Experimental analysis on energy and water consumptions at the domestic end use level: the particular case of showers

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Abstract

Water and energy are two decisive resources to survival whose current consumption is alarming and requires urgent attention from all the community. It is well known that the increasing demand of water is associated with an increase in the energy consumption and greenhouse-gas emissions. Research work in this field stated that, in the domestic sector, several devices consume great amount of water, being the consumption with baths and showers highlighted. So, an interconnected analysis between energy and water consumptions is extremely important to define strategies of these two resources rational use.

In this context, there is an undergoing project named ENERWAT that has as main goal to analyse the energy consumption related with the water consumption for urban and rural environments at the domestic end use level. It includes the characterization, measurement and modelling of those consumptions.

It will be presented the results of water and energy consumptions acquired during one week for the specific case of showers as an example of the data that can be obtained through the instrumentation and monitoring of the different devices in a household.

Introduction

It is stated that residential sector represents high values of energy and water consumptions. Worldwide, the domestic water consumption has increased along the last two decades leading to an increase in energy consumption, which represents about 40% of the total energy consumption. The majority of this energy is used for lighting, water heating, cooking and air-conditioning (Duarte *et al.*, 2010). The overall contribution of water heating in housings is high (Kenway *et al.*, 2013; Gutierrez-Escolar *et al.*, 2014; Nair *et al.*, 2014; Silva-Afonso *et al.*, 2011) and the domestic water end use that consumes more heated water is bath and showers (Willis *et al.*, 2010; Hoover and Scott, 2009; Matos *et al.*, 2017).

It is intended, with the research work developed in ENERWAT project, to contribute to this knowledge. An experimental work based on the monitoring of showers allowed to determine water and energy consumptions.

Methodology

• Case study

The case study refers to an apartment with 3 bedrooms located in an urban area, in the centre of Vila Real, Portugal (Figure 1). It is occupied by a Portuguese standard family, where a couple lives with a teenager son. This dwelling has two bathrooms and a kitchen, and it is supplied by public water, electricity and natural gas. The water heating is ensured by natural gas. There is also a dishwashing machine and a laundry machine (Cunha *et al.*, 2017). It is also important to refer that a flow reducing valve is included in the shower device.

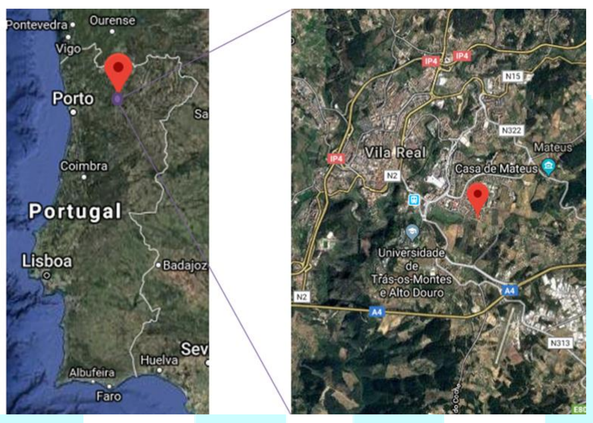

Figure 1- Location of the case study.

• Instrumentation and monitoring

A continuous measurement of the water and energy consumptions (Cunha *et al.*, 2017) was carried out in this dwelling following the model WATERS defined by the ENERWAT project, schematized in Figure 2. All the devices using water were monitored during a week. However, as referred previously, it will only be presented and analysed the data acquired for showers.

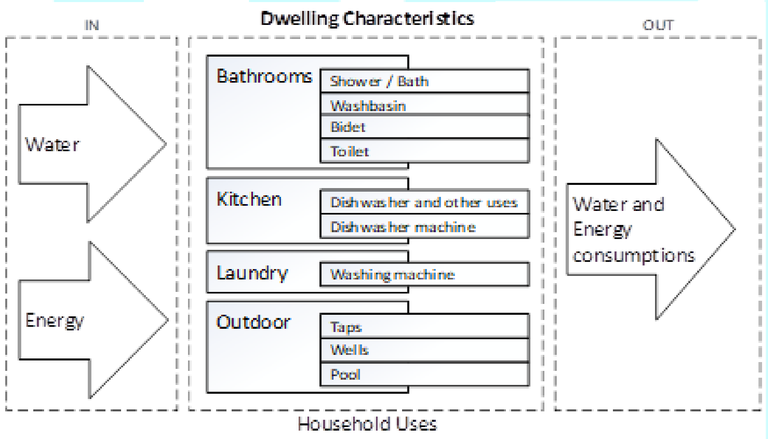

Figure 2 - WATERS model defined in the ENERWAT project to characterize water and energy consumptions.

