MANAGEMENT OF WATER RESOURCE IN THE CONSTRUCTION INDUSTRY

WATER CONSERVATION AND DEMAND MANAGEMENT

CBIC 60 anos

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Edition by:

SENAI

Iniciativa da CNI - Confederação Nacional da Indústria

Co-edition:

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MANAGEMENT OF WATER RESOURCES IN THE CONSTRUCTION INDUSTRY: WATER CONSERVATION AND MANAGEMENT OF THE DEMAND

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PREFACE

Practicing sustainability implies, at this moment, implementing actions of economic, social and environmental nature that will contribute to the quality of life of the generations to come.

Since, in most buildings built in Brazil there is still waste of water, it can be said that practicing sustainability, with regard to the Construction Industry and the use of water, means delivering buildings that favor the efficient use of water throughout its life span.

The first document on the subject (published in July 2016 by the Commission of Environment of the Brazilian Chamber of Construction Industry - CMA-CBIC - in partnership with the Brazilian National Industrial Apprenticeship Service - SENAI[1]): "Water Resource Management in the construction industry – the efficient use of water in residential buildings " describes the Hydraulic Systems in Buildings and it highlights the performance requirements related to the efficient use of water.

This second document seeks to expand and go deeper in some of the issues presented in the previous publication, aiming at providing support to construction companies, builders, designers and executors in the quest for achieving sustainable buildings.

1 Available for download in both Portuguese and Spanish at http://cbic.org.br/pagina/publicacoes-cma

INTRODUCTION

1. INTRODUCTION

Initially, it is already a common sense the fact that water is a finite and noble resource,vital for life's existence, which must be used with moderation, avoiding its waste.

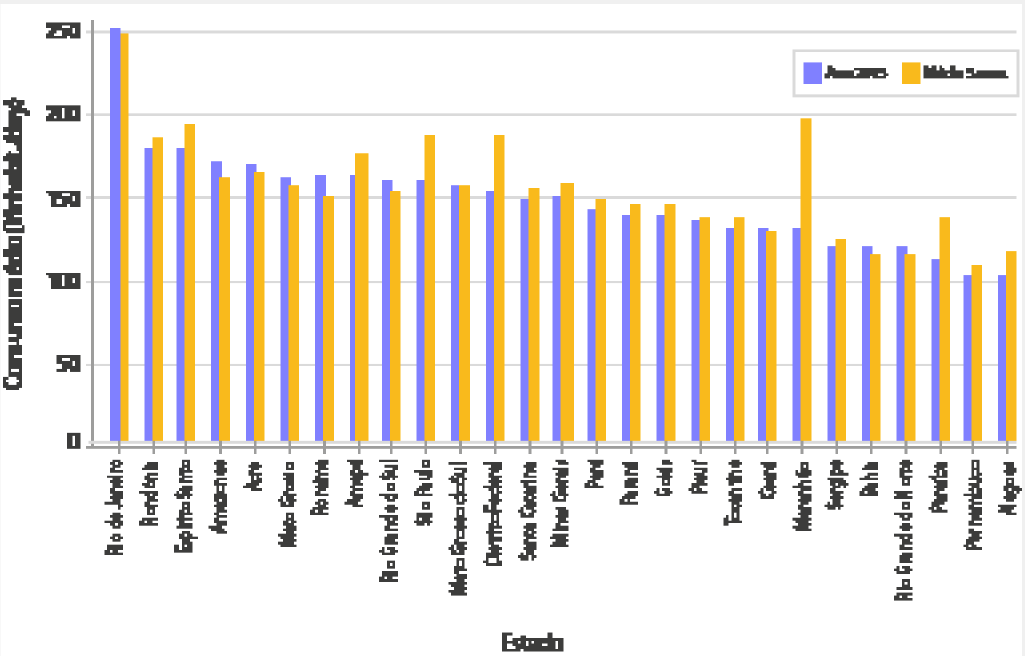
In practice, however, consumption indicators tell us differently.

According to data from the Brazilian National Sanitation Information System of the Ministry of Cities (SNIS[2] 2015), published in February 2017, the water consumption per capita in Brazil in 2015 was 154 liters per day, with regional variations of 116.1 liters per inhabitant per day in the Northeast to 176 liters per inhabitant per day in the south-east. This data, provided by the water supply service providers, cover 5,088 cities (91.3% of the total Brazilian cities) , with a total of 169 million inhabitants (97.8% of the urban population in Brazil.

The Graph 1 below shows the average consumption per capita in each Brazilian state in the year of 2015 and the consumption average over the three previous years (from 2012 to 2014).

GRAPHIC 1: AVERAGE CONSUMPTION PER CAPITA IN BRAZILIAN STATES

Year 2015 - Average over 3 years
Average consumption (l/inhabit./day)/States



Source: SNIS 2015

2 Available at http:// www.snis.gov.br/component/content/article?id=120

The average consumption per person in the state of Rio de Janeiro is quite high when compared to the others states, 44.6% above the average in the south-east region and 65.3% above the country average. It is also brought to attention the reduction in consumption in states that have undergone a rainfall shortage during the period.

The Metropolitan Region of São Paulo (RMSP), which was affected by lack of historical rainfall between the end of 2013 and 2015, is an interesting example in the matter. During the scarcity period, in which the water supply system of São Paulo metropolis was heavily compromised, undergoing emergency constructions in order to provide access to more water supply. The intense media exposure of the low level of water reserves in the public water system supply and the implementation of penalties and bonuses incentives to encourage the consumption reduction by the population, resulted in a significant reduction in consumption per person.

With the return of the rainfalls and the end of the fines and bonuses, even with some campaign promoting the conscious consumption still present in the media, the consumption of water increased again.

Table 1, below, presents the water production data in AMSY before, during and after the period named "water crisis" in 2015.

TABLE 1: WATER PRODUCTION IN THE METROPOLITAN REGION OF SÃO PAULO SYSTEM (M^3/S).

SYSTEM	MAR/14	MAR/15	MAR/16	MAR/17
Cantareira SISTEMA	27,65	14,04	22,65	25,93
Guarapiranga	14,10	14,65	13,98	13,79
Alto Tietê	14,99	11,91	11,59	11,33
Rio Grande	4,82	4,94	4,92	4,85
Rio Claro	3,82	3,93	3,97	3,92
Alto Cotia	1,07	0,79	1,28	1,26
Baixo Cotia	0,89	1,01	0,89	0,85
Ribeirão Estiva	0,10	0,08	0,08	0,08
TOTAL RMSP	67,43	51,34	59,38	62,01

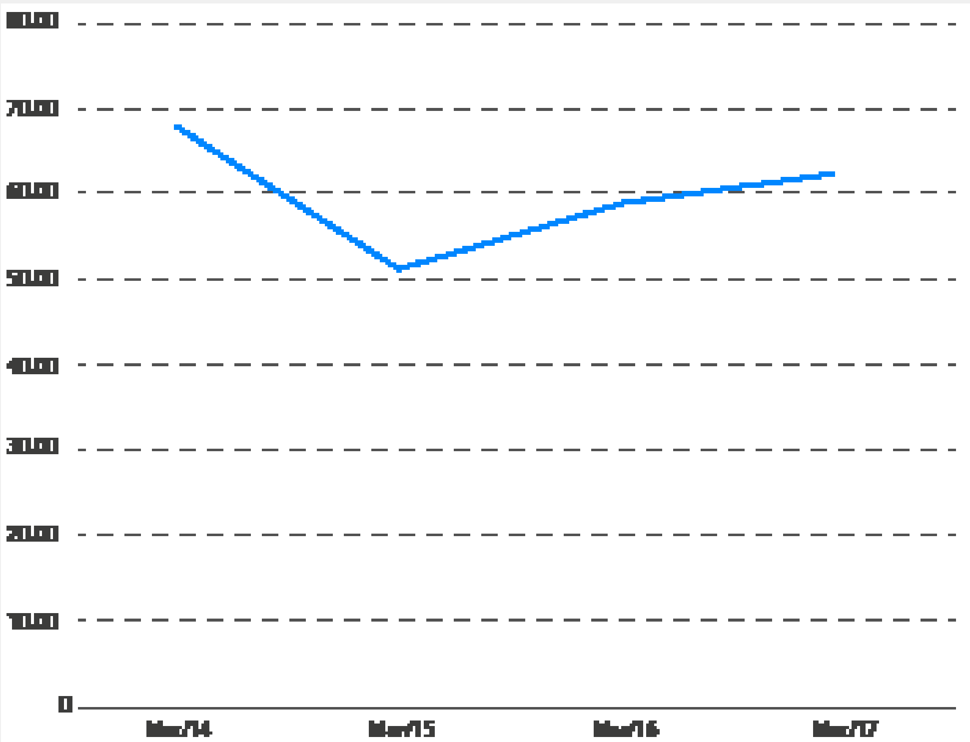
Source: Sabesp (2017)

One can observe the strong reduction during the period, and the increase of the consumption after the drought.

Graph 2 illustrates the variation in consumption and increase tendency.

It is reasonable to consider that the strong economic crisis which Brazil is experiencing prevented an even greater increase in water consumption from happening after the rainfalls returned.

GRAPHIC 2: THE EVOLUTION OF WATER PRODUCTION IN THE METROPOLITAN REGION OF SÃO PAULO BY SYSTEM TYPE (M^3/S).



Source: created from data provided by Sabesp (2017)

The reality in São Paulo Metropolitan Region is not different from what happens in other urban centers in the country. During periods of water scarcity, users reduce consumption (also because there is no water in their water tanks) and, with the return of the rainfalls, the consumption goes back up, which shows that behavior-based actions oriented towards the reduce in water consumption, especially extreme actions taken during times of crisis, are not permanent.

To reduce consumption in a permanent basis, it is necessary to invest on structuring and technological actions that promote the efficient use of water besides promoting educational campaigns for conscious use. In the case of the construction industry, changes in the way of conceiving and designing the buildings contribute to a significant reduction in water consumption indicators.

With the growth of population, the demand for water and the production of sewage is increasing throughtout the time. Sewage and wastewater dumped in rivers due to urbanization and industrialization also contribute considerably to the increasing demand on available water resources.

Reversing this process is one of the biggest challenges society faces at the moment.

The risk of a shortage in potable water supplies in urban centers has been studied and published in Brazil since the late1990's. At that time, the Rational Use of Water Program (Sabesp) had started, and the first versions of the National Program to Fight Water Waste documents were published. In 1999 ANA - Agência Nacional de Águas (Brazilian National Water Agency) was founded.

Since then, much progress has been made in technological knowledge, but much still needs to be done in the construction industry field. In November 2014, the CBCS - Brazilian Council for Sustainable Construction -, together with the Ministry of the Environment and the UNEP-MA - United Nations Environment Program - developed a study on sustainable construction in Brazil[3] as support to future national policies to promote sustainable construction. This study resulted in the publication "Aspects of Sustainable Building in Brasil[3]" which deals with water issues, energy and materials. In this document, the water vulnerability of cities and the need to establish public policies with structural-based actions to reduce demand are highlighted.

In the construction industry, the most comprehensive and permanent actions that took place in Brazil were taken by sanitary ware and sanitary metal wareware manufacturers. The organization of these sectors, through the PBQP-H[4] Sectoral Quality Programs, the development of technical standards for products, the development of toilets that require low flushing volume, the development of metal fittings and devices that reduce the amount of water needed for consumer activities and combating non-compliance to

3 Available at http://www.cbcs.org.br/website/aspectos-construcao-sustentavel/show.asp?ppgCode=DAE7FB-57-D662-4F48-9CA6-1B3047C09318

4 PBQP-H: Programa Brasileiro de Qualidade (Brazilian Quality Program)

standards are examples of structural-based actions that contribute in a permanent way to the fight water waste.

It is worth thinking about how the water crisis periods in several Brazilian cities would have been if the toilets installed since 2002 still used from 9 to 15 liters for each flush. How much water has been saved in Brazil since 2002, after low flush volume toilets started to be manufactured[5]? This is a clear example of a technological action to reduce water consumption: despite the user's behavior, the volume required to flush toilets is now lower than before.

In most buildings built in Brazil, the water consumption still results in a significant waste. The usual ways and common pratice in conceiving, designing, implementing, operating and maintaining buildings, still result in a higher water consumption than necessary to performance activities that demand water use. This is not about user's behavior, but about technology. The main aspects to be considered for fighting the waste of water in residential buildings, discussed in this document, are:

- building design;
- demand management;
- Water outflow at outlets.

5 Since 2002, through a sectoral agreement, toilets that consume from 9 to 15 liters per flush have ceased to be manufactured in Brazil, with the beginning of the production of toilets that only require 6.8 liters (nominal flow) to drag solids and 3 liters for liquids.

THE EFFICIENT USE OF WATER AND WATER CONSERVATION

2. THE EFFICIENT USE OF WATER AND WATER CONSERVATION

Some decisions that are part of the construction process of new buildings or renovation of existing buildings entail the use of greater or lesser amount of water in the consumer activities, regardless of the user's behavior. When, in fact, sustainability is to be practiced, even if there is no legal obligation, therefore actions should be taken that favor the optimization of consumption.

2.1 THE EFFICIENT USE OF WATER

The main concept to be implemented in buildings is **the efficient use of water,** which consists on implementing technological actions, which does not consider user's behavior, to reduce consumption to the minimum necessary for the performance of water consumption activities.

The design of a new building or the planning of the renovation of an existing building, based on the efficient use of water perspective, allows the achievement of consumption indicators lower than the current ones.

In 1997, ABNT NBR 13969: 1997 - Septic water tanks - has already given the warning: "In a sewage treatment system, the costs of implantation and operation are generally proportional to the volume of sewage to be treated." The reduction in water consumption also automatically promotes the reduction in the volume of sewage produced, which directly impacts on the costs of sewage treatment systems.

In 1998, ABNT NBR 5626 - Coldwater installation -, in item 5.1.2, the requirement for the hydraulic systems of buildings project was brought up: "to promote water and energy saving".

In practice, however, plenty of water is also wasted as a result of the way the buildings are designed, engineered, implemented, operated and maintained.

Actions for the efficient use of water that do not depend on the user's behavior have permanent results.

A classic example of water waste that is not related to user's behavior is the amount of cold water released between the activation of a shower through its valve and the actual arrival of the hot water in the outlet.

Decisions on project determine actions on this kind of waste.

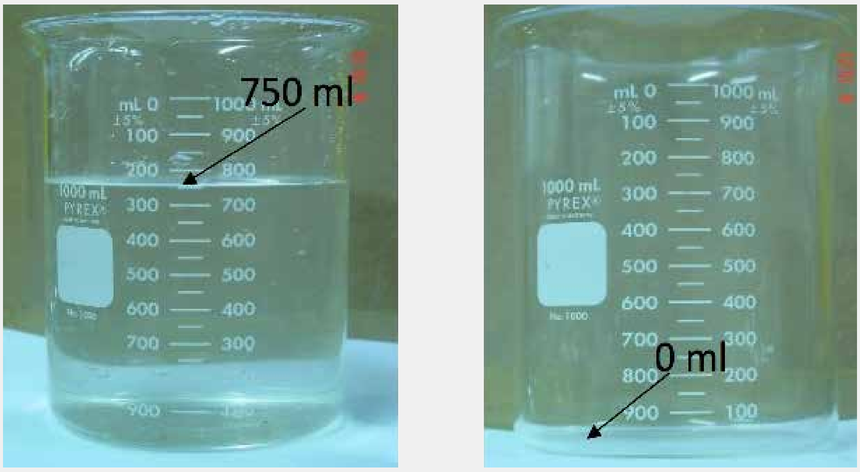
Preventing the waste of cold water at a shower outlet is an action associated to building design, architectural design and building hydraulic systems. Predicting the smallest possible distance between the heat source and the hot water outlet associated with water recirculation systems, anticipate thermal insulation pipes to reduce heat loss, among others, are technical actions that reduce the time waiting for hot water, and it permanently enables the efficient use of water.
Figure 1 shows another example of water waste, which occurs with the use of a tap with jet dispersion higher than the one determined in the product standard manufacture : part of the water is used and part is wasted.

