

**Potential reduction in drinking water consumption at the headquarters
of the Regional Electoral Court of Pernambuco - TRE/PE**

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SUMMARY

Water conservation in buildings includes not only reducing the demand for potable water, but also adopting alternative sources for activities with less noble purposes. Public buildings under the jurisdiction of the Federal, State, and Municipal governments are required to promote actions aimed at the rational use and conservation of water, according to the responsibility established in the Environmental Agenda in Public Administration. In light of the above, this study aims to analyze the potential for reducing drinking water consumption at the headquarters building of the Electoral Regional Court of Pernambuco - TRE/PE through the use of alternative water sources, such as rainwater and condensed water from air conditioners. The methodology began with the characterization of the study site and the consumption of potable water. Subsequently, the technical and economic feasibility of rainwater and condensate water use was investigated, as well as a comparison between the proposed measures. The results obtained indicate that the techniques studied are beneficial, presenting significant potential for reducing the consumption of potable water that would be used for toilet flushing, 63% for rainwater use and 62% for condensate water. In addition, they can also provide annual financial savings of R\$8,216.01 and R\$8,045.74, respectively. Thus, besides reducing drinking water consumption, the proposed measures also promote the minimization of financial costs, whose capital can be used in the search for continuous improvement of services provided to society.

KEYWORDS: Water conservation. Alternative sources. Public buildings.

1 INTRODUCTION

The concept of water conservation comprises the reduction of the demand for potable water, together with the diversification of the supply of this input through the use of water from alternative sources for activities that do not require water of higher quality (Gonçalves et al., 2017). The authors also point out that "less noble" waters should be used for "less noble" purposes. And given that the water crisis was classified by the World Economic Forum as one of the greatest global risks (WEF, 2016), actions aimed at conservation and sustainability in the use of water resources are of fundamental importance.

According to Silva A. (2018), it is the function of the public authorities to adopt drinking water conservation measures in the buildings under their responsibility, serving as an example for society, promoting its awareness regarding the preservation of the resource, and also reducing their operating costs. Moreover, this type of building presents a great potential for water economy through the adoption of alternative sources, since they are large consumers and their main uses do not require higher quality water, such as toilet flushing, room cleaning, and garden watering.

Silva T. (2018) analyzed the feasibility of rainwater and condensed water use as alternatives for reducing potable water consumption at the Campo das Princesas Palace, headquarters of the Pernambuco State Government. The results obtained indicate that the use of a reservoir with a capacity of 250m³ would be sufficient to meet the demand for watering the gardens from rainwater throughout the year, and that the measure has the potential to generate financial savings of R\$ 17,927.28/year. As for the condensed water, an annual volume of 321.6m³ was estimated, which could imply in an annual economy of R\$2,865.46.

To help develop a new institutional culture in public entities and bodies, the Ministry of the Environment launched the Environmental Agenda in Public Administration program – A3P. The booklet created presents principles and criteria of socio-environmental management aimed at encouraging federal, state, and municipal public managers to insert such concepts in their workplaces (BRASIL, 2009). Specifically for the public buildings of the Judiciary, there is

also the CNJ Resolution No. 201 (BRASIL, 2015), which establishes the creation and competencies of socio-environmental units or cores and the implementation of the Sustainable Logistic Plan (PLS).

It is the responsibility of the socio-environmental centers to promote reflection and encourage changes in consumption patterns. In addition, they have a permanent character for the planning, implementation, monitoring of annual goals, and evaluation of performance indicators. Among the actions that should be promoted by the socio-environmental centers is the sustainable use of natural resources and public assets (BRASIL, 2015).

The Sustainable Logistic Plan must contain information about the actions, goals, deadlines for execution, monitoring mechanism, and results evaluation. The resolution also establishes which themes the practices of sustainability, rationalization, and conscious consumption of materials and services must cover, including the theme "water and sewage". In addition, the PLS must be made available by the respective bodies, providing greater transparency and control of society over social and environmental practices implemented by the Judiciary (BRASIL, 2015).

Pinto (2018) points out that the resolution of the National Council of Justice represented an important step by the Judiciary in changing concepts on environmental management in public agencies, since, for the public sector, environmental management is synonymous with preventive action and commitment to continuous improvement.

