GREENHOUSE GAS EMISSIONS FROM THE FEDERAL JUSTICE OF BRAZIL: A STUDY BASED ON ELECTRICITY AND FUEL CONSUMPTION BETWEEN 2016 AND 2022

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ABSTRACT

Objective: The primary aim of the study was to examine the emissions of greenhouse gases by the Federal Justice from 2016 to 2022, arising from the consumption of fuels and electrical energy. Secondly, it sought to ascertain the variation of these emissions over time and their potential correlation with the workforce.

Theoretical Framework: There exist two methodologies to effectuate a lucid and transparent assessment of emissions; the one selected for this investigation was consumption-based accounting. In this vein, the Greenhouse Gas Protocol stratifies institutional emissions into three scopes, with the inquiry concentrating on Scope 1 and 2 emissions owing to the intricate data requisites for Scope 3 evaluation.

Method: Data were amassed and categorized by the geographic region of 34 Federal Justice units, analyzing the total CO2-equivalent emissions for fuels and electrical energy and correlating them with the total workforce strength.

Results and conclusion: The findings indicated total emissions of 6,549.35 t CO2-eq from fuel consumption and 89,670.76 t CO2-eq from electricity consumption. The Northeast region exhibited the highest greenhouse gas emissions per worker from fuel and electricity consumption. Moreover, a significant influence of the workforce on emissions was observed, with an R² of 67% for energy and 27.66% for fuels.

Implications of the research: It is emphasized the significance of integrated approaches that amalgamate energy efficiency and human resource management in diminishing greenhouse gas emissions, proposing additional strategic sustainability actions for the mitigation of emissions within the Federal Justice.

Originality/Value: The novelty of this study lies in its approach segmented by geographical regions, offering a detailed analysis of the GHG emissions associated with energy and fuel consumption and the relationship of these emissions with the workforce, thereby contributing to the literature on GHG emissions and sustainability in the public sector.

Keywords: Greenhouse Gases, Federal Justice, Electric Energy, Fuels.

EMISSÃO DE GASES DE EFEITO ESTUFA DA JUSTIÇA FEDERAL DO BRASIL. UM ESTUDO A PARTIR DO CONSUMO DE ENERGIA ELÉTRICA E DE COMBUSTÍVEIS ENTRE 2016 E 2022

RESUMO

Objetivo: O estudo teve como objetivo principal analisar as emissões de gases de efeito estufa pela Justiça Federal, entre 2016 e 2022, decorrentes do consumo de combustíveis e energia elétrica. Secundariamente, buscou verificar a variação dessas emissões ao longo do tempo e a possível correlação com a força de trabalho.

Referencial teórico: Podem ser utilizadas duas metodologias para estabelecer uma avaliação clara e transparente das emissões, a escolhida para este estudo foi a de contabilidade baseada no consumo. Nessa esteira, o Protocolo de GEE categoriza as emissões institucionais em três escopos, com a pesquisa focando nas emissões de Escopo 1 e 2 devido à complexidade dos dados exigidos para o Escopo 3.

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Método: Foram coletados dados de 34 unidades, agrupadas por região geográfica, analisando as emissões totais de CO2-equivalente para combustíveis e energia elétrica e correlacionando-as com a força de trabalho total.

Resultado e conclusão: Os resultados indicaram emissões de 6.549,35 t CO2-eq pelo consumo de combustíveis e de 89.670,76 t CO2-eq pelo consumo de energia elétrica. A região Nordeste teve a maior emissão de GEE per capita por consumo de combustível e de energia elétrica. Além disso, observou-se uma influência significativa da força de trabalho sobre as emissões, com um R² de 67% para energia e 27,66% para combustíveis.

Implicações da pesquisa: Sublinha-se a importância de abordagens combinadas que integrem eficiência energética e gestão de recursos humanos na redução das emissões de GEE, sugerindo outras ações estratégicas de sustentabilidade para a mitigação das emissões na Justiça Federal.

Originalidade/Valor: A originalidade do estudo reside na sua abordagem dividida por regiões geográficas, oferecendo uma análise detalhada das emissões de GEE associadas ao consumo de energia e combustíveis e a relação dessas emissões com a força de trabalho, contribuindo assim para a literatura sobre emissões de GEE e sustentabilidade no setor público.

