“Asymmetries in energy consumption: Efficiency of public spending across Portuguese municipalities”

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ASYMMETRIES IN ENERGY CONSUMPTION: EFFICIENCY OF PUBLIC SPENDING ACROSS PORTUGUESE MUNICIPALITIES

Abstract

The efficient allocation of public financial resources to energy consumption in Portuguese municipalities is one of the most discussed topics in public finance, given the growing relevance of sustainability and energy efficiency. The study analyzes how public spending affects energy efficiency through a combination of data analysis and hypotheses testing to assess the relationship between public spending and energy consumption. The methodology includes DEA analysis of the financial data and energy consumption of the municipalities, as well as the definition of hypotheses to determine the possible correlations between investment and efficiency. The results suggest that, in general, municipalities with higher levels of public spending have lower levels of energy efficiency. Meanwhile, municipalities with smaller budgets and fewer resources tend to be more efficient. The DEA analysis of the data suggests that energy efficiency is not directly related to the size and/or economic aptitude of municipalities but rather to their ability to adopt new technologies and more efficient budgetary and financial management practices. The hypotheses tested show varying levels of efficiency in public spending in relation to energy consumption. The study also concludes that public policies should focus on technological innovation and benchmarking to improve energy efficiency. The analysis suggests that collaboration between municipalities and the adoption of best practices are essential to tackle regional disparities and promote energy sustainability.

Keywords energy efficiency, public spending, resource allocation, benchmarking practices, regional disparities

JEL Classification Q48, R11, O13

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INTRODUCTION

The study of public energy expenditure efficiency in municipalities stems from the need to reduce fossil energy consumption and the ability to provide relevant findings to design public policies geared toward energy efficiency and financial sustainability. In contexts of budgetary constraints, the theory advocates the need to define new instruments for optimizing the allocation of financial resources in order to increase the energy efficiency of cities. On the other hand, it allows for the adoption of benchmarking practices that can be compared with the best international practices.

Analyzing the efficiency of public spending and the management of public resources in a municipal context has not only direct implications for the formulation of local policies but also for debates on sustainability, energy efficiency, the allocation of resources, and the reduction of municipal asymmetries. The research thus makes it possible to align the financial management of municipalities with the global objectives of reducing carbon dioxide emissions and improving the quality of urban life.

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The research question arises from the need to address how the allocation of public financial resources influences municipal energy efficiency and how public spending can be optimized to achieve maximum efficiency.

Research into the efficiency of financial resource allocation in relation to municipal energy consumption is paramount for the development of more effective and sustainable financial management practices. Analyzing the relationship between public investment, management practices, and energy efficiency contributes to a deeper understanding of the factors that influence the efficiency of public spending by local governments.

The results are essential for guiding strategic decisions by municipalities to promote sustainable development and optimize the allocation of resources, especially in scenarios that increasingly require effective action against climate change and the depletion of natural resources.

1. LITERATURE REVIEW AND HYPOTHESES

Analyzing the efficiency of the allocation of public financial resources in relation to local energy consumption is currently one of the main areas on the public finance agenda (Vine et al., 2003), especially in relation to the sustainable development of territories. The study of energy consumption levels through the lens of the DEA super-efficiency methodology requires an in-depth understanding of the relationships between municipal spending levels (Bang, 2020), the management practices of available funds (Nath & Madhoo, 2022), and the ability of municipalities to adopt more efficient energy technologies (Yang & Yu, 2015). The literature review aims to take a critical look at the most relevant studies examining energy consumption efficiency and the management of financial resources in a municipal context.

An important point in analyzing energy efficiency is the relationship between levels of investment spending and municipal energy development (Taşkın et al., 2022). Huang and Wang (2022) analyze the relationship between the regulations developed by local authorities and the energy efficiency of the logistics industry in China. The authors applied the DEA super-efficiency model, evaluated the relationship between the different levels of public investment and the sector's energy efficiency, and concluded that greater public investment in implementing active policies and increasing consumption efficiency leads to greater sector efficiency. According to Ma et al. (2017), the best methodology for observing the efficiency of energy expenditure is the super-efficiency DEA model since it allows the relationship between energy expenditure and actual energy consumption to be analyzed accurately based on data from municipalities.

The study highlights the relevance of allocating public resources, specifically in terms of the development of economic sectors and the quality of municipal energy policy development and implementation. The results suggest that the municipalities that invest the most are those with the highest levels of energy efficiency, the best levels of optimization in allocating financial resources, and the greatest contribution to sustainable development.

Another approach was developed by Yu et al. (2018) related to the analysis of undesired outputs. The authors used the super-efficiency DEA model to study asymmetries in the energy efficiency of industry in 30 Chinese municipalities. The results point to the presence of significant disparities between industries at the municipal level. The authors also conclude that public policies aimed at adopting more efficient energy technologies can reduce municipal disparities.

The study is relevant for understanding how municipal asymmetries in the consumption structure and investment capacity of municipalities influence energy efficiency and the efficient use of public resources. However, for the theory, more than financial incentives, it is essential to share more efficient technologies between municipalities in order to achieve greater convergence in energy efficiency (Mega, 2018). According to Li et al. (2023),

there are differences in the energy efficiency levels of municipalities due to economic development, the structure of energy consumption, and the quantity and quality of expenditure.

In addition to the financial perspective, the doctrine advocates analyzing technological development (Shabalov et al., 2021), the local market (Hua et al., 2022), and the influence of local governments on energy efficiency levels (Antunes et al., 2023). In terms of this approach, Bai et al. (2012) analyzed the energy efficiency levels of 11 Chinese municipalities using the input-output-orientated super-efficiency DEA methodology. The analysis reveals that despite the low levels of energy efficiency exhibited by the municipalities, through the acquisition of new technologies and the implementation of local structural reforms, it was possible to achieve efficiency gains from 2005 onwards. The work suggests that to achieve super-efficiency in consumption, it is essential to make a coordinated effort that includes adopting new technologies, implementing structural reforms that encourage innovation and modernization of infrastructure, and increasing financial spending.

Along these lines, Jaffe and Stavins (1994) also defend the need to adopt more efficient technologies and suggest that public policies should not only encourage the adoption of new technologies but should also promote the removal of budgetary limits that serve as a financial barrier to increasing the quality of public spending. The authors conclude that budget limits prevent the adoption of more efficient technologies, which, despite being more financially viable, are not purchased.

However, as Soares (2024) points out, a greater allocation of financial resources does not in itself guarantee greater operational efficiency. Starting with the urban waste collection sector in Portuguese municipalities, the study, using the DEA methodology, reveals the importance of the strategic management of public financial resources, suggesting that efficiency in the allocation of resources can be achieved by optimizing management processes and adopting more effective practices. In fact, for the theory, it is essential to guarantee an adequate balance between the resources available and the efficiency achieved (Borja-Patiño et al., 2024).

The same view is adopted by Lovins (1976), who argues that energy efficiency, indicated as 'negawatts' or energy saved through efficiency, is, in most situations, more economical than increasing the value of the investment and/or the energy production capacity. This position implies that by investing in energy efficiency, municipalities not only reduce spending on energy consumption but also free up financial resources for other needs (Sorrel et al., 2020), increasing the efficiency of public spending.

Studies suggest an interrelationship between the level of municipal spending and the efficiency of public spending (Afonso & Fernandes, 2006). The efficient adoption of public financial resources, especially with regard to the acquisition of new, more efficient technologies, is key to reducing public spending on energy consumption and increasing the operational efficiency of municipal services (Martínez-Peláez et al., 2023). To achieve super-efficiency, municipalities must not only adopt an integrated vision that includes the allocation of financial resources; they must also seek to modernize infrastructure and implement technological innovations. For Wade (2018), even in the context of limited resources, it is possible to achieve high levels of super-efficiency through the effective and strategic management of available financial resources.

An important perspective for analyzing energy efficiency is benchmarking, which addresses energy efficiency in municipal operations by analyzing the management models, standards, and practices used by the local managers considered for benchmarking (Geraldi & Ghisi, 2022). This approach is essential because local governments play a crucial role in managing financial resources and energy consumption, especially in actions of public interest involving significant energy consumption, such as buildings, transport, and public lighting. For Yang and Yu (2015), benchmarking allows local actors to assess the energy performance of their public actions in comparison with established standards or other similar entities. In fact, this type of analysis tool makes it possible to identify opportunities for improvement, set targets at the best cost, and monitor the evolution of efficiency (Ettorchi-Tardy et al., 2012). However, the effectiveness of efficiency analysis depends on the quality of the data col-

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lected (Singh, 2015) and the competence of local decision-makers to interpret and act on the information (Heinelt & Lamping, 2018).

Studies encourage the adoption of new technologies, especially in municipalities with less investment capacity, in order to reduce asymmetries (David et al., 2023). On the other hand, there is also a need to look at how public policies can be adapted to improve the energy efficiency of municipalities with budgetary constraints (Dias et al., 2019). The doctrine lacks studies on the definition of new financing models (Bartle et al., 2011), making it possible to realize public investments to increase energy efficiency (Caneparo, 2020) in the context of limited financial resources.

The aim of this study is to analyze the efficiency of municipal energy expenditure in order to assess the effectiveness of spending and its relationship with consumption levels. To this end, the following hypotheses were established:

H1: The efficiency of municipal energy expenditure is not directly related to the level of energy consumption, with an efficiency of less than 1 ($e\lambda < 1$).

H2: The efficiency of municipal energy expenditure shows some relation to energy consumption, with an efficiency equal to 1 ($e\lambda = 1$).

H3: The efficiency of municipal energy expenditure is directly related to the level of energy consumption, with efficiency greater than 1 ($e\lambda > 1$).

2. METHODS

This analysis is centered on the application of a case study that analyses the statistical data of 308 Portuguese municipalities covering the period from 2018 to 2022. The variables analyzed include public energy expenditure (inputs) and energy consumption (outputs), providing an analysis of municipal energy efficiency. The data were collected from the Directorate-General for Local Authorities (DGAL) and the official PORDATA website.

The methodology adopted was data envelopment analysis (DEA), more specifically super-efficiency analysis, which makes it possible to measure the efficiency of production units. The model makes it possible to define energy efficiency rankings for municipalities without imposing a predefined direct relationship between inputs and outputs and is used to compare efficiency in the management of financial resources (Mozaffari et al., 2014).

The DEA model aims to organize the efficiency of municipalities in the use of public financial resources to assess the efficiency levels of energy expenditure and consumption. In this analysis, the inputs (municipal expenditure) reflect the amount of financial resources allocated to the purchase of energy. The outputs (energy consumption) show the consumption of energy, including electricity and natural gas, used by municipalities in the operation of public services such as buildings, lighting, and public transport.

The model assesses decision-making units (municipalities) based on how efficiently they transform inputs (municipal expenditure) into outputs (reducing or optimizing energy consumption). In this model, when a DMU (municipality) achieves an efficiency index greater than 1, it is classified as super-efficient. This indicates that the municipality absorbs less energy with the same or fewer financial resources than other municipalities.

The selected analysis model, which makes it possible to determine the most efficient municipalities, is obtained using the following formula (Putri, 2014):

$$Efficiency\left(SE_{(0)}\right) = \max\left(\frac{\sum_{i=1}^{n}\lambda_i\, y_{r0}}{\sum_{i=1}^{n}\lambda_i\, y_{ri}}, \forall r\right), \quad (1)$$

where $SE_{(0)}$ = super-efficiency index for municipality o; λ_i = weights assigned to each DMU (municipality) i; y_{ro} = energy consumption of municipality o; y_{ri} = energy consumption of municipality i; and n the total number of decision units (DMUs).

