in Section 3. Zooms in on the energy consumption relative to the building sector via a multi-angle analysis covering the general impacting factors are discussed in Section 4. Founded on the feedback of the early adopters, Sections 5 discusses the critical aspects of energy efficiency policies as a powerful method to reduce energy consumption in buildings and the resulting CO_2 emissions.

2. Methodology

An extensive literature review is presented in this paper to gather detailed information about the status of energy

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consumption in the building sector. Several international reports and recent academic publications were regrouped. The second stage of this approach is data selection through examining the relevant documents and official reports. As a consequence, some countries were selected as references throughout the different sections of this paper.

The reporting of the updated information related to energy consumption in the building has allowed the description and the analysis of the key factors impacting energy use in the building sector. Then, the topic of energy efficiency was treated by discussing the most important options and solutions and the prospective barriers encountered.

Fig. 1 shows the followed approach conducted for the current investigation.

3. World energy use: past orientations, recent status and future trends

Energy is indispensable for socioeconomic development and life-quality improvement in all nations (ASHRAE, 1990; Kousksou et al., 2014). Ensuring the energy supply and minimizing the resulting environmental impacts (Global warming and ozone layer depletion) are certainly the greatest challenges related to the twenty first century's energy advances. The need to analyze past data and forecast future trends of energy consumption is one of the important measures to take in order to draw next strategies for energy production and supply concerns. For that, the International Energy Agency (IEA) publishes periodically new statistics on the world energy status. In its last report, the IEA presented a figure of world final energy consumption and world CO_2 emissions from 1971 to 2011 (Figs. 2–3 (IEA, 2013)). It is clear that the global energy consumption and CO_2 emissions approximately doubled during the concerned period.

Between 2005 and 2011 an average annual energy consumption growth of about 3.15% is observed. In 2011, the global energy consumption rate was 8.92 Gtoe/year and it is predicted that this rate would amount to 14 Gtoe/year by 2020. These data indicate that the global energy consumption and CO_2 emission rates are on the rise in the next years.

The analysis of many preponderant socioeconomic and energy parameters are fundamental to draw a clear picture about the world energy consumption evolution; a legitimate reflection should be taken in order to link these socioeconomic parameters with energy use evolution in time. Table 1 illustrates the 2001's and 2011's values of the main indicators. Interesting conclusions can be deduced after analyzing these indicators:

- The total energy consumption is growing faster than population (2.75% vs 1.4%); it can be explained by the increasing need for individual energy; in fact, the Per Capita Energy Consumption has increased by 11.18% in 10 years as a result of the improvement of comfort level and the extension of human activities.

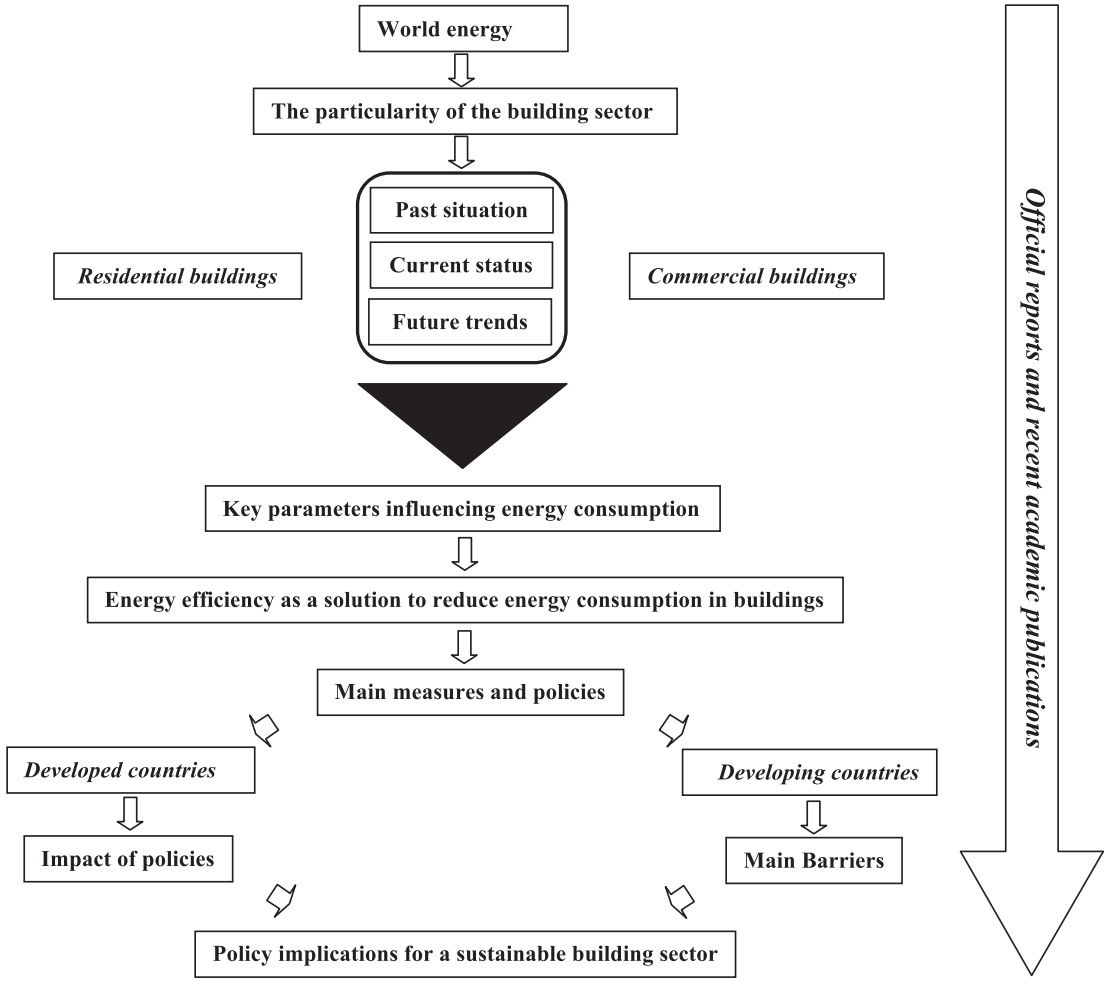

Fig. 1. Adopted approach in the study.