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ON THE TEMPERATURE CONVERSION IN MEASURING NATURAL GAS VOLUMES FOR HOUSEHOLD CONSUMERS

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Abstract. *This study evaluates the technical and economic feasibility of implementing a temperature conversion factor in all consumer measurers in a Brazilian metropolitan region. Residential consumer measurers of the natural gas network are volumetric, and diaphragm-type; therefore, they are impacted by the ambient temperature fluctuations, but no conversion is practiced. Natural gas distribution companies operate with volumes of gas expressed in standard-state conditions, complying with the regulations in force. The volumes of gas received in the Regulating Measuring Stations (RMSs) are converted to the standard state, but for the small consumers, their gas volume mechanical meters do not permit to apply conversions. Consequently, there are differences between the converted gas volumes received through the RMSs and the gas volumes delivered to the small consumers. The conversion factors for gas volume measurements are often determined based on the annual average values of the atmospheric pressure and ambient temperature. Here, they were generated on an hourly base and a comparison was performed between using hourly or average values. Hourly ambient temperatures were obtained from the nearest weather station, as an hourly average within at least a ten-year period. This study assumes that the measurer is located indoors, so the occasional heating due to sunlight exposure is not considered. For the low-consumption homes, there is not a satisfactory cost-benefit relation in implementing the temperature conversion, since the meters have a fixed rate for minimum consumption and the measurement error would be included. On the other hand, the economic feasibility of inserting temperature conversions was achieved for commercial natural gas consumers. The gas utilities in Brazil are equipped, almost in their entirety, with mechanical gas meters. An obvious and high-cost solution is to replace all mechanical gas meters with others that enable temperature conversion. The proposed methodology for reducing the errors associated with using mechanical gas meters for domestic consumers is a viable alternative for faster and more effective measures.*

Keywords: *Natural gas network, natural gas, gas volume conversion, volumetric gas meter*

1. INTRODUCTION

This study evaluates the technical and economic feasibility of implementing a temperature conversion factor for all consumer measurers in the metropolitan region of Rio de Janeiro. Residential consumer measurers of the natural gas network are volumetric, and diaphragm-type; therefore, they are impacted by ambient temperature fluctuations, but no conversion is practiced. Natural gas distribution companies operate with volumes of gas expressed in standard-state conditions, complying with the regulations in force. The volumes of gas received in the Regulating Measuring Stations (RMSs) are converted to the standard state; however, for the small consumers, their gas volume mechanical meters do not permit to apply conversions. Consequently, there are differences between the converted gas volumes received through the RMSs and those delivered to small consumers.

Sorin et al. (2008) discussed the issues of gas metering with household meters and highlighted some factors that affect the accuracy of metering measurements. They analyzed the loss of used gas volume due to systematic faults in domestic gas meters in Romania. Examples provided in their study demonstrated that such problems can lead to significant commercial losses for gas suppliers. The authors proposed measures to address these shortcomings and enhance the economic efficiency of gas supply companies. Other studies, such as Mihai et al. (2008) and Atabaeva et al. (2022), also investigated similar issues in cold climates where natural gas consumption for space heating is substantial. The literature lacks of similar studies in tropical climates. Natural gas consumption for space heating is scarce in Brazil, with prevailing cooking and domestic water heating usage.

2. METHODOLOGY

This study assumes that the measurer is indoors, so the occasional heating due to sunlight exposure is not considered.

The mathematical method for converting gas volumes delivered at a pressure **p** and a temperature **T** into standard state volumes is known as conversion, and the resulting gas volumes are referred to as converted volumes (**Vc**). The conversion is performed using the Equation (1) (Mihai et al., 2008). The conversion factor **FC** is the ratio of **Vc** and **V**.

$$Vc = V * \left[\frac{Zs}{Z}\right] * \left[\frac{p}{ps}\right] * \left[\frac{Ts}{T}\right], \tag{1}$$

Where **V** is the measured volume, **Z** is the compressibility factor, **ps** is the reference pressure, **Ts** is the reference temperature, and **Zs** is the compressibility factor at the reference state, which is considered equal to unity.