Palavras-chave: Gases de Efeito Estufa, Justiça Federal, Energia Elétrica, Combustíveis.
1 INTRODUCTION

The escalation of global warming, triggered by greenhouse gas (GHG) emissions, calls for urgent action, as well as a thorough reassessment of energy and consumption practices across society. This transition from the current energy paradigm to a low-carbon resilient model is imperative for everyone. The challenge is amplified by the need for effective implementation of public policies and by the review of the responsibilities of all economic sectors, including the public administration. In the face of the climate crisis, public capital plays a central role in a transition, especially in times of economic uncertainty, through, among other actions, investments in green infrastructure and clean technologies (Davidescu, Popovici; & Strat, 2022).

In this regard, it should not be dispensed with to mention the IPCC's prescription in its AR6 report of a 43% reduction in global emissions by 2030 compared to 2019 levels, to limit the increase in global temperature by up to 1.5 °C (Lee et al., 2023). In this context, the transition to green development depends crucially on the regulatory and executive role of the state, which must not only establish but also implement effective policies for the promotion of sustainable technologies and practices with low environmental impact (Davidescu et al., 2022).

In the light of the above, the central objective of this study is to establish how to analyze greenhouse gas (GHG) emissions by the Federal Justice - JF, between 2016 and 2022, due to fuel and electric energy consumption. The first secondary objective is to check whether there are significant variations in emissions over the period or regions analyzed. The second secondary objective is to check whether there is a correlation between the workforce and GHG emissions, considering the possibility that the number of employees can directly influence GHG emissions volumes. Together, this study aims to contribute to the improvement of the socio-environmental strategies adopted by the Federal Court, aligning itself with broader objectives of sustainability advocated in international agreements and also with the Resolutions of the National Council of Justice, like Article 24, of CNJ Resolution n. 400 of 16 June 2021.
2 THEORETICAL FRAME

2.1 EMISSIONS BY SCOPE

To this end, the adoption of key policies must be accompanied by a rigorous and transparent evaluation of emissions. For this, there are two methods of assessing GHG emissions: production-based accounting and consumption-based accounting (Gallo et al., 2016; Davies, 2022). The first method focuses on emissions generated by the production of goods and services at the borders of a country, regardless of where those goods and services are consumed. This approach is traditionally used to create national GHG inventories and focuses on the direct emissions that occur within a country's territory. The second method analyzes GHG emissions attributed to goods and services consumed by a specific region or country, regardless of where they were manufactured. The latter, chosen to guide the present work, plays a vital role in emissions mitigation actions (Fernández-Amador; Oberdabernig; & Tomberger, 2022).

Another premise for this work was the development of emission analyzes from the GHG Protocol. This standard called the Greenhouse Gas Protocol was developed by the World Resources Institute and the World Council for Sustainable Development (WRI & WBCSD, 2004; Wiedmann & Barret, 2011; Gallo et al., 2016). Under this methodology, the assessment of institutional emissions is divided into three categories, which are also referred to as emission scopes.

Scope 1 emissions are those from sources owned or controlled by the organization, which are: gas heating systems, vehicle fleet, and gas leaks from refrigeration or air conditioning units (WRI; WBCSD, 2004). Scope 2 emissions include indirect emissions associated with the generation of electricity purchased and consumed by the organization (WRI & WBCSD, 2004). Scope 3 issues are all other issues that occur due to an organization's activities, but from sources that are not owned or controlled by an organization. This includes business travel, goods and services from external suppliers, or issues related to investments and use of any goods the organization may produce. Measuring these emissions is a major challenge due to the demand for information that is sometimes maintained by other bodies (WRI & WBCSD, 2004). This, incidentally, was the main reason why this study did not include Scope 3 emissions.
2.2 GHG EMISSIONS IN INTERNATIONAL PUBLIC ADMINISTRATIONS

Measuring and reporting emissions is essential for GHG mitigation. In this sense, public sector organizations need adequate data to understand the impact of their operations on emissions, allowing monitoring of the progress of reductions as well as external performance monitoring by stakeholders.

An example of recording GHG emissions from public organizations is the UK central government (Wiedmann & Barret, 2011; Davies, 2022). There are two findings in the report presented in 2022. The first is that there was an average annual decrease of 7.23% in total emissions between 2009 and 2020, and another is that the pattern of emissions also varied over this period. In 2008, it was noted that Scope 3 emissions accounted for the substantial majority of government units’ emissions, reaching 77% of the total emitted (Davies, 2022). In contrast, Scope 1 emissions were 13%, while Scope 2 emissions comprised 10% (Davies, 2022).

