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Identification of opportunities to improve efficiency by water consumption assessment

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ABSTRACT

Characterization of water demand can be of great value for the management of water supply systems. Especially when water resources are limited, permanently or seasonally, the identification of the types of consumers and their characteristics is essential to identify opportunities to promote efficiency and demand management options. For each customer category, information to be obtained includes individual uses, typical daily usage patterns (average and dispersion), specific characteristics and magnitude. Knowledge and systematization of water uses also provide data to improve water balance and thus allow reducing uncertainty in estimation of losses. A study carried out in Algarve, a region where stress on water supply resources has been increasing, is presented aiming at better characterization of water consumption in the region to improve response both to normal and emergency situations.

Keywords: Demand management; Efficient use; Water consumption

1. Introduction

Characterization of water demand can be of great value for the management of water supply systems. Especially when water resources are limited, permanently or seasonally, the identification of the types of consumers and its characteristics are essential to identify opportunities to promote efficiency and demand management options [1,2]. For each type of consumer, information to be ideally obtained includes individual uses, typical daily usage patterns (average and dispersion), specific characteristics and magnitude. In practice, it is often not feasible to collect this information for every type of consumer, and the emphasis is put on the billed volumes per customer category, on the total water supplied, and on the consumption patterns at system and district levels. Knowledge and systematization of water uses also provide data to improve water balance and thus allow reducing uncertainty in estimation of losses. Furthermore, detailed knowledge about water demand allows for the identification of appropriate actions to be incorporated in contingency plans, e.g. in case of drought.

In Portugal, systematic metering is generalized for most customers of water utilities, including residential, industrial, and commercial users, but some uses are still not measured or individualized. Additionally, types of consumers are established by each water utility leading to a broad variety of categories, more related with billing than with the actual uses.

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In Algarve, the southern region of Portugal, the multi-municipal water supply system (bulk water supply), managed by Águas do Algarve (AdA), provides potable water to 16 municipalities, population per municipality ranging from 3,770 to 59,160 inhabitants, according to the 2001 National Census. The region, well known for its tourism industry profiting from the extensive coast and warm climate, receives visitors throughout the year but with strong seasonality, with most visitors present during the dry and hottest season.

Stress on water supply systems and resources has been increasing, both due to the increasing trend in water consumption, and to drought periods, such as that occurring in 2004–2005. The AdA contingency plan, approved in 2005, emphasizes the need to better characterize water consumption in the region to improve responses both in normal and in emergency situations.

2. Objectives

A study was promoted by AdA, with the technical support of the National Civil Engineering Laboratory (LNEC), involving the sixteen municipalities, aiming at:

1. assessing evolution of overall water demand in Algarve, in the period 2002–2004;
2. characterizing and carrying out a critical analysis of the demand, per customer category and consumer types;
3. setting up supply priorities from the system in emergency or contingency scenarios;
4. supporting municipalities in establishing procedures to improve efficiency in the management of water, including water loss control.

3. Methodology

The first stage of the study involved the collection and processing of data about the water supplied by AdA and the water consumed in all the 16 municipalities during the period 2002–2004. The year of 2005 was not included because there was a very severe drought and several measures were implemented to decrease the consumption (i.e., the demand was not fully satisfied). Available data from the period 1996–1998 are used for comparison purposes between the present situation of a regional bulk water system and the previous regional configuration of more dispersed systems.

Information collected included billed metered consumption per customer category, billed unmetered consumption, unbilled authorized consumption, total number of meters (per customer category and per meter size).

Data processing was split into two levels of analysis, as follows:

- Global information about water supply and consumption involving the following stages:

1. Assessment of total system input volume for each municipality (including water supplied by AdA system and by municipal own sources);
2. Assessment of billed metered consumption;
3. Data analysis for the period 2002–2004;
4. Calculation of non-revenue water on a bi-monthly and annual basis;
5. Comparison of the consumption between 1996 and 2004.