Sorin et al. (2008) calculated the natural gas compressibility factors using the correlations of Hall-Yarborough (Z1), Dranchuck Abu Kassem (Z2), Dranchuck Purvis Robinson (Z3), Papay (Z4), and Istomin (Z5), through a specialized software elaborated by the Hydraulics, Thermodynamics and Reservoir Engineering Department team from Caransebes. Table 1 reproduces the conversion factors from Sorin et al. (2008) for temperatures of 10, 20, and 40°C, chosen to represent the minimum, reference, and maximum ambient temperatures typically encountered in the city of Rio de Janeiro. The study acknowledges that temperatures outside of this range are infrequent on an annual basis. Therefore, this correction is neglected in this study.

Table 1. Natural gas compressibility factors, adapted from Sorin et al. (2008).

T (°C)	**Z1**	**Z2**	**Z3**	**Z4**	**Z5**
10	0.9975	0.9959	0.9976	0.9943	0.997
20	0.9978	0.9962	0.9979	0.9945	0.9974
40	0.9983	0.9966	0.9983	0.9949	0.9981
% of influence of the Z correction factor.	0.05011%	0.04015%	0.04008%	0.04022%	0.07018%

The gas network pressure fluctuates, decreasing as gas consumption increases, and is then restored through the gas network automation. The network gauge pressure of 2,157 Pa was considered, adding 10% to the value presented by Pallottino et al. (2008) as the pressure required by domestic natural gas appliances. The pressure conversion factor reached 1.0213%.

To assess the isolated impact of temperature, standard atmospheric pressure was assumed for the gas network, and the converted volume for the temperature **Vc (T)** was calculated using Equation (2). The temperature conversion factor **FC (T)** is the ratio of **Vc (T)** and **V**.

$$Vc\ (T) = V * \left[\frac{Ts}{T}\right], \tag{2}$$

The conversion factors for gas volume measurements are often determined based on the annual average ambient temperature and atmospheric pressure. In this study, conversion factors were generated hourly, and a comparison was performed using hourly, monthly, or yearly average values. Monthly average hourly ambient temperatures presented in Table 2 came from Silva (2019), who calculated them between 2008 and 2018 from the São Cristóvão weather station of the Precipitation Monitoring System from the Rio de Janeiro City Hall (ALERTA RIO, 2022).

Table 2. Monthly average hourly temperature (ºC) within 2008-2018, adapted from Silva (2019).