At the Spanish Ministry of Agriculture and Fisheries, Food and Environment (Miteco, 2018 as quoted in Virgens; Andrade; & Hidalgo, 2020), the 2016 report revealed that of the total analyzed, a small fraction, 4.9%, was attributed to Scope 1 emissions (mobile combustion, fuel consumption in buildings and air conditioning/cooling systems). There were no Scope 2 emissions thanks to the supply of electricity from renewable energy sources and high-efficiency cogeneration. The majority of emissions, 95.1%, corresponded to Scope 3, encompassing purchases and contracts (largest single emitter with 58%), travel, internal and external transportation, and waste management. This data reflects the significant challenge of managing indirect emissions that, while not directly generated by organizations' activities, are associated with their operations and their supply chain.

In Norway, according to Larsen et al. (2016), the public administration presents a GHG emissions distribution that also highlights the significant impact of indirect activities. Direct emissions, categorized as Scope 1, accounted for only 3% of emissions; Scope 2 accounted for 9%; and Scope 3 accounted for 88% of the total. This total Scope 3 emissions underscore the challenge and importance of addressing indirect sources for the effective emission management of organizations, both public and non-public.

In 2020, the European Union cataloged emissions according to economic activity, showing that fuel combustion accounted for the largest share of emissions, with 74.0% of the total (Eurostat, 2023). The transport sector, along with the energy industries, led with nearly identical percentages of 23.2% and 23.3%, respectively. Residences, trade and other
institutions, including government institutions, issued 15.4% (Eurostat, 2023). This overview emphasizes the predominance of the transport sector and energy industries in GHG emissions, which is why these were the sectors chosen for the sectoral evaluation of this study.

2.3 GHG EMISSIONS IN BRAZIL AND ITS PUBLIC ADMINISTRATION

In 2022, Brazil recorded 2.3 billion tons of gross CO₂-equivalent emissions, ranking as the sixth largest GHG emitter in the world (Tsai et al., 2023). The pattern of these emissions, however, differs significantly from the global pattern, reflecting the country's economic and environmental particularities (Imori; Guilloto; & Waisman, 2017). While overall industry and electricity are the largest emitters, accounting for 31% and 28% respectively, in Brazil, agriculture dominates with 74.3% of emissions, much due to the change in land use in the Amazon (Tsai et al., 2023; Climate Watch, 2023). Emissions from the electric power sector in Brazil are relatively low (4.5%) compared to the world standard, reflecting a cleaner energy matrix. Transport has a lower weight in Brazilian emissions, with 8.6%, against 16%, in world terms (Tsai et al., 2023; Climate Watch, 2023).

In the context of government emissions, the research conducted by Lima et al. (2014) showed that, at the Embrapa Vegetables Unit, the total emissions in 2012 were 455.59 t CO₂-equiv. Scope 1 emissions represented 69.6% of the total; Scope 2 emissions corresponded to 18.8%, and Scope 3 emissions reached 11.6% (Lima et al., 2014).

The analysis of the public records of the Brazilian GHG Protocol Program of the Federal Police, from 2008 to 2019, show that Scope 1 emissions constituted 75.95% of the total, reflecting the preponderance of direct emission sources (FGV, 2023). The mean Scope 2 emissions were 18.11% and Scope 3 emissions, on the other hand, accounted for only 5.94%, on average, of the emissions, indicating a lesser impact of the indirect activities of the corporation (FGV, 2023).

The University of Campinas, in the 2019 and 2020 inventories, reported total emissions of 3,564,388 t CO₂-equivalent and 1,825,220 t CO₂-equivalent, respectively. In the first year, Scope 1 emissions were 30.93%, Scope 2 emissions were only 0.20%, and Scope 3 emissions were 68.87%. In the subsequent year, the highest percentage of emissions was Scope 1 with 62.60%, Scope 2 with 0.42% of the total, and Scope 3 with 36.98% for Scope 3. This change is mainly due to a sharp drop in indirect Scope 3 emissions in 2020 due to the pandemic and a certain stability of emissions from the other two Scopes (Green Institute, 2021).
The Federal Justice Council in its 2022 emissions inventory pointed to a total emissions of 1,019,389 t CO$_2$-eq. Of the total, 13.96% were Scope 1, Scope 2 were 7.7% and 78.34% were Scope 3. Of Scope 1 emissions, fugitive emissions from the cooling system accounted for 86% of emissions. Of Scope 3 emissions, the majority of emissions come from server displacement (87%), which points to the need for mitigation regarding server and magistrate mobility (CJF, 2023).