1: WATER WASTE IN THE TAP WATER

Source: TESIS (2017)

Figure 2 shows the amount of water wasted in 1 minute by a tap that was manufactured in non-conformity to the technical standards of Figure 1. The jet dispersion test was carried out and provided in ABNT NBR 10281 - Taps - Requirements and test methods.

FIGURE 2: AMOUNT OF WATER WASTED IN 1 MINUTE



Not in accordance to the dispersion 12%

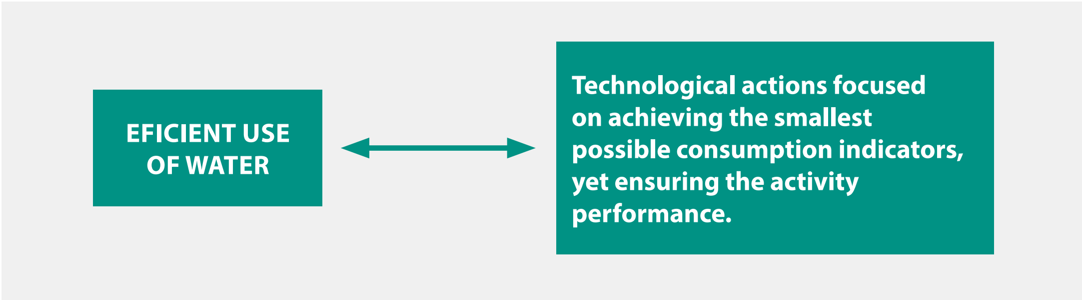
According to dispersion 0%

Source: TESIS (2017)

During periods of water shortage, many users are encouraged to work on behavioral change to reduce consumption, whether by raising awareness, or by economic motivation (fines and bonuses). After the critical period, however, depending on the type of behavior change adopted, previous habits are retaken[6] and consumption rates increase again.
The technical knowledge available makes it possible for each building constructed or renovated to achieve much more efficient consumption indicators than the current ones. Ensure technological actions that allow the permanent efficient use of water, the new consumption reductions may be related to the behavior of users and the conscious consumption.
Producing a new building or remodeling an existing building with a focus on the efficient use of water means interfering, technically, in all aspects related to water waste. Performance requirements associated with the efficient water use were Annex 1 presents results obtained in the implementation of actions in favor of the efficient use of water in buildings, with significant reductions in water con-

6 Example no permanent change in behavior: placing a bucket beneath the shower cold water to collect and use it for another purpose (toilet flush, for example). After the period of shortage, the buckets are left aside, given the effort involved, and waste returns to each bath, presented in the Water Resources Management in the Construction Industry - efficient use of water in residential buildings, document, published by the Commission of Environment and Sustainability - CMA - of the Brazilian Chamber of Construction Industry - CBIC - in May 2016[7].

sumption and periods of investment return that confirm the feasibility of such interventions.



Summary table 1

2.2 WATER CONSERVATION

According to Decree No. 2914, of the Brazilian Ministry of Health, dated back to December 12, 2011[8], which "provides the procedures for controlling and monitoring the quality of water for human consumption and its potability standards " and "it applies to the water intended for human consumption and supplied by an alternative water supply system and solution ", potable water is appropriate water for intake, for food preparation and production, and personal hygiene, regardless of its source.

In residential buildings, there will always be the potable water supply system, a condition that either reinforces the importance of actions for the efficient use or it technically interferes in potable water systems to facilitate obtaining the lowest possible consumption indicator, still ensuring the performance of the activity.

However, certain activities, such as floor washing and garden watering, can be carried out with the use of non-potable water (considered unfit for human consumption, as it does not meet the drinking standard established by Decree No. 2914 of the Ministry of Health).

The expansion of the concept of **efficient use of water** to the concept of **water conservation** consists in promoting the optimization of the potable water demand supplied by the Utility companies, associated with the supply of water from an alternative source, using "less noble" water for "less noble" purposes.

The main difference between the exclusive use of potable water from the Utility company and including alternative water sources is the need for **quality water management.**

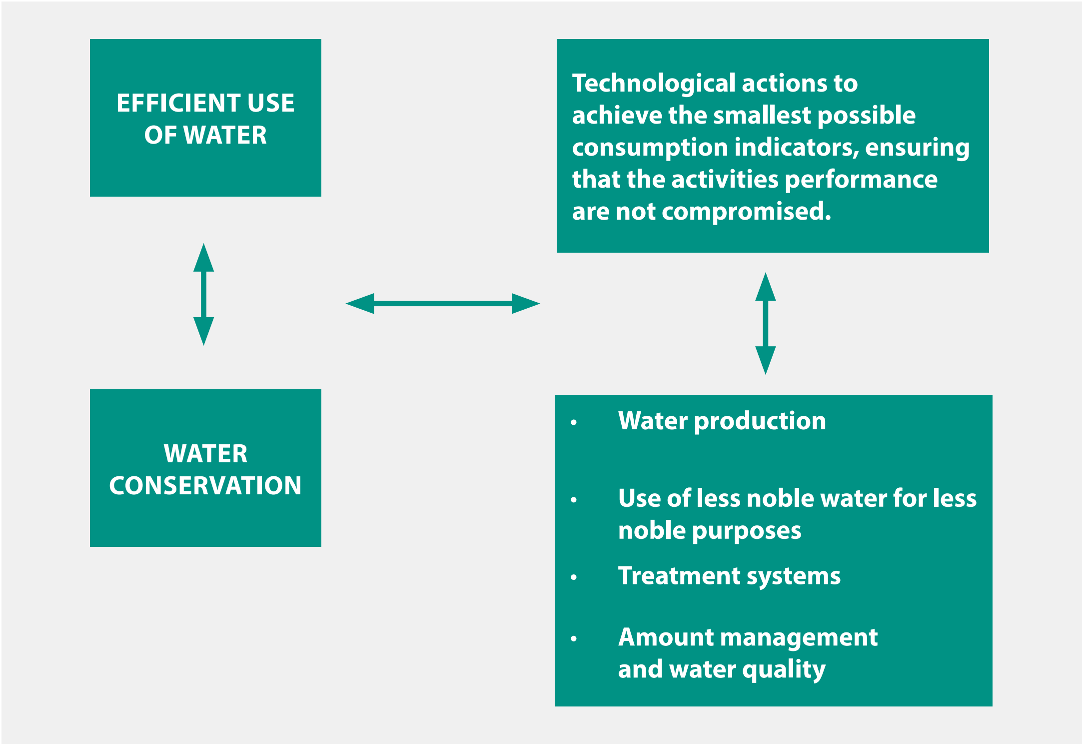
The concern with unfit water for human consumption, a potential disease agent, is quite old. The Egyptians in 2000 BC used aluminum sulfate for water clarification, and dated back to that time the oldest writings in Sanskrit about the care that should be taken with drinking water, such as its storage in copper vessels, its

7 Available to download in Portuguese and Spanish version at http://cbic.org.br/pagina/publicacoes-cma

8 Available at http://bvsms.saude.gov.br/bvs/saudelegis/gm/2011/prt2914_12_12_2011.html

exposure to the sun and its filtration through coal. Such writings describe the purification of water by boiling, heating in the sun, or the introduction of a heated iron rod into the liquid mass, followed by filtration through sand and coarse gravel.
When the water comes from the public supply system, the Utility company is responsible for its quality, according to the standards established by Decree 2,914, of the Ministry of Health.
The option of using an alternative source of water supply in an enterprise transfers the responsibility for the water quality to the manager in site, since he becomes a water "producer", being obliged to guarantee the minimum quality standards that are consistent with the activities that will use it, in order to prevent contamination of users, whether due to improper use of the non-potable system or the contamination of the potable system with water from the non-potable system.
The use of water from an alternative source to the public supply system requires the implementation of treatment systems and the permanent monitoring of the quality of the water produced.
So the main difference between the **efficient use of water** and water conservation is the inevitable need of the operation of a treatment system and the requirement for permanent monitoring of water quality.
The standardizing process in Brazil does not yet provide all the necessary guidance for the conservation of water in buildings, especially for the installation of non-potable systems. The Brazilian Association of Technical Standards - ABNT -, through CB-002, Brazilian Council of Civil Construction, installed, on 12/13/2016, the study group CE-002: 146.004 - Water conservation in buildings. This study committee aims to standardize aspects which are relevant to the topics "Water conservation" and "Non-potable water systems in buildings".
Specific aspects of the implementation of non-potable systems in buildings are presented in Annex 2. TECHNICAL AND ECONOMIC VIABILITY STATUS

9 REZENDE, S. C.; HELLER, L. Sanitation in Brazil: policies and interfaces. Belo Horizonte: Editora UFMG, 2002. 310 p



Summary table 2

TECHNICAL AND ECONOMIC VIABILITY ASSESSMENT

3. TECHNICAL AND ECONOMIC VIABILITY ASSESSMENT

There are no standard solutions that can be effectively applied to any building. Each case is unique, requiring specific study and expert involvement. When it comes to water, there is no way to say, for example, that the use of rainwater should be considered for all buildings. Local rainfall may not meet the demand, or there may be no demand to justify the provision of the system , or investment and operating costs can derail the implementation of the system, or even there can be no room for the system, among others.

The main tool used for decision making concerning the types of viable or interesting water supply systems for a given building is the technical and economic viability assessment, which must be carried out in the design stage of the building to be constructed or in the design of a renovation to be held in an existing building. And considering that it is not possible to reduce the consumption of one input at the expense of increasing consumption of other inputs, specially in unaware impetus, a technical and economic viability assessment should involve all the inputs used by the construction, even if only for systems of water. Even if the focus of a technical and economic viability assessment is water, there is no way to affirm that a given solution is viable without analising the impacts caused on other inputs (electricity and gas). The more complex the construction or the greater the consumption of the inputs associated with it, the more complete and detailed the study should be.

Through an assessment of technical and economic viability, it is possible to understand and come up with consistent solutions that will balance the consumption of inputs in order to rationalize the use without affecting the performance of activities. The technical and economic viability assessment provides technical and financial subsidies that allow identifying, for each evaluated solution, input consumption estimation, necessary investment, payback period and operating costs.

In general, the main aspects to be considered for the preparation of an assessment on technical and economic viability for implementing water conservation actions , are:

- **Population:** fixed and variable; users' profile; availability or not of qualified equipment for operation and maintenance; the ability to absorb operating costs.

- **Water-consuming activities:** identification and quantification of water-consuming activities (consumption); identification of the largest consumers of water (activities and equipment); identification of appropriate consumption indicators; identification (and quantification) of activities that require potable water; identification (and quantification) of activities that can be supplied by water from alternative sources; historical consumption of water and energy (for existing buildings).

- **Building location:** climate / temperature; local habits; access (or not); existence (or not) of qualified suppliers and service providers in the region; existence (or not) of qualified laboratory for water quality monitoring trials; existence (or not) of suitable site for the disposal of sludge generated in treatment plants.

- **Water supply:** rainfall indexes; estimation of possible volumes of sewage production; quantity of groundwater available, when suitable.

- **Treatment:** water quality required for activities that can be supplied by water from alternative sources; possible and available treatments; spaces required; deployment, operation, and maintenance costs.

- **Architecture Project:** possible volume of rainwater collection (coverage areas); possibility (or not) of space for predicting water tanks for alternative sources before and after treatment; existence (or not) of space for treatment system; in the case of existing buildings, assessment of the physical and financial impact of civil construction for the introduction of new systems; space existence (or not) to pipes and hydraulic systems equipment for the use of alternative sources of water.

Some of the aspects described above can be quantified. Other aspects, however, may have a subjective nature. For example: the difficulty of accessing qualified laboratories for certain tests can increase too much the costs for managing the system, or contribute to the incapability of carrying out such tests and put the health of users to risk through possible misuse of identification in the treatment system, which may fail to provide the water with the expected quality. The need for technical assistance for the installed equipment can compromise the maintenance viability of a certain solution. Another condition of difficult and subjective assessment is the capability of a condominium, and of those responsible, understanding the risks related to a water system whose quality is not under the responsibility of the public system, but of the condominium itself.

Castilho, C. (2016), in "Assessment during operation of non-potable water systems"[10] comments that initiatives oriented to the use of water from alternative sources nowadays in Brazil "have little technical standards support, guidelines or legal regulations to guide managers, implementers and professionals about the proper implementation, management and monitoring practices of this type of system, putting at risk the safety of users and the success of technology. " When conducting the evaluation during the operation (ADO) of six residential high-standard buildings in the Metropolitan Region of São Paulo, through field research, Castilho found that, even in conceived, designed and executed systems done by qualified professionals, the subsequent intervention of the condominium compromised the performance of the system and, in addition to not achieving the intended results, put the health of users at risk. Considering that the person in charge of a residential condominium (manager) is also, most of the times, a resident of the condominium, with no intention of jeopardizing his own health or that of his relatives, it can be concluded that, there can be a diligent and well-intentioned purpose. However, the results show a total lack of knowledge regarding the associated risks.

The survey conducted by Castilho, C. (2016) demonstrates the need to take to decision-making meetings, the risks related to alternative water supply systems.

Peixoto, L. (2008) on "Requirements and Performance Criteria for Non-Potable Water System in Residential buildings[11]" proposes applying an effect mode and failure analysis tool (FMEA) as basic requirements for non-potable water systems, to give support to designers, implementers, and managers in their decision-making process. The developed tool allows hierarchizing and quantifying system requirements, including the risk to users' health, transforming subjective aspects into objective quantities.

From the building-specific data, the possible configurations of supply and demand (scenarios), from the simplest (efficient use ofdrinking water) to the most complex, considering the treatment to obtain the necessary quality to supply water-consuming activities that allow the use of non-potable water, operating costs associated with each scenario and risks involved. It is considered that the scenario of "optimization of water consumption" is always the simplest, as it does not require the management of water quality obtained by a treatment system within the building.

Depending on the type of building and location, the planning of each

10 Dissertation submitted to the Escola Politécnica da Universidade de São Paulo, available at http://sites.usp.br/construinova/wp-content/uploads/sites/97/2016/07/Carolina-Castilho1.pdf

11 Dissertation submitted to the Escola Politécnica da Universidade de São Paulo, available at http://www.teses.usp.br/teses/disponiveis/3/3146/tde-14052009-145414/pt-br.php

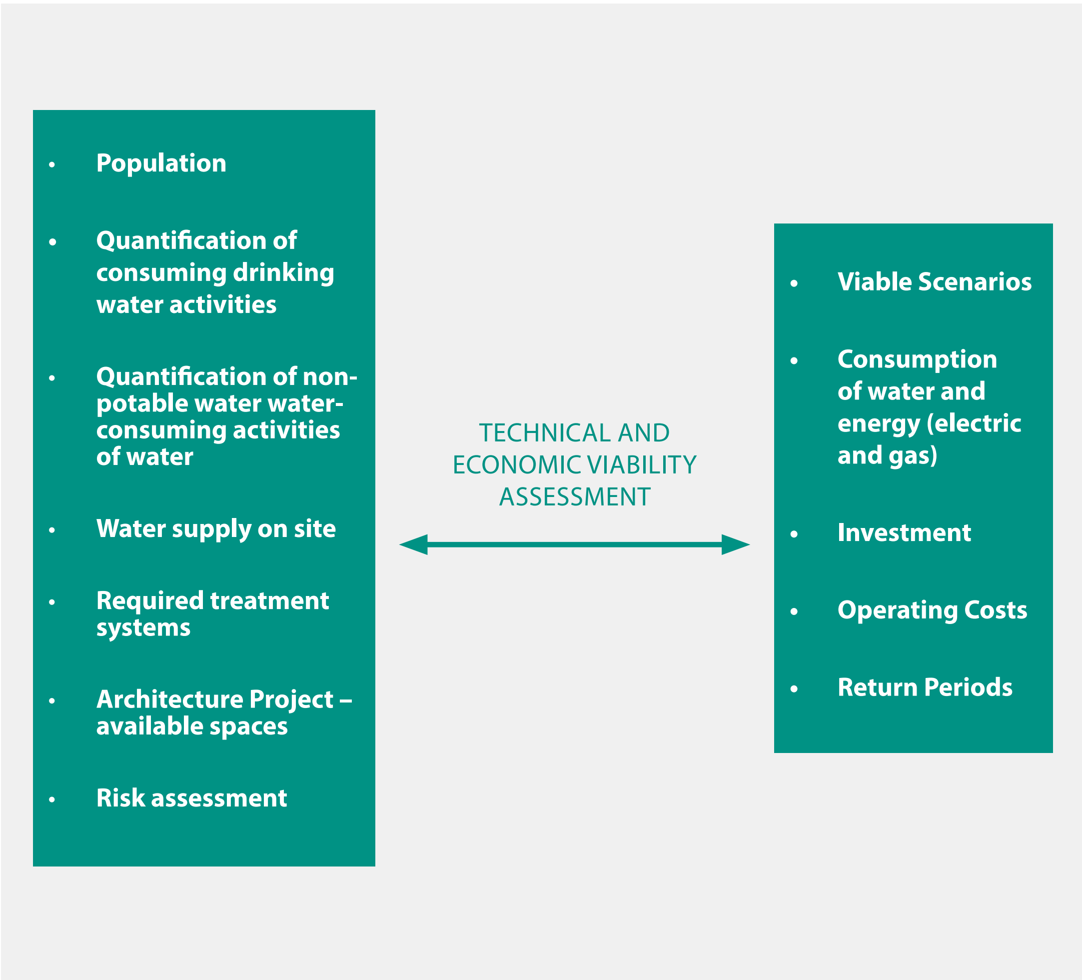
scenario should take into account the permanent needs and incorporation of possibilities for staff or qualified professional for monitoring the quality of non-potable water. The more complex the system of treatment necessary to technically viability in a given scenario, the greater the need for inclusion of a team or qualified professionals not only in the installation and startup of the system but also in the permanent management of the operation and maintenance of the system and monitoring the quality of the water system. It should also take into account the impacts of non-potable water systems in operation and maintenance costs, to be borne by investors. The associated costs can reach unaffordable prices, which may result in the interruption of operation and abandonment of the system or, worse, improper operation and maintenance.