The numerator $\Sigma^{n}_{i=1}(\lambda_i . y_{ro})$ represents the weighted sum of the outputs of all the municipalities, i.e., the total energy consumption between the municipalities compared. The denominator $\Sigma^{n}_{i=1}(\lambda_i . y_{ri})$

represents the output of the assessed municipality, i.e., the energy consumption of municipality I. The model makes it possible to analyze the energy consumption efficiency of municipalities by comparing the amount of financial resources allocated (inputs) with energy consumption (outputs).

The fewer the resources allocated to achieve the same or better levels of energy consumption, the more efficient the municipality. Efficiency is achieved when the municipality is able to reduce the amount of financial resources allocated while reducing or maintaining energy consumption.

The efficiency levels of Portuguese municipalities were measured using Excel software. This type of analysis provides a possible methodology for municipalities to optimize the allocation of financial resources in order to achieve efficiency gains. Using the DEA model, it is possible to identify which municipalities utilize resources most effectively, promoting a real reduction in energy consumption without the need for significant increases in expenditure.

3. RESULTS

After applying the adopted methodology, the results provide a new perspective on the efficiency of the allocation of financial resources among the 308 municipalities.

Tables A1 to A5 (Appendix A) highlight the efficiency levels of the municipalities, making it possible to identify those that are most financially efficient in energy consumption.

According to the estimated results, the most efficient municipalities in 2018, in terms of the ratio between public spending and electricity and natural gas consumption, were Vila Nova de Famalicão, with an efficiency of 726.274% (Braga); Torre de Moncorvo, with 521.381% (Bragança); Sines, with 481.020% (Setúbal); Portel with 475.346% (Évora); Aguiar da Beira, with 415.126% (Guarda); Lajes das Flores, with 404.419% (Autonomous Region of the Açores); Constância, with 363.064% (Santarém); Estarreja, with 286.901% (Aveiro); Vila do Conde, with 230.990% (Porto); Guarda, with 222.232% (Guarda); Castro Marim, with 192.812% (Faro); Nelas, with 181.581% (Viseu); Monchique, with 174.977% (Faro); Viana do Castelo, with 171.106% (Viana do Castelo); Vila Pouca de Aguiar, with 140.787% (Vila Real); Castanheira de Pêra, with 136.366% (Leiria); Albufeira, with 133.075% (Faro); Vila Franca de Xira, with 109.905% (Lisboa); Avis, with 108.821% (Portalegre); Castro Verde, with 108.280% (Beja); Calheta, with 107.963% (Madeira Autonomous Region); and Arcos de Valdevez, with 107.210% (Viana do Castelo).

In the opposite direction, the results suggest that the least efficient municipalities in the allocation of public resources to energy consumption in 2018 were Ourém, with 2.195% (Santarém); Odivelas, with 2.182% (Lisboa); Sintra, with 2.179% (Lisboa); Proença-a-Nova, with 2.171% (Castelo Branco); Palmela, with 2.132% (Setúbal); Vila de Rei, with 2.099% (Castelo Branco); Setúbal, with 2.066% (Setúbal); Sertã, with 1.793% (Castelo Branco); Cascais, with 1.687% (Lisboa); Belmonte, with 1.613% (Castelo Branco); Lisboa, with 1.456% (Lisboa); Moita, with 1.412% (Setúbal); Idanha-a-Nova, with 1.374% (Castelo Branco); Barreiro, with 1.219% (Setúbal); Covilhã, with 1.144% (Castelo Branco); Seixal, with 1.032% (Setúbal); Sesimbra, with 0.939% (Setúbal); Fundão, with 0.921% (Castelo Branco); Castelo Branco, with 0.750% (Castelo Branco); and Almada, with 0.576% (Setúbal).

For 2019, the results show that the most efficient municipalities in allocating financial resources to energy consumption were Lajes das Flores, with 1762.990% (Autonomous Region of the Açores); Vila Nova de Famalicão, with 738.660% (Braga); Torre de Moncorvo, with 554.182% (Bragança); Aguiar da Beira, with 471.785% (Guarda); Sines, with 420.222% (Setúbal); Constância, with 370.350% (Santarém); Castro Marim, with 341.444% (Faro); Estarreja, with 315.669% (Aveiro); Vila do Conde, with 215.258% (Porto); Maia, with 188.640% (Porto); Viana do Castelo, with 187.803% (Viana do Castelo); Nelas, with 176.699% (Viseu); Monchique, with 136.567% (Faro); Pedrógão Grande, with 135.819% (Leiria); Albufeira, with 125.662% (Faro); Vila Velha de Ródão, with 121.734% (Castelo Branco); Avis, with 118.841% (Portalegre); Paredes de Coura, with 118.280% (Viana do Castelo); Mesão Frio, with 111.472% (Vila Real); Castro Verde, with 104.815% (Beja); Vila Franca de Xira, with 104.019% (Lisboa); and Valença, with 102.551% (Viana do Castelo).

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Conversely, in the same period, the results indicate that the least efficient municipalities were Belmonte, with 2.495% (Castelo Branco); Odivelas, with 2.400% (Lisboa); Ourém, with 2.262% (Santarém); Proença-a-Nova, with 2.236% (Castelo Branco); Setúbal, with 2.204% (Setúbal); Montijo, with 2.170% (Setúbal); Sintra, with 2.089% (Lisboa); Sertã, with 2.007% (Castelo Branco); Vila de Rei, with 1.994% (Castelo Branco); Lisboa, with 1.501% (Lisboa); Cascais, with 1.449% (Lisboa); Moita, with 1.432% (Setúbal); Idanha-a-Nova, with 1.377% (Castelo Branco); Covilhã, with 1.230% (Castelo Branco); Barreiro, with 1.215% (Setúbal); Seixal, with 1.016% (Setúbal); Sesimbra, with 0.975% (Setúbal); Fundão, with 0.939% (Castelo Branco); Castelo Branco, with 0.792% (Castelo Branco); and Almada, with 0.620% (Setúbal).

For 2020, the results indicate that the most financially efficient municipalities in terms of energy expenditure were Castro Marim, with 672.788% (Faro); Constância, with 407.852% (Santarém); Estarreja, with 354.085% (Aveiro); Aguiar da Beira, with 299.721% (Guarda); Maia, with 206.768% (Porto); Viana do Castelo, with 202.514% (Viana do Castelo); Porto Santo, with 200.455% (Madeira Autonomous Region); Trofa, with 199.559% (Porto); Santa Maria da Feira, with 197.204% (Aveiro); Nelas, with 194.726% (Viseu); Vieira do Minho, with 189.999% (Braga); Pedrógão Grande, with 161.815% (Leiria); Vila Velha de Ródão, with 160.677% (Castelo Branco); Boticas, with 155.889% (Vila Real); Vila Flor, with 136.385% (Bragança); Vizela, with 134.606% (Braga); Sines, with 132.771% (Setúbal); Albufeira, with 129.653% (Faro); Corvo, with 118.969% (Açores Autonomous Region); Avis, with 111.082% (Portalegre); Tavira, with 108.196% (Faro); and Sabugal, with 102.133% (Guarda).

Conversely, the estimated data suggest that the least efficient municipalities when it comes to allocating expenditure were Odemira, with 2.897% (Beja); Ourém, with 2.751% (Santarém); Oeiras, with 2.648% (Lisboa); Odivelas, with 2.305% (Lisboa); Proença-a-Nova, with 2.298% (Castelo Branco); Sernancelhe, with 2.122% (Viseu); Penamacor, with 2.121% (Castelo Branco); Sertã, with 2.071% (Castelo Branco); Moita, with 2.016% (Setúbal); Sobral de Monte Agraço, with 1.972% (Lisboa); Barreiro, with 1.485% (Setúbal); Belmonte, with 1.358% (Castelo Branco); Idanha-a-Nova, with 1.343% (Castelo Branco); Lisboa, with 1.342% (Lisboa); Cascais, with 1.316% (Lisboa); Covilhã, with 0.994% (Castelo Branco); Almada, with 0.984% (Setúbal); Sever do Vouga, with 0.854% (Aveiro); Fundão, with 0.742% (Castelo Branco); and Castelo Branco, with 0.727% (Castelo Branco).

As for 2021, the estimated results suggest that the most financially efficient municipalities were Castro Marim, with 1010.605% (Faro); Estarreja, with 497.150% (Aveiro); Sines, with 442.669% (Setúbal); Azambuja, with 425.266% (Lisboa); Constância, with 381.234% (Santarém); Aguiar da Beira, with 283.287% (Guarda); Vila Nova de Cerveira, with 281.702% (Viana do Castelo); Vizela, with 237.863% (Braga); Nelas, with 214.594% (Viseu); Trofa, with 184.088% (Porto); Porto Santo, with 149.777% (Madeira Autonomous Region); Boticas, with 149.619% (Vila Real); Torre de Moncorvo, with 139.458% (Bragança); Castanheira de Pêra, with 136.049% (Leiria); Vila Velha de Ródão, with 132.776% (Castelo Branco); Monchique, with 114.487% (Faro); Avis, with 110.724% (Portalegre); Corvo, with 110.403% (Açores Autonomous Region); Castro Verde, with 109.355% (Beja); Sabrosa, with 108.668% (Vila Real); and Vieira do Minho, with 103.713% (Viana do Castelo).

On the contrary, the data show that the least efficient municipalities were Odemira, with 2.597% (Beja); Penamacor, with 2.403% (Castelo Branco); Lisboa, with 2.263% (Lisboa); Proença-a-Nova, with 2.262% (Castelo Branco); Funchal, with 2.154% (Madeira Autonomous Region); Setúbal, with 2.049% (Setúbal); Sertã, with 2.011% (Castelo Branco); Palmela, with 1.983% (Setúbal); Cascais, with 1.971% (Lisboa); Montijo, with 1.847% (Setúbal); Idanha-a-Nova, with 1.396% (Castelo Branco); Belmonte, with 1.290% (Castelo Branco); Moita, with 1.119% (Setúbal); Covilhã, with 0.931% (Castelo Branco); Barreiro, with 0.925% (Setúbal); Sesimbra, with 0.921% (Setúbal); Fundão, with 0.855% (Castelo Branco); Seixal, with 0.849% (Setúbal); Castelo Branco, with 0.687% (Castelo Branco); and Almada with 0.539% (Setúbal).