2.4 THE FEDERAL COURTS OF BRAZIL

The JF was structured on the basis of Law No 100/2001. 5.010, of May 30, 1966, which defined the organization of Judicial Sections in each State, Territory and the Federal District, as well as the creation of the Council of Federal Justice. The aforementioned law provided for an initial structure with 44 federal rods distributed throughout Brazil. Currently JF consists of 824 branches and 179 federal special courts.

Currently the JF is divided into first and second degrees. The first degree is represented by the Judicial Chambers present in all the units of the federation. The second degree is composed of TRFs with headquarters in Brasilia, Rio de Janeiro, São Paulo, Porto Alegre and Recife. According to data from the Observatory of Federal Justice (2023), currently the Midwest region has 155 units, the Northeast has 332 units, the North has 81 units, the Southeast has 799 units and the South has 517 units of Federal Justice.

To compose the *per capita* analyzes of JF's emissions, the numbers of workers per geographic region were analyzed between 2016 and 2022, according to data from the PLS bank of CNJ (CNJ, 2023).

**Table 1**

*Total number of magistrates, servants and auxiliary labor force per geographic region and per year of the Federal Justice units.*

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Midwest</td>
<td>6,755</td>
<td>7,167</td>
<td>6,650</td>
<td>6,604</td>
<td>6,052</td>
<td>6,177</td>
<td>6,099</td>
<td>6,501</td>
</tr>
<tr>
<td>Northeast</td>
<td>9,577</td>
<td>9,654</td>
<td>10,017</td>
<td>9,314</td>
<td>9,076</td>
<td>9,193</td>
<td>9,261</td>
<td>9,442</td>
</tr>
<tr>
<td>North</td>
<td>3,109</td>
<td>3,137</td>
<td>3,113</td>
<td>2,831</td>
<td>2,778</td>
<td>2,704</td>
<td>2,706</td>
<td>2,911</td>
</tr>
<tr>
<td>Southeast</td>
<td>19,142</td>
<td>18,450</td>
<td>19,207</td>
<td>19,122</td>
<td>18,652</td>
<td>19,805</td>
<td>17,505</td>
<td>18,841</td>
</tr>
<tr>
<td>South</td>
<td>8,527</td>
<td>8,468</td>
<td>8,364</td>
<td>7,770</td>
<td>7,686</td>
<td>7,697</td>
<td>7,474</td>
<td>7,998</td>
</tr>
<tr>
<td><strong>ANNUAL TOTAL</strong></td>
<td>47,110</td>
<td>46,876</td>
<td>47,351</td>
<td>45,648</td>
<td>44,244</td>
<td>45,576</td>
<td>43,045</td>
<td></td>
</tr>
</tbody>
</table>
3 METHODOLOGY

3.1 MODEL

The calculation of emissions was performed using the methodology proposed by the Brazilian GHG Protocol Program, as operationalized by the tool made available by the Getúlio Vargas Foundation (FGV, 2023). The tool consolidates emission factors outlined in the IPCC guidelines for National Greenhouse Gas Inventories, as well as the requirements established by the Brazilian GHG Protocol Program and by EN 16258:2012, European standard on energy consumption, fuel and GHG emissions (Green Institute, 2021). Greenhouse Gas (GHG) emissions and removals are calculated for each source and sink individually. The equation used for this calculation is expressed as:

\[ E_{i,g,y} = DA_{i,y} \times FE_{i,g,y} \times GWP_g \]  

Where:

- \( E_{i,g,y} \) represents the GHG emissions or removals attributable to the source or sink \( i \) during the year \( y \), expressed in tons of CO\(_2\) equivalent (t CO\(_2\)-eq).
- The term ‘\( i \)’ corresponds to the index that identifies a specific activity of the source or sink under analysis, while ‘\( g \)’ denotes a specific type of GHG.
- The reference year for the report is represented by ‘\( y \)’.
- \( DA_{i,y} \) refers to the consolidated activity data for the source or sink \( i \) in year \( y \).
- \( FE_{i,g,y} \) is the emission or removal factor for GHG \( g \) applicable to the source or sink \( i \) in year \( y \), in GHG tons per unit (t GHG/u).
- \( GWP_g \) represents the global warming potential of GHG, converting emissions to tons of CO\(_2\) equivalent per ton of GHG (t CO\(_2\)-eq/t GHG), thus ensuring comparability between different greenhouse gases based on their global warming potential.

