Efficient Appliances for People & the Planet

In-depth Assessment of Water Efficiency Opportunities in Brazil

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Contents

Note

Water efficiency standards represent a major, untapped global opportunity to mitigate CO_2 emissions, address water scarcity, and promote resource efficiency policies, therefore playing a major role in advancing sustainable development. CLASP, supported by philanthropic funds, conducted a global scoping study exploring how water efficiency standards can mitigate the impacts of climate change in several economies around the world.

Our objective was to evaluate the opportunity to reduce CO_2 emissions from water efficiency standards for faucets and showerheads and prioritize countries for engagement. In particular, efficient showerheads and faucets both save water and reduce CO_2 emissions by reducing demand for hot water. A comprehensive scoping approach involved consideration of the following factors:

- **Impact Assessment** to investigate of the presence of "concurring factors" which would influence the potential impact of implementing water efficiency standards. These factors include hot water consumption, pressure on water resources (water scarcity and water crises), and projected urban population increase.
- **Policy Environment Assessment** on the viability of successfully implementing said water standards, based on policy prerequisites.
- **Geographic Diversity:** The scoping study maintained a global approach, therefore ensuring a global coverage of one country in each region.

The global study identified India, Brazil and South Africa as countries with the highest impact opportunities.

- **India** is a country where both water resources are under pressure and the policy environment is receptive to the introduction of water efficiency standards.
- **Brazil** is another priority country where recent and severe droughts have led to strict water rationing and water management and security are a top priority for policy makers.
- **South Africa** is the only African country among the top-20 carbon-emitting countries, and policymakers are beginning to examine the existing water policy framework from an efficiency and conservation standpoint.

CLASP, with the support of local partners, led in-depth assessments of each country above, analyzing the existing policy and institutional environment along with barriers and opportunities to introduce water efficiency policies. The global scoping study and each individual report are located on our website at clasp.ngo.

Introduction and Methodology

Water efficiency policies for electric showers in Brazil can reduce CO_2 emissions by reducing hot water consumption, aligning with national priorities to address impending water crises

1.1 INTRODUCTION

Brazil is a federal republic with a population of over 209 million[1] over a territory of 9.5 million km[2 2]. The country is the largest national economy in Latin America, with abundant water resources. However, water availability is not homogeneous. For example, the Amazon basin accounts for 73.6% of Brazil's water resources, but only 5.2% of the total population, while the Southeast region has only 6.4% of the water resources but 32% of the population[3] and has recently experienced water crises[4]. In 2017, agricultural irrigation accounted for 52% of total national water use, followed by urban consumption at 23.8%, industry at 9.1%, animal farming at 8%, and other uses at 7.1%[5].
Water consumption in Brazilian households is around 70 to 120 liters per person, per day, depending on the income of the family and on the geographic region and climate[6,7]. Another study estimates the range at 113 to 174 L/person/day[8].

Only about 43% of Brazilian households use a water heating system. Of these, nearly 96.3% of households use electric showers while only 1.2% use gas water heaters and 2.3% use solar water heaters[9]. Therefore, electric showers are the overwhelming user of hot water and energy embedded in water. In terms of sales, in 2017, more than 17 million electric showers were sold in Brazil, compared to 104,000 gas heaters and 310,000 solar water heater[10]. An electric shower is a point-of-use heater combined with a showerhead and connected to a cold-water pipe. Its popularity in Brazil is due to its low price, with units available on the market for less than 10 USD. Also, most Brazilian homes do not have hot water piping, only single cold water piping. The lack of hot water infrastructure in buildings is a barrier to solar heating adoption and to the use of hot water in other fixtures, such as bathroom or kitchen taps.

This report focuses on the opportunity to reduce CO_2 emissions by reducing hot water consumption, aligning with emerging national priorities to increase water efficiency. Due to their ubiquity, CLASP focused on electric showers and specifically, the viability and the policy impact of re-introducing a water efficiency performance standard or label for this water fixture[11]. Throughout the report, these will be distinguished from showerheads, which require piped hot water heated in a separate heater.

[1] World Bank, 2018 https://data.worldbank.org/country/brazil?view=chart
[2] Porto, Monica & Kelman, Jerson. (2000). Water resources policy in Brazil.
[3] IBGE - Brazilian Institute of Geography and Statistics (2018). Brasil: uma visão geográfica e ambiental no início do século XXI. Available at https://biblioteca.ibge.gov.br/. Rio de Janeiro, Brazil, 2016.
[4] The city of São Paulo faced a water supply crisis between the years 2014 and 2016, when the Cantareira System, the region's main water resource, reached a storage level of only 5%. AKEL, S. (2015). Nível do Sistema Cantareira cai após seis dias estável. Avaliable at: https://exame.com/brasil/nivel-do-sistema-cantareira-cai-apos-seis-dias-estavel/. Sao Paulo, Brazil, February 2015).
[5] National Water Agency (ANA), Conjuntura Recursos Hídricos Brasil 2017. Federal District, Brazil, 2017. http://www.snirh.gov.br/portal/snirh/centrais-de-conteudos/conjuntura-dos-recursos-hidricos/relatorio-conjuntura-2017.pdf
[6] ANA – The National Water Agency (2019). Manual de Usos Consuntivos da Água no Brasil. Superintendência de Planejamento de Recursos Hídricos. Federal District, Brazil, 2019. Avaliable at http://biblioteca.ana.gov.br/asp/download.asp?codigo=134951&tipo_midia=2.
[7] FERNANDES NETO, M. L. et al. Assessing the relevance of intervening parameters on the per capita water consumption rates in Brazilian urban communities. Water Science & Technology: Water Supply, v.1, n.5, p.9-15, 2005.
[8] DIAS, D. M. et al. Evaluation of the income variation impact on household water consumption. Engenharia Sanitaria e Ambiental. Print version ISSN 1413-4152. Eng. Sanit. Ambient. vol.15 no.2 Rio de Janeiro June 2010.
[9] ELETROBRAS - Centrais Eletricas Brasileiras S.A. (2019). National Program for Energy Preservation and Technical Efficiency (Procel) – Electrical Appliances Possession and Usage Habits Research for the Residential Sector– PPH Brazil 2019. Rio de Janeiro, Brazil, 2019.
[10] IBGE - Brazilian Institute of Geography and Statistics (2018). Pesquisa Nacional por Amostra de Domicilios. Available at https://sidra.ibge.gov.br/home/pnadcm. Federal District, Brazil, 2018.
[11] Other appliances, including lavatory and kitchen faucets are not part of the scope of this report because of the lack of water heating systems and hot water for this appliance in the majority of the households.

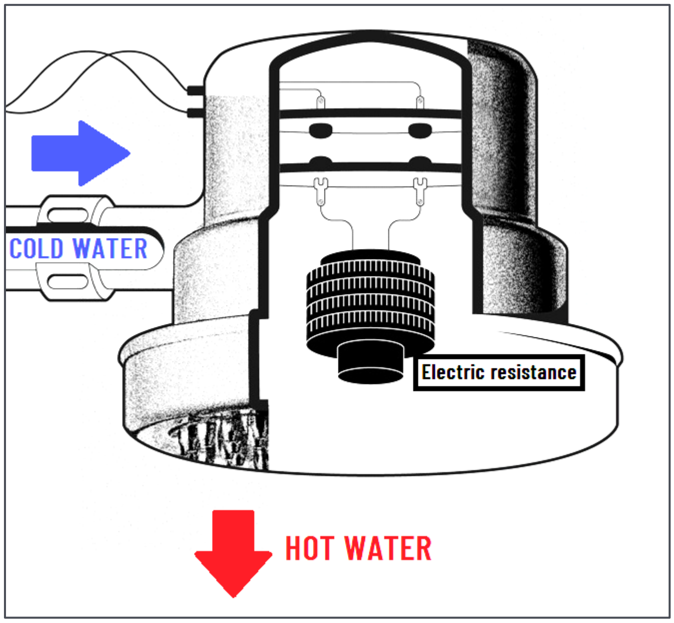


FIGURE 1. SCHEMATIC OF AN ELECTRIC SHOWER

1.2 METHODOLOGY

As water efficiency data in Brazil is the limited and decentralized, we adopted the following survey methodologies, depending on the following data sources: (1) interviews with institutions and manufacturers; (2) analysis of articles from scientific journals; (3) access to the government product database, and (4) download of product specifications from manufacturers and e-commerce websites.

