# Household appliances penetration and ownership trends in residential buildings

Luisa F. Cabeza[a,*], Diana Ürge-Vorsatz[b], Daniel Ürge[c], Anabel Palacios[a,d], Camila Barreneche[d]

[a] GREiA Research Group, INSPIRES Research Centre, Universitat de Lleida, Pere de Cabrera s/n, 25001 Lleida, Spain
[b] Center for Climate Change and Sustainable Energy Policy (3CSEP), Department of Environmental Sciences and Policy, Central European University (CEU), Nádor utca 9, 1051 Budapest, Hungary
[c] Dániel Ürge, Fazekas Mihály Gimnázium, Budapest, Hungary
[d] Department of Materials Science & Physical Chemistry, Universitat de Barcelona, Martí iFranqués 1–11, 08028 Barcelona, Spain

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ABSTRACT

Understanding the development of the trends in the ownership of different appliances in a historic context in various countries of the world can not only provide important insights for understanding the dynamics of adoption of different appliances, but can also help with foresight: how the future may develop for these or other, new appliances on the market. Although available literature in household appliances energy consumption, energy management and energy efficiency has seen some advances, there is a clear lack in the literature on household appliance ownership. In this paper, historic data is gathered and analysed for several groups of appliance types (white appliances, brown appliances and small appliances) for 12 countries representing four continents, when available since 1970 to date. Countries representing different parts of the world were selected to present an overview on household appliances ownership and energy consumption. One of the first conclusions of the study is that there is little or no information in many countries from South America, Africa or South Asia. Refrigerators, freezers and washing machines ownership are an example of most other white goods. Brown goods appeared in the market at very different time, depending on each one (from the 70s to the late 90s) and their ownership growth is much higher than for the previous ones. Most of small line appliances ownership has not reached saturation yet.

## 1. Introduction

Household appliances are key contributors to residential energy consumption [1] and at the same time there is limited understanding about their ownership and use. While there is growing literature on their energy consumption, energy management and energy efficiency and many of these papers recognise that the number of appliances is growing, there is a clear gap in publicly available, consistent, and comparable knowledge on their ownership and the historic trends of these. A short summary of such literature found in 2015 is given below as example.

A precise factual and numeric understanding of appliance ownership, and its historic trends, in an international context can help answer many research questions. First, it is important to understand how the ownership and use of these appliances compare throughout different countries, cultures, geographic, and economic contexts. Second, understanding the historic dynamics of the penetration and ownership of

household appliances can help in advancing many other research questions, such as predicting future adoption of existing and new appliances, can help in modelling future building energy use, etc. The dynamics of adoption of different equipment in different cultures and geographies can help in understanding and projecting the use and adoption of other appliances and equipment for other uses.

In the following, we provide a brief review of the literature on energy consumption and management of household appliances to direct the reader to the primary sources of information in the subject. On energy consumption, Desroches et al. [2] stated that while the share of electricity consumed by consumer electronics in US households has increased in the last decade, many devices lack robust energy use data, making energy consumption estimates difficult and uncertain; therefore they present the results of a survey collecting data from 880 households. Belman-Flores et al. [3] identified refrigerators among the home appliances that use most energy; but the only ownership data presented is from Mexico (authors state that in the period 2011–2014 Mexico

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made an annual average number of refrigerators of 1,4430,483 units per year for volumetric capacities of up to $0.3\,m^3$, and approximately double for units with bigger capacities). On the other hand, on energy management, Abushnaf et al. [4] identified home energy management systems technology as a way of optimizing energy use in residential buildings since they can contribute in reducing energy use and energy wastage by monitoring and controlling household appliances, since the number of electrical home appliances is increasing in the average household. Moreover, on energy efficiency, Datta and Filippini [5] estimated the impact of rebate policies in USA on the sales of share of highly efficient household appliances. Hoşgör and Fischbeck [6] examined the energy efficiency profile of 7091 individual single-family houses from USA. Jridi et al. [7] showed that in Tunisia gains in energy efficiency is one of the reasons for acceptance of changes in refrigerators prices. Finally, on energy usage, Lu et al. [8] conducted a field study on off-shore islands in Taiwan to investigate the energy usage of local residents comparing household appliance usage in mainland Taiwan. Interestingly, the authors present penetration percentages of appliances such as refrigerators and freezers, but no absolute ownership data is presented. Mills and Mills [9] identified gaming as the most energy-intensive use of personal computers and present peak demand data on the topic, highlighting the need to collect more market data and raise the issue to the consumer.