3.2 DATA SOURCES

Secondary data refer to the amounts of electric energy consumed and fuel (gasoline, diesel oil and ethanol) used by the official fleets of all the Judicial Sections, Federal Regional Courts and the Federal Justice Council, totaling 34 public bodies. The data was extracted from the electronic portal of the CNJ PLS database (CNJ, 2023).

The information was segmented by geographical region. The first reason for this is that the data would reflect climatic variations that may influence the energy consumption and mobility practices of the units analyzed. The second reason is to capture regional socio-
economic disparities affecting institutional infrastructure and logistics. The third reason is to allow for a more granular analysis that would reveal emission patterns and potential of specific interventions in light of the local and regional policies already adopted.

3.3 TOOL USED

With the energy and fuel consumption data, the individualized emissions were calculated for each type of fuel and for the electricity consumed using the intersectional tool of the Brazilian GHG Protocol Program for each of the years analyzed. The tool used by the Brazilian Program of the GHG Protocol provides calculations and emission factors for road, air, waterway and rail transport (FGV, 2023). For the calculation of emissions related to the purchase of electric energy, the tool used provides the total emissions based on the monthly emission factors of the Ministry of Science, Technology and Innovation (MCTI) of the Brazilian National Interconnected System, the Amazon Isolated System and other electric systems of the country (FGV, 2023).

4 RESULTS AND DISCUSSION

Despite global efforts to combat climate change at various international levels, projections point to an increase in short-term climate dangers across the planet, intensifying risks to ecosystems and humans (Lee et al., 2023). In this context, it is the role of the public administration not only to regulate and supervise, but also to act as an active agent in implementing adaptation strategies that aim to mitigate climate risks and foster present and future sustainable development.

4.1 EMISSIONS BY FUEL CONSUMPTION

The data in Table 2 indicate that there is significant variation in emissions between geographical regions (F =39.3767; p-value =3.2601E-10). In addition, there was a significant variation over the years (F =12.572; p-value = 2.1503E-06, critical F = 2.5081). If we take the years 2020 and 2021 from the analysis (COVID pandemic), the variation remains significant (F = 4.623; p value = 0.011; F critical = 3.006), if we consider 95% the confidence degree. This indicates that the GHG emissions varied significantly over the time analyzed.
Table 2

Emission of GHG by fuel consumption (gasoline, diesel oil and ethanol) by geographical region and by year (in t CO$_2$-eq) of Federal Justice units

<table>
<thead>
<tr>
<th>GEOGRAPHIC REGION</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
<th>2022</th>
<th>Total</th>
<th>Regional</th>
<th>Regional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Midwest</td>
<td>197.045</td>
<td>211.918</td>
<td>207.358</td>
<td>193.052</td>
<td>98.431</td>
<td>111.028</td>
<td>174.423</td>
<td>1,193.256</td>
<td>170.465</td>
<td>170.465</td>
</tr>
<tr>
<td>Northeast</td>
<td>460.026</td>
<td>385.816</td>
<td>354.728</td>
<td>372.249</td>
<td>155.837</td>
<td>178.187</td>
<td>251.241</td>
<td>2,158.084</td>
<td>308.298</td>
<td>146.406</td>
</tr>
<tr>
<td>North</td>
<td>82.282</td>
<td>83.004</td>
<td>72.615</td>
<td>88.147</td>
<td>31.401</td>
<td>45.050</td>
<td>56.887</td>
<td>459.388</td>
<td>65.627</td>
<td>65.627</td>
</tr>
<tr>
<td>Southeast</td>
<td>325.280</td>
<td>320.698</td>
<td>300.860</td>
<td>279.876</td>
<td>158.458</td>
<td>130.684</td>
<td>197.930</td>
<td>1,713.787</td>
<td>244.827</td>
<td>244.827</td>
</tr>
<tr>
<td>South</td>
<td>177.431</td>
<td>188.172</td>
<td>193.017</td>
<td>174.386</td>
<td>56.616</td>
<td>71.943</td>
<td>163.277</td>
<td>1,024.842</td>
<td>146.406</td>
<td>146.406</td>
</tr>
<tr>
<td><strong>ANNUAL TOTAL</strong></td>
<td>1,242.065</td>
<td>1,189.609</td>
<td>1,128.578</td>
<td>1,107.711</td>
<td>500.743</td>
<td>536.892</td>
<td>843.759</td>
<td>6,549.356</td>
<td>1,024.842</td>
<td>1,024.842</td>
</tr>
<tr>
<td><strong>ANNUAL AVERAGE</strong></td>
<td>248.413</td>
<td>237.922</td>
<td>225.716</td>
<td>221.542</td>
<td>100.149</td>
<td>107.378</td>
<td>168.752</td>
<td>1,024.842</td>
<td>146.406</td>
<td>146.406</td>
</tr>
</tbody>
</table>