At the Regional Electoral Court of Maranhão - TRE/MA, one of the actions applied is the so-called "Sustainable Irrigation", which comprises a system for capturing, storing, and reusing water from air-conditioning units, for cleaning the premises of the headquarters buildings and for use in the garden irrigation system (PINTO, 2018; TRE/MA, 2020). The action represents annual financial savings of approximately R\$ 6,000.00 and about 504m³ of water are reused per year (TRE/MA, 2018). The PLS of the Regional Electoral Court of Paraná - TRE/PR has the implementation of rainwater harvesting and utilization systems as one of its goals. The use purposes are sanitary systems, washing, and external irrigation, with 80% of the goal already implemented in 2017 (REK, 2017).

At the Regional Electoral Court of Pernambuco - TRE/PE, the socio-environmental center has sustainable water management as one of its actions and has promoted educational and control actions on this theme. The PLS of the agency establishes some water indicators to be monitored, such as the volume consumed, as well as identifying action plans to be followed, including a feasibility study for rainwater catchment and the structuring of a system to reuse water from the cooling towers of the headquarters building (TRE/PE, 2016).

Besides the PLS, TRE/PE also prepares Social and Environmental Performance Reports that present the balance of the actions implemented each year and the results achieved in the environmental, social, and economic areas. In the water issue, for example, the 2018 report established the goal to reduce 20% of total consumption in relation to 2016, considering all the buildings that make up the TRE in the state. Although there was a reduction in consumption, the report concluded that the goal was not met (TRE/PE, 2018).

2 OBJECTIVES

This research aims to present a proposal for water conservation measures for an administrative building of the judiciary power, the Electoral Regional Court of Pernambuco - TRE/PE, through the use of alternative water sources, in line with the sustainable actions established in the PSL of the agency.

3 METHODOLOGY

In order to achieve the proposed objective, the methodology consisted of four steps, as described in the following sub-items. The data were collected in the year 2019.

3.1 CHARACTERIZATION OF THE STUDY SITE

The building was registered through site visits in order to obtain information on water sources used in the building, supply frequency, among others. The characterization of the sanitary equipment installed in the building was also obtained in terms of the number, type, and presence of water-saving technology. In order to assess the use of condensation water, it is essential to know the number and power of the air conditioners installed and in operation at the study site. This survey was obtained from the Maintenance Section of the CEA of TRE/PE.

3.2 ESTIMATION OF NON-POTABLE WATER DEMAND

In order to help estimate the non-potable water demand, which can be replaced by water from alternative sources, we need the population data of the study site, which were obtained from the Department of Personnel Management (SGP) of TRE/PE.

As a non-potable water demand, a simulation of toilet flush use was performed, since among the potable water uses in the headquarters building, this equipment has the potential to be a significant portion of the consumption.

3.3 RAINWATER UTILIZATION

3.3.1 ESTIMATION OF USABLE RAINWATER VOLUME

The volume of potentially usable rainwater was obtained through Equation 1 of NBR 15,527 (ABNT, 2007):

$$Q(t) = C \times \text{rainfall (t) (mm)} \times \text{catchment area (m}^2\text{)} \quad (\text{Equation 1})$$

$Q(t)$ represents the rainfall volume at time t , in m^3 . The rainfall data were obtained through the website of the *Agência Pernambucana de Águas e Clima* (APAC - Pernambuco State Water and Climate Agency), and the post 30 (Reef-Flood plains) was chosen to determine the monthly precipitation volumes. The choice was made based on the shortest distance from

the building under study, as well as the existence of an extensive series of data with absence of gaps.

The Engineering Section of the Engineering and Architecture Coordination (CEA) of TRE/PE provided the location and roof plan of the headquarters building. The catchment area corresponds to the roof area of the building. The runoff coefficient (C) refers to the initial losses due to roof cleaning, evaporation, among others (TOMAZ, 2010).

3.3.2 ESTIMATION OF THE RESERVOIR VOLUME

Next, the volume of the reservoir was estimated using the Simulation Method, which is one of the methods recommended by NBR 15.527 (ABNT, 2007). The choice of the method was based on the fact that the reservoir volume is a limiting factor, considering that the area available for its installation in the studied building is restricted. According to Bozzini, Pontes, and Mello Júnior (2017), the Simulation Method is suitable for these cases.