The figure below exemplifies the content of a technical and economic viability assessment with the minimum information needed to identify the solution of most interest to a given building.

FIGURE 3 – EXAMPLE OF CONTENT OF TECHNICAL AND ECONOMIC VIABILITY ASSESSMENT.

Scenarios	Consumption			investment	Return on investment period	Operating cost
	potable water m^3/month | R$/month	electric energy kWh/month | R$/month	gas m^3/month | R$/month	R$/$m^2$	month	R$/month
Scenario 1	Efficient use of water - actions to obtain the lowest consumption indicator for drinking water.					
Scenario 2	Scenario 1 + collect, storage and treatment of rainwater for floor washing and irrigation of gardens.					
Scenario 3	Scenario 2 + collect, storage and treatment of effluents to discharge of sanitary basins.					
Scenario 4	Scenario 1 + collect, storage and treatment of effluents for floor washing, irrigation of gardens and discharge of sanitary basins.					
Scenario 5	Scenario 2 + Scenario 4.					

It should be emphasized that the efficient use of water (scenario 1) should always be considered in all scenarios, since the actions to fight the waste of potable water are, as a rule, those of lower investment and operating cost. And that, also in the use of non-potable water, the actions for the efficient use must be considered to obtain the best possible consumption indicators, since it would be a paradox wasting treated water and, consequently, increase the cost of treatment and the production of sewage unnecessarily.
Annex 3 presents aspects of the characterization of water use in residential buildings.IV.



Summary table 3

DEMAND MANAGEMENT – SECTORIZATION OF WATER CONSUMPTION

4. DEMAND MANAGEMENT – SECTORIZATION OF WATER CONSUMPTION

The management of water demand applied to the building allows the achievement and maintenance of efficient consumption indicators, reducing losses and waste.
The main tool for the water amount management is the constant monitoring of consumption, through the reading of water meters. When the water consumption is not monitored, eventual elevation will only be noticed every 30 days, in the water bill.
The implementation of the management system, with frequent reading of the water meter, preferably daily, identifies possible increase in consumption, it draws its origin and makes the correction allowing the return to the previous consumption indicator.
Most existing condominiums only have one water meter device at the entrance of the building supply system. In recent years, however, the demand for individual water bills, similar to the electricity billing system, has proved to be a necessity. Paying the consumed amount, rather than spliting the consumption into all the residents, besides the evident economic benefits for apartments with fewer residents, it encourages the conscious consumption and taking corrective measures for water loss incidents. Several previous studies find that the user that is aware of his usual water consumption tends to get from 15% to 30% lower consumption indicators compared to the user that is not aware of it [12].
It is through the "sectorisation of water consumption", with the installation of water meters at certain points of the distribution system, that permits the continuous monitoring of consumption and the quick identification and intervention when an unexpected consumption increase is noticed.

12 MALAN, G.J; CRABTREE, P.R. The effect of individual meters on the water consumption in apartment buildings. In: CIB W62. International symposium on water supply and drainage for buildings, Proceedings, 1997.

YAMADA, E.S., Os impactos de medição individualizada no consumo de água em edifícios residenciais multifamiliares. Thesis (Engineering MD) – Escola Politécnica, Universidade de São Paulo, São Paulo, 2001.

ZEEB, W. A holist approach to metering rates. In: ANNUAL AMRA SYMPOSIUM, 11th 1998 Washington. Proceedings. Washington, 1998.

When the sectorization of water consumption coincides with the installation of a water meter for each apartment or house of a condominium, it is named "Individualized metering".

To establish the water consumption of a residential condominium means to install a water meter in the water supply entrance of each apartment, to allow the individualized measurement of water and, in addition, to identify if there are other "water consumers" adding up to the total consumption indicators. For example, to condos with many buildings and a single water meter from the Utility company, you may want to install a water meter to the water inlet of each building, which will identify whether a building is a much higher consumer compared to another with a similar population, that is, identify if there is any room for adjustments.

It will also allow the identification of the water consumption in the external common area, by the difference between the consumption obtained by reading the water meter of the Utility company and the sum of the consumption of the buildings. For condos located in large areas, the installation of water meters in certain points of the water distribution system facilitates the spotting of losses. Or, the installation of a water meter in a water intake of a party room permits charging directly the responsible for the amount of water used in a specific event.

The current usual procedure of monthly splitting of the water bill among condominium owners in residential buildings, besides not portraying the reality of consumption of each apartment, because it is not proportional to the actual consumption, it causes waste of water to the extent that there is no evident motivation for the saving.

The water and sewage Utility companies that already provide individual water for condos usually issue a bill with the total consumption measured by the main water meter, the condominium water inlet, and a bill for each apartment. Any other water meter installed in a sector of the building will not have an associated bill but will facilitate water loss identification (by the increased consumption associated with the sector) and allow charging for certain use, when appropriate, on apportionment of the condominium itself.

The sectorization of water consumption is the main tool of demand management. The individualized measurement contributes to the practice of conscious consumption and allows for charging per unit, making just the relation between consumption and associated cost. Users who consume less water pay a smaller bill, which favors the effort to reduce consumption.

Federal Law 13.312, published on 12/7/2016[13], makes it mandatory to measure individualized water in new condominium buildings.

An individualized measurement system that quantifies the use of all the components that use hot and cold water from each autonomous unit.

In condominiums with an individual metering system, as well as the main water meter of the utility company water meters are installed in all autonomous

13 Available at http://www2.camara.leg.br/legin/fed/lei/2016/lei-13312-12-julho-2016-783353-publicacaooriginal-150766-pl.html

units. These water meters should be carefully selected and installed so that the volumes consumed are accurately logged and there should be a convergence between the reading of the main water meter and the volumes recorded in the water meters installed in each unit.

For buildings where, in addition to autonomous units, water consumption also occurs in common areas, the volume of water consumed in the common area is obtained by the difference between the reading of the main water meter and the sum of the readings of the separate water meters.

There are standards set by dealers of various municipalities that specify how it should be the infrastructure for the measurement of water. Compliance with such standards makes it possible to issue individual bills.

For buildings to be built in municipalities whose utilities have not yet established standards for individual measurement, it is recommended that consideration is given to installing a single water meter per apartment, always in common area of the building. This increases the possibility that, in the future, the condominium owners will be able to contract individual water bills with these Utility companies.

In certain cases, depending on the characteristics of the building hydraulic system and the architecture, it may be necessary to provide a second water meter for the measurement of hot water. This second water meter, if necessary, must also be installed in common area, to enable future billing.

Annex 4 shows specific aspects of the individual metering of water.

Obtaining consumption data is fundamental to the management of water demand. The possibility of reading the water meter is a fast instrument for the identification of variations of consumption, which allows the beginning of a corrective action in a shorter time.

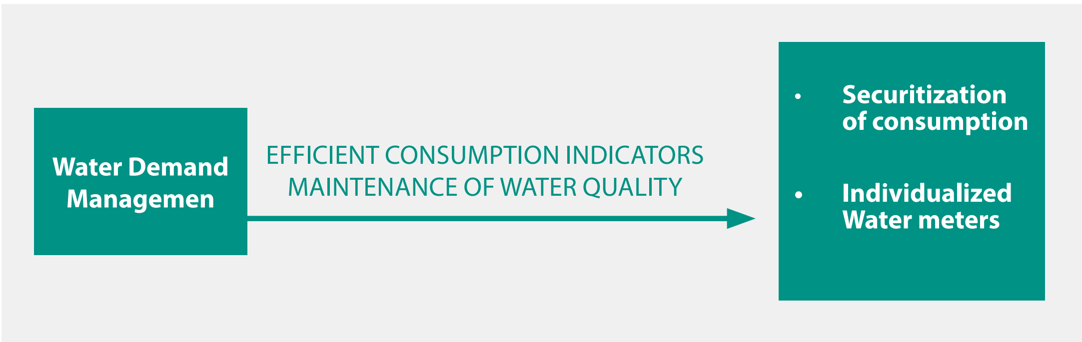
The consumption data can be entered in electronic tables or spreadsheets, can be raised graphics, compare with previous data and act on the systems.

Can be determined, for each of the units, the daily consumption per person and use it to compare with the historical rates of the unit, establishing thus the unit water consumption indicator (liters per person per day).

The monitoring, over time, of the indicator of consumption of the unit, allows the responsible to acquire sensitivity with respect to efficient rates of water consumption and establish goals and actions for reduction, when appropriate.

There are no generic consumption indicators, which reflect consumption targets for each and every residential building. The consumption of water in buildings depends, besides the consumption made by the residents in their apartments, of the amount of water needed to carry out the activities of the common areas. Variations in architectural features and water-consuming activities indicate the need to establish water consumption indicators for each building. In a building with large floor area to be washed or garden be watered, with pool, among others, the water consumption in common area will be higher than that of another building without these characteristics. So in addition to allowing residents to take science to their apartments water consumption and calculate the indicator associated consumption, individualization of water consumption also allows those responsible for managing the common area of equipment do the same: to know the water consumption of the common area, those responsible can calculate the consumption indicator of that building and establish targets and actions for the reduction, when applicable.

When a non-potable water distribution system is incorporated into the building for use in certain activities, the management of water demand also involves obtaining and maintaining the quality of water required for activities that consume non-potable water. It is through demand management of water that prevents the risk of contamination of users by unconscious use of non-potable water or improper connection between the potable and non-potable water systems.



CONCEPTION OF NEW BUILDINGS FOR THE EFFICIENT USE OF WATER

5. CONCEPTION OF NEW BUILDINGS FOR THE EFFICIENT USE OF WATER

Favoring the efficient use of water in a new building does not depend only on the design of the building's hydraulic systems. Premises of the architecture project, mainly, and of other disciplines that need water supply (landscaping and decoration, among others) interfere in the consumption indicators of the buildings.

When considering assumptions that favor the efficient use of water in the project's design, architectural design optimizes design solutions for hydraulic building systems. The ideal condition is the joint development of the main disciplines (architecture, structures and hydraulic and electrical building systems) so that the various performance requirements to be met are discussed in search of equilibrium.

Some architectural design features that directly interfere with the design of hydraulic systems and water use efficiency can be highlighted:

- The arrangement of the environments: the layout of the water distribution piping is a consequence of the arrangement of the sanitary areas and, in these, the location of the points that use water. sanitary areas concentrated in a particular region of a flat result, usually in the shorter length of tubing and fewer connections. As a consequence, in addition to material cost reduction, the system's loss of load is reduced (with impact on the reduction of pipe diameters) and the possibility of locations of leakage is also minimized. For the hot water distribution system, the lower the path to be traversed, the less the loss of associated heat, which leads to the reduction in energy consumption (electric or gas), less need for thermal insulation, the lower length of tubing for recirculation of water.

- Space for tanks and kites: the volume of water to be stored in a building is calculated in the design of the hydraulic building systems. The location of the tanks is made in architectural design. The tank space forecast also needs to consider the barrel and sufficient space for proper operation and maintenance of the system. It is not unusual to find buildings with virtually inaccessible barrels, which makes it very difficult any kind of operation or maintenance. Access to the interior of tanks needs to be facilitated, as cleaning is recommended at least every six months.

- *Technical shafts: The leasing of piping and components in technical shafts (registers, water meters and locking valves, among others) has the objective of facilitating access for possible maintenance. It is not uncommon, however, forecast shafts with dimensions lower than those that would be recommended to enable access to pipelines.*

- Specification of sanitary metal wares: all sanitary metal ware is manufactured to operate under certain conditions of pressure and flow. The specification of metal fittings, usually made by the responsible for the architectural design must be provided, along with the pressure curves and flow of equipment, the responsible for sizing the water distribution system in order to be considered in the hydraulic design. The pressure and flow curves of the specified metals can be obtained from the manufacturers. The design of the water distribution system contemplating the metals that will be effectively installed allows the responsible designer to adjust the flow rates at the point of use and to avoid the release of a quantity of water that is greater than that required for the performance of the activity. Annex 5 of document Water Resources Management in the Construction Industry - efficient use of water in residential buildings -, published by the Environment Committee - CMA - Brazilian Chamber of Construction Industry - CBIC - in May 2016[14], presents aspects to be considered in the specification of sanitary metal wares to favor the efficient use of water.

14 Available for download in both Portuguese and Spanish versions. http://cbic.org.br/pagina/publicacoes-cma

ARCHITECTURE DESIGN PROJECT AND THE EFFICIENT USE OF WATER

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- **Spaces layouts: reduction of pipes and fittings**
- **Determining tank spaces and barrils: access viability for operation, maintenance, and possible replacement**
- **Technical shafts - dimensions that allow access for maintenance**
- **Specification of sanitary metal wareware: pressure and outflow curves**

WATER OUTFLOW IN BUILDING HYDRAULIC SYSTEMS

6. WATER OUTFLOW IN BUILDING HYDRAULIC SYSTEMS

The calculation of the design flow rates of the pipes of the water distribution system of buildings is a determining issue for the system performance and efficient use of water.

The water distribution system (hot and cold) must be sized so that each unit or medical device is supplied with the water quantity necessary and sufficient for the user to perform activities associated with comfort and without waste.

For the dimensioning of a piece of piping that feeds a set of sanitary appliances, the flow rates and simultaneity of use of the appliances must be defined.

When flow rates and simultaneity of use are overestimated, the piping design results in diameters greater than those required for system performance, which can contribute to the waste of water and materials required for installation.

On the contrary, the establishment of lower flow rates to the minimum necessary for the operation of equipment or the consideration of simultaneity lower than the reality can cause discomfort to the user and compromise the system performance over the entire life of the building.

Most of the methods still used to determine project flows were proposed in the first half of the last century, when, among others, access to computers did not exist, buildings were not as high and individualized water measurement was not a reality. In addition, the scarcity of water and the emergence of the decrease in consumption were not part of the agenda of society.

Traditionally, in Brazil, the water distribution system (cold and hot) is dimensioned from minimum flows at points of use, established in ABNT NBR 5626/1998, with concurrency of use estimated by the Weight Method. The diameters of the branches are calculated passage section, considering the weights of the devices connected to the downstream passage to scale. The plumb (or columns) are dimensioned in the same way.

FIGURE 4 – DIMENTIONS OF SYSTEM

That is, a system of weights scaled by the method considers that the pipe feeding the health of an apartment with a single bed has the same diameter as the pipe feeding the health of an apartment with three bedrooms. No matter how many users.

In general, the various methods and models for determining project flows in water systems proposed since 1920 can be classified in empirical methods or probabilistic methods.