In this wake, the emission data by fossil fuel consumption of JF (Table 2) point to a reduction, which is contrary to that presented by SEEG 10 for emissions associated with transport in Brazil, in the same period analyzed (Tsai et al., 2023). For the JF (table 2), the mean year-to-year drop was 0.27%, while in the national scenario it was an average annual increase of 1.31% (Tsai et al., 2023).

Crossing data from tables 1 and 2, it can be observed that the Northeast appears to be the region with the highest emissions per capita. With 32.7 kg of CO2 eq emitted per capita for the whole period analyzed, this region significantly outstrips the others, such as the Midwest (26.2 kg), North (22.5 kg), Southeast (13.0 kg) and South (18.3 kg). It is possible to say that the geographical peculiarities of the Northeast may impose greater distances for the movement between the judicial units, increasing the consumption of fuel, not to mention that the climate, predominantly hot and dry, may increase the demand for air conditioning in vehicles, which may increase the consumption of fuel.

In this wake, the importance of prioritizing the use of biodiesel and ethanol as alternatives is highlighted, as they have lower GHG emissions. With only 9.91% in relation to the total fuel consumed, according to the CNJ’s PLS bank (CNJ, 2023), it is clear that it is necessary to rethink the types of fuel used.

Finally, it is important to highlight the prioritization of modes of transport and routes that promote superior logistical efficiency, encouraging collective displacements rather than individual ones. Policies and strategies that favor institutional collective transport, to the detriment of the individual and private, not only mitigate environmental and social problems, but also contribute to the improvement of health and the quality of urban life. The
implementation of these strategies requires an integrated and collaborative approach among urban planners, policymakers and all JF stakeholders, which will ensure solutions aligned with sustainability goals that meet the mobility needs of servers and magistrates in an inclusive and equitable manner.

4.2 Emissions by electric energy consumption

The data in Table 3 point to a decrease in total annual emissions from the purchase of electricity by JF units. The Southeast region, in spite of having the highest percentage of regional emissions, also experienced a notable reduction, aligning itself with the general tendency of the fall amongst all the regions.

Table 3
GHG emission by electric energy consumption by location (in t CO₂-eq) by geographical region and by year (in t CO₂-eq) of the Federal Justice units

<table>
<thead>
<tr>
<th>GEOGRAPHIC REGION</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
<th>2022</th>
<th>Total regional</th>
<th>Regional average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Midwest</td>
<td>1 994.65</td>
<td>1 978.39</td>
<td>1 906.04</td>
<td>1 891.91</td>
<td>1 407.56</td>
<td>1 374.42</td>
<td>1 436.00</td>
<td>11 988.97</td>
<td>1 712.71</td>
</tr>
<tr>
<td>Northeast</td>
<td>5 815.41</td>
<td>5 685.88</td>
<td>3 939.11</td>
<td>3 406.53</td>
<td>2 089.79</td>
<td>2 145.34</td>
<td>2 467.77</td>
<td>25 549.82</td>
<td>3 649.97</td>
</tr>
<tr>
<td>North</td>
<td>1 234.92</td>
<td>844.60</td>
<td>670.68</td>
<td>652.48</td>
<td>566.05</td>
<td>921.17</td>
<td>985.14</td>
<td>5 874.55</td>
<td>839.22</td>
</tr>
<tr>
<td>Southeast</td>
<td>6 148.78</td>
<td>5 626.49</td>
<td>5 621.01</td>
<td>5 491.66</td>
<td>3 498.60</td>
<td>2 457.70</td>
<td>3 836.33</td>
<td>3 680.58</td>
<td>4 811.51</td>
</tr>
<tr>
<td>South</td>
<td>2 239.52</td>
<td>1 911.09</td>
<td>2 142.34</td>
<td>2 118.73</td>
<td>1 363.44</td>
<td>1 252.82</td>
<td>1 548.89</td>
<td>1 2 576.84</td>
<td>1 796.69</td>
</tr>
<tr>
<td><strong>ANNUAL TOTAL</strong></td>
<td>17 433.28</td>
<td>16 045.99</td>
<td>14 279.18</td>
<td>13 561.31</td>
<td>8 925.44</td>
<td>9 151.44</td>
<td>10 274.12</td>
<td>12 670.76</td>
<td>1 796.69</td>
</tr>
<tr>
<td><strong>ANNUAL AVERAGE</strong></td>
<td>3 486.66</td>
<td>3 209.20</td>
<td>2 855.84</td>
<td>2 712.26</td>
<td>1 785.09</td>
<td>1 830.29</td>
<td>2 054.82</td>
<td></td>
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</tr>
</tbody>
</table>

