*International Journal of Sustainable Construction Engineering & Technology (ISSN: 2180-3242)*
*Vol 4, No 2, 2013*

# SUSTAINABLE CONSTRUCTION: WATER USE IN RESIDENTIAL BUILDINGS IN PORTUGAL

Miguel Pires Amado[1], Luis Marques Barroso[2]

[1] Department of Civil Engineering, Universidade Nova de Lisboa, Caparica, Portugal
[2] GEOTPU, Faculdade de Ciencias e Tecnologia, Universidade Nova de Lisboa, Caparica, Portugal

*Corresponding E-mail : ma@fct.unl.pt

Received 20 November 2012; Revised 2 July 2013; Accepted 21 September 2013

## Abstract

Water is the most important resource to all life on our planet. The impact that buildings have on the consumption of this resource throughout their life cycle (planning, construction, operation and deconstruction) but mainly during the operation phase, has resulted in very high and unsustainable consumption patterns. Sustainable development, while a long-term goal, requires that the preservation of natural resources becomes a central point of any project strategy. Water is of vital importance to human life, it should be preserved to ensure its availability for a long period of time. However, little concern has been given to the importance of introducing a selection of more efficient solutions to save water in buildings and consequently increase sustainability in the construction sector. In this context it is on the design phase that the main resource saving water measures should be considered. Research on saving water involves an analysis of quantitative and qualitative measures and their adaptation to different contexts. Nowadays there are systems of voluntary certification of sustainable construction, which can help the design phase to achieve sustainability. This paper discusses a set of measures to reduce water consumption and enable a more efficient use of this resource in residential buildings. The measures presented are focused on user awareness campaigns, systems of rainwater and grey water recycling, the use of more efficient devices and reduction of leaks. The measures are analyzed and compared taking into account the consumption patterns for each device both inside and outside a domestic building and its effective reduction in water consumption.

***Keywords:*** *Certification, efficiency, water, residential buildings*

## 1.0 Introduction

The present article discusses a new dialectical and comprehensive understanding of sustainable construction as an approach to the efficient use of water in buildings. This “efficient water use” must encourage the construction of buildings based on a set of solutions that strive to reduce the natural resource consumption throughout the buildings entire life cycle. The main objective of this article is to analyze different measures that improve water efficiency in residential buildings, based on the calculation of water savings associated with their use.

The construction of new buildings has huge impact on the environment because the construction sector is responsible for the largest physical man-made objects on Earth and the corresponding consumption of a large amount of natural resources.

The large amounts of natural resources used in the construction phase are obviously less of then the amount consumed in the buildings entire life cycle. In this context it is mandatory to seek alternatives and in this context the use of water emerges as one of the most important issues because it is a resource vital for humans and their activities. The vital importance of this resource justifies the continuous study of its use so that, in the long term, humans continue to enjoy the services it provides.

It important to enumerate the main benefits that result from the reuse and recycling of storm waters: reduction of the consumption of potable water, reduced need for wastewater treatment plants (WWTP); efficient operation and maintenance; reduction in underground water consumption; aid in urban flood control; reduction of $CO_2$ emissions by using more efficient systems [1]. The main benefits of reuse and recycling of gray waters are: reduction of the volume to be treated by the WWTP, reduction of consumption of potable water; enables integrated management of water resources, reduction of the costs of invoicing for users, high social acceptance, reduction of volume of the reservoirs of potable water; allows the creation of alternative supply chains for different uses and activities [1]. The key question this study aims to address is, given all the aforementioned benefits, which systems produce the biggest efficiency gains?

## 2.0 Literature Review

The concept of Sustainability has evolved over the years, having come to prominence since the late '70s, firstly in an economic perspective and with little environmental concern. Only in the late 80s, this concept became associated to environmental issues, leading to the well-known definition of sustainable development [2]. The need for sustainable construction of new buildings and for sustainable renovation of existing buildings arises from the current reality of construction in the developed world. The quality and efficiency of buildings has a great impact on the environmental, economic and social conditions of populations. The purpose of sustainable construction is to ensure that, through improvement in all dimensions of human activity: economic, social and environmental, the livelihoods of future generations will be unaffected and the quality of life of existing generations maintained or improved [3].