When it comes to 2022, the results show that the most financially efficient municipalities in terms of energy expenditure are Sines, with 1209.412%

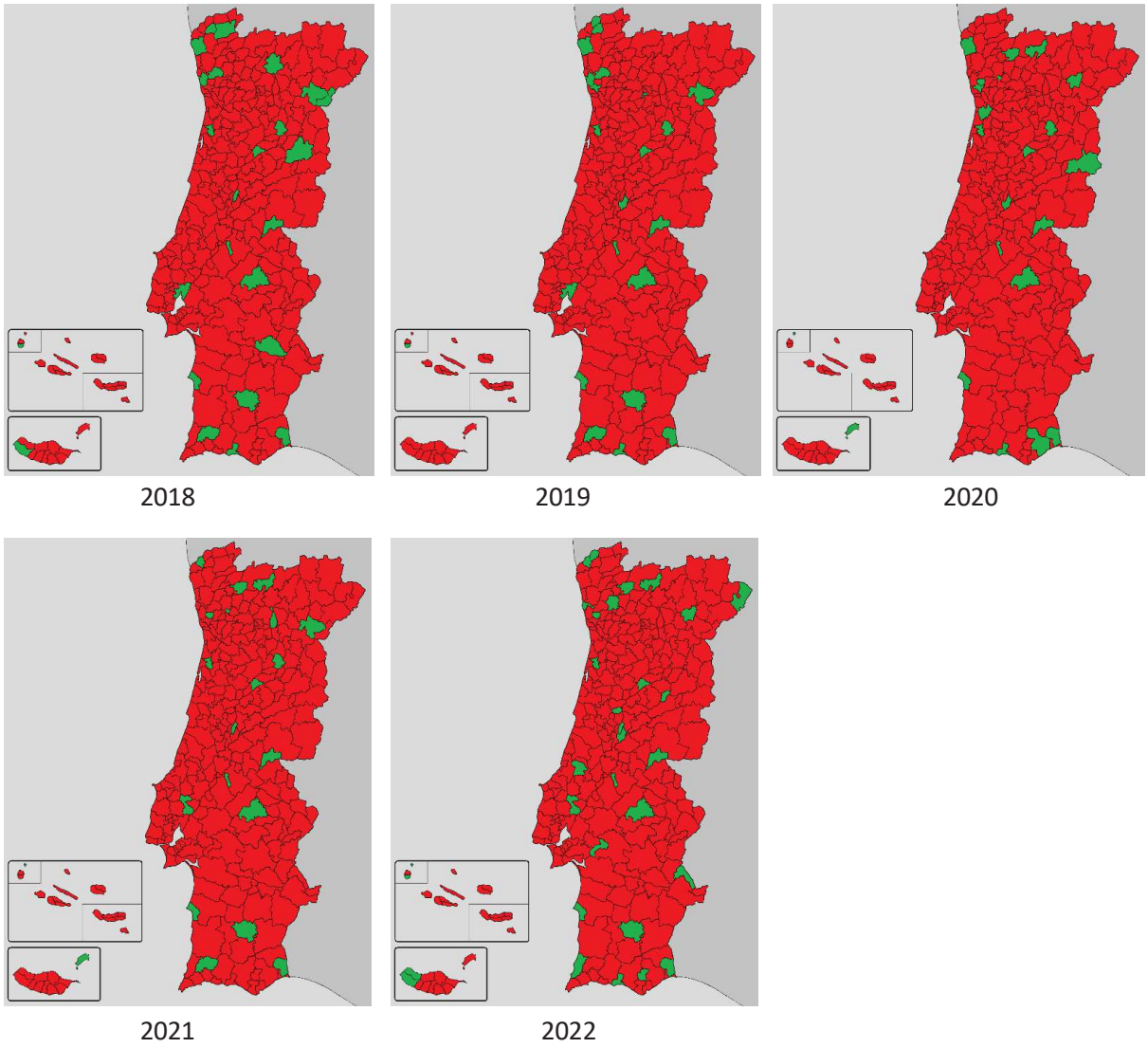

Figure 1. The most (green) and least (red) financially efficient municipalities in terms of energy expenditure in 2018–2022

(Setúbal); Nelas, with 897.910% (Viseu); Estarreja, with 887.554% (Aveiro); Lajes das Flores, with 699.759% (Açores Autonomous Region); Vila Velha de Ródão, with 606.373% (Castelo Branco); Albufeira, with 489.383% (Faro); Constância, with 432.390% (Santarém); Vila Nova de Cerveira, with 404.018% (Viana do Castelo); Avis, with 354.322% (Portalegre); Manteigas, with 346.423% (Guarda); Póvoa de Varzim, with 292.147% (Porto); Trofa, with 287.718% (Porto); Vila Flor, with 277.094% (Bragança); Boticas, with 200.471% (Vila Real); Corvo, with 177.951% (Açores Autonomous Region); Vieira do Minho, with 169.930% (Braga); Vendas Novas, with 154.372% (Évora); Valença, with 148.722% (Viana do Castelo); Castro Marim, with 147.708% (Faro); Miranda do Douro, with 143.212% (Bragança); Castanheira de Pêra, with 137.925% (Leiria); Porto Moniz, with 131.952% (Madeira Autonomous Region); Guimarães, with 127.861% (Braga); Calheta, with 123.985% (Madeira Autonomous Region); São Brás de Alportel, with 119.578% (Faro); Aljezur, with 114.366% (Faro); Mourão, with 110.480% (Portalegre); Porto de Mós, with 109.978% (Leiria); Castro Verde, with 107.447% (Beja); Vila Nova de Poiares, with 104.520% (Coimbra); Pedrógão, with 100.007% (Leiria); and Azambuja, with 100% (Lisboa).

When it comes to the relationship between public spending and energy consumption, the data suggest that the least efficient municipalities were Funchal, with 1.841% (Madeira

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Autonomous Region); Calheta, with 1.691% (Açores Autonomous Region); Palmela, with 1.370% (Setúbal); Santiago do Cacém, with 1.343% (Setúbal); Oleiros, with 1.258% (Castelo Branco); Sesimbra, with 0.989% (Setúbal); Barreiro, with 0.936% (Setúbal); Penamacor, with 0.936% (Penamacor); Setúbal, with 0.900% (Setúbal); Seixal, with 0.747% (Setúbal); Moita, with 0.707% (Setúbal); Covilhã, with 0.647% (Castelo Branco); Belmonte, with 0.565% (Castelo Branco); Almada, with 0.535% (Setúbal); Montijo, with 0.487% (Setúbal); Fundão, with 0.468% (Castelo Branco); Vila de Rei, with 0.369% (Castelo Branco); Proença-a-Nova, with 0.350% (Castelo Branco); Castelo Branco, with 0.120% (Castelo Branco); and Idanha-a-Nova, with 0.120% (Castelo Branco).

The financial efficiency of allocating financial resources to energy consumption averaged 45.895% in 2018. In 2019, the average efficiency was 48.244%. In 2020, the average financial efficiency of municipalities was 39.366%. In 2021, the average financial efficiency of municipalities was 44.123%. In 2022, the average for Portuguese municipalities was 51.558% (Figure 1).

In terms of the hypotheses, in 2018, the results validate hypothesis 1 ($e\lambda < 1$) in 283 municipalities, reject hypothesis 2 ($e\lambda = 1$), and confirm hypothesis 3 ($e\lambda > 1$) in 25 municipalities. In 2019, the results validate hypothesis 1 ($e\lambda < 1$) in 286 municipalities, reject hypothesis 2 ($e\lambda = 1$), and validate hypothesis 3 in 22 municipalities ($e\lambda > 1$). In 2020, the data validate hypothesis 1 $e\lambda < 1$) in 286 municipalities, reject hypothesis 2 ($e\lambda = 1$), and confirm hypothesis 3 ($e\lambda < 1$) in 22 municipalities. As for 2021, the results obtained validate hypothesis 1 ($e\lambda < 1$) in 287 municipalities, reject hypothesis 2 ($e\lambda = 1$), and confirm hypothesis 3 ($e\lambda > 1$) in 22 municipalities. In 2022, the estimated data validate hypothesis 1 ($e\lambda < 1$) in 276 municipalities, validate hypothesis 2 ($e\lambda = 1$) in 1 municipality, and reject hypothesis 3 ($e\lambda > 1$) in 31 municipalities.

4. DISCUSSION

The study of the efficient allocation of public resources, especially in terms of energy consumption, is one of the most debated issues in public finance. The importance of studying the possible relationships between public spending and energy consumption stems from the need for municipalities to identify the possible patterns of financial expenditure (Zhang et al., 2021), the financial effects (Nguyen & Su, 2022), and the way they are defined and entered in budgets (Aktaş, 2023).

The efficiency of public spending on energy consumption, as Taşkın et al. (2022) stressed, is essential for the development and adoption of benchmarking standards for the allocation of financial resources and energy consumption of the most financially and ecologically sustainable municipalities.

Huang and Wang (2022) analyzed the relationship between financial legislation developed by political actors and the energy efficiency of budget execution, translated into expenditure. Accordingly, the greater the public investment, the greater the energy efficiency of the public sector. However, the results of this study point to the opposite, i.e., the municipalities with the highest levels of expenditure on energy consumption are those with the lowest levels of efficiency, compared to the municipalities that consume the least financial resources. Municipalities such as Lisbon, Cascais, and Sintra have much lower levels of financial efficiency than would be expected, i.e., despite allocating notable financial resources, they are the ones that contribute the least to sustainable development and reducing disparities.

The current paper, on the other hand, corroborates Yu et al.'s (2018) conclusions, i.e., the results validate the presence of high disparities between municipalities' levels of financial efficiency. In this sense, this study is relevant to understanding the extent of regional asymmetries, how gas and electricity consumption is distributed, and the capacity to adopt more efficient practices. In fact, as Li et al. (2023) argue, disparities in energy efficiency stem from economic development, the structure of energy consumption, and the quantity and quality of municipal spending.

The study also validates Mega's (2018) conclusions, which argue that it is essential for municipalities to share the most efficient procedures with each other in order to achieve greater convergence in energy efficiency. Bai et al. (2012) believe that new technologies need to be acquired and structural reforms implemented to enable municipalities to achieve energy

efficiency gains. According to them, there needs to be coordinated work between municipalities to increase the quality of financial expenditure, adopt new technologies, and implement structural reforms that encourage innovation and modernization of energy infrastructure.

Regarding the quality of financial expenditure, like Jaffe and Stavins (1994), the study validates the need to remove budgetary barriers since their consequences in Portuguese municipalities result in a high number of municipalities that are inefficient in allocating expenditure to energy consumption. In this sense, budget limits prevent the adoption of more efficient technologies, which, despite being more financially viable, the political option was to refuse to make new investments. However, as Soares (2024) concludes, greater allocation of financial resources does not in itself guarantee greater financial efficiency.

The study demonstrates that it is essential to maintain an adequate level of allocation of public financial resources and the desired financial efficiency. Lovins (1976), who concludes that energy efficiency is more economical than increasing the value of the investment and/or energy production capacity, reached a similar conclusion. In this sense, this study supports Sorrel et al. (2020) that investing in energy efficiency, in addition to reducing energy costs, frees up possible financial resources for other more pressing needs.

The results point out, like Wade's (2018) findings, that municipalities should not simply seek financial efficiency by optimizing the allocation of financial resources but should also modernize infrastructure, implement technological innovations, and adopt more energy-efficient practices. On the other hand, even in contexts of scarce resources, municipalities can achieve high levels of efficiency through more effective and strategic financial management practices. The results show that the smallest municipalities, with the fewest resources, are the ones that demonstrate the highest levels of efficiency when it comes to allocating resources to energy consumption.

In relation to the energy efficiency of municipalities, this study contradicts Ma et al. (2024), who argue that the efficiency of energy consumption is due to the size of municipalities, their economic capacity, and the type of urbanization that exists. The data suggest that the highest levels of energy efficiency are mainly due to the ability to adopt new financial management models and new technologies that are more efficient in terms of energy consumption.

Geraldi and Ghisi (2022) believe that municipalities need to adopt the benchmarking methodology to increase efficiency levels by adopting more efficient practices for allocating financial resources from more efficient municipalities to less efficient ones. The study attests to and agrees with this perspective since it is possible to find a group of municipalities that are more efficient in allocating their financial resources, which can serve as examples for other local authorities. In other words, by analyzing the financial management models of the most efficient municipalities, the less efficient ones can adopt the standards and practices used by the local managers considered to be benchmarking (O'Loughlin & Wilson, 2021).

The results make it possible, as Yang and Yu (2015) advocate, to carry out benchmarking analyses in the sense that they allow local public authorities to assess the energy performance of public action in comparison with the standards and practices adopted by similar entities. Like Ettorchi-Tardy et al. (2012), the study identifies possible opportunities for improving municipalities' financial management practices by setting consumption targets at the best cost and monitoring the evolution of energy efficiency. However, the effectiveness of efficiency analysis depends, above all, on the quality of the data collected (Bensoussan & Fleisher, 2008) and the competence of decision-makers to analyze and act on the available data (Edejer et al., 2003; Awan et al., 2021).