Interviews with institutions and manufacturers

At the beginning of this project, face-to-face meetings and store visits were planned, but this activity was not possible with the closing of commercial activities amid the COVID-19 pandemic. Therefore, we conducted the interviews by telephone and videoconference. Ten institutions and manufacturers participated in the interviews, as shown in Appendix A.

The interviews touched on themes such as current policies for water consumption systems and historical background, certification, barriers to the adoption of more ambitious policies, and incentive programs.

Articles from scientific journals

To supplement the interviews, we evaluated studies from scientific journals available in main national electronic libraries such as Scielo and CAPES Journal Portal. The following keywords were used: water heating, electric shower, and water efficiency. The results of the research supported the discussion section and provided data for the tables in Appendix B.

Government databases

After conducting the first interviews, we identified the main government providers of water use data in Brazil and their relevant publications. These references were fundamental for collecting data on consumption, efficiency, and market share of different water heating systems.

- ANA / IBGE: Environmental-Economic Accounts for Water in Brazil 2013-2015 (CEAA)
- ANA: Brazilian Water Balance; Water Resources Report
- Brazilian Institute of Geography and Statistics (IBGE): CENSO 2010
- EPE: National Energy Balance (BEN) 2019; Energy Expansion Plan 2029[12]
- Procel – Eletrobras: Electrical Appliances Possession and Usage Habits Research for the Residential Sector (PPH) 2019
- SNIS: Diagnosis of water and sewage services[13]

Product specifications

Data regarding purchases and market share were collected from the National Production and Sales Research carried by IBGE (Annual Industrial Survey, PIA) and from balance sheets and annual reports from leading manufacturers: Lorenzetti S.A. and Hydra (Duratex S.A[14].).

We complemented the market data with electric shower performance data from INMETRO and information from the main Brazilian e-commerce websites[15]. We compiled the results in a table according to the product, model, manufacturer, price, and access link. The objective was to identify the level of efficiency and average costs between different technologies and product models (Electric showers, gas water heaters, solar water heaters, electric taps, and others). Although online shopping is not the main channel for water fixtures, Brazilian consumers usually check prices online. Other similar studies that have adopted this methodology have achieved reliable results compared to in-store visits. This methodology was adopted to overcome the limitations imposed by the COVID-19 pandemic, which led to the closing of stores and malls in the State of São Paulo, during the study period.

[12] EPE – Empresa Brasileira de Energia (2019). Plano Decenal de Expansao de Energia 2029. Rio de Janeiro, Brazil, 2019.
[13] SNIS- National Sanitation Information System (2018) – 24 Diagnostico de Servicos de Agua e Esgoto. Brasilia, Brazil, December 2019.
[14] DURATEX SA (2019) – Annual report for Stakeholders. September 2019.
[15] Online platforms included: Buscape, Bondfaro and Google Shopping.

Stakeholder and Policy Mapping

Several key stakeholders and policies govern water administration throughout Brazil and must be considered in the development of water efficiency policies for electric showers.

2.1 STAKEHOLDER MAPPING

Overarching Water Stakeholder Framework

The following are the key federal government agencies responsible for water management in the country.

- **Water National Agency (ANA):** Created by law No. 9,984 of 2000, ANA is the regulatory agency responsible for implementing the principles of Law 9,433 of 1997. In particular, the agency is responsible for regulating and issuing concessions for water use in the country, as well as planning the best use of water resources[16] and monitoring the implementation of corresponding programs. ANA is regulated under the Ministry of Regional Development (MRD).
- **Ministry of Regional Development (MRD):** Created on January 1, 2019, from a merger of the Ministry of National Integration with the Ministry of Cities. MDR manages water supply and sewage services in Brazil through the National Sanitation Secretariat (SNS), which in turn is responsible for the National Sanitation Information System (SNIS). SNIS periodically publishes a diagnosis of services in the country, the latest version was issued in December 2019.
- **Ministry of the Environment (MMA):** MMA was created in 1992, on the occasion of ECO-92 in Rio de Janeiro and its mission is to promote the principles and strategies for the sustainable use of natural resources and the environment. MMA participates in the National Water Resources Policy, but only collaboratively. Other institutions are linked, but not subordinated to MMA. In addition to overarching water management roles, specifically about water efficiency, MMA coordinates a certification program called A3P, which recognizes organizations committed to environmentally friendly practices, especially in the public sector. The program considers water consumption as one of the criteria for certification.

Water efficiency government stakeholders in Brazil

- **National Institute of Metrology, Standardization, and Industrial Quality (INMETRO)**

INMETRO is a federal agency linked to the Ministry of Economy, created by Law 5,966, of December 11, 1973. Its mission is to deal with metrology and the assessment of product compliance in the country.

INMETRO is the coordinator of the Brazilian Labeling Program (PBE). PBE is responsible for testing, monitoring, and labeling the performance of products considering different attribute such as energy efficiency. According to interviews with INMETRO representatives, INMETRO was initially responsible for the development of compliance assessments, and gradually extended its role as a regulator. As a result of this transition, its role in the regulation of water-consuming appliances[17] is unclear.

[16] For more information https://www.ana.gov.br/panorama-das-aguas/balanco-hidrico
[17] In Brazil, electric showerheads are formally classified under the term *household appliance* (*pt. eletrodoméstico*) either in standards, in the national census, or in marketplaces.

INMETRO led past efforts to improve the water efficiency of fixtures through the creation of a water labeling scheme based on the Australian/New Zealand Water Efficiency Labeling and Standards (WELS) and Portuguese standards. INMETRO started the effort in 2015 with a technical working group (TWG) seeking to establish compliance assessment for toilets since technical standards for flush valves were the only standards in place. INMETRO proposed a scheme for introducing ranges of water efficiency through a more comprehensive label and proposed the scheme to the compliance assessment body, Technology and Quality of Systems in Engineering Ltd. (TESIS), but encountered industry opposition. Taps and showerheads were also scheduled for assessment, but due to a change of priorities, the TWG was dissolved with no program in place.

In addition to water efficiency efforts, and until the beginning of 2019, INMETRO was responsible for energy labeling for electric showers. However, as the labeling did not address the efficiency level of the electric showers, only their nominal power, the label was suspended.

INMETRO's role is currently under discussion since the current government seeks to change the evaluation methodology of many products, replacing tests in certified laboratories with self-declarations.

- **Ministry of Mines and Energy (MME)**

MME is responsible for establishing minimum energy performance standards (MEPS) for different appliances, which include, among others, washing machines and solar water heaters. MEPS are discussed and instituted by the Energy Efficiency Indicators Steering Committee (CGIEE). From the discussions with MME it emerged that if water fixtures are proved to save energy consumption, a possibility might exist for MME to consider water fixtures fall under their area of regulation.

- **Eletrobras**

Eletrobras is the biggest electric utility company in Latin America and the tenth-largest in the world. Eletrobras holds stakes in several Brazilian electricity companies, generating about 40% and transmitting about 69% of Brazil's electricity supply. The federal government holds 52% of the company's shares.

Eletrobras manages the Procel label for appliances (Procel Seal) and buildings (Procel Edifica). The Procel Seal is an initiative that complements the PBE, recognizing the excellence of products that exceed the minimum criteria established by the program. The Procel Seal is well known by consumers and is influential in the market.

Standardization bodies

- **Associação Brasileira de Normas Técnicas (ABNT)**

ABNT is a private non-profit organization responsible for technical standards in Brazil. The main ABNT standards dealing with water-consuming appliances are shown in Appendix A, Table 2.

ABNT is an important reference in Brazil and its standards are mandatory. In this context, the approval of the new NBR 5626 standard for plumbing installations in residential buildings and, later, the revision of flow rate requirements, would be critical for the advancement of fixture water efficiency in the country.

Industry Associations

- **Brazilian Association of Sanitation Materials Manufacturers (ASFAMAS)**

ASFAMAS is the main association that represents manufacturers of materials and appliances for hydraulics and sanitation. The organization manages voluntary compliance assessment schemes for sanitary appliances (faucets and single-lever mixers) and water-saving appliances[18].

2.2 POLICY MAPPING

Water Efficiency Standards and Labeling Programs

Despite a priority for the Brazilian Government to use water sustainably, Brazil does not have an efficiency program for water-saving fixtures. The main technical standards for these types of components (like faucets, heaters, pipes, and heating systems) - published by the ABNT[19] - encompass only functional aspects, ensuring minimal quality conditions for consumers. Maximum flow rate requirements are not included in the standards and are left to the discretion of each manufacturer.