A building can only be considered sustainable when the different dimensions of sustainable development - environmental, economic, social and cultural - are considered from the planning to the implementation phase [3]. The main objective of certification systems is to gather all the available data and information and produce reports. These reports are the base for the complex decision-making processes taking place during the various stages of a building's life cycle in sustainable construction. There are parameters considered at both the scale of the building and to assess the building's interaction with the environment in which it is inserted, evaluating sustainability in a broad fashion [4]. Typically, the parameters that serve to support the assessment of sustainability are related directly or indirectly with the following general objectives:

- Reducing the use of nonrenewable energy and materials;
- Reducing of water consumption;
- Reducing waster production;
- Cutting pollutant emission.

Internationally there are two widely used certification systems to evaluate the "sustainable performance" of buildings, the Building Research Establishment (BREEAM) and the Leadership in Energy and Environmental design (LEED) systems. The BREEAM system appeared in 1988 and was the first certificate system, followed by LEED in 1998. In Portugal the Liderar pelo Ambiente (LIDERA) certification system was introduced in 2005. These three systems of evaluation use similar methods to assess sustainability, differing mainly in the importance that each system gives to a particular category and in its subdivisions. Regarding the assessment of water sustainability the LEED system allocates the biggest weight to it with 10%, compared to the 9% in the BREEAM system and the 8% in the LIDERA system. It also noted the proposal of the BREEAM system that mentions daily per capita water consumption of all those 80 litres as a goal to reach in the United Kingdom [5, 6, 7].

Currently, the estimated total volume of water on Earth is around 1400 million km3, of which only 2.5% (35 million km3) corresponds to freshwater. Most of this water is in glaciers and is not used for consumption. Therefore, the main sources for human consumption are lakes, rivers, ground waters and underground aquifers, which contain an estimated 200,000 km3 of water, less than 1% of all freshwater and only 0.01% of all water on Earth [8].

Although access to drinkable water is growing, [in 1990 about 79% of the population (4.1 billion) had access to drinkable water and in 2000 this number surged to 82% (4.9 billion)], 1.1 billion people still lack access to freshwater and 2.4 billion lack access to sanitation facilities, directly and indirectly causing more than 5 million deaths per year. Today one third of the world population lives in countries with a moderate to high level of water stress, that is where water consumption exceeds 10 per cent of renewable freshwater resources and it is predicted that and within 25 years two thirds of the world population will live under these conditions [8].

According to Barroso [8], Portugal needs 7500 x 106 m3/year of freshwater, the equivalent to 1,880 million Euros. The largest share is consumed by the agricultural sector in irrigation, about 6550 x 106 m3/year (87% of total). The second largest share is in domestic use (mainly from showers, baths and cistern discharges) in the urban water supply with 570 x 106 m3/year (8% of total). Finally, the manufacturing industry uses 385 x 106 m3/year (5% of total) (Figure 1) [8].

From an economic perspective the urban sector is the key sector to make investments. It is a sector that uses 8% of water but has associated costs of 46% (Figure 2) [9]. It is necessary to reduce inefficiency in this sector to bring down costs and losses. For example, the use of high grade filters to produce drinkable water when it will be used in car washes or watering the garden is unnecessary. Another issue afflicting urban water efficiency is losses occurring by adduction when the distances required for distribution are long [9].

