Energy Efficiency Benchmark Industry

Tino Schuette[1]

[1] Faculty of Management and Engineering, University of Applied Science Zittau/Goerlitz, 02763 Zittau, Germany
t.schuette@hszg.de

Abstract. The rational use of energy is crucial to industrial companies especially when energy prices are rising and the necessity for green energy is increasing. In order to improve energy efficiency, companies need to compare their energy efficiency with others to see whether their own performance is better or worse than that of competitors, to show whether rational use increased or decreased and to control their own improvement goals. To give reliable measures, suitable energy performance indicators need to be calculated which base on robust data. Founded on available data since 2015 from of the Federal Statistical Office in Germany for over 45,000 companies with 20 or more employees summarized in over 300 economic sectors (NACE 4-digits) the Energy Efficiency Benchmark for the Industry (EEBI) was developed. The benchmark is calculated using the annual survey of energy use in manufacturing, mining and quarrying, the cost structure survey and the annual report for companies in the manufacturing sector. Besides a wide inter- and cross-sectional view, the developed EEBI gives a solid set of longitudinal data. The calculated indicators allow for fact-based comparisons of companies of different sizes by reference values, esp. turnover, gross value added and employees with regard to fuel intensity, electricity intensity, total energy consumption and CO2-emissions. The available database of indicators in the EEBI gives industrial companies from mining and manufacturing the possibility to generate an own benchmark report which shows how the firm performers in relation to the direct competitors in the same sector (with the same NACE-Code). Remark: NACE is a four-digit classification providing the framework for collecting and presenting statistical data according to economic activity.

Keywords: Energy Efficiency, Energy Performance Indicators, Industry.

1 Motivation

The Energy Efficiency Directive (EU/2023/1791) significantly raises the EU's ambition on energy efficiency. [8] The EED is a legal framework for increasing energy efficiency in member states to achieve climate targets. Among other things, the directive requires greater transparency regarding energy consumption. Energy flows and performance indicators for energy efficiency must be determined and evaluated. These EPIs must be comparable and verifiable. On the national level the EED is the basis for the German Energy Services and Energy Efficiency Measures Act (EDL-G). [9] The German Energy Efficiency Act (EnEfG) expands on these requirements by imposing new obligations for energy management systems. [10]

Regardless of whether a regular energy audit (according to DIN EN 16247-1) or an energy management certification (according to DIN EN ISO 50001) is to be conducted, energy performance indicators (EPIs) are playing an increasingly

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important role, as they describe the energy-related performance of a process or organizational unit and thus contribute to the setting of objectives as well as control and monitoring in energy management. [1][2] This is also explicitly reflected in the DIN ISO 50006 standard for measuring energy-related performance using energy baselines and energy performance indicators. [3]

Comparability is important when working with indicators. The discussed Energy Efficiency Benchmark for the Industry (EEBI) in this paper is helpful in this regard. It enables a company to compare itself with its industry branch and thus assess its efficiency situation in relation to its major competitors.

2 Date Source and Calculation

2.1 Benchmarking

In its simplest form, a benchmark is a reference point. It serves as a standard of comparison. In companies, benchmarking is a process for evaluating results, working methods, or processes in relation to best practice. It can be used to identify important areas for improvement. For this, appropriate data must be used. Energy efficiency indicators must then be introduced that allow the operator to assess the performance of the system over time or to compare it with others in the same field. It is important that the criteria used in data collection are traceable and kept up to date. The energy efficiency benchmarking methodology based on the DIN EN 16231 standard states: The purpose of energy efficiency benchmarking is to determine the relevant data and indicators of energy consumption, both from a technical and behavioral, quantitative and qualitative perspective, by comparing performance between or within units. [4] It can be conducted internally (within an organization) and/or externally (between organizations). The boundaries to which the benchmarking refers must be defined. The focus is on specific energy consumption. Energy efficiency benchmarking should be understood as part of the continuous improvement processes required by the energy management standard DIN EN ISO 50001.