Therefore the authors of this paper identified a gap on presenting data on ownership of household appliances to be able to assess the trends in appliances for residential buildings considering the different appliances types. The data gathered is presented with appliances grouped by appliance type and the countries chosen represent different areas of the world and different level of gross domestic product (GDP), although no data on some interesting and potentially important countries was found.

Moreover, an overview regarding appliances ownership and energy consumption was performed and several countries have been included in this study because they are representative for several parts of the world:

– South and North Europe areas are represented by Spain, France, Austria, Denmark, and UK, respectively.
– Eastern Europe is represented by Hungary.
– USA is the country where households consume high amounts of energy and one reason is because of high appliances ownership.
– Japan and China are clearly good representation of Asia because Japan is considered high-tech since decades while China is an emergent country where the situation regarding everything including appliances ownership has change a lot during the last decades. Therefore, Asia countries that have not emerged yet may be considered as China 20 years ago. India is also very important because it is in an extremely dynamic development phase in terms of household appliance ownership and use; but unfortunately very limited information was found that was publicly available.
– Australia is a single case because they have low population density in a huge country within a very different climate zone but the economy is considered inside the OCDE and these are the reasons why Australia is included in this study.

However, unfortunately little to no information is available about countries of other world areas as South America, Africa, or South Asia, etc.

## 2. Methodology

### 2.1. Appliances considered

Information regarding appliances is available in several different ways, such as those used by the National Centre of Statistics Denmark [10], Statistic Austria [11], Australian Government department of

industry [12], National Bureau of Statistics of China [13], etc. Therefore, the data information must be classified and organized in order to evaluate the overview regarding the appliance ownership trends and usage energy consumption in residential buildings.

In general, the appliances are divided in three categories: white goods, brown goods, and small appliances [14], which are defined as follows:

– White goods are considered those that historically present a white cover like washing machine, refrigerator or freezer, cloth dryer, dishwasher, etc. These appliances are those that comprise the basics needs of society. Moreover, the appliances included in this category are the ones with highest energy consumption due to their continuous usage.
– Brown goods are intended for used in leisure time as well as secondary needs, such as TV, computers, DVD, cameras, videogames, etc. In last years, this category has been expanded by the proliferation of new appliances based on the personal communication in a very different way. Therefore, smartphones, music player, and tablets are included in this group because they have become a very important need for the new XXI century generations. Brown goods usage consists of part time use related with the connection between the technology and the society and they have background energy consumption since they are in standby during their time of no use.
– Small line appliances are described as those one that are needed domestically to make small works, such as griddle, coffee maker, microwave, beater, hair dryer, fans, etc. The energy consumption of these appliances is high but the short time of use compensates this fact becoming a low contribution of the final energy consumed by appliances.

Table 1 summarizes the appliances considered in this paper classified in each category here described.

### 2.2. Data sources

Data from the different countries considered was obtained from the following sources:

– Spain: *Intituto Nacional de Estadística* [15]
– France: *Institute National de la Statistique et des Études Économiques* [16]
– Austria: *Statistik Austria* [11] and Hass et al. [17]
– Denmark: *Statistics Denmark* [10]
– UK: *Department of Energy & Climate Change* [18]
– USA: *U.S. Energy Information Administration* (EIA) [19]
– Japan: *The Institute of Energy Economics* [20]
– China: *Chinese Statistical yearbook* [13,21–27]
– Australia: *Australian Bureau of Statistics* [28] and *Department of Industry and Science* [12].
– Hungary: *Statistical Yearbook of Hungary* [29–32]
– India: *United States Agency International Development* [33]

**Table 1**
Appliances included in this study classified in each category.

| White goods | Brown goods | Small appliances |
| --- | --- | --- |
| Refrigerator | Television | Microwave |
| Freezer | Video recorder | |
| Washing machine | Computer | |
| Clothes dryer | Mobile phone | |
| Dishwasher | DVD player | |