Time	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual average**
0-1	26.6	27.0	25.7	24.5	22.1	21.1	21.1	21.2	22.1	22.2	24.0	25.6	23.6
1-2	26.3	26.6	25.5	24.2	21.8	20.9	20.8	20.9	21.8	22.0	23.8	25.3	23.3
2-3	26.1	26.4	25.4	24.0	21.6	20.6	20.6	20.7	21.6	21.8	23.6	25.1	23.1
3-4	26.0	26.1	25.2	23.8	21.4	20.4	20.4	20.5	21.4	21.5	23.6	24.8	22.9
4-5	25.7	25.9	25.0	23.7	21.3	20.2	20.3	20.3	21.3	21.5	23.3	24.7	22.8
5-6	25.6	25.9	24.9	23.6	21.2	20.1	20.2	20.2	21.2	21.5	23.3	24.7	22.7
6-7	25.7	26.2	25.1	23.7	21.1	20.1	20.1	20.2	21.5	21.9	23.6	24.9	22.8
7-8	26.4	27.0	26.0	24.5	21.9	20.7	20.7	21.1	22.4	22.7	24.3	25.7	23.6
8-9	27.3	28.1	26.9	25.3	22.9	21.8	21.6	22.1	23.4	23.5	25.1	26.5	24.5
9-10	28.2	29.1	27.8	26.1	23.7	22.6	22.4	22.9	24.3	24.3	25.9	27.4	25.4
10-11	29.2	30.1	28.8	26.9	24.3	23.2	23.1	23.7	25.1	25.1	26.6	28.3	26.2
11-12	30.1	31.0	29.5	27.7	25.2	24.0	24.0	24.6	25.9	25.8	27.2	29.0	27.0
0-1	30.7	31.6	30.0	28.5	25.8	24.6	24.7	25.3	26.5	26.3	27.6	29.6	27.6
1-2	31.2	31.9	30.1	28.5	26.1	25.0	25.0	25.5	26.7	26.4	27.7	29.9	27.8
2-3	31.2	31.8	29.8	28.2	26.1	25.1	25.0	25.5	26.4	26.2	27.6	29.8	27.7
3-4	30.9	31.4	29.2	27.7	25.6	24.9	24.8	25.2	26.0	25.8	27.3	29.3	27.3
4-5	30.3	30.7	28.6	27.0	25.0	24.3	24.2	24.6	25.4	25.3	26.8	28.8	26.8
5-6	29.6	30.0	27.9	26.2	24.3	23.4	23.4	23.9	24.7	24.8	26.3	28.0	26.0
6-7	28.8	29.3	27.3	25.8	23.9	23.0	22.8	23.3	24.2	24.2	25.8	27.4	25.5
7-8	28.2	28.7	27.0	25.6	23.6	22.6	22.6	23.0	23.8	23.8	25.4	27.0	25.1
8-9	27.8	28.3	26.7	25.4	23.3	22.3	22.2	22.6	23.4	23.4	25.1	26.7	24.8
9-10	27.5	27.9	26.4	25.1	23.0	22.0	21.9	22.2	23.0	23.1	24.8	26.4	24.4
10-11	27.2	27.5	26.2	24.8	22.7	21.7	21.6	21.8	22.7	22.8	24.6	26.1	24.1
11-12	26.9	27.2	25.9	24.6	22.4	21.4	21.3	21.5	22.4	22.5	24.3	25.9	23.9
Month Average	28.1	28.6	27.1	25.6	23.4	22.3	22.3	22.6	23.6	23.7	25.3	27.0	-
Annual Average	25.0	-	-	-	-	-	-	-	-	-	-	-	-

To demonstrate the impact of temperature associated with consumption patterns, a gas volume of 16 m^3 was selected. The hottest month, February, was selected for applying the required temperature conversions. Figure 1 illustrates the monthly average hourly temperatures for February and the three daily gas delivery profiles considered in this study. The delivered gas volumes were converted and compared hourly to their original values using relative errors calculated with the delivery volume as the reference. This process was repeated. In the first, the pressure conversion factor was inserted. In the second, the monthly average temperature replaced hourly values without applying the pressure conversion factor. The calculated error was then compared with the limits set by the Ordinance n° 156 (INMETRO, 2022), as reproduced in Table 3.