The most relevant water fixture standard to date is the National Brazilian Standard (NBR) 5626 of 1998 which covers residential plumbing installations and is currently under discussion. The review process started 6 years ago and the expected date for approval is unclear. NBR 5626 is mandatory and deals with the installations and type of devices to be used for cold water, specifying design criteria, dimensioning, and fundamental characteristics to be observed in all buildings. The revised version of NBR 5626 will unify cold water and water heating standards, which define the parameters for testing, sizing, and installing water distribution systems, as well as define requirements for rational consumption and maximum flow rates. However, the maximum flow rate requirements are not included in the body of the standard but in an informational annex, and are therefore not mandatory.

Energy Efficiency Standards and Labeling Programs

Brazil initiated its S&L program for energy efficiency in 1984, covering both voluntary and mandatory labels and standards for domestic, industrial, and commercial energy-consuming products. The PBE program is coordinated by INMETRO. An INMETRO efficiency label for electric showers was in place, shown in Figure 3 but it was retired. According to INMETRO, the electric shower label is under revision and it is not clear when it was discontinued and if a new program will be developed.

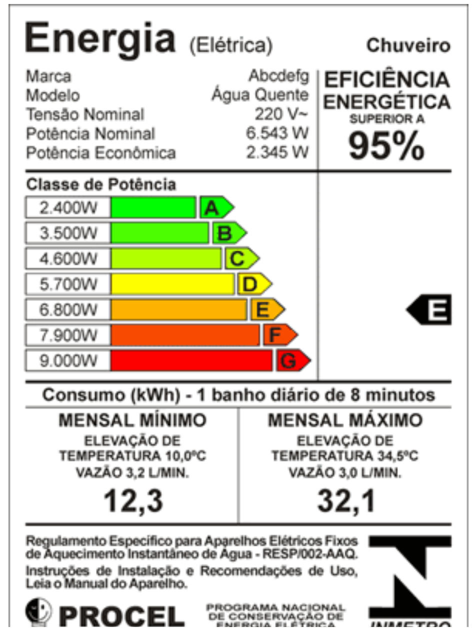
In addition to the PBE, Eletrobras coordinates the National Electrical Energy Conservation Program (Procel), which issues energy efficiency labels for products that meet more demanding criteria. CLASP is currently collaborating with the Brazilian Government to support decision-makers in revising or expanding the energy performance labels for street lighting and cooling appliances[20].

The Procel seal (Figure 2) is issued only to the most efficient appliances or components on the market, which meet stricter criteria than those of the PBE Program from INMETRO. Each type of appliance or component has different criteria for obtaining the seal.

[18] Products are tested according to ABNT NBR 10281:2015 Faucets standard.
[19] ABNT - Brazilian National Standards Organization (2019). Review of the Standard 5626. Sao Paulo, 2019.
[20] https://clasp.ngo/updates/2019/clasp-launches-expanded-partnership-with-procel-in-brazil-1

FIGURE 3. PROCEL SEAL

FIGURE 3. ENERGY EFFICIENCY LABEL FOR ELECTRIC SHOWERS (INMETRO, 2016)



Eletrobras is also responsible for the Electrical Appliances Possession and Usage Habits Research for the Residential Sector (PPH)[21]. The 2019 study shows that more than half of the Brazilian households (56.99%) do not have any sort of water heating system. This is an opportunity to create and improve policies to promote economical and sustainable systems.

Building codes and initiatives

Even if no water efficiency standards exist at the residential and public levels, the Federal Law Nº. 13,647 of 2018 established that all public bathrooms of new buildings must have an electronic or mechanical device to reduce the cold water consumption of faucets and toilets. New buildings built after the publication of the law will not receive the “Habite-se” if they do not meet this requirement. “Habite-se” is the main municipal document that authorizes the use of a building.

Among the labels for energy consumption, those that have criteria for water consumption are the ones regarding the certification of buildings as a whole. In addition to the LEED for commercial and residential buildings, adapted from the American version, other labels such as PBE Edifica, ACQUA, and Selo Casa Azul Caixa are the current alternatives for the certification of commercial and residential buildings. The most adopted labels in the market for commercial buildings are LEED NB and ACQUA since they are used for corporate commercial buildings[22]. On a smaller scale, some low-income households built under the Minha Casa Minha Vida Program, the Federal Government program for the construction of social housing, have certification through the label Casa Azul Caixa. The PBE Edifica label, issued by INMETRO, is not mandatory, thus limiting the number of certifications in the country. More information on labeling programs is available in Appendix B. An analysis of the methodologies of the different labels for buildings revealed that the labels encourage water reductions through a series of measures, such as installation of flow reducing components, water reuse, and rainwater capture.

[21] Available at https://eletrobras.com/pt/Paginas/PPH-2019.aspx
[22] Information collected through an interview with UFMG in May 2020.

Roadmap to Introducing Water Efficiency Policies

Water mangement in Brazil is fragmented, but the oversight of multiple agencies provide numerous pathways for water efficiency policy opportunities

3.1 BARRIERS AND OPPORTUNITIES TO THE INTRODUCTION OF WATER EFFICIENCY POLICY

Brazil's abundant but unequal water distribution has spurred decades of policy debates—later driving the 1997 act to increase the integrated and participatory approach to water management. Despite these efforts, water management continues to be fragmented and with blurry responsibilities across multiple government bodies at different levels of government. The stakeholder and policy assessment above reflects this fragmentation within the water efficiency space.

We looked further into INMETRO's discontinued PBE labeling program for electric showers and ABNT technical discussion committee's revision of NBR 5626. Also, we briefly looked into additional opportunities to introduce standards through solar water heating (SWH) systems.

INMETRO's discontinued PBE labeling program

As electric showers are the main way of heating water in Brazil, we investigated the methodology for the discontinued INMETRO electric shower labeling program. The PBE label rated electric showers based on their input power as shown in Figure 4. Since electric showers use resistive heating[23] with a maximum flow rate typically less than 4 L/min, their input power and related classification of efficiency levels corresponds primarily to the water temperature rise that the electric shower can provide. For example, at the same flow rate, an electric shower in power class D will raise the temperature of the same quantity of water coming into the shower twice as high than the temperature of an electric shower in power class A. This explains why INMETRO recommended higher power (lower label class) electric showers in colder climates (Figure 4).

FIGURE 4. EFFICIENCY LEVELS FOR ELECTRIC SHOWERS[24]

POWER CLASSES	POWER (w)	USE	CONSUMPTION (kWh)
A	P ≤ 2,400	PREFERENTIALLY, WARMER CLIMATE REGIONS, SUCH AS THE NORTH REGION	< consumption
B	2,400 > **P** ≤ 3,500		
C	3,500 > **P** ≤ 4,600		
D	4,600 > **P** ≤ 5,700	PREFERENTIALLY, REGIONS OF MEDIUM TO HOT CLIMATES, SUCH AS THE NORTHEAST AND CENTRAL WEST REGIONS	
E	5,700 > **P** ≤ 6,800		
F	6,800 > **P** ≤ 7,900	PREFERENTIALLY, COLDER CLIMATE REGIONS, SUCH AS SOUTH AND SOUTHEAST REGIONS	
G	**P** > 7,900		> consumption

Following further review of the measured performance of products previously covered by the label, we concluded that the majority of electric showers in Brazil already have flow rates between 3 and 4 liters per minute while maintaining 10 °C temperature rise, which represents a very efficient use of water. (In contrast the US WaterSense requirements for showerheads specify the maximum flow rate at 2.0 gallons/minute or approximately 7.6 liters/minute).