In addition to the study reinforcing the need to adopt new technologies, it highlights the importance of analyzing how public policies can be adapted to improve energy efficiency, especially in contexts of budgetary constraints (David et al., 2023; Dias et al., 2019). The theory, in fact, calls for new studies to be carried out on the definition of possible financing models (Simpson et al., 2019), which would allow municipalities to carry out new, more energy-efficient, and sustainable public investments.

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CONCLUSION

The study analyzed the efficiency levels of Portuguese municipalities in allocating financial resources to energy consumption. By analyzing the financial efficiency of allocating resources to energy consumption, it was possible to draw some conclusions.

The results suggest that municipalities with higher levels of public spending have lower levels of energy efficiency, while smaller municipalities with fewer resources tend to be more financially efficient. This situation reveals serious disparities in the management of financial resources and energy efficiency between municipalities.

The results indicate that energy efficiency is not directly linked to the size and/or economic capacity of municipalities but rather to their ability to adopt new financial management models and more efficient technologies. In fact, infrastructure modernization and technological innovation are essential for increasing energy efficiency.

The results suggest a strong correlation between public spending and electricity and natural gas consumption. To this end, hypothesis 1, in which expenditure efficiency is not directly related to the level of energy consumption, was validated for most municipalities in all years. Hypothesis 2, in which expenditure efficiency has some kind of relationship with energy consumption, was validated in one municipality in 2023, while in the other years analyzed, it was rejected. Hypothesis 3, in which the efficiency of municipal spending is directly related to the level of energy consumption, was validated in 25 municipalities in 2018, 22 municipalities in 2019 and 2020, 21 municipalities in 2021, and 31 municipalities in 2022.

The conclusions emphasize the importance of adopting benchmarking practices between municipalities, i.e., decision-makers need to learn from the examples of the most efficient municipalities in allocating financial resources to energy consumption. The exchange of good practices can help increase energy efficiency in contexts of budgetary constraints.

The conclusions emphasize the importance of defining public policies focused on technological innovation, financial efficiency, and collaboration between municipalities in order to achieve greater energy sustainability and reduce regional disparities.

AUTHOR CONTRIBUTIONS

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APPENDIX A

Table A1. Results for the efficiency of public spending on energy, by municipality, in 2018

Municipalities	Efficiency	Rank	Municipalities	Efficiency	Rank	Municipalities	Efficiency	Rank	Municipalities	Efficiency	Rank	Municipalities	Efficiency	Rank	Municipalities	Efficiency	Rank
Vila Nova Famalicão	726.274%	1	Fronteira	64.139%	52	Santa Marta Penaguião	39.973%	103	Pombal	26.141%	154	Portimão	14.559%	205	Braga	6.721%	257
Torre Moncorvo	521.381%	2	Marinha Grande	64.027%	53	Montemor-o-Novo	39.972%	104	Mirandela	26.081%	155	Tabuaço	14.537%	206	Espinho	6.671%	258
Sines	481.020%	3	Bombarral	61.871%	54	Mondim de Basto	39.529%	105	Ponte de Lima	25.809%	156	Ferreira do Zêzere	14.264%	207	Paredes	6.564%	259
Portel	475.346%	4	Mêda	61.288%	55	Crato	39.201%	106	Câmara de Lobos	25.239%	157	Golegã	14.099%	208	Serpa	6.262%	260
Aguiar da Beira	415.126%	5	Aljezur	60.714%	56	Machico	38.764%	107	Póvoa de Lanhoso	25.128%	158	Vagos	14.043%	209	Entroncamento	6.147%	261
Lajes das Flores	404.419%	6	Cantanhede	59.967%	57	Redondo	38.671%	108	Moimenta da Beira	24.724%	159	Paços de Ferreira	13.944%	210	Valongo	6.146%	262
Constância	363.064%	7	Marvão	59.296%	58	Vila Nova de Paiva	37.744%	109	Santa Comba Dão	24.655%	160	Águeda	13.921%	211	Póvoa de Varzim	6.065%	263
Estarreja	286.901%	8	Monforte	59.095%	59	São Brás de Alportel	37.709%	110	Alcobaça	24.595%	161	Vila Flor	13.879%	212	Salvaterra Magos	5.819%	264
Vila do Conde	230.989%	9	Óbidos	58.420%	60	Vinhais	37.286%	111	Albergaria-a-Velha	24.547%	162	Vila Real	13.818%	213	Benavente	5.730%	265
Guarda	222.232%	10	Boticas	57.129%	61	Tavira	37.262%	112	Celorico de Basto	23.491%	163	Reguengos Monsaraz	13.746%	214	Ribeira Grande	5.678%	266
Castro Marim	192.812%	11	Mourão	57.048%	62	Figueira Castelo Rodrigo	36.375%	113	Faro	22.800%	164	Santa Cruz	13.645%	215	Oleiros	5.583%	267
Nelas	181.581%	12	Azambuja	56.595%	63	Gavião	35.427%	114	Pinhel	22.522%	165	São João da Madeira	13.357%	216	Almeirim	5.554%	268
Monchique	174.977%	13	Vizela	56.196%	64	Ansião	35.273%	115	Nordeste	22.511%	166	Ferreira do Alentejo	13.259%	217	Almodôvar	5.266%	269
Viana do Castelo	171.106%	14	Alter do Chão	55.967%	65	Tarouca	34.787%	116	Lourinhã	22.405%	167	Abrantes	13.224%	218	Amadora	5.178%	270
Vila Pouca Aguiar	140.787%	15	Vila Viçosa	55.646%	66	Armamar	34.207%	117	Sátão	22.397%	168	Castro Daire	12.029%	219	Moura	4.989%	271
Castanheira Pêra	136.366%	16	Arganil	55.626%	67	Peniche	34.141%	118	Estremoz	21.753%	169	Oliveira de Azeméis	11.931%	220	Mértola	4.712%	272
Albufeira	133.075%	17	Miranda Douro	55.135%	68	Pampilhosa da Serra	34.019%	119	Cabeceiras Basto	21.709%	170	Ourique	11.853%	221	Alcochete	4.377%	273
Vila Velha Ródão	119.398%	18	Sabrosa	55.084%	69	Arraiolos	33.463%	120	Seia	21.229%	171	Ílhavo	11.839%	222	Ponta Delgada	4.246%	274
Paredes Coura	118.419%	19	Tábua	54.378%	70	Alijó	32.744%	121	Mealhada	21.044%	172	Guimarães	11.604%	223	Loures	4.225%	275
Freixo Espada Cinta	115.278%	20	Almeida	52.555%	71	Carregal do Sal	32.719%	122	Nisa	20.870%	173	Mação	11.578%	224	Santa Maria Feira	3.996%	276
Vila Franca Xira	109.905%	21	Caminha	52.449%	72	São Roque do Pico	32.709%	123	Macedo Cavaleiros	20.789%	174	Cinfães	11.408%	225	Vila Nova Barquinha	3.771%	277
Avis	108.821%	22	Alvaiázere	52.094%	73	Mangualde	32.627%	124	Oliveira do Bairro	20.748%	175	Aveiro	11.149%	226	Mafra	3.752%	278
Castro Verde	108.280%	23	Trofa	51.899%	74	Povoação	32.603%	125	Vidigueira	20.511%	176	Vila Verde	10.816%	227	Grândola	3.707%	279
Calheta [R.A.M.]	107.963%	24	Góis	51.101%	75	Lousã	32.315%	126	Portalegre	20.490%	177	Lousada	10.768%	228	Viseu	3.687%	280
Arcos Valdevez	107.210%	25	Nazaré	50.904%	76	Lajes do Pico	32.295%	127	Madalena	20.210%	178	Angra do Heroísmo	10.664%	229	Santarém	3.485%	281
Porto Santo	99.354%	26	Vimioso	50.864%	77	Sobral Monte Agraço	32.265%	128	Lagos	20.164%	179	Leiria	10.638%	230	Tomar	3.383%	282
Valença	96.729%	27	Oliveira Frades	50.392%	78	Mogadouro	32.188%	129	Matosinhos	19.517%	180	Elvas	10.567%	231	Oeiras	3.312%	283
Castelo de Vide	93.971%	28	Aljustrel	50.097%	79	Amares	32.174%	130	Sernancelhe	19.484%	181	Alcanena	10.394%	232	Santiago Cacém	3.206%	284
Melgaço	88.042%	29	Mira	50.065%	80	Celorico da Beira	31.916%	131	Silves	19.431%	182	Porto	10.339%	233	Beja	3.185%	285
Manteigas	86.377%	30	Mortágua	49.857%	81	Vila Nova de Poiares	31.817%	132	Resende	18.606%	183	Calheta [R.A.A.]	10.296%	234	Odemira	2.565%	286
Maia	84.761%	31	Santana	49.719%	82	Penalva Castelo	31.069%	133	Castelo Paiva	18.189%	184	Vila Franca Campo	10.247%	235	Montijo	2.527%	287
Penela	80.721%	32	Oliveira Hospital	49.457%	83	Alvito	30.639%	134	Sever do Vouga	17.720%	185	Penafiel	10.222%	236	Penamacor	2.501%	288
Alenquer	79.807%	33	Soure	49.448%	84	Sabugal	30.422%	135	Vila do Porto	17.422%	186	Ovar	10.154%	237	Ourém	2.195%	289
Arronches	78.845%	34	São Vicente	49.259%	85	Vouzela	30.044%	136	Vila Nova Foz Côa	17.216%	187	Sardoal	10.075%	238	Odivelas	2.183%	290
Vila Nova Gaia	74.439%	35	Porto de Mós	48.851%	86	Arruda dos Vinhos	29.744%	137	Montalegre	16.879%	188	Horta	9.852%	239	Sintra	2.179%	291
Mesão Frio	73.885%	36	Borba	47.772%	87	Ribeira Brava	29.562%	138	Ponte de Sor	16.779%	189	Marco de Canaveses	9.812%	240	Proença-a-Nova	2.171%	292
Pedrógão Grande	73.706%	37	Vila Nova Cerveira	47.409%	88	Barrancos	29.469%	139	Anadia	16.648%	190	Barcelos	9.802%	241	Palmela	2.132%	293
Figueiró Vinhos	73.345%	38	Batalha	46.539%	89	Alandroal	29.323%	140	Tondela	16.543%	191	Felgueiras	9.773%	242	Vila de Rei	2.099%	294
Vila do Bispo	73.042%	39	Murça	46.178%	90	Gouveia	28.645%	141	Esposende	16.522%	192	Coimbra	9.706%	243	Setúbal	2.066%	295

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Table A1 (cont.). Results for the efficiency of public spending on energy, by municipality, in 2018