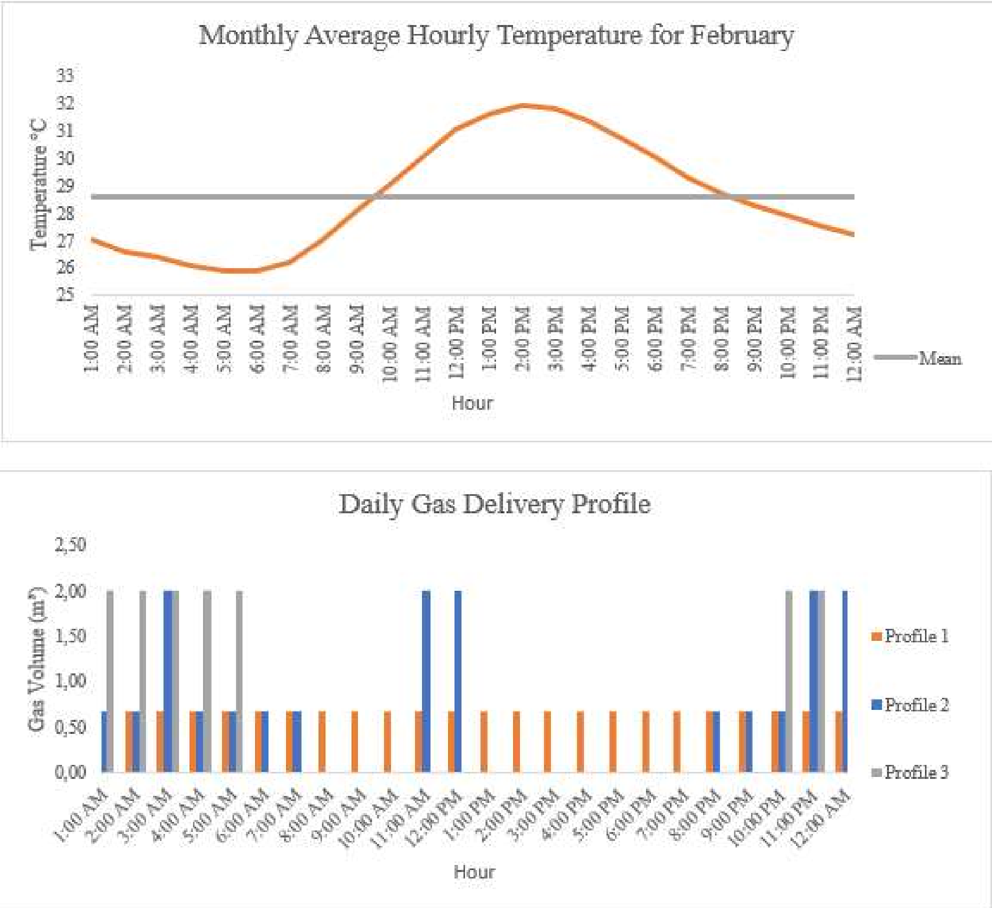

Figure 1. Monthly average hourly temperature for February and daily gas delivery profiles

Table 3. Maximum permissible errors, reproduced from Ordinance n° 156 (INMETRO, 2022).

Flow range Q	Subsequent Verification
Qmin≤Q<Qt	± 6%
Qt≤Q e ≤Qmax	± 3%

Where **Q** is the measured flow rate, **Qmin** and **Qmax** are the lower and upper limits of the flowmeter range, and **Qt** is the midpoint of the measuring range.

3. RESULTS

Tables 4, 5, and 6 present the hourly delivery and converted gas volumes, the temperature, and the overall conversion factor with the corresponding relative errors, respectively for the gas delivery profiles 1, 2, and 3 shown in Figure 1. The daily converted volumes, using the overall conversion factors for delivery profiles 1, 2, and 3, were 15.88, 15.91, and 15.97 m³, respectively, resulting in corresponding daily average relative errors of 0.76, 0.57, and 0.19%.

It can be observed that errors increase with the ambient temperature. This is due to consumption patterns combined with temperature evolution. The correction is applied only when the supplied gas volume is non-zero; thus, the conversion factors and relative errors vary accordingly. Considering the gas delivery profile 1, Tables 7, 8, and 9 display the converted gas volumes, the overall and the temperature conversion factors with the corresponding relative errors, respectively calculated using the yearly average hourly temperature, their month, and annual averages.

Table 4. Delivery and converted gas volumes, temperature conversion factor, overall conversion factor, and relative errors for gas delivery profile 1.