- Information about customer categories according to the following steps:

1. Characterization of customer categories (involving the identification of types of consumers in each category);
2. Identification of customer categories common to the 16 municipalities;
3. Calculation of statistics per customer category (PCC) for common categories between municipalities, on a bi-monthly and annual basis.

4. Results and discussion

4.1. Global analysis of water supplied and consumption

4.1.1. Total system input volume for municipalities

Based on the analysis of total annual water supplied by AdA, per municipality, Fig. 1 shows a general increase in the period 2002–2004 for more than half of the 13 municipalities. Three municipalities were not connected to AdA bulk water system in the period considered and thus not included herein.

The increase of annual water supplied is consistent with the increase of total billed consumption (Fig. 2).

Fig. 3 shows the monthly variation of the supplied water and billed consumption for one municipality for the period 2002–2004. An increase in the volume of water supplied and the influence of seasonality can be clearly seen.

4.1.2. Assessment of non-revenue water

Results for total non-revenue water [3] are presented in Table 1 on an annual basis. In average, total non-revenue water exceeds 40% for the period 2002–2004, although a slight decrease in this indicator can be observed during this period. In terms of percentiles, for 50% of municipalities' values for total non-revenue water are within the range 34% to 53% on average for the period analyzed. These results reveal that the percentage of non-revenue water, in most municipalities, is significantly higher than the threshold value recommended by the national regulator, IRAR (indicator of non-revenue water up to 20%).

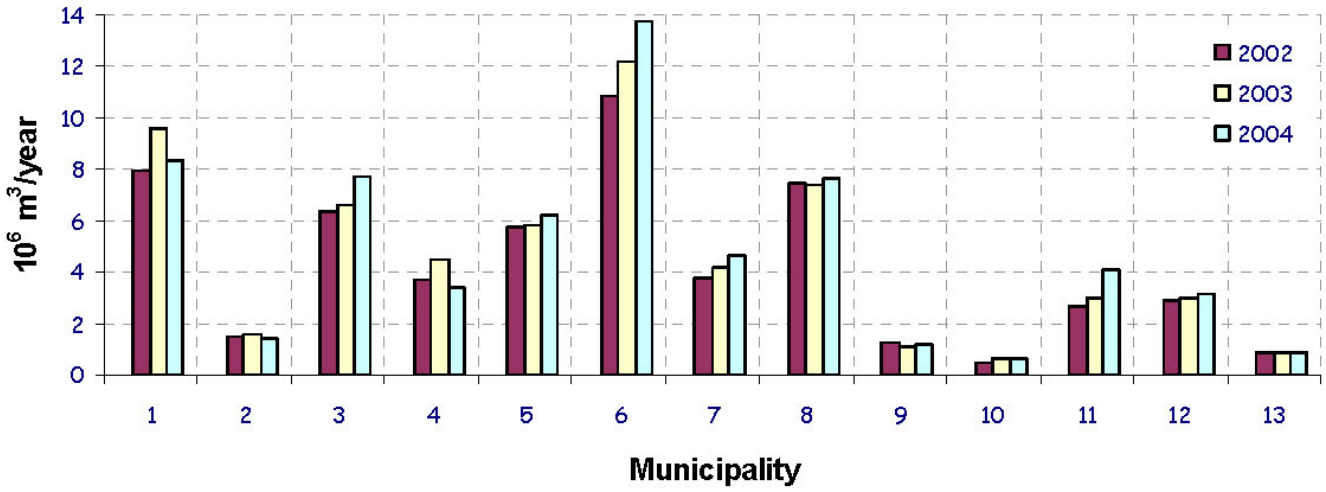

Fig. 1. Evolution of water supplied by AdA, per municipality, for the period 2002–2004.