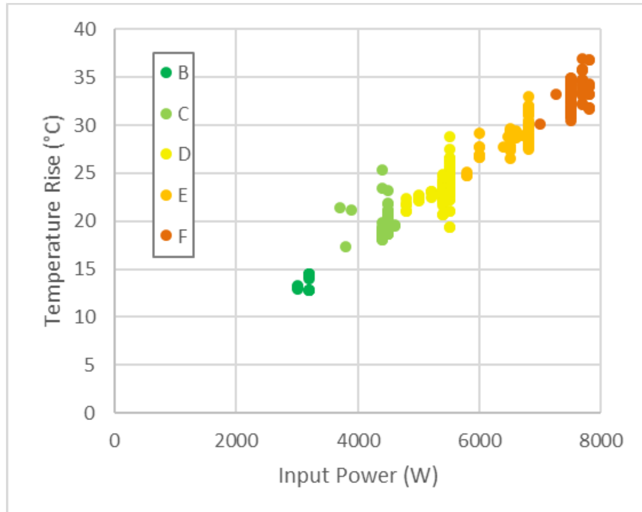
23 INMETRO - National Institute of Metrology Standardization and Industrial Quality (2016). Product list for electric showers. Published on August 02, 2016.
24 INMETRO - National Institute of Metrology Standardization and Industrial Quality (2016). Product list for electric showers. August 2, 2016.

As a result, the input power, which was the criterion to distinguish among the efficiency levels in the PBE, does not reflect water efficiency. Most of the fixtures have similarly low flow rates, and the extra input power goes to providing additional temperature rise or faster heating. This information is visualized in Figure 6 and 7.

FIGURE 5 ANALYSIS INMETRO DATA SHOWING DISTRIBUTION OF ELECTRIC SHOWERHEADS BY POWER (W) AND FLOW RATE (L/MIN)

Lower Bound of Power (W) →	3000	4000	5000	6000	7000	8000
Lower Bound of Flow Rate (L/min) ↓						
3	3%	5%	20%	10%	12%	
3.5	1%	8%	7%	3%	3%	
4	0%	5%	8%	0%	0%	
4.5		1%	7%	0%		
5			3%	0%		
6						
7						
8			0%			
9			0%		0%	

FIGURE 6 ANALYSIS OF INMETRO PRODUCT DATA SHOWING AN INCREASE IN POWER CORRESPONDS TO AN INCREASE IN TEMPERATURE



While the average flow rate of an electric shower is of a standalone showerhead is around 12 L/min[25] or approximately three times that of electric shower, gas heating is rare in Brazil (0.5% of households). Gas heating is used in homes with higher purchasing power because their cost is higher[26]. Even the most expensive electric shower model (Lorenzetti Acqua Duo) which has input power of 7,800W and a flow rate of more than 11 liters/minute[27] is four times cheaper than the simplest model of gas heater (USD 44.06[28] versus USD 190.12, not including infrastructure and installation costs). Therefore, this is a small opportunity that is unlikely to grow in the near future.

ABNT Technical Discussion Committee's revision of NBR 5626

The ABNT technical discussion committee is responsible for determining the standards for electric showers and is composed of several stakeholders, including manufacturers. The diverse composition of the committee reveals a good degree of organization encompassing all sectors to discuss the parameters of quality, consumption, and installation of electric showers. Despite the sector's engagement, no water efficiency standard exists setting the maximum flow of water fixtures and the revision of the NBR 5626 standard for residential plumbing installations has been ongoing for over 6 years. In addition to this, the maximum flow rate included as part of the NBR 5626 is currently an annexed voluntary recommendation whose level is even above the market average: the draft requirement for electric shower maximum flow rate is 7.2 liters/minute, against a market average of 3.62 liters/minute.

According to the professionals and institutions consulted, the fastest and most effective way to address the water flow of electric showers, showerheads, taps, and other water-consuming appliances would be via ABNT and its national standards. The standards are relevant on the national scene and are respected by manufacturers and construction

[25] ABNT - Brazilian National Standards Organization (2019). Review of the Standard 5676. Sao Paulo, 2019.
[26] Interview conducted with ABRINSTAL, 2020.
[27] Lorenzetti, "Acqua Duo Ultra", https://www.lorenzetti.com.br/en/product/acqua-duo-ultra-1540. Accessed July 23, 2020.
[28] Considering that US$ 1 equals RS$ 0.17

companies, representing a powerful tool for changing the market. Besides, as ABNT is not a federal government body, the discussion of new criteria and standards takes place through technical committees and public consultations, which gives the standards a good degree of impartiality.

Solar systems for water heating

Solar systems for water heating could represent an alternative to traditional electric showers. Solar collectors for water heating have been used in the country for years. Some municipal laws - such as Decree 49.148 of 2008 in the city of São Paulo - require the installation of solar collectors in some types of buildings, as well as requiring that all buildings have a minimal infrastructure for their installation in the future. However, the strong preference for electric showers and the cold-water-only plumbing system represent a limitation for the successful introduction of solar water heating.

3.2 POLICY IMPACTS

While the flow rates of electric showers are low by international standards, their average power is 5,774 watts[29] which makes them the biggest draw in Brazilian households. By comparison, an 18,000 BTU/h air conditioner draws 5,200 watts. Through interviews with DURATEX, we found that new technologies have been developed to reduce this power draw by better controlling temperature (potentially avoiding overheating the water and control through increase flow).

To analyze the potential of heating efficiency, rather than water efficiency improvements, in electric showers, CLASP developed a model of national showerhead and electric shower energy consumption, based on the performance of models on the PBE product list and additional data outlined in Appendix B. CLASP then varied the efficiency of the electric shower from the PBE product list average of 86% to 91%, reflecting the average efficiency under a potential standard at 90% efficiency.

The potential impacts of such as standard are show in Figure 7 below, once the full stock of electric showers have been replaced. For comparison, CLASP also analyzed a potential flow rate standard for showerheads, which would reduce the average flow rate of gas-heated showerheads from 12 L/min to 7.56 L/min, in line with US WaterSense requirements and similar to the 7.2 L/min requirement in draft NBR 5626. As can be seen, both requirements would have limited impact due to the limited amount of hot water flowing through the two types of fixtures (for electric showers, due to low flow rates; for showerheads, due to low stock). While Mitsidi did not collect any data on faucets, the impacts are likely to be even smaller due to their shorter daily use.

FIGURE 7: ENERGY AND CO_2 EMISSIONS REDUCTION POTENTIAL FROM A POTENTIAL 90% EFFICIENCY STANDARD FOR ELECTRIC SHOWERS (NO WATER REDUCTION POTENTIAL COULD BE CALCULATED FOR SHOWERHEADS AS THE STOCK OF COLD-WATER-ONLY SHOWERHEADS IS UNKNOWN)

PRODUCT	STANDARD REQUIREMENT	WATER REDUCTION (trillion L/yr)	ENERGY REDUCTION (TWh/yr)	CO_2 REDUCTION ($MtCO_2$/yr)
Electric shower	90%	0	1	0.3
Showerhead	7.56 L/min	N/A	0.1	0.1
Total		**N/A**	**1.1**	**0.4**

[29] INMETRO - National Institute of Metrology Standardization and Industrial Quality (2016). Product list for electric showers. Published on August 02, 2016.

3.3 RECOMMENDED NEXT STEPS

According to an interview with MME, if a Regulatory Impact Assessment study shows that the reduction of water consumption in electric showers is directly related to energy consumption, it would be possible to collaborate with INMETRO and Procel on MEPS and new labels. However, given the low potential impacts from electric showers shown above, this does not appear to be a promising path forward. Policy for the other plumbing fixtures (showerheads and faucets) would deliver even smaller energy and CO_2 impacts.

However, there could be a larger potential water reduction impacts due to the larger stock cold-water-only fixtures. These were not analyzed in this study (whose focus was on energy and CO_2 reductions) but could be the focus of future work. From this perspective, supporting ABNT and its committees could be promising. Committee CB-02 is responsible for reviewing technical standards related to building installations, including the generation and distribution of hot water. An initial contact could be made through ABRINSTAL, which expressed an interest in collaborating with CLASP in the process.

Longer-term, since more than half of Brazilian households do not have a water heating system, a roadmap could be developed to promote more economical and sustainable systems. For example, ABRASOL has an open agenda with the MME for the integration of solar thermal energy in the Federal Government's incentive programs.