Time	V (m³)	CF (T)	Vc (T) (m³)	Error (%)	CF	Vc (m³)	Error (%)
0-1	0.67	0.97668	0.65	2.39	0.99747	0.66	0.25
1-2	0.67	0.97798	0.65	2.25	0.99880	0.67	0.12
2-3	0.67	0.97863	0.65	2.18	0.99947	0.67	0.05
3-4	0.67	0.97962	0.65	2.08	1.00047	0.67	-0.05
4-5	0.67	0.98027	0.65	2.01	1.00114	0.67	-0.11
5-6	0.67	0.98027	0.65	2.01	1.00114	0.67	-0.11
6-7	0.67	0.97929	0.65	2.11	1.00014	0.67	-0.01
7-8	0.67	0.97655	0.65	2.40	0.99734	0.66	0.27
8-9	0.67	0.97324	0.65	2.75	0.99395	0.66	0.61
9-10	0.67	0.97005	0.65	3.09	0.99070	0.66	0.94
10-11	0.67	0.96684	0.64	3.43	0.98743	0.66	1.27
11-12	0.67	0.96380	0.64	3.76	0.98432	0.66	1.59
0-1	0.67	0.96187	0.64	3.96	0.98235	0.65	1.80
1-2	0.67	0.96104	0.64	4.05	0.98150	0.65	1.88
2-3	0.67	0.96140	0.64	4.01	0.98187	0.65	1.85
3-4	0.67	0.96265	0.64	3.88	0.98315	0.66	1.71
4-5	0.67	0.96470	0.64	3.66	0.98524	0.66	1.50
5-6	0.67	0.96701	0.64	3.41	0.98760	0.66	1.26
6-7	0.67	0.96925	0.65	3.17	0.98988	0.66	1.02
7-8	0.67	0.97118	0.65	2.97	0.99185	0.66	0.82
8-9	0.67	0.97247	0.65	2.83	0.99317	0.66	0.69
9-10	0.67	0.97376	0.65	2.69	0.99449	0.66	0.55
10-11	0.67	0.97505	0.65	2.56	0.99581	0.66	0.42
11-12	0.67	0.97603	0.65	2.46	0.99681	0.66	0.32

Table 5. Delivery and converted gas volumes, temperature conversion factor, overall conversion factor, and relative errors for gas delivery profile 2.

Time	V (m³)	CF (T)	Vc (T) (m³)	Error (%)	CF	Vc (m³)	Error (%)
0-1	0.67	0.97668	0.65	2.39	0.99747	0.66	0.25
1-2	0.67	0.97798	0.65	2.25	0.99880	0.67	0.12
2-3	2.00	0.97863	1.96	2.18	0.99947	2.00	0.05
3-4	0.67	0.97962	0.65	2.08	1.00047	0.67	-0.05
4-5	0.67	0.98027	0.65	2.01	1.00114	0.67	-0.11
5-6	0.67	0.98027	0.65	2.01	1.00114	0.67	-0.11
6-7	0.67	0.97929	0.65	2.11	1.00014	0.67	-0.01
7-8		0.97655	0.00	-	0.99734	0.00	-
8-9		0.97324	0.00	-	0.99395	0.00	-
9-10		0.97005	0.00	-	0.99070	0.00	-
10-11	2.00	0.96684	1.93	3.43	0.98743	1.97	1.27
11-12	2.00	0.96380	1.93	3.76	0.98432	1.97	1.59
0-1		0.96187	0.00	-	0.98235	0.00	-
1-2		0.96104	0.00	-	0.98150	0.00	-
2-3		0.96140	0.00	-	0.98187	0.00	-
3-4		0.96265	0.00	-	0.98315	0.00	-
4-5		0.96470	0.00	-	0.98524	0.00	-
5-6		0.96701	0.00	-	0.98760	0.00	-
6-7		0.96925	0.00	-	0.98988	0.00	-
7-8	0.67	0.97118	0.65	2.97	0.99185	0.66	0.82
8-9	0.67	0.97247	0.65	2.83	0.99317	0.66	0.69
9-10	0.67	0.97376	0.65	2.69	0.99449	0.66	0.55
10-11	2.00	0.97505	1.95	2.56	0.99581	1.99	0.42
11-12	2.00	0.97603	1.95	2.46	0.99681	1.99	0.32

Table 6. Delivery and converted gas volumes, temperature conversion factor, overall conversion factor, and relative errors for gas delivery profile 3.