The analysis also reveals statistically significant differences between the regions (F=39.94 and p-value of 2.80989E-10) and between the years analyzed (F=5.02; p-value= 0.001829). Excluding 2020 and 2021, the differences remained between regions (F = 49.26; p-value=8.493E-10) and between years (F=4.59; p-value=0.011). These results highlight the need for mitigation strategies and policies tailored to regional and evolving specificities in the context of JF.

The analysis of the data in table 3 points out that the Southeast region shows the highest volume of emissions and the North region the lowest. In the case of the Southeast region, it is possible that the higher density (42%) of JF units compared to other regions of the country, results in a higher demand for electric energy (JF Observatory, 2023). For emissions in the
northern region, the lowest emissions can be linked to the configuration of the Amazonas Isolated System, characterized by being a supply network that operates independently of the National Interconnected System.

By adjusting the total emissions by electric energy consumption (table 3) by the number of JF units in each region (see item 2.4), the southern region has the lowest emission with 24.32 tons of CO₂-eq per unit. This indicates higher efficiency or lower energy usage intensity per unit in this region compared to other regions.

On the other hand, crossing data from tables 1 and 3, the analysis reveals that the Northeast region has the second highest emission per capita. This suggests that, for the Northeast region, the number of employees has great relevance for the emission of GHG by electricity consumption (Table 5), suggesting a low energy efficiency per capita of the region. In this respect, it can be said that the predominantly hot region of the Northeast requires the most intensive use of acclimatization systems, which can lead to an increase in energy consumption per capita or even by administrative unit. Another hypothesis is the use of equipment with low energy efficiency associated with the quality of the infrastructure of buildings, including there, for example, thermal insulation, which can influence energy consumption.

One option for increasing JF's energy efficiency, and trailing behind the mitigation of emissions, is the use of photovoltaic energy. Studies point to it as a promising alternative for the mitigation of GHG. This is mainly due to the low carbon footprint of this type of energy, namely: 45.4 g CO₂-eq. kWh⁻¹ in South America (Bosmans et al., 2021). Thus, the transition to solar energy not only significantly reduces dependence on fossil fuels, but serves as a long-term economic measure, considering the trend of increase in conventional energy costs, especially in regions with high irradiation (Dalfovo et al., 2019).

On the efficient and sustainable use of energy in workplaces, teleworking is currently presented as a very viable option for various organizational and global contexts, but needs an adaptation to regional specificities and to the nuances of working conditions (Hook et al., 2020; Tao et al., 2023). It is essential that the adoption of teleworking takes into account multiple factors, including local urban mobility, residential and corporate energy consumption, so that it is not seen as a panacea, but as part of a wider spectrum of adaptive labor strategies (Hook et al., 2020).

When evaluating the total emissions compared in this study, which is 96,220.11 t CO₂-eq., (Tables 2 and 3), the REDD+ projects (Reduction of Emissions from Deforestation and
Forest Degradation), as environmental compensation instruments, can be established as viable alternatives in the mitigation strategy (Guizar-Coutiño et al., 2022). However, it has to be stressed that this type of project does not represent a panacea. As highlighted by Kreibich and Hermwille (2021), the effectiveness of this solution is often questioned due to the growing demand for carbon credits and the ability to provide these credits in a legitimate manner. A critical point in this debate is the environmental integrity of the credits and the guarantee that they represent a real reduction in emissions. West et al. (2020) raise concerns about the baselines of these credits, suggesting that they can often overestimate avoided deforestation, thus creating an excess of credits that do not correspond to a real decrease in deforestation. In this vein, while these projects offer a valuable opportunity for climate mitigation, robust governance and accountability mechanisms are crucial to ensure real and verifiable GHG emissions reductions (West et al., 2020).