Appendix A: Organizations in the Brazilian water space and interviews conducted

STAKEHOLDER	DESCRIPTION	INTERVIEWED
Brazilian Council for Sustainable Building (CBCS)	The objective of the CBCS is knowledge generation and sharing, along with sustainability practices in the civil construction sector. One of their main programs is the Operational Energy Performance in Buildings.	Yes
International Energy Initiative Brazil (IEI)	IEI is a civil society organization that aims to initiate, strengthen, and move forward sustainable and efficient use of energy. IEI develops national and international projects with government and civil society actors.	No
ABRASOL	ABRASOL is a non-profit association representative of companies in the solar thermal energy sector. Its main objective is to promote and develop the market for solar thermal energy in the country and to increase society's awareness.	Yes
ABRINSTAL	ABRINSTAL is a non-profit organization that aims to plan, organize, promote, and execute actions that seek the conformity, performance, and efficiency of building installations, including, among others, solar water heating.	Yes
Duratex	Fixture manufacturer	Yes

Institute for Climate and Society (iCS)	ICS is an NGO involved in the development of policies to reduce CO_2 emissions.	Yes
Institute for the Development of Alternative Energy in Latin America (IDEAL)	IDEAL is a private non-profit organization that aims to promote renewable energies and energy integration policies in Latin America.	No
Ministry of Mines and Energy (MME)	MME is responsible for establishing minimum energy performance standards (MEPS) for different appliances, but only if regulation can reduce energy use.	Yes
Federal University of Santa Catarina (UFSC)	The main laboratory that deals with energy efficiency at UFSC is Laboratory for Energy Efficiency in Buildings (LabEEE). LabEEE was created in 1996 and is linked to the Construction Research Center of the Civil Engineering Department. The laboratory's objective is to reduce energy consumption in new and existing buildings.	Yes
Federal University of Minas Gerais (UFMG)	The Laboratory of Environmental Comfort and Energy Efficiency in Buildings LABCON deals with energy efficiency. LABCON is associated with the Department of Architecture and Urbanism Technology, of the Architecture School.	Yes
World Plumbing Council (WPC)	The World Plumbing Council is an international organization of plumbing associations and plumbing industry stakeholders. The members are mainly national level plumbing industry associations and unions. The Brazilian members of the Council are part of ABRINSTAL. A board to discuss energy efficiency is being created.	Yes

Summarized policy mapping

All information previously presented on standards, certifications, and labels is summarized in Table 2.

TABLE 1.ORGANIZATIONS FOR WATER EFFICIENCY POLICIES IN BRAZIL

INSTITUTIONS	WATER FIXTURE/APPLIANCE							COMMERCIAL BUILDINGS	RESIDENTIAL BUILDINGS
	Showers	Electric showers	Res. Faucets	Comm. Faucets	Washing Machine	Gas Water Heater	Solar Water Heater		
Overarching Policy (General & National)	Brazilian Water Law, Law N°. 9,433 of 1997; PROSOL – Brazilian National Program to Promote Solar Systems (under discussion); Specific State legislation to promote solar water heating systems and water reuse;							PBQP-H - Brazilian Quality and Productivity Habitat Program	
Test Method	ABNT	ABNT	ABNT	ABNT	ABNT	ABNT	ABNT		

Voluntary Programs (P&D – Bonus to improve)	PBE Edifica / Procel / CONPET (PBE is the label from INMETRO, Procel is the label from Eletrobras, CONPET is the label from Petrobras)							PBE Edifica; LEED (GBC Brasil); AQUA (Vanzolini Foundation)	PBE Edifica; LEED for Households (GBC Brasil); AQUA (Vanzolini Foundation); Caixa Blue Label (Caixa Economica)
Compliance Scheme (Industry requirements)			ASFAMAS TESIS	ASFAMAS TESIS		ABRINSTAL	ABRINSTAL	ISO 460001	ABNT NBR 15575
Standards (MEPS) Minimum level					CGIEE (MME) (updated in 2011)	CGIEE (MME) (updated in 2017)	CGIEE (MME)		
Comparative Label (A, B, C, D)		INMETRO (unavailable)			INMETRO	INMETRO/CONPET	INMETRO	PBE Edifica (voluntary)	PBE Edifica (voluntary)
Endorsement Label (Procel Seal)		Electrobras (unavailable)			Electrobras		Electrobras		

In Table 3 we present a summary of relevant policies in Brazil, considering all official information about water use and water appliances and devices.

TABLE 2 OVERVIEW OF WATER EFFICIENCY POLICIES AND INSTITUTIONS IN BRAZIL

INSTITUTION	STANDARD	YEAR	TOPIC
ABNT	NBR 15206	2005	Showers
	NBR 12483	2015	Electric showers
	NBR 10281	2015	Faucets
	NBR 13713	2009	Faucets
	NBR 15267	2017	Faucets
	NM 60335-1	2010	Washing machine
	NBR 13103	2013	Gas water heater
	NBR 15569	2014	Solar water heater
	NBR 10185	2018	Solar water heater
	NBR 16641	2018	Solar water heater
	NBR 15575-6	2013	Residential buildings
	NBR 5626	1998	Residential buildings
	NBR 5626	2020?	Buildings

LABELS AND SEALS		
National Government	PBQP-H	Low-rise residential buildings
INMETRO	PBE Edifica	Commercial and Residential buildings
ELETROBRAS	Procel	Appliances and Buildings
Vanzolini Foundation	ACQUA-HQE	Commercial and Residential buildings
GBC Brazil	LEED for Households	Residential buildings
Caixa Economica	Caixa Blue Label	Residential buildings

REGULATION			
National Government	Federal Law 13.647	2018	Commercial and Residential buildings
	Pro-Sol	2020?	Solar systems
	PL 107/19 - Sao Paulo	2020?	Commercial and Residential buildings
Municipalities	IPTU Verde	-	Commercial and Residential buildings
	Municipal Law 49.148	2008	Commercial and Residential buildings

Appendix B: Model Methodology and Inputs

- **Model Methodology**

  CLASP's water efficiency impact model estimates the water, energy, and CO_2 emissions reductions due to maximum flow rate standards. It is based on the model developed by the Appliance Standards Awareness Project to estimate the impacts of flow rate standards in the United States. The model first calculates the annual amount of water that flows through an average fixture under business-as-usual conditions and under an efficiency policy.

  Mitsidi collected performance data for electric showers and showerheads from several secondary sources as well as the INMETRO PBE product list from 2016, before the program was discontinued. Centralized water heating is not common in Brazil—only 0.5% percent of households report using gas water heating[30], or approximately 300 thousand, and the roughly 41% that use electric heating, do so through point-of-use electric showers. As a result, CLASP expected very little hot water use due to faucets and standalone showerheads, and focused on analyzing and modeling the performance of electric showers.

  The average flow rates of the electric shower dataset (3.6 L/min) were already lower than most showerheads around the world. For example, the Australia/New Zealand Water Efficiency Labeling and Standards (WELS) top rating (4-star, Range E) captures products with flow rates 4.5 to 6 L/min. Showerheads with flow rates less than 4.5 L/min are not rated. Since it is not practical to lower the flow rates further, CLASP analyzed the efficiency of the electric showers, but comparing their measured energy consumption to the energy required to heat the water to the temperatures in the ABNT NBR 12089 Electric Shower Energy Consumption test method used by the PBE program.

The test method requires two tests:

[30] ELETROBRAS - Centrais Eletricas Brasileiras S.A. (2019). National Program for Energy Preservation and Technical Efficiency (Procel) – Electrical Appliances Possession and Usage Habits Research for the Residential Sector– PPH Brazil 2019. Rio de Janeiro, Brazil, 2019.

- A maximum condition where the electric shower is set to its maximum setting, and the temperature rise is measured at a flow rate greater than or equal to 3 L/min; and
- A minimum condition where the electric shower is set to the minimum setting that can heat the water by at least 10 °C, and the flow rate is measured (but must be at least 3 L/min)

Both tests are conducted over 8 minutes to model a typical shower (plus any warm-up time), and the measured energy is multiplied by 30 to provide a monthly estimate.