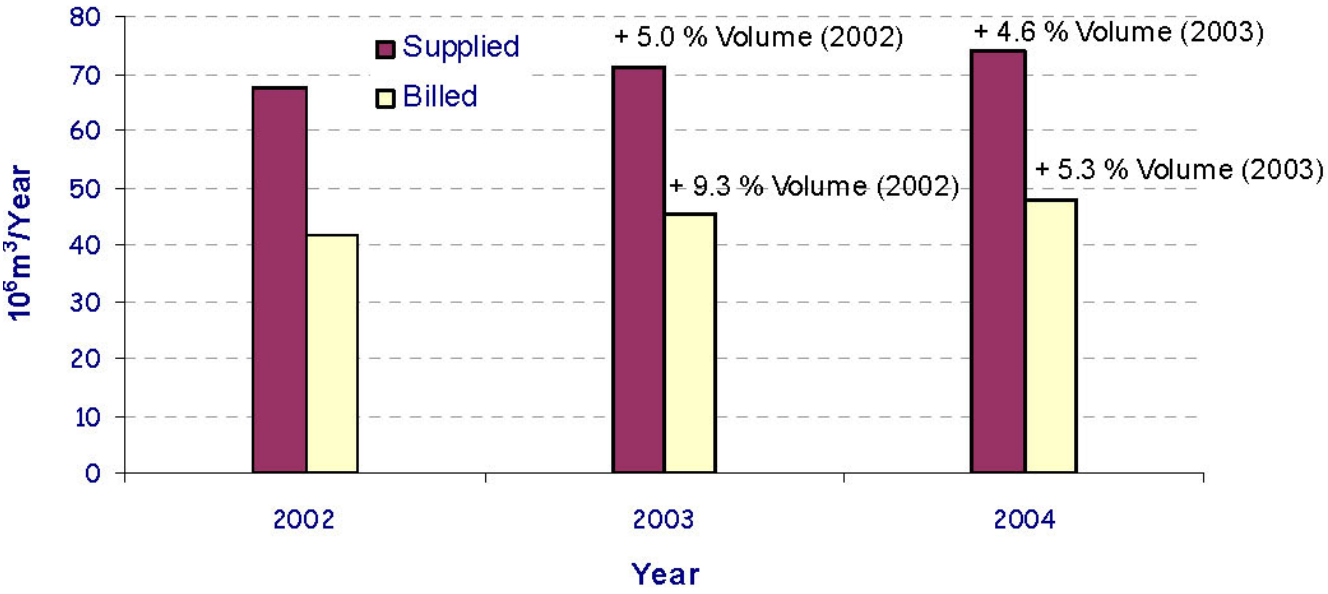

Fig. 2. Comparison between total annual water supplied and total annual billed consumption, for the period 2002–2004.

