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4

Micro-components and Explanatory Factors on Domestic Water Consumption in the Comunidad de Madrid

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PRESENTATION

Canal de Isabel II's Research, Development & Innovation Booklets form part of the company's Knowledge Management Strategy and of the development involved in the Investigation, Development and Innovation Plan.

These Booklets represent an element for diffusion of projects and initiatives that are developed and sponsored by Canal de Isabel II for innovation in those areas related with water service in the urban environment.

A series of different problems that have been undertaken in each project are put forward in the Booklets, along with the results that have been obtained. The intention behind their diffusion by means of these publications is to share the experiences and knowledge that has been acquired with the entire water services sector, with the scientific community and with all those working on investigation and innovation tasks. What is pretended with the publication of these Booklets is to contribute to improvement and efficiency in water management and, consequently, in the quality of the service that is provided for the citizens.

Apart from its publication in printed format, the booklets will also be available on Canal de Isabel II's web site, into the Publications section.

TECHNICAL INVENTORY

Project Title	Micro-components and explanatory factors on domestic water consumption in the Comunidad de Madrid
Line of Research	Assurance availability / demand balance
Units of Canal involved	Deputy Direction of Research, Development & Innovation
External Partnership	Sigma-2. Monedero Instalaciones y Servicios, S.A. Instituto Tecnológico del Agua.
Object and project justification	To improve knowledge on consumption of water in the Comunidad de Madrid and, in particular, on the main factors depending on it by means of characterization of the demand and breakdown of domestic consumption into its essential components.
Contribution to the State of the Art	The study represents an advance in quantification of end uses in domestic water in Spain. This is the broadest experimental study having been elaborated and published in Europe. In addition, it represents the first documented appraisal of the influence of the main explanatory factors on domestic water consumption.
Summary of project and relevant milestones	Selection of samples and survey on explanatory factors to 4,625 households. Continuous monitoring of consumption in 292 permanent residences. Extension of continuous monitoring to 691 old-age and high occupation housing units. Final analysis of results.
Summary of obtained results	The variables discriminating consumption the most are presence of private gardens, occupation, housing equipment and income level. Characterization of seasonal variations, peak flows, consumption timetable modulations, climate influence and holydays, for each one of the study phases. Distribution of consumption micro-components. Broken-down study of each one of these end uses or micro-components, including, flows employed, hour and monthly modulations, frequency in use. Calculation of consumption, both per capita and per housing unit and day, for each one of them.
Lines of Research opened to the continuation of the project	Currently, a project is being carried out in which a permanent control panel is established for a long-term monitoring of the same, with the aim of identifying possible changes in patterns, domestic consumer habits and end uses of comsumption. There is an ongoing project to evaluate efficiency alternatives in the use of water for gardening and potential savings in efficient plumbing and household appliances.

The work outlined in the present document is Micro-components and explanatory factors on domestic water consumption in the Comunidad de Madrid, which has been designed to cover specific questions on the use that Madrid-based families give to the water supplied and the factors that determine said use. The study has been based on two different, but linked, pillars: on the one hand, the assessment of the explanatory variables on domestic consumption, by means of a series of surveys carried out in the Comunidad de Madrid, and, on the other, the characterization of the micro-components and end residential uses, by means of continuous monitoring of real consumptions, with a representative sample-taking of permanent residencess.

Objectives

The ultimate objective of the work is to improve knowledge of, as many factors determining domestic consumption as the basis for the implementation of an efficient management of urban water service and an adjusted future planning that, in a precise way, includes all possible demand management measures. Two different lines of action have been integrated to achieve this main objective.

In the first place, a study of the factors and rules concerned to the behavior of the demand and water consumption in the Comunidad de Madrid, identifying the variables that in greater measure influence in the increase or decrease of this consumption and its seasonal variation patterns.

In the second place obtaining of precise and reliable information on consumption of water for each type of use into the housing units, obtaining information on timetable distribution and the different flows and frequency of use in each case. The water consumption patterns have also been segregated into essential components and the relation with the most significant characteristics of the users and installations and consumer habits have been determined.

Method

The work was undertaken in two phases one firstly, for data taking. A second phase, for the analysis and the assessment of the collected information. The data taking phase took place between 2001 and 2003, and throughout 2006.

First of all, an estimation of the explanatory variables for domestic consumption was accomplished by means of 4,625 surveys, over a stratified, random housing unit sample, in such a way that the total of the Comunidad de Madrid would be sufficiently represented. The relationship of water consumption with the characteristics of each housing unit and its members allowed obtaining an evaluation of the functions and variables that govern annual and seasonal consumption.

Then, monitoring of a group of 292 main permanent residences was carried out, selected as a part of the surveyed sample according to their representativity and agreed availability to participate in the monitoring phase. The sample that was initially selected for monitoring proved to be insufficient for characterization of the whole of

housing units in the Comunidad de Madrid, reason why it was decided to extend monitoring to a complementary sample of 691 main permanent residences, in which housing units with very specific characteristics were selected: permanent residences with high and long-standing occupation, permanent residences with interior and exterior uses similar to those foreseen in future urban development plans and gardened areas linked to permanent residences with consumption exclusively dedicated to landscaping.

The monitoring technique was based on the installation of precise meters, capable of transmitting pulses over each second of consumption. Information from these pulses, once duly treated and compared with a prior characterization of magnitudes and temporary patterns, carried out for each equipment in each housing unit, allowed to identify the use and final destination of the water at each given instant and housing unit.