In the Simulation Method, the reservoir volume is initially fixed, and the reservoir is considered full. Furthermore, evaporation should not be considered. To calculate the rainwater volume and the water volume in the reservoir for a given month, Equation 2 is applied, according to NBR 15,527 (ABNT, 2007):

$$S(t) = Q(t) + S(t-1) - D(t) \quad (\text{Equation 2})$$

In which: $0 \leq S(t) \leq V$

$S(t)$ represents the water volume in the reservoir at time t in m^3 ; $S(t-1)$, water volume in the reservoir at time $t-1$ in m^3 ; $Q(t)$, rainfall volume at time t in m^3 ; $D(t)$, consumption or demand at time t in m^3 ; V , fixed reservoir volume in m^3 ; and C , the runoff coefficient.

3.3.3 ESTIMATE OF COST AND PAYBACK TIME

In a simplified way, a rainwater harvesting system is composed of the catchment area, transportation components and reservoir (AMORIM; PEREIRA, 2008). Among these, the reservoir is the most expensive item and can become a barrier to the implementation of the system (AMORIM; PEREIRA, 2008; BEZERRA et al., 2010; HONORATO, 2018).

Thus, determining the cost for reservoir construction is of great importance. In this study, this estimate was made using the equation established by Tomaz (2010), based on linear regression analysis, according to Equation 3 below:

$$C = 336 \times V^{0,85} \quad (\text{Equation 3})$$

C represents the cost of the reservoir in US\$; V , the reservoir volume in m^3 .

The savings to be generated from rainwater usage were also estimated, using the tariff structure of the local water utility. And, finally, the payback time was estimated, represented by the quotient between the construction cost of the reservoir and the savings

generated by rainwater use.

3.4 UTILIZATION OF CONDENSATION WATER

3.4.1 ESTIMATION OF THE VOLUME OF CONDENSED WATER PRODUCED

To estimate the volume of water produced by the air conditioning equipment installed in the studied building, the following Equation 4 was used:

$$V_{total} = Q \times (H_{functioning} \times Ductile) \quad (\text{Equation 4})$$

V_{total} represents the total volume produced by equipment in m^3/month ; Q , the hourly flow of condensed water generated by equipment in m^3/h ; $H_{working}$, the amount of daily equipment working hours in h/day ; and $Ductile$, the amount of working days in the month in day/month .

Due to the impossibility of determining in loco the hourly flow rates of air conditioners, in view of the formality of the activities performed at the Electoral Regional Court - TRE/PE, we used reference values found in the literature. Thus, the flow rates found by Pimenta (2016) were adopted, according to Table 1. For equipment with different powers, the value of the immediately lower power was considered.

The number of daily hours and the working days for the equipment were established according to the working hours of the TRE/PE and the specificities of the place where each equipment was installed, considering the data collected during building characterization.

Table 1: Reference flow rate for the respective power

Power (BTUs)	Flow rate(L/h)
7000	0.84
7500	0.95
9000	1.04
12000	1.06
18000	1.13
22000	1.44
24000	2.25
36000	4.18
48000	4.03

Source: ADAPTED FROM PIMENTA, 2016

3.4.2 ESTIMATED FINANCIAL SAVINGS

To estimate the financial savings to be generated from the use of condensation water and the consequent reduction in potable water consumption, the tariff structure of the local water utility was used. From this data, it was possible to calculate the monetary value to be saved based on the cost of drinking water.

4 RESULTS

4.1 CHARACTERIZATION OF THE STUDY SITE

The headquarters of the Regional Electoral Court of Pernambuco - TRE/PE is located at Avenida Governador Agamenon Magalhães, 1160, in the Derby district of Recife-PE. Its administrative complex is composed of the Antônio Camarotti headquarters building and three annexes: two mansions and a ground floor building.

According to the person responsible for the maintenance sector of TRE/PE, the only source of drinking water for the building is the local utility, with daily supply frequency. In total, there are three reservoirs: a lower one and two upper ones with volume capacities of 38m^3 , 20m^3 , and 6m^3 , respectively.

As for the sanitary hydromechanical equipment, 81% of the total appliances installed in the main building and 67% of the existing ones in the annexes present water-saving technologies, such as hydromechanical faucets and toilets with dual flush cisterns.

As for the water final destination systems, the main building has a rainwater collection system, which collects the water that falls on the roof, through drains, and sends it to the public drainage system, through pipes. In the annexed building on the ground floor, the condensed water from the air conditioning equipment is used to water a small garden area (Figure 1).

