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Strategies for reducing the environmental impacts of room air conditioners in Europe

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ABSTRACT

In Europe, buildings tend to be equipped with individual air conditioners, which constitute a fast growing electrical end-use. In this context, this study aims to assess the environmental impacts of European individual air conditioners and to analyse policy strategies to reduce these impacts. After analysing the European context concerning individual air conditioners, the environmental impacts of European air conditioners are assessed using a Life Cycle Analysis approach. The following step consists in studying, both technically and economically, different improvement options aiming at reducing the environmental impacts of these appliances. These results, obtained at the product level, are then generalised at the European level and different policy measures are defined and analysed. The main conclusion is that the implementation of a Minimum Energy Performance Standard based on Least Life Cycle Costs could save up to 49 TWh and 20 $MtCO_{2\text{-eq}}$ in 2020 and be economically beneficial to the European end-user.

1. Introduction

In Europe, individual air conditioners tend to be installed in an increasing number of buildings and constitute a fast growing electrical end-use. The European market is relatively new but is growing substantially: about 3.5 million units were sold in 2005 (BSRIA, 2005) whereas only 1.6 million had been sold in 1996 (Adnot et al., 1999). Market growth is driven by different factors: the diminution of purchase costs due to massive production in Asia, the increase in comfort requirements, the heat island effect (Adnot et al., 2004) or the fear of heat waves.

In this context, this study aims to assess the environmental impacts of European individual air conditioners and to analyse policy strategies aimed at reducing these impacts. This article presents the main results of a study we undertook (Rivière et al., 2009) in the framework of the Energy using Products directive[3] (CEC, 2009a). If needed, we recommend the reader to refer to this study for more comprehensive results.

After analysing the European context concerning individual air conditioning (Section 2), the first step consists in undertaking a Life Cycle Analysis (LCA) of reference cases (i.e. products representative of the European market) in order to assess their environmental impacts and determine improvement paths (Section 3). Then, different improvement options aimed at reducing the environmental impacts of these appliances are studied, both technically and economically (Section 4). All these allow the assessment of the cost of low environmental impact air conditioners.

Finally, these results, obtained at the product level, are extended to the European level. Different minimum energy efficiency standards are defined and their impact is evaluated. Finally, policy recommendations derived from these findings are discussed (Section 5).

2. Overview of the European situation regarding room air conditioners

2.1. Technical descriptions of room air conditioners

2.1.1. What does "room air conditioner" mean?

An air conditioner is an appliance designed to maintain the temperature of indoor air at a given temperature level. Individual air conditioners theoretically aim to cool a single room and not a whole building that, in practise, means to a capacity limit of 12 kW. This criterion is used by the European Commission (e.g. in the labelling directive, CEC, 2002a) and the manufacturers (e.g. the Eurovent certification programme, Eurovent, 2006).

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[3] In 2006, room air conditioners were included in the 12 first product families in the scope of the Energy using Products (EuP) directive (CEC, 2009a). This directive aims at establishing a framework for setting ecodesign requirements for energy using products in the residential, tertiary, and industrial sectors.

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There are different types of air conditioners (Table 1); the single split type is by far the most common type in Europe.

The single-split system is composed of two packages (one indoor and one outdoor unit) connected only by a pipe that transfers the refrigerant. The indoor unit includes the evaporator and a fan, while the outdoor unit contains a compressor and a condenser. The multi-split system is similar to the previous product but includes several indoor units, each connected to the outdoor unit. The single-duct system is a movable packaged unit that contains the compressor, the heat exchangers and the fans. The condenser ejects hot air through a duct to the outside i.e. air used to cool the condenser is taken from inside the room and rejected outside by a duct. Operating schemes of the single-split and the single-duct systems are given in Figs. 1 and 2.

All the systems can be designed as reversible operating then as heat pumps. The percentage of reversible air conditioners is increasing in Europe and, e.g. more than 80% of split air conditioners sold nowadays are reversible in countries like France, Portugal or Greece (Pout and Hitchin, 2009).

2.1.2. The air-conditioning market in Europe

The European market is still growing substantially: about 3.5 million units were sold in 2005 (BSRIA, 2005) compared with only 1.6 million in 1996 (Adnot et al. 1999). Most units are produced in China and surrounding Asian countries.