After this, once all the information had been collected and purged, a series of analysis and assessment for characterization of the consumption patterns and the micro-components and end uses of the same led to the conclusions outlined in the present paper, which are detailed in-depth in the complete document.

An example of characterization of patterns on different uses in each housing unit can be seen in Fig. 1.

Figure 1. Example of initial reconnaissance
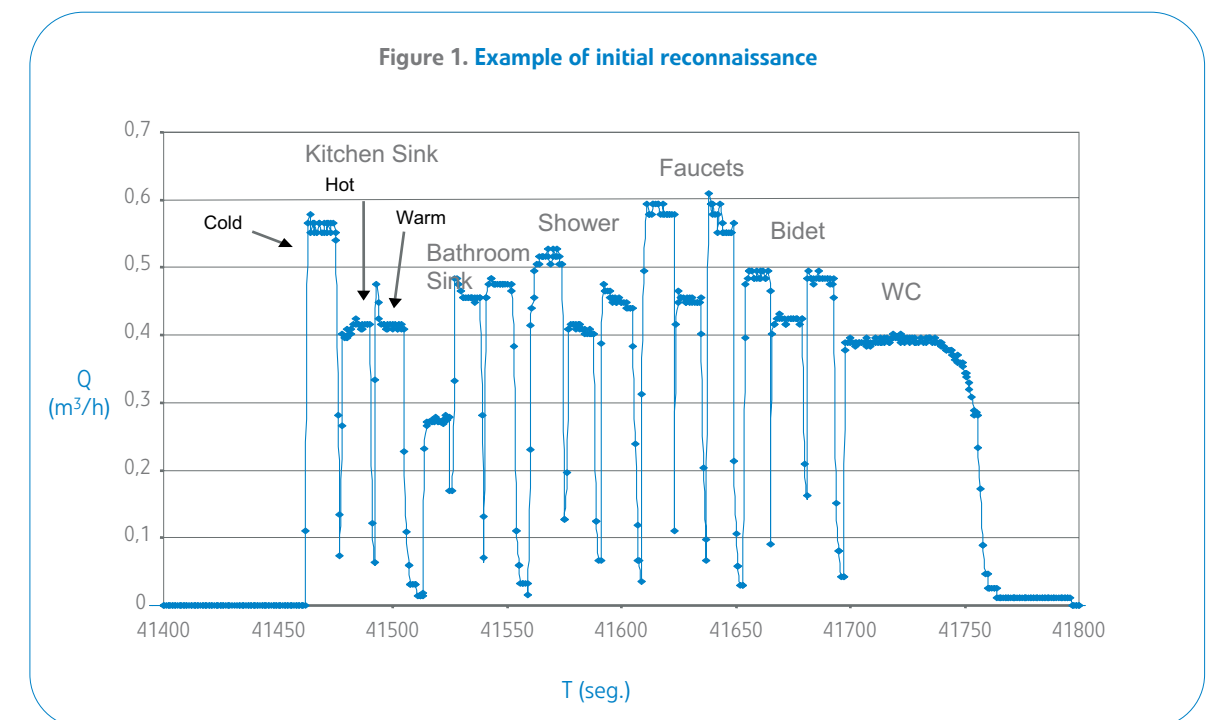
Conclusions