Figure 1: (A) Condensed water collection system of the attached ground floor building; (B) Garden area irrigated by the condensed water



Source: ELABORATED BY THE AUTHORS

4.2 ESTIMATION OF NON-POTABLE WATER DEMAND

Dual flush toilets have two operating volumes: 3L for liquids and 6L for solids (MMA, 2014). Considering that all flush toilets in the main building are of the dual flush type and that each user activates an equipment three times a day, twice with its smallest volume and once with its largest volume, there is a total daily demand of 12 L/day/user.

In April 2019, the headquarters building had 344 effective servers and 79 interns,

totaling 423 users who, together, are responsible for a total monthly demand of 111,672L or 111.7m³. Annually, this demand would correspond to 1,340,064L or 1,340.1m³. Table 2 summarizes the information described.

Table 2: Estimated non-potable water demand for sanitary flushing

Dual flush	Use	Equipment volume	Total daily demand	Population Quantity	Workdays in the month	Total monthly demand	Total annual demand
	2x per day	3 L/activation	12 L/day	423 people	22 days	111,672 L	1,340,064 L
	1x per day	6 L/activation					

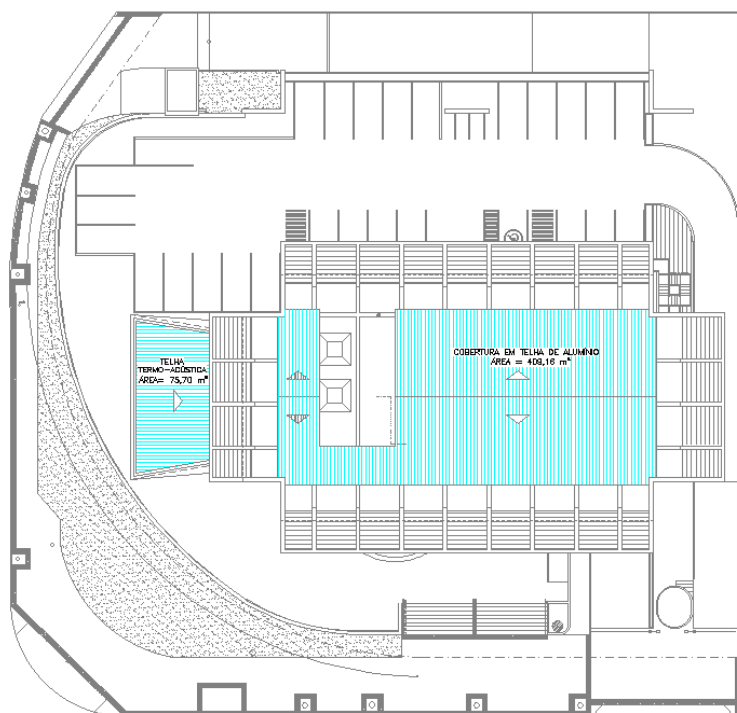
Source: ELABORATED BY THE AUTHORS

4.3 RAINWATER UTILIZATION

4.3.1 ESTIMATION OF USABLE RAINWATER VOLUME

Considering only the covered areas, two types of roof tiles are installed at the head office building. The first is the thermoacoustic tile, covering an area of 75.70m². And the second corresponds to aluminum tile, with an area of 409.16m² (Figure 2). To determine the runoff coefficient, both typologies were assumed to be corrugated metal roof tiles, totaling an area of 484.86m², and an average coefficient of 0.85, based on the values established by Tomaz (2010).

Figure 2: Covering the headquarters building



Source: ADAPTED BY THE AUTHORS

From the rainfall data for APAC post 30 (Reef-Flood plains) for the period from 1999

to 2018, and the application of Equation 1, it was possible to obtain the usable volume of rainwater for the headquarters building of the TRE/PE, whose monthly values are shown in Table 3.

Table 3: Usable rainwater volume per month

Month	Q (m ³)	Month	Q (m ³)	Month	Q (m ³)
January	46.6	May	130.2	September	37.5
February	51.8	June	167.8	October	21.0
March	79.7	July	135.7	November	15.1
April	116.4	August	77.2	December	30.8
Total				909.8m³	

Source: ELABORATED BY THE AUTHORS

The total volume usable from precipitation in the considered catchment area was 909.8m³, which corresponds to approximately 68% of the annual non-potable water demand for toilet flushing (1,340.1m³). Considering the monthly values, the months from April to July present values higher than the non-potable monthly hydric demand (111.7m³), being able to supply the use of flushing without the need for potable water.

Only the period with the highest precipitation (March - August) corresponds to 707.0m³, that is, approximately 78% of the annual precipitated volume in the considered catchment area. The accumulated volume in this period (March - August) represents 53% of the annual non-potable water demand for sanitary flushing.