The empirical methods used in tables and abacuses were developed from the system behavior observation and based on previous experiences of the authors. Several studies show that these routines for the calculation of the flow lead to inaccurate rates when compared to real situations, which are generally overestimated (Gonçalves, 1978[15]; Gonçalves, 1986[16]; Oliveira, 2010[17], among others).

It is not reasonable to consider that all the sanitary appliances of an environment or apartment or set of apartments will be activated simultaneously

15 GONÇALVES, O. M. Influência do uso simultâneo de aparelhos sanitários no dimensionamento de instalações prediais de água fria. 135 p. Thesis (Civil Engineering MD) – Escola Politécnica, Universidade de São Paulo, 1978.

16 GONÇALVES, O. M. Formulação de modelo para o estabelecimento de vazões de projeto em sistemas prediais de distribuição de água fria. 203 p. Thesis (Civil Engineering PhD) – Escola Politécnica, Universidade de São Paulo, São Paulo, 1986.

17 OLIVEIRA, L. H. de. Modelo para a simulação de vazões de projeto em sistemas prediais de água com medição individualizada empregando a lógica nebulosa e o método de Monte Carlo. 111 p. Thesis (Habilitation thesis at the Civil Construction Engineering Department) – Escola Politécnica, Universidade de São Paulo, 2010

It can be assumed that the probability of occurrence of this phenomenon tends to zero. From this premise, there are probabilistic methods.

Probabilistic methods seek to represent a real situation or the behavior of a given system from mathematical models. They were developed from the theory of probability and can be classified into open or closed.

Closed probabilistic models, although based on probability theory, do not guarantee the necessary flexibility to the various dimensioning situations, since they use tables or graphs idealized from the particular situations studied by their proponents. This condition of use was necessary at the time they were developed, the difficulty of calculating complex formulations without routine access to computers.

With the diffusion of computers, the use of open probabilistic models, which allow the designer to establish the rates of the variables that will be considered according to the boundary conditions of each building, becomes feasible. open probabilistic methods allow the designer to consider specific characteristics of each situation, with flexibility in establishing the performance levels of systems, depending on the specific conditions of each project

Several authors question the conventional methods for determining project flows, which generate overestimated rates in the water distribution system. In recent years we have not proposed new empirical methods, only models based on the theory of probability and, more recently, based on simulation modeling methods (using probability theory and stochastic processes for system behavior prediction over a period of time pre-established). Although satisfactorily efficient probabilistic models are available, some empirical methods, although completely obsolete, continue to be widely used.

Some examples of open models can be cited:

- Generalized Binomial Model: proposed by Webster, in 1972. It is based on the application of the binomial probability distribution function, generalized, for a given heterogeneous set of devices. It considers that the use of different types of installed sanitary appliances has probabilistic independence. The model requires a significant computational effort, since it requires the list of all possible combinations of flow rates for your application, in addition to calculating the probability of each of these flows.

- Multinomial model: proposed by Courtney in 1976, is based on the application of the multinomial probability distribution for the determination of the design flow of a particular section of pipeline that feeds mixed systems of sanitary appliances. Similar to Webster's (1972) proposal, this model also requires that all possible flow combinations be determined for its application.

The model also requires the calculation of the probability of occurrence of zero flows, obtained from theoretical considerations of statistical independence between sanitary appliances of a sanitary area. In the case of more than one sanitary area fed by a single piece of pipe belonging to the same apartment, common in systems with individualized measurement, these considerations of statistical independence need to be extrapolated. Modelo Probabilístico Aberto: apresentado por Gonçalves, em 1986, propõe o cálculo das médias e variância das variáveis consideradas intervenientes, inclusive do número de aparelhos sanitários em uso simultâneo, consideradas como variáveis aleatórias. O conhecimento do número de aparelhos sanitários em uso simultâneo de um conjunto homogêneo de aparelhos é dado pela distribuição beta-binomial. Na abordagem teórica, foram desconsideradas as probabilidades de ocorrência de vazões nulas. Para o cálculo da vazão de projeto de um determinado trecho foi considerada uma aproximação com a função de distribuição de probabilidades do tipo gama.

- Probabilistic Model Open: presented by Gonçalves, in 1986, proposed the calculation of mean and variance of the variables considered stakeholders, including the number of sanitary appliances in simultaneous use, considered as random variables. Knowledge of the number of sanitary appliances in simultaneous use of a homogeneous set of devices is provided by the beta-binomial distribution. In the theoretical approach, the probability of occurrence of zero flows was disregarded. For the calculation of the design flow for a given area was considered an approximation to the probability distribution function of the gamma type.

The Open Probabilistic Model was adopted by Sabesp's ProAcqua program for the dimensioning of water meters for the individualization of water consumption. Annex 5 details this method.

FINAL CONSIDERATIONS

7. FINAL CONSIDERATIONS

The aspects presented in this document highlight two main issues:

- the demand for water in residential buildings is significantly reduced when actions are considered for the efficient use of water in designing new buildings and renovating existing buildings. Promoting the efficient use of water depends crucially on the interaction and the premises of the architectural designs and gross hydraulic systems. While these projects are developed in the traditional way and without interaction between disciplines, cities continue to receive buildings that wastewater.=

- practice of water conservation, with the use of alternative sources for water supply in residential buildings, involves a risk to users' health, mainly due to the lack of technical capacity of those involved with the operation and maintenance of the non-potable water system, which requires more care and attention to the delivery of the system.

So much for the efficient use of water and for water conservation, obtaining consumption indicators and system performance depends on the involvement of skilled professionals, and maintenance of efficient consumption indicators and the proper performance of the system depends on the system management.
The water vulnerability condition of the Brazilian urban centers indicates the need to establish measures that guarantee the balance between supply and demand of water, with quality appropriate to the types of use, as a condition for such urban centers not to become economically unviable. The establishment of institutional character actions, technological, quality and sustainability awareness and professional training together can contribute to a significant reduction in current consumption levels.
In this context, the construction industry has the challenge of ensuring the production of buildings that use water efficiently.

ANNEX 1 – EFFICIENT USE OF WATER - RESULTS OF IMPLEMENTATION

ANNEX 1 – THE EFFICIENT USE OF WATER - RESULTS OF ACTIONS

Since the end of the 1990s, in the context of Sabesp's PURA program, actions for the efficient use of water were implemented in several existing buildings. Some cases are presented below and show how much buildings wastewater and how much can reduce the demand through technological actions for efficient use.

CASE A1 – HOSPITAL

INSTITUTE OF THE HEART OF THE HOSPITAL OF THE CLINICS (SÃO PAULO, SP)

	REDUCTION OF CONSUMPTION	INVESTMENT	MONTHLY WATER
Correction of leaks	28,40%	R$ 79.518,56	R$ 54.256,88
Equipment suitability	15,30%		

Source: Oliveira (1999)[18]

CASE A2 – SCHOOL

SCHOOL STADUAL FERNÃO DIAS PAES (SÃO PAULO, SP)

	REDUCTION OF CONSUMPTION	INVESTMENT	MONTHLY WATER ECONOMY
Initial Consumption	81,1 litros/aluno*dia		
Consumption after correction	4,5 litros/aluno*dia	R$2.645,95	R$37.409,60
Consumption after adequacy	4,1 litros/aluno*dia	R$1.938,58	R$199,76

Source: Oliveira (1999)[17]

18 Oliveira, L.H. e Gonçalves, O.M., Metodologia para Implantação de Programa de Uso Racional da Água em Edifícios, Boletim Técnico da Escola Politécnica da USP, 1999.

Available at http://www.sef.usp.br/wp-content/uploads/sites/52/2015/08/PUERHE_%C3%81gua-BT_Oliveira.pdf

In the two cases above, it is interesting to observe the impact resulting from actions to identify and correct water losses by visible and invisible leaks. In existing buildings, especially on older, lack of knowledge of efficient water consumption indicators can bring those responsible to not realize, or through water bills, the consumption can be significantly higher than would be reasonable.
In the second case, the school, there was a major break in the land feeder, subjected to the pressure of public network. Due to the loss of water in underground piping, leakage was not noticed for many years.

CASE A3 - INDUSTRIAL KITCHEN

INDUSTRIAL KITCHEN FORD IPIRANGA

Initial Consumption (1996)	40,35 liters/meal
Final Consumption (1998)	19,90 liters/meal
Investment	~R$7.000,00
Reduction	51%
Investment Return period	< 2 months

Soruce: TESIS (1998), contract SABESP

The water uses were monitored for 3 months, after which the interventions were performed: correction of leaks, adequacy of equipment and alteration of procedures.

CASE A4 - PUB

CONTINENTAL BREWERY (SAO PAULO, SP)

Initial Consumption (1996)	55,46 m^3/week
Final Consumption (1998)	40,83 m^3/week
Investment	**************
Reduction	27%
Investment Return Period	**************

Fonte: TESIS (1999)

CASE A5 – RESIDENTIAL BUILDING

RESIDENTIAL BUILDING (SÃO PAULO, SP)

Initial Consumption (1998)	1.460 m^3/month
Final Consumption (1999)	1.045 m^3/month
Investment	~R$4.000,00
Reduction	28%
Investment Return Period	< 2 month

SOURCE: TESIS (1999)

Only leak correction was performed.

CASE A6 – OFFICE BUILDING

OFFICE BUILDING (SÃO PAULO, SP)

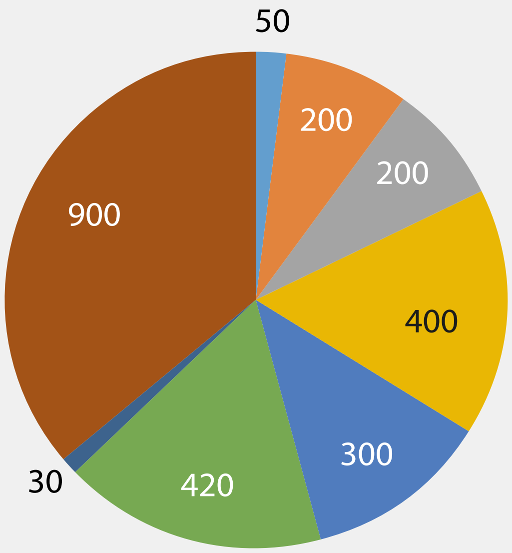
Initial Consumption (1996)	93.800 m^3/month
Final Consumption (1998)	78.700 m^3/month
Investment	~R$80.000,00
Reduction	16%
Investment Return Period	9 meses

Source: TESIS (1999)

Replacement of 592 equipment.

TABLE A7 - DAIRY FACTORY

Inicial Water Consumption = 2500 m³/per day



Optimized Water = ~1.200 m3/per day Consumption

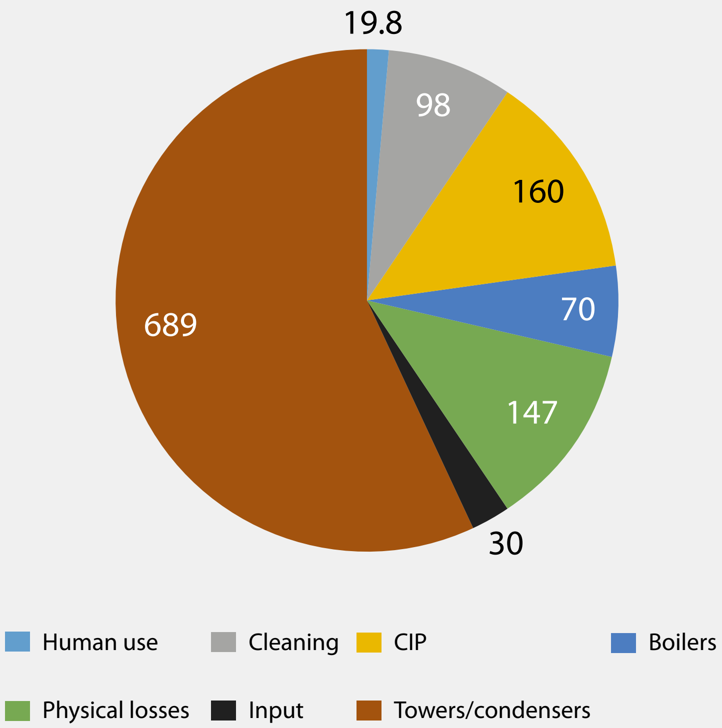
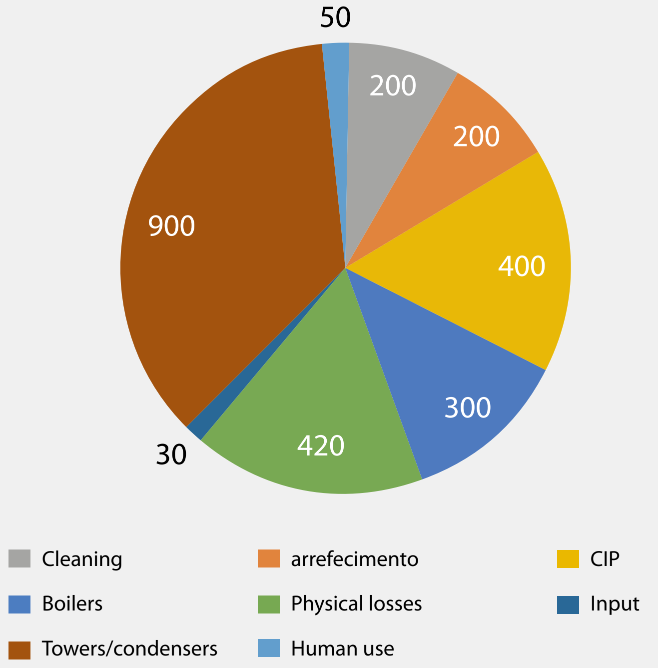
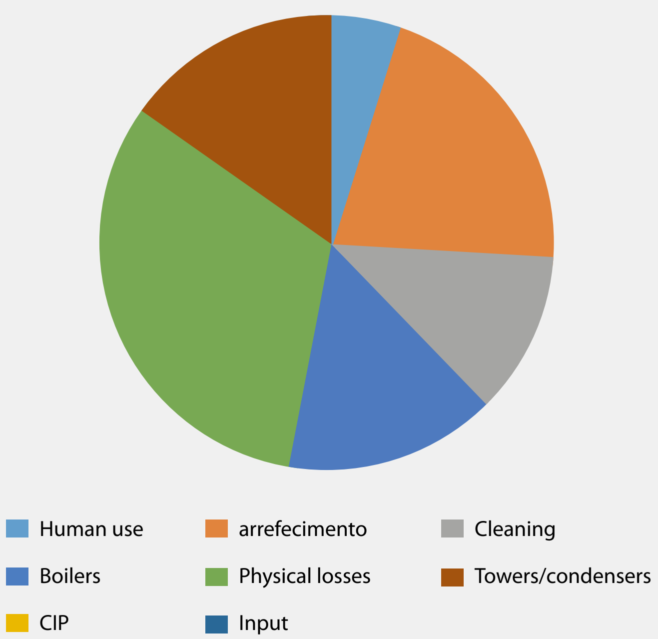


TABLE A7 – DAIRY FACTORY (CONTINUATION)

Inicial Water Consumption = 2500 m³/per day



Effluent production after water consumption decrease = 457 m3/ per day

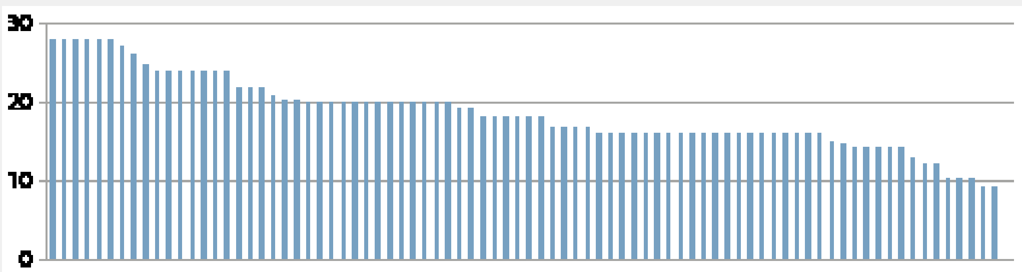


The impacts caused by the reduction of about 52% water demand caused a strong reduction of the generation of sewage (63%) and prevented the introduction of a second wastewater treatment plant unit that was already scheduled.