In the first place, it is to be highlighted that each sample is representative of a series of groups of variables and characteristic of domestic consumption, and that none of them correspond with the totality of housing units that are supplied in the territory, amongst other reasons because they are exclusively representative of those corresponding to permanent use, presenting different values between each other such as, average rate of occupation and habits involving total absence in the housing units. Fig. 2 displays an example of monthly
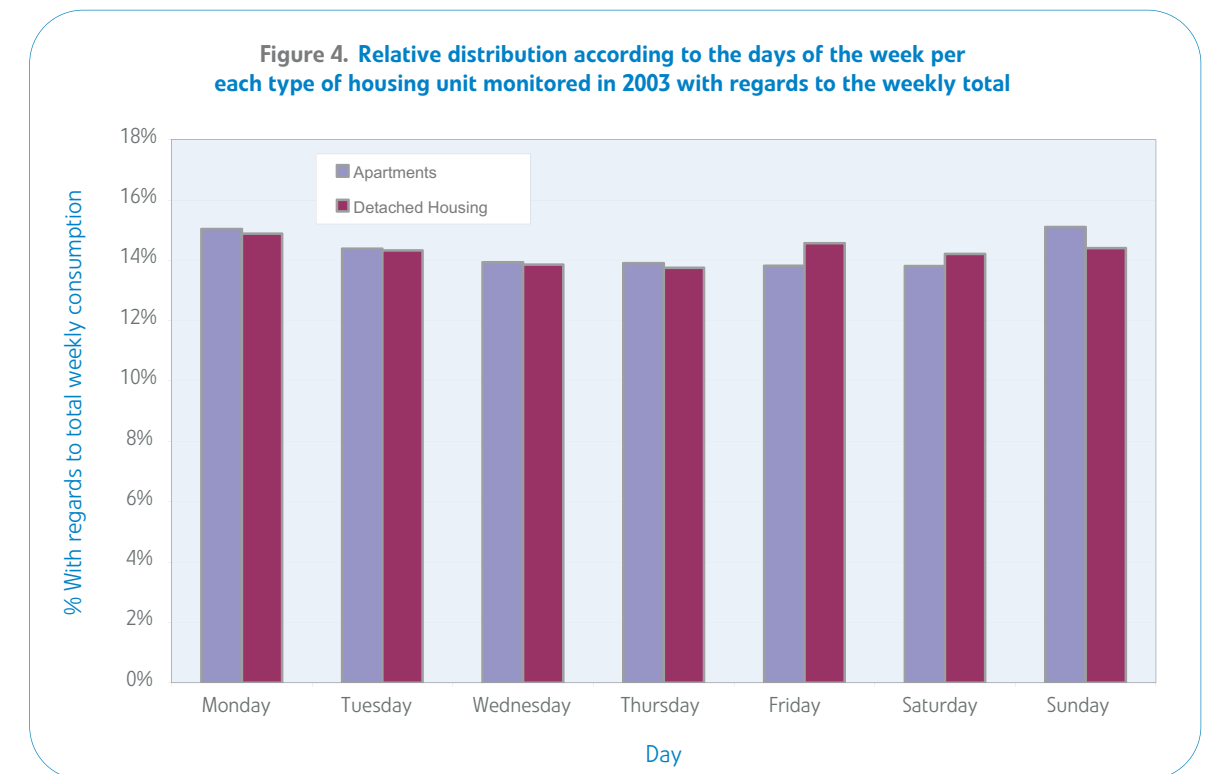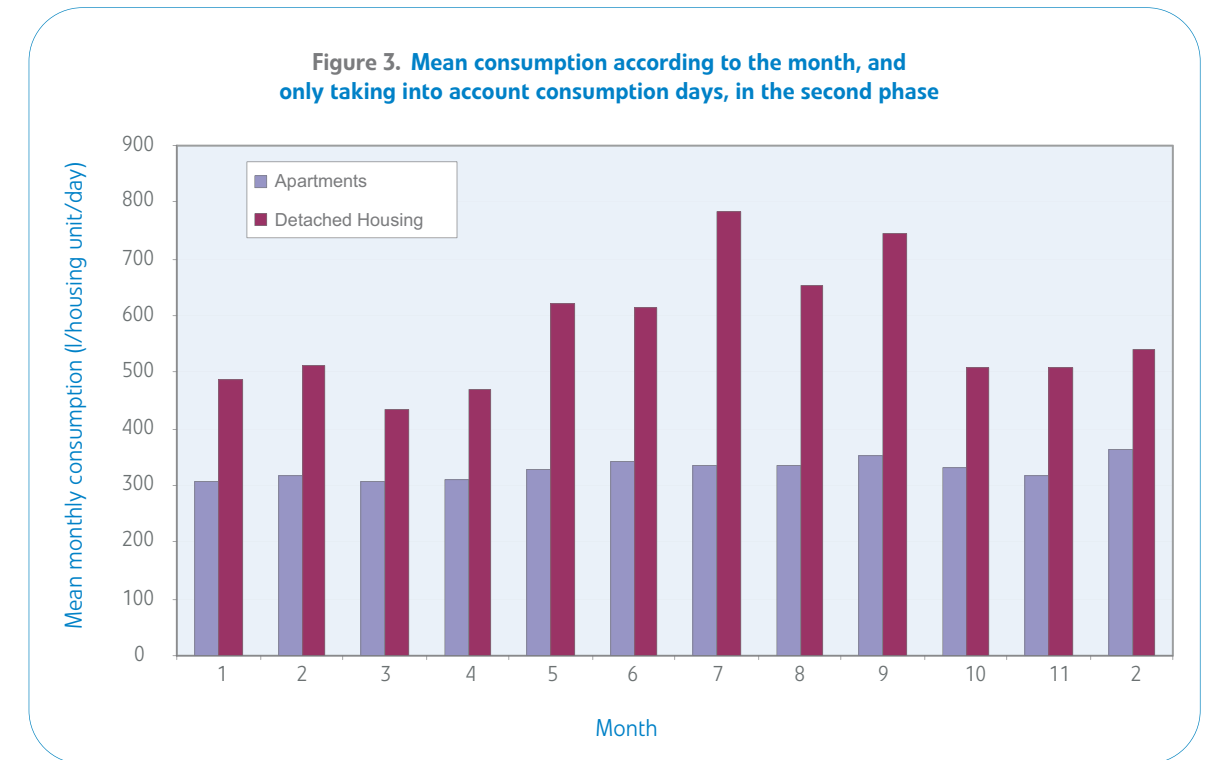
variation of the days that have zero consumption in some of the housing unit types. This consideration has great influence on the global consumption values, which in some cases, has led us to specify the results for the whole of monitored days and exclusively for the days when there is presence in the housing unit and the consequent consumption. Influence of seasonal movements in consumption is lower in detached family units, which present less days with zero consumption during the summer, quite probably due to automating of irrigation or to greater occupation of the housing units.