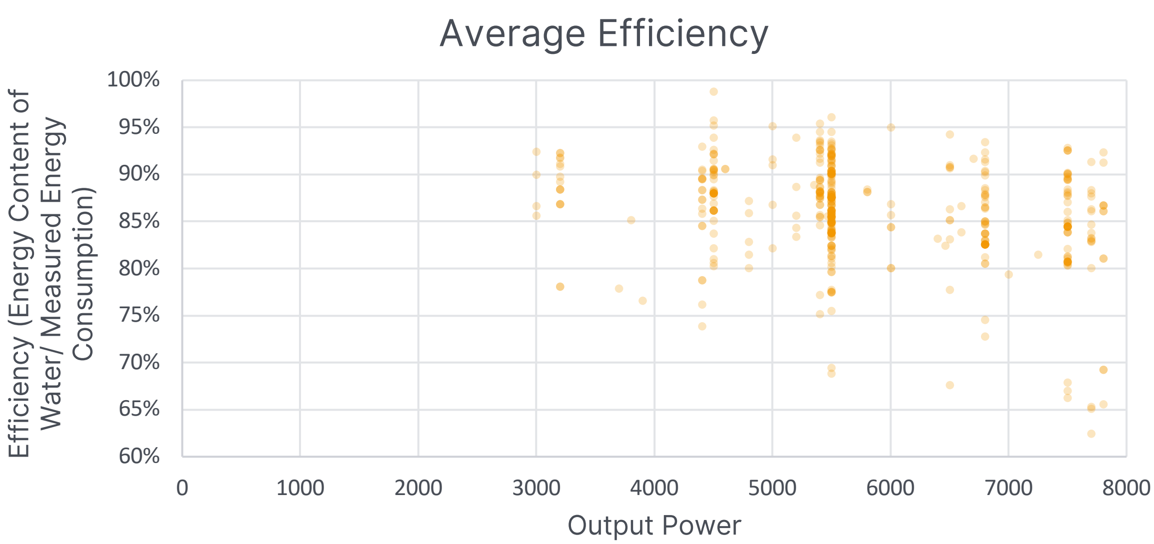
CLASP measured the average efficiency over these two tests as follows:

$$Avg\ Efficiency = \frac{8\text{ min}\cdot 30\text{ days}}{2}\left(\frac{Specific\ Heat\ \cdot \Delta T \cdot \frac{3\text{ L}}{\text{min}}\cdot}{Max\ Monthly\ Energy\ Consumption} + \frac{Specific\ Heat\ \cdot 10\,^{\circ}\text{C} \cdot Min\ Flow\ Rate}{Min\ Monthly\ Energy\ Consumption}\right),$$

Where:

- $Specific\ Heat$ is the specific heat of water equal to 0.0011622 kWh/kg/°C
- ΔT is the measured temperature rise during the maximum condition test
- $Min\ flow\ rate$ is the measured flow rate during the minimum condition test.

The resultant efficiency across the dataset is shown below:



As efficiency up to 92% is achievable across a range of output powers, CLASP modeled the effect of an efficiency standard at 90%. If non-compliant modes were redesigned to just meet the requirement, the average efficiency would increase from 87% to 91%. This would result in a decrease in energy consumption and CO_2 emissions, even as flow rates stayed constant.

In addition, Mitsidi collected estimates of the stock of electric showers, their lifetime, and usage, as well as some key facts about home plumbing systems, such as the share of water heaters of different types and the shares of hot and cold water flowing through the fixtures (which reflect the average water temperature coming into the house from the municipal water utility's pipes, as well as the proportion of houses with water heating). CLASP combined these data with assumptions on the efficiency of the various types of water heaters, how much of a fixture's full flow is used, amount of water wasted while waiting for hot water to arrive, and emissions factor for electricity.

As inputs, the model takes the following country data regarding the number and flow rate of water fixtures, the plumbing system that they are connected to, and their usage:

- Number of fixtures in use (stock) or shipments and lifetimes to estimate stock
- Usage (minutes/fixture/day)
- Average flow rate (calculated from the performance of models on the market average and the shift in response to policy assuming non-compliant models are replaced with models just meeting the flow-rate standard)
- Electric shower water heating efficiency (87% to 91%)
- Typical piped water temperature (based on study of hotels around the country)[31]
- Average temperature rise (25.6 °C in max condition, 10 °C in min condition, for an average of 17.8 °C)

These are combined with the following assumptions:

- How much of a fixture's maximum flow is actually used (85% for showerheads[32] but assumed 100% for electric showers because of their already low flow rates)
- Water wasted while waiting for hot water to arrive (additional 272 L/showerhead/yr for low-flow showerheads[33], assumed unchanged for electric showers because flow rates are not changing)
- Energy required for water heating is calculated by multiplying the volume of water in liters, by the temperature rise, and the specific heat of water ($1.16 \times 10^{-3}\ kWh/kg/°C$), and dividing by the electric shower's efficiency
- Emissions factors for electricity generation (0.201 $MtCO_2$/TWh) 34, and electric transmission and distribution losses (16%)35

Key Modeling Data

(Because of the small number of standalone water heaters in the country, data on faucets was not collected, and only electric showers were modeled)

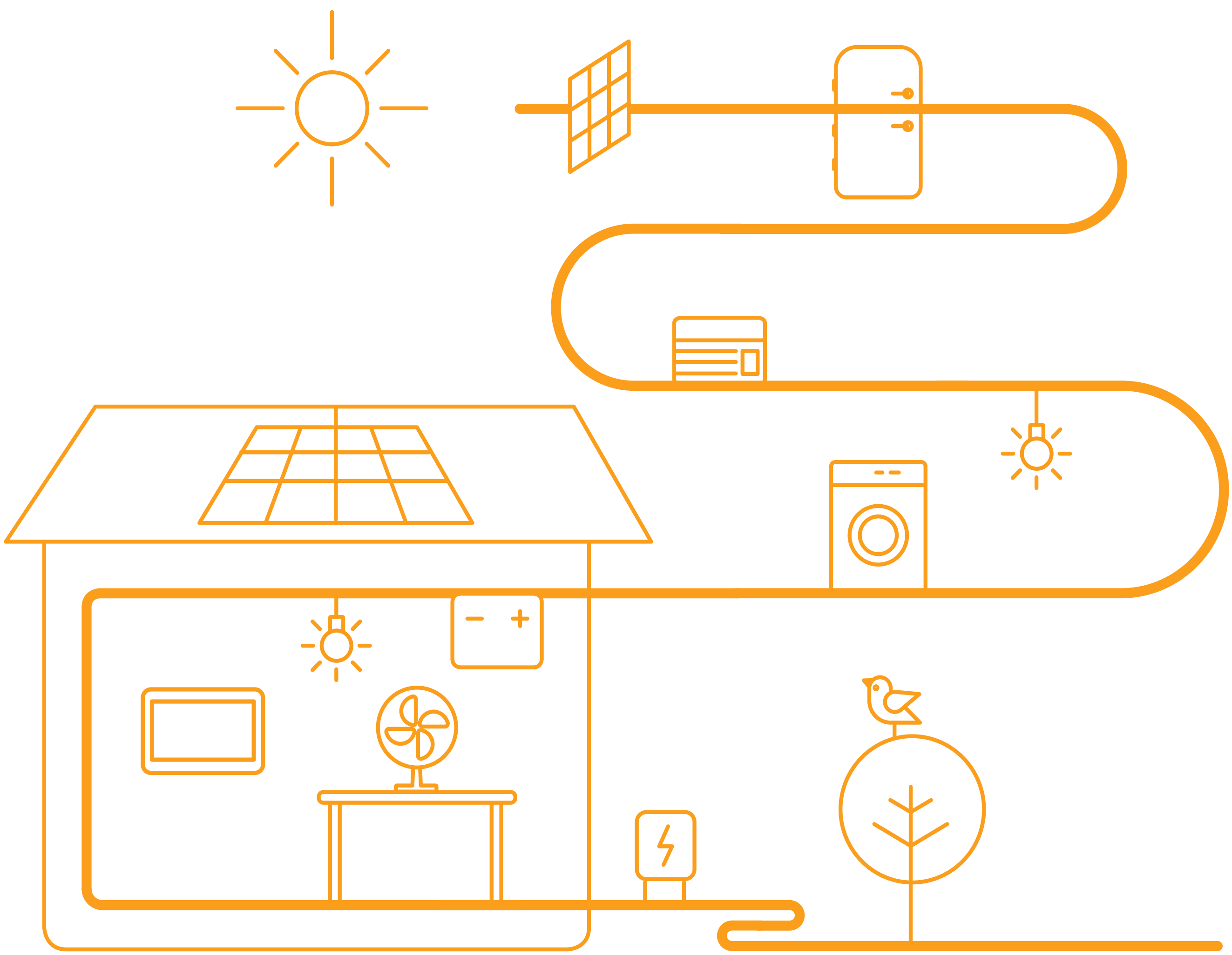
DATA	VALUE	SOURCE AND METHOD	NOTES
Current stock (million units)36			
Shower head	0.3	Estimated based on the number of households with gas heater systems	(Total number of households * Percentage of households with gas heater systems)
Electric Shower	23	DURATEX, 2015 – Based on sales by HYDRA[37] Estimated based on ELETROBRAS, 2019 (PPH) and IBGE, 2010 (SIDRA)	The estimate from Duratex matches within a million units an estimate calculated by multiplying the number of households times the Percentage of electrical water heaters