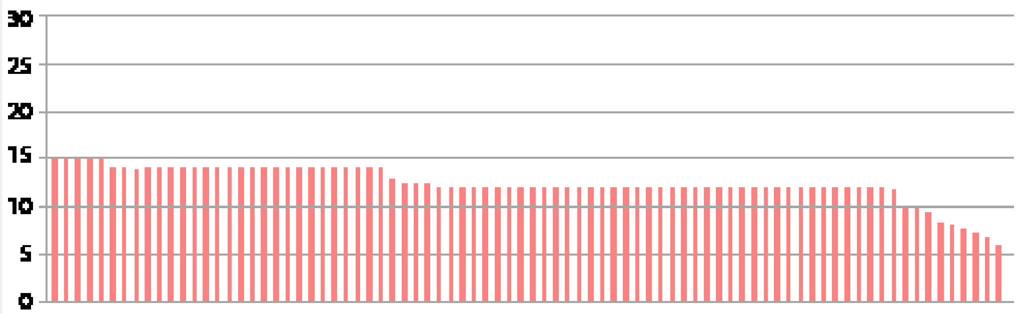
CASE A8 – RESIDENTIAL BUILDING

A high-standard residential building in the city of São Paulo (TESIS, 2015), in which, due to the lack of water[19], the condominium owners decided to invest in technological actions to encourage consumption reduction.
The building, with 21 floors and 37 apartments, was delivered by the construction company in 2008, therefore already had toilets of reduced volume.
The building's water consumption increased from 275 liters/inhabitant * day in 2012 (historical consumption) to 170 liters/inhabitant * day in 2015, after the completion of interventions.

Outflow rates before the intervention actions – showers (l/min) / AVERAGE 18,5 l/min



Outflow rates after the intervention actions – showers (l/min) / AVERAGE 12,4 l/min



19 Due to its location in the upper region of the city, during the recent period of severe drought in São Paulo, the actions taken by Sabesp against water losses in the public supply system by reducing water pressure resulted in a difficulty in supplying the underground water tank of the building.

The interventions were

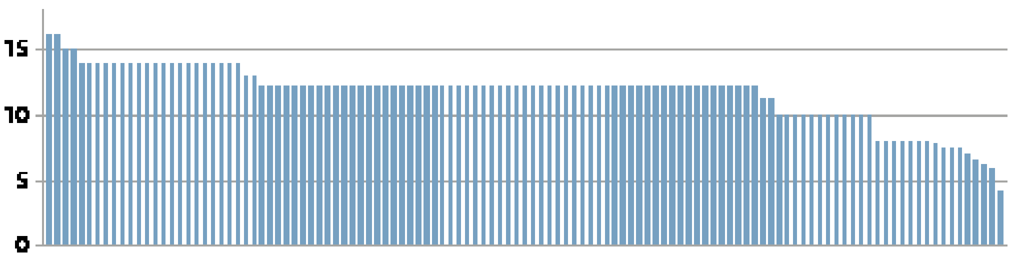
- adequacy of the pressurizing system of the water of the last floors: the building counts on the pressurizing system for water supply of floors 18º to 21º. The contractor for the building maintenance promoted changes to the original system resulted in deregulation and permanent leak. The manufacturer was started and adjusted the system;

- regulation of two pressure reducing stations: the pressure reducing stations had not received any type of maintenance by 2015. The following were deregulated in relation to the pressures specified in the original building design, causing strong waste water on some floors and even pipe break. The manufacturer was started and adjusted the system;

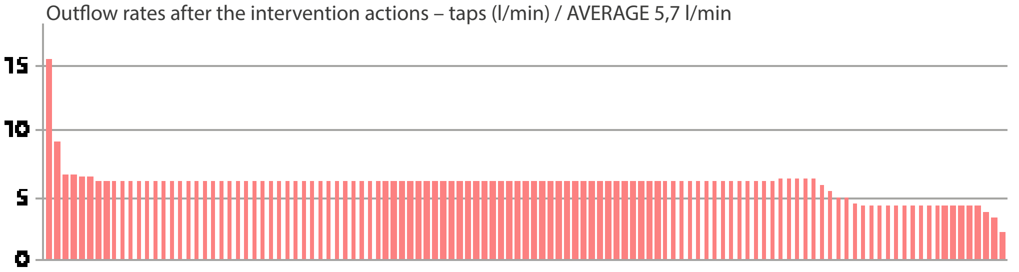
- installation of dual activation mechanisms in toilets;

- installation of the pressure regulating devices in showers and faucets.

Outflow rates before the intervention actions – taps (l/min) / AVERAGE 11,6 l/min



Outflow rates after the intervention actions – taps (l/min) / AVERAGE 5,7 l/min



CASE A9 – PURA-SABESP

On February 16, 2017, at an event held by Sabesp, together with the State Department of Education, recent results were presented on the reduction of consumption in buildings that received interventions for the efficient use of water through the PURA (Rational Use Program of Sabesp Water):

CLIENT	NUMBER OF PROPERTY	AVERAGE CONSUMPTION BEFORE PURA PROGRAM (M^3/MONTH)	REDUCTION COMPARED TO PREVIOUS CONSUMPTION
State Education Department Phase 1	345	138409	67%
State Education Department Phase 2	243	83592	62%
Municipal government of Ferraz de Vasconcelos	2	1113	44%
Municipal government of Franco da Rocha	16	2467	76%
Municipal government of Caleiras	16	2747	63%
Municipal government of Cajamar	18	6369	86%
Female Penitenciary of Santana	3	56416	47%
Municipal government of São Paulo	2284	605581	46%
Military Police Hospital	1	5572	60%

Source: adapted from data provided by Sabesp

ANNEX 2 – NON-POTABLE WATER SYSTEMS

ANNEX 2 – NON-POTABLE WATER SYSTEMS

The use of non-potable water for certain activities that are not associated to human consumption can occur collectively or individually, through a public system of supply or private production.

An example of a public non-potable water supply system is Aquapolo[20], which currently supplies 650 liters per second of reuse water to the ABC Paulista Petrochemical Complex (equivalent to supplying a city of 500,000 population). The quality of drinking water is not guaranteed by Aquapolo, which receives water from the Sewage Treatment Plant of SABESP, the ABC Paulista treats and distributes to the Petrochemical Complex. The parameters of water quality were determined by the Petrochemical Complex, which uses non-potable water mainly to clean cooling towers and boilers.

In recent years, the use of an alternative source of water in residential buildings has been practiced in order to reduce the demand for drinking water. Among the activities that usually use water in the routine of residential buildings, some demands do not require potable water, such as irrigation of gardens or washing floors. Among the possibilities of private water production, as an alternative to the water provided by the public system, stand out: use of rainwater, reuse of water and groundwater recharge water.

The use of non-potable water requires respecting criteria to preserve users' health, considering the associated risks: contamination of the drinking water provided by the Utility companyor improper use of non-potable water.

Non-potable systems require professional design, implementation, and management to ensure water quality, prevent the risk of contamination of the environment and, above all, preserve the health of users.

The use of alternative water supply in buildings should be applied with responsibilities similar to those of the Utility companies. In addition to producing quality standard water for specific use, the producer of such water must:

- comply with the normalization and the current legislation of granting;

20 Available at http://www.aquapolo.com.br/quem-somos/sobre-o-aquapolo/

- implement a management system and continuously monitor the quality and quantity of non-potable water;

- empowering and making users aware.

The main concern associated with the implementation of non-potable systems is the health of users. The average citizen, who lives in urban centers, knows little or nothing about the origin of the water that he consumes and the associated treatment so that this water becomes drinkable. The user used to get drinking water from the public supply system uses water without questioning their quality.

The inclusion of non-potable systems in residential buildings is recent. Perhaps the degree of maturity required to ensure the health of users has not yet been acquired, especially when the person in charge of the building is not necessarily a specialist, a reality of most residential buildings.

When considering buildings of other types, even hospitals, where there is a permanent maintenance engineering team, the risks exist but are minimized. When proposing a non-potable system for a residential building, the entrepreneur must consider the existing boundary conditions and take all measures to prevent risks.

A non-potable water system consists of the hydraulic system for reservation and distribution and the treatment system. Not necessarily, or even rarely, the same professional will be qualified to design, execute, operate and maintain both systems. In general, there are two different technical managers, one for the hydraulic system and another for the water treatment system.

The forecast of alternative water supply systems involves three fundamental aspects: independence between hydraulic systems, adequate treatment, and professional management.

The first aspect, mandatory total **independence between a system of non--potable water and the drinking system** from the public network, is provided in the legislation:

- Federal Law 11,445 / 2007, paragraph 2, art. 45: The hydraulic installation connected to the public water supply network cannot be fed from other sources.

- Federal Decree No. 7,177 / 2010, art. 7º: the hydraulic installation connected to the public water supply network cannot be also fed from other sources.

- Ordinance No. 2914/2011 of the Ministry of Health, art. 16: water from an individual or collective alternative solution for purposes of human consumption may not be mixed with the water distribution system.

- ABNT NBR5626 / 1998, item 5.4.4.1: there should be no interconnection between piping that will lead to water supplied by utility public networks and piping that will conduct water from a private supply system (cross connection), whether the latter is with drinking water or not.

Therefore, providing a non-clean system to feed certain points of use for specific activities, requires a hydraulic system completely independent of the building drinking water system: Tank (s) distribution system, usage points. In addition, the two systems (drinking and non-drinking) should **remain independent** over time, which means provision for protection and impediment for eventual interconnection to occur in reforms, for example.
The second aspect to be considered refers to the **treatment necessary to obtain and maintain non-potable water quality characteristics** that allow the use in the specific activities for which the system is designed, without prejudice to users or equipment. Lack of treatment or inadequate treatment can compromise the outcome of the activity. For example, using the effluent from washing machines to irrigate gardens without eliminating the soap probably damage the vegetation. The treatment system should be designed by a qualified professional, consider the characteristics of water or effluent to be treated and the quality required for the performance of the activity to which the non-potable water will be used.
And the third aspect, not least, is the permanent professional management of the non-potable system. The delivery of a residential building with non-potable water system requires specific care training and awareness of users. The user needs to know that a certain point of use provides non-potable water. The employee of a building that uses non-potable water for washing floors, need to use PPE (Personal Protection Equipment - boots, gloves, and mask to prevent aspiration of non-potable water) to avoid compromising their health. The trustee of a building where non-potable water is used needs to understand the importance of maintaining specialized monitoring for the treatment system and the need to permanently monitor the quality of non-potable water.

A2.1 HYDRAULIC SYSTEM IN BUILDINGS

Some design assumptions are recommended in addition to those in the relevant technical standards:

Storage System:

- provide for at least two tanks: one for storing water or effluent prior to treatment and another for storing non-potable water.

- Avoid prolonged storage of non-potable water before and after treatment, to avoid changes in its characteristics and proliferation of unwanted agents and not covered by the adopted treatment system. It is recommended to reserve at most one day of consumption.

- Provide drinking water supply to the treated non-potable water tank, in case of interruption or production of treated water in an amount lower than that required for the intended activities. In this case, analogously to the feeding pipe of drinking water tanks, air must be used separation device to prevent contamination of the drinking water system.

- Take all possible precautions to avoid any possibility of contamination of the drinking system and the environment. For example, pipe overflow and cleaning should lead to non-potable water directly to the sewage system, with the automatic forecast for overflow warning; in buried tanks, soil separation must be provided; there can be no passage pipe drinking water within the storage volume of the non-potable water tank; among others.

Distribution system:

- To specify non-potable water distribution piping, preferably in material other than non-potable water distribution piping, as a way of alerting and hindering interconnection between systems in later reforms. If it is not possible to use different materials, pipe non-potable system must be at least a different color of the pipe drinking system. The purple color is indicated for non-potable systems. The material and different color of the drinking system must take place throughout the distribution system.

- Provide safe distances between drinking system and non-potable system piping, at least 30 cm, with potable water piping always above non-potable water piping.

Points of use:

- specify all the points of use of non-potable water with restricted access and clearly identified. It is recommended to install warning signs, preferably embossed letters that are not easily removable, with the words "NON-POTABLE WATER" and easy-to-understand figures, especially for children

- When the use of non-potable water for flushing toilets, as well as warning sign installation, it is recommended to provide feed point of drinking water next to the toilet, to facilitate eventual installation of equipment in need of drinking water, as showers hygienic, without risk of the user to obtain this feeding in the entrance of the tubing that feeds the toilet.

A2.2 WATER TREATMENT SYSTEM

The non-potable water treatment system must be selected, sized and specified by a qualified practitioner. The determination of appropriate technology varies case by case, depending on the alternative source of water features, characteristics required for the intended non-potable uses, the design and technique available flow area. Some design assumptions may be recommended in addition to those in the relevant technical standards:

- provide adequate ventilation (to exhaust any gases); bottom drains and spillways adequately connected to the sewage system; circulation area for safe movement during deployment, operation, and maintenance.

- Provide equalization unit to eliminate possible generation peaks and to homogenize loads of the water to be treated.

- Provide devices that allow the performance of hydraulic maneuvers in maintenance and/or emergency situations.

- Provide at least one non-potable water treatment flow meter, specified according to the qualitative and quantitative characteristics of the fluid to be measured.

- Provide, whenever possible, pigmentation of non-potable water as a way to clear differentiation of drinking water.

- Specify the analyzes to be performed to maintain non-potable water quality parameters and frequency of achievement.

It should also be noted that the sludge produced, due to the treatment, should be considered as solid waste, according to ABNT NBR 10004/2004-Solid Waste - Classification, and cannot be discarded in the municipal sewage collection network without prior authorization from the Utility company.

The acquisition, installation and "startup" of equipment should always be accompanied by a qualified professional.

A2.3 PROFESSIONAL MANAGEMENT

Depending on the profile of the users of residential buildings, measures to ensure the adequacy of procedures for the use, operation, and maintenance of non-potable water systems are of great importance.

As highlighted in Water Resources Management document in the Construction Industry - Efficient Use of Water in Residential Buildings, published by the Environment Committee - CMA - Brazilian Chamber of Construction Industry - CBIC - in May 2016[21], the set of users of a busy residential building is composed of residents, visitors, employees, maintenance professionals, animals, vegetation, equipment.

Such a set of users presents specific characteristics that cause impacts on the use, operation, and maintenance of building systems:

- training: residents have diverse backgrounds;

- Socioeconomic profile: the socioeconomic profile of the potential buyers to whom a building is destined determines the range of possible cost for the condominium fee, which, in turn, determines the financial capacity of the residents to bear the costs of operation and maintenance.

- The dynamics of operation and maintenance of residential buildings should also be remembered,

Responsibilities:

- the responsibility and the burden for the operation and maintenance of apartments belong to their owners or tenants;

- The responsibility for the operation and maintenance of common area is usually delegated to a liquidator, with an apportionment of expenses among all the residents. In general, the owners are unaware that even delegating responsibility to the liquidator, are also co-responsible for the operation and maintenance of the common area.

Residents (including the receiver) do not necessarily have specific technical training for the necessary decisions in establishing the operation and maintenance routines of the various building systems. And, in general, the function of "trustee" is rotating, with the change of the person in charge. Decision dynamics: decisions that cause the financial impact on condominium fees or that alter original

21 Available for download in both Portuguese and Spanish versions.

http://cbic.org.br/pagina/publicacoes-cma characteristics of the building are mandatorily taken at meetings. condominiums assemblies together owners from diverse backgrounds, with different capacities of technical understanding of the needs of building systems and with different financial priorities and capabilities.

Condominium managers: Most residential building managers do not maintain technical staff to support syndics or residents in system operation and maintenance decisions.

This user profile is not necessarily able to properly operate and maintain building systems, starting with the potable water distribution system. It is common to observe, in residential buildings, pressure reducing valves which operate with pressures greater than those specified in design by losing regulation (lack of maintenance), drinking water tank cleaning operations performed improperly, high flow in use points, reforms in the hydraulic system that compromise the performance of the system, among others. O Users generally know little or nothing about the building's hydraulic building systems. Whereas cleaning tanks is directly related to health, and reducing stations deregulated pressure is directly related to system performance and the possible increase in water bills (when operating with pressures above or below the specified project), it is reasonable to conclude that system maintenance is not intended as it should be because users are unaware of the consequences of health risks and higher expenses with the input. As residents, in general, the managers of condominiums are unaware of the consequences of events on systems that do not receive proper maintenance.