Figure 2. Percentage of zero consumption days for each type of housing unit that was monitored in 2006
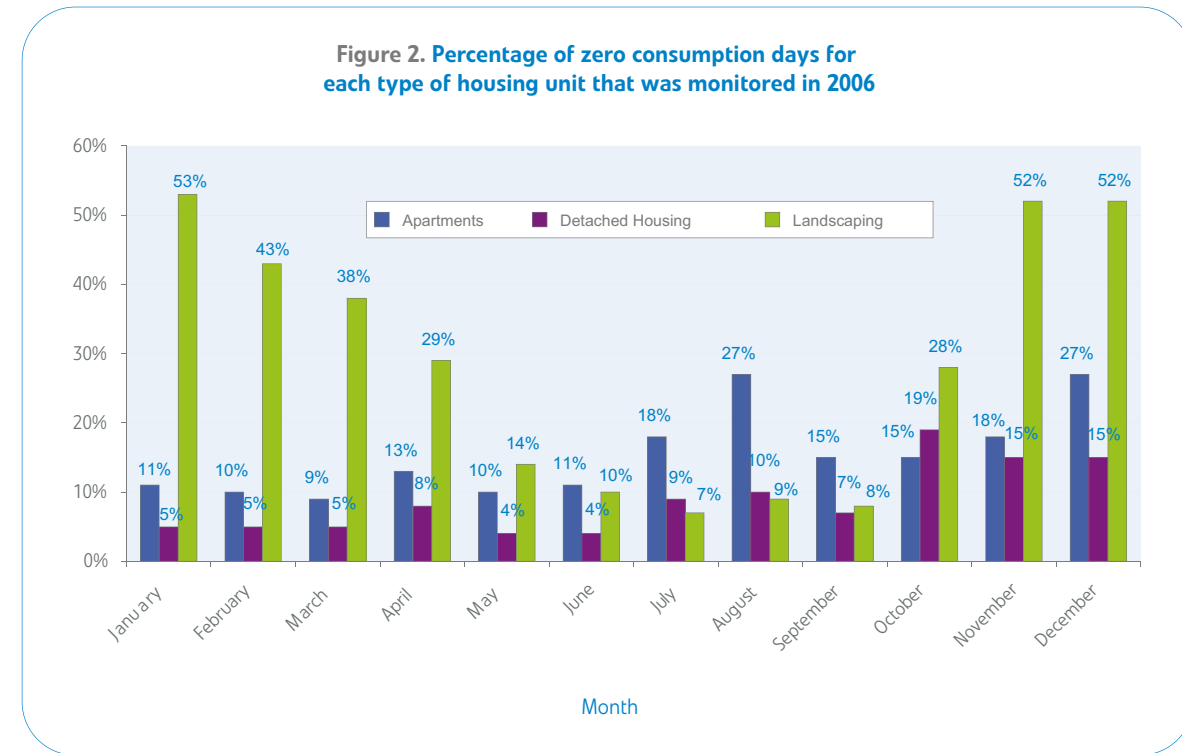
The analysis of recorded values of second phase monitoring in coincidence with a severe drought in the Comunidad de Madrid was relevant, circumstance that forced us to strengthen persuasive measures for responsible use of water and restrictions in some of the uses, which undoubtedly influenced the values on consumption in the sample.

Characterization of seasonal distribution of domestic consumption according to types has been carried out with results such as those outlined in Fig. 3 to 5 or distribution of instant peak flows as is shown in Fig. 6.

Figure 3. Mean consumption according to the month, and only taking into account consumption days, in the second phase

Figure 4. Relative distribution according to the days of the week per each type of housing unit monitored in 2003 with regards to the weekly total

Figure 5. Relative distribution according to the days of the week per each type of housing unit monitored in 2003 with regards to the weekly total


% With regards to daily total

Apartments Detached Housing

Hour

Figure 6. Histogram on frequency of appearance of instantaneous flows for the 1st study phase

Frequency of appearance

Q (l/h)
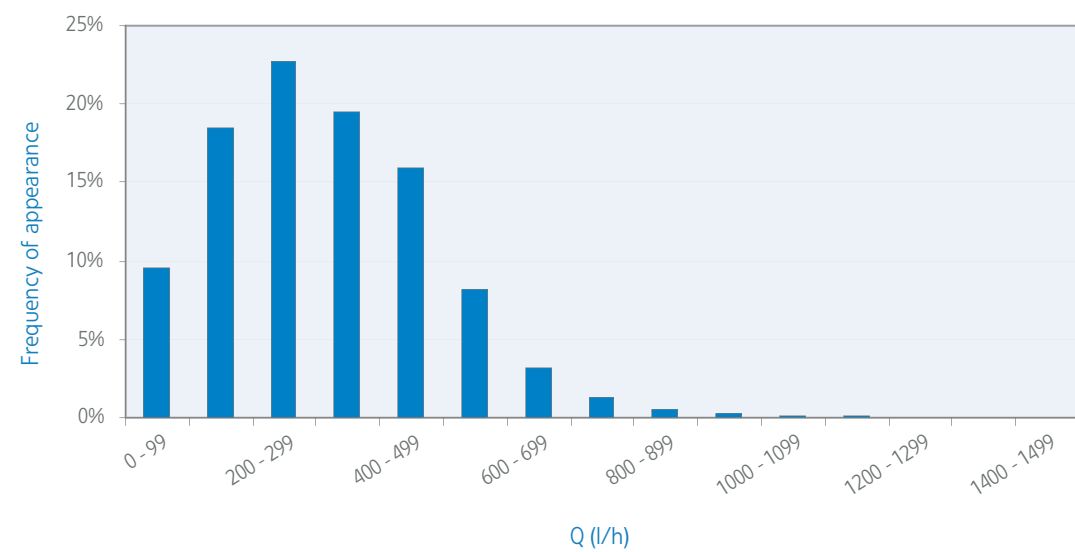
Allocations per housing unit and per capita corresponding to the monitored samples have only served to characterize these samples in relationship with the Comunidad de Madrid global figure, representing a value that is known in its whole, independently of this study. During the monitored period, the samples have in general presented values that are lower than the average value for the Comunidad de Madrid, as is detailed and justified in the complete booklet. Merely as information, the average unitary values per housing unit and day of the sample corresponding to the first phase were 630 liters in detached housing units and 300 liters in apartments housing units. While in the case of the second phase, taking into account influence of the drought, these values dropped to 499 liters per housing unit and day for detached housing units and 283 liters per housing unit and day for apartments.