Municipalities	Efficiency	Rank	Municipalities	Efficiency	Rank	Municipalities	Efficiency	Rank	Municipalities	Efficiency	Rank	Municipalities	Efficiency	Rank	Municipalities	Efficiency	Rank
Fornos Algodres	71.208%	40	Santo Tirso	45.783%	91	Figueira da Foz	28.369%	142	Cuba	16.471%	193	Torres Vedras	9.505%	244	Sertã	1.793%	296
Sousel	69.179%	41	Ribeira de Pena	44.988%	92	Ponta do Sol	27.905%	143	Fafe	16.260%	194	Coruche	9.453%	245	Cascais	1.687%	297
Mora	69.082%	42	Santa Cruz Flores	44.193%	93	Condeixa-a-Nova	27.814%	144	Vila Praia Vitória	16.132%	195	Lamego	9.410%	246	Belmonte	1.613%	298
Monção	68.529%	43	Terras de Bouro	44.130%	94	Gondomar	27.668%	145	Baião	16.026%	196	Montemor-o-Velho	9.276%	247	Lisboa	1.456%	299
Alfândega Fé	67.924%	44	Velas	41.540%	95	Valpaços	27.526%	146	Peso da Régua	16.007%	197	Évora	9.256%	248	Moita	1.412%	300
Campo Maior	67.805%	45	Cadaval	41.479%	96	Viana do Alentejo	27.466%	147	São Pedro do Sul	15.719%	198	Funchal	8.321%	249	Idanha-a-Nova	1.374%	301
Porto Moniz	66.908%	46	Miranda do Corvo	41.124%	97	Penedono	27.060%	148	Olhão	15.542%	199	Lagoa [R.A.A.]	8.253%	250	Barreiro	1.219%	302
Santa Cruz Graciosa	66.189%	47	Trancoso	40.924%	98	Alpiarça	27.058%	149	Caldas da Rainha	15.272%	200	Arouca	7.852%	251	Covilhã	1.144%	303
Carrazeda Ansiães	66.046%	48	Loulé	40.419%	99	Penacova	26.870%	150	Chaves	15.154%	201	Rio Maior	7.455%	252	Seixal	1.032%	304
Corvo	65.884%	49	Vieira do Minho	40.402%	100	Vale de Cambra	26.869%	151	Chamusca	14.991%	202	Cartaxo	7.299%	253	Sesimbra	0.939%	305
Alcoutim	64.781%	50	Vendas Novas	40.280%	101	Vila Real Santo António	26.457%	152	São João Pesqueira	14.792%	203	Alcácer do Sal	7.252%	254	Fundão	0.921%	306
Ponte da Barca	64.767%	51	Lagoa	40.251%	102	Murtosa	26.164%	153	Bragança	14.617%	204	Amarante	7.045%	255	Castelo Branco	0.750%	307

Table A2. Results for the efficiency of public spending on energy, by municipality, in 2019

Municipalities	Efficiency	Rank	Municipalities	Efficiency	Rank	Municipalities	Efficiency	Rank	Municipalities	Efficiency	Rank	Municipalities	Efficiency	Rank	Municipalities	Efficiency	Rank
Lajes das Flores	1762.990%	1	Bombarral	60.144%	52	Alvito	37.585%	103	Lajes do Pico	24.664%	154	Tondela	13.413%	205	Torres Novas	6.582%	257
Vila Nova Famalicão	738.659%	2	Santa Cruz Graciosa	60.037%	53	Mondim de Basto	36.769%	104	Cabeceiras Basto	24.575%	155	Santa Cruz	13.073%	206	Entroncamento	6.507%	258
Torre Moncorvo	554.182%	3	São Vicente	59.963%	54	Sobral Monte Agraço	36.609%	105	Santa Comba Dão	23.548%	156	Chamusca	12.499%	207	Espinho	5.741%	259
Aguiar da Beira	471.785%	4	Sousel	59.892%	55	Tarouca	36.413%	106	Matosinhos	23.068%	157	Ourique	12.497%	208	Valongo	5.706%	260
Sines	420.222%	5	Aljustrel	58.335%	56	Montemor-o-Novo	35.585%	107	Mirandela	22.979%	158	Castro Daire	12.389%	209	Almeirim	5.685%	261
Constância	370.350%	6	Carrazeda Ansiães	57.925%	57	Gavião	34.829%	108	Oliveira do Bairro	22.449%	159	Guarda	12.271%	210	Braga	5.677%	262
Castro Marim	341.444%	7	Trofa	57.896%	58	Tavira	34.819%	109	Nordeste	22.301%	160	São João Madeira	12.072%	211	Almodôvar	5.665%	263
Estarreja	315.669%	8	Arronches	56.898%	59	Penacova	34.670%	110	Vale de Cambra	22.179%	161	Sever do Vouga	11.766%	212	Moura	5.626%	264
Vila do Conde	215.258%	9	Arganil	56.599%	60	Gouveia	34.510%	111	Ribeira Brava	21.986%	162	Sardoal	11.723%	213	Amadora	5.574%	265
Maia	188.639%	10	Oliveira de Frades	55.835%	61	Redondo	34.352%	112	Mealhada	21.977%	163	Águeda	11.633%	214	Salvaterra Magos	5.525%	266
Viana do Castelo	187.803%	11	Santo Tirso	55.759%	62	Ansião	34.187%	113	Alpiarça	21.909%	164	Alcanena	11.579%	215	Vila Nova Foz Côa	5.518%	267
Nelas	176.699%	12	Mourão	55.240%	63	Vinhais	33.348%	114	Cuba	21.890%	165	Bragança	11.354%	216	Póvoa de Varzim	5.297%	268
Monchique	136.567%	13	Monforte	55.195%	64	Vendas Novas	33.229%	115	Seia	21.666%	166	São João Pesqueira	11.102%	217	Mértola	5.254%	269
Pedrógão Grande	135.819%	14	Ribeira de Pena	54.731%	65	Sabugal	33.010%	116	Nisa	21.535%	167	Oliveira Azeméis	11.083%	218	Benavente	5.179%	270
Albufeira	125.662%	15	Freixo Espada à Cinta	53.632%	66	Pampilhosa Serra	32.847%	117	Pombal	21.472%	168	Lamego	11.059%	219	Oleiros	5.033%	271
Vila Velha Ródão	121.734%	16	Murça	53.543%	67	Peniche	31.579%	118	Resende	21.457%	169	Guimarães	10.926%	220	Ribeira Grande	4.851%	272
Avis	118.841%	17	Cantanhede	51.793%	68	Viana do Alentejo	31.563%	119	Lourinhã	21.255%	170	Elvas	10.841%	221	Viseu	4.185%	273
Paredes de Coura	118.279%	18	Azambuja	51.423%	69	Penalva Castelo	30.784%	120	Albergaria-a-Velha	21.211%	171	Lousada	10.737%	222	Loures	4.147%	274
Mesão Frio	111.472%	19	Vizela	50.925%	70	Macedo Cavaleiros	30.653%	121	Sernancelhe	21.046%	172	Torres Vedras	10.609%	223	Ponta Delgada	4.107%	275
Castro Verde	104.815%	20	Marvão	50.705%	71	Vila Nova Paiva	30.591%	122	Gondomar	20.738%	173	Calheta [R.A.A.]	10.582%	224	Grândola	3.968%	276
Vila Franca de Xira	104.019%	21	Góis	50.161%	72	Vila do Bispo	30.327%	123	Madalena	20.504%	174	Ferreira do Zêzere	10.536%	225	Beja	3.864%	277
Valença	102.551%	22	Trancoso	49.529%	73	Mogadouro	30.314%	124	Reguengos Monsaraz	20.196%	175	Portimão	10.529%	226	Mafra	3.766%	278
Penela	97.537%	23	São Brás Alportel	47.695%	74	Lousã	30.311%	125	Esposende	19.889%	176	Vila Franca Campo	10.522%	227	Alcochete	3.656%	279

Table A2 (cont.). Results for the efficiency of public spending on energy, by municipality, in 2019

Municipalities	Efficiency	Rank	Municipalities	Efficiency	Rank	Municipalities	Efficiency	Rank	Municipalities	Efficiency	Rank	Municipalities	Efficiency	Rank	Municipalities	Efficiency	Rank
Vila Pouca Aguiar	96.982%	24	Santa Cruz Flores	47.601%	75	Valpaços	29.988%	126	Silves	19.385%	177	Aveiro	10.516%	228	Santa Maria Feira	3.462%	280
Manteigas	96.465%	25	Figueira Castelo Rodrigo	47.575%	76	Barrancos	29.948%	127	Portalegre	19.283%	178	Vila Verde	10.457%	229	Santiago Cacém	3.322%	281
Porto Santo	96.181%	26	Santana	47.384%	77	Crato	29.892%	128	Vila do Porto	19.208%	179	Vagos	10.249%	230	Vila Nova Barquinha	3.308%	282
Arcos de Valdevez	91.852%	27	Alvaiázere	46.512%	78	Ponta do Sol	29.756%	129	Vila Praia da Vitória	18.640%	180	Ílhavo	10.226%	231	Tomar	3.254%	283
Vila Nova de Gaia	91.385%	28	Oliveira Hospital	46.349%	79	Penedono	29.651%	130	Alcobaça	18.590%	181	Barcelos	10.189%	232	Odemira	3.185%	284
Calheta [R.A.M.]	91.187%	29	Óbidos	46.264%	80	Loulé	29.535%	131	Faro	18.352%	182	Vila Flor	10.161%	233	Santarém	2.996%	285
Castanheira Pêra	89.719%	30	Armamar	45.624%	81	Carregal do Sal	29.527%	132	Olhão	18.239%	183	Angra Heroísmo	10.097%	234	Oeiras	2.911%	286
Alenquer	88.659%	31	Fronteira	45.469%	82	Condeixa-a-Nova	29.276%	133	Miranda do Corvo	18.223%	184	Penafiel	9.869%	235	Penamacor	2.628%	287
Alcoutim	85.019%	32	Vieira do Minho	45.087%	83	São Roque Pico	29.266%	134	São Pedro do Sul	17.549%	185	Porto	9.736%	236	Palmela	2.549%	288
Corvo	84.478%	33	Terras de Bouro	44.879%	84	Celorico de Basto	29.173%	135	Baião	17.538%	186	Serpa	9.633%	237	Belmonte	2.495%	289
Melgaço	83.165%	34	Cadaval	44.512%	85	Povoação	29.083%	136	Estremoz	17.375%	187	Felgueiras	9.526%	238	Odivelas	2.399%	290
Castelo Vide	81.550%	35	Vila Nova Cerveira	42.974%	86	Vila Nova Poiares	29.046%	137	Golegã	16.949%	188	Horta	9.439%	239	Ourém	2.262%	291
Boticas	79.738%	36	Santa Marta Penaguião	42.458%	87	Lagoa	28.808%	138	Vila Real Santo António	16.835%	189	Marco Canaveses	9.383%	240	Proença-a-Nova	2.236%	292
Ponte da Barca	73.662%	37	Machico	42.175%	88	Vidigueira	28.627%	139	Câmara de Lobos	16.817%	190	Coruche	9.265%	241	Setúbal	2.204%	293
Fornos de Algodres	73.655%	38	Porto de Mós	42.152%	89	Figueira da Foz	28.606%	140	Montalegre	16.815%	191	Ovar	9.222%	242	Montijo	2.171%	294
Celorico da Beira	71.191%	39	Caminha	42.093%	90	Arraiolos	28.139%	141	Vila Real	16.545%	192	Funchal	8.907%	243	Sintra	2.089%	295
Alfândega da Fé	71.040%	40	Soure	41.399%	91	Alandroal	27.877%	142	Tabuaço	16.519%	193	Mação	8.829%	244	Sertã	2.007%	296
Mêda	69.764%	41	Batalha	41.344%	92	Peso da Régua	26.791%	143	Lagos	16.276%	194	Cinfães	8.659%	245	Vila de Rei	1.994%	297
Aljezur	67.067%	42	Mangualde	40.834%	93	Arruda dos Vinhos	26.757%	144	Fafe	15.787%	195	Leiria	8.377%	246	Lisboa	1.501%	298
Porto Moniz	66.913%	43	Vila Viçosa	40.809%	94	Murtosa	26.462%	145	Abrantes	15.462%	196	Coimbra	8.028%	247	Cascais	1.449%	299
Monção	66.789%	44	Alijó	40.679%	95	Sátão	26.159%	146	Caldas da Rainha	14.653%	197	Alcácer do Sal	7.689%	248	Moita	1.432%	300
Portel	64.577%	45	Velas	40.486%	96	Moimenta da Beira	25.945%	147	Paços de Ferreira	14.539%	198	Évora	7.480%	249	Idanha-a-Nova	1.377%	301
Figueiró dos Vinhos	63.797%	46	Vimioso	40.392%	97	Marinha Grande	25.778%	148	Nazaré	14.427%	199	Rio Maior	7.359%	250	Covilhã	1.230%	302
Mortágua	63.649%	47	Borba	40.213%	98	Pinhel	25.469%	149	Anadia	14.356%	200	Lagoa [R.A.A.]	7.258%	251	Barreiro	1.215%	303
Almeida	63.120%	48	Tábua	40.112%	99	Amares	25.452%	150	Ferreira do Alentejo	14.163%	201	Cartaxo	7.143%	252	Seixal	1.016%	304
Sabrosa	62.793%	49	Mira	39.925%	100	Vouzela	25.331%	151	Castelo de Paiva	13.995%	202	Paredes	6.959%	253	Sesimbra	0.975%	305
Mora	61.993%	50	Miranda do Douro	38.268%	101	Póvoa de Lanhoso	25.246%	152	Chaves	13.959%	203	Amarante	6.903%	254	Fundão	0.939%	306
Campo Maior	60.829%	51	Alter do Chão	38.201%	102	Ponte de Lima	24.964%	153	Ponte de Sor	13.918%	204	Arouca	6.737%	255	Castelo Branco	0.793%	307