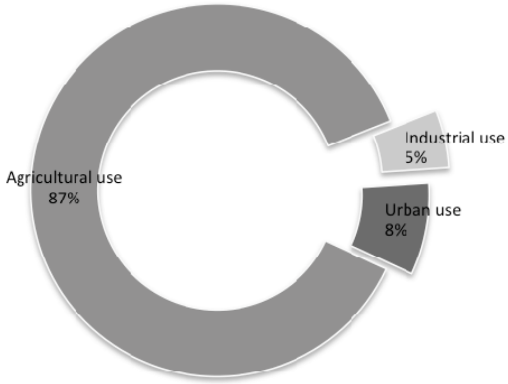


**Figure 1**: Water use by sector

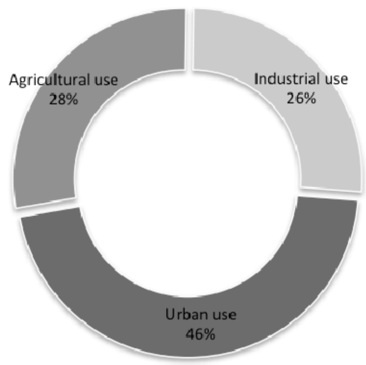


**Figure 2**: Costs associated with the water

In terms of the associated costs with water use, the urban sector is followed by the agricultural and industrial sectors, both with roughly equivalent costs (28% and 26% respectively). Several measures have been taken internationally to reduce water consumption in these sectors and also to tackle the shortages that may occur in some of the areas where these measures were put to practice. These measures where, among others: grey water treatment, fog retention, and desalination [9, 10]. In Portugal, there are no studies or statistical analysis characterizing domestic consumption patterns, although it can be calculated approximately considering the capacity of water consuming devices (Table 1) [8].

**Table 1** – Distribution of daily average consumptions

| Use | Consumption (L/capita/day) | | | |
|---|---|---|---|---|
| | Multifamily House | | Single-family House | |
| Cistern/Toilet | 43 | 31% | 43 | 27% |
| Taps | 22 | 16% | 22 | 14% |
| Bath/Shower | 52 | 37% | 52 | 32% |
| Washing Machine | 13 | 9% | 13 | 8% |
| Dishwashing Machine | 3 | 2% | 3 | 2% |
| Leaks | 7 | 5% | 7 | 4% |
| External Use | - | - | 20 | 13% |

Considering the consumption of a single-family house, it is possible to see that the highest consumption of domestic water in Portugal is associated with baths and showers (32%) followed by cisterns (27%); these devices represent about 59% of all domestic consumption. In the case of multifamily dwellings, where the portion of the external water use is excluded, the consumption of both these devices increases to 68% [11].

According to Pedroso [11] campaigns of awareness and motivation must allude to the reality that surrounds us, creating new ways to reduce unnecessary expenses. Still on the scope of reduction, actions like the use of low-consumption taps; creation of systems for rainwater utilization and the reuse of some waste waters (grey waters) are typically encouraged in campaigns. To reduce and mend past mismanagement, it is important to reduce the cost of consumed water. If limits are created for everyday water use then penalty measures can be applied to incentivize sustainable behaviors. It may also be noted that the additional revenues should be used in promoting the measures that increase water sustainability.

According to Barroso [8], some of the existing water losses in buildings, either cold or hot, occur due to leaks in the devices and appliances used. To prevent this occurrence, campaigns must allude to these causes; examine in detail the origins of these leaks and present preventive measures. It is possible to use more efficient devices to reduce the high levels of water consumption, such as cisterns with smaller discharge volumes and with dual discharge, thermostatic taps for showers, low-flow taps systems, and handles for rapid closure of water showers, low-flow shower heads and velocity amplifiers for discharge. Several of these devices are currently certified by the Associação Nacional para a Qualidade nas Instalações Prediais – (ANQIP) (National Quality in Building Installation Association), the responsible identity for this certification in Portugal.

The use of rainwater raises different opinions on some cases; for instance, the use of rainwater for washing clothes is conditioned by Brazilian standards (for bacteriological reasons) [13], but accepted by German standards. In Portugal there is no specific regulation and this water may be used for washing clothes, flushing toilets, for several external uses such as washing floors and cars, watering of green areas and several industrial uses such as cooling towers, fire systems, networks and HVAC systems [14] with special attention to bacteriological issues.

The volume of rainwater needed for storage must take several factors into account, which should consider the type of dwelling, the type of roof and the location where the dwelling is located [13]. Such factors include:

- Run off coefficient of the roof covering;
- Average annual rainfall;
- Catchment area of the roof surface;
- Hydraulic efficiency of filtering;

The storage of rainwater and its subsequent use for domestic purposes may be, in many cases, one of the best solutions to reduce freshwater consumption and an adequately dimensioned rainwater supply can help to reduce the consumption rates around 43% [9, 11, 13].

The reutilization of these waters will contribute to reduce the need for water treatment and their subsequent distribution. This will both generate economic gains and environmental benefits [11].