In the case of non-potable water systems in residential buildings, these specific characteristics of the users cannot be disregarded, given the increased risk involved.

In condominiums accompanied by Castilho, C. (2016)[22], it becomes evident the need for actions that go beyond the handbook of use, operation and maintenance, especially when the user will live with non-potable water.

Among accompanied condominiums, it was not uncommon to find residents who did not even know of the existence of a non-potable water system in your house. It was also evident the lack of discernment of those responsible with regard to the existing risks, considering changes found in both the hydraulic system and the treatment system specified in the project.

In order to guarantee quality parameters, non-potable water needs to be permanently monitored by means of laboratory analysis, with sample withdrawn from the distribution tank. The frequency of analysis to be performed - daily, weekly, monthly or quarterly - should comply with the specifications of the treatment system project.

Whether for a new building, to be occupied or to an existing building, delivery of the non-potable water system requires specific care:

22 Available at http://sites.usp.br/construinova/wp-content/uploads/sites/97/2016/07/Carolina-Castilho1.pdf

- clearly indicate the obligation to maintain among the services contracted by the condominium, company or professional qualified for the professional management of the non-potable water system. Preferably, include such a requirement in the condominium statutes, so that receivers are prevented from operating and maintaining the system without professional assistance in the same way as with maintenance of elevators, for example.

- Disclose the existence of non-potable system: in addition to the information of the use of manual, operation and maintenance, providing the building with permanent visual information distributed public area environments (information stands, hall of elevators, using points) in places of greater circulation of people, with explanations about the existence of the non-potable system and the necessary care[23]. Provide information in a permanent way, affixed in a way that can not be easily removed.

- Promote training for trustees, janitors, and condominium professionals and guide them to recycling whenever there is a substitution of trustees, janitors or employees. Such training should be provided by those responsible for system installation, together with the company contracted to manage the system, and should be such that those involved clearly understand the risks and the importance of using, operating and maintaining the system the way specified the operation, and maintenance manual.

- Provide, in the operating manual, operation, and maintenance, guidance for proper deactivation of the system: at any time and for any reason, if the condominium decides to disable the non-potable system, it must be oriented on the proper form.

23 The need for massive and continuous spreading of information is necessary because of the risk associated to the system. All residents, visitors, staff people and service providers need to be aware of the existence of the non-potable water system.

ANNEX 3 – CHARACTERIZATION OF WATER USE IN RESIDENTIAL BUILDINGS

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The characterization of water use in residential buildings, for quantification and qualification of potable and non-potable uses and the establishment of volumes to be reserved, and best supply solutions for each building, is no simple task.

Knowing the indicators and profiles of water consumption makes more precise a series hypotheses and assumptions adopted, be they associated to investment policies in basic sanitation, or in the scope of water use within buildings, the focus of this document.

For example, will it be reasonable to use consumption indicators in the range of 150 to 200 liters per person per day and consider two inhabitants per dormitory[24] to calculate volumes of drinking water tanks? If, on the one hand, one can justify these rates based on the fact that "in times of water crisis, the more water stored better"; On the other hand, the water reserves above the required borne by the enterprise in raising the necessary materials for the installation and further storage for longer than the desired change can cause water quality.

The establishment of indicators and water consumption profiles in residential buildings makes it necessary to calculate the demands of drinking water and the demands of non-potable water.

A3.1 – CONSUMER INDICATORS

Water consumption in the household is influenced by several factors (culture, customs, climate, education, environmental awareness, socioeconomic profile). Hafner (2007), in "Conservation and Reuse of Water in Buildings"[25], presented the following rates for some countries:

24 According to PNAD 2011, Pesquisa Nacional de Amostra por Domicílio (Brazilian National Survey by Household Sample), the drop in the number of members of the families takes place in all regions over the country. In the south and southeast, the average number is 2.9 members per family. Northern states of the country have the largest families. In Amazonas, the average number of members per family is 3.6. Rio Grande do Sul has the lowest number, with 2.8 members per family.

25 Thesis submitted to the Engenharia da Universidade Federal do Rio de Janeiro, available at

http://wwwp.coc.ufrj.br/teses/mestrado/rh/2007/Teses/HAFNER_AV_07_t_M_rhs.pdf

TABLE A3.1 – CONSUMPTION INDICATORS IN DIFFERENT COUNTRIES

COUNTRY	DOMESTIC CONSUMPTION (LITERS/ PERSON * DAY)
United States	573
Australia	493
Japan	374
Mexico	365
Norway	304
France	287
Israel	273
Brazil	187
India	136
China	87
Uganda	14
Somalia	3

Source: FAO, 2006a (AQUASTAT database) apud Hafner (2007)

Such significant variations allow us to state that the use of consumption data obtained from international surveys may result in serious errors.

As shown previously, the data of water consumption per person per day provided by NHIS 2015[26] show the variations in consumption indicators between regions and states.

In addition to water consumption varying among states, residential consumption in urban centers varies significantly with the socioeconomic profile of households.

Macintyre (1986)[27] proposed daily consumption 200 to 250 liters per person for apartments increased to 300 to 400 liters per person in luxury homes. It also proposes occupancy rate of two people per dormitory in apartment buildings, rates that are traditionally used in the design of buildings for the design of potable water tanks.

26 Available at http://www.snis.gov.br/component/content/article?id=120

27 Macintyre, A.J., Instalações Hidráulicas Prediais e Industriais, Editora Guanabara Dois, 2ª Edição, 1986

Borja (1997), in a study, carried out in 5 different neighborhoods of the city of Salvador, obtained the following consumption indicators:

TABLE A3.2 – CONSUMPTION INDICATORS IN DIFFERENT NEIGHBORHOODS OF SALVADOR

NEIGHBORHOOD (SALVADOR, BA)	CONSUMPTION: LITERS / INHABIT. * DAY
Vila Yolanda Pires	40
Alto do Cruzeiro	80
Conjunto dos Comerciários	162
Vila Laura	248
Horto Florestal	729

Source: Borja(1997) adaptado de Cohim, E. et al, Consumo de água em residências de baixa renda – estudo de caso. In: 25º Congresso Brasileiro de Engenharia Sanitária e Ambiental. Pernambuco. ABES. 2009[28].

Houses built before 2002 received toilets that consumed 9 to 15 liters per flush. Unless these toilets were replaced in a possible reform after 2002, when only low volume toilets were made in Brazil, the contribution to the daily consumption of houses with old toilets became higher than the flushing volume of the current toilets which, in itself, already raises the water consumption indicators of housing built before 2002[29].

Based on the figures presented, it is reasonable to consider, among others, that:

- indicators of water consumption in dwellings vary significantly between countries, especially due to very different cultural habits regarding hygiene, cleanliness, and food. Indicators of consumption for application in Brazil need to be obtained from measurement in Brazilian households;

- water consumption indicators of single-family homes tend to be lower than in multifamily residences, especially due to the lack of knowledge that residents of multifamily residences usually have in relation to the rates consumed, which stimulates the nonconscious use of water;

- Water consumption indicators of multifamily homes with individual metering tend to be lower than in multifamily residences with the single measurement. It can be assumed that the separation of the volumes

28 Available at http://www.teclim.ufba.br/site/material_online/publicacoes/pub_art90.pdf

29 Consumption surveys must contain the descriptions of the installed equipment, especially toilets, so that the rates obtained can be understood and corrected, if necessary.

consumed and proportionate collection are stimuli to actions for the efficient use of water;

- indicators of consumption tend to increase with increasing socioeconomic profile of users.

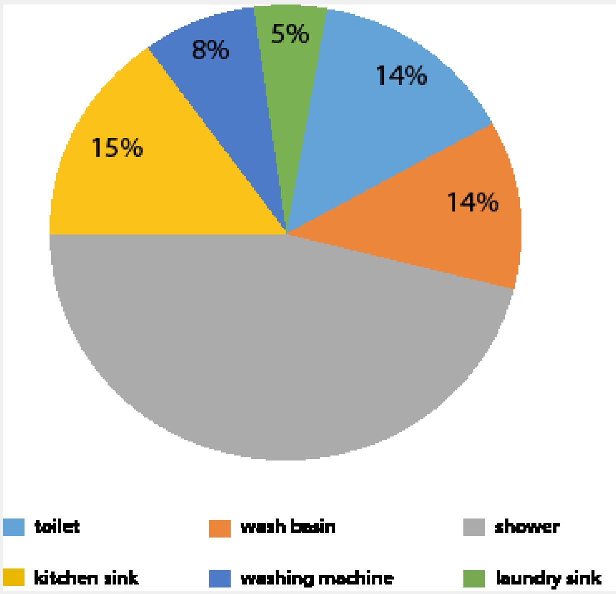
Available data confirm that during the production process of a new building or an existing building retirement planning, it is reasonable to check, at least in that region of Brazil is located this building and consider consumption indicators and the number of residents compatible information.

A3.2 – CONSUMER PROFILE

Considering a typical townhouse, the common uses associated with water are in sanitary areas (bathrooms, kitchens and service areas), in practice hygiene activities, cleaning and cooking.
As well as the consumption indicators, the profile of water consumption in dwellings, by type of activity, also varies according to the region of the Country and with the socioeconomic profile of the users.
Brazil still lacks sufficient field surveys and consumption monitoring to characterize the consumption profile of residential buildings.
Also in cultural diversity function, territorial size, number of inhabitants and significant variation of the socioeconomic profile of the population, it is not reasonable to assume that a particular and unique profile of water consumption reflects a national condition.
However, some field research has already indicated trends. Before the manufacture of reduced volume toilets, the largest water consumption of a dwelling would probably be associated with this equipment.
With the reduction of the volume of water necessary for discharging toilets, the showers started to have the highest associated consumption.
The identification and quantification of the increased consumption of water activities in a building are critical to the establishment of scenario studies of technical and economic feasibility. Interventions performed on activities or equipment of higher consumption tend to promote the best results.
Hafner (2007), in "Conservation and Water Reuse in Buildings"[30] analyzed "the distribution of water consumption in residential units of various studies and work" and found the range of rates, but also some trends, such as higher associated consumption to shower. Results of some of these works are presented below.

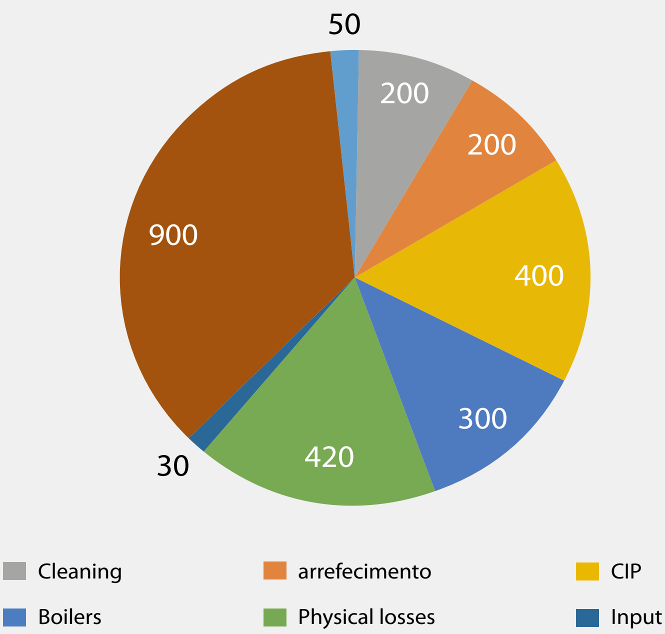
30 Essay submitted to Engenharia da Universidade Federal do Rio de Janeiro, available at http://wwwp.coc.ufrj.br/teses/mestrado/rh/2007/Teses/HAFNER_AV_07_t_M_rhs.pdf

GRAPHIC A3.1 – DOMESTIC CONSUMPTION PROFILE - DECA



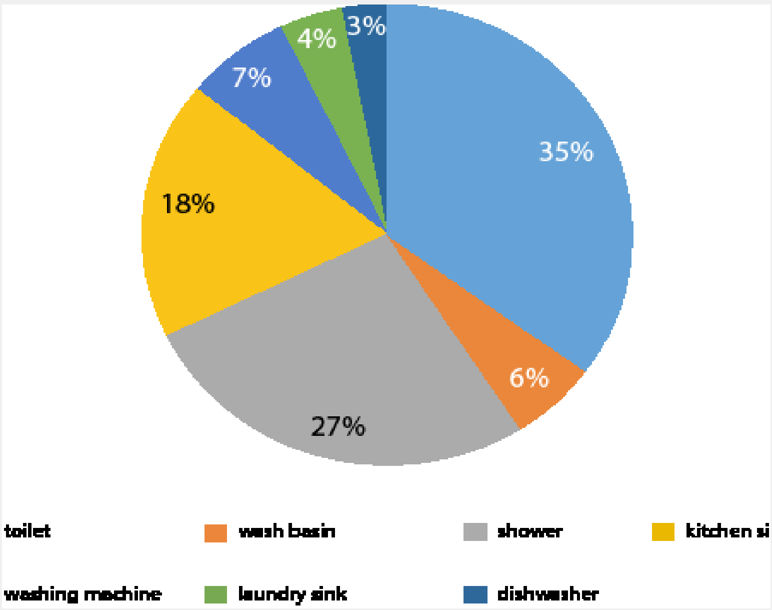
Source: DECA (2006), adapted from Hafner (2007) Source: PURA-USP (2006), adapted from Hafner (2007)

GRAPHIC A3.2 – DOMESTIC CONSUMPTION PROFILE - PURA-USP



Source: PURA-USP (2006), adapted from Hafner (2007)

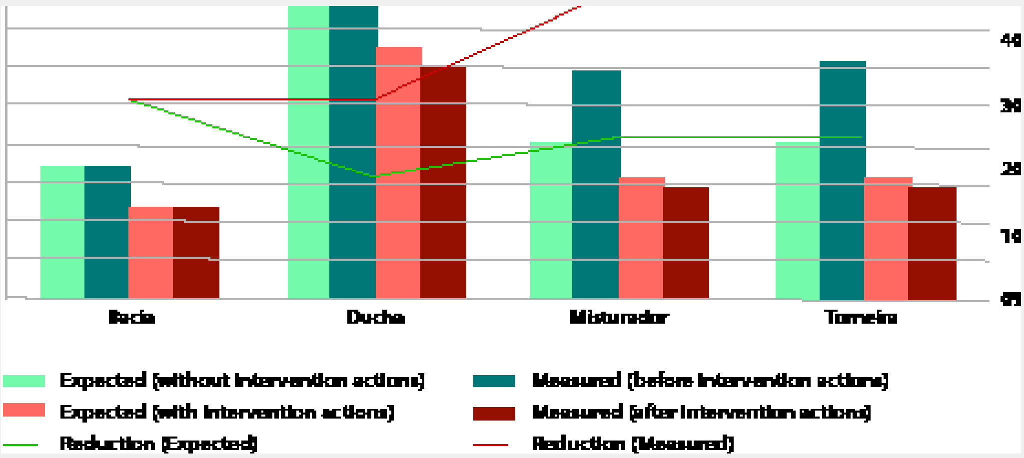
GRAPHIC A3.3 – DOMESTIC CONSUMPTION PROFILE – MIELI



Source: Mieli (2001), adapted from Hafner (2007)

TESIS (2015)[31] the outflow rates in sanitary appliances were measured in 37 apartments in a medium-high standard building in the city of São Paulo, before and after interventions against water waste:

GRAPHIC A3.4 – CONSUMER PROFILE - TESIS

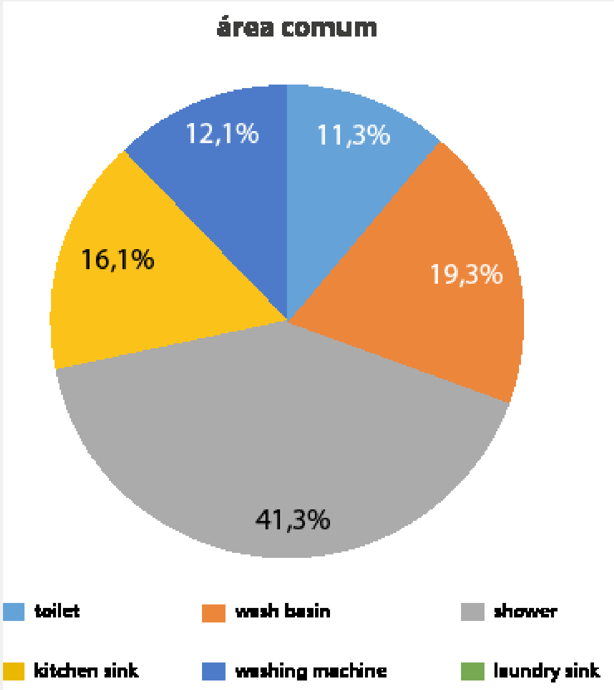


Source: TESIS (2015)

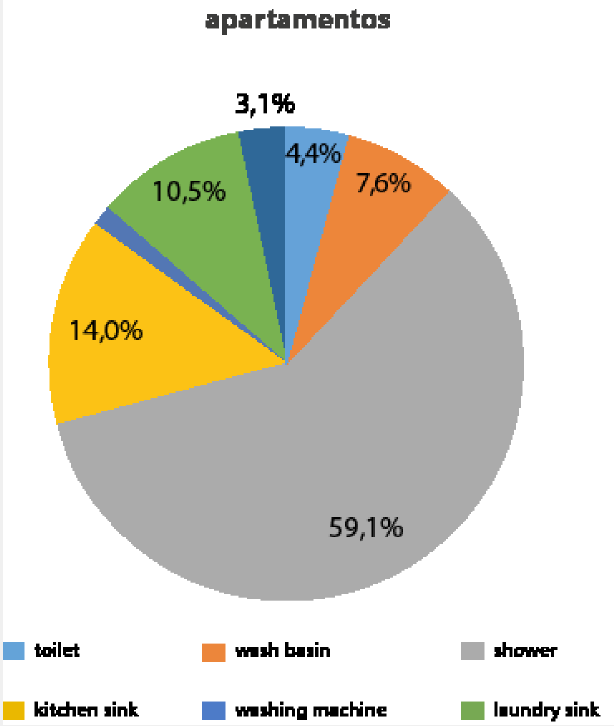
31 Implementation of actions to reduce water consumption in a medium-high standard building in the city of São Paulo, carried out by TESIS, in 2015.