Table A3. Results for the efficiency of public spending on energy, by municipality, in 2020

Municipalities	Efficiency	Rank	Municipalities	Efficiency	Rank	Municipalities	Efficiency	Rank	Municipalities	Efficiency	Rank	Municipalities	Efficiency	Rank	Municipalities	Efficiency	Rank
Castro Marim	672.788%	1	Arronches	63.568%	52	Macedo Cavaleiros	34.305%	103	Nordeste	18.848%	154	Castro Daire	12.572%	205	Almodôvar	6.894%	257
Constância	407.852%	2	Celorico da Beira	63.502%	53	Mora	34.195%	104	Vila Real	18.588%	155	Monção	12.362%	206	Setúbal	6.697%	258
Estarreja	354.085%	3	Miranda do Douro	63.461%	54	Valongo	33.805%	105	Olhão	18.561%	156	Ourique	12.181%	207	Cartaxo	6.524%	259
Aguiar da Beira	299.721%	4	Lajes das Flores	63.263%	55	Barrancos	33.781%	106	Madalena	18.559%	157	Guarda	12.124%	208	Alcochete	5.958%	260
Maia	206.768%	5	Azambuja	62.530%	56	Lousã	32.917%	107	Chaves	18.434%	158	Amarante	11.564%	209	Ponte de Lima	5.851%	261
Viana do Castelo	202.514%	6	Freixo Espada à Cinta	62.128%	57	Mangualde	32.811%	108	Matosinhos	18.332%	159	Vila Franca Xira	11.549%	210	Sesimbra	5.704%	262

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Table A3 (cont.). Results for the efficiency of public spending on energy, by municipality, in 2020

Municipalities	Efficiency	Rank	Municipalities	Efficiency	Rank	Municipalities	Efficiency	Rank	Municipalities	Efficiency	Rank	Municipalities	Efficiency	Rank	Municipalities	Efficiency	Rank
Porto Santo	200.455%	7	Torre de Moncorvo	62.100%	58	Baião	32.549%	109	Abrantes	18.271%	160	Elvas	11.394%	211	Entroncamento	5.667%	263
Trofa	199.559%	8	Marinha Grande	60.901%	59	Carregal do Sal	32.471%	110	Lagoa	18.172%	161	Vila da Praia Vitória	11.353%	212	Amadora	5.564%	264
Santa Maria Feira	197.204%	9	Góis	60.427%	60	Vila do Porto	32.324%	111	Oliveira do Bairro	18.135%	162	São Brás Alportel	11.348%	213	Montemor-o-Velho	5.509%	265
Nelas	194.726%	10	Mortágua	60.181%	61	Nazaré	32.003%	112	Santarém	18.018%	163	Paredes	11.309%	214	Moura	5.439%	266
Vieira do Minho	189.999%	11	Alijó	58.768%	62	Porto Moniz	31.823%	113	São João da Madeira	17.851%	164	Serpa	11.215%	215	Santa Cruz Graciosa	5.432%	267
Pedrógão Grande	161.815%	12	Campo Maior	58.059%	63	Arruda dos Vinhos	31.759%	114	Albergaria-a-Velha	17.758%	165	Cinfães	11.161%	216	Santa Marta Penaguião	5.404%	268
Vila Velha Ródão	160.677%	13	Loulé	56.315%	64	Povoação	31.621%	115	Gondomar	17.700%	166	Velas	10.629%	217	Porto	5.231%	269
Boticas	155.889%	14	Vimioso	54.408%	65	Póvoa de Lanhoso	31.106%	116	Pombal	17.396%	167	Lagos	10.551%	218	Vila Nova Gaia	5.140%	270
Vila Flor	136.385%	15	Fronteira	54.398%	66	Figueira da Foz	31.012%	117	Viana do Alentejo	17.233%	168	Coruche	10.453%	219	Benavente	4.882%	271
Vizela	134.606%	16	Oliveira de Frades	53.388%	67	Gouveia	29.795%	118	Faro	17.210%	169	Sardoal	10.390%	220	Mértola	4.803%	272
Sines	132.771%	17	Monforte	52.728%	68	Penedono	28.271%	119	Valença	17.161%	170	Calheta [R.A.A.]	9.956%	221	Mafra	4.430%	273
Albufeira	129.653%	18	Almeida	52.656%	69	Lajes do Pico	27.965%	120	Portalegre	16.847%	171	Valpaços	9.618%	222	Évora	4.375%	274
Corvo	118.969%	19	Cantanhede	50.840%	70	Reguengos Monsaraz	27.847%	121	Tarouca	16.503%	172	São João Pesqueira	9.565%	223	Ponta Delgada	4.290%	275
Avis	111.082%	20	Arganil	49.884%	71	Sabrosa	27.460%	122	Alandroal	16.375%	173	Angra do Heroísmo	9.237%	224	Funchal	4.079%	276
Tavira	108.196%	21	Cadaval	49.618%	72	Borba	27.390%	123	Marco de Canaveses	16.062%	174	São Roque do Pico	9.203%	225	Loures	3.911%	277
Sabugal	102.133%	22	Vila Nova de Paiva	49.340%	73	Penalva do Castelo	27.214%	124	Felgueiras	15.719%	175	Póvoa de Varzim	9.170%	226	Viseu	3.886%	278
Santo Tirso	97.591%	23	Calheta [R.A.M.]	48.720%	74	Barcelos	27.104%	125	Bragança	15.691%	176	Ponte da Barca	9.117%	227	Arouca	3.847%	279
Mesão Frio	97.469%	24	Pampilhosa da Serra	47.526%	75	Miranda do Corvo	26.645%	126	Murtosa	15.641%	177	Portimão	9.015%	228	Santiago Cacém	3.758%	280
Castro Verde	95.878%	25	Alter do Chão	46.541%	76	Vouzela	26.630%	127	Redondo	15.573%	178	Trancoso	8.928%	229	Montijo	3.728%	281
Portel	95.400%	26	Oliveira do Hospital	46.503%	77	Cabeceiras de Basto	26.542%	128	Mealhada	15.447%	179	Ovar	8.871%	230	Beja	3.647%	282
Monchique	92.650%	27	Marvão	44.833%	78	Vila Viçosa	26.360%	129	Vila Real Santo António	15.173%	180	Vale de Cambra	8.871%	231	Espinho	3.603%	283
Castanheira Pêra	87.596%	28	Vendas Novas	44.201%	79	Condeixa-a-Nova	25.836%	130	Penafiel	15.100%	181	Alcanena	8.814%	232	Palmela	3.567%	284
Penela	87.339%	29	Vila Pouca de Aguiar	43.900%	80	Pinhel	25.342%	131	Lousada	14.618%	182	Anadia	8.665%	233	Vidigueira	3.535%	285
Carrazeda Ansiães	85.571%	30	Figueira Castelo Rodrigo	43.756%	81	Terras de Bouro	24.822%	132	Santa Cruz	14.592%	183	Sintra	8.651%	234	Vila de Rei	3.488%	286
Murça	84.288%	31	Mogadouro	43.499%	82	Paredes de Coura	24.490%	133	Santana	14.592%	184	Machico	8.401%	235	Oleiros	3.367%	287
Alcoutim	82.990%	32	Figueiró dos Vinhos	42.267%	83	Amares	24.006%	134	Alcácer do Sal	14.392%	185	Rio Maior	8.356%	236	Salvaterra Magos	3.190%	288
Alfândega da Fé	82.314%	33	Penacova	40.886%	84	Esposende	23.290%	135	Chamusca	14.326%	186	Seixal	8.353%	237	Odemira	2.897%	289
Manteigas	81.025%	34	Bombarral	40.489%	85	Arraiolos	22.925%	136	Estremoz	14.245%	187	Mação	8.320%	238	Ourém	2.751%	290
Alenquer	80.540%	35	Alvaiázere	40.269%	86	Nisa	22.851%	137	Melgaço	14.005%	188	Castelo de Paiva	8.270%	239	Oeiras	2.647%	291
Castelo de Vide	80.082%	36	Crato	40.214%	87	Montalegre	22.733%	138	Resende	13.894%	189	Câmara de Lobos	8.245%	240	Odivelas	2.305%	292
Ribeira de Pena	79.294%	37	Vinhais	40.042%	88	Peniche	22.657%	139	Ferreira do Alentejo	13.835%	190	Braga	8.163%	241	Proença-a-Nova	2.298%	293
Guimarães	79.199%	38	Gavião	39.978%	89	Mirandela	22.110%	140	Ferreira do Zêzere	13.786%	191	Lamego	8.085%	242	Sernancelhe	2.122%	294
Aljezur	77.800%	39	Sátão	39.967%	90	Torres Vedras	21.797%	141	Alpiarça	13.775%	192	Aveiro	8.072%	243	Penamacor	2.121%	295
Vila do Bispo	76.545%	40	Vila Nova Cerveira	39.845%	91	Paços de Ferreira	21.686%	142	Arcos de Valdevez	13.757%	193	Vila Franca Campo	7.849%	244	Sertã	2.071%	296
Fornos de Algodres	72.857%	41	Armamar	39.610%	92	Fafe	21.647%	143	Ponte de Sor	13.609%	194	Lagoa [R.A.A.]	7.791%	245	Moita	2.016%	297
Tábua	71.011%	42	Celorico Basto	38.724%	93	São Vicente	21.443%	144	Tabuaço	13.597%	195	Águeda	7.731%	246	Sobral Monte Agraço	1.972%	298

Table A3 (cont.). Results for the efficiency of public spending on energy, by municipality, in 2020

Municipalities	Efficiency	Rank	Municipalities	Efficiency	Rank	Municipalities	Efficiency	Rank	Municipalities	Efficiency	Rank	Municipalities	Efficiency	Rank	Municipalities	Efficiency	Rank
Vila Nova Foz Côa	69.648%	43	Porto de Mós	38.203%	94	São Pedro do Sul	21.341%	145	Torres Novas	13.527%	196	Caminha	7.609%	247	Barreiro	1.485%	299
Vila Nova Famalicão	69.524%	44	Montemor-o-Novo	37.593%	95	Sousel	21.326%	146	Horta	13.411%	197	Ílhavo	7.589%	248	Belmonte	1.358%	300
Mêda	68.799%	45	Óbidos	37.517%	96	Tondela	20.548%	147	Ribeira Brava	13.184%	198	Oliveira de Azeméis	7.581%	249	Idanha-a-Nova	1.343%	301
Silves	68.151%	46	Batalha	36.971%	97	Mourão	20.525%	148	Golegã	13.118%	199	Tomar	7.547%	250	Lisboa	1.342%	302
Vila Nova Poiares	67.944%	47	Mira	36.938%	98	Moimenta da Beira	20.244%	149	Vila do Conde	12.971%	200	Almeirim	7.503%	251	Cascais	1.316%	303
Seia	66.842%	48	Alvito	36.917%	99	Santa Comba Dão	19.885%	150	Ribeira Grande	12.782%	201	Grândola	7.501%	252	Covilhã	0.994%	304
Soure	65.147%	49	Peso da Régua	36.526%	100	Lourinhã	19.871%	151	Vila Verde	12.744%	202	Vagos	7.211%	253	Almada	0.984%	305
Aljustrel	64.905%	50	Santa Cruz das Flores	36.022%	101	Cuba	19.627%	152	Ponta do Sol	12.698%	203	Vila Nova Barquinha	7.057%	254	Sever do Vouga	0.854%	306
Mondim de Basto	64.265%	51	Ansião	34.431%	102	Alcobaça	18.954%	153	Caldas da Rainha	12.621%	204	Coimbra	7.048%	255	Fundão	0.742%	307