The use of gray water – wastewater from showers and washbasins – after appropriate treatment is already a recognized method for saving water in several countries. Although there are some countries which limit the possibility of using these waters citing the risk to public health resulting from splashes in its use that may cause problems. Their contribution to water saving is given by its discharge in toilets, use in irrigation systems and firefighting systems. In general, it needs an appropriate treatment (filtration and disinfection) depending on the quality of the water expected in its future use [9, 12].

## 3.0 Methodology

In terms of water saving in building sector, the research should carry out in the following three fields: buildings; equipment's and water. In these fields the natural resource - water is present and the different way of water potential use are integrated in the model framework of water efficiency. The methodology used to develop the study uses a simple 6 step structure:

Step 1: Identification of water saving using equipment/devices applicable in residential buildings both single family and multifamily.
Step 2: Characterization of the potential savings from each system.
Step 3: Comparison between current devices and the alternatives.
Step 4: Accounting for the potential use of rainwater
Step 5: Accounting for the potential use of gray water
Step 6: Estimated return of investment period

Considerations are made in the study: the use of rainwater is based on ETA ANQIP normative [15, 16, 17]; the sizing of the reservoirs is calculated for 30 days of demand; the dishwasher is considered to consume about 70% of total consumption; faucets and dishwasher reutilization comes from cisterns enhancing availability. This method enables a correct assessment between consumption needs and water saving potential in different conditions. Comparison between models is realized in terms of savings according to efficiency class [15, 16, 17] and the ecological and economic performance. The last step examines the various solutions in a cost-benefit framework and determines the return on investment periods.

## 4.0 Results and discussions

Using the described method a case study water savings was specified to three different dwellings with four occupants each one in three different rainfall catchment geographical conditions in Portugal – north, center and south. National data of rainfall will be providing by Portuguese Meteorological Center. The focus on the three different regions pretend to put out the effective capacity of implemented the water saving system in multifamily and single family building. These results take into account various considerations, such as:

- Number of days per year that each inhabitant remains inside his home – 330 days;
- Number of inhabitants in family houses – 4 people;
- Number of residents in multifamily buildings – 3 people;
- Roof catchment area of single-family building – 200m2;
- Roof catchment area of multifamily building – 48m2;
- Different rainfall catchment locations – Lisboa, Faro, Porto

The study considering also the different usage patterns and values of the flow, it is possible to draw a comparison between efficient devices and conventional devices (Table 2 and 3).

**Table 2 -** Savings multifamily building using the efficient devices

| **Multifamily Building** | **Consumption without saving measures** | | | **Saving with efficient equipment** | **Consumption with saving measures** | | | |
|---|---|---|---|---|---|---|---|---|
| **Devices/Appliances** | Consuptiom (l/hab.day) | Consumption (m3/hab.year) | Consumption (m3/agr.year) | | Consumption (l/hab.day) | Consumtion (m3/hab.year) | Consumption (m3/agr.year | |
| **Cisterns/Toilets** | 43 | 14,2 | 42,6 | 57% | 18,5 | 6,1 | 18,3 | |
| **Faucets Dishwasher** | 15 | 5 | 14,9 | 67% | 10,0 | 3,3 | 9,9 | |
| **Basin tap** | 7 | 2,3 | 6,9 | 63% | 5,0 | 1,7 | 5,0 | |
| **Showers** | 52 | 17,2 | 51,5 | 67% | 17,2 | 5,7 | 17,0 | |
| **Washing machine** | 13 | 4,3 | 12,9 | 44% | 7,3 | 2,4 | 7,2 | |
| **Disheasher** | 3 | 1,0 | 3,0 | 50% | 1,5 | 0,5 | 1,5 | **Absolut savings** |
| **Leaks** | 7 | 2,31 | 6,9 | - | - | - | - | |
| **Total** | 140 | 46 | 138,6 | - | 59 | 20 | 58,8 | **58%** |