The following steps must be considered:

Objective Setting and Planning. Defining the objectives for benchmarking, including determining and selecting the approach and type of benchmarking, developing a project plan, and allocating resources.

Data Collection and Verification. Agreeing on the data collection procedure as well as collecting and verifying the data, and classifying the results.

Evaluation and Results. Assessing current performance levels as well as creating tables, charts, and graphs to support the evaluation and seek explanations for differences in performance.

Reporting. Communicating the results, including conclusions.

Monitoring and Action (optional). Implementing specific actions; monitoring the development and implementation of specific actions, including actions resulting from the conclusions.

Energy data collection must be carried out carefully. Data should be meaningful and traceable. In some cases, data may require adjustment factors (e.g., weather conditions, operating regimes, production volumes). Relevant variables are also referred to as those that significantly influence energy-related performance. As a result, EPIs must be created that enable comparability. To fulfill this task, they must, among other things, demonstrate high explanatory power and comprehensibility, as well as consistency and verifiability. Furthermore, they must be analytically sound and updatable. This places high demands on data availability and quality. It is therefore recommended that EPIs shouldn't be formulated arbitrarily, but based on a clear calculation. In the simplest case, these are common, specific energy performance indicators. In a broader sense, statistical models could be used to describe the relationship between energy consumption and relevant influencing variables. Here, the focus is exclusively on ratios.

2.2 Specific Energy Performance Indicators

The EEBI enables a comparison of key figures for the energy efficiency of a company with the corresponding average of all companies in this sector in Germany. The data used to calculate the average are official annual statistical surveys of energy consumption and its reference values from over 45,000 companies with 20 or more employees for approximately 300 economic sectors (4-digit classification of the EU-wide NACE-classification). The NACE-code (nomenclature statistique des activités économiques dans la communauté européenne) is a standardized classification system for economic activities used by the European Union. It serves to structure and categorize the various economic activities, which is important for statistical purposes, legal regulations, and international comparisons. [5] The focus on companies with more than 20 employees is determined by the available, reliable data. Even when small companies are excluded here, big companies cause the major amount of energy consumption and thus are the primary target group for the benchmark.

The Energy Efficiency Benchmark Industry (EEBI) is usable for all companies in the economic sectors WZ 0510–3320. Company information on energy consumption is required to make an efficiency comparison. The energy sources covered are electricity, district heating, renewable energies, natural gas, heating oil, coal, and other energy sources. To make companies of different sizes comparable, three values are normalized: (i) sales, (ii) gross value added, and (iii) number of employees. The Federal Statistical Office has discontinued the annual publication of the cost structure survey for the manufacturing sector, as well as mining and quarrying, starting in 2021. This means that the values for gross value added by economic sectors are no longer available in their previous form, based on the manufacturing prices of companies.

Therefore, the current Energy Efficiency Benchmark Industry (EEBI) that determines energy efficiency indicators for the individual economic sector calculated gross value added at factor cost, which is statistically available. As a result, a comparison of the 2022 gross value added indicators for the respective economic sectors with those of previous years is not meaningful, as it uses a different calculation basis. However, the sales-related and employee-related energy efficiency indicators for 2022 are not affected by this change and are therefore comparable with previous years as before.

It is important to notice that the EEBI is not a regression analysis in the sense of inductive statistics but clearly uses simple descriptive ratios that are easy to understand and computable for the companies by themselves. Because the statistical data for every industrial sector are anonymized the mean of each WZ-class is calculated.

For the following industry sectors, including sub-sectors, the EEBI is available on an annual basis (Table 1).