Time	V (m³)	CF (T)	Vc (T) (m³)	Error (%)	CF	Vc (m³)	Error (%)
0-1	2.00	0.97668	1.95	2.39	0.99747	1.99	0.25
1-2	2.00	0.97798	1.96	2.25	0.99880	2.00	0.12
2-3	2.00	0.97863	1.96	2.18	0.99947	2.00	0.05
3-4	2.00	0.97962	1.96	2.08	1.00047	2.00	-0.05
4-5	2.00	0.98027	1.96	2.01	1.00114	2.00	-0.11
5-6		0.98027	0.00	-	1.00114	0.00	-
6-7		0.97929	0.00	-	1.00014	0.00	-
7-8		0.97655	0.00	-	0.99734	0.00	-
8-9		0.97324	0.00	-	0.99395	0.00	-
9-10		0.97005	0.00	-	0.99070	0.00	-
10-11		0.96684	0.00	-	0.98743	0.00	-
11-12		0.96380	0.00	-	0.98432	0.00	-
0-1		0.96187	0.00	-	0.98235	0.00	-
1-2		0.96104	0.00	-	0.98150	0.00	-
2-3		0.96140	0.00	-	0.98187	0.00	-
3-4		0.96265	0.00	-	0.98315	0.00	-
4-5		0.96470	0.00	-	0.98524	0.00	-
5-6		0.96701	0.00	-	0.98760	0.00	-
6-7		0.96925	0.00	-	0.98988	0.00	-
7-8		0.97118	0.00	-	0.99185	0.00	-
8-9		0.97247	0.00	-	0.99317	0.00	-
9-10	2.00	0.97376	1.95	2.69	0.99449	1.99	0.55
10-11	2.00	0.97505	1.95	2.56	0.99581	1.99	0.42
11-12	2.00	0.97603	1.95	2.46	0.99681	1.99	0.32

Table 7. Yearly average hourly values of converted gas volumes, temperature conversion factor, overall conversion factor, and relative errors for gas delivery profile 1.

Time	FC (T)	Vc (T) (m³)	Error (%)	FC	Vc (m³)	Error (%)
0-1	0.98787	15.8059	1.23	1.00890	16.1424	-0.88
1-2	0.98878	15.8206	1.13	1.00983	16.1573	-0.97
2-3	0.98945	15.8312	1.07	1.01052	16.1683	-1.04
3-4	0.99012	15.8419	1.00	1.01120	16.1792	-1.11
4-5	0.99065	15.8504	0.94	1.01174	16.1878	-1.16
5-6	0.99087	15.8540	0.92	1.01197	16.1915	-1.18
6-7	0.99040	15.8464	0.97	1.01148	16.1837	-1.14
7-8	0.98778	15.8045	1.24	1.00881	16.1410	-0.87
8-9	0.98475	15.7560	1.55	1.00572	16.0915	-0.57
9-10	0.98201	15.7121	1.83	1.00291	16.0466	-0.29
10-11	0.97930	15.6688	2.11	1.00015	16.0023	-0.01
11-12	0.97665	15.6264	2.39	0.99744	15.9591	0.26
0-1	0.97476	15.5961	2.59	0.99551	15.9281	0.45
1-2	0.97399	15.5838	2.67	0.99472	15.9156	0.53
2-3	0.97434	15.5894	2.63	0.99508	15.9212	0.49
3-4	0.97557	15.6090	2.50	0.99633	15.9413	0.37
4-5	0.97748	15.6397	2.30	0.99829	15.9727	0.17
5-6	0.97981	15.6769	2.06	1.00066	16.0106	-0.07
6-7	0.98164	15.7062	1.87	1.00254	16.0406	-0.25
7-8	0.98287	15.7260	1.74	1.00380	16.0607	-0.38
8-9	0.98400	15.7440	1.63	1.00495	16.0792	-0.49
9-10	0.98507	15.7612	1.52	1.00604	16.0967	-0.60
10-11	0.98607	15.7771	1.41	1.00706	16.1130	-0.70
11-12	0.98701	15.7921	1.32	1.00802	16.1283	-0.80

Table 8. Monthly average converted gas volumes, temperature conversion factors, overall conversion factors, and relative errors for gas delivery profile 1.