In as far as analysis of the annual consumption values with regards to the characteristics of the recorded housing units is concerned, a series of variables have been identified, which are highly related between each other (surface, number of rooms, number of bathrooms and sanitary equipment, housing occupation) these keeping up an important relation with the volume of consumed water. Quantitatively, the variable that discriminates water consumption in the Comunidad de Madrid the most is the presence of a private garden or plot of land, followed up by the degree of occupation of the housing unit, number of toilets as representation of the size and equipment in the housing units and the level of income. The relationship between unitary consumption per capita and degree of occupation can be seen in Fig. 7.

Figure 7. Consumption per capita and day in accordance to occupation

Consumption (l/per capita/day)

Occupation
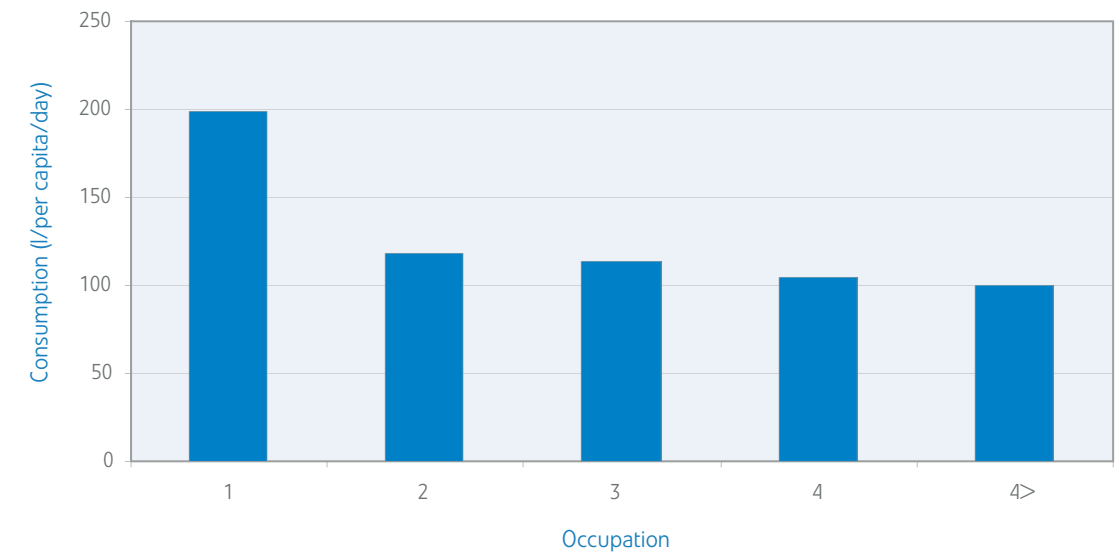
Influence of climatic factors have rendered slightly different results in each phase, with relations of daily indoor consumption practically independent from the maximum daily temperatures up to high temperatures, standing at about 30°C, and a certain linear variation in exterior uses that is also enhanced as of 30°C. Similar results were verified with daily precipitation rates, effect of which is particularly evident in detached housing units, with a drop in consumption as of 5 mm of daily precipitation and a very superior threshold of effect for apartments. Fig. 8 and 9 summarize this evaluation.