Table 1. Industry Sections. [6]

Section No.	WZ2008
	Mining and Quarrying
05	Mining of coal and lignite
06	Extraction of crude petroleum and natural gas
07	Mining of metal ores
08	Other mining and quarrying
09	Mining support service activities
	Manufacturing
10	Food products
11	Beverages
12	Tobacco products
13	Textiles
14	Wearing apparel
15	Leather and related products
16	Wood and products of wood and cork, except furniture
17	Paper and paper products
18	Printing and reproduction of recorded media
19	Coke and refined petroleum products
20	Chemicals and chemical products
21	Basic pharmaceutical products and preparations
22	Rubber and plastic products
23	Other non-metallic mineral products
24	Basic metals
25	Fabricated metal products, except machinery and equipment

26	Computer, electronic and optical products
27	Electrical equipment
28	Machinery and equipment n.e.c.
29	Motor vehicles, trailers and semi-trailers
30	Other transport equipment
31	Furniture
32	Other manufacturing
33	Repair and installation of machinery and equipment

Benchmarking is conducted using a series of comparative indicators that describe the industry or the company conducting the benchmark. For the proper implementation of the EEBI, certain information is required from the company being compared. In addition to sales, gross value added, and number of employees, this includes the economic sector number, as well as energy consumption classified by energy source. The energy efficiency benchmark can be conducted internally using the calculated catalog of indicators published by the author since 2015. The energy efficiency benchmark should be repeated annually, which will reveal development trends between the participating company and the economic sector. Due to the EU-wide classification of economic sectors, an efficiency comparison can generally be implemented in Germany as well as in other EU countries, preferably in countries within the Euro area.

3 Examples

3.1 WZ08-08

The first example demonstrates the implementation of the EEBI for the sector 08: Quarrying of Minerals and Earth, other mining (2022). The key figures represent the average of 1,064 companies in this industry in Germany.

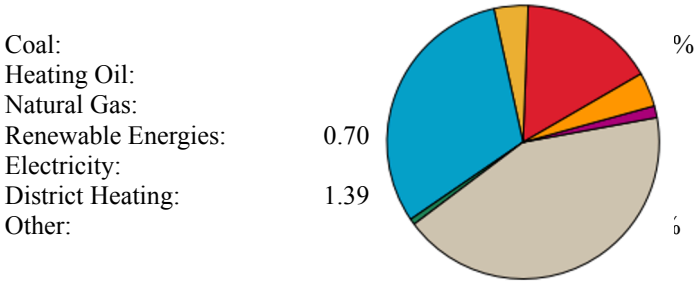

Fig. 1. Example.WZ08-08: Other mining. [7]

(i) Sales (S) related indicators

a) Total energy consumption of S: 2.32 GJ/TEUR
b) Fuel consumption of S: 1.33 GJ/TEUR
c) Electricity consumption of S: 275.78 kWh/TEUR
d) CO2 emissions of S: 213.89 kgCO2/TEUR

(ii) Gross value added (GVA) related indicators

a) Total energy consumption of GVA: 4.26 GJ/TEUR
b) Fuel consumption of GVA: 2.45 GJ/TEUR
c) Electricity consumption of GVA: 505.63 kWh/TEUR
d) CO2 emissions of GVA: 393.59 kgCO2/TEUR

(iii) Employee (E) related indicators

a) Total energy consumption per E: 539.20 GJ/E
b) Fuel consumption per E: 309.24 GJ/E
c) Electricity consumption per E: 63,927.68 kWh/E
d) CO2 emissions per E: 49,762.70 kgCO2/E

(iv) Productivity indicators

a) Sales per employee:
232.65 TEUR
b) Share of gross value added in sales: 54.34 %

The example gives you an inside into the average energy efficiency of the sector so that you can compare your own performance with the competitors. Of course, you have to make sure that you are a comparable company. Otherwise, you may get wrong interpretations because of individual specifics.

3.2 **WZ08-10**

The second example demonstrates the implementation of the EEBI for the sector 10: Food products (2022). The key figures represent the average of 5,635 companies in this industry in Germany.

