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Combined carbon and energy intensity benchmarks for sustainable retail stores

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ABSTRACT

Retail stores are amongst the building typologies with the highest carbon (CI) and energy intensities (EI). However, previous studies have only explored the EI of food and non-food retailers. This study is the first of its kind to examine the link between CI and EI. Establishing the nature of this link will allow a deeper understanding of how to decarbonize the retail sector. Here, we hypothesised whether in retail low EI correlated with low CI and how corporate revenue affected these variables. "Best practice" and "conventional practice" benchmarks were then developed to assess retail buildings' sustainability. These represent missing and highly desirable tools in retail sustainable management.

Average EI and CI of food retailers were twice that of non-food retailers (EI-548 *vs* 238 kWh/m^2/y; CI266 *vs* 132 kg CO_2eq/m^2/y). The correlation found between EI and CI indicates that low energy consumption leads to low greenhouse gas (GHG) emissions. CI variability resulted mostly of energy-efficiency strategies, of the energy production process and of GHG emissions from refrigeration systems. EI variability resulted mostly from store typology, volume and usage.

The proposed benchmarks help to set energy and carbon reference performance levels in retail buildings and to stimulate best sustainable practice amongst retailers.

1. Introduction

Retail stores are amongst the building typologies with the highest carbon and energy intensity, placing this segment in the top 10 most carbon-intensive business sectors [1]. In addition, retail stores are responsible for 9% of the European building stock [2] with a standard energy intensity (EI) that ranges from 500 to 1000 kWh/m^2/y, corresponding to three times that of conventional residential buildings and five times that of office buildings [3]. Furthermore, some of the retailers' activities like refrigeration are particularly carbon intensive in terms of direct emissions. Hydrofluorocarbon emissions from refrigeration systems and air conditioning can further increase the greenhouse effect because the global warming potential (GWP) of these gases is up to 11,700 times that of carbon dioxide [4]. Thus, retailers' overall carbon footprint is a high impact problem requiring a more sustainability-driven management solution.

Previous studies identified energy-efficiency strategies and best practices in food and non-food retail buildings [3,5–8]. Other studies have explored the link between energy consumption and carbon emissions from an energy efficiency perspective [9–13]. However, our current knowledge on retailers' carbon intensity (CI) is extremely limited and the retail sector is missing CI benchmarks. This absence is partly due to the perceived difficulty in considering carbon emissions as a variable controllable by retailers. Nonetheless, the missing benchmarks are key to enable defining "best" and "conventional practice"; in turn important tools for sustainable management. Hence, both EI and CI need to be simultaneously addressed to effectively minimize climate change impacts related to the retail sector.

This study is unique in assessing a potential energy efficiency link between CI and EI. Two specific questions were tested within the retail sector using "EI", "CI" and "revenue" as variables: *a low EI profile corresponds to a low CI profile?* and *to what extent corporate revenue impacts these variables*?. Additionally, benchmarks with "best practice" and "conventional practice" thresholds values were developed for both CI and EI, as (still missing) tools for more efficient energy management in the retail sector, providing knowledge

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regarding allowable limits for energy use. These benchmarks empower decision-makers to rank their stores according to what is known as the "*what to*" approach in decision theory [14], considering for the first time a linked action of EI and CI. They also support the design process of new or refurbished retail stores targeting efficient sustainability. Benchmarks are further expected to provide a framework for enhanced environmental performance, adding novel energy and carbon "best practice" reference levels for sustainability assessment tools.

2. Materials and methods

A qualitative comparison was made on the energy intensity (EI) and carbon intensity (CI) patterns of retail stores. EI stands as the consumption of energy per unit of m^2 of gross floor sales area per year (expressed in $kWh/m^2/y$), whereas CI stands as the emission of Greenhouse Gas (GHG) per unit of m^2 of gross floor sales area per year (expressed in kg $CO_2eq/m^2/y$). The initial sample comprised the 250 highest revenue retailers around the world, assessed according to publicly available data from the fiscal year 2016 [15]. However, inclusion and exclusion criteria were applied to the sample. Two inclusion criteria were defined: the companies had to be globally representative and have a mixed – food and non-food - retail profile. Both non-food and food retailers had to be analysed because EI and CI vary considerably per typology of retail business [5]. Furthermore, retailers that operated online businesses were excluded, since no EI or CI analysis could be performed. The final sample was thus reduced to 242 retailers.

2.1. Data selection procedure

Five main data steps were considered for sample selection accordingly to public data (Fig. 1).