Table A4. Results for the efficiency of public spending on energy, by municipality, in 2021

Municipalities	Efficiency	Rank	Municipalities	Efficiency	Rank	Municipalities	Efficiency	Rank	Municipalities	Efficiency	Rank	Municipalities	Efficiency	Rank	Municipalities	Efficiency	Rank
Castro Marim	1010.605%	1	Fornos de Algodres	61.838%	52	Vila Viçosa	38.028%	103	Ponte da Barca	24.121%	154	Chaves	14.783%	205	Santa Cruz	7.642%	257
Estarreja	497.150%	2	Celorico de Basto	61.026%	53	Povoação	37.962%	104	Peniche	23.414%	155	Ponte de Lima	14.736%	206	Alcácer do Sal	7.614%	258
Sines	442.670%	3	Ribeira de Pena	59.555%	54	Mortágua	37.852%	105	Carregal do Sal	23.413%	156	Machico	14.725%	207	Rio Maior	7.527%	259
Azambuja	425.266%	4	Vila Nova de Foz Côa	58.935%	55	Arcos de Valdevez	37.756%	106	Nisa	23.321%	157	Santa Comba Dão	14.384%	208	Aveiro	7.165%	260
Constância	381.234%	5	Campo Maior	58.885%	56	Alvito	37.024%	107	Nordeste	23.291%	158	Tondela	14.093%	209	Almeirim	6.756%	261
Aguiar da Beira	283.287%	6	Calheta [R.A.M.]	58.230%	57	Condeixa-a-Nova	36.219%	108	Alpiarça	23.199%	159	Viseu	14.093%	210	Cartaxo	6.731%	262
Vila Nova Cerveira	281.701%	7	Santa Marta Penaguião	57.577%	58	Vimioso	36.139%	109	Tarouca	23.135%	160	Sernancelhe	14.009%	211	Arouca	6.635%	263
Vizela	237.863%	8	Sousel	57.363%	59	Nazaré	35.922%	110	Caminha	22.291%	161	Horta	13.997%	212	Almodôvar	6.371%	264
Nelas	214.594%	9	Marinha Grande	57.120%	60	Ansião	35.849%	111	Paredes	22.289%	162	São Pedro do Sul	13.533%	213	Entroncamento	6.236%	265
Trofa	184.088%	10	Mêda	56.828%	61	Monção	35.693%	112	Penedono	22.266%	163	Ponte de Sor	13.477%	214	Torres Novas	6.168%	266
Porto Santo	149.777%	11	Santa Cruz Graciosa	56.721%	62	Valpaços	35.043%	113	Penalva Castelo	22.266%	164	Vila Real	13.460%	215	Salvaterra Magos	5.845%	267
Boticas	149.619%	12	Batalha	56.482%	63	Lourinhã	34.635%	114	Seia	22.190%	165	Tabuaço	13.352%	216	Benavente	5.837%	268
Torre de Moncorvo	139.458%	13	Celorico da Beira	56.288%	64	Viana do Alentejo	34.375%	115	Ribeira Brava	21.540%	166	Anadia	13.333%	217	Lamego	5.811%	269
Castanheira de Pêra	136.050%	14	Monforte	55.602%	65	Gouveia	34.229%	116	Oliveira do Bairro	21.517%	167	Ourique	12.595%	218	Évora	5.751%	270
Vila Velha de Ródão	132.776%	15	Santa Cruz das Flores	54.503%	66	Esposende	34.225%	117	Portalegre	21.336%	168	Albufeira	12.057%	219	Moura	5.490%	271
Monchique	114.487%	16	Guimarães	54.128%	67	Redondo	33.807%	118	Vila Verde	20.943%	169	São João Pesqueira	11.985%	220	Vila Franca Campo	5.103%	272
Avis	110.724%	17	São Brás de Alportel	54.118%	68	Penafiel	33.631%	119	Torres Vedras	20.824%	170	Chamusca	11.773%	221	Espinho	5.093%	273
Corvo	110.403%	18	Pampilhosa da Serra	54.089%	69	Tavira	33.193%	120	Moimenta da Beira	20.708%	171	Câmara de Lobos	11.746%	222	Oleiros	4.794%	274
Castro Verde	109.355%	19	Paredes de Coura	54.005%	70	Lousada	32.968%	121	Albergaria-a-Velha	20.700%	172	Lagos	11.700%	223	Mértola	4.767%	275
Sabrosa	108.668%	20	Alter do Chão	53.689%	71	Gondomar	32.634%	122	Sabugal	20.638%	173	Caldas da Rainha	11.614%	224	Ponta Delgada	4.401%	276
Vieira do Minho	103.713%	21	Mondim de Basto	53.361%	72	Alvaiázere	32.585%	123	Abrantes	20.549%	174	Vila Nova de Gaia	11.602%	225	Odivelas	4.155%	277
Vila do Bispo	99.631%	22	Porto de Mós	53.105%	73	Vinhais	32.543%	124	Mealhada	20.061%	175	Elvas	11.415%	226	Vila de Rei	4.134%	278
Pedrógão Grande	98.050%	23	Trancoso	52.703%	74	Fafe	32.500%	125	Sátão	19.796%	176	Coruche	11.267%	227	Beja	3.880%	279
Vila Nova Poiares	93.925%	24	Aljustrel	51.941%	75	Peso da Régua	32.348%	126	Olhão	19.752%	177	São João Madeira	11.252%	228	Grândola	3.771%	280
Mesão Frio	92.969%	25	Fronteira	51.908%	76	Felgueiras	32.250%	127	Estremoz	19.555%	178	Oliveira de Azeméis	10.958%	229	Oeiras	3.655%	281
Portel	92.024%	26	Valença	51.392%	77	Vila do Porto	32.102%	128	Póvoa de Varzim	19.520%	179	Mação	10.346%	230	Sintra	3.489%	282
Cadaval	92.020%	27	Lousã	51.143%	78	Miranda do Corvo	31.714%	129	Alandroal	19.298%	180	Guarda	10.201%	231	Alcochete	3.400%	283

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Table A4 (cont.). Results for the efficiency of public spending on energy, by municipality, in 2021

Municipalities	Efficiency	Rank	Municipalities	Efficiency	Rank	Municipalities	Efficiency	Rank	Municipalities	Efficiency	Rank	Municipalities	Efficiency	Rank	Municipalities	Efficiency	Rank
Terras de Bouro	88.343%	28	Mora	50.171%	79	Figueiró Vinhos	31.519%	130	Reguengos Monsaraz	19.187%	181	Calheta [R.A.A.]	10.157%	232	Santa Maria Feira	3.374%	284
Vila Nova Famalicão	87.372%	29	Tábua	48.723%	80	Arraiolos	31.274%	131	Ferreira do Zêzere	19.144%	182	Bragança	9.964%	233	Tomar	3.345%	285
Alcoutim	85.547%	30	Montemor-o-Novo	48.667%	81	Crato	30.909%	132	Cuba	18.956%	183	Alenquer	9.907%	234	Santiago Cacém	3.108%	286
Sobral Monte Agraço	85.379%	31	Alijó	47.978%	82	Vila Nova Paiva	30.779%	133	Barcelos	18.321%	184	Vila Nova Barquinha	9.864%	235	Ourém	2.897%	287
Penela	82.638%	32	Almeida	47.846%	83	Vouzela	30.779%	134	Montalegre	18.180%	185	Loulé	9.757%	236	Santarém	2.879%	288
Góis	81.324%	33	Óbidos	47.544%	84	Mogadouro	30.438%	135	Vale de Cambra	18.054%	186	Serpa	9.621%	237	Odemira	2.597%	289
Murça	77.102%	34	Freixo Espada à Cinta	47.111%	85	Vendas Novas	30.359%	136	Madalena	17.725%	187	Braga	9.616%	238	Penamacor	2.403%	290
Cantanhede	74.808%	35	Paços de Ferreira	47.044%	86	Mangualde	29.828%	137	Vila Franca de Xira	17.566%	188	Alcanena	9.576%	239	Lisboa	2.263%	291
Aljezur	72.794%	36	Póvoa de Lanhoso	46.229%	87	Armamar	29.517%	138	Ponta do Sol	17.184%	189	Ribeira Grande	9.525%	240	Proença-a-Nova	2.262%	292
Manteigas	72.542%	37	Mourão	45.920%	88	Barrancos	29.073%	139	Vila da Praia Vitória	17.182%	190	Ovar	9.497%	241	Funchal	2.154%	293
Castelo Vide	71.482%	38	Bombarral	45.595%	89	Macedo Cavaleiros	28.678%	140	Lagoa	16.918%	191	Porto	9.476%	242	Setúbal	2.049%	294
Vila Flor	71.230%	39	Oliveira Frades	45.515%	90	Marco Canaveses	28.589%	141	Silves	16.905%	192	Montemor-o-Velho	9.473%	243	Sertã	2.011%	295
Carrazeda Ansiães	70.243%	40	Figueira Castelo Rodrigo	44.855%	91	Lajes do Pico	27.782%	142	Faro	16.773%	193	Águeda	9.465%	244	Palmela	1.983%	296
Oliveira do Hospital	69.356%	41	Marvão	44.507%	92	Pinhel	27.645%	143	Mirandela	16.520%	194	Vagos	9.443%	245	Cascais	1.971%	297
Lajes das Flores	69.248%	42	Velas	44.027%	93	Viana do Castelo	27.611%	144	Alcobaça	16.440%	195	Portimão	9.368%	246	Montijo	1.847%	298
Mira	68.790%	43	Penacova	43.960%	94	Figueira da Foz	27.438%	145	Sever do Vouga	16.297%	196	Ílhavo	9.264%	247	Idanha-a-Nova	1.396%	299
Soure	68.406%	44	Amares	43.873%	95	São Roque do Pico	27.268%	146	São Vicente	16.276%	197	Amadora	8.424%	248	Belmonte	1.290%	300
Alfândega da Fé	67.911%	45	Vila Pouca de Aguiar	43.338%	96	Vila do Conde	26.032%	147	Matosinhos	16.038%	198	Lagoa [R.A.A.]	8.282%	249	Moita	1.119%	301
Arronches	67.737%	46	Gavião	42.067%	97	Santana	25.927%	148	Castelo de Paiva	15.638%	199	Coimbra	8.254%	250	Covilhã	0.930%	302
Santo Tirso	67.592%	47	Miranda do Douro	41.576%	98	Vidigueira	25.280%	149	Ferreira do Alentejo	15.536%	200	Castro Daire	8.119%	251	Barreiro	0.925%	303
Maia	67.326%	48	Cabeceiras de Basto	41.331%	99	Amarante	25.237%	150	Golegã	15.499%	201	Cinfães	7.908%	252	Sesimbra	0.921%	304
Baião	65.138%	49	Porto Moniz	40.344%	100	Murtosa	25.204%	151	Sardoal	15.479%	202	Mafra	7.863%	253	Fundão	0.855%	305
Arruda Vinhos	62.717%	50	Melgaço	38.945%	101	Vila Real Santo António	25.027%	152	Valongo	15.435%	203	Leiria	7.856%	254	Seixal	0.850%	306
Arganil	62.587%	51	Borba	38.589%	102	Pombal	24.810%	153	Resende	14.972%	204	Angra Heroísmo	7.723%	255	Castelo Branco	0.686%	307