The installed stock is far from the saturation levels seen in other parts of the world (e.g. 85% of households in Japan own at least one individual air conditioner (Rivière et al., 2009) and the sales figures show no sign of approaching market saturation. Italy and Spain, together, account for more than half of all European sales (BSRIA, 2005). The annual additional cooling capacity is about 12.6 GW for both countries together, that is, about a 5 GW increase in electric peak demand with an energy efficiency ratio of 2.5.

Table 1
Shares of air conditioners sold in Europe by type (Hitchin and Pout, 2008).

Types of air conditioners	Market shares in Europe (%)
Single-split	78
Multi-split	10
Single-duct	6
Other package (window/wall)	6
Total	100

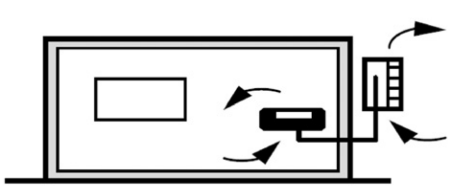

Fig. 1. Operating schemes of a single-split system (Orphelin, 1999).

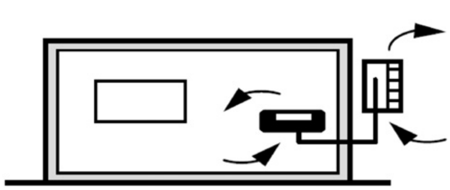

Fig. 2. Operating schemes of a single-duct system (Orphelin, 1999).

According to Pout and Hitchin (2009), individual air conditioners are primarily installed in non-residential buildings, e.g. offices, retail units, with this sector accounting for 63% of all sales (expressed in cooling capacity). About 30% of split and multi splits are installed in new buildings, about 15–20% are used in existing buildings for replacement; the remainder goes into existing buildings for first time installation.

2.1.3. Energy efficiency of air conditioners

The energy efficiency of individual air conditioners is characterised by the Energy Efficiency Ratio (EER), defined as the ratio between the cooling power and the electric power input. Similarly, in heating mode, the Coefficient Of Performance (COP) is defined as the ratio between the heating power and electric power input.

The EER and COP depend on climatic conditions (e.g. the EER decreases when the indoor temperature decreases or when the outdoor temperature increases) and on the part load ratio (the ratio between the required cooling load and the maximum cooling load that can be extracted by the appliance). Air conditioner standard performance is evaluated at full capacity with an outside air temperature of 35 °C in cooling mode, and of 7 °C in heating mode (ISO, 1994, 1995).

2.1.4. Energy efficiency of the European market

Two main mechanisms have been implemented in Europe in order to improve the energy efficiency of the whole market.

Since 2002, an energy label has been applied to individual air conditioners (CEC, 2002a). It aims to guide potential buyers in their choice of efficient products but does not contain any minimum efficiency requirement.

The second mechanism consists in voluntary minimum energy efficiency requirements. By participating in the Eurovent-Certification scheme, manufacturers are allowed to include their products in the annual Eurovent-Certification product directory, which is widely used among consultants and installers. However, in return, they have to certify all their equipments (“Certify All” policy) and these products can be independently tested. Furthermore, a minimum EER for air conditioners is required in order to be certified. Thus, since 2004, products rated G, according to the Labelling Directive, were eliminated from the Eurovent Certification air conditioner programme, which prevents Eurovent certified manufacturers (more than 75% of the market) from selling such products.

An analysis was carried out in order to compare current efficiency levels in Europe to Minimum Energy Performance Standards (MEPS) existing in other countries. COP and EER values come from the Eurovent-Certification public database (Eurovent, 2006)[4]. In Fig. 3, each point represents the EER value of a split system air conditioner (reversible or cooling only) sold in 2006 in Europe. Chinese and South Korean MEPS, which are based on the same rating standards as in Europe (ISO, 1994), are also plotted. The analysis shows that a significant number of the products sold in Europe would not comply with the legislation of these countries. To illustrate the gap, 80–90% of the cooling only air conditioners (i.e. non reversible air conditioners) (in the Eurovent database) do not reach South Korean MEPS and even some products rated A in Europe would not be allowed in South Korea. Similar conclusions were obtained for other countries (Australia, Japan) and for the heating mode (Rivière et al., 2009).

[4] As efficiency values come from the Eurovent-Certification database, products are at least rated F according to the Labelling Directive. Nevertheless, less efficient air conditioners can be found on the market since several manufacturers do not participate in the Eurovent voluntary MEPS requirement.