The graphs below indicate the profile of the distribution of water consumption in these apartments and in the sanitary equipment of the common area of the building::

GRAPHIC A3.5 – CONSUMER PROFILE - TESIS

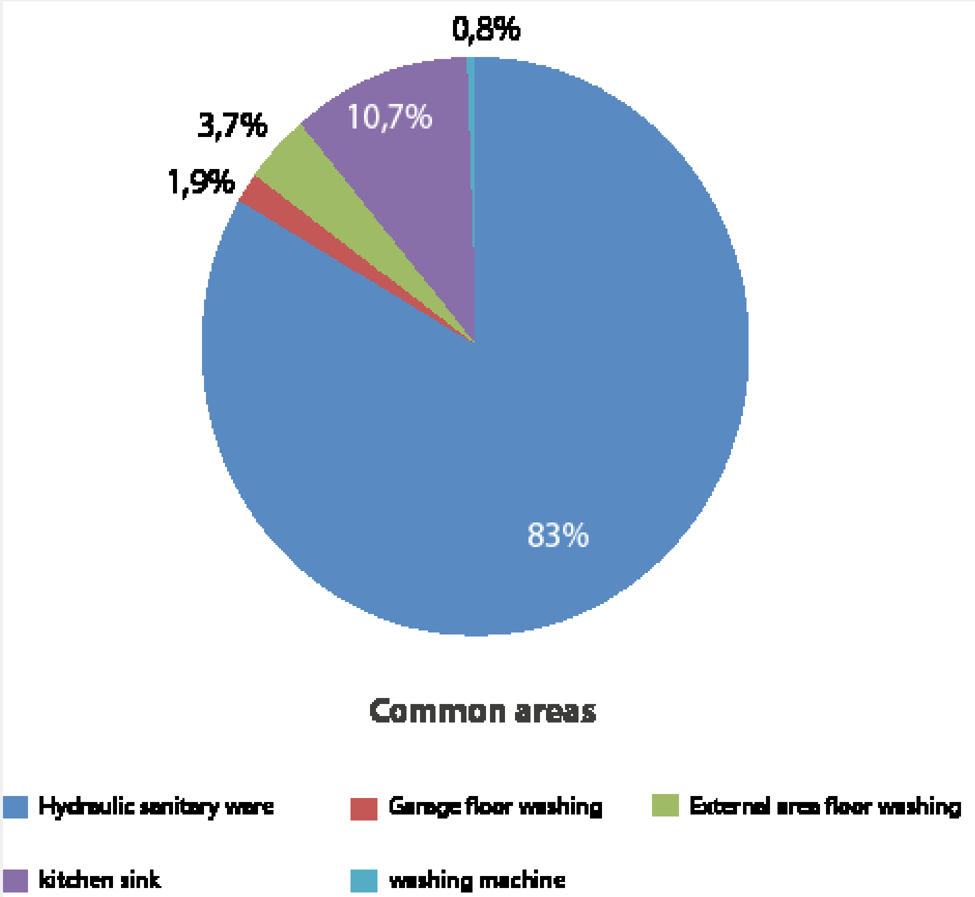


Source: TESIS (2015)



Also in common areas, when considering other uses of water, TESIS (2015) obtained the following consumption profile:

GRAPHIC A3.6 – CONSUMER PROFILE - TESIS



Interestingly, in this case, where the common area of the measurement was performed, the predominance of water consumption in sanitary equipment on other activities in the building.

ANNEX 4 – INDIVIDUALIZED WATER METERING SYSTEM: WATER METER SPECIFICATIONS AND DATA ACQUISITION

ANNEX 4 – INDIVIDUALIZED WATER METERING SYSTEM: WATER METER SPECIFICATIONS AND DATA ACQUISITION

Depending on the water supply characteristics of public systems in Brazil, building water supply system most often used for buildings is the mixed system that combines direct system (one or more fed use parts directly by the public) with the indirect system, where the public system supplies a water tank and this water provides the water for the building's distribution system. The distribution system, in turn, is composed of a barrel, distribution columns, branches and sub-branches that feed the points of use of water.

The individualization of the water consumption adds to the hydraulic systems the measurement subsystem, which requires specific design. The individual measurement system design should be composed of descriptive elements (descriptive memorial, calculation memorial and technical specifications of materials, components, and services) and graphics (plans, views, and details).

The individualized measurement system shall meet the following fundamental requirements:

- allow the quantification of individual consumption with reliability;
- not compromise the use of water and the performance of installed sanitary equipment;
- not degrade the quality of the water from the reservation system.

The following aspects must also be observed:

- The installation location of the meters should preferably be in common area of the building (roof, hall of movement of each pavement type, ground floor, basement, etc.), and the meters properly housed and accessible for reading and maintenance;
- adopt, preferably, a single supply branch for each autonomous unit, so it is necessary only a single water meter (depending on the characteristics and architectural designs and building water distribution, you may need more than one water meter for each apartment, although it is not recommended,

given the complexity of the systems and costs and the possibility of the Utility company not issuing the individual bill);

- consider the possibility or the interest of adoption of a remote water meter reading system, providing up adequate infrastructure as needed (eg, ducts for communication and supply of meters, powerpoint etc.).

The implementation of an individualized measurement system in existing buildings can be complex and begins with the study of the cold water distribution system, verifying the position of the columns and the distribution branches. The amount of each apartment feed columns and civil works required for the individualization of water consumption may hinder the measurement by means of only a water meter. And, in certain cases, the water meters may be positioned within the autonomous units. In such situations, if the utility does not issue individual bills, the condo can apportion the bill cost in proportion to the actual consumption of each apartment.

When it is not possible to use existing columns and extensions to individualize the water consumption, or if, by the age of the building, a renovation is already necessary, it is recommended to deactivate the existing system in order to reduce the points of possible future leaks. It is suggested where the possible lease of new columns and extensions in shafts, in order to minimize costs and the implementation disorders, reducing the number of tears in masonry and finishes reconstitution. The passage of new branches through structural elements of the building (beams, slabs, and pillars) should be avoided. In cases where there is no alternative, it must be issued advice of a qualified professional, if possible the designer of the original building structures.

The water meters should preferably be housed in enclosures (or equivalent) exclusively for this purpose, for one or more meters. The enclosures shall be designed to allow visual inspection, maintenance of water meters and any interruption in the supply of water for a particular apartment, in addition to providing access only to authorized persons.

The option to adopt the individual metering of water in the planning phase of a building can determine, for example, the favorable choice of sanitary appliances and water distribution columns are leased at appropriate points for the insertion of meters (outside the unit autonomous); which areas that use water (bathrooms, kitchens, laundry rooms) are positioned next to each other, to allow lower extensions of the distribution branches, among other benefits.

There are several possible solutions for the implementation of the individualized metering system in buildings, always considering the installation of the water meter in common areas so that maintenance and reading are facilitated. Each case requires specific study of factors such as pressure and flow must be guaranteed during operation.

32 The ABNT NBR 16280 – Reforma em edificações – Sistema de gestão de reformas – Requisitos (Building Renovations – Renovation Management System – Requirements) requirements must always be met.

Individual water metering systems consist of at least one individual water meter (at least one per apartment), preferably installed in common area, for visual or remote reading. To perform remote reading, the measuring system should include, in addition to water meters, the infrastructure associated with the reading system to be installed (electrical point, communication ducts) and space for installation of a metering station in the common area (booth or the janitor's room, for example). The measuring system may also provide for the installation of devices for remote interruption of the water supply in case of need.[33].

Some water utilities have already defined technical standards for acceptance of individualized metering systems and issuance of individual bills.

In such cases, such standards should be followed in buildings to be constructed and, where possible, also in existing buildings reforms. For buildings in locations where utilities have not yet defined standards for individualized metering systems, it is recommended to place the water meters in a common area whenever possible and to provide a maximum of two water meters per apartment (one for cold water and one for hot water). This increases the risk for the issuance of individual bills.

The NBR 15806/2010 - systems of the remote and centralized building measuring water and gas consumption - establishes the minimum requirements needed for implementation of remote gross measurement systems and centralized water consumption in residential buildings. An ABNT NBR 16496/2016 - Me measuring water and gas - metering service provider for residential and commercial buildings - Requirements for minimum requirements recommended to be served by the measurement service provider in relation to the operation of secondary meters, advanced metering systems and management of data measurement in residential condominiums.

A4.1 – SPECIFICATION OF WATER METER DEVICES

A water meter is an instrument designed to continuously measure the volume of water flowing through it. Because it is legal[34] metrology, the water meters sold in Brazil are verified by INMETRO.

The fundamental parameters for the specification of water meters are the pressure (loss of charge) and the water flow. The verification of the water meter the pressure drop in the hydraulic system design flow is indispensable, since the NBR 5626/1998, item 5.3.5.2, specifies that the water pressure in dynamic conditions, anywhere in the building network must always be greater than 5 k Pa (0.5 mca) and under static conditions the maximum pressure rate is 400 kPa (40 mca)[34].

33 It should be noted that, at first, only the public water supply providers can interrupt the supply of a certain apartment due to non-payment of the bill. Even by deciding for the individualized metering system at the condo meeting, both judges as lawyers have diverged about managers interrupting watersupply to defaulting apartments.

The higher the network pressure, the greater the possibility of leakage in pipes: depending on the intensity and duration of the leak, the water meter may operate above its nominal flow, resulting in damage to the same.

For the opposite case, in which the water meter is installed in a low-pressure condition, attention must be paid to the loss of load generated in the system, which may compromise the performance of the activities carried out through the points of use installed downstream. Many points of use have only 20 to 30 kPa available static pressure and, therefore, would present a significantly smaller flow rate with the installation of the water meter.

Some ways to alleviate this problem are: the adoption of higher capacity and higher measurement class meters, lower load loss for the same flow rate exclusive distribution or column prediction pressurization system for floors that present the required pressure.

Regarding flows, for the selection of the water meter, one must consider the design flow of the supply branch of the design in which you want to install the meter, ie the probable maximum flow that will be submitted to the water meter.

The adoption of the same type and gauge model and same capacity for all apartments of a building are interesting because, in addition to the clear uniformity of the performance of water meters, maintenance is facilitated.

It is important to emphasize that the water meter should not be selected according to the diameter of the pipe of the supply branch, but of the design flow.

The selection of the water meter must consider the real conditions of meter operation within the ranges and working conditions for which it was designed. The proper dimensioning of the water meters involves the determination of the design flows in the stretch in which the meter will be installed.

The estimate of the pressure loss of the water meter can be obtained by means of the equation (ABNT NBR5626 / 1998):

$\Delta h = (36 \times Q)^2 \times (Qmax)$ -2

On what:

Δh = pressure drop in the water meter, in kPa;

Q = estimated flow in the considered section, in l / s;

Qmax = maximum flow rate specified for the water meter, in m^3 / h.

34 Legal Metrology is part of metrology related to activities resulting from mandatory requirements, relating to measurements, units of measurement, instruments, and methods of measurement, and its main objective is to protect the consumer by dealing with the units of measure, of the measuring instruments, in accordance with the mandatory technical and legal requirements. In Brazil, the activities of Metrology Legal are an attribution of Inmetro.

35 For the efficient use of water, it is recommended that the maximum static pressure in the water distribution system be limited to 300 kPa (30 mca).

A4.2 – HYDRAULIC AND MEASUREMENT CHARACTERIZATION OF WATER METERS

There are two types of water meters: velocimetric and volumetric. Volumetric water meter are those in which a given chamber volume is filled by the passage of fluid each cycle. The most common volumetric water meters are of the rotary piston type. In the operation of this model, a cylindrical piston eccentrically rotates within a cylindrical chamber, allowing passage of a given volume of water at each revolution of the piston. Meters of this type are usually small in size for connections up to 25 mm (1 ").
velocimetric water meters are those in which the measurement of water volume is performed by counting the number of revolutions of a turbine (propeller), by establishing a relationship between the revolution of the turbine and the corresponding volume drained. The movement of the turbine takes place under the hydrodynamic action of the water flow on the blades of the same one. Thus, the drive of the turbine and hence the computation volume disposed of begins when the frictional forces are overcome by the buoyancy forces of the water flow.
The velocimetric meters are classified in three groups, depending on the form of incidence of the water jet on the turbine, in the measuring chamber

- unijato: when the incidence of a single jet in the direction perpendicular to the axis of the turbine and the plane thereof;multijato: quando da incidência de múltiplos jatos também na mesma direção;

- multijato: when the incidence of multiple jets also in the same direction;

- woltmann: when the direction of the water flow is orthogonal to the plane of the turbine, coinciding with the axis of the turbine.

The water meter of the unijated type has as its measuring chamber the housing itself, a characteristic that allows the adoption of a simpler, lightweight and compact mechanism. Because of the simplicity and lightness, is more sensitive to small flow rates and lower manufacturing costs, and tolerate water with higher suspended solids. However, due to the eccentricity of the jet incidence, the resulting stresses can cause problems of premature wear on the turbine bearings, reducing the life of the meter.

Other drawbacks are the maintenance difficult because the housing interferes with the water meter measuring performance and the need, in many cases, more straight pipe section upstream of the meter (for better measurement performance).

The unijated type water meter is usually used in small connections - 20 mm (3/4 ") and maximum characteristic flow of 1.5 or 3.0 m^3 / h - usually domiciliaries and that serve a single family.

The multi-type water meter has the measuring chamber located inside the housing. The measuring chamber receives water flow the through holes and equidistant slits between them, located at a bottom of the chamber up and eliminates other openings located at a top plan view of the chamber, evenly distributed, after the impact of the jets on the blades of the turbine. With this design, the distribution of stresses on the turbine is symmetrical, allowing for balanced operation and greater accuracy over the entire measuring range, favoring the durability of measurement conditions of the water meter.

The greater complexity of this model in relation to unijato takes acquisition costs to higher levels, although their maintenance is facilitated. The Multijet water meter is normally found in nominal diameters, varying from 20 to 50 mm (3/4 "to 2"), for maximum flow rates from 1.5 to 30 m^3 / h.