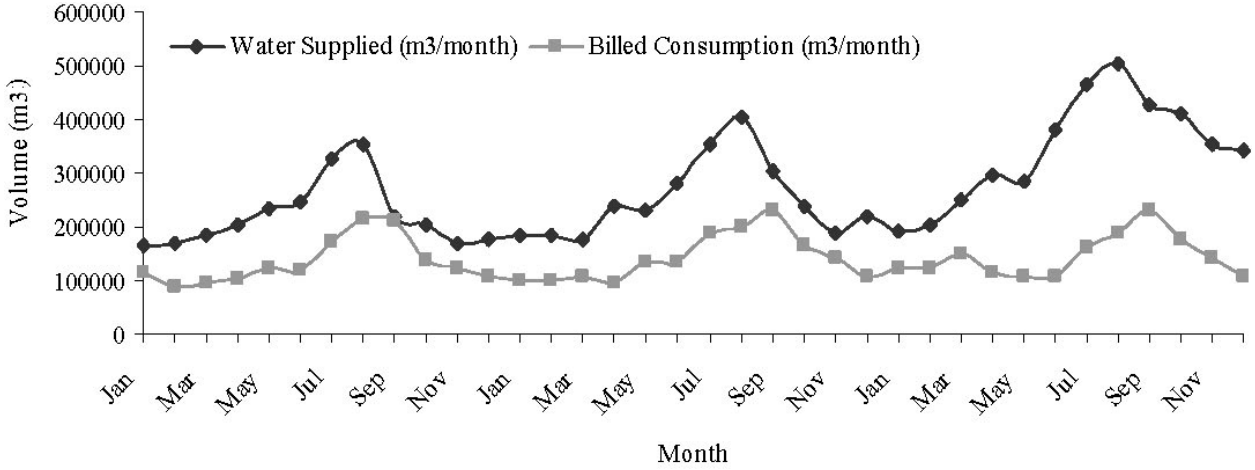

Fig. 3. Evolution of supplied water and billed consumption for a municipality, for the period 2002–2004.

Table 1
Total non-revenue water for the municipalities in the period 2002–2004

Year	Average (%)	Percentile 25 (%)	Percentile 75 (%)
2002	38	34	45
2003	36	29	45
2004	36	34	47
Mean	37	32	46

The example shown in Fig. 3 corresponds to a municipality where the percentage of non-revenue water ranges from 39.2% to 58.0%, for the period considered. The total system input volume per municipality was assessed considering not only the water supplied by AdA system but also by the municipal own sources, whenever applicable.

4.2. Analysis in terms of customer categories

4.2.1. Characterization of customer categories

The study revealed that the aggregation of customers in categories was very different from one municipality to another. Similarly, the type of customers included in categories common to several municipalities was also different (e.g., elementary schools and tourism facilities can be found in different customer categories, depending on the municipality).

From the 16 municipalities considered in the study, only two categories were found to be common to all municipalities: "residential" and "commercial" customers. The total number of categories per municipality ranges from 5 to 14.

In terms of billed consumption, residential and commercial and industrial customers are the most important categories. To carry out this study, for both periods (1996–1998 and 2002–2004), tourism has been included in the commercial and industrial category since this is an assumption common to several municipalities. Comparing the two 3-year periods, from 1996–1998 to 2002–2004, a small decrease is observed for the residential and for the commercial and industrial billed consumption, while for the remaining categories (construction works and "all other" categories), a significant increase was observed (Table 2). These changes are not necessarily due to relative changes in actual consumption in the different categories but can result from modifications in the criteria used by the technical staff in municipalities for categorizing the customers, during the periods analyzed.

Regarding the water tariffs applied by the 16 municipalities, minimum and maximum values are presented in Figs. 4 and 5 for the two common categories, residential and commercial, respectively, for both periods considered [4,5]. For the first 3-year period (1996–1998), only 12 municipalities were analyzed since three were not yet supplied by AdA in this period and there was no information available about tariffs for a fourth municipality.

Table 2
Billed consumption (%) per customer category for all municipalities

Year	Residential	Commercial and industrial	Construction works	All other categories
1996	62.9	30.3	0.4	6.4
1997	62.4	30.1	0.5	7.0
1998	62.1	28.9	1.4	7.6
2002	50.5	28.0	3.0	18.5
2003	48.4	28.8	3.0	19.9
2004	49.0	27.1	2.8	21.0

In general, for the residential consumption category, the tariffs have block structures, with increasing unit cost with consumption by the customers. Tariffs increased significantly from the first to the second 3-year period. A minimum tariff applied to the residential category increased 60% (mean value for the 12 municipalities) while the maximum tariff, applied for higher consumption values, increased 87% (Fig. 4).

For the commercial consumption category, a flat rate per cubic meter consumed is usually adopted, regardless of the total customer consumption. For this category, municipal tariffs also increased significantly from the first to the second three-year period. The minimum tariff applied by the municipalities increased 80%, the median tariff increased 48% and maximum tariff increased 18% (Fig. 5).