Month	FC (T)	Vc (T) (m³)	Error (%)	FC	Vc (m³)	Error (%)
Jan	0.97324	15.5719	2.75	0.99396	15.9034	0.61
Feb	0.97161	15.5457	2.92	0.99229	15.8767	0.78
Mar	0.97631	15.6209	2.43	0.99709	15.9534	0.29
Apr	0.98111	15.6978	1.93	1.00200	16.0320	-0.20
May	0.98869	15.8191	1.14	1.00974	16.1558	-0.96
Jun	0.99211	15.8738	0.79	1.01323	16.2118	-1.31
Jul	0.99227	15.8762	0.78	1.01339	16.2142	-1.32
Aug	0.99115	15.8584	0.89	1.01225	16.1960	-1.21
Sep	0.98777	15.8043	1.24	1.00880	16.1407	-0.87
Oct	0.98759	15.8014	1.26	1.00861	16.1378	-0.85
Nov	0.98219	15.7151	1.81	1.00310	16.0496	-0.31
Dec	0.97683	15.6293	2.37	0.99763	15.9620	0.24

Table 9. Annual average converted gas volume, temperature conversion factor, overall conversion factor, and relative errors for gas delivery profile 1.

Annual	FC (T)	Vc (T) (m³)	Error (%)	FC	Vc (m³)	Error (%)
-	0.98335	15.7337	1.69	1.00429	16.0686	-0.43

The Ordinance n° 156 (INMETRO, 2022) stipulates that for the accuracy class of diaphragm-type meters, in subsequent calibration, the equipment should comply with an allowable error of +/-6% at the lower limit of flow rate range and +/-3% at the midpoint and the upper flow rate limit of flow rate range.

Figure 2 presents a comparison of errors resulting from the application of temperature conversion factors, using the annual minimum, average, and maximum temperatures in the flow rates against the specified limits outlined in Ordinance n° 156 (INMETRO, 2022), where 20°C is the reference temperature, 15°C and 25°C are the lower and upper-temperature permissible limits. The last coincides with the annual average, and the annual minimum at 20.1°C is almost the reference temperature. In Figure 3, the overall replaced the temperature conversion factors.