Figure 8. Effect of temperature in consumption in detached housing units corresponding to the 2nd study phase
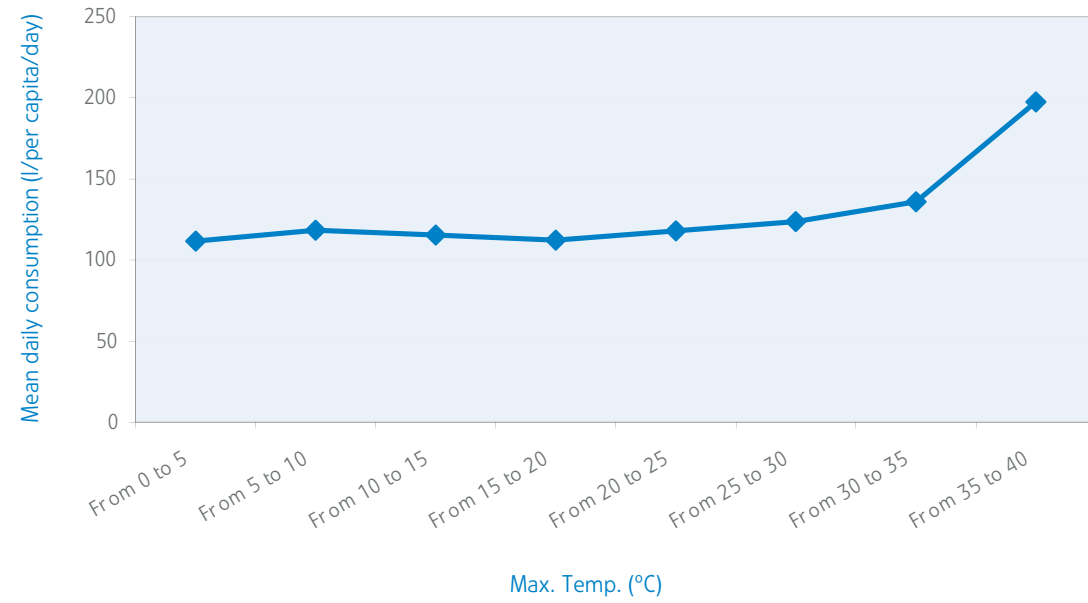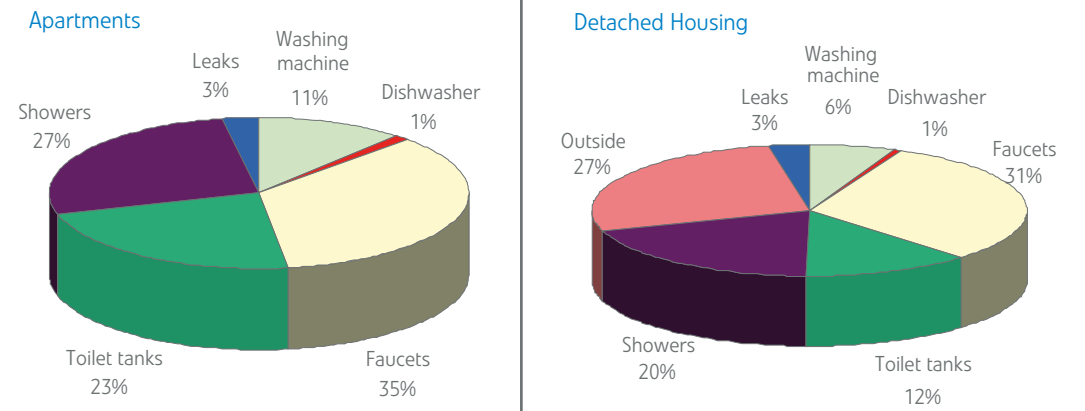

Figure 9. Effect of daily precipitation in apartments corresponding to the 2nd study hase
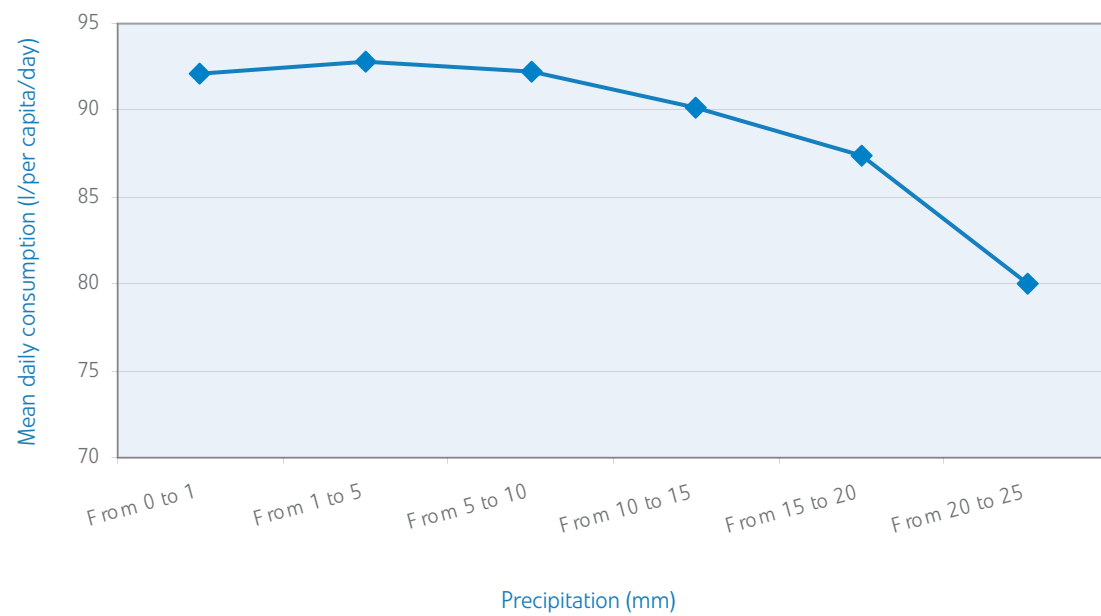
Analysis of end uses distribution reveals that the main consumption corresponds to faucets, in any type of housing unit, followed by showers and toilet tanks in housing units with exclusive interior end uses or apartments. In the case of monitored detached housing units, use corresponded to faucets followed by outdoor use, showers and toilet tanks. Fig. 10 and Table 1 outline the average distributions of one of the monitored samples.