4.3.2 ESTIMATION OF THE RESERVOIR VOLUME

According to Bozzini, Pontes, and Mello Júnior (2017), the Simulation Method is adequate for these cases. The volume of the reservoir was set at 38m³, because it was the volume of the largest reservoir found at TRE/PE. As recommended by the method, the reservoir was considered full at the beginning of time counting. The beginning of the system's operation was assumed to be in March, the first month of the heaviest rainfall period.

It was observed that the reservoir volume set at 38m³ is sufficient to completely meet the monthly non-potable water demand of the toilet flushing system in five months of the year (April - August). Such action would imply a reduction of about 42% in the annual consumption of potable water for flushing.

For the remaining months (September - August), it is necessary to supplement with water from the local utility. This complementation is 495.7m³, which corresponds to approximately 37% of the total annual demand estimated for the toilet flushes.

Analysis of all months shows that the use of rainwater can represent a 63% reduction in potable water consumption of the estimated water demand. In relation to the total average annual consumption (2015-2018) of the building under study, the adoption of such a measure would represent a nearly 12% reduction.

4.3.3 ESTIMATE OF COST AND PAYBACK TIME

From the application of Equation 3, the value found for the construction cost of the reservoir was US\$7,398.70, equivalent to R\$42,098.60, based on the value of R\$5.69 of the commercial dollar on March 07, 2021 (DOLARHOJE, 2021).

The adoption of rainwater harvesting would provide a reduction of 844.4m³ of annual potable water consumption from the local utility, which would be used for toilet flushing. That is, 63% of the estimated annual non-potable water demand would be satisfied by using rainwater. This decrease would imply in monetary savings of R\$8,216.01 per year, considering Resolution No. 170/2020 (ARPE, 2020), which establishes the tariff value of R\$9.73 per m³ for public buildings, whose consumption is higher than 10m³/month. From these data, it is estimated that the payback time would be five years, one month and fifteen days.

Note that besides the costs with the reservoir construction, there are other expenses involved, such as the pump house construction, the purchase of the pumps, and electricity consumption. Furthermore, the studies, projects and future construction of the elevated reservoir and internal canalization system destined for connection with the sanitary flushing are necessary. Thus, it is essential to conduct more in-depth evaluations on the costs listed above, since they can be quite high and make the implementation of the system unfeasible.

4.4 UTILIZATION OF CONDENSATION WATER

Two air cooling systems operate in the headquarters building. The first is the cooling system, which covers most of the building under study. This system has several components, including fancoils, which are responsible for the condensation water. The condensed water generated by them is directed to the rainwater collection system. The second system is the split-type air conditioners, and the condensation water volume generated is directed to the sewage collection system. In total, there are 219 equipment units under study in the building (Table 4).

Table 4: Total power and quantities of air-cooling equipment

Power (BTUs)	Qty	Power (BTUs)	Qty	Power (BTUs)	Qty	Power (BTUs)	Qty
8,000	10	18,000	03	23,000	01	35,000	22
9,000	01	19,000	02	24,000	21	36,000	16
12,000	01	21,000	01	25,000	24	45,000	03
15,000	47	22,000	60	30,000	01	60,000	06
Total							219

Source: ELABORATED BY THE AUTHORS

4.4.1 ESTIMATION OF THE VOLUME OF CONDENSED WATER PRODUCED

To calculate the production of condensation water, the following were not considered: one 8,000BTU unit located in the guardhouse, since this location is outside the headquarters building; and two 8,000BTU and 15,000BTU units located in the Plenary Room, since the operating hours of this environment vary according to the occurrence of events and

sections.

Although the reference flows used were obtained for air conditioners, their use in the refrigeration system with fan coils is allowed. This is because, theoretically, the condensing water production flow rate is the same for devices of same power, regardless of their external physical structure. It must be noted that the ratio is only theoretical, since there are several factors that influence the generation of condensed water, such as area and amount of people inside the climatized environment (FERRAZ, 2017), as well as the age of the appliances and the season (QUEIROZ, 2014).

In general, the devices have six hours of daily operation over 22 working days per month, corresponding to the regime of activities of TRE/PE, except those with powers of 9,000BTUs and 60,000BTUs, which operate 24 hours a day throughout the month. This is because they are installed in the Network Room, which houses the TRE/PE network servers that need constant cooling for their correct operation.