In step 1 (*Desk research*) and for each identified retailer, the following digital elements were searched: published sustainability/corporate social responsibility (CSR) reports, annual reports, environmental policies and other energy or building data available online. A detailed content analysis of the information presented in retailers' sustainability/CSR reports was conducted, according to the variables "energy consumption" and "GHG emissions", adopting the methodology of Sullivan & Gouldson [16]. Only the most recent (dating from 2016) and available sustainability/CSR retailers' reports were considered as to compare the most updated data. In step 2 (*Retailer's categorization*), retailers were divided into food or non-food groups according to the predominance of goods sold. The food typology included the categories of hypermarkets, superstores or supercentres, supermarkets, discount stores, convenience stores, neighbourhood market stores, grocery stores, liquor stores and cash & carry stores. The non-food typology included the categories of Do-It-Yourself (DIY) or home improvement stores, drug stores and pharmacies, department stores, shopping centres and neighbourhood malls, furniture decoration stores, household appliances and electronics stores, auto-shops, office supplies stores and other specialty stores. Even though some retailers had a mixed typology of store formats in their business portfolio, these were characterized as food or non-food retailers according to the predominant number of stores in each format. As a result, 120 of the studied retailers were classified as food retailers and 122 as non-food retailers (Fig. 2).

In *step 3 (Sample screening)*, the sample was further screened to only include retailers which presented data on energy consumption and/or GHG emissions (39% included considering the initial sample). All other retailers either did not have sustainability/CSR reports online (typically this information is disclosed within) or did not present such data in these reports. Further emails contacts requesting information were unfruitful. Most of the sampled retailers (90%) had their data either certified by a third party or followed the standards of the Global Reporting Initiative. Additionally, the GHG emissions reported by retailers followed the GHG Protocol methodology for Scopes 1 and 2. The presented CIs are based on reported Scope 1 and Scope 2 emissions. Scope 1 covered all direct GHG emissions of a company including: i. stationary combustion for comfort heating or other industrial applications, ii. mobile combustion used in the operation of vehicles, and iii. fugitive emissions as an unintentional release of GHG from refrigerant systems and natural gas distribution [4]. Scope 2 covered all indirect GHG emissions from the consumption of purchased electricity, heat or steam [4].

There were important differences in the way retailers presented energy consumption and/or GHG emissions data and this influenced their consideration as a valid sample. On one hand, about 3% of those retailers presented information about GHG emissions and/or energy consumption but did not reveal the correspondent total sales floor area, so data normalization was not possible. Hence, these retailers were also excluded from the study. On another hand, 3% of retailers detailed the EI of each brand/typology of business operation and another 2% detailed EI and CI according to the country of operation. Hence, these retailers indicated more than

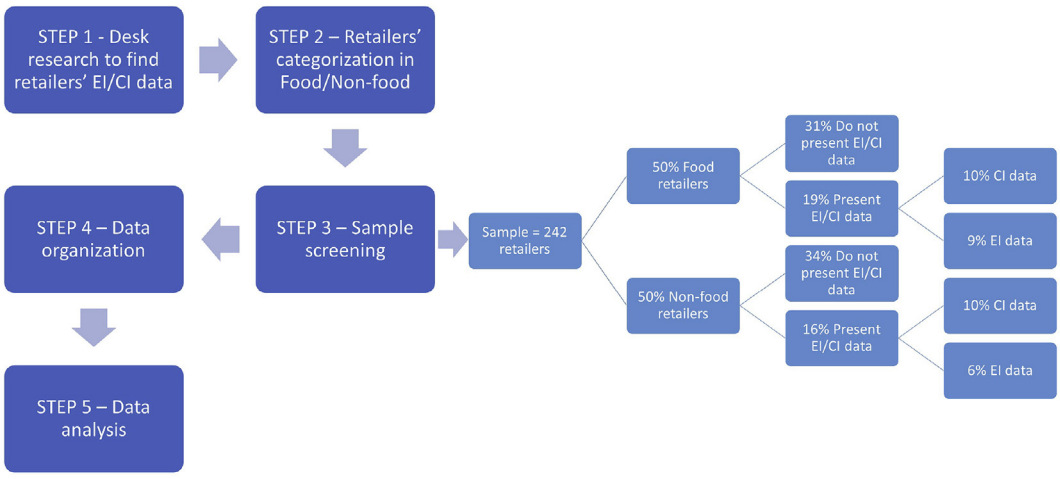

Fig. 1. Data selection procedure diagram.