The Woltmann type meter is used in large bonds - from 50 to 300 mm (2 "to 12") - for maximum flow rates from 300 to 15,000 m^3 / day - mainly in industrial and commercial users and macro measurement.

The velocimetric water meters have characteristic operating curves that represent their hydraulic behavior (loss of load as a function of flow) and measurement capacity (expressed as percentage error, as a function of flow), typical of each type and meter model. The characteristic curves are made by the error curve and the pressure drop curve.

As defined by Ordinance No. 246, of October 17, 2000, INMETRO - National Institute of Metrology, Standardization and Industrial Quality (INMETRO, 2000)[36] -, the terms that describe and characterize the operation of water meters are:

- flow rate (Q): the quotient of the volume of water flowing through the water meter by the time of the flow of this volume, expressed in cubic meters per hour (m^3 / h).

- Maximum flow (Qmax): higher flow rate, expressed in m^3/h, in which the water meter is required to operate for a short period of time, within its maximum permissible errors, maintaining its measurement performance when subsequently used within its conditions of use.

36 Available in http://www.inmetro.gov.br/legislacao/rtac/pdf/RTAC000667.pdf

- Nominal flow rate (Qn): greater flow under the conditions of use, expressed in m3 / h, in which the meter is required to function satisfactorily within the maximum permissible errors.

- Transition flow (Qt): flow in uniform flow, which defines the separation of the lower and upper measurement fields.

- Minimum flow (Qmin): the lowest flow rate at which the water meter provides indications that do not have errors greater than the maximum permissible errors.

- Start of movement: flow from which the water meter begins to give the indication of volume, without submission to the maximum permissible errors.

- Working pressure: pressure in the supply line, under normal conditions, upstream of the water meter.

- Loss of load: loss of pressure in the supply line, due to the insertion of the water meter in it.

- Faixa de medição: intervalo que comporta vazões compreendidas entre a vazão mínima e a vazão máxima.

- A range of measurement: the range that includes flows between the minimum flow and the maximum flow.

- Lower measuring range: the range that includes flows between the minimum flow (inclusive) and the transition flow (exclusive).

- Upper measuring range: the range that includes flows between the transition flow (inclusive) and the maximum flow rate.

- Error curve: graphical representation of the errors of indication as a function of the flows, where the abscissa axis represents the flows and the axis of the ordinates represents the corresponding relative error (percentage).

- Pressure drop curve: graphical representation of the pressure loss due to the flow, in which the x-axis represents the flow rates and the ordinate axis represents the loss of the corresponding charge.

- Description: inscription on the dial, which is the numerical value of the nominal flow rate of the water meter.

The maximum permissible errors in the indication of the volume flowed by the water meters are ± 5% between the minimum (inclusive) and the (exclusive) flow, and ± 2% between the (inclusive) and the maximum (exclusive) flow rate.

With respect to the water meter performance, especially in low flow regime measurement classes were set INMETRO, whereby the minimum flow-transition and limits must be met.

Classes A, B, and C, in ascending order of measurement requirement, define these limits for the various nominal flows, as shown in the table below:

TABELA A 4.1 – WATER METERS MEASUREMENT CLASSES

WATER METERS MEASUREMENT CLASSES		NOMINAL FLOW (M^3/H)									
		0,6	0,75	1	1,5	2,5	3,5	5	6	10	15
A	Qmin(m^3/h)	0,0240	0,0300	0,040	0,0400	0,1000	0,1400	0,200	0,240	0,40	0,600
	Qt(m^3/h)	0,0600	0,0750	0,100	0,1500	0,2500	0,3500	0,500	0,600	1,00	1,500
B	Qmin(m^3/h)	0,0120	0,0150	0,020	0,0300	0,0500	0,0700	0,100	0,120	0,20	0,300
	Qt(m^3/h)	0,0480	0,0600	0,080	0,1200	0,2000	0,2800	0,400	0,480	0,80	1,200
C	Qmin(m^3/h)	0,0060	0,0075	0,010	0,0150	0,0250	0,0350	0,050	0,060	0,10	0,150
	Qt(m^3/h)	0,0090	0,0110	0,015	0,0225	0,0375	0,0525	0,075	0,090	0,15	0,225

Source: INMETRO, 2000

The water meters measurement classes is performed according to the measurement capacity.

An important factor for themeasurement performance of the water meter is its installation position, for working out the ideal condition for which it was designed, accuracy is affected or even durability is compromised. Pipes for the installation of water meters may be horizontal, vertical or inclined, and the watchmaking may be positioned upwards or to the sides (relative to the pipe axis). The usual installation position is in the horizontal tubing and the watch is turned upwards. However, due to constructive aspects, some water meters can be installed in another position other than the default, in order to meet special needs. Thus, the same water meter, depending on the installation position, can assume different measurement classes, such as B in the horizontal position and A in the vertical position. Should always be subject to the installation conditions specified by the manufacturer of the water meter to be specified.

Another relevant factor regarding the durability of the water meter and its measurement performance is the operating regime of the meter. For systems up to nominal flow rates, the water meter has a good functioning, without compromising its useful life. To above the rated flow to maximum flow schemes, only sporadic occurrences and are tolerable short (to avoid damage to the water meter). Thus, in addition to the probable maximum flow rate for piping design, it is important to consider the flow rates of the installed equipment downstream of the individual water meter. toilet bowls with dump valve, for example, require high flow rates (of the order of 1.70 l / s or 6.0 m^3 / h), which far outnumber other sanitary equipment (of the order of 0.15 l / s or 0.5 m^3 / h on lavatory taps, for example).

ANNEX 5 - DETERMINATION

ANNEX 5 – DETERMINATION OF OUTFLOW BY THE METHOD OF OPEN PROBABILISTIC MODEL

OF OUTFLOW BY THE METHOD OF OPEN PROBABILISTIC MODEL

DETERMINATION OF OUTFLOW BY THE METHOD OF OPEN PROBABILISTIC MODEL

The design flows that occur in the water distribution system depend basically on the following factors:

- behavior of users: function of the typology of the building and the characteristics of the users, determined by physiological, regional, cultural, social, climatic factors;

- Building characteristics: population (quantity and distribution) and spatial organization;

- Characteristics of the sanitary appliance assembly: function of the type and quantity of appliances available.

- Briefly, the factors that determine the design flow in the different sections of the building water system can be expressed by using the following variables:

- Unit flows of existing sanitary appliances in the building (q);

- Intensity of use of the set of sanitary appliances existing in the section considered.

- The intensity of use of the set of sanitary appliances depends, in turn, on the following parameters:

- flushing duration of the sanitary appliance (t);

- time interval between consecutive flushess of an apparatus (T);

- number of sanitary appliances installed downstream of the stretch considered (n).

The variable n is deterministic, that is, there is a fixed and known number of sanitary apparatuses downstream of any part considered.

The variables q, t, T are random variables.

The **duration of the flush apparatus (t)** is the period between the beginning of flush (opening of registration or activation of a shower flush tank button or activation of a valve etc.) and the purpose of its use. It can be determined from field surveys, with the calculation of the mean and the variance of the data set. In the absence of measured data, t may be estimated from the estimation method on three points: a minimum value (tmin), another more likely (tprov) and another maximum (tmax), using the following expressions for determining the average (μt) and the variance (σ2t):

Similarly, the **unit flow rate of each apparatus (q)** can also be determined by means of field surveys, with the calculation of the mean and the variance, or from the estimation method by three points: a minimum value, a more probable one and another maximum, using expressions similar to the previous ones:

In the case of toilet with flush tank, the flow depends mainly on the characte-

$$\mu_t = \frac{t_{mín} + 3 * t_{prov} + t_{máx}}{5} \quad (1)$$

e

$$\sigma^2{}_t = \frac{(t_{máx} - t_{mín})^2}{25} \quad (2)$$

ristics of the apparatus and the available pressure, not being determined by users. In the case of conventional bowls with dump valves, flow and is previously set depending on the feed pressure constant at each firing, and the firing time can be determined by the user. In the case of toilets with a fixed-

$$\mu_q = \frac{q_{mín} + 3 * q_{prov} + q_{máx}}{5} \quad (3)$$

e

$$\sigma^2{}_q = \frac{(q_{máx} - q_{mín})^2}{25} \quad (4)$$

-cycle flush valve, time control is also no longer the responsibility of the user.

The **interval between two consecutive uses (T)** depends on several factors, which can be represented by the following variables:

- number of appliances of the same type installed in the sanitary area (n);

- number of per capita uses of a "type" equipment during the peak period (u), the peak period that the most likely use of the device; population served by sanitary area in which the appliance is installed (P) .

Note that a "type" apparatus is characterized by a set of parameters in the period of further use (peak period): number of uses per capita, flush duration, interval between two successive flushes and flush unit. Thus, a suite lavatory meets two people is a "type" different device than a service sink that caters to a third person, different from the other two. And it is different from the bathroom sink, which serves, for example, four other people (considering that this bathroom meets two bedrooms with two people each).
The number of per capita uses of each type of sanitary appliance in the peak period (u) can be determined in a manner similar to that presented for the unit flow and for the duration of the flush, that is, from field surveys, by calculating the mean and variance or from the estimated three-point method: a minimum value, and most likely other different maximum, using expressions similar to the above:
The **population served by the sanitary appliance corresponds to the number of people who use the appliance in question (P).** In the case of residential buildings, to calculate the volume of water to be reserved has been usual to consider two people per bedroom and one person for service dormitory, when it exists. It is, however, remember that the average size of the Brazilian family has decreased,

$$\mu_u = \frac{u_{mín} + 3 * u_{prov} + u_{máx}}{5} \quad (5)$$

e

$$\sigma^2{}_u = \frac{(u_{máx} - u_{mín})^2}{25} \quad (6)$$

with three residents, on average, according to the National Household Survey 2011 and variation of this rate depending on the region of the country. Thus, consider an apartment with three bedrooms will be occupied by six people promotes the sizing of storage and distribution systems and water.
The mean and variance of the **interval between two consecutive uses of a sanitary appliance in the peak period** can be determined from the expressions:
It is verified that the variable T depends on a series of other variables, making

it difficult to use generalized values for different design situations (types of buildings, for example).
The system flow can be determined by the equation:
On what:

$$\mu_T = \frac{n * t_p}{P} * \left(\frac{1}{\mu_u} + \frac{\sigma^2_u}{\mu^3_u} \right) \quad \textbf{(7)}$$

e

$$\sigma^2_T = \left(\frac{n * t_p}{P} \right)^2 * \frac{\sigma^2_u}{\mu^4_u} \quad \textbf{(8)}$$

qi is the unit flow rate of the type i apparatus; and ri is the number of devices of type i, in simultaneous use, which follows a beta-binomial distribution:
, with parameters ai, bi and pi dependent, given by:
com parâmetros *ai*, *bi* e dependentes de *pi*, dado por:

$$Q = \sum_i ri * qi$$

The designer also has the flexibility to determine as project premise, which are the acceptable fault factors, compatible with the level of performance desired for the system:

$$r_i^d = B - B(a_i, b_i, n_i)$$

ε_G – global failure factor – corresponds to the probability that the project flow

$$p_i = \frac{t_i}{T_i}$$

is exceeded during the considered peak period. Expresses the supported fault in the system. Thus, it is desired that the design flow calculated for the portions is not exceeded by more than 1% of the time, the overall failure factor should be 1/100 = 0.01.

$\varepsilon_{LMÁX}$ – **local maximum failure factor** – probability that the project flow is exceeded, considering only the time intervals in which flows occur in the section considered during the peak period. Thus, it is desired that the design flow calculated for the portions is not exceeded by more than 5% of the time flows occurring in the peak period the local fault factor should be 5/100 = 0.05.

Routine use of probabilistic methods requires programming and computer support to become feasible.

The Open Probabilistic Model adopted by ProAcqua of Sabesp was programmed and the software has been made available to the participants of the ProAcqua qualification processes, promoted by ABES-SP[37].

By way of illustration, an example below shows the design of a feeding column cold water of a building by the method of the weights and probabilistic method Open. The flow rates in each section were calculated by the two methods, considering that from the 8th to the 3rd floor the feed is made by gravity and, for the 2nd and 1st floors, by means of a pressure reducing station. In both cases, the diameters given are the reference (table A5.1).

Characterization: 10 floors type, with 6 apartments per floor, 4 apartments with 3 bedrooms and 2 bathrooms, and 2 apartments with 2 bedrooms and 1 bathroom. Ground floor (floor to floor) of 2.75 m.

Assumptions:

- Population: two people per dormitory (therefore 6 people for apartments with 3 dormitories and 4 people for apartments with 2 dormitories).
- Material: PVC
- Maximum static pressure: 30 mca.
- Maximum speed: 2.8 m/s.
- Peak period: 2 hours.

Considerations:

37 http://www.abes-sp.org.br/

- As mentioned, a Brazilian average family now has three people. When considering two people for sleeping this example, a conventional assumption suppose, indicating That flows calculated as hair After probabilistic method could result in even lower rates;

- Floors 9 and 10 would be powered by an independent, pressurized column. There were no trials in this example;

- For sizing of flow through probabilistic method Open specific assumptions were made for this example (minimum number of uses, maximum, and most likely, minimum, maximum, and most likely flow during use of each equipment, minimum time, maximum, and most likely use of each equipment, local fault factor, global failure factor). These assumptions are variable and are not presented, as they vary from case to case.

TABLE A5.1 - FLOWS BY THE METHOD OF WEIGHTS, BY THE OPEN PROBABILISTIC METHOD AND RESULTING DIAMETERS

STRETCH	Q PROBABILISTIC (L/S)	F PROBABILÍSTIC (MM^2)	Q WEIGHTS (L/S)	F WEIGHTS (MM^2)
1 pavement	0,98	25	1,71	40
2 pavement	1,60	32	2,41	40
3 pavement	2,14	40	2,96	50
4 pavement	2,63	40	3,42	50
5 pavement	3,10	50	3,82	50
6 pavement	3,56	50	4,18	50
7 pavement	4,00	50	4,52	60
8 pavement	4,16	50	4,83	60

Source: QIT Engenharia

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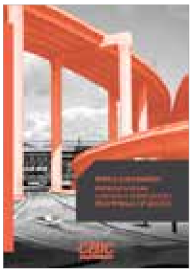

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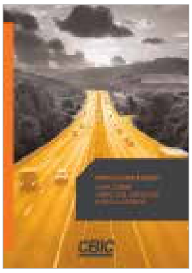

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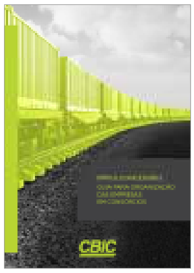

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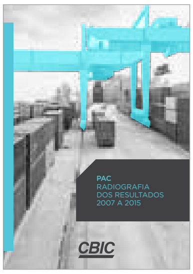

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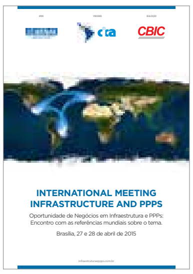

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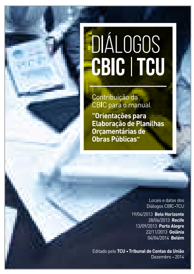

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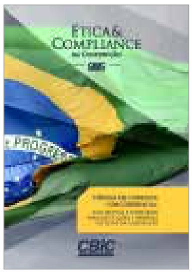

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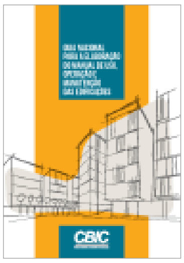

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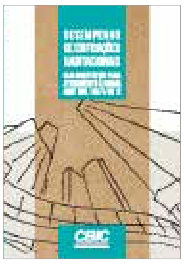

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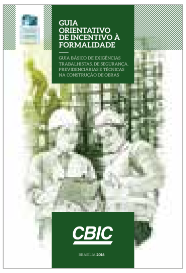

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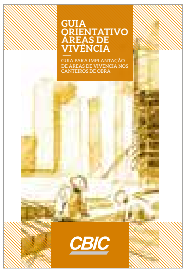

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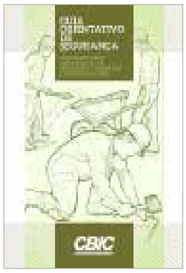

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