**Table 3** - Savings single family building using the efficient devices

| Single family Building | Consumption without saving measures | | | Saving with efficient equipment | Consumption with saving measures | | | |
|---|---|---|---|---|---|---|---|---|
| Devices/Appliances | Consuptiom( l/hab.day) | Consumption (m3/hab.year) | Consumption (m3/agr.year) | | Consumption (l/hab.day) | Consumtion (m3/hab.year) | Consumption (m3/agr.year) | |
| Cisterns/Toilets | 43 | 14,2 | 56,8 | 57% | 18,5 | 5,7 | 24,4 | |
| Faucets Dishwasher | 15 | 5 | 19,8 | 67% | 10,0 | 3,3 | 13,2 | |
| Basin tap | 7 | 2,3 | 9,2 | 63% | 5,0 | 1,7 | 6,6 | |
| Showers | 52 | 17,2 | 68,6 | 67% | 17,2 | 5,7 | 22,7 | |
| Washing machine | 13 | 4,3 | 17,2 | 44% | 7,3 | 2,4 | 9,6 | |
| Disheasher | 3 | 1,0 | 4,0 | 50% | 1,5 | 0,5 | 2,0 | |
| Exteriors | 20 | 6,6 | 26,4 | - | 20,0 | 6,6 | 26,4 | Absolut savings |
| Leaks | 7 | 2,3 | 9,2 | - | - | - | - | |
| Total | 160 | 52,8 | 211,2 | - | 79 | 26 | 105 | 51% |

The comparison of the Table 2 and 3 can be seen in Table 4, where the class of water efficiency according to ANQIP can also be found [15, 16, 17].

**Table 4** – Savings associated with efficient equipment and appliances

| Devices/Appliances | Certification according to ANQIP | Savings (%) |
|---|---|---|
| Cisterns/Toilets | A | 57 |
| Showers | A+ | 67 |
| Basin Taps | A | 62,5 |
| Faucets Dishwasher | A | 67 |
| Washing Machine | A | 44 |
| Dishwasher | A | 50 |

The evaluation of the potential for rainwater harvesting was assessed using the procedure of ANQIP [17]. To study and establish a comparative analysis of rainwater harvesting in buildings made use of the same context referred before.

The total amount of available rainwater is calculated using the following formula

$$V_a = C \times P \times A \times \eta_f \quad \ldots\ldots\ldots\ldots\ldots\ldots \text{Ref[15]}$$

Where:

Va - Annual volume of rainwater usable (liters)
C - Coefficient of run off of the roof
P - Cumulative average annual rainfall (mm)
A - Catchment area
ηf - Hydraulic efficiency of filtering

The value of hydraulic efficiency of filtration is determined at: ηf = 0.9 and the values for run off of various roof types are displayed in Table 5.

**Table 5** – Values to run off coefficient of the roof, Source: Barroso,(2010)

| run off coefficient of the roof (C) | | |
|---|---|---|
| Type A | Impermeable roof | 0,8 |
| Type B | Gravel roof | 0,6 |
| Type C | Extensive green roof | 0,5 |
| Type D | Intensive green roof | 0,3 |

Thus, for the case of a single-family housing, each measure provides savings that vary between 40% and 76.3% – from the use of grey water to the use rainwater together with efficient devices, respectively (Table 6). Although the savings of 76.3% would result in reducing the flow from 160 to 37.9 L/capita/day, which may seem very ambitious, such reduction is possible, because this consumption covers all the needs of water for one person.

**Table 6** – Comparison of measures in single family building

| Measure | Normal consumption (m3/agr.year) | Reduction (m3/agr.year) | Final Consumption (m3/agr.year) | Consumption (L/capita/day) | Savings (%) |
|---|---|---|---|---|---|
| Gray Waters | 211.2 | 83.2 | 128 | 117 | 40 |
| Rainwater | 211.2 | 91.2 | 120 | 90.8 | 43.2 |
| Efficient Appliances | 211.2 | 106.2 | 105 | 79 | 50 |
| Rainwater + Efficient Appliances | 211.2 | 161.2 | 50 | 37.9 | 76.3 |

For the case of a multifamily building, the use of grey water and rainwater is quite similar, with both being the measures with lower efficiency, nevertheless providing savings ranging between 31% and 31.5%. If it is a system of rainwater harvesting in conjunction with efficient devices, it becomes an ideal choice because it allows reducing consumption by about 73.7%, which translates into a consumption of 36.7 L/capita/day (Table 7).