Table A5. Results for the efficiency of public spending on energy, by municipality, in 2022

Municipalities	Efficiency	Rank	Municipalities	Efficiency	Rank	Municipalities	Efficiency	Rank	Municipalities	Efficiency	Rank	Municipalities	Efficiency	Rank	Municipalities	Efficiency	Rank
Sines	1209.412%	1	Alcoutim	58.614%	52	Torres Novas	30.980%	103	Mação	18.686%	154	Moimenta da Beira	9.663%	205	Castelo de Paiva	4.640%	257
Nelas	897.910%	2	Cantanhede	57.049%	53	Vidigueira	30.973%	104	Carregal do Sal	18.657%	155	Mortágua	9.582%	206	Santa Cruz Graciosa	4.562%	258
Estarreja	887.554%	3	Ribeira de Pena	55.376%	54	Torre de Moncorvo	30.913%	105	Benavente	18.531%	156	Sardoal	9.504%	207	Ribeira Grande	4.562%	259
Lajes das Flores	699.759%	4	Vimioso	55.280%	55	Barcelos	29.785%	106	Miranda do Corvo	18.353%	157	Olhão	9.202%	208	Vila Nova de Gaia	4.463%	260
Vila Velha de Ródão	606.373%	5	Mogadouro	54.883%	56	Castelo de Vide	29.746%	107	Viana do Castelo	18.038%	158	Albergaria-a-Velha	9.128%	209	Coimbra	4.369%	261
Albufeira	489.383%	6	Guarda	53.994%	57	Mira	29.267%	108	Tábua	17.942%	159	Lajes do Pico	8.987%	210	Povoação	4.216%	262
Constância	432.390%	7	Figueira Castelo Rodrigo	53.865%	58	Póvoa Lanhoso	28.917%	109	Bragança	17.387%	160	São Roque Pico	8.873%	211	Sever do Vouga	4.211%	263
Vila Nova Cerveira	404.018%	8	Alandroal	53.042%	59	Matosinhos	28.736%	110	Lousada	17.295%	161	Amadora	8.792%	212	São Vicente	4.162%	264
Avis	354.322%	9	Murça	52.136%	60	Lagoa	28.679%	111	Évora	17.252%	162	Baião	8.545%	213	Paredes	4.128%	265
Manteigas	346.423%	10	Marvão	51.215%	61	Santa Cruz Flores	27.984%	112	Vouzela	16.979%	163	Vila Nova de Paiva	8.493%	214	Tomar	4.044%	266
Póvoa de Varzim	292.147%	11	Borba	50.004%	62	Penela	27.853%	113	Salvaterra Magos	16.582%	164	Amarante	8.287%	215	São João Madeira	4.008%	267

Table A5 (cont.). Results for the efficiency of public spending on energy, by municipality, in 2022

Municipalities	Efficiency	Rank	Municipalities	Efficiency	Rank	Municipalities	Efficiency	Rank	Municipalities	Efficiency	Rank	Municipalities	Efficiency	Rank	Municipalities	Efficiency	Rank
Trofa	287.718%	12	Condeixa-a-Nova	48.510%	63	Fafe	27.801%	114	Nisa	16.431%	165	Alcobaça	8.155%	216	Ílhavo	3.954%	268
Vila Flor	277.094%	13	Vila Viçosa	48.116%	64	Golegã	27.756%	115	Alcanena	16.084%	166	Caldas da Rainha	8.134%	217	Cascais	3.950%	269
Boticas	200.471%	14	Pombal	48.106%	65	Porto Santo	27.665%	116	Vila do Conde	16.082%	167	Portimão	8.088%	218	Aveiro	3.917%	270
Corvo	177.951%	15	Alijó	48.083%	66	Ourique	27.649%	117	Sousel	15.830%	168	Alcácer do Sal	8.081%	219	Alcochete	3.855%	271
Vieira do Minho	169.930%	16	Montalegre	48.071%	67	Barrancos	27.492%	118	Penacova	15.818%	169	Vila Franca Campo	7.889%	220	Lagoa [R.A.A.]	3.823%	272
Vendas Novas	154.372%	17	Óbidos	47.547%	68	Seia	27.478%	119	Resende	15.553%	170	Portalegre	7.839%	221	Odemira	3.806%	273
Valença	148.722%	18	Batalha	47.356%	69	Vila Nova Foz Côa	27.478%	120	Monção	15.508%	171	Murtosa	7.830%	222	Beja	3.723%	274
Castro Marim	147.708%	19	Aljustrel	46.908%	70	Caminha	27.445%	121	Cuba	15.378%	172	Mangualde	7.661%	223	Sintra	3.684%	275
Miranda do Douro	143.212%	20	Figueiró dos Vinhos	46.164%	71	Penedono	27.337%	122	Estremoz	15.220%	173	Oliveira Azeméis	7.381%	224	Câmara de Lobos	3.565%	276
Castanheira de Pêra	137.925%	21	Maia	46.071%	72	Porto	27.172%	123	Sernancelhe	15.055%	174	Mafra	7.011%	225	Elvas	3.057%	277
Porto Moniz	131.952%	22	Trancoso	45.645%	73	Mirandela	27.001%	124	Santa Cruz	14.972%	175	Ovar	6.979%	226	Lisboa	3.029%	278
Guimarães	127.861%	23	Gondomar	44.747%	74	Macedo Cavaleiros	26.923%	125	Arronches	14.512%	176	Almodôvar	6.978%	227	Odivelas	2.949%	279
Calheta [R.A.M.]	123.985%	24	Aguiar da Beira	44.580%	75	Montemor-o-Novo	26.575%	126	Melgaço	14.305%	177	Felgueiras	6.929%	228	Ponta Delgada	2.879%	280
São Brás Alportel	119.578%	25	Paredes de Coura	44.557%	76	Soure	26.456%	127	Almeirim	14.082%	178	Loures	6.797%	229	Santa Maria Feira	2.695%	281
Aljezur	114.366%	26	Valpaços	43.952%	77	Ansião	25.620%	128	Vale de Cambra	13.964%	179	Cinfães	6.639%	230	Castro Daire	2.692%	282
Mourão	110.480%	27	Alenquer	43.616%	78	Tavira	25.387%	129	Gouveia	13.300%	180	Nordeste	6.514%	231	Horta	2.613%	283
Porto de Mós	109.978%	28	Silves	43.392%	79	Marinha Grande	24.653%	130	Paços de Ferreira	13.193%	181	Águeda	6.475%	232	Ponte de Sor	2.389%	284
Castro Verde	107.447%	29	Arraiolos	43.282%	80	Chaves	24.254%	131	Vila Franca de Xira	13.151%	182	São Pedro do Sul	6.466%	233	Angra Heroísmo	2.364%	285
Vila Nova Poiares	104.520%	30	Mondim de Basto	42.909%	81	Oliveira de Frades	24.060%	132	Ponte da Barca	12.719%	183	Marco Canaveses	6.434%	234	Sertã	2.203%	286
Pedrógão Grande	100.007%	31	Celorico de Basto	42.822%	82	Fronteira	23.841%	133	Sátão	12.654%	184	Faro	6.394%	235	Viseu	2.133%	287
Azambuja	100.000%	32	Fornos Algodres	42.585%	83	Arganil	23.175%	134	Braga	12.609%	185	Vila do Porto	6.153%	236	Anadia	1.845%	288
Terras de Bouro	99.215%	33	Cadaval	42.559%	84	Almeida	22.971%	135	Ferreira do Alentejo	12.602%	186	Sabugal	6.116%	237	Funchal	1.841%	289
Vizela	93.741%	34	Nazaré	40.938%	85	Entroncamento	22.655%	136	Crato	12.592%	187	Pinhel	6.116%	238	Calheta [R.A.A.]	1.691%	290
Oliveira do Hospital	93.415%	35	Vila Pouca Aguiar	39.162%	86	Tarouca	22.430%	137	Serpa	12.552%	188	Espinho	5.906%	239	Palmela	1.370%	291
Alfândega da Fé	92.035%	36	Mora	38.934%	87	Alter do Chão	21.879%	138	Cabeceiras Basto	12.480%	189	Oliveira do Bairro	5.839%	240	Santiago Cacém	1.343%	292
Vila do Bispo	90.894%	37	Vila Nova Famalicão	37.914%	88	Ponte de Lima	21.417%	139	Vila Verde	12.444%	190	Vila Praia Vitória	5.806%	241	Oleiros	1.258%	293
Góis	88.782%	38	Mesão Frio	36.735%	89	Abrantes	21.295%	140	Loulé	12.121%	191	Velas	5.806%	242	Sesimbra	0.989%	294
Monchique	79.779%	39	Arcos de Valdevez	36.715%	90	Lagos	21.200%	141	Celorico da Beira	11.883%	192	Ourém	5.759%	243	Barreiro	0.936%	295
Vinhais	77.044%	40	Sabrosa	36.682%	91	Peso da Régua	21.144%	142	Oeiras	11.673%	193	Machico	5.703%	244	Penamacor	0.936%	296
Santo Tirso	76.444%	41	Viana do Alentejo	36.619%	92	Monforte	21.008%	143	Tondela	11.656%	194	Lamego	5.610%	245	Setúbal	0.900%	297
Sobral Monte Agraço	74.165%	42	Figueira da Foz	36.403%	93	Torres Vedras	20.726%	144	Gavião	11.635%	195	Santa Comba Dão	5.556%	246	Seixal	0.747%	298
Pampilhosa Serra	70.646%	43	Alpiarça	35.960%	94	Mêda	20.577%	145	São João Pesqueira	11.497%	196	Mealhada	5.533%	247	Moita	0.707%	299
Portel	68.852%	44	Reguengos de Monsaraz	34.940%	95	Armamar	20.247%	146	Vila Real	11.279%	197	Penafiel	5.516%	248	Covilhã	0.647%	300
Redondo	67.996%	45	Amares	33.627%	96	Lousã	19.882%	147	Vila Real Santo António	11.224%	198	Vagos	5.482%	249	Belmonte	0.565%	301
Bombarral	66.274%	46	Coruche	33.441%	97	Alvaiázere	19.876%	148	Penalva do Castelo	11.179%	199	Arouca	5.456%	250	Almada	0.535%	302
Tabuaço	65.310%	47	Carrazeda de Ansiães	33.029%	98	Ponta do Sol	19.474%	149	Moura	10.857%	200	Madalena	5.437%	251	Montijo	0.487%	303
Esposende	64.053%	48	Lourinhã	32.629%	99	Peniche	19.224%	150	Montemor-o-Velho	10.657%	201	Valongo	5.416%	252	Fundão	0.468%	304
Arruda Vinhos	61.185%	49	Santa Marta Penaguião	32.495%	100	Campo Maior	19.019%	151	Santana	10.256%	202	Ribeira Brava	5.350%	253	Vila de Rei	0.369%	305
Chamusca	60.924%	50	Ferreira do Zêzere	32.324%	101	Alvito	18.936%	152	Vila Nova Barquinha	9.953%	203	Grândola	5.142%	254	Proença-a-Nova	0.350%	306
Freixo Espada à Cinta	58.862%	51	Rio Maior	31.327%	102	Cartaxo	18.877%	153	Santarém	9.842%	204	Mértola	4.796%	255	Castelo Branco	0.120%	307

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