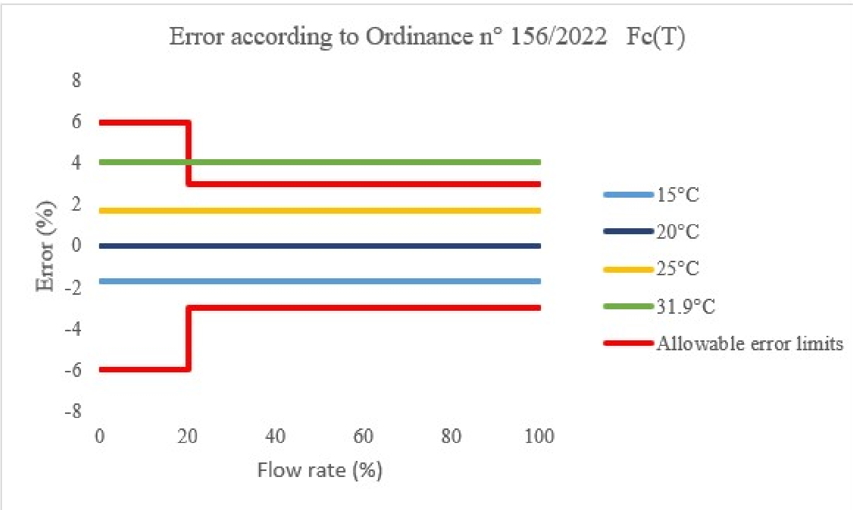

Figure 2. Errors in gas delivery at 15, 25 and 31.9 °C for **FC (T)**

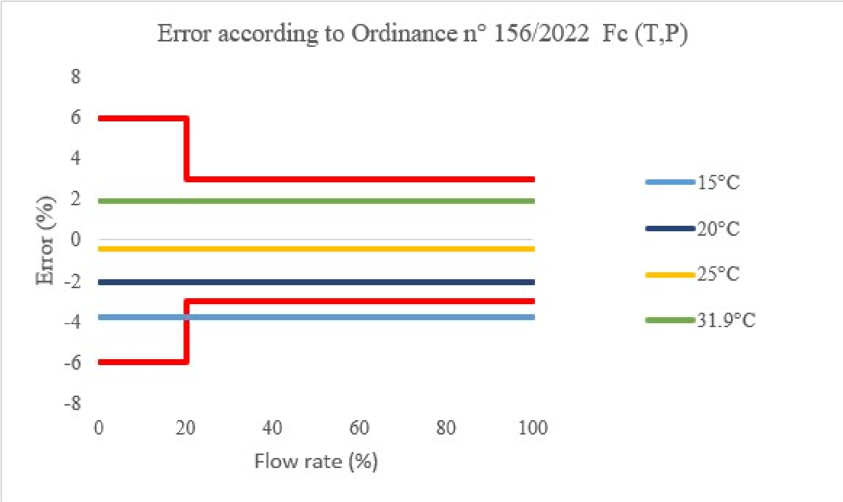

Figure 3. Errors in gas delivery at 15, 25 and 31.9 °C for **FC**

4. CONCLUSIONS

Although the lack of temperature conversion factors lead to errors overcoming the limits sets by the Ordinance n° 156 (INMETRO, 2022) for the hottest hours in Rio de Janeiro, the lack of pressure conversion factors compensate them. The combined effect brings the errors to within these limits. The household gas meters showed satisfactory results in the climate of Rio de Janeiro, where the hourly average is predominantly within a range of suitable behavior for these devices. Since the gas consumption follows a daily profile with seasonal fluctuations, hourly conversion factors are requested. The absolute errors are related to the volume consumed.

Gas distribution companies in Brazil are equipped, almost entirely, with mechanical gas meters. An obvious and high-cost solution would be to replace all mechanical gas meters with others that allow temperature conversion. The gas utility in Rio de Janeiro, charges a minimum monthly bill for natural gas equivalent to 7 m³/month, even when there is no consumption. This fee covers the cost of maintaining the infrastructure necessary for the gas supply, including meters, network, telephone service, emergency centers, and other related services (NATURGY, 2023). Therefore, for low-consumption homes, there is not a satisfactory cost-benefit relation in implementing temperature and pressure conversion. The economic viability for introducing temperature conversion can, however, be achieved for consumers when the hourly, monthly, or yearly variation is of great amplitude. It is suggested to continue the study for States with greater temperature variation, especially in the coldest ones, as there is a higher gas consumption with a more significant conversion factor.

The distribution sectors in Brazil for residential consumers are predominantly equipped with G1.6 to G2.5 diaphragm-type meters. The use of mechanical meters implies billing domestic consumers based on unconverted gas volumes. Since the gas volumes received by a gas distribution sector are expressed in converted volume, volumetric and financial balances are not defined. Alternatively, instead of replacing the actual household gas meters by new that incorporate temperature and pressure measurements, the conversion can be applied to the meter readings in the commercial department of the gas utility. The gas network pressure is available within its automation, and the metropolitan regions can be divided to use data from the nearest weather station. The proposed methodology for reducing errors associated with the use of mechanical gas meters for domestic consumers is a technical alternative for faster and more effective measurements.

The aforementioned considerations indicate the usefulness of a rigorous methodology for locations with external temperature variations outside the expected range and, consequently, the creation of conversion factors that minimize the impacts of these external factors on domestic consumers and distributors, serving as a basis for regulatory agency decisions.

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6. RESPONSIBILITY NOTICE

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