Figure 10. Distribution of end uses

Apartments

Leaks 3%
Washing machine 11%
Dishwasher 1%
Showers 27%
Toilet tanks 23%
Faucets 35%

Detached Housing

Washing machine 6%
Leaks 3%
Dishwasher 1%
Outside 27%
Faucets 31%
Showers 20%
Toilet tanks 12%

Table *a*. Daily consumptions (per capita and housing unit) according to final use for monitored sample in 2003

		Detached Housing Units	Apartments Housing Units
Consumption per capita and day (liters)	Toilet tanks	18.9 l/cap. day	19.4 l/cap. day
	Showers	30.1 l/cap. day	22.5 l/cap. day
	Faucets	46.8 l/cap. day	30.1 l/cap. day
	Dishwashers	0.3 l/cap. day	0.9 l/cap. day
	Washers	9.6 l/cap. day	9.6 l/cap. day
	Exterior	41.2 l/cap. day	-
	Leaks	4.5 l/cap. day	2.4 l/cap. day
Consumption per housing unit and day (liters)	Toilet tanks	78.9 l/housing unit/day	66.5 l/housing unit/day
	Showers	124.9 l/housing unit/day	77.2 l/housing unit/day
	Faucets	194.4 l/housing unit/day	103.1 l/housing unit/day
	Dishwashers	4.7 l/housing unit/day	3.1 l/housing unit/day
	Washers	40.0 l/housing unit/day	32.9 l/housing unit/day
	Exterior	171.4 l/housing unit/day	-
	Leaks	18.9 l/housing unit/day	8.3 l/housing unit/day

A broken-down study has been made of each one of these final uses or micro-components, including employed flows, timetable and monthly modulations, frequency in use and penetration rate in the case of household appliances; and consumptions for both per capita and per housing unit and day have been calculated for each one of these variables. Figs. 11 to 14 illustrate the type of information that is outlined in the complete document.