4.2 INFLUENCE OF EMPLOYEES ON GHG EMISSIONS

The data point to a statistically significant relationship between the total workforce and the fuel emissions of the JF units ($R^2=27.66\%$; $F$ of significance $0.0011$). The coefficient for the independent variable (workforce) is positive, indicating that for each additional unit in the workforce, there is an increase in fuel emissions by $0.0105$ t CO2-eq, keeping all other factors constant. This result is statistically significant, as illustrated by the p-value ($0.0012$) for the independent variable coefficient, and the confidence intervals shown in table 4.

Table 4

| Simple regression analysis between the variables total workforce and GHG emission by fuel consumption of the Federal Justice units |

<table>
<thead>
<tr>
<th>REGRESSION STATISTICS</th>
</tr>
</thead>
<tbody>
<tr>
<td>R multiple</td>
</tr>
<tr>
<td>R Square</td>
</tr>
<tr>
<td>R-square adjusted</td>
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<tr>
<td>Standard Error</td>
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<td>Comments</td>
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<td>Regression</td>
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<tr>
<td>Residual</td>
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<tr>
<td>Total</td>
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</table>
The results show the significant association ($R^2=67\%; F$ of significance=$1, 88557E-09$) between the total workforce and the emissions resulting from the consumption of electric energy in the JF units. This implies that, as the workforce varies, there is a corresponding impact on GHG emissions by electric energy consumption.

### Table 5

**Simple regression analysis between the variables total workforce and GHG emission by electric energy consumption of the Federal Justice units**

| Source: Prepared by the author |

On the interaction between the workforce and GHG emissions (Tables 4 and 5), predictive models need to be created that help estimate the impact of the increase in the number of employees on fuel and energy consumption, enabling the development of more efficient and effective strategies and policies for reducing emissions. Policy makers should expand the focus from the individual to the collective, avoiding hegemonic or restricted narratives about the consumption, in particular of fuels, promoting a development that not only respects but benefits the multiplicity of the workforce in the adopted sustainability strategies.
Finally, also on the significant correlation between the number of employees and GHG emissions (tables 4 and 5), it has to be said that this data reinforces the understanding of socioeconomic systems as key elements in the dynamics of climate change. By demonstrating that the increase in the workforce is associated with higher GHG emissions, the argument about the need to consider not only the technological factors for greater energy efficiency of JF, but also the social factors in the formulation of climate mitigation and adaptation policies is ratified (Ribeiro & Gavrons, 2021).

5 CONCLUSION

The study data point to a progressive reduction in total GHG emissions from JF. These reductions provide a roadmap for future improvements, aligning with JF's domestic national targets and the international emission reduction targets assumed by the Judiciary. As regards the positive and significant correlations between labor force and GHG emissions, the need for integrated approaches to human resource management, strategic management and environmental management is reinforced, which can encourage the implementation of more sustainable working practices, such as teleworking, or emission prediction models based on the size of the workforce.

The scientific relevance of this study is based, among other points, on the analysis of data by geographical regions of GHG emissions. This approach not only enriched the understanding of the emission profile, but also proved to be fundamental for the aggregated analysis of the units. In addition, this focus can support the development of future environmental mitigation research and policies, enriching the literature on environmental management in the public sector with regionalized data.

Technical limitations are based on reliance on secondary data and the absence of Scope 3 data. Future research should explore the Scope 3 issues of Federal Justice through other methodologies, such as that used by Virgens; Andrade; & Hidalgo (2020), including the supply chain and also the impact of remote work policies on employee transport-related emissions.

For future research, it is suggested to investigate topics such as the effectiveness of integrating energy efficiency policies and the impact of adopting renewable energy sources in JF. It would also be useful to analyze the cost-benefit ratio of various emission reduction strategies, as well as employees' perceptions about sustainable practices, paving the way for a truly more collaborative and case-sensitive Federal Court.
REFERENCES


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