Results and Discussion

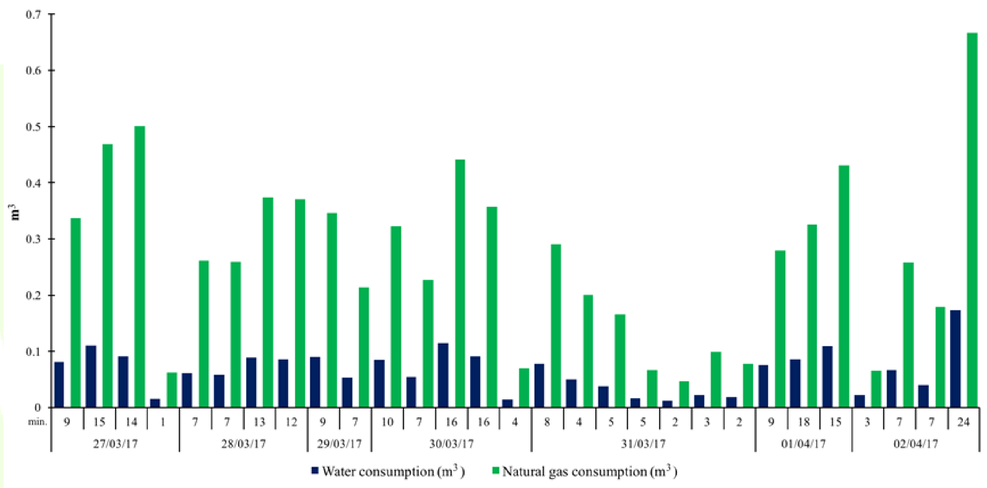

Figure 3 - Characterization of the showers and water and gas consumptions variation during the analysed week.

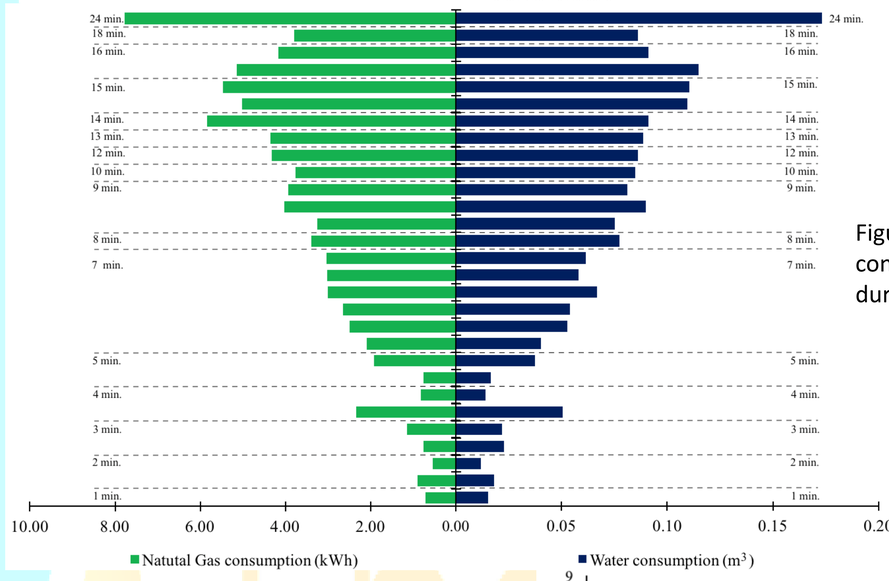

Figure 4 - Water and natural gas consumptions for different showers duration.