[31] INMETRO, Normative Instruction for the Energy Efficiency Class of Commercial Building
[32] California Energy Commission, "Staff Analysis of Water Efficiency Standards for Showerheads", February 2015, California Energy Commission 2015 Appliance Efficiency Rulemaking, Docket Number 15-AAER-5, p. A-2. https://efiling.energy.ca.gov/GetDocument.aspx?tn=205654&DocumentContentId=11944
[33] Heidi Hauenstein, and Carolyn Richter, "Codes and Standards Enhancement (CASE) Initiative For PY 2015: Title 20 Standards Development: Analysis of Standards Proposal for Showerheads", July 31, 2015, California Energy Commission Docket Number 15-AAER- 05, p. https://efiling.energy.ca.gov/GetDocument.aspx?tn=205606&DocumentContentId=11922
[34] International Finance Institutions, "Harmonized Grid Emission factor data set", July 2019, https://unfccc.int/sites/default/files/resource/Harmonized_Grid_Emission_factor_data_set.xlsx.
[35] US Energy Information Administration (EIA), "International", Data for Electricity Consumption and Distribution losses, 2019.
[36] This stock number takes into account fixtures of each type connected to cold water, hot water, or both. However, the usage of hot water below has been adjusted to reflect that not all fixtures are connected to hot water.
[37] DURATEX SA (2015) - Corporate presentation. Apimec. Sao Paulo, Brazil, 2015.

Shipments (million units)			
Shower head	N/A		
Electric Shower	17	IBGE, 2017 – PIA – Table 1 – Production and sales by industry, according to product classes	This information is gathered by the government using a code for each product produced in the country. The electric shower code is 2759.2070
Lifetime (years)			
Shower head	N/A		
Electric Shower	2.8	DURATEX, 2015 – Based on sales by HYDRA	Considering the annual sales of electric showers and estimates of stock, 2.8 years or less appears reasonable.
Flow rates of fixtures in the market (L/min)			
Shower head	12	ABNT, 2019 – Informative Annex based on different institutions research and discussion	
Electric Shower	3.6	INMETRO, 2016 – PBE Electric shower labeled product list	3-10 L/min range for models on the product list. The draft annex of NBR 5626 specifies a maximum flow rate of 7.2 L/min.
Water heater technologies stock share %	Electric shower: 40.9% Gas: 0.51% Solar: 0.96% Firewood: 0.03% Other: 0.06 No hot water: 56.99%	ELETROBRAS, 2019 – PPH 2019	
Water heater technologies market share %	N/A		
Average energy efficiency by type of water heater technology %	Electric: 87% Gas: 84%	INMETRO, 2016 – PBE Electric shower product list INMETRO, 2017 – PBE Instantaneous Gas Heater product list	Comparison of the tested energy consumption of electric showers on the PBE product list to the heat embedded in the hot water finds average efficiency of 87%

Typical use (min/fixture)			
Shower head	10	EPE, 2014 – Energy Plan for 2029 (DEA)[38]	ABNT NBR 12089 Electric Shower Energy Consumption has an assumption of 8 minutes per shower (excluding time waiting for water to warm up)
Electric Shower	10		
Hot Water Share			
Shower head	N/A		
Electric Shower	0%	INMETRO, Normative Instruction for the Energy Efficiency Class of Commercial Building INMETRO, 2016 – PBE Electric shower product list	Average cold water temperature for hotels across a range of climate zones is 20.4 °C, while average temperature rise for tested showerheads was 25.6 °C in max condition, 10 °C in min condition, for an average of 17.8 °C
Price of fixture in the market (BRL)			
Shower head	1,106	BONDFARO comparison shopping site	Average of lowest prices of models on the market found by Bondfaro
Electric Shower	110		
Energy embedded in water desalination; treatment; pumping; waste processing (TWh)	12.9 (11.5 TWh for pumping and 1.4 TWh for waste processing)	SNIS, 2018 – Water Diagnostics in Brazil	The data considers almost all water companies operating in Brazil.
Residential water rates (BRL/kL)	3.97	SNIS, 2018 – Water Diagnostics in Brazil	The average tariff is calculated from the total costs of the water distribution for the volume of water distributed
Residential electricity rate (BRL /kWh)	0.78	ANEEL, 2020 – ANEEL Reports[39]	The average rate is calculated by weighting the average tariff for each electric company by its number of customers (Number of costumers per electric company / total number of costumers * average rate per electric company)
Residential gas rates (BRL/m3)	1.79–4.81	COMGAS, 2020 – Natural Gas Rates for Residential Use (according to volume consumption per month)[40]	Residential rates of COMGAS, the biggest gas company in Brazil Includes monthly charge: • 9.12 R$/month + 1.79 R$/m³ • 14.04 R$/month + 4.81 R$/m³

[38] EPE – Empresa Brasileira de Energia (2014). Nota Tecnica DEA 26/14. Rio de Janeiro, Brazil, December 2014.
[39] ANEEL - Brazilian Electricity Regulatory Agency (2020). Energy rates for residential households. Brasilia, Brazil, April 2020.
[40] COMGAS SA – Gas rates for residential households. Sao Paulo, Brazil, April 2020.



Annex

List of Acronyms

ACRONYM	DEFINITION
ABRASOL	Brazilian Association of Solar Thermal Energy
ABNT	Brazilian Association of Technical Standards
ABRINSTAL	Brazilian Association for the Conformity and Efficiency of Facilities
ABSOLAR	Brazilian Association of Photovoltaic Solar Energy
ANA	National Water Agency
ANEEL	Brazilian Electricity Regulatory Agency
CBCS	Brazilian Council on Sustainable Construction
CGIEE	Energy Efficiency Indicators Steering Committee
CNRH	National Water Resources Council
EPE	National Energy Research Company
IBGE	Brazilian Institute of Geography and Statistics
ICS	Institute for Climate and Society
IPTU	Urban Property and Territorial Tax
INMETRO	National Institute of Metrology Standardization and Industrial Quality
LEED	Leadership in Energy and Environmental Design
MCID	Ministry of Cities
MDR	Ministry of Regional Development
MME	Ministry of Mines and Energy
MEPS	Minimum Energy Performance Standard
NBR	Norma Brazileira Registrada Brazilian National Standard
PBE	Programa Brasileiro de Etiquetagem Brazilian Labeling Program
PIA	Annual Industrial Survey
PNRH	National Policy for Water Resources
PPH	Electrical Appliances Possession and Usage Habits Research for the Residential Sector
PROCEL	National Electrical Energy Conservation Program
SNIS	National Sanitation Information System
SNIRH	National Water Resources System
SNS	National Sanitation Secretariat
USD	United States Dollar

GUIDANCE ON SETTING WATER EFFICIENCY STANDARDS FOR FAUCETS AND SHOWERHEADS

CLASP has developed the following general guidance for setting new water efficiency standards based on experiences in the United States, where water efficiency standards have been in place since 1994. These recommendations should be adapted to the country context and requirements but can serve as a starting point for analysis and discussions.

Product Types for Coverage

We recommend including faucets/taps, showerheads, and replacement aerators within the scope of any water efficiency standards. Faucets and showerheads are the water fixtures/fittings that typically deliver hot water, so regulating their flow rates will deliver not just water but also CO_2 emissions reductions due to reduced energy use for water heating.

We recommend consolidating products into fewer classes/types with clear definitions to eliminate confusion and potential loopholes. Also, fewer product types will simplify manufacturer stocking, as manufacturers will only have to keep one type of aerator for all configurations of the same fixture (e.g., overhead and handheld showers).

We also recommend including replacement aerators within the scope of the standard as labeling these will promote correct replacement[41]

Pressure Conditions for Testing

We recommend testing performance across a several pressure conditions between 1 and 7 bar (0.1 to 0.7 MPa) to reflect performance across a range of pressure conditions in plumbing installations, from gravity-fed rooftop tanks (as low as 1 bar) to high-pressure water mains (7 bar).