Figure 11. Histogram of frequency of volume in toilet tanks
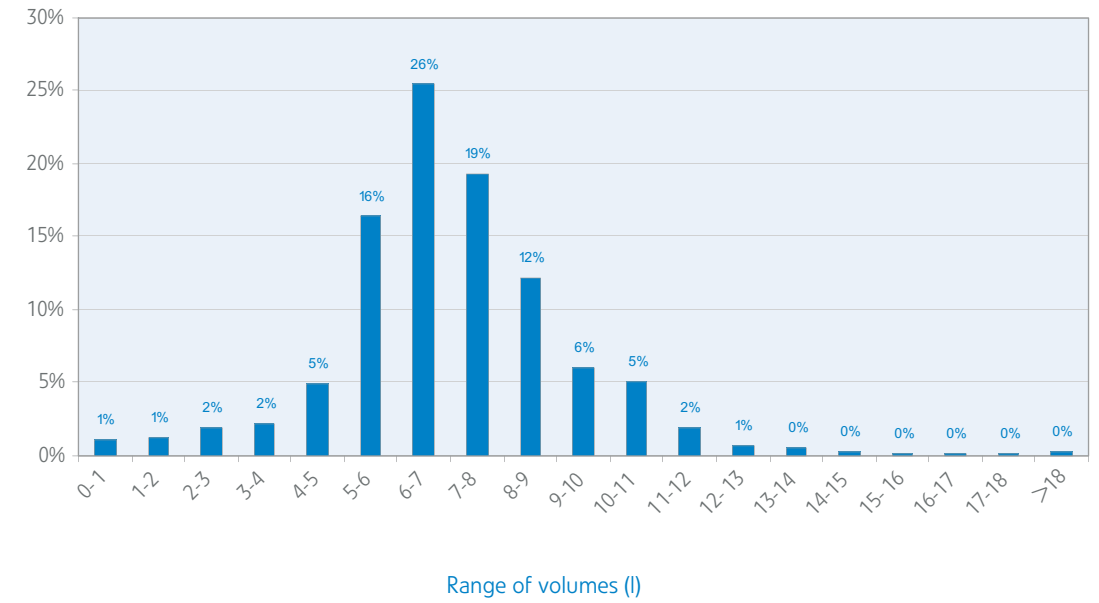
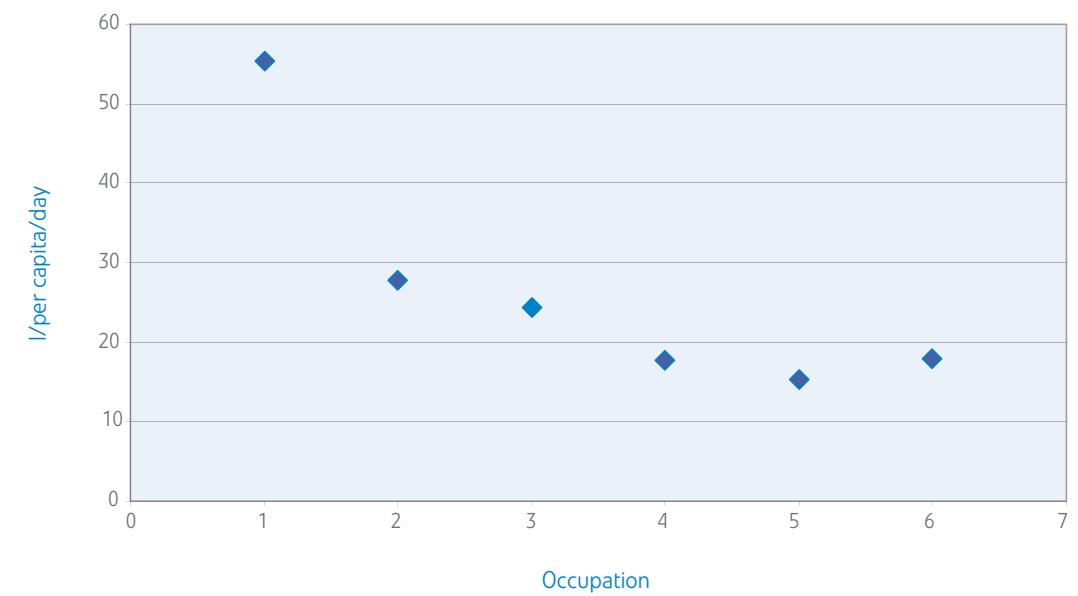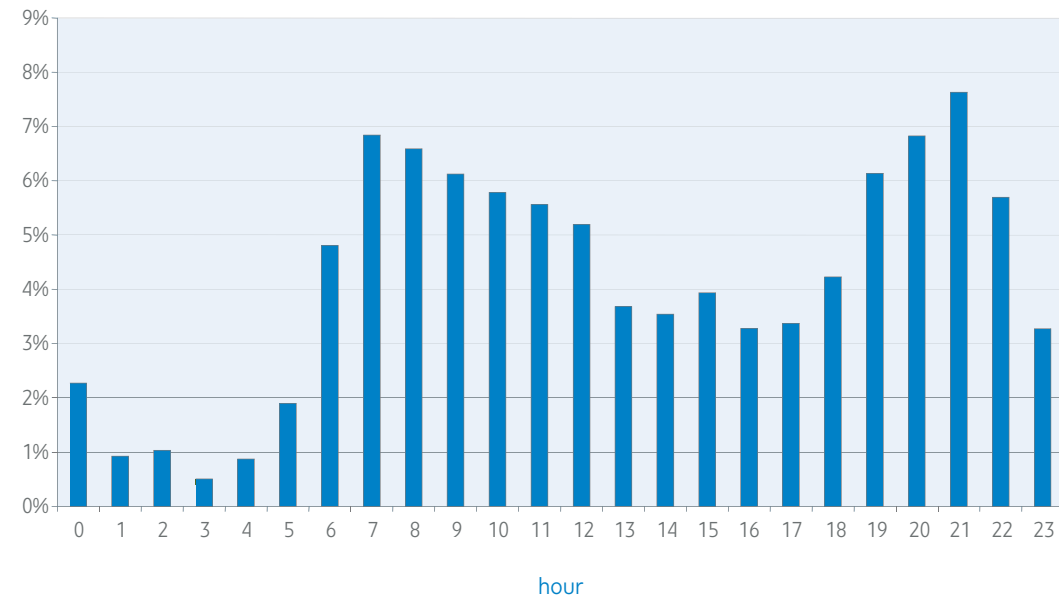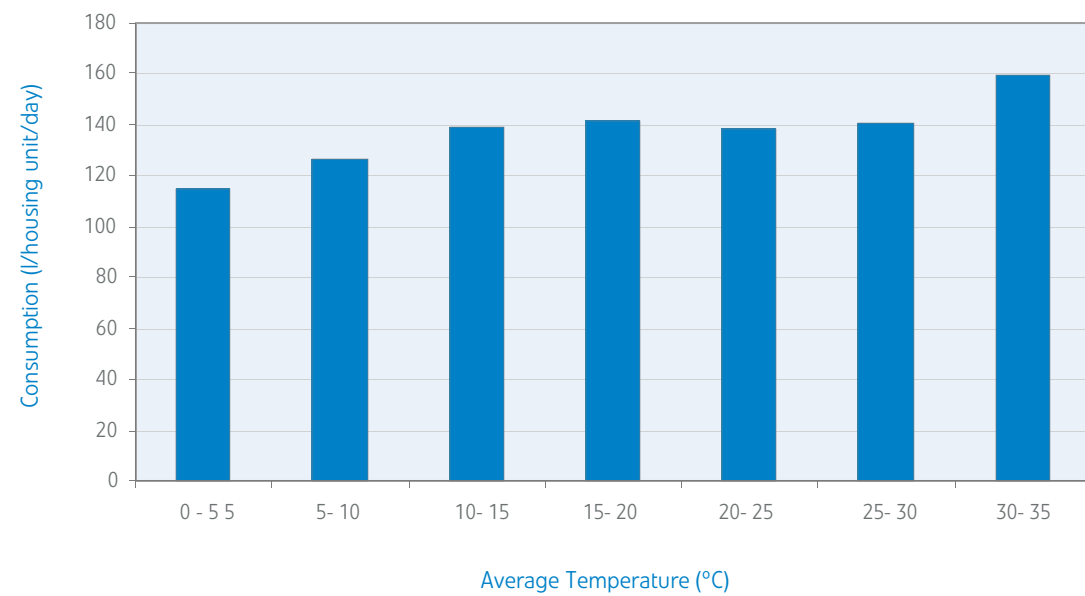**Figure 12. Volume per capita of consumption in toilet tanks according to occupation**

Figure 13. Timetable modulation of consumption in showers in the sample for 2003

hour

Figure 14. Timetable modulation of consumption in showers in the sample for 2003

Consumption (l/housing unit/day)

Average Temperature (°C)

A break-down of consumption patterns into its essential components has never been published before with such an in-depth analysis in Spain, thus making certain differences with regards to the bibliography that is currently available in other countries more than manifest. The results obtained in this paper have been compared with the conclusions obtained from several studies that have been carried in the United States and Australia, and substantial differences have been found in that pertaining to distribution and amount of final uses. An important effort has been made, which may constitute the basis for efficient management of urban water service and to advance in the future research tasks on the demand for water.

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