**Table 7** – Comparison of measures in multifamily building

| Measure | Normal consumption (m3/agr.year) | Reduction (m3/agr.year) | Final Consumption (m3/agr.year) | Consumption (L/capita/day) | Savings (%) |
|---|---|---|---|---|---|
| Gray waters | 138.6 | 42.5 | 96.1 | 97.1 | 31 |
| Rainwater | 138.6 | 43.7 | 94.9 | 95.9 | 31.5 |
| Efficient appliances | 138.6 | 79.8 | 58.8 | 59 | 58 |
| Rainwater + efficient appliances | 138.6 | 102.2 | 36.4 | 36.7 | 73.7 |

The potential of the measures analyzed and presented translates into economic gains and environmental benefits. These gains are strengthened in technical terms by an economic analysis of the proposed measures. In this sense, the analysis of the various proposed devices and water-saving systems, equated with the objective of estimating the cost-benefit and to validate the period of return on investments, seems to be advantageous.

The payback period of the various measures presented is estimated, considering the total costs of benefits and the total investment. In Table 8 is possible to see the return of the various saving measures in the three different geographical locations in Portugal under consideration, for the case of private houses and in Table 9 for the case of multifamily houses (zones defined according to the level of rainfall and water prices).

**Table 8 –** Estimated return of investment period on single family buildings (years)

| Measure | Location | | |
|---|---|---|---|
| | Lisboa | Faro | Porto |
| Gray water | > 18 | > 15 | > 14 |
| Rainwater | > 35 | > 34 | > 32 |
| Efficient appliances | > 7 | > 6 | > 6 |
| Efficient appliances + Rainwater | > 30 | > 27 | > 24 |
| Effic. appliances (without wash machine and dishwasher) | < 2 | < 2 | < 2 |

**Table 9** – Estimated return of investment period in multifamily buildings (years)

| Measure | Location | | |
|---|---|---|---|
| | Lisboa | Faro | Porto |
| Efficient appliances | > 12 | > 10 | > 9 |
| Efficient appliances (without wash machine and dishwasher) | < 3 | < 2 | < 2 |

It is evident that the return period of the investment is quite high. Only the implementation of efficient appliances constitutes a measure that leads to a shorter return period. However, the social value of water resources must not be forgotten; a situation that can lead to consider what should be the way forward in the long term, i.e. a decision-making framework for sustainability.

In this cost/benefit analysis, where the suggested measures are economically analyzed, there is an important factor of difficult quantification, given the unpredictability and uncertainty of the availability of water resources in the future. Within 25 years two thirds of the world population will live in water stress conditions and we can't predict what changes will occur in the water supply industry due to this factor of scarcity, and how this situation will be reflected in the value of water. The rate of water availability may not increase at today's commonly used annual rate, and could see its value fairly inflated due to resource scarcity. Moreover, the availability of water from other sources, like the sea, through the use of other technologies has a cost of production, associated with the high-energy consumption they require, which also contributes to the increasing of the cost of water.

Therefore it is important to diffuse knowledge and establish an operating procedure applicable to a project that will push the implementation, throughout the building's life cycle, of measures to contribute to the saving of water resources. This will lead to the economic efficiency of the process, which ultimately translates into a more sustainable project.

## 5.0 Conclusions

Given the fact that the scarcity of water is expected to occur in foreseeable future, it is essential that we develop a set of measures aiming to increase the efficiency of water use, a situation that has been analyzed in this study, through the various measures of action proposed, whose performance tests results were presented above.

Although the values of 37.9 or 36.7 L/capita/day seem extremely low when compared to current consumption, they are closer to the minimum value of 50 L/capita/day, which includes all the basic needs of a human being in their day-to-day life. Thus, it is considered that a final proposal should suggest the following procedures:

- For existing buildings, in a first phase, the consumption dropping to 80 L/capita/day, which is a decrease of 50% for single-family house and a decrease of 42% for multifamily house, could be attained through changes in the devices, which can be replaced by others with greater efficiency and without changes in the water distribution networks. In the next phase it will be possible to study the implementation of systems for rainwater utilization, which is the measure that, coupled with more efficient devices, would translate into lower levels of freshwater consumption.
- In new buildings, a consumption reduction to 40 L/capita/day could be achieved through the implementation of a rainwater collecting system combined with more efficient devices. This is justified with the measures developed in this paper and translates into a growth of a much wider social consciousness.