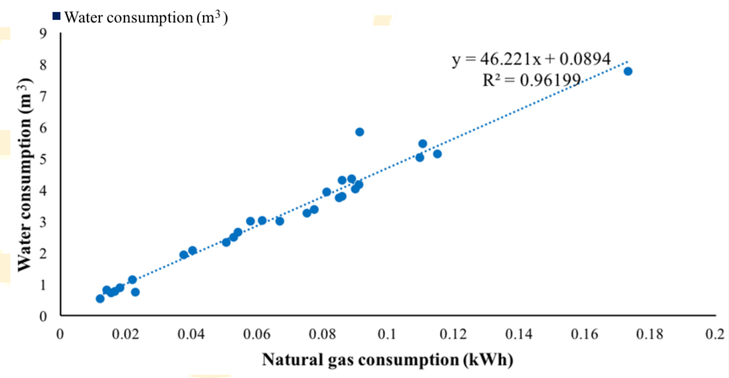

Figure 5- Correlation between water and natural gas consumptions.

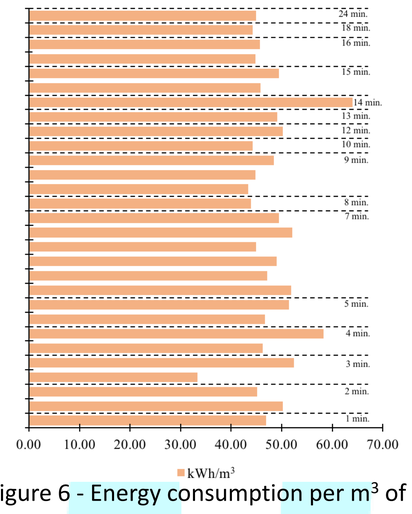

Figure 6 - Energy consumption per m^3 of water in the monitored showers.

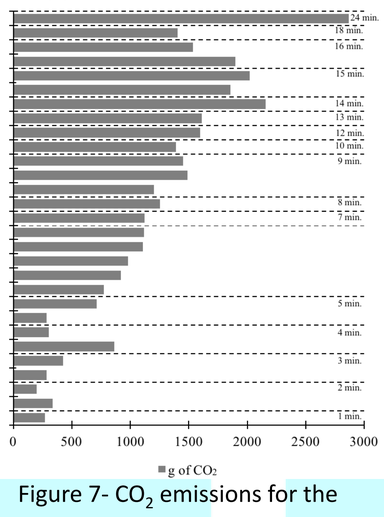

Figure 7- CO_2 emissions for the monitored showers.

Final remarks

In the domestic sector, various appliances and processes consume great amounts of water and, consequently, energy. One of those, and the most important, are the baths and showers. ENERWAT project includes in situ measurements of water and energy consumptions at the residential level. In the specific case of showers, it was presented the data acquired during a measurement period of a week in a dwelling with 3 inhabitants. It was possible to identify that the consumptions of natural gas and water increased with the showers duration, as expected, and a high linear correlation between those consumptions was verified. Analysing the showers duration, an average of 9.5 minutes was found, which is in accordance with the literature review. It was observed that a user takes less time in the shower, showing the influence of the user's behaviour patterns. The impact of those consumptions in the environment can also be obtained through a simple analysis of the CO_2 emissions. These results also show that a continuous analysis of the consumptions associated to the showers will allow to identify consumptions patterns and user's behaviours. This will be extremely important to identify the influencing factors of the consumption values and define future strategies of water and energy efficiency.

Acknowledgments

This work was partially funded by POCI-0-0145-FEDER-016730 Project (PTDC/AAG-REC/4700/2014) with the designation ENERWAT: Water to energy: characterization, modelling and measures for the reduction of urban and rural household consumption, financed by the Foundation for Science and Technology and co-financed by the European Regional Development Fund (FEDER) through the COMPETE 2020 - Programme Operational Competitiveness and Internationalization (POCI).

This work was partially supported by the FCT (Portuguese Foundation for Science and Technology) through the project PEst-OE/ECI/UI4082/2013 (C-MADE).

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