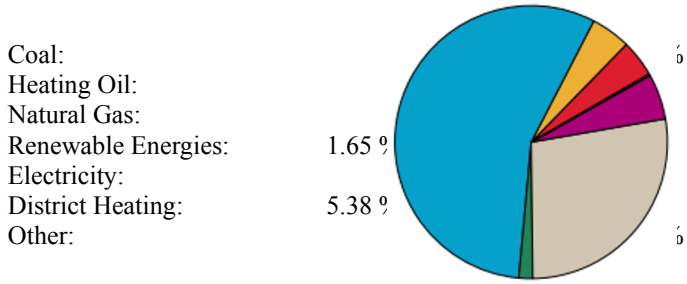

Fig. 2. Example.WZ08-10: Food products. [7]

(i) Sales (S) related indicators

a) Total energy consumption of S: 1.09 GJ/TEUR
b) Fuel consumption of S: 0.79 GJ/TEUR
c) Electricity consumption of S: 83.28 kWh/TEUR
d) CO2 emissions of S: 83.36 kgCO2/TEUR

(ii) Gross value added (GVA) related indicators

a) Total energy consumption of GVA: 4.38 GJ/TEUR
b) Fuel consumption of GVA: 3.17 GJ/TEUR
c) Electricity consumption of GVA: 335.48 kWh/TEUR
d) CO2 emissions of GVA: 335.81 kgCO2/TEUR

(iii) Employee (E) related indicators

a) Total energy consumption per E: 365.62 GJ/E
b) Fuel consumption per E: 264.87 GJ/E
c) Electricity consumption per E: 28,006.41 kWh/E
d) CO2 emissions per E: 28,003.42 kgCO2/E

(iv) Productivity indicators

a) Sales per employee:
336.28 TEUR

b) Share of gross value added in sales: 24.82 %

In order to get a good comparison with your own company you need to calculate the EPIs of the EEBI for your business. Usually, the data should be directly available.

In order to use the EEBI for comparisons you need to determine the relevant, individual data. The needed values are listed below (Table2.

Table 2. Company Information.

Dimension	Measurement
Economic Sector	4-digit-NACE-code
Sales in Thousand Euros	TEUR
Gross Value Added in Thousand Euros	TEUR
Employees (excl. temporary workers)	Number
Electricity consumption	kWh or GJ respectively
District Heating consumption	kWh or GJ respectively
Natural Gas consumption	kWh or GJ respectively
Heating Oil consumption	kWh or GJ respectively
Coal and Lignite consumption	kWh or GJ respectively
Renewable Energies (excl. electricity)	kWh or GJ respectively
0ther Energy sources	kWh or GJ respectively

The values must be specified in the required dimension (maybe convert if necessary) or marked with 0 for energy sources that are not used. If not directly available, the gross value added (GVA) can be calculated by taking the total output (revenue) minus intermediate consumption (cost of goods and services used in production). In other words, it's the value of a company's production after subtracting the cost of the materials and services used to create it. Thus, the GVA is the value that producers have added to the goods and services they have bought.

When all the energy data and economic measures are derived the EPIs as used in the EEBI can be calculated. After that, the company can compare its individual values with the average of the corresponding industry sector and check whether they are below or above average. Of course, the comparison is only senseful if the company is representative for the compared branch. When it has e.g. specific business cases or technologies applied that differ strongly from its competitors a comparison is not really valuable because of heterogeneity.

4 Conclusion

The EEBI provides companies with a basis for comparing their energy consumption with similar facilities. Benefits of such a benchmark are manifold. By comparing with similar operations, inefficient processes or excessive energy consumption can be more easily identified. Companies that operate particularly energy efficiently can use this as a marketing tool. It strengthens their image. Appropriate benchmarks provide clarity about their own energy consumption compared to their industry peers. Regular benchmarking enables the success of efficiency measures to be monitored over time. Comparison with other companies generally creates incentives for continuous improvement.
Benchmarking data can also be used as a basis for investment decisions, e.g. when replacing equipment.

Obviously, the presented EEBI is based on simple descriptive statistics from the official national statistical bureau and thus easy to understand and applicable by companies. The focus of the benchmark is not a detailed econometric analysis about the driving forces of EPIs but a helpful orientation for firms to compare its own energy consumption performance with the average of comparable competitors. Because it is based on mean values the EEBI it is not useful for firms with very specific characteristics. Nevertheless, the approach can be transferred to other countries, if similar data is available.

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