Given all these factors, it becomes increasingly clearer that water is an endangered resource and all the measures to reduce its consumption or increase the level of efficiency of its use must be taken.

In terms of saving water resources, any of the measures considered will be of great advantage. It is possible to conclude that all the presented measures are valid and feasible to implement taking into account the results presented above, which point to a clear reduction of water resources for the same activities that today are used in unsustainable manners.

## Acknowledgement

Researchers express the acknowledgement to GEOTPU FCT UNL, for the important support provide to the development of this research.

## References

[1] M. Neves, and E. Bertolo, “Aproveitamento e Reutilização da Água para Usos Domésticos”, Jornadas de Hidráulica, Recursos Hídricos e Ambiente, FEUP (in portuguese), 2006.
[2] M. P. Amado, “Planeamento Urbano Sustentável”, Editora Caleidoscópio, Casal de Cambra, Lisboa, ISBN: 9789728801748, (in portuguese), 2005.
[3] M. P. Amado, “The Sustainable Building Process”, In CD: Ron Wakefield (eds): RMIT University, Australia, ISBN: 978-1-921166-68, pp. 65-69, 2007.
[4] L. Bragança, “Sustentabilidade de soluções construtivas”, Universidade do Minho, Braga (in portuguese), 2006.
[5] LEED, “LEED for New Construction and Major Renovations Rating System”, U.S. Green Building Council, LEED, USA, 2009.
[6] BREEAM, “Code for Sustainable Homes”, Technical guide, BREEAM, London, 2009.
[7] LIDERA, “Lidera Sistema de Avaliação da Sustentabilidade”, Versão para Ambientes Construídos (V2.00b) Lidera, IST UTL, Lisboa (in portuguese), 2009.
[8] L. Barroso, “Construção Sustentável – Soluções Comparativas para o uso eficiente da água nos edifícios de habitação”, Dissertação de Mestrado em Engenharia Civil, FCT UNL (in portuguese), 2010.
[9] S. Muthukumaran, K. Baskaran, and N. Sexton, “Quantification of potable water savings by residential water conservation and reuse – A case study”, Resources, Conservation and Recycling, vol. 55: pp. 945-952, 2011.
[10] L. Domènech, and D. Saurí, “A comparative appraisal of the use of rainwater harversting in single and multifamily buildings of the metropolitan area of Barcelona (Spain): Social experience, drinking water savings and economic costs,” Journal of Cleaner Production, vol. 19, pp. 598-608, 2011.
[11] V. M. E. Pedroso, “Medidas para um uso mais eficiente da água nos edifícios, Informações Cientificas Técnicas”, LNEC, Lisboa (in portuguese), 2009.
[12] M. C. Almeida, P. Vieira, and R. Ribeiro, “Uso Eficiente da água no sector urbano”, Série Guias Técnicos, Ed: IRAR, INAG e LNEC, Lisboa (in portuguese), 2006.
[13] E. Ghisi, “Potential for potable water savings by using rainwater : An analysis over 62 cities in southern Brazil”, Building and Environment Journal, vol. 42 (2), pp. 204-210, 2006.
[14] A. Arpke, and N. Hutzler, “Operational Life-Cycle Assessment and Life-Cycle Cost Analysis for Water Use in Multioccupant Buildings”, Journal of Architectural Engineering, vol. 11 (3), pp. 99-109, 2005.
[15] ANQIP, “ETA 0806 – Especificações para atribuição de rótulos de eficiência hídrica ANQIP a duches e sistemas de duche”, ANQIP, Aveiro (in portuguese), 2009.
[16] ANQIP, “ETA 0808 – Especificações para atribuição de rótulos de eficiência hídrica ANQIP a torneiras e fluxómetros”, ANQIP, Aveiro (in portuguese), 2010.
[17] ANQIP, “ETA 0906 – Certificação de sistemas prediais de reutilização e reciclagem de águas cinzentas”, ANQIP, Aveiro (in portuguese), 2011.