4.2.2. Analysis per customer category (PCC)

Fig. 6 shows the average values of PCC for the most relevant customer categories — residential and commercial and industrial. A significant increase of PCC occurred for commercial and industrial customers during the period 2002–2004. For the period 1996–1998, the PCC corresponds to an average value of 1000 l/customer/day and for the period 2002–2004 to an average value of 8000 l/customer/day, for the commercial and industrial category. A detailed analysis of this category revealed that this increase is mainly due to a tourism-related consumption increase.

5. Conclusions

The study carried out allowed for the identification of various opportunities for improving the information regularly collected and for increase the efficiency in the

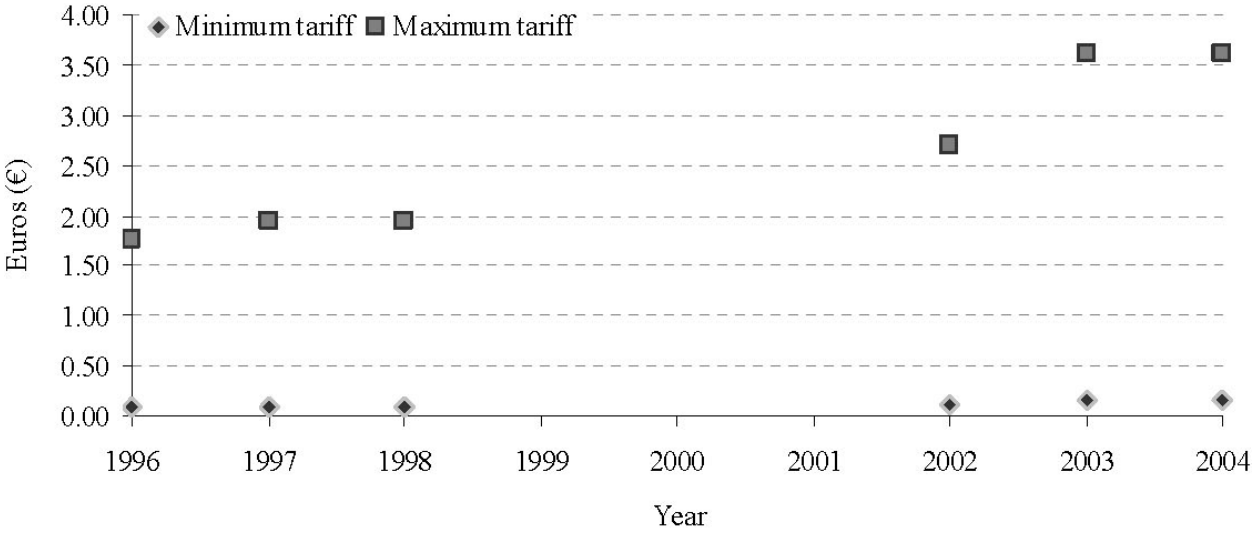

Fig. 4. Minimum and maximum values for residential consumption tariffs (199 –1998 and 2002–2004).