Note that 2,912.0L of condensed water are produced daily, of which about 52% comes from the 60,000BTU (20%), 22,000BTU (18%), and 36,000BTU (14%) devices, in decreasing order of generation. Although the 60,000BTUs are in small quantity, its higher flow rate, together with its special operation regime, justifies that it is the largest producer of condensed water.

The 22,000BTU devices are in second place in the production of condensed water, even though they present a lower flow rate than the 36,000BTU ones. However, in the same operation period, their expressive quantity of 60 units becomes preponderant. Conversely, the 15,000BTUs appliances, which are also present in large numbers and with equal operating time, account for only 10% of the daily volume generated, in view of their lower flow rate.

Such observations indicate that the relationship between flow, quantity and operation regime directly influence the definition of the equipment responsible for the largest generation of condensation water. This classification is crucial for the utilization actions to be initially prioritized for the largest producers.

The total monthly volume generated is 68,907.1L or 68.9m³, which corresponds to nearly 62% of the monthly non-potable water demand for toilet flushing. Annually, the condensation water volume produced is 826,885.4L or 826.9m³, which also corresponds to 62% of the annual non-potable water demand for toilet flushing.

4.4.2 ESTIMATED FINANCIAL SAVINGS

With the application of the use of condensation water, 62% of drinking water consumption that would be destined for flushing would be reduced monthly. This reduction would represent an economy of R\$670.40, also considering Resolution 170/2020 (ARPE, 2020).

Annually, the utilization would imply in a monetary saving of R\$8,045.74, which could be invested in improvements for the functioning of TRE/PE. It is worth pointing out that, although the sizing and estimated construction costs of the condensation water collection and storage systems are not contemplated in this work. The expenses resulting from these structures need to be considered for a more detailed assessment of the savings to be generated.

4.4 COMPARATIVE ANALYSIS OF THE PROPOSED UTILIZATION MEASURES

The two proposed measures with potential for reducing water consumption for the TRE/PE headquarters building are summarized in Chart 1.

Chart 1: Summary of information on the proposed measures

Measurement	Use	Implementation Cost	Annual savings
Rainwater utilization	Meeting 63% of the annual non-potable water demand	R\$ 42,098.60	R\$8,216.01
Condensation water utilization	Meeting 62% of the annual non-potable water demand	Low	R\$8,045.74

Source: ELABORATED BY THE AUTHORS

It can be seen that the two proposed measures have similar consumption reductions and annual financial savings, as they meet the annual non-potable water demand from toilet flushes with almost the same proportion. The differential factor between the two is the implementation cost, which is higher for rainwater utilization. Although the estimated implementation cost of condensed water use has not been considered in this paper, it can be stated, based on the literature on the subject, that this cost is much lower than the amount needed for rainwater use (RIGOTTI, 2014; PANZO, 2015).

If such measures are applied together, the entire non-potable water demand from toilet flushing will be met over time. The remaining volume could still be used for washing the floors and/or vehicles of the agency, as well as for watering the garden areas.

In general, the adoption of any of the techniques analyzed for TRE/PE will contribute to saving water and will serve as an incentive for other public buildings of the federal, state, or municipal governments. Additionally, it will contribute to the rationalization of the institution's financial expenses, enabling new investments to improve the service provided to society.

5 CONCLUSION

The analysis of rainwater use showed a potential for supplying 63% of the total volume of non-potable water demand from toilet flushing and could provide a significant reduction for the organization under study in expenses with potable water consumption. The prior evaluation of the necessary adjustments in the building and their respective costs is essential to verify the economic feasibility of the system implementation.

When analyzing the use of condensation water generated by air-cooling equipment, beneficial conclusions were also reached. The water volume generated supplies 62% of the estimated non-potable water demand, with the potential for a valuable financial reduction. It can be stated that the large number of appliances and their operating regime substantially influenced the results found.

The analysis of such practice also denoted its relevance in the current context of the water crisis, so that it can serve as an incentive for the development of laws and regulations

that ensure the use of condensed water. As it could be observed, the volume generated is significant and should not be wasted and/or underestimated.

The joint action of the two utilization measures is configured as the ideal situation in environmental and financial terms. For, besides meeting 100% of the estimated non-potable water demand, promoting the reduction of potable water consumption, and using lower quality water for less noble purposes, it also accumulates financial advantages. Cost rationalization allows agencies to invest in other parts of their functional structure, enabling their continuous improvement and enhancing the quality of the services provided to society.

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