Maximum Flow Rate Requirements

While maximum flow rate requirements will depend on local conditions, including national water, energy, and CO2 reduction goals and availability of efficient products, the following requirement levels can serve as a starting point for analysis and discussions.

FIXTURE	MAXIMUM FLOW RATE (L/min)	% OF MODELS MEETING SIMILAR VOLUNTARY REQUIREMENT IN THE UNITED STATES[42]	FLOW RATE FOR HIGH-PERFORMANCE DESIGNATION (L/min)
Faucet	6	84%	4
Showerhead	8	73%	6

As can be seen in the table above, fixtures that meet the above requirements are widely available in the global market due to popular voluntary EPA WaterSense specifications in the United States. High-performance requirements are based on the top efficiency of products in the Australia/New Zealand WELS product database.[43]

Applicability of Requirements

We recommend that fixtures meet requirements over the full range of pressure conditions in plumbing installations, as tested above. In addition to maximum flow rate requirements for water efficiency, requirements should require that fixtures maintain a minimum flow rate to guarantee performance and user satisfaction. Example requirements are shown below:

The flow rate shall be:

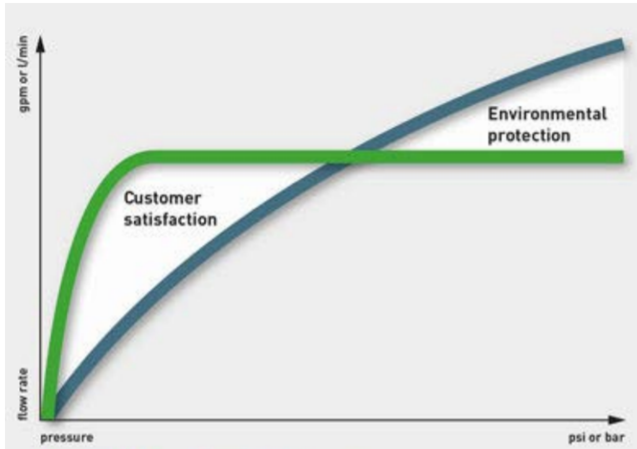
1. Less than or equal to the applicable maximum flow rate (in liters per minute) shown in <REQUIREMENTS TABLE> at all of the tested pressure conditions
2. Greater than or equal to 90% of the intended flow rate, when measured at 0.2 MPa (minimum flow rate)
3. Greater than or equal to 70% of the intended flow rate, when measured at 0.1 MPa (minimum flow rate)

[41] California Code of Regulations, Title 20, Section 1605.3(h)(2)

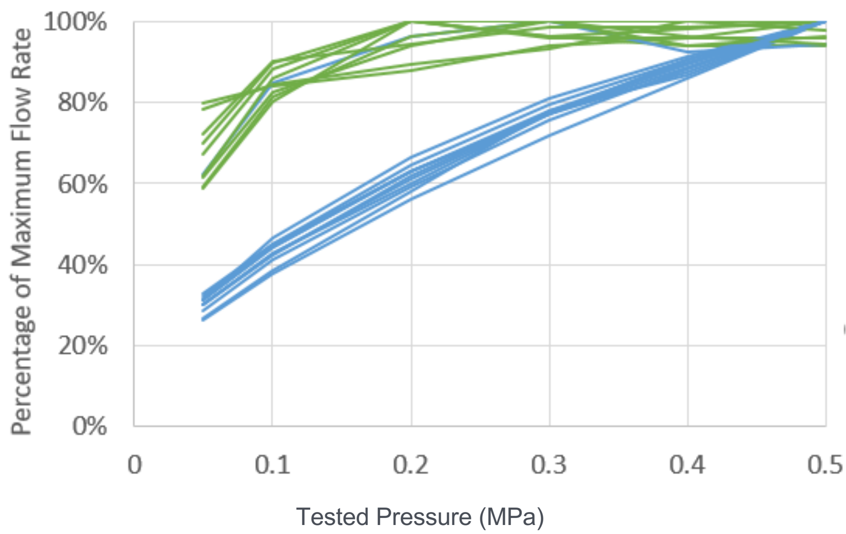
[42] Mauer, deLaski, and DiMascio. "States Go First 2020 Assumptions update".

[43] Australian Government, Water Rating Product Search, accessed August 31, 2020.

Excessively low flow rate at low pressure was a concern with early water-saving fixtures using fixed-orifice aerators. This is illustrated in the figure below[44], with the green line showing the desired performance that maintains a satisfactory flow rate across a range of pressures. The blue line is a traditional fixed-orifice aerator which may meet a flow-rate specification at one pressure, but deliver unsatisfactory flow at lower pressures while wasting water at higher pressures.



In practice, satisfactory performance at a range of pressures is achieved with pressure-compensating orifices, which reduce flow at higher pressures. Pressure compensation is used by all global plumbing brands in both faucets and showerheads. Manufacturer-reported performance curves for an Indian manufacturer of lavatory faucets are shown below, showing the pressure-compensating orifices maintaining flow rate across a range of pressures (green), in contrast to fixed orifice (blue).



Other Requirements:

Spray Force and Coverage

As flow rate decreases, maintaining sufficient force and coverage will ensure customer satisfaction with water efficient fixtures. The WaterSense voluntary specification in the US has the following requirements for minimum performance for spray force and coverage, based on the American Society of Mechanical Engineers (ASME) standard A112.18.1.

1. The minimum spray force for high-efficiency showerheads and hand-held showers shall not be less than 2.0 ounces (0.56 newtons [N]) at a flowing pressure of 20 ± 1 psi (140 ± 7 kPa) at the inlet. 4.1.2.
2. The minimum spray force for high-efficiency rain showers shall not be less than 1.4 ounces (0.40 N) at a flowing pressure of 20 ± 1 psi (140 ± 7 kPa) at the inlet.

[44] Gary Klein, "Flow Rates for Faucets, Showers and Tub/Shower Combination Valves", ACEEE Hot Water Forum presentation, p. 11.

3. The total combined maximum volume of water collected in the 2- and 4-inch (50-, 101-millimeter [mm]) annular rings shall not exceed 75 percent of the total volume of water collected, and;
4. The total combined minimum volume of water collected in the 2-, 4-, and 6-inch (50-, 101-, 152-mm) annular rings shall not be less than 25 percent of the total volume of water collected.[45]

As an alternative to minimum requirements, standards organizations can consider labeling with icons depicting different ranges of spray force and coverage performance on the label to allow customers to choose showerheads to meet their preferences (e.g., harder stream versus mist).

Multiple Showerheads

The following requirement addresses the risks of a situation where multiple showerheads are added to a shower to avoid standards:

> The total flow rate for showerheads with multiple nozzles must be less than or equal to the maximum flow rate in <REQUIREMENTS TABLE> when any or all the nozzles are in use at the same time[46]

Multiple Modes

We suggest that operation of multi-function equipment be precisely specified during test to avoid ambiguity or loopholes (e.g., mist or massage settings on showers, temporary pot-filling mode on kitchen faucets). This ensures that the typical mode is tested while still allowing for some product features that may temporarily use more water.

> If the product has multiple modes of operation, the test shall be conducted in the product's normal mode, as indicated with a label, or for temporary modes, the default mode.

Anti-Tampering

We recommend adding anti-tampering requirements to ensure water savings throughout the life of the fixture. Requirements can take the form of warnings or mechanical impediments to retain the original water-efficient aerator. An example of a warning requirement is shown below

> The fitting shall not be packaged, marked, or provided with instructions directing the user to an alternative water-use setting that would override reported flow rate.
>
> Any instruction related to the maintenance of the product, including changing or cleaning faucet accessories, shall direct the user on how to return the product to its intended maximum flow rate.
>
> Accessory, as defined in ASME 112.18.1/CSA B125.1, means a component that can, at the discretion of the user, be readily added, removed, or replaced, and that, when removed, will not prevent the fitting from fulfilling its primary function. For the purpose of this specification, an accessory can include, but is not limited to lavatory faucet flow restrictors, flow regulators, aerator devices, and laminar devices.[47]

45 EPA WaterSense, "High-Efficiency Lavatory Faucet Specification", Version 1.0, October 1, 2007, pp. 2-3.
46 California Code of Regulations, Title 20, Section 1605.3, Table H-5.
47 EPA WaterSense, "High-Efficiency Lavatory Faucet Specification", Version 1.0, October 1, 2007, pp. 1-2.

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