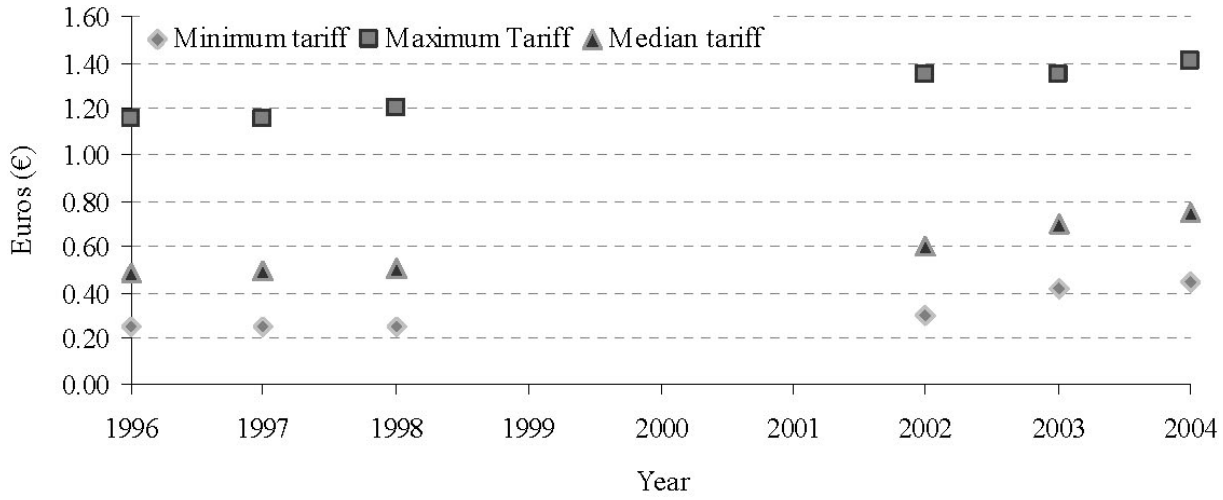

Fig. 5. Tariffs for commercial consumption category applied by municipalities (1996–1998 and 2002–2004).

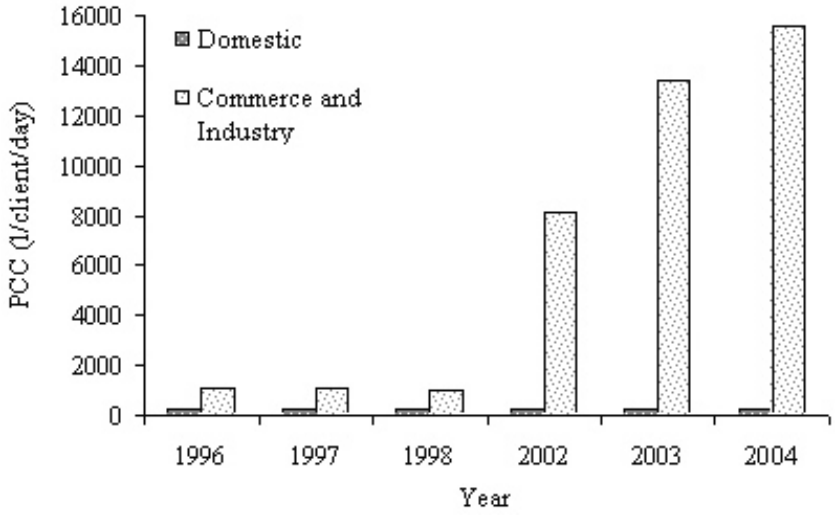

Fig. 6. PPC for residential and commercial and industrial consumption categories for the periods 1996–1998 and 2002–2004.

use of water. Priority measures identified include:

- Recommendation to the municipalities for elaboration of yearly water audits to assess and improve estimation of real losses and of total unbilled water, both average values and estimates of uncertainties and reliabilities;
- Improvement of systematic and continuous monitoring of all water abstractions in the whole regional system;
- Improvement of systematic monitoring of unbilled authorized uses, such as public uses including irrigation of public areas and other municipal uses. Within the 16 municipalities, only five have records of unbilled authorized consumption;
- Standardization of customer categories for all municipalities;
- Recommendations to the municipalities on individual uses to be metered separately, e.g. for municipal authorised uses or within the premises of large consumers (e.g. tourism facilities).

A second phase of this study, currently in an advanced stage of development, includes the analysis of the customers of the 10 highest consumption customers in each category per municipality (in 2004). This analysis allows for the establishment of priorities of intervention.

The study allowed for an improved knowledge of the regional and municipal patterns of consumption. In a region where higher consumption is experienced in the driest season, and where risk of drought is moderate, the identification of opportunities to improve efficiency facilitates the application of measures both in normal and in drought periods (e.g. minimum supply flows for each municipality and priority abstractions). However, the availability and compatibility of information was found to be the first priority of action in order to proceed with the application of measures of demand management, as such recommended by the national program for the efficient use of water.

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